From:	Grizzle, Betty
To:	Shoemaker, Justin
Subject:	Fwd: Inquiry about wolverine status review regarding soon-to-be-published wolverine research
Date:	Tuesday, November 14, 2017 1:14:56 PM

FYI.

---------- Forwarded message ----------
From: **Rebecca Watters** <watters.rj@gmail.com>
Date: Tue, Nov 14, 2017 at 12:07 PM
Subject: Inquiry about wolverine status review regarding soon-to-be-published wolverine research
To: betty_grizzle@fws.gov, bryon_holt@fws.gov

Hi Betty and Bryon -

I'm the director of the Wolverine Foundation. We support wolverine research projects and are strictly a science-based organization - we don't do advocacy. I have a quick question for one or both of you.

I've recently heard that the wolverine status review is being peer-reviewed. One of the research projects to which we gave funding is on the verge of publishing their results, which pertain to the potential threats posed by non-motorized and motorized backcountry recreation. The researchers anticipate publication by the end of the year. I know it's too late for these results to enter the record for the current status review, but will there be an opportunity to submit them further down the line in a public-comment period, or otherwise enter the official record?

The question of recreation effects on wolverine is one of the least understood areas of potential threat (or lack thereof) and it's the one that I most often see people with an agenda (mostly anti-snowmobile folks) making unsupported claims about. It would be great to see this question dealt with on a scientific basis in the official process.

Thanks so much for any insight you can give!

Best,

Rebecca

--
Rebecca Watters

Executive Director
The Wolverine Foundation
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Bozeman, MT 59771
wolverinefoundation.org

Director
The Mongolian Wolverine Project
www.egulo.wordpress.com

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
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2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
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COLORADO
Parks and Wildlife
Department of Natural Resources

317 West Prospect Road
Fort Collins, CO 80526

Jodi Bush
Office Supervisor
Montana State Ecological Services Office
585 Shepard Way, Suite 1
Helena, MT 59601

RE: Wolverine Species Status Assessment Comments

Dear Ms Bush:

Colorado Parks and Wildlife thanks you for the opportunity to review the Species Status Assessment (SSA) for the North American wolverine. This is a well written document that compiles a wealth of information on the species.

Specific comments are supplied by Eric Odell, Species Conservation Program Manager, as an attachment to this letter. Please contact Eric at 970-472-4340 or eric.odell@state.co.us with any questions.

Once again, thank you for the opportunity to review.

Sincerely,

David Klute
Species Conservation Unit Supervisor

CC: Reid DeWalt, Assistant Director, Wildlife and Natural Resources
Craig McLaughlin, Terrestrial Section Manager

Bob D. Broscheid, Director, Colorado Parks and Wildlife • Parks and Wildlife Commission: Robert W. Bray • Marie Haskett • Carrie Hauser
John Howard, Vice-Chair • Marvin McDaniel • Dale Pizel • Jim Spehar • James Vigil • Dean Wingfield • Michelle Zimmerman, Secretary • Alex Zipp

Colorado Parks and Wildlife Comments on
North American Wolverine Species Status Assessment (SSA)

Prepared by: Eric Odell, Species Conservation Program Manager
14 November 2017

The SSA is a well developed, well organized document describing the state of the knowledge and science of the North American wolverine.

Our primary comment relates to the description of the status of the species in the Southern Rockies, specifically Colorado. Wolverine are undoubtedly native to the state of Colorado, however, it has likely been over 100 years since there was a viable, self-sustaining population. Colorado represents unoccupied, historical range of the wolverine.

The discussion on page 15 of the SSA, and the associated Figure 3 describe the current range of the wolverine. All modeled wolverine habitat in Colorado is included in Figure 3 as current range. We feel that this is a broad overestimation, as there are no confirmed individuals or populations in the state. The last known individual (M56) was a dispersing male from Wyoming that was first confirmed individual in Colorado in nearly 100 years. His tenure in the state was from 2009 until at least 2012. He was killed in North Dakota in May 2016, and his whereabouts from 2012-2016 remain unknown.

The SSA acknowledges that the depiction in Figure 3 does not necessarily represent current areas where reproducing populations of wolverine are found (p.15). If that is the case, we suggest that the legend on Figure 3 be changed from 'Current Range' to either 'Historical Range' or 'Potential Range'. This figure is referenced later (p.46) in the "Biological Status – Current Condition" section. Importantly, and correctly, Colorado is not included in this section describing the population abundance and distribution within the Contiguous United States (p. 46-47).

Other than this minor but important clarification, Colorado Parks and Wildlife does not have further contributions to the literature or scientific knowledge of the species.

On an editorial note, the figures in the SSA retain a comment "DRAFT Not for real use yet" (or something along those lines). It will be important to remove those notations prior to finalization of the document.

From: stephanie_potter@fws.gov
To: Justin Shoemaker; Matt Hogan; Stephen Torbit; Noreen Walsh; Wanda Cantrell; Rose Reed; Theresa Rabot; Rollie White; Paul Souza; Betty Grizzle; Caitlin Snyder; Bryon Holt; John Guinotte; Josh Hull; Madeline Drake; Kit Hershey; Jodi Bush; Michael Thabault; Marjorie Nelson; Dana Jacobsen; Gregg Kurz
Subject: Wolverine Rec Meeting (2 Days)

POC:

Justin Shoemaker

Classification and Recovery Biologist

U.S. Fish and Wildlife Service, Region 6

Phone: 309-757-5800 x214

Email: justin_shoemaker@fws.gov

From: Grizzle, Betty
To: John Guinotte
Subject: Second Draft of PPT
Date: Monday, November 27, 2017 1:30:13 PM
Attachments: DRAFT North American Wolverine PPT.pdf

Hi John - Here is my latest draft, incorporating comments from you and Steve, new maps, etc.
I would like to send this to the Core Team before our call next week, or at least to Justin this week.
Obviously, this draft does not have peer review comments, which are due on Friday, or other partner review feedback, also due this week.
Will be here today and tomorrow (and Friday), if you want to discuss, and part of the day Wed and Thur.

--

Betty J. Grizzle, D.Env.
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Carlsbad, CA 92008
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760-431-5901 fax

North American Wolverine

Gulo gulo luscus

Photo credit: Mark Packila; used with permission.

Prepared for Recommendation Team Meeting
Mountain Prairie Regional Office
January 10-11, 2017

Timeline of Federal Actions

1995, 2003: 90-day Not Substantial Findings

- 2003 finding challenged; 12-mo finding ordered by Court
- **2008: Not Warranted Finding (no DPS in contiguous U.S.)**
- Challenged; FWS agreed to issue new finding

2010: 12-month Finding

- **DPS warranted**, but precluded by higher priority listing actions
- MDL agreement – publish either proposed rule or withdraw warranted finding; agreed to publish in FY 2013

2013: Proposed Rule, with DPS (using 2010 analysis), 4(d)

- Based primarily on synergistic effects of climate change, persistent snow
- **2014: Withdrawal of proposed rule**
- Remanded back to FWS

Current Action: 12-month Finding

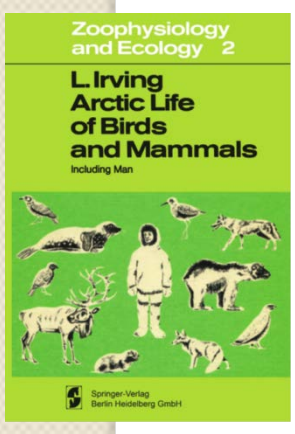
- Listing options – Not warranted or Warranted
- *Using 4-Phase Approach, SSA Report*
- 4 peer reviewers
- Withdrawal or Final Rule to publish FY 2018

Species Description & Needs

- Taxonomy of No American & Eurasian wolverines – same species, *subspecies* unclear
- Culturally important to Aboriginal Peoples and Native Americans
- Curious, cautious, learned behaviors (e.g., avalanche rescue)
- Unique fur properties – valuable for trade
  - Other morphological/physiological adaptations
- Key physical/ecological needs
  - Large territories, remote areas, high elevations
  - Access to variety of food, seasonal variability
  - Physical/Structural habitat features (e.g., talus slopes)
    - Linked to reproductive behavior

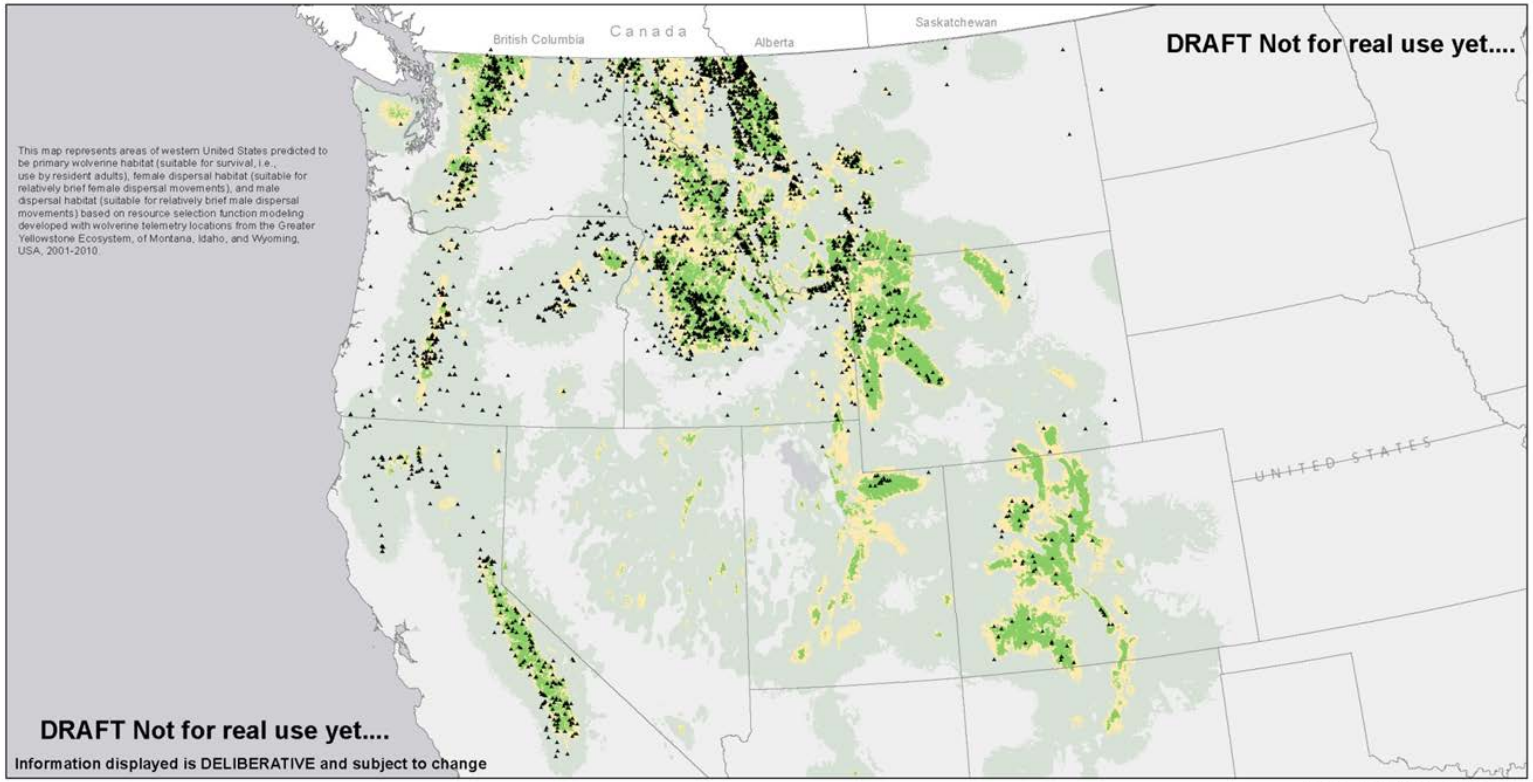
Species Description & Needs (cont.)

- *However*, still many unknowns
  - Difficult animal to survey/study
    - Most studies conducted in winter months
  - Recent Scandinavian & Canadian studies providing new insights
- Physiology (Arctic studies, 1950s-1970s) not well-documented in previous rules
    - Important to describe critical temperatures and elements of thermoneutrality for evaluating effects of climate change



“Potential” Range

- Using ALL available records (western U.S. only)



Current Range

- Developed from Ecoregions mapping (EPA); COSEWIC report; Inman *et al.* 2013; recent observations
- Only 6% is within contiguous United States (75% Canada, 19% AK)
- Using Inman et al. model
  - 96% on Federal lands
  - 41% in designated wilderness areas

Comparison with previous range map (not published)

Habitat Use

WAFWA 2017

Clevenger et al. 2017

Copeland and Yates 2008

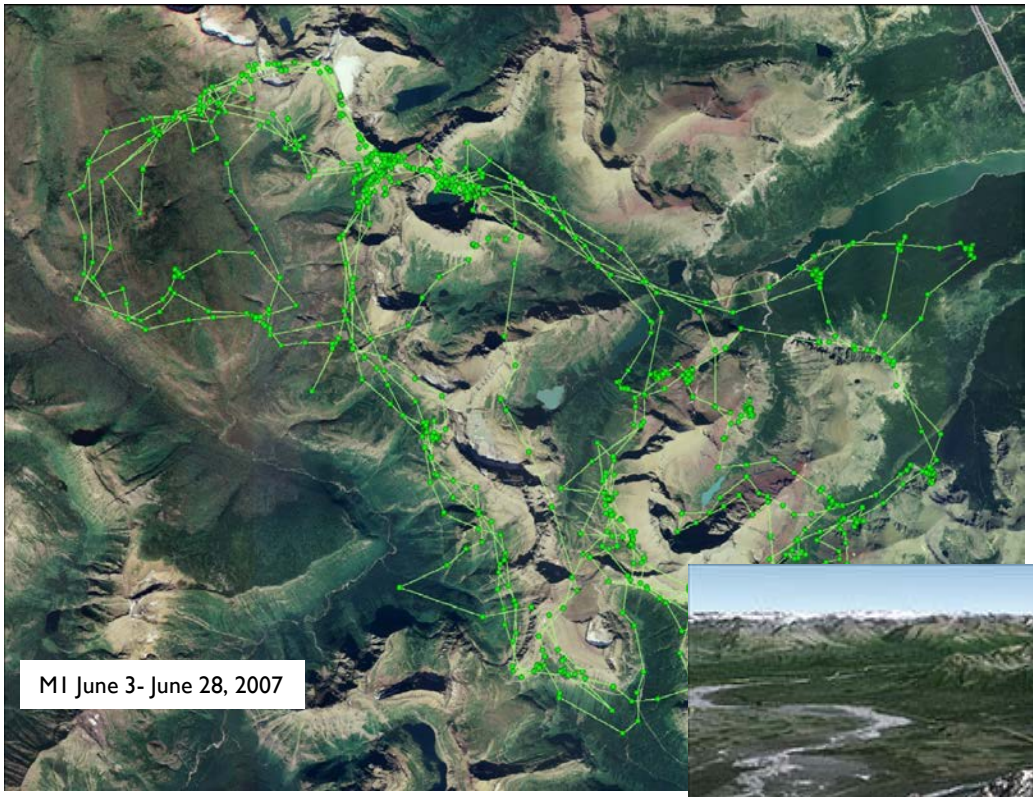
Heinemeyer and Squires 2015

wolverinepedia.zaxtor.net

Summary of Habitat Use related to Life History

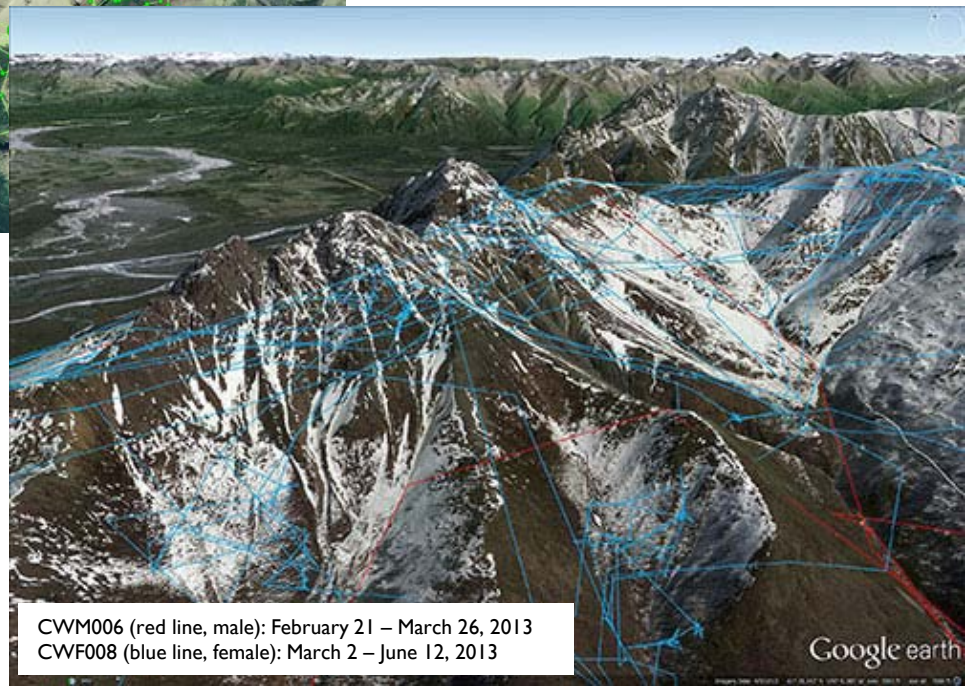
- Broad, landscape scale vegetation associations
  - Arctic tundra, boreal forests, mixed forests
- Other important habitat associations
  - At high elevations (esp. in lower 48), with talus slopes
  - Contains a "ruggedness" element (topographic heterogeneity)
  - Away from human footprint & predators (esp. while raising young)
  - Available food resources, including caching areas
  - Access to water (esp. in summer)
- Large, exclusive territories
  - 54-148 mi^2 for females; 201-610 mi^2 for males (lower U.S.)
- Extensive movement and dispersal capabilities

Example of Movement Patterns



Glacier NP; Copeland and Yates 2008

Southern Alaska; Woodford 2014



Reproduction and Growth

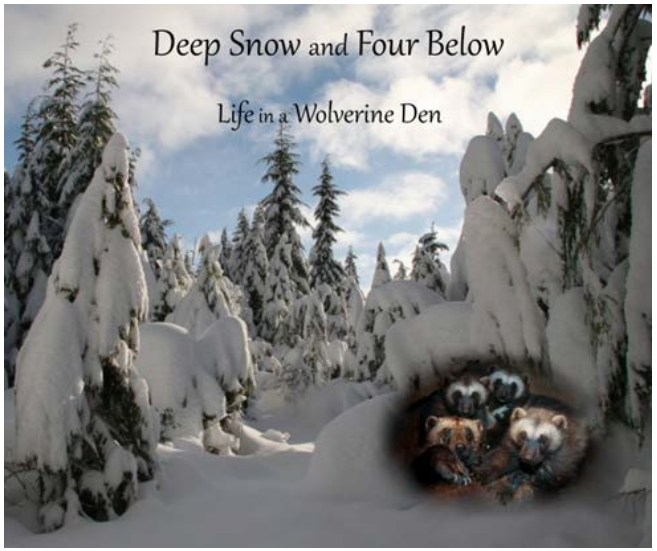
- Polygamous behavior
- Delayed implantation
- Low reproductive rate (less than1 young per adult female per year)
- Short gestation period
- Denning behavior, altricial young
- Extended period of maternal care, but young grow rapidly (fully grown at 8 months)

Magoun 2010

Use of Dens & Denning Habitat

Denning "habitat" in Glacier NP, from Copeland and Yates 2008

Entrance to natal den, Glacier NP, from Copeland and Yates 2008



March 2 2017 den, Sweden (lower left, under boulder)

Wolverine habitat, denning, & snow – only one piece of the puzzle

- Copeland *et al.* 2010 – ***assumed*** persistent of wolverine populations is linked to availability of suitable reproductive den sites
  - Thus, snow cover that persists throughout the denning period ***may be*** a critical habitat component limiting their geographic distribution
- This (now 7-year old paper) was good, first effort to model where wolverines might be found; limitations w/ bioclimatic models
- The snow cover depths and (late) dates of snow cover persistence were then used to predict wolverine distributions and population-level effects from CC (McKelvey *et al.* 2011)
- ➢ This became narrative for evaluating effects of CC w/o understanding methods/limitations of these models

Wolverine habitat, denning, & snow – only one piece of the puzzle

- Two peer reviewers of 2013 proposed rule raised substantive concerns on this issue and the Service's interpretation
- New studies – Copeland et al. model does not always predict either wolverine occurrences or den sites
- To discuss later – results of new CC modeling

Summary points re denning

- Very few studies have evaluated denning habitat relative to reproductive success
- Denning habitat varies across Holarctic range
- Young moved from natal den in **late April**;
  - Become mobile and more reliant on solid food brought by mother (rendezvous sites)
- Many factors influence den locations and shifts in den locations (not just temp/snow depth or persistence)
- Analysis of "melt-out" dates for natal den sites in U.S. – earliest was May 25

Other Life History Elements

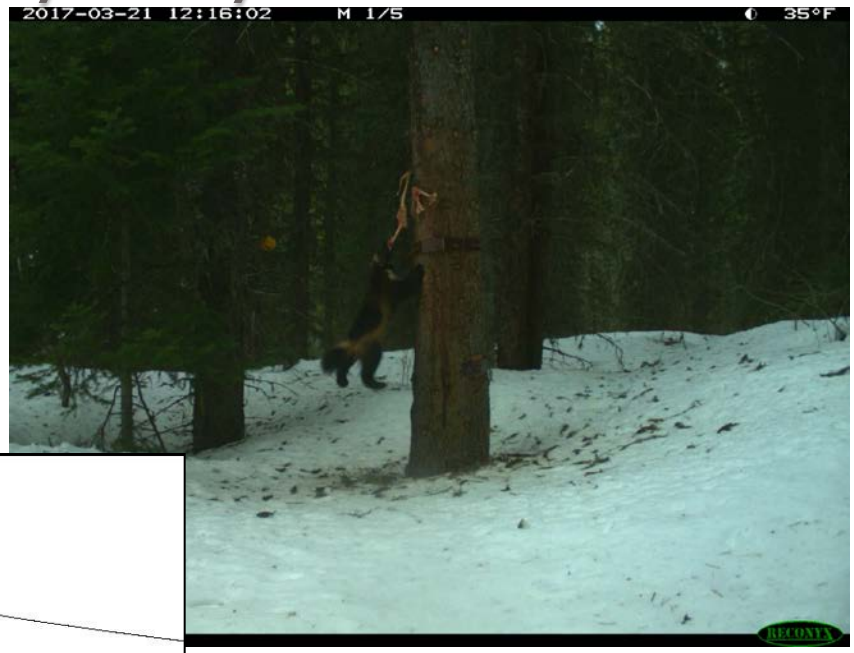
- Diet and Feeding
  - Both scavengers and predators
  - Diet varies regionally, seasonally, yearly
  - Commonly "switch" food sources
- Population Structure
  - Metapopulation in lower 48
  - Panmictic population in Canada
  - Naturally low densities across No America
- Genetic diversity/structure – unclear answers
  - Wolverines still recovering from many decades of hunting and trapping pressures
  - Newer/more complete sampling/analysis and demographic studies needed

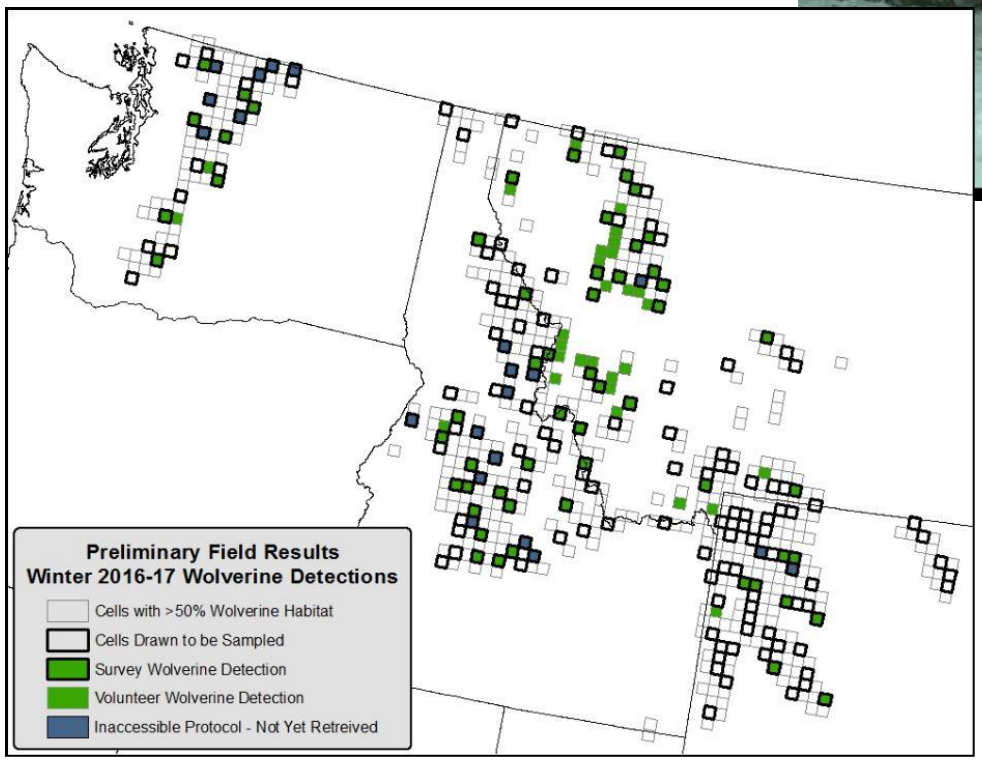
Biological Status (current conditions)

- Population size
  - In No America: uncommon and at naturally low densities
  - Lower 48: model estimate of 318 individuals (range 249 to 626)
    - Wolverine working group developing occupancy analysis
  - Canada – over 10,000 adults
    - Stable or increasing in this northern part of No Am range
  - AK uses density estimates (5-10 per 386 mi^2)
- Movement between AK and Canada, and between lower 48 and Canada

Wolverine detections, Winter 2016-2017 Western States Occupancy Study

- 86 cells (as of 7/2017)
- 157 genetic samples
- Also, Grand Teton NP





Key Potential Stressors Evaluated

- Effects from roads
- Effects from wildland fire
- Disturbance – winter recreational activity, other infrastructure
- Disease and Predation
- Overutilization
  - Research activities
  - Harvesting and incidental trapping
- For Future Conditions
  - Effects of Climate Change
  - Cumulative Effects

Effects from roads (mortality, den site selection)

US287, MT: road-kill death of M204 as he utilized a road-killed elk carcass; from Packila *et al.* 2007

- Mortalities
  - 1972 to 2001: 3 (No America)
  - 2004 to 2016: 6 (lower 48 States)
  - 2013 to 2015: 10 (Alberta, Canada)
- Road miles/density (modeled habitat)
  - > 7,500 ft elevation - high density in So Rockies

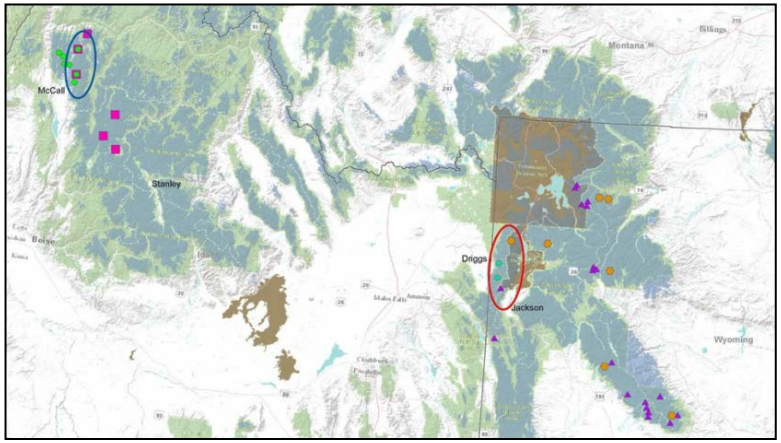
> 7,500 ft elevation:

95% secondary roads

Disturbance

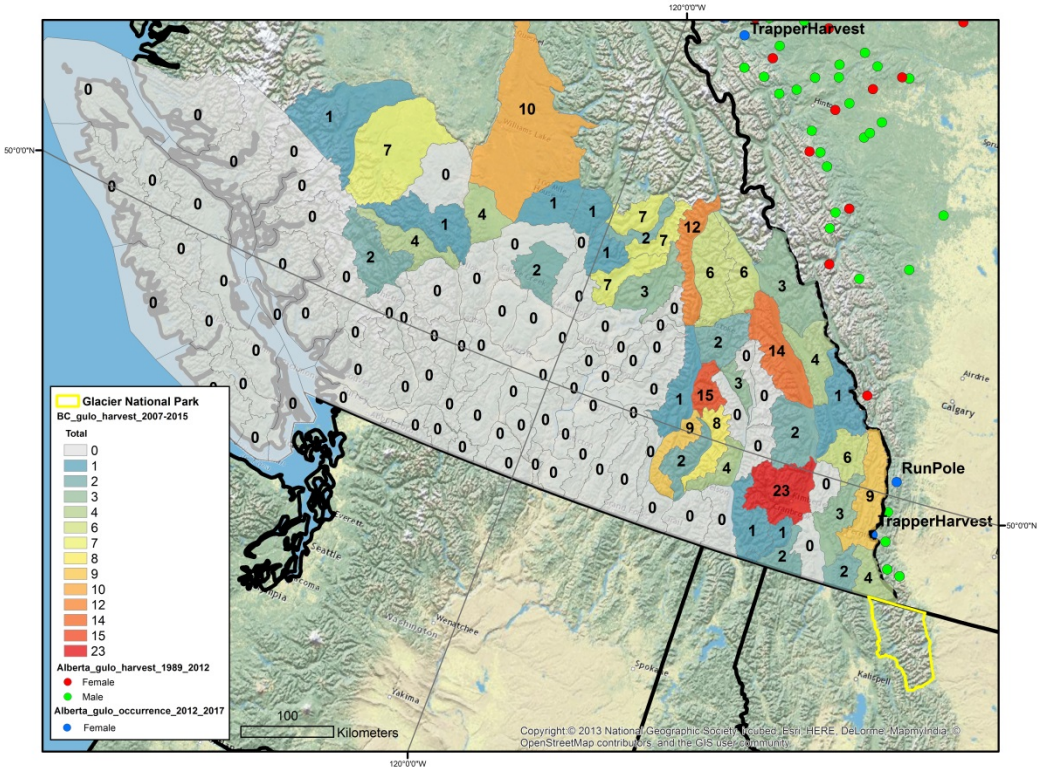
- Winter Recreation
  - Wolverines maintained home ranges within high use areas, over several years
  - No evidence re effects on reproductive success
  - Winter road closures
  - Recent detections (2016, 2017) in recreational study areas (Appendix C map)

Heinemeyer and Squires 2013



Overutilization (e.g., trapping)

- No current trapping in lower 48
- U.S.-Canada border (68 mi, avg max. dispersal distance)
  - Alberta: Avg < 1.0 animals/year
  - B.C.: Avg 8.5 animals/year
  - Trapping pressure & genetic structure being studied in Canada



Additional stressors evaluated

- Other human disturbance
  - Mixed results – wolverines dens found in clear cut areas, associated with some roads & infrastructure, but avoid others
    - May be associated with avoiding predation risk
- Wildland fire – no empirical studies
  - Likely not a positive or negative
  - USFS implementing fire mgt practices
- Disease and Predation
    - No evidence that these act as stressors beyond few individuals

Future "Scenario": Most likely condition

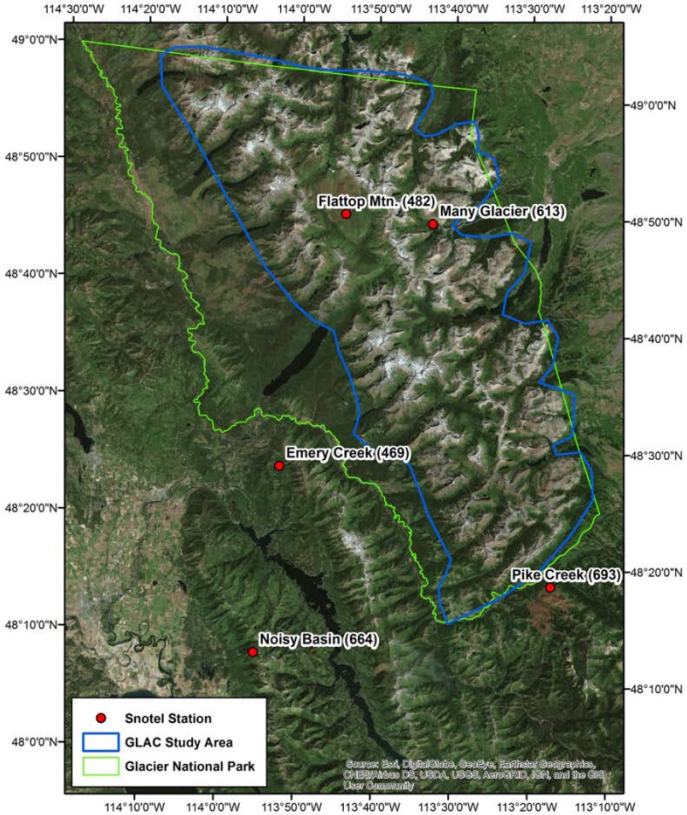
- Effects of climate change
  - Elevated temperature
  - Decline in snowpack
  - Potential increase in wildland fire
- No change expected in levels of other stressors

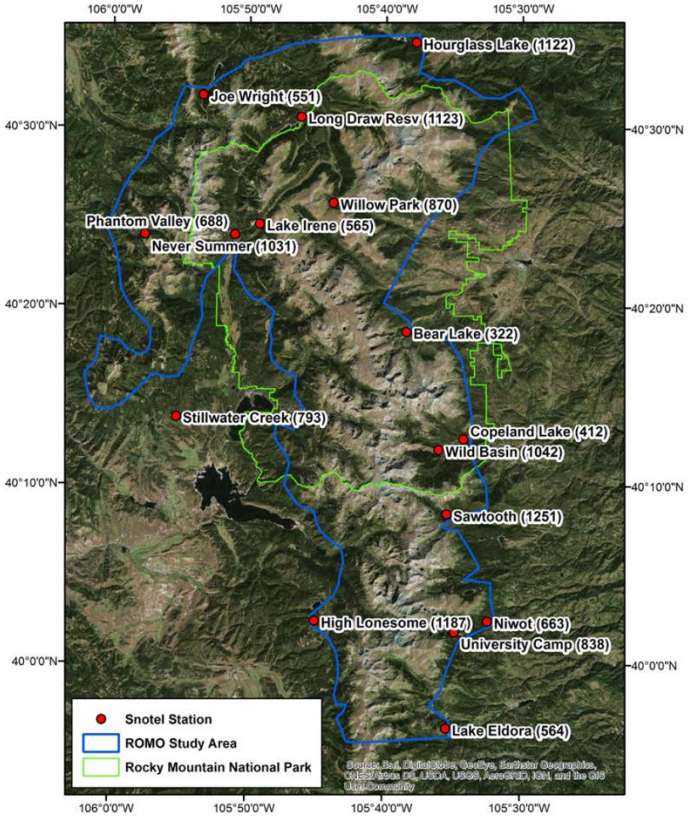
Future Conditions: Climate Change Effects – Summary by Region

Region	Observed trend : Temperature	Observed trend: Precipitation	Projected trend: Temperature	Projected trend: Precipitation
California (Tahoe area)	↑1.66°F since 1895; ↑3.94°F since 1975	No trend	↑ 3.8 to 5.8° F (by 2060s)	↑ in winter; but 3% ↓ yearly
Columbia River Basin	↑ 1.3°F (Pacific NW), 1895-2011	No trend; decline in amount of snow	↑ 2.34°F (2010-2039); ↑ 5.04°F (2070-2099)	↑ up to 8.5% (less than annual variability)
Upper Snake River Basin	↑ 0.5 to 1.0°F, 1895-2014	No trend	↑ 5.0°F (2100)	Small ↑
Southern Rocky Mtns	↑ 2.0°F, past 30 years	No trend (more severe drought conditions)	↑ 2.5 to 5.0°F (2050s)	↑ in winter (2050s)

Cumulative Effects with Climate Change – Snowpack/Snow Cover

- Northern and Southern Rocky Mountains (NOAA/CU study): 2 study areas to assess snow extent and depth (to evaluate snow persistence/CC)





Ray et al. (2017)

- 0.24 mi^2 spatial resolution
  - Glacier and Rocky Mtn NP
- Topographic features used (slope, aspect, shading)
- Validated with SNOTEL and MODIS
- 17 years of MODIS data
- Snow cover dates include April 15, May 1, May 15 (better aligns w/ life history)
- Snow presence defined: 1.25 cm (0.5 in) snow depth on May 15

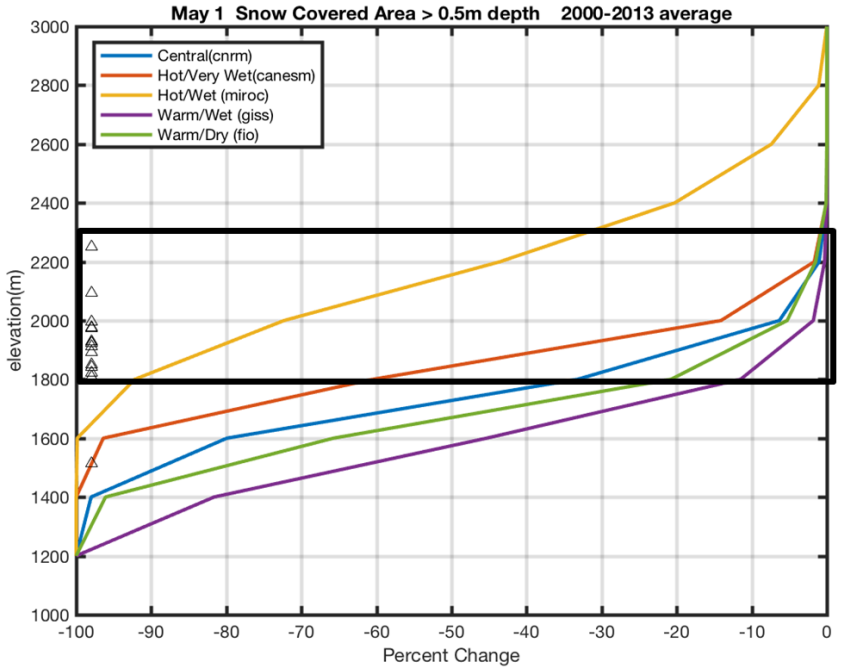
Copeland et al. (2010); McKelvey et al. (2011)

- 14.29 mi^2 spatial resolution
  - Western U.S. (except CA, GB)
- No topo features used
- No validation for snow
- 7 years of MODIS data
- Snow cover dates include May 15 and May 29 (both derived)
- Snow presence defined: 13 cm (5.12 in) snow depth on May 1

Comparison of Methods

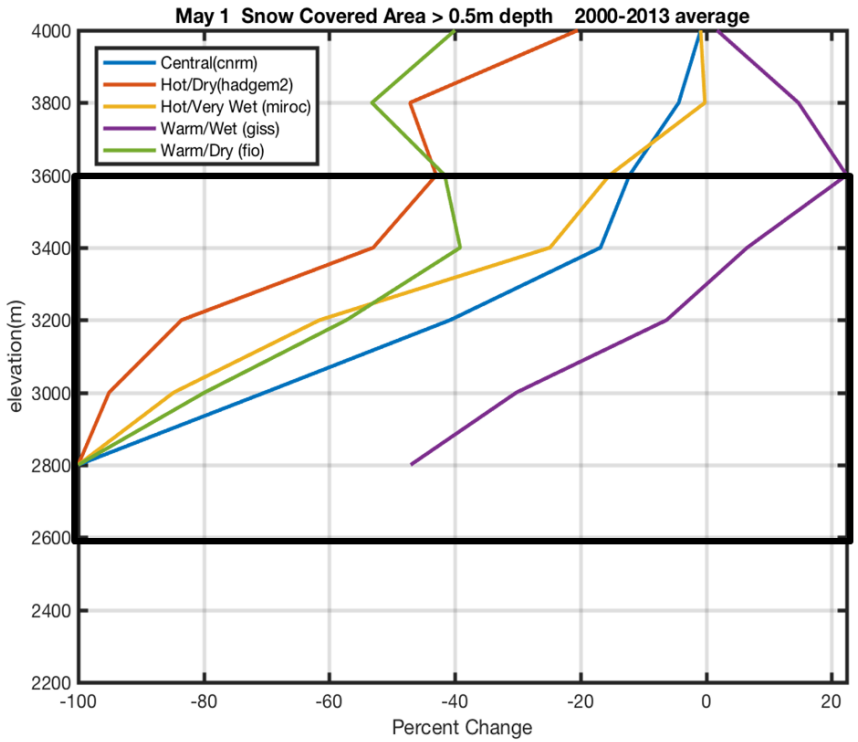
Key Results – Glacier NP

- Average Snow Covered Area (depth ≥ 0.5 m or 20 in) percent change at elevation bands for five future scenarios on May 1.



Key Results – Rocky Mtn NP

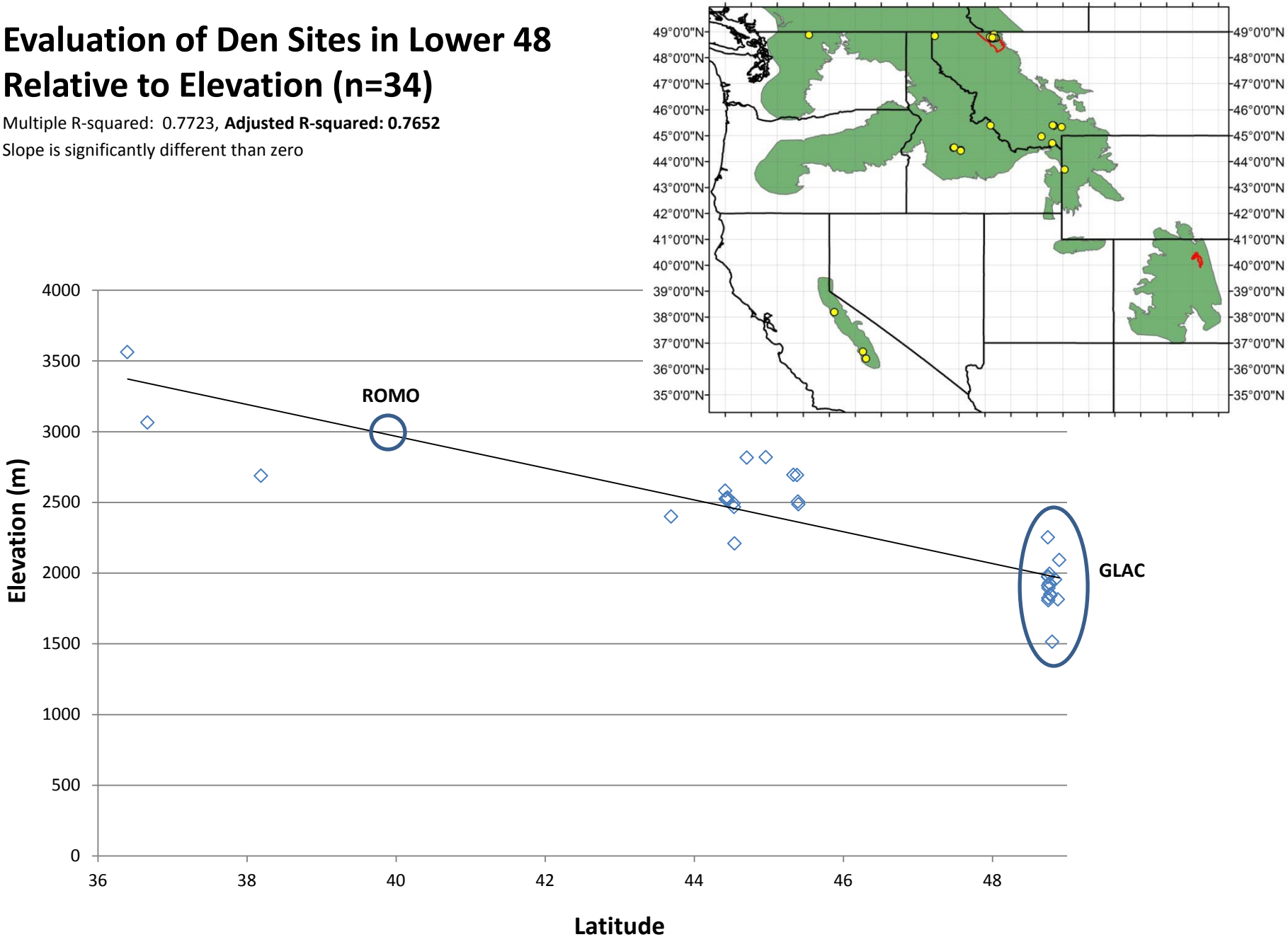
- Average Snow Covered Area (depth ≥ 0.5 m or 20 in) percent change at elevation bands for five future scenarios on May 1.



Evaluation of Den Sites in Lower 48 Relative to Elevation (n=34)

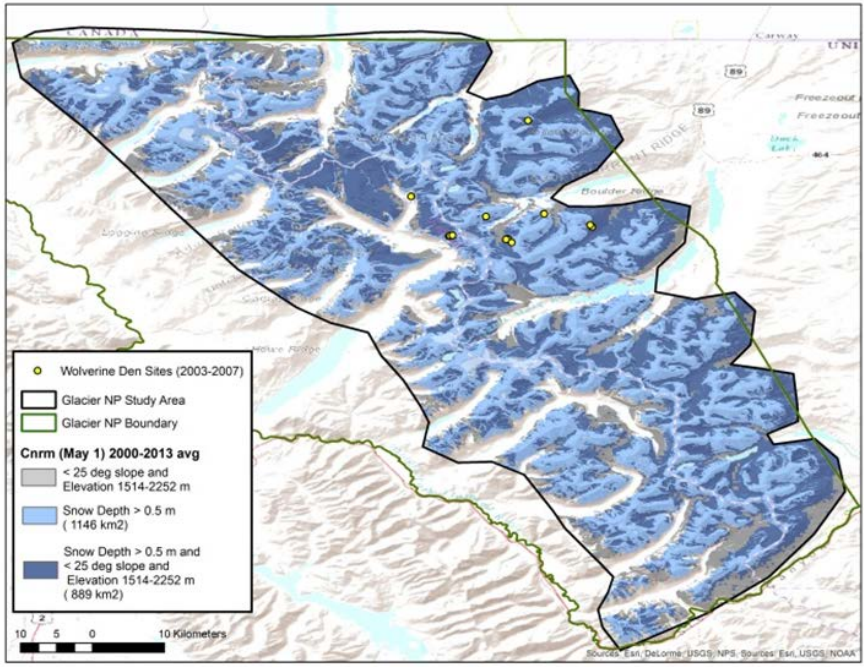
Multiple R-squared: 0.7723, **Adjusted R-squared: 0.7652**

Slope is significantly different than zero



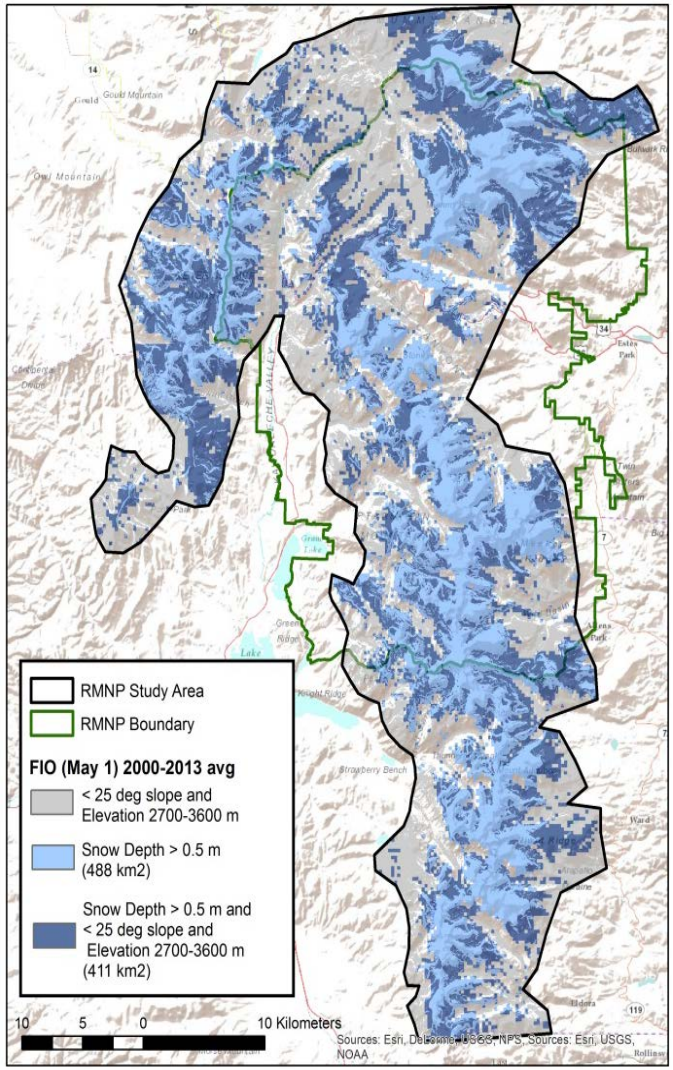
Key Results – Glacier NP

- Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1; Central scenario.
- Map identifies where slopes are less than 25 degrees and elevations 1514–2252 m (4,968–7,389 ft) (where dens have been documented).



Key Results – Rocky Mtn NP

- Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1; Warm/Dry scenario.
- Map identifies where slopes are less than 25 degrees and elevations 2,700-3,600 m (8,858–11,811 ft) (inferred elevations where dens would be expected).



Snowpack/Snow Cover:

General Conclusions for Northern & Southern Rocky Mtns

- Large portions of the study areas meet all three criteria in future (Year 2055):
  - Greater than 0.5 m (20 in) snow depth on May 1;
  - At elevation 4,967–7,389 ft for Glacier NP or 8,858 to 11,811 ft for Rocky Mtn NP; and
  - With a slope less than 25 degrees
- Large tracts of significant snow-covered area are projected in close proximity to documented historical den sites across all three scenarios

Future Conditions Summary

- CC model projections for areas within wolverine's range in contiguous U.S.
  - Increases in temperature by the mid-21st century
  - Drought duration/intensity could be worse with increase temperatures
  - Snow cover projected to decline, but will vary by elevation, topography, region
    - Higher elevations more resilient
- Wildland fire risk is site-specific, but likely to increase
- Wolverines possess physiological and behavioral adaptations to respond to these changes

Peer Review Comments

(AMEC mgt oversight; report sent to 4 individuals)

- First reviewer:
- Second reviewer:
- Third reviewer:
- Fourth reviewer:

Public, Agency, Other Parties' Concerns

- Public Comments –
- SSA Report review:
  - CO Parks & Wildlife – Recommended not including State in current range

Federal and State Mechanisms

- National Forest Management Act
  - USFS – Forest Plans
- Wilderness Act
- Federal Land Policy and Management Act
  - BLM – Land Use and Resource Mgt Plans
  - BLM Manual 6840 (Special Status Species Mgt)
- State permitting regulations for research
- State Wildlife Action Plans
  - Wolverine is *Species of Greatest Conservation Need* (all western States)
  - Idaho Wolverine Conservation Plan

Federal and State Mechanisms (cont.)

- State Protections (currently, no legal trapping in lower 48)
  - Threatened in CA, OR
  - Endangered in CO
  - Candidate in WA
  - Non-game (protected) species in ID, WY
  - Species of concern in MT
- Canada: varying provincial designations, from E to T (eastern areas), sensitive/special concern, or no ranking
- AK and Canada regulate trapping/hunting
- Recent settlements or agreements w/ Wildlife Services

Other Conservation Mechanisms

- Nez Perce Tribe
  - Wolverine – species of conservation concern in 3 draft conservation plans
    - IRMP, Plant and Wildlife Conservation Strategy, & Forest Mgt Plan
- Shoshone-Bannock Tribes
  - Preparing Climate Change Adaptation Plan
    - To be used for developing adaptation actions and monitoring

Acknowledgements

- Many thanks to Core Team members for their participation and review of drafts!
- Spatial Analysis and GIS Support – John Guinotte and Ed Turner (CFWO)
- Literature procurement – Wayne Nuckols (CFWO)
- Funding support for NOAA study
- And wolverine researchers, Federal/State agency and Canadian biologists

"Buddy" in California, May 2016; Photo credit: Chris Stermer, CDFW

From:	Meghan Lockwood
To:	betty_grizzle@fws.gov
Cc:	wyominges@fws.gov; Nichole Bjornlie; Matthew Fry; Chris Wichmann; Scott Smith
Subject:	Draft Species Status Assessment for Wolverine (WER 9792.02) - WGFD Comments
Date:	Monday, November 27, 2017 2:42:41 PM
Attachments:	wer9792.02_Signed Letter.pdf

Dear Ms. Grizzle,

Please see the attached comments by the Wyoming Game and Fish Department on the Draft Species Status Assessment for the North American Wolverine.

Best regards,
Meghan Lockwood

--
Meghan Lockwood
Administrative Assistant
Habitat Protection Program
Wyoming Game and Fish Department

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5400 Bishop Blvd.
Cheyenne, WY 82006

E-Mail to and from me, in connection with the transaction
of public business, is subject to the Wyoming Public Records
Act and may be disclosed to third parties.

WYOMING GAME AND FISH DEPARTMENT

5400 Bishop Blvd. Cheyenne, WY 82006

Phone: (307) 777-4600 Fax: (307) 777-4699

wgfd.wyo.gov

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GAY LYNN BYRD
PATRICK CRANK
PETER J. DUBE
DAVID RAEL
MIKE SCHMID

November 27, 2017

WER 9792.02
U.S. Fish and Wildlife Service
Draft Species Status Assessment for the North American Wolverine
Nationwide

Betty Grizzle
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008

Dear Ms. Grizzle,

Thank you for the opportunity to comment on the Draft Species Status Assessment (SSA) for the North American Wolverine (*Gulo gulo luscus*). Both the Wyoming Game and Fish Department (Department) and the Office of the Governor of Wyoming have provided previous comments related to the proposed listing rule, the proposed 4(d) rule, proposed critical habitat, potential threats, and provided information on current and historic distribution. The State of Wyoming has also been involved in on-going management and monitoring activities. As our previous comments are already on file with the Service, the Department focused our review on whether the best available information was used, the quality of the scientific information, and the interpretation and analysis of the data. Overall, the Department agrees that the best available information was used and appreciates the thorough review provided by the Service in this SSA.

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data has been analyzed and should be updated in this SSA. From this survey, we recommend that the Service add the language included in Appendix A of this letter (replacing and updating redundant text relevant to this effort where appropriate in the SSA).

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The title of the map in Appendix B should be changed to 'Wolverine Detections, Winters 2015-16 and 2016-17', since the Wyoming surveys spanned 2 winters. This map has also been updated since it was provided to the Service in July, and the updated map is provided here as Figure 1. It is important to note that although volunteer and incidental sightings are included on this map and contribute to the overall picture of wolverine distribution in the 4-state region, they were not part of the occupancy surveys and resulting analyses conducted by the states.

In Appendix C, the description of the Wyoming camera detections in the legend (orange hexagons) should be changed to 'Wyoming Winter 2015-2016 and 2016-2017 Camera Detections' to reflect that the Wyoming effort spanned 2 winters.

On page 147 in Appendix G, the Department began implementing the multi-state monitoring strategy in the winter of 2015-2016 and completed surveys in the winter of 2016-2017. As part of the section on Tribal efforts on page 148, we request that the Service reach out to the Eastern Shoshoni and Northern Arapaho tribes in Wyoming. As part of the multi-state monitoring effort, the Department collaborated with the Tribes to conduct surveys on tribal lands in 2015, and, since that initial effort, they have continued to conduct surveys and have plans to do so again this winter to monitor wolverines on the Wind River Reservation.

Thank you again for the opportunity to provide comments on the Draft SSA for the North American Wolverine. Given the species' status as a Protected Animal and Species of Greatest Conservation Need, the Department considers wolverines a priority species and remains committed to conservation, management, and monitoring activities for the species. If you have any questions, please contact Nichole Bjornlie, Nongame Mammal Biologist, 307-335-2611.

Sincerely,

Scott G. Smith
Deputy Director

SS/nb/ml

cc: USFWS
Nichole Bjornlie, WGFD, Lander
Matthew Fry, Governor Mead's Policy Office
Chris Wichmann, Wyoming Department of Agriculture

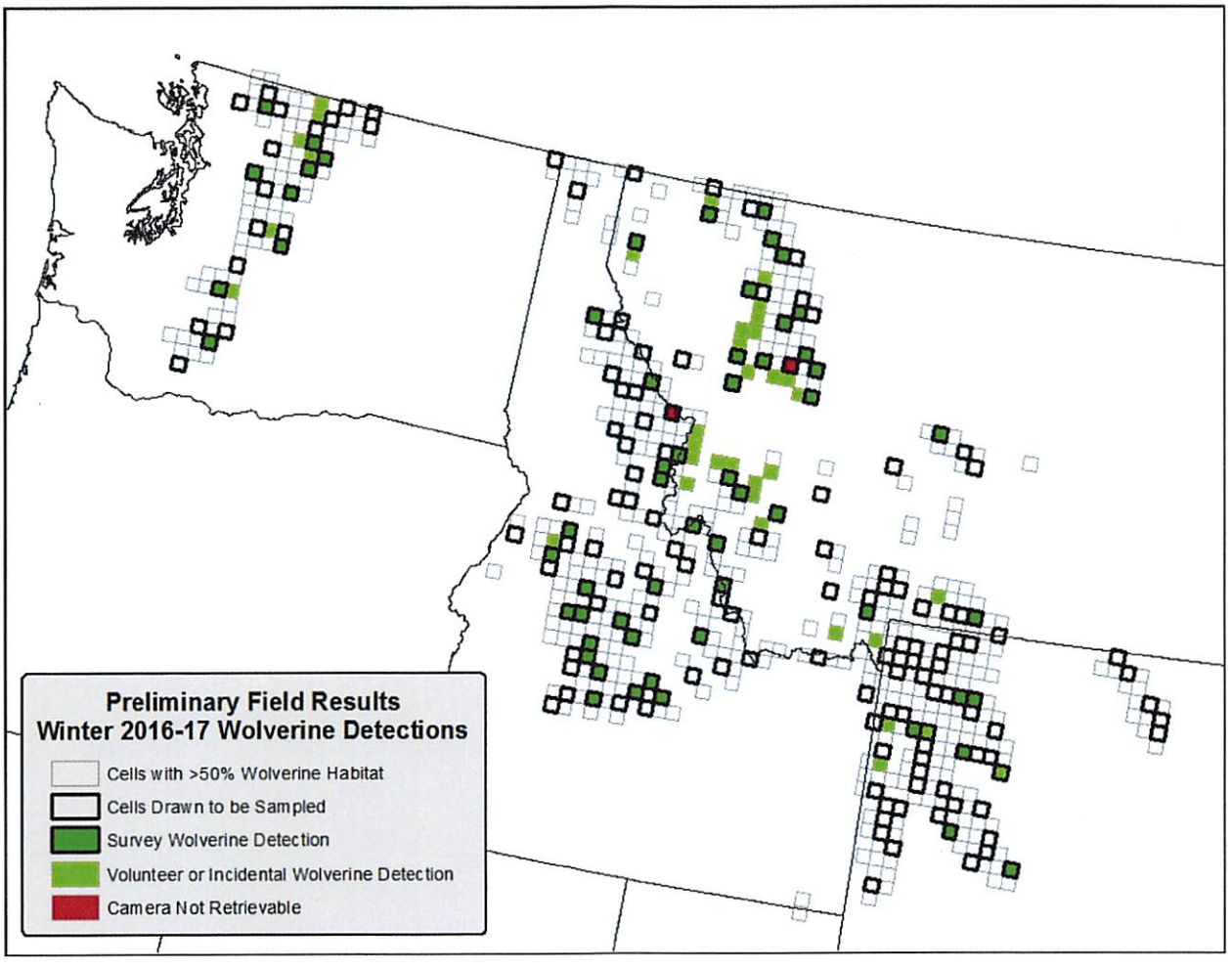


Figure 1. Wolverine Detections, Winters 2015-2016 and 2016-2017.

Appendix A. Summary of Multi-State Wolverine Occupancy

Wolverines are a naturally uncommon and rarely encountered species that resides in remote, high-elevation areas of the western United States. Proactive conservation measures are needed for this inherently small population that exists as a metapopulation across the region. One key component of a wolverine conservation strategy is development of a population monitoring program – up to now, records of wolverine occurrence have been rare and collected in an uncoordinated and opportunistic fashion, which makes it difficult to assess the species distribution, status and trend. The continued absence of a monitoring program jeopardizes the ability of agencies to allocate resources effectively among wolverines and other conservation priorities. State wildlife agencies in WA, ID, MT, and WY, along with federal, tribal, and NGO partners, developed a collaborative monitoring program that can be implemented in a coordinated fashion across the species range in the western U.S. The foundation for this monitoring program is a coordinated camera survey to obtain baseline information on distribution, genetics, and occupancy of wolverines. When repeated over time, trends in occupancy and distribution can be evaluated.

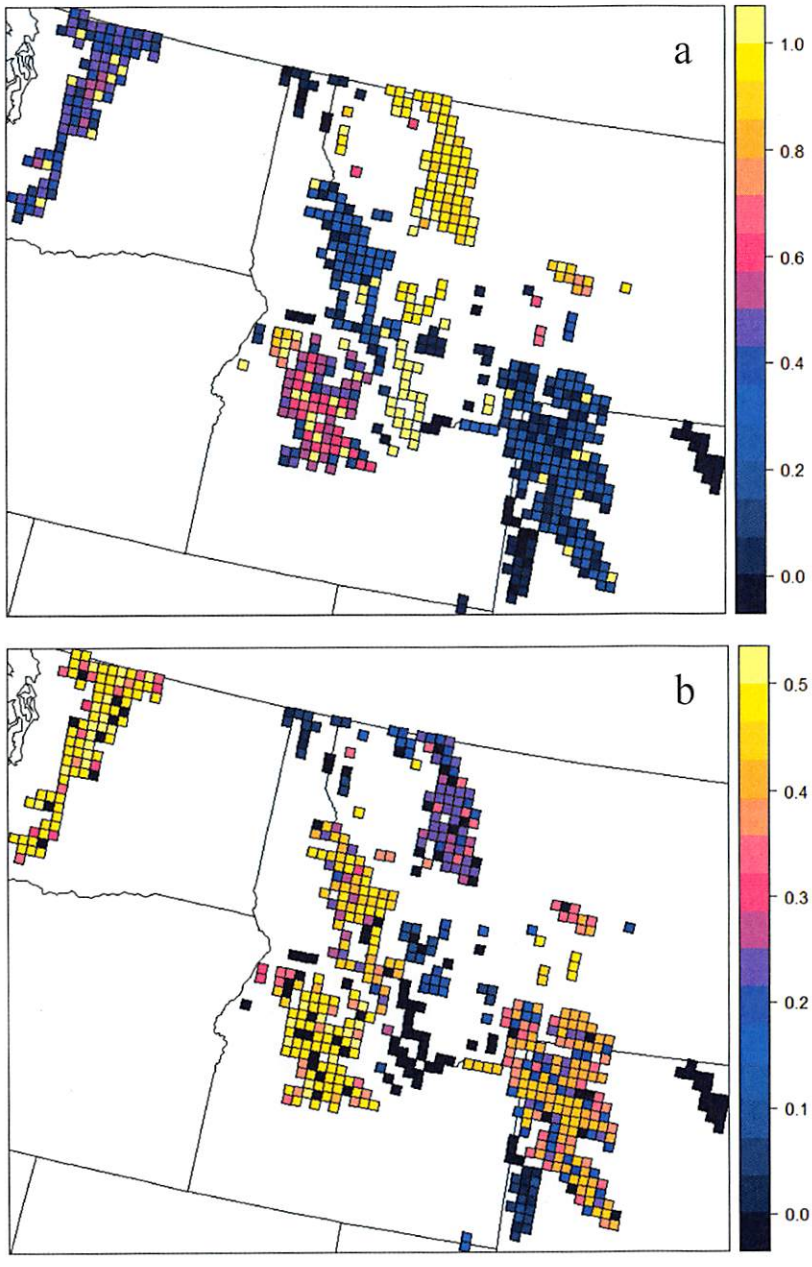
We developed a sampling frame based on existing models of wolverine habitat. The sampling frame consisted of 633 15x15 km grid cells. We selected 185 cells to sample from the frame using a GRTS sampling method. A single remotely triggered camera was placed in likely wolverine habitat within each selected cell along with a bait or scent attractant. Sampling occurred across a four-state area (ID, MT, WA, WY) during the winters of 2015-16 and 2016-17.

We obtained data from 183 sites and detected wolverines at 59 of the sampled cells. Detection rate was exceptionally high ($p=0.92$), and did not differ between sites that were baited and revisited multiple times vs. sites that were scented only and visited less frequently. The average estimated probability of wolverine occupancy during our study was 0.42 (95% credible interval 0.29-0.55) suggesting that wolverines used nearly half of all sites during the study period. Wolverine occupancy varied across the region with highest occupancy in the Northern Continental Divide Ecosystem and lower on the southern and eastern periphery of the study area (Figure 1).

The multi-state wolverine survey produced several important outcomes. First, it provided a rigorous and previously unavailable evaluation of wolverine distribution for the first time since the species was extirpated from the contiguous U.S. a century ago. This evaluation confirms the broad distribution of wolverines across the region and that recovery has progressed substantially since historical lows. The effort also demonstrates that occupancy probability varies throughout the region. The variability may be due to differences in habitat quality, differences in wolverine survival, or could be due to the time required to recover from historical absence. Perhaps most importantly, the regional occupancy estimates provide a baseline for future evaluations of change in wolverine distribution through time, including the possibility of detecting any influences due to climate change. In addition, the high detection rate and equal performance of stations visited

less frequently indicates the potential for substantial cost savings during future surveys. The effort also demonstrated strong and fruitful collaboration among state, federal and tribal agencies at the scale of a species range, and the results provide management-level guidance on where to direct wolverine conservation in the future. For instance, information on occupancy may be used to inform criteria for translocation, should some states pursue that as a means for enhancing the conservation status of wolverines.

Figure 1. Predicted wolverine occupancy (a) and standard errors (b) for the multi-state wolverine survey in 2016 and 2017.



From:	Grizzle, Betty
To:	Bush, Jodi
Subject:	Fwd: Draft Species Status Assessment for Wolverine (WER 9792.02) - WGFD Comments
Date:	Monday, November 27, 2017 2:52:08 PM
Attachments:	wer9792.02_Signed Letter.pdf

FYI
---------- Forwarded message ----------
From: **Meghan Lockwood** <meghan.lockwood@wyo.gov>
Date: Mon, Nov 27, 2017 at 1:42 PM
Subject: Draft Species Status Assessment for Wolverine (WER 9792.02) - WGFD Comments
To: betty_grizzle@fws.gov
Cc: wyominges@fws.gov, Nichole Bjornlie <nichole.cudworth@wyo.gov>, Matthew Fry <matthew.fry@wyo.gov>, Chris Wichmann <chris.wichmann@wyo.gov>, Scott Smith <scott.smith1@wyo.gov>

Dear Ms. Grizzle,

Please see the attached comments by the Wyoming Game and Fish Department on the Draft Species Status Assessment for the North American Wolverine.

Best regards,
Meghan Lockwood

--
Meghan Lockwood
Administrative Assistant
Habitat Protection Program
Wyoming Game and Fish Department

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5400 Bishop Blvd.
Cheyenne, WY 82006

E-Mail to and from me, in connection with the transaction
of public business, is subject to the Wyoming Public Records
Act and may be disclosed to third parties.

--

Betty J. Grizzle, D.Env.
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U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008

760-431-9440, ext. 215
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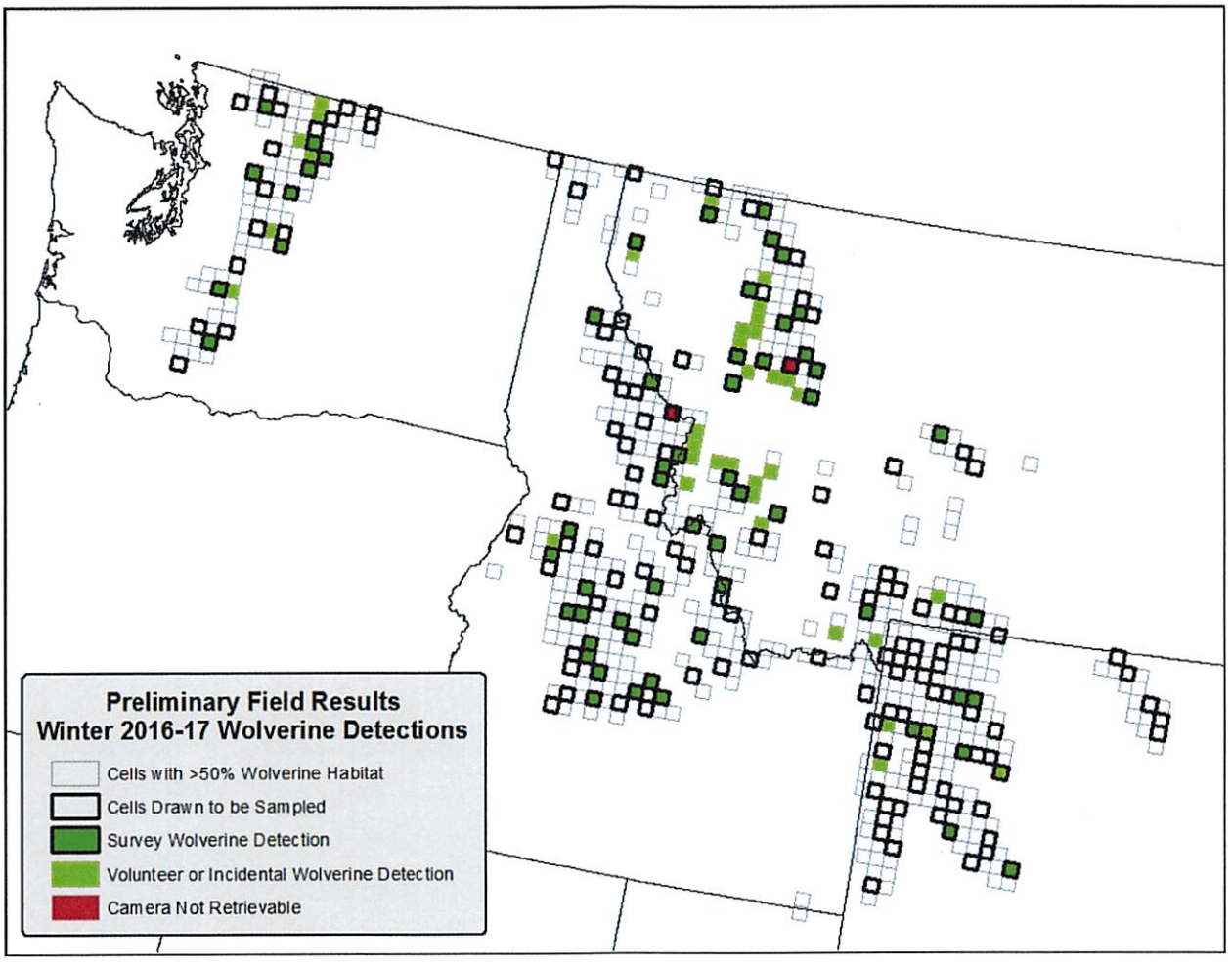
Deputy Director

SS/nb/ml

cc: USFWS
Nichole Bjornlie, WGFD, Lander
Matthew Fry, Governor Mead's Policy Office
Chris Wichmann, Wyoming Department of Agriculture



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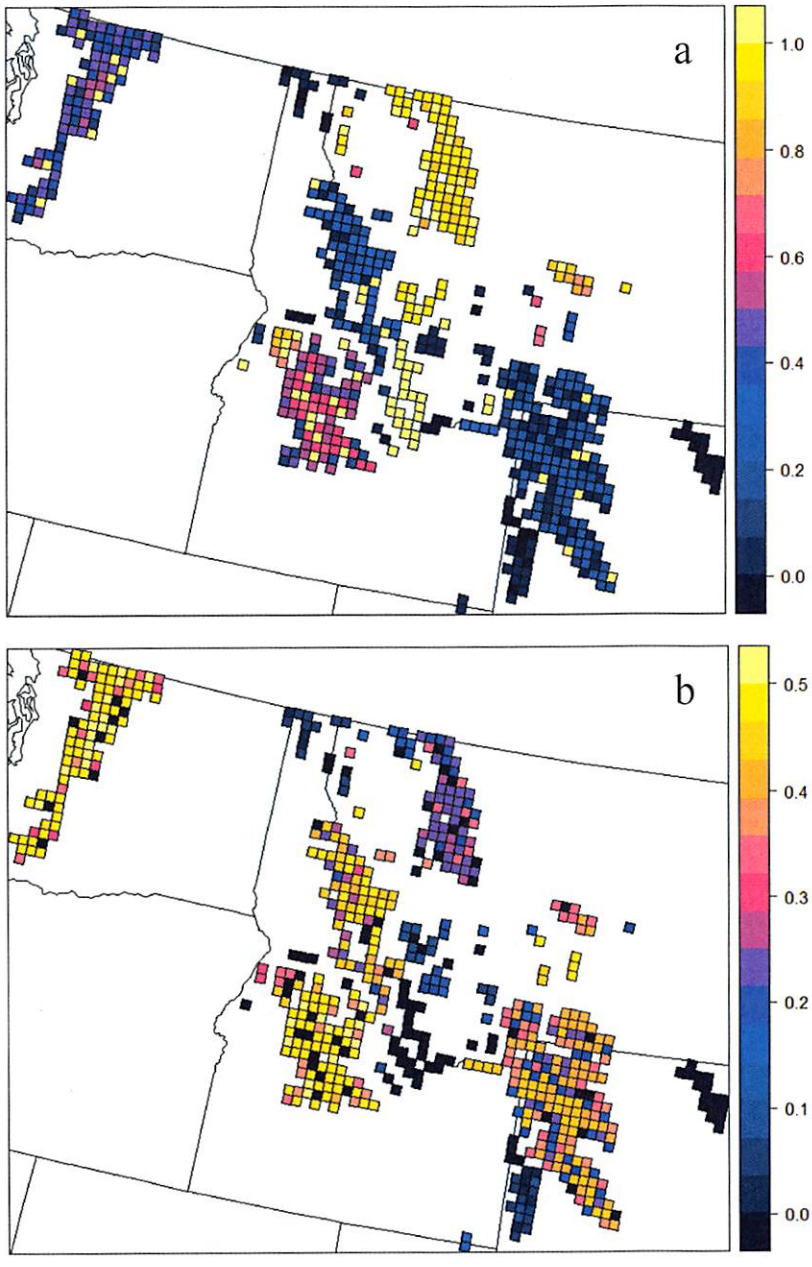

From:	Bush, Jodi
To:	Betty Grizzle
Subject:	Fwd: For Review: Draft Wolverine SSA
Date:	Monday, November 27, 2017 2:52:39 PM
Attachments:	Wolverine draft SSA-NMDGF.pdf

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here you go. JB

Jodi L. Bush
Office Supervisor
Montana State Ecological Services Office
585 Shepard Way, Suite 1
Helena, MT 59601
(406) 449-5225, ext.205

---------- Forwarded message ----------
From: **Liley, Stewart, DGF** <Stewart.Liley@state.nm.us>
Date: Mon, Nov 27, 2017 at 11:27 AM
Subject: RE: For Review: Draft Wolverine SSA
To: "Betty_Grizzle@fws.gov." <Betty_Grizzle@fws.gov>
Cc: "Bush, Jodi" <jodi_bush@fws.gov>, "Stuart, James N., DGF" <james.stuart@state.nm.us>

Attached please find NM comments to the draft SSA

Stewart Liley, Chief

Wildlife Management Division

New Mexico Game and Fish

One Wildlife Way

Santa Fe, NM 87507

Ph: 505-476-8038

stewart.liley@state.nm.us

CONSERVING NEW MEXICO'S WILDLIFE FOR FUTURE GENERATIONS

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From: Bush, Jodi [mailto:jodi_bush@fws.gov]
Sent: Thursday, October 26, 2017 9:30 AM
To: tschultz@idl.idaho.gov; twasley@ndow.org; curt.melcher@state.or.us; Sandoval, Alexandra J., DGF; Jim Unsworth; Dustin Miller (dustin.miller@osc.idaho.gov); Moore,Virgil; Martha Williams; Scott Talbott; Mike Fowlks; bob.broscheid@state.co.us; Kimberly Hersey; reid.dewalt@state.co.us; Sam Eaton; Chuck.Bonham@wildlife.ca.gov
Cc: Anderson, Hannah E (DFW); McDonald, Ken; Bob Lanka; Smith, Scott; H Jerome Hansen; ccorsi@idfg.idaho.gov; pseymour@idl.idaho.gov; Justin Shannon; Zack Walker; Inman, Bob; Cc:; Liley, Stewart, DGF; Betty Grizzle; Scott.Gardner@wildlife.ca.gov; karen.miner@wildlife.ca.gov; DeBerry, Drue; Gregory Hughes; Paul Henson; Eric Rickerson; Abbott, Tyler; Larry Crist
Subject: For Review: Draft Wolverine SSA

Dear Wolverine Conservation Partners:

Attached please find the DRAFT Species Status Assessment (SSA) for the North American Wolverine. As you may be aware, the draft report is currently undergoing peer review.

We are providing this draft to your agency for review by members of your organization with expert knowledge of the species and its habitat. Your review will help us ensure that we have appropriately considered the best scientific and commercial information when evaluating the current status and future viability of the North American wolverine. We request your independent scientific perspectives on the comprehensiveness and logic of the document, as well as how well the technical conclusions are supported by the data and analyses.

As the literature cited is lengthy, if you need a copy of any document cited in the draft report, please contact Betty Grizzle at the email address below.

The Draft SSA is not intended to solicit public comment and will be revised after this scientific review. The SSA does not predetermine any future agency decision under the Endangered Species Act.

In general we ask that your comments on the Draft SSA report focus specifically on whether the best available information was used, the quality of the scientific information, and our interpretation and analyses of the data with regard to the species' viability in the contiguous United States. We request that you direct your review to the scientific issues and assumptions related to your expertise.

General Information about SSAs:

The Species Status Assessment framework is a new tool the U.S. Fish and Wildlife Service is using to improve transparency while conducting listing determinations and other Act actions, and peer review of our analyses of the

viability of species is part of that new process. The attached draft SSA report is a rough draft; we are seeking comments at this stage to ensure that we have time to incorporate any substantial comments as we finalize the report.

In reviewing the document, please note that this draft SSA report does not result in or predetermine a decision by the Service on whether the Canada lynx warrants protections of the Act. This document is strictly a characterization of the viability species' viability in the contiguous United States. As a reminder, all reviews and comments submitted to the Service will become public documents and part of our administrative record for this document.

We welcome consolidated comments from your organization by November 30, 2017. Please send comments by that date to Thank you for your interest and assistance. JB

Jodi L. Bush

Office Supervisor

Montana State Ecological Services Office

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Helena, MT 59601

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STATE GAME COMMISSION

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ELIZABETH A. RYAN
Roswell

THOMAS "DICK" SALOPEK
Las Cruces

November 27, 2017

Betty Grizzle

RE: Comments on Wolverine draft SSA

The New Mexico Department of Game and Fish (Department) has reviewed the Draft Species Status Assessment (SSA) for the North American Wolverine (Gulo gulo luscus), Version 1.0 (October 23, 2017), prepared by the U.S. Fish and Wildlife Service (Service).

The Department previously responded to proposed listing actions under the U.S. Endangered Species Act (ESA) that pertain to the wolverine. In two letters dated 6 May 2013, we addressed proposed rules to 1) list the wolverine in the contiguous United States as Threatened under the ESA, and 2) designate a non-essential experimental population (NEP) area for the species in New Mexico, in anticipation of proposed reintroductions in Colorado. In both letters we clarified the status of wolverine in New Mexico as a species for which there is no compelling evidence of current or historical occurrence and that is not recognized by New Mexico state laws or regulations as a native wildlife species. The Department also stated its opposition to the proposed NEP area in the state.

The draft SSA largely addresses the comments we provided in the 2013 correspondence. On page 64 (first paragraph) of the draft SSA, the Service correctly notes that "The State of New Mexico Department of Game and Fish does not recognize the wolverine as a native mammal." We suggest that the draft SSA should make clear that verified evidence of current or historical presence of this species is lacking for New Mexico and therefore the species has not been recognized under state wildlife laws or regulations as part of the New Mexico fauna. The Department does recognize wolverine as a species that possibly occurred historically in northern New Mexico; if so, those occurrences were most likely the result of individuals dispersing from established breeding populations located further north in the Southern Rocky Mountains.

We believe the maps and their captions in the draft SSA are potentially misleading in their portrayal of the current and historical distribution of wolverine in the Southern Rocky Mountains, despite the explanation of the mapping rationale on page 15 of the document. For example, Figure 2 denotes "primary habitat" in green, which is defined on page 46 as areas suitable for long-term survival of wolverines and is derived from the predictive model by Inman et al. (2013). Given wolverines were not verified to have occupied the high elevation areas of northern New Mexico at any time, we believe the green-shaded areas in the state would perhaps be best described as "predicted suitable habitat." A better approach might be to map areas for which there is predicted suitable habitat but

no evidence of historical occurrence in a different color. Similarly, Figure 3 indicates that the "current range" of the species includes the high-elevation areas of Colorado as far south as the Colorado-New Mexico border. However, there is no evidence that the current distribution of wolverines in the Southern Rocky Mountains is that extensive; although, historical records exist from as far south as southern Colorado. Maps in Appendix E also suggest that the "current range" extends to the northern New Mexico border. Range maps are often subject to misinterpretation when they conflate current and historical location data with areas of potential occurrence (e.g., predicted suitable habitat). We suggest additional clarification in the captions of the maps in the draft SSA, or illustrating areas of current, historical, or potential (predicted) occurrence in different colors.

We note a few minor errors in the SSA: canadensis is misspelled on page 10, paragraph 5; and the term "historic" is used incorrectly in a few places in the document instead of "historical."

We appreciate the opportunity to comment on the draft SSA. Should you have any questions, please contact Jim Stuart, Non-game Mammologist at james.stuart@state.nm.us .

Sincerely,

Stewart Liley
Chief of Wildlife Management Division

GOVERNOR
Susana Martinez

DIRECTOR AND SECRETARY
TO THE COMMISSION
Alexandra Sandoval

DEPUTY DIRECTOR
Donald L. Jaramillo

STATE OF NEW MEXICO
DEPARTMENT OF GAME & FISH

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Las Cruces

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Cimarron

ELIZABETH A. RYAN
Roswell

THOMAS "DICK" SALOPEK
Las Cruces

November 27, 2017

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Sincerely,

Stewart Liley
Chief of Wildlife Management Division

WYOMING GAME AND FISH DEPARTMENT

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MIKE SCHMID

November 27, 2017

WER 9792.02
U.S. Fish and Wildlife Service
Draft Species Status Assessment for the North American Wolverine
Nationwide

Betty Grizzle
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008

Dear Ms. Grizzle,

Thank you for the opportunity to comment on the Draft Species Status Assessment (SSA) for the North American Wolverine (*Gulo gulo luscus*). Both the Wyoming Game and Fish Department (Department) and the Office of the Governor of Wyoming have provided previous comments related to the proposed listing rule, the proposed 4(d) rule, proposed critical habitat, potential threats, and provided information on current and historic distribution. The State of Wyoming has also been involved in on-going management and monitoring activities. As our previous comments are already on file with the Service, the Department focused our review on whether the best available information was used, the quality of the scientific information, and the interpretation and analysis of the data. Overall, the Department agrees that the best available information was used and appreciates the thorough review provided by the Service in this SSA.

The current range of the wolverine is presented on page 17; however, this map would benefit from an explanation on how 'current range' is defined. There appears to be some inconsistencies in how an area qualifies as current range. For example, does the presence of a single animal result in inclusion as current range? Does this animal need to be considered a resident? The Department recommends that current range only includes areas with a resident population that has the potential to result in reproduction. In this case, California, Colorado, Utah, and likely much of Oregon would not qualify as current range. A similar explanation for 'historic range' in addition to a comparison of what percentage of historic range is now considered current range is also warranted.

As stated within the SSA, at the beginning of page 47, the Western States Wolverine Working Group has been formed to address a number of conservation and management actions for wolverines throughout the 4-state region, including developing and implementing a statistically rigorous and repeatable monitoring strategy. Although this report is still in draft, much of the

data has been analyzed and should be updated in this SSA. From this survey, we recommend that the Service add the language included in Appendix A of this letter (replacing and updating redundant text relevant to this effort where appropriate in the SSA).

Additionally, in the last paragraph on page 47, Bjornlie et al. (2017) is cited for the multi state survey protocol. A new protocol was developed for the winter of 2016-2017, which included a lynx monitoring component. The protocol citation should be replaced with:

> Western States Wolverine Working Group. 2016. Western States Wolverine Conservation Project Baseline Survey Standard Operating Procedures for Camera-DNA Stations. Version 3.2.

It is important to note the development of the Western Association of Fish and Wildlife Agencies (WAFWA) Wolverine Subcommittee and its dedication to wolverine conservation and management. Specifically, a multi-state, landscape-scale conservation strategy for wolverines has been developed and initiated with help from other agencies and conservation organizations. These activities are officially sanctioned by the WAFWA and acted upon by WAFWA's Wildlife Chiefs wolverine subcommittee. Current partners in this effort include State Wildlife Agencies of the western U.S., USFWS, U.S. Forest Service, and National Park Service along with several tribes, universities, and non-governmental organizations. These ongoing activities are very similar to the goals of the USFWS's 2013 Draft Recovery Outline and in some cases go above and beyond those goals. As such, there is an active, funded, region-wide wolverine conservation program. We urge the USFWS to include on-going wolverine conservation efforts in the western U.S.. Consideration of this collaborative and progressive work on future conditions for the species should be an important component of the SSA.

The Department has a number of corrections for the Wyoming-specific results of the multi-state monitoring effort and associated incidental sightings. Beginning in the first full paragraph on page 48, it is noted that at least 2 wolverines were detected during the first winter. Based upon location and chest patterns, we detected at least 3 wolverines from that effort. It is also important to clarify later in that paragraph that a wolverine visit is defined as a photo of a wolverine ≥60 minutes from the previous photo of a wolverine.

In the second full paragraph on page 48, surveys in Wyoming resulted in detections at 6 survey cells, not 9 as indicated. Additionally, these detections were from both survey years, not only the 2016-2017 season. Any other cells with detections were not a part of the multi-state monitoring protocol (see below for comments on Appendix B). We also request that the Service re-check the additional incidental sightings reported in the following paragraph for Wyoming. We are aware of the sightings in the northern Teton Range as part of a lynx survey, track observations in the southern Tetons by a skier that were later confirmed by a USFS biologist, and tracks observed as part of our multi-state effort that did not result in a photographic detection. We are not aware of the other observations included in this paragraph.

On page 64, the paragraph referring to Chapter 33 permits in Wyoming is outdated and somewhat misleading. To date, the Department has issued 5 different Chapter 33 permits for research activities in Wyoming. However, 4 of the 5 permits have been issued for live capture and the 5th for camera trapping surveys. Although Chapter 33 permits can be used for 'take' resulting in removal of individuals for scientific or research purposes, no permits allowing the take of wolverine have been issued in Wyoming. We additionally have had no accidental take reported from permits issued. We request that the Service reword this paragraph to clarify the substance of these permits.

The discussion on potential effects of climate change and behavioral plasticity of the American pika beginning on page 93 seems a little out of place. Although both pikas and wolverines have been suggested to respond negatively to the effects of climate change, the ecology of American pikas and wolverines is very different. Pikas are highly sensitive to thermal stressors, are fairly specialized in terms of their habitat, and have a much more limited capability to disperse than do wolverines.Given these important ecological differences, we are not sure how useful or appropriate this discussion is to the evaluation of the current and future status of wolverines.

The title of the map in Appendix B should be changed to 'Wolverine Detections, Winters 2015-16 and 2016-17', since the Wyoming surveys spanned 2 winters. This map has also been updated since it was provided to the Service in July, and the updated map is provided here as Figure 1. It is important to note that although volunteer and incidental sightings are included on this map and contribute to the overall picture of wolverine distribution in the 4-state region, they were not part of the occupancy surveys and resulting analyses conducted by the states.

In Appendix C, the description of the Wyoming camera detections in the legend (orange hexagons) should be changed to 'Wyoming Winter 2015-2016 and 2016-2017 Camera Detections' to reflect that the Wyoming effort spanned 2 winters.

On page 147 in Appendix G, the Department began implementing the multi-state monitoring strategy in the winter of 2015-2016 and completed surveys in the winter of 2016-2017. As part of the section on Tribal efforts on page 148, we request that the Service reach out to the Eastern Shoshoni and Northern Arapaho tribes in Wyoming. As part of the multi-state monitoring effort, the Department collaborated with the Tribes to conduct surveys on tribal lands in 2015, and, since that initial effort, they have continued to conduct surveys and have plans to do so again this winter to monitor wolverines on the Wind River Reservation.

Thank you again for the opportunity to provide comments on the Draft SSA for the North American Wolverine. Given the species' status as a Protected Animal and Species of Greatest Conservation Need, the Department considers wolverines a priority species and remains committed to conservation, management, and monitoring activities for the species. If you have any questions, please contact Nichole Bjornlie, Nongame Mammal Biologist, 307-335-2611.

Sincerely,

Scott G. Smith
Deputy Director

SS/nb/ml

cc: USFWS
Nichole Bjornlie, WGFD, Lander
Matthew Fry, Governor Mead's Policy Office
Chris Wichmann, Wyoming Department of Agriculture

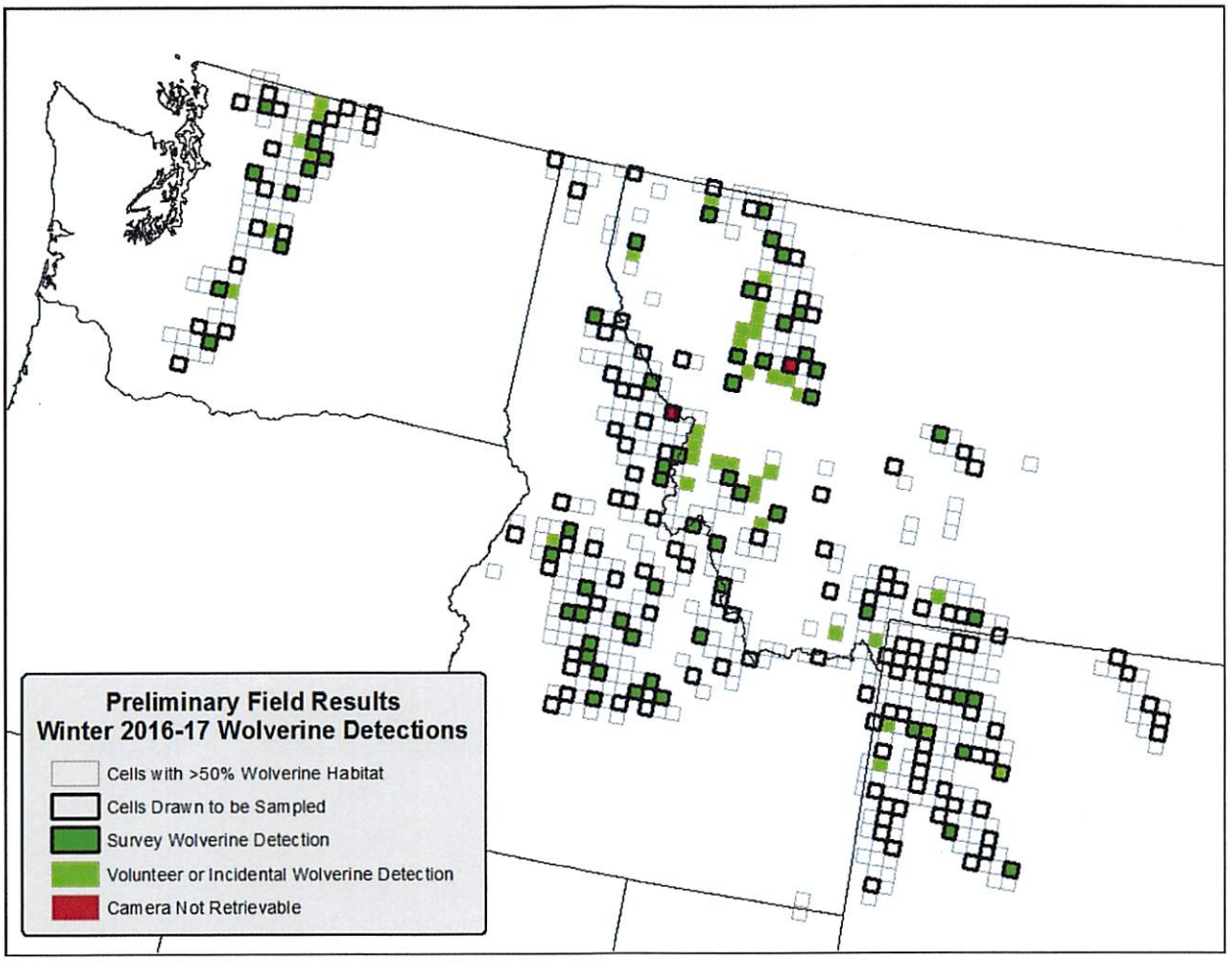


Figure 1. Wolverine Detections, Winters 2015-2016 and 2016-2017.

Appendix A. Summary of Multi-State Wolverine Occupancy

Wolverines are a naturally uncommon and rarely encountered species that resides in remote, high-elevation areas of the western United States. Proactive conservation measures are needed for this inherently small population that exists as a metapopulation across the region. One key component of a wolverine conservation strategy is development of a population monitoring program – up to now, records of wolverine occurrence have been rare and collected in an uncoordinated and opportunistic fashion, which makes it difficult to assess the species distribution, status and trend. The continued absence of a monitoring program jeopardizes the ability of agencies to allocate resources effectively among wolverines and other conservation priorities. State wildlife agencies in WA, ID, MT, and WY, along with federal, tribal, and NGO partners, developed a collaborative monitoring program that can be implemented in a coordinated fashion across the species range in the western U.S. The foundation for this monitoring program is a coordinated camera survey to obtain baseline information on distribution, genetics, and occupancy of wolverines. When repeated over time, trends in occupancy and distribution can be evaluated.

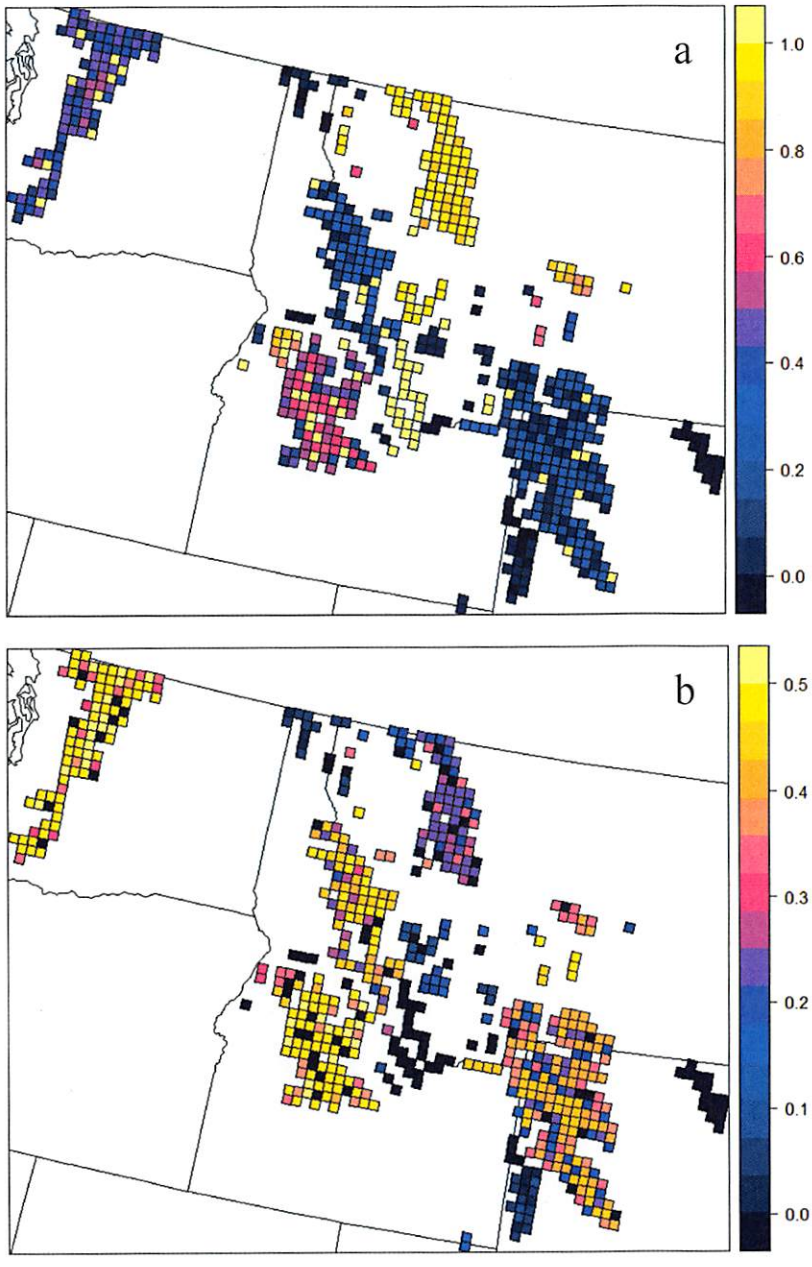
We developed a sampling frame based on existing models of wolverine habitat. The sampling frame consisted of 633 15x15 km grid cells. We selected 185 cells to sample from the frame using a GRTS sampling method. A single remotely triggered camera was placed in likely wolverine habitat within each selected cell along with a bait or scent attractant. Sampling occurred across a four-state area (ID, MT, WA, WY) during the winters of 2015-16 and 2016-17.

We obtained data from 183 sites and detected wolverines at 59 of the sampled cells. Detection rate was exceptionally high ($p=0.92$), and did not differ between sites that were baited and revisited multiple times vs. sites that were scented only and visited less frequently. The average estimated probability of wolverine occupancy during our study was 0.42 (95% credible interval 0.29-0.55) suggesting that wolverines used nearly half of all sites during the study period. Wolverine occupancy varied across the region with highest occupancy in the Northern Continental Divide Ecosystem and lower on the southern and eastern periphery of the study area (Figure 1).

The multi-state wolverine survey produced several important outcomes. First, it provided a rigorous and previously unavailable evaluation of wolverine distribution for the first time since the species was extirpated from the contiguous U.S. a century ago. This evaluation confirms the broad distribution of wolverines across the region and that recovery has progressed substantially since historical lows. The effort also demonstrates that occupancy probability varies throughout the region. The variability may be due to differences in habitat quality, differences in wolverine survival, or could be due to the time required to recover from historical absence. Perhaps most importantly, the regional occupancy estimates provide a baseline for future evaluations of change in wolverine distribution through time, including the possibility of detecting any influences due to climate change. In addition, the high detection rate and equal performance of stations visited

less frequently indicates the potential for substantial cost savings during future surveys. The effort also demonstrated strong and fruitful collaboration among state, federal and tribal agencies at the scale of a species range, and the results provide management-level guidance on where to direct wolverine conservation in the future. For instance, information on occupancy may be used to inform criteria for translocation, should some states pursue that as a means for enhancing the conservation status of wolverines.

Figure 1. Predicted wolverine occupancy (a) and standard errors (b) for the multi-state wolverine survey in 2016 and 2017.



From: Holt, Bryon
To: Betty Grizzle
Subject: Fwd: For Review: Draft Wolverine SSA
Date: Tuesday, November 28, 2017 12:06:28 PM
Attachments: Wolverine SSA comments_27Nov2017.docx

Betty,

Attached are general comments from our Idaho office.

Bryon

---------- Forwarded message ----------
From: **Fisher, Sandi** <sandi_fisher@fws.gov>
Date: Mon, Nov 27, 2017 at 11:48 AM
Subject: Re: For Review: Draft Wolverine SSA
To: Bryon Holt <bryon_holt@fws.gov>
Cc: Evan Ohr <evan_ohr@fws.gov>

Hi Bryon...attached our EIFO comments on the Wolverine SSA. These were pulled together by Evan, so if you have any questions, please contact him directly. Evan, if I've misconstrued anything from your comments, please let us know.

Thanks,

~S~

On Temporary Detail Through 12/22
Acting IFWO Deputy State Supervisor
(208) 378-5267 (O)
(208) 241-8043 (C)

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Sandi Fisher, Field Office Lead
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IFWO - Eastern Idaho Field Office
4425 Burley Drive, Suite A
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(208) 241-8043 (cell)

---------- Forwarded message ----------
From: **Bush, Jodi** <jodi_bush@fws.gov>
Date: Thu, Oct 26, 2017 at 9:29 AM
Subject: For Review: Draft Wolverine SSA
To: tschultz@idl.idaho.gov, twasley@ndow.org, curt.melcher@state.or.us, "Lexi J., Sandoval" <alexandra.sandoval@state.nm.us>, Jim Unsworth <Jim.Unsworth@dfw.wa.gov>, "Dustin Miller (dustin.miller@osc.idaho.gov)"

<dustin.miller@osc.idaho.gov>, "Moore,Virgil" <virgil.moore@idfg.idaho.gov>, Martha Williams <Martha.Williams@mt.gov>, Scott Talbott <scott.talbott@wyo.gov>, Mike Fowlks <mikefowlks@utah.gov>, bob.broscheid@state.co.us, Kimberly Hersey <kimberlyasmus@utah.gov>, reid.dewalt@state.co.us, Sam Eaton <Sam.Eaton@osc.idaho.gov>, Chuck.Bonham@wildlife.ca.gov
Cc: "Anderson, Hannah E (DFW)" <hannah.anderson@dfw.wa.gov>, "McDonald, Ken" <kmcdonald@mt.gov>, Bob Lanka <bob.lanka@wyo.gov>, "Smith, Scott" <Scott.Smith1@wyo.gov>, H Jerome Hansen <jerome.hansen@idfg.idaho.gov>, ccorsi@idfg.idaho.gov, pseymour@idl.idaho.gov, Justin Shannon <justinshannon@utah.gov>, Zack Walker <zack.walker@wyo.gov>, "Inman, Bob" <bobinman@mt.gov>, "Cc:" <derek.j.broman@state.or.us>, "Liley, Stewart, DGF" <stewart.liley@state.nm.us>, Betty Grizzle <betty_grizzle@fws.gov>, Scott.Gardner@wildlife.ca.gov, karen.miner@wildlife.ca.gov, "DeBerry, Drue" <drue_deberry@fws.gov>, Gregory Hughes <greg_m_hughes@fws.gov>, Paul Henson <paul_henson@fws.gov>, Eric Rickerson <eric_rickerson@fws.gov>, "Abbott, Tyler" <tyler_abbott@fws.gov>, Larry Crist <Larry_Crist@fws.gov>

Dear Wolverine Conservation Partners:

Attached please find the DRAFT Species Status Assessment (SSA) for the North American Wolverine. As you may be aware, the draft report is currently undergoing peer review.

We are providing this draft to your agency for review by members of your organization with expert knowledge of the species and its habitat. Your review will help us ensure that we have appropriately considered the best scientific and commercial information when evaluating the current status and future viability of the North American wolverine. We request your independent scientific perspectives on the comprehensiveness and logic of the document, as well as how well the technical conclusions are supported by the data and analyses.

As the literature cited is lengthy, if you need a copy of any document cited in the draft report, please contact Betty Grizzle at the email address below.

The Draft SSA is not intended to solicit public comment and will be revised after this scientific review. The SSA does not predetermine any future agency decision under the Endangered Species Act.

In general we ask that your comments on the Draft SSA report focus specifically on whether the best available information was used, the quality of the scientific information, and our interpretation and analyses of the data with regard to the species' viability in the contiguous United States. We request that you direct your review to the scientific issues and assumptions related to your expertise.

General Information about SSAs:

The Species Status Assessment framework is a new tool the U.S. Fish and Wildlife Service is using to improve transparency while conducting listing determinations and other Act actions, and peer review of our analyses of the viability of species is part of that new process. The attached draft SSA report is a rough draft; we are seeking comments at this stage to ensure that we have time to incorporate any substantial comments as we finalize the report.

In reviewing the document, please note that this draft SSA report does not result in or predetermine a decision by the Service on whether the Canada lynx warrants protections of the Act. This document is strictly a characterization of the viability species' viability in the contiguous United States. As a reminder, all reviews and comments submitted to the Service will become public documents and part of our administrative record for this document.

We welcome consolidated comments from your organization by November 30, 2017. Please send comments by that date to Betty_Grizzle@fws.gov. Thank you for your interest and assistance. JB

Jodi L. Bush
Office Supervisor
Montana State Ecological Services Office
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Helena, MT 59601
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Bryon Holt
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****

GENERAL COMMENTS

Conclusions made in the 2013 proposed rule include a statement that "We have determined that habitat loss due to increasing temperatures and reduced late spring snowpack due to climate change is likely to have a significant negative population-level impact on wolverine populations. . .". This conclusion seems contrary to the conclusion reported in the SSA Report, with no justification provided as to why the 2013 conclusion is no longer appropriate.

The SSA Report outlines several flaws with the Copeland *et al.* paper, a citation for which we relied on for the 2013 proposed rule. Further explanation should be provided in the SSA Report to account for the FWS's change in perspective on the applicability of the Copeland *et al.* paper.

It would be beneficial to strengthen the rationale for why the decrease in snowpack, due to climate change, will not have a detrimental effect on reproductive success. It is stated in the SSA Report that snowpack will be impacted by climate change, and the 2013 proposed rule states that wolverines will be impacted by snowpack loss. A stronger rationale that explains these seemingly contradictory statements will help support the conclusions in the SSA Report.

From: Grizzle, Betty
To: Shoemaker, Justin; Bush, Jodi
Subject: Fwd: For Review: Draft Wolverine SSA
Date: Tuesday, November 28, 2017 12:17:59 PM
Attachments: Wolverine SSA comments_27Nov2017.docx

FYI
---------- Forwarded message ----------
From: **Holt, Bryon** <bryon_holt@fws.gov>
Date: Tue, Nov 28, 2017 at 11:06 AM
Subject: Fwd: For Review: Draft Wolverine SSA
To: Betty Grizzle <betty_grizzle@fws.gov>

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Date: Thu, Oct 26, 2017 at 9:29 AM
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Cc: "Anderson, Hannah E (DFW)" <hannah.anderson@dfw.wa.gov>, "McDonald, Ken" <kmcdonald@mt.gov>, Bob Lanka <bob.lanka@wyo.gov>, "Smith, Scott" <Scott.Smith1@wyo.gov>, H Jerome Hansen <jerome.hansen@idfg.idaho.gov>, ccorsi@idfg.idaho.gov, pseymour@idl.idaho.gov, Justin Shannon <justinshannon@utah.gov>, Zack Walker <zack.walker@wyo.gov>, "Inman, Bob" <bobinman@mt.gov>, "Cc:" <derek.j.broman@state.or.us>, "Liley, Stewart, DGF" <stewart.liley@state.nm.us>, Betty Grizzle <betty_grizzle@fws.gov>, Scott.Gardner@wildlife.ca.gov, karen.miner@wildlife.ca.gov, "DeBerry, Drue" <drue_deberry@fws.gov>, Gregory Hughes <greg_m_hughes@fws.gov>, Paul Henson <paul_henson@fws.gov>, Eric Rickerson <eric_rickerson@fws.gov>, "Abbott, Tyler" <tyler_abbott@fws.gov>, Larry Crist <Larry_Crist@fws.gov>

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We are providing this draft to your agency for review by members of your organization with expert knowledge of the species and its habitat. Your review will help us ensure that we have appropriately considered the best scientific and commercial information when evaluating the current status and future viability of the North American wolverine. We request your independent scientific perspectives on the comprehensiveness and logic of the document, as well as how well the technical conclusions are supported by the data and analyses.

As the literature cited is lengthy, if you need a copy of any document cited in the draft report, please contact Betty Grizzle at the email address below.

The Draft SSA is not intended to solicit public comment and will be revised after this scientific review. The SSA does not predetermine any future agency decision under the Endangered Species Act.

In general we ask that your comments on the Draft SSA report focus specifically on whether the best available information was used, the quality of the scientific information, and our interpretation and analyses of the data with regard to the species' viability in the contiguous United States. We request that you direct your review to the scientific issues and assumptions related to your expertise.

General Information about SSAs:

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In reviewing the document, please note that this draft SSA report does not result in or predetermine a decision by the Service on whether the Canada lynx warrants protections of the Act. This document is strictly a characterization of the viability species' viability in the contiguous United States. As a reminder, all reviews and comments submitted to the Service will become public documents and part of our administrative record for this document.

We welcome consolidated comments from your organization by November 30, 2017. Please send comments by that date to Betty_Grizzle@fws.gov. Thank you for your interest and assistance. JB

Jodi L. Bush
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Bryon Holt
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GENERAL COMMENTS

Conclusions made in the 2013 proposed rule include a statement that "We have determined that habitat loss due to increasing temperatures and reduced late spring snowpack due to climate change is likely to have a significant negative population-level impact on wolverine populations. . .". This conclusion seems contrary to the conclusion reported in the SSA Report, with no justification provided as to why the 2013 conclusion is no longer appropriate.

The SSA Report outlines several flaws with the Copeland *et al.* paper, a citation for which we relied on for the 2013 proposed rule. Further explanation should be provided in the SSA Report to account for the FWS's change in perspective on the applicability of the Copeland *et al.* paper.

It would be beneficial to strengthen the rationale for why the decrease in snowpack, due to climate change, will not have a detrimental effect on reproductive success. It is stated in the SSA Report that snowpack will be impacted by climate change, and the 2013 proposed rule states that wolverines will be impacted by snowpack loss. A stronger rationale that explains these seemingly contradictory statements will help support the conclusions in the SSA Report.

From: Jodi Bush
To: Grizzle, Betty
Cc: Shoemaker, Justin
Subject: Re: For Review: Draft Wolverine SSA
Date: Tuesday, November 28, 2017 12:30:03 PM

Why is the ifwo providing comments. Didn't we give them opportunity previously?

Sent from my iPhone

On Nov 28, 2017, at 12:18 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:

> FYI
> ---------- Forwarded message ----------
> From: **Holt, Bryon** <bryon_holt@fws.gov>
> Date: Tue, Nov 28, 2017 at 11:06 AM
> Subject: Fwd: For Review: Draft Wolverine SSA
> To: Betty Grizzle <betty_grizzle@fws.gov>
>
> Betty,
>
> Attached are general comments from our Idaho office.
>
> Bryon
>
> ---------- Forwarded message ----------
> From: **Fisher, Sandi** <sandi_fisher@fws.gov>
> Date: Mon, Nov 27, 2017 at 11:48 AM
> Subject: Re: For Review: Draft Wolverine SSA
> To: Bryon Holt <bryon_holt@fws.gov>
> Cc: Evan Ohr <evan_ohr@fws.gov>
>
> Hi Bryon...attached our EIFO comments on the Wolverine SSA. These were pulled together by Evan, so if you have any questions, please contact him directly. Evan, if I've misconstrued anything from your comments, please let us know.
>
> Thanks,
>
> ~S~
>
> On Temporary Detail Through 12/22
> Acting IFWO Deputy State Supervisor
> (208) 378-5267 (O)
> (208) 241-8043 (C)
>
> ><((((*> ... ><((((*> ... ><((((*>
> Sandi Fisher, Field Office Lead
> U.S. Fish and Wildlife Service
> IFWO - Eastern Idaho Field Office

4425 Burley Drive, Suite A
Chubbuck, Idaho 83202
(208) 237-6975 x 102 (office)
(208) 241-8043 (cell)

---------- Forwarded message ----------
From: **Bush, Jodi** <jodi_bush@fws.gov>
Date: Thu, Oct 26, 2017 at 9:29 AM
Subject: For Review: Draft Wolverine SSA
To: tschultz@idl.idaho.gov, twasley@ndow.org, curt.melcher@state.or.us, "Lexi J., Sandoval" <alexandra.sandoval@state.nm.us>, Jim Unsworth <Jim.Unsworth@dfw.wa.gov>, "Dustin Miller (dustin.miller@osc.idaho.gov)" <dustin.miller@osc.idaho.gov>, "Moore,Virgil" <virgil.moore@idfg.idaho.gov>, Martha Williams <Martha.Williams@mt.gov>, Scott Talbott <scott.talbott@wyo.gov>, Mike Fowlks <mikefowlks@utah.gov>, bob.broscheid@state.co.us, Kimberly Hersey <kimberlyasmus@utah.gov>, reid.dewalt@state.co.us, Sam Eaton <Sam.Eaton@osc.idaho.gov>, Chuck.Bonham@wildlife.ca.gov
Cc: "Anderson, Hannah E (DFW)" <hannah.anderson@dfw.wa.gov>, "McDonald, Ken" <kmcdonald@mt.gov>, Bob Lanka <bob.lanka@wyo.gov>, "Smith, Scott" <Scott.Smith1@wyo.gov>, H Jerome Hansen <jerome.hansen@idfg.idaho.gov>, ccorsi@idfg.idaho.gov, pseymour@idl.idaho.gov, Justin Shannon <justinshannon@utah.gov>, Zack Walker <zack.walker@wyo.gov>, "Inman, Bob" <bobinman@mt.gov>, "Cc:" <derek.j.broman@state.or.us>, "Liley, Stewart, DGF" <stewart.liley@state.nm.us>, Betty Grizzle <betty_grizzle@fws.gov>, Scott.Gardner@wildlife.ca.gov, karen.miner@wildlife.ca.gov, "DeBerry, Drue" <drue_deberry@fws.gov>, Gregory Hughes <greg_m_hughes@fws.gov>, Paul Henson <paul_henson@fws.gov>, Eric Rickerson <eric_rickerson@fws.gov>, "Abbott, Tyler" <tyler_abbott@fws.gov>, Larry Crist <Larry_Crist@fws.gov>

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<Wolverine SSA comments_27Nov2017.docx>

State of Washington
DEPARTMENT OF FISH AND WILDLIFE
Mailing Address: P.O. Box 43200, Olympia, WA 98504-3200 • (360) 902-2200 • TDD (360) 902-2207
Main Office Location: Natural Resources Building, 1111 Washington Street SE, Olympia, WA

November 29, 2017

Jodi L. Bush
US Fish and Wildlife Service
Montana State Ecological Services Office
585 Shepard Way, Suite 1
Helena, MT 59601

Dear Ms. Bush:

Washington Department of Fish and Wildlife (WDFW) is grateful for the opportunity to review the species status assessment (SSA) for the North American Wolverine *(Gulo gulo luscus)*. WDFW is invested in better understanding wolverine ecology and in implementing measures to further the species' conservation in Washington and in the western United States.

We appreciate the significant amount of work required to pull together such a comprehensive document. Our primary concerns are related to the treatment and presentation of two specific subject areas within the SSA, the need for comprehensive ecological knowledge and the association of wolverines with snow.

As is the case with most wildlife species, we lack a complete understanding of wolverine biology and ecology. Wolverines are very difficult to study and there are a limited number of studies that have been conducted in the western states. However, recent and ongoing studies of wolverine ecology in Washington, Idaho, Montana, Wyoming, British Columbia and Alberta provide valuable information on this topic and we are fortunate to have a wealth of data to inform decision-making. Rather than heavily focusing on gaps in our knowledge, we recommend that the SSA present the current state of knowledge as the "Best Available Information."

WDFW is concerned about the doubt sown in the SSA regarding the importance of snow as a significant habitat component. The SSA focuses on exceptions, extensively states specific aspects of wolverine ecology that are unknown, and counters what we do know about wolverine ecology (i.e., that wolverines have a strong association with snow, and most wolverine dens in the lower 48 states occur in/with snow). This is a concern throughout the document and we have pointed out several instances in our attached table of specific comments.

Further, we agree that there is not a complete understanding of how climate change can or will alter habitats for wolverines and other species in the near and distant future. However, we are confident that best available information provides clear indications that climate change is, and will be, creating conditions that will alter wolverine habitats in ways that will affect the

distribution and resilience of wolverines where they now occur in Washington. We look forward to working with the Service to advance wolverine research, monitoring and conservation as we address and gain a greater understanding of the conservation challenges facing this species.

Attached, we have provided a table of our specific comments for consideration. We also include information about the initial findings of the Western States Wolverine Conservation Project. Please contact Hannah Anderson, Listing and Recovery Manager, by email at hannah.anderson@dfw.wa.gov if you have any questions about our comments or WDFW's efforts to advance wolverine conservation in Washington.

Sincerely,

Eric Gardner, Assistant Director
Wildlife Program

Attachments: 1. WDFW Comment Table - Wolverine SSA
2. Summary of Multi-State Wolverine Occupancy Survey

cc: Jim Unsworth, Director, WDFW
Mick Cope, Deputy Assistant Director, Wildlife Program, WDFW
Penny Becker, Diversity Division Manager, Wildlife Program, WDFW
Hannah Anderson, Listing and Recovery Section Manager, Wildlife Program, WDFW
Eric Rickerson, Washington State Supervisor, USFWS

IDAHO DEPARTMENT OF FISH AND GAME
600 S Walnut / P.O. Box 25
Boise, Idaho 83707

C.L. "Butch" Otter / Governor
Virgil Moore / Director

Idaho Department of Fish and Game Comments Re: Draft Species Status Assessment for the North American Wolverine.

November 29, 2017

Background

The U.S. Fish and Wildlife Service (Service) has provided the V1.0 October 23, 2017 draft Species Status Assessment (SSA) for the North American wolverine to the Idaho Department of Fish and Game (Department) for review by staff with expert knowledge of the species and its habitat. The focus of the review is to ensure that the Service has appropriately considered the best scientific and commercial information when evaluating the current status and future viability of the North American wolverine. Specifically, the Service requested the Department's independent scientific perspective about the comprehensiveness and logic of the SSA, as well as how well the technical conclusions are supported by the data and analyses.

The SSA framework is a new tool the Service is using to improve transparency while conducting listing determinations and other Endangered Species Act actions, and peer review of analyses of the viability of species is part of this new process. Public comment about the SSA report will not be solicited but the report will be revised after this scientific review.

In response to the request from the Service, the Department submits the following technical comments about the draft SSA. If there are questions about our comments, please direct them to Dr. Rex Sallabanks, Wildlife Diversity Program Manager, rex.sallabanks@idfg.idaho.gov.

In general, the Department finds the draft SSA to be an accurate interpretation of the best available data, concurs with the overall conclusions regarding redundancy, representation and resiliency, and appreciates the thoroughness of the report. More specific suggestions, arranged chronologically by page number, addressing how we believe the draft SSA can be improved occur below.

Executive Summary

Page v, last paragraph
Please see our comments under **Disturbance due to Winter Recreational Activity,** below, regarding the conclusion that winter recreational activity poses low demographic risk to wolverines.

Current Range
Page 14, Figure 2
Previous comments submitted by the Department included maps of wolverine observations compiled through March 9, 2017. Since that submission, an additional 7 verified observations (based on photographs and DNA) were documented in the Panhandle Region during 2015/2016 field seasons and 25 incidental observations (15 verified/trusted, 10 possible) have been reported to the Department. These new observations do not drastically change the current known range extent in Idaho (e.g., Figures 2 and 3 in the SSA), and thus are not included with our comments. However, they are available to the Service upon request.

In addition, updated observations from the Western States Wolverine Conservation Project are available (Page 48, paragraph 2; Appendix B).

Current Range
Pages 14–15 and Figure 3
The Department recommends that the Service define the terms "current" and "historical" in this discussion. The first paragraph under the heading "Current Range" (Page 14), along with Figure 2 (Page 16), appears to be historical information—a compilation of records dating back to the 1800s. In contrast, Figure 3 (Page 17) is described as "a current North American range" (Page 15, paragraph 2) based on "more recent observations". However, no time frame for "recent" is given. Figure 3 includes Colorado and a large part of Oregon in a current range. To the best of our knowledge, the single animal documented in Colorado in the past decade left that state sometime after 2012 and was killed in North Dakota in 2016. Thus, we question if Colorado is part of the current range. Please note that Page 147 states there is no known current resident or reproducing wolverine population in Colorado. Likewise, we are unaware of recent occurrences that cause the Oregon Cascade Mountains to be considered occupied, unless the observations cited on Page 47 are recent. In the Sierra Nevada range in California, if the only currently confirmed occurrence is the single male that traveled to this region from the Rocky Mountains, we suggest this area should be depicted with a single dot on the map rather than broadly identified as occupied. If this animal is no longer extant, it falls in the same category as Colorado. Inclusion of Utah in the range would depend on the recentness of sightings in this state and the definition of 'current'.

The Department also finds inconsistency in which observations are considered in the description of the "current North American range" and which are not. The female wolverine that occurred in Michigan from 2004–2010 had an apparent longer period of occupancy than the male in Colorado, yet Michigan is not included in the current range map. If Figure 3 is intended to depict *western* North America only, then the map should be relabeled as such.

The Department suggests the Service also should define the minimum criteria they are using for inclusion in the current range (e.g., single observations of animals of unknown status, known resident animals, or a reproducing subpopulation). We suggest the Service consider using resident animals as the criterion to define range.

Denning Habitat

Page 28

This paragraph includes a statement that "…den site locations for North America reported in the past have been biased to tundra regions where dens are more readily observed and located". The Department suggests that many (most?) known den sites, at least in the contiguous U.S., are the result of telemetry studies whereby the den location is revealed by telemetry locations. This is unaffected by the presence or absence of snow cover for tracking.

Page 29, Box 1

The Department recognizes this box as a call-out specifically addressing the Formozov references. However, there are many more recent publications that both support and refute different points in this Box.

Page 30, paragraph 1 through Page 31

The Department concurs with the Service's recognition that the relationship between wolverines and snow has not been empirically analyzed. The Service might consider introducing this portion of the 'Denning Habitat' section with acknowledgement that the relationship between wolverine dens and snow cover remains unclear and that geography could influence this relationship. The Service makes this acknowledgement on Page 35, first paragraph: "Additional studies are needed to further document wolverine den structure, snow conditions at dens, and how long dens are used, particularly for those locations outside of areas expected to have spring snow cover, to better understand the relationship of wolverines and snow cover."

In addition, several other factors contributing to den habitat are recognized, evaluated, and addressed as the best available information known to affect wolverines (e.g., large, remote, high elevation landscapes, variety of food resources by season, physical/structural features). The Department recognizes that reproductive success has not been evaluated with respect to any of these important characteristics. We also appreciate the discussion of the usefulness and limitations of bioclimatic models and recognize that the Copeland *et al*. (2010) snow model does not necessarily reflect denning habitat, but rather a correlation of known dens with a spatial layer of predicted spring snow.

Nevertheless, it is unclear if the main point of the discussion of Denning Habitat, specifically Pages 32–34, is to discount the theory that wolverines require snow cover for denning or to discount the reliability of the Copeland *et al*. (2010) persistent spring snow model to predict all persistent spring snow. The Department recommends the Service make a concise statement as to the point this discussion is making.

For example, it is unclear how many of the studies listed on Page 30, last paragraph, (other than Pulliainen 1968), found dens without snow cover. We concur that other substrates are important features for denning (e.g., large boulders and large downed logs), and in Idaho these features are snow covered when used for den sites. Please clarify which of the studies in this paragraph found den sites that were not in snow at the time of use for denning.

Likewise, Webb *et al*. 2016 is discussed as demonstration that wolverines occur outside of predicted persistent spring snow, but uses occurrence, not den sites, as the metric. On the other hand, Makkonen (2015) did find dens without snow cover. Studies in Sweden (Aronsson and Persson 2016, Aronsson 2017) are cited as examples of wolverines denning outside of the Copeland *et al*. (2010) persistent spring snow model, with over 80 reproductive dens observed outside the boundary of the snow model as of 2017, yet the placement of those dens relative to snow cover is not addressed in the SSA. Koskela (2013) also is cited as an example of dens found outside the Copeland *et al*. (2010) persistent spring snow model, and in this case these dens were snow dens. The inclusion of Magoun *et al*. (2017) in this discussion goes in yet another direction, as Magoun *et al*. found persistent spring snow later in the spring than the Copeland *et al*. model in some locations associated with denning. Magoun *et al*. made the point that if persistent spring snow is important at the den-site level, remote sensing techniques aren't precise enough to capture it at all locations, and different scales and resolutions are needed to examine this relationship.

Page 33–34
The Department appreciates the attention the Service gives to the effect of topographic complexity (e.g., slope, aspect, elevation, ruggedness) on the micro-climate characteristics of an area and the potential impact on snow depth and cover. Additional factors that may want to be considered include wind and vegetation cover.

Table 3, Wolverine Den Site Melt-out Dates
Page 34
The MODIS data from which this table is derived is currently available through 2016. Why was this limited to only include melt-out dates from 2002–2008? Also, was the Service not able to obtain den locations from Heinemeyer and Squires for this analysis? Their winter recreation study would increase the sample size by ~43%.

Genetic Diversity
Page 42, paragraph 4, and Page 43
The discussion of Cegelski *et al*. (2006) notes that significant differentiation between wolverine populations in the U.S. and Canada was found but that some migration was occurring, with the exception of Idaho. However, the sample size from Idaho used in this study (n = 15) was extremely small and limited to only a small portion of south-central Idaho. Although Cegelski *et al*. (2006) conclude that "the Idaho population was highly differentiated", the Department suggests additional analyses are necessary to accurately represent the diversity in Idaho wolverine populations given more recent information on known distributions and movements, including at least one individual wolverine known to travel between northern Idaho and Canada (see next page).

Population Abundance and Distribution
Page 46, paragraph 3
The SSA refers back to Figure 3, current range map, in the context of population size and distribution. Please see previous comments, above, on Figure 3 in the context of defining current distribution.

Contiguous United States

Page 46, paragraph 4

The Department recommends that this entire section begin with an acknowledgement that no comprehensive surveys have been conducted across the species' range to provide a reliable range-wide population estimate. The population size in the contiguous U.S. is essentially unknown. The SSA has a similar statement farther into the section on Page 47, first paragraph; we recommend this precede all other discussion of population size.

The Department recommends putting less emphasis on enumerating population size. Values put forth in the literature have limitations. An effective population size of 35 for the Rocky Mountains put forth by Schwartz *et al*. (2009) was limited by small sample size and gaps in samples. The estimate of 318 put forth by Inman *et al*. (2013) was a projection based on a habitat model built from wolverine habitat use in the Greater Yellowstone Ecosystem and extrapolated to the rest of the listed regions assuming similar densities and habitat use as the GYE population. In reality, wolverine abundance likely falls somewhere between these two estimates, but is unknown.

Page 47

Since 2010, the Department has led a multi-species forest carnivore monitoring program in the Idaho Panhandle and adjoining areas of Washington, Montana, and British Columbia (Lucid *et al*. 2016, Lucid *et al*. 2017). From 2010–2014, 497 forest carnivore bait stations (Robinson *et al*. 2016) were used to survey the study area on a 5x5 km grid. Three male wolverines were detected and only one of those individuals (LS11) was detected in multiple years and therefore considered a resident. LS11 was detected six times from 2010–2013 in Idaho (n = 5 detections) and British Columbia (n = 1 detection). The British Columbia detection of LS11 was north of Canada's Highway 3 which is considered by some to be a barrier to wildlife passage. LS11 was most recently detected in Idaho on March 6, 2013.

From 2015–2016 a less extensive, but more focused, monitoring effort was conducted to maintain contact with individual wolverines detected during the 2010–2014 survey. Two new male wolverines were detected during the 2015–2016 survey. However, the three known males were not redetected.

In summary, from 2010–2015, five male and zero female wolverines were detected in the study area. The study area contains a substantial amount of predicted wolverine habitat which is currently considered occupied (USFWS 2013). However, these results suggest the Idaho Panhandle and adjoining mountain ranges did not have a resident wolverine population from 2010–2016 (Lucid *et al*. 2016).

Page 47, paragraph 5

Please note that the pilot effort in Wyoming (Inman *et al*. 2015) evolved to become a pilot for the Western States Wolverine Conservation Project to field test techniques and provide estimates of occupancy that were subsequently used to inform sample size needed for the four-state coordinated survey.

Page 47, last paragraph
The protocol for the Western States Wolverine Conservation Project's Coordinated Occupancy Survey should be attributed to the Working Group, not Bjornlie *et al*. 2017. The correct citation is 'Western States Wolverine Working Group. 2016. Western States Wolverine Conservation Project Baseline Survey – Standard Operating Procedures for Camera–DNA Stations v3.2. 2016'.

Page 48, first and second full paragraphs
Results from the Western States Wolverine Conservation Project's Coordinated Occupancy Survey have been updated following preliminary analysis of the entire dataset. Please replace the first and second full paragraphs on Page 48 with information from the summary of results provided as an addendum to these comments, and replace **Appendix B** with the updated map provided by Robert Inman, MFWP, on behalf of the group.

Page 48, third full paragraph
As reported in the SSA, Heinemeyer suggested that "…subpopulations of the species at this southern periphery of their North American range are still unstable with low rates of recruitment." The Service used observations of wolverines in 2017 to assess this suggestion. The Department is not convinced this is an appropriate approach. Heinemeyer's data is based on following individual animals over time and with known home ranges, distribution, and relatedness. We question whether reports of one-time detections of unknown animals from 2017 can be used to provide any information on population dynamics and stability. For the same reasons, we feel Appendix C is incomplete and confusing. The map lacks key elements, such as inclusion of all 7 of Heinemeyer's research areas. If the Service decides to retain the map in Appendix C, the Department recommends they work with Diane Evans Mack (diane.evansmack@idfg.idaho.gov) of our agency to clarify and correct what is depicted.

Canada
Page 49
Extensive wolverine surveys were conducted in the Kootenay Region of southern British Columbia from 2013–2016. These sampling efforts suggest low wolverine abundance and limited genetic connectivity between mountain ranges in the study area. Recommended management actions include monitoring and managing harvest pressure on a range by range basis, a need for population trend monitoring, and to identify and maintain movement corridors (Hausleitner and Kortello 2015).

Roads/Roadkill
Page 52, paragraph 5
No additional road mortalities have been reported in Idaho since our last comments (dated 11.17.16).

Page 53, paragraph 3
The Department suggests that the Service acknowledge the error associated with road data: while data from primary roads (e.g., interstates, U.S./state highways) are generally robust, errors in the secondary road data can be quite significant depending on location. For example, secondary

roads mapped in many portions of the more remote sections of Idaho are actually trails, or obliterated roads, or deemed unpassable due to surface conditions.

Disturbance due to Winter Recreational Activity
Page 55, paragraphs 2 and 3
Interpretation of results from the Wolverine–Winter Recreation Study (Heinemeyer and Squires) reflects information available at the time. However, much like the Western States Wolverine Conservation Project, the Winter Recreation Study is poised to deliver comprehensive final results. These are scheduled for release by the end of 2017. Lead scientists for the study have conducted intensive data analysis over the past two years (since 2015), including habitat modeling and exploring behavioral and spatial response of wolverines to recreational activity. We strongly encourage the Service to try to obtain these findings to further inform a Service conclusion about the effect of winter recreational activity (Page 56, paragraph 2; also Page 65, Summary of Current Conditions, paragraph 4).

If the most current findings cannot be obtained, the Department suggests that, at a minimum, the relationship between wolverines and winter recreational activity be identified as a 'data gap' as described on Page 4 of the SSA (Species Status Assessment Methodology, paragraph 2).

Incidental Take
Page 60, paragraph 1
Since submission of the Department's last comments (dated 11.17.16) one additional incidental trapping occurred in March 2016. In this instance the animal released itself prior to discovery but left hair on the trap that was subsequently verified to have been that of a wolverine by DNA testing. The fate of the animal is unknown although there was no obvious evidence of injury.

Climate Change
Page 66, paragraphs 2 and 3
The use of the terms "scenario" and "future scenario" in these paragraphs is misleading (e.g., "the most likely future scenario to potentially have an effect on wolverine…"). With regard to climate change, the phrases "scenario" and "future scenario" have specific meanings (see IPCC definitions). The Department suggests rephrasing to more precisely reflect what is intended—that climate change is the *stressor* most likely to affect wolverine populations in the next 50 years.

Pages 67–72
Similar to our previous comments, the Department stresses the range of uncertainty in climate change information. The Service acknowledges that the variability in global climate model results is small until about 2030 then larger through the end of the century (Page 67, paragraph 3) and that projected changes can vary substantially through space (Page 67, paragraph 4; Page 72, paragraph 2). However, little else is mentioned with regard to the substantial range of variability among climate models, in particular for precipitation, both in magnitude and direction, as well as through space and time. The Department suggests the Service further elaborate on this range of potential futures.

Page 67, paragraph 4
The Department greatly appreciates the acknowledgement and effort given to examining multiple lines of evidence and not just projections derived from the climate models.

Page 70, paragraph 2; Page 71, paragraph 2
The Department suggests further discussion on the spatial resolution of the global climate models and resulting estimates provided by Rupp *et al*. (2017) and Petersen *et al*. (2017). For both of these projects, knowledge of the spatial resolution of the data is significant in correctly interpreting the results.

Page 72, paragraph 2; Page 95, paragraph 2 (also Page v, paragraph 4)
The Department concurs with the Service's interpretation that the best available information suggests the wolverine is resilient to current and projected changing climatic conditions for the time period assessed (40–50 years). This is a reasonable timeframe to assess, given the range of uncertainty in climate models. However, the ability of this species to adapt behaviorally and physiologically will be relative to the increase in temperature and precipitation experienced, and thus will be variable through space and time. We find the Service's conclusion that wolverines will move to water bodies or higher in elevation (Summary, Page 72) to be overly simplistic and encourage the Service to focus more on the traits that generally are used to assess vulnerability, such as narrow- or wide-ranging, highly specialized or not, and degree of physiological sensitivity. The lack of empirical studies that address wolverine behavioral and physiological adaptations should be recognized as an information gap.

Page 74, paragraph 2
Again, the resolution of global climate models used in the analysis should be noted and taken into consideration in interpretation.

Pages 75–78
The Department greatly appreciates the efforts to develop a fine-scale assessment of snow cover persistence in the selected parks (i.e., Ray *et al*. 2017) and recognizes the time constraints in doing so. However, it is our opinion that further discussion is necessary highlighting the limitations in using the Delta Method (versus other downscaling methods) as well as the selection and use of a limited number of models versus an ensemble mean of several models.

Page 92, paragraph 2
The Department concurs with the Service's conclusion that while snow cover is projected to decline, this will vary by elevation, topography and geographic region. In addition, the inter-annual variability will likely be substantial as well and should be included here.

Other
Page 92, paragraph 4
Idaho Wolverine Conservation Plan should read "Management Plan for the Conservation of Wolverines in Idaho".

Page 92, paragraph 4
The Department generally concurs with the statement, “These management measures, currently and in the future, will alleviate effects associated with potential impacts related to stressors discussed in this report.” provided that measures are implemented as envisioned and their effectiveness is monitored. The Department remains committed to proactive measures to conserve wolverines as it continues to implement the *Management Plan for the Conservation of Wolverines in Idaho*. We are also an active member of the WAFWA Wildlife Chiefs Wolverine Subcommittee which provides a forum for the western states to work collaboratively together and with the Service on conservation and management efforts intended to benefit wolverines.

Personal Communications
Page 126
The appropriate cite for ‘Mack, D.’ is ‘Evans Mack, D.’

Appendix E
Pages 134–136
Analyses of road densities are based on the Service’s delineation of current range. Please see our previous comments, above, regarding definition of current range.

Citations
Hausleitner, D., and Kortello, A., Bio, R. P. (2015). Abundance and Distribution of Wolverine in the Kootenay Region. 2016 Field Season Report: Central Purcell Mountains. *Seepanee Ecological Consulting, Nelson, British Columbia, Canada.*

Lucid, M. K., Robinson, L., and Ehlers, S. (2016). Multi-species Baseline Initiative Project Report: 2010-2014. *Idaho Department of Fish and Game, Coeur d'Alene, Idaho, USA.*

Lucid, M.K., Swartz, L., and McCormack, C. (2017). Project F15AF00962, Idaho Panhandle Forest Carnivores, Final Performance Report. *Idaho Department of Fish and Game, Coeur d’Alene, Idaho, USA.*

Robinson, L., Cushman, S. A., and Lucid, M. K. (2017). Winter bait stations as a multispecies survey tool. *Ecology and evolution*, *7*(17), 6826-6838.

Addendum: Summary of Multi-State Wolverine Occupancy Survey

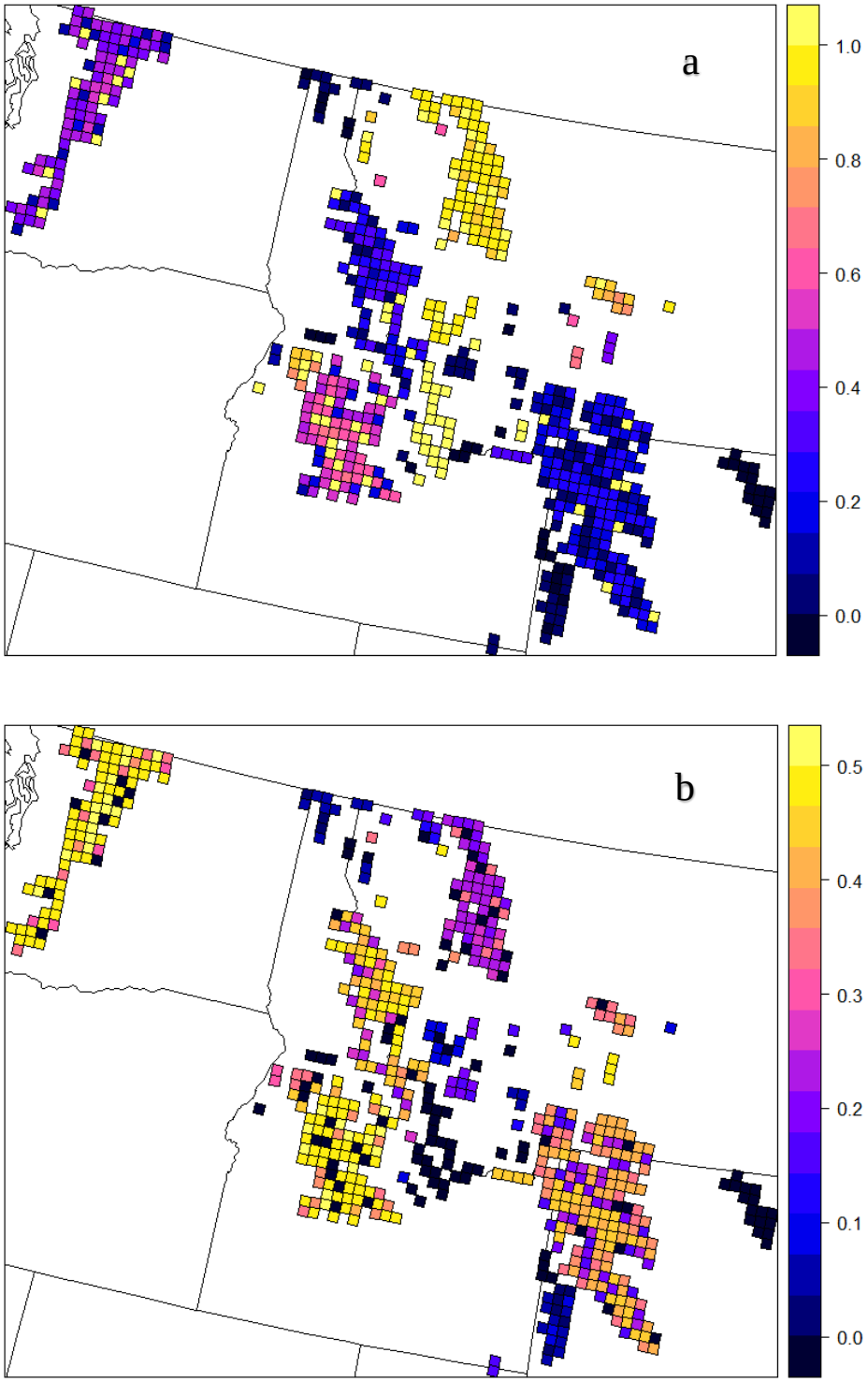
Wolverines are a naturally uncommon and rarely encountered species that resides in remote, high-elevation areas of the western United States. Proactive conservation measures are needed for this inherently small population that exists as a metapopulation across the region. One key component of a wolverine conservation strategy is development of a population monitoring program – up to now, records of wolverine occurrence have been rare and collected in an uncoordinated and opportunistic fashion, which makes it difficult to assess the species distribution, status and trend. The continued absence of a monitoring program jeopardizes the ability of agencies to allocate resources effectively among wolverines and other conservation priorities. State wildlife agencies in WA, ID, MT, and WY, along with federal, tribal, and NGO partners, developed a collaborative monitoring program that can be implemented in a coordinated fashion across the species range in the western U.S. The foundation for this monitoring program is a coordinated camera survey to obtain baseline information on distribution, genetics, and occupancy of wolverines. When repeated over time, trends in occupancy and distribution can be evaluated.

We developed a sampling frame based on existing models of wolverine habitat. The sampling frame consisted of 633 15x15 km grid cells. We selected 185 cells to sample from the frame using a GRTS sampling method. A single remotely triggered camera was placed in likely wolverine habitat within each selected cell along with a bait or scent attractant. Sampling occurred across a four-state area (ID, MT, WA, WY) during the winters of 2015-16 and 2016-17.

We obtained data from 183 sites and detected wolverines at 59 of the sampled cells. Detection rate was exceptionally high ($p=0.92$), and did not differ between sites that were baited and revisited multiple times vs. sites that were scented only and visited less frequently. The average estimated probability of wolverine occupancy during our study was 0.42 (95% credible interval 0.29-0.55) suggesting that wolverines used nearly half of all sites during the study period. Wolverine occupancy varied across the region with highest occupancy in the Northern Continental Divide Ecosystem and lower on the southern and eastern periphery of the study area (Figure 1).

The multi-state wolverine survey produced several important outcomes. First, it provided a rigorous and previously unavailable evaluation of wolverine distribution for the first time since the species was extirpated from the contiguous U.S. a century ago. This evaluation confirms the broad distribution of wolverines across the region and that recovery has progressed substantially since historical lows. The effort also demonstrates that occupancy probability varies throughout the region. The variability may be due to differences in habitat quality, differences in wolverine survival, or could be due to the time required to recover from historical absence. Perhaps most importantly, the regional occupancy estimates provide a baseline for future evaluations of change in wolverine distribution through time, including the possibility of detecting any influences due to climate change. In addition, the high detection rate and equal performance of stations visited less frequently indicates the potential for substantial cost savings during future surveys. The effort also demonstrated strong and fruitful collaboration among state, federal and tribal agencies at the scale of a species range, and the results provide management-level guidance on where to direct wolverine conservation in the future. For instance, information on occupancy may be used to inform criteria for translocation, should some states pursue that as a method to advance wolverine conservation.

Figure 1. Predicted wolverine occupancy (a) and standard errors (b) for the multistate wolverine survey in 2016 and 2017.



From:	Grizzle, Betty
To:	Bush, Jodi; Shoemaker, Justin; John Guinotte
Subject:	Fwd: Utah Wolverine Comments
Date:	Thursday, November 30, 2017 2:24:02 PM
Attachments:	Utah SSA comments.pdf

From Utah.

---------- Forwarded message ----------
From: **Kimberly Hersey** <kimberlyasmus@utah.gov>
Date: Thu, Nov 30, 2017 at 12:51 PM
Subject: Utah Wolverine Comments
To: betty_grizzle@fws.gov

Please accept the attached comment letter on the wolverine SSA on behalf of the Utah Division of Wildlife.

Thanks,
Kim

--
Kimberly Asmus Hersey
Mammal Conservation Coordinator
Utah Division of Wildlife
(801) 362-0795
kimberlyasmus@utah.gov

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

GARY R. HERBERT
Governor

SPENCER J. COX
Lieutenant Governor

State of Utah

DEPARTMENT OF NATURAL RESOURCES

MICHAEL R. STYLER
Executive Director

Division of Wildlife Resources

MICHAL D. FOWLKS
Division Director

November 30, 2017

Emailed to Betty_Grizzle@fws.gov

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008

SUBJECT – Draft Species Status Assessment (SSA) for the North American wolverine

Dear Ms. Grizzle:

Thank you for the opportunity to review the draft wolverine Species Status Assessment. Although Utah has only a small or transient wolverine population, we are invested in the conservation of the species. Overall, we view the draft SSA as a substantial improvement to the prior Proposed Rule and feel it relies upon the most up-to-date and best available science on wolverines.

Importantly, wolverine populations continue to expand from historical lows and there is no evidence to suggest abundance is declining. Wolverines may be more adaptable and flexible in their distribution than previously assumed, as shown in recent research documenting populations and dens outside of previously modeled projections of suitable habitat (Webb et al. 2016, Aronsson et al. 2016). Those discoveries combined with finer scale analysis predicting adequate snow cover at the den site level (Ray et al. 2017 and Magoun et al. 2017) support the finding that wolverine populations in the continental United States will maintain redundancy, representation, and resiliency into the foreseeable future.

We especially appreciate the U.S. Fish and Wildlife Service considering recent survey efforts undertaken by the states of Montana, Idaho, Wyoming, and Washington, which give us a more complete picture of current wolverine distribution and provide a baseline against which to measure any future changes. Although we were not formal partners in the multi-state wolverine survey effort, Utah has been selecting grid cells and monitoring with remote cameras following the developed protocol. From 2014 to 2017, we have placed remote cameras in potential habitat in the Uinta and Bear River mountains. That effort produced one positive detection in 2014. We found tracks in 2015 and a road-killed female in 2016. We intend to continue camera monitoring in coordination with other states and we expect to document continued expansion of wolverines into Utah.

1594 West North Temple, Suite 2110, PO Box 146301, Salt Lake City, UT 84114-6301
telephone (801) 538-4700 • facsimile (801) 538-4709 • TTY (801) 538-7458 • *www.wildlife.utah.gov*

UTAH DNR WILDLIFE RESOURCES

Although Utah is included in habitat models and has recorded wolverines in recent years, the state is not included in any of the sections of the SSA dealing with legal protections. References should be included along with the other states on pages vi and 92, and in Appendix G. The Utah Division of Wildlife Resources has protections in place and is taking conservation actions for wolverines. Wolverines are classified as non-game, they are protected in Utah, and they are included as a Species of Greatest Conservation Need in the *Utah Wildlife Action Plan: 2015-2025*. As such, wolverines are eligible for State Wildlife Grant Funding and are considered in efforts aimed at landscape-scale conservation. Utah maintains a highly regulated trapping program with mandatory trap check intervals. Any accidentally trapped wolverines must be released and any mortalities reported to the Division within 48 hours. We have no records of incidental captures.

The source of the data points from Utah used to create Figure 2- wolverine observations 1800s to 2017, is unclear to us. The points shown are inconsistent with our Natural Heritage Program records, our knowledge of museum and trapping records, and the verifiable and documented occurrence records from Aubry el al. 2007. We would appreciate the opportunity to review those records to both assess their validity and potentially update our own Natural Heritage Program data.

Again, thank you for your diligent work on the wolverine SSA.

Sincerely,

Bill Bates ACTING DIRECTOR

Michal D. Fowlks
Director

Copy to: *Jodi_Bush @fws.gov*

Oregon
Kate Brown, Governor

Department of Fish and Wildlife
Wildlife Division
4034 Fairview Industrial Drive SE
Salem, OR 97302
(503) 947-6301
FAX: (503) 947-6330
Internet: www.dfw.state.or.us/

November 30, 2017

Betty J. Grizzle, D.Env.
U.S. Fish and Wildlife Service
2177 Salk Ave #250
Carlsbad, CA 92008
Betty_grizzle@fws.gov

SUBJECT- Draft Species Status Assessment (SSA) for the North American Wolverine

Dear Ms. Grizzle,

Thank you for the opportunity for Oregon Department of Fish and Wildlife (ODFW) to review and provide comment on the scientific merit to the Draft SSA for the North American Wolverine (2017). ODFW believes the findings of the 3R framework (Redundancy, Representation, and Resiliency) are founded on the scientific information presented.

ODFW applauds the incorporation of new data and research into the SSA. Published research since the 2013 proposed rule are insightful on previously identified limiting factors. Findings in many of these new studies reflect the habitat plasticity observed in Oregon.

The inclusion of recent surveys are vital to the value of the SSA. While not a participant, ODFW is aware of the recent multistate wolverine survey (Washington, Idaho, Montana, and Wyoming) and believes it has value to the SSA and the future of monitoring. While techniques differ, various efforts have been underway in Oregon to survey and detect wolverines. Recent completed efforts (Magoun et al. 2013, McFadden-Hiller and Hiller 2014) could be considered for inclusion in the SSA.

We recommend continued caution when illustrating historical observations and maps of 'current range'. Text on page 15 provides a disclaimer that historical observation 'records may be in error or inaccurately located' and the depiction of wolverine current range "does not necessarily represent current areas where reproducing populations are found". That clarification is appreciated and could be included elsewhere in the body text, and it is requested similar language accompanies each associated figure (e.g. Figure 2, Figure 3).

The science presented in the draft SSA appears to include the majority of available information and the SSA correctly interprets that information.

Sincerely,

Derek Broman
Carnivore-Furbearer Coordinator
Oregon Department of Fish & Wildlife
503-947-6095
derek.j.broman@state.or.us

Literature:

Magoun, A.J., Valkenburg, P., Long, C.D., and J.K. Long. 2013. Monitoring wolverines in northeast Oregon. Jan 2011- Dec 2012. Final Report. The Wolverine Foundation, Inc. Kuna, ID

McFadden-Hiller, J.E. and T.L. Hiller. 2014. Forest carnivore researching in the northern Cascades of Oregon. Oct 2012-May 2013, Oct 2013-June 2014. Final progress report. Oregon Department of Fish and Wildlife, Salem, OR.

GARY R. HERBERT
Governor

SPENCER J. COX
Lieutenant Governor

State of Utah

DEPARTMENT OF NATURAL RESOURCES

MICHAEL R. STYLER
Executive Director

Division of Wildlife Resources

MICHAL D. FOWLKS
Division Director

November 30, 2017

Emailed to Betty_Grizzle@fws.gov

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008

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Importantly, wolverine populations continue to expand from historical lows and there is no evidence to suggest abundance is declining. Wolverines may be more adaptable and flexible in their distribution than previously assumed, as shown in recent research documenting populations and dens outside of previously modeled projections of suitable habitat (Webb et al. 2016, Aronsson et al. 2016). Those discoveries combined with finer scale analysis predicting adequate snow cover at the den site level (Ray et al. 2017 and Magoun et al. 2017) support the finding that wolverine populations in the continental United States will maintain redundancy, representation, and resiliency into the foreseeable future.

We especially appreciate the U.S. Fish and Wildlife Service considering recent survey efforts undertaken by the states of Montana, Idaho, Wyoming, and Washington, which give us a more complete picture of current wolverine distribution and provide a baseline against which to measure any future changes. Although we were not formal partners in the multi-state wolverine survey effort, Utah has been selecting grid cells and monitoring with remote cameras following the developed protocol. From 2014 to 2017, we have placed remote cameras in potential habitat in the Uinta and Bear River mountains. That effort produced one positive detection in 2014. We found tracks in 2015 and a road-killed female in 2016. We intend to continue camera monitoring in coordination with other states and we expect to document continued expansion of wolverines into Utah.

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UTAH DNR WILDLIFE RESOURCES

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Again, thank you for your diligent work on the wolverine SSA.

Sincerely,

Bill Bates ACTING DIRECTOR

Michal D. Fowlks
Director

Copy to: *Jodi_Bush @fws.gov*

Montana Fish, Wildlife & Parks

P.O. Box 200701
Helena, MT 59620-0701
Phone: 406-444-2612
FAX: 406-444-4952
Ref: DO175-13

November 30, 2017

Jodi L. Bush
United States Fish and Wildlife Service
Montana State Ecological Services Office
585 Shepard Way, Suite 1, Helena, MT 59601

Dear U.S. Fish and Wildlife Service:

On behalf of Montana Fish, Wildlife and Parks (FWP) please accept these comments, supporting documents, and technical review in response to the U.S. Fish and Wildlife Service's (USFWS) request for review of their 2017 wolverine Species Status Assessment (SSA).

First and foremost, we thank you for incorporating important newly available information into the SSA, and for a far more thorough and objective description of the scientific underpinnings and biology of the wolverine. We appreciate the effort and attention to detail that went into the SSA, and offer the following to emphasize those areas where we see important improvements toward using quality scientific information and objective interpretation of the best available information. We also note a few areas where we suggest additional refinement.

- Several studies that were not available for the 2013 proposed rule clearly demonstrate that the May 15 in at least 1 of 7 years snow model (Copeland et al. 2010) is not an accurate predictor of wolverine distribution now, and cannot be used to predict distribution in the future. Webb et al. (2016) and Aronsson et al. (2016) found evidence of females living and reproducing outside of areas classified as suitable wolverine habitat based on the 2010 snow model. As the authors of both new papers note, *the wolverine may be more flexible in its distribution than previously assumed.* Considering these studies and including the findings in the SSA was a critical step in using quality scientific information and providing an objective interpretation of the best available information.

We also agree with the Service that it is critical to consider the scale at which snow may be important for wolverine dens. This was one of several major flaws in the scientific papers that the 2013 proposed rule hinged upon. The new works by Ray et al. (2017) and Magoun et al. (2017) demonstrate that previous analyses (McKelvey et al. 2011) produced an exaggerated effect. Contrary to previous analyses, both new papers consider fundamental biology such as

elevation, aspect, and the size of a snow patch that is actually needed for a wolverine den, and show that this resource will not be a limiting factor for wolverines in the foreseeable future. Again, this was a critical step in using quality scientific information and providing an objective interpretation of the best available information.

While we understand the necessity for the NOAA analysis by Ray et al. (2017) to use the May 15 (and May 1) dates to draw a comparison with what was presented by Copeland et al. (2010) and McKelvey et al. (2011), we urge the Service to use extreme caution in inadvertently furthering the narrative that May 15 is a date of important biological consequence to wolverines. While this date is a point in time when the effects of climate change on snow may be most apparent, it is not a date for which the presence or absence of snow has been demonstrated in practice to have any negative effects on wolverines. Even in theory, if snow is critical for dens, it is likely most important at a much earlier date such as February and March when young are less developed and climate impacts are not likely to be as severe.

It was important that the Service addressed several of the flaws in the previous works that the proposed rule hinged upon, but we urge the Service to consider making additional clarifications due to the widespread public misunderstanding that exists in relation to those works. For instance, one reason the 2010 snow model found a correlation between spring snow and dens was that most of the dens had been located by tracking wolverines in the snow to their dens during spring (in Scandinavia). No conclusion other than a relationship between spring snow and dens is possible using this field method. The fact that wolverines are expanding to areas outside of the May 15 snow area coupled with this methodological limitation is of such significance that Sweden has had to adapt their national population monitoring program to find wolverines in some way that does not depend on tracks in the snow (Aronsson et al. 2016). This is but one example, and there are several other major issues with the science underpinning the 2013 proposed rule that may need explicit clarification within the SSA. We urge you to consider and do so where appropriate.

The SSA has a far more objective consideration of the genetic composition, effective population size, and continuity of the population across the border with Canada. This, again, was a critical step toward an objective interpretation of the best available information. We ask that the Service make clear in the SSA that it is plausible that wolverine population size, genetic diversity, and effective population size are currently at a similar level to what existed 500 years ago, with the exception of those areas such as Colorado and California where functional populations have been absent for decades.

Because the 2017 SSA differs from the 2013 proposed rule in its assessment regarding threats to the wolverine, it is imperative that the reasons for the new and more informed assessment be made clear. That is done to a great and sufficient degree within the SSA, but every effort to express this reasoning in a clear and concise manner is warranted. It is our understanding that the shift has occurred consistently with the Service's joint policy on peer review, which states, "The

purpose of peer review is to ensure that our listing determination and critical habitat designation are based on *scientifically sound data, assumptions, and analyses*." (FR Vol. 78, No. 3. Page 7889). The newly available scientific information clearly demonstrates that peer-review and objective scrutiny from wildlife professionals was necessary, and that it functioned precisely as intended. Indeed, many of concerns raised in the peer-review process for the 2013 proposed rule have now been verified in the peer-reviewed scientific literature. We commend the Service for adhering to the appropriate process and ensuring that its decision was based on scientifically sound data, assumptions, and analysis.

Throughout the document, the early period of unregulated take of wildlife is simply referred to as "overhunting." Today, because most citizens do not hunt or trap, it is critical to draw the distinction between early historical periods when there were no rules or limits to the amount of wildlife that could be killed vs. modern, regulated, professional wildlife management that is required to be sustainable. Please make this distinction wherever possible within the SSA.

We also ask that the Service recognize in the SSA that Montana's wolverine management program has served for decades to conserve and manage the species sustainably. This is noted for some jurisdictions, e.g., Alaska, but omitted for Montana. We hold that there is sufficient evidence to note Montana's sustainable management also. Beginning in the 1970s, Montana has a long history of positive, progressive efforts to conserve wolverine that we would like to see fully described in Appendix G of the SSA. This includes a wolverine management strategy that was conceived at a multi-state, landscape scale and implemented nearly a decade ago, in 2008. Please see Attachment A and previous comments for relevant material.

More recently, and with help from other agencies and conservation organizations, a multi-state, landscape-scale conservation strategy for wolverines has been developed and initiated. These activities are officially sanctioned by the Western Association of Fish and Wildlife Agencies (WAFWA) and acted upon by WAFWA's Wildlife Chiefs' wolverine subcommittee. Current partners in this effort include multiple state wildlife agencies from the western U.S., USFWS, U.S. Forest Service, and National Park Service along with several tribes, universities, and non-governmental organizations. These ongoing activities, described in Attachments A and B, are very similar to the goals of the USFWS's 2013 Draft Recovery Outline (USFWS 2013, Page 8), and in some cases go above and beyond those goals. *As such, there is an active, funded, region-wide wolverine conservation program that contains most, if not all, and some additional components of any recovery plan that could be created.* We urge the USFWS to fully describe in the SSA the path to wolverine conservation in the western U.S. that has been building for many years. Consideration of this positive and progressive work on future conditions for the species is as important a component of an SSA as consideration of negatives such as potential threats and stressors.

We suggest that the Service consider adding a section to this and all SSAs that evaluates what conservation could be done to improve the situation for a given species. Doing so would provide

leadership by outlining progressive steps for the species, and it would help and encourage all parties interested in conservation to focus their resources on real-world, on-the-ground activities that make a difference.

FWP recognizes that wolverines are a Holarctic species adapted to cold, snowy conditions. And of course, at some point, as it would be for any species located primarily in the far north, it is possible for warming conditions to negatively influence distribution. However, this general supposition standing alone does not drive a listing determination under the ESA unless it is backed by sound science. At present it is unclear exactly how much cold or snow is necessary for wolverines to survive, and therefore impossible to predict with any degree of confidence an extinction within the foreseeable future. We note that a baseline survey has been undertaken (multi-state survey) and is set up to be repeated in a manner that can identify changes in population distribution over time, including reductions in distribution in relation to climate. We maintain that the science underpinning the proposed rule to list greatly exaggerates the potential threat to wolverines. Furthermore, as stated directly in the proposed rule, listing due to the threat of climate change will not result in regulation or alleviation of the proposed threat. In short, there is insufficient scientific basis for listing and listing would not address the threat identified.

Montana remains committed to managing wolverines in a conservative and responsive manner. While this species' natural situation warrants a relatively cautious approach, populations continue to expand and conservation efforts including population monitoring are underway. Therefore, once again, we assert that wolverines are not threatened with extinction in North America or the contiguous United States in the foreseeable future, and they do not meet the criteria for federal listing. As such the USFWS should withdraw its proposed rule to list wolverine as threatened under the Endangered Species Act.

Sincerely,

Martha Williams, Director

Attachments:
1) Technical Review
2) Attachment A - Wolverine Conservation in Montana and Collaborative Efforts Across the Western US.
3) Attachment B - Summary of Multi-State Wolverine Occupancy Survey

From:	Grizzle, Betty
To:	Shoemaker, Justin; John Guinotte
Subject:	Fwd: Nov 30 FWP Comments on Wolverine SSA
Date:	Friday, December 1, 2017 8:31:25 AM
Attachments:	Untitled attachment 29347.html Montana Technical Review of Wolverine SSA 11.22.17.docx Montana Attachment A Montana-Multistate Wolverine Management for SSA Comments 11.22.17.docx Untitled attachment 29350.html Montana Attachment B Wolverine Survey Summary for SSA Comments 11.22.17 Final MT.docx Untitled attachment 29353.html wolverine SSA signed cover letter.pdf Untitled attachment 29356.html

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From Montana.

---------- Forwarded message ----------
From: **Jodi Bush** <jodi_bush@fws.gov>
Date: Thu, Nov 30, 2017 at 4:13 PM
Subject: Fwd: Nov 30 FWP Comments on Wolverine SSA
To: betty_grizzle@fws.gov

FYI

Sent from my iPhone

Begin forwarded message:

> **From:** "Kujala, Quentin" <qkujala@mt.gov>
> **To:** Jodi Bush <jodi_bush@fws.gov>
> **Cc:** "Williams, Martha" <Martha.Williams@mt.gov>, "McDonald, Ken" <kmcdonald@mt.gov>, "Inman, Bob" <bobinman@mt.gov>, "Zipfel, Zachary" <ZZipfel@mt.gov>, "Vore, John" <jvore@mt.gov>, "Gude, Justin" <Jgude@mt.gov>
> **Subject: Nov 30 FWP Comments on Wolverine SSA**
>
> Jodi—
>
> On behalf of Director Williams, I am forwarding to you several documents representing comment from Montana Fish, Wildlife and Parks on the wolverine SSA. Included in the attachments are a cover letter signed by Director Williams, two separate attachments A & B, and a technical review.
>
> Please let me know if there are any questions or concerns I can address in this regard. And, as always, thank you for your significant efforts on this topic and all the others.

Regards,

Quentin Kujala

wildlife bureau coordinator

Montana Fish, Wildlife and Parks

qkujala@mt.gov

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

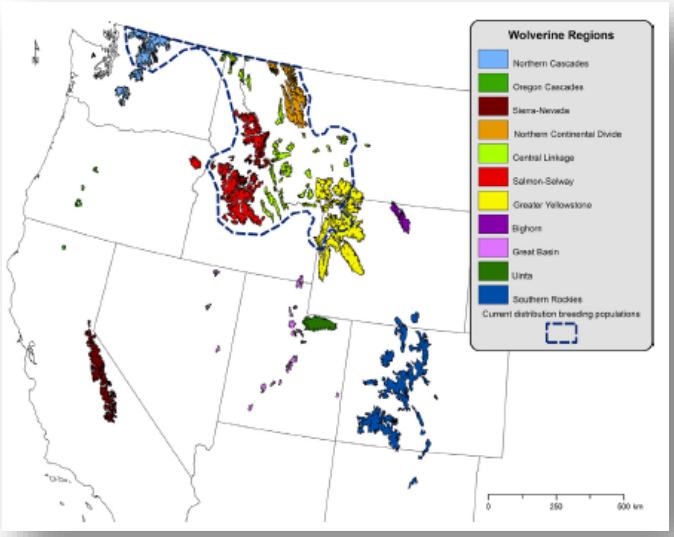
Technical Review of Wolverine SSA, November 2017.

These notes are based on page numbers in the pdf. In general, each comment below is accompanied by a yellow highlight on the pdf on the page noted and in order.

EXECUTIVE SUMMARY

iv The SSA notes the appropriate caveats related to this population estimate (density in one area extrapolated to predicted habitat). However, that is not apparent in the executive summary and it might be important to provide some context here for the use of the 2013 population estimate in general. This "estimate" was put forth as an initial hypothesis or "rough estimate" (in 2013 abstract) of capacity. It was based on a single density estimate extrapolated to many areas. The intent of the paper was to provide a conceptualization of scale and conservation needs for the wolverine population in the western US. In relation to population size, this essentially meant providing as logical as possible of a way of narrowing the range of possibilities from somewhere between 50 - 5,000 wolverines in the contiguous US, or a number based on someone's best guess. It was not intended to be an accurate point in time population estimate, given that densities will vary with regional conditions. Having noted that limitation of the "estimate," we believe this remains a useful tool and is still the best available hypothesis (or estimate) for distribution and abundance at this time. The recent 4-state occupancy survey adds some information to this hypothesis, but interpretation is limited to generalities such as:

- The Cascades of Washington MAY be occupied further to the south than the 2013 paper accounted for (+)
- Occupancy in the GYE was lower than other ecosystems during this winter's survey. This is the study area where density was measured and subsequently extrapolated to get the estimate across the western US. If habitat quality in GYE is lower than in the NCDE and SS ecosystems, this could have led to an underestimate in those areas. The NCDE estimate of 49 has always seemed low relative to other ecosystems given the high densities in Glacier NP and higher fecundity rates noted by Anderson and Aune (2008). (+)



- A rather large portion of the Salmon-Selway (north, St. Joe/Clearwater) had low occupancy during this winter's survey. This could be due to a misunderstanding of habitat (overprediction), demographic reasons (poor reproduction or survival there), or some factor related to the survey that we are unaware of at this point. If this piece of habitat was not occupied or not even habitat, that would lower the estimate in the SSE (-)

- Occupancy during the survey was low to none in Selkirks of north Idaho could mean lower numbers in the Central Linkage Ecosystem (-)
- Detections in more of GYE than included in current range of 2013 estimate (+)
- Recent detection in Wallowas of eastern Oregon again but not in current range for 2013 estimate (+)
- Recent detections in Uintas of Utah but not in current range for 2013 estimate (+)

It may also be important to note at the appropriate places in the SSA that wolverine conservation is likely better served by a focus on distribution within suitable habitat rather than an estimate of abundance.

At some appropriate place in the SSA it may also be important to note that despite the small population size, this is near what is believed to have been historically present and at or near the capacity in those areas where wolverines reside, i.e., it is unlikely that more wolverines could exist in these areas.

iv Please indicate that humans and wolverines generally select different habitats so that the impression of avoidance is not inferred from the general lack of overlap.

vi This sentence is a bit confusing. Believe what trying to say is that 40-50 years is as far out as there is any confidence in wildfire, climate, etc.. models that can be used – correct?

vi Please indicate that WAFWA, which includes the state agencies from all western states that have wolverine habitat and federal land and wildlife management agencies, through its Wolverine Subcommittee, is currently executing what could be considered a proactive recovery plan. Several landscape-level conservation priorities have been jointly identified for wolverines, and WAFWA is committed to implementing these priorities – Connectivity, Restorations, and Monitoring.

INTRODUCTION

4 Please specify as “unregulated” trapping instead of “over-trapping.” Please do this throughout the document. It is critically important to note the difference between the period of history when there were no rules, no concept of sustainable wildlife management, and a mindset focused on eliminating predators vs. modern, professional wildlife conservation and management.

4 What is this estimate of 37% range loss (historic vs. current) based on? There was no reliable estimate of wolverine historical distribution (range) available during 2004 (date of paper referenced).

SPECIES DESCRIPTION

7 Thank you for reviewing the situation that has led to 2 sub-species being designated. This is a topic that wolverine experts cannot readily identify any cause for such separation. It sounds like further investigation is warranted.

12 Thank you for this very thorough delve into physiology.

RANGE AND HABITAT USE

12 Thank you for completing a very thorough review of phylogeogrpahy/phylogeneitcs.

14 Please note “unregulated” hunting and trapping here too.

15/17 Fig. 3. Why are there small areas that are separated (islands) such as the Little Belt Mountains of Montana and the Uintas of Utah when other areas such as central Oregon are continuous. This does not seem to be consistent in approach. Belts and Uintas area more well-connected than Oregon Cascades through central Oregon.

15/17 Fig. 3. Why are Colorado and California depicted as current range? One male?

15 Is it more appropriate to describe this as – “even before widespread and *unregulated Anglo*” trapping and hunting. To indicate that trapping and hunting by native Americans probably did occur and to again note the unregulated aspect.

REPRODUCTION & GROWTH

24 Since various types of dens are used, should that be noted here in this chart? It is in the text below.

26 There are good data from Sweden via GPS collared females on how much time they spend in dens without coming out. I see below that this info is in the doc (p 27). Add here?

DENNING HABITAT

30 Thank you for recognizing that the “obligate” relationship has been ***assumed***.

32 6-7, meaning 6 or 7 out of 7?

30-32 This section identifies some of the flaws of the 2010 paper, but there are several important shortcomings that are not identified. Other previously submitted documents list these flaws.

33 The paragraph describing the results of the Webb et al study does not seem to fully emphasize the degree to which the study showed the 2010 snow model to be inaccurate. This section could be strengthened by considering and incorporating the full findings. From Webb et al – “Further, all female wolverines (n=8) positively identified from camera traps in the Boreal Forest, including 5 lactating females, were located within townships predicted to have no spring snow cover.” This is a clear failure of the model and a clear example of why it cannot reliably be used to predict distribution now or in the future.

33 We were not aware of the total number of dens located outside of the 2010 snow model being so large. For many reasons this model and further examinations based on it must be interpreted with extreme caution if at all.

33 Thank you for recognizing the importance of this 2017 study that shows clearly that snow for dens is not a limiting factor for wolverine distribution even under climate change scenarios.

35 use - (*more northerly*) latitudes.

DEMOGRAPHY

36 The swedes have tracked individual females to about 14-15 years of age (known age via capture at birth). I believe this female was still reproducing at that age.

MORTALITY

37 The Swedes have also observed at least one case of what seemed to be a deliberate attempt by a male to search out and kill juveniles at dens. I believe they saw a male travel to two different dens and kill young within a very short period of time. I have wondered whether the movement from natal den to maternal dens and around within maternal dens is related to hiding the young via a "shuffle game" that makes it harder for an unrelated male to find and kill the young. Something to consider in relation to assumptions of movement of dens by human disturbance.

37 Bears too, seemingly at places like a carcass where competing for food. We had 2 of these in 2007 report.

DIET AND FEEDING

38 Predation of neonatal or young ungulates may be a very significant portion of the diet. This has not been studied very frequently (summer), but anecdotally, it is observed frequently enough to have every suspicion that it is of significance to wolverines. Suggest pulling this into its own paragraph.

40 Other studies have even found wolverines caching in peat bogs, where the acidity helps preserve meat I believe. Can't remember the citation though…

41 the entire winter? Or what amount of time? Ungulates can be very different sizes, eg moose vs deer.

41 Says taken together, but then limits dates to March April. Was that intended or March – August?

POPULATION STRUCTURE

41 Population Structure is often used to describe a genetic situation. The first 3 paragraphs do not address genetic structure directly. Rather they seem to be describing the overall pattern of habitat and what is connected or not in a way that begins to explain what would be expected genetically based on habitat. Perhaps it would help the reader to identify this with a sub heading or something referring to the intent here?

GENETICS

42 Thank you for pointing out the need to look beyond just MtDNA.

42 Not clear on why it is difficult to distinguish between long distance dispersal and fragmentation due to extensive dispersal movement of both sexes? Can you clarify?

42 mitochondria – I missing the L?

42 please use “during a period of unregulated hunting and trapping” to differentiate that from modern, limited, regulated hunting/trapping.

43 Assumed correctly or incorrectly?

43 Can you please clarify the significance of “*when compared to*”?

SUMMARY

45 Suggest move eg Magoun 2017 to be after “our proposed 2013 rule.

46 What we presently perceive as “Remote” may simply be a result of wolverines selecting different habitats than humans. I am not sure they are inherently bothered by human presence. Of course, more roads may mean lower survival for various reasons, but not sure that presence of a human or group of humans within sight of a wolverine is of any consequence to a wolverine. Mentioning so that the SSA does not unintentionally suggest a clear need for avoidance of humans due to an inherent “fear” of humans by wolverines.

BIOLOGICAL STATUS – CURRENT CONDITION

46 Please note here or at an appropriate section the following - Given that you have thoroughly documented the past climate changes that have been occurring up to present day (including the accelerated warming in the more recent decades), please include a discussion about how this relates to what has been seen in wolverine populations and distribution over that time. i.e., tie this together with the point that wolverines are doing well and expanding to the best of our knowledge. Maybe the expanding distribution is because the warming climate has not limited habitat enough to have an effect (i.e., wolverines are not saturated throughout available habitat, so the ever-more-limited habitat has not had negative effects yet). But it is also distinctly possible that wolverine populations have coped with the warming to date just fine.

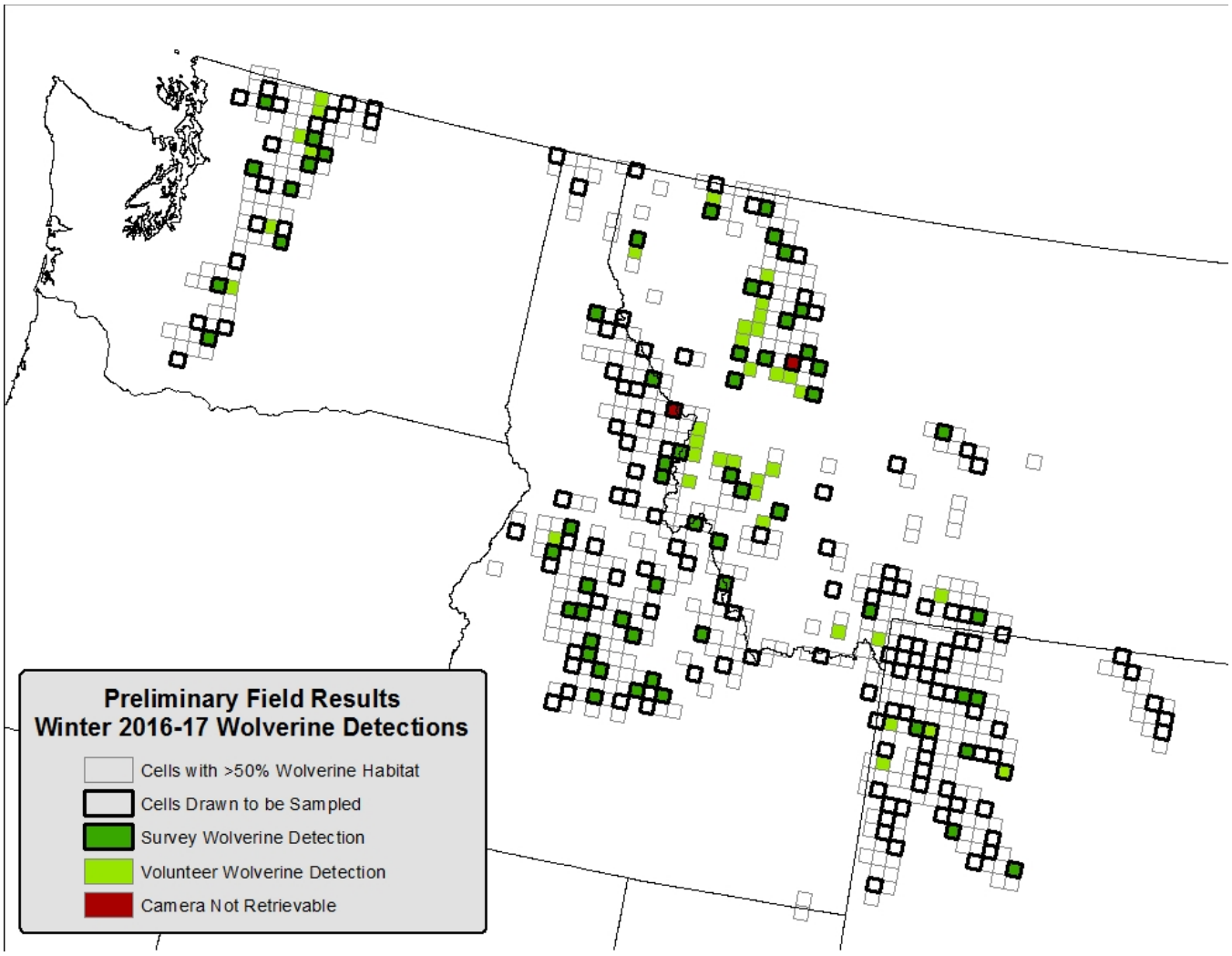
47 Need to go back to look at this after talking with Jake Ivan of Colorado, who ran the data analysis, to make sure this means an estimate of 63% of the surveyed cells were likely occupied.

47 Please include the information in the next few paragraphs in the executive summary to note the significant ongoing wolverine conservation work.

47 Bjornlie et al - The final version of the protocol that was used was “Version 3.2 Sept.30, 2016.” Can get you the specific protocol and a copy of the funding proposal to reference if that is helpful?

48 185

48 We have updated results. Map below. The survey detected wolverines in 59 cells (22,641 detections). Volunteers detected wolverines in another 36 cells, total 95. WA had 9 survey cells and another 6 volunteer cells. ID had 21 survey cells and 1 volunteer. Montana had 23 survey cells and 25 volunteer. WY had 6 survey and 4 volunteer. A summary of the survey is included as an attachment.



48 How did Heinemeyer determine that subpopulations are unstable with low rates of recruitment? A lack of capture success in their research activities? An alternative explanation could be ineffective capture site placement and/or effort. Thank you for following up and determining that others have in fact found evidence of wolverines in the areas Heinemeyer et al have suggested are currently devoid.

49 2013-2014? Also, does N/A indicate no data available?

49 Can you quickly indicate here where the boundary between western and eastern Canada is? (looks like Quebec and Labrador as per below, maybe move up?)

50 The relatively rigorous estimates from BC, i.e. Lofroth and Krebs 2007, need to be presented.

51 Please check the amount of area surveyed (1.5 million acres?) where the 22 individuals were found. I don't believe the SWCC group surveyed that entire area for wolverine, as I understand it, they have done a great job of surveying southwestern fringe of this very large area.

51 Does the COSEWIC document present data or information that is reliable to suggest that three should be some concern for populations in the northern US? Is this concern justified?

STRESSORS – CAUSES AND EFFECTS

52 Is the COSEWIC p. 21 info justified? How have recreational users been shown to influence mortality (or reproduction)?

52 May need to be careful here that these are not the same road mortalities. Brent Brock, a coauthor on Kociolek, and I worked closely together for several years. I suspect the 2 mortalities in that report are the same 2 we documented during our telemetry study. However these are different than the 2 that I found and reported to USFWS recently, so this tally appears correct.

53 Because of the large range of coverage north to south, would it be more appropriate to use latitude adjusted elevation? Does not appear to have been used given the small patches in the north in Appendix E.

55 Several wolverines have been captured for research on or near active ski hills, for instance in the Tetons. While overall use level is not known to increase or decrease, ski hills are not an absolute non-use area.

56 denning season?

56 Appendix G

56 Note on Appendix G, Montana section – Montana has not developed a specific wolverine strategy similar to that of Idaho's. However, Montana has focused efforts since 2007 on landscape scale collaborative wolverine conservation with other agencies. Please note these efforts in the SSA. This began in 2008 with a shift in harvest units and quotas that emphasized protection in smaller mountain ranges (closing 40% of the state to harvest) and protection of places where reproduction occurs in-between large ecosystems so that dispersal and genetic exchange would occur more readily. It also included a Montana Fish and Wildlife Commission ruling that will allow harvest quota to be used to live-trap and translocate wolverines to areas of historical distribution that are not currently occupied. Since that time, Montana has also been instrumental in developing the WAFWA collaborative work focused on Connectivity, Restorations, and Monitoring that are currently occurring.

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC, or EDUCATIONAL PURPOSES

60 Please note that wolverine harvest in Montana occurred in a sustainable manner. Please refer to the 2008 landscape-scale harvest management strategy and quotas that had been reduced to half their historic and sustainable levels.

60 Montana adopted mandatory trapper education in Aug 2017. The course, which will begin in 2018, will emphasize avoidance of incidental captures and modern equipment that minimizes injury.

61 Evidence for additive mortality from trapping in Krebs et al 2004 is extremely weak at best. Please see discussion in peer review of 2013 Proposed Rule by Inman, pages 8-11.

62 Please consider including a discussion of the effects, or lack thereof, of trapping wolverines in Montana at the rates that occurred during recovery from historical lows and for ~40 years along with the quotas and spatial management that was in place when take of wolverine was eliminated by a court case. Survey results from the winter 2016-17 multi-state survey suggest occupancy is higher in MT than in states that have not allowed wolverine trapping for 50 years. There is no evidence to suggest the harvest of wolverines in Montana at historical rates (~10/year) was detrimental to the population. And, since 2008, with rates and spatial arrangement of harvest significantly more conservative than those apparently sustainable historical rates, there is no reason to believe harvest at those levels is detrimental to the population. Please incorporate the information on wolverine management in Montana that was in MFWP's response to the Oct 2016 request for information – pages 15-17 – beginning with the "Early management in Montana…" title in FWP's Nov. 2016 letter. This is important information to have in the discussion.

62 Again, what basis does COSEWIC have to accurately suggest some concern for populations in the northern US?

62 Lofroth and Ott 2007 paper may be informative here too.

62 Please indicate that naturally uncommon species like wolverine can incur some level of human mortality and still remain viable.

LEGAL STATUS / PROTECTION

64 Same process in Montana. Aware of 1 handling related mortality.

64 Montana's wolverine management has clearly been sustainable. Please add Montana to the list of places where trapping has been sustainable.

SUMMARY OF CURRENT CONDITIONS

65 Please add word unregulated – from intensive and unregulated…

65 Is this suggesting that they are being detected in CO and CA? Bulk of evidence suggests absence in those states for decades and no indication of a population there now.

65 Please indicate that harvest levels in Montana have been sustainable.

65 Montana is implementing mandatory trapper education also.

STATUS – FUTURE CONDITIONS

66 Please make sure to convey the level of certainty, or lack thereof, related to long term forecasting of climate affects.

72 Thank you for recognizing the potential for wolverines to adapt to some degree.

76 Ray et al 2017 focuses on May 15. While it is understandable to do so to compare with McKelvey et al 2011 to show the limitations of that analysis, it is very important to make explicitly clear that May 15 is not a date of great significance, that there is no known significance for the presence or lack of snow on May 15, and that even if snow presence on May 15 were thought to be critical the issue of how much snow – how deep, how much coverage, how far apart… - is completely unknown. The point being that May 15 is not a date of meaningful biological significance for wolverines and it is important that that widely held narrative is not furthered.

78 Please give the meaning of SCA here again.

80 The analysis shows that wolverines would not have to move far or at all to get to snow for dens under any scenario. Thank you for recognizing that the one-dimensional perspective on the availability of snow that was presented by Copeland et al. 2010 and used by McKelvey et al 2011 was overly simplistic and inappropriate.

82 Is the y-axis correct for ROMO in Fig 7? Seems odd that 0% change occurs at 2000 m elevation that far south relative to 0% change occurring closer to 3500 m elevation in GLAC.

89 Does this summary paragraph need to include a description of how this is expected to influence wolverines? As noted earlier, fire is not necessarily bad for wolverines. They are not limited to forested areas, and earlier stages of succession might even increase prey availability.

89 The cumulative effects section seems very limited. Winter recreation and climate only. It could be argued that winter rec will intensify in wolverine habitat during the shorter rec season which would also occur in a smaller area. Trapping? Genetics?... Do these things need to be directly addressed?

SUMMARY OF FUTURE CONDITIONS

90 last paragraph. If not here, earlier, please make sure to include a complete and convincing list of the flaws in the 2010 and 2011 papers given the belief by many that these are scientifically accurate and critical evidence. For instance, in the 2010 paper, wolverines selected against areas with 1-3 out of 7 years of May 15 snow, however, in the 2011 paper, the analysis included loss of snow from all areas, including 1-3/7 years areas that were selected against. This exaggerated the potential affect. Please also note the major scientific methodological errors of data dredging and assigning a cause to an observed effect. Please note the use of May 15 as a biologically inappropriate date for examining den use (Feb-Mar) which also exaggerated the purported effect.

OVERALL ASSESSMENT

91 Genetic work and early observations also suggests movement from BC/AB to Montana, especially at the early stages of recovery (Cegelski, Newby Wright 1955, Newby McDougal 1964).

92 Please recognize that trapping in Montana has every appearance of having been sustainable, and no evidence to the contrary.

93 Please use the word “unregulated”

93 across its (historical) range? What about CO and CA?

93 This may not hold up given no populations or females in CO and CA.

95 foreseeable future?

95 Is genetics addressed well enough in the Overall Assessment section?

APPENDIX B

131 Updated maps available.

APPENDIX G

143 Here or somewhere in this appendix and elsewhere it is imperative to include a full description of the proactive efforts by WAFWA, including collaboration by states, federal agencies and tribes, in relation to those wolverine conservation priorities that can be achieved – Connectivity, Restorations, Monitoring.

145 There are very strong and important regulatory mechanisms in place related to harvest. As shown below as part of the history of MCA 87-1-201 (highlighted), these regulatory mechanisms have been in place for nearly 100 years (1921). The 2017 furbearer regulations are 16 pages long and provide an extensive list of rules and regulations related to wolverines and all classified furbearers. These regulatory mechanisms, and numerous other state statutes, are primary regulatory tools of the Department, and harvest is far more regulated than things like housing development impacts, road impacts, and climate impacts. Please emphasize the degree to which harvest is and has been subject to regulation for decades. In Montana, regulations related to all furbearers are reviewed on an annual basis and must be approved by the Fish and Wildlife Commission.

Related material:

Regulations protecting Montana’s wildlife are found in both state statute and in rules and regulations promulgated by the Montana Fish and Wildlife Commission. FWP, acting through the commission, is the public trust steward of the state’s wildlife, including wolverines. Its powers and duties to discharge this public trust are codified in law (MCA 87-1-201, attached) and its commitment to its stewardship responsibilities is found in a number of places including both its mission statement and strategic plan:

> Mission Statement: *Montana Fish, Wildlife & Parks, through its employees and citizen Commission, provides for the stewardship of the fish, wildlife, parks and recreational resources of Montana while contributing to the quality of life for present and future generations. (Montana Fish, Wildlife & Parks. 2008 P 1. and 2015a p 4)*
>
> Strategic Plan: *Montana Fish, Wildlife & Parks will provide the leadership necessary to create a commitment in the hearts and minds of people to ensure that, in our second century, and in partnership with many others, we will sustain our diverse fish, wildlife and parks resources and the quality*

recreational opportunities that are essential to a high quality of life for Montanans and our guests (Montana Fish, Wildlife & Parks 2008, P 1).

Montana's 2015 Vision and Guide 2016-2026 also speaks to FWP using the best information available in natural resource management when it mentions that one of the eight core values guiding the department is to, "Use Science. We use the best biological and social sciences to inform and make management decisions." (Montana Fish, Wildlife & Parks. 2015a p 4.)

Trapping – Furbearer trapping in Montana is highly regulated with season dates and harvest limits set by the Fish and Wildlife Commission. In addition to protections for wolverines in the various laws in state statute Title 87, specific regulations governing their legal harvest are found in FWP's Furbearer and Trapping Regulations (attached).

Montana State Statute

87-1-201. Powers and duties. (1) Except as provided in subsection (11), the department shall supervise all the wildlife, fish, game, game and nongame birds, waterfowl, and the game and fur-bearing animals of the state and may implement voluntary programs that encourage hunting access on private lands and that promote harmonious relations between landowners and the hunting public. The department possesses all powers necessary to fulfill the duties prescribed by law and to bring actions in the proper courts of this state for the enforcement of the fish and game laws and the rules adopted by the department.

(2) Except as provided in subsection (11), the department shall enforce all the laws of the state regarding the protection, preservation, management, and propagation of fish, game, fur-bearing animals, and game and nongame birds within the state.

(3) The department has the exclusive power to spend for the protection, preservation, management, and propagation of fish, game, fur-bearing animals, and game and nongame birds all state funds collected or acquired for that purpose, whether arising from state appropriation, licenses, fines, gifts, or otherwise. Money collected or received from the sale of hunting and fishing licenses or permits, from the sale of seized game or hides, from fines or damages collected for violations of the fish and game laws, or from appropriations or received by the department from any other sources is under the control of the department and is available for appropriation to the department.

(4) The department may discharge any appointee or employee of the department for cause at any time.

(5) The department may dispose of all property owned by the state used for the protection, preservation, management, and propagation of fish, game, fur-bearing animals, and game and nongame birds that is of no further value or use to the state and shall turn over the proceeds from the sale to the state treasurer to be credited to the fish and game account in the state special revenue fund.

(6) The department may not issue permits to carry firearms within this state to anyone except regularly appointed officers or wardens.

(7) Except as provided in subsection (11), the department is authorized to make, promulgate, and enforce reasonable rules and regulations not inconsistent with the provisions of Title 87, chapter 2, that in its judgment will accomplish the purpose of chapter 2.

(8) The department is authorized to promulgate rules relative to tagging, possession, or transportation of bear within or outside of the state.

(9) (a) The department shall implement programs that:

(i) manage wildlife, fish, game, and nongame animals in a manner that prevents the need for listing under 87-5-107 or under the federal Endangered Species Act, 16 U.S.C. 1531, et seq.;

(ii) manage listed species, sensitive species, or a species that is a potential candidate for listing under 87-5-107 or under the federal Endangered Species Act, 16 U.S.C. 1531, et seq., in a manner that assists in the maintenance or recovery of those species;

(iii) manage elk, deer, and antelope populations based on habitat estimates determined as provided in 87-1-322 and maintain elk, deer, and antelope population numbers at or below population estimates as provided in 87-1-323. In implementing an elk management plan, the department shall, as necessary to achieve harvest and population objectives, request that land management agencies open public lands and public roads to public access during the big game hunting season.

(iv) in accordance with the forest management plan required by 87-1-622, address fire mitigation, pine beetle infestation, and wildlife habitat enhancement giving priority to forested lands in excess of 50 contiguous acres in any state park, fishing access site, or wildlife management area under the department's jurisdiction.

(b) In maintaining or recovering a listed species, a sensitive species, or a species that is a potential candidate for listing, the department shall seek, to the fullest extent possible, to balance maintenance or recovery of those species with the social and economic impacts of species maintenance or recovery.

(c) Any management plan developed by the department pursuant to this subsection (9) is subject to the requirements of Title 75, chapter 1, part 1.

(d) This subsection (9) does not affect the ownership or possession, as authorized under law, of a privately held listed species, a sensitive species, or a species that is a potential candidate for listing.

(10) The department shall publish an annual game count, estimating to the department's best ability the numbers of each species of game animal, as defined in 87-2-101, in the hunting districts and administrative regions of the state. In preparing the publication, the department may incorporate field observations, hunter reporting statistics, or any other suitable method of determining game numbers. The publication must include an explanation of the basis used in determining the game count.

(11) The department may not regulate the use or possession of firearms, firearm accessories, or ammunition, including the chemical elements of ammunition used for hunting. This does not prevent:

(a) the restriction of certain hunting seasons to the use of specified hunting arms, such as the establishment of special archery seasons;

(b) for human safety, the restriction of certain areas to the use of only specified hunting arms, including bows and arrows, traditional handguns, and muzzleloading rifles;

(c) the restriction of the use of shotguns for the hunting of deer and elk pursuant to 87-6-401(1)(f);

(d) the regulation of migratory game bird hunting pursuant to 87-3-403; or

(e) the restriction of the use of rifles for bird hunting pursuant to 87-6-401(1)(g) or (1)(h).

History: Ap. p. Sec. 4, Ch. 193, L. 1921; re-en. Sec. 3653, R.C.M. 1921; amd. Sec. 2, Ch. 77, L. 1923; amd. Sec. 2, Ch. 192, L. 1925; amd. Sec. 1, Ch. 200, L. 1935; re-en. Sec. 3653, R.C.M. 1935; amd. Sec. 1, Ch. 157, L. 1941; amd. Sec. 1, Ch. 40, L. 1951; amd. Sec. 1, Ch. 157, L. 1955; amd. Sec. 1, Ch. 151, L. 1957; amd. Sec. 1, Ch. 36, L. 1959; amd. Sec. 1, Ch. 96, L. 1959; amd. Sec. 1, Ch. 173, L. 1965; amd. Sec. 1, Ch. 344, L. 1969; amd. Sec. 1, Ch. 279, L. 1971; amd. Sec. 1, Ch. 364, L. 1973; amd. Sec. 3, Ch. 511, L. 1973; amd. Sec. 13, Ch. 417, L. 1977; Sec. 26-104, R.C.M. 1947; Ap. p. Sec. 4, Ch. 267, L. 1955; amd. Sec. 13, Ch. 417, L. 1977; Sec. 26-202.4, R.C.M. 1947; Ap. p. Sec. 1, Ch. 239, L. 1965; amd. Sec. 2, Ch. 319, L. 1967; amd. Sec. 4, Ch. 9, L. 1977; amd. Sec. 13, Ch. 417, L. 1977; Sec. 26-202.5, R.C.M. 1947; R.C.M. 1947, 26-104, 26-202.4, 26-202.5(2); amd. Sec. 2, Ch. 44, L. 1979; amd. Sec. 1, Ch. 277, L. 1983; amd. Sec. 4, Ch. 459, L. 1995; amd. Sec. 1, Ch. 369, L. 1999; amd. Sec. 1, Ch. 454, L. 2003; amd. Sec. 1, Ch. 461, L. 2003; amd. Sec. 6, Ch. 553, L. 2003; amd. Sec. 1, Ch. 262, L. 2007; amd. Sec. 17, Ch. 10, L. 2009; amd. Sec. 2, Ch. 330, L. 2009; amd. Sec. 1, Ch. 370, L. 2011; amd. Sec. 2, Ch. 395, L. 2011.

Attachment A

Wolverine Conservation in Montana

and Collaborative Efforts Across the Western U.S.

Early Management in Montana Resulted in Range Reoccupation and Important Population Data

The vast majority of information available on wolverines in the contiguous U.S. from the early 1900s through 2000 comes from Montana. Montana Furbearer Biologist Fletcher Newby collected data that provided some of the earliest documentation on wolverine recovery from historical lows as the species returned into the contiguous U.S. (Newby and Wright 1955, Newby and McDougal 1964). Montana's Furbearer Biologist Howard Hash was instrumental in initiating and carrying out the first radio-telemetry study of wolverines anywhere, which occurred in northwest Montana (Hornocker and Hash 1981).

Despite wolverine recovery and expansion across western Montana occurring during an era when there were no limitations on killing wolverines, FWP gave the wolverine status as a furbearer during 1978. Although this change from an unregulated predator to a classified furbearer has been portrayed by some (see Chadwick 2010, Page 120) as an aggressive and insensitive management approach, the Department was in fact taking a step toward a more conservative approach because furbearer status allowed the department to establish a limited time during which a wolverine could be taken along with individual limits to the number that could be taken.

While critics argue that allowing any take of wolverines at that time was unwarranted, it is important to consider the fact that the allowed take was a move toward more conservative management and was accompanied by a requirement to provide FWP with several types of data that were the only data available on wolverines for several decades. These data included harvest locations that were critical for understanding historical patterns of distribution (Aubry et al. 2007); genetic samples critical for understanding recovery patterns and current population structure (Cegelski et al. 2006, Schwartz et al. 2009), and reproductive data critical for understanding the species biology at the edge of its range and differences within Montana (Anderson and Aune 2008). These harvest-based samples were also critical pieces used to investigate effective population size (Schwartz et al. 2009) and habitat relationships (Aubry et al. 2007, Schwartz et al. 2009, Copeland et al. 2010, Inman et al. 2013). Comparable data do not exist from other states that did not allow any wolverine harvest. Data derived from a limited season on wolverine were also used annually by the Department to assess the impacts of harvest through sex ratios, age-structure of the population, and distribution of harvest across the state.

Wolverines recovered from historical lows at the turn of the century to their former range within Montana during a 40-year period when there was little to no regulation on take whatsoever (~1930-1970). Since that time, regulations have been more conservative, and wolverines continue to occupy those areas in Montana that have suitable habitat.

Initiation of Landscape-level Management in Montana Nearly a Decade Ago

FWP has a long history of responding to newly available information on wolverines to adjust its management accordingly, whether from data collected during mandatory check-in, from research derived from these samples, or from telemetry studies. In recent years, this included a deliberate attempt to manage wolverines at a multi-state, landscape scale.

The importance of doing so became apparent when the first GPS collar put on a wolverine revealed an amazing capacity for dispersal, and other data on large home range size, extensive movements, territoriality, and naturally low densities became available. In response, Montana made significant changes to its management strategy (MFWP 2008). These changes included eliminating wolverine harvest within approximately 40% of wolverine habitat within the state, i.e., from within the Central Insular Management Unit (Fig. 2, WMU 4). This CIMU contains the smaller island mountain ranges of the state where local population capacities would be lower, and it is situated between the largest blocks of wolverine habitat. This management change was undertaken as a more conservative approach toward more successful reproduction within the CIMU, and more successful dispersal and genetic interchange among the large blocks of habitat. Notably, these large blocks of habitat extended into neighboring states and provinces – the Greater Yellowstone Ecosystem, the Salmon-Selway Ecosystem, and the Northern Continental Divide Ecosystem. At the same time, wolverine quotas were reduced to less than half of what they had been for the last 30+ years despite no indications that previous management had deleterious effects on wolverines in Montana. Thus during 2008 Montana began implementing a conservative, multi-state, landscape-level approach to wolverine management.

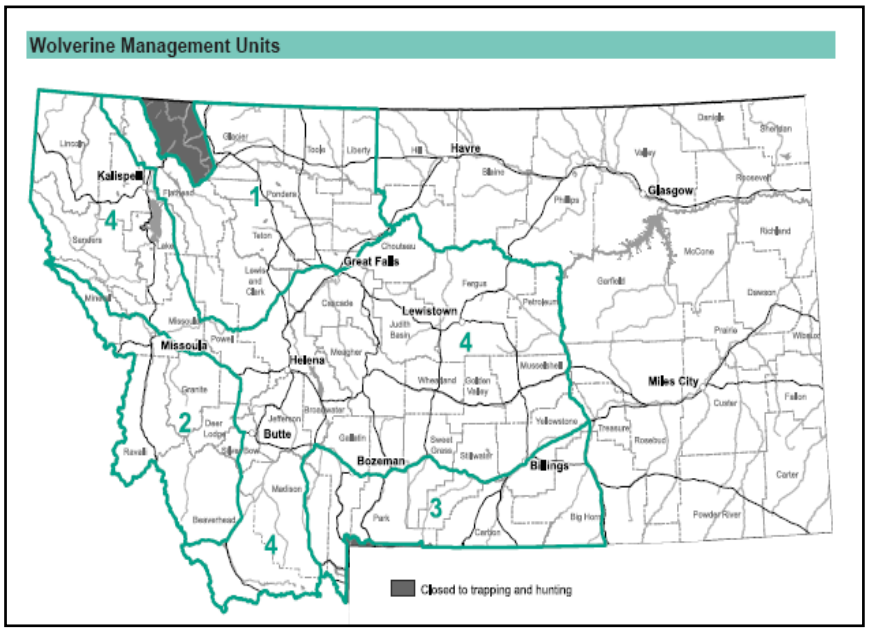


Figure 2. Wolverine Management Units in Montana, 2008. WMU 4, The Central Insular Mountains, was closed to wolverine harvest to protect sub-populations in smaller mountain ranges and to facilitate landscape-level gene flow among the major ecosystems of the northern U.S. Rockies.

The Western States Wolverine Conservation Program

By 2009 it had become apparent that significant amounts of wolverine habitat that had been historically occupied remained unoccupied at present and could be of significant conservation benefit to the species in the contiguous U.S. The largest areas were in Colorado and California. The 2008 photograph of a

wolverine in California was the first record in that state in nearly a century (Moriarty et al. 2009). And the documented dispersal of a male wolverine to Colorado, which was the first verified record of the species in that state in nearly a century (Inman et al. 2009), provided further impetus for a collaborative, multi-state, landscape-scale approach to wolverine conservation in the contiguous U.S. Montana FWP responded with an official Fish and Wildlife Commission action that would allow Montana's harvest quota (max of 5 at that time) to be used for live-capture of wolverines for transplant efforts into unoccupied historical range. This was the second step Montana made toward a collaborative landscape-scale approach to wolverine management.

After four multi-agency wolverine workshops (2007-2012) focused on identifying and implementing collaborative multi-state strategies for conserving wolverines, a formal publication including coauthors from four state wildlife agencies, the USFS, NPS, USFWS and two NGOs outlined wolverine conservation priorities at the multi-state scale (Inman et al. 2013). Population-level priorities included 1) Connectivity, 2) Restorations, and 3) Monitoring. These recommendations formed the basis for much of the USFWS's Draft Recovery Outline (2013). With priorities identified, WAFWA formed a Wolverine Subcommittee, and the Western States Wolverine Working Group met in February 2015 to identify agreed upon conservation priorities for wolverines and to commit personnel and develop funding to actively initiate the program. A brief summary of the collaborative project that was identified is provided here and is available in its entirety (Western Association of Fish and Wildlife Agencies 2015, Western States Wolverine Working Group 2016).

In the 2013 Draft Recovery Outline, the USFWS states, "Because we are unable to address the primary threat of climate change directly, wolverine recovery will be a matter of ensuring that the DPS is resilient to the changes that we expect to occur." ***We emphasize here that those efforts are well underway***.

Brief Project Summary:
The southernmost extant population of wolverines in North America occurs in small, semi-isolated subpopulations in the Rocky Mountains of Montana, Idaho, and northwest Wyoming; the north Cascade Range of Washington; and the Wallowa Mountains of Oregon. Maintaining wolverine distribution in suitable habitat and connectivity at the metapopulation, multi-state scale are critical for ensuring wolverine persistence over the long term. Montana, Wyoming, Idaho, and Washington have initiated a collaborative multi-state monitoring effort that is intended to advance wolverine conservation across the species range within the contiguous United States. This project includes maintaining landscape connectivity among occupied wolverine habitats, assessing the feasibility to assist with expansion of wolverine distribution with translocation, developing and implementing a collaborative multi-state monitoring plan to provide baseline information on distribution, genetic characteristics, and factors influencing the presence of wolverines. The project will also engage key partners at multiple levels to prioritize habitat conservation, population connectivity, and management activities. The project addresses needs identified as priority actions in State Wildlife Action Plans (SWAPs) from all four states.

Overall Goal:
Advance wolverine conservation across the northwestern U.S.

Primary Objectives:
1. *Maintain landscape connectivity among occupied, core wolverine habitats of the northern U.S. Rockies and north Cascades.*
2. *Develop and implement a collaborative multi-state monitoring plan to assess distribution, occupancy, and genetic characteristics of the metapopulation.*
3. *Develop policies that address the socio-political needs for assisting wolverine population expansion with translocation and establish protocols for testing wolverine translocation methods.*
4. *Engage key partners at multiple levels to prioritize habitat conservation, population connectivity, and management activities.*

Four collaborative projects, which represent sequential and parallel actions at the metapopulation scale, will be implemented to achieve these objectives:
Project 1: Model connectivity to focus and prioritize habitat conservation delivery.
Project 2: Further the translocation of wolverines as a conservation tool.
Project 3: Develop a coordinated multi-state monitoring strategy.
Project 4: Define current baseline distribution and genetics of wolverine across WA, ID, MT, and WY

Funding:
At present, over $1.5 Million has been committed to implementation of the above goal and objectives. Funding from partners includes:

National Fish and Wildlife Foundation	*$385,000*
Wyoming Game and Fish	*$337,000*
U.S. Fish and Wildlife Service	
Competitive SWG	*$200,000*
GNLCC	*$150,000*
Montana Fish Wildlife and Parks	*$160,000*
Idaho Fish and Game	*$81,000*
National Park Service	*$72,000*
Washington Fish and Wildlife	*$60,000*
Montana State University	*$50,000*
U.S. Forest Service	*$35,000*
The Wolverine Initiative	*$10,000*
Total	***$1,540,000***

Project Activities & Outcomes:

The project, "Wolverine Metapopulation Monitoring and Connectivity in the U.S. Rocky Mountains and North Cascades," has made significant progress toward implementation and all three wolverine conservation goals: 1) Monitoring, 2) Connectivity, and 3) Restorations.

Activity 1. Define baseline wolverine distribution and genetics across MT, ID, WY, and WA.

Action 1.1: Implement multi-state monitoring in WY during winter 2015/16 and MT, ID, WA during winter 2016/17 to establish baseline metrics. This activity will allow us to quantify baseline distribution of wolverines across the four-state area with a snapshot in-time approach using non-invasive genetic and photo collection techniques at baited camera stations. It is also designed to be compatible with future efforts to assess changes in occupancy and genetics over time.

Action 1.2: Utilize survey results to identify areas where wolverine translocation can improve occupancy of suitable habitats, total population size, and genetic diversity.

Action 1.3: Assess and revise monitoring design.

Activity 2. Model Connectivity to Focus and Prioritize Habitat Conservation Delivery

Action 2.1: Develop ecological and human land-use forecasts. Our overall approach for projecting land use change into the future across the study area involves quantifying past change, testing hypotheses on drivers, using the results to update a land use change simulation model, and projecting change under various future scenarios with the model.

Action 2.2: Model wolverine habitat at 2015, 2030, and 2050.

Action 2.3: Prioritize areas from connectivity conservation.

Action 2.4: Deliver GIS layers of priority connectivity areas to land trusts and agencies.

Action 2.5: Develop wolverine-friendly transportation plans.

Activity 3. Further the Translocation of Wolverines as a Conservation Tool

Action 3.1: Explore options to establish regulatory certainty for states that reintroduce wolverine.

Action 3.2: Develop a project-specific study plan for translocation in the Rocky Mountains. This activity is targeted for summer 2017 after the distribution-wide survey effort.

Progress Update:

Activity 1. Define baseline wolverine distribution and genetics across MT, ID, WY, and WA.

Project partners communicated within and among agencies to gain cooperation and give ownership to local field offices and personnel who will be directly or indirectly involved in the survey. Numerous meetings were held to discuss logistics of the upcoming surveys and insure local awareness. The USFS completed its minimum tools analysis for use of remote cameras in designated wilderness areas. The major field effort of the baseline distribution and genetics survey using camera and DNA stations across the 4-state area was completed safely and successfully during the winter of 2016-17. ***A summary of preliminary results is presented in Attachment B****. This collaborative effort occurring at the landscape scale was recognized by the Western Association of Fish and Wildlife Agencies with a Special Recognition Award at WAFWA's summer 2017 conference.*

Activity 2. Model Connectivity to Focus and Prioritize Habitat Conservation Delivery

Kathleen Carroll was hired in 2016 as the PhD student in Dr. Hansen's lab at Montana State University who will lead this analysis. An analytical design team has been put together and includes Justin Gude and Dr. Robert Inman of Montana Fish Wildlife and Parks, Dr. Scott Bergen of Idaho Fish and Game, Dr. Mike Schwartz and Dr. John Squires of the USFS Rocky Mountain Research Station, Dr. and Paul Lukacs of the University of Montana. We have selected 1100 1 km2 samples across the study area under a stratified random design based on hypothesized predictors of land use change: urban/rural status, economic type, infrastructure and development, climate, and natural amenities. We are now quantifying land use change during 1990 to 2015 in these samples through aerial imagery interpretation and analysis of remote sensing data sets. Thus, the land use change work is proceeding on schedule. Kathleen is currently working on the connectivity analysis and has attended a CSC training, and an NCAR workshop.

Activity 3. Further the Translocation of Wolverines as a Conservation Tool

Gary Frazer, USFWS Assistant Director for Endangered Species, attended the 2017 WAFWA summer meeting and committed USFWS personnel to work on policy options that will facilitate reintroductions of species that may be candidates for listing as threatened or endangered. The 2016-17 Multi-state survey has identified areas with very low occupancy that may in some cases be suitable for translocations.

Attachment B

Summary of Multi-State Wolverine Occupancy Survey

Summary of 2016-17 Multi-State Wolverine Occupancy Survey

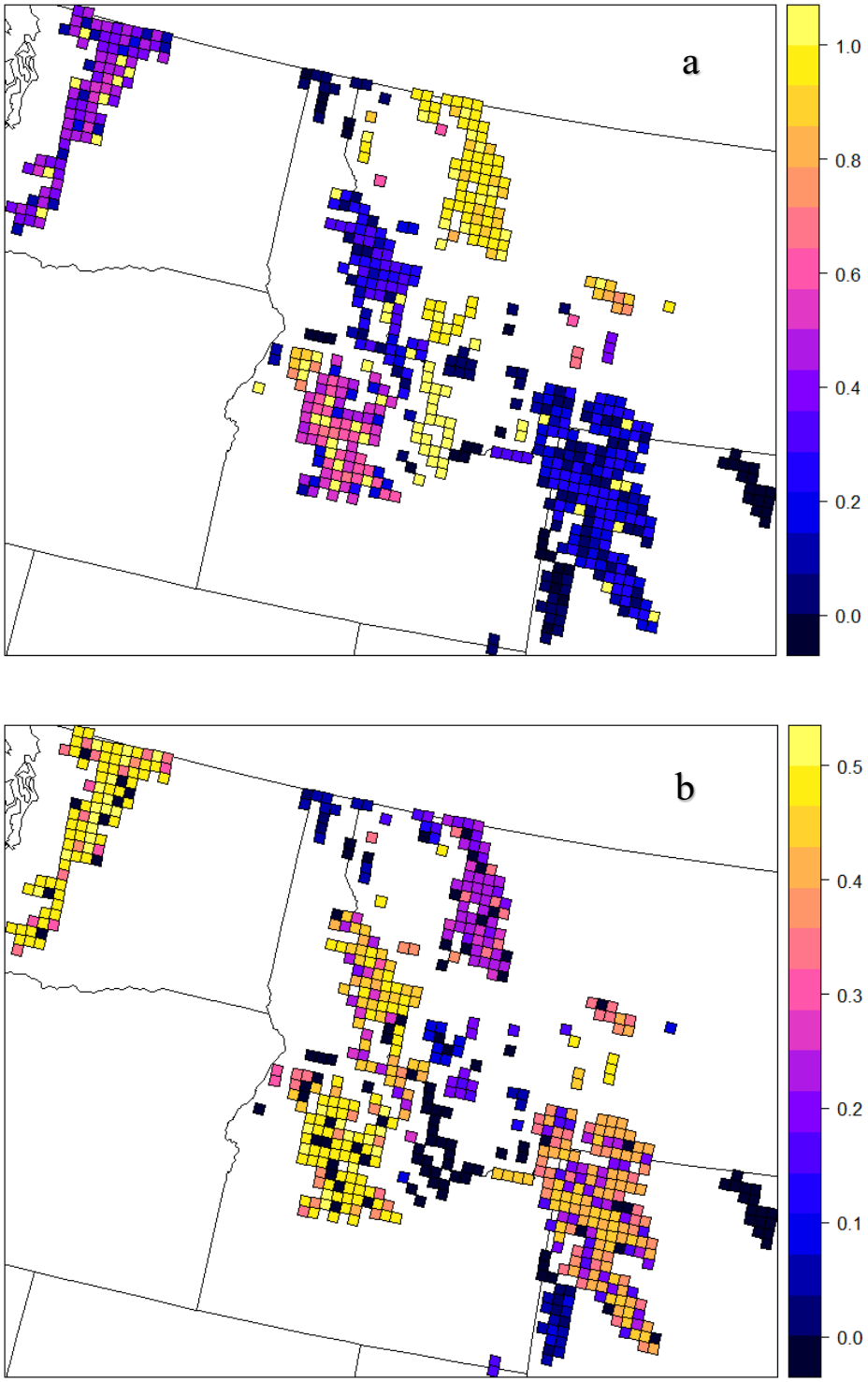
Wolverines are a naturally uncommon and rarely encountered species that resides in remote, high-elevation areas of the western United States. Proactive conservation measures are needed for this inherently small population that exists as a metapopulation across the region. One key component of a wolverine conservation strategy is development of a population monitoring program – up to now, records of wolverine occurrence have been rare and collected in an uncoordinated and opportunistic fashion, which makes it difficult to assess the species distribution, status and trend. The continued absence of a monitoring program jeopardizes the ability of agencies to allocate resources effectively among wolverines and other conservation priorities. State wildlife agencies in WA, ID, MT, and WY, along with federal, tribal, and NGO partners, developed a collaborative monitoring program that can be implemented in a coordinated fashion across the species range in the western U.S. The foundation for this monitoring program is a coordinated camera survey to obtain baseline information on distribution, genetics, and occupancy of wolverines. When repeated over time, trends in occupancy and distribution can be evaluated.

We developed a sampling frame based on existing models of wolverine habitat. The sampling frame consisted of 633 15x15 km grid cells. We selected 185 cells to sample from the frame using a GRTS sampling method. A single remotely triggered camera was placed in likely wolverine habitat within each selected cell along with a bait or scent attractant. Sampling occurred across a four-state area (ID, MT, WA, WY) during the winters of 2015-16 and 2016-17.

We obtained data from 183 sites and detected wolverines at 59 of the sampled cells. Detection rate was exceptionally high ($p=0.92$), and did not differ between sites that were baited and revisited multiple times vs. sites that were scented only and visited less frequently. The average estimated probability of wolverine occupancy during our study was 0.42 (95% credible interval 0.29-0.55) suggesting that wolverines used nearly half of all sites during the study period. Wolverine occupancy varied across the region with highest occupancy in the Northern Continental Divide Ecosystem and lower on the southern and eastern periphery of the study area (Figure 1).

The multi-state wolverine survey produced several important outcomes. First, it provided a rigorous and previously unavailable evaluation of wolverine distribution for the first time since the species was extirpated from the contiguous U.S. a century ago. This evaluation confirms the broad distribution of wolverines across the region and that recovery has progressed substantially since historical lows. The effort also demonstrates that occupancy probability varies throughout the region. The variability may be due to differences in habitat quality, differences in wolverine survival, or could be due to the time required to recover from historical absence. Perhaps most importantly, the regional occupancy estimates provide a baseline for future evaluations of change in wolverine distribution through time, including the possibility of detecting any influences due to climate change. In addition, the high detection rate and equal performance of stations visited less frequently indicates the potential for substantial cost savings during future surveys. The effort also demonstrated strong and fruitful collaboration among state, federal and tribal agencies at the scale of a species range, and the results provide management-level guidance on where to direct wolverine conservation in the future. For instance, information on occupancy may be used to inform criteria for translocation, should some states pursue that as a means for enhancing the conservation status of wolverines.

Figure 1. Predicted wolverine occupancy (a) and standard errors (b) for the multistate wolverine survey in 2016 and 2017.



Montana Fish, Wildlife & Parks

P.O. Box 200701
Helena, MT 59620-0701
Phone: 406-444-2612
FAX: 406-444-4952
Ref: DO175-13

November 30, 2017

Jodi L. Bush
United States Fish and Wildlife Service
Montana State Ecological Services Office
585 Shepard Way, Suite 1, Helena, MT 59601

Dear U.S. Fish and Wildlife Service:

On behalf of Montana Fish, Wildlife and Parks (FWP) please accept these comments, supporting documents, and technical review in response to the U.S. Fish and Wildlife Service's (USFWS) request for review of their 2017 wolverine Species Status Assessment (SSA).

First and foremost, we thank you for incorporating important newly available information into the SSA, and for a far more thorough and objective description of the scientific underpinnings and biology of the wolverine. We appreciate the effort and attention to detail that went into the SSA, and offer the following to emphasize those areas where we see important improvements toward using quality scientific information and objective interpretation of the best available information. We also note a few areas where we suggest additional refinement.

- Several studies that were not available for the 2013 proposed rule clearly demonstrate that the May 15 in at least 1 of 7 years snow model (Copeland et al. 2010) is not an accurate predictor of wolverine distribution now, and cannot be used to predict distribution in the future. Webb et al. (2016) and Aronsson et al. (2016) found evidence of females living and reproducing outside of areas classified as suitable wolverine habitat based on the 2010 snow model. As the authors of both new papers note, *the wolverine may be more flexible in its distribution than previously assumed.* Considering these studies and including the findings in the SSA was a critical step in using quality scientific information and providing an objective interpretation of the best available information.

We also agree with the Service that it is critical to consider the scale at which snow may be important for wolverine dens. This was one of several major flaws in the scientific papers that the 2013 proposed rule hinged upon. The new works by Ray et al. (2017) and Magoun et al. (2017) demonstrate that previous analyses (McKelvey et al. 2011) produced an exaggerated effect. Contrary to previous analyses, both new papers consider fundamental biology such as

elevation, aspect, and the size of a snow patch that is actually needed for a wolverine den, and show that this resource will not be a limiting factor for wolverines in the foreseeable future. Again, this was a critical step in using quality scientific information and providing an objective interpretation of the best available information.

While we understand the necessity for the NOAA analysis by Ray et al. (2017) to use the May 15 (and May 1) dates to draw a comparison with what was presented by Copeland et al. (2010) and McKelvey et al. (2011), we urge the Service to use extreme caution in inadvertently furthering the narrative that May 15 is a date of important biological consequence to wolverines. While this date is a point in time when the effects of climate change on snow may be most apparent, it is not a date for which the presence or absence of snow has been demonstrated in practice to have any negative effects on wolverines. Even in theory, if snow is critical for dens, it is likely most important at a much earlier date such as February and March when young are less developed and climate impacts are not likely to be as severe.

It was important that the Service addressed several of the flaws in the previous works that the proposed rule hinged upon, but we urge the Service to consider making additional clarifications due to the widespread public misunderstanding that exists in relation to those works. For instance, one reason the 2010 snow model found a correlation between spring snow and dens was that most of the dens had been located by tracking wolverines in the snow to their dens during spring (in Scandinavia). No conclusion other than a relationship between spring snow and dens is possible using this field method. The fact that wolverines are expanding to areas outside of the May 15 snow area coupled with this methodological limitation is of such significance that Sweden has had to adapt their national population monitoring program to find wolverines in some way that does not depend on tracks in the snow (Aronsson et al. 2016). This is but one example, and there are several other major issues with the science underpinning the 2013 proposed rule that may need explicit clarification within the SSA. We urge you to consider and do so where appropriate.

The SSA has a far more objective consideration of the genetic composition, effective population size, and continuity of the population across the border with Canada. This, again, was a critical step toward an objective interpretation of the best available information. We ask that the Service make clear in the SSA that it is plausible that wolverine population size, genetic diversity, and effective population size are currently at a similar level to what existed 500 years ago, with the exception of those areas such as Colorado and California where functional populations have been absent for decades.

Because the 2017 SSA differs from the 2013 proposed rule in its assessment regarding threats to the wolverine, it is imperative that the reasons for the new and more informed assessment be made clear. That is done to a great and sufficient degree within the SSA, but every effort to express this reasoning in a clear and concise manner is warranted. It is our understanding that the shift has occurred consistently with the Service's joint policy on peer review, which states, "The

purpose of peer review is to ensure that our listing determination and critical habitat designation are based on *scientifically sound data, assumptions, and analyses*." (FR Vol. 78, No. 3. Page 7889). The newly available scientific information clearly demonstrates that peer-review and objective scrutiny from wildlife professionals was necessary, and that it functioned precisely as intended. Indeed, many of concerns raised in the peer-review process for the 2013 proposed rule have now been verified in the peer-reviewed scientific literature. We commend the Service for adhering to the appropriate process and ensuring that its decision was based on scientifically sound data, assumptions, and analysis.

Throughout the document, the early period of unregulated take of wildlife is simply referred to as "overhunting." Today, because most citizens do not hunt or trap, it is critical to draw the distinction between early historical periods when there were no rules or limits to the amount of wildlife that could be killed vs. modern, regulated, professional wildlife management that is required to be sustainable. Please make this distinction wherever possible within the SSA.

We also ask that the Service recognize in the SSA that Montana's wolverine management program has served for decades to conserve and manage the species sustainably. This is noted for some jurisdictions, e.g., Alaska, but omitted for Montana. We hold that there is sufficient evidence to note Montana's sustainable management also. Beginning in the 1970s, Montana has a long history of positive, progressive efforts to conserve wolverine that we would like to see fully described in Appendix G of the SSA. This includes a wolverine management strategy that was conceived at a multi-state, landscape scale and implemented nearly a decade ago, in 2008. Please see Attachment A and previous comments for relevant material.

More recently, and with help from other agencies and conservation organizations, a multi-state, landscape-scale conservation strategy for wolverines has been developed and initiated. These activities are officially sanctioned by the Western Association of Fish and Wildlife Agencies (WAFWA) and acted upon by WAFWA's Wildlife Chiefs' wolverine subcommittee. Current partners in this effort include multiple state wildlife agencies from the western U.S., USFWS, U.S. Forest Service, and National Park Service along with several tribes, universities, and non-governmental organizations. These ongoing activities, described in Attachments A and B, are very similar to the goals of the USFWS's 2013 Draft Recovery Outline (USFWS 2013, Page 8), and in some cases go above and beyond those goals. *As such, there is an active, funded, region-wide wolverine conservation program that contains most, if not all, and some additional components of any recovery plan that could be created.* We urge the USFWS to fully describe in the SSA the path to wolverine conservation in the western U.S. that has been building for many years. Consideration of this positive and progressive work on future conditions for the species is as important a component of an SSA as consideration of negatives such as potential threats and stressors.

We suggest that the Service consider adding a section to this and all SSAs that evaluates what conservation could be done to improve the situation for a given species. Doing so would provide

leadership by outlining progressive steps for the species, and it would help and encourage all parties interested in conservation to focus their resources on real-world, on-the-ground activities that make a difference.

FWP recognizes that wolverines are a Holarctic species adapted to cold, snowy conditions. And of course, at some point, as it would be for any species located primarily in the far north, it is possible for warming conditions to negatively influence distribution. However, this general supposition standing alone does not drive a listing determination under the ESA unless it is backed by sound science. At present it is unclear exactly how much cold or snow is necessary for wolverines to survive, and therefore impossible to predict with any degree of confidence an extinction within the foreseeable future. We note that a baseline survey has been undertaken (multi-state survey) and is set up to be repeated in a manner that can identify changes in population distribution over time, including reductions in distribution in relation to climate. We maintain that the science underpinning the proposed rule to list greatly exaggerates the potential threat to wolverines. Furthermore, as stated directly in the proposed rule, listing due to the threat of climate change will not result in regulation or alleviation of the proposed threat. In short, there is insufficient scientific basis for listing and listing would not address the threat identified.

Montana remains committed to managing wolverines in a conservative and responsive manner. While this species' natural situation warrants a relatively cautious approach, populations continue to expand and conservation efforts including population monitoring are underway. Therefore, once again, we assert that wolverines are not threatened with extinction in North America or the contiguous United States in the foreseeable future, and they do not meet the criteria for federal listing. As such the USFWS should withdraw its proposed rule to list wolverine as threatened under the Endangered Species Act.

Sincerely,

Martha Williams, Director

Attachments:
1) Technical Review
2) Attachment A - Wolverine Conservation in Montana and Collaborative Efforts Across the Western US.
3) Attachment B - Summary of Multi-State Wolverine Occupancy Survey

From:	Grizzle, Betty
To:	Shoemaker, Justin; John Guinotte
Subject:	Fwd: FW: WDFW Wolverine SSA Comments
Date:	Friday, December 1, 2017 3:01:06 PM
Attachments:	Washington DFW response letter to Wolverine SSA1.pdf WDFW Comment Table_Wolverine SSA_29 Nov 2017.docx WDFW Wolverine SSA Comments_Attachment 2_Survey Summary.docx

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From Washington DFW.

---------- Forwarded message ----------
From: **Anderson, Hannah E (DFW)** <Hannah.Anderson@dfw.wa.gov>
Date: Fri, Dec 1, 2017 at 12:50 PM
Subject: FW: WDFW Wolverine SSA Comments
To: "betty_grizzle@fws.gov" <betty_grizzle@fws.gov>

My apologies. I had the wrong email address.

Best,

Hannah

Hannah Anderson

Listing and Recovery Section Manager

Washington Department of Fish and Wildlife

PO Box 43200, Olympia, WA 98504-3200

hannah.anderson@dfw.wa.gov

360-902-8403 (desk)

360-515-6885 (cell)

From: Anderson, Hannah E (DFW)
Sent: Friday, December 01, 2017 12:47 PM
To: 'jodi_bush@fws.gov' <jodi_bush@fws.gov>; 'betsy_grizzle@fws.gov' <betsy_grizzle@fws.gov>

Subject: WDFW Wolverine SSA Comments

Good Afternoon Jodi and Betsy –

I apologize this is coming today. I tried to send yesterday, but realized only just now that it was sitting in my outbox instead.

Please find attached WDFW's comments on the Wolverine SSA. We appreciate the opportunity to provide our input.

My very best,

Hannah

Hannah Anderson

Listing and Recovery Section Manager

Washington Department of Fish and Wildlife

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Mailing Address: P.O. Box 43200, Olympia, WA 98504-3200 • (360) 902-2200 • TDD (360) 902-2207
Main Office Location: Natural Resources Building, 1111 Washington Street SE, Olympia, WA

November 29, 2017

Jodi L. Bush
US Fish and Wildlife Service
Montana State Ecological Services Office
585 Shepard Way, Suite 1
Helena, MT 59601

Dear Ms. Bush:

Washington Department of Fish and Wildlife (WDFW) is grateful for the opportunity to review the species status assessment (SSA) for the North American Wolverine *(Gulo gulo luscus)*. WDFW is invested in better understanding wolverine ecology and in implementing measures to further the species' conservation in Washington and in the western United States.

We appreciate the significant amount of work required to pull together such a comprehensive document. Our primary concerns are related to the treatment and presentation of two specific subject areas within the SSA, the need for comprehensive ecological knowledge and the association of wolverines with snow.

As is the case with most wildlife species, we lack a complete understanding of wolverine biology and ecology. Wolverines are very difficult to study and there are a limited number of studies that have been conducted in the western states. However, recent and ongoing studies of wolverine ecology in Washington, Idaho, Montana, Wyoming, British Columbia and Alberta provide valuable information on this topic and we are fortunate to have a wealth of data to inform decision-making. Rather than heavily focusing on gaps in our knowledge, we recommend that the SSA present the current state of knowledge as the "Best Available Information."

WDFW is concerned about the doubt sown in the SSA regarding the importance of snow as a significant habitat component. The SSA focuses on exceptions, extensively states specific aspects of wolverine ecology that are unknown, and counters what we do know about wolverine ecology (i.e., that wolverines have a strong association with snow, and most wolverine dens in the lower 48 states occur in/with snow). This is a concern throughout the document and we have pointed out several instances in our attached table of specific comments.

Further, we agree that there is not a complete understanding of how climate change can or will alter habitats for wolverines and other species in the near and distant future. However, we are confident that best available information provides clear indications that climate change is, and will be, creating conditions that will alter wolverine habitats in ways that will affect the

distribution and resilience of wolverines where they now occur in Washington. We look forward to working with the Service to advance wolverine research, monitoring and conservation as we address and gain a greater understanding of the conservation challenges facing this species.

Attached, we have provided a table of our specific comments for consideration. We also include information about the initial findings of the Western States Wolverine Conservation Project. Please contact Hannah Anderson, Listing and Recovery Manager, by email at hannah.anderson@dfw.wa.gov if you have any questions about our comments or WDFW's efforts to advance wolverine conservation in Washington.

Sincerely,

Eric Gardner, Assistant Director
Wildlife Program

Attachments: 1. WDFW Comment Table - Wolverine SSA
2. Summary of Multi-State Wolverine Occupancy Survey

cc: Jim Unsworth, Director, WDFW
Mick Cope, Deputy Assistant Director, Wildlife Program, WDFW
Penny Becker, Diversity Division Manager, Wildlife Program, WDFW
Hannah Anderson, Listing and Recovery Section Manager, Wildlife Program, WDFW
Eric Rickerson, Washington State Supervisor, USFWS

Washington Department of Fish and Wildlife Comments:

Species Status Assessment for the NORTH AMERICAN WOLVERINE *(Gulo gulo luscus)*

#	Document Section	Page #	Comment
1	Overall	throughout	Considerable caution is warranted when making inferences about the behaviors of wolverines in the mountainous areas of the western United States (MT, ID, WY and WA) based on the behaviors of wolverines in arctic and subarctic regions of North America and Scandanavia and the behaviors of pika (see text at bottom of page 93 and all of page 94).
2	Introduction	Suggest adding	The SSA would benefit from a Section (perhaps within the introduction) that addresses the aspects of the wolverine's life history that are associated with snow and an explanation for those associations. For example, these topics would include natal denning, maternal denning, food caching, food caching by mothers with newborn kits, foraging across seasons, predator avoidance, protective cover, etc.
3	Introduction	4	First Sentence is incorrect. The wolverine is not the largest member of the Mustelidae (max weight of adult males is ~18 kg; Copeland and Whitman 2003); the sea otter is (max weight of adult males is ~46 kg; Bodkin 2003).
4	Introduction	4	2nd Paragraph – Among the many traits, qualities and behaviors stated about wolverines, their very strong association with high-elevation rock/ice/snow habitats above tree line in the contiguous 48 states is not included. This seems to be a significant omission.
5	Introduction	4	3rd paragraph – No citations are used to support the statement in the last sentence that wolverines have recovered from a population decline in various states in the west. Given the significance of this statement, it is important to reference the citations for the data/information that show this recovery and the period when it occurred.
6	SSA Methodology	5	First full paragraph - last sentence: It would be valuable to inform the reader that one of the study areas is occupied by wolverines (GNP) and one is not (RMNP).
7	SSA Methodology	5	Figure 1 is lacking detail and is unclear. It could be deleted.
8	Life History and Ecology	10	Physiology; first paragraph – The first clause of the 2nd sentence distracts from the main point that wolverines are morphologically and physiologically adapted to snow and snowy environments. Recommend deleting 2nd sentence.
9	Historical range and distribution	13	3rd and 4th paragraphs – There is a redundant passage about the rapid warming ~21,000 YBP in these 2 paragraphs

10	Current Range	17	The current range map as presented gives a falsely optimistic view of the current range. For example, in Colorado and California there is only recent documentation of one adult male in each location and I believe the Colorado animal ended up being killed in North Dakota. I question whether there are any recent verifiable occurrences (i.e., photo, video, carcass, DNA) in the Oregon Cascades or Uintas in Utah. Verified reproducing populations are limited to Idaho, Montana, the North Cascades of Washington, and a small portion of NW Wyoming.
11	Habitat use	18, 19	5th Paragraph (starting at bottom of page) – In the beginning of the 2nd sentence, it states that high elevation and north-facing cirques are significant predictors of wolverine habitat, but the latter half of the sentence appears to diminish this finding by pointing out that there is a lot of unexplained variation in the findings. Substantial unexplained variation is not unusual in habitat studies; however, the second part of the sentence appears to be stated in a way that would undermine the initial findings. Later in the 5th paragraph (page 19)- the 4th and 5th Sentences appear to contradict each other by stating wolverines move to slightly lower in elevation in summer, but then the following sentence indicates use of higher elevation habitats in summer and mid-elevation habitats in winter.
12	Habitat use	19	3rd full paragraph, 3rd sentence – Sentence states that occurrence varies more strongly with linear features but doesn't explain how/why. The meaning of the last sentence is unclear – what behavioral signal is being referenced?
13	Movement	22	2nd Paragraph – This paragraph does not sufficiently take kinship into account as it describes philopatry, dispersal, and home range overlap.
14	Movement	22	Table 1 – There should be an indication of sample size of individual wolverines for each row in this table. Similarly, there should be an indication of which home range estimator was used. Presumably this table indicates annual home ranges, but that is not stated.
15	Movement	23	Dispersal definition – Dispersal is defined in a very narrow way. Because many individuals (juveniles and adults) can die during dispersal (prior to home range establishment or reestablishment), excluding these individuals in a definition may cause the reader to misinterpret the risks and outcomes of dispersal events in a population.
16	Reproduction and Growth	24	The gestation period (30-40 days) mentioned in the first paragraph is not consistent with the gestation period estimate (45 days) in Table 2.
17	Reproduction and Growth	25	2nd Full paragraph – Data (if they exist) for the percentage of adult females that den per year would be a great addition to this paragraph as this value is essential demographic data. 3rd full Paragraph – The meaning of the 2nd sentence is unclear. The use of delayed implantation followed by resorption in parens in the 3rd sentence is confusing because these terms are very dissimilar.

18	Use of dens and denning behavior	27	First full paragraph – It is unclear how rendezvous sites differ from maternal den sites. Given the significance of these sites, it would be helpful to know how they differ.
19	Use of dens and denning behavior	28	Figure 4. – This figure appears blurry, has small font, and does not show ungulate prey availability relative to kit rearing phases.
20	Denning Habitat	28	First paragraph, 3rd sentence – The FWS emphasizes that there have been limited comprehensive studies on wolverine behavior and then cites 7 studies. Given the difficulty of studying this species, 7 studies is a very significant number. Also, if these 7 studies are the best available information, the FWS could use these studies and the associated findings as an indication of what is known about wolverines rather than speculate that these data should be viewed with caution because they are not comprehensive or because there are only 7 of them. Is the FWS also indicating that these studies did not include any data/observations of wolverine behavior outside of the winter months?
21	Denning Habitat	29 (Box 1)	Box 1 provides a summary and bullets of the characteristics of snow that is very informative. While it provides meaningful information, it is based on 2 studies that were conducted/published over 50 years ago. In the era of climate change and glacial retreat, are there more recent papers that provide additional or better information on snow?
22	Denning Habitat (pg 30) Summary of future conditions (pg 90)	30, 90	Page 30 First paragraph, first sentence; and Page 90, last paragraph, first sentence – This sentence appears to indicate that an assumed "obligate relationship with snow for natal denning" may not be well supported by best available information because it has not been empirically analyzed. Indeed, the relationship between natal den placement and snow is not comprehensively understood, however, the best available information indicates a very close relationship between snow and natal dens. We do not want this important point to be lost in this discussion (see also Magoun et al. 2017. Detecting snow at the den-site scale in wolverine denning habitat. Wildlife Society Bulletin 41(2):381-387).
23	Denning Habitat	30	Second paragraph – In this paragraph the Service mentions that it is unclear if wolverines are using snow because it is associated with other den sites structures (i.e. bare rock, boulders) in remote areas. As stated above, there is a lack of comprehensive understanding of the relationship of wolverine den site selection and snow and other structures, however the best available information indicates that wolverine den sites are strongly associated with snow, and there is no data to suggest that wolverines could not select for snow <u>and</u> other structures when denning. We do not want this important point to be missed in this discussion.
24	Denning Habitat	30	3rd Paragraph – It is not clear from the narrative if snow-associated dens make up the majority of dens or if they make up a smaller number. Given the importance of denning habitat, we feel it

			would be valuable for the Service to provide a table that shows the number of dens that were associated with snow, the number that were not associated with snow, and the number which an association with snow was unknown. *We recognize that the 3rd full paragraph on page 32 and the first paragraph on page 33 relate to this topic and this comment.*
25	Denning Habitat	30	3rd Paragraph - Exceptions do not invalidate a rule. To date, the vast majority of literature supports the relationship between persistent spring snow cover and wolverine habitat in general (Magoun and Copeland 1998, Aubry et al. 2007, Copeland et al. 2010, McKelvey et al. 2011, Inman et al. 2012 in J. Mamm., Inman et al. 2012 in J. Wildl. Mgt, Magoun et al. 2017) and female denning habitat, in particular (Magoun and Copeland 1998, Copeland et al. 2010, Inman et al. 2012 in J. of Mamm., Magoun et al. 2017). This is particularly true south of the 54th parallel, where wolverine habitat is primarily in mountainous habitat, and the relationship is very strong in the contiguous 48 states. Reports of potential exceptions have come from boreal and/or tundra habitat far to the north of the Lower 48, and even in these areas, a recent paper by Magoun et al. (2017) suggests that even here denning females may still be actually be utilizing snow cover (drifted patches) when their habitat selection is analyzed at the microsite level.
26	Denning Habitat	31, 32	Page 31, Paragraphs 1, 2, and 3 – These paragraphs appear to question the validity of best available information by: 1) stating that its "Limited" (first word of paragraph 1); 2) stating the research on a topic has not been conducted, e.g., "studies of wolverine denning activity have not reported on the condition of ….." (3rd sentence in paragraph 1); 3) questioning the premises of the hypotheses, methodologies, and analyses of research conducted by Copeland et al. 2010 (page 31 2nd paragraph, page 32 2nd full paragraph), but providing no indication that these premises were unsubstantiated or invalid or inappropriate; 4) discussing the limitations of correlation analyses in bioclimatic models (page 31 last paragraph), and 5) stating only the limitations of the Delphi Process; and stating only information on the lack of consensus and on uncertainties about applicable breadth of spatial-scales, among wolverine experts. We attest it is important to clearly state the findings and the conclusions that can be drawn from the best available information, with the clear recognition that we lack perfect knowledge, perfect data, perfect analyses, certainty, and a comprehensive understanding of wolverine habitat selection.
27	Denning Habitat	35	First Paragraph, 3rd sentence – We agree that additional studies are needed to better understand wolverine den site selection; however, the SSA must use the best available information to summarize the current knowledge of wolverine den site selection and other important aspects of wolverine ecology and biology. A lack of comprehensive knowledge does not invalidate the utility of the best available information.

			Last paragraph, Summary statement – This summary statement and the last sentence in particular, restates the aspects of den site selection that we do not yet understand, rather than the aspects we do understand.
28	Demography	36	The demographic data collected to date in the Lower 48 states is largely presence/absence data with little info on vital rates or population trend information, thus we cannot say much about the security of the current population(s), irrespective of what might happen as climate change progresses. Climate models suggest conditions are going to be less favorable for cold/snow adapted species like wolverine south of the 49th parallel.
29	Life history and ecology, summary; Overall Summary on page 92	46, 92	First Paragraph, last sentence (list of ecological needs) and Overall summary page 92 4th full paragraph – The absence of snow in this list is significant omission given its prevalence in the wolverine literature, in habitat models, at the elevation where wolverines typically occur, and their close association with snow.
30	Biological Status – current condition	Page 47 in Contiguous US	2nd full paragraph (about Oregon wolverine observations) – We are not aware of any verifiable recent detections of wolverines (i.e., photo, video, carcass, DNA) in the Oregon Cascades.
31	Biological Status – current condition	Page 49, Alaska	A map and definitions of how many individuals are indicated by each abundance term would make Table 4 more useful. Perhaps draw from data in Table 7 (page 61), and include a map?
32	Effects of Roads	52	A wolverine was killed on Hwy 20 in northwestern Washington in the late 1990s or early 2000s, and could be included in this summary. This specimen is located at the Burke Museum at the University of Washington, Seattle (contact: Jeff Bradley, Curator of Mammals)
33	Overutilization	63, last paragraph page 64	First Paragraph, first sentence – This sentence apparently refers to data in the Figure 5 (also page 63) and makes the assumption that no legal harvest of wolverines in BC management units in southern BC indicates that trapping effort does not represent a significant barrier to wolverine movement and dispersal along the international border. This ignores the potential for incidental capture of wolverines in traps set for other species or poaching.
34	Summary of Current Conditions	65 and top of page 66	First Paragraph, first sentence – Indications of recovery should be supported with literature citations. This same statement is made in the Overall Summary on page 93, without any references to support it. Last Paragraph, last sentence - without a citation for this last sentence, it is unclear as to the source of the best available commercial and scientific information that establishes that overutilization is not a threat. Does this refer to the Weir, pers comm. in the previous sentence?

35	Snowpack/snow cover- Upper Snake River Watershed (PNW region)	70, 73	Maps would be helpful, in the interests of determining how the projected decreases in snowpack compares with area encompassed by Wolverine range. The SSA references a study of "the Columbia River Basin Region" which includes "portions of the current range of the Wolverine". The study is referenced as Rupp et al 2017. It is not clear from the narrative if the area under consideration includes the Cascade Mountains. It would be a significant omission to not include the Cascades. Other studies have projected changes in snowpack across Washington, as reported by the Climate Impacts Group (2009) Washington Climate Change Impacts Assessment. Climate Impacts Group, 2009. *The Washington Climate Change Impacts Assessment*, M. McGuire Elsner, J. Littell, and L Whitely Binder (eds). Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle, Washington. *Available at: http://www.cses.washington.edu/db/pdf/wacciareport681.pdf*
36	Status – Future Conditions: Summary	72	There are several statements in the document which appear to be inadequately supported by the data, e.g., "These physiological and behavior adaptations allow wolverines to adapt to warming temperatures." This portrays an overall certainty, as if loss of snow and warmer temperatures will not affect wolverines or wolverine populations. At a minimum the statement should be qualified and supported with citations.
37	Snowpack/snow cover- Upper Snake River Watershed (PNW region)	73	The document should provide more explicit and robust climate information for Washington. At a minimum, the studies that are referenced should include a description of the geography they cover.
38	Overall Summary	93	First full paragraph, 3rd sentence – This statement is not entirely correct. Wolverines had been detected recently in several locations south of I-90 in Washington.

Summary of Multi-State Wolverine Occupancy Survey

Wolverines are a naturally uncommon and rarely encountered species that resides in remote, high-elevation areas of the western United States. Proactive conservation measures are needed for this inherently small population that exists as a metapopulation across the region. One key component of a wolverine conservation strategy is development of a population monitoring program – up to now, records of wolverine occurrence have been rare and collected in an uncoordinated and opportunistic fashion, which makes it difficult to assess the species distribution, status and trend. The continued absence of a monitoring program jeopardizes the ability of agencies to allocate resources effectively among wolverines and other conservation priorities. State wildlife agencies in WA, ID, MT, and WY, along with federal, tribal, and NGO partners, developed a collaborative monitoring program that can be implemented in a coordinated fashion across the species range in the western U.S. The foundation for this monitoring program is a coordinated camera survey to obtain baseline information on distribution, genetics, and occupancy of wolverines. When repeated over time, trends in occupancy and distribution can be evaluated.

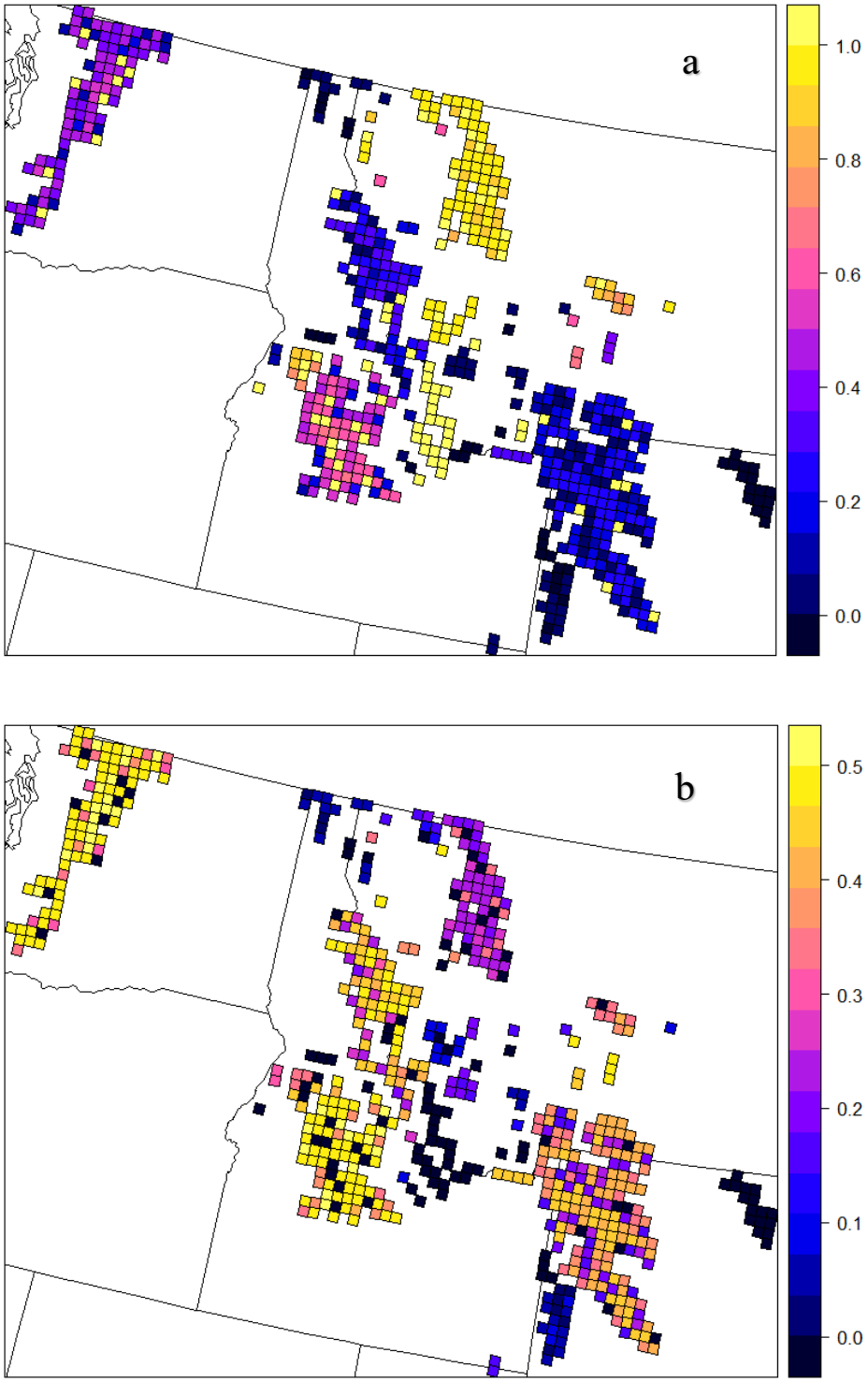
We developed a sampling frame based on existing models of wolverine habitat. The sampling frame consisted of 633 15x15 km grid cells. We selected 185 cells to sample from the frame using a GRTS sampling method. A single remotely triggered camera was placed in likely wolverine habitat within each selected cell along with a bait or scent attractant. Sampling occurred across a four-state area (ID, MT, WA, WY) during the winters of 2015-16 and 2016-17.

We obtained data from 183 sites and detected wolverines at 59 of the sampled cells. Detection rate was exceptionally high ($p=0.92$), and did not differ between sites that were baited and revisited multiple times vs. sites that were scented only and visited less frequently. The average estimated probability of wolverine occupancy during our study was 0.42 (95% credible interval 0.29-0.55) suggesting that wolverines used nearly half of all sites during the study period. Wolverine occupancy varied across the region with highest occupancy in the Northern Continental Divide Ecosystem and lower on the southern and eastern periphery of the study area (Figure 1).

The multi-state wolverine survey produced several important outcomes. First, it provided a rigorous and previously unavailable evaluation of wolverine distribution for the first time since the species was extirpated from the contiguous U.S. a century ago. The effort also demonstrates that occupancy probability varies throughout the region. The variability may be due to differences in habitat quality, differences in wolverine survival, or could be due to the time required to recover from historical absence. Perhaps most importantly, the regional occupancy estimates provide a baseline for future evaluations of change in wolverine distribution through time, including the possibility of detecting any influences due to climate change. In addition, the high detection rate and equal performance of stations visited less frequently indicates the potential for substantial cost savings during future surveys. The effort also demonstrated strong and fruitful collaboration among state, federal and tribal agencies at the scale of a species range, and the results provide management-level guidance on where to direct wolverine conservation in the future. For instance, information on occupancy may be used to inform criteria for translocation, should some states pursue that as a means for enhancing the conservation status of wolverines.

Summary of Multi-State Wolverine Occupancy Survey

Figure 1. Predicted wolverine occupancy (a) and standard errors (b) for the multistate wolverine survey in 2016 and 2017.



From:	Grizzle, Betty
To:	Shoemaker, Justin; John Guinotte
Subject:	Fwd: draft wolverine SSA comments
Date:	Monday, December 4, 2017 8:34:33 AM
Attachments:	image004.png image003.png image001.png image002.png Wolverine draft SSA comments.docx Yates_edits_11_17Draft Wolverine SSA Report_Oct 23 2017.pdf

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From USFS.

---------- Forwarded message ----------
From: **Jackson, Scott -FS** <sjackson03@fs.fed.us>
Date: Fri, Dec 1, 2017 at 5:20 PM
Subject: RE: draft wolverine SSA comments
To: "Grizzle, Betty" <betty_grizzle@fws.gov>
Cc: "Jodi_Bush@fws.gov" <Jodi_Bush@fws.gov>

Hi Betty,

Please accept this email as the USFS comments on the FWS's draft Species Status Assessment for the North American Wolverine (v. 1.0, Oct. 23, 2017). I've attached a Word document that provides comments primarily pertaining to the North Cascades, and a pdf of the draft SSA that includes comments in track changes, with a focus more on the Northern Rockies.

In addition, I've included the following from a USFS commenter, which summarizes some of the comments in the attached pdf file.

> Attached are my comments on the Wolverine SSA. I appreciate the opportunity to comment and I do hope my comments are helpful in perpetuating the conservation of wolverines in the lower 48 states.
>
> As you are aware, much of the SSA climate change discussion was based on specific

data from our Glacier National Park wolverine study between 2002 and 2007. I feel it is my obligation as a wildlife biologist to provide comments on the proper use and interpretation of those data, and once again, I appreciate the opportunity to do so. I made comments throughout the document, including editions for grammatical errors. However the Glacier Climate Change analysis, as it relates to den site habitat and persistent snow cover, is the section of the document I had the most comments on. The other issue was how Copeland et al. 2010 was presented. Here are a few summary highlights.

Snow pack at active wolverine den sites in Glacier averaged 2.6m in depth at the end of April and in to early May. I know this because I visited these sites and did the measurements. This metric is not based on a model. For some reason, the depth used as the standard for the SSA models was 0.5m. If snow depth diminishes from an average of 2.6m to 0.5m and we call that "no change", because it is still "snow cover", it is not the same thing where a wolverine is concerned. Not all snow cover is the same, ask any hydrologist. Our den sites had a deep snow pack at the time of use. A half meter is not deep.

The model for the changes in snow cover in Glacier used years 2000 to 2013 as the "historic average". I have a real problem with this. 2012 was the hottest year ever recorded, and 13 of the 14 hottest years occurred during this supposed "historic" period. Using this average and projecting 40 years into the future produced little change in the snow cover in Glacier. I believe this is a misrepresentation of what is occurring on the ground.

Finally, Copeland et al. 2010 was a seminal work that correlated persistent spring snow cover with wolverine den sites (n=562), across the Northern Hemisphere. It was not intended to be the final word on wolverine reproductive denning habitat or temperature conditions. The model Copeland used explained 96% of the relationship between wolverine dens and persistent spring snow. There are, of course, exceptions/outliers. That is not surprising. However, the SSA goes to great lengths to suggest that wolverines can den in areas that do not show persistent spring snow as a habitat feature. There may be reasons for this that are explained by the limitations of the models. But, to use a sample size of 8, at a different scale, to refute a hemispheric model of 562 den sites seems rather capricious. There is no doubt that wolverine reproductive denning ecology is in need of further study. Perhaps wolverines can adapt to increases in temperature and to losses of snow cover (den substrate),

perhaps not.

Thank you, Betty, for providing the USFS the opportunity to review and comment. You've done a nice job of assembling a lot of good information and I very much appreciate the effort that went into this document. As managers of the majority of wolverine habitat in the lower 48, the USFS very much supports the use of the best science available, in the most accurate way possible, to help conserve this rare species and its habitat.

Scott Jackson
National Carnivore Program Leader
Forest Service

Northern Regional Office

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Caring for the land and serving people

From: Grizzle, Betty [mailto:betty_grizzle@fws.gov]
Sent: Wednesday, November 29, 2017 5:00 PM
To: Jackson, Scott -FS <sjackson03@fs.fed.us>
Subject: Re: draft wolverine SSA comments

Hi Scott - As much as it would make it easier to have everything in one document, given our time constraints, it's probably best just to send everything and we will sort through them.

Thanks to you and others for your review,

Betty

On Wed, Nov 29, 2017 at 3:54 PM, Jackson, Scott -FS <sjackson03@fs.fed.us> wrote:

Hi Betty,

I've collected some USFS comments on the draft wolverine SSA and would like to provide them to you. Do you have a preference for the format? Some of what I've received are written out in a Word doc and some are in track changes within the document. Would it work for you if I just forward them to you? Or do you need a summary of comments?

Thank you for the chance to comment. I appreciate the work that went into the draft SSA report.

Scott Jackson
National Carnivore Program Leader
Forest Service

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Caring for the land and serving people

Dear Wolverine Conservation Partners:

Attached please find the DRAFT Species Status Assessment (SSA) for the North American Wolverine. As you may be aware, the draft report is currently undergoing peer review.

We are providing this draft to your agency for review by members of your organization with expert knowledge of the species and its habitat. Your review will help us ensure that we have appropriately considered the best scientific and commercial information when evaluating the current status and future viability of the North American wolverine. We request your independent scientific perspectives on the comprehensiveness and logic of

the document, as well as how well the technical conclusions are supported by the data and analyses.

As the literature cited is lengthy, if you need a copy of any document cited in the draft report, please contact Betty Grizzle at the email address below.

The Draft SSA is not intended to solicit public comment and will be revised after this scientific review. The SSA does not predetermine any future agency decision under the Endangered Species Act.

In general we ask that your comments on the Draft SSA report focus specifically on whether the best available information was used, the quality of the scientific information, and our interpretation and analyses of the data with regard to the species' viability in the contiguous United States. We request that you direct your review to the scientific issues and assumptions related to your expertise.

General Information about SSAs:

The Species Status Assessment framework is a new tool the U.S. Fish and Wildlife Service is using to improve transparency while conducting listing determinations and other Act actions, and peer review of our analyses of the viability of species is part of that new process. The attached draft SSA report is a rough draft; we are seeking comments at this stage to ensure that we have time to incorporate any substantial comments as we finalize the report.

In reviewing the document, please note that this draft SSA report does not result in or predetermine a decision by the Service on whether the Canada lynx warrants protections of the Act. This document is strictly a characterization of the viability species' viability in the contiguous United States. As a reminder, all reviews and comments submitted to the Service will become public documents and part of our administrative record for this document.

We welcome consolidated comments from your organization by November 30, 2017. Please send comments by that date to Betty_Grizzle@fws.gov. Thank you for your interest and assistance. JB

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Betty J. Grizzle, D.Env.

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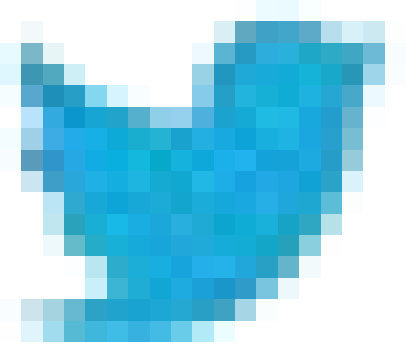

Comments, as requested, on
***Draft* Species Status Assessment for the North American Wolverine; USFWS; Version 1.0**

Page 17; Figure 3 – The title for this figure seems to be misleading, "Current range of North American wolverine". The map delineates areas in Oregon, California, Utah, and Colorado implying that wolverines are distributed throughout these areas, which does not seem to be an accurate reflection of current data. Using the presence of one male wolverine in Colorado to illustrate that the entire southern Rocky Mtn range is inhabited seems to be a stretch. Same thing for California and all of Oregon except the NE corner. There have been numerous track and baited camera station surveys in the Oregon Cascades in recent years that have targeted wolverine, with no detections.

Page 27; paragraph 3 – This section seems to be making the case that wolverines give birth in late February/early March because that is when food resources are most available. I do not think that is the case, especially in the North Cascades of Washington and, from what I've read, not in the Rocky Mtns either. The 2 known natal den sites in the North Cascades (Aubry et al. 2016) were at approximately 5500 ft elevation. Both those sites had 7-8 ft of snow at them when discovered and into early May when we inspected them. Food resources at that elevation at that time of year are minimal; snowshoe hares, red squirrels, and hibernating rodents. From Dec through May, wolverine food resources in the form of ungulate carrion are most available on winter ranges, about 3000 – 4000 ft lower in elevation than the den sites. The wolverines collared and monitored during the 10 year North Cascades Wolverine Study (Aubry et al. 2016) never went to these lower elevations, in winter or summer. We documented over 2400 telemetry locations on 11 different wolverines and 91% of those fell within the area modelled by Copeland et al (2010) for persistent spring snow cover. At the den sites elevation, it would seem wolverine food resources are most available from late June through September, when rodents aren't hibernating and ungulates are using those high elevation areas.

Page 48; paragraph 4 – "*and a member of the public reported wolverine tracks within Grand Teton National Park in March 2017, while skiing . . .* " Seems like you would want to limit wolverine sightings that you include in this assessment to those that are verified with a carcass, photograph or DNA sample. I would not categorize a report of wolverine tracks in the snow from a member of the public as a verified sighting without a good photo of the tracks. Based on my 27 years as a wildlife biologist and the numerous follow-ups I have done on reports of rare carnivores, I have found reports by members of the public to often be unreliable.

In general, there seem to be inconsistencies between some of the final conclusions and some of the information presented in the assessment:
Page 92; paragraph 2 – "Although the persistence of spring snow has not yet been evaluated as critical to wolverine survival in North America . . . ." Yet on page 32; paragraph 5 – ". . . indicated that most panelists allocated points to an obligate relationship of wolverines with deep snow at the den-site scale."
And on page 10; paragraph 1 – "The wolverine is a snow-adapted, cold climate animal in its physiology, morphology, behavior, and habits." But on page v, ". . .we have no indication that this species is unable to adapt or adjust to changing conditions."

Page 93; paragraph 4 – " . . both direct and cumulative effects of climate change may affect the resilience of the wolverine by creating an environment that is less favorable to its physiological and ecological needs." Yet on page 95; paragraph 2 – " . . we do not predict a significant loss of individual and population resiliency to the species in the future within its North America range, including the

contiguous United States." And page 95; paragraph 3 – "We do not expect a reduction in representation of the wolverines in the contiguous United States in the future."

In regards to the 2 statements with conclusions regarding the population in the contiguous U.S.:
page 95; paragraph 2 - " . . we do not predict a significant loss of individual and population resiliency to the species in the future within its North America range, including the contiguous United States." And page 95; paragraph 3 – "We do not expect a reduction in representation of the wolverines in the contiguous United States in the future."
Known wolverine natal dens in the contiguous US are in deep snow areas. New data from northern Canada, Russia, and Scandinavia doesn't change that. Wolverines seem to be made for occupying deep snow; their large feet, frost-resistant fur, powerful jaws for eating frozen meat, foot-load, threshold of thermoneutrality all indicate that they are adapted to a deep-snow, cold environment. Their global distribution is largely restricted to areas that are snowy and cold. In the contiguous US they are currently only found in northern, high mountain ranges. They live in the snow, they give birth to altricial young in the middle of winter at elevations with deep snow. And they seem to be able to do that by caching food items in snowbanks that last year round (Inman et al. 2012). The conclusions in the Draft SSA seem to be based on the assumption that wolverines don't need deep snow and can survive/adapt to areas without snow because there is no data showing exactly why deep snow is needed by wolverines, or because there is no data that precisely proves that wolverines cannot survive in areas without snow. Wolverines in the North Cascades only used high elevations year-round (Aubry et al. 2016) despite the fact that one of their reportedly primary food sources, ungulate carrion, is much more abundant at lower elevations. The Draft SSA does not make a compelling argument that this population is secure into the future, especially with a changing climate that will reduce and constrict the amount of deep snow habitat in the Cascade and Rocky Mtn ranges.

Thank you for the opportunity to comment.

DRAFT
SPECIES STATUS ASSESSMENT
FOR THE
NORTH AMERICAN WOLVERINE
(*Gulo gulo luscus*)

Wolverines in southwestern Montana. *Photo credit: Mark Packila; used with permission.*

U.S. Fish and Wildlife Service

Version 1.0
October 23, 2017

Suggested citation:

U.S. Fish and Wildlife Service. 2017. Species status assessment report for the North American wolverine (*Gulo gulo luscus*). Version 1.0. October 2017. U.S. Fish and Wildlife Service, Mountain-Prairie Region, Lakewood, CO.

Executive Summary

The North American wolverine (*Gulo gulo luscus*; wolverine) is a medium-sized carnivore found across the west-northwestern contiguous United States, Alaska, and Canada. The most recent estimate of wolverine populations in the contiguous United States based on resource function modeling is 318 individuals, with a range from 249 to 949; however, systematic monitoring across the wolverine's North American range has not been conducted given the difficulty in surveying this highly mobile species, and its occupation across large and remote areas. A multi-state effort to determine wolverine occupancy in Montana, Idaho, and Washington was conducted in winter of 2016–2017 and in Wyoming for the winters of 2015 and 2016–2017. Results from this study are still being analyzed, but photographic detections of wolverines were found across all States, including areas where wolverines have not recently been observed. In Canada, the population is estimated to exceed 10,000 mature individuals and has been stable over the last two decades. Recent density estimates indicate no declining trend for wolverines in Alaska. Wolverine populations in Alaska are considered to be continuous with populations in the Yukon and British Columbia provinces of Canada. Wolverines that occupy the North Cascades region are known to move from Washington into British Columbia.

Wolverines are highly mobile, capable of moving and dispersing over great distances over short periods of time. Wolverine populations are also characterized by naturally low densities in North America. The species is highly territorial, with very little overlap between same-sex adults. Wolverines occupy a variety of habitats, but are generally found in remote locations, away from human settlements. Wolverines consume a variety of food resources and seasonal switching of prey likely allows for adjustment for nutritional needs throughout their life history. As observed in other arctic mammals, wolverines have the ability to dissipate body heat to balance the heat loss from 30°C to −40°C (86°F to −40°F), due in large part to vasodilatation and rise of skin temperature, and rapid and seasonal adjustments in fur insulation. Wolverines can also adapt to both cold and warm temperatures by movement and, relatedly, micro- and macro-habitat selection. Further, wolverines have been observed near and in lakes and other water bodies.

Wolverine reproduction includes the following characteristics: polygamous behavior (i.e., male mates with more than one female each year), delayed implantation (up to 6 months), a short gestation period (30–40 days), denning behavior and an extended period of maternal care (3.5 months). The reproductive behavior in wolverines is temporally adapted to take advantage of the availability of food resources, limited interspecific competition, and snow cover in the winter.

Since the publication of the Service's 2013 proposed rule to list the distinct population segment of the North American wolverine in the contiguous United States (78 FR 7864; February 4, 2013), several new wolverine studies have been published, which has added to our understanding of wolverine biology while also highlighting new insights into identifying key species' needs and their interactions with both abiotic and biotic factors. In particular, wolverine populations and wolverine dens have been observed outside previously modeled projections of spring snow cover. Our evaluation of snow cover at previously recorded natal den site locations in the western United States indicated that 'melt-out' dates at these locations extend well past the May 15 date used in persistent spring snow cover models.

Overall, the best available information indicates that within the contiguous United States the wolverine's physical and ecological needs include:

(1) large territories in remote landscapes; at high elevation (1,800 to 3,500 meters (5,906 to 11,483 feet));
(2) access to a variety of food resources, that varies with seasons; and
(3) physical/structural features (e.g., talus slopes, rugged terrain) linked to reproductive behavioral patterns.

In this Species Status Assessment (SSA) Report, we provide a discussion of the ecological needs of the wolverine, its current conditions, and projected future conditions. We evaluate potential stressors to the species, with a particular focus on the impacts associated with projected effects of climate change.

In our analysis, we applied the conservation biology principles of redundancy, resiliency, and representation (collectively known as the "3Rs") to evaluate the current and projected future condition of the wolverine and its ability to sustain itself (as one or more populations) in the wild over time (Carroll *et al.* 1996, entire; Wolf *et al.* 2015, entire). This evaluation considers the unique demographic, distribution, and diversity characteristics unique to the species. After applying the framework of the 3Rs, we determined the following:

(1) Redundancy: The wolverine occurs across the contiguous United States within a metapopulation structure. The best available information indicates that the species continues to expand into historical, previously occupied areas in the contiguous United States following decades of hunting and trapping.
(2) Representation: The wolverine is currently found across the west-northwestern United States, as well as much of Canada, and Alaska. The best available information indicates that the species is found across a wide range of habitats. Modeled primary habitat for the wolverine in the contiguous United States has been estimated at 164,125 square kilometers (km^2) (63,369 square miles (mi^2).
(3) Resiliency: The wolverine appears resilient within its contiguous United States range. The species exhibits physiological (e.g., seasonal changes in fur) and behavioral plasticity in its life history (e.g., reproduction, feeding, movement and use of habitat). Estimated population size and growth rates across its North American range are uncertain, but the best available information does not suggest that abundance is declining in the contiguous United States, or in North America. The most significant stressor currently and in the future appears to be the effects of climate change, such as warming temperatures and loss of snowpack. However, based on the best available information, we have no indication that this species is unable to adapt or adjust to changing conditions.

Demographic risks to the species from either known or most likely potential stressors (i.e., effects from roads, disturbance due to winter recreational activities, effects of wildland fire, and overutilization) are low based on our evaluation of the best available information as it applies to current and potential future conditions for the wolverine and in the context of the attributes that affect its viability. We analyzed the potential effects of climate change to wolverine habitat, including snow persistence in the Northern and Southern Rocky Mountains. The future

timeframe evaluated in this analysis is approximately 40 to 50 years, which captures the range of time periods for proposed projects within the species range, as well as our best professional judgment of the projected future conditions related to climate change, wildland fire conditions, or other potential cumulative impacts. While population information is lacking for this subspecies in some parts of its range, the best available information does not indicate that, winter recreational activities, infrastructure features, mortality from road crossings or trapping (authorized and incidental), currently or in the future will result in a decline in the subspecies across its range. Our evaluation of climate change indicates that snow cover is projected to decline in response to warming temperatures and changing precipitation patterns, but this varies by elevation, topography, and by geographic region. In general, models indicate higher elevations will retain more snow cover than lower elevations, particularly in early spring (April 30/May1). Further, significant snow persistence (greater than 0.5 meters (20 inches)) is projected at high elevations.

Legal protections include State listing in California and Oregon (as threatened), as endangered in Colorado, as a candidate species in Washington, and protection as a non-game species in Idaho and Wyoming. In Canada, provincial designations range from endangered to threatened in eastern provinces, and sensitive/special concern to no ranking in other provinces. Legal trapping or hunting of wolverines is currently prohibited in the contiguous United States. Trapping effort along the U.S.–Canada border does not represent a significant barrier to wolverine movement and dispersal along the international border.

Within the contiguous United States, approximately 96 percent of modeled wolverine primary habitat is located on Federal lands, with 41 percent located in designated wilderness areas. Management actions, including State Wildlife Action Plans, the Idaho Wolverine Conservation Plan, and USDA Forest Service Land and Resource Management Plans, and other Federal and Tribal partners, include winter road closures, fire management, land acquisition or conservation easements.

Abbreviations and Acronyms Used

ADF&G = Alaska Department of Fish and Game
BLM = Bureau of Land Management
°C = degrees Celsius
CDFW = California Department of Fish and Wildlife
CNDDB = California Natural Diversity Database
COSEWIC = Committee on the Status of Endangered Wildlife in Canada
cm = centimeter
DNA = deoxyribonucleic acid
EIS = Environmental Impact Statement
EPA = U.S. Environmental Protection Agency
°F = degrees Fahrenheit
ft = feet
GCMs = Global Climate Models
GHG = Greenhouse gas
GPS = Global Positioning System
IDFG = Idaho Department of Fish and Game
in = inch
IPCC = Intergovernmental Panel on Climate Change
IUCN = International Union for Conservation of Nature and Natural Resources
kg = kilogram
km = kilometer
lb = pound
m = meter
mi = mile
MODIS = Moderate-Resolution Imaging Spectroradiometer
Montana FWP = Montana Fish, Wildlife, & Parks
NRC = National Research Council
NRIS = Natural Resource Information System
ODFW = Oregon Department of Fish and Wildlife
RCPs = Representative Concentration Pathways
Service = U.S. Fish and Wildlife Service
SSA = Species Status Assessment
SCA = Snow Covered Area
SGCN = Species of Greatest Conservation Need
SWCC = Southwestern Crown of the Continent
SWE = Snow Water Equivalent
WAFWA = Western Association of Fish and Wildlife Agencies
WDFW = Washington Department of Fish and Wildlife
WGFD = Wyoming Game and Fish Department
WRCC = Western Regional Climate Center
WSWCP = Western States Wolverine Conservation Project
YBP = Years Before Present

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Introduction

The wolverine (*Gulo gulo*) is the largest member of the Mustelidae family (weasels, mink, marten, and others) and resembles a small bear with a bushy tail (Hash 1987, p. 575). Wolverines have a Holarctic distribution that includes the northern portions of Europe, Asia, and North America. In North America, they are found in Alaska, much of Canada, and the western-northwestern United States. The wolverine is important to the culture of Native Americans and Aboriginal Peoples in North America, as is its conservation status in aboriginal territory (Cardinal 2004, p. iv; Edmo 2016; pers. comm.; Miles 2017, pers. comm.).

Wolverines possess a number of morphological and physiological adaptations that allow them to travel long distances and they maintain large territories in remote areas (Pasitschniak-Arts and Larivière 1995, p. 6). They have been described as curious, intelligent, and playful, but cautious animals (e.g., Krott 1958, p. 241; Krott 1960, pp. 25–26; Magoun 1985, p. 94; Cardinal 2004, p. 7–8; Woodford 2014; entire), though their social behavior and social organization has not been well-studied.

During the late 1800s and early 1900s, the wolverine population declined or was extirpated in much of the conterminous United States (lower 48 States), which has been attributed to over-trapping and habitat degradation (Hash 1987, p. 583). Similar range reductions and extirpations of some wolverine populations were observed in parts of Canada during this time period (van Zyll de Jong 1975, entire; Committee on the Status of Endangered Wildlife in Canada (COSEWIC) 2014, p. iv), attributed largely to human exploitation and availability of food (e.g., decline in caribou (*Rangifer tarandus*)), not climate or habitat changes (van Zyll de Jong 1975, pp. 434, 436). Habitat loss (historic vs. current range) for the North American wolverine (i.e., Canada and United States) has been estimated at 37 percent (Laliberte and Ripple 2004, p. 126). Wolverine numbers have recovered to some extent from this decline; in the United States, wolverines are currently found in parts of Washington, Oregon, Idaho, Montana, Wyoming, and California, and, as recently as 2012 in Colorado and 2016 in Utah, though not all of these areas contain resident, reproductive populations.

Species Status Assessment Methodology

In preparing the Species Status Assessment (SSA) Report for the wolverine, we reviewed available reports and peer-reviewed literature, incorporated survey information, and contacted species experts to collect additional unpublished information for the North American subspecies (*Gulo gulo luscus*), including Canada and Alaska. We identified uncertainties and data gaps in our assessment of the current and future status of the species. We also evaluated the appropriate analytical tools to address these gaps and conducted discussions with species experts and prepared updated maps of the known species' range and denning areas across North America. In some instances, we used publications and other reports (primarily from Fenno-Scandinavia) of the Eurasian subspecies (*Gulo gulo gulo*) in completing this assessment.

Importantly, we note here that, since the publication of the 2013 proposed listing rule (78 FR 7864; February 4, 2013), many new wolverine studies have been published, which has added to our understanding of wolverine biology while also highlighting new insights into identifying key

species' needs and their interactions with both abiotic and biotic factors. This is particularly relevant for a difficult to study animal like the wolverine.

Using the species, individual, and population needs identified for the wolverine and location results from surveys and studies, we conducted a geospatial analysis to estimate the North American wolverine's current range. We then evaluated this range and previous estimates of potentially suitable habitat in the west-northwestern United States to assess the species' current conditions within that region. Our future condition analysis includes the potential conditions that the species or its habitat may face, that is, the most probable scenario if those conditions are realized in the future. This most probable scenario includes consideration of the sources that have the potential to most likely impact the species at the population or rangewide scales in the future, including potential cumulative impacts. Potential future impacts associated with climate change (probabilistic estimates for temperature and precipitation) were based on downscaled climate model projections, including a detailed study of two regions in the western United States (Glacier National Park and Rocky Mountain National Park).

For the purpose of this assessment, we generally define viability as "consisting of self-sustaining populations that are well distributed throughout the species' range," and where "[s]elf-sustaining populations are those that are sufficiently abundant and have sufficient genetic diversity to display the array of life history strategies and forms that will provide for their persistence and adaptability in the planning area over time" (Committee of Scientists 1999, p. 38). We use a timeframe of approximately 40 to 50 years because it is within the range of the available modeling efforts related to climate change. We believe this is a reasonable timeframe to consider as it includes the potential for observing these effects over several generations of the wolverine.

Using the SSA framework (Figure 1), we consider what the species needs to maintain viability by characterizing the status of the species in terms of resiliency, redundancy, and representation (Wolf *et al*. 2015, entire).

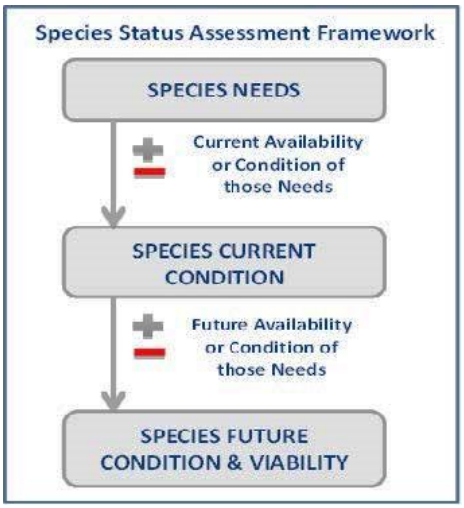

Figure 1. Species Status Assessment Framework.

- **Resiliency** is having sufficiently large populations for the species to withstand stochastic events (arising from random factors). We can measure resiliency based on metrics of population health; for example, birth versus death rates and population size. Resilient populations are better able to withstand disturbances such as random fluctuations in birth rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the effects of anthropogenic activities.
- **Redundancy** is having a sufficient number of populations for the species to withstand catastrophic events (such as a rare destructive natural event or episode involving many populations). Redundancy is about spreading the risk and can be measured through the

duplication and distribution of populations across the range of the species. The greater the number of populations a species has distributed over a larger landscape, the better it can withstand catastrophic events.

- **Representation** is having the breadth of genetic makeup of the species to adapt to changing environmental conditions. Representation can be measured through the genetic diversity within and among populations and the ecological diversity (also called environmental variation or diversity) of populations across the species' range. The more representation, or diversity, a species has, the more it is capable of adapting to changes (natural or human caused) in its environment. In the absence of species-specific genetic and ecological diversity information, we evaluate representation based on the extent and variability of habitat characteristics within the geographical range.

Species Description

Taxonomy

The taxonomic relationship between North American and Eurasian wolverines has been a debated topic (Pasitschniak-Arts and Larivière 1995, p. 1). Most authorities consider all wolverines to belong to a single species, *Gulo gulo* (Rausch 1953, p. 114; Kurten and Rausch 1959, p. 19; Wozencraft 2008 [in *Wilson and Reeder's Mammal Species of the World*, online publication]). Some also further consider the New World and Old World wolverines to be two subspecies, *Gulo gulo luscus* and *G. g. gulo*, respectively, based on morphological measurements. Degerbøl (1935, pp. 35–43) noted slight color differences and very slight, if any, cranium differences, based on 10 North American (Hudson Bay) specimens examined, and regarded the North American and Old World wolverines as conspecific, but identified two subspecies. This reference also cites Coues (1877, p. 43), who, based on observations of a slight similar cranium difference, had posited that the wolverines of the Old World and New World were the same species (Degerbøl 1935, p. 35).

In their *Checklist of Palaearctic and Indian Mammals* (1st and 2nd editions) Ellerman and Morrison-Scott (1951, p. 251; 1966, p. 251) identified one species of wolverine, but listed several subspecies. A comparative analysis of various measurements from 1 wolverine skull collected from the northern Ural Mountains to 41 Alaskan skulls by Rausch (1953, entire) reported "no appreciable differences," noting the highly variable skull characteristics for the Alaskan specimens. Additionally, Krott (1960, p. 20) found no distinct differences between Old World and New World wolverines, and that pelt size and quality were not distinguishable. However, using biometric measurements of both newly collected and previously published cranial measurements (e.g., Degerbøl 1935; Rausch 1953), Kurtén and Rausch (1959, p. 19) reported that the North American and European wolverine were significantly different in several quantitative characters related to the size and shape of the skull size and teeth size. They concluded that the two wolverine populations represented two distinct subspecies, but were the same species, *Gulo gulo*.

The International Union for Conservation of Nature and Natural Resources (IUCN) states that "Most recent accounts [citing Jones *et al*. 1992, Pasitschniak-Arts and Larivière 1995, Wozencraft 2005] treat *luscus* as a subspecies of *Gulo gulo*, following Degerbøl (1935) and

Kurtén and Rausch (1959)" (Abramov 2016, p. 1). We reviewed the references cited by IUCN. Jones *et al*. (1992, p. 17) only considers *Gulo gulo*. Pasitschniak-Arts and Larivière (1995, p. 1) state there are differences in the taxonomic treatment, and that, while *Gulo gulo* is now considered by most to be the extant *species*, others (including the above-cited Kurtén and Rausch (1959) and Rausch (1953)) have considered two *subspecies*. The Wozencraft (2005) citation is from Wilson and Reeder's previous 2005 publication, which was updated as of 2008. That account lists several "offspring" of *Gulo gulo*, but does not provide citations for the subspecies identified there, and at least two of those listed are not considered to be subspecific entities (e.g., *G. g. vancouverensis* and *G. g. luteus* (see Banci 1982, p. ii; Banci 1994, p. 104)). Finally, the COSEWIC Assessment and Status Report on the Wolverine (*Gulo gulo*) in Canada indicated that taxonomists recognize only a single subspecies (*Gulo gulo luscus*) in North America *or* consider *G. gulo* as single Holarctic taxon (COSEWIC 2014, p. 4).

Genetic analyses for the North American wolverine populations have primarily focused on genetic structure and variation of wolverine populations or subpopulations (see Kyle and Strobeck 2001; Kyle and Strobeck 2002; Zigouris *et al*. 2012, Zigouris *et al*. 2013). However, Frances' (2008, pp. 20–21) assessment of wolverine spatial genetic structure and demographic history (using mitochondrial DNA) indicated incomplete lineage sorting between North American and Eurasian populations, though comprehensive sampling has not been conducted for some areas (e.g., eastern Asia). A study by Tomasik and Cook (2005, entire) also concluded that reciprocal monophyly (i.e., distinct *species*) had not been attained between Eurasian and North American wolverine populations. Until additional studies are published, including robust genetic analyses in conjunction with additional sampling, the Service recognizes the North American wolverine as *G. g. luscus*.

Physical Appearance

Detailed descriptions of the wolverine are described in Novikov (1962, pp. 196–202), Hash (1987, p. 575), Pasitschniak-Arts and Larivière (1995, pp. 1–2), and Wilson (1982, pp. 644–646), among others. Key distinguishing features are summarized here.

Wolverines are a medium-sized (about 1 meter (m) (3.3 feet (ft)) in length) carnivore, with a large head, broad forehead, and short neck (Pasitschniak-Arts and Larivière 1995, p. 1). Males are larger than females (Hall 1981, p. 1,007; Banci 1987, p. 35). Wolverines have heavy musculature and relatively short legs, and large feet with strong, curved claws for digging and climbing (Hash 1987, p. 575). Their feet are well-adapted for travel through deep snow and, during the winter, dense, stiff, bristle-type hairs are found between the toes and around the foot pad (Grinnell *et al*. 1937, pp. 265–266; Hash 1987, p. 575); this characteristic becomes diminished in the summer (Hash 1987, p. 575).

Adult wolverines are sexually dimorphic, with females weighing from 7 to 13 kilogram (kg) (15.4 to 29 pounds (lbs)) and males weighing between 10 to 18 kg (22 to 40 lbs) (North America) (Rausch and Pearson 1972, p. 264; Magoun 1985, pp. 19–21; Banci 1994, p. 99; Copeland 1996, p. 20; Cardinal 2004, p. 8; Lofroth 2001, p. 11; Inman 2013, pers. comm.; Magoun 2013, pers. comm.; Aubry *et al*. 2016, pp. 17–18). The skulls of wolverine are large and heavy, and the strong jaw structure allows animals to feed on frozen flesh and crush bone

(Haglund 1966, p. 269; Hash 1987, p. 575). Some geographic variation and sexual differences in skull morphology have been reported (Pasitschniak-Arts and Larivière 1995, p. 2). Wolverines have small, wide-set eyes, and are reported to have excellent hearing (Grinnell *et al*. 1937, p. 265; Krott 1960, p. 25; Bevanger 1992, p. 8).

Wolverine fur is short, thick, and uniform in thickness on the head and becomes longer towards the rear of the body (Hash 1987, p. 1). The coat consists of dense, woolly underfur (2-3 centimeters (cm) (0.8-1.2 inches (in) long) and coarse, stiff guard hairs, 6-10 cm (2.4-4 in) in length (Hash 1987, p. 1). The rich glossy coat can vary from medium brown to black (Banci 1994, p. 99; Pasitschniak-Arts and Larivière 1995, p. 1). Seasonal and individual variation in pelt color has been described (Degerbøl 1935, pp. 38–42; Grinnell *et al*. 1937, p. 252). In general, the head, tail and legs are darker than the face (Pasitschniak-Arts and Larivière 1995, p. 1). An upper body stripe, which varies from creamy, pale buff to light brown or reddish in color (Pasitschniak-Arts and Larivière 1995, p. 1), extends from the nape of the neck, along the sides of the body, to the base of the bushy tail (Banci 1994, p. 99). White or orange patches are commonly found on the throat or chest (Pasitschniak-Arts and Larivière 1995, p. 1; Magoun *et al*. 2008, p. 24; Figure 14). The unique property of wolverine fur to shed frost (Hardy 1948, p. 330; Quick 1952, pp. 492–493), along with its rarity, has made wolverine pelts valuable for trade (Hash 1987, p. 575).

Various accounts state that wolverines have a strong sense of smell (Grinnell *et al*. 1937, p. 265; Bevanger 1992, p. 8) that allows them to locate carrion from great distances (Hornocker and Hash 1981, p. 1,297; *in litt.* Bevanger 1992, p. 8, citing Røskaft 1990; Copeland 1996, p. 100; Cardinal 2004, p. 8); however, experiments with young wolverines indicated a poor sense of smell, and that wolverines may locate food (areas where previously located or cached) based on their memory skills (Magoun 2013, pers. comm.) or learning abilities (e.g., Krott 1958, p. 241).

Scent-marking is used by mammalian carnivores for chemical communication (Hutchings and White 2000, p. 160). For wolverines, this behavior commonly includes urination (e.g., trees, stumps, snow) (Copeland 1996, p. 115; Magoun 1985, p. 105), but also includes scat, and scratches and bites on trees (Haglund 1966, pp. 225, 277; Copeland 1996, p. 115). Scent rubbing (see review by Rieger 1979) of the ventral (abdomen/stomach) area and anal rubbing have also been observed in wolverines (Pulliainen and Oyaskainen 1975, pp. 268–269; Rieger 1979, p. 22, *in litt.* Goethe 1964; Magoun 1985, p. 105). Scent marking by wolverines may also be an important chemical communication signal for potential wolverine prey. Field experiments conducted by Sullivan *et al*. (1985, pp. 928, 930) and Sullivan (1986, p. 388) found that black-tailed deer (*Odocoileus hemionus columbianus*) and snowshoe hares (*Lepus americanus*) avoided feeding on seedlings that were marked with wolverine urine.

Life History and Ecology

In this section we provide a summary of the individual and population needs (collective, species needs), including its life history, physiology and behavior, resource functions necessary for each life stage (i.e., breeding, feeding, sheltering, dispersal), demographic information (abundance and distribution) and ecological setting.

Overview

Wolverines are active year-round and have been considered as primarily nocturnal (Iversen 1972b, p. 319; Pasitschniak-Arts and Larivière 1995, p. 7, and references cited therein). In his observational studies, Krott (1958, p. 168; 1960, p. 25) described periods of 3-4 hours of activity followed by 3-4 hours of sleep for wolverines in Scandinavia, a pattern also observed in Idaho (Copeland 1996, p. 77).

A study of body temperatures of caged wolverines, along with direct observations of animals obtained from Alaska and Sweden and previous studied animals (Alaska), suggested that wolverines were a day-active species, being very active in the morning, with periods of sleep during the night, a pattern that persisted in both winter and summer (Folk *et al*. 1977, p. 233). However, crepuscular activity (period just after dawn and just before sunset) may be a more accurate description for wolverine behavior (McCue *et al*. 2007, pp. 98–99). Others have remarked that wolverines exhibit a plasticity in their behavior (i.e., different behavior under different conditions) (Krott 1960, p. 26), a result attributed, in part, to their being a scavenging carnivore covering large areas (Stewart *et al*. 2016, pp. 1,495, 1,497). Several aspects of this plasticity are described below.

Wolverines are wide-ranging animals and known for traveling great distances in a short period of time (Krott 1960, p. 21; Gardner *et al*. 1986, p. 603; Woodford 2014, entire) (see Movement section below). This is due, in part, to their unique body structure. As described by Krott (1960, p. 20), they are "lumbrosacrally overbuilt" with heavy musculature and legs that are acutely angled when walking. Wolverine gait is characterized as either a 2X pattern (when patterns of two footprints repeat), used primarily in deep snow, and the more common 3X lopes (patterns of three footprints), for covering long distances over more compacted snow (Halfpenny *et al*. 1995, p. 104). The latter is described as a bouncing gait where all four feet may leave the ground at the same time (Halfpenny *et al*. 1995, p. 104).

As noted in our Species Description section above, in winter, the dense hairs on the foot pad and its body structure supports a low foot load, which has been estimated at 22 gram/cm^2 (Knorre 1959, p. 26) and 27–35 gram/cm^2 (Novikov 1962, pp. 22–23 (citing Dulkeit 1953)). This foot loading is believed to provide an advantage for wolverines preying on ungulates and other large mammals whose movements become restricted in deep snow (Knorre 1959, p. 26; Formozov 1963, pp. 40–41; van Zyll de Jong 1975, p. 435; Banci 1994, p. 113). However, a study of wolverines in boreal forest habitat in Canada present a differing interpretation of the wolverine foot adaptation based on tracking wolverines in snow over three winters (Wright and Ernst 2004a, pp. 58–59), in which they observed wolverines in their study area continuously selected for a path of least snow cover, where practicable, and only traveled in upland areas (Wright and Ernst 2004a, p. 59). They concluded that the low foot load is advantageous when snow crusts form, but, in deep snow, wolverines shift to an inefficient walking gait which increases energy demand (Wright and Ernst 2004a, p. 59). They hypothesized that traveling in deep snow during winter in search of food may increase the risk of starvation due to the greater energy expenditure (Wright and Ernst 2004a, p. 59).

Physiology

The wolverine is a snow-adapted, cold climate animal in its physiology, morphology (Telfer and Kelsall 1984, p. 1,830), behavior, and habits. The wolverine was considered by Formozov (1963, p. 65) as one of several "chioneuphores," or those vertebrates who tolerate snow but have no special adaptations; however, wolverines could also be considered as a "chionphile" or those animals with adaptations for snow (e.g., increased surface area on feet, pelt characteristics) (see definitions in Pruitt 1959, p. 172; Cathcart 2014, p. 22).

In general, mustelids weighing more than 1 kilogram (kg) (2.2 pounds (lbs)) have a basal metabolism (defined as the minimum metabolic rate for maintaining a comfortable warm temperature; Irving 1972, p. 121) that is about 20 percent higher than other mammals (Iversen 1972a, p. 343). For the wolverine, Young *et al*. (2012, p. 222) estimated a basal metabolic rate for a 15 kg (33 lbs) adult at 669.4 kcal/day, using Iversen's derived equation [Metabolic rate (M)=84.6*Weight (W, in kg)$^{(0.78)}$ ± 0.15] (Iversen 1972a, p. 343). By comparison, the estimated basal metabolic rate for a 53 g (1.9 ounce (oz)) least weasel (*Mustela nivalis*) is about 40 kcal/day, and approximately 250 kcal/day for a 3.8–5.5 kg (8.4–12 lbs) Arctic fox (*Vulpes lagopus*) (both sampled from Barrow, Alaska) (Irving 1972, p. 115; Figure 9.1).

Experimental studies by Iversen (1972, pp. 320–321; Figure 4) found that during their first 2½ months, the basal metabolic rate for young wolverines was substantially higher than rates reported for other mammals ($W^{1.41}$ vs. $W^{1.0}$), then declined after 3 months, and declined again after 8 months. Because the early period coincides with weaning, Wilson (1982, p. 646) suggested that the observed peak may be related to changes in food consumed as well as improved thermoregulation since the mother is leaving the young for longer periods of time.

Energy expenditure during pregnancy is relatively low for mustelids (Oftedal and Gittleman 1989, p. 374); however, energy requirements for lactation in mammals can be over 4 to 7 times basal metabolic rates (Allen and Ullrey 2004, p. 478). Thus, estimates of energetic requirements (e.g., less than 1 kg prey/day annually) may be too low to support reproductive activity (Young *et al*. 2012, p. 226). Wolverines are known to consume a variety of food resources and seasonal switching of prey likely allows for adjustment for nutritional needs throughout their life history (Krebs *et al*. 2007, p. 2,187 (Canada); Koskela *et al*. 2013a, pp. 103–104 (Finland); Yates and Copeland *in prep* (Montana)). Additional details on diet and feeding behavior for wolverines are provided below.

Relatedly, Casey *et al*. (1979, p. 335) evaluated metabolic and respiratory responses of eight terrestrial Arctic mammals to ambient temperature during summer months. For wolverines, they found that the frequency of respiration was generally constant (15-20 per minute), but their tidal volume (air moved per breath) increased nearly constantly with *decreasing* ambient temperature, unlike Canada lynx (*Lynx canadiensis*), which is similar in body mass (Casey *et al*. 1979, p. 335). The researchers inferred that the increased ventilation of wolverines at low ambient temperatures was the result of an increased energy metabolism (Casey *et al*. 1979, p. 336).

Thermal neutrality (or **thermoneutrality**) is the temperature range at which resting metabolism is at minimum (Barnett and Mount 1967, p. 468) and animals produce heat at a minimum rate in

a thermal neutral environment (Barnett and Mount 1967, p. 413). For a resting mammal at thermal neutrality, body temperature is primarily maintained by "physical thermoregulation," that is, control of circulation in the skin and by sweating (Barnett and Mount 1967, p. 413). The body temperature of wolverine (measured by an implanted temperature transducer) at thermoneutrality has been reported at 38°C (100.4°F) (Folk *et al*; 1977, p. 231; Casey *et al*. 1979, pp. 332–333). The **critical temperature** is the point at which the metabolic rate starts to rise; thus, animals with lower critical temperatures are able to better conserve their energy expenditure (Barnett and Mount 1967, p. 413). Studies of arctic mammals defined a zone of thermoneutrality in Eskimo dogs (*Canis lupus familiaris*) and Arctic foxes that extended to at least −40°C (−40°F), with an estimated critical temperature between −45°C (−49°F) and −50°C (−58°F) (Scholander *et al*. 1950a, p. 254).

Arctic mammals, including wolverine, Arctic fox, and wolf (*Canis lupus*), have a threshold of thermoneutrality of between −30°C to −40°C (–22°F to –40°F) (Iversen 1972b, p. 322; citing studies by Scholander *et al*. (1950b) and Hart (1956)). Relatedly, Casey *et al*. (1979, p. 340) estimated a critical temperature for wolverine (14 kg (31 lb)) in *summer* pelage of 5°C (41°F) based on an observed increase in oxygen uptake at air temperatures below this temperature. For comparison, measurements of metabolic rates for the red fox (*Vulpes vulpes alascensis*) (Alaska) observed critical temperatures of 8°C (46°F) in summer (Irving *et al*. 1955, p. 184). These Arctic mammals therefore have the ability to dissipate heat to balance the heat loss from 30°C to −40°C (86°F to −40°F), due in large part to vasodilatation and rise of skin temperature (Scholander *et al*. 1950a, p. 251).

Arctic mammals, particularly small mammals, also adapt behaviorally to cold temperatures by creating burrows and building nest sites under the snow. Wolverines are known to dig holes in snow for shelter (Pruitt 2005, p. 120), and wolverine reproductive den sites located under deep snow may provide a thermoneutrality advantage for newborn cubs (Magoun and Copeland 1998, p. 1,313). This topic is discussed in more detail below under Use of Dens and Denning Behavior.

Wolverines can also adapt to both cold and warm temperatures by movement and, relatedly, micro- and macro-habitat selection. Wolverines have been observed near and in lakes and other water bodies and are good swimmers, easily crossing lakes and rivers (Seton 1909, p. 950; Krott 1960, p. 23; Magoun 2017, pers. comm.). They likely use these areas more frequently during warmer months both for cooling and hydration, or possibly for hygienic reasons (Krott 1960, p. 23).

Changes in endocrine (hormone) function can also represent a physiological adaptation to cold by acting on organs to generate energy (Barnett and Mount 1967, p. 428). The best available information does not indicate that these functions have been evaluated in wolverines. However, one veterinarian reported an enlarged thyroid in a wolverine during a necropsy procedure (Copeland 2017, pers. comm.), which is suggestive of a high metabolism.

In addition to these physiological processes, rapid and seasonal adjustments of fur insulation provide an additional mechanism for mammals to overcome large seasonal changes in temperature (Casey *et al*. 1979, p. 340) and have been described for wolverine and other mammals in Alaska (Henshaw 1970, p. 522). The seasonal increase in fur depth for captive

wolverines was reported to be 65 percent (Henshaw 1970, p. 522). That study identified a metric termed seasonal insulative advantage (or SIA) as a measure of the degree to which insulative compensation changes seasonally in response to ambient temperature (Henshaw 1970, p. 522). For wolverines, this advantage was found to be less than unity; that is, the increase in fur did not fully compensate for average winter cold, and therefore other compensating mechanisms were needed (Henshaw 1970, p. 522).

Similarly, an evaluation of the seasonal change in the insulation of fur of wolverine (pelts from Canada) found a 41.2 percent change in mean insulation values (measured as °C/cal/m^2/hr) from winter to summer (Hart 1956, p. 56). A single annual molting (between August and December) was noted in Grinnell *et al*. (1937, p. 251) (California), but twice yearly was described by Novikov (1962, p. 201) (Russia). The large seasonal change in insulation observed for wolverine and other larger mammals is, in large part, due to changes in fur depth, and can be interpreted as an adaptation to both high summer temperatures and low winter temperatures (Hart 1956, p. 57). The reported seasonal decrease in wolverine fur thickness also correlates with experimental results of Casey *et al*. (1979, p. 337) who indicated that a seasonal shift in oxygen consumption below critical temperature was likely due to an increased rate of heat loss in summer.

Range and Habitat Use

Historical Range and Distribution

Phylogeography/Phylogenetics

Results from a molecular study of phylogenetic relationships of the Mustelidae family suggest at least six radiation episodes within this family since the Early Eocene Epoch (approximately 50 million years before present (YBP)) (Marmi *et al*. 2004, pp. 488, 492). The split of the marten (*Martes*, *Gulo*) and weasel (*Mustela*) lineages occurred in the Early Middle Miocene Epoch (14 to 11 million YBP), with the separation of Old World and New World lineages (*Martes*, *Gulo*) occurring in the Late Miocene Epoch (8.6 to 5.8 million YBP) (Marmi *et al*. 2004, p. 488). The *Gulo* genus appears in the fossil record in the mid-Pleistocene in both Europe and North America (Bryant 1987, p. 659).

The dispersal of *Gulo* across Beringia (land mass that extended from Siberia into interior Alaska during the Pleistocene) is believed to have produced contemporaneous records for the species in Europe and North America (Bryant 1987, p. 659). Genomic data was examined using a molecular dating technique to estimate an approximate age of the *G. gulo* ancestor (Malyarchuk *et al*. 2015, entire). The researchers estimated a relatively recent origin of the species *Gulo gulo* at about 181,000 to 234,000 YBP (Malyarchuk *et al*. 2015, pp. 1,115–1,116). They note that this latter time period corresponds to the Riss glaciation period (187,000 to 230,000 YBP), a time of genetic divergence of amphi-Beringian (both sides of Beringia) species and speciation events (Hope *et al*. 2013, p. 426). Their results, along with fossil information, also indicate the divergence of the *Gulo* branch and the other *Martes* taxa occurred during the Late Miocene-Early Pliocene (5.6 million YBP), and lends support for strong evolutionary processes in the northern Siberian ecosystems in the Pliocene and Pleistocene Epochs (Malyarchuk *et al*. 2015, pp. 1,116–1,117).

An evolutionary trend was described in which *Gulo* increased in size from the mid- to late-Pleistocene, with a subsequent reduction in size post glaciation, as well as small changes in selected teeth, and a possible shift to colder habitats (Bryant 1987, p. 660). The Late Pleistocene and the Pleistocene-Holocene transition represent the end of prolonged period that was characterized by climate fluctuations followed by rapid warming (Post 2013, p. 28). This analysis also indicated that both the mid-Pleistocene European *Gulo schlosseri* and the early North American *Gulo* appear to be adapted to a warmer climatic environment, but are likely to have also occupied colder climates (Bryant 1987, p. 660). Other factors such as competition (Guilday 1971, p. 237), predator avoidance, and prey abundance may also have been important in creating significant shifts in geographic ranges for certain species during glacial cycles.

Wolverines are believed to have migrated to North America during the late Pleistocene, although fossil evidence from the Pleistocene Epoch for wolverine is limited (Anderson 1977, p. 15; Bryant 1987, p. 660), and most fossil material is either cranial or dental fragments (Bryant 1987, p. 660). A summary of records for both Pleistocene and extant *Gulo* (Bryant 1987, p. 659; Table 3) includes findings in the United States from Colorado, Idaho (e.g., White *et al*. 1984, p. 248 (lava tubes)), Alaska, Maryland, and Pennsylvania, and Canada (primarily the Yukon region) ranging from the Irvingtonian Age (1.8–2.4 million YBP) to Late Wisconsinan-Holocene (15,000 YBP to present day).

Genetic studies can provide an understanding of the postglacial recolonization of wolverines following the Last Glacial Maximum, a period of rapid cooling, and movement patterns due to changed climatic conditions (Frances 2008; Zigouris *et al*. 2013; McKelvey *et al*. 2014). Following the Last Glacial Maximum, beginning about 21,000 YBP, was a period of rapid warming, resulting in a second wave of extinction events, particularly of large mammalian megafauna that were cold-adapted (Post 2013, pp. 29, 31).

During the late Wisconsin period (10,000 to 25,000 YBP), approximately 60 percent of North America was covered by glacial ice (Rogers *et al*. 1991, p. 624). However, several ice-free refugia existed at that time including the Beringian refugium, which included eastern Siberia, most of Alaska, areas of northwestern Canada, and areas of the Bering Sea shelf that were exposed by lower sea levels, and this refugium harbored a number of mammalian species including wolverine (Rogers *et al*. 1991, pp. 624, 626). Analyses by Frances (2008, entire) and Zigouris *et al*. (2013, entire) supported a wolverine colonization of North America in which individuals "followed retreating glaciers" (Zigouris *et al*. 2013, pp. 10–11), beginning about 21,000 YBP, following the Last Glacial Maximum, when a period of rapid warming occurred that resulted in additional extinction events, particularly large mammalian megafauna (Post 2013, p. 29)

A phylogeographic analysis presented by McKelvey *et al*. (2014, p. 331) proposed that a unique haplotype (Cali 1) observed in historical wolverine samples from California was reflective of an independent evolutionary history resulting from isolation (i.e., southern ice-free refugium) of wolverines during glacial retreat. However, Zigouris *et al*. (2013, p. 10, Supplemental Table S5) found the Cali 1 haplotype described by Schwartz *et al*. (2007, p. 2,173; Tables 2 and 4) (relabeled as Haplotype 21) also occurred in historical wolverine samples from the eastern region

of Canada (Quebec-Labrador). In addition, as noted by Zigouris (2014, pp. 232–233) the historical samples analyzed by McKelvey *et al*. (2014, p. 327; Table 1) were primarily those from locations at the southwestern edge of the wolverine's North American range (e.g., California, Colorado, Idaho, Montana, Wyoming, Utah, Washington). Without additional sampling, it is unclear if this particular haplotype distribution from two of the most peripheral North American wolverine populations is a reflection of a skewed dispersal after post-glacial colonization, or was a more widely distributed haplotype that declined or was lost due to hunting and trapping pressures (beginning in 18th century) or fragmentation (late-20th century) (Zigouris *et al*. 2013, p. 10).

Additional discussion of our current understanding of wolverine genetic structure and diversity is provided in the *Population Structure* section below.

Historical Range

In North America, wolverines were historically distributed in much of the northern portion of the continent, extending southward to the northernmost region of the United States (Maine to Washington) or approximately north of the 38th parallel (Hash 1987, p. 576; Banci 1994, p. 102).

An estimate of wolverine observations and distribution in the contiguous United States was prepared by compiling 901 verifiable or documented records of wolverine occurrence dating from 1801 to 2005 from 24 states in the contiguous United States (Aubry *et al*. 2007, entire). This included a total of 809 verifiable or documented records for the Rocky Mountain and Pacific Coast mountains (west-northwestern United States) for this time period (Aubry *et al*. 2007, p. 2,151).

The historical population size of wolverines in Canada is not known (Fortin 2005, p. 4). Its historical distribution, as depicted by Seton (1909, p. 947; Map 51) and also later by van Zyll de Jong (1975, p. 435; Figure 9) shows a broad range across much of Canada. Examples of early descriptive accounts include de Puyjalon (1900, pp. 126–144), who described wolverines as inhabiting Labrador, Canada (de Puyjalon, p. 101), and extending in range to the 66th parallel and perhaps further (de Puyjalon 1900, p. 144); reports of both trapped and live wolverines in Labrador in the late 1700s (Townsend (ed.), 1911, pp. 73, 93, 228, 255); and reports of wolverines as "common" in Canada's Nunavut Territory (Hudson Bay region) during a 1920s Danish excursion (the Fifth Thule Expedition) to Arctic North America (Freuchen 1935, p. 101). The 2014 COSEWIC report presents a historical range distribution for Canada based on personal accounts and interpretation of the fur trade (COSEWIC 2014, pp. 12–13; Figure 3).

Current Range

We created a map depicting wolverine observations for the west-northwestern United States by requesting all available wolverine records from State agencies (e.g., wildlife agencies, natural heritage programs) and the Forest Service Natural Resource Information System (NRIS) Wildlife Database. We found a total of 4,215 records (1800s to 2017) for this portion of the United States (*cf*. 809 records from Aubrey *et al*. 2007; Table 1). Figure 2 presents a map of these compiled

observations, overlaid with the habitat suitability model results presented by Inman *et al*. (2013, p. 281). We acknowledge that some of these records may be in error or inaccurately located, and although wolverines have been reported from the Central Great Plains, Great Lakes region, Upper Midwest, or Northeast (Wilson 1982, p. 650), we did not create a historical range for these regions given the very low number (92) reported by Aubry *et al*. (2007, p. 2,151) from the 1880s to 2005, and to present day, and an incomplete historical record of trapping. We also found a few additional historical records that do not appear in Aubry *et al*. (2007, p. 2,151). For example, Nead *et al*. (1985, entire) identified several positive and probable reports of wolverines in Colorado in the late 1970s. A wolverine was reported from the Squaw Valley region of California in the summer of 1953 (Ruth 1954, pp. 594–595). Our intent in creating this map was to present an overall geographical depiction of the wolverine's estimated range only for the west-northwestern United States, and is not intended to represent an estimate of population numbers.

Using the best available information, we also created a current North American range based on results presented by COSEWIC (2014, p. 12) for Canada and Alaska, Forest Service NRIS data, and more recent observations (e.g., telemetry, camera traps, mortality reports) reported from California, Washington, Colorado, Wyoming, Utah, and North Dakota (e.g., California Natural Diversity Database (CNDDB); Forest Service NRIS; Idaho Department of Fish and Game; Utah Division of Wildlife; Wyoming Game and Fish Department). This range is illustrated in Figure 3.

We recognize that this depiction does not necessarily represent current areas where reproducing populations of wolverines are found, nor does it capture unverified accounts from New Mexico, described in Frey (2006, pp. 20–21) for the Sangre de Cristo Range, and visual observations reported by two individuals (2005 and 2016) in response to our *Federal Register* notice (81 FR71670; October 18, 2016) requesting information for our status review. In addition, we did not incorporate the Central Great Plains, Great Lakes region, Upper Midwest, or Northeast. However, we note here that a female wolverine was observed over several years (2004–2010) in the lower peninsula of Michigan, and genetic testing after her death in 2010 suggested she was more closely associated with eastern Canada wolverine populations (i.e., Manitoba and Ontario) (*in litt* Zigouris 2013, pers. comm.). It's unclear how this individual came to occupy this region, but given the long distant movements reported for this species (e.g., male wolverine that traveled from Wyoming into Colorado and then back to North Dakota), dispersal from Canada is plausible. Wilson (1982, p. 650) reported that wolverines on occasion may enter Minnesota from Canada. Jackson (1961, pp. 359–360) also reported several authentic records of wolverine in Wisconsin and in areas in Minnesota, along the Wisconsin-Minnesota border. However, the wolverine was likely never abundant in Wisconsin, even before trapping and hunting in the late 19th and early 20th centuries (Jackson 1961, p. 359).

We provide a discussion of wolverine population abundance and distribution in more detail in the *Biological Status–Current Condition* section below.

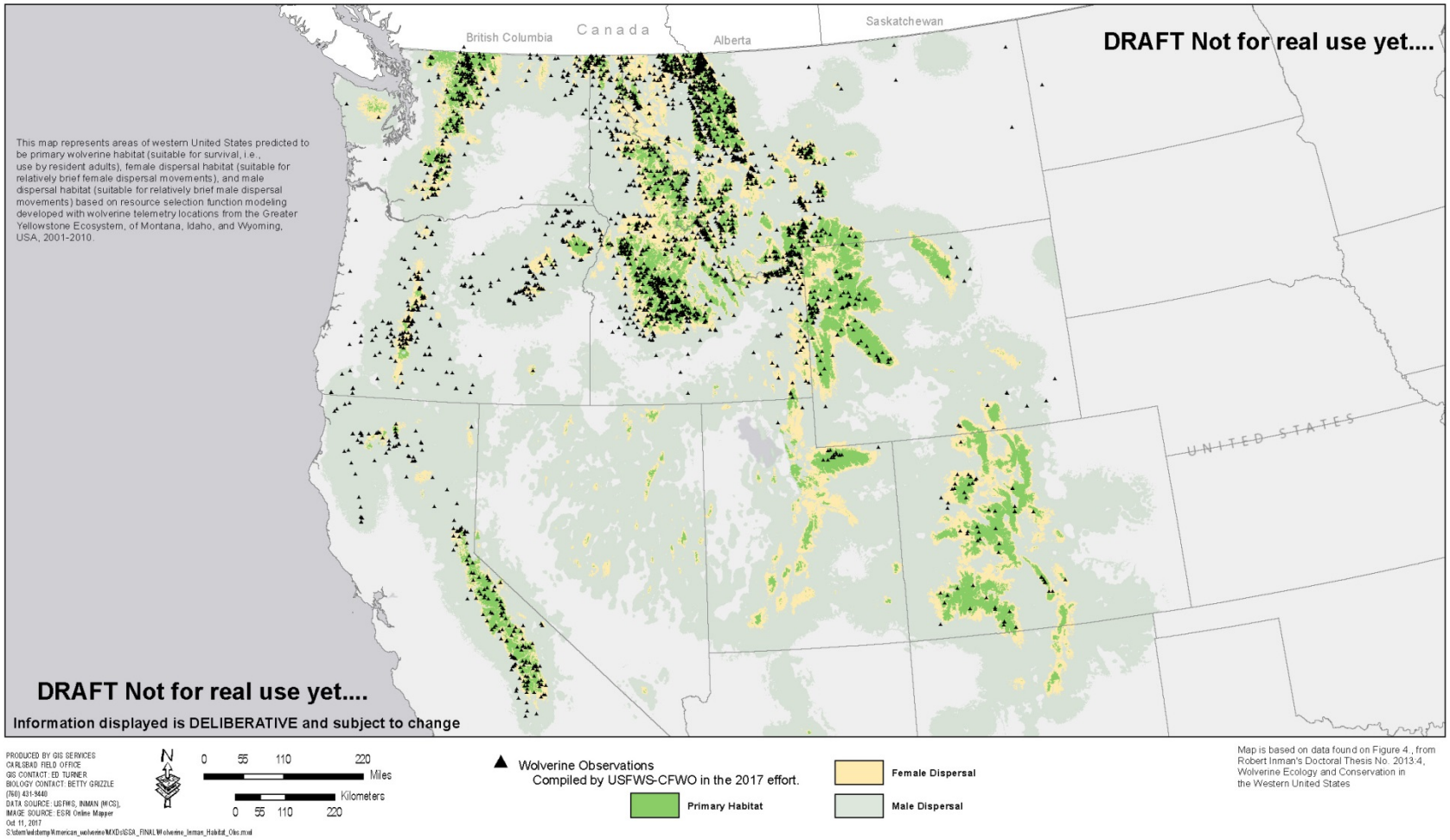

Figure 2. North America wolverine observations within the west-northwestern United States (1800s to 2017); shown with Inman *et al*. (2013) modeled habitat.

Figure 3. Current range of North American wolverine. Adapted from COSEWIC (2014), EPA (2010), Inman *et al*. (2013), records from CNDDB; Forest Service NRIS; Idaho Department of Fish and Game; Utah Division of Wildlife; Wyoming Game and Fish Department, and den records from CNDDB, Inman, and Copeland.

Habitat Use

Wolverines occupy a variety of habitats within their current range, including Arctic tundra, subarctic-alpine tundra, boreal forest, mixed forest, redwood forest, and coniferous forest (Banci 1994, p. 114). However, these broad, landscape-scale vegetation associations can obscure other habitat variables important for wolverines, including features found within peripherally occupied areas or areas of high elevation (Banci 1994, p. 114). In Canada, wolverines use a wide variety of forested and tundra vegetation, at all elevations (COSEWIC 2014, p. 18).

When viewed by ecoregion (U.S. Environmental Protection Agency (EPA) 2010), in general, wolverine observations in the contiguous United States are most commonly found in the Northwestern Forested Mountains ecoregion. In Canada, our estimate of current range includes Northwestern Forested Mountains, Northern Forests, Marine West Coast Forest, Hudson Plain, Taiga (Boreal Forest), Tundra, and parts of the Arctic Cordillera (northeastern fringe of Nunavut and northern Labrador); in Alaska, Marine West Coast Forest, Northwestern Forested Mountains, Taiga, and Tundra are represented. **Appendix A** provides an illustration of these ecoregions of North America in relationship to our Current Range map presented in Figure 3.

Studies of wolverines in central Idaho found that montane coniferous forests comprised two-thirds of available habitat (Copeland 1996, p. 120). Wolverines in this region also exhibited a seasonal preference, with subalpine rock habitats used in summer and montane coniferous forests used most often in winter (Copeland 1996, p. 120). In addition, individuals within this study population commonly crossed natural openings and those areas with little cover, including burn areas, meadows, or open mountain-top areas (Copeland 1996, p. 124).

Observations of summer movements of wolverines in northwestern Montana indicated that both males and females moved to higher, cooler elevations and remained there throughout the summer (Hornocker and Hash 1981, p. 1,299). In the Greater Yellowstone Ecosystem, wolverines selected areas that contained steep terrain with tree cover, high elevation meadows, boulder or talus fields, and avalanche chutes (Inman *et al*. 2012a, p. 785). In this region, wolverines selected elevations at and above the treeline during summer, moved slightly lower during winter, but avoided low-elevation winter ranges occupied by potential prey (e.g., elk) or areas with little human activity (Inman *et al*. 2012a, p. 785). The avoidance of these areas may be the result of lack of tree or talus field cover at these low elevations, in combination with presence of potential predators (e.g., wolf, mountain lion (*Puma concolor*) or competitors (e.g., coyote (*Canis latrans*), bobcat (*Lynx rufus*) (Inman *et al*. 2012a, p. 785).

Several habitat association-type models have been developed for both North American and European wolverines. In the northern Rockies (including Canada and the United States), Carroll *et al*. (2001, p. 975) found that elevation and north-facing cirque habitat variables (i.e., alpine areas), when incorporated into empirical habitat models, were significantly correlated with wolverine occurrence; however, results from multiple regression analyses of these and other habitat variables indicated a high degree of unexplained variance for predicting wolverine habitat relationships, and underscores the inherent difficulty in identifying appropriate metrics to represent difficult to measure underlying factors, or other unrecognized limiting variables (Carroll *et al*. 2001, pp. 971, 973–974). Copeland *et al*. (2007, entire) also evaluated habitat

associations for wolverines in central Idaho. Wolverines were found to be associated with high elevations (2,200 to 2,600 m (7,218 to 8,530 ft)) with a slight downward shift in summer (Copeland *et al*. 2007, p. 2,207). These movements correspond with a shift in cover types, from high-elevation whitebark pine (*Pinus albicaulis*) communities in summer to mid-elevation Douglas fir (*Pseudotsuga menziezii*) and lodgepole pine (*Pinus contorta*) in winter (Copeland *et al*. 2007, pp. 2,207–2,208). Results from a study of wolverines in Scandinavia suggested that topography may be important in providing refugia from predators and may therefore facilitate the co-existence of wolverines with larger carnivores such as wolves (Khalil *et al*. 2014, p. 636).

In interior Alaska, wolverines were also found to be positively associated with high elevations (Gardner *et al*. 2010, p. 1,901). The authors concluded that wolverines avoided human influences based on observations that both elevation and human influence were found to have significant effects on wolverine occurrence probabilities, but were not correlated (Gardner *et al*. 2010, p. 1,901). However, they indicate that their sampling design was not able to determine which human activities influenced wolverine behaviors; a combination of intensity of development and harvest activities was suggested (Gardner *et al*. 2010, p. 1,901). Current studies are underway in the North Slope region of Alaska to evaluate fine-scale habitat selection of wolverines related to denning, caching, day bed use, and snow holes (Dorendorf 2016, p. 6). Day beds were also described by Haglund (1966, p. 268) for wolverines studied in Sweden.

A study also found that habitat associations, at least for females, are more complex, and include combinations of several modeled variables that supported hypotheses related to food (prey distribution), predation risk (based on a ruggedness index), or human disturbance (winter recreation activity, roads, and forest harvesting) for both summer and winter in two study areas located in northcentral and southeast British Columbia (Krebs *et al*. 2007, pp. 2,186–2,187). Wolverines in the Rocky Mountains of Alberta, Canada, were found to more likely occupy areas with increasingly rugged terrain (Fisher *et al*. (2013, pp. 710–712).

Camera trapping was used to study wolverine behavior in varying habitat in the Rocky Mountains of Alberta, Canada (Stewart *et al*. 2016, entire). That study found that wolverine behavior differed in landscapes that had been significantly modified by human activities as compared to those with light modifications or in protected areas (Stewart *et al*. 2016, p. 1,499). They concluded that wolverine occurrence in their study areas varied more strongly with linear features (seismic lines created from oil and gas exploration, pipelines, transmission lines, roads, and rail lines) than with the degree of snowpack, and supports the idea that human “footprint” as a driver of habitat suitability for wolverines; that is, if snowpack conditions was the only driver for suitable habitat, then a behavioral signal would not be expected (Stewart *et al*. 2016, p. 1,501).

Aboriginal knowledge holders (the knowledge Aboriginal Peoples have accumulated about wildlife species and their environment) in Canada have reported that while wolverines appear to avoid human habitation and developed areas, some wolverine will visit these areas if they do not appear to be threatened or if development activities cease (Cardinal 2004, p. 22). Wolverines have also been described as occupying deserted snow huts (Nunavut Territory, Canada) during winter months (Freuchen 1935, p. 98).

A negative association with roads and wolverine (and caribou) occurrence in boreal forest habitat was reported in northwestern Ontario, Canada, and wolverines in that study area avoided deciduous forests (Bowman *et al*. 2010, p. 464). However, a study of wolverines in upland boreal forests of Canada found that wolverines followed open linear corridors that offered compact snow conditions, including winter roads, recent seismic lines, snowmobile trails, and all-terrain vehicle tire tracks for travel of distances up to 3 kilometers (km) (1.86 miles (mi)) (Wright and Ernst 2004b, p. 59). In central Idaho, wolverines were reported using snowmobile winter access (unmaintained) roads for travel (Copeland *et al*. 2007, p. 2,210).

A study of wolverine selection patterns in boreal forests in northwestern Alberta using resource selection function (RSF) modeling techniques[1] and data from telemetered wolverines found that, for the winter season, both male and female wolverines selected for streams, forested areas (broadleaf, coniferous, and mixed) and bogs or fens, while avoiding active oil and gas well sites and low-traffic winter roads (Scrafford *et al*. 2017, pp. 31, 32). That study also found that wolverines did not avoid older seismic lines, likely due to the intermediate stage of regeneration found in their study area as well as availability of small prey in conjunction with minimal risk of human or wolf presence (Scrafford *et al*. 2017, p. 34).

RSF-based modeling was used to quantify the relationship between the observed distribution of the wolverine and variables representative of habitats and human disturbance in the taiga and tundra ecoregions (shown in Appendix A) of the Canadian central Arctic (Nunavut and Northwest Territories) (Johnson *et al*. 2005, p. 10). Using a range defined by previous studies of collared wolverines, researchers identified two seasons for wolverines, based on presence or absence of barren-ground caribou (*Rangifer tarandus groenlandicus*) (Johnson *et al*. 2005, p. 8). They found that, in winter, the occurrence of wolverines was correlated with patches of heath rock and rock association, and areas dominated by sedge (Johnson *et al*. 2005, pp. 23–25). Results for models for summer season were less clear, but models that included grizzly bear (*Ursus arctos*), caribou, and wolf were found to be positively associated with wolverine, likely due to the scavenging opportunities and hunting of caribou provided by these other carnivores (Johnson *et al*. 2005, p. 24). In Finland, the presence of wolves was found to be one of the most important variables influencing habitat selection of wolverines (Koskela 2013, p. 35) likely due to the increased scavenging opportunities provided by wolf kills (Koskela 2013, p. 36).

A RSF model was also used to develop a predictive map of wolverine habitat for the western United States (Inman *et al*. (2013, p. 281), as shown in the background of our Figure 3. Their best fit model found that, in general, wolverine were most likely to be distributed at high elevations, with steeper terrain, more snow, fewer roads, and reduced human activity, but also in proximity to high elevation talus, tree cover, and areas that had snow cover on April 1 (Inman *et al*. 2013, pp. 280–281). Primary habitat for the wolverine in the western United States was estimated at 164,125 km^2 (63,369 mi^2) (Inman *et al*. 2013, p. 281). Additional information

[1] RSF is any mathematical function that is proportional to the probability of use of a resource unit (Manly *et al*. 2002, p. 15). A RSF contains several coefficients that quantify the selection for or avoidance of an environmental feature, and the sign/strength of those coefficients represents a differential variation in the distribution of each environmental feature measured at a sample of locations to a comparable set of random sites. Thus, when an animal's observed use of a resource is greater than those random sites, selection of that feature is inferred (Johnson *et al*. 2005, p. 10).

related to the results of this modeling effort is discussed in the *Population Distribution and Abundance* section below.

Movement

Wolverine movements are related to both territoriality (within home ranges) and dispersal (adults and young). Movement within home ranges by adult male and female wolverines is extensive. For example, wolverines monitored in the Greater Yellowstone Ecosystem traveled a distance that was equivalent to their average home range diameter in less than 2 days, which is also about the size of their home range circumference in less than 1 week (Inman *et al*. 2012a, pp. 782–783). This study also found that, for a 24-hour period, the average minimum distance traveled was 15.5 (km) (9.63 (mi) for males and 7.5 km (4.66 mi) for females (Inman *et al*. 2012a, p. 783). Telemetry studies of wolverines in south-central Alaska indicate an average distance traveled per day of approximately 12 km (7.46 mi) for females and 8–21 km (4.97–13 mi) for males (Woodford 2014, no page number). Observations from snow tracking studies have found instances where two individual wolverines traveled together (Wright and Ernst 2004b, p. 63).

A study of female Fennoscandinavian wolverines found that most (86 percent) females remained stationary in their established territories, with 8 percent vacating and 6 percent expanding their territory (Aronsson 2017, p. 40). In addition, this study of 42 female wolverines in 122 territories reported that females with established territories only moved to available territories that were higher than average in quality (Aronsson 2017, p. 41). In central Norway, a study of spatial and temporal patterns in wolverines using noninvasive genetic sampling methods also found that individuals tended to stay in the same general area from one year to the next (Bischof *et al*.'s 2016, p. 1,533).

A number of factors can affect wolverine movements within territories, such as availability of food, temperature, and breeding activity. Seasonal shifts in elevation have also been observed for wolverines in the contiguous United States. An ecological study of wolverines in southcentral Alaska found significant movement up in elevation during late winter and early spring as well as significant movement down in elevation during the late fall and winter (Gardner 1985, p. 21). Wolverines were also observed moving to and occupying higher and presumably cooler elevations in summer months in northwestern Montana (Hornocker and Hash 1981, p. 1,299). In Central Idaho, wolverines exhibited a preference for higher elevation areas containing rock and talus cover in summer months, but moved to lower elevations in winter; this was likely the result of an increase in availability of carrion related to the fall hunting season (Copeland 1996, p. iv). Two aboriginal knowledge holders in the Kivalliq region (Nunavut, Canada) reported that wolverines will move closer to communities during caribou migration in the fall, likely attracted by the large number of caribou carcasses left by hunters (Cardinal 2004, p. 22).

A study of wolverine movement in boreal forest habitat in Canada (northwestern Alberta and northeastern British Columbia) during winter months found that wolverines chose the most direct travel route with the least snow cover (Wright and Ernst 2004a, pp. 58–59). Woodford's (2014, no page number) account of wolverine observations from studies in Alaska indicated that, when pursued, wolverines will run uphill, which may represent a predator-avoidance adaptive behavior.

As discussed in more detail below (*Diet and Feeding*), several studies have shown that wolverines exhibit a seasonal shift in diet, and Hornocker and Hash (1981, p. 1298) concluded that food availability was the primary factor determining both movements and home ranges for wolverines studied in northwestern Montana. Movement patterns of adult males during the summer months are also likely influenced by breeding activity (Magoun 1985, p. 66).

Males and females maintain large territories with very little overlap between same-sex adults (Magoun 1985, p. 38; Banci 1994, p. 118; Inman *et al*. 2012a, p. 783; Bischof *et al*. 2016, pp. 1,532–1,533; Regehr and Lacroix 2016, p. 249), but breeding pairs have overlapping territories (Copeland 1996, pp. 55–61; Hedmark *et al*. 2007, p. 19; Dawson *et al*. 2010, p. 413; Persson 2010, p. 52; Inman *et al*. 2012a, p. 787). However, ranges of young males, who have not yet dispersed, can overlap with resident adult male home ranges (Alaska) (Magoun 1985, p. 64). Studies of wolverines in the Greater Yellowstone Ecosystem found a mean percent overlap of 12.7 percent for same sex, adult–sub-adult pairs and about 24 percent for opposite sex, adult–sub-adult pairs (Inman *et al*. 2012a, p. 787). In addition, Inman *et al*. (2012a, p. 783) found that when a resident adult wolverine died, same-sex adults (not known to be located within the dead wolverine's home range) would begin using (within 3–7 weeks) areas of the unoccupied home range, or same-sex subadults would expand into and then occupy most or all of the dead wolverine's former home range. A study of territoriality of wolverines in central Norway (using scat analysis) indicated that within their study population, wolverines were also more likely to choose a home range area that was previously used by a neighboring same sex individual after that individual's death (Bischof *et al*. 2016, p. 1,533).

Table 1 below presents a summary of annual home ranges of resident wolverines.

Table 1. Home Range Size for Adult, Resident Wolverines.

Region	Female, km^2 (mi^2)	Male, km^2 (mi^2)	Reference
Central Idaho	384 (148)	1,582 (610)	Copeland 1996
Central Idaho / Yellowstone Region	357 (138)	1,138 (439)	Heinemeyer and Squires 2015
Greater Yellowstone Ecosystem	303 (117)	797 (308)	Inman *et al*. 2012a
Glacier National Park (MT)	139 (54)	521 (201)	Copeland and Yates 2008
Alaska (Northwestern)	53-232 (20-89.6)	488-917 (188-354)	Magoun 1985
Canada Northwest Ontario	50-400 (19-154) 423 (163)	230-1,580 (89-610) 2,563 (990)	COSEWIC 2014 Dawson *et al*. 2010
Central Norway	331 (128)	757 (292)	Bischof *et al*. 2016
Southern Norway	274 (106)	663 (256)	Landa *et al*. 1998
Northern Sweden	170 (66)	669 (258)	Persson *et al*. 2010

Home range use is smaller for female wolverines during the reproductive period. For a parturient (about to bear young) female, estimates of home range size in the Greater Yellowstone region were significantly smaller, with a minimum of 100–150 km^2 (39–58 mi^2) (i.e., during year raising young) (Inman *et al*. 2012a, p. 782). The average home range size for lactating females rearing young was estimated at 70 km^2 (27 mi^2) from March through August (Alaska) (Magoun 1985, p. 36). In northwestern Ontario, researchers reported a home range of 262 km^2 (101 mi^2) for a lactating female (Dawson *et al*. 2010, pp. 141–142). In general, the distance traveled by female wolverines depends on the location of the reproductive den site within the home range, the areas used for locating food/prey, and the territory border (Myhr 2017, no page number).

In summary, habitat diversity, food availability, and competition for resources can collectively or individually influence home range sizes of wolverines (Magoun 1985, p. 63; Inman *et al*. 2012a, p. 785), which affects wolverine densities and population structure. Home range sizes of male wolverines are likely influenced by the density and reproductive condition of female wolverines (Magoun 1985, p. 63).

Dispersal relates to the successful establishment of a breeding territory, generally by juveniles, at a location removed from the natal denning area, and can be confused with long-range movements of wolverines and other carnivores (Ruggiero *et al*. 1994, pp. 4–5).

Based on telemetry studies, wolverines have been observed to disperse over very long distances. Both male and females can move long distances (Flagstad *et al*. 2004, pp. 684–686), but young (yearling) females tend to establish home ranges closer to their natal ranges than do young males (COSEWIC 2014, p. 24), which supports a male-biased dispersal pattern (from natal range) for wolverine populations. Vangen *et al*. (2001, p. 1,647) indicated that dispersal patterns of females were likely determined by competition for resources (that is, high quality territories) while male dispersal patterns were likely determined by competition for mates.

As noted above, wolverines readily cross water bodies such as rivers, and can cross rugged terrain (COSEWIC 2014, p. 24; Woodford 2014, entire). Dispersing wolverines in Idaho traveled over 200 km (124 mi) following routes across isolated subalpine habitat (Copeland 1996, p. 130). Inman *et al*. (2012a, p. 784) recorded dispersal-related movements of wolverines in the Greater Yellowstone Ecosystem and found that the maximum dispersal distance of subadults from the home range of their mothers was 170 km (106 mi) for males and 173 km (108 mi) for females, with an average maximum distance per dispersal movement of 102 km (63 mi) for males and 57 km (35 mi) for females (Inman *et al*. 2012a, p. 784). In the Ontario, Canada, region a juvenile male reportedly dispersed 100 km (62 mi) (COSEWIC 2014, p. 24, citing unpublished data from Dawson *et al*. 2013).

Two recent examples illustrate the extensive dispersal capability of wolverines. A male wolverine apparently dispersed (2008 or earlier) from the western edge of the Rocky Mountain region to the Sierra Nevada region of California (Moriarty *et al*. 2009, p. 160). Another male wolverine (designated as M56), whose natal area was the Greater Yellowstone Ecosystem (northwest Wyoming), moved south to Colorado (about 500 miles), where it remained for about 3 years (2009–2012), when its tracking signal was lost. In April 2016, M56 was legally shot and

killed by a rancher in western North Dakota, about 1126.5 km (700 mi) from where it was last seen (Wyoming Game and Fish Department (WGFD) 2016, pers. comm).

Additional discussion of population distribution and density estimates is provided below (see Biological Status–Current Conditions).

Reproduction and Growth

Wolverine reproduction includes the following characteristics: polygamous behavior (i.e., a male mates with more than one female each year), delayed implantation (up to 6 months), short gestation period (30–40 days), denning behavior, and an extended period of maternal care (Rausch and Pearson 1972, pp. 255–256; Pasitschniak-Arts and Larivière 1995, p. 5; Magoun and Copeland 1998, pp. 1,315–1,316; Hedmark *et al*. 2007, p. 19; Persson *et al*. 2017 *in prep*).

Table 2 below presents a summary of wolverine reproductive chronology (extent and peak of reproductive events) based on a review of the literature and personal knowledge from field studies (Inman *et al*. 2012b, entire), and studies from Scandinavia (Aronsson 2017; Persson *et al*. 2017 *in prep*).

Table 2. Chronology of wolverine reproductive events (adapted from Inman *et al*. 2012b).

Reproductive Biology Event	Time Interval
Mating Season	May – August; *peak in* ***June***
Nidation (implantation of embryo)	November – March; *peak in* ***late December–early February***
Gestation (45 days)	November – April; *peak in* ***January–mid-March***
Parturition (birth of young)	late January – mid-April; *peak in* ***February–mid-March*** (**Sweden**: *peak in* ***mid-February***, range from end of January to early March)[a]
Reproductive Den Use	late January – end of June; most commonly, ***early February–mid-May***
Lactation	About 10 weeks; generally February–June
Weaning	April – June; most commonly, ***late April–May***
Rendezvous Sites	April – June; peak in ***early May***
Independence	August – January; *peak in* ***September–December***
Dispersal	Peak period at ***10–15 months of age***; February–mid-April

[a] Persson *et al*. (2017, *in prep*).

Wolverine mating is generally assumed to occur in May, June, and July (Pulliainen 1968, p. 341; Rausch and Pearson 1972, p. 249). A review of both the literature and personal observations by Inman *et al*. (2012, p. 636) indicated that June represented the peak in a wolverine mating season, but began in at least May and extended into early August. Female wolverines have been reported as not breeding in their first summer (under 1 year of age) based on examination of reproductive tracts from wolverine carcasses obtained from trappers (Yukon) (Banci and Harestad 1988, p. 268) and ages of pregnant female wolverines were estimated at 1 to 11-plus years of age (Banci and Harestad 1988, p. 266). In another study of wolverine carcasses (also in Yukon), some female wolverines were said to be mature at about 1 year (about 15 months), but first litters were not produced until 2 years of age (Rausch and Pearson 1972, p. 253). In Scandinavia, the mean age of first reproduction for female wolverines was 3.4 years, based on

monitoring of telemetered animals (Persson *et al*. 2006, p. 76). Breeding ages were reported at 2 to 13 years of age for wolverines in Sweden (mean age of first birth was 3.4, range of 2 to 5 years), based on monitoring/observations of female wolverines (Rauset *et al*. 2015, p. 3,157).

A genetic-based wolverine study in Scandinavia found that "females often reproduced with the same male in subsequent breeding years" (Hedmark *et al*. 2007, p. 18). However, this study also found (with some assumptions regarding sampling and paternity) that 8 of 13 female wolverines bred with different males, and, based on telemetry results, 2 females bred with a new male even though their previous breeding partner was still alive (Hedmark *et al*. 2007, p. 18). This shift in partners may have resulted from a change in the resident male wolverine in the area (Hedmark *et al*. 2007, p. 19).

The reproductive rate of wolverines is relatively low. An early study of 31 wolverine dens in Finland, as reported by hunters, found an average of 2 young per den (range 1–4) (Pulliainen 1968, pp. 338–341). Average litter size for northern Europe (161 litters) was 2.5 (range 1–4) (Pulliainen 1968, p. 343). In Alaska, average litter size was reported as 1.75 young, with a reproductive rate of 0.69 young per adult female per year (Magoun 1985, p. 28). A summary of average litter size for earlier studies of New World and Old World wolverines, based on method of determination, was presented in Magoun (1985, p. 29), indicating a range of 2.2 to 3.5. Anderson and Aune (2008, entire) evaluated pregnancy rates based on presence of corpora lutea (CL) and fetuses in trapper-harvested wolverines from western Montana. That study found median CL counts for pregnant adults ranging from 1.6 to 3.0, depending on the subpopulation (Anderson and Aune 2008, p. 22), with a mean litter size based on number of fetuses for pregnant adult females of 2.6 (Anderson and Aune 2008, p. 23). Studies of telemetered female wolverine in Scandinavia, from 1993 to 2002, reported a mean litter size of 1.88, with a range of 1 to 4 young, with a mean annual birth rate of 0.74 young per female (Persson *et al*. 2006, pp. 76–77). More recently, the average number of young per female per year reported for wolverines in Sweden was 0.84 (range 0–3); however, for those animals with recorded denning behavior, this value increased to 1.38 (range 0–3) (Rauset *et al*. 2015, p. 3,157).

Results from studies of telemetered female wolverines indicate that studies of wolverine reproductive tracts are likely to overestimate wolverine productivity (Persson *et al*. 2006, p. 77). Their findings suggest that young are either lost during pregnancy and/or shortly after birth, and are not likely to occur before implantation due, in part, to presumed delayed implantation (Persson 2006, p. 77). Delayed implantation (or reabsorption) of fetuses has been observed in other mustelids, including mink (Hansson 1947, p. 62; and references cited therein, pp. 65–66). However, the factors that contribute to the observations that female wolverines do not give birth during some years are not well understood, and could be due to failure to breed, pseudo-pregnancy (as demonstrated by Mead *et al*. 1993, entire), failure of a fetus to implant, absorption of implanted fetus, stillbirth, or mortality before emerging from den (e.g. infanticide, etc.) (Magoun 2013, pers. comm.).

Carnivorous mammals generally have altricial young (poorly developed and dependent young (Derrickson 1992, p. 58)), and prepare shelter in dens where the mother can feed their young and keep them warm (Irving 1972, p. 174). Young wolverines (kits or cubs) weigh about 0.1 kg (3.5 oz) at birth and are blind until about 4 weeks of age (Krott 1960, p. 23). Newborns are covered

with whitish to yellow hair (Krott 1958, p. 87; Mehrer 1976, p. 570), 4.5 millimeters (mm) (0.18 in) in length (Shilo and Tamarovskaya 1981, p. 147), with unerupted teeth (Mehrer 1976, p. 570; Pasitschniak-Arts and Larivière 1995, p. 5) and closed ear canals (Shilo and Tamarovskaya 1981, p. 147). They are generally not left alone at the den during the first 3-4 weeks (Krott 1958, pp. 88, 108). A study of telemetered wolverines in Scandinavia found that, on average, a female wolverine spends most of her time within 1,000 m (3,281 ft) of the reproductive den during the denning period (Myhr 2017, no page number).

Mustelids, in general, have a short period of growth (Iversen 1972b, p. 317). As noted above, the metabolism of young wolverines is highest during the first 2.5 months, and individuals are almost two-thirds grown by the fall (at about 6 months) (Krott 1960, p. 25). As described by Shilo and Tamarovskaya (1981, p. 146), 45-50 day old cubs (Norway) have woolly coats, are muddy grey in color, with teeth beginning to erupt at this age. At about 150 days, all permanent teeth have been established (Shilo and Tamaovskaya 1981, p. 147). After 2.5 months, young wolverines replace their juvenile coat with the adult summer coat (Shilo and Tamarovskaya 1981, p. 147). With growth ending at about 8 months (Iversen 1972b, p. 320; Magoun 1985, p. 23), cubs are generally full grown by October or November.

Use of Dens and Denning Behavior

Dens and breeding burrows of animals are, in general, carefully constructed, well-camouflaged, and located in areas not easily accessible (Novikov 1962, p. 25). Wolverines use both natal dens (used for birthing) and maternal dens (used subsequent to natal den and before weaning) for rearing young (Magoun and Copeland 1998, p. 1,314). The average relocation distance to maternal den sites for active wolverine den sites studied in Norway was 268 m (879 ft) (95% confidence interval: 40–497 m (131–1,631 ft)) (May *et al*. 2012, p. 199). The young remain at the natal den site for 6 to 8 weeks (Krott 1960, p. 24), and are weaned at 9 to 10 weeks (Copeland 1996, p. iv (Central Idaho); Koskela *et al*. 2013a, p. 101 (Finland)) (*cf*. 7 to 8 weeks reported by Myhre and Myrberget, 1975, p. 754 (Norway)). After weaning, the young are dependent on the mother and begin to travel with her by late April (Koskela *et al*. 2013a, p. 101 (Finland)). Observations of wolverines in central Idaho reported that females traveled up to 17.9 km (11 mi) from maternal dens to forage (Copeland 1996, p. 97).

The exact timing of when females abandon natal dens and begin using maternal dens is difficult to establish (Inman *et al*. 2012b, p. 638). In general, studies have found that den abandonment (natal) occurs before May (Magoun and Copeland 1998, p. 1,315; Table 1; Inman *et al*. 2012b, p. 637; Figure 2). A study by Aubry *et al*. (2016, p. 24) reported that a female wolverine moved her single young (estimated to be at least 9 weeks old) from a natal den in *late April* in the North Cascades region of Washington. More recently, a comprehensive study of wolverines in Scandinavia found that females begin to shift den locations more frequently beginning in *late April* as young are more mobile and are more reliant on solid food brought to them by the mother (Aronsson 2017, p. 46). Natal den abandonment in Alaska and Idaho reportedly "coincided with a period when maximum daily temperatures rose above freezing for a number of days for the first time since denning commenced" (Magoun and Copeland 1998, p. 1,316). Factors other than temperature can influence shifts in the locations of these dens, including intraspecific predation, parasites, or other disturbances (Inman *et al*. 2012b, p. 638). In central Idaho, Copeland (1996, p.

iv) concluded that human disturbance at maternal den sites resulted in den abandonment, but not *abandonment of young*.

Rendezvous sites are locations in which the female leaves young while she hunts for food, and from which they will not leave without her (Magoun 1985, pp. 16, 77). These areas provide security to young (Copeland 1996, p. 94) and serve as locations at which females bring food to the young, or from which she will guide them to a food source (Inman *et al*. 2012b, p. 638). Rendezvous sites of wolverines studied in central Idaho consisted of large boulder talus or riparian areas associated with mature overstory and dense timber deadfall (Copeland 1996, p. iv). Magoun (1985, p. 76) reported that rock caves and hilltops containing boulders without large snowdrifts were used as rendezvous sites in Alaska. Females may move their young to new rendezvous sites several times over a two month period (Magoun 1985, p. 73), and distances between consecutives sites have been reported as far away as 8.5 km (5.3 mi) (Magoun 1985, p. 76).

Studies of adult female wolverines in Scandinavia (northern Sweden) have provided additional details regarding the temporal patterns of reproductive behavior and den site use. Aronsson (2017, p. 45) (see also Persson *et al*. 2017, in prep) found that, in general, most births occurred in mid-February. Females spend very little time outside the natal den for the first 2 weeks (Aronsson 2017, p. 45). During the first period of den site use, or approximately 2 to 2.5 months from mid-February (when females generally give birth and are lactating), females will move short distances and do not need to bring food to young (Aronsson 2017, p. 46). This time period generally coincides with snow cover and favorable conditions for food caching, and dens offer protection from predators and the environment (Aronsson 2017, p. 46). In addition, during the first 1.5 months of the denning period, females rarely changed den sites, but begin to move outside the den in early March (Aronsson 2017, p. 45). In the later denning period (after April 15), females begin to move more frequently and at greater distances between den sites (Aronsson 2017, p. 45). By late April, the young are more active and also begin to rely more on solid food that is brought back to them by their mother (Aronsson 2017, p. 46). This also corresponds to a time period when prey are more available (reindeer migration and calving period in Sweden) and expected shorter distance movements by the mother back to denning or rendezvous sites (Aronsson 2017, p. 46). These observations are consistent with Inman *et al*.'s (2012b, entire) proposed cold, low productivity niche for wolverines based on studies of wolverines in the Greater Yellowstone Ecosystem. That is, reproductive chronology in wolverines is considered to be adapted to take advantage of the availability of food resources, limited interspecific competition, and snow cover in the winter (Inman *et al*. 2012b, p. 635).

In summary, as described by Inman *et al*. (2012b, entire) and Persson *et al*. (2017, in prep), reproductive behavior of wolverines reflect seasonal shifts in resource abundance within the wolverine's range; that is, adaptation that matches the time of birth and development of young to changes in the availability of resources and foraging strategies (Persson *et al*. 2017, in prep). We present in Figure 4 a visual summary of wolverine feeding strategies relative to resource availability from time of birth to post-weaning.

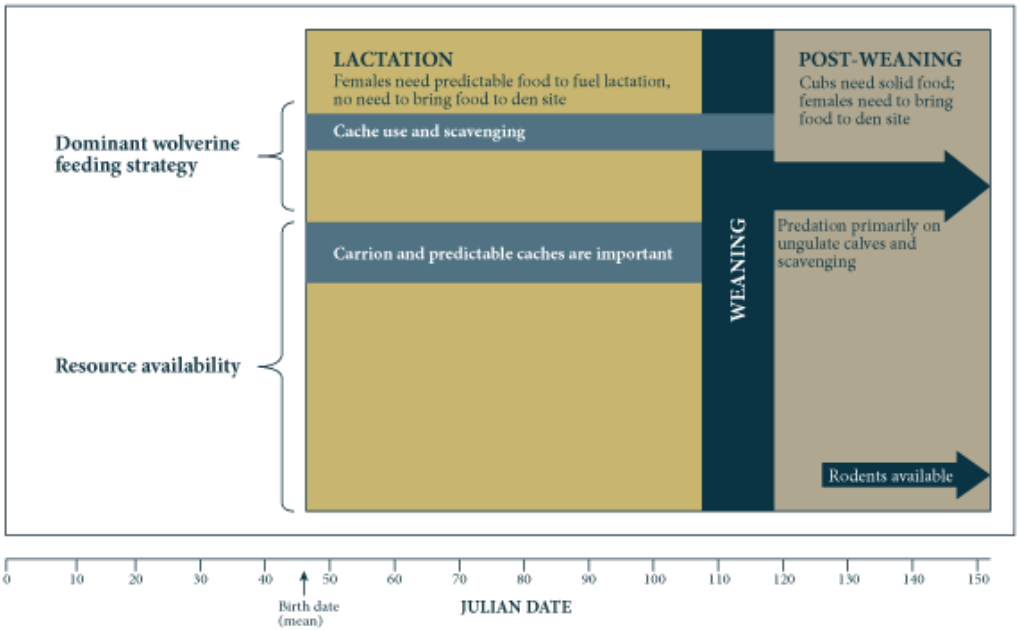

Figure 4. Wolverine feeding strategies relative to resource availability. Adapted from Persson *et al*. 2017, in prep.

Denning Habitat

Given the wolverine's observed association with snow, we provide in **Box 1** a summary of the importance of snow, in general, for ecological systems. This summary provides a detailed perspective of how various physical properties of snow can influence ecological systems occupied by snow-adapted wildlife, including insulating properties, differences in snow cover in mountainous vs. forested habitat, and changes in snow cover due to wind and slope/aspect. However, we also emphasize here that there have been limited comprehensive studies of wolverine behavior, or its physical and ecological requirements outside of the winter months in North America (*cf.* Banci 1987 (Yukon); Hornocker and Hash 1981 (Montana); Gardner 1985 (Alaska); Magoun 1985 (Alaska); Copeland 1996 (Idaho); Krebs *et al*. 2007 (Canada); Inman *et al*. 2013 (Greater Yellowstone Ecosystem)) due, in part, to the difficulty in tracking animals when snow cover is absent and their ability to move great distances across rugged terrain. In addition, den site locations for North America reported in the past have been biased to tundra regions where dens are more readily observed and located (Banci 1994, p. 110). In Scandinavia, snow cover has also been found to be a poor technique for tracking female wolverines during the time when they give birth and initiate denning (Aronsson and Persson 2016, p. 266).

Box 1. Snow Cover in an Ecological Context

Formozov (1961; 1963) prepared comprehensive reviews of the unique properties of snow in the context of its role in the ecology of animals and plants in Russia. In his 1963 review (translated from the 1946 original), he identified two important factors attributed to snow cover — *nastization* (the thickness of the crust on the surface of mature snow cover) and *firnization* (process of snow compaction) — relative to its ecological influence (Formozov 1963, p. 8). Snow cover provides not only a substrate that allows some animals to move across the landscape, it also provides a matrix within which other animals can create tunnels and build nests (Formozov 1963, p. 8). Additional fundamental concepts described in this study are provided below:

- Snow has very low thermal conductivity which promotes cooling at the surface while at the same time protects the deeper layers from chilling; but this property varies by region, by depth, by season, and by year (e.g., the more continuous the snow cover during winter, the greater the warming effect); as snow changes to ice (through compaction and melting), the thermal conductivity decreases (Formozov 1963, pp. 7, 8, 108)
- Snow therefore creates a thermo-insulating layer, which allows for a unique temperature regime on the surface and underneath; as an example, soil temperatures measured in January (near Saint Petersburg, Russia) averaged 15°C higher with snow cover than without snow cover, with up to a 32°C difference, depending on the day and depth measured (Formozov 1963, p. 109)
- Snow cover in mountains:
    - Depth of snow cover and its duration increases with elevation; even minor elevation differences are noticeable (Formozov 1963, p. 123)
    - This spotty distribution is also affected by unequal distribution of snow precipitation on slopes with different exposures, transport of snow by wind, melting of snow on sun-exposed slopes, avalanche or rolling down of snow from steeper areas, and vegetation (Formozov 1963, p. 123)
    - Snow cover areas near Arctic limits and at treeline in mountain regions is more strongly influenced by wind (which compacts and re-works snow cover) (Formozov 1963, p. 29)
- Snow cover in forests:
    - The maximum depth, density, duration and date of melting, thickness of snow surface crust are all much different in forested areas as compared to open treeless areas (Formozov 1963, p. 19)
    - Snow accumulates slowly under trees and is generally thicker the further away from the forest than within the forest; thus, the compaction and settling of snow under a forest canopy is less than tundra or open fields (with a less icy crust), so for some vertebrates, forested areas can provide a more preferable place to winter or migrate (Formozov 1963, pp. 24, 26)
    - Snow cover in forested areas also melts slower than open fields and clearings (Formozov 1963, p. 28)
- Snow cover also plays an important role in the overwintering conditions for insect eggs, caterpillars, pupae, and adult insects in litter and soil, and some plants (Formozov 1963, p. 121)

Although it has been assumed that wolverines have an obligate relationship with snow for natal denning, including persistent spring snow cover, the key elements or combination of elements that define this relationship have not been empirically analyzed. As noted above, adult wolverines have a wide range of thermoneutrality. However, newborns, who are born with lighter, less dense fur are likely to have a more limited ability to control their internal temperature, though huddling (a thermotactic behavior) of small mammals in dens can conserve heat (Barnett and Mount 1967, p. 439). Relatedly, basal metabolic production of heat is the source of heat that maintains bodily warmth, and is not easily modifiable unlike the flexibility of insulation (Irving 1972, p. 121). However, metabolic heat above an animal's basal rate for preservation of warmth is restricted by its limited capacity for metabolic production of heat, but also by food availability and the time and opportunity for nourishment (Irving 1972, p. 121). In general, metabolic production of heat is costly to animals, but variable insulation represents a conservative strategy (Irving 1972, p. 121).

Another key element related to den location is the protection that dens provide to a nursing female and her young. Because wolverines are known to den in a variety of structures, it is unclear if the apparent relationship to snow cover is based on selecting den locations in remote, high elevation areas to avoid predators. Bare rock and boulders at den sites can offer dry and secure cavities and enhance the ruggedness of the landscape (May *et al*. 2012, p. 198). "Ruggedness," a measure derived from elevational changes and irregularity of land surface (density of contour lines) traversing a given area (Beasom *et al*. 1983, p. 1,163) has been found to be an important variable (i.e., secure habitat from predation risk) for female wolverines in winter (British Columbia, Canada) (Krebs *et al*. 2007, p. 2,188) and for den site selection at site-specific, home range, and landscape scales (southcentral Norway) (May *et al*. 2012, pp. 200–201).

Wolverine denning habitat varies across its Holarctic range. For example, in southcentral Norway, wolverine dens were snow tunnels dug into deep snow at the tree line (elevation 1,100 m (3,609 ft)), but most of the tunnel systems extended down to boulder fields, talus slopes, or rock crevices such that young could crawl around within these structures (May *et al*. 2012, p. 201). Snow tunnels are also reported for wolverine natal dens in Alaska (Magoun 1985, pp. 84, 185, 190). However, reproductive dens are not always excavated in deep snow. In Canada, female wolverines are said to give birth in dens where snow cover persists at least until April, and can den under snow-covered rocks, logs, or within snow tunnels (COSEWIC 2014, p. v). As an example, in northwestern Ontario, den site habitat for a female in lower Boreal Forest habitat (elevation 250 to 500 m (820 to 1,640 ft), 51°N) included large boulders and downed trees, similar to dens described for wolverines in montane ecosystems (Dawson *et al*. 2010, p. 139). In Finland, Pulliainen (1968, p. 340) reported a den site (January) at the base of a tree and not covered in snow, and also described other structural features such as rocks, fallen trees, and deep ravines as denning habitat (likely both natal and maternal dens) (Pullianinen 1968, pp. 338–341). In Russia, where wolverine habitat has been described as located far from human-inhabited areas within boreal forests and, to some extent, tundra, and taiga (Novikov 1962, pp. 199, 200), den locations were described as "clefts in rocks, among stones, and under roots of upturned trees" (Novikov 1962, p. 200). A study from northwestern Ontario noted that, because lowland boreal forest habitat in this region does not support deep, wind-hardened snowdrifts, other structural

elements within snow layers such as trees and boulders can be important components of wolverine denning habitat (Dawson *et al*. 2010, p. 142).

Limited studies to date have evaluated the importance of denning habitat to reproductive success, or the key physiological and ecological characteristics, including avoidance and/or protection from predators, prey availability, availability of caching habitat, that define denning behavior and den site selection. Population density, trapping pressure, population genetics, and other measures of habitat quality may also influence wolverine fecundity (Anderson and Aune 2008, p. 28). In addition, studies of wolverine denning activity have not reported the condition of the natal or maternal den location following abandonment; that is, what is the persistence and/or depth of snow at the natal den at the end of the denning season and how does this affect survival of young?

A bioclimatic model was used by Copeland *et al*. (2010, p. 234) to test the following hypothesis: "…wolverine distribution **at the broadest spatial scale** is constrained within a climatic envelope defined by an obligate association with persistent spring snow cover and by an upper limit of thermoneutrality." However, this hypothesis was based on the premise "**If persistence of wolverine populations is linked to** the availability of suitable reproductive den sites ([citing] Banci 1994), snow cover that persists throughout the denning period **may be** a critical habitat component **that limits the wolverine's geographic distribution**" (Copeland *et al*. 2010, p. 234). The authors tested this hypothesis by "comparing and **correlating** the locations of wolverine reproductive dens from throughout their circumboreal range, and telemetry locations from 10 recent wolverine studies in western North America and Scandinavia, with spatial models representing the distribution of spring snow cover and average maximum August temperatures" (Copeland *et al*. 2010, p. 234) (emphasis added).

Bioclimatic models "use associations between aspects of climate and known occurrences of species across landscapes of interest to define sets of conditions under which species are likely to maintain viable populations" (Araújo and Peterson 2012, p. 1,527). They are correlational by nature and are often applied to study a variety of conservation issues, including forecasting potential climate change effects on species' distributions (Araújo and Peterson 2012, p. 1,527). However, these types of correlational models have received some criticisms and require careful framing to avoid misapplication (Sieck *et al*. 2011, p. 6; review by Araújo and Peterson 2012, entire). They generally represent a first step for evaluating current and future species distributions, and, when coupled with climate change scenarios, results are presented at a coarse scale that may not accurately project shifts in species distribution at a smaller scale (Sieck *et al*. 2011, p. 6). In particular, when used to estimate extinction risk, these types of models provide only an estimate of the empirical relationships between a species' current distribution and climate variables and then use inferred relationships to identify potential areas where the species is distributed under future climate scenarios (Araújo and Peterson 2012, p. 1,553). Extinction risk is not represented in the model's input data and therefore is not the targeted parameter of the model; thus, a bioclimatic model's usefulness may be limited in these types of applications given that it only offers partial explanatory evidence for reasons for potential extinction related to the shifts in climate suitability within the time frame being modeled (Araújo and Peterson 2012, p. 1,533 and citations therein). In addition, climate niche projections generally do not incorporate factors such as competition, dispersal, and evolutionary capacity, which also influence range

boundaries (Michalak *et al*. 2017, p. 370). Thus, these types of models are more applicable at broad scales in which the effects of fine-scaled topography and biological interactions play a more limited role (Michalak *et al*. 2017, p. 370); however, both of those factors are important for wolverine, particularly at the den-site scale.

Finally, Post (2013, p. 50) suggested that the niche conservatism approach may not be appropriate in predicting changes to species' distributions under future climate change scenarios. He concluded that, based on redistribution patterns of flora and fauna throughout the Pleistocene epoch, but particularly the Late Pleistocene period of rapid warming, species movement is not always predictable in directions or rates based simply on their association with the more predictably changing environmental/abiotic measures.

As noted above, Copeland *et al*. (2010, entire), used a bioclimatic model to evaluate an assumed association not at the den site scale, but at a broad scale. The results presented in Copeland *et al*. (2010, entire) were based not on the condition of snow cover at a particular den site at the time of denning, but rather their evaluation of snow persistence (April 24 to May 15) was based on satellite images summed over a 7-year period (2000 to 2006) for the den locations. The spatial resolution of the snow measurement used to detect daily snow cover was 500 m (1,640 ft) using Moderate-Resolution Imaging Spectroradiometer (MODIS). If persistent snow cover was observed in any one year, it was included in the bioclimatic model regardless of whether denning occurred during that particular year.

In addition, although the study found that 69 percent of dens for North American wolverines were located within satellite images (pixels) in areas that had snow cover for 6–7 years, just over one-third (31 percent) of the identified den locations were located in areas that were identified as having spring snow cover 5 years or less out of 7 years. Also, the den location attributes (e.g., den structure, how long it was used) were not recorded relative to the observed persistent snow cover and some of the 560 dens (e.g., Norway) were identified by snow tracking rather than direct observation. In essence, the results presented by Copeland *et al*. (2010, entire) provided a fairly accurate, though preliminary, assessment of where **wolverine populations** are expected to be observed, but did not evaluate (model) snow persistence at the den site scale based on location and denning period (emphasis added).

We also note here that results from group scoring exercises using modified (no consensus) Delphi techniques (i.e., group discussions followed by group scoring exercises with points allocated for beliefs on wolverine habitat needs and behavior, as well as uncertainty in allocation of points) of a panel of scientists convened by the Service in April 2014 (Wolverine Science Panel Workshop), indicated that most panelists allocated points to an obligate relationship of wolverines with deep snow at the den-site scale, but there was a wide range of scores from the panel as to whether contiguous snow was limiting at the home-range or species-range scales (Wolverine Science Panel Workshop Report 2014, pp. 9–11).

Since the 2013 (78 FR 7864; February 4, 2013) and 2014 (79 FR 47522; August 13, 2014) proposed rules for the wolverine, several publications have presented additional study results related to wolverine distribution and snow cover. In Alberta, Canada, Webb *et al*. (2016, entire) found that, based on wolverine harvest data, wolverine occurrence relative to spring snow cover (percent of area covered, with greater than 75 percent snow coverage, on April 1 and 15) varied

based on the different regions of Alberta. This study used meterological data from 2009 to 2015, in northern Alberta (north of 54°N) and differentiated between spring snow cover that persisted in ≥ 1 of 7 years and more frequently (≥4 of 7 yr) (Webb *et al*. 2016, pp. 1462–1464). Although the study found an overall positive trend of more frequent wolverine harvests in those areas expected to have spring snow cover, the study did not find consistent large differences between these areas, and did not typically detect significant relationships with frequent spring snow cover (4–7 years) in all regions (Webb *et al*. 2016, p. 6). The Rocky Mountains region was the only region in which wolverines were reported in areas with more frequent spring snow cover (4–7 years) (Webb *et al*. 2016, p. 5). This region, which is located along the western border of Alberta, contains montane, subalpine and alpine habitat, with elevations from 1,000 m (3,281 ft) to 3,700 m (12,139 ft) (Webb *et al*. 2016, p. 9). Conversely, the study found that in the Boreal Forest region of Alberta (i.e., wetland habitat interspersed with coniferous, mixed wood, and deciduous forests, with elevations between 1,500 m (4,921 ft) to 1,100 m (3,609 ft)), a female wolverine denned under large boulders and downed trees (Webb *et al*. 2016, p. 8). The authors noted that wolverine den locations within low elevation, forest habitats have not been well-described (Webb *et al*. 2016, p. 8). As noted above (Novikov 1962, p. 200), in boreal forested habitat, wolverines den in rock areas and in tree root structures. A similar finding was reported in Sweden, where a majority of dens (n=49) were in boulder areas located within mature, mixed coniferous forests (i.e., not alpine or tundra habitat) (Makkonen 2015, p. 14); all den sites provided cover for young *without snow* (Makkonen 2015, p. 17). A recently published study reported two wolverine natal dens in logged areas (cutblocks) in northern Alberta, Canada; specifically, within a slash pile and log deck (Scrafford *et al*. 2017, p. 35).

A study of wolverine populations and distribution in Sweden observed that wolverine populations were found outside areas with persistent spring snow cover (mean snow depth and proportion of years with snow cover on March 15; 1961–1990) and expanding into boreal forest habitat located to the east and south of alpine areas (Aronsson and Persson 2016, p. 266). This southern and eastern expansion (from 1996 to 2014) indicates recolonization of their historical distribution in Sweden, and is thought to be the result of an increase in population, with more dispersers colonizing forest habitat, and an increase in year-round scavenging opportunities due to an increase in Scandinavian wolf packs (Aronsson and Persson 2016, p. 266; Aronsson 2017, pp. 43–44). As of the spring of 2017, over 80 reproductive dens have been observed outside the boundary of the snow model presented in Copeland *et al*. (2010) (Persson 2017, pers. comm.). Similarly, in Finland, Koskela (2013, p. 38) found that 10 observed wolverine dens observed were determined to be "snow dens," but 8 of the 10 dens were located in areas outside the Copeland *et al*. (2010) modeled, satellite-based spring snow cover area.

Snow depth can be affected at a local level by terrain, ruggedness, slope and aspect; slope and aspect together will affect the exposure to snow accumulation (May *et al*. 2012, p. 198). In an effort to document and compare snow persistence at the wolverine den-site scale, Magoun *et al*. (2017, entire) evaluated the use of low-altitude aerial photography during late May 2016 in areas within the Rocky Mountains (Idaho and Montana) and northwestern Alaska. In Idaho and Montana, flight lines were established along transects through the long axis of previously documented home ranges of denning female wolverines and, in Alaska, known den sites (from 2016) were visited by helicopter and remaining snow was photographed (Magoun *et al*. 2017, p. 383). Transect segments in the Rocky Mountain study areas documented snow on May 31 in all but one segment, with 82 percent classified in low to heavy snow retention categories, and 58 percent considered as moderate to heavy (Magoun *et al*. 2017, p. 383). In the Alaska study area,

photographs documented widely scattered patches of snow on May 29, with remnant snowdrifts observed at all four wolverine den sites (Magoun *et al*. 2017, p. 383). The documentation of the existence of scattered patches of snow in the Rocky Mountains persisting into late May in areas previously detected to be bare of snow on May 29 (MODIS persistent spring snow cover, McKelvey *et al*. 2011, p. 2,889, Figure 4D; Magoun *et al*. 2017, p. 384, Figures 2b and 2d) suggests that persistent spring cover may not always be detectable at the den-site scale using remote sensing methods (Magoun *et al*. 2017, p. 384), and is affected by terrain, ruggedness, slope, and aspect.

To evaluate snow cover at previously recorded den site locations in the western United States, we reviewed natal, maternal, and known den sites relative to derived 'melt-out' dates using MODIS/Terra Snow Cover, 8-day series (Hall and Riggs 2016). Melt-out dates represent the first day of the 8-day composite series when the cell in which the den was located switches from "snow" to "no snow." The spatial resolution for these data is 500 m by 500 m (1,640 ft by 1,640 ft). Because MODIS data was only available from the years 2000 to present, we were only able to evaluate 21 of the 34 den sites documented in our records. As shown in Table 3, the earliest melt-out date was May 14 (2006) and the latest was July 12 (2002).

Table 3. Wolverine Den Site Melt-Out Dates, 2002–2008.

Den #	Den Type	Melt-out Date	Elevation, meters (feet)	Structure	State
1	Unknown	7/12/2002	1,814 m (5,951 ft)	None Listed	WA
2	**Natal**	5/25/2003	1,928 m (6,326 ft)	Log Complex	MT
3	Maternal	5/25/2003	1,995 m (6,545 ft)	Log Complex	MT
4	**Natal**	6/4/2004	1,807 m (5,923 ft)	Log Complex	MT
5	**Natal**	6/9/2004	2,399 m (7,871 ft)	None Listed	WY
6	**Natal**	6/17/2004	2,487 m (8,160 ft)	None Listed	MT
7	Maternal	6/29/2004	1,823 m (5,981 ft)	Downed Log	MT
8	Maternal	6/29/2004	1,893 m (6,211 ft)	Log/Boulder	MT
9	Maternal	6/11/2005	1,912 m (6,273 ft)	Spider Tree	MT
10	Maternal	6/11/2005	1,973 m (6,473 ft)	Spider Tree	MT
11	**Natal**	6/11/2005	1,977 m (6,486 ft)	Spider Tree	MT
12	**Natal**	7/12/2005	2,693 m (8,835 ft)	None Listed	MT
13	Unknown	5/14/2006	1,514 m (4,967 ft)	Log Complex	MT
14	Unknown	5/25/2006	2,093 m (6,867 ft)	None Listed	MT
15	Maternal	5/31/2006	1,851 m (6,073 ft)	Log Complex	MT
16	**Natal**	5/31/2006	1,843 m (6,047 ft)	Log Complex	MT
17	Unknown	6/7/2006	2,252 m (7,389 ft)	None Listed	MT
18	**Natal**	6/18/2006	2,695 m (8,842 ft)	None Listed	MT
19	**Natal**	5/25/2007	2,820 m (9,252 ft)	None Listed	MT
20	**Natal**	6/4/2007	1,922 m (6,306 ft)	Log/Boulder	MT
21	Unknown	7/3/2008	2,505 m (8,219 ft)	None Listed	ID

For *natal* den sites only, the range for melt-out dates was May 25 to July 12. All of these sites indicate a melt-out date that is past the May 15 date used for the persistent spring snow cover model presented in Copeland *et al*. (2010), which suggests that snow is persistent at these locations past the time when young begin moving out of natal dens (i.e., late April; see Use of Dens and Denning Behavior section). Additional studies are needed to further document wolverine den structure, snow conditions at dens, and how long dens are used, particularly for those locations outside of areas expected to have spring snow cover to better understand the relationship of wolverines and snow cover (Webb *et al*. 2016, p. 8; Magoun *et al*. 2017, pp. 6–7).

Other physical or biotic variables are also likely to be important for wolverine den site locations. Elevation affects snow depth and persistence at the landscape scale (May *et al*. 2012, p. 198). Inman *et al*. (2012a, p. 782) found that wolverines (12 females and 6 males) monitored in the Greater Yellowstone Ecosystem selected, on an annual basis, areas above 2,600 m (8,530 ft) latitude-adjusted elevation. In central Idaho, natal dens were also found in secluded, high elevation (above 2,500 m (8,202 ft)) cirque basins (Copeland 1996, p. 94).

We evaluated 34 den sites in the lower United States using a linear regression model to evaluate whether the elevation of wolverine den sites is related to latitude. We note here that not all of these dens were characterized as to whether they were natal or maternal dens and a few records were not verified through tracking of females or direct observations. Given these caveats, our examination of these records indicated that, in general, wolverine dens at lower latitudes (36 to 38°N) occur at higher elevations (range: 2,688 to 3,562 m) (8,819 to 11,686 ft) while the converse is seen for those dens at higher latitudes, or approximately 44 to 49°N (range: 1,514 to 2,820 m) (4,967 to 9,252 ft). Given our assumptions (small sample size, test of normality (i.e., Shapiro test for elevation is just met)) we used linear regression (R Software; R Development Core Team, 2014) to test this association. We found a significant association with elevation and latitude [adjusted $R^2 = 0.76$, $F = 108.1$, $df=32$; *p-value* = 8.24×10^{-12}], such that dens found at lower elevation were associated with higher latitudes. However, the results of this simple model indicate that 76 percent of the elevation for this sample is explained by latitude; thus, other potential explanatory variables or interactions between variables should be considered using multiple regression techniques.

The steep slopes found at higher elevations also provide conditions conducive to avalanches, which result in debris and talus/boulder piles that provide structure for dens (Inman 2013, pers. comm.). Steep slopes and the availability of rocks were found to be important to wolverine den site selection for wolverines studied in Norway (May *et al*. 2012, p. 200). These areas also offer either exclusive or higher frequencies of maternal food sources during the high energy demands for reproducing females, such as marmot emerging from hibernation and neonatal ungulates (Inman 2013, pers. comm.) (see *Diet and Feeding* discussion below).

In summary, wolverines select den sites for different characteristics depending on location. Dens located under snow cover may be related to wolverine distribution based on other life history traits, including morphological, demographic, and behavioral adaptations that allow them to successfully compete for food resources (Inman 2013, pers. comm.). Structure (e.g., uprooted trees, boulders and talus fields) appears to be essential for natal den sites with or without snow cover. Sensitivity to human disturbance and predator avoidance are also likely important factors

in selecting both natal and maternal den sites. However, reproductive success of wolverines has not been evaluated relative to the depth and persistence of snow cover, or in combination with these or other important characteristics, including prey availability and predator avoidance.

Demography

The lifespan of the wolverine is variable. Jackson (1961, p. 361) reported an upper range of 8–10 years in the wild and potentially up to 18 years in captivity. Based on trapper-submitted carcasses from the Yukon, an upper age of 11.9 years for a male wolverine and 12.9 years for (pregnant) female was reported (Jung and Kukka 2013, pp. 8–12). Inman *et al*. (2012a, p. 781) classified wolverines less than 1 year old as juveniles (or cubs), those 1 to 2 years old as subadults, and those at least 3 years old as adults. Generation time for wolverines has been estimated at 7.5 years (COSEWIC 2014, p. 23).

Survival of adult female wolverines is considered to be an important demographic parameter in the wolverine's life history (Sæther *et al*. 2005, entire). As noted by Aronsson (2017, p. 13), because most polygamous species display a dispersal pattern that is sex-based, their population distribution is generally limited by the dispersal behavior of the sex that is more philopatric (the tendency of a species to remain within or return to its birth area). Thus, the distribution of wolverine populations and colonization is generally limited by dispersal of female wolverines (Aronsson *et al*. 2017, p. 2).

Stochastic factors (both demographic and environmental) also strongly influence the population dynamics of the wolverine (Sæther *et al*. 2005, p. 1,011–1,012). Given the rapid maturity of young wolverines, survival of female wolverines with young is likely dependent on the availability and distribution of food sources during the "snow-free season" (late spring and summer) (Banci 1994, p. 114). For example, a study of wolverines in Norway found that survival of young was primarily influenced by the abundance of small rodents (Landa *et al*. 1997, p. 1,293).

Evaluating how variations in demographic rates are influenced by the interactions between costs of reproduction, individual quality (e.g., breeding status), and environmental factors can provide a better understanding of the dynamics and viability of animal populations (Robert *et al*. 2012; p. entire; Rauset *et al*. 2015, entire). The interactions between individual age, environmental resources, and reproductive costs of wolverines in Sweden were recently examined (Rauset *et al*. 2015, entire). The results of this study provide important details regarding the influences on wolverine reproduction productivity. The study found that age-related variation in reproductive output for female wolverines is driven by the interactions between age, reproductive costs, and availability of resources (Rauset *et al*. 2015, p. 3,160). As an example, female wolverines were found to be more likely to give birth and nurse young in home ranges with greater food resource abundance at the time of fetal development (Rauset *et al*. 2015, p. 3,158). The study also concluded that a favorable reproductive strategy for female wolverines is a conservative one, wherein older female wolverines do not "trade" current reproduction against their own survival (Rauset *et al*. 2015, p. 3,161).

Intraspecific predation of wolverines is another important influence on wolverine population dynamics (Persson *et al*. 2003, p. 26). The altricial life history stage (early May to end of July) is likely a period of high juvenile mortality in solitary carnivores, such as the wolverine, since females are balancing the energetic demands of lactation (Sadleir 1984, pp. 179–180) and providing protection to young (Persson *et al*. 2003, p. 22). Young (juveniles) wolverines are vulnerable to predation during the time period when left unattended in the natal den (generally March-April) and when they first exit the natal den and are left at rendezvous sites, or around May-June (Magoun 1985, pp. 49, 73, 77). An additional vulnerability occurs when juvenile wolverines are required to become nutritionally independent and begin exploratory movements away from their mother's protection, generally August-September (Vangen *et al*. 2001, p. 1,644).

Mortality

There are a few natural predators of wolverines, but interactions with wolves can lead to severe injury and death (Burkholder 1962, p. 264; Banci 1987, pp. 81, 91; White *et al*. 2002, p. 132). Mountain lions are suspected of killing wolverines (Copeland 1996, p. 46; Krebs *et al*. 2004, p. 497; Aubry *et al*. 2016, pp. 27, 32). Starvation has also been identified as a cause of mortality in wolverines (Hornocker and Hash 1981, p. 1,296; Banci 1987, pp. 91, 110; Krebs *et al*. 2004, p. 497). Intraspecific predation also contributes to wolverine deaths. Persson *et al*. (2003, p. 25) found that juvenile survival rate tended to be lower during the altricial period (May–July), and intraspecific predation was the most common cause of mortality, occurring either as infanticide or after independence. Avalanches have also been documented as a cause of wolverine deaths (Inman *et al*. 2007, p. 89).

In North America, anthropogenic causes of mortality for wolverine populations include hunting, trapping, and road kill. Discussion of the effects of hunting, trapping, and human development is provided below (see Biological Status–Current Condition section).

Diet and Feeding

Wolverines have been described as opportunistic foragers (Inman *et al*. 2012b, p. 639) and as a "seasonal scavenger on the fringe of the food web" (Larsen 1980, p. 399). They are both scavengers and predators, with a diet that varies between seasons and years, and switching between food sources depending on availability (Magoun 1987, p. 396; Cardinal 2004, pp. 19–22; Mattisson *et al*. 2016, p. 9). The term "polyphagous" was used by Landa *et al*. (1997, p. 1,292) to describe the switching of food sources depending on prey availability by wolverines. Regional variations in diet have also been observed for wolverine populations (Nunavut, Canada) (Awan and Szor 2012, p. 9). The availability of ungulate carrion is believed to be more important than a particular habitat type for wolverines (Cardinal 2004, p. 20).

Early studies from northwestern Montana using scat analysis found that carrion (deer or elk) was an important component of wolverine diet (Hornocker and Hash 1981, p. 1,297). However, during winter, hoary marmots (*Marmota caligata*) were also important food items consumed and, in the spring, Columbian ground squirrels (*Urocitellus columbianus*) were heavily preyed upon (Hornocker and Hash 1981, p. 1,298). As reported by Cardinal (2004, pp. 20–21), wolverines in Canada have a large and varying diet based on reports from aboriginal traditional

knowledge holders; in addition to large animals as prey or carrion, wolverine diet includes rabbits and ptarmigans (*Lagopus* sp.), porcupine (*Erethizon dorsatum*), mice, beaver (*Castor canadensis*), fish, ducks, seals, gulls and gull eggs, and lemmings, as well as antlers, bones, and skulls. Native mountain goats (*Oreamnos americanus*) and bighorn sheep (*Ovis canadensis*), that occupy high elevation winter ranges in portions of North America, have also been suggested as important components of wolverine winter diet, particularly during the reproductive denning period (Buell Environmental 2016, pers. comm.). Snowshoe hares may also be an important food item for wolverines in parts of Canada (Jung and Kukka 2013, p. 20).

In northwestern Alaska, analyses of wolverine winter diet using carcasses collected from hunters (1996–2002) within the migratory range of the Western Arctic Caribou Herd found that caribou represented the most common food item, likely through scavenging behavior, followed by moose (*Alces alces*), and to a lesser degree, microtine rodents, Arctic ground squirrels (*Spermophilus parryii*), porcupines, wolverines, red fox (*Vulpes vulpes*), sheep and ptarmigan (Dalerum *et al*. 2009, p. 249). One study year found stomach contents contained a large portion of muskoxen (*Ovibos moschatus*) and Dall's sheep (*Ovis dalli*) (Dalerum *et al*. 2009, p. 249). Wolverines were found to be the main predator of caribou calves (less than 14 days of age) in northern British Columbia, Canada (Gustine *et al*. (2006, pp. 13–14). Wolverine diets in winter (scat analysis) and summer (primarily direct observation) were evaluated by Magoun (1987, entire) in northwestern Alaska. Results from that study indicate a large number of Arctic ground squirrels were eaten in summer, while the winter diet consisted primarily of caribou and Arctic ground squirrels (Magoun 1987, p. 393). Scavenging was found to be an important feeding strategy in winter, including remnants of buried caribou carcasses or bone/hide in the tundra (Magoun 1987, p. 396).

Food habits of wolverines from 2002 to 2007 in Glacier National Park were evaluated by Yates and Copeland (*in prep*) by reviewing prey remains and scat samples, or direct observations of feeding behavior. Their scat analysis found that 72 percent of samples contained more than one prey species, and 89 percent contained plant material, primarily conifer needles (Yates and Copeland, *in prep*). The latter may be related to scent marking behavior of territories, either by defecation after chewing on twigs/shrubs or terpenes released during urination, or the result of stomach contents found within their consumed herbivorous prey (Yates and Copeland, *in prep*). Overall, deer and elk represented the most frequent prey item (37 percent), but hibernating rodents were also common in scats (36 percent). Other prey items included mice, voles, lemmings, bovids (e.g., bighorn sheep, mountain goat), birds, and hares (Yates and Copeland, *in prep*). Temporal differences in the occurrence of prey were also observed.

Snow tracking in Montana found that wolverines hunted in brush piles, log jams, and heavy cover, and routinely entered "tree wells," areas immediately under dense, low growing conifers where snow does not accumulate, that provide easy access to small, ground-dwelling mammals (Hornocker and Hash 1981, p. 1298). Wolverines have been described as moving and lifting large stones in order to access human-cached meat (Freuchen 1935, p. 98).

Several foraging strategies have been described for wolverines. Predation behavior on reindeer (Sweden) was detailed by Haglund (1966, p. 275). A study of elk in Siberia, Russia, noted that, in most instances, wolverines will attack young, pregnant females, young of the year, and

wounded or sick animals (Knorre 1959, p. 27). Elk were chased, sometimes by two wolverines during periods of heavy snow (Knorre 1959, pp. 10, 27) and wolverines have been observed feeding in groups on large animal carcasses (Cardinal 2004, p.21). However, wolverines have been described as neither an effective predator of large game animals, nor a serious competitor with other predators (Cardinal 2004, p. 21).

Based on studies in Alaska, Dalerum *et al*. (2009, p. 251) suggested that wolverines occupying this region are large ungulate specialists, but use a generalist feeding strategy by switching between ungulate food sources (e.g., caribou and moose) depending on their availability. Thus, during periods of low caribou abundance, wolverines can switch from caribou (migratory) to moose (non-migratory) while still maintaining their ecological role as a scavenger on ungulate carcasses (Dalerum *et al*. 2009, p. 251).

A study of wolverine diet using scat samples in Finland found that breeding female wolverines opportunistically used carrion and hunted less on small prey as compared to males and non-breeding females (Koskela 2013, p. 35). In addition, in areas with low densities of mid-size ungulates, smaller prey and carcasses may be important in the wolverine diet (Koskela 2013, p. 35). These results supported an optimal foraging theory; that is, wolverines will opportunistically use foods that are the most energy-efficiently available (Koskela 2013, p. 41). In other words, hunting ungulates or smaller prey (rabbits, birds) may incur greater energetic costs than scavenging for food, but searching for wolf- or human-killed carcasses will take more time (Koskela 2013, p. 41).

Finally, diet and feeding strategies of wolverines were evaluated in Scandinavia (Mattisson *et al*. 2016, entire). Wolverine feeding strategies were found to be flexible and temporarily shifted from scavenging to predation and heavily influenced by seasonal dependent responses to availability of prey and the supply of carrion (Mattisson *et al*. 2016, p. 9). Predictable anthropogenic food sources (i.e., remains from hunted ungulates) also influenced wolverine feeding strategies in their study area by increasing scavenging behavior relative to predation (Mattisson *et al*. 2016, p. 10).

Aboriginal traditional knowledge holders in Canada have reported wolverines as being largely dependent on wolves or another large predator to obtain large mammal carrion such as caribou, but also scavenge off polar bear (*Ursus maritimus*) and grizzly bear (summer) kills (Cardinal 2004, p. 20). Wolverines were observed following the tracks of Eurasian lynx (*Lynx lynx*) and then scavenging on prey left behind from lynx kills (Haglund 1966, pp. 272–273). Myhre and Myrberget (1975, p. 756) noted that the hunting abilities of wolverine and Eurasian lynx are not the same and that the two animals use the meat of their prey differently, which, together, may allow the two carnivores to coexist in the same environment.

In Sweden, Mattisson *et al*.'s (2011b, p. 1,326) study of Global Positioning System (GPS)-collared wolverines found that they spent three times longer scavenging ungulate carrion as compared to feeding on wolverine-killed prey, and more than half of the reindeer carcasses scavenged by wolverines were killed by Eurasian lynx. That study concluded that lynx can increase the availability of food for wolverines and other scavengers and that lynx behavior around kill sites minimizes potential encounter conflicts (Mattisson *et al*. 2011b, p. 1,328). In

their study area, Eurasian lynx do not appear to pose a significant threat to wolverines, neither by exclusion in space or time (Mattisson *et al*. 2011a, p. 79) nor from mortality (Persson *et al*. 2009, p. 327). We are not aware of similar evaluations for North American populations of wolverines and Canada lynx. This lack of study on interspecific processes in the more predator-diverse North American landscape is an important gap in our understanding of wolverine distribution (Fisher *et al*. 2013, p. 712).

Large carnivores can act as "sympatric ungulate predators" (Dalerum *et al*. 2009, p. 251), generating carrion at kill sites, particularly during winter months, but also as competitors and potential sources of mortality (White *et al*. 2002, p. 132; Krebs *et al*. 2004, p. 497; Koskela *et al*. 2013b, p. 221). Wolverines apparently balance their exposure to the risk of predation with foraging opportunities (Scrafford *et al.* (2017, p. 32). Thus, even though wolverines may not be dependent on lynx or other sympatric predators for their survival or reproduction, an increase in the availability of carrion likely has a positive influence on the reproductive rate (e.g., number of offspring) in wolverine populations (Mattisson *et al*. 2011b, p. 1,328).

Caching of food is an important behavior of wolverines and is a key component of wolverine population dynamics (Hornocker and Hash 1981, p. 1,297; Inman *et al*. 2012b, p. 640). Food is cached in both summer and winter, by both sexes, and allows for food to be available past the peak periods of mortality and predation (Inman *et al*. 2012b, p. 639). Wolverines will typically move between carcasses and cache sites and are able to remove large parts of a carcass in a short time (Mattisson *et al*. 2011b, p. 1,327). Caching behavior in Sweden was reported most commonly in snow, as well as crevices in rock piles, and found that wolverines carried food to cache sites over long distances (8 and 10 km (5 and 6 mi)) (Haglund 1966, p. 274). As an example, Bjärvall (1982, p. 319) reported a female wolverine carried a reindeer head (with antlers) about 22 km (13.67 mi) back to a den site in Sweden. In northwestern Alaska, wolverines fed on cached ground squirrels during winter (Magoun 1987, p. 395).

A study of wolverine caching behavior in boreal forest habitat in Canada reported that cache sites varied from simple caches, a single feeding site or excavation, to cache complexes, which included feeding stations, latrines, resting sites, and climbing trees dispersed over varying spatial landscapes (Wright and Ernst 2004b, pp. 61–62). All cache sites included bones and hides of moose, which were likely scavenged from wolf kills (Wright and Ernst 2004b, p. 62). Cache sites were often excavated in snow, but also in the ground under boughs of large spruce (*Picea* spp.) trees (Wright and Ernst, 2004b, p. 62). Wolverines also appeared to select cache sites and resting areas that offered good visibility of approaching competitors or predators (Wright and Ernst 2004b, pp. 63–64).

Wolverine energetic demands and food requirements are related to their foraging strategies. Caching provides important energy for female wolverines during the lactation period and helps ensure survival of newborns (Inman *et al*. 2012b, p. 640). Wolverines were found to have high energetic needs compared to other mammalian carnivores (Young *et al*. (2012, p. 2,252), similar to results previously presented by Iversen (1972a, p. 343), who concluded the basal metabolism of mustelids weighing over 1 kg (2.2 lbs) is approximately 20 percent higher than for other mammals. A study by Andrén *et al*. (2011, p. 36) estimated a 1.2 kg/day (2.65 lbs/day) (range: 1.0–1.4 kg/day (2.2–3 lbs/day)) food requirement for wolverines, while Young *et al*. (2012, p.

223) estimated a male wolverine would require an average of 0.85 kg (1.87 lb) of prey/day in winter and 0.95 kg/day (2.1 lbs/day) in "snow-free" periods." Based on energy equivalent value of various prey sources, Young *et al*. (2012, pp. 223, 225) estimated that a winter diet for a male wolverine would include the equivalent of 1.8 ungulates, 70.7 sciurids (squirrels), 20.6 lagomorphs (rabbits), and 832.7 small mammals, while in snow free season this would include the equivalent of 0.9 ungulates, 122.9 sciurids, and 3362.1 small mammals.

The study by Young *et al*. (2012, p. 225) concluded that wolverines consume 0.1 kg (0.22 lb) of prey per day more outside winter season, but that prey expected to be consumed in winter had a higher caloric content than other seasons; thus, the mass requirement is lower. As an example, they cite the higher proportion of ungulates consumed in winter, which provide about 1.3 times more energy (kilojoules per kilogram) than squirrels (Young *et al*. 2012, p. 225). Other researchers have also noted that food during the summer is just as important as the availability of cached ungulate food in the winter (e.g., during the energy demanding lactation period) (Inman *et al*. 2012b, pp. 640–642). The post-weaning growth period (May–August) was identified as a high energetic demand for food by a wolverine family group (Inman *et al*. 2012b, p. 640). Taken together with the lactation period, the calories available to wolverines therefore likely reaches a maximum from March to April (Inman *et al*. 2012b, p. 640).

Population Structure

As discussed above, wolverines recolonized much of North America after periods of glaciation and then experienced heavy human persecution in much of their range. As shown in our current range map (Figure 3) and described below in our *Population Abundance and Distribution* section, wolverines occur across a broad expanse of North America, where the contiguous United States represents the southern extent of the species' range. A number of biological factors can affect wolverine populations, including the species' low intrinsic rate of population increase, naturally low densities, and need for large, intra-sexual home ranges (Banci and Proulx 1999, p. 180). Their extensive dispersal abilities make possible the recolonization of individuals into vacant habitats (Vangen *et al*. 2001, p; 1,647; Aronsson 2017, p. 43). As noted above (*Diet and Feeding*), interactions with sympatric predators and the availability of prey and carrion can also directly and indirectly affect wolverine populations.

Wolverines in the contiguous United States are considered to represent a metapopulation (set of local or subpopulations within a larger area and where migration is possible between patches (Hanski and Simberloff 1997, p. 11)) (Inman *et al*. 2013, p. 277) and occupy habitat in high alpine patches at low densities, dispersing into suitable areas (Inman *et al*. 2012a, pp. 782–784). Wolverines in Canada are considered to occur as a single large group as they are easily able to move between areas of good habitat and because wolverine habitat is relatively contiguous (Harrower 2017, pers. comm.).Wolverine populations in Alaska are considered to be continuous with populations in the Yukon and British Columbia provinces of Canada based on genetic studies (COSEWIC 2014, p. 37).

Studies of wolverines in the North Cascades region have documented movement of wolverines from Washington into British Columbia (Aubry *et al*. 2016, pp. 16, 20). The 2014 COSEWIC Report indicated that rescue (immigration from another population) of Canadian wolverine

populations along the Canada-Alaska international boundary was likely (based on nuclear DNA evidence), but was negligible *from* the contiguous United States (COSEWIC 2014, p. 37). Based on mitochondrial DNA studies, Tomasik and Cook (2005, p. 390) concluded the gene flow in wolverines in northwestern North America is likely male-mediated, and is primarily due to long distance dispersal between low-density populations. Genetic studies of North American wolverines conducted by Kyle and Strobeck (2002, entire) found high levels of gene flow across northern populations (Canada and Alaska).

Genetics

Evaluation of genetic material can provide an understanding of population dynamics (Cegelski *et al*. 2006, p. 209). The geographical genetic structure of wolverines is believed to be largely structured around the strong female philopatry characteristic of this species (Rico *et al*. 2015, p. 2), and, given the species polygamous behavior, wolverine population distributions (at least in Scandinavia) are considered to be primarily limited by dispersal of the more philopatric sex (females) (Aronsson 2017, p. 13). However, the extensive and often asymmetrical movement of male wolverines from core populations to the periphery of their range can result in the addition of nuclear genetic material to these edges (Zigouris *et al*. 2012, p. 1,553). Thus, the dispersal pattern for male wolverines may help explain why allelic richness (i.e., nuclear DNA) can be similar across regions, but haplotype richness (mitochondria DNA) is lower at the periphery of the species' range (Zigouris *et al*. 2012, p. 1,553). Additionally, the extensive dispersal movements of both male and female wolverines can produce gene flow among diverged populations, making it difficult to distinguish, without additional sampling and analysis, between long-distance dispersal and fragmentation based on the patchy distribution of some haplotypes (Zigouris *et al*. 2013, p.10).

Studies evaluating the genetic structure of wolverines, primarily within its core range in North America, were presented in Chappell *et al*. (2004) and Kyle and Strobeck (2001, 2002). Using microsatellite markers, Kyle and Strobeck (2002) and Zigouris *et al*. (2012) found a greater genetic structure of wolverines toward their eastern and southern peripheries of their North American distribution, likely due to a west-to-east recolonization during the Holocene (Zigouris *et al*. 2013, p. 9). Similarly, based on mitochondria DNA, McKelvey *et al*. (2014, p. 330) concluded that modern wolverine populations in the contiguous United States are the result of recolonization (following persecution from hunting and trapping) from the north.

Genetic diversity and population genetic structure of a larger sample size of wolverines were examined by Cegelski *et al*. (2006, entire) for the southern extent of their North American range using both microsatellite markers and mitochondrial DNA. They concluded that the wolverine populations in the contiguous United States were not sources for dispersing individuals into Canada (Cegelski *et al*. 2006, p. 208). They found that there was significant differentiation between most of the populations in Canada and the United States (Cegelski *et al*. 2006, p. 208). However, they cautioned that their statistical analysis may not have been able to detect "effective migrants" and that sample size can affect the detection of dispersers (Cegelski *et al*. 2006, p. 208). They concluded that some migration of wolverines was occurring between the Rocky Mountain Front region (northwestern Montana) and Canada as well as among wolverine populations in the United States, with the exception of Idaho (Cegelski *et al*. 2006, p. 208). In

addition, results from testing of allelic differences among the populations were interpreted by the authors as likely inadequate to counter the effects of genetic drift due to low numbers of migrants (Cegelski *et al*. 2006, p. 208). They estimated that, based on genetic diversity observed at that time, two effective migrants from either Canada or Wyoming into the Rocky Mountain Front population would be needed to maintain the levels of genetic diversity in that population, and one effective migrant was needed to maintain levels of diversity in the Gallatin, Crazybelt, or Idaho populations (Cegelski *et al*. 2006, p. 209). The authors concluded that migration is essential for maintaining diversity in wolverine populations in the contiguous United States since effective population size may never be reached due to the naturally low population densities of wolverines (Cegelski *et al*. 2006, p. 209).

Effective population size (N_e) (see **Box 2**) is defined as "the size of an idealized population that would experience the same amount of genetic drift and inbreeding as the population of interest. In popular terms, N_e is the number of individuals in a population that contribute offspring to the next generation" (Hoffman *et al*. 2017, p. 507). It represents a metric for quantifying rates of inbreeding and genetic drift and is often used in conservation management to set genetic viability targets (Olsson *et al*. 2017, p. 1). It is not the same as the more commonly used metric, census population size (N), but is often assumed to represent the *genetically* effective population size.

An effective population size analysis for wolverines in the contiguous United States was presented in Schwartz *et al*. (2009, p. 3,225) using wolverine samples from the main part of the Rocky Mountains populations (e.g., central and eastern Idaho, Montana, northwestern Wyoming). Excluded in this analysis, were subpopulations from Crazy and Belt Mountains in Montana (based on suggestion by Cegelski *et al*. (2003) that they represented separate groups) (Schwartz *et al*. 2009, p. 3,225). Samples were divided into three time frames and the computer program ONeSAMP was used to estimate effective population size in each time frame [sample size appears to be between 142 and 210]. The summed effective population size was estimated at 35, with credible limits from 28–52, and the summed values for the three time frames was reported as follows: $N_{e\ 1989–1994}$ = 33, credible limits 27–43; $N_{e\ 1995–2000}$ = 35, credible limits 28–57; $N_{e\ 2001–2006}$ = 38, credible limits 33–59 (Schwartz *et al*. 2009, p. 3,226).

However, Cegelski *et al*.'s (2006, p. 203) evaluation of nuclear DNA population structure in wolverines in Canada (sample size of 101) and the contiguous United States (sample size of 116), as depicted by a principle component analysis plot and dendrogram, found that all of the Canadian wolverine populations clustered together. In the contiguous United States, the Rocky Mountain Front subpopulation clustered with the Wyoming subpopulation, the Crazybelt Mountains' area subpopulation clustered with the Gallatin (Montana) population, and the Idaho population was highly differentiated (Cegelski *et al*. 2006, p. 203). That study concluded that some exchange of migrants is occurring between the Gallatin and Crazybelt wolverine populations (Cegelski *et al*. 2006, p. 207), but noted that this grouping is more genetically differentiated and isolated from the other populations they sampled *when compared to* the Rocky Mountain Front population (Cegelski *et al*. 2003).

In addition, the map presented in Schwartz *et al*. (2009, p. 3,223) depicting the locations of the wolverine samples used in preparing their effective population size estimate shows significant gaps within the wolverine's range in Idaho and parts of Montana (e.g., interior of the Bob

Marshall Wilderness area). Thus, other wolverine subpopulations and/or individuals were likely missed for this analysis. Studies within the Southwestern Crown of the Continent (SWCC) in northwestern Montana have detected cross-valley movements of wolverines, which researchers believe is an indication of good connectivity in this region (SWCC Wildlife Working Group 2016, pers. comm.). Current efforts to collect additional wolverine hair samples for genetic analyses are underway through a multi-state occupancy survey project (see *Population Abundance and Distribution* section below).

Another evaluation of mitochondria DNA was conducted by Francis (2008), who found an overall lack of regional (geographic) genetic structure for North American wolverines, but noted that a few populations (Crazybelts (Montana), Southeast Alaska, Nunavut (Canada), and Kenai Peninsula) appeared to be isolated from the others (Francis 2008, p. 12). However, statistical testing did not identify any genetically defined sampling localities (Francis 2008, p. 13). Minimal differences were found between core and peripheral wolverine populations, as grouped in that analysis (Francis 2008, p. 21; Table 4). Conversely, the study by Zigouris *et al*. (2012, p. 1,554; Table 5) did find support for genetic clusters for wolverine populations in Canada, and Zigouris *et al*. (2013, p. 5; Table 3) identified several worldwide regional genetic groups. In addition, an analysis of estimated population growth found signals of population expansion in several wolverine populations (Francis 2008, p. 13; Table 5) including Rocky Mountain Front, Wyoming, Central, South, and Northwestern Alaska, British Columbia, Northwest Territories, and Nunavut.

Box 2. Effective Population Size and Genetic Variation

The concept of effective population size (N_e) (see review by Wang *et al*. 2016) and, relatedly, minimum viable population, has been a topic of debate, particularly the 50/500 rule, which was developed over 30 years ago. As noted by Laikre *et al*. (2016, p. 280), the concept and guidelines for *genetically* effective population size were developed for single, isolated populations, but it's unclear which of the various N_e metrics was referenced in the original concept proposed by Franklin (1980) (i.e., inbreeding effective size, realized effective size, total inbreeding effective size of a metapopulation, or eigenvalue effective size (Laikre *et al*. 2016, p. 288)).

There are differing interpretations of the values proposed for effective population size. For example, should the minimum viable effective population size be derived genetically to set a threshold for a minimum viable population? Here, the rule is interpreted as 50 being the short-term number (for inbreeding depression) and 500 as the long-term number (for retention of genetic variation). Or should the N_e value of 500 be interpreted as a long-term goal for maintaining a healthy, genetically robust population, and not a threshold trigger that predicts extinction risk? In addition, some view the 500 value to be a global reference value rather than a local value, and that it may not be necessary to maintain a local N_e of 500 as long as there is some gene flow into a population (Jamieson and Allendorf 2012, p. 580).

Finally, others have recommended changes to the 50/500 rule. Laikre *et al*. (2016, entire) presented an analysis of the metapopulation effective size for the Fennoscandian wolf population and recommended that long-term conservation genetic target for metapopulations (N_{eMeta}) $\geq$ 500, but also a realized effective size of *each subpopulation* (N_{eRx}) $\geq$ 500. Frankham *et al*. (2014, p. 59) have recommended modifying the 50/500 rule to 100/1000.

It can be difficult to make inferences about the relationship between population size and point estimates of genetic diversity without continued genetic monitoring and an understanding of the demographic history of a species' population (Hoffman *et al*. 2017, p. 507), including factors that have influenced movement patterns and connectivity. It's also important to note that genetic diversity can be a reflection of favorable adaptations (natural selection) and is necessary for species to locally adapt to environmental stressors or to facilitate range shifts (Zigouris *et al*. 2012, p. 1,544). Genetic distinctiveness in peripheral populations may play a role in both maintaining and generating biological diversity for a species (Zigouris *et al*. 2012, p. 1,544; citing results presented in Channell and Lomolino 2000, p. 84). Genetic variation that is adaptive is a better predictor of the long-term success of populations as compared to overall genetic variation (Hoffman *et al*. 2017, p. 510). The challenge is to be able to determine whether genetic variation is adaptive and is a reflection of remnants of high genetic diversity from ancestral populations, or whether that variation is a reflection of accumulated deleterious, nonadaptive genes due to genetic drift in small populations (Hoffman *et al*. 2017, p. 509).

In summary, the currently known spatial distribution of genetic variability in wolverines in North America appears to be a reflection of a complex history where population abundance has fluctuated since the time of the last glaciation, and insufficient time has passed since human persecution for a full recovery of wolverine densities (Cardinal 2004, pp. 23–24; Zigouris *et al*. 2012, p. 1,554). Zigouris *et al*. (2012, p.1,545) noted that the genetic diversity reported in Cegelski *et al*. (2006) and Kyle and Strobeck (2001, 2002) for the southwestern edge of the North American range represented only part of the diversity in the northern populations of wolverines. Zigouris *et al*. (2012, p. 1,545) posit that the irregular distribution of wolverines in the southwestern periphery and the genetic diversity observed in those analyses is a result of population bottlenecks that were caused by range contractions from a panmictic (random mating) northern core population approximately 150 years ago coinciding with human persecution. Demographic studies as well as additional genetic analyses from contemporaneous wolverines currently occupying the contiguous United States are needed to evaluate the current status of wolverine populations in North America. In addition, ecological, phenotypical, and environmental information should be used to complement genomic data when interpreting the strength of conclusions or inferences of spatial patterns of adaptation or for adaptively divergent populations (Jamieson and Allendorf 2012, p. 492).

Summary

In this SSA report, we have incorporated information from several new studies related to the wolverine published since our 2013 proposed rule and previous studies that were not considered (e.g., Magoun *et al*. 2017). We have also reviewed new publications and publications in preparation from wolverine researchers in Scandinavia (e.g., Aronsson 2017; Bischof *et al*. 2016; Makkonen 2015; Mattisson *et al*. 2016; Myhr 2015; Persson *et al*. 2017, *in prep*). This information informs our assessment of the most current information regarding the description of the wolverine and its life history and ecology across its North American range. We have included in this SSA Report detailed discussions of wolverine physiology, and spatial and temporal patterns and trends related to reproduction and diet/feeding. We also prepared a revised current range map (see Figure 3) based on information we received from Federal, State, and others, including Canada.

A species' current and future conditions and overall viability (in terms of resiliency, redundancy, and representation), are largely impacted by the availability of what the species needs at the individual, population, and species level. The needs described below are necessary for wolverines to have resources for the basic requirements of life (breeding, feeding, and sheltering) at all levels. Overall, the best available information indicates that within the contiguous United States the wolverine's physical and ecological needs include:

(1) large territories in remote landscapes; at high elevation (1,800 to 3,500 meters (5,906 to 11,483 feet))
(2) access to a variety of food resources, that varies with seasons; and
(3) physical/structural features (e.g., talus slopes, rugged terrain) linked to reproductive behavioral patterns.

Biological Status – Current Condition

This section provides an overview of the wolverine's current condition, including those stressors that may be impacting the species or its habitat. In this SSA Report, we have identified stressors based on impacts that may negatively affect the physical and ecological needs of the species, including temporary or permanent impacts to habitat features that the species relies on for survival and reproduction.

Population Abundance and Distribution

Since our 2013 proposed rule, we have received additional reports of wolverine observations including Utah, Colorado, and Oregon, and an updated Canadian status review for the wolverine has been prepared (COSEWIC 2014, entire). Additional studies have also been published related to wolverine populations in British Columbia and Alberta (e.g., Regehr and Lacroix 2016; Stewart *et al*. 2016; Webb *et al*. 2016). As noted above, we developed a Current Range map for the North American wolverine (see Figure 3). For the conterminous United States, this map was based on several resources, including the primary habitat model developed by Inman *et al*. (2013), EPA Ecoregion mapping (2010), Forest Service NRIS data, and information received from State agencies. We used the 2014 COSEWIC Assessment and Status Report's current range map for Canada and Alaska. For Canada, the range of occurrence includes the Yukon, Northwest Territories, Nunavut, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec, Newfoundland, and Labrador (COSEWIC 2014, p. vii).

Contiguous United States

Areas in the western contiguous United States were identified by Inman *et al*. (2013, entire) as suitable for wolverine survival (long-term survival; used by resident adults), or **primary habitat** (Inman *et al*. 2013, p. 279), reproduction (used by reproductive females), and dispersal (female and male) of wolverines (see methodology in Inman *et al*. 2013, pp. 279–280; Figure 2). From these results, the researchers estimated potential and current distribution and abundance of wolverines in the western contiguous United States (Inman *et al*. 2013, p. 282). They estimated current population size of wolverines to be 318 (range 249–626) located within the Northern Continental Divide (Montana) and areas within the following ecoregions: Salmon-Selway

(Idaho, portion of eastern Oregon), Central Linkage (primarily Idaho, Montana), Greater Yellowstone (Montana, Idaho, Wyoming), and Northern Cascades (Washington) (Inman *et al*. 2013, p. 282). Potential wolverine population capacity based on their RSF habitat modeling was estimated to be 644 (range: 506–1881) (Inman *et al*. 2013, p. 282). However, these estimates did not consider spatial characteristics related to behavior, such as territoriality, of wolverine populations. The discussion below provides a summary of recent studies of wolverine detections and observations in the western United States; however, no comprehensive surveys have been conducted across the species' entire range.

In the northern Cascades region of Washington and Canada, researchers tracked activity areas for 14 wolverines via satellite telemetry from 2007 through 2015 (Aubry *et al*. 2016, entire). This study demonstrated that the region supports a resident population, with 9 of 11 study animals documented primarily within Washington (Aubry *et al*. 2016, p. 40).

The Oregon Department of Fish and Wildlife (ODFW) reports that wolverines have been found in the Oregon Cascades on Three-fingered Jack (glaciated volcano) in Linn County, on the Steens Mountain in Harney County, and Broken Top Mountain in Deschutes County, in the Eagle Cap Wilderness Area in the Wallowa Mountains of northeastern Oregon, and, more recently (2012), in Wallowa County, northeast Oregon (ODFW 2017, no page number).

In California, camera trap data indicate the continued presence of a single male wolverine in the Truckee area, as of March 2017 (Shufelberger 2017, pers. comm .). The California Department of Fish and Wildlife (CDFW) has received reports of wolverine detections from the public over past several years, particularly the region near Carson Pass, as well as near Meeks Bay, Lake Tahoe (Stermer 2017, pers. comm.). CDFW researchers are conducting multi-species predator surveys, targeting the potential occurrence of Sierra Nevada red fox and wolverine using camera trapping with hair snares in an effort to determine occupancy, detection probability, distribution, and habitat associations (Stermer 2017, pers. comm.).

A pilot study to evaluate wolverine occupancy was conducted in Wyoming from February through June in 2015 (Inman *et al*. 2015, entire). Results from that survey (hair snares and camera traps in 18 stations across 5 mountain ranges) indicated at least three individual wolverines (at five stations) with at least one individual in the Gros Ventre and Wind River mountain ranges, and at least two individuals in the Southern Absaroka mountain range (Inman *et al*. 2015, p. 9). Occupancy modeling estimated a probability of occupancy for sampled sites of 62.9 percent (Inman *et al*. 2015, p. 8).

In an effort to assess wolverine occupancy in the western United States, the Western Association of Fish and Wildlife Agencies (WAFWA), in coordination with Tribal partners, have formed a multi-state, multi-agency working group (Western States Wolverine Working Group) to design and implement the Western States Wolverine Conservation Project (WSWCP)–Coordinated Occupancy Survey (see Bjornlie *et al*. 2017 for details of protocol). The primary objectives of the WSWCP include: 1) implement a monitoring program to define a baseline wolverine distribution and genetic characteristics of the metapopulation across Montana, Idaho, Wyoming, and Washington, 2) model and maintain the connectivity of the wolverine metapopulation in western United States, and 3) develop policies to address socio-political needs to assist wolverine

population expansion as a conservation tool, including translocation of wolverines (IDFG 2016, pers. comm.; Montana Fish, Wildlife, & Parks (FWP) 2016, pers. comm.; WGFD 2016, pers. comm.).
The WGFD began implementation of the survey in Wyoming in the Greater Yellowstone Ecosystem region and the Bighorn Mountains (25 grid cells) in the winter of 2015–2016 (WGFD 2016, pers. comm.). That initial survey detected, based on unique fur markings, at least two unique wolverines in the Wind River and southern Absaroka Mountain Ranges (WGFD 2016, pers. comm.). The WGFD reported 26 independent wolverine visits, and detections at least once within their study area during each of the four sampling periods (December 2015 through March 2016) (Bjornlie *et al*. 2017, pp. 4–5). Genetic analyses of collected hair samples, including sex and individual identification, are underway.

The monitoring effort was expanded in the winter of 2016–2017 to 187 cells (cell area of 225 km^2 (87 mi^2)) across four states (Washington, Idaho, Montana, and Wyoming). Preliminary results for the 2016–2017 winter detected wolverines in 85 survey cells (WAFWA 2017). Photographic detections of wolverine include 18 from Idaho, 48 in Montana (including detection of wolverines in all 10 cells surveyed in the SWCC region (Davis 2017, pers. comm.)), 10 in Washington, including detections south of Interstate 90 (Davis 2017, pers. comm.), and 9 in Wyoming; genetic analyses, to date, have reported a total of 157 wolverine samples (WAFWA 2017). It has not yet been determined from the camera-trap images and hair samples how many of these detections are the same individual. **Appendix B** contains a map illustrating these preliminary detections (as of July 2017).

Based on a 6-year study of monitoring resident wolverines (live trapping and camera stations) in central Idaho (Centennial, Smoky, and Salmon Mountains) and the western Yellowstone region (Teton Mountains), Heinemeyer (2016, pers. comm.) suggested that subpopulations of the species at this southern periphery of their North American range are still unstable with low rates of recruitment. We therefore requested additional information from State and Federal agencies regarding the most recent wolverine detections in the Winter Recreation Project study areas of Idaho and Wyoming. In the Teton Mountains region, two wolverines were detected in March 2017, in two different areas (Dewey 2017, pers. comm.). In addition, at least one wolverine was detected on the east side of the Teton Mountains during the winter of 2016-2017, as part of the Western States Wolverine Conservation Project–Coordinated Occupancy Survey monitoring and occupancy study, and a member of the public reported wolverine tracks within Grand Teton National Park in March 2017, while skiing (Walker 2017, pers. comm.). In Idaho, IDFG reported 5 wolverine detections in the Salmon Mountains in Central Idaho in the winter of 2016 (Mack 2017a and 2017b, pers. comm.). These recent detections are displayed in **Appendix C** relative to the study areas of the Winter Recreation Project study areas for the McCall, Idaho, and Teton Mountains. A wolverine was also detected in the winter of 2016-2017 in the Gravelly Range in southwestern Montana about 25 km (15.5 mi) north of the Centennial Mountains area surveyed during the winter recreation project (Inman 2017b, pers. comm.).

Alaska

The ADF&G Trapper Questionnaire Annual Reports include estimates of relative abundance and trends of wolverines and other furbearers as reported by trappers (Parr 2016, p. 38). Table 4 below provides a summary of abundance and trends from 2010–2016 of those reports by region.

Table 4. Relative Abundance and Trend of Wolverine Populations, Alaska (as reported by trappers), 2010-2016.* For Trend, + indicates increase, − indicates declining/decrease, and n/c indicates no change. Sources: ADF&G 2012, 2013a, 2013b; Parr 2016.

Region	Relative Abundance				Trend			
	2010-2011	2011-2012	2012-2013	2015-2016	2010-2011	2011-2012	2012-2013	2015-2016
Region I – Southeast Alaska	scarce	scarce	scarce	scarce	n/c	n/c	n/c	−
Region II – Southcentral Alaska	scarce	scarce	scarce	scarce	n/c	n/c	n/c	−
Region III – Interior Alaska	scarce	scarce	scarce	scarce	n/c	n/c	n/c	−
Region IV – Central and Southwest Alaska	N/A	N/A	N/A	scarce	N/A	N/A	N/A	−
Region V - Northwest	N/A	N/A	N/A	scarce	N/A	N/A	N/A	−
Southwest	common	scarce	scarce	N/A	n/c	−	n/c	N/A
Arctic and Western	common	common	scarce	N/A	n/c	n/c	n/c	N/A

*No reports written for years 2009-2010, 2013-2015.

However, relying exclusively on trapping reports is likely to present an incomplete assessment of wolverine populations. The accuracy of information provided in the most recent report is dependent on how many trappers reply to the annual survey; for 2016 the response rate was only 11.7 percent (Parr 2016, p. 3). Trapping effort was reported to have increased by some trappers (45 percent of those reporting) during the 2015–2016 season, and 80 percent of those who increased their efforts reported an increase in their overall catch (Parr 2016, p. 15). However, this assessment does not consider how this increased trapper effort relates to harvest levels for wolverine, nor does it account for an unknown and unreported number of wolverines taken for subsistence purposes (Gardner *et al*. 2010, p. 1,894). Estimates of density, described below, provide a better depiction of wolverine population status in Alaska.

Canada

Similar to Alaska, determining wolverine population abundance and trends in Canada is difficult as numbers are developed from harvest activity (COSEWIC 2014, p. 25). Wolverine harvest trends are also difficult to estimate given the temporal and spatial variability in trapping effort and reporting of harvest, and not all regions use mandatory pelt sealing, compulsory reporting, or fur export permits/fur dealer records (COSEWIC 2014, p. 26).

According to the most recent COSEWIC Assessment and Status Report on the Wolverine, *Gulo gulo* in Canada (COSEWIC 2014, entire), Canada's western subpopulation has been estimated at 15,688 to 23,830 adults, though this value is based on several assumptions (consistent trapping effort and uniform densities across the species' range); the eastern population is estimated at less than 100 individuals or may be extirpated (COSEWIC 2014, p. 36). Population trends across all

of Canada are not known, but wolverine populations have been stable over areas within the country's northern range for the last three generations (22.5 years) (COSEWIC 2014, p. v).

In northern Manitoba and Ontario, wolverines may be increasing in number as aerial surveys in northern Ontario have indicated an eastward reoccupation of its former range (towards James Bay and Québec) (COSEWIC 2014, p. v). However, although observations of wolverines continue to be reported within Québec and Labrador (the eastern sub-population), there have been no verifiable observations since 1978, and wolverines are likely extirpated from much of southeastern Canada (COSEWIC 2014, p. v). In addition, declines in the southern regions (within parts of British Columbia and Alberta) may be occurring (COSEWIC 2014, p. 36). Table 5 presents a more detailed summary of wolverine populations in Canada.

Table 5. Wolverine Population Estimates for Canadian Territories. Source: COSEWIC, 2014.

Territory	Number of wolverines
Yukon Territory	3,500–4,500
Northwest Territories	3,430–7,325 (with an additional 220–470 juveniles)
Nunavut	Estimated at 2,000–2,500
British Columbia	2,700–4,760
Alberta	Estimated at 1,500–2,000
Saskatchewan	Less than 1,000
Manitoba	1,100–1,600
Ontario	458–645
Québec	Very rare, at non-detectable level, or extirpated
Labrador (including mainland Newfoundland)	Very rare or extirpated

In addition to the 2014 COSEWIC summary, Cardinal 2004 (entire) prepared a complimentary summary report of wolverine trends in Canada based on Aboriginal traditional knowledge. Trends reported indicate: (1) high, relatively stable levels of wolverines in the Yukon; (2) high levels of wolverines in the North Slave region of the Northwest Territories, though population levels are estimated to be stable to decreasing; (3) high levels of wolverine along forested areas in the northern portions of the mainland within the Inuvialuit Settlement Region (ISR) (located in the northwest corner of the Northwest Territories) and Kitikmeot region of Nunavut; (4) an increase in wolverines in the Kivalliq region of Nunavut, but at lower levels than populations in the Boreal and North Mountain ecological areas; and (5) least abundant in the northeastern corner of Nunavut and the Arctic Islands (Cardinal 2004, pp. 22–29). In sum, the majority of traditional knowledge holders in Nunavut, Northwest Territory, and Yukon Territory describe wolverine populations as either stable or increasing in northern Canada and is now found in areas where they occurred in the past; however, they are still considered naturally uncommon; only in Yellowknife did people report that wolverines might be decreasing (Cardinal 2004, pp. iii– iv, 10, 23).

Other inventory and occupancy studies include an inventory of wolverines conducted by Regehr and Lacroix (2016, entire) in the winter of 2012 on the east side of the Coast Mountains in British Columbia using a multi-method approach. They identified six individuals using genetic analysis, and one additional individual by photography, which was higher than expected as compared to model predictions of density and habitat quality (Regehr and Lacroix 2016, pp.

248–249). Estimates of wolverine occupancy were also evaluated for the Canadian Crown of the Continent ecosystem (central and southern Canadian Rockies) (Clevenger *et al*. 2016, entire). Occupancy estimates were found to vary from year-to-year and exhibited a north-south gradient, likely due to the differences in habitat quality among areas that were sampled by year (Clevenger *et al*. 2016, p. 4). For 2016, estimated wolverine occupancy probability was 0.40 for their British Columbia Rockies study area, with a declining pattern from north to south (Clevenger *et al*. 2016, p. 4). In general, their research has found that wolverines are more abundant in rugged, remote areas that have minimal human activity and landscape disturbance (Clevenger *et al*. 2016, p. 5). This study projected an expected number of wolverines in their study area of about 28 (Clevenger *et al*. (2017, p. 6). To the south, in the Southwestern Crown of the Continent (SWCC) region (northwestern Montana, approximately 1.5 million acres), wolverine surveys (snow tracking, bait stations/hair snares) have been conducted since 2012 (SWCC Wildlife Working Group 2016, pers. comm.). These survey efforts have detected 22 unique wolverines (11 males, 11 females) across three U.S. Forest Service districts, and they reported an increase in the frequency of detections from 2012 to 2015 (SWCC Wildlife Working Group 2016, pers. comm.).

The 2014 COSEWIC report indicates that trends in wolverine populations in the northern range, while uncertain, appear to be stable or increasing, but also notes that there is some concern for populations in the southern areas of British Columbia and parts of the northern United States (COSEWIC 2014, p. 22, and references cited therein). In British Columbia, researchers are currently conducting a multi-phase project using landscape genetic analyses to identify and delineate functional populations of wolverines and provide an estimate of size and sustainable harvest within each functional population (Weir 2017, pers. comm.).

Estimates of Density

Wolverine densities vary across North America, and have been described as “naturally low” (van Zyll de Jong 1975, p. 434) and “naturally uncommon” (Cardinal 2004, p. iii) given the species’ large home range, wide-ranging movements, and solitary characteristics. The most recent estimates (at that time) of density (number of wolverines per 1,000 km^2 (386 mi^2)) for North America were prepared by Inman *et al*. (2012a, p. 789; Table 5). In the contiguous United States, density estimates ranged from 3.5 for the Greater Yellowstone region (2001–2008) (areas above 2,150 m (7,054 ft) (latitude-adjusted elevation), 4.5 for central Idaho (1992–1995), to 15.4 for northwestern Montana (1972–1977).

In Alaska and Yukon, density estimates presented by Inman *et al*. (2012a, p. 789) range from 3 to about 14 wolverines per 1000 km^2 (386 mi^2), using a number of methods. For example, Royle *et al*. (2011, p. 609) estimated wolverine densities for southeastern Alaska (Tongass National Forest; 2008) from 8.2 to 9.7 per 1000 km^2 (386 mi^2) (using mark-recapture), where the higher estimate incorporates a positive, trap-specific behavioral response. Density of wolverines were recently reported as an estimated 5–10 wolverines per 1000 km^2 (386 mi^2) (based on snow tracking) for southcentral Alaska, and approximately 10 per 1000 km^2 (386 mi^2) (based on DNA mark-recapture methods) for southeast Alaska (Golden 2017, pers. comm.). A wolverine occupancy study in 2015 within an area of central Alaska reported a density estimate of 9.48 wolverines per 1,000 km^2 (386 mi^2) (ADF&G 2015a, p. 7).

Wolverine density estimates for Canada varies across regions, from 5 to 10 per 1000 km^2 (386 mi^2) in northern mountain and boreal regions to 1 to 4 per 1000 km^2 (386 mi^2) in southern boreal areas (COSEWIC 2014, p. 27). More recently, Clevenger *et al*. (2017, entire) presented a density estimate (using spatial capture/recapture models) for the Kootenay region of British Columbia of 0.78 wolverines per 1000 km^2 (386 mi^2), for 3 study years (2014–2016), which they reported as lower than expected (Clevenger *et al*. 2017, p. 6).

Stressors – Causes and Effects

We reviewed the best available information to identify current conditions and potential stressors that may be affecting wolverine populations or its habitat. These include roads and other infrastructure, recreational activity and other human disturbances, wildland fire, disease or predation, and overutilization for commercial, recreational, scientific, or educational purposes. Because wolverines in North America move between both borders of Canada (i.e., contiguous United States, Alaska), we included in our evaluation stressors identified for wolverines in Canada and Alaska that are also relevant for wolverine populations in the contiguous United States.

As an initial step, we reviewed the land ownership of the area defined as primary habitat by Inman *et al*. (2013, entire) in the contiguous United States, and determined that 96 percent of that modeled habitat is located on Federal land (see **Appendix D**). Lands managed by the Forest Service represent the largest portion of Federal lands (89 percent) within this modeled primary habitat.

Effects from Roads

Roads and rail lines can be a cause of mortality to wolverines and habitat models have identified road density as an important association (avoidance) for selection of habitat (e.g., Rowland *et al*. 2003; Bowman *et al*. 2010; Inman *et al*. 2013). Road density has been listed as a threat to wolverines occupying the boreal/western mountain regions of Canada (Canadian Boreal Forest Agreement 2014, p. 2). In the wolverine's southern Canadian range, roads may be facilitating direct mortality by improving motorized access of hunters, trappers, and recreational users into remote areas (COSEWIC 2014, p. 21).

In their review of 12 radio-telemetry studies (1972 to 2001) of wolverines in North America, Krebs *et al*. (2004, p. 497) reported 3 mortalities of wolverines from road-rail kills. More recently, road mortalities have been recorded in Idaho (1 confirmed in 2014) (IDFG 2017a) and 2 in Montana (2004) (Kociolek *et al*. 2016, p. 68), one in Utah (2016) (Hersey 2017, pers. comm.); and two other wolverine road-rail fatalities in Montana were reported in 2015 (Inman 2017a, pers. comm.). In Canada, anthropogenic causes of mortality for wolverine populations also include road kill (COSEWSIC 2014, p. v). One road mortality of a male wolverine was reported in a lowland boreal forest region of Ontario, Canada (Dawson *et al*. (2010, p. 142). More recently, Scrafford *et al*. (2017, p. 34) described a report in which 9 wolverines were struck and killed by vehicles in the Hay-Zama region of northwestern Alberta, Canada (2013–2015), and 1 road mortality occurred within the town of Rainbow Lake in Alberta.

Roads may also affect den site selection (May *et al*. 2012, p. 202), particularly areas within their range where they cannot select for high elevation habitat (e.g., central lowland forests of Canada) (Dawson *et al*. 2010, p. 143). In Norway, May *et al*. (2012, p 202) found that wolverine dens were generally located far from infrastructure (public roads and private roads and/or recreational cabins). The authors reported a minimum threshold in den site selection relative to infrastructure of 1.4 km (0.87 mi) from private roads and 7.5 km (4.7 mi) from public roads (May *et al*. 2012, p. 202). However, they found that wolverines in their study area had a wide tolerance range at the home-range scale (1.0–2.75 km (0.62–1.7 mi) for private roads and 6.0–11.0 (3.7–6.8 mi) for public roads) (May *et al*. 2012, p. 201; Figure 4), supporting conclusions from other studies that have found that, once a general area is used, it appears to be re-used in subsequent years including by successive individuals colonizing the sites (May *et al*. 2012, p. 202).

Wolverine road crossings were evaluated in the western Greater Yellowstone region through telemetered animals and visual observations of snow tracks, direct observations of crossings, and road-kill mortality (Packila *et al*. 2007, entire). That study documented 43 crossings of U.S. and State highways by 12 wolverines (Packila *et al*. 2007, p. 105). Within the Big Sky, Montana, area, they documented 67 crossings of MT64/Jack Creek Road by 4 wolverines (Packila *et al*. 2007, p. 105). Most (76%) road crossings were made by subadult wolverines, dispersing or otherwise exploring new areas (Packila *et al*. 2007, p. 105). One road-caused mortality was observed and the authors report two others from additional sources during their study period (Inman *et al*. 2007, p. 89). The study results indicate that roads do not act as absolute barriers to movement by wolverines, but they can directly affect individuals (road kill) and may have secondary effects at the population level (Packila *et al*. 2007, p. 105).

In an effort to evaluate the potential impact of major roads to wolverine (individuals and populations), we conducted a spatial analysis of roads[2] found within Inman *et al*.'s (2013, p. 281) primary wolverine habitat and female wolverine dispersal habitat in the western United States, as measured by number of kilometers (miles). In our analysis, we identified four road classes: Interstate Highway, U.S. Highway, State Highway, and secondary roads. Secondary roads encompassed all roads not included in any of the first three categories and include paved and unpaved roads, including Forest Service roads, and are generally likely to have less traffic volume than major highways in the regions evaluated. Our analysis found that secondary roads represented 97 percent (29,892 km (18,574 mi)) of all roads (30,805 km (19,141 mi)) within modeled primary habitat, and 97.5 percent (144,279 km (89,650 mi)) of all roads (148,029 km (91,980 mi)) within modeled female dispersal habitat.

We then evaluated the type of roads at high elevation within our estimated Current Range (shown in Figure 3). Using the 2,300 m (7,546 ft) elevation as a benchmark (based on its use as a predictor variable for wolverine occurrence in Inman *et al*. 2013, and results from predictive models presented in Copeland *et al*. 2007, p. 2,205), we evaluated the length of roads above and below this elevation, and also the type of roads at or above 2,300 m (7,546 ft). The results are illustrated in **Appendix E**. Overall, we found that approximately 85 percent of *all* roads were

[2] Using U.S. Geological Survey National Transportation Dataset Downloadable Data Collection based on TIGER/Line data provided through U.S. Census Bureau and supplemented with 'HERE' road data to create tile cache base maps.

below 2,300 m (7,546 ft). Of the roads located at or above 2,300 m (7,546 ft), 95 percent are *secondary* roads (see charts in **Appendix E**).

Using the same dataset, we evaluated road density (km/km^2) based on regional blocks of primary wolverine habitat in the western United States delineated by Inman *et al*. (2013; Figure 3). Those results are shown in Table 6. With the exception of the Southern Rockies (at 0.47 km/km^2), the mean road densities at elevations equal to or greater than 2,300 m (7,546 ft) are very low.

Table 6. Mean Road Density in Wolverine Primary Habitat.

Geographic Region[‡]	Mean density (km/km^2), all roads	Mean density (km/km^2), all roads ≥ 2,300 m (7,546 ft)
Northern Cascade	0.54	0.00
North Continental Divide	0.54	0.00
Salmon-Selway	0.70	0.03
Central Linkage	0.84	0.06
Greater Yellowstone	0.24	0.06
Southern Rockies	0.55	0.47
Sierra Nevada	0.09	0.03
Uinta	0.15	0.12
Bighorn	0.00	0.00
Great Basin	0.06	0.03
Oregon Cascade	0.72	0.00

[‡]Regions defined in Inman *et al*. (2013; Figure 3).

We also reviewed den site locations (natal, maternal, or unknown dens) within our database relative to roads (see map in **Appendix E**). Our results indicate that wolverine dens are located in areas with minimal roads, including secondary roads; however, we caution that this analysis is based on a limited den site dataset and should be viewed in the context of other abiotic and biotic variables including landscape features at the den site scale and availability of food. Additionally, most den locations in much of the wolverine's range in the contiguous United States are at high elevations and roads in these areas would likely be impassable or closed entirely to vehicles during the time of denning (January–March).

In summary, wolverines are associated with habitat found in high elevation areas, but are known to disperse across great distances. Major highways can present mortality risks to dispersing individuals and affect immigration to open territories, but roads do not represent absolute barriers to wolverine movements. Wolverines den during winter months in remote locations that are often inaccessible or restricted to motorized vehicles, though, secondary roads and trails are used for winter recreational activity. Although we recognize there are likely additional events that have not been reported, we estimated the total number of wolverine mortalities due to roads from 1972 to 2016 (44 years) in North America was 20, at least 11 of which are from Canada (see citations above). As discussed above, we calculated a low proportion of major highways in both modeled primary habitat and female dispersal habitat, and a low mean density of roads at high elevations where wolverines have been observed, with the exception of the southern Rocky Mountains. Roads present a low stressor to wolverines at the individual and population level in most of its current contiguous United States range.

Disturbance due to Winter Recreational Activity

Wolverine behavior patterns, such as denning, rearing of young, movement and dispersal, and foraging/scavenging, may be affected by recreational activities (COSEWIC 2014, p. 42). As noted above, in Norway, May *et al*. (2012, p. 201) found, at the home range scale, a minimal threshold distance of approximately 1.5 km (0.93 mi) for wolverine den sites from private roads and/or recreational cabins. Krebs *et al*. (2007, entire) evaluated habitat use associations for wolverines in two multiple use areas in British Columbia, Canada. Using logistic regression models, the authors found that in an area of active recreation (Columbia Mountains), female wolverines were negatively associated with helicopter and backcountry skiing in their winter models (Krebs *et al*. 2007, pp. 2,187–2,188). However, in summer months, Copeland *et al*. (2007, p. 2,210) reported that wolverines in their study area of central Idaho were not uncommonly found near maintained trails and active campgrounds.

The Wolverine–Winter Recreation Study represents an on-going project to evaluate the potential effects of backcountry winter recreation (e.g., backcountry skiers, heli-skiers, cat-skiers, snowmobilers) on wolverines (Heinemeyer 2016, pers. comm.). The multiyear study areas include central Idaho and areas in the western Yellowstone region ('Island Park' and Teton Mountains) (Heinemeyer and Squires 2015, p. 3). The study has been monitoring wolverines using GPS collars using movement rates and percent of time active (vs. resting) as indicators of potential responses of wolverines to winter recreation activities (Heinemeyer 2013, pers. comm.). Backcountry winter recreation activities are monitored through GPS units voluntarily carried by recreationists (Heinemeyer 2016, pers. comm.). Early analysis of the data suggest that wolverines demonstrate a behavioral response to recreation activities, such as increased movement rates and a reduction in resting periods in areas of high recreation activity, especially high recreation days (Saturday and Sunday) (Heinemeyer and Squires 2013, pp. 5, 7–8).

However, this research has also found that wolverines maintained their home ranges within areas with relatively high winter recreation activity over several years of monitoring, including some areas found to contain the highest recreational activities (Heimemeyer 2016, pers. comm.). The study has not been able to determine whether these resident wolverines are reproductively successful due to the limited monitoring information available for reproductive females (Heinemeyer 2016, pers. comm.).

Conservation measures currently being implemented that address the effects of roads in the Teton Mountains include winter closures in certain areas (generally from November 1 through May 1), including road closures in the Bridger-Teton and Caribou-Targhee National Forests and in Grand Teton National Park as shown in **Appendix F** (additional details for Grand Teton National Park are described in Superintendent's Compendium (National Park Service (NPS) 2017; pp. 8–9); see also maps at https://jhalliance.org/campaigns/dont-poach-the-powder/ Jackson Hole Conservation Alliance 2017). These closures are being implemented to help minimize disturbance to wildlife (e.g., migration pathways).

State Wildlife Action Plans prepared for individual western States identify recreation management strategies within wolverine habitats. For example, in the State of Oregon, the

ODFW Conservation Strategy identifies management of winter recreation use in order to avoid impacts to wolverines (ODFW 2016). In Montana's State Wildlife Action Plan, conservation actions are identified for addressing potential impacts from recreation, such as consideration of seasonal closures during breeding season (Montana FWP 2015, p. 63). The IDFG *Management Plan for the Conservation of Wolverines in Idaho* also includes conservation strategies related to winter recreation (e.g., characterizing wolverine response to recreational activities (IDFG 2014, p. 35)), and the State continues to support the Wolverine-Winter Recreation Study. **Appendix F** provides additional details on individual State conservation strategies.

In summary, wolverine behavior (movement) can be affected by winter recreational activity. Results from one long-term study in parts of the wolverine's range in the contiguous United States have found that wolverines can maintain residency in high winter recreational use areas. Wolverines have recently been detected in areas that experience winter recreational activity. Conservation strategies and actions have been identified in several western States' Wildlife Action Plan to address potential impacts of this stressor to wolverines. Based on the best available scientific and commercial information, the effect of winter recreational activity represents a low stressor to wolverines in the contiguous United States at the individual and population level.

Other Human Disturbance

Infrastructure, such as pipelines, active logging or clearcuts, seismic lines, and activities associated with mining (e.g., producing mines, mines under development, mineral exploration areas), may also affect individual wolverine behavior (e.g., avoidance) or loss or modification of wolverine habitat. As discussed above (see Habitat Use section), Johnson *et al*. (2005, entire) evaluated habitat relationships for the wolverine and other arctic wildlife, including the cumulative effects of human activities and associated infrastructure on the distribution of wolverines in the Canadian central Arctic using RSF modeling. However, because human disturbance factors (i.e., major developments, mineral explorations, seasonal outfitter camps) were mostly absent from the range of monitored wolverines, the researchers were not able to reliably model their effects (Johnson *et al*. 2005, p. 23).

The 2014 COSEWIC status review identified several potential stressors to wolverines and their habitat in Canadian territories. They indicated potential permanent, temporary, and functional losses to wolverine habitat from forestry; oil, gas and mineral exploration and development; and large hydroelectric reservoirs (COSEWIC 2014, p. 21). As discussed above, Scrafford *et al*. (2017, entire) evaluated habitat selection of wolverines in response to human disturbance in the western Canadian boreal forest in both winter and summer months. Their analysis found that wolverines were attracted to some industrial infrastructure (older seismic lines exhibiting latter stages of regeneration) and disturbance (areas of active logging), likely related to foraging opportunities (e.g., small prey), but avoided interior areas of intermediate-aged cutblocks (areas authorized for logging) (Scrafford *et al*. 2017, pp. 32–34). Their results found evidence of road avoidance, but wolverines were attracted to all-season road sections with borrow pits, which they suggest was related to foraging opportunities at these pits (e.g., presence of beavers in water-filled pits) and less predation risk, since wolves avoid these roads (Scrafford *et al*. 2017, p. 34). In sum, these authors concluded that wolverine selection patterns relative to industrial activity

and infrastructure in their study area represent a balance between exposure to predators and foraging opportunities (Scrafford *et al*. 2017, p. 32).

Additional studies of wolverine behaviors related to the effects of disturbance due to infrastructure and other human activities are needed. Based on the best available scientific and commercial information, these effects are small or narrow in scope and scale and appear to represent a trade-off between foraging opportunities in areas that provide minimal risk of predation and avoidance of open areas and/or higher predation risk (Scrafford *et al*. 2017, pp. 33–34).

Effects from Wildland Fire

Wildland fire can produce both direct and indirect effects to wildlife. Direct effects include injury and mortality as well as escape or emigration movement away from fires (Lyon *et al*. 2000, pp. 17–21). Small mammals will generally find refuge underground or within sheltered places within the burning area, while larger mammals will move to safe areas in unburned patches or outside the burn (Lyon *et al*. 2000, p. 18). For animals that emigrate during fire events, the length of time before they return is dependent on the degree to which fire has altered habitat structure and food supply (Lyon *et al*. 2000, p. 20).

We are unaware of any studies evaluating direct effects of wildland fire to wolverines. Wildland fire is likely to temporarily displace wolverines, which could affect home range dynamics. Given that wolverines can travel long distances in a short period of time, individuals would be expected to move away from fire and smoke (Luensmann 2008, p. 14). In addition, because young are born during winter months, fire risk at that critical life stage is very low (Luensmann 2008, p. 14).

Indirect effects of wildland fire can include habitat-related effects or effects to prey and competitors/predators; however, we are unaware of empirical studies evaluating these potential effects as they relate to wolverines. In a study area within the Yukon (Canada), wolverines were reported occupying regenerating forested habitat that contained remnants of mature timber which had burned 30 years prior (Slough and Mowat 1996, p. 948). Additionally, fire suppression in conjunction with logging activities in boreal forests (northwestern Ontario) can increase the prevalence of deciduous tree habitats, at least at a regional level, which is negatively associated with wolverine occurrence (Bowman *et al*. 2010, p. 464).

A study in northern Idaho of the effects of multiple wildland fires over several years, including very large fires, to forest habitat occupied by another mustelid, the American marten (*Martes americana*) found that fire events had created a mosaic of vegetation that supported a diverse assemblage of cover and food resources that was favorable to this species (Koehler and Hornocker 1977, p. 503). Similar to wolverines, the summer and fall diet of the American marten is represented by diverse prey, and wildland fire events can create and maintain forest openings for ground squirrels and voles (Koehler and Hornocker 1977, p. 504). The development of these types of mosaic forest communities following certain wildland fire events also provides discontinuous fuel loads, which in turn should result in smaller and cooler wildland fires, with less replacement of marten habitat (Koehler and Hornocker 1977, p. 504). However, large,

uniform burns would be expected to result in more severe impacts to American marten habitat (Lyon *et al*. 2000, p. 21).

Studies of the effects of wildland fire to a key prey species for the wolverine in parts of its North American range, the caribou, was reviewed by Klein (1982, entire). This review highlighted the importance of separating short-term effects of wildland fire in boreal forests to caribou ecology from long-term effects (Klein 1982, p. 393). Given that long-term benefits to the species' ecology can be disproportionate to the short-term detrimental effects on populations and herds, (including the species' lack of reproductive plasticity), caribou may be more appropriately considered as fire-influenced, rather than fire-adapted (Klein 1982, p. 393). Other ungulate prey species respond more positively to fire. An increase in spring and summer grasses following fall burns can provide forage for elk and deer, and sprouting of deciduous trees, such as aspen, birch and willow, following burns provides forage for moose (Luensmann 2008, p. 18).

Management measures to address this potential stressor are identified in USDA Forest Service National Forest Land Management Plans. Examples of these goals and objectives are described in **Appendix G**. In addition, the Idaho State Wildlife Action Plan includes measures to address fire threats to the wolverine and its habitat, including removal of perceived barriers to allow more prescribed natural fire on State and private forest lands and promoting/facilitating the use of prescribed fire as a habitat restoration tool, on both public and private lands where appropriate, and leaving fire-killed trees standing as wildlife habitat if they pose no safety hazard, all in an effort to restore a more natural fire interval that allows for return to historical forest conditions (IDFG 2017b, pp. 91, 134, 180).

Given the diversity of habitats occupied by wolverines, their occupancy of high elevations, and extensive mobility, wildland fire represents a limited stressor, in scope and scale, to wolverine habitat and its prey in the contiguous United States range.

Disease or Predation

Disease

We are unaware of comprehensive surveys evaluating the prevalence of diseases in wolverines in the contiguous United States. Early accounts of endoparasites species and their prevalence in wolverines include a review by Erickson (1946, p. 503), and a report by Rausch (1959, entire), who documented 7 species of helminth parasites in 86 percent of wolverines examined from trapper-supplied carcasses in Alaska. In 1994, Copeland (1996, p. 26) collected a single specimen of the parasite *Toxascaris* sp. from wolverine scat in Idaho. In Alaska, carcasses sampled (during necropsy or predator control activities) in 2012–2014 to determine the prevalence of *Trichinella* and its genotypes reported one wolverine with *Trichinella* T6 genotype in that single sample (ADF&G 2015b, p. 8). Results from Alaska trapper questionnaires for the prevalence of ectoparasites on wolverines were either scarce or not present across all reporting regions in 2015–2016 (Parr 2016, p. 21).

Rabies is endemic to Alaska in Arctic and red fox along north and west coasts of Alaska (ADF&G 2013c). Under the ADF&G enhanced rabies surveillance program, the agency

confirmed rabies in one wolverine (out of 49 sampled) in 2012, a female found dead in the North Slope region (Woodford and Beckman 2012). This was the first confirmed case of rabies in wolverines in North America (Woodford and Beckham 2012).

The 2014 COSEWIC Assessment and Status Report for the wolverine presented a summary of reported parasitic species observed in wolverines in Canada (COSEWIC 2014, p. 25). These observations included: parasitic nematode roundworms (*Trichinella* spp.) in 88 percent of wolverine samples tested from Nunavut and 26 percent from the lower MacKenzie region; helminth parasites (trematodes, cestodes and nematodes) in wolverine digestive tracts from the lower Mackenzie River valley; and, from the Nunavut region, protozoan parasites infections including *Sacrosystis* spp. (80 percent) and *Toxoplasma gondii* (41 percent) (citations omitted). Banci (1987, pp. 81, 110) reported parasitic pneumonia as a cause of mortality in southwest Yukon Territory, a female thought be nutritionally-stressed following the raising of young.

An evaluation of trapper-submitted wolverine carcasses harvested was conducted for the Yukon Territory in the fur trapping seasons 2005–2006 through 2011–2012 (Jung and Kukka 2013, entire). No samples tested positive for rabies (Jung and Kukka 2013, p. 17). Another study of intestinal parasites of wolverine carcasses from both the Yukon and Northwest Territories reported *Trichinella* spp. in 74 percent of carcasses and several intestinal parasites, including cestodes (parasitic flatworms) such as *Taenia* spp. (Luck *et al*. 2016, no page number).

In summary, other than a parasitic pneumonia mortality event and the single rabies case, we are not aware of any other studies documenting impacts of disease to wolverines in North America. At this time, based on the best available scientific and commercial information, we do not find that disease is a population or species level stressor to the wolverine in the contiguous United States.

Predation

As discussed above (*Diet and Feeding* section), a number of potential natural predators have been identified for wolverines across its North American range, including intraspecific predation. However, we have no information that suggests this predation represents a significant stressor to the wolverine at either an individual or population level.

In summary, the best scientific and commercial information available indicates that disease or predation is not a stressor the wolverine. We are unaware of any management or conservation measures currently in place to reduce potential impacts associated with disease or predation.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

There is currently no allowable trapping or harvesting of wolverines in the contiguous United States, though incidental trapping mortalities have been documented as we reported in our proposed rule (78 FR 7881; February 4, 2013). Two mortality events from shootings of wolverines were documented in Idaho (2001, 2007) (Idaho Department of Fish and Game (IDFG) 2014, p. 26).

In Montana, wolverines were a legally harvested furbearer in Montana up until 2012; however, the trapping season is currently suspended with a zero statewide quota (Montana Natural Heritage Program and Montana FWP 2017). Unlike populations in Eurasia, wolverines rarely prey on livestock in North America (*cf.* domestic sheep predation in Wyoming reported (Mead 2013, pers. comm.)) and therefore they are not directly targeted for predator control (COSEWIC 2014, p. 41). However, incidental trapping can result in the capture of non-target species such as wolverine. In Idaho, the IDFG has a mandatory furtaker harvest report that requests all live incidental catches be reported by species and any wolverine catch that results in mortality is required to be reported (IDFG 2013, pers. comm.). Since 1965, over a period of just over 50 years, 16 incidentally-trapped wolverines were reported during the State's furbearing seasons, with 6 animals known to be released alive and 6 mortalities (IDFG 2013, pers. comm.; IDFG 2016, pers. comm.). This total includes four wolverines caught during the 2013-2014 furbearer season, with three released alive and one mortality (IDFG 2014, p. 26). Within the State of Wyoming, there are two confirmed reports of incidental take, one in 1996 (Mead 2013, pers. comm.) one in 2006. The 2006 animal was released unharmed (Inman 2012, pers. comm.). In Montana, since the closing of the trapping season for wolverine in 2013 (2013 through 2016), four wolverines have been incidentally trapped, one in 2013 and three in 2014 (Inman 2017c, pers. comm.). The 2013 capture was released unharmed and the three caught in 2014 were all mortalities (Inman 2017c, pers. comm.).

Predator control programs targeting wolves, including poison and incidental trapping, can result in incidental losses of wolverines (COSEWIC 2014, p. 41). Specific to wolf control for livestock protection in Idaho, three wolverines have been trapped incidental to authorized wolf control activities since 1995, with two released alive and one animal euthanized (IDFG 2014, p. 26). Preventive measures have been adopted to reduce these incidental captures, including implementation of educational programs to minimize incidental capture of wolverines during trapping seasons (IDFG 2014, p. 27). Licensed wolf trappers are required to complete a Wolf Trapper Education course with specific instruction for reducing incidental trapping of wolverine, Canada lynx, and other non-target species (IDFG 2014, p. 27). In addition, the U.S. Department of Agriculture Wildlife Services (Wildlife Services) agency has also temporarily stopped (as of April 2017) using cyanide predator control devices in the State of Idaho (Moeller 2017).

In Alaska, wolverine trapping and hunting is controlled by seasons and bag limits, with about 550 animals harvested each year (Alaska Department of Fish and Game (ADF&G) 2017a). For the 2015–2016 reporting period, wolverine harvest, based on furbearer sealing records,[3] totaled 527 animals (Parr 2016, p. 42). This level of harvest has been fairly consistent since 2010, as shown in Table 7 below.

[3] Wolverines taken in Alaska are required to be sealed by an authorized department representative before pelts are shipped to an out-of-state buyer or auction house (Parr 2016, p. 44). For those species that require sealing, the number of animals sealed represents the best information regarding the statewide harvest (Parr 2016, p. 41).

Table 7. Number of wolverines harvested in Alaska, as reported from regulatory year sealing records, 2010–2015. Adapted from Parr (2016, p. 42; Table 10).

Alaska Region	2010	2011	2012	2013	2014	2015
I	25	20	25	31	14	15
II	25	29	50	31	16	37
III	233	235	261	358	268	214
IV	180	160	170	158	99	150
V	140	110	135	133	109	111
Total	603	554	641	711	506	527

Trapping and harvesting of wolverines occurs over much of the range in Canada, as summarized in the 2014 COSEWIC wolverine status review (COSEWIC 2014, pp. 10, 29–35). Specifically, wolverines are harvested in the northern and western territories–Manitoba, Saskatchewan, Alberta, British Columbia, Yukon, Northwest Territories, and Nunavut (COSEWIC 2014, p. 43). Non-aboriginal harvest of wolverines has not been permitted since 2001–2002 in Québec and Labrador (COSEWIC 2014, p. 43). Trapping is closed in Ontario (except through treaty rights), though incidental trapping results in 1 to 4 mortalities per year (Bowman *et al*. 2010, p. 465). Harvest levels in western provinces have remained relatively stable since 1992 (COSEWIC 2014, p. 38; Table 1).

The management of wolverine harvest in Canada incorporates spatial and temporal elements such as season length, quotas, limited entry, and trapline management by trappers (reviewed by Slough *et al*. 1987). Wolverine harvest levels in Canada are monitored using mandatory pelt sealing, annual harvest reporting, or through monitoring of fur exports (COSEWIC 2014, p. 43). In some northern communities, wolverine pelts are used locally and harvests are monitored through carcass collection programs (COSEWIC 2014, p. 43).

The COSEWIC Assessment and Status Report for the wolverine also noted that range contraction and habitat trends of wolverines in Canada are not solely the result of habitat or trapping pressure (COSEWIC 2014, p. 20). Reductions in ungulate (e.g., caribou) populations, which provide an important winter food resource, were also likely an important factor in range contractions of wolverines in its northern range (COSEWIC 2014, p. 20), and likely continue to influence populations today. Snowmobiles have allowed for better access for hunters and trappers and may be increasing the number of wolverine harvested in its northern North America range; however, the areas of exploitation are still relatively small concentrated areas, and large areas of refugia continue to be found (Cardinal 2004, p. 31).

Population growth rate scenarios for North American wolverines were modeled by Krebs *et al*. (2004, p. 499), including trapped and untrapped populations. Of note, at the time of this study, wolverines were considered furbearer or game animals and trapped or hunted in 8 of their 12 study areas in North America, including Montana (Krebs *et al*. 2004, p. 495; Table 1). Estimated (logistic) rates of population growth (λ) were found to be lower for trapped populations (λ = 0.878) as compared to untrapped populations (λ = 1.064) (Krebs *et al*. 2004, p. 499). Based on their analysis, harvesting was considered to be an “additive mortality” in the populations studied and is likely sustained by dispersal from untrapped areas that provide refugia (Krebs *et al*. 2004,

pp. 499–500). However, as described in the 2014 COSEWIC report, trends in wolverine populations in the northern range, while uncertain, appear to be stable or increasing, with some concern for populations in the southern areas of British Columbia and parts of the northern United States (COSEWIC 2014, p. 22, and references cited therein). Similarly, in Alaska, over the past 6 years, on average, 590 wolverines are taken each year (see Table 7). The consistent harvest levels in these regions suggest relatively stable wolverine populations.

We evaluated trapping of wolverines in British Columbia and Alberta regions of Canada in an effort to document potential impacts to dispersing wolverines along the U.S.–Canada border. As described above (*Population Abundance and Distribution*), the population of wolverines in British Columbia is estimated to be 2,700–4,760 and 1,500–2,000 animals in Alberta (COSEWIC 2014, p 36). We obtained 9 years (2007-2015) of harvest data for southern BC wildlife management units from the British Columbia Ministry of Environment, Ecosystems Branch for our analysis. Twenty seven years (1989–2015) of harvest data was obtained for Alberta in addition to locations of wolverines from a 2012–2015 study and other sources (Webb *et al*. 2016, p. 1,465; Webb 2017, pers. comm.).

Figure 5 presents the results from our spatial analysis and indicates a total of 77 wolverines were trapped in British Columbia wildlife management units within 110 km (68.35 mi) of the U.S.–Canada border from 2007–2015 (average of 8.5 animals per year). We used this distance since it's similar to both the average maximum distance per dispersal movement of 102 km (63 mi) for male wolverines reported by Inman *et al*. (2012a, p. 784) for the Greater Yellowstone region of Montana, and a reported 100 km (62 mi) dispersal distance for a juvenile male for Ontario, Canada (COSEWIC 2014, p. 24, citing unpublished data from Dawson *et al*. 2013). As shown below, one management area contains nearly one-third (23 individuals) of this total number. The other management units along the international border indicate very few animals harvested over this 8-year period (i.e., areas on map identified as zero). There is no open trapping season or hunting season on wolverines in the management units in the Okanagan (Region 8) (north of Washington State) or South Coast (Region 2) (southwest corner of British Columbia) with a trapping season for wolverines only in the Kootenay (Region 4, the eastern half of the southern part of the province) (Weir 2017b, pers. comm.). In addition, there has not been an open trapping season in Region 2 since at least 1985 and since 1993 in the Okanagan region (Weir 2017c, pers. comm.). For Alberta, we identified a total of 15 wolverines harvested by trappers and data presented in other studies within 110 km (68.35 mi) of the U.S.–Canada border from 1989–2014 (average of less than 1.0 animal per year). Researchers in Canada are currently conducting a landscape level analysis to estimate the size and sustainable harvest for wolverine populations within British Columbia (Weir 2017a, pers. comm.).

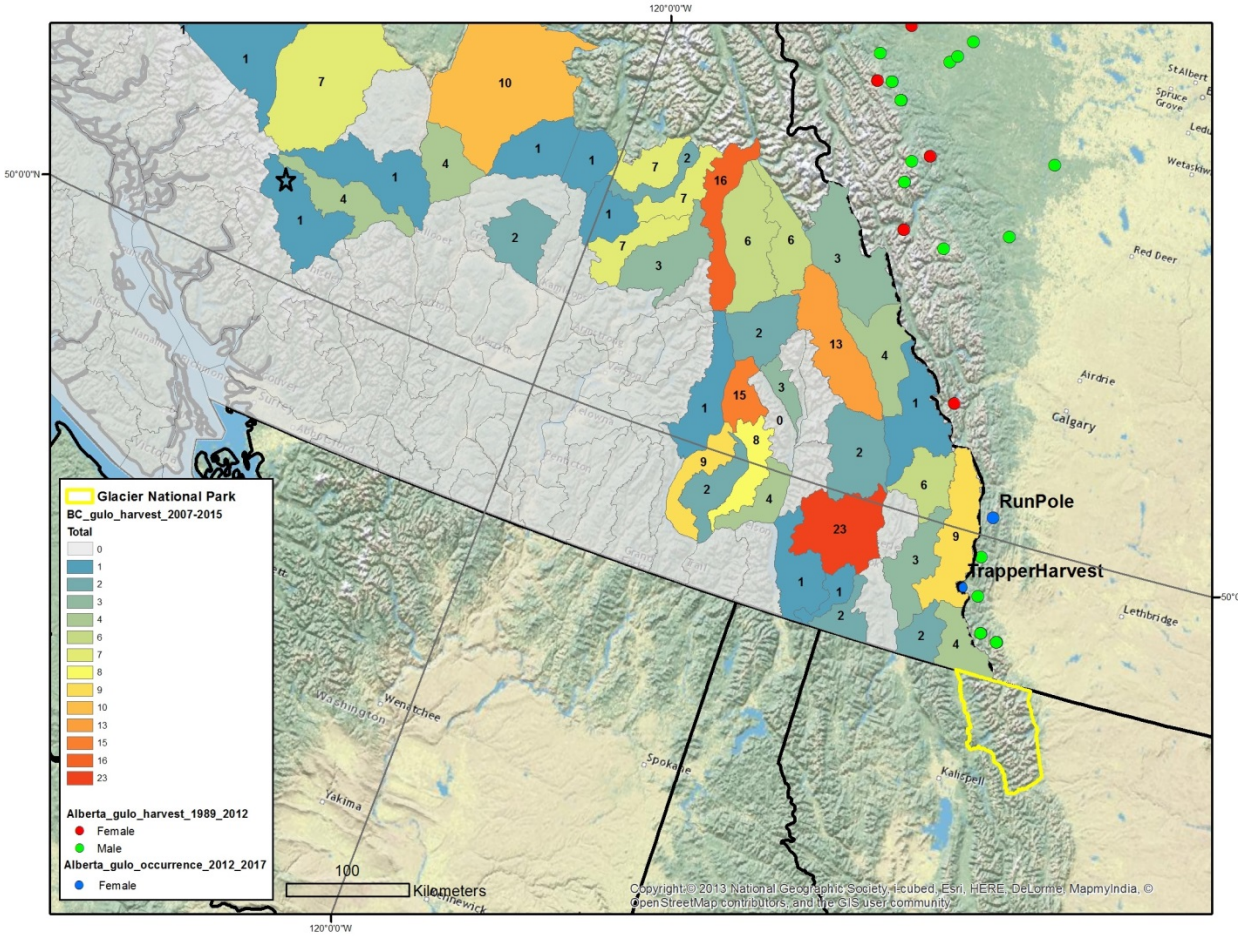

Figure 5. Numbers of wolverines harvested in British Columbia and Alberta, Canada. Sources: British Columbia Ministry of Environment; Webb *et al.* 2016; Webb 2017, pers. comm.

Based on this analysis, trapping effort along the U.S.–Canada border does not represent a significant barrier to wolverine movement and dispersal along the international border. As noted above, Regehr and Lacroix's (2016, entire) multi-method inventory of wolverines within an area located in the eastern side of the Coast Mountains of British Columbia (see **black** star in Figure 5 above) found unexpectedly high numbers of wolverines, which may have been the result of the rugged landscape features in this mountainous area and abundant food resources (both winter and summer) (Regehr and Lacroix 2016, pp. 249–250).

Legal Status/Protection

In the western United States, the wolverine status is as follows: a state-threatened species in Oregon (ODFW 2016) and California (CDFW 2017a); state-endangered species in Colorado (Colorado Parks and Wildlife 2015a) ; a candidate species in Washington (Washington Department of Fish and Wildlife (WDFW) 2013); a protected nongame species and species of greatest conservation need in Idaho (IDFG 2014); a protected animal and species of greatest conservation need in Wyoming (WGFD 2017); a species of greatest conservation need in Utah (Utah Wildlife Action Plan Joint Team 2015); a furbearer and species of concern in Montana (Montana Natural Heritage Program and Montana FWP 2017); and, in Nevada, the Nevada

Administrative Code lists wolverines as a protected mammal (NAC 503.030), which provides full legal protection. There is no protected status for wolverines in the State of Alaska. The State of New Mexico Department of Game and Fish does not recognize the wolverine as a native mammal. Additional discussion regarding State regulatory mechanisms that provide protections for wolverines is provided in **Appendix G**.

The Idaho Department of Fish and Game issues permits allowing live capture, handling, and release of wolverines for scientific studies, which usually involved log box-traps that do not cause physical injury to the captured animals (IDFG 2014, p. 27). The agency also issues scientific collection permits to various agencies and organizations and to IDFG biologists that can include the capture, chemical immobilization, and placement of radio-collars/radio-markers on wolverines (IDFG 2014, p. 27). These permittees (and IDFG staff) are required to comply with animal trapping and handling protocols approved by IDFG's Wildlife Health/Forensic Laboratory and other animal welfare and research institutions. Over the past 20 years, there have been two documented wolverine deaths due to live capture activities in Idaho (IDFG 2014, p. 27).

In Wyoming, the Wyoming Game and Fish Commission (Commission) Regulation Chapter 52, Nongame Wildlife, authorizes take of wolverine only for scientific or educational purposes as regulated by Commission Regulation Chapter 33 (Regulation Governing Issuance of Scientific, Research, Educational, or Special Purpose Permits). We received information from the State of Wyoming indicating that a search of electronic records of Chapter 33 permits (issued since 1997) found (as of May 2013) three permits have been issued for scientific purposes to further understanding of wolverine ecology in Wyoming (Mead 2013, pers. comm.).

In California, research permits for State-listed, State-candidate, and fully protected species in California are issued as a Memorandum of Understanding (MOU). Currently, there are no active MOUs for research on wolverine in California (Burkett 2017, pers. comm.).

In Canada, provincial designations for the wolverine include Endangered in Labrador, and Threatened in Ontario and Québec ('Threatened' is equivalent to Endangered in Québec), with the remaining provincial designations ranging from no ranking to Sensitive or Special Concern and the Vancouver Island population designated as Imperilled (COSEWIC 2014, p. 44). Recovery planning for the wolverine is focused on the eastern population (Canadian Boreal Forest Agreement Secretariat 2015, p. 3).

In summary, [illegible]rutilization does not represent a stressor to the wolverine the contiguous United States at the individual, population, or species level. Wolverine populations in the contiguous United States are currently protected under several State laws and regulations. Hunting and trapping activities for wolverines are currently suspended or closed entirely for animals within the contiguous United States, though occasional incidental trapping can occur. Trapping in Alaska and Canada has been and appears to be sustainable given large areas of available refugia in these regions. Trapping or harvesting of wolverines along the contiguous U.S.–Canada border does not represent a stressor to wolverines migrating into the contiguous United States at the individual or population level. In addition, wolverine populations along the Alaska–Canada

border are continuous with the Yukon region of Canada, which suggests a rescue effect for Canadian populations along this international boundary (COSEWIC 2014, p. 37).

Summary of Current Conditions

Wolverine populations in much of North America are still recovering from large losses of individuals from intensive hunting and persecution pressures in the late 1880s into the mid-20th century. Although there is limited rangewide survey information, based on the best available information, wolverines continue to be detected across suitable habitat within the contiguous United States. Studies are currently underway to estimate the species' current distribution and genetic characteristics of the metapopulation across Montana, Idaho, Wyoming, and Washington. In Canada, the total wolverine population is estimated at over 10,000 adults (COSEWIC 2014, p. 47). In Alaska, estimates of populations are not available and are best evaluated based on density (Parr 2017, pers.comm.), which are naturally low for this species. Recent density estimates range from 5 to 10 wolverines per 1000 km^2 (386 mi^2) for Alaska (Parr 2017, pers. comm).

Based on our collection of observations and detections of wolverines in the contiguous United States and the 2014 status review for Canada, we prepared a Current Range map to illustrate the species' North American range (Figure 3). We estimated that the proportion of the current North American range of the wolverine encompassed within the contiguous United States is approximately 6 percent.

We determined that 96 percent of the previously modeled primary habitat (Inman *et al*. 2013) in the lower United States is considered to be lands owned or managed by the Federal government (see **Appendix D**). We also estimated that 41 percent of this modeled primary habitat is located in designated wilderness areas. **Appendix G**, *Regulatory Mechanisms and Conservation Measures*, provides a more detailed summary of management actions.

We evaluated several potential stressors that may be affecting wolverine populations or its habitat, including effects from roads, disturbance due to winter recreation and other activities, effects from wildland fire, disease and predation, and overutilization for (primarily) commercial purposes. We determined that the effects of roads (evaluated by number of miles, density, and location) and disturbance represent low level stressors to the wolverine in the contiguous United States. Wildland fire was determined to be a short-term stressor to wolverine habitat and its prey. Disease and predation are not considered stressors to the wolverine.

Legal trapping or hunting of wolverines is currently prohibited in the contiguous United States. Incidental trapping of wolverines is infrequent in the contiguous United States, and, in Idaho, education programs are being implemented to reduce this stressor. In Alaska, the level of harvest of wolverines has been fairly consistent since 2010, and, as noted above, density estimates indicate no declining trend in wolverine populations.

Wolverines are harvested in several Canadian provinces with management and monitoring oversight based on spatial and temporal elements. We reviewed trapping information from Canada (within 110 km (68.35 mi) of the contiguous U.S.–Canada border) to assess potential impacts to dispersing wolverines into the United States. We found that, in Alberta, 15 wolverines

were harvest over a 25 year period (average of less than 1.0 animal per year), and, for British Columbia, we found an average of 8.5 animals per year, though one management area contained nearly one-third (23 individuals) of this total. Researchers in Canada are currently conducting a landscape level analysis to estimate the size and sustainable harvest for wolverine populations within British Columbia (Weir 2017, pers. comm.). Based on the best available commercial and scientific information, overutilization does not represent a stressor to the wolverine in the contiguous United States.

Status – Future Conditions

The future timeframe evaluated in our analysis is approximately 40 to 50 years, which captures the range of time periods for proposed projects within the species' range, as well as our best professional judgment of the projected future conditions related to trapping/harvesting, climate change, or other potential cumulative impacts.

After considering the current conditions for the wolverine and its habitat, we describe here the most likely future scenario to potentially have an effect on wolverine at the population level in the contiguous United States:

- Climate change effects (i.e., significantly elevated temperatures resulting in decline in snowpack) may modify suitable habitat, which could also change the scope of the wildland fire stressor.

Based on our review of the best available information, we determined that there were no other plausible scenarios that were likely to have population level impacts to wolverine in the contiguous United States. We expect that the effects of trapping and roads, human disturbance, effects of wildland fire to continue to be at low levels in the future. We have no information that indicates that mortality from roads or disease would increase within the range of wolverine in the contiguous United States in the future.

Climate Change Effects

In this section, we consider climate changes that may affect environmental conditions that the wolverine relies on. As defined by the Intergovernmental Panel on Climate Change (IPCC), the term "climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2013a, p. 1450). The term "climate change" thus refers to a change in the mean or the variability of relevant properties, which persists for an extended period, typically decades or longer, due to natural conditions (e.g., solar cycles) or human-caused changes in the composition of atmosphere or in land use (IPCC 2013a, p. 1,450).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring. In particular, warming of the climate system is unequivocal and many of the observed changes in the last 60 years are unprecedented over decades to millennia (IPCC 2013b, p. 4). The change in temperature reported in the Northern Hemisphere in recent history (past 150 years) at +0.6°C (1.08°F) is twice the change reported for the Southern Hemisphere (+0.3°C (0.54°F)) and there is much year-to-year variation (Post 2013, p. 4). With regard to precipitation over land,

there has been a decline in global total annual precipitation, but the variability between years in total precipitation has increased since about the 1970s (Post 2013, p. 9). The Palmer Drought Severity Index (PDSI) compares the actual amount of precipitation received in an area during a certain time period with the normal or average amount expected during that same period (National Weather Service (NWS) 2015) and is generally used as a measure of water stress. Time series analysis of the PDSI indicates worsening persistent drought-like or drought-potential conditions across the globe since 1980, a reflection of the influence of temperature on atmospheric dynamics (Post 2013, pp. 10–11).

Comprehensive assessments of other observed and projected changes in climate and associated effects and risks, and the basis for them, are provided for global and regional scales in recent reports issued by the IPCC (2013c, 2014), and similar types of information for the United States and regions within it can be found in the National Climate Assessment (Melillo *et al*. 2014, entire). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate and is "extremely likely" (defined by the IPCC as 95 to 100 percent likelihood) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from fossil fuel use (IPCC 2013b, p. 17 and related citations).

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions. Model results yield very similar projections of average global warming until about 2030, and thereafter the magnitude and rate of warming vary through the end of the century depending on the assumptions about human population levels, emissions of GHGs, and other factors that influence climate change. Thus, absent extremely rapid stabilization of GHGs at a global level, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by human actions regarding GHG emissions (IPCC 2013b, 2014; entire).

Global climate projections are informative, and, in some cases, the only or the best scientific information available. However, projected changes in climate and related impacts can vary substantially across and, as noted above, within different regions and hemispheres (e.g., IPCC 2013c, 2014; entire) and within the United States (Melillo *et al*. 2014, entire). Therefore, we use "downscaled" projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species (see Glick *et al*. 2011, pp. 58–61, for a discussion of downscaling). We note here that multiple lines of evidence, not just projections derived from quantitative models, should be examined when conducting climate vulnerability assessments (Michalak *et al*. 2017, entire). Thus, we provide below projected effects from climate change in the western United States relative to both abiotic (e.g., temperature, precipitation, snow cover) and biotic (e.g., phenology, behavior) factors.

Abiotic Factors

California

Regional temperature and precipitation observations for assessing climate change are often used as an indicator of how climate is changing. For evaluating climate trends in California, the Western Regional Climate Center (WRCC) has defined 11 climate regions (Abatzoglou *et al*. 2009, p. 1,535). The relevant region for our assessment is the north/north-central Sierra Nevada region (Tahoe National Forest), currently occupied by a male wolverine, or the northeast region as defined in Abatzoglou *et al*. (2009, p. 1,535) .

Two indicators of temperature, the increase in mean temperature and the increase in maximum temperature, are important for evaluating trends in climate change in California. For the climate region that encompasses the Tahoe National Forest region, the 100-year linear trends provided by the WRCC indicate an increase in mean temperatures (Jan–Dec) of approximately 0.92°C/100 yr (± 0.29°C/100 yr) (1.66°F ± 0.53°F/100 yr) since 1895 from present day; 1.55°C/100 yr (± 0.67°C/100 yr) (2.79°F ± 1.21°F/100 yr) since 1949 to present day; and 2.41°C/100 yr (±1.54°C/100 yr) (4.33°F ± 2.78°F/100 yr) since 1975 to present day (WRCC 2017). Thus, the increase in mean temperature has not been constant—the rate of increase over the past 42 years in this region has been 2.6 times higher than the past 122 years. We assume the rate of temperature increase for this region is higher for the second and third time periods (since 1949 and 1975, respectively) than for the first time period (since 1895) due to the increased use of fossil fuels in the later part of the 20th and early 21st century.

Although these observed trends provide information as to how climate has changed in the past, climate models can be used to simulate and develop future climate projections. Both state-wide and regional probabilistic estimates of temperature and precipitation changes for California (by the 2060s) using downscaled data from 16 global circulation models and 3 nested regional climate models were presented by Pierce *et al*. (2013, entire). The study looked at a historical (1985–1994) and a future (2060–2069) time period using the IPCC Special Report on Emission Scenarios A2 (Pierce *et al*. 2013, p. 841), which is an IPCC-defined scenario used for the IPCCs Third and Fourth Assessment reports, and is based on a global population growth scenario and economic conditions that result in a relatively high level of atmospheric GHGs by 2100 (IPCC 2000, pp. 4–5; see Stocker *et al*. 2013, pp. 60–68, and Walsh *et al*. 2014, pp. 25–28, for discussions and comparisons of the prior and current IPCC approaches and outcomes). Importantly, the projections by Pierce *et al*. (2013, pp. 852–853) include daily distributions and natural internal climate variability.

Simulations using these downscaling methods project an increase in *yearly* temperature for the area that encompasses the Tahoe National Forest (Sierra Nevada) ranging from 2.1°C (3.78°F) to 3.2°C (5.76°F) by the 2060s time period (Pierce *et al*. 2013, p. 844), compared to 1985–1994. The simulations indicated a yearly *upper* temperature increase of 2.5°C (4.5°F) from 1985–1994 to 2060–2069 (averaged across models) for this area, and an increase of 1.9°C (3.42°F) for the December–February period (Pierce *et al*. 2013, p. 842).

Beginning in 2012 and continuing into 2016, California experienced a severe drought throughout most of the state (Griffin and Anchukaitis 2014, p. 9,020). Although three-year droughts in California are not unusual when evaluated over the past 1000 years, the severity of these drought conditions during this period was demonstrated in the 2014 summer PDSI, which was estimated to be the lowest on record (1901–2014) (Williams *et al*. 2015, p. 6,823). An evaluation of how unusual this drought event was in the context of the last millennium using blue oak (*Quercus douglasii*) tree ring data from four sampling sites (with additional tree sampling following the 2014 growth season) was conducted by Griffin and Anchukaitis (2014, entire). Their paleoclimate drought and precipitation reconstructions for Central and Southern California show that, although the precipitation during this drought has not been anomalously low, it was not outside the range of variability (Griffin and Anchukaitis 2014, p. 9,017). However, the 2014 drought was the worst single drought year of at least the last 1,200 years in California and the 2012–2014 drought was the most severe of three consecutive drought years, based on three events found in the record for the last 1,200 years (Griffin and Anchukaitis 2014, pp. 9,020–9,021). The study concluded that low precipitation combined with high temperatures was responsible for creating this worst short-term drought episode (Griffin and Anchukaitis 2014, pp. 9,021–9,022).

A study by Williams *et al.* (2015, entire) estimated the anthropogenic contribution to California's drought during 2012–2014. They found that the intensifying effect of high potential evapotranspiration on this drought event (measured by summer PDSI) was almost entirely the result of high temperatures (18–27 percent in 2012–2014; 20–26 percent in 2014) (Williams *et al*. 2015, p. 6,825). Another study evaluating the influence of temperature on the drought in water year 2014 in California found that, although the low level of precipitation was the primary driver for the drought conditions, temperature was an important factor in exacerbating the drought, noting that the water year 2014 was the third year of the multiyear drought event and therefore conditions were drier than normal at the beginning of the water year (Shukla *et al*. 2015, p. 4,392).

In sum, these projections indicate that increased temperatures are likely to occur in the Tahoe National Forest region by the 2060s due to the effects of climate change.

Precipitation patterns can also be used as an indicator of potential climate change. We obtained yearly snowfall data for the Tahoe City station located in the northern Sierra Nevada region from the WRCC (https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca8758) since that dataset was the most complete for the area. We then conducted a nonparametric correlation test, the Mann-Kendall statistical test (Hipel and McLeod 1994, pp. 63–64, 856–858), which is commonly used for analyzing climatic time series (e.g., Ahmad *et al*. 2015, entire), to evaluate trends in snowfall over time. This analysis was conducted using the R and R Studio software programs (Version 3.1.2; R Development Core Team, 2014) with the "Kendall" package (Version 2.2) (McLeod 2011). We found that annual snowfall amounts showed no statistically significant trend (increasing or decreasing) from 1909–2017 (tau = –0.0289, two-sided *p*-value of 0.6705) for the Tahoe City station.

State-wide and regional probabilistic estimates of precipitation changes for California were also evaluated by Pierce *et al*. (2013, entire). When averaged across all models and downscaling

methods, small annual mean decreases in precipitation were found for the Sierra Nevada region of California, but that study also found an increase in precipitation for the December through February period (wetter winters) (Pierce *et al*. 2013, pp. 849, 855). There was significant disagreement across the models, with percent changes ranging from a12 percent decrease to a 9 percent increase (Pierce *et al*. 2013, p. 851), and the projected changes in seasonal-mean precipitation were generally small when compared to natural internal climate variability (Pierce *et al*. 2013, p. 850; Figure 9).

Columbia River Basin Region

This region covers a large area within Washington, Oregon, and Idaho, and parts of British Columbia, Canada, and includes portions of the current range of the wolverine. Rupp *et al*. (2017, entire) used simulations from 35 Global Climate Models (GCMs) to provide projections of climate in the Columbia River Basin into the 2080s under two emissions scenarios, Representative Concentration Pathways (RCP) (RCP 4.5, which represents moderate reduction in GHG emissions ("intermediate emissions"), and RCP 8.5, which represents a continued increase in GHG emission "high emission"). The results of their multi-model ensemble for the RCP 4.5 scenario indicate mean annual temperature increases (above Bonneville Dam), above the 1970–1999 baseline average, of 1.3°C (2.34°F) for the 2010–2039 period, 2.3°C (4.14°F) for the 2040–2069 period, and 2.8°C (5.04°F), for the 2070–2099 future period (Rupp *et al*. 2017, p. 1,788). By season, the winter period (December–February) mean change result indicates an increase of 1.1°C (2.52°F) for 2010–2039, 2.2°C (3.96°F) for 2040-2069, and 2.7°C (4.86°F) for 2070–2099, as compared to the 1970–1999 baseline average (Rupp et al. 2017, p. 1,788).

For the RCP 8.5 scenario, the multi-model ensemble projections indicate mean annual temperature increases, above the 1970–1999 baseline average, of 1.4°C (2.34°F) for the 2010–2039 period, 3.1°C (5.58°F) for the 2040–2069 period, and 5.0°C (9.0°F), for the 2070–2099 period (Rupp *et al*. 2017, p. 1,788). For the winter season (December–February) mean change increase of 1.4°C (2.34 °F) for 2010–2039, 2.9°C (5.22°F) for 2040-2069, and 4.7°C (8.46°F) for 2070–2099, as compared to the 1970–1999 baseline average (Rupp *et al*. 2017, p. 1,788). The anthropogenic-forced (human caused or influenced) change for these projections is higher than the annual variability; thus, by the year 2050, it is very unlikely that the temperature for this year or any year following during this century would be as low as the historical average (Rupp *et al*. 2017, p. 1,788).

Precipitation projections were much less robust; the multi-model ensemble mean precipitation projections indicate an increase above baseline of up to 8 percent by 2099 for RCP 8.5 and slightly less for RCP 4.5 (Rupp *et al*. 2017, p. 1,788). When viewed seasonally, for the winter season, the ensemble projections indicate increases in precipitation for all three future time periods for both the RCP 4.5 and RCP 8.5 scenarios (ranging from 3 to 14 percent) as compared to the baseline period (1970–1999) (Rupp *et al*. 2017, p. 1,788). The projections of anthropogenic-forced increases in precipitation are lower than the interannual variability; however, despite these increases, the authors indicate that years of anomalously low precipitation relative to baseline would be expected with high frequency throughout the 21st century (Rupp *et al*. 2017, p. 1,788).

Within three subregions of the Pacific Northwest within the current range of the wolverine, Sheehan *et al*. (2015, p. 20; Table 4) also found that, when compared to a historical baseline (1971–2000), all future climate projections (RCP scenarios 4.5 and 8.5; 2036–2066, 2071–2100) indicate a rise in both minimum and maximum monthly temperatures, and a generally positive change in mean annual precipitation, though the latter results varied across projections.

Upper Snake River Basin

The Upper Snake River Tribe Foundation and its Tribal members prepared a climate change vulnerability assessment for the Upper Snake River Watershed (Petersen *et al*. 2017, entire). The assessment covers large areas of southern Idaho and eastern Oregon, and small areas of northern Nevada, northern Utah, and western Wyoming (Petersen *et al*. 2017, p. 15). Within three geographic/model domains of this larger region, downscaled climate projections were created from 20 GCMs run with two emissions scenarios (RCPs 4.5 and 8.5) and these outputs were then used to calculate potential future changes in temperature and precipitation (Petersen *et al*. 2017, pp. 15–16). The projections were analyzed in reference to a baseline period (1950-2005) for three future time periods—the 2030s (2020–2049), the 2050s (2040–2069), and the 2080s (2070–2099) (Petersen *et al*. 2017, p. 16).

For temperature, their projections indicated an increase in average annual temperatures in both future emission scenarios and across all time periods. Under RCP 8.5 (high emissions scenario), the ensemble mean temperature increase was about 6.11°C (11ºF), and 2.78°C (5ºF) under the RCP 4.5 intermediate emissions scenario across all three geographic/model domains (Petersen *et al*. 2017, Appendix A, p. 2). For the North and East domains (areas with greater topographical variability), there was some indication of a small increase in total annual precipitation by the end of the century, though there was less agreement among the models (Petersen *et al*. 2017, Appendix A, p. 2).

For all geographic/model domains, the average temperature is projected to increase under both emissions scenarios for all seasons (Petersen *et al*. 2017, Appendix A, p. 2). For the winter months (December, January, February), for RCP 4.5, the average seasonal temperature is projected to increase by 3.89 to 5°C (7 to 9ºF) by the end of the century, and an increase of approximately 2.22 to 3.33°C (4 to 6ºF) for the other seasons (Petersen *et al*. 2017, Appendix A, pp. 2, 6). The winter season projections for RCP 8.5 add an additional 1.67 to 2.22°C (3 to 4ºF) by the end of the century (Petersen *et al*. 2017, Appendix A, pp. 2, 6).

Rocky Mountain Region (Colorado)

A report by Lukas *et al*. (2014, entire) presented an assessment of observed and future projections of climate change effects for Colorado. They reported that, statewide, annual average temperatures have increased by 1.1°C (2.0°F) over the past 30 years, and 1.4°C (2.5°F) over the past 50 years (Lukas *et al*. 2014, p. 11). These warming trends have been observed in much of the State (Lukas *et al*. 2014, p. 11). They report no significant long-term trends in annual precipitation (30-, 50-, and 100-year trends) through 2012, but they indicate an observed trend towards more severe soil-moisture drought conditions in Colorado, based on the PDSI, over the past 30 years (Lukas *et al*. 2014, pp. 12, 21).

This report also presents results from climate change modeling using an ensemble of CMIP5 model projections, run with RCP 4.5 and 8.5 scenarios (Lukas *et al*. 2014; Section 5). The results indicate future warming in Colorado for all of the climate model projections (Lukas *et al*. 2014, p. 59). By 2050, for the RCP 4.5 (intermediate) emissions scenario, the statewide average annual temperatures are projected to increase by 1.4 to 2.8°C (2.5 to 5°F) (relative to a 1971–2000 baseline), and increase by 1.9 to 3.6°C (3.5 to 6.5°F) under the RCP 8.5 (high) emissions scenario (Lukas *et al*. 2014, p. 59). For precipitation, they report that climate model projections show less agreement regarding future precipitation change for Colorado, but most projections indicate increasing winter precipitation by 2050 (Lukas *et al*. 2014, p. 59).

Summary

Observed trends and future climate model projections indicate warming temperatures for much of the western United States, including areas within the current range of the wolverine. The degree of future warming varies by region and is dependent upon the future emission scenario used during the modeling process. Future precipitation trends are less certain for many regions, in part, due to naturally high, inter-annual variability; some regions are projected to experience greater winter precipitation. Wolverines have been found to have a wide range in critical temperature depending on season, and undergo seasonal changes in fur insulation to adapt to warmer temperatures in summer. Wolverines also exhibit changes in behavior, such as moving to water bodies or higher elevations in summer months. These physiological and behavioral adaptations allow wolverines to adapt to warming temperatures.

Biotic Factors

In addition to evaluating changes in these abiotic factors, biotic interactions should be considered in evaluating species' response to climate change (reviewed by Post 2013). Although abiotic changes drive ecological processes, the alterations in biotic interactions (e.g., competition among conspecifics, interactions with competitors, resources, and predators) represent the ecological responses that result from those changes (Post 2013, p 1). Changes in certain abiotic factors, such as snow and ice cover, should also be considered in an ecological context since they represent habitat for many species (Post 2013, p. 11).

Ecological studies evaluating the effects of climate change often evaluate phenology, the timing of life history events and how they vary in space and time, generally at the population or site-specific level, though phenological variation at the individual level may also be important (Post 2013, p. 54). Previous meta-analyses of the rate of phenological advancement have suggested advances of between 2–5 days per decade, across taxa, and between low-mid to mid-high latitudes (Post 2013, p. 59). A more recent meta-analysis from Cohen *et al*. (2017, p. 4) found, on average, significant advancement in the phenology of animals since 1950, advancing by about 2.88 days per decade and 3.08 days per degree Celsius.

Within the Pacific Northwest region, Ford *et al*. 2016 (entire) modeled the timing of growth initiation in coast Douglas-fir trees (*Pseudotsuga menziezii* var. *menziezii*) within the species' range in Washington and Oregon to evaluate its ability to track changes in climate with changes

in phenology. This study found that, for high latitudes and elevations, growth initiation was predicted to occur earlier in the year, which allows trees to track the beginning of favorable growing conditions, without exposure to frost risk (i.e., adaptive phenological response) (Ford *et al*. 2016, pp. 3718, 3,721). Conversely, their model predicted that at lower latitudes and elevations, growth initiation will lag behind climate change shifts due to reduced chilling with lower productivity, which suggested that coast Douglas-fir has an obligate chilling requirement for height (but not diameter growth initiation) (Ford *et al*. 2016, pp. 3,717–3,719).

Another study reported on the effects of encroachment of woody plants (willows (*Salix* sp.)) in alpine environments to alpine wildflowers and their pollinators due to temporal overlap in flowering phenology, which may result in establishment of plant species with broader environmental tolerance in high alpine ecosystems (Kettenbach *et al*. 2017, p. 6,969). Similarly, in Sweden, Wilson and Nilsson (2009, entire) reported on encroachment of woody vegetation in arctic-mountain habitat, though primarily at lower elevations in response to observed temperature increase of 2.0°C (3.6°F) over 20 years, though this increase in cover was observed primarily at lower elevations (Wilson and Nilsson 2009, p. 1,682).

A high-latitude, North American study evaluated the effect of weather and broad-scale climate variables and vegetation productivity on the timing of spring and fall migrations of migratory caribou herds in northern Québec and Labrador, Canada (Le Corre *et al*. 2017, entire). That study found that, since 2000, except for the spring arrival, migrations occurred earlier, and were affected by resource availability, likely through intraspecific competition factors (Le Corre *et al*. 2017, p. 266).

In addition to phenological changes related to habitat variables or reproduction patterns, the effects of climate change may affect food resources important to wolverine, either directly (e.g., survival) or indirectly (e.g., effects to their habitat). An early study by Wang *et al*. (2002, p. 217) projected a potential increase in ungulate populations in Rocky Mountain National Park (Colorado) under future climate scenarios due to enhanced survival and recruitment of juvenile animals in response to less severe winters. The authors note that their results should be interpreted qualitatively given the uncertainties in applying climate change scenarios based on global models to ecological systems at the local scale (Wang *et al*. 2002, p. 217). In addition, they report that vegetation response (e.g., succession) to climate change effects may result in changes to ungulate habitat (Wang *et al*. 2002, p. 219). Overall, the study concluded that their results were consistent with those reported in other studies that have evaluated the relationships between the effect of weather and density dependence and ungulate population dynamics (Wang *et al*. 2002, p. 219).

Summary

The results presented above indicate biotic effects resulting from climate change, varying from phenological changes to shifts in vegetation and vegetation succession. We are unaware of studies that have directly evaluated these types of effects to the North American wolverine or its habitat. Given the extensive range and varied habitats occupied by wolverines in the contiguous United States, the shifts in vegetation are likely to be relatively narrow in scope and scale. Furthermore, we have no information to suggest that wolverines selectively use any specific

vegetation type and some changes in vegetation may actually be advantageous for wolverine prey.

Climate Change and Potential for Cumulative Effects

Threats can work in concert with one another to cumulatively create conditions that may impact the wolverine or its habitat beyond the scope of each individual threat. Given an expected increase in temperature in the western United States, the best available information indicates that, if there are any cumulative impacts in the future, the most likely to have population level effects on wolverine in the contiguous United States could be: 1) changes in snowpack from the combination of increased temperature and changes in precipitation patterns, or 2) changes in snowpack and increase in wildland fire potential.

Snowpack/Snow Cover

Upper Snake River Watershed (Pacific Northwest region)

The Upper Snake River Tribal Foundation assessment (discussed above) included projected changes in snowpack for three locations in the Upper Snake River watershed, including areas located within our estimated Current Range of the wolverine (from Climate Impacts Group Pacific Northwest (PNW) Hydroclimate Scenarios Project (2860); http://warm.atmos.washington.edu/2860/products/sites/). Model results, based on snow water equivalent (SWE) (the water content of snowpack, expressed as depth), indicate a projected loss in April 1st snowpack of 36 percent for the 2030–2059 period and 64 percent for the 2070–2099 period for the *Salmon River at White Bird* location (average of percent change across all models relative to the long-term average for 1916–2006 ("historical period")). For the *Snake River at Brownlee Dam* location, the projected loss is 37 percent for the 2030–2059 period and 64 percent for the 2070–2099 period (summary presented in Petersen *et al*. 2017, p. 20). These projected changes were found to be consistent with overall changes projected for the Columbia River Basin snowpack in an earlier study. Hamlet *et al*. (2013, p. 404; Figure 7) found that, relative to the long-term average for 1916 to 2006, the April 1st snowpack in the Columbia River Basin is projected to decline by 29% for the 30-year period spanning 2030-2059 and decline by 52% for the period spanning 2070-2099 for the A1B emissions scenario. [Note: the A1B emission scenario represents a more balanced energy portfolio than RCP 8.5, with GHG emissions leveling off by the middle of the 21st century].

Sierra Nevada

Walton *et al*. (2017, entire) developed snow cover projections for the Sierra Nevada region in California, incorporating snow albedo feedback using a hybrid downscaling approach to develop future climate projections. This feedback loop is known to be important for regional climate change (Thackeray and Fletcher 2016, p. 395) and occurs when warming causes snow pack to shrink at margins and the exposed ground absorbs more sunlight than snow, which enhances the warming, resulting in more melting of snow (Walton *et al*. 2017, p. 1,417). This study (using 3 km (1.86 mi) resolution) found that, by the end of the 21st century (2081–2100), warming and loss of snow cover is expected to occur, though the degree varies depending on the GHG

scenario (Walton *et al*. 2017, p. 1,430). Under the RCP 8.5 (high emissions) scenario, the study found that the total area covered by snow during the typical month of April decreases by 48 percent, as compared to historical average (1981–2000) (using ensemble mean) (Walton *et al*. 2017, p. 1,432). Under the RCP 4.5 (moderate emissions) scenario, snow cover losses were projected at about half of those for RCP 8.5 (Walton *et al*. 2017, p. 1,434; Figure 13). The effects of warming were more pronounced at lower elevations and were most severe in May and June (Walton *et al*. 2017, p. 1,431; Figure 12). For the months of March and April, the highest elevations were found to have nearly complete snow cover (measured as snow covered fraction) for all GCM simulations (Walton *et al*. 2017, p. 1,431; Figure 12).

Northern and Southern Rocky Mountains–Glacier and Rocky Mountain National Parks

The effects of climate change on snow persistence has been suggested as an important negative impact on wolverine habitat and populations by the mid-21st century (McKelvey *et al*., 2011, entire). The Service therefore pursued a refined methodology to provide insights into the potential impacts of climate change on snow persistence.

The Service engaged the National Oceanic and Atmospheric Administration (NOAA) laboratories and University of Colorado in Boulder, Colorado (CU) to evaluate and model fine scale persistence of snow in occupied and potential wolverine habitat in the contiguous United States. Those discussions revealed significant progress in fine scale modeling approaches since the early 2000s. The Service provided funding for an assessment of snow extent and depth to assess the effects of climate change on snow persistence in two areas of the western United States, Rocky Mountain and Glacier National Parks (Ray *et al*. 2017, entire). The primary objective of this study was to refine the spatial and temporal scale of snow modeling efforts and improve the scientific understanding of the extent of spring snow retention currently and into the future under a changing climate (Ray *et al*. 2017, p. 9). The objectives of the study included (Ray *et al*. 2017, p. 10):

- Use of fine-scale models to analyze the topographic effects of snow, including slope and aspect (compass direction that slope faces)
- Use of a range of plausible future climate change scenarios to assess snow persistence
- Analysis of extremes and year-to-year variability by selecting representative wet, dry, and near normal years (using observed conditions) and then modeling changes for those base years under several future climate scenarios
- Assessment of changes in snow persistence by elevation

The study was designed to parallel as much as possible and thereby refine the previous assessment of snow cover persistence in the western United States presented in McKelvey *et al*. (2011). However, an exact replication of the McKelvey *et al* (2011) study was not possible given the time, funding, and computational constraints needed to develop a fine-scale assessment. The current study was limited to two study areas (approximately 1,500 to 3,000 km^2 (579 to 1,158 mi^2) each) in the northern and southern Rocky Mountains (see **Appendix H** for maps). The two study areas were selected because they encompass the latitude and elevational range of wolverines within the contiguous United States. Glacier National Park (GLAC) is representative of a high latitude and relatively low elevation area currently occupied by wolverines. The Rocky

Mountain National Park region (ROMO) is a lower latitude and higher elevation area within the wolverine's historical range, which was recently occupied by a wolverine from 2009 to at least 2012.

Methods: We provide here a brief summary of the methods used in this study. Additional details are contained in the full report authored by Ray *et al*. (2017). The initial step of the analysis was a review of the observed climate and variability to provide context for trends and year-to-year variability. Next, historical snow cover extent and variability were analyzed using satellite remote sensing (MODIS) data from 2000 to 2016 to calculate a snow disappearance date for each year at each pixel. Summary statistics include total snow covered area (total area covered by snow), representation of snow pack by aspect (percent of land areas covered by snow for each of the 17 years in the historical record by topographic aspect based on compass direction that the slope faces), and elevation dependence for wet, near-normal, and dry years (with median of all years used as reference). Future snow pack projections were then generated using the Distributed Hydrology Soil Vegetation Model (DHSVM), for the historic period 1998-2013, and then validated against SNOTEL observing stations and MODIS satellite data.

Both Ray *et al*. (2017) and McKelvey *et al*. (2011) used the delta method to estimate future snow persistence. The NOAA-DHSVM delta method uses historical observed weather (1998–2013) as the baseline and applies future changes in temperature and precipitation from the chosen GCMs (approximately Year 2055) to estimate future snow persistence on the landscape. Five future scenarios (GCMs) were selected from CMIP5 global climate model projections to capture variability in temperature and precipitation, using the RCP 4.5 (moderate) and RCP 8.5 (high) emissions scenarios. Representative wet, near normal, and dry years were analyzed for the historical simulations and evaluated for the five future scenarios. The number of years (out of 16) with snow depth greater than 0.5 m (20 in) was also analyzed as was the change in Snowcovered Area (SCA) (area with depth greater than 0.5 m (20 in)). This snow depth was selected based on an analysis of the depth of snow at documented wolverine den sites in Glacier National Park (Ray *et al*. 2017; Table 5-2). Results were reported for "light snow cover" (snow depth greater than 1.25 cm (0.5 in)) and "significant" snow (snow depth > 0.5 m (20 in)) for April 15, May 1, and May 15 for previously defined representative years. These dates were selected based on studies indicating den site abandonment generally occurs before May 1 (see Use of Dens and Denning Behavior discussion above in *Reproduction and Growth* section). The term "light snow cover" was incorporated as the most directly comparable parameter to McKelvey *et al*.'s "light" snow cover. The average change in SCA and SWE was analyzed as a function for both study areas of elevation and was overlaid with the elevations of documented wolverine den sites (2003–2007) in GLAC.

Comparison with McKelvey *et al*. (2011): Although the methods used in this study have similarities with those presented in McKelvey *et al*. (2011), there are several key differences. Ray *et al*. (2017) used a finer spatial resolution model (DHSVM) than McKelvey *et al*. (2011) (0.0625 km^2 vs. 35 km^2) that incorporated slope and aspect. The grid cells represented in McKelvey *et al*. (2011) were assumed to be flat (i.e., north-facing slopes treated as identical to south-facing slopes). McKelvey *et al*. (2011) focused on May 1st snow depth as a proxy for May 15th snow disappearance, while Ray *et al*. (2017) focused directly on May 15th snow disappearance and produced results for the presence or absence of deeper snow (nominally

greater than or equal to 0.5 m (20 in) depth) on May 1st *and* April 15th.[4] Because of the increased resolution of this study, Ray *et al*. (2017) were able to consider whether any areas of snow with depth greater than 0.5 m (20 in) will persist in these areas. Additional comparisons are outlined below in Table 8 and in Ray *et al*. (2017, p. 6).

Table 8. Comparison of Methods, Ray *et al*. (2017) vs. Copeland *et al*. (2010) and McKelvey *et al*. (2011)

Feature	Ray *et al*. (2017)	Copeland *et al*. (2010) and McKelvey *et al*. (2011)
Spatial Resolution	250 m x 250 m = 62,500 m^2 or 0.0625 km^2 (0.24 mi^2)	0.125 degrees (~5 km x 7 km; 37 km^2 (14.29 mi^2))
Geographic Area	Glacier and Rocky Mountain National Parks, 300 m below treeline and above	Western United States, except California and Great Basin
Topography	Slope, aspect, and shading were used	Slope and aspect were not used
Validation	SNOTEL (in-situ observations) and MODIS (satellite remote sensing)	None specific to the snow dataset used
Future Scenario Method	Delta Method, used to project 2000-2013 conditions out to Year 2055 (average of 2041–2070)	Delta Method (Years: 2045 (2030–2059), 2085 (2070-2099)
Future Scenarios (GCMs)	*miroc*, *giss*, *fio*, *cnrm* (both study areas); *canesm* (Glacier National Park only) *hadgem2* (Rocky Mountain National Park only)	Ensemble mean of 10 GCMs, *pcm1*, and *miroc 3.2*
Time-related Results	Long-term means and year-to-year variability (i.e., wet, near normal, and dry years)	Changes in long-term mean snowpack only
Snow Detection and Measurements	Snow presence: 1.25 cm (0.5 in) snow depth threshold on May 15. "Significant snow": snow depth (0.5 meter (20 in) threshold. Snow depth determined by conversion from Snow Water Equivalent using bulk snow density.	Snow presence (13 cm (5.12 in) snow depth threshold on May 1). Snow depth determined by VIC model.
Number of Years of MODIS Data	17 (2000-2016)	7 (2000-2006)
Snow Model	DHSVM (University of Washington)	VIC (University of Washington)
Snow Cover Dates Analyzed	April 15, May 1, and May 15	May 15 (derived from May 1), May 29 (derived from May 1)

Results: While there are challenges in comparing the results from McKelvey *et al*. (2011) directly to the Ray *et al*. (2017) study due to differences in methodology and focus, the qualitative picture can be summarized as follows: projected warming has a larger effect at lower elevations whereas projected precipitation changes may dominate the springtime snowpack in the high country. We present below a summary of the main results from Ray *et al*. (2017).

[4] Ray *et al*. (2017) originally focused on May 15th to compare to the McKelvey *et al*. (2011) study, and June 1st to bracket the snowmelt season. However, April 15 and April 30 dates were added to the evaluation of snowcovered areas to align with temporal reproductive patterns of the wolverine (see Use of Dens and Denning Behavior discussion in *Reproduction and Growth* section above).

MODIS Observed Historic Snowpack Variability Analysis:

- In GLAC, SCA varies considerably by year, including wet years such as 2011 with very persistent snow, years with strong melt in early May, such as 2012, or in late May (2009, 2001), and dry years (2004, 2005) (Ray *et al*. 2017, Section 4.3).
- Even in dry years, northeast-facing slopes in GLAC tend to hold more snow and melt later in the season.
- More than 80 percent of the GLAC study area above approximately 2,000 m (6,562 ft) elevation on May 1 has snow cover during dry years, and more than 95 percent has snow cover above approximately 1,200 m (3,937 ft) during wet years.
- In ROMO, the SCA also varies considerably by year.
- The northwest-facing slopes in ROMO tend to hold more snow even during dry years. In very dry years, snow cover peaks at intermediate elevations, suggesting that the high-altitude snowpack may be particularly vulnerable in this region under warm/dry conditions.

Future Snowpack Projections: The area-wide SCA results include snow cover changes in both forested and above-treeline (alpine) terrain, which may have different implications for wolverine biology.

Glacier National Park (GLAC):

- Projections for April 15th, May 1st, and May 15th SCA and area with snow depth greater than 0.5 m (20 in) show declines on average in all scenarios, compared to the 2000–2013 historic average, except for small increases in the Warm/Wet scenario and for almost all years.
    - For April 15th, light SCA area is reduced by 3–23 percent and significant snow cover (greater than 0.5 m (20 in)) declines by 7–44 percent.
    - For May 15th, light SCA is reduced by 10–36 percent, and the area with significant snow cover declines by 13–50 percent.
- All projections show declines in the number of years with significant snow (equal to or greater than 0.5 m (20 in)), which varies by scenario (e.g., Figure 5-14 in Ray *et al*. 2017). Areas with frequent availability (at least 14 out of 16 years) of significant snow become concentrated in smaller high elevation areas. Lower elevation areas had the largest decreases in the number of years with significant snow cover.
- Most of the known den sites are located between 1,800 m (5,906 ft) and 2,000 m (6,562 ft) in GLAC. Below that elevation band, large snow losses are predicted (40 to 70 percent decrease for two of the scenarios, 16–20 percent for the other three). Above that elevation band, there is little change in SCA for four of the five scenarios (2–8 percent) except in maximum warming scenario (decline of 40 percent (Ray *et al*. 2017; Figure 5-22). In the 1,800–2,000 m (5,906–6,562 ft) band, the snowpack change is sensitive to elevation and to the future climate scenario used.
- For representative wet years, for May 15th, the higher elevations of the study areas experience only 2–7 percent loss of snowpack under the scenarios with “least” change and the “moderate” change, although for the dry years, losses range from 18–57 percent.

- The implication is that the wet, cold climate of the GLAC study area could act as a "buffer" to change in areas with of 0.5 m (20 in) of deep snow on May 1st, at least for elevations above 1,800 m (5,906 ft).

Rocky Mountain National Park (ROMO):

- Projections of May 15th SCA in ROMO decline on average in all scenarios, except for small increases in the Warm/Wet scenario, and for almost all years.
  - For April 15th, light SCA (depth ≥ 5 mm (0.2 in)) declines by 3–18 percent and significant SCA (depth > 0.5 m (20 in)) changes from −1– +16 percent for the five scenarios considered (compared to the 2000-2013 historical average).
  - For May 15th, the area with light snow cover declines 8–35 percent and the area with significant snow cover declines 6–38 percent.
- All projections show declines in the number of years with significant snow (equal to or greater than 0.5 (20 in), which varies by scenario (e.g., Figure 5-21in Ray *et al*. 2017). The areas with frequent availability (at least 14 out of 16 years) of significant snow become concentrated in smaller high elevation areas. In contrast, lower elevation areas had the largest decreases in the number of years with significant snow cover.
- Although no dens have been documented in ROMO, the elevation band for denning, modeled by regression analysis, is estimated at 2,700 to 3,600 m (8,858 to 11,811 ft). On May 1st, modest declines in SWE of about 15 percent and less for areas at 3,400 m (11,155 ft) or above result in losses of only about 10 percent snow cover.
  - The implication is that the wet, cold climate of the higher parts of the ROMO study area could also act as a "buffer" to change in the area of 0.5 m (20 in) deep snow on May 1st.

Elevation Dependence of Change: In general, and supported by the literature, the snowpack in the higher elevations of both areas is more responsive to precipitation change, while lower elevations are more responsive to temperature change. For GLAC, most of the observed den sites are located within the zone where temperature dominates the future effects of change. For the elevation of den sites in GLAC (i.e., above 1800 m (5,906 ft)), loss of SCA on May 1st spans the range of 5–40 percent, with a 70 percent decrease for the Hot/Wet (*miroc* GCM) scenario. Above 2,200 m (7,218 ft), the losses are less than 5 percent for all but the Hot/Wet scenario.

Current results may be a reasonable estimate for the high mountain ranges within the Rockies that lie between GLAC and ROMO. However, without further study, we cannot reasonably extend these results to say whether or not snow refugia will persist in the Central Rockies below our study elevations (approximately 1,000 m (3,281 ft)). These lower elevations are where McKelvey *et al*. (2011) predicted the greatest losses in snowpack. The NOAA/CU results also cannot be extrapolated to mountain ranges outside of the Rockies (i.e. the Cascade Range) that have different climates (temperature and precipitation). We note here that we have no documented wolverine den sites in the contiguous United States below 1,500 m (4,921 ft) elevation; that is, no documented den locations in the areas where McKelvey *et al*. (2011) predicted the greatest loss in snowpack.

Interpretation and additional analysis relative to wolverine den site scale: The Service was interested in exploring the question, "If snow cover is required for wolverine denning, will there be a sufficient amount of significant snow cover in the future in areas wolverines have historically used for denning in the contiguous United States?" The Service integrated future DHSVM projections (2000–2013 averages) of snow covered area (greater than 0.5 m (20 in) depth) on May 1st for GLAC and ROMO with new information obtained from a spatial analysis of documented den sites in the contiguous United States. This spatial analysis indicated 31 of 34 documented den sites in the contiguous United States were located in areas with slope less than 25 degrees. Avalanche risk increases significantly in areas with slope greater than 25 degrees (Scott 2017, pers. comm.) and wolverines may avoid these areas for denning due to this risk.

Using the projections prepared by Ray *et al*. (2017), we present in Figures 6–13 the spatial distribution of significant snow covered area with slopes less than 25 degrees and within the elevation bands indicated above for three future scenarios in each study area. The three scenarios for GLAC (*miroc*, *cnrm*, and *giss*) and for ROMO (*hadgem2*, *fio*, and *giss*) were chosen to span the range of GCM uncertainty regarding temperature and precipitation, and by extension significant SCA (see Figure 6 and Figure 7). We found that large portions of the study areas meet all three criteria—greater than 0.5 m (20 in) snow depth on May 1st, at elevation 1,514–2,252 m (4,967–7,389 ft) for GLAC or 2,700 to 3,600 m (8,858 to 11,811 ft) for ROMO, and with a slope less than 25 degrees—across both study sites in the future.

The GLAC *miroc* simulation shows the greatest decrease in future snow covered area in the elevation band historically used for denning (orange line in Figure 6). Figure 8 shows the spatial distribution of significant SCA with slope less than 25 degrees and elevation of 1,514–2,252 m (4,967–7,389 ft) for the *miroc* simulation on May 1st (approximately Year 2055). Approximately 494 km^2 (191 mi^2) of area meet the three criteria with an additional 803 km^2 (310 mi^2) of area retaining significant snow covered area, primarily at higher elevations. Moreover, we determined that large tracts of significant SCA are projected in close proximity to documented historical den sites across all three scenarios (Figures 8–10). As shown in Table 9, wolverines would not have to travel far, or at all, relative to either distance or elevation to reach areas with significant snow covered area in the future.

A similar analysis was performed for the ROMO study area and the results indicate that large portions of the study area meet all three criteria identified above. The *hadgem2* (Figure 11) and *cnrm* scenarios were found to have the greatest decrease in significant snow covered area of the five scenarios analyzed. Figure 11 (*hadgem2* simulation) shows the spatial distribution of significant SCA (greater than 0.5 m (20 in) depth), elevation of 2,700–3,600 m (8,858–11,811 ft), and slopes less than 25 degrees where denning would be expected to occur. Total area meeting these three criteria was 339 km^2 (131 mi^2) (dark blue in Figure 11), with an additional 446 km^2 (172 mi^2) with snow depth greater than 0.5 m (20 in) (light blue in Figure 11), mostly at higher elevations. Figures 12 (*fio* scenario) and Figure 13 (*giss* scenario) show a similar distribution, albeit larger areas of significant snow retention in the future (see map legends in Figures 12 and 13 for area estimates).

Table 9. Distance of historical GLAC dens (Years 2003–2007) from projected significant snow covered area in the future (approximately Year 2055) (using 2000–2013 average)

A 0 (zero) value indicates the den site location meets all three criteria in the future (greater than 0.5 m (20 in) snow depth on May 1st, at elevation 1,514–2,252 m (4,967–7,389 ft), and with a slope less than 25 degrees).

Den Site	Elevation, m (ft)	Distance from den site to nearest model cell, m (ft)		
		GCM scenario		
		miroc	*cnrm*	*giss*
1	2,252 (7,389 ft)	0	0	0
2	2,093 (6,867 ft)	0	0	0
3	1,995 (6,545 ft)	0	0	0
4	1,977 (6,486 ft)	210 (689 ft)	0	0
5	1,973 (6,473 ft)	208 (682 ft)	0	0
6	1,928 (6,326 ft)	0	0	0
7	1,922 (6,306 ft)	9 (29.5 ft)	8 (26 ft)	8 (26 ft)
8	1,912 (6,273 ft)	170 (558 ft)	0	0
9	1,893 (6,211 ft)	110 (361 ft)	0	0
10	1,851 (6,073 ft)	87 (285 ft)	0	0
11	1,843 (6,047 ft)	74 (243 ft)	0	0
12	1,823 (5,981 ft)	56 (184 ft)	0	0
13	1,807 (5,929 ft)	0	0	0
14	1,514 (4,967 ft)	574 (1,883 ft)	571(1,873 ft)	296 (971 ft)

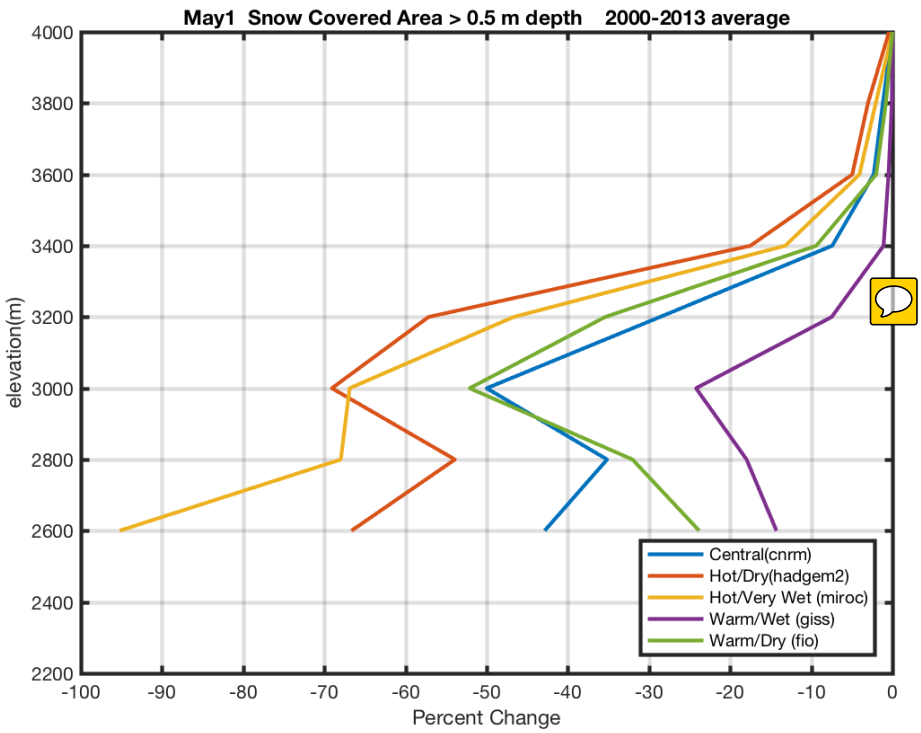

Figure 6. Average Snow Covered Area (depth ≥ 0.5 m (20 in)) percent change at elevation bands for GLAC for five future scenarios on May 1.

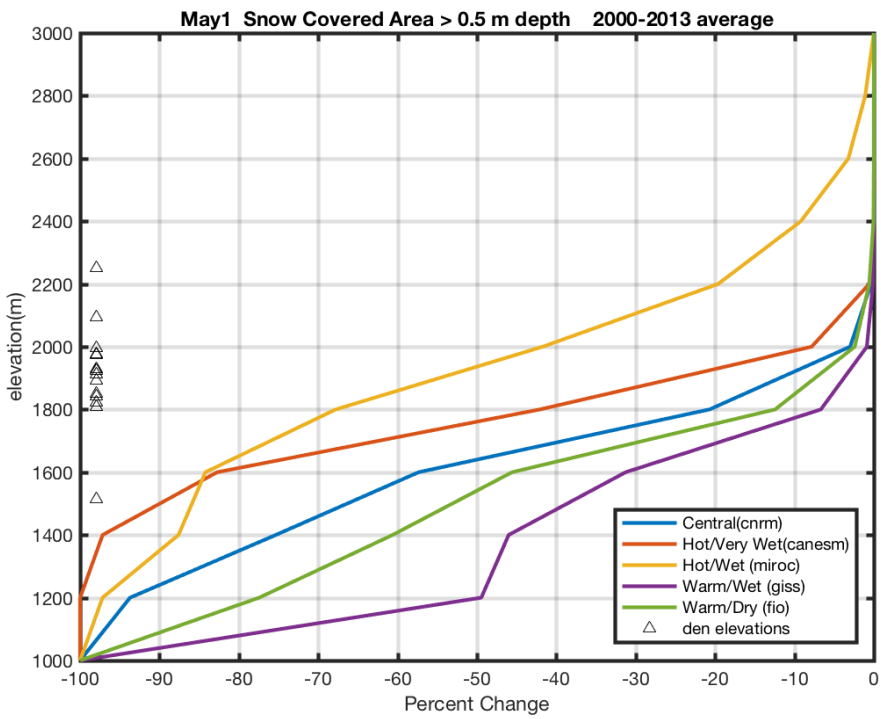

Figure 7. Average Snow Covered Area (depth ≥ 0.5 m (20 in)) percent change at elevation bands for ROMO for five future scenarios on May 1.

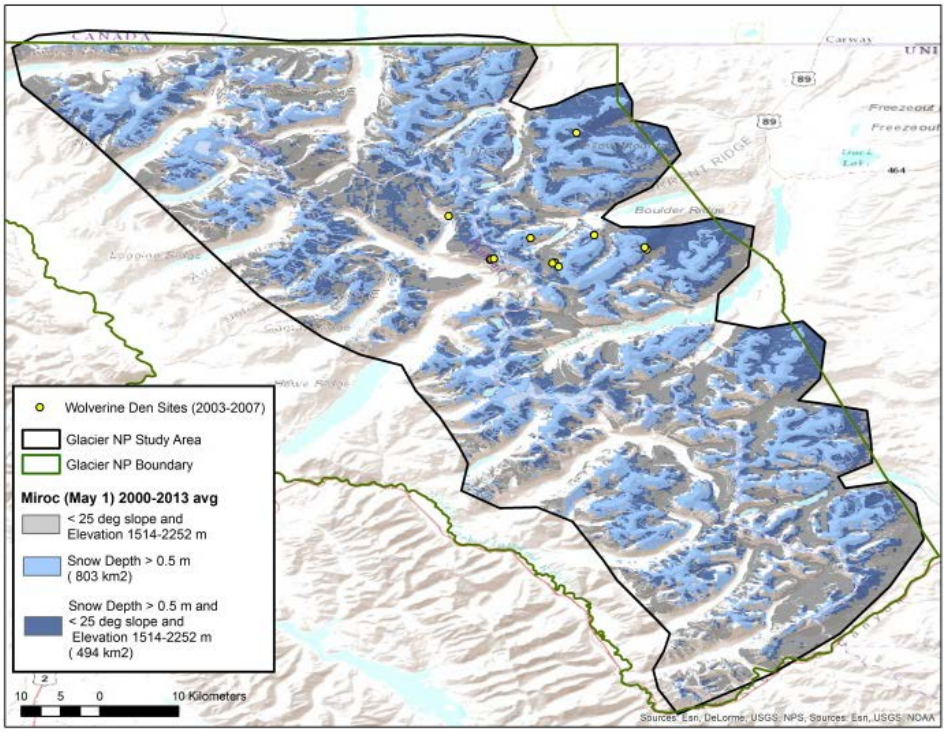

Figure 8. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *miroc* (Hot/Wet) scenario in Glacier National Park study area. Map legend shows where slopes are less than 25 degrees and elevations of 1,514–2,252 m (4,968–7,389 ft) (where dens have been documented).

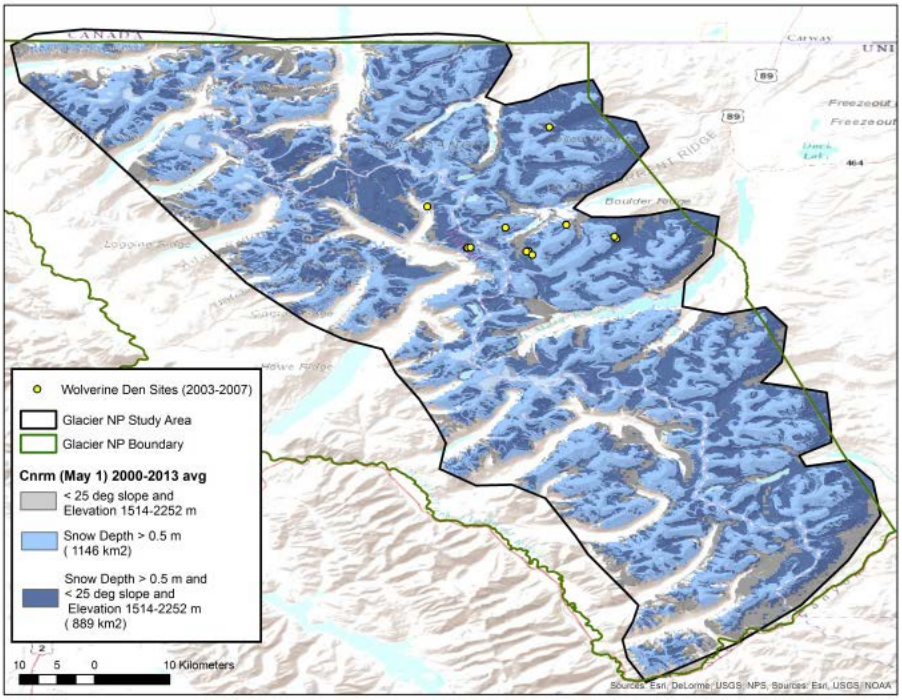

Figure 9. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *cnrm* (Central) scenario in Glacier National Park study area. Map legend shows where slopes are less than 25 degrees and elevations 1514–2252 m (4,968–7,389 ft) (where dens have been documented).

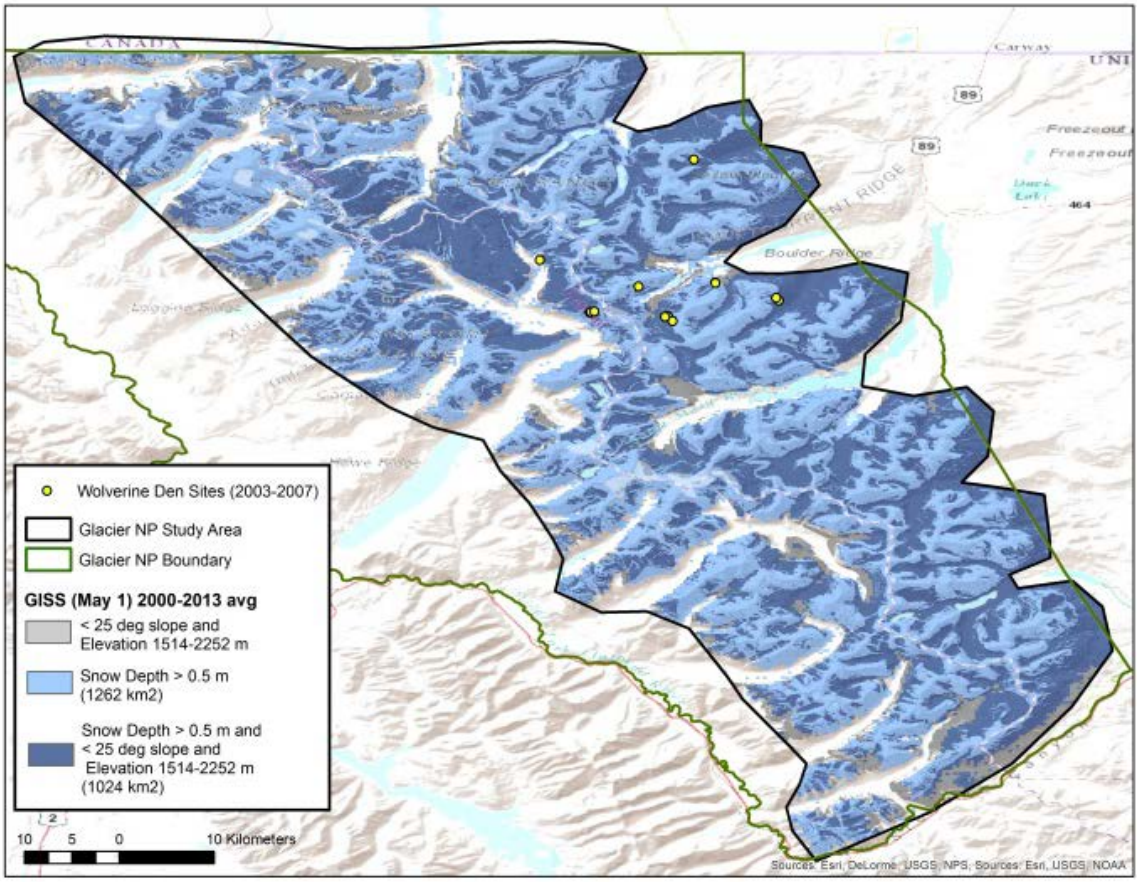

Figure 10. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *giss* (Warm/Wet) scenario in Glacier National Park study area. Map legend shows where slopes are less than 25 degrees and elevations 1,514–2,252 m (4,968–7,389 ft) (where dens have been documented).

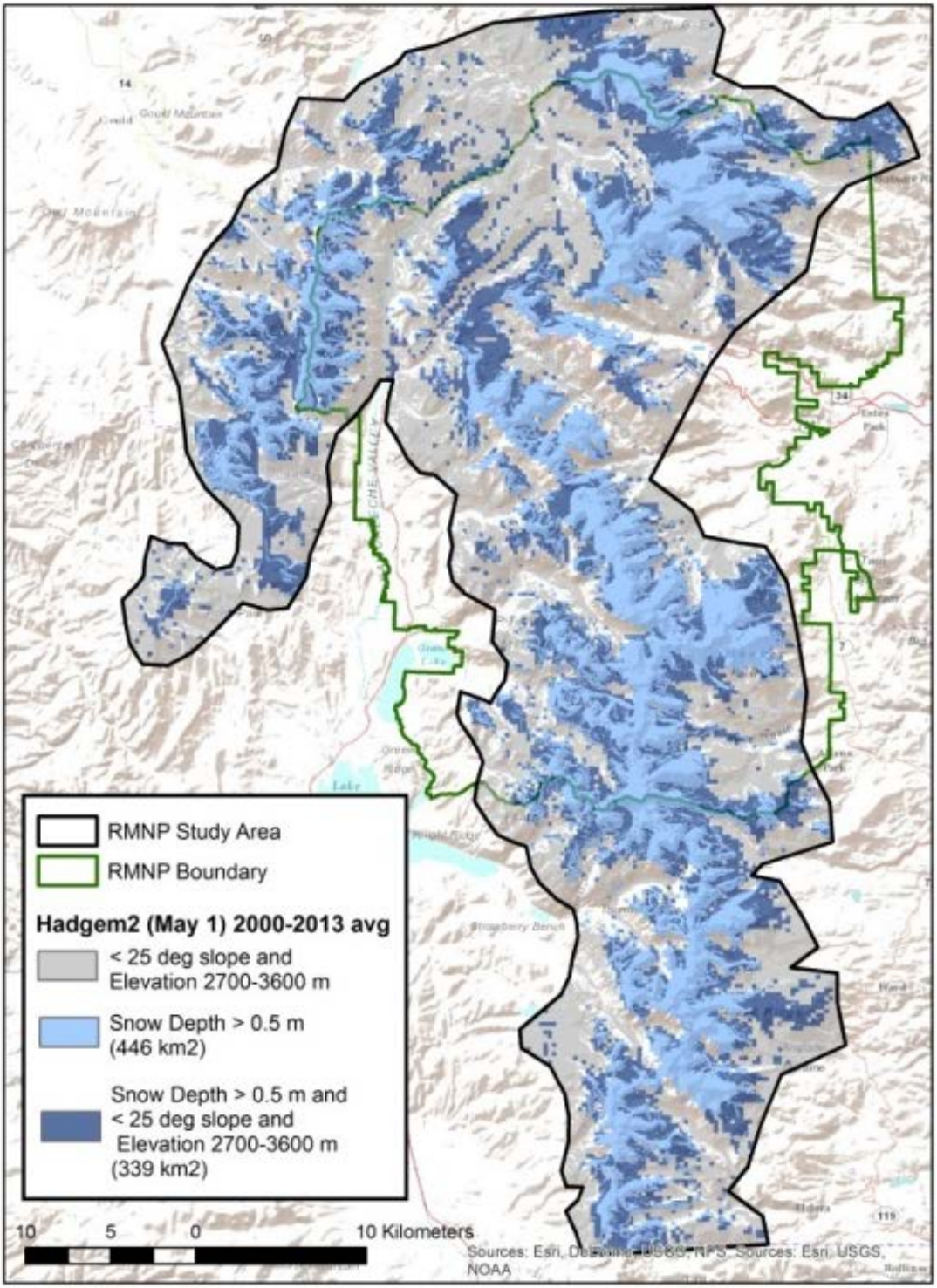

Figure 11. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *hadgem2* (Hot/Dry) scenario in Rocky Mountain National Park study area. Map legend shows where slopes are less than 25 degrees and elevations 2,700–3,600 m (8,858–11,811 ft) (inferred elevations where dens would be expected if occupied).

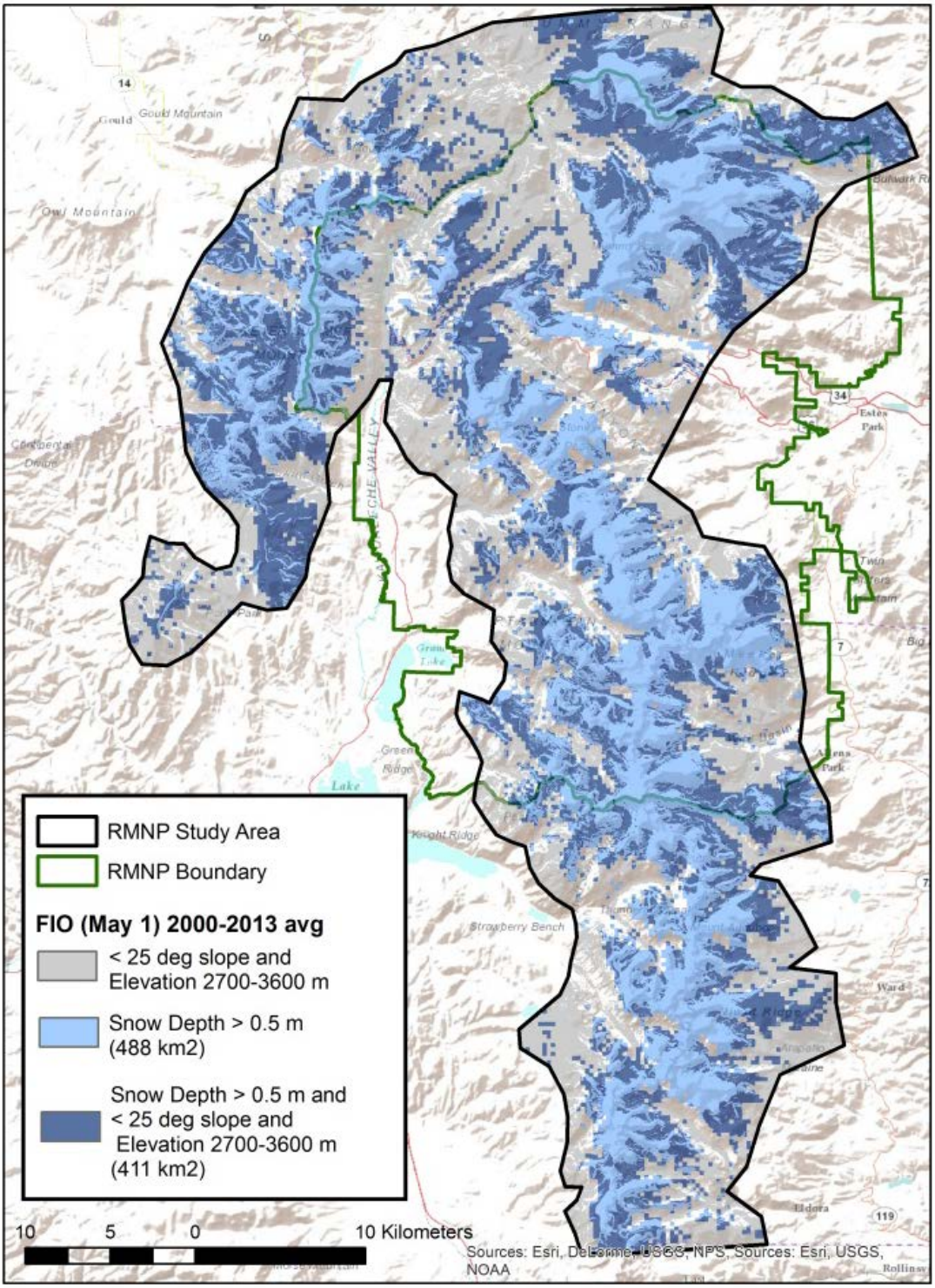

Figure 12. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *fio* (Warm/Dry) scenario in Rocky Mountain National Park study area. Map legend shows where slopes are less than 25 degrees and elevations 2,700-3,600 m (8,858–11,811 ft) (inferred elevations where dens would be expected if occupied).

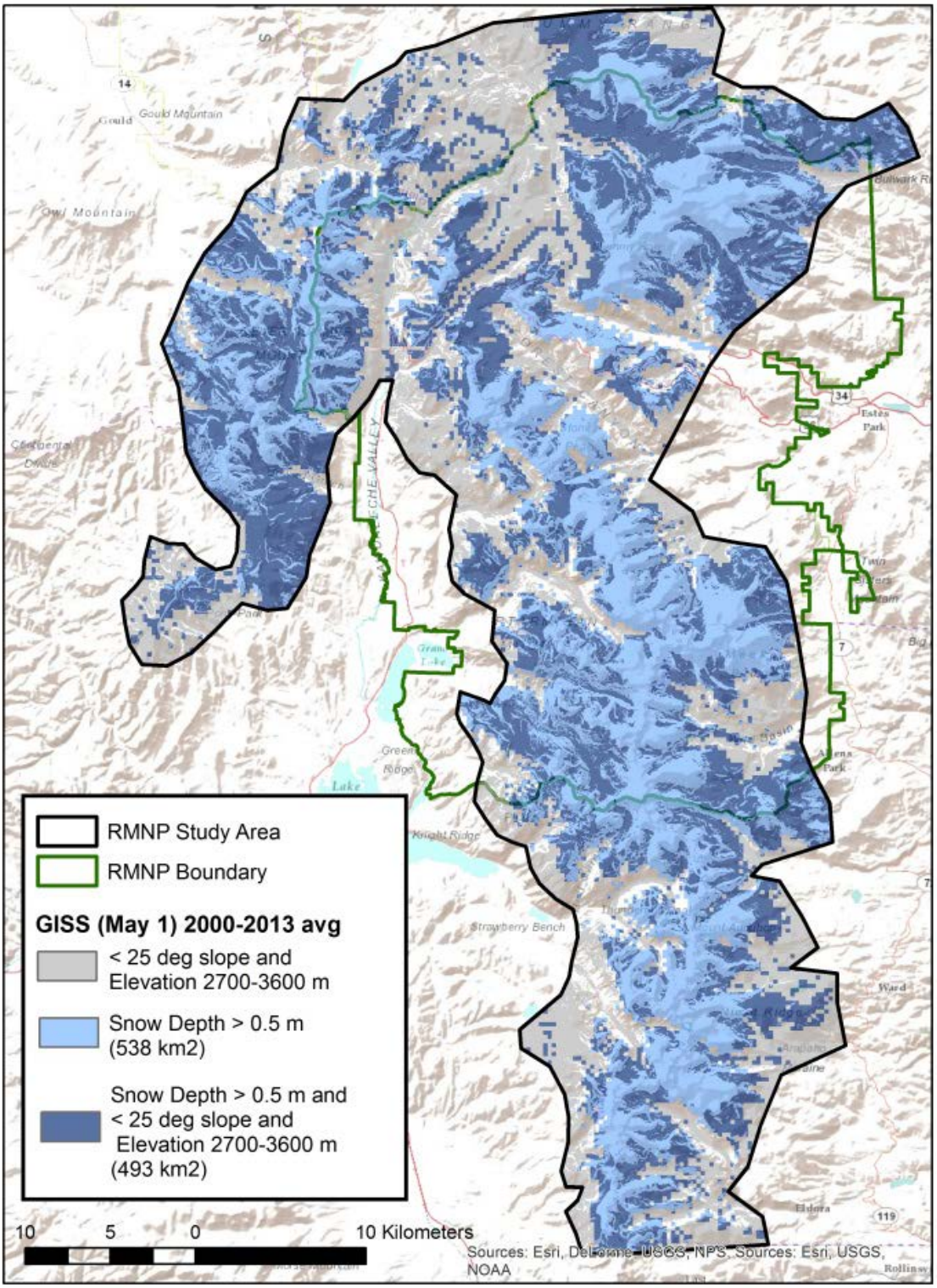

Figure 13. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *giss* (Warm/Wet) scenario in Rocky Mountain National Park study area. Map legend shows where slopes are less than 25 degrees and elevations 2,700-3,600 m (8,858–11,811 ft) (inferred elevations where dens would be expected if occupied).

Montana Climate Assessment

Another recent assessment of snowpack was conducted for the State of Montana (Whitlock *et al*. 2017, no page number). The report analyzed recent climate trends in Montana and assessed how climate is projected to change in the future (2040–2069). The study found that snowpack that accumulates at high elevations tends to be more stable and persists longer than at low elevations, due largely to the colder temperatures at high elevations. The largest projected changes in snowpack appear to be in areas located west of the Continental Divide, given their exposure to relatively warm Pacific air masses. Overall, the assessment found that declines in snowpack volume are likely in the future in the basins studied.

Wildland Fire

California

Keeley and Syphard (2016, entire) analyzed fire-climate relationships relative to predicting future fire regimes in California. Their review concluded that: (1) Climate is not a major determinant of fire activity across all landscapes; (2) hotter and drier conditions for areas at lower elevations and lower latitude were found to have little or no increase in fire activity as vegetation types in these regions are ignition limited; (3) increasing annual temperatures by themselves are not good predictors of increased fire activity; seasonality, especially spring and summer temperatures, are more important; and (4) fire-climate models need to be scaled to vegetation types; broad-scale models may produce over-predictions of the total increase in future fire regimes (Keeley and Syphard 2016, pp. 1, 10). Additionally, drought is a key factor in defining fire regimes and annual precipitation is the primary driver of drought variability (Williams *et al*. 2015, p. 6,819), but, at the present time, it is difficult to separate current droughts in California from natural cycles of drought (Keeley and Syphard 2016, p. 6).

Pacific Northwest

Sheehan *et al*. (2015, entire) used downscaled CMIP5 projections to model vegetation and fire changes, with and without fire suppression, within three subregions of the Pacific Northwest. Emission scenarios RCP 4.5 and 8.5 were used for future climate projections (2011–2100). The resulting trends varied by geographic region. In the Western Northwest subregion (from the crest of the Cascade Mountains west), the mean fire interval (MFI) averaged over all climate projections decreased by up to 48 percent, an increase in annual percent area burned (PAB), and the predominant conifer forest is replaced by mixed forest under future climate under both RCP scenarios, with and without fire suppression; thus, climate, rather than fire was found to be the primary influence in this subregion (Sheehan *et al*. 2015, pp. 22–26). In the Eastern Northwest Mountains (ENWM) subregion (mountainous areas east of the Cascade Mountains), the MFI (averaged across all climate projections) decreased by up to 81 percent, there was a projected increase in mean annual PAB, and, while subalpine communities are projected to be lost, conifer forests were projected to continue to dominate this subregion (Sheehan *et al*. 2015, pp. 22–24). When modeled using a without fire suppression regime, the future projections for ENWM indicated a lower MFI and higher mean annual PAB as compared to the with fire suppression regime (Sheehan *et al*. 2015, p. 22; Table 5). However, the eastern portion of the ENWM

subregion was found to show a differing response based on elevation; that is, higher elevations were found to have a *higher* MFI and a *lower* mean annual PAB during the 20th century as compared to lower elevations (Sheehan *et al*. 2015, p. 23).

Gergel *et al*. (2017, entire) evaluated the effects of climate change on snowpack, and soil moisture and fuel moisture (fire potential) in the western United States. This study used a statistical downscaling approach, using an ensemble of 10 GCMs across several mountainous regions known to be occupied by wolverines, with a 6.25 km (3.88 mi) spatial resolution hydrologic model. Simulations were run for three future periods: 2020s (2010–2029), 2050s (2040–2069), and 2080s (2070–2099) (Gergel *et al*. 2017, p. 291). The authors report significant declines in snowpack (measured as SWE) in all mountain ranges for all future scenarios (using RCPs 4.5 and 8.5) and GCMs (Gergel *et al*. 2017, p. 295). This study found that spring snowpack in mountains along the Pacific Coast is quite sensitive to warmer temperatures, but in the continental mountain ranges (Northern and Southern Rocky Mountains) spring snowpack is more sensitive to changes in precipitation (Gergel *et al*. 2017, p. 295). Differences were observed based on elevation (Gergel *et al*. 2017, p. 292). The study reported on future projected declines of summer soil moisture in forested areas (e.g., Northern Rockies) and the likelihood of increased risk of drought and therefore an increase in wildland fire risk for forested areas (e.g., Northern Rocky Mountains), though they recognize there is significant uncertainty in these future projections in high-elevation areas (Gergel *et al*. 2017, pp. 295–296).

In summary, based on these projections, wildland fire risk is likely to increase across the western United States, but future patterns and trends of wildland fire are dependent on several factors (e.g., degree of warming and drought conditions, fuel and soil moisture, wildland fire management practices, elevation) and geographic region.

Other Cumulative Effects

Finally, we note here that the effects of climate change on snowpack are projected to negatively affect the season lengths for winter recreational activities, such as skiing and snowmobiling (Wobus *et al*. 2017, entire), thus, potentially reducing this stressor to the wolverine in the future. Wobus *et al*. (2017) modeled potential changes in snowpack at locations across the contiguous United States using output from five GCMs, two representative pathways (RCPs) that represent a future scenario with continued high emissions growth with limited efforts to reduce GHGs (RCP 8.5) and a future scenario with global GHG mitigation (RCP 4.5), and two future time periods (2050 and 2090) (Wobus *et al*. 2017, pp. 2, 5). Although there was some inter-annual variability in 2050 for some model projections, in general, the Rocky Mountains and Sierra Nevada regions had smaller reductions in season length than other locations due to higher elevation, though for the RCP 8.5 scenario coupled with the 2090 future time period, the smallest projected reduction in season length was 15 percent (Wobus *et al*. 2017, p. 9).

Summary of Future Conditions

Models represent tools to describe basic physical and biological behaviors using the best available science, and, by presenting a range of plausible future outcomes, they can help generate hypotheses while also identifying knowledge gaps where greater accuracy is needed (Batchelet *et*

al. 2016, p. 23). Detecting a species' response to climate change in a single population, and sometimes multiple populations, may not always indicate the response throughout its range given the variation in annual mean surface temperatures over the past century (Post 2013, p. 5). In addition, inter-annual variability in temperature can be as important to a species' ecological needs as the actual temperature itself (Post 2013, p. 7).

Climate change model projections for the range of the wolverine within the contiguous United States indicate increases in temperature by the mid-21st century as compared to early to mid-20th century values. Precipitation patterns into the future are less clear as the climate models show significant disagreement in their many regional projections. Although drought conditions in the western United States are not unusual, drought duration and intensity have the potential to be exacerbated by projected temperature increases. Projected temperature and precipitation changes will affect future snow cover and the persistence of snow on the landscape.

Snow cover is projected to decline in response to warming temperatures and changing precipitation patterns, but this varies by elevation, topography, and by geographic region. Simulations of natural snow accumulation at winter recreation locations have found that, overall, higher elevation areas (e.g., Rocky Mountains, Sierra Nevada Mountains) are more resilient to projected changes in temperature and precipitation as compared to lower elevations (Wobus *et al*. 2017, p. 12). In general, models indicate higher elevations will retain more snow cover than lower elevations, particularly in early spring (April 30/May1).We present results (above) from several recent climate models projecting snowpack declines in the western United States. More specifically, we reviewed a new analysis from NOAA/CU that modeled future snow persistence for Glacier and Rocky Mountain National Parks (areas that encompass the latitudinal and elevational range of the wolverine in the contiguous United States) at high spatial resolution (Ray *et al*. 2017, entire). Their results indicate significant areas (several hundred square kilometers (miles) for each site) of future snow (greater than 0.5 m (20 in) in depth) will persist on May 1st at elevations currently used by wolverines for denning. This is true, on average, across the range of climate models used out to approximately Year 2055.

Although it has been assumed that wolverines have an obligate relationship with snow for natal denning, the key variables or combination of variables, that defined this relationship have not been empirically analyzed. As discussed above (**Box 1**), depth of snow cover and its duration increases with elevation; even minor elevation differences are noticeable (Formozov 1963, p. 123). The spotty distribution of snow cover is also affected by unequal distribution of snow precipitation on slopes with different exposures, transport of snow by wind, melting of snow on sun-exposed slopes, avalanche or rolling down of snow from steeper areas, and vegetation (Formozov 1963, p. 123). As discussed above (Denning Habitat), wolverines select den sites for differing characteristics depending on location, and wolverine (natal) dens have been observed outside of the boundary of the snow model presented in Copeland *et al*. (2010). In addition, very few studies to date have evaluated the importance of denning habitat to reproductive success, or the key physiological and ecological characteristics, including avoidance and/or protection from predators, prey availability, availability of food caching habitat, that define denning behavior and den site selection.

We also considered temperature and precipitation projections from climate change models in conjunction with wildland fire risk. This risk is likely to increase across the western United States, but patterns and trends are dependent on several factors (e.g., degree of warming and drought conditions, fuel and soil moisture) and geographic region.

As described above (see *Life History and Ecology* section), across their North American range, wolverines are found in a number of habitats, and exhibit wide-ranging movements. In conjunction with behavioral responses (e.g., dispersal over great distances, prey switching), physiological adaptations, including observed seasonal changes in the insulative capacity of fur, allow wolverines to occupy a variety of habitats throughout the year. Physiological adaptations at the cellular and biochemical level are also important in adapting to projected increases in temperature due to climate changes, though we are unaware of studies evaluating these types of responses in wolverines.

Overall Assessment

The wolverine's current range extends across the west-northwestern United States, large areas of Canada, and Alaska. In the contiguous United States, potentially suitable habitat (i.e., primary habitat), as determined by the physical and ecological features and the ecological needs of the wolverine, has been estimated at 164,125 km^2 (63,369 mi^2) (Inman *et al*. 2013, p. 281). The species is found in a variety of habitats, but generally occurs in remote locations.

In the contiguous United States, the structure of the wolverine population is represented as a metapopulation, although its genetic structure relative to its entire North American range has not been comprehensively evaluated. Wolverine populations in Alaska are considered to be continuous with populations in the Yukon and British Columbia provinces of Canada based on genetic studies (COSEWIC 2014, p. 37). Similarly, studies of wolverines in the North Cascades region have documented movement of wolverines from Washington into British Columbia (Aubry *et al*. 2016, pp. 16, 20).

Based on the best available information, wolverines select den sites for different characteristics depending on location. Dens located under snow cover may be related to wolverine distribution based on other life history traits, including morphological, demographic, and behavioral adaptations that allow them to successfully compete for food resources (Inman 2013, pers. comm.). Structure (e.g., uprooted trees, boulders and talus fields) appears to be essential for natal den sites. However, reproductive success of wolverines has not been evaluated relative to the depth and persistence of snow cover, or in combination with these or other important characteristics, including prey availability and predator avoidance. Recent studies of wolverine populations and distribution in Sweden have observed wolverine populations and reproductive den sites outside areas with persistent spring snow cover (Aronsson and Persson 2016; Persson 2017, pers. comm.).

We identified several potential stressors that may be affecting the species' and its habitat currently or in the future, including impacts associated with climate change effects. We recognize there is limited information available for the wolverine, including population estimates and abundance trends. Based on the best available information, demographic risks to the species

from either known or most likely potential stressors (i.e., effects from roads, disturbance due to winter recreational activities, effects of wildland fire, and overutilization) are low based on our evaluation of the best available information as it applies to current and potential future conditions for the wolverine and in the context of the attributes that affect the needs of the species.

Climate change model projections for the range of the wolverine within the contiguous United States indicate increases in temperature by the mid-21st century as compared to early to mid-20th century values. Our evaluation of climate change indicates that snow cover is projected to decline in response to warming temperatures and changing precipitation patterns, but this varies by elevation, topography, and by geographic region. In general, models indicate higher elevations will retain more snow cover than lower elevations, particularly in early spring (April 30/May1). Although the persistence of spring snow has not yet been evaluated as critical to wolverine survival in North America, our review of projected snow persistence (to approximately Year 2055) within the Northern and Southern Rocky Mountains, indicates that several hundred kilometers (miles) of deep snow will persist on May 1st at elevations used by the wolverine for denning.

Legal protections include State listing in California and Oregon (as threatened), endangered in Colorado, as a candidate species in Washington, and protection as a non-game species in Idaho and Wyoming. In Canada, provincial designations range from endangered to threatened in eastern provinces, and sensitive/special concern to no ranking in other provinces. Legal trapping or hunting of wolverines is currently prohibited in the contiguous United States. Trapping effort along the U.S.–Canada border does not represent a significant barrier to wolverine movement and dispersal along the international border.

Approximately 96 percent of modeled wolverine primary habitat in the contiguous United States is located on Federal lands, with 41 percent located in designated wilderness areas. Management actions for conservation of the wolverine and its habitat are included within State Wildlife Action Plans, the Idaho Wolverine Conservation Plan, and USDA Forest Service Land and Resource Management Plans (see **Appendix G**). Various provisions of these plans include, but are not limited to, winter road closures, fire management, and land acquisition or conservation easements. These management measures, currently and in the future, will alleviate effects associated with potential impacts related to stressors discussed in this report.

Based on our review of available relevant literature for similar species, we identified the physical and ecological needs of the species as follows: large territories in remote landscapes; at high elevation (1,800 to 3,500 meters (5,906 to 11,483 feet)) within the contiguous United States; access to a variety of food resources, that varies with seasons; and reproductive behavior linked to both temporal and physical features. These needs are currently met for wolverines in the contiguous United States and are expected to be met in the future.

Risk Assessment

In order to characterize a species' viability and demographic risks, we consider the concepts of resilience, representation, and redundancy. We also consider known and potential stressors that may negatively impact the physical and biological features that the species needs for survival and

reproduction. Stressors are expressed as risks to its demographic features such as abundance, population and spatial structure, and genetic or ecological diversity. We consider the level of impact a stressor may have on a species along with the consideration of demographic factors (e.g., whether a species has stable, increasing, or decreasing trends in abundance, population growth rates, diversity of populations, and loss or degradation of habitat).

Wolverine populations in much of North America are still recovering from large losses of individuals from intensively hunting and persecution pressures in the late 1880s into the mid-20th century. Surveys conducted in the winter of 2015, and 2016–2017 continue to document its presence across its range in the contiguous United States. These surveys have recorded 85 observations, including in locations where they have not been recently detected (e.g., south of Interstate 90 in Washington, Teton Mountain Range/Grand Teton National Park). Thus, based on the best available information, wolverines continue to be detected across suitable habitat within the contiguous United States. Redundancy, the ability to withstand catastrophic events, can be characterized by the distribution and connectivity of populations. In considering wolverine in the contiguous United States, individuals are spread across a wide range of locations and connected habitats, affording protection to withstand catastrophic events. Additionally, wolverines in the contiguous United States appear to be connected to wolverine populations in Canada, also contributing to current and future redundancy.

Resiliency, the ability to withstand stochastic events, can be characterized by numbers of individuals and abundance trends. As indicated above, population size, growth rate, and current population trends are unknown for the wolverine due to the lack of abundance information. The range of the wolverine occurs within a large area of northern North America (see Figure 3). The most recent estimate for Canada indicates over 10,000 adult wolverines, as well as expansion of wolverines into historically occupied areas in both Canada and the contiguous United States with movement across both international borders. The 2014 COSEWIC report concluded that a climate-driven decline in wolverine populations in North America is not evident at this time in much of its range (COSEWIC 2014, p. 22). Wolverine populations in Canada are considered stable. Density estimates indicate no declining trend in wolverine populations in Alaska. We recognize that there is limited information on population sizes for the wolverine in the contiguous United States, and no comprehensive studies to indicate what a viable (or minimal) wolverine population size should be across its North American range. However, the best available information does not indicate either increasing or declining numbers of the wolverine in North America, including the contiguous United States. Further, at this time, the best available information does not indicate that the species' abundance is significantly impacted by human-caused stressors and this is unlikely to change in the future, supporting current and future resiliency.

As discussed above (Status–Future Conditions), both direct and cumulative effects of climate change (e.g., higher temperatures, loss of snow cover, wildland fire) may affect the resilience of the wolverine by creating an environment that is less favorable to its physiological and ecological needs. We are unaware of studies of the wolverine that have formally evaluated the species' responses (e.g., reproductive success) to warming temperatures or other climate change effects. However, a recent evaluation of behavioral plasticity, as an adaptive response to climate change effects, was presented for another mammal considered to be sensitive to climate change

effects—the American pika (*Ochotona princeps*; pika) (Beever et al. 2017, entire). As with the wolverine, this species is known to use several behavioral responses to variability in climate including changes in foraging strategies, use of habitat, and thermoregulation (Beever *et al*. 2017, p. 302). The pika was recently detected in heavily shaded rainforest habitat adjacent to talus patches at lower elevation (Columbia River Gorge) not typical of the talus-type habitats commonly used in many alpine areas of the western United States (Beever *et al*. 2017, p. 302). The authors suggest that, in the Columbia River Gorge region, this species is selecting microclimates in nearby shaded forests that provide insulation from warm summer temperatures (Beever *et al*. 2017, p. 302).This study also included results from a review of available literature related to behavior as a response to changing environmental conditions for several taxonomic groups. They found that behavioral responses to climate change effects were most commonly observed in longer-lived species, and the most common response, across all taxa, was a change in reproductive behavior, followed by dispersal or migration (Beever *et al*. 2017, p. 300). Most of the studies they evaluated identified temperature as the climate metric that was responsible for, or correlated with, changes in behavior; however, about 14 percent of the examined literature included responses to indirect (biotic) factors, such as changes in food resources (Beever *et al*. 2017, p. 300).

The authors also note that there are tradeoffs (e.g., reduction in time for foraging due to sheltering) that may impact long-term persistence and population viability (Beever *et al*. 2017, pp. 301–302), and the pika's flexibility in habitat selection has not been observed in populations in the Great Basin (Beever *et al*. 2017, p. 302), where some populations have been extirpated (Beever *et al*. 2016, p. 1,498; Table 1). A recent study concluded that the pika has been extirpated from an interior portion of its geographic distribution in the Sierra Nevada region (California) due to climate effects (i.e., increase in temperature, decline in snowpack), and although sites surrounding this core area still harbor the species, the net effect has been fragmentation of habitat and species distribution (Stewart *et al*., 2017, entire).

However, the pika continues to be found at sites that are outside of areas contained within bioclimatic envelop models (Jeffress *et al*. p. 253). The study found previously undocumented extant populations of the American pika in a region of the Great Basin (northwestern Nevada) that has been described as extirpated (Jeffress *et al*. 2017, entire). Relative to wolverine, the authors note that these results highlight the need for monitoring programs, particularly at remote and isolated locations, and the importance of evaluating occupancy at multiple scales (Jeffress *et al*. 2017, p. 266). In addition, the study noted the inconsistency of modeled climate factors in explaining occupied/unoccupied sites, and the likely importance of the pika's talus (micro) habitat as well as the scale in which environmental variables are examined (Jeffress *et al*. 2017, p, 264). Resilience of pika populations is therefore likely related to these types of landforms, which act to decouple surface temperatures, with the talus rock habitat providing cool refugia (Jeffress *et al*. 2017, pp. 253, 264–265), but additional microsite data is needed as well as analyses of physiological variables to develop predictions of persistence (Jeffress *et al*. 2017, pp. 265–266). In sum, these studies indicate that small mammals exhibit adaptive responses to changing climate provided that refugia are available to support life history requirements. These studies also highlight the importance of continued monitoring and surveillance for difficult to study animals such as the wolverine, who are found in remote areas in naturally low densities, as

well as the potential for geographical variation and habitat structure in adaptation to climate change effects.

As described in this SSA Report, the best available information indicates confirmed observations of wolverines denning in areas with patchy snow cover in Alaska, Canada, and Scandinavia. Given their high rate of movement, large dispersal, and other observed life history traits (e.g., behavioral plasticity) observed in wolverines, we do not predict a significant loss of individual and population resiliency to the species in the future within its North America range, including the contiguous United States.

Currently, we are unaware of any documented specific risks for the wolverine related to a substantial change or loss of diversity in life history traits, population demographics, morphology, behavior, or genetic characteristics which can be used to characterize species representation (the ability to adapt to change). Rates of dispersal or gene flow are not known to have changed. Additionally, there is no currently available information to indicate that the current abundance of the wolverine across its current range is at a level that is causing inbreeding depression or loss of genetic variation that would affect representation. Nor is there any information to indicate that this species is unable to adapt or adjust to changing conditions (e.g., potential reduction in snow cover). We do not expect a reduction in representation of the wolverines in the contiguous United States in the future.

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[**Add reviewer names, agency, Tribal Nations**]

USDA Forest Service (Regional Offices)
California State Agency
Washington State Agency
Oregon State Agency
Idaho State Agency
Montana State Agency
Wyoming State Agency
Tribal Nations

[**Add peer reviewer names**]

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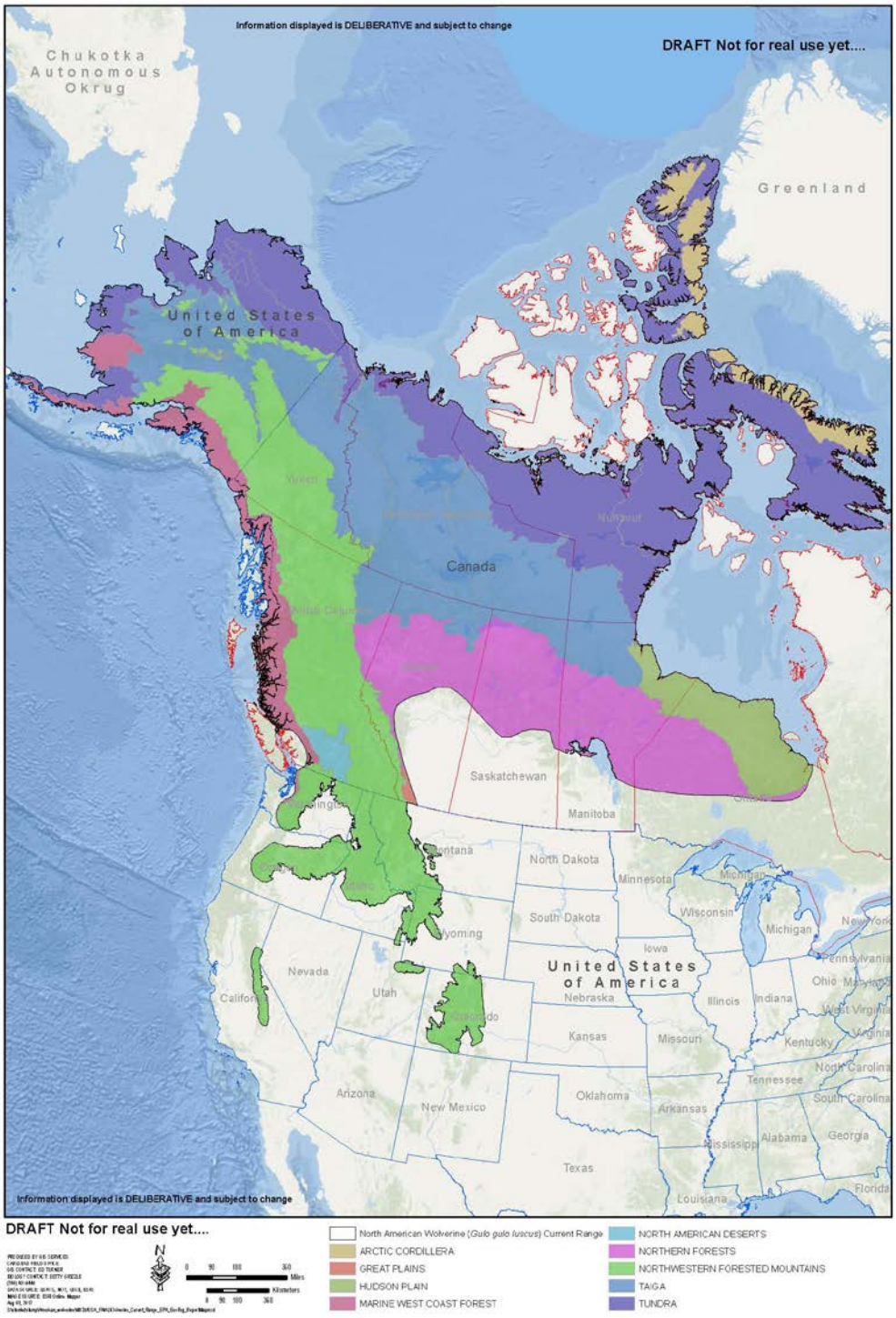
Weir, R. 2017b. Electronic mail message from Rich Weir, Carnivore Conservation Specialist, Ministry of Environment, British Columbia, Canada, re wolverine trapping by region, to Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. October 6, 2017

Weir, R. 2017c. Electronic mail message from Rich Weir, Carnivore Conservation Specialist, Ministry of Environment, British Columbia, Canada, re wolverine trapping, to Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. October 10, 2017

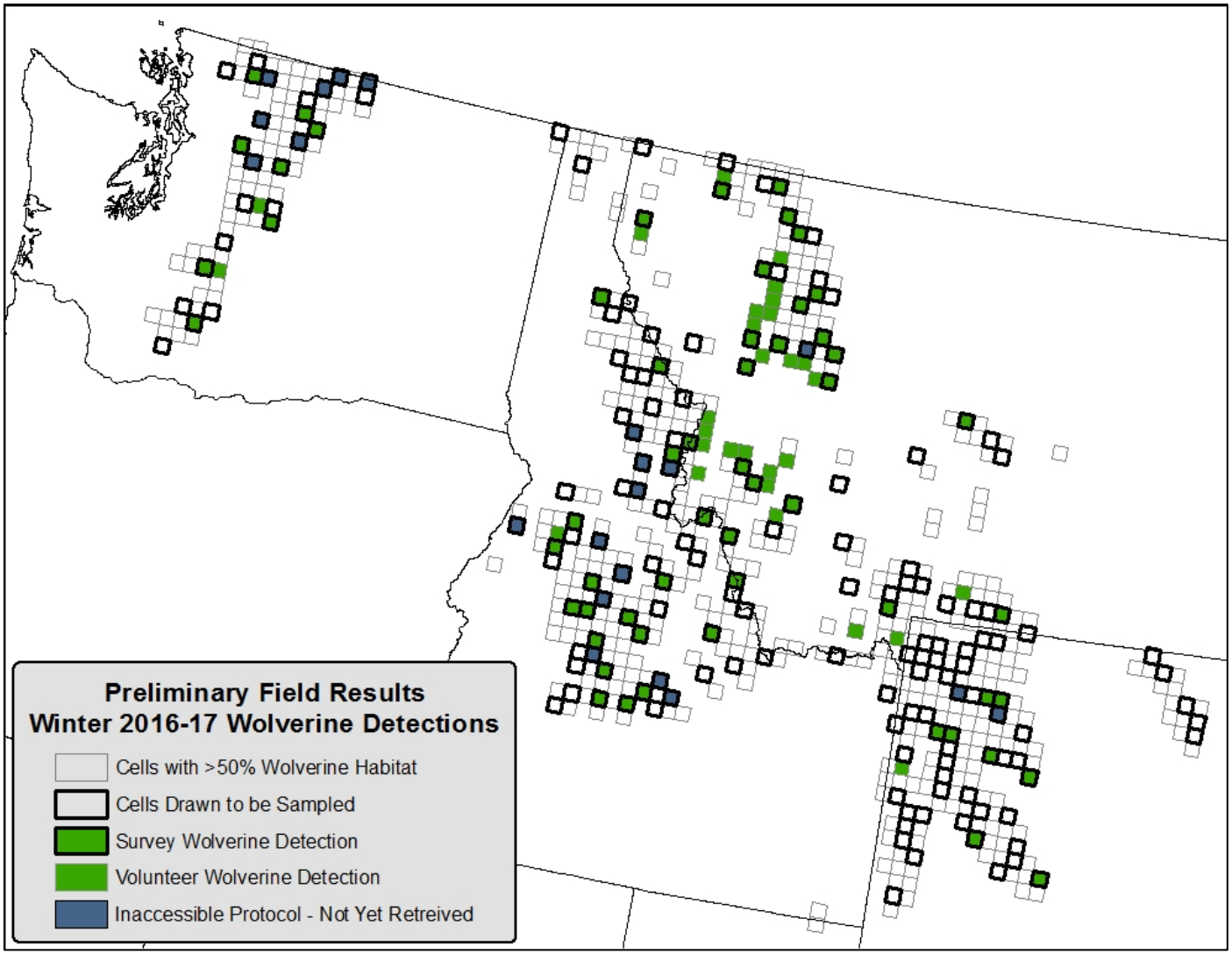
[WGFD] Wyoming Game and Fish Department. 2016. Letter received from Wyoming Game and Fish Department in response to proposed rule reopening of comment period and request for information for North American wolverine (81 FR 71670; October 18, 2016). November 3, 2016.

Appendices

Appendix A – Ecoregions of North American within Estimated Current Range of North American Wolverine
(Adapted from EPA 2010)

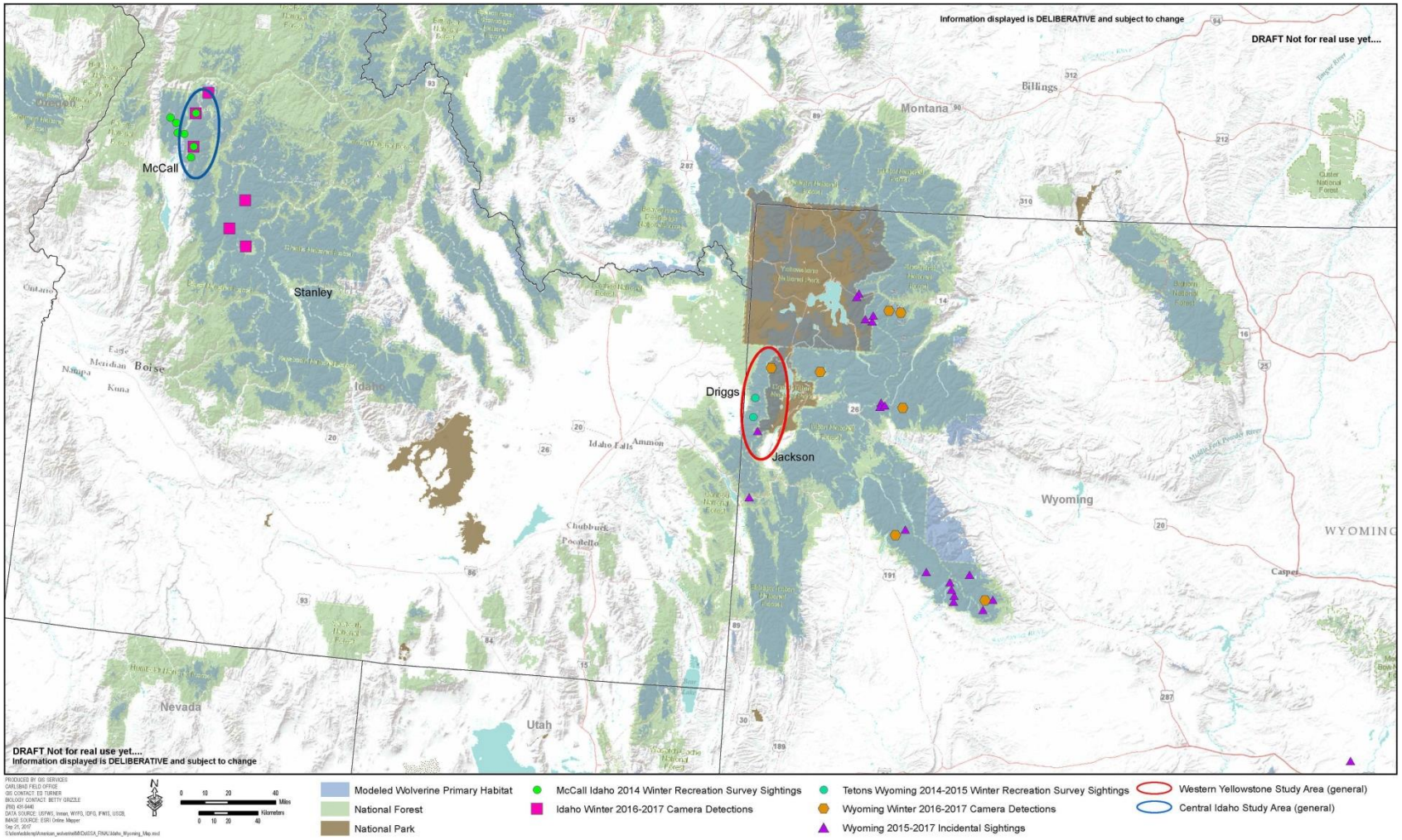


Appendix B – Wolverine Detections, Winter 2016–2017 (as of July 2017)
Source: Inman 2017b, pers. comm.



Appendix C – Recent Wolverine Detections, Idaho and Wyoming

Sources: Dewey 2017, pers. comm.; Evans Mack 2017a and 2017b, pers. comm.; Walker 2017, pers. comm.

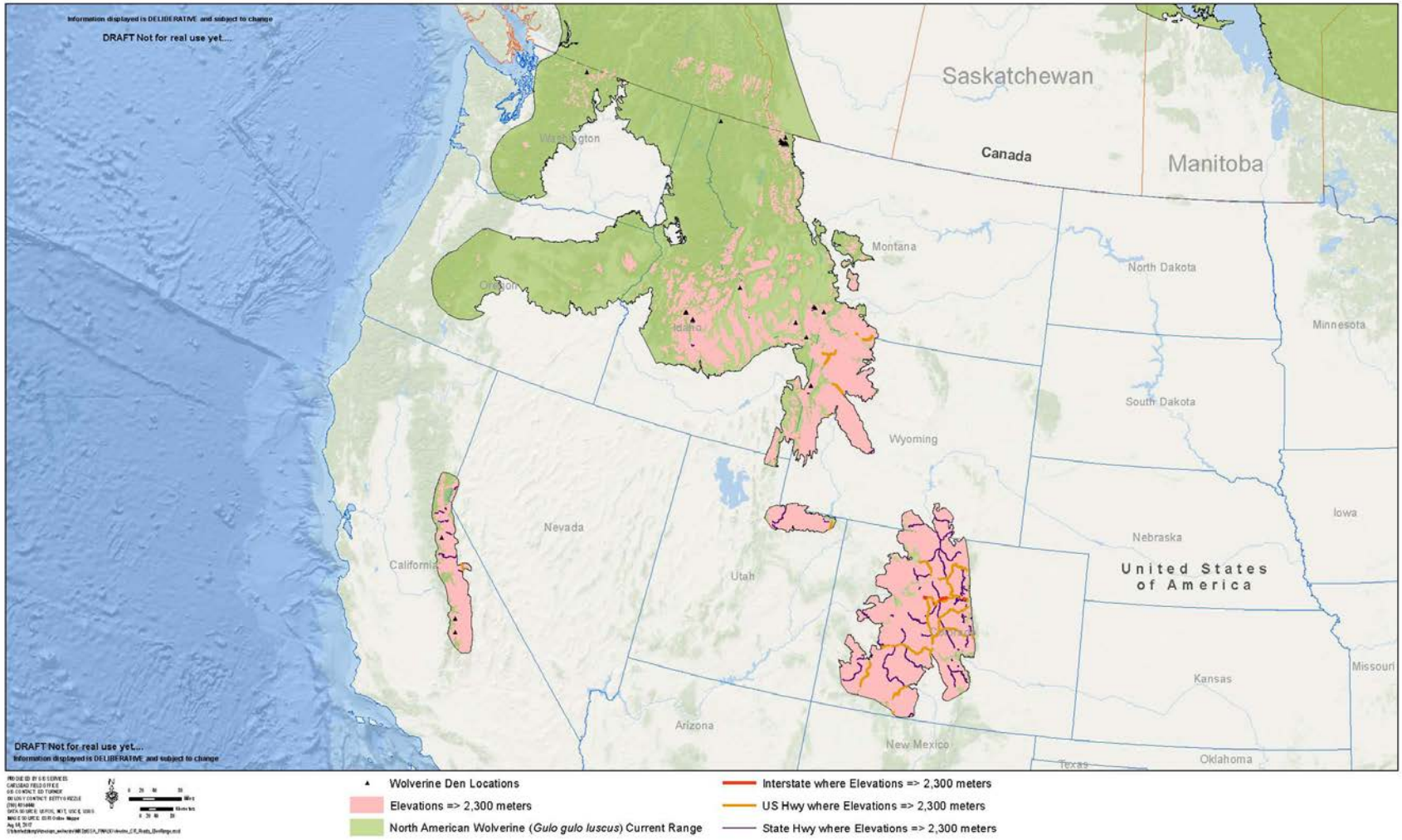


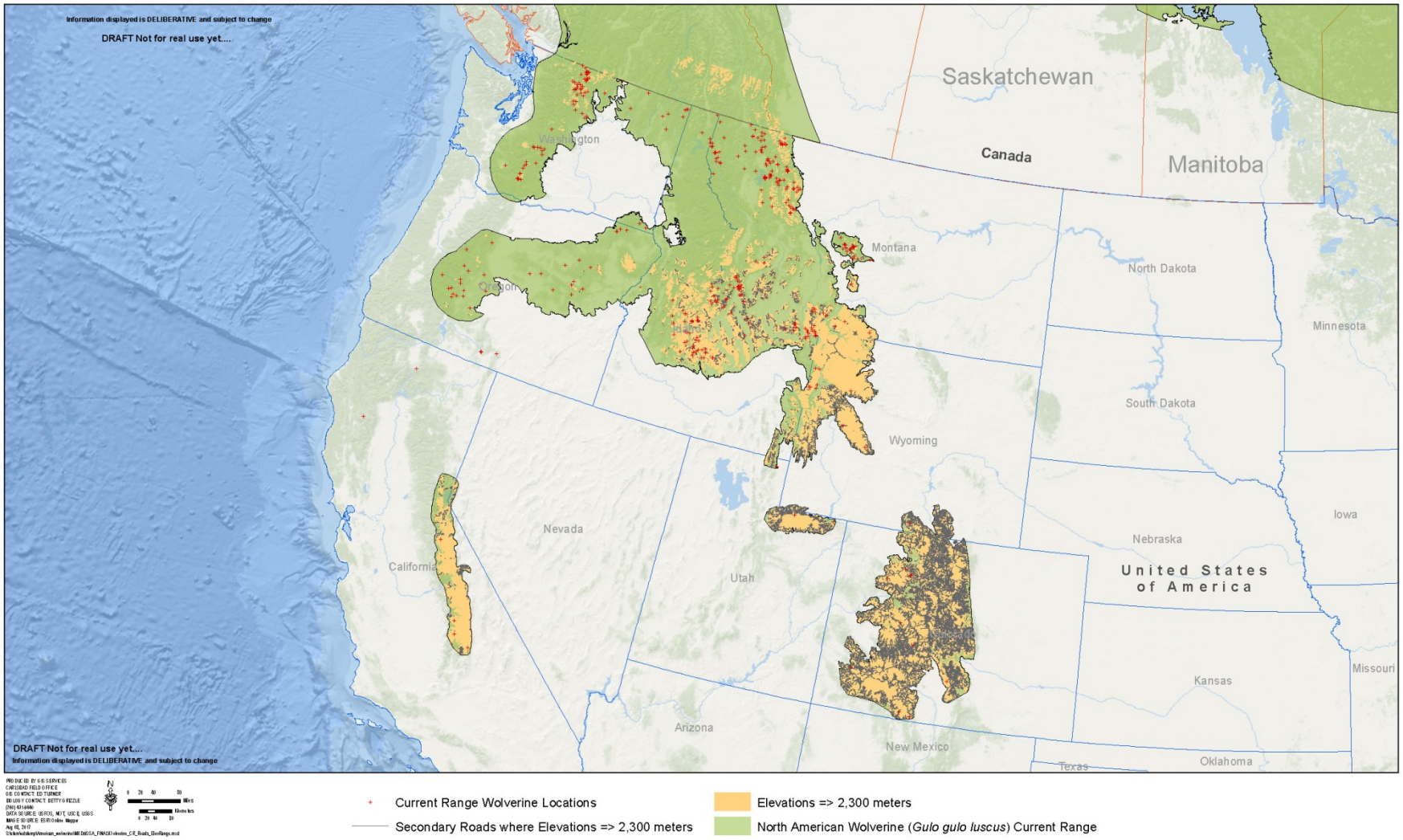
Appendix D – Land Ownership of Modeled Wolverine Primary Habitat in Contiguous United States
(based on model from Inman *et al*. 2013)

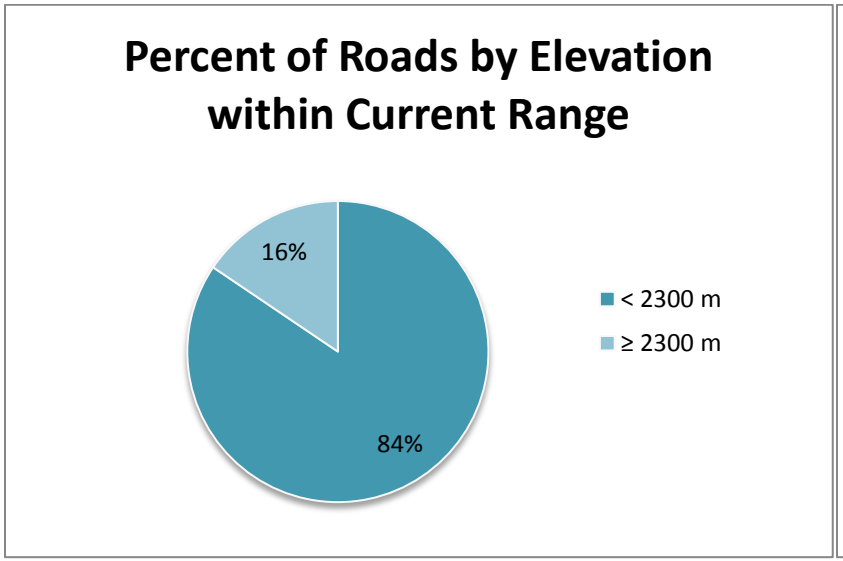
Ownership (% of total)	**Agency or other Entity**	**Total (acres)**	**Total (hectares)**
Federal Lands	Bureau of Indian Affairs	453,866	183,673
	Bureau of Land Management	498,977	201,929
	Bureau of Reclamation	1,868	756
	Forest Service	34,331,515	13,893,471
	U.S. Fish and Wildlife Service	5,528	2,237
	National Park Service	3,791,491	1,534,362
	Other U.S. Department of Agriculture	13,312	5,387
	Other Federal	0.05	0.02
Total Federal (96.4%)		**39,096,557**	**15,821,815**
State Lands (0.68%)	Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming	**277,181**	**112,171**
Local Government (0.12%)		**49,464**	**20,017**
Private Lands (2.63%)		**1,064,858**	**430,933**
No Code (“99”) (0.15%)		**60,380**	**24,435**
Undetermined (0.02%)		**7,598**	**3,075**
Total (100%)		**40,556,038**	**16,412,446**

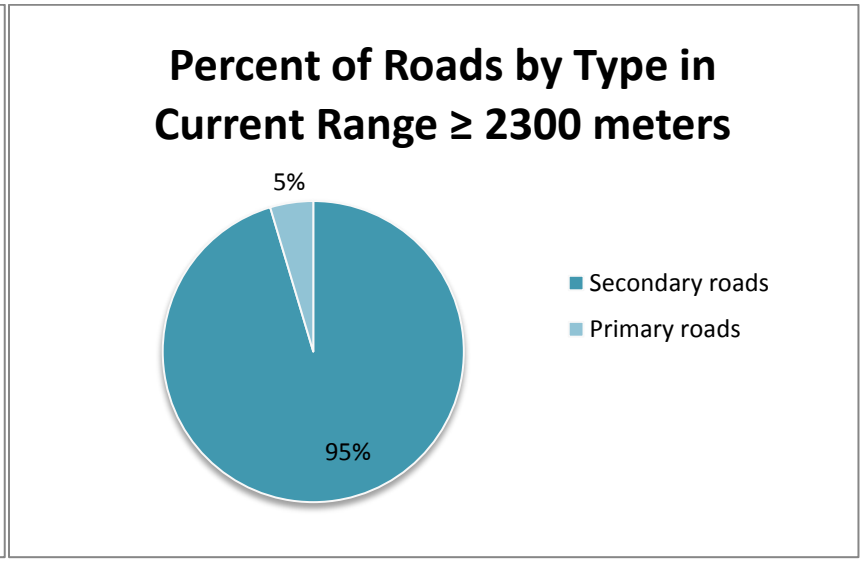
Note: Numbers may not total to 100 percent due to rounding.

Appendix E – Results from Spatial Analysis of Roads within Current Range of Wolverine

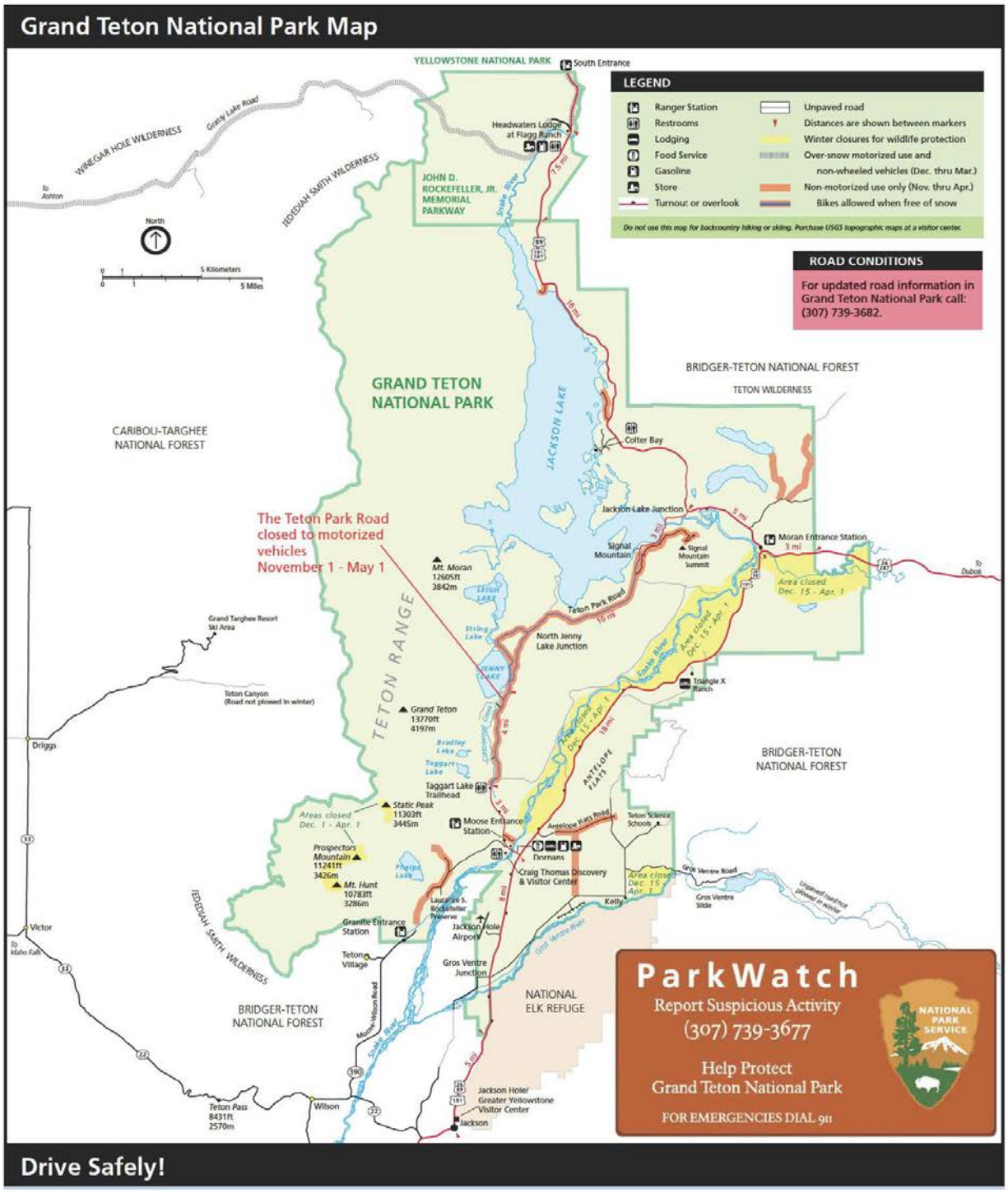



Information displayed is DELIBERATIVE and subject to change
DRAFT Not for real use yet....
Saskatchewan
Canada
Manitoba
Washington
Montana
North Dakota
Minnesota
South Dakota
Wyoming
Nevada
California
Utah
Nebraska
United States of America
Iowa
Missouri
Kansas
Arizona
New Mexico
Texas
Oklahoma
DRAFT Not for real use yet....
Information displayed is DELIBERATIVE and subject to change
Current Range Wolverine Locations
Secondary Roads where Elevations => 2,300 meters
Elevations => 2,300 meters
North American Wolverine (*Gulo gulo luscus*) Current Range


Percent of Roads by Elevation within Current Range
16%
84%
< 2300 m
≥ 2300 m


Percent of Roads by Type in Current Range ≥ 2300 meters
5%
95%
Secondary roads
Primary roads

Appendix F – Road Closure Map, Grand Teton National Park
Retrieved from: https://2v9usu38jb9t3l8big1ialsn-wpengine.netdna-ssl.com/wp-content/uploads/2015/11/GTNP-closure-map.pdf



Appendix G – Existing Regulatory Mechanisms and Voluntary Conservation Measures

Federal Mechanisms

Organic Administration Act of 1897 and the Multiple–Use, Sustained–Yield Act of 1960

The USFS Organic Act of 1897 (16 U.S.C. § 475–482) established general guidelines for administration of timber on USFS lands, which was followed by the Multiple–Use, Sustained–Yield Act (MUSY) of 1960 (16 U.S.C. § 528–531), which broadened the management of USFS lands to include outdoor recreation, range, watershed, and wildlife and fish purposes.

National Forest Management Act

The National Forest Management Act (NFMA) (16 U.S.C. § 1600 *et seq*.) requires the Forest Service to develop a planning rule under the principles of the MUSY of 1960 (16 U.S.C. § 528–531). The NFMA outlines the process for the development and revision of the land management plans and their guidelines and standards (16 U.S.C. § 1604(g)).

A new National Forest System (NFS) land management planning rule (Planning Rule) was adopted by the U.S. Department of Agriculture Forest Service (Forest Service) in 2012 (77 FR 21162; April 9, 2012). The new Planning Rule guides the development, amendment, and revision of land management plans for all units of the NFS to maintain and restore NFS land and water ecosystems while providing for ecosystem services and multiple uses. Land management plans (also called Forest Plans) are designed to: (1) Provide for the sustainability of ecosystems and resources; (2) meet the need for forest restoration and conservation, watershed protection, and species diversity and conservation; and (3) assist the Forest Service in providing a sustainable flow of benefits, services, and uses of NFS lands that provide jobs and contribute to the economic and social sustainability of communities (77 FR 21261, April 9, 2012). A land management plan does not authorize projects or activities, but projects and activities must be consistent with the plan (77 FR 21261; April 9, 2012). The plan must provide for the diversity of plant and animal communities including species-specific plan components in which a determination is made as to whether the plan provides the "ecological conditions necessary to…contribute to the recovery of federally listed threatened and endangered species…" (77 FR 21265; April 9, 2012).

The Record of Decision for the final Planning Rule was based on the analyses presented in the *Final Programmatic Environmental Impact Statement, National Forest System Land Management Planning* (77 FR 21162–21276; April 9, 2012), which was prepared in accordance with the requirements of the National Environmental Policy Act (NEPA) (discussed below). In addition, the NFMA requires land management plans to be developed in accordance with the procedural requirements of NEPA, with a similar effect as zoning requirements or regulations as these plans control activities on the national forests and are judicially enforceable until properly revised (Coggins *et al.* 2001, p. 720).

A Species of Conservation Concern (SCC) is defined in the 2012 Planning Rule and in regulation (36 CFR 219.9(c)), as "a species, other than federally recognized threatened,

endangered, proposed, or candidate species, that is known to occur in the plan area and for which the regional forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area." The 2012 Planning Rule requires Regional Foresters to identify SCC for plan revision, and, when identified for a National Forest, monitoring plans are changed as needed (77 FR 21250, 21267; April 9, 2012). Wolverine is considered a SCC in the Rocky Mountain Region (Region 2). It is considered a Sensitive Species in the Intermountain Region (Region 4) and Northern Region (Region 1).

Within our estimated Current Range of the wolverine (see Figure 3), we identified 49 National Forests or Scenic Recreation Areas in the contiguous United States, and 2 within the State of Alaska. These areas are contained within 6 Forest Service Regions across the western United States and Alaska.

National Forest Land Management Plans (Forest Plans)

We reviewed several Forest Plans or related planning documents in an effort to describe how these plans provide conservation management for the wolverine and its habitat, including wildland fire management practices. The sections below are, in most cases, taken directly from relevant documents. However, this discussion is not intended to be inclusive of all NFS management strategies and activities across the entire Current Range of the wolverine in the contiguous United States.

Sierra Nevada Forest Plan Implementation

The 2004 Sierra Nevada Forest Plan Amendment (referred to as the Sierra Nevada Framework) amended the Land and Resource Management Plans (LRMP) for the eleven National Forests in the Sierra Nevada range to improve protection of old forests, wildlife habitats, watersheds and communities in the Sierra Nevada Mountains and Modoc Plateau. This amendment applies to the Tahoe National Forest, which has been occupied by a single male wolverine since at least 2008 (Moriarty *et al*. 2009, p. 150). The emphasis of the 2004 Sierra Nevada Framework is to adopt an integrated strategy for vegetation management that is aggressive enough to reduce the risk of wildfire to communities in the wildland urban interface, while modifying fire behavior over the broader landscape. Direction is provided as management goals and strategies, desired conditions, management intents and objectives, and management standards and guidelines. The 2004 Framework addressed five problem areas: old forest ecosystems and associated species; aquatic, riparian and meadow ecosystems and associated species; fire and fuels management; noxious weeds; and lower west side hardwood ecosystems (Forest Service 2013, p. 2–3).

Kootenai National Forest

The Kootenai National Forest is located in the northwest corner of Montana along the Canadian border and includes about 2.2 million acres of public land (Forest Service 2015, p. 7). The Forest Service published a Revised Land Management Plan for the Kootenai National Forest in 2015 that identifies forestwide direction, including goals, desired conditions, objectives, standards, and guidelines for physical and biological elements including wildlife such as management activities

that promote connectivity and avoiding or minimizing disturbance at known active denning sites for sensitive, proposed, threatened, or endangered species not covered under other forestwide guidelines. It also outlines objectives and guidelines related to the use of fire to maintain or improve habitat and maintaining unlogged conditions in some portions of areas burned by wildfires for 5 years post-fire (Forest Service 2015, pp. 28–32).

The Kootenai National Forest Land Management Plan also identifies *proposed or possible* actions for wildlife management that includes establishing and maintaining the vegetation diversity necessary to provide food, cover, and security for wildlife species native to the Kootenai National Forest in cooperation with federal, state, and other organizations. For wolverine, those management activities might include maintaining, managing, and protecting lands known or suspected to contribute to landscape linkages for wolverine (and other carnivores) in order to promote genetic dispersal and healthy populations (Forest Service 2015, p. 128).

Beaverhead-Deerlodge National Forest

The Beaverhead-Deerlodge National Forest covers 3.38 million acres in southwest Montana (Forest Service 2009, p. 2). The Beaverhead-Deerlodge National Forest Land and Resource Management Plan identifies goals, objectives, and standards for wildlife management (Forest Service 2009, pp. 45–49). Of relevance to the wolverine, wildlife security management goals include securing areas and connectivity for ungulates and large carnivores and managing the density of open motorized roads and trails by landscape region (Forest Service 2009, p. 45). Objectives include management of habitat conditions for elk security and winter habitat integrity for wolverine and mountain goat relative to changes in abundance of these Management Indicator Species (Forest Service 2009, p. 47). Monitoring elements are defined in the Land and Resource Management Plan that link goals and objectives to elements of the National Monitoring and Evaluation Framework (Forest Service 2009, pp. 273–280). For wildlife security, three performance measures relative to determining whether management activities are effectively protecting high elevation winter habitats for wolverines and mountain goats are defined: (1) presence or absence of wolverines in high elevation habitats, (2) populations of mountain goats (from Montana Fish Wildlife & Parks), and (3) number of snowmobile entries into non-motorized high elevation units protected for wolverines and mountain goats (Forest Service 2009, p. 277). In addition, in order to evaluate objectives related to road and trail densities, a performance measure related to changes in open motorized road and trail density for both seasons by landscape is included (Forest Service 2009, p. 277).

The Forest Service is monitoring the Mount Jefferson Recommended Wilderness boundary for illegal snowmobile intrusions into the wolverine habitat closure; that is, illegal use will be monitored and recorded (number and distance of intrusions) during the period open to snowmobiles December 2 to May 15 and any other time of the year snow conditions make snowmobiling possible (Forest Service 2009, p. 277). A reassessment of the decision to allow snowmobile use will be triggered if: (1) illegal intrusions are documented throughout the closure period; (2) illegal intrusions into the closed area, or (3) illegal intrusions that extend as far as the Bureau of Land Management (BLM) Wilderness Study Area (Forest Service 2009, p. 277).

Flathead National Forest

The Flathead National Forest is located in the northern Rocky Mountains in western Montana and includes approximately 2.4 million acres of public land (Forest Service 2016a, p. 3). This National Forest is surrounded by the Kootenai, Lewis and Clark, and Lolo National Forests, Glacier National Park, and Canada and includes large areas of designated wilderness (e.g., Bob Marshall Wilderness Complex, Mission Mountains Wilderness), Crown of the Continent Ecosystem, and wild and scenic river systems (Forest Service 2016a, pp. 3–4).

A Draft Revised Forest Plan was prepared for the Flathead National Forest in 2016 (Forest Service 2016b, entire). The Draft Revised Forest Plan identifies components to guide future projects and activities and the plan monitoring program, though these components are not commitments or final decisions approving projects or activities (Forest Service 2016b, p. 3). These components include desired conditions, objectives, standards, guidelines, suitability, and monitoring questions and monitoring indicators (Forest Service 2016b, p. 3). [A *desired condition* is a description of specific social, economic, and/or ecological characteristics of the plan area, or a portion of the plan area, toward which management of the land and resources should be directed, while an *objective* a concise, measurable, and time-specific statement of a desired rate of progress toward a desired condition or conditions (Forest Service 2016b, p. 4). A *standard* is a mandatory constraint on project and activity decision making, established to help achieve or maintain the desired condition or conditions, and a *guideline* is a constraint on project and activity decision-making that allows for departure from its terms, and are established to help achieve or maintain a desired condition or conditions, to avoid or mitigate undesirable effects, or to meet applicable legal requirements (Forest Service 2016b, pp. 4–5).]

Relative to wolverine, plan components for the revised forest plan include two guidelines that are protective of wolverine habitat; one that would protect modeled wolverine maternal denning habitat with respect to new projects or activity authorizations involving helicopter use and one that stipulates no net increase in the percentage of modeled wolverine maternal denning habitat where motorized over-snow vehicle use would be suitable on National Forest System lands. Additionally, as described in the Final EIS, management area allocations for Alternatives A, B modified and C include recommended wilderness areas that would add to existing wilderness. Desired conditions related to maintaining connectivity for wolverine and other wildlife are also identified within several geographic areas (Kuennen 2017, pers. comm.).

Federal Land Policy and Management Act (FLPMA) of 1976

FLMPA (43 U.S.C. 1711-1712) represents the BLM's "organic act" for public lands management under the principles of multiple use and sustained yield. Its implementing regulations give BLM regulatory authority over activities for protection of the environment, including mining claims. Under FLPMA and BLM policy, public lands must be managed so as to protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archaeological values (BLM 2005, p. 1).

Land Use and Resource Management Plans

BLM land use planning requirements are established by Sections 201 and 202 of FLMPA and regulations at 43 CFR 1600 (BLM 2005, p. 1). A *Land Use Planning Handbook* (BLM 2005, entire) provides guidance for implementing land use planning requirements established under FLMPA and implementing regulations. Land use plans prepared by BLM include resource management plans (RMPs) and management framework plans (BLM 2005, p. 1). The RMPs establish the basis for actions and approved uses on the public lands and are prepared for areas of public lands, called planning areas (BLM 2005, pp. 1, 14). These plans are periodically evaluated and revised in response to changed conditions and resource demands (BLM 2005, pp. 33–34).

National Environmental Policy Act (NEPA)

All Federal agencies are required to adhere to the NEPA of 1970 (42 U.S.C. 4321 et seq.) for projects they fund, authorize, or carry out. Prior to implementation of such projects with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. The Council on Environmental Quality's regulations for implementing NEPA state that agencies shall include a discussion on the environmental impacts of the various project alternatives (including the proposed action), any adverse environmental effects that cannot be avoided, and any irreversible or irretrievable commitments of resources involved (40 CFR part 1502). The public notice provisions of NEPA provide an opportunity for the Service and other interested parties to review proposed actions and provide recommendations to the implementing agency. NEPA does not impose substantive environmental obligations on Federal agencies—it merely prohibits an uninformed agency action. However, if an Environmental Impact Statement is prepared for an agency action, the agency must take a "hard look" at the consequences of this action and must consider all potentially significant environmental impacts. Federal agencies may include mitigation measures in the final Environmental Impact Statement as a result of the NEPA process that may help to conserve the wolverine and its habitat.

Although NEPA requires full evaluation and disclosure of information regarding the effects of contemplated Federal actions on sensitive species and their habitats, it does not by itself regulate activities that might affect the wolverine; that is, effects to the subspecies and its habitat would receive the same scrutiny as other plant and wildlife resources during the NEPA process and associated analyses of a project's potential impacts to the human environment. The Service receives notification letters for Draft and Final Environmental Impact Statements prepared by the Forest Service, BLM and other Federal agencies pursuant to NEPA for specific proposed projects including those within National Forests or National Parks, and preparation of Forest Service Land and Resource Management Plans, as discussed above.

Wilderness Act

The Wilderness Act of 1964 (16 U.S.C. 1131–1136) provides protection of habitat from most forms of development, though no single agency is responsible for administration of lands provided this designation, which are designated (or modified) by Congress. The Wilderness Act prohibits commercial enterprises and permanent roads within wilderness area and restricts temporary roads, motorized and mechanical transport, and structures, but does not prohibit all commercial uses (e.g., grazing). Within the portion of our estimated Current Range of the

wolverine in the contiguous United States and Alaska, approximately 15 percent is designated as wilderness areas under the Wilderness Act. We also evaluated wilderness contained within modeled wolverine primary habitat from Inman *et al*. (2013). We found 41 percent of this suitable habitat was designated as wilderness areas.

State Mechanisms

California

As noted above, the wolverine is a threatened species under the California Endangered Species Act or CESA, which prohibits the take of any species of wildlife designated by the California Fish and Game Commission as endangered, threatened, or candidate species (CDFW 2017b). CDFW may authorize the take of any such species if certain conditions are met through the issuance of permits (e.g., Incidental Take Permits) (CDFW 2017b). The wolverine is also a Species of Greatest Conservation Need (SGCN) in the State's Wildlife Action Plan[5] and is a focal species of conservation strategies for conservation targets in the Southern Cascades and Sierra Nevada Ecoregions, and in the Mono Ecoregion of the Deserts Province section (Big Sagebrush Scrub (CDFW 2015, pp. 5.2-16, 5.4-23, 5.6-19).

In 2011, the CDFW (formerly California Department of Fish and Game) prepared an assessment/briefing document, *California Wolverine Population Augmentation Considerations*, in response to a *Feasibility Assessment and Implementation Plan for Population Augmentation of Wolverines in California* (November 2010) submitted to the Department by the Institute for Wildlife Studies (California Department of Fish and Game (CDFG) 2011). As of August 2017, no action has been taken by CDFW toward implementation of augmentation of wolverines in California.

Oregon

The wolverine has been listed as threatened species in Oregon since 1975, under the Oregon Endangered Species Act, and is fully protected under management authority of the ODFW (Anglin 2013, pers. comm.).

A Conservation Strategy for conserving the State's fish and wildlife has been prepared by the ODFW. The Conservation Strategy identifies 294 Strategy Species, which are Oregon's SGCN, (including wolverine) and are defined as those species having small or declining populations, are at-risk, and/or are of management concern (ODFW 2016). For each of the Strategy Species, the Conservation Strategy identifies information on the special needs, limiting factors, data gaps, and conservation actions. For wolverine, conservation actions include management of recreational use to avoid impacts to the species (ODFW 2016). Other Strategy Species identified in the

[5] The U.S. Congress created the State Wildlife Grant (SWG) funding program in 2000 (Title IX, Public Law 106-553 and Title 1, Public Law 107-63). SWG funds are to be used "…for the planning and implementation of [States and territories] wildlife conservation and restoration program and wildlife conservation strategy, including wildlife conservation, wildlife conservation education, and wildlife-associated recreation projects." Congress stipulated that each State or territory applying for this funding program must develop a wildlife conservation strategy (**State Wildlife Action Plan** (SWAP)) by October 1, 2005. All 56 states and territories submitted SWAPs by 2005 and made commitments to review and/or revise their SWAP at least every 10 years.

State's Conservation Strategy are prey species important to wolverine, including the Rocky Mountain bighorn sheep and Columbian white-tailed deer (ODFW 2016).

Washington

The wolverine is a candidate species for listing in the State of Washington and, since 2006, the Washington Department of Fish and Wildlife (WDFW) has been collaborating with wolverine researchers in the Cascades of northern Washington and southern British Columbia to better understand the status, distribution, and general ecology of wolverines in this region (WDFW 2013). It is also considered a SGCN, and is identified as a species whose population is in critical condition (WDFW 2013, pp. 3-7).

Washington's State Wildlife Action Plan (updated in 2015) identifies several major conservation strategies to address the conservation of fish and wildlife habitat and biodiversity in Washington, on both public and private lands (WDFW 2015, pp. 2-12–2-28). The wolverine is included in several identified ecological systems of concern such as alpine scrub, forb meadow, and grassland vegetation, cliff, scree and rock vegetation, and temperate forests (WDFW 2015, pp. 4-19, 4-27, 4-98). The State's *Wildlife Action Plan* identifies major stressors and key actions needed to maintain habitat quality for each of these ecological systems.

Of relevance to wolverine, the WDFW and its partners have been targeting land acquisition and conservation easements with high habitat or biodiversity values such as mixed-conifer forests as well as areas that support winter range and connectivity for wolverine and other carnivores (e.g., Methow River and Okanogan River Watersheds projects) (WDFW 2015, pp. 2-15–2-17). Other landscape conservation efforts highlighted in the State's Wildlife Action Plan include a Federal-State partnership with Washington's Department of Transportation to implement the Interstate-90 Snoqualmie Pass East Project to enhance wildlife connectivity that includes wildlife underpasses under the highway along creeks and rivers and two 150-foot wide wildlife bridges over the highway (WDFW 2015, p. 2-26).

Idaho

In Idaho, the wolverine is a protected nongame species and SGCN in Idaho (IDFG 2014). The *Idaho State Wildlife Action Plan, 2015* is a statewide plan for conserving and managing Idaho's fish and wildlife and their habitats, and provides a framework for conserving Idaho's 205 SGCN and their habitats, which includes the wolverine (IDFG 2017b, pp. xv–xviii). The wolverine is identified as a Tier 1 SGCN, which indicates it represents a species of most critical conservation need (IDFG 2017b, p. xvi). The statewide plan presents a species assessment for each SGCN and ecological section plans. Each of the ecological section plans presents a conservation target (e.g., habitat, species assemblage) that summarizes its viability as well as prioritized threats and strategies (IDFG 2017b, p. xv). A section outlining species designation, planning, and monitoring is also provided. The wolverine is included in three of the defined conservation targets—forested lowlands, subalpine-high montane conifer forest, and low density forest carnivores (IDFG 2017b, p. 76). Along with objectives and strategies, these summaries identify actions for the SGCNs included in the defined conservation targets. Examples include: develop and implement a long-term multi-taxa monitoring program; determine high risk areas for wildlife

crossings; construct highway over- and underpasses; promote and/or facilitate the use of prescribed fire as a habitat restoration tool, on both public and private lands where appropriate; determine best management practices to maintain cool microsites and benefit cool air associated species; and implement strategies to minimize disturbance from winter recreation activities as outlined in the *Management Plan for the Conservation of Wolverines in Idaho, 2014–2019* (IDFG 2017b, pp. 79, 80, 91, 94, 110).

The *Management Plan for the Conservation of Wolverines in Idaho, 2014–2019* (Management Plan) (IDFG 2014, entire) represents a framework for proactive efforts to ensure the long-term persistence and viability of wolverine populations in Idaho (IDFG 2016, pers. comm.). The Management Plan is described as a voluntary guidance document to lead conservation efforts at the State and local level, as well as to facilitate communication and collaboration efforts among wildlife and land managers (IDFG 2014, p. v).

Conservation issues and management actions are described in the Management Plan and the appropriate section plans of the *Idaho State Wildlife Action Plan*. The recommended strategies include development of finer-scale climate projections, research regarding wolverine-snow relationships, characterizing wolverine response to recreational activities, developing predictions of the potential overlap of wolverine and high levels of snow-sports recreation, and educating trappers to minimize incidental trapping of nontarget species, including the wolverine (IDFG 2014, pp. 32–39; IDFG 2017b, p. 1058). Seven conservation and management objectives are outlined in the Management Plan (IDFG 2014, pp. 32–39) and, as outlined in a November 2016 response letter, there has been progress on all of these objectives (IDFG 2016, pers. comm.). As an example, the agency (under the Multi-species Baseline Initiative) has developed and implemented a baseline micro-climate monitoring protocol for collecting environmental parameters in an effort to identify areas that serve as cool-air refugia (IDFG 2016, pers. comm.). As described above (*Overutilization for Commercial, Recreational, Scientific, or Educational Purposes*), the IDFG has prepared educational materials to promote best management practices for minimizing non-target wolverine captures and continues to educate trappers under a legislative mandate passed in 2016 (State of Idaho House Bill 378) (IDFG 2016, pers. comm.).

In addition, management of prey species important to the wolverine diet is outlined in the Idaho Elk Management Plan 2014-2024 (IDFG 2014a), the Mule Deer Management Plan 2008-2017 (2008) and the Bighorn Sheep Management Plan (2010).

Montana

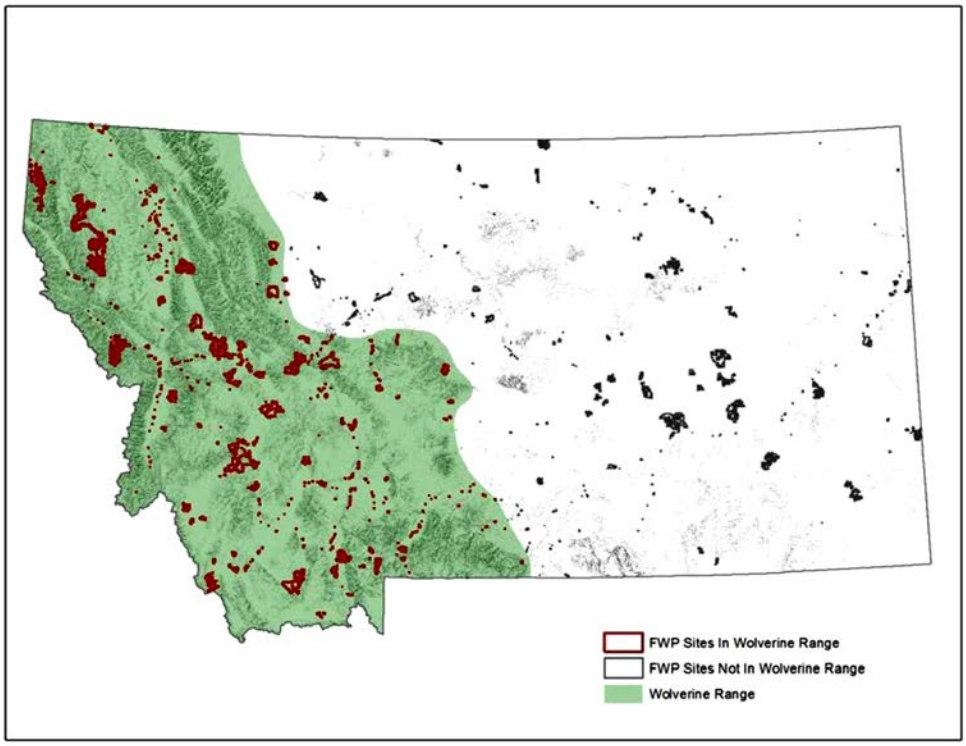
In the State of Montana, the wolverine is classified as a furbearer and species of concern. Since 2013, there has been a zero quota for trapping or harvest of wolverine and trappers that capture a wolverine must notify a designated Montana FWP employee within the relevant trapping district within 24 hours for collection if the animal cannot be released uninjured (Montana FWP 2016, pers. comm.).

There are two broad-scale wildlife conservation efforts that provide conservation benefits to the wolverine. *Montana's State Wildlife Action Plan* (updated and revised in 2015) identifies the wolverine as one of 128 SGCN (Montana FWP 2015, Appendix N). The State's Wildlife Action

Plan identifies priority community types, focal Areas, and species to help informing Montana FWP's priorities and decisions and to assist other agencies and organizations in making decisions as to where to focus their conservation efforts (Montana FWP 2015, p. 2). Community types and focal areas are designed to identify and direct attention to specific geographical areas in the State that have the greatest conservation need (Montana FWP 2015, p. 5). For the wolverine, *Montana's State Wildlife Action Plan* identifies wolverine habitats in seven community types, all designate Tier I (or those with greatest conservation need), and in all focal areas (also Tier I) within those community types (Montana FWP 2016, pers. comm.). For each community type, impacts, threats, and corresponding conservation actions are identified, as well as specific impacts and threats such as habitat fragmentation (e.g., prioritize land acquisition, provide wildlife under- and overpasses), land management (e.g., management to address altered fire regimes), recreation (e.g., consider seasonal closures during breeding season), and climate change (e.g., collection of baseline data to document shifting range limits of SGCN and Community Types of Greatest Conservation Need) (Montana FWP 2015, pp. 59–63).

The second conservation effort in the State of Montana is a Crucial Area Assessment to identify crucial areas and fish and wildlife corridors, and development of a Crucial Areas Planning System (URL: http://fwp.mt.gov/fishAndWildlife/conservationInAction/crucialAreas.html). This is a Montana FWP mapping application and planning tool designed to assist in future planning of development and conservation (Montana FWP 2016, pers. comm.).

The State of Montana is also conserving wildlife habitat through land acquisition and conservation easements (Montana FWP 2016, pers. comm.). In western Montana, including areas known to be occupied by the wolverine, 425 properties for a total 310,523 ha (767,320 ac) have been either acquired (e.g., State Parks, Wildlife Management Areas) or protected by conservation easements, as of November 2016, as shown in figure below (Montana FWP 2016, pers. comm.).



Wyoming

The wolverine is a protected animal and SGCN in Wyoming (WGFD 2017). The *Wyoming Game and Fish Department State Wildlife Action Plan* directs the activities of the WGFD and serves to guide in conserving Wyoming's SGCN through the combined efforts of government agencies, conservation organizations, academia, tribes, and others (WGFD 2017, p. I–1-1). As noted above, the wolverine is identified as a SGCN, a designation intended to identify species whose conservation status warrants increased management attention and funding, and consideration in conservation, land use, and development planning in the State (WGFD 2017, p. IV– i-1). The *State Wildlife Action Plan* incorporates the wolverine as a SGCN in several terrestrial habitat types or ecological systems, including cliffs, canyons, and rock outcrops, montane and subalpine forests, and mountain grasslands and alpine tundra (WGFD 2017, pp. III–2-5, III–5-7, III–6-5).

In 2015, Wyoming funded a pilot project (through The Wolverine Initiative) to evaluate wolverine detection and monitoring of the species in the State and is a contributing collaborator in the Multistate Wolverine Working Group implementing a monitoring strategy (the WSWCP) in the winter of 2016–2017 across four western states (WGFD 2017, p. IV–5-357). Results of those studies (e.g., Inman *et al*. 2015) are summarized above (*Population Abundance and Distribution*). The WSWCP is also updating and refining connectivity models for the wolverine in an effort to focus and prioritize habitat conservation and management (WGFD 2016, pers. comm.).

Colorado

The wolverine is a state-endangered species in Colorado (Colorado Parks and Wildlife 2015a); however, there is no known current resident or reproducing wolverine population.

The *Colorado State Action Plan* (Colorado Parks and Wildlife 2015b) provides a blueprint for a collaborative effort to conserve Colorado's at-risk wildlife and their habitats, with a primary goal for securing wildlife populations in order to avoid protections implemented so that they do not require protection via federal or state listing regulations (Colorado Parks and Wildlife 2015b, p. 1). The wolverine is designated as a Tier 1 (highest conservation priority; up from Tier 2) SGCN (Colorado Parks and Wildlife 2015b, p. 19). The primary conservation action for wolverine described in the 2015 State Action Plan is to continue discussions among wildlife managers, conservation partners and stakeholders of the social and political aspects regarding reintroduction of wolverine populations into the southern Rocky Mountains (Colorado Parks and Wildlife 2015b, p. 186). The State has not yet prepared a potential restoration program for the species (Broscheid 2016, pers. comm.).

Other Conservation Mechanisms

Tribes

Nez Perce Tribe

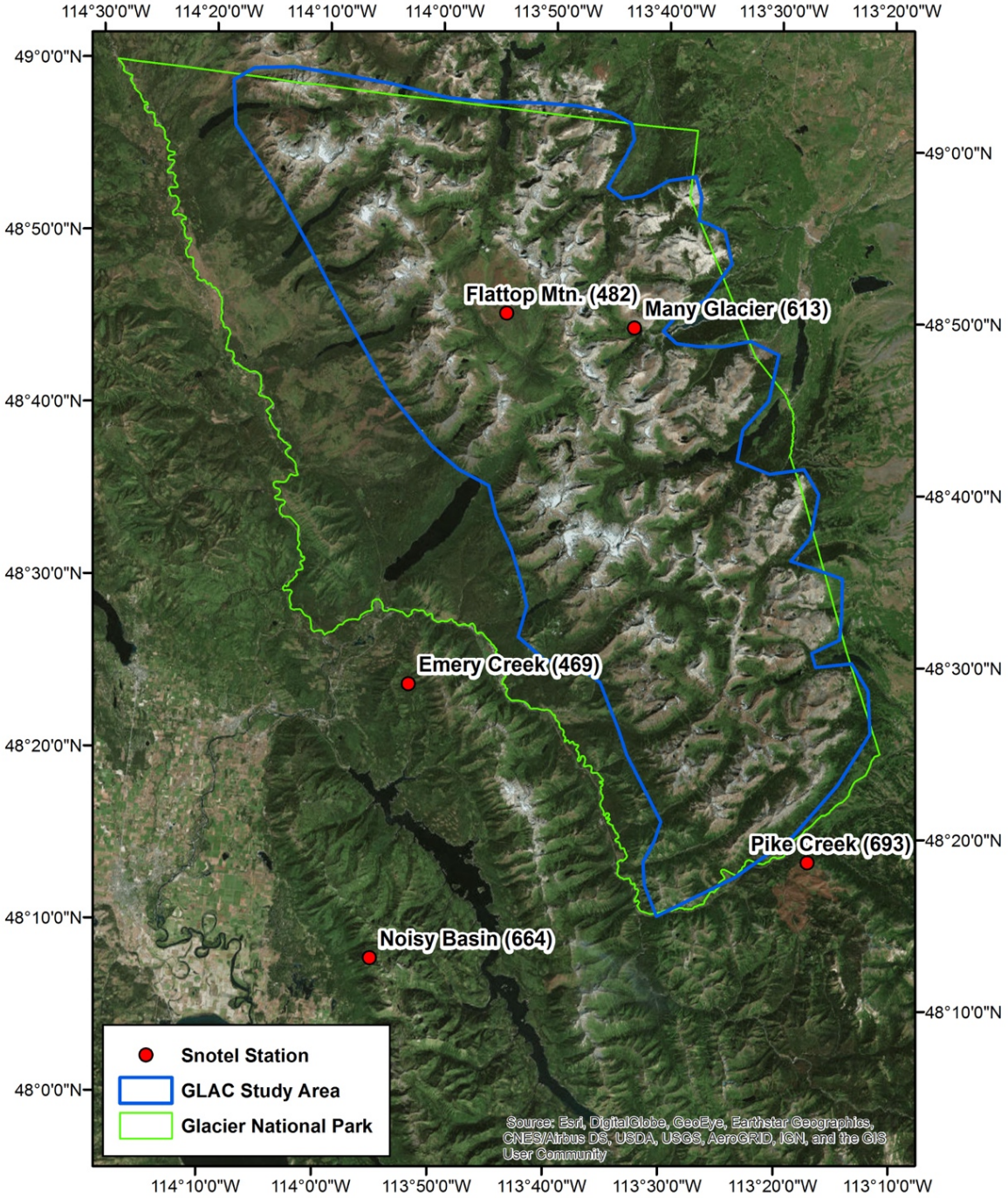
Wolverines are found within the aboriginal territory of the Nez Perce Tribe in north-central Idaho, and conservation and restoration of the species within the Nez Perce homeland is important to the Nez Perce Tribe (Miles 2017, pers. comm.). The Nez Perce Tribe is currently preparing an Integrated Resource Management Plan (IRMP), a Plant and Wildlife Conservation Strategy, and a Forest Management plan with the wolverine defined as a species of conservation concern in all three draft plans (Miles 2017, pers. comm.). The planning area for the IRMP, which is being prepared in partnership with the Bureau of Indian Affairs, incorporates the approximately 311,608 ha (770,000 ac) Nez Perce Reservation, located within portions of Nez Perce, Lewis, Clearwater, Latah, and Idaho Counties in north-central Idaho (http://www.nezperce.org/irmp/; accessed August 24, 2017). The preparation of the IRMP is currently at the scoping stage in the NEPA process for development of a Programmatic Environmental Impact Statement (http://www.nezperce.org/irmp/; accessed August 24, 2017).

The Shoshone-Bannock Tribes

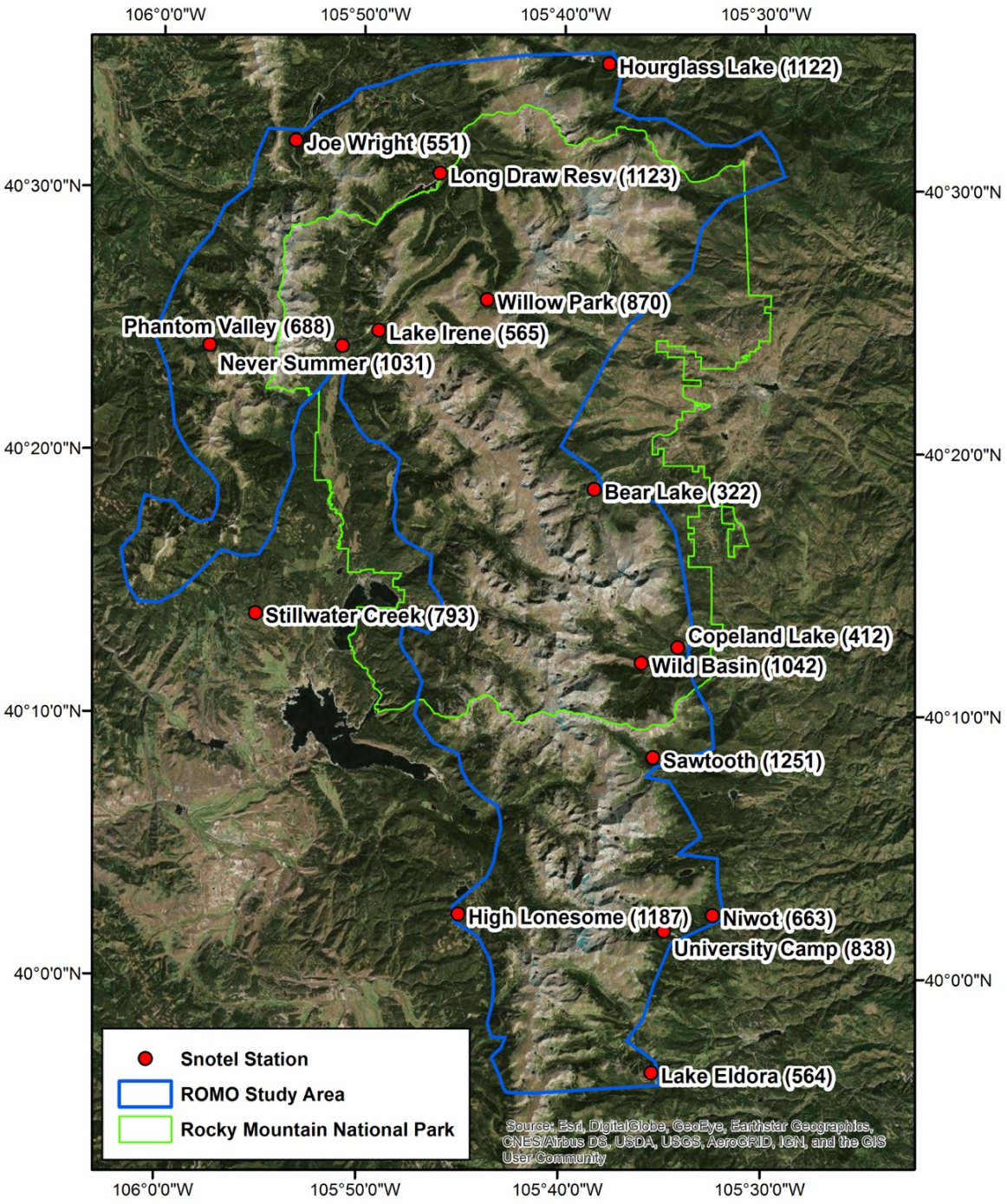
The Shoshone-Bannock Tribes are currently conducting climate change modeling for the Northern Rocky Mountains as part of its preparation of a Climate Change Adaptation Plan (Edmo 2016, pers. comm.). The Upper Snake River Tribes Foundation (USRT), which is comprised of four member tribes—the Burns Paiute Tribe, Fort McDermitt Paiute-Shoshone Tribe, Shoshone-Bannock Tribes of the Fort Hall Reservation, and Shoshone-Paiute Tribes of the Duck Valley Reservation—within the Upper Snake River Watershed region, prepared a *Climate Change Vulnerability Assessment* in February 2017 (Petersen *et al*. 2017, entire). The assessment is the first of three steps the USRT and its member tribes plan activities over the next several years as part of a comprehensive climate change effort, and will include an Adaptation Plan (expected to be completed in 2017–2018), and, depending on future funding, a process for development of Implementing Adaptation Actions and Monitoring (Petersen *et al*. 2017, p. 7).

Appendix H–NOAA/CU Study Areas Used to Evaluate Future Snow Persistence (from Ray et al., 2017)

Glacier National Park Study Area



Rocky Mountain National Park Study Area



From: Grizzle, Betty
To: Shoemaker, Justin; John Guinotte
Subject: Fwd: Wolverine SSA, Sparks" Comments
Date: Monday, December 4, 2017 9:54:39 AM

From BLM.

---------- Forwarded message ----------
From: **Bush, Jodi** <jodi_bush@fws.gov>
Date: Mon, Dec 4, 2017 at 8:51 AM
Subject: Fwd: Wolverine SSA, Sparks' Comments
To: Betty Grizzle <betty_grizzle@fws.gov>

BLM Comments. JB

Jodi L. Bush
Office Supervisor
Montana State Ecological Services Office
585 Shepard Way, Suite 1
Helena, MT 59601
(406) 449-5225, ext.205

---------- Forwarded message ----------
From: **Boone, Christopher** <ctboone@blm.gov>
Date: Mon, Dec 4, 2017 at 9:26 AM
Subject: Fwd: Wolverine SSA, Sparks' Comments
To: "Bush, Jodi" <jodi_bush@fws.gov>

Sorry for this late forward, I was on A/L and in training since 4 pm 11/20.

---------- Forwarded message ----------
From: **Sparks, James** <jrsparks@blm.gov>
Date: Mon, Nov 20, 2017 at 4:19 PM
Subject: Wolverine SSA, Sparks' Comments
To: "Boone, Christopher" <ctboone@blm.gov>

iV - "The most recent estimate of wolverine populations in the contiguous United States based on resource function modeling is 318 individuals." Why not apply the 50/500 rule... 50 breeding individuals maintained for ensuring short-term viability and 500 individuals maintained for long-term viability?

Vi and pg 92 - legal protection - no mention of Montana and Utah. This section may need updating.

Vi - Future time-frame 40-50 years. Why not 100 years (10 generations) for gauging the lag-effects of demographic dynamics?

Pg 94 - Comparison of wolverine and pika may not be necessary.

Lots of information outside of DPS, otherwise, a very exhaustive list of best-science research.

Consider including information from the Lolo National Forest Southwest Crown of the Continent Forest Carnivore Monitoring.

--

Betty J. Grizzle, D.Env.
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760-431-5901 fax

From:	Grizzle, Betty
To:	Bush, Jodi; Shoemaker, Justin; John Guinotte
Subject:	Fwd: Draft Wolverine SSA
Date:	Tuesday, December 5, 2017 1:18:53 PM
Attachments:	image001.png ODFW Wolverine SSA Response.pdf

From Oregon.

---------- Forwarded message ----------
From: **Derek J Broman** <Derek.J.Broman@state.or.us>
Date: Tue, Dec 5, 2017 at 12:15 PM
Subject: Re: Draft Wolverine SSA
To: "Betty_Grizzle@fws.gov" <Betty_Grizzle@fws.gov>

Hello Betty,

If not too late, please consider the attached ODFW response on the Draft Wolverine SSA.

Please contact me with any questions.

Sincerely,

Derek

-

Derek JA Broman

Carnivore-Furbearer Coordinator

Oregon Dept of Fish & Wildlife

4034 Fairview Industrial Drive SE

Salem, OR 97302

Office 503.947.6095

http://www.dfw.state.or.us/

--

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OREGON

Fish & Wildlife

Oregon
Kate Brown, Governor

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November 30, 2017

Betty J. Grizzle, D.Env.
U.S. Fish and Wildlife Service
2177 Salk Ave #250
Carlsbad, CA 92008
Betty_grizzle@fws.gov

SUBJECT- Draft Species Status Assessment (SSA) for the North American Wolverine

Dear Ms. Grizzle,

Thank you for the opportunity for Oregon Department of Fish and Wildlife (ODFW) to review and provide comment on the scientific merit to the Draft SSA for the North American Wolverine (2017). ODFW believes the findings of the 3R framework (Redundancy, Representation, and Resiliency) are founded on the scientific information presented.

ODFW applauds the incorporation of new data and research into the SSA. Published research since the 2013 proposed rule are insightful on previously identified limiting factors. Findings in many of these new studies reflect the habitat plasticity observed in Oregon.

The inclusion of recent surveys are vital to the value of the SSA. While not a participant, ODFW is aware of the recent multistate wolverine survey (Washington, Idaho, Montana, and Wyoming) and believes it has value to the SSA and the future of monitoring. While techniques differ, various efforts have been underway in Oregon to survey and detect wolverines. Recent completed efforts (Magoun et al. 2013, McFadden-Hiller and Hiller 2014) could be considered for inclusion in the SSA.

We recommend continued caution when illustrating historical observations and maps of 'current range'. Text on page 15 provides a disclaimer that historical observation 'records may be in error or inaccurately located' and the depiction of wolverine current range "does not necessarily represent current areas where reproducing populations are found". That clarification is appreciated and could be included elsewhere in the body text, and it is requested similar language accompanies each associated figure (e.g. Figure 2, Figure 3).

The science presented in the draft SSA appears to include the majority of available information and the SSA correctly interprets that information.

Sincerely,

Derek Broman
Carnivore-Furbearer Coordinator
Oregon Department of Fish & Wildlife
503-947-6095
derek.j.broman@state.or.us

Literature:

Magoun, A.J., Valkenburg, P., Long, C.D., and J.K. Long. 2013. Monitoring wolverines in northeast Oregon. Jan 2011- Dec 2012. Final Report. The Wolverine Foundation, Inc. Kuna, ID

McFadden-Hiller, J.E. and T.L. Hiller. 2014. Forest carnivore researching in the northern Cascades of Oregon. Oct 2012-May 2013, Oct 2013-June 2014. Final progress report. Oregon Department of Fish and Wildlife, Salem, OR.

From: Johnson, Dawn
To: betty_grizzle@fws.gov
Subject: RE: i have review
Date: Wednesday, December 6, 2017 3:12:40 PM

Well, I have the review but the questions were not answered in the direct order asked, so the reviewer has to make sure his response addressed all the questions and reformat and get back to me tonight and I'll get out to you as soon as I have it from him. It will be in your inbox when arrive tomorrow morning. Very close now.

Sorry about the delay. Both parents are back in the hospital and his son broke his hand. Yowza! I wouldn't trade my last month for his month that's for sure.

Sincerely,

Dawn Johnson PhD
Senior Biologist
Amec Foster Wheeler Environment & Infrastructure, Inc.
Now owned by Wood plc
Austin/Santa Barbara
D/M 805 252 4370
dawn.johnson@woodplc.com www.**woodplc.com**

-

From: Johnson, Dawn
Sent: Wednesday, December 06, 2017 3:29 PM
To: betty_grizzle@fws.gov
Subject: i have review

Betty-

I have the 4th review. Putting in the correct format and proofreading now. You should have within hour.

Sincerely,

Dawn Johnson PhD
Senior Biologist
Amec Foster Wheeler Environment & Infrastructure, Inc.
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-

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From: Grizzle, Betty
To: Johnson, Dawn
Subject: Re: i have review
Date: Wednesday, December 6, 2017 4:09:49 PM

Thanks for the update.

On Wed, Dec 6, 2017 at 2:12 PM, Johnson, Dawn <dawn.johnson@woodplc.com> wrote:

> Well, I have the review but the questions were not answered in the direct order asked, so the reviewer has to make sure his response addressed all the questions and reformat and get back to me tonight and I'll get out to you as soon as I have it from him. It will be in your inbox when arrive tomorrow morning. Very close now.
>
> Sorry about the delay. Both parents are back in the hospital and his son broke his hand. Yowza! I wouldn't trade my last month for his month that's for sure.
>
> Sincerely,
>
> **Dawn Johnson PhD**
>
> Senior Biologist
>
> Amec Foster Wheeler Environment & Infrastructure, Inc.
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> Austin/Santa Barbara
>
> D/M 805 252 4370
>
> dawn.johnson@woodplc.com www.**woodplc.com**
>
> ---
>
> **From:** Johnson, Dawn
> **Sent:** Wednesday, December 06, 2017 3:29 PM
> **To:** betty_grizzle@fws.gov
> **Subject:** i have review

Betty-

I have the 4th review. Putting in the correct format and proofreading now. You should have within hour.

Sincerely,

Dawn Johnson PhD

Senior Biologist

Amec Foster Wheeler Environment & Infrastructure, Inc.

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Austin/Santa Barbara

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dawn.johnson@woodplc.com www.**woodplc.com**

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Carlsbad, CA 92008
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760-431-5901 fax

From: Grizzle, Betty
To: Shoemaker, Justin; John Guinotte
Subject: Fwd: For Review: Draft Wolverine SSA
Date: Friday, December 8, 2017 8:32:02 AM
Attachments: CDFW_Wolverine_SSA_Comments_121617.pdf

From California.

---------- Forwarded message ----------
From: **Stermer, Chris@Wildlife** <Chris.Stermer@wildlife.ca.gov>
Date: Thu, Dec 7, 2017 at 4:45 PM
Subject: For Review: Draft Wolverine SSA
To: "jodi_bush@fws.gov" <jodi_bush@fws.gov>, "betty_grizzle@fws.gov" <betty_grizzle@fws.gov>
Cc: "Gardner, Scott@Wildlife" <Scott.Gardner@wildlife.ca.gov>

Hello Jodi and Betty,

Please accept the attached comments on the Wolverine SSA. You did an excellent job pulling the incredible amount of information on the species and compiling it into a document that was actually enjoyable to read.

Moreover, thank you for the additional time you provided for our comments!

Chris

From: Bush, Jodi [mailto:jodi_bush@fws.gov]
Sent: Thursday, October 26, 2017 8:30 AM
To: tschultz@idl.idaho.gov; twasley@ndow.org; curt.melcher@state.or.us; Lexi J., Sandoval <alexandra.sandoval@state.nm.us>; Jim Unsworth <Jim.Unsworth@dfw.wa.gov>; Dustin Miller (dustin.miller@osc.idaho.gov) <dustin.miller@osc.idaho.gov>; Moore,Virgil <virgil.moore@idfg.idaho.gov>; Martha Williams <Martha.Williams@mt.gov>; Scott Talbott <scott.talbott@wyo.gov>; Mike Fowlks <mikefowlks@utah.gov>; bob.broscheid@state.co.us; Kimberly Hersey <kimberlyasmus@utah.gov>; reid.dewalt@state.co.us; Sam Eaton

<Sam.Eaton@osc.idaho.gov>; Bonham, Chuck@Wildlife <Chuck.Bonham@wildlife.ca.gov>
Cc: Anderson, Hannah E (DFW) <hannah.anderson@dfw.wa.gov>; McDonald, Ken <kmcdonald@mt.gov>; Bob Lanka <bob.lanka@wyo.gov>; Smith, Scott <Scott.Smith1@wyo.gov>; H Jerome Hansen <jerome.hansen@idfg.idaho.gov>; ccorsi@idfg.idaho.gov; pseymour@idl.idaho.gov; Justin Shannon <justinshannon@utah.gov>; Zack Walker <zack.walker@wyo.gov>; Inman, Bob <bobinman@mt.gov>; Cc: <derek.j.broman@state.or.us>; Liley, Stewart, DGF <stewart.liley@state.nm.us>; Betty Grizzle <betty_grizzle@fws.gov>; Gardner, Scott@Wildlife <Scott.Gardner@wildlife.ca.gov>; Miner, Karen@Wildlife <Karen.Miner@wildlife.ca.gov>; DeBerry, Drue <drue_deberry@fws.gov>; Gregory Hughes <greg_m_hughes@fws.gov>; Paul Henson <paul_henson@fws.gov>; Eric Rickerson <eric_rickerson@fws.gov>; Abbott, Tyler <tyler_abbott@fws.gov>; Larry Crist <Larry_Crist@fws.gov>
Subject: For Review: Draft Wolverine SSA

Dear Wolverine Conservation Partners:

Attached please find the DRAFT Species Status Assessment (SSA) for the North American Wolverine. As you may be aware, the draft report is currently undergoing peer review.

We are providing this draft to your agency for review by members of your organization with expert knowledge of the species and its habitat. Your review will help us ensure that we have appropriately considered the best scientific and commercial information when evaluating the current status and future viability of the North American wolverine. We request your independent scientific perspectives on the comprehensiveness and logic of the document, as well as how well the technical conclusions are supported by the data and analyses.

As the literature cited is lengthy, if you need a copy of any document cited in the draft report, please contact Betty Grizzle at the email address below.

The Draft SSA is not intended to solicit public comment and will be revised after this scientific review. The SSA does not predetermine any future agency decision under the Endangered Species Act.

In general we ask that your comments on the Draft SSA report focus specifically on whether the best available information was used, the quality of the scientific information, and our interpretation and analyses of the data with regard to the species' viability in the contiguous United States. We request that you direct your review to the scientific issues and assumptions related to your expertise.

General Information about SSAs:

The Species Status Assessment framework is a new tool the U.S. Fish and Wildlife Service is using to improve transparency while conducting listing determinations and other Act actions, and peer review of our analyses of the viability of species is part of that new process. The attached draft SSA report is a rough draft; we are seeking comments at this stage to ensure that we have time to incorporate any substantial comments as we finalize the report.

In reviewing the document, please note that this draft SSA report does not result in or predetermine a decision by the Service on whether the Canada lynx warrants protections of the Act. This document is strictly a characterization of the viability species' viability in the contiguous United States. As a reminder, all reviews and comments submitted to the Service will become public documents and part of our administrative record for this document.

We welcome consolidated comments from your organization by November 30, 2017. Please send comments by that date to Betty_Grizzle@fws.gov. Thank you for your interest and assistance. JB

Jodi L. Bush

Office Supervisor

Montana State Ecological Services Office

585 Shepard Way, Suite 1

Helena, MT 59601

(406) 449-5225, ext.205

--

Betty J. Grizzle, D.Env.
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Comments on the USFW's Species Status Assessment for the North American Wolverine
Provided by the California Department of Fish and Wildlife
(December 7, 2017)

<u>Comments by Chris Stermer (Senior Env. Scientist; conservation lead for Wolverine (currently n = 1))</u>

Thank you for the opportunity to provide comments on the Species Status Assessment for the North American Wolverine (*Gulo gulo luscus*). Congratulations on the near completion of this massive undertaking, and for the overall quality of the document. I also appreciate the amount of time we were given for our comments, and the prior notice of when to expect the comment period, as it helps us plan around our other deadlines.

My comments are sparse, given we really don't have wolverines per se, but just the one to date. Hopefully this situation changes in the near future, and we can begin recovering this species back into their historic range in California. I have pasted the particular sections of the SSA having to do with California, and then added comments below.

Page 4. "*Wolverine numbers have recovered to some extent from this decline; in the United States, wolverines are currently found in parts of Washington, Oregon, Idaho, Montana, Wyoming, and California, and, as recently as 2012 in Colorado and 2016 in Utah, though not all of these areas contain resident, reproductive populations.*"

- I believe this sentence could be misinterpreted as California's wolverine population is experiencing a population recovery. The beginning of this sentence begins with a positive statement about wolverine recovery in portions of the U.S., and ends with a disclaimer wolverines found in these regions may not represent reproductive populations, and in the case of California occurs a single male wolverine. Recovery implies a reproductive population, or at bare minimum a single reproductive pair. I understand the point being made in that a single animal dispersing a fair distance into historic range is a step toward recovery, however the first part of this sentence seems overly optimistic for California. Consider adding additional language explaining that even with the species potential for long-distance dispersal, particularly with males, does not guarantee population recovery, which is particularly true for California.

Page 23. *"Based on telemetry studies, wolverines have been observed to disperse over very long distances. Both male and females can move long distances (Flagstad et al. 2004, pp. 684–686)"*

"Two recent examples illustrate the extensive dispersal capability of wolverines. A male wolverine apparently dispersed (2008 or earlier) from the western edge of the Rocky Mountain region to the Sierra Nevada region of California (Moriarty et al. 2009, p. 160)."

- My read of these two sentences, and other similar statements in the document, is that rare long distance dispersal events can be relied on as a means for population recovery in areas they have been historically extirpated from, and specifically I am referring to California's situation. I believe there is a high probability our one documented male wolverine in California made the journey from the Rocky Mountain Region, though there is a probability it had human assistance, which Moriarty et al. 2009 also mentions. Regardless, from what I have read in the literature, the roughly 600 miles the one male wolverine would have traveled to its established territory in California, is extremely unlikely for a female

wolverine, or generally just an extremely rare event that cannot be relied on for recovery. Evidence of this can be demonstrated by the numerous long-term survey efforts for carnivores throughout the Southern Cascades and Sierra Nevada, which I believe would positively detect a wolverine population, if one existed in California.

Over a two year period (2009 – 2010) while surveying in the Tahoe region where our one wolverine occurs, we calculated a 78% probability of detection using baited camera traps over a 60-day period (n = 50 detections). While I understand this is not truly representative of detecting a lone wolverine throughout the great expanse of potential habitat in California, it does demonstrate they highly detectable if they are present, which I believe other researchers have found (Apologies for not including a reference).

The point I am trying to make is that I believe it is extremely unlikely the recovery of a viable reproductive wolverine population can recover in California without some form of human assistance (i.e. translocation), and parts of this document seems to suggest they can.

Page 47. ***"The California Department of Fish and Wildlife (CDFW) has received reports of wolverine detections from the public over past several years, particularly the region near Carson Pass, as well as near Meeks Bay, Lake Tahoe (Stermer 2017, pers. comm.)."***

I would like to note that the reports of the wolverine detections mentioned above, and many others, have been followed up with extensive systematic surveys to attempt to detect wolverines in these areas, and to date we have not confirmed their occurrence. Carson Pass has been a hot zone over the last several years of wolverine sightings, and the Department continues to operate baited camera traps in the hope we confirm their presence.

Page 150. In addition the Wolverine being a CESA Threatened Species, it is also one of our **Fully Protected Mammals**. Fully Protected status is California's most restrictive protection regarding take. For your convenience, I have pasted the Section from our Fish and Game Code Book.

§ 4700. Enumeration of fully protected mammals; Prohibition against taking; Power to authorize collecting for scientific research

(a)(1) Except as provided in this section, Section 2081.7 , or Section 2835 , a fully protected mammal may not be taken or possessed at any time. No provision of this code or any other law shall be construed to authorize the issuance of a permit or license to take a fully protected mammal, and no permit or license previously issued shall have any force or effect for that purpose. However, the department may authorize the taking of a fully protected mammal for necessary scientific research, including efforts to recover fully protected, threatened, or endangered species. Before authorizing the take of a fully protected mammal, the department shall make an effort to notify all affected and interested parties to solicit information and comments on the proposed authorization. The notification shall be published in the California Regulatory Notice Register and be made available to each person who has notified the department, in writing, of his or her interest in fully protected species and who has provided an e-mail address, if available, or postal address to the department. Affected and interested parties shall have 30 days after notification is published in the California Regulatory Notice Register to provide relevant information and comments on the proposed authorization.

(2) As used in this subdivision, “scientific research” does not include an action taken as part of specified mitigation for a project, as defined in Section 21065 of the Public Resources Code .

(3) A legally imported fully protected mammal may be possessed under a permit issued by the department.

(b) The following are fully protected mammals:

(1) Morro Bay kangaroo rat (Dipodomys heermanni morroensis).

(2) Bighorn sheep (Ovis canadensis), except Nelson bighorn sheep (subspecies Ovis canadensis nelsoni) as provided by subdivision (b) of Section 4902 .

(3) Northern elephant seal (Mirounga angustirostris).

(4) Guadalupe fur seal (Arctocephalus townsendi).

(5) Ring-tailed cat (genus Bassariscus).

(6) Pacific right whale (Eubalaena sieboldi).

(7) Salt-marsh harvest mouse (Reithrodontomys raviventris).

(8) Southern sea otter (Enhydra lutris nereis).

(9) Wolverine (Gulo luscus).

From:	Grizzle, Betty
To:	John Guinotte; Shoemaker, Justin
Subject:	Fwd: New Wolverine Maps Dec 8 2017
Date:	Monday, December 11, 2017 8:27:12 AM
Attachments:	Wolverine_Current_Potential_Extent.pdf Wolverine_MExO.pdf

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New maps - Current Potential Extent and Maximum Extent of Occurrences (following IPAC terminology). I will be here until 3:45 if you want to discuss. Aubrey will be sending me GIS layer for locations in eastern US to add to the Max Extent of Occurrences Map.

---------- Forwarded message ----------
From: **Turner, Ed** <ed_turner@fws.gov>
Date: Fri, Dec 8, 2017 at 4:10 PM
Subject: New Wolverine Maps Dec 8 2017
To: Betty Grizzle <betty_grizzle@fws.gov>

--
Edwin Turner, Geographer
GIS Mapping and Analysis Branch

DOI-R8-CFWO
USFWS Carlsbad Fish and Wildlife Office
2177 Salk Ave. Suite 250
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760.431.9440 x266

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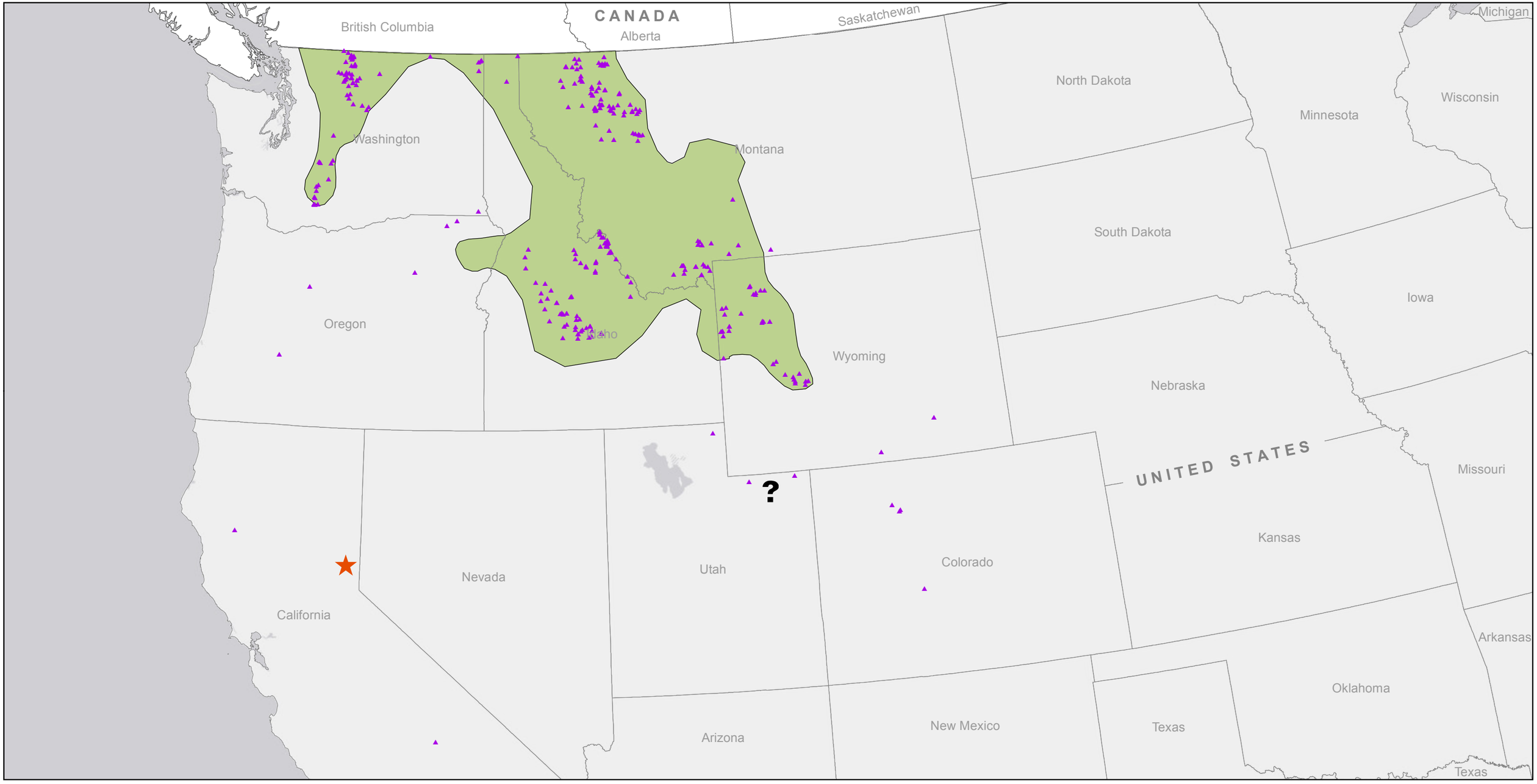
Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax



PRODUCED BY GIS SERVICES
CARLSBAD FIELD OFFICE
GIS CONTACT: ED TURNER
BIOLOGY CONTACT: BETTY GRIZZLE
(760) 431-9440
DATA SOURCE: USFWS, INMAN (WCS),
IMAGE SOURCE: ESRI Online Mapper
Dec 08, 2017
S:\stem\edstemp\American_wolverine\MXDs\SSA_FINAL\SSA_FINAL_MXDs\Wolverine_Current_Potential_Extent.mxd

N

0 55 110 220 Miles

0 55 110 220 Kilometers

▲ Wolverine Observations 2004 – 2017 and Den Locations 2002 - 2008

★ California CDFW Wolverine Observations 2008 – 2016

North American Wolverine (*Gulo gulo luscus*) Current Potential Extent

PRODUCED BY GIS SERVICES
CARLSBAD FIELD OFFICE
GIS CONTACT: ED TURNER
BIOLOGY CONTACT: BETTY GRIZZLE
(760) 431-9440
DATA SOURCE: USFWS, EPA, NWT, USCB, ESRI
IMAGE SOURCE: ESRI Online Mapper
Dec 08, 2017
S:\stemledstemp\American_wolverine\MXDs\SSA_FINAL\SSA_FINAL_MXDs\Wolverine_MExO.mxd

N

0 115 230 460 Miles

0 162.5 325 650 Kilometers

▲ Wolverine Observations 1876 – 2017 Compiled by USFWS in the 2017 effort

North American Wolverine (*Gulo gulo luscus*) Maximum Extent of Occurrence

From:	Shoemaker, Justin
To:	Jodi Bush; Kit Hershey; Jacobsen, Dana; Josh Hull; Grizzle, Betty; Bryon Holt; Caitlin Snyder; Gregg Kurz; Guinotte, John; Madeline Drake; Stephen Torbit
Cc:	Beth Forbus
Subject:	Wolverine Recommendation Team Meeting - Date Change
Date:	Monday, December 11, 2017 3:50:11 PM

Team,

We were notified today that we will need to reschedule the wolverine recommendation team meeting. It was scheduled for Jan 10-11. We're now looking at sometime between Jan 24-26 or the following week at the R6 RO. Our RD's office will be coordinating w/ yours to work out scheduling w/ your region's decision makers. I'll let you all know when we settle on a new date. Sorry for the inconvenience.

Justin Shoemaker
Classification and Recovery Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

From: stephanie_potter@fws.gov
To: Justin Shoemaker; Matt Hogan; Stephen Torbit; Noreen Walsh; Wanda Cantrell; Rose Reed; Theresa Rabot; Rollie White; Paul Souza; John Guinotte; Madeline Drake; Marjorie Nelson; Jodi Bush; Caitlin Snyder; Michael Thabault; Dana Jacobsen; Josh Hull; Gregg Kurz; Kit Hershey; Bryon Holt; Betty Grizzle; Michael Fris
Subject: Wolverine Rec Meeting (2 Days)

POC:

Justin Shoemaker

Classification and Recovery Biologist

U.S. Fish and Wildlife Service, Region 6

Phone: 309-757-5800 x214

Email: justin_shoemaker@fws.gov

From:	Grizzle, Betty
To:	John Guinotte
Subject:	2013 Proposed Rule Peer Reviews
Date:	Wednesday, December 13, 2017 10:15:09 AM
Attachments:	Inman 2013_Peer Review Cmts_edited document.pdf Magoun 2013_Peer Review Cmts_edited document.pdf

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Here are the reviews from Magoun and Inman.

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Betty J. Grizzle, D.Env.
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DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

[FWS–R6–ES–2012–0107]

[4500030113]

RIN 1018–AY26

Endangered and Threatened Wildlife and Plants; Threatened Status for the Distinct Population Segment of the North American Wolverine Occurring in the Contiguous United States

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Proposed rule.

SUMMARY: We, the U.S. Fish and Wildlife Service, propose to list the distinct population segment of the North American wolverine occurring in the contiguous United States, as a threatened species under the Endangered Species Act. If we finalize this rule as proposed, it would extend the Act's protections to this species. The effect of this regulation is to add the distinct population segment of the North

American wolverine occurring in the contiguous United States to the List of Endangered and Threatened Wildlife (50 CFR 17.11). We also propose a special rule under section 4(d) of the Act to apply the specific prohibitions of the Act necessary to protect the wolverine. We find that critical habitat is not determinable at this time. The Service seeks data and comments from the public on this proposed listing rule, the proposed special rule under section 4(d) of the Act, and our finding that the designation of critical habitat for the species is not determinable at this time.

DATES: We will accept comments received or postmarked on or before [INSERT DATE 90 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER]. Comments submitted electronically using the Federal eRulemaking Portal (see **ADDRESSES** section, below) must be received by 11:59 p.m. Eastern Time on the closing date. We must receive requests for public hearings, in writing, at the address shown in the **ADDRESSES** section by [INSERT DATE 45 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER].

Public Informational Sessions and Public Hearing: We will hold 3 public informational sessions and public hearings on this proposed rule. Public informational sessions will occur from 2:00 p.m. to 5:00 p.m. and public hearings will be held from 7:00 p.m. to 9:00 p.m. at each location. Public informational sessions and public hearings will occur in Boise, ID, on March 13, 2013, from 7:00 p.m. to 9:00 p.m.; in Lakewood, CO, on March 19, 2013, from 7:00 p.m. to 9:00 p.m.; and in Helena, MT, on March 27, 2013, from 7:00 p.m. to 9:00 p.m., all times local (see **ADDRESSES**). Registration for those providing testimony in the public hearings will begin at 6:00 p.m. at each location.

ADDRESSES: You may submit comments by one of the following methods:

(1) *Electronically*: Go to the Federal eRulemaking Portal: *http://www.regulations.gov*. In the Keyword box, enter Docket No. FWS–R6–ES–2012–0107, which is the docket number for this rulemaking. Then, in the Search panel on the left side of the screen, under the Document Type heading, click on the Proposed Rules link to locate this document. You may submit a comment by clicking on Comment Now!"

(2) *By hard copy*: Submit by U.S. mail or hand-delivery to: Public Comments Processing, Attn: FWS–R6–ES–2012–0107; Division of Policy and Directives Management; U.S. Fish and Wildlife Service; 4401 N. Fairfax Drive, MS 2042–PDM; Arlington, VA 22203.

(3) *At a public hearing*: We are holding three public hearings on this proposed rule (see **ADDRESSES** for location information). You may provide your comments at any of the three hearings.

We request that you send comments **only** by the methods described above. We will post all comments on *http://www.regulations.gov*. This generally means that we will post any personal information you provide us (see the **Public Comments** section below for more information).

Public Informational Sessions and Public Hearings: Public informational sessions and public hearings will be held on March 13, 2013, at the Boise Centre on the Grove, 850 West Front Street, Boise, ID 83702. The second is scheduled on March 19, 2013, at the Hampton Inn, 137 Union Boulevard, Lakewood, CO 80228. The third is scheduled on March 27, 2013, at the Red Lion Colonial Inn, 2301 Colonial Drive, Helena, MT 59601. At all three locations the public informational session will run from 2:00 p.m. to 5:00 p.m., followed by public speaker registration at 6:00 p.m., and then the public hearing for oral testimony from 7:00 p.m. to 9:00 p.m. People needing reasonable accommodations in order to attend and participate in the public hearing should contact Brent Esmoil,

Montana Ecological Services Field Office, as soon as possible (see **FOR FURTHER INFORMATION CONTACT**).

Any additional tools or supporting information that we may develop for this rulemaking will be available at http://www.fws.gov/mountain-prairie/species/mammals/wolverine/, at http://www.regulations.gov at Docket No. FWS–R6–ES–2012–0107, and at the Montana Field Office (see **FOR FURTHER INFORMATION CONTACT**).

FOR FURTHER INFORMATION CONTACT: Brent Esmoil, Field Supervisor (Acting), U.S. Fish and Wildlife Service, Montana Field Office, 585 Shepard Way, Helena, Montana 59601, by telephone (406) 449-5225. Persons who use a telecommunications device for the deaf (TDD) may call the Federal Information Relay Service (FIRS) at 800-877-8339.

SUPPLEMENTARY INFORMATION:

Executive Summary

Why we need to publish a rule. Under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) (Act or ESA), if a species is determined to be an endangered or threatened species throughout all or a significant portion of its range, we are required to promptly publish a proposal in the **Federal Register** and make a determination on our proposal within 1 year. Critical habitat shall be designated, to the maximum extent prudent and determinable, for any species determined to be an

endangered or threatened species under the Act. Listing a species as an endangered or threatened species and designations and revisions of critical habitat can only be completed by issuing a rule.

This rule consists of:

- A proposed rule to list the distinct population segment (DPS) of the North American wolverine occurring in the contiguous United States as a threatened species; and
- A proposed special rule under section 4(d) of the Act that outlines the prohibitions necessary and advisable for the conservation of the wolverine.

A proposed rule under section 10(j) of the Act to establish an experimental non-essential population of wolverine in Colorado is published concurrently in this issue of the **Federal Register**. Also, a draft Recovery Outline for the wolverine DPS is available on our website at http://www.fws.gov/mountain-prairie/species/mammals/wolverine/ or on http://www.regulations.gov.

The basis for our action. Under the Act, we can determine that a species is an endangered or threatened species based on any of five factors: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) Overutilization for commercial, recreational, scientific, or educational purposes; (C) Disease or predation; (D) The inadequacy of existing regulatory mechanisms; or (E) Other natural or manmade factors affecting its continued existence.

We have determined that habitat loss due to increasing temperatures and reduced late spring snowpack due to climate change is likely to have a significant negative population-level impact on wolverine populations in the contiguous United States. In the future, wolverine habitat is likely to be reduced to the point that the wolverine in the contiguous United States is in danger of extinction.

We will seek peer review. We are seeking comments from knowledgeable individuals with scientific expertise to review our analysis of the best available science and application of that science and to provide any additional scientific information to improve this proposed rule. Because we will consider all comments and information received during the comment period, our final determinations may differ from this proposal.

Information Requested

We intend that any final action resulting from this proposed rule will be based on the best scientific and commercial data available and be as accurate and as effective as possible. Therefore, we request comments or information from the public, other concerned governmental agencies, Native American tribes, the scientific community, industry, or any other interested parties concerning this proposed rule. We particularly seek comments concerning:

(1) Biological, commercial trade, or other relevant data concerning any threats (or lack thereof) to this species and regulations that may be addressing those threats.

(2) Additional information concerning the historical and current status, range, distribution, and population size of this species, including the locations of any additional populations of this species.

(3) Any information on the biological or ecological requirements of the species, and ongoing conservation measures for the species and its habitat.

(4) Current or planned activities in the areas occupied by the species and possible impacts of these activities on this species.

(5) The reasons why we should or should not designate habitat as “critical habitat” under section 4 of the Act (16 U.S.C. 1531 *et seq*.) including whether and how the wolverine may benefit from such a designation; whether there are threats to the species from human activity, the degree to which it can be expected to increase due to a critical habitat designation, and whether that increase in threat outweighs the benefit of designation such that the designation of critical habitat may not be prudent;

(6) Specific information on the amount and distribution of wolverine habitat,

(7) Information on the projected and reasonably likely impacts of climate change on the wolverine and its habitat;

(8) Suitability of the proposed 4(d) rule for the conservation, recovery, and management of the DPS of the North American wolverine occurring in the contiguous United States.

(9) Additional information concerning whether it is appropriate to prohibit incidental take of wolverine in the course of legal trapping activities directed at other species in the proposed 4(d) rule, including any information about State management plans related to trapping regulations and any

measures within those plans that may avoid or minimize the risk of wolverine mortality from incidental trapping for other species.

(10) Additional provisions the Service may wish to consider to conserve, recover, and manage the DPS of the North American wolverine occurring in the contiguous United States.

We will consider all comments and information received during the comment period on this proposed listing rule and special rule under section 4(d) of the Act during our preparation of a final determination. Accordingly, the final decision may differ from this proposal.

Please note that submissions merely stating support for or opposition to the action under consideration without providing supporting information, although noted, will not be considered in making a determination, as section 4(b)(1)(A) of the Act directs that determinations as to whether any species is an endangered or threatened species must be made "solely on the basis of the best scientific and commercial data available."

You may submit your comments and materials concerning this proposed rule by one of the methods listed in the **ADDRESSES** section. We request that you send comments **only** by the methods described in the **ADDRESSES** section.

If you submit information via *http://www.regulations.gov*, your entire submission—including any personal identifying information—will be posted on the website. If your submission is made via a hardcopy that includes personal identifying information, you may request at the top of your document

that we withhold this information from public review. However, we cannot guarantee that we will be able to do so. We will post all hardcopy submissions on *http://www.regulations.gov*. Please include sufficient information with your comments to allow us to verify any scientific or commercial information you include.

Comments and materials we receive, as well as supporting documentation we used in preparing this proposed rule, will be available for public inspection on *http://www.regulations.gov*, or by appointment, during normal business hours, at the U.S. Fish and Wildlife Service, Montana Field Office (see **FOR FURTHER INFORMATION CONTACT**).

Previous Federal Actions

On April 19, 1995, we published a finding (60 FR 19567) that a previous petition, dated August 3, 1994, submitted by the Predator Project (now named the Predator Conservation Alliance) and Biodiversity Legal Foundation to list the wolverine in the contiguous United States as an endangered or threatened species, did not provide substantial information indicating that listing the wolverine in the contiguous United States may be warranted.

On July 14, 2000, we received a petition dated July 11, 2000, submitted by the Biodiversity Legal Foundation, Predator Conservation Alliance, Defenders of Wildlife, Northwest Ecosystem Alliance, Friends of the Clearwater, and Superior Wilderness Action Network, to list the wolverine within the contiguous United States as an endangered or threatened species and designate critical habitat for the species.

On October 21, 2003, we published a 90-day finding that the petition failed to present substantial scientific and commercial information indicating that listing may be warranted (68 FR 60112).

On September 29, 2006, as a result of a complaint filed June 8, 2005 by Defenders of Wildlife and others alleging we used the wrong standards to assess the July 11, 2000, wolverine petition, the U.S. District Court, Montana District, ruled that our 90-day petition finding (68 FR 60112) was in error and ordered us to submit to the **Federal Register** a 12-month finding for the wolverine by September 29, 2007. On April 6, 2007, the deadline for this 12-month finding was extended to February 28, 2008.

On March 11, 2008, we published a 12-month finding of "not warranted" for the wolverine in the contiguous United States (73 FR 12929). In that finding we determined that the wolverine in the contiguous United States did not constitute a distinct population segment or a significant portion of the range of a listable entity of the wolverine in North America and so was not a listable entity under the Act.

On July 8, 2008 we received a Notice of Intent to Sue from Earthjustice alleging violations of the Act in our March 11, 2008, 12-month finding. On September 30, 2008, Earthjustice filed a complaint in the U.S. District Court, District of Montana, seeking to set aside and remand the 12-month finding back to the Service for reconsideration.

On March 6, 2009, the Service agreed to settle the case with Earthjustice by voluntarily remanding the 12-month finding and issuing a new 12-month finding by December 1, 2010. Following the settlement agreement, the court dismissed the case on June 15, 2009, and ordered the Service to comply with the settlement agreement.

On April 15, 2010, the Service published a Notice of Initiation of a 12-month finding for wolverines in the contiguous United States (75 FR 19591). That finding was published on December 14, 2010, and determined that the wolverine in the contiguous United States constituted a Distinct Population Segment and that the DPS warranted listing under the Act, but that listing was precluded by higher priority listing actions (75 FR 78030).

On September 9, 2011, we reached an agreement with plaintiffs in *Endangered Species Act Section 4 Deadline Litig.*, Misc. Action No. 10-377 (EGS), MDL Docket No. 2165 (D. D.C.) (known as the "MDL case") on a schedule to publish proposed rules or to withdraw warranted findings for the species on our list of candidate species. This agreement stipulated that we would submit for publication in the **Federal Register** a proposed listing rule for the wolverine, or withdraw the warranted 12-month finding, no later than the end of the 2013 Fiscal Year.

On April 13, 2012, several parties filed an action challenging the Service's December 14, 2010 warranted but precluded finding for wolverine. *Cottonwood Envtl. Law Ctr., et al. v. Salazar, et al.*, 9:12-cv-00057-DLC (D. Mont.) On September 20, 2012, the court granted the Service's motion to stay that litigation based on the Service's representation to the Court that it expected to submit this rule or withdraw the warranted finding to the **Federal Register** by January 18, 2013.

THREATENED STATUS FOR THE CONTIGUOUS UNITED STATES WOLVERINE DPS:

Background

It is our intent to discuss below only those topics directly relevant to the listing of the contiguous United States DPS of the North American wolverine as a threatened species in this section of the proposed rule.

Species Information

Taxonomy and Life History

The wolverine has a Holarctic (habitats found in the northern continents) distribution including northern portions of Europe, Asia, and North America. The currently accepted taxonomy classifies wolverines worldwide as a single species, *Gulo gulo*, with two subspecies. Old World wolverines are found in the Nordic countries of Europe, Russia, Mongolia, and Siberia and are part of the subspecies *Gulo gulo gulo*. New World wolverines occur in North America. The wolverines in the contiguous United States are a part of the New World subspecies, *G. g. luscus*: the North American wolverine (Kurten and Rausch 1959 p. 19; Pasitschniak-Arts and Lariviere 1995, p. 1). The species is known by several common names, including mountain devil, glutton, caracajou, quickhatch, gulon, skunk bear, as well as wolverine.

Comment [RMI1]: Subspecies designation is often subjective and this appears to be the case for the wolverine. I am not aware of any physical or behavioral differences that are given to separate wolverines into 2 subspecies.

The wolverine is the largest terrestrial member of the family Mustelidae. Adult males weigh 12 to 18 kilograms (kg) (26 to 40 pounds (lb)), and adult females weigh 8 to 12 kg (17 to 26 lb) (Banci 1994, p. 99). The wolverine resembles a small bear with a bushy tail. It has a broad, rounded head; short, rounded ears; and small eyes. Each foot has five toes with curved, semi-retractile claws used for digging and climbing (Banci 1994, p. 99).

A large number of female wolverines (40 percent) are capable of giving birth at 2 years old, become pregnant most years, and produce average litter sizes of 1 to 2 kits. In one study of known-aged females, none reproduced at age 2; 3 of 10 first reproduced at age 3; and 2 did not reproduce until age 4. The average age at first reproduction was 3.4 years (Persson *et al*. 2006, pp. 76-77). Another study from the contiguous US indicated that the average age at first reproduction is likely more than 3 years (Inman *et al*. 2007c, p. 70). Pregnant females commonly resorb or spontaneously abort litters prior to giving birth (Magoun 1985, pp. 30-31; Copeland 1996, p. 43; Persson *et al*. 2006, p. 77; Inman *et al*. 2007c, p. 70). This may in turn preserve resources to increase reproductive success in subsequent years (Persson 2005, p. 1456; Inman et al. 2012b). By age 3, nearly all female wolverines become pregnant every year (cite carcass studies, but caveat of age estimation errors), but energetic constraints due to low food availability result in loss of pregnancy in about half of them each year (Persson 2005). It is likely that, in many places in the range of wolverines, it takes 2 years of foraging for a female to store enough energy to successfully reproduce (Persson 2005, p. 1456). It is likely that, despite the high rate of initiation of pregnancy, due to the ~~spontaneous abortion~~loss of litters resulting from resource limitation (Persson 2005, p. 1456), ~~actual~~ realized rates of successful reproduction in wolverines are among the lowest known for mammals ~~(Persson 2005, p. 1456)~~.

Comment [RMI2]: We had adult males that weighed as little as 22 lbs.

Comment [RMI3]: This is from carcass studies where ages were estimated which may not be reliable. Persson et al. 2006 is the only data on known-age wolverine reproduction. The Swedes have captured numerous cubs at dens (~200) which provides a known age, and have subsequently recaptured those individuals later and pulled a tooth for cementum annuli age estimation. Their information suggests that cementum annuli are not accurate for estimating age. So carcass studies that use cementum annuli for age estimation may have errors. Other methods for age estimation during carcass studies may be even less reliable.

Comment [RMI4]: as written this suggests 2 year olds become pregnant most years. I am not sure this is the case. Again, carcass studies are probably the only data and may be flawed in their age estimation. If the meaning here is that most sexually mature females become pregnant each year, the carcass studies are accurate in that regard.

Comment [RMI5]: citation?

Comment [RMI6]: This was based on nulliparity at initial capture (via teats), and assumption of minimum age at capture (which would only bias the estimate low), and no documented births until > (at least) age 3.

Comment [RMI7]: Carcass studies suggest virtually all adult females are pregnant. Field studies suggest very few retain litters through May. Something happens but nobody knows for sure what or how. Could be resorbtion, abortion, death from starvation or cold, ingestion by female, killed by other wolverines, killed by other species…

Suggest citing carcass studies (Rausch and Pearson, Wright and Rausch, Banci and Harestad, Liskop et al., Anderson and Aune.

I see that the lit cited and literature package does not include Anderson and Aunes carcass and reproductive info from Montana. This is obviously relevant to the DPS and should be included. I will include a copy of that paper in the info returned to USFWS.

Supplemental feeding of females increases reproductive potential (Persson 2005, p. 1456). Food-supplemented females were also more successful at raising kits to the time of weaning, suggesting that wolverine reproduction and ultimately population growth rates and viability are food-limited. Female wolverines appear to use a complex strategy of food accumulation and caching to attain enough resources to successfully raise a litter (Inman *et al*. 2012b, pp. 640-641).

Breeding generally occurs from late spring to early fall (Magoun and Valkenburg 1983, p. 175; Mead *et al*. 1991, pp. 808-811). Females undergo delayed implantation until the following winter or spring, when active gestation lasts from 30 to 40 days (Rausch and Pearson 1972, pp. 254-257; Mead et al. 1993). Most ~~L~~litters are born from mid-February through March (Inman et al. 2012b), containing one to five kits, with an average in North America of between one and two kits (Magoun 1985, pp. 28-31; Copeland 1996, p. 36; Krebs and Lewis 1999, p. 698; Copeland and Yates 2006, pp. 32-36; Inman *et al*. 2007c, p. 68).

Female wolverines use natal (birthing) dens that are excavated in snow. Persistent, stable snow greater than 1.5 meters (m) (5 feet (ft)) deep appears to be a requirement for natal denning, because it provides security for offspring and buffers cold winter temperatures (Pulliainen 1968, p. 342; Copeland 1996, pp. 92-97; Magoun and Copeland 1998, pp. 1317-1318; Banci 1994, pp. 109-110; Inman *et al*. 2007c, pp. 71-72; Copeland *et al*. 2010, pp. 240-242). Female wolverines go to great lengths to find secure den sites, suggesting that predation is a concern (Banci 1994, p. 107). Natal dens consist of tunnels that contain well-used runways and bed sites ~~and~~and the primary structure is nearly always ~~may naturally incorporate shrubs,~~ rocks, ~~and~~ downed logs as part of their structure (Magoun and Copeland 1998, pp. 1315-1316; Inman *et al*. 2007c, pp. 71-72). In Idaho, natal den sites occur above 2,500 m

Comment [RMI8]: Suggest moving this paragraph above the previous as this info justifies much of the above.

Comment [RMI9]: We reviewed virtually all info on reproduction for the J Mammalogy paper and suggested that gestation is likely about 45 days.

Comment [RMI10]: I don't believe any of these NA studies documented litters of 5. Is there a citation for 5?

Comment [RMI11]: This is number at "observation date" and not at birth. No one has counted number at birth. Carcass studies may be better indication of potential whereas field studies are more a "realized" rate. It should be noted also that counts of cubs after leaving the natal den is difficult, has been achieved very rarely in North America (~<10), and can only provide a minimum estimate. Structures where wolverines "stash" young are often very complex and impossible to search thoroughly. We have had instances where the female was travelling with only one of multiple cubs too.

Comment [RMI12]: This is not a good description of the dens we found. Snow was a part of each den, but certainly not even close to the majority of structure/material. Logs and rocks were the primary structure, by far, at all of our dens. Photos in 2007 report. This description suggests only snow.

Comment [RMI13]: This is not the case. We had natal dens covered in <25 cm of snow. This is stated in the 2007 report chapter on reproduction, pate 71, last paragraph. Not sure where these numbers came from (1.5m)?

Comment [RMI14]: Wolverine dens are almost always associated with snow. However, deep snow is not an "obligate requirement" that limits wolverine distribution as suggested by Copeland et al. 2010 and relied upon by McKelvey et al. 2011 and the USFWS throughout this document.

I have seen photos of a female wolverine and cub emerging during April from a den that is simply a tunnel in the ground under rocks and dirt; no snow is present and covering the den; nowhere near 5 feet of snow. ...

Comment [RMI15]: Suitable den sites appear to be very common within a female's home range. In our study area, there were likely multiple hundreds of suitable dens sites within a given females' home range. Wolverines probably do not need to go to ...

Comment [RMI16]: Most likely predation from other wolverines is the primary driver. Infanticide was a major cause of juvenile mortality in the only study to document juvenile mortality (Persson et al. 2003). This fits well with the overall strategy of th ...

Comment [RMI17]:

Comment [RMI18]: They are primarily composed of these things. The suggestion that they "may" incorporate them is giving more emphasis to other features, such as snow, than the data warrants. Please correct. When snow is used exclusively, ...

(8,200 ft) on rocky sites, such as north-facing boulder talus or subalpine cirques (steep-walled semicircular basin carved by a glacier) in forest openings (Magoun and Copeland 1994, pp. 1315-1316). In southern Montana, natal dens occur above 2,400 m (7,874 ft) and are located on north aspects in avalanche debris, typically in alpine habitats near timberline (Inman *et al*. 2007c, pp. 71-72). Offspring are born from January through April, with most being born from mid-February through mid-March and the dens are typically used through late April or early May (Myrberget 1968, p. 115; Magoun and Copeland 1998, pp. 1314-1317; Inman *et al*. 2007b, pp. 55-59). Occupation of natal dens is variable, ranging from approximately 9 to 65 days (Magoun and Copeland 1998, pp. 1316-1317).

Females may move kits to multiple secondary (maternal) dens prior to weaning ~~as they grow during the month of May~~ (Pulliainen 1968, p. 343; Myrberget 1968, p. 115), although the prevalence of use of maternal dens is unknown~~may be minimal~~ (Inman *et al*. 2012b~~07c,~~ p. 638~~9~~). Timing of den abandonment is thought to be related to accumulation of water in dens (due to snow melt Magoun and Copeland 1998), the maturation of offspring (Inman et al. 2012b), disturbance, and geographic location (Myrberget 1968, p. 115; Magoun 1985, p. 73). After using natal and maternal dens, wolverines may also use rendezvous sites through early July (Inman et al. 2012b). These sites are characterized by natural (unexcavated) cavities formed by large boulders, downed logs (avalanche debris), and snow (Inman *et al*. 2007c, pp. 55-56). Male wolverines likely mate with several females, and although they are not known to directly contribute to rearing young, they do tolerate subadult wolverines in their territories (usually their own offspring) until they reach maturity (Copeland 1996, p. 72).

Habitat, Space, and Food

Comment [RMI19]: Need to mention that these elevations will change greatly based on latitude. Dens in Colorado or California will be limited to much higher elevations than in Montana.

Our latitude adjusted elevation paper suggests that 8,000 ft in Yellowstone is equivalent to

Comment [RMI20]: Inman et al. 2012 J Mammalogy review summarizes all available data.

Comment [RMI21]: See discussion of reproductive dens on page 638 of J Mammalogy 2012. There is much misconception surrounding how wolverines den. How much they move among different sites in a setting that is not influenced by humans is unknown. They may move frequently. VHF telemetry was not able to differentiate moves of a few hundred meters. Natal dens can be used for a short period of time (Copeland 1996) or until rendezvous sites are used.

Comment [RMI22]: These are inappropriate citations as evidence that females naturally change dens. These references, because they were based upon bounty hunters excavating dens to kill wolverines, would be appropriate as evidence that wolverines move dens after extreme levels of disturbance, which should not be surprising in the case of any animal. From Pulliainen 1968 – "The present paper is based on the reports of Finnish wolverine hunters." and "Since bounties are still paid on wolverines in this country, hunters take keen interest in their dens."

Comment [RMI23]: Because this is important to the critical arguments that USFWS uses in its proposed rule, citations for each cause should be used or it should be noted as speculation.

Comment [RMI24]: Please provide citations and note the level of disturbance (e.g., as with Pulliainen 1968). Other than extreme levels of disturbance such as Pulliainen, there are to my knowledge 2 observations of "den abandonment" in Idaho (Copeland 1996). These were both during April when it appears females may move cubs frequently during that time period even without human activity nearby (based on GPS collar data, much of it from Sweden).

Comment [RMI25]: Please clarify with the biological relevance.

Comment [RMI26]: Highly likely only their offspring. I am not aware of "tolerance" having ever been documented for an unrelated same-sex subadult. In fact just the opposite would be expected in a food limited, territorial species where significant intra-specific aggression has been documented (Persson et al. 2003). Magoun near Petersberg AK observed numerous injuries to subadult "floaters."

In North America, wolverines occur within a wide variety of alpine, boreal, and arctic habitats, including boreal forests, tundra, and western mountains throughout Alaska and Canada. The southern portion of the species' range extends into the contiguous United States, including high-elevation alpine portions of Washington, Oregon, Idaho, Montana, Wyoming, California, and Colorado Utah northern New Mexico (Wilson 1982, p. 644; Hash 1987, p. 576; Banci 1994, p. 102, Pasitschniak-Arts and Lariviere 1995, p. 499; Aubry *et al*. 2007, p. 2152; Moriarty *et al*. 2009, entire; Inman *et al*. 2009, pp. 22-25, Inman et al. 2013a, Frey 2006, Copeland et al. 2010). Wolverines do not appear to specialize on specific vegetation or geological habitat features~~aspects~~, but instead select areas that are relatively cold and receive enough winter precipitation to reliably maintain deep persistent snow late into the warm season (Copeland *et al*. 2010, entire). The requirement of cold, snowy conditions means that, in the southern portion of the species' range where ambient temperatures are warmest, wolverine distribution is restricted to high elevations, while at more northerly latitudes, wolverines are present at lower elevations and even at sea level in the far north (Copeland *et al*. 2010, Figure 1).

In the contiguous United States, wolverines ~~likely~~ exist as a metapopulation (Aubry *et al*. 2007, p. 2147, Figures 1, 3 Inman et al. 2013a). A population is a group of interbreeding individuals of the same species. A metapopulation is a population composed of a network of semi-isolated subpopulations, each occupying a suitable patch of habitat in a landscape of otherwise unsuitable habitat (Pulliam and Dunning 1997, pp. 212-214). Metapopulations require some level of regular or intermittent migration and gene flow among subpopulations, in which individual subpopulations support one-another by providing genetic and demographic enrichment through mutual exchange of individuals (Meffe and Carroll 1997, p. 678). Individual subpopulations may go extinct or lose genetic viability, but are then "rescued" by immigration from other subpopulations, thus ensuring the

Comment [RMI27]: this has not been investigated.

Comment [RMI28]: Please define "reliable." There is a correlation between wolverines and areas with 15 May snow in as few as 1 of 7 years (14% of years). When something occurs only 14% of the time, it is not reliable, rather it is unlikely.

Comment [RMI29]: The figures cited do not provide very good or the best available information for evidence of a metapopulation.

We used radio-telemetry data, resource selection function modelling, and k-fold cross validation with independent wolverine location datasets to predict habitat suitable for resident adults and apply a density estimate to that habitat. The result was 132 specific patches of suitable habitat and a rough estimate of the number of wolverines that could exist in each patch (ranging from 0-99) if at similar densities as empirically documented in Montana.

Inman, R. M., B.L. Brock, K.H. Inman, S.S. Sartorius, B.C. Aber, B. Giddings, S.L. Cain, M.L. Orme, J.A. Fredrick, B.J. Oakleaf, K.L. Alt, E. Odell, and G. Chapron. 2013. Developing a spatial framework and conservation priorities for a wolverine Metapopulation. Paper III *in* Wolverine ecology and conservation in the western United States. PhD Dissertation, R.M. Inman, 2013. Grimsö Wildlife Research Station, Department of Ecology, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Comment [RMI30]: Hanski, I. and O.E. Gaggiotti. 2004. Metapopulation biology: past, present, and future. Chapter 1 in Ecology, Genetic, and Evolution of Metapopulations, I. Hanski and O.E. Gaggiotti, eds. Elsevier Academic Press, Burlington, Massachusetts, USA.

persistence of the metapopulation as a whole. If metapopulation dynamics break down, either due to changes within subpopulations or loss of connectivity (i.e., loss of ability to disperse among subpopulations), then the entire metapopulation may be jeopardized due to subpopulations becoming unable to persist in the face of inbreeding or demographic and environmental stochasticity (Pulliam and Dunning 1997, pp. 221-222). The wolverine metapopulation in the DPS consists of a network of small subpopulations on mountain tops, some likely consisting of less than ten individuals (Inman et al. 2013a, Table S3). Persistence of subpopulations under these conditions requires movement between subpopulations across both suitable and unsuitable wolverine habitat. Wolverines prefer to move across suitable habitat (as defined by persistent spring snow cover and also the habitat model of Inman et al. (2013a) as shown by Rainey 2012) rather than to cross unsuitable habitats during dispersal movements (Schwartz et al. 2009, p. 3230). Therefore, we would expect that changes resulting in reduction of suitable habitat conditions would result in reduced movement rates between habitat patches if distances between the~~m~~n became greater. This could affect the metapopulation as a whole if movement rates became too low to ensure subpopulation demographic or genetic health.

Wolverines are opportunistic feeders and consume a variety of foods depending on availability. They primarily scavenge carrion, but also prey on small animals and birds, and eat fruits, berries, and insects (Hornocker and Hash 1981, p. 1290; Hash 1987, p. 579; Banci 1994, pp. 111-113). Wolverines have an excellent sense of smell that enables them to find food beneath deep snow (Hornocker and Hash 1981, p. 1297).

Wolverines require ~~a lot of space~~large areas; the availability and distribution of food is likely the primary factor in determining female wolverine movements and home range size (Hornocker and Hash

Comment [RMI31]: Rainey 2012 suggests that this is true to some degree, but that at some point crossing unsuitable habitat is preferential to dispersing far longer distances through suitable habitat.

Rainey, M.M., 2012. A test of the ability of connectivity models to predict dispersal movements using telemetry data from dispersing wolverines. Chapter 4 in Validating alternative methods of modeling wildlife corridors using relocation data from migrating elk and dispersing wolverines. PhD Dissertation, M.M. Rainey. 2012. Montana State University, Bozeman, Montana, USA.

Comment [RMI32]: Wolverines scavenge carrion, but this is overstated in the literature and is simply repeated with great frequency and taken to be true. The degree to which ungulate carrion is the major staple of their diet is questionable, especially at the southern extent of distribution. This is specifically addressed in the 2012 J Mammalogy paper on page 635, column 1, last paragraph, 3rd sentence and in the discussion, page 640, 2nd column, last paragraph. The timing of reproduction suggests summer foods may be as critical or even more so than the carrion documented during the 96% of food habits studies that occurred during winter. This is the information that is available simply because wolverines can be tracked in the snow during winter and not summer. Wolverines may simply survive winter on carrion (as evidenced by Persson 2005). They may recover from the demands of reproduction during the summer that typically occurs between reproductive events. Small prey, and neonatal ungulates (Gustine Monograph on caribou) may drive population dynamics, not scavenged ungulate carrion. There are likely regional differences, especially in areas with ungulate herds but limited small mammals (Sweden).

Comment [RMI33]: one instance of fruits that I am aware of – Rausch and Pearson I believe. Negligible.

Comment [RMI34]: There is a comprehensive list of food habits studies in the J Mammalogy paper on page 639, third paragraph. that can provide citations here.

Comment [RMI35]: They also prey on larger animals. Instances of killing moose mired in snow and they were the main predator on caribou calves in Canada (Gustine et al. Monograph 165).

1981, p. 1298; Banci 1994, pp. 117-118). Male wolverine home range size and location is likely tied to the presence of active female home ranges and breeding opportunities (Copeland 1996, p. 74). Female wolverines forage close to den sites in early summer, progressively ranging further from dens as kits become more independent (May *et al*. 2010, p. 941). Wolverines travel long distances over rough terrain and deep snow, and adult males generally cover greater distances than females (Hornocker and Hash 1981, p. 1298; Banci 1994, pp. 117-118; Moriarty *et al*. 2009, entire; Inman *et al*. 2009, pp. 22-28; Brian 2010, p. 3; Copeland and Yates 2006, Figure 9). Home ranges of wolverines are large, and vary greatly in size depending on availability and distribution of food and gender and age of the animal. Home ranges of adult wolverines also vary in size depending on geographic location. Home ranges in Alaska were approximately 100 square kilometers (km^2) to over 900 km^2 (38.5 square miles (mi^2) to 348 mi^2) (Banci 1994, p. 117). Average home ranges of resident adult females in central Idaho were 384 km^2 (148 mi^2), and average home ranges of resident adult males were 1,522 km^2 (588 mi^2) (Copeland 1996, p. 50). Wolverines in Glacier National Park had average adult male home ranges of 496 km^2 (193 mi^2) and adult female home ranges of 141 km^2 (55 mi^2) (Copeland and Yates 2006, p. 25). Wolverines in the Greater Yellowstone Ecosystem had average adult male home ranges of 797 km^2 (311 mi^2), and average adult female home ranges of ~~329~~ 303 km^2 (~~128~~ mi^2) (Inman *et al*. 2012~~07~~a, p. 785~~4~~). These home range sizes are large relative to the body size of wolverines, and may indicate that wolverines occupy a relatively unproductive niche in which they must forage over large areas to consume the amount of calories needed to meet their life-history requirements (Inman *et al*. ~~2007a~~2012a, p. 785~~11~~).

Across their worldwide distribution, wolverines are dependent on persistent spring snow cover for successful reproduction (Pulliainen 1968, pp. 338-341; Myrberget 1968, p. 115; Copeland 1996, pp.

Comment [RMI36]: The one female we had GPS'd while denning make some extensive movements across her home range while cubs were only a few weeks old.

Comment [RMI37]: we have very specific movement rate data showing this in JWM article 2012 spatial ecology, page 785.

Comment [RMI38]: Use published paper. 2012

Comment [RMI39]: This statement is not based in fact.

There is a correlation between persistent snow cover through 15 May during at least 1 of 7 years (14% of years) and wolverine dens, and it has been HYPOTHESIZED that the cause of this correlation is an "obligate" need for wolverines to den under "deep, reliable, persistent spring snow." However, this hypothesis is not based in sound theory, is not actually supported by the observed correlation, and is not proving to be true upon real-world testing/assessment.

The proposed rule begins here and continues throughout the document to draw its conclusions leading to the proposed rule on the flawed "obligate 15 May in at least 14% of years snow denning hypothesis."

Much of the proposed rule is based on the assumption that wolverine distribution is limited by an obligate need to den in deep, persistent, and reliable snow cover through 15 May as hypothesized in Copeland et al. (2010). This 2010 paper was a follow-up to the Aubry et al. 2007 paper discussed above, and both are used to assess historical records and suitable habitat in the proposed rule. The 2010 paper establishes that there is a correlation between the areas where snow persists through 15 May during at least 1 of 7 years (14% of years) and wolverine dens, and it then hypothesized that the cause of this correlation is an "obligate" need for wolverines to den under deep, reliable, persistent spring snow through 15 May. While I am a coauthor on that paper, I have, after further thought and new information, come to the conclusion that this hypothesis is not based in sound theory, is not actually supported by the observed correlation, and is not proving to be true upon subsequent real-world assessment.

The ecological theory behind the obligate snow den hypothesis is suspect. The concept of the niche is fundamental to evolutionary biology and speciation and is ultimately based on competition for food. Thus the distribution of a terrestrial mammal (realized niche) is primarily limited by conditions that allow the species to survive and successfully compete for enough food to persist and reproduce. All organisms must survive for a period of time prior to reproducing. In the case of a female wolverine, that period is typically 3-4 years, nearly a quarter of its lifespan. Failure to live (or be distributed) in an area where the species is adapted to compete successfully for enough food will result in death. So, for the first quarter of life, conditions suitable for surviving and obtaining food are the driving force ...

93-94; Magoun and Copeland 1998, pp. 1315-1319; Aubry *et al*. 2007, p. 2153; Inman *et al*. 2012a, p.785; Copeland *et al*. 2010, entire). No records exist of wolverines denning anywhere but in snow, despite the wide availability of snow-free denning opportunities within the species' geographic range. The snow tunnels and complex structure associated with dens are likely required to protect young from interspecific and intraspecific predation (Persson *et al*. 2003, pp. 25-26; Magoun and Copeland 1998, p. 1318). A layer of deep snow may also add crucial insulation from cold temperatures and wind prevalent in wolverine habitat (Pulliainen 1968, p. 342; Bjärvall *et al*. 1978, p. 24-25; Copeland 1996, p. 100; Magoun and Copeland 1998, p. 1318).

Female wolverines have been observed to abandon reproductive dens when temperatures warm and snow conditions become wet (Magoun and Copeland 1998, p. 1316); this response indicates that the condition of the snow is also important to successful reproduction, and that the onset of spring snowmelt forces female wolverines to move kits into alternate denning sites with better snow conditions, if they are available. These movements may be energetically costly and subject females and kits to predation risk, and if they were to occur more frequently due to climate change…. The deep, persistent spring snow layer in the Copeland et al. (2010) model captures all known wolverine den sites in the DPS; however, on average, most denning occurs at higher elevations within the area defined by the model. Female wolverines establish reproductive dens at elevations higher than average elevations used by nonreproductive wolverines (Copeland 1996, p. 94; Magoun and Copeland 1998, pp. 1315-1316; Inman *et al*. 2007c, p. 71), suggesting that females find the conditions necessary for successful denning in the upper portion of their home range where snow is most persistent and occurs in the heaviest accumulations.

Comment [RMI40]: This is not the case. As stated above, there are photographs of females with cubs exiting a den during April where the den was simply a tunnel under rock/dirt and there was no snow covering the den on April 24 and most likely for a periods of days before the photo was made. Clearly, wolverines are not "obligated" to den under snow.

Comment [RMI41]: This is typically the main component of a den, not snow, especially in the lower 48 and our study area.

Comment [RMI42]: If snow were critical for dens, protection from very cold ambient temperatures would be the reason. However, there is no reason to believe that ONLY SNOW could provide this adequately.

Comment [RMI43]: The fact that this occurs and wolverines continue to exist indicates that they seem to deal with this phenomenon successfully.

Comment [RMI44]: This and other considerations are of great significance to the interpretation of McKelvey et al. 2011.

Comment [RMI45]: this statement assumes that snow is the only factor in den habitat. The higher elevations are also the places where slopes are steep enough to result in A) avalanche activity and their resultant log debris piles that often form the major structural component of a den, and B) steep and rocky enough slopes that have cast and deposited large boulders and talus at the base of cliffs and which also form the major structure of many dens.

These areas are also the places where several important maternal food sources exist either exclusively or in much greater frequency during the time of greatest energetic demand on reproductive females, i.e., marmots after emergence from hibernation, alpine neonatal ungulates such as bighorn sheep, mountain goats, and to some degree elk.

There are numerous instances where the significance of snow for dens is overstated throughout the proposed rule.

Wolverine year-round habitat use also takes place almost entirely within the area defined by deep persistent spring snow (Copeland et al. 2010, pp. 242-243). Within the DPS, this area is generally centered on the alpine tree line (the maximum elevation beyond which tree growth is precluded and only low-growing vegetation is found). In the contiguous United States, wolverine year-round habitat is found at high elevations centered near the tree line in conifer forests (below tree line) and rocky alpine habitat (above tree-line) and in cirque basins and avalanche chutes that have food sources such as marmots, voles, and carrion (Hornocker and Hash 1981, p. 1296; Copeland 1996, p. 124; Magoun and Copeland 1998, p. 1318; Copeland *et al*. 2007, p. 2211; ~~Inman *et al*. 2007a, p. 11~~Inman et al. 2012a, 2013). In the southern portion of wolverine range in North America which includes the DPS, wolverines are constrained by their need for cold conditions ~~and persistent spring snow~~ to using only the coldest available landscapes (Copeland *et al*. 2010, Figure 6, (Inman et al. 2012a, 2012b, 2013a)).

Mean seasonal elevations used by wolverines in the northern Rocky Mountains and North Cascades vary between 1,400 and 2,600 m (4,592 and 8,528 ft) depending on location, but are always relatively high on mountain slopes (Hornocker and Hash 1981, p. 1291; Copeland *et al*. 2007, p. 2207, Aubry *et al*. 2007, p. 2153; Inman et al. 2012a, p.782). Elevation ranges used by historical wolverine populations in the Sierra Nevada and southern Rocky Mountains are unknown, but presumably wolverines used higher elevations, on average, than more northerly populations to compensate for the higher temperatures found at lower latitudes. In the contiguous United States, valley bottom habitat appears to be used only for dispersal movements and not for foraging or reproduction (Copeland et al. 2007; Inman *et al*. 2009, pp. 22-28; Inman et al. 2012a, 2013). Wolverine reproductive dens have been located in alpine, subalpine, taiga, or tundra habitat (Myrberget 1968, p. 115; Pulliainen 1968, pp. 338-341; Bjärvall 1982, p. 318; Lee and Niptanatiak 1996, p. 349; Landa *et al*. 1998, pp. 451-452; Magoun

Comment [RMI46]: Another example of overstating the significance of the spring snow model. Up to 25% of locations from some areas were outside the layer (Copeland et al 2010, table 1) . And it must be noted that this includes areas with spring snow in as few as 1 of 7 years. Again, what can be reliably taken from that work is that there is a correlation between wolverine locations and colder, more snowy areas.

Comment [RMI47]: do you mean the area of the spring snow model?

Comment [RMI48]: Has this been calculated in any way?

Comment [RMI49]: critical distinction, one has support, the other does not.

Comment [RMI50]: should use latitude adjusted elevation for better comparative purposes.

and Copeland 1998, pp. 1317-1318; Inman et al. 2007c). Wolverines rarely, or never, den in lower elevation forested habitats (Magoun and Copeland 1998, p. 1317; Inman et al. 2007c), although they may occupy these habitats occasionally (~~Magoun and Copeland 1998, p. 1317; Inman et al. 2007c,~~ Inman et al. 2012a, 2013a, citations from far north?).

Comment [RMI51]: Check Dawson et al. 2010.

Need to be careful here to either note that this is in the conterminous US or think about areas such as Alaska or Canada where good wolverine habitat may occur at low elevations.

Wolverine Densities

Wolverines naturally occur in low densities with a reported range from one animal per 65 km^2 (25 mi^2), to one animal per 337 km^2 (130 mi^2) (Hornocker and Hash 1981, pp. 1292-1295; Hash 1987, p. 578; Copeland 1996, pp. 31-32; Copeland and Yates 2006, p. 27; Inman *et al*. 2012~~07~~a, table 5, p. ~~p. 10~~789; Squires *et al*. 2007, p. 2218). No systematic population census exists over the entire current range of wolverines in the contiguous United States, so the current population level and trends are not known with certainty. However, based on our current knowledge of wolverine habitat, consistent occurrence records and records of females and reproduction, ~~occupied wolverine habita~~t and wolverine densities in this habitat, it is reasonable to estimate that the wolverine population in the contiguous United States numbers approximately 250 to 300 individuals (Inman et al.2013a ~~Inman 2010b, pers. comm.~~). The bulk of the current population occurs in the northern Rocky Mountains (Montana and Idaho), with a few individuals in the North Cascades of Washington and one known individual male in each of~~in~~ the Sierra Nevada and southern Rocky Mountains. Within the area known to currently have wolverine populations, relatively few wolverines can coexist due to their territoriality (Persson et al. 2010, Inman et al. 2012a) and naturally low population densities, even if all areas were occupied at or near carrying capacity. Given the natural limitations on wolverine population density, it is likely that historical wolverine population numbers were also low (Inman et al. ~~2007a~~2013a entire~~, Table 6~~).

Comment [RMI52]: This estimate does not fall within the range of 1 per 65-337 km2. It is reported as an "ecological density" of 1.4-1.8/1000 km2 or up to 1/556 km2. I interpret this to mean that this estimate does not consider limitations to habitats that wolverines regularly use, meaning that this includes areas of low elevation sagebrush and grassland habitats found in their study area.

Comment [RMI53]: There are only 3 estimates from western montane habitats that I am aware of that were derived from methods other than "we captured most or all of them and if so density would be …

These were Lofroth and Krebs 2007, Squires et al 2007, and Inman et al 2012. There are many other rigorous estimates from Alaska (Golden, Royale, Becker) listed in table 5 in Inman et al.

Modern studies have shown that wolverines of the contiguous US do not use low elevation valley bottom habitats even where known home ranges are adjacent to locations where ungulate densities are high during winter, large carnivores are present and creating carrion, and human activity is minimal or absent (Copeland et al. 2007, Inman et. al. 2012a). Because of these natural limitations, it is possible that densities and population levels in the northern Rocky Mountains and North Cascades where populations currently exist may not be substantially lower than population densities were in these areas prior to European settlement. A reasonable initial hypothesis for wolverine carrying capacity within the western contiguous U.S. is approximately 600 individuals (Inman et al. 2013). However, historically, the contiguous United States population would likely have been nearly double the size ~~larger than~~ it is today due to the larger area occupied by populations when the southern Rocky Mountains, Bighorn Mountains, Sierra Nevada, and possibly also the Oregon Cascades and mountains of Utah, were occupied at full capacity (Inman et al. 2013a).

Comment [RMI54]: Is there a reason or any evidence suggesting that current densities matching historical densities is not probable rather than possible?

Wolverine Status in Canada and Alaska

The bulk of the range of North American wolverines is found in Canada and Alaska, where wolverines inhabit alpine tundra, boreal forest, and arctic habitats (Slough 2007, p. 78). Wolverines in Canada have been divided into two populations for management by the Canadian Government: an eastern population in Labrador and Quebec, and a western population that extends from Ontario to the Pacific coast, and north to the Arctic Ocean. The eastern population is currently listed as endangered under the Species At Risk Act in Canada, and the western population is designated as a species of special concern (COSEWIC 2003, p. 8).

Comment [RMI55]: I suggest using the word tundra rather than alpine tundra.

Comment [RMI56]: citation here instead of below

Comment [RMI57]: this is currently under review and will be updated soon.

The current status of wolverines in eastern Canada is uncertain. Wolverines have not been confirmed to occur in Quebec since 1978 (Fortin *et al*. 2005, p. 4). Historical evidence of wolverine presence in eastern Canada is also suspect because no evidence exists to show that wolverine pelts attributed to Quebec or Labrador actually came from that region; animals were possibly trapped elsewhere and the pelts shipped through the eastern provinces (COSEWIC 2003, p. 20). Wolverines in eastern Canada may currently exist in an extremely low-density population, or may be extirpated. Wolverines in eastern Canada, both historically and currently, could represent migrants from western populations that never became resident animals (COSEWIC 2003, pp. 20-21). The Federal Government of Canada has completed a recovery plan for the eastern population with the goal of establishing a self-sustaining population through reintroduction and protection (Fortin *et al*. 2005, p. 16).

Comment [RMI58]: The way this paragraph is written it sounds as if USFWS is stating that evidence for historical populations in eastern Canada is suspect and that wolverines may not have existed there. Then in the next two sentences it is stated that wolverines may currently exist there or have been extirpated. Overall this paragraph is confusing and appears to dismiss the potential for populations in eastern Canada to a greater degree than evidence supports. The COSEWIC document states things such as "There is a consensus among local biologists that the species is either extremely rare or extirpated" However, wolverines are "extremely rare" relative to other species wherever they exist, so this statement of opinion should not be taken to mean that they did not exist there historically. The COSEWIC document also states that "Population declines of the eastern wolverine are thought to be due to…" The Canadian government also has plans to reintroduce wolverines there and achieve a "minimum viable population of 100 animals" (p 21).

This paragraph needs some clarification, even if that is to say that both historical and current distribution of wolverines is unknown/questionable in eastern Canada.

Please also note that the vast majority of eastern Canada is predicted as suitable habitat based on the 2010 snow model that much of the listing decision is based upon. This needs further clarification below. Were wolverines likely distributed through much of eastern Canada historically or does the snow model over predict habitat? If wolverines were not and are not there, then what are the implications for the interpretation of the snow model?

Wolverines in western Canada and Alaska inhabit a variety of habitats from sea level to high elevations (Slough 2007, pp. 77-78). They occur in Alaska, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, Yukon, Northwest Territories, and Nunavut (Slough 2007, pp. 77-78). Since European colonization, a generally recognized range contraction has taken place in boreal Ontario and the aspen parklands of Manitoba, Saskatchewan, and Alberta (COSEWIC 2003, pp. 20-21; Slough 2007, p. 77). This range contraction occurred concurrently with a reduction in wolverine records for the Great Lakes region in the contiguous United States (Aubry *et al*. 2007, pp. 2155-2156). Causes of these changes are uncertain, but may be related to increased harvest, habitat modification, or climate change (COSEWIC 2003, pp. 20-21; Aubry *et al*. 2007, pp. 2155-2156; Slough 2007, pp. 77-78). Analysis supports climate change as a factor contributing to population declines in southern Ontario, because snow conditions necessary to support wolverines do not currently exist in the Great Lakes

Comment [RMI59]: This is circular logic. The study cited here (Aubry et al. 2007) used historical records (or lack thereof) to suggest that certain snow conditions were necessary for wolverines and then this states that lack of those snow conditions led to an absence of records.

region of the contiguous United States, and are marginal in southern Ontario (Aubry *et al*. 2007, p. 2154). It is not known if these snow conditions existed historically in the Great Lakes of the contiguous United States; however, the small number of wolverine records from this area suggests that they did not. It is possible that suitable snow conditions did reach further south in eastern Canada in 1850 than they do today, making wolverine dispersal attempts from Canada to the Great Lakes region of the contiguous United States more likely than they are now. Wolverines occurred historically on Vancouver Island and have been given status as a separate subspecies by some (Hall 1981, p. 109). The Vancouver Island population is now regarded as possibly extirpated; no sightings have occurred since 1992 (COSEWIC 2003, p. 18).

Comment [RMI60]: same as above

Wolverines in western Canada and Alaska appear to persist everywhere that habitat and climate conditions are suitable (COSEWIC 2003, pp. 13-21; Aubry *et al*. 2007, pp. 2152-2155; Slough 2007, p. 79; Copeland *et al*. 2010, Figure 2). Throughout this area, wolverines are managed by regulated harvest at the Provincial and State level. Population estimates for Canada and Alaska are rough because no wolverine surveys have taken place at the State or Provincial scale. However, the population in western Canada is estimated to include approximately 15,089 to 18,967 individuals (COSEWIC 2003, p. 22). The number of wolverines in Alaska is unknown, but they appear to exist at naturally low densities in suitable habitats throughout the state (Alaska Department of Fish and Game 2004, pp. 1-359). We have no information to indicate that wolverine populations have been reduced in numbers or geographic range in Alaska.

Comment [RMI61]: Are the areas of Alaska that are non-habitat according to the 1 of 7 years snow model actually devoid of reproducing populations of wolverines? What do the harvest records, density estimates (Becker, Golden) indicate?

The Complexity of Geographic Range Delineation

Information on the nature of historical and current locations of wolverine is lacking for several reasons. Wolverines tend to live in remote and inhospitable places away from human settlements, where they are seldom encountered, documented, or studied. Wolverines naturally occur at low population densities and are rarely and unpredictably encountered where they do occur. Naturally occurring densities are low enough that populations could have been eliminated prior to collection of written records in the initial areas of eastern North America settled by Europeans. Wolverines often move long distances in short periods of time; for example, when dispersing from natal ranges, wolverines may transit through habitats that are unsuitable for long-term survival (Aubry *et al*. 2007, p. 2147; Moriarty *et al*. 2009, entire; Inman *et al*. 2009, pp. 22-28; Brian 2010, p. 3). Such movements make it difficult to distinguish with certainty between occurrence records that represent established populations in suitable habitats and records that represent short-term occupancy or exploratory movements without the potential for establishment of home ranges, reproduction, or populations. These natural attributes of wolverines make it difficult to precisely determine their present range, or trends in range expansion or contraction, that may have occurred in the past. Therefore, we are cautious and use multiple lines of evidence when trying to determine where past wolverine populations occurred. Below, these include 1) historical records, 2) …

Throughout the remainder of this proposed rule, we focus on the use of verifiable and documented wolverine occurrence records to define historical and present range as we have determined that these records constitute the best scientific information available on the past and present distribution of wolverines (see Aubry *et al*. 2007, p. 2148; McKelvey *et al*. 2008, entire). Verifiable records are records supported by physical evidence such as museum specimens, harvested pelts, DNA samples, and diagnostic photographs. Documented records are those based on accounts of wolverines being killed or

Comment [RMI62]: Care should be taken throughout to recognize that humans and wolverines generally select habitats with different conditions. It should not be assumed that wolverines avoid humans or are sensitive to human disturbance because they are not found where humans are. This has been a common assumption that has been repeated in the popular and scientific literature enough to lead to the general belief that wolverines are sensitive to human activity. They may be sensitive, but the fact that they occur where humans generally do not should not be taken as an indication that this is true. Please take care to make sure this myth is not furthered in the proposed rule.

Having said that, once within good wolveirne habitat, our modeling suggest road density is a negative influence. This has implications for infrastructure discussed below. Inman et al 2013a.

Comment [RMI63]: Again, careful here with the circular logic of using the historical records and the interpretation of suitable habitat based on them.

Comment [RMI64]: The route of this animal is unknown. Genetics suggest it came from Idaho. The snow model suggest there is nearly continuous habitat along the coastal ranges.

captured. Use of only verifiable and documented records avoids mistakes of misidentification often made in eyewitness accounts of visual encounters of unrestrained animals in the wild. Visual-encounter records often represent the majority of occurrence records for elusive forest carnivores, and they are subject to inherently high rates of misidentification of the species involved, including wolverines (McKelvey *et al*. 2008, pp. 551-552). These misidentifications can result in ~~wildly~~ inaccurate conclusions about species occurrence (McKelvey *et al*. 2008, pp. 550-553).

Comment [RMI65]: It should be noted that evidentiary standards represent minimum distributions.

Aubry *et al*. (2007, entire) used only verifiable and documented records to investigate wolverine distribution through time. This paper is the only available comprehensive treatment of these distribution patterns that attempts to distinguish between records that represent resident animals versus animals that have dispersed outside of suitable habitat. For these reasons, we find that Aubry *et al.* (2007, entire) represents the best available summary of wolverine occurrence records in the contiguous United States at this time. Since the publication of Aubry *et al*. (2007, entire), verified records of wolverines have also been documented in Colorado and California, which we will describe in greater detail below.

Comment [RMI66]: Circular logic. A select set of records define suitable habitat, and then that interpretation of suitable habitat is then used to differentiate which records should be in the select set or not.

Aubry *et al*. (2007, entire) used verifiable and documented records from museum collections, literature sources, and State and Federal institutions to ~~trace~~ estimate changes in geographic distribution of wolverines in the historical record. They then used ~~an~~ overlays of potentially suitable wolverine habitats to determine which records represent wolverines in habitats that may support residency, and, by extension, populations, and which records likely represent wolverines outside the range of suitable habitats, so called "extralimital" records. Aubry *et al.*'s (2007, entire) focus on verifiable and documented records corrected past overly broad approaches to wolverine range mapping (Nowak 1973,

p. 22; Hall 1981, p. 1009; Wilson 1982, p. 644; Hash 1987, p. 576), which used a more inclusive but potentially misleading approach when dealing with occurrence records. Many of the extralimital records used in these publications represented individuals that dispersed from natal ranges but ended up in habitats that could not support wolverines. Use of these data to determine the historical geographic range of wolverines results in gross overestimation of the area that can actually be used successfully by wolverines for the establishment of populations. Subsequent to publication of Aubry *et al*. (2007, entire), two publications (Copeland *et al*. 2010, entire; Brock *et al*. 2007, entire) further refined our understanding of wolverine habitat needs and corroborated the approach of Aubry *et al*. (2007, entire). Thus, despite the paucity of verifiable records, we now have strong information on the areas that are currently suitable to be occupied by wolverine based on habitat and climate conditions.

Comment [RM167]: This was available in May 2007, prior to Aubry et al which was published in Sept 2007

We agree with Aubry *et al*. (2007, p. 2149) that the most appropriate method to determine the current and historical range of wolverines is to use a combination of occurrence records and habitat suitability, along with other information, such as documented successful reproduction events, indicating where reproductive and potentially self-sustaining populations may occur. We also generally agree with their conclusions about the historical and current range of the species. We find that the species' range is the area that may support viable populations, and does not include extralimital occurrences outside of habitat that is likely to support wolverine life-history needs. Areas that can support wolverine populations may be referred to as potential "source" populations because they provide surplus individuals through reproduction beyond what is needed for replacement. Areas that have some of the habitat attributes of wolverine habitat but do not have enough habitat to support viable populations may be referred to as population "sinks" because wolverines may disperse to these areas and remain for some time, but will either die there without reproducing, leave the area in search of better habitat

conditions, or may actually reproduce, but at a rate lower than that needed for replacement of individuals lost to mortality or emigration, leading to eventual population extinction.

For a widely dispersing species like the wolverine, we expect many locality records to represent dispersal attempts into sink habitats or nonhabitat. The value to the population (and thus the DPS) of dispersers in these areas is unclear; it is likely that most dispersers into sink habitats or nonhabitat will be lost to the population unless they are able to move back into source habitats. Therefore, it is our conclusion that population sink areas and areas of non-wolverine habitat, here defined as places where wolverines may be found but where habitat is not suitable for long-term occupancy and reproduction, do not represent part of the species historical range and have little conservation value for the DPS, other than possibly serving as temporary stop-overs for attempted dispersers as they search for suitable habitats. Compared with broader approaches to defining historical geographic range, this focused approach (1) results in reducing the bias of extralimital dispersers and (2) concentrates conservation attention on areas capable of maintaining populations.

Aubry *et al*. (2007, pp. 2147-2148) divided records into "historical" (recorded prior to 1961), "recent" (recorded between 1961 and 1994), and "current" (recorded after 1994). Historical records occurred before systematic surveys. Historical records encompass the time during which wolverine numbers and distribution were hypothesized to be at their highest (prior to European settlement) and also at their lowest (early 20th century) (Wright and Thompson 1935; Grinnell *et al*. 1937; Allen 1942; Newby and Wright 1955, all as cited in Aubry *et al*. 2007, p. 2148). The recent time interval covers a hypothesized population expansion and rebound from the early 20th century low. Current records offer the most recent evidence available for wolverine occurrences and potential populations. All occurrence

Comment [RMI68]: "Sink" habitats can act as important genetic reservoirs and can become source areas. This may be important to consider in the context of contiguous US wolverines and climate change. Dias (1996) suggested if sink habitats hold enough individuals, a significant portion of the population can begin adapting to sink conditions, and the sinks can over the long-term become sources. Boughton (1999) documented this phenomenon. Recent genetics work by Zigouris et al. 2012 on wolverines at the edge of their range in eastern Canada are also relevant to the discussion here.

Boughton, D. A. 1999. Empirical Evidence for Complex Source-Sink Dynamics with Alternative States in a Butterfly Metapopulation. Ecology 80:2727–2739.

Dias, P. C. 1996. Sources and sinks in population biology. Trends in Ecology and Evolution 11:326–330.

Zigouris, J., F.N. Dawson, J. Bowman, R.M. Gillett, J.A. Schaefer, and C.J. Kyle. 2012. Genetic isolation of wolverine (Gulo gulo) populations at the eastern periphery of their North American distribution. Conservation Genetics 13:1543–1559.

Comment [RMI69]: see literature and discussion above.

Comment [RMI70]: Given the clear and absolutely necessary need for dispersal among patches of suitable habitat in the contiguous US (Copeland et al 2010, Inman et al 2012 2013) dismissing these areas as having "little conservation value" is completely out of line with our understanding of the species ecology. I understand that the intent here is to differentiate among core areas (sources) and non-core areas, but the non-core areas have an absolutely critical function for wolverines that cannot be overlooked and this impression should not be given in any way.

Comment [RMI71]: These records began in 1800. Can you be sure that the scarcity of records from the northeast and great lakes areas was due to unsuitable habitat conditions or is it possible that populations occurring in these areas/habitats were simply wiped out earlier than any attempt to keep records? Two centuries of european trapper activity.

Because it is assumed that records from these areas would have been attainable and recorded if habitat conditions were suitable for wolverines, this has important implications for the subsequent steps made in Copeland et al. 2010, McKelvey et al. 2011, and the proposed rule.

records must be individually analyzed in light of their context in terms of habitat conditions conducive to wolverine population establishment and whether or not they occur clustered with other records, which might indicate that populations have historically occurred in the area. The authors of Aubry *et al*. (2007) did such an analysis as they compiled their records.

Wolverine Distribution

We assessed the historical, recent, and current distribution data for each of the regions below to determine the likelihood of the presence of historical populations (rather than extralimital dispersers). Of 729 mappable records (those records with precise location information) compiled by Aubry *et al*. (2007, p. 2150), 188 were from the historical time interval (see Table 1). The discussion below draws heavily from both Aubry *et al*. (2007, entire) and Copeland *et al*. (2010, entire).

Comment [RMI72]: Much of the discussion below is based upon the circular logic of using historical records to define suitable habitat as the spring snow layer of Copeland 2010 followed by using the spring snow layer of Copeland 2010 to justify whether records were populations vs. extralimital.

Other independently derived sources of "suitable habitat" are available but not used (i.e., Inman et al 2013a). This estimation of suitable wolverine habitat uses telemetry data to define areas suitable for resident adults and also areas suitable for dispersing individuals. It defines populations vs. extralimital independent of the historical records. This estimation of suitable wolverine habitat was also tested with multiple independent wolverine location datasets and performed extremely well. One of the test datasets was the historical location dataset of Aubry et al. 2007.

Inman, R., B. Brock, K. Inman, S. Sartorius, B. Aber, B. Giddings, S. Cain, M. Orme, J. Fredrick, B. Oakleaf, K. Alt, E. Odell, and G. Chapron. 2013. Developing a spatial framework and conservation priorities for a wolverine metapopulation. Paper III in R. M. Inman, Wolverine ecology and conservation in the western United States. PhD Dissertation, Grimsö Wildlife Research Station, Department of Ecology, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Table 1. Wolverine records from three time periods from Aubry *et al*. 2007. Numbers represent total documented and verifiable records with the subset of those records that were verifiable in parentheses.

	Historical (<1964)	Recent (1961-1994)	Current (>1994)
Northeast			

	13 (1)
	0
	0
Upper Midwest	
	4 (2)
	0
	0
Great Lakes	
	36 (4)
	1
	0
Central Great Plains	
	71* (2)
	30

		1	
		0	
Rocky Mountains			
		147 (45)	
		332 (283)	
		215 (210)	
Pacific Coast			
		89 (14)	
		23 (15)	
		7	
TOTALS			
		362 (68)	
		357 (298)	
		31	

222 (210)

* 35 records from a single source (the journals of Alexander Henry).

Northeast and Upper Midwest—The low number of records and scattered nature of their distribution combined with a lack of suitable habitat indicate that wolverines were likely only occasional transients to the area and not present as a reproducing population after 1800.

Great Lakes—The lack of large numbers of verifiable records after 1900? in this area of relatively high human population density and the lack of suitable habitat suggests that wolverines did not exist in this area as a viable population after 1900. Widely scattered records generally before 1900, along with occasional subsequent records suggest that if a reproducing population existed in the Great Lakes, it predated 1900, and that any post-1900 records represent dispersal from a receding Canadian population. Wolverine distribution in Ontario, Canada, appears to have receded north from the Great Lakes region since the 1800s, and currently wolverines occupy only the northern portion of the province, a distance of over 644 km (400 mi) from the United States border (COSEWIC 2003, p. 9). The distribution pattern of record illustrated in Aubry *et al*. (2007, p. 2152) is consistent with what would be expected if those records were of dispersing individuals from a Canadian population that receded progressively further north into Canada after 1800, possibly due to natural climate changes (COSEWIC 2003, p. 28).

Comment [RMI73]: Again, circular logic. The records, or lack thereof, were used to identify suitable habitat. Then the absence of suitable habitat is used to suggest that the low number of records was due to there being no habitat. 200 years of european trapper activity totally unregulated prior to records used by Aubry et al 2007/

Comment [RMI74]: Again, the circular logic of records defining habitat and habitat defining the nature of records.

Comment [RMI75]: Human population density and land use changes may very well have been significant enough to cause this apparent decline by 1900. If that were the case, then the persistent snow coverage of Copeland et al 2010 would not capture or even come close to capturing all the areas of wolverine distribution (See figure 1 Copeland 2010 in area of Minnesota, Wisconsin, Michigan). In order to substantiate the conclusions of Copeland et al 2010, it is necessary to dismiss the great lakes region as having an historical population. Otherwise, the 1 of 7 year snow model would not capture all of the known areas of distribution.

I note here that a female wolverine was documented living in the wild for 6 years in the Michigan thumb, well south of the area that the temperature hypothesis in Copeland et al. 2010 uses. Further evidence against the temperature hypothesis include wolverines in zoos in Roanoke Virginia and Singapore.

Comment [RMI76]: Has climate changed only in the great lakes region?

Why is it OK to suggest the historical records don't match spring snow in the great lakes area because climate warming there has shifted habitat, but not do the same for other areas? Has climate warming "since the 1800s" only affected the great lakes region? How does the correlation between spring snow and wolverine records shift if this assumption is applied to all areas?

Central Great Plains—The lack of precise locality records and suitable habitat from the Great Plains States leads us to conclude that reproducing populations of wolverines did not historically inhabit this area. Of thirty-six records from North Dakota, 35 are from the journals of a single fur trader (see Table 1), and it is not clear that the records represent actual collection localities or are localities where trades or shipments occurred (Aubry 2007, pers. comm.). Given the correlation established in ~~the habitat relationships of wolverines (e.g.,~~ Copeland *et al*. (2010~~, Figure 1~~), it is unlikely that these records represent established wolverines or that this area served as wolverine habitat.

Comment [RM177]: Again, "suitable habitat" as defined by spring snow was deduced with the records. No records here means spring snow defines habitat, and no habitat here explains the lack of records.

Comment [RM178]: This is one place where the Inman et al 2013a a prediction of suitable habitat that was derived independently of the historical records would provide stronger support for the conclusion that the great plains were not and are not suitable for wolverines.

Rocky Mountains—Five Rocky Mountains States (Idaho, Montana, Wyoming, Colorado, and Utah) contained numerous wolverine records. Records with precise locality information appear to coalesce around several areas that may have been population centers, such as central Colorado, the greater Yellowstone region, and northern Idaho-northwestern Montana. The large number of verifiable and documented historical records for this region, including~~along with~~ the suggestion of population centers or strongholds, suggests that wolverines existed in reproducing populations throughout much of the Rocky Mountains during the historical time interval. Recent and current records (Aubry et al. 2007) along with telemetry studies (Hornocker and Hash 1981, Copeland 1996, Inman et al. 2012a) and widespread documentation of reproducing females in Montana (Anderson and Aune 2008) verify that this is the case. The lack of records for Colorado and Utah after 1921 suggests that the southern Rocky Mountains population of wolverines was extirpated in the early 1900s, concurrent with widespread systematic predator control by government agencies and livestock interests. The northern Rocky Mountains population (north of Wyoming) was reduced to historical lows or possibly even extirpated during the early 1900s, and then increased dramatically in the second half of the 1900s (see Table 1) as

Comment [RM179]: how many historical per square mile compared to great lakes?

predator control efforts subsided and trapping regulations became more restrictive (Aubry *et al*. 2007, p. 2151). This increase likely indicates a population rebound from historical lows in this period.

Wolverine records from 1995 to 2005 indicate that wolverine populations currently exist in the northern Rocky Mountains (see Table 1). Legal trapping in Montana in the recent past removed an average of 10.5 individuals from this population each year (Montana Department of Fish, Wildlife, and Parks 2007, p. 2), but harvest mortality has been reduced due to regulatory changes in 2004, 2008 (Montana Department of Fish, Wildlife and Parks 2008, p. 8). Populations in British Columbia and Alberta, Canada, are extant (COSEWIC 2003, pp. 18-19), and may have been a source of surplus wolverines to the contiguous United States population during population lows (Newby and Wright 1955). Recently, a male wolverine moved on its own from the southern Greater Yellowstone Area of Wyoming into the southern Rocky Mountains of Colorado, where it still persisted as of November 2012 (Inman *et al*. 2009, pp. 22-26; Odell 2012, pers. comm.). This attempted dispersal event is the first verified wolverine occurrence in Colorado since 1919 and may represent a continuation of the wolverine expansion in the Rocky Mountains noted~~detailed~~ above. It is possible that other wolverines have traveled to the southern Rocky Mountains and have remained undetected. There is no evidence that Colorado currently hosts a wolverine population or that female wolverines have made, or are likely to make, similar movements. Female dispersal movements tend to be much shorter than males, usually occupying home ranges adjacent to their natal range (Aronsson 2009), and female dispersal is typically not as distant as male dispersal ~~documented only for lesser distances than males routinely travel~~ (Hornocker and Hash 1981, p. 1290; Copeland 1996, p. 91; Kyle and Strobeck 2001, p. 338; Tomasik and Cook 2005, p. 390; Cegelski *et al.* 2006, p. 206, Inman *et al*. ~~2011~~2012a, p. 784). The largest documented female movement occurred in 2010 in the North Cascades of Washington (Aubry *et al*.

Comment [RMI80]: I have come to realize that regulation of trapping may not have had as much to do with populations increasing as I have thought previously. As shown by Newby and Wright 1955 and Newby and McDougal 1964 along with Aubry et al 2007, wolverines appeared to recover from a low point between about 1930 and 1970. Wolverines were not designated as protected species or even furbearers until the 1970s. Access may have played a large role if this were the case. Somewhere below I discuss this in more detail.

Comment [RMI81]: Given the eventual focus of the proposed rule on trapping and incidental take, this is an inadequate description of the information available regarding trapping and the management actions/history within Montana.

Comment [RMI82]: See Aronsson 2009

Comment [RMI83]: Need to check these references to make sure they have the info here. Missing Vangen et al. 2003, Flagstad. Magoun 1985

2011, pp. 21-22). In that instance, a radio-collared female wolverine moved an air-line distance of approximately 233 km (145 mi) over a 44-day period. During this movement, her course generally stayed within suitable wolverine habitat (as defined by Copeland *et al*. (2010, p. 242)) and was never more than about 19 km (12 mi) from suitable wolverine habitat.

Pacific Coast—Historical records show that wolverines occurred in two population centers in the North Cascades Range and the Sierra Nevada. However, records do not show occurrences between these centers (across~~from~~ southern Oregon through~~o~~ northern California), indicating that the historical distribution of wolverines in this area is best represented by two disjunct populations rather than a continuous peninsular extension from Canada. This conclusion is supported by genetic data indicating that the Sierra Nevada and Cascades wolverines were separated for at least 2,000 years prior to extirpation of the Sierra Nevada population (Schwartz *et al*. 2007, p. 2174).

Only one Sierra Nevada record exists after 1930, indicating that this population was likely extirpated in the first half of the 1900s, concurrent with widespread systematic predator control programs. In 2008, a male wolverine was discovered in the Sierra Nevada Range of California, the first verified record from California since 1922 (Moriarty *et al*. 2009, entire). Genetic testing revealed that this wolverine was not a descendant of the endemic Sierra Nevada wolverine population, but was likely derived from wolverines in the Rocky Mountains (Moriarty *et al*. 2009, p. 159). This attempted dispersal event may represent a continuation of the wolverine expansion in the contiguous United States as detailed above. Other wolverines may have travelled to the Sierra Nevada and remain undetected. There is no evidence that California currently hosts a wolverine population or that female wolverines have made, or are likely to make, similar dispersal movements.

Comment [RMI84]: For this paragraph, I suggest adding discussion of male-biased dispersal typical of mammals. Relevant material and citations can be found in Inman 2013 dissertation, paper III, page 17 2nd paragraph.

Comment [RMI85]: Also indicating that there are consequential limitations to the persistent spring snow model because it predicts nearly continuous habitat from Washington to California.

This is a good example of the lack of objectivity in assessing the validity of the snow model. Very little effort or substance was given to evaluation of A) dens/locations falling outside of the predicted snow coverage and B) areas of snow coverage with no records or evidence of a population. It may well overpredict in some places (Oregon, Greenland) as well as underpredict in other places (25% locations fall outside snow model in places [see table 1 in Copeland 2010], Ontario). This would not be as concerning if the snow model had been interpreted within its reasonable limits – that snow and cold temperatures are important for wolverines. But instead it was theorized that this was due to an obligate relationship, and this theory has been taken to be truth, i.e., as the single defining characteristic of "suitable wolverine habitat."

Comment [RMI86]: This statement is made frequently within this document and in many others. I have never seen a citation, and although this is general knowledge, I would like to see citations and specifics given related to the exact time periods when these activities began and ended.

Comment [RMI87]: If the snow model of Copeland et al. 2010 is taken as the "best available" prediction of habitat (USFWS p. this document), then this statement cannot be true. The snow model predicts nearly continuous habitat from the Canadian border to the Sierra Nevadas. Where gaps occur, they are certainly within the observed dispersal distances for female wolverines.

Wolverines were likely extirpated from the North Cascades in the early 20th century and then recently recolonized from Canada. Currently, a small population persists in this area (Aubrey *et al*. 2011, entire). In 2012, reproduction was documented for the first time in the North Cascades (Aubry *et al*. 2012, p. 2). Wolverines have also been documented in the southern portion of the North Cascades, near Mount Adams, since 2009 (Akins 2010, p. 4). The North Cascades population ~~may be~~is connected with, and is possibly dependent on, the larger Canadian population for future expansion and long-term persistence.

Comment [RMI88]: The low point in the historical records (Aubry et al 2007) for Washington occurred during the 1920s-1930s. There were 10 verifiable and documented records from Washington in the 1960's, only Montana had more with 14. There are consistent records from Washington from the 1940s through the present day. This is true for only 2 other pacific and rocky mountain states, Montana and Idaho. All 3 of these states border Canada where large populations exist and appear to have existed for decades, and both Montana and Idaho are known to host current reproducing populations of wolverines. What is the basis for stating that recolinization occurred only recently in Washington?

Summary of Wolverine Distribution

Historical wolverine records were found across the northern tier of the contiguous United States, with convincing evidence of wolverine populations in the northern and southern Rocky Mountains, Sierra Nevada Mountains, and North Cascades Mountains (Aubry *et al*. 2007, p. 2152).

Comment [RMI89]: This interpretation unduly dismisses the potential for historical populations in the great lakes and northeast. This interpretation is based too much on circular logic whereby records are used to justify habitat and then habitat is used to justify/distinguish populations from dispersers. This interpretation is also based on there being significant climate change effects in the great lakes region only, and it ignores the possibility that records in these areas are simply not present because the small populations typical of wolverines could have been extirpated in these areas during the 2 centuries of european trapper activity with no regulations whatsoever that occurred prior to records being collected or being a part of the records beginning in 1800 that Aubry et al 2007 examined.

European trappers were active by the early 1600s.

Currently, wolverines appear to be distributed as functioning populations in two regions in the contiguous United States: the North Cascades in Washington, and the northern Rocky Mountains in Idaho, Montana, and Wyoming (this area also includes the Wallowa Range in Oregon). Wolverines were likely extirpated, or nearly so, from the entire contiguous United States in the first half of the 20th century (Aubry *et al*. 2007, Table 1). Although the reasons for this extirpation are not known with certainty, unregulated trapping and widespread indiscriminant predator control likely contributed to population declines. The available evidence suggests that, in the second half of the 20th century and continuing into the present time, wolverine populations have expanded in the North Cascades and the

northern Rocky Mountains from sources in Canada, but that populations have not been reestablished in the Sierra Nevada Range or the southern Rocky Mountains, despite the known movement of single individual males to each of these areas. We conclude that the current range of the species in the contiguous United States includes the North Cascades Mountains, the northern Rocky Mountains, the southern Rocky Mountains, and the Sierra Nevada Mountains, but that reestablishment of populations in the southern Rocky Mountains and Sierra Nevada Mountains has not yet occurred.

We also conclude that wolverines either did not exist as established populations, or were extirpated prior to settlement and the compilation of historical records, in the Great Lakes region, possibly due to climate changes that occurred through the 1800s and 1900s. The Great Lakes region lacks suitable wolverine habitat, and suitable habitat does not appear to exist in adjacent Canada (Copeland *et al.* 2010, Figure 1). The widely scattered records from this region are consistent with dispersing individuals from a Canadian population that receded north early in the 1800s. We cannot rule out the possibility that wolverines existed as established populations prior to the onset of trapping in this area, but we have no evidence of this.

No evidence in the historical records indicates that wolverines were ever present as established populations in the Great Plains, Midwest, or Northeast.

Habitat Relationships and Wolverine Distribution

Deep, persistent, and reliable spring snow cover (April 15 to May 14) is the best overall predictor of wolverine occurrence in the contiguous United States (Aubry *et al*. 2007, pp. 2152-2156;

Comment [RMI90]: This conclusion is based on circular logic and is speculation that does not have adequate support.

Comment [RMI91]: This appears to have happened, but the cause is as likely to be from human activity as from climate change. Speculatory. If climate changed here, it must have changed elsewhere also. Why it this not considered when examining the match of records and habitat in other regions?

Comment [RMI92]: USFWS has relied entirely on a single estimate of what is suitable habitat to make this statement. Suitable climatic conditions may still exist. There is no evidence of this nor against it.

Comment [RMI93]: Areas where there is spring snow in only 14% of years (1 of 7) should not be referred to as "reliable."

Comment [RMI94]: I am not sure that USFWS can back this statement up. I agree that the area covered by snow through 15 May in at least 14% of years (C2010) is a parsimonious predictor of wolverine occurrence that fits well in the western United States and that can easily be related to climate variables. That is its intent and strength. However no test has been made to compare it with the predictive capabilities of the suitable habitat predicted with telemetry data and habitat variables including but not limited to snow in Inman et al. 2013a. Throwing all the telemetry and den locations at them both would be interesting.

Copeland *et al*. 2010, entire). Deep, persistent snow correlates well with wolverine year-round habitat use across wolverine distribution in North America and Eurasia at both regional and local scales (Copeland *et al*. 2010, entire; Inman *et al*. 2012a, p. 785, 2013). It is uncertain why spring snow cover so accurately predicts wolverine habitat use; however, it is likely related to wolverines' need for deep snow during the denning period. In addition, wolverines appear to take advantage of a cold, low-productivity niche by using food caching in cold habitats to survive food-scarce winters that other carnivores cannot (Inman *et al*. 2012b, pp. 640-642). Wolverines' physiological requirement for year-round cold temperatures may also play a role in habitat use (Copeland *et al*. 2010, pp. 242-243). Snow cover during the denning period is essential for successful wolverine reproduction range-wide (Hatler 1989, p. iv; Magoun and Copeland 1998, p. 1317; Inman *et al*. 2007c, pp. 71-72; Persson 2007; Copeland *et al*. 2010, p. 244). Wolverine dens tend to be in areas of high structural diversity such as logs and boulders with deep snow (Magoun and Copeland 1998, p. 1317; Inman *et al*. 2007c, pp. 71-72; Persson 2007, entire). Reproductive females dig deep snow tunnels to reach the protective structure provided by logs and boulders. This behavior presumably protects the vulnerable kits from predation by large carnivores, including other wolverines (Pulliainen 1968, p. 342; Zyryanov 1989, pp. 3-12), but may also have physiological benefits for kits by buffering them from extreme cold, wind, and desiccation (Pullianen 1968, p. 342, Bjärvall *et al*. 1978, p. 23). Wolverines live in low-temperature conditions and appear to select habitats in part to avoid high summer temperatures (Copeland *et al*. 2010, p. 242). Wolverine distribution is likely affected by climatic conditions at two different scales. Wolverines require deep persistent snow for denning, and this likely determines where wolverine populations can be found at the grossest range-wide scale (Copeland *et al*. 2010, p. 244). At smaller scales, wolverines likely select habitats to avoid high summer temperatures. These cool habitats also

Comment [RMI95]: THIS IS CRITICAL TO NOTE, See summary comments. More likely related to ability to compete for food.

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Comment [RMI96]: This is an overstatement of the available data. Yes dens almost always have snow, but this does not mean snow is essential for reproduction and the cause for the limit to distribution.

I believe this is the point in the proposed rule where the hypothesized explanation (obligate snow denning) for the correlation observed in Copeland et al. 2010 (snow through 15 May in at least 14% of years) begins being taken as an established fact, which it is not.

There is a correlation in Copeland et al. 2010. The correlation is between wolverines and areas with snow through 15 May in as few as 1 of 7 (14%) of years. However, there is no biological basis for the obligate denning hypothesis that is proposed as an explanation for the correlation: wolverines don't have to have dens under snow through May 15 when the young are well-furred and capable of travelling; snow is not the only material capable of insulating young from cold temperatures at this time (May) or any time. Wolverines were not absent from the great plains because they could not find thermal cover for newborn young there. It is far more likely that they were absent from the great plains because there was insufficient escape cover there and their adaptive strategies that allow them to successfully compete for enough food resources to survive and reproduce (Inman et al. 2012a, 2012b) simply do not function in those warm, highly productive areas where competition and biodiversity are vastly greater than in areas with short growing seasons and temperatures that are typically cold enough to inhibit competition from other scavengers such as insects and bacteria. Their distribution is limited by where they can successfully survive and compete for food. They all have to do this for about 3-4 years before giving birth.

The refrigeration hypothesis offers a far more compelling, although equally unproven (but less disproven), HYPOTHESIS for the limits to wolverine distribution and a correlation between wolverines and snow through 15 May in as few as 14% of years.

Certainly wolverines are linked to/correlated with cold, snowy places. But the reason that the spring ...

Comment [RMI97]: This implies that all dens consist of a tunnel through deep snow leading to structure. Somewhat misleading. Many of the dens we located had structure (logs) extending above the snow even during February and March. So the entrance was not a snow tunnel, but rather an opening in the snow that was largely a result of the log. Typically the tunnels were primarily under the logs rather than dug.

Comment [RMI98]: Speculation, here and in other pieces of literature and in the 2010 paper where presented as a hypothesis of this nature.

tend to retain snow late into spring, leading to wolverines' year-round association with areas of persistent spring snow (Copeland *et al*. 2010, p. 244).

All of the areas in the contiguous United States for which good evidence of persistent wolverine populations (either present or historical) exists (i.e., North Cascades, Sierra Nevada, northern and southern Rocky Mountains) contain large and well-distributed areas of deep snow cover that persists through the wolverine denning period (~~Inman *et al*. 2011, Fig. 3;~~ Aubry *et al*. 2007, p. 2154; Copeland *et al*. 2010, Figure 1). The Great Plains, Great Lakes, Midwest, and Northeast lack the spring snow conditions and low summer temperatures thought to be required by wolverines for successful reproduction and year-round occupancy (Aubry *et al*. 2007, p. 2154; Copeland *et al*. 2010, Figure 1). The lack of persistent spring snow conditions in the Great Plains, Great Lakes, Midwest, and Northeast supports the exclusion of these areas from the current range of wolverines. Whether wolverines once existed as established populations in any of these regions is uncertain, but the current climate appears to preclude their presence as reproducing populations, and the sparse historical record of wolverine presence in this area makes historical occupation of these areas by wolverine populations doubtful. It is our conclusion that the ecosystem that supports wolverines does not exist in these areas currently, and may not have existed at the time of European settlement of these areas.

Large areas of habitat with characteristics suitable for wolverines still occur in the southern Rocky Mountains and Sierra Nevada, despite the extirpation of wolverines from those areas (Aubry *et al*. 2007, p. 2154, ~~Inman et al. 2011~~Inman et al. 2013, Fig. 4; Copeland *et al*. 2010, Figure 1, Frey 2006). Wolverine extirpations in these areas were coincident with unregulated trapping and systematic predator eradication efforts in the early 1900s, which have been discontinued for many years. Each of

Comment [RMI99]: This is all speculation based on 2 hypotheses, neither of which appear to bear out.

The origins of the Michigan wolverine are debated, but it is a fact that she lived in the wild for ~6 years in an area far south of the snow model's 1/7 years layer and the temperature layer. See Copeland et al. 2010 Fig 1.

Comment [RMI100]: this is based on the circular logic of Aubry et al 2007.

Comment [RMI101]: should these citations be for telemetry studies and records such as historical and Montana? good evidence of populations

Comment [RMI102]: When this is constantly referred to as "spring snow conditions" it gives the impression that the obligate need to den in snow through 15 May is a fact and the primary reason wolverines either can or cannot be somewhere. This does not appear to bear out to be the case. Please use some other terminology such as "cold, often snow-covered conditions" to be more accurate.

Comment [RMI103]: Please use some other terminology such as "cold, often snow-covered conditions" to be more accurate.

Comment [RMI104]: Factors other than climate may be limiting their distribution in areas such as the great lakes, and if this were the case, the conclusions of Copeland et al. 2010 would be in error.

Comment [RMI105]: again, in the great lakes area records may not have been recorded prior to wolverines being wiped out.

Comment [RMI106]: I agree with this statement for the plains and Midwest (which may not have been defined), but question it for the great lakes and northeast.

these areas has received at least one and possibly more migrants from adjacent populations in the northern Rocky Mountains; however, there is no evidence that females have migrated to these areas or that populations of wolverines currently exist there (Aubry *et al*. 2007, *Table 1*; Moriarty *et al*. 2009, entire; Inman *et al*. 2009, entire).

We conclude that areas of wolverine historical occurrence can be placed in one of three categories: (1) Areas where wolverines are extant as reproducing and potentially self-sustaining populations (North Cascades, northern Rocky Mountains); (2) areas where wolverines historically existed as reproducing and potentially self-sustaining populations prior to human-induced extirpation, and where reestablishment of those populations is possible given current habitat conditions and management (the Sierra Nevada Mountains in California and the southern Rocky Mountains in Colorado, New Mexico, Wyoming, the Uinta Mountains and surrounding ranges in Utah, the Bighorn Mountains in Wyoming, and possibly the Oregon Cascades Mountains); and (3) areas where historical presence of wolverines in reproducing and potentially self-sustaining populations is doubtful, and where the current habitat conditions preclude the establishment of populations (Great Plains, Midwest, Great Lakes, and Northeast). We, therefore, consider the current range of wolverines to include suitable habitat in the North Cascades of Washington, the northern Rocky Mountains of Idaho, Wyoming, Montana, and eastern Oregon, the southern Rocky Mountains of Colorado and Wyoming, and the Sierra Nevada of California. We here include the Sierra Nevada and southern Rocky Mountains in the current range of wolverines despite the probability that functional populations do not exist in these areas. They are included due to the known existence of one individual in each area and the possibility that more, as yet undetected, individuals inhabit these areas.

Comment [RMI107]: Suggest removing. Much is made later with the effective population size discussion and elsewhere suggesting the entire contiguous US population is not "self-sustaining."

Comment [RMI108]: further analysis is needed to determine the likelihood of the Oregon cascades and Great Lakes.

Comment [RMI109]: I don't recall having seen any discussion of the recent, multi-year presence of the female wolverine in Michigan in the above section. The California and Colorado males are mentioned. Why not the female in Michigan? Is the presence of this female outside of the snow model's predicted habitat inconsequential? Dismissible? For what reason?

Distinct Population Segment

Pursuant to the Act, we must consider for listing any species, subspecies, or, for vertebrates, any Distinct Population Segment (DPS) of these taxa, if there is sufficient information to indicate that such action may be warranted. To interpret and implement the DPS provision of the Act and Congressional guidance, the Service and the National Marine Fisheries Service published, on February 7, 1996, an interagency Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Act (61 FR 4722). This policy addresses the recognition of DPSs for potential listing actions. The policy allows for more refined application of the Act that better reflects the biological needs of the taxon being considered, and avoids the inclusion of entities that do not require its protective measures.

Under our DPS policy, three elements are considered in a decision regarding the status of a possible DPS as endangered or threatened under the Act. These are applied similarly for additions to the list of endangered and threatened species, reclassification, and removal from the list. They are: (1) Discreteness of the population segment in relation to the remainder of the taxon; (2) the biological or ecological significance of the population segment to the taxon to which it belongs; and (3) the population segment's conservation status in relation to the Act's standards for listing (i.e., whether the population segment is, when treated as if it were a species or subspecies, an endangered or threatened species). Discreteness refers to the degree of isolation of a population from other members of the species, and we evaluate this factor based on specific criteria. If a population segment is considered discrete, we must consider whether the discrete segment is "significant" to the taxon to which it belongs by using the best available scientific and commercial information. If we determine that a population segment is both discrete and significant, we then evaluate it for endangered or threatened

species status based on the Act's standards. The DPS evaluation in this proposed rule concerns the segment of the wolverine species occurring within the contiguous 48 States, including the northern and southern Rocky Mountains, Sierra Nevada Range, and North Cascades Range.

Distinct Population Segment Analysis for Wolverine in the Contiguous United States

Analysis of Discreteness

Under our DPS Policy, a population segment of a vertebrate species may be considered discrete if it satisfies either one of the following conditions: (1) It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors (quantitative measures of genetic or morphological discontinuity may provide evidence of this separation); or (2) it is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act (inadequacy of existing regulatory mechanisms). The wolverine within the contiguous United States meets the second DPS discreteness condition because of differences in conservation status as delimited by the Canadian-United States international governmental boundary.

In our 12-month finding for the North American wolverine DPS (75 FR 78030) we conducted a complete analysis of the discreteness of the wolverine DPS that we incorporate here by reference. In that analysis we concluded that the international boundary between Canada and the United States currently leads to division of the control of exploitation and conservation status of the wolverine. This

division is significant because it allows for potential extirpation of the species within the contiguous United States through loss of small populations and lack of demographic and genetic connectivity of the two populations. This difference in conservation status is likely to become more significant in light of threats discussed in the five factors analyzed below. Therefore, we find that the difference in the conservation statuses in Canada and the United States result in vulnerability to the significant threat (discussed below) in the U.S. wolverine population but not for the Canadian population. Existing regulatory mechanisms are inadequate to ensure the continued existence of wolverines in the contiguous United States in the face of these threats. Therefore, it is our determination that the difference in conservation status between the two populations is significant in light of section 4(a)(1)(D) of the Act, because existing regulatory mechanisms appear sufficient to maintain the robust conservation status of the Canadian population, while existing regulatory mechanisms in the contiguous United States are insufficient to protect the wolverine from threats due to its depleted conservation status. As a result, the contiguous United States population of the wolverine meets the discreteness criterion in our DPS Policy (61 FR 4725). Consequently, we use the international border between the United States and Canada to define the northern boundary of the contiguous United States wolverine DPS.

Comment [RMI110]: How is it that existing regulatory mechanisms are sufficient to maintain Canadian but not US populations?

Analysis for Significance

If we determine a population segment is discrete, its biological and ecological significance will then be considered in light of Congressional guidance that the authority to list DPSs be used sparingly while encouraging the conservation of genetic diversity. In carrying out this examination, we consider available scientific evidence of the population's importance to the taxon to which it belongs (i.e., the

North American wolverine (*Gulo gulo luscus*)). Our DPS policy states that this consideration may include, but is not limited to: (1) Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon; (2) evidence that loss of the discrete population segment would result in a significant gap in the range of the taxon; (3) evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historical range; or (4) evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

In our 12-month finding (75 FR 78030), we conducted an exhaustive analysis of the significance of the contiguous United States population of the North American wolverine that we incorporate here by reference. In that analysis we concluded that the wolverine population in the contiguous United States is significant because its loss would result in a significant gap in the range of the taxon.

Summary of the Distinct Population Segment Analysis

We conclude that the wolverine population in the contiguous United States is both discrete and significant under our DPS policy. The conservation status of wolverines in the contiguous United States is less secure than wolverines in adjacent Canada due to fragmented habitat, small population size, reduced genetic diversity, and their vulnerability to threats analyzed in this finding. Loss of the contiguous United States wolverines would result in a significant gap in the range of the taxon. Therefore, we determine that the population of wolverines in the contiguous 48 States, as currently

described, meets both the discreteness and significance criteria of our DPS policy, and is a listable entity under the Act as a DPS.

Summary of Factors Affecting the Species

Section 4 of the Act (16 U.S.C. 1533), and its implementing regulations at 50 CFR part 424, set forth the procedures for adding species to the Federal Lists of Endangered and Threatened Wildlife and Plants. Under section 4(a)(1) of the Act, we may list a species based on any of the following five factors: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; and (E) other natural or manmade factors affecting its continued existence. Listing actions may be warranted based on any of the above threat factors, singly or in combination. Each of these factors is discussed below.

Factor A. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

Under Factor A we will discuss a variety of impacts to wolverine habitat including: (1) Climate change, (2) human use and disturbance, (3) dispersed recreational activities, (4) infrastructure development, (5) transportation corridors, and (6) land management. Many of these impact categories overlap or act in concert with each other to affect wolverine habitat. Climate change is discussed under Factor A because although climate change may affect wolverines directly by creating physiological stress, the primary impact of climate change on wolverines is expected to be through changes to the availability and distribution of wolverine habitat.

Comment [RMI111]: I am not aware of a citation to support this statement. If this is the temperature hypothesis, the female in Michigan and in zoos such as Roanoke Virginia Billings Montana and Singapore suggest that this is not supported.

Two efforts to map wolverine habitat in the contiguous United States have been completed (Inman et al. ~~2012~~2013a, entire; Copeland *et al*. 2010, entire). The two models were developed using different and independent approaches. Both of these habitat models rely on snow as a primary input. The Copeland *et al*. (2010) model defines wolverine habitat as simply the area continuously covered by snow from mid-winter until mid-May. This snow model was an exploratory effort where wolverine denning locations were mapped followed by an effort to determine if there was a correlation between dens and persistent spring snow based on the concept that wolverine distribution could be limited to areas where snow persists through 15 May due to thermoregulatory needs of kits. A correlation was discovered between dens and the areas retaining snow in at least 1 of 7 (14%) of years. Three hypotheses have been proposed as an explanation for the correlation between wolverine locations and areas retaining snow through 15 May in at least 14% of years, the "obligate denning hypothesis" and "upper temperature hypothesis" (Copeland et al. 2010) and the "refrigeration hypothesis" (Inman et al… 2012b).

The Inman *et al*. (~~2012~~2013a) model was based on wolverine telemetry location data, includes ~~is based on~~ snow depth~~pack~~, and also incorporates other habitat variables that represent specific and necessary components of wolverine habitat (e.g., structure for dens and caching, escape cover, and human-related variables such as road density [Table 1 in Inman et al. 2013a])~~, such as terrain ruggedness and some aspects of human development~~. Snow depth was one of several variables retained as significant for improving model fit to the telemetry locations. While developed from 2 different and independent methods, t~~T~~he two models result in estimates of wolverine habitat that are very similar across most of the range of wolverines in the western contiguous United States. Areas of significant departure between the models are the California Sierras and Oregon Cascades where the

Comment [RMI112]: This and the below descriptions strengthen the argument by showing how independent methods arrived at a similar conclusion.

Comment [RMI113]: During 14% of years. Failing to recognize and acknowledge this limitation to the analysis suggests inadequate scrutiny of the hypothesis that the listing decision is primarily based upon.

Copeland *et al*. (2010) model predicts significantly greater habitat area than does the Inman *et al*. (~~2012~~2013a) model. Given the general agreement between the two models, we combined the areas depicted by them into a composite wolverine habitat model that includes all areas described by one or both of these models. This composite model serves as the basis for our estimates of wolverine habitat below. Within the four States that currently harbor wolverines (Montana, Idaho, Oregon (Wallowas) and Wyoming), an estimated 124,014 km^2 (47,882 mi^2) of wolverine habitat exists. Habitat in the North Cascades and Eastern Washington (Kettle Range and associated habitat) add approximately 20,356 km^2 (7859 mi^2). Ninety-four percent (135,396 km^2; 52,277 mi^2) of total wolverine habitat is in Federal ownership with most of that managed by the U.S. Forest Service (Forest Service).

Reduction in Habitat due to Climate Change

Our analyses under the Act include consideration of ongoing and projected changes in climate. The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). "Climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007, p. 78). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007, p. 78). Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007, pp. 8–14, 18–19).

We recognize that there are scientific uncertainties on many aspects of climate change, including the role of natural variability in climate. In our analysis, we rely both on synthesis documents (e.g., IPCC 2007; Karl *et al*. 2009) that present the consensus view of a very large number of experts on climate change from around the world, and on five analyses that relate the effects of climate changes directly to wolverines (Gonzalez *et al*. 2008, entire; Brodie and Post 2009, entire; Peacock 2011, entire; McKelvey *et al*. 2011, entire, Johnston *et al*. 2012, entire). To date, McKelvey *et al*. (2011) is the most sophisticated analysis regarding climate change effects to wolverines. This report is based on data from global climate models including both temperature and precipitation, downscaled to reflect the regional climate patterns and topography found within the range of wolverines in the contiguous United States. For this reason we find that McKelvey *et al*. (2011, entire) represents the best scientific information available regarding the impacts of climate change to wolverine habitat.

Snowpack changes as well as concomitant changes to wolverine habitat suitability result from both changes in temperature (negative relationship) and changes in snowfall (positive relationship). Because many climate models predict higher precipitation levels associated with climate warming, the interaction between these two variables can be quite complex. Consequently, predictions about snow coverage that rely only on temperature projections are less reliable than those that rely on both temperature and precipitation. McKelvey *et al*. (2011, entire) report projections for wolverine habitat and dispersal routes through the time interval from 2070 to 2099.

Climate Effects to Wolverines

Comment [RMI114]: This analysis is very limited with no detail on methods. It also appears to be based on the assumption of an obligate denning hypothesis, which does not appear to be bearing out to be the case (Ontario dens, Sweden dens, persistent snow in only 14% of years…..).

It is my understanding that 7 reviewers were selected to peer review the proposed rule and that none are climate-specific scientists. How has USFWS evaluated the reliability of the scientific works noted here?

Comment [RMI115]: This paper has been rebutted by McKelvey et al. .

Comment [RMI116]: This paper was criticized by McKelvey et al. for being of inappropriate scale.

Comment [RMI117]: This paper relies on the obligate denning hypothesis as truth.

Comment [RMI118]: This analysis begins with the assumption that GAP prediction of wolverine distribution in Washington is correct. It appears to be likely to be close.

Comment [RMI119]: However it is based on the flawed assumption that wolverines must have persistent snow through 15 May in 14% of years to provide thermal cover for young, and is misapplies that hypothesis for the limits of distribution by calculating snow loss at all elevation and aspects when the ecology they claim limits distributon occurs only at the highest elevations on north slopes, which will be the least and last affected. Could overestimate by 75% or more. See summary comments.

Comment [RMI120]: As noted, this paper is based on the flawed assumption that wolverine distribution is limited by an obligate need for "deep" (undefined), "reliable" persistent snow through 15 May in at least 14% of years.

Comment [RMI121]: wording needs to be addressed here, use increases instead of changes.

Comment [RMI122]: It is important to note that there are limits to the positive relationship between snowfall and wolverines. Too much snowfall is not good for wolverines. They are not distributed within Greenland (Copeland et al. 2010 Fig 1) where there is so much snowfall that there are glaciers. Glaciers are avoided (Royale et al. 2011, Krebs et al. 2007 Table 2, entire). The quadratic term for snow depth was retained in our telemetry based habitat model, also indicating a non-linear relationship (positive but becoming negative at a point) between wolverines and snow (Inman et al 2013a).

Due to dependence of wolverines on deep snow that persists into late spring both for successful reproduction and for year-round habitat (citations?), and their restricted distribution to areas that maintain significant snow late into the spring season, we conclude that deep snow maintained through the denning period is required for wolverines to successfully live and reproduce. Reduction of this habitat feature would proportionally reduce wolverine habitat, or to an even greater extent if habitat reduction involved increasing fragmentation.

Based on the information described above, we analyzed the effects of climate change on wolverines through three primary mechanisms: (1) Reduced snowpack and earlier spring runoff, which would reduce suitable habitat for wolverine denning; (2) increase in summer temperatures beyond the physiological tolerance of wolverines; and (3) ecosystem changes due to increased temperatures, which would move lower elevation ecosystems to higher elevations, thereby eliminating high-elevation ecosystems on which wolverines depend and increasing competitive interactions with species that currently inhabit lower elevations. These mechanisms would tend to push the ~~narrow~~ limited elevation band that wolverines use within the contiguous U.S. into higher elevation. Due to the conical structure of mountains, this upward shift would result in reduced overall suitable habitat for wolverines.

Reduced Snow Pack and Earlier Spring Runoff

Warmer winter temperatures are reducing snow pack in western North American mountains through a higher proportion of precipitation falling as rain and higher rates of snowmelt during winter (Hamlet and Lettenmaier 1999, p. 1609; Brown 2000, p. 2347; Mote 2003, p. 3-1; Christensen *et al*. 2004, p. 347; Knowles *et al*. 2006, pp. 4548-4549). This trend is expected to continue with future

Comment [RMI123]: How deep?

Comment [RMI124]: 15 May?

Comment [RMI125]: Please provide definitions and scientifically defensible citations for these statements.

Comment [RMI126]: ditto

Comment [RMI127]: To a far lesser degree than predicted by McKelvey et al 2011.

Comment [RMI128]: Suggest removing. This is not based in fact. It is pure speculation and is likely unfounded. Individual wolverines have persisted in the wild for >5 years in areas that are beyond the temperature correlation presented in Copeland et al. 2010, i.e., in the Michigan 'thumb'. Individuals also persist at zoos in Virginia, Billings Montana, and elsewhere. There is no reason to believe there is some upper limit to thermal tolerance that limits wolverine distribution.

Comment [RMI129]: ok

Comment [RMI130]: But at what point will this actually impact wolverines, especially if USFWS is relying on the obligate snow den hypothesis as the explanation for the correlation between wolverines and 15 May snow in at least 14% of years? That claim is biologically unsupported and USFWS has put too many eggs in that basket. There are hundreds if not thousands of potential dens in a female home range. Snow is not even absolutely necessary, especially if temperatures are warm.

Is this statement true for the sites actually used by wolverines for dens, i.e., high elevation north slopes?

warming (Hamlet and Lettenmaier 1999, p. 1611; Christensen *et al*. 2004, p. 347; Mote *et al*. 2005, p. 48). Shifts in the initiation of spring runoff toward earlier dates are also well documented (Hamlet and Lettenmaier 1999, p. 1609; Brown 2000, p. 2347; Cayan *et al*. 2001, pp. 409-410; Christensen *et al*. 2004, p. 347; Mote *et al*. 2005, p. 41; Knowles *et al*. 2006, p. 4554). Earlier spring runoff leads to lack of snow or degraded snow conditions during April and May, the critical time period for wolverine reproductive denning. In addition, a feedback effect hastens the loss of snow cover due to the reflective nature of snow and the relative heat-absorbing properties of non-snow-covered ground. This effect leads to the highest magnitude of warming occurring at the interface of snow-covered and exposed areas, increasing the rate at which melting occurs in spring (Groisman *et al*. 1994a, pp. 1637-1648; Groisman *et al*. 1994b, pp. 198-200). Due to the importance of deep snow cover in spring for wolverine reproduction, currently suitable habitat that loses this feature would be rendered unsuitable for wolverines.

Comment [RMI131]: Not true. The critical time period is February and March when young are small and thermoregulation most critical.

Please note that had the theory behind the obligate denning hypothesis of the persistent snow model been focused on this actual critical period, the snow coverage would extend far beyond those area where wolverines den and populations occur. There would not have been a correlation.

Comment [RMI132]: February, March, maybe part of April.

Comment [RMI133]: The importance of snow, specifically, and especially for deep snow, may primarily be related to the following: Areas of deep snow that make it difficult for animals that are less morphologically adapted for travel over snow than wolverines, limit competition for the relatively scarce food resources present in these type of environments (see Inman et al. 2012a and b). This effect is likely responsible to some degree for the observed correlation between wolverines and 15 May snow in at least 14% of year

Ecosystem Changes Associated with Climate Change

Changes in temperature and rainfall patterns are expected to shift the distribution of ecosystems northward (IPCC 2007c, p. 230) and up mountain slopes (McDonald and Brown 1992, pp. 411-412; Danby and Hik 2007, pp. 358-359; IPCC 2007c, p. 232). As climate changes over a landscape, the ecosystems that support wolverines are likely to move according to the change of temperature, but with a time lag depending on the ability of individual plant species to migrate (McDonald and Brown 1992, pp. 413-414; Hall and Fagre 2003, p. 138; Peterson 2003, p. 652). Wolverines are not dependent on any particular ecosystem in the sense that they do not appear to depend on a certain vegetative component or other biological ecosystem attribute; however, it is likely that wolverines would respond

to similar climatic cues as other members of the alpine ecosystem such that changes in tree-line location up or down slope would predict a similar change in wolverine distribution. Because of their reliance on mountainous habitat, wolverines in the contiguous United States will most likely adjust to climate changes by using higher elevations on mountain slopes, not by shifting their latitudinal distribution. Along a latitudinal gradient through the historical distribution of wolverines, records tend to be found at higher elevations in southern latitudes (Aubry *et al*. 2007, p. 2153), suggesting that wolverines compensate for increased temperature at low latitudes by selecting higher elevations. Therefore, the regional availability of suitable habitat is not likely to significantly change (i.e., at least some wolverine habitat will continue to be available in all regions where wolverines currently occur), but within these landscapes, smaller areas will remain suitable for wolverines. Mountain ranges with maximum elevations within the elevation band that wolverines currently use, such as much of the wolverine habitat in central Idaho, may become entirely unsuitable for wolverines with the projected level of warming reported in McKelvey *et al*. (2011, Figure 3; see below for discussion).

Comment [RMI134]: why? what is the biological reason for this? This is key.

Comment [RMI135]: Why?

Comment [RMI136]: These 2 sentences seem to be in opposition. reword?

Timing of Climate Effects

Unlike snow conditions, which respond directly to temperature change without a time lag, ecosystem responses to temperature change do lag, with the magnitude of the lag depending on constituent species' individual migratory abilities. Wolverines are described as a "tree-line" species in the contiguous U.S. because they are most often found in an elevation band that is approximately centered on the alpine tree-line at any given locality within their range (Inman *et al*. 2012a, p. 785). Alpine tree lines are maintained by a complex set of climactic and biotic factors, of which temperature is significantly important (Cogbill and White 1991, p. 169; Hättenschwiler and Körner 1995, p. 367;

Jobbágy and Jackson 2000, p. 259; Pellat *et al*. 2000, pp. 80-81). However, the conditions that favor tree establishment and lead to elevation advance in the tree line (e.g. soil development) may exist only sporadically, increasing time lags associated with tree line response to warming beyond the species-specific generation time of the trees involved (Hessl and Baker 1997, p. 181; Klasner and Fagre 2002, p. 54). Within wolverine habitats, tree lines have advanced up mountain slopes since 1850, due to climate warming, and this trend is expected to continue into the future (Hessl and Baker 1997, p. 176; Hall and Fagre 2003, p. 138). We expect that species reliant on resources associated with this biome, such as wolverines, will need to shift accordingly, not necessarily due to their dependence on the specific vegetation conditions, but due to wolverines likely being keyed into similar climatic variables such as relatively short growing seasons and low ambient temperatures (Inman et al. 2012b). Since wolverine association with tree-line location is likely coincident with their dependence on climatic conditions, and the fact that wolverines can move about in response to climate changes, it is not likely that wolverines would respond to climate changes with a similar time lag. More likely, wolverines would respond to climate changes in real time, shifting habitat use more rapidly than tree-line shifts would occur. Given the irregular nature of tree-line response to warming, tree-line migration is likely to lag behind the climate warming that causes it.

Comment [RMI137]: The purpose of including this section is not clear.

Magnitude of Climate Effects on Wolverine

Several studies relating the effects of climate changes on wolverines in the past, present, and future are now available (Brock and Inman Personal Communication 2007, entire; Gonzales *et al*. 2008, pp. 1-5; Brodie and Post 2010, entire; McKelvey *et al*. 2011, entire; Peacock 2011, entire; Johnston *et al*. 2012, entire). The Gonzalez *et al*. report and the report by Brock and Inman (Personal

Communication 2007) were both preliminary attempts to analyze climate change impacts to wolverines, but are not currently considered the best available science because they did not consider the effects of both changes in temperature and precipitation that may affect the distribution of persistent spring snow cover (McKelvey 2011, entire). The analysis by Peacock (2011) is a sophisticated look at climate change impacts to wolverines, but suffers from the large-scale data presentation used. This large scale makes relating specific impacts to wolverines difficult, because the montane habitat inhabited by wolverines is climatologically complex on a small scale, and without significant downscaling of climate results, it is not possible to determine how much habitat may be left after climate change impacts have occurred. Both Brock and Inman (Personal Communication 2007) and Gonzalez *et al.* (2008) have been superseded by a more sophisticated analysis provided by McKelvey *et al.* (2011, entire). The course-grain scale of the analysis in Peacock (2011, entire) limits its use to that of supporting the conclusion that wolverine habitat is likely to decline. Likewise, the limited area analyzed by Johnston *et al*. (2012) also limits its use for this wide-ranging species. The McKelvey *et al.* (2011, entire) analysis includes climate projections at a local scale for wolverine habitats and analyzes the effects of both temperature changes and changes to precipitation patterns. Lack of accounting for changes in precipitation was a weakness of their own work cited by the authors of both Brock and Inman (Personal Communication 2007) and Gonzalez *et al*. (2008).

Brodie and Post (2010, entire) correlate the decline in wolverine populations in Canada over the past century with declining snowpack due to climate change over the same period. However, correlation does not infer causation; other factors could have caused the decline. The Brodie and Post (2010, entire) analysis used harvest data to infer population trends in addition to its reliance on correlation to infer causation (McKelvey *et al*. 2010a, entire); in this case, historic climate changes are

Comment [RMI138]: This was definitely a preliminary attempt.

Comment [RMI139]: The McKelvey et al. 2011 analysis also has serious limitations if not flaws that render it unreliable.

First, the obligate snow denning hypothesis does not bear out under close examination (See many comments above and summary).

Second, even if problem 1 above were not the case, similar to the scaling issue that McKelvey et al 2011 and the USFWS here point out regarding the Peacock 2011 analysis, McKelvey et al 2011 also suffers from an inadequate examination at the appropriate scale.

In the contiguous U.S., wolverines den on north slopes at higher elevations (Magoun and Copeland 1998, Inman et al. 2007x, …). These areas will be impacted to a far lesser degree than other areas within wolverine habitat. They will also be impacted in a significant enough manner to actually influence wolverine survival or reproduction through the mechanisms proposed by Copeland et al 2010 and McKelvey et al 2011 over a much longer time frame IF at all (which is unlikely given the flawed presumption that wolverine distribution is limited to areas with 15 May snow in at least 14% of years). By predicting loss of snow throughout wolverine habitat instead of limiting their analysis to the high elevation north slopes where wolverines den, McKelvey et al. 2011 grossly overestimate the impact to wolverines under the obligate snow denning hypothesis.

Comment [RMI140]: The fact that the USFWS should heed its own words here with regard to the correlation and the inferred causation of the "obligate snow denning hypothesis" cannot be overemphasized.

The causation inferred by that hypothesis is the basis for the entire listing decision. It does not hold up under scrutiny.

inferred to have caused the declines in harvest returns, which are thought by the authors to reflect actual population declines. Due to the above-stated concerns, we view the analysis of Brodie and Post (2010, entire) with caution, although we do agree that the posited mechanism, of loss of snowpack affecting wolverine populations and distribution, likely has merit.

McKelvey *et al*. (2011, entire) used downscaled global climate models to project the impacts of changes in temperature and precipitation to wolverine habitat as modeled by Copeland *et al*. (2010, entire). The authors also present an alternative method for evaluating climate impacts on wolverine habitat, by merely projecting onset of spring snowmelt to occur 2 weeks earlier than it currently does. Based on this information, wolverine habitat in the contiguous United States, which supports approximately 250 to 300 wolverines, is shrinking and is likely to continue to shrink with increased climate warming (McKelvey *et al*. 2011, Figure 4). Habitat losses are likely to occur throughout the range of the DPS and are projected to be most severe in central Idaho. However, large areas of snow cover are likely to remain in the North Cascades, Greater Yellowstone Area (GYA), and the Glacier Park-Bob Marshall Wilderness of Montana (McKelvey *et al*. 2011 Figures 4, 13). The southern Rocky Mountains of Colorado retained significant high-elevation snow in some models but not others, and so may be another area that could support wolverine populations in the face of climate changes (McKelvey *et al*. 2011, p. 2889).

Overall, wolverine habitat in the contiguous United States is expected to get smaller and more highly fragmented as individual habitat islands become smaller and the intervening areas between wolverine habitats become larger (McKelvey *et al*. 2011, Figures 4, 13). McKelvey et al. (2011) predict that 31 percent of current wolverine habitat in the contiguous United States will be lost due to climate

Comment [RMI141]: This statements suggests that USFWS is tentatively agreeing that there was a documented population decline in Canada and that this was most likely due to climate as suggested by B&P.

B&P do not consider any other factors as potentially accounting for some or all of the "trend." Fur prices, number of trappers, effort, access conditions…The B&P trend is stable in BC as supported by Lofroth and Ott 2007. B&P also use snow data from all areas of provinces, including low elevations where wolverines have not likely existed at any point in time, rather than examining trends in snow depth in the areas where wolverines are actually found. Less snow may be occurring at lower elevations, but this does not mean that the same happens in areas where temperatures still remain below freezing for a significant portion of the year.

In their abstract B&P mention "critical thresholds in snowpack depth" but this is not described or discussed again. What critical threshold exists and how did they measure it to relate to wolverine data?

Comment [RMI142]: This is A) based on faulty logic regarding the significance of snow through 15 May for wolverines and B) is likely a vast over-prediction of habitat loss.

This assumes that the area predicted as suitable wolverine habitat by the C2010 snow model is accurate. The C2010 snow model is based upon a single variable, 15 May snow presence in at least 14% of years. There are vast areas that meet this criteria, but which are not within wolverine range, e.g., Greenland (C2010 fig 1). Obviously, snow is not the only feature that is important for wolverines. Hence the statement by USFWS above that "it is unknown why persistent spring snow describes wolverine distribution so well…" Other models of wolverine habitat in the contiguous US suggest that areas such as the Oregon Cascades and northern California have far less suitable habitat than is predicted by the single variable snow model, and this is supported by the lack of historical record in those areas along with isolated genetics of CA. If there were less habitat available to begin with, then it cannot be lost, thus the predicted amounts would be less. This would potentially result in a relatively small, but locally significant, over-prediction in habitat loss.

In addition, and more importantly, the McKelvey et al. 2011 analysis assumes that all reduction of spring snowpack is negative for wolverines. This includes all areas on all aspects at all elevations. Yet by their own hypothesis regarding the cause or explanation for the significance of the spring snowpack model of habitat that their analysis is based on, snow for dens for thermal cover for young is the critical need. Natal dens occur exclusively on north facing slopes at higher elevations in the contiguous US. Therefore the loss of snow at low elevations or on any aspect other than north is unlikely to influence the availability of suitable wolverine dens. Assuming that aspects occur in relatively equal amounts, accounting for this factor could reduce the predic ...

warming by the time interval centered on 2045 (2030-2059) (McKelvey *et al*. 2011, pp. 2887-2888). That loss expands to 63 percent of wolverine habitat by the time interval centered on 2085 (2070 to 2099). Estimates for the northern Rocky Mountain States (Montana, Idaho, and Wyoming) are similar, with an estimated 32 percent and 63 percent of persistent spring snow lost for the 2045 and 2085 intervals respectively. Central Idaho is predicted to be especially sensitive to climate change effects losing 43 percent and 78 percent of wolverine habitat for the 2045 and 2085 intervals respectively. Conversely, the mountains of Colorado appear to be slightly less sensitive to climate changes in their analysis losing 31 percent and 57 percent of habitat over the same intervals. Given the spatial needs of wolverines and the limited availability of suitable wolverine habitat in the contiguous United States, this projected gross loss of habitat area is likely to result in a loss of wolverine numbers that is greater than the overall loss of habitat area.

We expect wolverine populations to be negatively affected by changes in the spatial distribution of habitat patches as remaining habitat islands become progressively more isolated from each other due to climate changes (McKelvey *et al*. 2011, Figure 8). Currently, wolverine habitat in the contiguous United States can be described as a series of habitat islands. Some of these groups of islands are large and clumped closely together, such as in the North Cascades, Glacier Park-Bob Marshall Wilderness complex in Montana, and the GYA. Other islands are smaller and more isolated, such as the island mountain ranges of central and southwestern Montana. Inbreeding and consequent loss of genetic diversity have occurred in the past within these smaller islands of habitat (Cegelski *et al*. 2006, p. 208), and genetic exchange between subpopulations is difficult to achieve (Schwartz *et al*. 2009, Figure 4). Climate change projections indicate that, as warming continues, large contiguous blocks of habitat will decrease in size and become isolated to the extent that their ability to support robust populations

Comment [RMI143]: This is not likely to be the case if snow dens through 15 May (or at any other time) are considered to be the critical factor limiting distribution.

Comment [RMI144]: Again, habitats for dens on north facing slopes at high elevations will be the last places to be affected and will likely remain sufficient for wolverine use (which is actually critical during February, March, and perhaps early April, not all the way through to 15 May) to a much greater degree than predicted by McKelvey et al. 2011 or any of the other wolverine climate modeling efforts cited by USFWS. Since the patches of habitat suitable for dens will remain to a far greater degree than predicted by McKelvey et al 2011, the isolation of these patches also will not occur to the degree indicated by McKelvey et al 2011, i.e., sufficient patches for suitable dens on high elevation north slopes will likely remain for far longer periods than predicted in virtually all areas.

Comment [RMI145]: This statement is not supported. Cegelski et al do not provide or suggest there is evidence of inbreeding or loss of diversity in the post-recovery period. There are fewer haplotypes in the contiguous US than north of Jasper Canada (numerous genetics works citations) but the cause of this lower number of haplotypes is unknown. Naturally fragmented habitats, low population carrying capacity, and historical extirpation are all potential explanations. The degree to which inbreeding and/or low genetic diversity occurs in these areas has not been evaluated against historical baseline data.

Comment [RMI146]: By the USFWS's own logic below where it is stated that there are no current inhibitions to dispersal due to infrastructure development etc… this suggests that there has always been a significant degree of natural isolation in at least portions of the contiguous US.

If denning habitat is the only factor limiting wolverine distribution and it will not change nearly as significantly as predicted by McKelvey et al 2011, and human infrastructure is not limiting dispersal now or in the foreseeable future, then wolverine populations should not experience any significant negative impacts in the foreseeable future and should not be listed.

Comment [RMI147]: Not denning habitat.

Comment [RMI148]: Not denning habitat.

becomes questionable (McKelvey *et al*. 2010b, Figure 8). Under the moderate climate change scenarios analyzed by McKelvey *et al*. (2011, entire), the current wolverine stronghold in central Idaho begins to look similar to the current situation in the more isolated mountain ranges of southwestern Montana (McKelvey *et al*. 2011, Figure 4) where wolverines persist, but subpopulations are small. These subpopulations are essentially family groups, which require connectivity with other groups for genetic and possibly demographic enrichment. This habitat alteration would result in a high likelihood of reduced genetic diversity due to inbreeding within a few generations (Cegelski *et al*. 2006, p. 209). Further isolation of wolverines on small habitat islands with reduced connectivity to other subpopulations would also increase the likelihood of subpopulations loss due to demographic stochasticity, impairing the functionality of the wolverine metapopulation in the contiguous United States.

Comment [RMI149]: If it only "becomes questionable" under the over predicted scenario presented, then it must not be of any consequence under a more realistic scenario.

Comment [RMI150]: Most of the habitat in Idaho is connected by public land. In Montana, this is not true, private lands frequently separate suitable wolverine habitats. This sounds like a strong argument for beginning to maintain connectivity in southwestern Montana now.

Comment [RMI151]: Reduced connectivity is not likely to occur because of the climate scenario presented by McKelvey et al 2011 for the reasons described above. It is more likely to occur on private lands separating suitable habitats and via traffic volumes. USFWS has brushed this aside (below) even though their strength directed at this task is needed to a far greater degree and would potentially be far more effective than a listing based on climate change coupled with a lack of any plan on how to solve that problem.

We find that McKelvey *et al*. (2011, entire) represents the best available science for projecting the future impacts of climate change on wolverine habitat for four primary reasons. First, their habitat projections are based on global climate models that are thought to be the most reliable predictors of future climate available (IPCC 2007a, p. 12). Second, they conducted downscaling analyses to infer geographic climate variation at a scale relevant to wolverine habitat. Third, they used a hydrologic model to predict snow coverage during the spring denning period (the strongest correlate with wolverine reproductive success). Fourth, they used the habitat model developed by Copeland *et al*. (2010, entire), to relate projected climate changes to wolverine habitat. Based on our analysis of the methods and analysis used by the authors, we conclude it constitutes the best available information on the likely impact of climate change on wolverine distribution in the contiguous United States. Other analyses of climate change discussed above (Brock and Inman Personal Communication 2007, entire;

Comment [RMI152]: This is false. They have not scaled the analysis to high elevation north slopes where the biology they claim limits wolverine distribution actually occurs.

Comment [RMI153]: Faulty assumptions regarding wolverine biology negate this prediction.

Comment [RMI154]: It is unclear why this is different from #3.

Gonzales *et al*. 2008, entire; Brodie and Post 2010, entire; Peacock 2011, entire) all support the conclusion that climate changes caused by warming are likely to negatively affect wolverine habitat in the future. Based on the analysis presented, we conclude that climate changes are likely to result in permanent loss of a significant portion of wolverine habitat in the future. Additional impacts of climate change will be increased habitat fragmentation as habitat islands become smaller and intervening habitat disappears. Eventually, habitat fragmentation will likely lead to a breakdown of wolverine metapopulation dynamics, as subpopulations are no longer able to rescue each other after local extinctions due to a lack of connectivity. It is also likely that loss of genetic diversity resulting in lower fitness will occur as population isolation increases.

Summary of Impacts of Climate Changes

Wolverine habitat is projected to decrease in area and become more fragmented in the future as a result of climate changes that result in increasing temperatures, earlier spring snowmelt, and loss of deep, persistent, spring snowpack. These climate change impacts are expected to have direct and indirect effects to wolverine populations in the contiguous United States including reducing the number of wolverines that can be supported by available habitat and reducing the ability of wolverines to travel between patches of suitable habitat. This reduction in population size and connectivity is likely to affect metapopulation dynamics, making it more difficult for subpopulations to recolonize areas where wolverines have been extirpated and to bolster the genetics or demographics of adjacent subpopulations.

Comment [RMI155]: This is vastly over-predicted by McKelvey et al. 2011 for reasons stated above.

Comment [RMI156]: The basis for this factor limiting wolverine distributions is flawed.

Comment [RMI157]: If habitat recedes up each of 2 separate mountain ranges 1000 feet in elevation, and these ranges are 25 miles apart, how much has the total distance that a wolverine must move increased? Are these distances biologically significant? How do the increases in distance noted here compare to increasing levels of human infrastructure between the 2 ranges in their potential impact to wolverine dispersal? More below under connectivity section.

Habitat Impacts Due to Human Use and Disturbance

Because primary wolverine habitat (areas used by resident adults, Inman et al. 2013) is generally inhospitable to human use and occupation and most wolverine habitat is also federally managed in ways that must consider environmental impacts, wolverines are somewhat insulated from impacts of human disturbances from industry, agriculture, infrastructure development, or recreation in those areas. Human disturbance in wolverine habitat in the contiguous United States has likely resulted in the loss of some minor amount of wolverine habitat, although this loss has not yet been quantified. Sources of human disturbance to wolverines has been speculated to include winter and summer recreation, housing and industrial development, road corridors, and extractive industry, such as logging or mining. In the contiguous United States, these human activities and developments sometimes occur within or immediately adjacent to wolverine home ranges, such as in alpine or boreal forest environments at high elevations on mountain slopes. They can also occur in a broader range of habitats that are occasionally used by wolverines during dispersal or exploratory movements—habitats that are not suitable for the establishment of home ranges and reproduction, but which are critical for metapopulation function.

Little is known about the behavioral responses of individual wolverines to human presence, or about the species' ability to tolerate and adapt to repeated human disturbance. Some speculate that ~~disturbance~~ roads may reduce the wolverine's ability to complete essential life-history activities, such as foraging, breeding, maternal care, routine travel, and dispersal (Packila *et al*. 2007, pp. 105-110). However, wolverines have been documented to persist and reproduce in areas with high levels of human use and disturbance including developed alpine ski areas and areas with motorized use of snowmobiles (Heinenmeyer 2012, entire). This suggests that wolverines can survive and reproduce in areas that experience human use and disturbance. How or whether effects of disturbance extend from

Comment [RMI158]: the further north you go, the lower the elevations that wolverines use. in areas where primary habitat occurs in valley bottoms, the more likely wolverines can or may have been displaced. This does not appear to be the case in the western contiguous US. (Inman et al. 2013a).

Comment [RMI159]: Overall there is a high level of incongruence in the proposed rule regarding the way dispersal and connectivity are treated. In the discussion on climate change impacts, connectivity/dispersal is noted as critical and its potential reduction due to climate is a factor contributing to the listing decision. It is essentially dismissed in all other contexts despite numerous places in the proposed rule where metapopulation function is noted as critical.

This is a major oversight, and a listing rule or recovery plan that fails to account for connectivity and the potential for human infrastructure to inhibit connectivity will not suffice for wolverine persistence over the long run.

Comment [RMI160]: I did not find a reference to maternal care in the Packila citation listed.

Comment [RMI161]: This citation is specific to roads and not disturbance in any general form as suggested as currently written. Please clarify and provide additional citations to describe the degree to which this view of potential disturbance is prevalent. There are a plethora of writings, both scientific and popular, that claim wolverines are sensitive to human activity (Copeland 1996, Heinemeyer and Copeland 1999, Carlton et al 1994…

Comment [RMI162]: Wolverines do not persist and reproduce in ski areas, they have been captured and documented using these areas on occasion, which only indicates that they do not completely avoid them, not that they persist and reproduce in them.

This paragraph goes too far toward suggesting that there is evidence that human activity is just not an influence on wolverines or a potential impact.

It ignores the finding in Inman et al 2013a where road density was a variable that influenced wolverine habitat quality negatively.

individuals to characteristics of subpopulations and populations, such as vital rates (e.g., reproduction, survival, emigration, and immigration) and gene flow, and ultimately to wolverine population or metapopulation persistence, remains unknown at this time. This paragraph is weak and misleading in several ways. It needs to be reworked to include a more complete discussion of both the degree to which human disturbance has been suggested in both the professional and popular literature to negatively impact wolverines and the places that this has been shown to be or not to be the case. It singles out the Packila citation as speculation about "disturbance" when that paper deals exclusively with roads and describes over 100 road crossings; it dismisses the speculations of Packila et al regarding the importance of dispersal with a citation that is specific to winter recreation, which is an entirely different type of potential disturbance than roads and has nothing to do with dispersal. It fails to discuss the fact that a female occupying a mountain range too small for a typical male home range and surrounded by roads failed to yield evidence of reproduction through age 5 and that the adult male occupying that range for a period was killed on the road that bisected his home range as reported in Packila et al. 2007. (we never found evidence of her reproducing through age 7). Krebs et al 2007 discuss disturbance and suggest it influences wolverine habitat selection, but this is not mentioned. It ignores information such as Austin 1998, Cegelski et al 2003, 2006, Schwartz et al 2009. Copeland 1996 suggested that human disturbance caused den abandonment, and this along with the general perception of wolverines living where people are not has led to the idea that wolverines avoid and are disturbed by humans. Rowland et al 2003 and Carroll et al 2001 (incorrectly) suggest human disturbance led to the displacement of wolverines; Copeland et al 2007 and Inman et al 2012a suggest that this was not the case.

Comment [RMI163]: What is the explanation for the subpopulation structure observed by Cegelski et al 2003, 2006 and Schwartz et al 2009 in the Crazy/Belt population of Montana?

Wolverine habitat in the contiguous US is characterized primarily by spring snowpack, but also by the absence of human presence and development (Hornocker and Hash 1981 p. 1299; Banci 1994, p. 114; Landa *et al*. 1998, p. 448; Rowland *et al*. 2003 p. 101; Copeland 1996, pp. 124-127; Krebs *et al*. 2007, pp. 2187-2190). This negative association with human presence is sometimes interpreted as active avoidance of human disturbance (Carroll et al 2001, Rowland et al 2003), but it may simply reflect the wolverine's preference for cold, snowy, and high-elevation habitat that humans avoid (Copeland et al. 2007, Inman et al. 20112a). In the contiguous United States, wolverine habitat is typically associated with high-elevation (e.g., 2,100 m to 2,600 m (6,888 ft to 8,528 ft)) subalpine forests that comprise the Hudsonian Life Zone (weather similar to that found in northern Canada), environments not typically used by people for housing, industry, agriculture, or transportation. However, a variety of activities associated with extractive industry, such as logging and mining, as well as recreational activities in both summer and winter are located in a small amount of occupied wolverine habitat.

For the purposes of this rulemaking, we analyze human disturbance in four categories: (1) Dispersed recreational activities with primary impacts to wolverines through direct disturbance (e.g., snowmobiling and heli-skiing); (2) disturbance associated with permanent infrastructure such as residential and commercial developments, mines, and campgrounds; (3) disturbance and mortality associated with transportation corridors; and (4) disturbance associated with land management activities such as forestry, or fire/fuels reduction activities. Overlap between these categories is extensive, and it is often difficult to distinguish effects of infrastructure from the dispersed activities associated with that infrastructure. However, we conclude that these categories account for most of the human activities that occur in occupied wolverine habitat.

Comment [RMI164]: As the authors of the snow model suggest and USFWS states earlier, spring snowpack represents some unknown set of characteristics. It was a parsimonious way to look for the impacts of climate change and should not be taken to define wolverine habitat. There are other better ways to generally refer to wolverine habitat that better describe the breadth of requisites. high elevation alpine and forested areas for instance.

Comment [RMI165]: Using the range of latitude adjusted elevations that wolverines selected in Yellowstone would be more appropriate here since LAE can be relevant to areas with as different latitudes as Montana/Washington and Colorado/California. Using actual elevations from one area will lead to errors in other areas.

Comment [RMI166]: odd statement, only northern?

Comment [RMI167]: Suggest making this first paragraph in section. Some of the material above might be moved into specific sections below.

Dispersed Recreational Activities

Dispersed recreational activities occurring in wolverine habitat include snowmobiling, heli-skiing, hiking, biking, off- and on-road motorized use, hunting, fishing, and other uses.

One study documented (in two reports) the extent that winter recreational activity spatially and temporally overlapped modeled wolverine denning habitat (which denning habitat model? citation) in the Centennial Range of the Greater Yellowstone Area~~contiguous United States~~ (Heinemeyer and Copeland 1999, pp. 1-17; Heinemeyer *et al*. 2001, pp. 1-35). This study took place ~~in the Greater Yellowstone Area (GYA)~~ in an area of high dispersed recreational use. The overlap of modeled wolverine denning habitat and dispersed recreational activities was extensive. Strong temporal overlap existed between snowmobile activity (February–April) and the wolverine denning period (February–May). During 2000, six of nine survey units, ranging from 3,500 to 13,600 (ha) (8,645 to 33,592 (ac)) in size, showed evidence of recent snowmobile use. Among the six survey units with snowmobile activity, the highest use covered 20 percent of the modeled denning habitat, and use ranged from 3 to 7 percent over the other survey units. Snowmobile activity was typically intensive where detected.

Three of nine survey units in this study showed evidence of skier activity (Heinemeyer and Copeland 1999, p. 10; Heinemeyer *et al*. 2001, p. 16). Among the three units with activity, skier use covered 3 to 19 percent of the survey unit. Skiers also intensively used the sites they visited. Combined skier and snowmobile use covered as much as 27 percent of potential denning habitat in one unit where no evidence of wolverine presence was detected. We conclude from this study that in some

Comment [RMI168]: measured how?

Comment [RMI169]: which model?

Comment [RMI170]: what is recent, within one month?

Comment [RMI171]: highest use in a unit or high use as classified by the surveyors?

Comment [RMI172]: of units? of area?

Comment [RMI173]: this is misleading as no information is given as to the size of the unit and whether it was larger than a home range or smaller. In either case, what would be the expectation of actually detecting tracks with the survey method? What % of the units with no or low use had tracks?

areas, high recreational use may coincide substantially with wolverine habitat. The authors of the study cited above chose the study area based on its unusually high level of motorized recreational use. Although we do not have information on the overlap of wolverine and winter recreation in the remaining part of the contiguous United States range, it is unlikely that any of the large areas of wolverine habitat such as the southern Rocky Mountains, Northern Rocky Mountains, GYA, or North Cascades get the high levels of recreational use seen in the portion of the GYA examined in this study across the entire landscape. Rather, each of these areas has small (relative to wolverine home range size) areas of intensive recreational use (ski resorts, motorized play areas) surrounded by a landscape that is used for more dispersed recreation such as backcountry skiing or snowmobile trail use.

Comment [RMI174]: Note that wolverine reproduction has never been detected to my knowledge in the Centennial Range. This could be due to any of several factors, including a lack of effort to do so.

Comment [RMI175]: we have additional data on this topic, specifically maps depicting results of approximately 5 surveys of the entire study area and the relative levels of winter recreation activity.

Although we can demonstrate that recreational use of wolverine habitat is heavy in some areas, we do not have any information to suggest that these activities have negative effects on wolverines. No rigorous assessments of anthropogenic disturbance on wolverine den fidelity, food provisioning, or offspring survival have been conducted. Disturbance from foot and snowmobile traffic associated with historical wolverine control activities (Pulliainen 1968, p. 343), and field research activities, have been purported to cause maternal females to abandon natal dens and relocate kits to maternal dens (Myrberget 1968, p. 115; Magoun and Copeland 1998, p. 1316; Inman *et al*. 2007c, p. 71). However, this behavior appears to be rare, even under intense disturbance associated with capture of family groups at the den site (Persson et al. 2006, p. 76), and other causes of den abandonment may have acted in these cases. Preliminary results from an ongoing study on the potential impacts of winter recreation on wolverines in central Idaho indicate that wolverines are present and reproducing in this area in spite of relatively heavy recreational use, including a developed ski area, dispersed winter and summer recreation, and dispersed snowmobile use (Heinemeyer *et al*. 2012, entire). The security of the den and

Comment [RMI176]: The abandonment here was most likely due to hunters excavating the den to kill the wolverines for bounty, a common practice at the time. This level of disturbance is not likely to occur today, and this study should not be cited as evidence that wolverines abandon dens in the context of modern activities.

Comment [RMI177]: This reference specifically states "It is unknown whether the move to the maternal den [which occurred a minimum of 5-7 days after our visit] was the result of our slight alteration of the den, the presence of snowmobile activity, or neither." So I don't believe it should be cited as having purported to cause abandonment. It was at least 5-7 days based on GPS collar data, after we accidentally poked a hole in the roof of the den before the female moved.

Comment [RMI178]: which cases, all of the citations or just Persson 2006?

the surrounding foraging areas (i.e., protection from predation by carnivores) ~~is~~ appears to be an important aspect of den site selection based on…?. Abandonment of natal and maternal dens may be a preemptive strategy that females use in the absence of predators (i.e. females may abandon dens without external stimuli), as this may confer an advantage to females if prolonged use of the same den makes that den more evident to predators. Evidence for effects to wolverines from den abandonment due to human disturbance is lacking. The best scientific information available does not substantiate dispersed recreational activities as a threat to wolverine at this time.

Comment [RMI179]: Agreed. I am only aware of 2 reported observations of abandonment, both in Copeland 1996 and then M&C 1998. These both occurred in April, after the time when females can be moving young to new sites regularly.

Most roads in wolverine habitat are low-traffic volume dirt or gravel roads used for local access. Larger, high-volume roads are dealt with below in the section "transportation corridors. At both a site-specific and landscape scale, wolverine natal dens were located particularly distant from public (greater than 7.5 km (4.6 mi)) and private (greater than 3 km (1.9 mi)) roads (May 2007, p. 14-31; Dawson et al. 2010). Placement of dens away from public roads (and away from associated human-caused mortality) was also a positive influence on successful reproduction (citations). It is not known if the detected correlation is due to the influence of the roads but we find it unlikely that wolverines avoid the type of low-use forest roads that generally occur in wolverine habitat. Other types of high-use roads are rare in wolverine habitat and are not likely to affect a significant amount of wolverine habitat (see transportation corridors section below).

Comment [RMI180]: Packila et al. 2007 provide a significant amount of information relevant to this section. Over 60 documented crossings of a fairly well used dirt road, primarily by an adult male monitored for >5 years in his regular home range movements.

Infrastructure Development

Infrastructure includes all residential, industrial, and governmental developments such as buildings, houses, oil and gas wells, and ski areas. Infrastructure development on private lands in the

Rocky Mountain West has been rapidly increasing in recent years and is expected to continue as people move to this area for its natural amenities (Hansen *et al*. 2002, p. 151). Infrastructure development may affect wildlife directly by eliminating habitats, or indirectly, by displacing animals from suitable habitats near developments, or influencing dispersal or migratory movements.

Wolverine home ranges generally do not occur near human settlements, and this separation is largely due to differential habitat selection by wolverines and humans (May *et al*. 2006, pp. 289-292; Copeland *et al*. 2007, p. 2211, Inman et al. 2012a). In one study, wolverines did not strongly avoid developed habitat within their home ranges (May *et al* 2006, p. 289). Wolverines may respond positively to human activity and developments that are a source of food. They scavenge food at dumps in and adjacent to urban areas, at trapper cabins, and at mines (LeResche and Hinman 1973 as cited in Banci 1994 p. 115; Banci 1994, p. 99). Based on the best available science, we conclude that wolverines do not avoid human development of the types that occur within suitable wolverine habitat.

There is no evidence that wolverine dispersal is affected by infrastructure development. Linkage zones are places where animals can find food, shelter, and security while moving across the landscape between suitable habitats. Wolverines prefer to travel in habitat that is most similar to habitat they use for home-range establishment, i.e., alpine habitats that maintain snow cover well into the spring (Schwartz *et al*. 2009, p. 3227, Inman et al. 2013b, Rainey 2012, Inman et al. 2009). Wolverines may move large distances in an attempt to establish new home ranges, but the probability of making such movements decreases with increased distance between suitable habitat patches, and the degree to which the characteristics of the habitat to be traversed diverge from preferred habitat in terms of climatic conditions (Copeland *et al*. 2010, entire; Schwartz *et al*. 2009, p. 3230).

Comment [RMI181]: There is a large body of literature documenting this phenomenon, and valley bottom development is prevalent as a threat to many species of greatest conservation need in the USFWS SWG-required State Wildlife Action Plans of many western states. Why is this overlooked?

This cursory glance toward the literature and subsequent dismissal of the entire issue is indicative of a narrowly focused effort to list wolverines due to climate change and forgo any other issues. The impacts of infrastructure development on wildlife in general and especially on migratory or dispersal movements is not even noted as written.

Comment [RMI182]: This conclusion is not supported by the best available information.

Road density, in a negative relationship, was retained as one of the variables improving model fit in the telemetry-based habitat analysis of Inman et al. 2013. There was an interaction with elevation, suggesting that roads at lower elevations that are not typically used by resident wolverines did not influence wolverine locations, but that roads at higher elevations did.

Comment [RMI183]: Do the biologists of the United States Fish and Wildlife Service actually believe that the best available and reliable information on wolverines supports the conclusion that climate change is a more significant threat to wolverine dispersal and connectivity 100 years from now than infrastructure? On what basis? That wolverines will have to travel farther to disperse under climate change? Does distance seem to be an obstacle to wolverines? The USFWS is compelled to believe that distance matters but the level of human activity in-between is inconsequential?

Comment [RMI184]: Inman, R.M., S. Bergen, and J. Beckmann. 2013b. Wildlife as public domain: Endangered status, connectivity, and critical habitat of the wolverine. Paper IV *in* Wolverine ecology and conservation in the western United States. PhD Dissertation, R.M. Inman, 2013. Grimsö Wildlife Research Station, Department of Ecology, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Rainey, M.M., 2012. A test of the ability of connectivity models to predict dispersal movements using telemetry data from dispersing wolverines. Chapter 4 in Validating alternative methods of modeling wildlife corridors using relocation data from migrating elk and dispersing wolverines. PhD Dissertation, M.M. Rainey. 2012. Montana State University, Bozeman, Montana, USA.

Comment [RMI185]: this reference does not support the statement. Schwartz 20009 does.

The level of development in these linkage areas that wolverines can tolerate is unknown, but it appears that the current landscape does allow wolverine dispersal (Schwartz *et al*. 2009, Figures 4, 5; Moriarty *et al*. 2009, entire; Inman *et al*. 2009, pp. 22-28, Packila et al. 2007, Inman et al. 2013a). For example, wolverine populations in the northern Rocky Mountains appear to be connected to each other at the present time through dispersal routes that correspond to habitat suitability (Schwartz *et al*. 2009, Figures 4, 5). However, gene flow between wolverine subpopulations in the contiguous United States may not be high enough to prevent genetic drift (Cegelski *et al*. 2006, p. 208). To ensure long-term genetic viability, each subpopulation within the contiguous United States would need an estimated 400 breeding pairs, or 1 to 2 effective migrants per generation (Cegelski *et al*. 2006, p. 209). Our current understanding of wolverine ecology suggests that no subpopulation historically or presently at carrying capacity would approach 400 breeding pairs within the contiguous United States (Brock *et al*. 2007, p. 26 Inman et al. 2013a); nor is the habitat capable of supporting anywhere near this number. It is highly unlikely that 400 breeding pairs exist in the entire contiguous United States. Because no wolverine subpopulations are likely to be large enough to maintain genetic diversity over time on their own, long-term viability of wolverines in the contiguous United States requires exchange of individuals between subpopulations.

Comment [RMI186]: This is absolutely critical for long-term persistence

Wolverines are capable of long-distance movements through variable and anthropogenically altered terrain, crossing numerous transportation corridors (Moriarty *et al*. 2009, entire; Inman *et al*. 2009, pp. 22-28, Packila et al. 2007). Wolverines are able to successfully disperse between habitats, despite the level of development that is currently taking place in the current range of the DPS (Copeland 1996, p. 80; Copeland and Yates 2006, pp. 17-36; Inman *et al*. 2007a, pp. 9-10; Packila *et al*.

2007, pp. 105-109; Schwartz *et al*. 2009, Figures 4, 5). Dispersal between populations is needed to avoid further reduction in genetic diversity; however, there is no evidence that human development and associated activities are preventing wolverine movements between suitable habitat patches. Rather, wolverine movement rates are limited by suitable habitat and proximity of suitable habitat patches, not the characteristics of the intervening unsuitable habitat (Schwartz *et al*. p. 3230).

Comment [RMI187]: This conclusion is completely incongruent with the approach taken to investigate the influence of climate change on wolverines.

Transportation Corridors

Transportation corridors are places where transportation infrastructure and other forms of related infrastructure are concentrated together. Examples include interstate highways and high-volume secondary highways. These types of highway corridors often include railroads, retail, industrial, and residential development and also electrical and other types of energy transmission infrastructure. Transportation corridors may affect wolverines if located in wolverine habitat or between habitat patches. If located in wolverine habitat, transportation corridors result in direct loss of habitat. Direct mortality due to collisions with vehicles ~~is~~ also occurs~~possible~~ (Krebs et al. 2004, Table 3, Packila *et al*. 2007, Table 1).

The Trans Canada Highway at Kicking Horse Pass in southern British Columbia, an important travel corridor over the Continental Divide, has a negative effect on wolverine movement (Austin 1998, p. 30). Wolverines partially avoided areas within 100 m (328 ft) of the highway, and preferred to use distant sites (greater than 1,100 m (3,608 ft)). Wolverines that approached the highway to cross repeatedly retreated, and successful crossing occurred in only half of the attempts (Austin 1998, p. 30). Highway-related mortality was not documented in the study. Where wolverines did successfully cross,

they used the narrowest portions of the highway right-of-way. A railway with minimal human activity, adjacent to the highway, had little effect on wolverine movements. Wolverines did not avoid, and even preferred, compacted, lightly used ski trails in the area. The extent to which avoidance of the highway may have affected wolverine vital rates or life history was not measured.

In the tri-State area of Idaho, Montana, and Wyoming, most crossings of Federal or State highways were done by subadult wolverines making exploratory or dispersal movements (ranges of resident adults typically did not contain major roads) (Packila *et al*. 2007, p. 105). Roads in the study area, typically two-lane highways or roads with less improvement, were not absolute barriers to wolverine movement. The individual wolverine that moved to Colorado from Wyoming in 2008 successfully crossed Interstate 80 in southern Wyoming (Inman *et al*. ~~2008~~2009, Figure 6). Wolverines in Norway successfully cross deep valleys that contain light human developments such as railway lines, settlements, and roads (Landa *et al*. 1998, p. 454). Wolverines in central Idaho avoided portions of a study area that contained roads, although this was possibly an artifact of unequal distribution of roads that occurred at low elevations and peripheral to the study site (Copeland *et al*. 2007, p. 2211). Wolverines frequently used un-maintained roads for traveling during the winter, and did not avoid trails used infrequently by people or active campgrounds during the summer (Copeland *et al*. 2007, p. 2211).

At both a site-specific and landscape scale, wolverine natal dens were located particularly distant from public (greater than 7.5 km (4.6 mi)) and private (greater than 3 km (1.9 mi)) roads (May 2007, p. 14-31). Placement of dens away from public roads (and away from associated human-caused mortality) was a positive influence on successful reproduction (May 2007, p. 14-31). Predictive, broad-scale habitat models, developed using historical records of wolverine occurrence, indicated that roads

were negatively associated with wolverine occurrence (Rowland *et al*. 2003, p. 101). Although wolverines appear to avoid transportation corridors in their daily movements, studies of the few areas where transportation corridors are located in wolverine habitat leads us to conclude that the effects are most likely local in scale. There are no studies that address potential effects of transportation corridors in linkage areas (i.e. outside of wolverine habitat). In the few documented long-distance movements by wolverines, the animals successfully crossed transportation corridors (Inman *et al*. 2009, Fig. 6). The available evidence indicates that dispersing wolverines can successfully cross transportation corridors.

Comment [RMI188]: And what about the scenario 100 years from now as climate change was treated? No reasonable attempt or even discussion of this potentially more influential issue is made by USFWS.

Land Management

Few effects to wolverines from land management actions such as grazing, timber harvest, and prescribed fire have been documented. Wolverines in British Columbia used recently logged areas in the summer and moose winter ranges for foraging (Krebs *et al*. 2007, pp. 2189-2190). Males did not appear to be influenced strongly by the presence of roadless areas (Krebs *et al*. 2007, pp. 2189-2190). In Idaho, wolverines used recently burned areas despite the loss of canopy cover (Copeland 1996, p. 124).

Intensive management activities such as timber harvest and prescribed fire do occur in wolverine habitat; however, for the most part, wolverine habitat tends to be located at high elevations and in rugged topography that is unsuitable for intensive timber management. Much of wolverine habitat is managed by the U.S. Forest Service or other Federal agencies and is protected from some practices or activities such as residential development. In addition, much of wolverine habitat within the contiguous United States is already in a management status such as wilderness or national park (see

Factor D for more discussion) that provides some protection from management, industrial, and recreational activities. Wolverines are not thought to be dependent on specific vegetation or habitat features that might be manipulated by land management activities, nor is there evidence to suggest that land management activities are a threat to the conservation of the species.

Summary of Factor A

The threat of current, and future impacts to wolverine habitat due to climate change occurs over the entire range of the contiguous United States population of the wolverine. This threat is likely to have already reduced the overall areal extent and distribution of wolverine suitable habitat. Determining whether or not wolverine populations have been impacted by this threat is complicated by the historical extirpation of wolverines in the early 20th century followed by recolonization and expansion. It is possible that expansion of wolverine populations through the second half of the 20th century has masked climate change effects that would have otherwise reduced populations had they existed at presettlement levels. Despite the lack of detectable population-level impacts, it is still likely that habitat is already reduced from historic levels due to this threat.

Suitable wolverine habitat is projected to be reduced by 31 percent in the contiguous United States by 2045 and 63 percent by the time interval 2070 to 2099 due to climate warming. This reduction will likely result in suitable wolverine habitat shifting up mountain slopes, and becoming smaller and more isolated due to the conical structure of mountains. Because wolverine home ranges tend to be so large, some small mountain ranges are likely to lose the ability to support wolverine

populations. We expect that the secondary effects of this habitat loss, such as increased habitat fragmentation and isolation, will intensify the overall impacts of habitat loss on wolverines.

Deep snow that persists into the month of May is essential for wolverine reproduction. This life-history parameter for the species (reproductive rate) is likely to be most sensitive to climate changes. Wolverine are vulnerable to habitat modification (specifically, reduction in persistent spring snow cover) due to climate warming in the contiguous United States. Further, it is likely that year-round wolverine habitat, not just denning habitat, will also be significantly reduced due to the effects of climate warming. Reductions in habitat would result in greater habitat isolation, thereby likely reducing the frequency of dispersal between habitat patches and the likelihood of recolonization after local extinction events. This reduced dispersal ability, if not compensated for by higher population levels or assisted dispersal, is likely to result in loss of genetic diversity within remaining habitat patches and population loss due to demographic stochasticity. The contiguous United States population of wolverines is already very small and fragmented and is, therefore, particularly vulnerable to these impacts.

Human activities, including dispersed recreation activities, infrastructure, and the presence of transportation corridors occur in occupied wolverine habitat. However, the alpine and subalpine habitats preferred by wolverine typically receive little human use relative to lower elevation habitats. The majority of wolverine habitat (over 90 percent) occurs within Forest Service and National Park Service lands that are subject to activities, but usually not direct habitat loss to infrastructure development. The best available science leads us to determine that human activities and developments do not pose a current threat to wolverines in the contiguous United States.

Comment [RMI189]: This is an unwarranted dismissal of a key issue for maintaining wolverine persistence in the contiguous US. There is some evidence to the contrary.

Wolverines coexist with some modification of their environment, as wilderness characteristics such as complete lack of motorized use or any permanent human presence are likely not critical for maintenance of populations. It is clear that wolverines coexist with some level of human disturbance and habitat modification.

We know of no examples where human activities such as dispersed recreation have occurred at a scale that could render a large enough area unsuitable so that a wolverine home range would be likely to be rendered unsuitable or unproductive. Given the large size of home ranges used by wolverine, most human activities affect such a small portion that negative effects to individuals are unlikely. These activities do not occur at a scale that is likely to have population-level effects to wolverine.

Little scientific or commercial information exists regarding effects to wolverines from development or human disturbances associated with them. What little information does exist suggests that wolverines can adjust to moderate habitat modification, infrastructure development, and human disturbance. In addition, large amounts of wolverine habitat are protected from human disturbances and development, either legally through wilderness and National Park designation, or by being located at remote and high-elevation sites. Therefore, wolverines are afforded a relatively high degree of protection from the effects of human activities by the nature of their habitat. Wolverines are known to successfully disperse long distances between habitats through human-dominated landscapes and across transportation corridors. The current level of residential, industrial, and transportation development in the western United States does not appear to have precluded the long-distance dispersal movements that wolverines require for maintenance of genetic diversity. We do not have information to suggest that

future levels of residential, industrial, and transportation development would be a significant conservation concern for the DPS.

In summary, the best scientific and commercial information available indicates that only the projected decrease and fragmentation of wolverine habitat or range due to future climate change is a threat to the species now and in the future. The available scientific and commercial information does not indicate that other potential stressors such as land management, recreation, infrastructure development, and transportation corridors pose a threat to the DPS.

Factor B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Over much of recent history, trapping has been a primary cause of documented wolverine mortality (Banci 1994, p. 108; Krebs *et al*. 2004, p. 497; Lofroth and Ott 2007, pp. 2196-2197; Squires *et al*. 2007, p. 2217), Inman et al. 2007d). Unregulated trapping is believed to have played a role in the historical decline of wolverines in North America in the late 1800s and early 1900s (Hash 1987, p. 580). However, it is possible that the role of this particular factor in the declines has been overestimated. Wolverines were not given protected status in Idaho until 1965 (Groves 1988), in Wyoming until 1973 (B. Oakleaf pers com.), Washington (?), and no season or bag limit was put in place in Montana until the late 1970s. Yet trends in verifiable and documented records (Aubry et al. 2007, Table 1) indicate that wolverines were likely recovering in Montana, Idaho, and Washington decades before any restrictions at all on killing wolverines were put in place in these states. Wolverines are especially vulnerable to targeted trapping and predator reduction campaigns due to their habit of ranging widely in search of carrion, bringing them into frequent contact with poison baits and traps

Comment [RMI190]: This section fails to provide a balanced and unbiased presentation of the significant and available information that should be considered by the USFWS in its decisions related to the topic within the proposed rule and the 10j designation.

The conclusions of this section are made without sufficient scrutiny to ascertain the merits of the works cited as evidence within and without due consideration of additional information.

Please see summary comments for more discussion.

Comment [RMI191]: This study certainly presents evidence that wolverines are trapped, but it does not have information on other causes of mortality to back up the statement that trapping is a "primary" cause. suggest removing.

Comment [RMI192]: This study was a research-induced anomaly and should not be cited here. No wolverines had been harvested for over 20 years from the study area where this project took place until it began. There were extenuating and unusual circumstances related to the research activities that led to the trapping mortality there. See Summary comments.

Comment [RMI193]: Trapping is certainly a well-documented cause of mortality for wolverines, however this does not mean that that mortality is in and of itself additive and/or detrimental to population persistence. There is ample evidence to the contrary for wolverines and a host of other wildlife species, none of which is mentioned herein. The USFWS needs to make this clear to a public, that they are asking to provide feedback relative to the use of their scarce conservation dollars, most of whom do not know of or understand the concepts of additive and compensatory mortality.

(Copeland 1996, p. 78; Inman *et al*. 2007a, pp. 4-10; Packila *et al*. 2007, p. 105; Squires *et al*. 2007, p. 2219).

Human-caused mortality of wolverines is likely additive to natural mortality due to the low reproductive rate and relatively long life expectancy of wolverines (Krebs *et al*. 2004, p. 499; Lofroth and Ott 2007, pp. 2197-2198; Squires *et al*. 2007, pp. 2218-2219). This means that trapped subpopulations likely live at densities that are lower than carrying capacity, and may need to be reinforced by recruits from untrapped subpopulations to maintain population viability and persistence.

In order to present the public with some idea of the system, history, and apparent sustainability of regulated fur harvest along with the ability to understand the relative harvest levels, season lengths, and bag limits in Montana vs. Canadian Provinces, especially those where the Krebs et al 2004 wolverine survival rates and "additive" mortality were derived, it is necessary to provide a great deal more information. There is an abundance of relevant information that is readily available. The proposed rule acts to take substantial actions to influence this issue, but as written this is a very limited treatment of the available information that cannot help lead the USFWS or the public to make reasonably informed conclusions regarding where to prioritize limited conservation funds and efforts in order to achieve wolverine persistence or that of other threatened species.

Wolverines in BC have been harvested commercially for nearly 2 centuries, and annual harvest has ranged from 40 to 634 since 1919 (Lofroth and Ott 2007). Lofroth and Krebs (2007) estimated total wolverine population of BC to be 3,532 (95% CI 2,693–4,759). In more recent years (1985–2004), approximately 170 wolverines were harvested per year in BC, and recruitment was estimated to be 196

Comment [RMI194]: These citations may state something along these lines, but none of them provide any support to back this up with evidence. This is one of those statements we all never question because it sounds likely. In the case of dropping poison baits from an airplane, I agree that wolverines would be highly susceptible due to the habits mentioned here. However, in the case of trapping, access to wolverine habitat, especially those areas where success rates would be reasonably high, is often extremely difficult. This is evidenced by the high number of trap nights required to capture wolverines for research. This is compounded because trapping is necessarily done in winter. At other times of the year, efforts to bait and trap wolverines would be futile because bears would remove baits with such regularity that catching a wolverine would be near impossible. This statement should be substantiated, removed, or additional discussion as noted here should also be included.

Comment [RMI195]: This is a blanket, one-size-fits-all statement, i.e. trapping at any level and under all circumstance, that is not backed-up by the citations provided and shows a lack of due consideration of the facts in relation to this topic.

wolverines per year (Lofroth and Ott 2007). These numbers suggest that approximately 5% of the provincial population is harvested annually and that this rate is sustainable in British Columbia. Total number of wolverines taken annually over the 15-year period 1989–2004 in Yukon Territory averaged 144 (Slough 2007). Wolverine harvest in the Northwest Territories over the same 15-year period averaged 107 per year (Slough 2007). In Alaska, an average of 545 wolverines was taken per year 1984–2003 (Golden et al. 2007a). In all cases, these consistent harvest levels for over a decade in recent years suggest relatively stable populations.

Please describe the season lengths and bag limits associated with the above wolverine harvest so that the public is able to better evaluate whether and how the take of 3-5 wolverines per year under a spatially controlled strategy that considers landscape-level gene flow by closing 40% of Montana's wolverine habitat to harvest is either adequate or not. A proper evaluation of this issue has further bearing on the proposed 10j rule that may be influential in the success of efforts to reestablish populations within historical range of the contiguous U.S. Please see summary comments.

A study in British Columbia determined that, under a regulated trapping regime, trapping mortality in 15 of 71 wolverine population units was unsustainable, and that populations in those unsustainable population units were dependent on immigration from neighboring populations or untrapped refugia (Lofroth and Ott 2007, pp. 2197-2198). Similarly, in southwestern Montana, legal trapping in isolated mountain ranges accounted for 64 percent of documented mortality and reduced the local wolverine subpopulation (Squires *et al*. 2007, pp. 2218-2219). The observed harvest levels, which included two pregnant females in a small mountain range, could have significant negative effects on a small subpopulation (Squires *et al*. 2007, p. 2219). Harvest refugia, such as jurisdictions with closed seasons, national parks, and large wilderness areas, are important to wolverine persistence on the landscape because they can serve as sources of surplus individuals to bolster trapped populations

Comment [RMI196]: This also suggests that harvest was sustainable in 80% of units and that adequate regulations are typically in place and can be applied to maintain wolverine populations. This study also concludes that harvest was sustainable at the Provincial scale, but this is not noted by the USFWS.

This same study also concluded that "Overharvest issues in all [15] population units of management concern can be addressed by reducing mean annual harvests by as little as 3 wolverines." page 2199. This could be done with season lengths, individual bag limits, total quotas, spatial closures… all things in place in MT. This is important to note given that otherwise the reader and public is given the impression that wolverine populations are so sensitive to trapping that over harvest is common and leads to serious declines in the absence of neighboring refugia.

Comment [RMI197]: We found 2 dens in one winter (without using telemetry and compared to a total of 5 over 7 years in a larger area with telemetry) and captured several adult females in this area in 2008, just after the end of this study. Inman et al 2008, 2009. Please see summary comments.

Comment [RMI198]: These results cannot be taken to reflect anything approaching a normal situation. This study is widely cited because it was published and frequently cited as evidence of the mismanagement of wolverines by the state of Montana. It should not be cited here or otherwise without a full disclosure of the situation that led to its results. Please see summary comments.

(Squires *et al*. 2007, p. 2219; Krebs et al.~~and Ott~~ 2004, p. 500). Due to their large space requirements, wolverine population refuges must be large enough to provide protection from harvest mortality; and complete protection is only available for wolverines whose entire home range occurs within protected areas. Glacier National Park, though an important refuge for a relatively robust population of wolverines, was still vulnerable to trapping because most resident wolverine home ranges extended into large areas outside the park (Squires *et al*. 2007, p. 2219). It is likely that the larger-scale refuges provided by the states of Idaho and Wyoming (which do not permit wolverine trapping) provide wolverine habitat that is fully protected from legal harvest in Montana; however, wolverines with home ranges that partially overlap Montana and dispersers that move into Montana would be vulnerable to harvest. Due to the restrictive, low level of harvest now allowed by Montana, the number of affected wolverines would be correspondingly small.

Despite the impacts of trapping on wolverines in the past, trapping is no longer a potential threat within most of the wolverine range in the contiguous United States. Montana is the only State where wolverine trapping is still legal. Before 2004, average wolverine harvest in the state of Montana was 10.5 wolverines per year and this was sustained over a >30 year period (and perhaps longer, as records were not kept prior to wolverines being give status as a furbearer in 1977) without any information to suggest that populations were becoming restricted in their distribution or numbers. Due to the ~~preliminary results~~research induced anomaly of extraordinarily high wolverine mortality ~~of~~ during the study reported in Squires *et al*. (2007, pp. 2213-2220), the Montana Department of Fish, Wildlife, and Parks adopted new regulations for the 2004–2005 trapping season that divided the State into three units, with the goal of spreading the harvest more equitably throughout the State.

Comment [RMI199]: Additional information on this topic are available in Inman et al. 2007d, entire.

Comment [RMI200]: The vast majority of the information in this paragraph suggests, by inference, that Montana harvest is unsustainable and only made possible through immigration from other protected states. Overall this gives an unwarranted impression that cannot be supported by any scientific works. Is there any indication from the genetic data that Montana's population is heavily supported by immigrants from Idaho? Why has USFWS not bothered to examine this from a genetics standpoint or even bring it up as a possibility in the discussion here? Several of the over harvested units from BC that the USFWS mentions in the opening of this paragraph occur in southeastern BC, just across the border from Montana. Does USFWS believe that these areas have been supplying Montana with wolverines? If not, where are they coming from if not from within Montana?

I also note here that the proposed rule does not cite Anderson and Aune 2008 nor have it in their lit cited package. This work shows clearly that wolverines are reproducing within the state.

Comment [RMI201]: As written, this statement suggests that MFWP made changes to their harvest regulations solely on the basis of the Pioneers wolverine study having documented an unacceptable level of mortality. I am under the impression that the genetics work of Cegelski et al, supported by FWP and published in 2003, was also a part of the decision to change regulations. Also that it was widely recognized within FWP that the unusually high mortality rates of the Squires et al. study were an anomaly caused by an ill-advised public presentation wherein one of the USFS researchers stated something to the effect of "wolverines should not be trapped in Montana and our research is going to prove it." This statement led to a defensive reaction on the part of trappers, who were, unbeknownst to the USFS researcher, in the audience, whereby they intended to 'ruin the study.' This unfortunate and entirely preventable series of events led to extraordinarily high levels of harvest in the study area, and this was the first harvest in the study area in over 20 years Despite knowledge on the background of the events that led to the "preliminary results" that the USFWS mentions here, FWP recognized that their regulations were not designed to prevent higher than normal or acceptable harvest levels from any one area. So they moved to prevent that from being able to happen again. If there is one thing to take from the Squires et al. 2007 study related to wolverine survival, it was the need to design regulations with spatial considerations, not that wolverine harvest is unsustainable. As the authors of that paper state, "If populations are exploited, we suggest that wolverine harvest be managed by individual mountain ranges or small groupings of mountain ranges. The inten ...

Comment [RMI202]: I don't believe the USFWS's description here captures the intent of the new regulations sufficiently.

For the 2008–2009 trapping season, the Montana Department of Fish, Wildlife, and Parks adjusted its wolverine trapping regulations again to reduce the vulnerability of subpopulations in small mountain ranges and increase gene-flow among the major ecosystems of the Northern U.S. Rockies. This new regulation closed wolverine trapping within the smaller island mountain ranges of Montana that sit between the 3 large core areas of publically owned wolverine habitat in the Northern U.S. Rockies, i.e., the Greater Yellowstone, Northern Continental Divide, and Salmon-Selway ecosystems (Montana Department of Fish Wildlife and Parks 2008, pp. 8-11). . This new regulation closed wolverine trapping in approximately 40% of wolverine habitat within the state, and was focused on areas that were most vulnerable to overharvest (Inman et al. 2007d). ~~further increase the geographic control on harvest to prevent concentrated trapping in any single area, and to completely stop trapping in isolated mountain ranges where small populations are most vulnerable (Montana Department of Fish Wildlife and Parks 2010, pp. 8-11).~~ The 2008~~ir new~~ regulations also~~spread harvest across three geographic units (the Northern Continental Divide area, the Greater Yellowstone area, and the Bitterroot Mountains), and~~ established a lower statewide limit of five wolverines. In the four trapping seasons that have occurred since these rules were implemented, wolverine take averaged 3.25 wolverines annually (Montana Department of Fish Wildlife and Parks 2010, pp. 8-11; Brian Giddings Pers. Comm. August 30, 2012), with reduced harvest being due to season closure rather than lack of wolverines. Under the current regulations, no more than three female wolverines can be legally harvested each year, and harvest in the more vulnerable isolated mountain ranges is prohibited. The size of the wolverine population subjected to trapping in this area is not known precisely but is likely not more than about 300 animals in states of Montana, Idaho, and Wyoming combined (Bob Inman pers. comm. 2010b).

Comment [RMI203]: Please describe the spatially explicit limits, i.e., only one each in the Yellowstone and Salmon-Selway Ecosystems, and inform the USFWS decision makers and public of the logic behind the different levels of allowable harvest in the NCDE. See Anderson and Aune 2008.

The Montana Department of Fish, Wildlife, and Parks conduct yearly furbearer monitoring using track surveys. These surveys involve snowmobiling along transect routes under good tracking conditions and visually identifying all carnivore tracks encountered. The protocol does not use verification methods such as DNA collection or camera stations to confirm identifications. Consequently, misidentifications are likely to occur. Given the relative rarity of wolverines and the relative abundance of other species with which they may be confused, such as bobcats (*Lynx rufus*), Canada lynx (*Lynx canadensis*), and mountain lions (*Felis concolor*), lack of certainty of identifications of tracks makes it highly likely that the rare species is overrepresented in unverified tracking records (McKelvey *et al.* 2008, entire). The Montana Department of Fish, Wildlife, and Parks wolverine track survey information does not meet our standard for reliability described in the geographic distribution section, and we have not relied on this information in this finding.

Comment [RMI204]: What is the purpose of including this information? Please make it clear how is it related to factor B, overutilization?

Montana wolverine populations have rebounded from historic lows in the early 1900s while at the same time being subjected to regulated trapping (Aubry *et al*. 2007, p. 2151; Montana Department of Fish, Wildlife, and Parks 2007, p. 1). In fact, much of the wolverine expansion that we have described above took place under less-restrictive (i.e., higher harvest levels) harvest regulations than are in place today. The extent to which wolverine population growth has occurred in Montana as a result of within-Montana population growth, versus population growth attributable to surrounding states where wolverines are not trapped, i.e., population growth driven by the entire metapopulation versus just the portion of the metapopulation found in Montana, is unknown.

Comment [RMI205]: Newby and Wright 1955 and Newby and McDougal 1964 show and suggest that population expansion throughout Montana likely initiated from Canada. This information should be used here. Subsequent to that time, is there any basis in fact to suggest that population growth/maintenance from the 1970's forward was from anything other than that occurring within Montana? The Absaroka study (Murphy et al. 2011) would suggest it is not occurring from Wyoming. What does the genetic information indicate and why is that not presented here? Is there any indication from the genetic data that Montana's population is heavily supported by immigrants from Idaho? Why has USFWS not bothered to examine this from a genetics standpoint or even bring it up as a possibility in the discussion here? Several of the over harvested units from BC that the USFWS mentions above occur in southeastern BC, just across the border from Montana. Does USFWS believe that these areas have been supplying Montana with wolverines? If not, where are they coming from if not from within Montana?

I also note here that the proposed rule does not cite Anderson and Aune 2008 nor have it in their lit cited package. This work shows clearly that wolverines are reproducing within the state. As does the telemetry research (Inman et al. 2007x, Copeland and Yates 2008), including in the Squires et al. 2007 study area soon after that study concluded (See summary comments).

Current levels of incidental trapping (i.e., capture in traps set for species other than wolverine) have been suggested by the petitioners to be a threat to wolverines. In the 2008–2009 trapping season,

two wolverines were incidentally killed in traps set for other species in Beaverhead and Granite Counties, Montana (Montana Fish, Wildlife, and Parks 2010, p. 2). These two mortalities occurred within the portion of southwestern Montana that is currently closed to legal wolverine trapping to ensure that wolverines are not unsustainably harvested in this area of small, relatively isolated mountain ranges. Four cases of incidental wolverine trapping have occurred in Idaho in recent years. One wolverine was trapped by a coyote/bobcat trapper in 2006 and upon discovering the wolverine the trapper alerted IDFG; the wolverine ~~and~~ was collared and released after all of its toes and a portion of its left front foot were amputated ~~(Inman et al. 2008, p. 1)~~; t~~. T~~hat animal (a female) survived and successfully reproduced after release (Inman et al. 2008, p. 1). The Department of Agriculture Wildlife Services trapped three wolverines (one each in 2004, 2005, and 2010) incidental to trapping wolves involved in livestock depredations. One of these sustained severe injuries and was euthanized. The other two were released without visible injury. Another wolverine was trapped in Wyoming in 2006. This animal was reported to WGF and released unharmed (Inman 2012, pers. comm.). The three documented mortalities are possibly locally significant for wolverines in these areas because local populations in each of the mountain ranges are small and relatively isolated from nearby source populations. If I am reading this correctly, there have been 7 documented incidental captures over the last 12 years within the DPS; 9 of those 12 were released; an additional 1 may have been in lieu of a legal harvest. So there have been 2-3 confirmed incidental mortalities within the DPS over a 12 year period, or 1 every 4 years on average. I am personally aware of more (5) wolverine road-kill mortalities in only Montana and Wyoming over the same time period. More discussion below.

This section also does not describe for decision makers and the public the basic biology such as territoriality or density-dependent population regulation that is related to this issue. This includes the

Comment [RMI206]: What was MFWP's response to these events? Was the season closed without a legal harvest or did these occur after the 1 legal harvest had occurred?

Comment [RMI207]: Please note in this section that despite the use of abdominal implants to monitor wolverines, there have not been any cases of intentional illegal killing documented in any of the contiguous U.S. studies to my knowledge.

Comment [RMI208]: This statement has not been subjected to the same requirement for evidence that the USFWS has required in the proposed rule to act upon the potential for human infrastructure and transportation corridors to negatively impact wolverines. Why?

almost immediate reoccupation of home ranges of individuals that died during our research project (Inman et al. 2012a, and more description in Inman et al. 2007, Chapter 1, Appendix A, page 16).

Summary of Factor B

Legal wolverine harvest occurs in one state, Montana, within the range of the DPS. The extent to which this harvest affects populations occurring outside of Montana is unknown. However, the State of Montana contains most of the habitat and wolverines that exist in the current range of the DPS, has more evidence of widespread distribution and reproduction than any other area, and regulates trapping to reduce the impact of harvest on wolverine populations. Incidental harvest also occurs within the range of the DPS; however, the level of mortality from incidental trapping appears to be very low, lower than that from road-kill of wolverines. Harvest, when combined with the likely effects of climate change, may contribute to the likelihood that the wolverine will become extirpated in the future. This may occur by increasing the speed with which small populations of wolverine are lost from isolated habitats, and also by increasing mortality levels for dispersing wolverines, with the result of reducing dispersal rates. Regular dispersal and exchange of genetic material are required to maintain the genetics and demographics of wolverine subpopulations in the contiguous United States.

Comment [RMI209]: If the proposed rule is going to suggest this may happen, please provide clear biology and logic for what and how.

Comment [RMI210]: At what level? 1 per year? 5 per year? 10 per year? As written, this could be taken to mean that even a single mortality from any human source is a threat to the wolverine DPS.

Comment [RMI211]: Agreed, but not until the impact from climate becomes severe, which would likely be decades from now, and there is a history of adaptive management by MFWP.

The current known level of incidental trapping mortality is low. We note that it is unknown whether or not increased trapping of wolves associated with wolf trapping regulations recently approved by the states of Idaho and Montana would be likely to result in increased incidental trapping of wolverines. Idaho began its wolf trapping program in the winter of 2011–2012, and Montana began theirs in the winter of 2012–2013. These wolf trapping activities are relatively new in the DPS area, and

we do not yet have reliable information on the level of incidental take of wolverines that may result from them.

Based on the best scientific and commercial information available, we conclude that trapping, including known rates of incidental trapping in Montana and Idaho, result in a small number of wolverine mortalities each year and that this level of mortality by itself would not be a threat to the wolverine DPS. However, by working in concert with habitat loss resulting from climate change, mortality due to harvest and incidental trapping may contribute to population declines. Therefore, we conclude that trapping, when considered cumulatively with habitat loss resulting from climate change, is likely to become a threat to the DPS (see discussion under Synergistic Interactions Between Threat Factors, below).

Comment [RMI212]: This would likely be true, but only after climate change has had severe impacts on wolverines. This conclusion also fails to consider the history of actions by MFWP to maintain wolverines.

Factor C. Disease or Predation

No information is currently available on the potential effects of disease on wild wolverine populations. Wolverines are sometimes killed by wolves (*Canis lupus*), black bears (*Ursus americanus*), and mountain lion (White et al. Can. Field nat. 116:132-134;Burkholder 1962, p. 264; Hornocker and Hash 1981, p. 1296; Copeland 1996, p. 44-46; Inman *et al*. 2007d, p. 89). In addition, wolverine reproductive dens are likely subject to predation, although so few dens have been discovered in North America that determining the intensity of this predation is not possible.

Summary of Factor C

We have no information to suggest that wolverine mortality from predation and disease is above natural or sustainable levels. The best scientific and commercial information available indicates that disease or predation is not a threat to the species now or likely to become so in the future.

Factor D. Inadequacy of Existing Regulatory Mechanisms

Based on our calculations using a composite map showing the coverage of both the Copeland *et al*. (2010, entire) and Inman et al. (2012, entire) wolverine habitat models, the majority (94 percent) of wolverine habitat currently occupied by wolverine populations in the lower contiguous United States is Federally owned and managed, mostly by the U.S. Forest Service. An estimated 144,371 km^2 (49,258 mi^2) of wolverine habitat occurs in the occupied area in Montana, Idaho, Oregon (Wallowa Range), and Wyoming. Of that, 135,396 km^2 (46,332 mi^2) (?%) is in Federal ownership. Additionally, 47,150 km^2 (12,973 mi^2) (32.7 percent) occurs in designated wilderness, and 23,062 km^2 (1,630 mi^2) (16.0 percent) occurs in inventoried roadless areas. An additional 13,784 km^2 (3,288 mi^2) (9.5 percent) are within national parks.

This description fails to highlight or even consider the ownership of the absolutely necessary metapopulation linkage habitat. New information (Inman et al. 2013b) suggests that 44% of the area ranking ≥98.5th percentile of wolverine connectivity habitat is in private ownership.

Comment [RMI213]: Inman, R.M., S. Bergen, and J. Beckmann. 2013b. Wildlife as public domain: Endangered status, connectivity, and critical habitat of the wolverine. Paper IV *in* Wolverine ecology and conservation in the western United States. PhD Dissertation, R.M. Inman, 2013. Grimsö Wildlife Research Station, Department of Ecology, Swedish University of Agricultural Sciences, Uppsala, Sweden.

None of the existing Federal or State regulatory mechanisms were designed to address the threat of modification of wolverine habitat due to the loss of snowpack associated with climate change. Several existing regulatory mechanisms protect wolverine from other forms of disturbance and from overutilization from harvesting; these are described in more detail below.

Federal Laws and Regulations

The Wilderness Act

The Forest Service and National Park Service both manage lands designated as wilderness areas under the Wilderness Act of 1964 (16 U.S.C. 1131-1136). Within these areas, the Wilderness Act states the following: (1) New or temporary roads cannot be built; (2) there can be no use of motor vehicles, motorized equipment, or motorboats; (3) there can be no landing of aircraft; (4) there can be no other form of mechanical transport; and (5) no structure or installation may be built. A large amount of suitable wolverine habitat, about 28 percent for the states of Montana, Idaho, and Wyoming, occurs within Federal wilderness areas in the United States (Inman personal communication 2007b). As such, a large proportion of existing wolverine habitat is protected from direct loss or degradation by the prohibitions of the Wilderness Act.

National Environmental Policy Act

All Federal agencies are required to adhere to the National Environmental Policy Act (NEPA) of 1970 (42 U.S.C. 4321 *et seq.*) for projects they fund, authorize, or carry out. The Council on Environmental Quality's regulations for implementing NEPA (40 CFR 1500–1518) state that agencies shall include a discussion on the environmental impacts of the various project alternatives (including the proposed action), any adverse environmental effects which cannot be avoided, and any irreversible or irretrievable commitments of resources involved (40 CFR 1502). The NEPA itself is a disclosure

law, and does not require subsequent minimization or mitigation measures by the Federal agency involved. Although Federal agencies may include conservation measures for wolverines as a result of the NEPA process, any such measures are typically voluntary in nature and are not required by the statute. Additionally, activities on non-Federal lands are subject to NEPA if there is a Federal action.

For example, wolverines are designated as a sensitive species by the Forest Service, which requires that effects to wolverines be considered in documentation completed under NEPA. NEPA does not itself regulate activities that might affect wolverines, but it does require full evaluation and disclosure of information regarding the effects of contemplated Federal actions on sensitive species and their habitats.

National Forest Management Act

Under the National Forest Management Act of 1976, as amended (16 U.S.C. 1600–1614), the Forest Service shall strive to provide for a diversity of plant and animal communities when managing national forest lands. Individual national forests may identify species of concern that are significant to each forest's biodiversity. Outside of designated wilderness but still on Forest Service-managed lands, wolverines occur mainly in alpine areas. Their habitat is generally offered more protections from timber harvest than would otherwise be the case in lowland areas due to the difficulty of accessing wolverine habitat, especially in areas where motorized access is limited or absent, such as most National Forest land and all designated wilderness areas.

National Park Service Organic Act

The NPS Organic Act of 1916 (16 U.S.C. 1 *et seq.*), as amended, states that the NPS ‘‘shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations to conserve the scenery and the national and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.’’ Where wolverines occur in National Parks, they and their habitats are protected from large-scale loss or degradation due to the Park Service’s mandate to ‘‘...conserve scenery... and wildlife...[by leaving] them unimpaired.’’ Wolverine harvest and trapping of other furbearers is also prohibited in National Parks.

Clean Air Act of 1970

On December 15, 2009, the Environmental Protection Agency (EPA) published in the Federal Register (74 FR 66496) a rule titled, “Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act.” In this rule, the EPA Administrator found that the current and projected concentrations of the six long-lived and directly emitted greenhouse gases (GHGs)—carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride—in the atmosphere threaten the public health and welfare of current and future generations; and that the combined emissions of these GHGs from new motor vehicles and new motor vehicle engines contribute to the GHG pollution that threatens public health and welfare (74 FR 66496). In effect, the EPA has concluded that the GHGs linked to climate change are pollutants, whose emissions can now be subject to the Clean Air Act (42 U.S.C. 7401 *et seq.*) (see 74 FR 66496). However, specific regulations to limit GHG emissions were only proposed in 2010 and, therefore,

cannot be considered an existing regulatory mechanism. At present, we have no basis to conclude that implementation of the Clean Air Act in the future (40 years, based on global climate projections) will substantially reduce the current rate of global climate change through regulation of GHG emissions. Thus, we conclude the Clean Air Act is not designed to address the primary threat to wolverine of the loss of snowpack due to the effects of climate change.

State Laws and Regulations

State Comprehensive Wildlife Conservation Strategies and State Environmental Policy and Protection Acts

The wolverine is listed as State Endangered in Washington, California, and Colorado. In Idaho and Wyoming it is designated as a protected nongame species (Idaho Department of Fish and Game 2010, p. 4; Wyoming Game and Fish 2005, p. 2). Oregon, while currently not considered to have any individuals other than possible unsuccessful dispersers, has a closed season on trapping of wolverines. These designations largely protect the wolverine from mortality due to hunting and trapping. In Montana, the wolverine is classified as a regulated furbearer (Montana Fish, Wildlife, and Parks 2010, p. 8). Montana is the only State in the contiguous United States where wolverine trapping is still legal.

Comment [RMI214]: Would it be more accurate to say established males but no known female presence (Magoun et al 2012).

Wolverines receive some protection under State laws in Washington, California, Idaho, Montana, Wyoming, and Colorado. Each State's fish and wildlife agency has some version of a State Comprehensive Wildlife Conservation Strategy (CWCS) in place. These strategies, while not State or Federal legislation, can help prioritize conservation actions within each State. Named species and

habitats within each CWCS may receive focused attention during State Environmental Protection Act (SEPA) reviews as a result of being included in a State's CWCS. However, only Washington, California, and Montana appear to have SEPA-type regulations in place. In addition, each State's fish and wildlife agency often specifically names or implies protection of wolverines in its hunting and trapping regulations. Only the State of Montana currently allows wolverine harvest (see discussion under Factor B).

Before 2004, the Montana Department of Fish, Wildlife, and Parks regulated wolverine harvest through the licensing of trappers, a bag limit of one wolverine per year per trapper, and no statewide limit. Under this management, average wolverine harvest was 10.5 wolverines per year. Due to preliminary results of the study reported in Squires *et al*. (2007, pp. 2213-2220), Montana Department of Fish, Wildlife, and Parks adopted new regulations for the 2004–2005 trapping season that divided the State into three units with the goal of spreading the harvest more equitably among available habitat. In 2008, Montana Department of Fish, Wildlife, and Parks further refined their regulations to prohibit trapping in isolated mountain ranges, and reduced the overall statewide harvest to five wolverines with a statewide female harvest limit of three. Under factor B, above, we concluded that trapping, including known rates of incidental trapping in Montana, by itself, is not a threat to the wolverine DPS, but that by working in concert with the primary threat of climate change, the trapping program may contribute to population declines (see Synergistic Interactions Between Threat Factors, below).

Comment [RMI215]: See comments above under factor B. This is an inadequate description of the events, information and context within which this management decision was made by MFWP.

Summary of Factor D

The existing regulatory mechanisms appear to protect wolverine from several of the factors described in Factors A and B above. Specifically, State regulations for wolverine harvest appear to be sufficient to prohibit range–wide overutilization from hunting and trapping in the absence of other threats. However, given that climate change impacts are expected to reduce wolverine populations and fragment habitat, the impact of harvest to wolverine would be expected to increase if harvest levels were maintained at current levels. Federal ownership of much of occupied wolverine habitat protects the species from direct losses of habitat and provides further protection from many of the forms of disturbance described above. Wolverines use habitats affected by human disturbance, and additional protection is afforded wolverines by the large area of their range that occurs in designated wilderness and national parks. The current regulatory regime does not address the potential impacts of dispersed winter recreation outside of protected areas; however, at this time the available information does not suggest that dispersed winter recreation is a threat to the DPS.

Comment [RMI216]: an assumption that disregards the pattern and previous actions by the state of Montana.

Comment [RMI217]: Of notable exception is the all-critical linkage habitat, which USFWS seems content to ignore throughout the document even though valley bottom development is a common concern within many state wildlife action plans in the west.

Our review of the regulatory mechanisms in place at the national and State level demonstrates that the short-term, site-specific threats to wolverine from direct loss of habitat, disturbance by humans, and direct mortality from hunting and trapping are, for the most part, adequately addressed through State and Federal regulatory mechanisms. However, as described under Factor A, the primary threat with the greatest severity and magnitude of impact to the species is loss of habitat due to continuing climate warming. The existing regulatory mechanisms currently in place at the national level were not designed to address the threat to wolverine habitat from climate change.

Comment [RMI218]: which part is not?

Comment [RMI219]: Is this all the USFWS has to say about regulatory mechanisms and climate change? This is a 118 page word document that proposes to list wolverines due primarily to the threat of climate change, and there is one sentence here on this topic?? Where are the solutions?

Factor E. Other Natural or Manmade Factors Affecting its Continued Existence

Small Population Size

Population ecologists use the concept of a population's "effective" size as a measure of the proportion of the actual population that contributes to future generations (for a review of effective population size, see Schwartz *et al*. 1998, entire). In a population where all of the individuals contribute offspring equally, effective population size would equal true population size, referred to as the population census size. For populations where contribution to the next generations is often unequal, effective population size will be smaller than the census size. The smaller the effective population size, the more reproduction in each generation is dominated by a few individuals in each generation. For wolverines it is likely that high-quality home ranges are limited, and individuals occupying them are better able to reproduce. Therefore, mature males and females that are successful at acquiring and defending a territory may dominate reproduction. Another contributing factor that reduces effective population size is the tendency in wolverines for a few males to monopolize the reproduction of several females, reducing reproductive opportunities for other males. Although this monopolization is a natural feature of wolverine life history strategy, it can lead to lower effective population size and reduce population viability by reducing genetic diversity. The effective population is not static, members of the effective population in 1 year may lose this status in the following year and possibly regain it again later depending on their reproductive success. When members of the effective population are lost, it is likely that their territories are quickly filled by younger individuals who may not have been able to secure a productive territory previously.

Comment [RMI220]: Lower than what? The natural effective population sixe that wolverines have experienced successfully for hundreds or thousands of years?

Effective population size is important because it determines rates of loss of genetic variation and the rate of inbreeding (citations). Populations with small effective population sizes show

reductions in population growth rates and increases in extinction probabilities when genetic diversity is low enough to lead to inbreeding depression (Leberg 1990, p. 194; Jimenez *et al*. 1994, pp. 272-273; Newman and Pilson 1997, p. 360; Saccheri *et al*. 1998, p. 492; Reed and Bryant 2000, p. 11; Schwartz and Mills 2005, p. 419; Hogg *et al*. 2006, p. 1495, 1498; Allendorf and Luikart 2007, pp. 338-342). Franklin (1980, as cited in Allendorf and Luikart 2007, p. 359) proposed an empirically based rule suggesting that for short-term (a few generations) maintenance of genetic diversity, effective population size should not be less than 50. For long-term (hundreds of generations) maintenance of genetic diversity, effective population size should not be less than 500 (for appropriate use of this rule and its limitations see Allendorf and Luikart 2007, pp. 359-360). Others suggest that even higher numbers are required to ensure that populations remain viable, suggesting that long-term connectivity to the reservoir of genetic resources in the Canadian population of wolverines will be required for the long-term genetic health of the DPS (Traill *et al.* 2010, p. 32). All evidence suggests that no habitat area within the contiguous United States is now nor ever was large enough to support a wolverine population with an effective population size of 500 animals. Given the life history of wolverines that includes high inequality of reproductive success and a metapopulation of semi-isolated subpopulations, effective population sizes would likely never reach even 100 individuals at full habitat occupancy as this would suggest a census population of over 1,000. In this case, population connectivity exchange with the larger Canadian/Alaskan population would likely be required for long-term viability.

Wolverine effective population size in the northern Rocky Mountains, which is the largest extant population in the contiguous United States, is exceptionally low and is below what is thought necessary for short-term maintenance of genetic diversity. Estimates for effective population size for wolverines in the northern Rocky Mountains averaged 35 (credible limits = 28–52) (Schwartz *et al*.

Comment [RMI221]: USFWS is considering effective population size and appears to be basing their considerations on this rule, so some discussion here for the decision makers and public is warranted .regarding the degree to which this rule is fact vs. rule of thumb with no species-specific knowledge based in fact that I am aware of.

Would wolverines and cotton-tailed rabbits be expected to have the same effective population size? Does the rule of 50/500 apply no matter the ecology of the species?

Comment [RMI222]: So if 1,000 wolverines (or more) would be expected to display an effective population size of 100, then a population of approximately 250 in Idaho, Montana and a small portion of Wyoming would be expected to display an effective population size of 25?

And, this population would require successful dispersal and exchange with larger Canadian populations.

Comment [RMI223]: Which appears to be higher than would be expected given a population of 250 wolverines based on the above numbers provided in the discussion by USFWS. Does this estimate suggest that there are 350 wolverines in the sampled area at the 10:1 ratio in the text?

Please explain how the estimate is affected, or not, via the collection of samples over a 19-year period.

2009, p. 3226). This study excluded the small population from the Crazy and Belt Mountains (hereafter "CrazyBelts") as they may be an isolated population, which could bias the estimate using the methods of Tallmon *et al*. (2007, entire). Measures of the effective population sizes of the other populations in the contiguous United States have not been completed, but given their small census sizes, their effective sizes are expected to be smaller than for the northern Rocky Mountains population. Thus, wolverine effective population sizes in the contiguous U.S.? are very low. For comparison, estimates of wolverine effective population size are bracketed by critically endangered species, such as the black-footed ferret (*Mustela nigripes*) (4.10) (Wisely *et al*. 2007, p. 3) and the ocelot (*Leopardus pardalis*) (2.9 to 13.9) (Janecka *et al*. 2007, p. 1), but are substantially smaller than estimates for the Yellowstone grizzly bear (*Ursus arctos*) (greater than 100), which has reached the level of recovery under the Act (Miller and Waits 2003, p. 4338). Therefore, we conclude that effective population size estimates for wolverines do not suggest that populations are currently critically endangered, but they do suggest that populations are low enough that they could be vulnerable to loss of genetic diversity, and may require intervention in the future to remain viable. To date, no adverse effects of the lower genetic diversity of the contiguous United States wolverines have been documented.

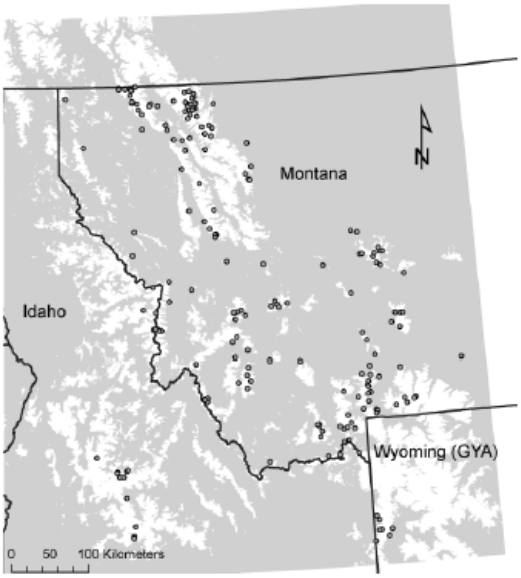

FIG. 1. Map of the northern U.S. Rockies. The white areas are locations of the spring snow cover bioclimatic envelope (J. P. Copeland et al., *unpublished manuscript*), whereas the gray areas do not have spring snow cover. Circles are locations of samples collected between 1989 and 2006. GYA stands for the Greater Yellowstone Area.

Comment [RMI224]: But excluding the area does not bias the estimate? Clearly it must bias the estimate low.

Comment [RMI225]: Populations of what, wolverines?

Comment [RMI226]: potential census sizes, i.e., population capacities?

Comment [RMI227]: Clearly the Schwartz et al 2009 analysis is a MINIMUM estimate of effective population size for the wolverine DPS. The Crazy/Belt samples were purposefully excluded, and viewing figure 1 from the paper (pasted below), vast areas of predicted habitat are unsampled, perhaps as much as half (or more considering the Crazy/Belt) of the area logically presumed to be occupied by wolverines.

Does this mean that effective population size is more likely to be near 70? Does this mean that the interbreeding population is closer to 700 and extends into Canada?

Comment [RMI228]: Plural? Why is the USFWS discussing wolverine populations as opposed to a single metapopulation. Is there evidence of a lack of connectivity via the genetic data or some other data? If this is the case, why is this not addressed as a serious threat to the DPS at the present date and why is infrastructure and transportation not on the list of suspected causes?

Comment [RMI229]: What is the natural variation in viable effective population size among species? Would white-tailed deer and wolverines be expected to have similar naturally occurring effective population sizes?

Clearly there is a maximum potential naturally-occurring effective population size for a species in a particular location, and assessing the degree to which a current population is at or below that capacity requires information on historical effective population size or carrying capacity.

Comment [RMI230]:
What is the USFWS's assessment regarding the degree to which the wolverine DPS is at or below maximum potential effective population size?

What does this assessment suggest about the impacts of harvesting 10.5 wolverines per year for the past 30+ years in Montana?

What does this assessment suggest about impacts of the current, reduced and spatially controlled season?

Comment [RMI231]: Establishing individuals with new genetic material in the DPS would require removal of a current individual from a territory. Simply releasing new individuals would result in territorial battles where the desired outcome (new individuals establish) would be uncertain and thus much less financially efficient.

The USFWS should carefully consider this potential need with regard to its proposed rule, 10j designation, and proposal to exclude any "take" o ...

Wolverines in the contiguous United States are thought to be derived from a recent recolonization event after they were extirpated from the area in the early 20th century (Aubry *et al*. 2007, Table 1). Consequently, wolverine populations in the contiguous United States have reduced genetic diversity relative to larger Canadian populations as a result of founder effects or inbreeding (Schwartz *et al*. 2009, pp. 3228-3230). Wolverine effective population size in the northern Rocky Mountains was estimated to be 35 (Schwartz et al. 2009, p. 3226) and is below what is thought to be adequate for short-term maintenance of genetic diversity. Loss of genetic diversity can lead to inbreeding depression and is associated with increased risk of extinction (Allendorf and Luikart 2007, pp. 338-343). Small effective population sizes are caused by small actual population size (census size), or by other factors that limit the genetic contribution of portions of the population, such as polygamous mating systems. Populations may increase their effective size by increasing census size or by the regular exchange of genetic material with other populations through interpopulation mating.

Comment [RMI232]: Newby et al 1955 and Newby and McDougal 1964 show this pattern well.

Comment [RMI233]: Or naturally low population potential due to total available habitat/territory limitations.

Comment [RMI234]: the previous paragraph appeared to be a summary, so not clear where this one is going?

The concern with the low effective population size was highlighted in a recent analysis that determined that, without immigration from other wolverine populations, at least 400 breeding pairs would be necessary to sustain the long-term genetic viability of the northern Rocky Mountains wolverine population (Cegelski *et al*. 2006, p. 197). However, the entire population is likely only 250 to 300 (Inman 2010b, pers. comm.), with a substantial number of these being unsuccessful breeders or nonbreeding subadults (i.e., part of the census population, but not part of the effective population).

Comment [RMI235]: This analysis simply suggests that genetic viability has always been maintained by dispersal in the contiguous US.

Genetic studies demonstrate the essential role that genetic exchange plays in maintaining genetic diversity in small wolverine populations. The concern that low effective population size would result in negative effects is already being realized for the contiguous United States population of

Comment [RMI236]: Negative effects relative to what? What is baseline? What is maximum potential? Which of these metrics is being used to gauge a negative effect?

wolverine. Genetic drift has already occurred in subpopulations of the contiguous United States: Wolverines here contained 3 of 13 haplotypes found in Canadian populations (Kyle and Strobeck 2001, p. 343; Cegelski *et al*. 2003, pp. 2914-2915; Cegelski *et al*. 2006, p. 208; Schwartz *et al*. 2007, p. 2176; Schwartz *et al*. 2009, p. 3229). The haplotypes found in these contiguous US subpopulations were a subset of those in the larger Canadian population, indicating that genetic drift had caused a loss of genetic diversity. One study found that a single haplotype dominated the northern Rocky Mountain wolverine population, with 71 of 73 wolverines sampled expressing that haplotype (Schwartz *et al*. 2007, p. 2176). The reduced number of haplotypes indicates not only that genetic drift has occurred but also some level of genetic separation; if these populations were freely interbreeding, they would share more haplotypes (Schwartz *et al*. 2009, p. 3229). The reduction of haplotypes is likely a result of the fragmented nature of wolverine habitat in the United States and is consistent with an emerging pattern of reduced genetic variation at the southern edge of the range documented in a suite of boreal forest carnivores (Schwartz *et al*. 2007, p. 2177).

Immigration of wolverines from Canada is not likely to bolster the genetic diversity of wolverines in the contiguous United States. There is an apparent lack of connectivity between wolverine populations in Canada and the United States based on genetic data (Schwartz *et al.* 2009, pp. 3228-3230). The apparent loss of connectivity between wolverines in the northern Rocky Mountains and Canada prevents the influx of genetic material needed to maintain or increase the genetic diversity in the contiguous United States. The continued loss of genetic diversity may lead to inbreeding depression, potentially reducing the species' ability to persist through reduced reproductive output or reduced survival. Currently, the cause for this lack of connectivity is uncertain. Wolverine habitat appears to be well-connected across the border region (Copeland *et al.* 2010, Figure 2) and there are

Comment [RMI237]: Is this due to drift or a limited number of founders? What was the maximum number of haplotypes ever found in the contiguous US?

Comment [RMI238]: Again, relative to what. Is there reason to assume that the contiguous US contained all 13 haplotypes at some point in time? Would the habitat here ever have supported the maximum number of haplotypes found in large, contiguous populations?

Is it possible that the haplotypes found here are specifically adapted to the conditions of the contiguous US? Or, conversely, is it possible that the haplotypes found elsewhere but not here are not adapted to DPS conditions?

New information on the genetics of a peripheral wolverine population is now available and should be discussed, especially with regard to the potential importance of DPS genetics being represented in wolverines translocated to the 10j area (Zigouris et al 2012.

Comment [RMI239]: If reduced genetic variation is a concern, shouldn't the USFWS be focused to a much greater degree than it is in this proposed rule on connectivity and the potential for infrastructure and transportation corridors to impact wolverines.

Why has the USFWS put so much effort into assessing climate change impacts on wolverines out to 100 years, yet completely dismisses the issue of the influence of infrastructure and transportation on connectivity?

This appears to be a major flaw in the proposed rule as to its ability to conserve wolverines over the long term..

Comment [RMI240]: OK,. so immigrants from Canada can be ruled out as responsible for the maintenance of the harvested population in Montana as was inferred as a possibility above under factor B. Please also consider these data in relation to the unharvested population in Idaho and go back and correct that section.

few manmade obstructions such as transportation corridors or alpine developments. However, this lack of genetically detectable connectivity may be related to harvest management in southern Canada (Lofroth and Ott 2007).

Summary of Factor E

Small population size and resulting inbreeding depression are potential, though as-yet undocumented, threats to wolverines in the contiguous United States. There is good evidence that genetic diversity is lower in wolverines in the DPS than it is in the more contiguous habitat in Canada and Alaska. The significance of this lower genetic diversity to wolverine conservation is unknown. We do not discount the possibility that loss of genetic diversity could be negatively affecting wolverines now and continue to do so in the future. It is important to point out, however, that wolverine populations in the DPS area are thought to be the result of colonization events that have occurred since the 1930s. Such recent colonizations by relatively few individuals and subsequent population growth are likely to have resulted in founder effects, which could contribute to low genetic diversity. The effect of small population sizes and low genetic diversity may become more significant if populations become smaller and more isolated, as predicted due to climate changes.

Based on the best scientific and commercial information available we conclude that demographic stochasticity and loss of genetic diversity due to small effective population sizes, by itself, is not a threat to the wolverine DPS. However, by working in concert with the primary threat of habitat loss due to climate change, this may contribute to the cumulative effect of population declines. Therefore, we conclude that demographic stochasticity and loss of genetic diversity due to small

effective population sizes is a threat to wolverines when considered cumulatively with habitat loss due to climate change (see discussion under Synergistic Interactions Between Threat Factors).

Synergistic Interactions Between Threat Factors

We have evaluated individual threats to the distinct population segment of the North American Wolverine throughout its range in the contiguous United States. The wolverine DPS faces one primary threat that is likely to drive its conservation status in the future: habitat change and loss due to climate change. This factor alone is enough to determine that the species should be proposed for listing under the Act. Other factors, though not as severe or geographically comprehensive as the potential habitat effects from climate change may, when considered in the context of changes likely to occur due to climate change, become threats due to the cumulative effects they have on wolverine populations. For wolverines, the only such threat factors found in our analysis to have a basis of support as threats to wolverines were the effects of small subpopulation sizes and subpopulation isolation on wolverine genetic and demographic health, and the subsequent potential future influence of trapping.

Comment [RMI241]: The proposed rule, as written, bases this decision on a flawed assumption and an over prediction of the impact of climate change on wolverines.

Comment [RMI242]: This is connectivity, but USFWS is ignoring the future influence infrastructure and transportation corridors, which leaves one of the major potential threats at large.

As discussed in our analysis of the effects on wolverine habitat from climate change under Factor A, wolverine habitat in the contiguous United States is likely to become smaller overall, and remaining habitat is likely to be more fragmented and fragments more isolated from one another than they are today (McKelvey *et al*. 2011, Figure 8). Given that wolverine subpopulations in the DPS are already so small, and movement between subpopulations so restricted, inbreeding has become likely (Kyle and Strobeck 2001, p. 343; Cegelski *et al*. 2003, pp. 2914-2915; Cegelski *et al*. 2006, p. 208; Schwartz *et al*. 2007, p. 2176; Schwartz *et al*. 2009, p. 3229). The longterm maintenance of wolverines

Comment [RMI243]: Restricted by what? And what is USFWS proposing to do about this?

in the DPS will require continued connectivity between subpopulations within the DPS, and with populations to the north in Canada. To the extent that wolverine habitat becomes more fragmented, and fragments become more isolated due habitat loss resulting from climate change, these factors will become more significant to wolverine conservation. The risk factor of small population size, including measures of effective population size and their consequent effects on maintenance of genetic diversity, is a threat to the North American wolverine DPS when considered cumulatively with habitat loss resulting from climate change.

Comment [RMI244]: So what does this require and how is USFWS identifying it as a threat and proposing to deal with it in this proposed rule?

Comment [RMI245]: And this, based on climate and increased distance alone, will be the only factors influencing connectivity/dispersal?

Wolverine populations have been expanding in the DPS area since the early 20th century, when they were likely at or near zero (Aubry *et al*. 2007, p. 2151). Most of this expansion has occurred under trapping regulations that allowed a higher level of trapping than currently occurs (see Montana Department of Fish, Wildlife, and Parks 2007, p. 1). Therefore, it might be argued that wolverine trapping is not occurring at levels that would significantly affect conservation of the DPS. However, future habitat changes due to climate change are predicted to reduce habitat connectivity and extent. As described above, these changes are likely to exacerbate the problem of loss of genetic diversity and demographic stability caused by low effective population size and insufficient movement between populations, leading to inbreeding. Given these likely secondary effects of climate change, human-caused mortality due to harvest is likely to become more significant to the ~~wolvereine~~wolverine population as connectivity needs increase and connectivity simultaneously becomes more difficult. As habitats become smaller and more isolated from one another, more wolverines will be needed to attempt to move between subpopulations to maintain population viability. Harvest currently removes up to five wolverines from the population every year, reducing the number of animals available for dispersal. In addition, incidental trapping of wolverines removes still more. For these reasons, we find

Comment [RMI246]: This is not necessarily a 1:1 relationship, which should be noted for the public. This statement also ignores the fact that a disperser must have an open territory, or kill or push another individual out.

Comment [RMI247]: But fewer than road kill. What is the USFWS proposing to do about road-kill?

that harvest and incidental trapping, when considered cumulatively with habitat loss resulting from climate change, are likely to become threats to the DPS due to the likely synergistic effects they may have on the population as habitat becomes smaller and more fragmented.

Proposed Determination

We have carefully assessed the best scientific and commercial information available regarding the past, present, and future threats to the wolverine DPS. We have identified threats to the contiguous United States population of the North American wolverine attributable to Factors A, B, and E. The primary threat to the DPS is from habitat and range loss due to climate warming (Factor A). Wolverines require habitats with near-arctic conditions wherever they occur. In the contiguous United States, wolverine habitat is restricted to high-elevation areas in the West. Wolverines are dependent on deep persistent snow cover for successful denning, and they concentrate their year-round activities in areas that maintain deep snow into spring and cool temperatures throughout summer. Wolverines in the contiguous United States exist as small and semi-isolated subpopulations in a larger metapopulation that requires regular dispersal of wolverines between habitat patches to maintain itself. These dispersers achieve both genetic enrichment and demographic support of recipient populations. Climate changes are predicted to reduce wolverine habitat and range by 31 percent over the next 30 years and 63 percent over the next 75 years, rendering remaining wolverine habitat significantly smaller and more fragmented. We anticipate that, by 2045, maintenance of the contiguous United States wolverine population in the currently occupied area may require human intervention to facilitate genetic exchange and possibly also to facilitate metapopulation dynamics by moving individuals between habitat patches if they are no longer accessed regularly by dispersers, or risk loss of the population.

Comment [RMI248]: There is still much work to be done.

Comment [RMI249]: This is based on flawed assumptions about the species biology.

Comment [RMI250]: This is an overestimate, perhaps vastly so, if, as suggested herein, wolverine distribution is limited by 15 May snow during at least 14% of years for dens.

Comment [RMI251]: I am anxious to see what the plan is here, trading territories?

Other threats are minor in comparison to the driving primary threat of climate change; however, cumulatively, they could become significant when working in concert with climate change if they further suppress an already stressed population. These secondary threats include harvest (including incidental harvest) (Factor B) and demographic stochasticity and loss of genetic diversity due to small effective population sizes (Factor E). All of these factors affect wolverines across their current range in the contiguous United States. The lack of attention to infrastructure and transportation corridors and their potential if not likely influence on the all-important connectivity is a glaring omission from the proposed rule. When compared to the potential influence of increasing distances expected by climate change…

The Act defines an endangered species as any species that is "in danger of extinction throughout all or a significant portion of its range" and a threatened species as any species "that is likely to become endangered throughout all or a significant portion of its range within the foreseeable future." We find that the contiguous United States wolverine DPS presently meets the definition of a threatened species due to the likelihood of habitat loss caused by climate change resulting in population decline leading to breakdown of metapopulation dynamics. Breakdown in metapopulation dynamics would make the DPS vulnerable to further loss of genetic diversity through inbreeding, and likely vulnerable to demographic endangerment as small subpopulations could no longer rely on demographic rescue from nearby populations. At that point wolverine populations would meet the definition of an endangered species under the Act. We base this determination on the immediacy, severity, and scope of the threats described above. Therefore, on the basis of the best available scientific and commercial information,

we propose listing the contiguous United State DPS of the North American wolverine as a threatened species in accordance with sections 3(6) and 4(a)(1) of the Act.

Under the Act and our implementing regulations, a species may warrant listing if it meets the definition of an endangered or threatened species throughout all or a significant portion of its range. The contiguous United States DPS of the North American wolverine proposed for listing in this rule is wide-ranging and the threats occur throughout its range. Therefore, we assessed the status of the DPS throughout its entire range. The threats to the survival of the species occur throughout the species' range and are not restricted to any particular significant portion of that range. Accordingly, our assessment and proposed determination applies to the DPS throughout its entire range.

Available Conservation Measures

Conservation measures provided to species listed as an endangered or threatened species under the Act include recognition, recovery actions, requirements for Federal protection, and prohibitions against certain practices. Recognition through listing results in the potential for public awareness and conservation by Federal, State, Tribal, and local agencies, private organizations, and individuals. The Act encourages cooperation with the States and requires that recovery actions be carried out for all listed species. The protection required by Federal agencies and the prohibitions against certain activities are discussed, in part, below.

Comment [RMI252]: By failing to take specific actions to prevent climate change and establish corridors that will not be impeded by infrastructure and transportation, this rule does little, other than removing the ESA in the case of the 10j, to help or cooperate with states in their efforts to conserve wolverines

The primary purpose of the Act is the conservation of endangered and threatened species and the ecosystems upon which they depend. The ultimate goal of such conservation efforts is the recovery of

these listed species, so that they no longer need the protective measures of the Act. Subsection 4(f) of the Act requires the Service to develop and implement recovery plans for the conservation of endangered and threatened species. The recovery planning process involves the identification of actions that are necessary to halt or reverse the species' decline by addressing the threats to its survival and recovery. The goal of this process is to restore listed species to a point where they are secure, self-sustaining, and functioning components of their ecosystems.

Recovery planning includes the development of a recovery outline shortly after a species is listed, preparation of a draft and final recovery plan, and revisions to the plan as significant new information becomes available. The recovery outline guides the immediate implementation of urgent recovery actions and describes the process to be used to develop a recovery plan. The recovery plan identifies site-specific management actions that will achieve recovery of the species, measurable criteria that determine when a species may be downlisted or delisted, and methods for monitoring recovery progress. Recovery plans also establish a framework for agencies to coordinate their recovery efforts and provide estimates of the cost of implementing recovery tasks. Recovery teams (composed of species experts, Federal and State agencies, nongovernmental organizations, and stakeholders) are often established to develop recovery plans. The recovery outline is available on our website at http://www.fws.gov/mountain-prairie/species/mammals/wolverine/ and on http://www.regulations.gov concurrently with the publication of this proposed rule. When completed, the draft recovery plan and the final recovery plan will be available on our website or from our Montana Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**).

Implementation of recovery actions generally requires the participation of a broad range of partners, including other Federal agencies, States, Tribal, nongovernmental organizations, businesses, and private landowners. Examples of recovery actions include habitat restoration (e.g., restoration of native vegetation), research, captive propagation and reintroduction, and outreach and education. The recovery of many listed species cannot be accomplished solely on Federal lands because their range may occur primarily or solely on non-Federal lands. To achieve recovery of these species requires cooperative conservation efforts on private, State, and Tribal lands.

If this species is listed, funding for recovery actions will be available from a variety of sources, including Federal budgets, State programs, and cost share grants for nonfederal landowners, the academic community, and nongovernmental organizations. In addition, pursuant to section 6 of the Act, the States inhabited by wolverines or uninhabited states with suitable habitat would be eligible for Federal funds to implement management actions that promote the protection and recovery of wolverines. Information on our grant programs that are available to aid species recovery can be found at: *http://www.fws.gov/grants*.

Although the wolverine DPS is only proposed for listing under the Act at this time, please let us know if you are interested in participating in recovery efforts for this species. Additionally, we invite you to submit any new information on this species whenever it becomes available and any information you may have for recovery planning purposes (see **FOR FURTHER INFORMATION CONTACT**).

Section 7(a) of the Act requires Federal agencies to evaluate their actions with respect to any species that is proposed or listed as endangered or threatened and with respect to its critical habitat, if

any is designated. Regulations implementing this interagency cooperation provision of the Act are codified at 50 CFR part 402. Section 7(a)(4) of the Act requires Federal agencies to confer with the Service on any action that is likely to jeopardize the continued existence of a species proposed for listing or result in destruction or adverse modification of proposed critical habitat. If a species is listed subsequently, section 7(a)(2) of the Act requires Federal agencies to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of the species or destroy or adversely modify its critical habitat. If a Federal action may affect a listed species or its critical habitat, the responsible Federal agency must enter into formal consultation with the Service.

Federal agency actions within the species habitat that may require conference or consultation or both as described in the preceding paragraph include management and any other landscape altering activities on Federal lands in suitable wolverine habitat within the range of the species administered by the Department of Defense, U.S. Fish and Wildlife Service, Bureau of Land Management, National Park Service, and U.S. Forest Service; construction and management of gas pipeline and power line rights-of-way in suitable wolverine habitat by the Federal Energy Regulatory Commission; construction and maintenance of roads or highways by the Federal Highway Administration in suitable wolverine habitat; and permitting of infrastructure development in suitable wolverine habitat for recreation, oil and gas development, or residential development by the U.S. Forest Service, National Park Service, Bureau of Land Management, U.S. Fish and Wildlife Service, or Department of Defense.

The Act and its implementing regulations set forth a series of general prohibitions and exceptions that apply to all endangered wildlife. The prohibitions of section 9(a)(2) of the Act, codified at 50 CFR 17.21 for endangered wildlife, in part, make it illegal for any person subject to the

jurisdiction of the United States to take (includes harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect; or to attempt any of these), import, export, ship in interstate commerce in the course of commercial activity, or sell or offer for sale in interstate or foreign commerce any listed species. Under the Lacey Act (18 U.S.C. 42–43; 16 U.S.C. 3371–3378), it is also illegal to possess, sell, deliver, carry, transport, or ship any such wildlife that has been taken illegally. Certain exceptions apply to agents of the Service and State conservation agencies.

We may issue permits to carry out otherwise prohibited activities involving endangered and threatened wildlife species under certain circumstances. Regulations governing permits are codified at 50 CFR 17.22 for endangered species, and at 17.32 for threatened species. With regard to endangered wildlife, a permit must be issued for the following purposes: for scientific purposes, to enhance the propagation or survival of the species, and for incidental take in connection with otherwise lawful activities.

It is our policy, as published in the **Federal Register** on July 1, 1994 (59 FR 34272), to identify to the maximum extent practicable at the time a species is listed, those activities that would or would not constitute a violation of section 9 of the Act. The intent of this policy is to increase public awareness of the effect of a proposed listing on proposed and ongoing activities within the range of species proposed for listing. The following activities could potentially result in a violation of section 9 of the Act; this list is not comprehensive:

Unauthorized collecting, handling, possessing, selling, delivering, carrying, or transporting of the species, including import or export across State lines and international boundaries, except for

properly documented antique specimens of these taxa at least 100 years old, as defined by section 10(h)(1) of the Act.

Questions regarding whether specific activities would constitute a violation of section 9 of the Act should be directed to the Montana Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**). Requests for copies of the regulations concerning listed animals and general inquiries regarding prohibitions and permits may be addressed to the U.S. Fish and Wildlife Service, Endangered Species Permits, 134 Union Boulevard, Suite 650, Lakewood, CO 80228; Telephone 303-236-4265.

A determination to list the contiguous United States DPS of the North American wolverine as a threatened species under the Act, if we ultimately determine that listing is warranted, will not regulate greenhouse gas emissions. Rather, it will reflect a determination that the DPS meets the definition of a threatened species under the Act, thereby establishing certain protections for them under the ESA. While we acknowledge that listing will not have a direct impact on the loss of deep, persistent, late spring snowpack or the reduction of greenhouse gases, we expect that it will indirectly enhance national and international cooperation and coordination of conservation efforts, enhance research programs, and encourage the development of mitigation measures that could help slow habitat loss and population declines. In addition, the development of a recovery plan will guide efforts intended to ensure the long-term survival and eventual recovery of the lower 48 states DPS of the wolverine.

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Comment [RMI253]: Including efforts to address climate change?

Special Rule Under Section 4(d) of the Act

Whenever a species is listed as a threatened species under the Act, the Secretary may specify regulations that he deems necessary and advisable to provide for the conservation of that species under the authorization of section 4(d) of the Act. These rules, commonly referred to as ‘‘special rules,’’ are found in part 17 of title 50 of the Code of Federal Regulations (CFR) in §§ 17.40–17.48. This special rule for § 17.40 would prohibit take of any wolverine in the contiguous United States when associated with or related to trapping, hunting, shooting, collection, capturing, pursuing, wounding, killing, and trade. In this context, any activity where wolverines are attempted to be, or are intended to be, trapped, hunted, shot, captured, or collected, in the contiguous United States, will be prohibited. It will also be prohibited to incidentally trap, hunt, shoot, capture, pursue, or collect wolverines in the course of otherwise legal activities. All otherwise legal activities involving wolverines and their habitat that are conducted in accordance with applicable State, Federal, tribal, and local laws and regulations are not considered to be take under this regulation. This includes activities that occur in and may modify wolverine habitat such as those described below.

Comment [RMI254]: Why is an activity that results in fewer wolverine deaths per year and will likely decrease over time (trapping) prohibited whereas other more significant activities that kill wolverines will not be prohibited (road-kill)?

In this proposed listing rule, we identified several risk factors for the wolverine DPS that, in concert with climate change, may result in reduced habitat value for the species. These risk factors include human activities like dispersed recreation, land management activities by Federal agencies and private landowners, and infrastructure development. However, the scale at which these activities occur is relatively small compared to the average size of wolverine’s home range, between 300 and 500 km^2 (186 and 310 mi^2). For example, ski resorts constitute the largest developments in wolverine habitats. In Colorado, the state with the most ski resorts in the range of the wolverine, ski resort developments cover only 0.6 percent of available wolverine habitat (Colorado Division of Wildlife 2010, p. 16). Other developments are more localized still, such as mines and small infrastructure. It is possible that

these forms of habitat alteration may affect individual wolverines, by causing the temporary movement of a few individuals within or outside of their home ranges during or shortly after construction. However, due to the small scale of the habitat alteration involved in these sorts of activities, we conclude that the overall impact of these activities is not significant to the conservation of the species. Dispersed recreation like snowmobiling and back country skiing, and warm season activities like backpacking and hunting, occur over larger scales; however, there is little evidence to suggest that these activities may affect wolverines significantly or have a significant effect on conservation of the DPS. Preliminary evidence suggests that wolverines can coexist amid high levels of dispersed motorized and nonmotorized use (Heinenmeyer *et al*. 2012, entire), possibly shifting activity to avoid the most heavily used areas within their home ranges.

Transportation corridors and urban development in valley bottoms between patches of wolverine habitat may inhibit individual wolverines' movement between habitat patches; however, wolverines have made several long-distance movements in the recent past that indicates they are able to navigate current landscapes as they search for new home ranges. As described above, we have no evidence to suggest that current levels of transportation infrastructure development or residential development are a threat to the DPS or will become one in the future.

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Land management activities (principally timber harvest, wildland firefighting, prescribed fire, and silviculture) can modify wolverine habitat, but this generalist species appears to be little affected by changes to the vegetative characteristics of its habitat. In addition, most wolverine habitat occurs at high elevations in rugged terrain that is not conducive to intensive forms of silviculture and timber harvest. Therefore, we anticipate that habitat modifications resulting from these types of land

management activities would not significantly affect the conservation of the DPS, as we described above.

The proposed special rule under section 4(d) of the Act will provide for the possession and take of wolverines that are (1) legally held at the time of listing (2) legally imported pursuant to applicable Federal and state statutes, or (3) captively bred without a permit. The special rule will also allow the continuation of the export of captive-bred wolverines provided applicable Federal and state laws are followed, and provide for the transportation of wolverine skins in commerce within the United States. The export skins from wolverines documented as captive-bred will be permitted. Legally possessed skins may be transported in interstate trade without permits.

In this proposed rule, we include a prohibition against incidental take of wolverine in the course of legal trapping activities directed at other species. However, documented take of wolverine from incidental trapping has been low. In the 2008–2009 trapping season, two wolverines were incidentally killed in traps set for other species in Beaverhead and Granite Counties, Montana (Montana Fish, Wildlife, and Parks 2010, p. 2). In Idaho, the U.S. Department of Agriculture Wildlife Services trapped three wolverines (one each in 2004, 2005, and 2010) incidental to trapping wolves involved in livestock depredations. One of these sustained severe injuries and was euthanized. We are requesting the public, Federal agencies, and the affected State fish and wildlife agencies to submit public comments on this issue, including any State management plans related to trapping regulations and any measures within those plans that may avoid or minimize the risk of wolverine mortality from incidental trapping for other species.

CRITICAL HABITAT

Section 3(5)(A) of the Act defines critical habitat as "(i) the specific areas within the geographical area occupied by the species, at the time it is listed...on which are found those physical or biological features (I) Essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed...upon a determination by the Secretaries of Commerce and Interior that such areas are essential for the conservation of the species." Section 3(3) of the Act (16 U.S.C. 1532(3)) also defines the terms "conserve," "conserving," and "conservation" to mean "to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this chapter are no longer necessary."

Section 4(a)(3) of the Act and implementing regulations (50 CFR 424.12) require that, to the maximum extent prudent and determinable, we designate critical habitat at the time a species is determined to be an endangered or threatened species. Critical habitat may only be designated within the jurisdiction of the United States, and may not be designated for jurisdictions outside of the United States (50 CFR 424(h)). Our regulations (50 CFR 424.12(a)(1)) state that designation of critical habitat is not prudent when one or both of the following situations exist: (1) The species is threatened by taking or other activity and the identification of critical habitat can be expected to increase the degree of threat to the species; or (2) such designation of critical habitat would not be beneficial to the species. Our regulations (50 CFR 424.12(a)(2)) further state that critical habitat is not determinable when one or both of the following situations exists: (1) Information sufficient to perform required analysis of the

impacts of the designation is lacking; or (2) the biological needs of the species are not sufficiently well known to permit identification of an area as critical habitat.

Delineation of critical habitat requires, within the geographical area occupied by the DPS of the North American wolverine in the contiguous United States, identification of the physical and biological features essential to the conservation of the species. In general terms, physical and biological features essential to the wolverine may include (1) Areas defined by persistent spring snowpack and (2) areas with avalanche debris (bottom of avalanche chutes where large trees, rocks, and other debris are swept) and talus slopes or boulder fields (debris piles of large rocks, trees, and branches) in which females can construct dens which provide security from large predators and buffer against wind and low temperatures.

Information regarding the wolverine's life functions and habitats associated with these functions has expanded greatly in recent years. We need additional time to assess the potential impact of a critical habitat designation, including whether there will be any benefit to wolverine from such a designation. A careful assessment of the habitats that may qualify for designation as critical habitat will require a thorough assessment in light of projected climate change and other threats. At this time, we also need more time to analyze the comprehensive data to identify specific areas appropriate for critical habitat designation. Accordingly, we find designation of critical habitat to be "not determinable" at this time.

Peer Review

In accordance with our joint policy on peer review published in the **Federal Register** on July 1, 1994 (59 FR 34270), we will seek the expert opinions of at least three appropriate and independent specialists regarding this proposed rule. The purpose of peer review is to ensure that our listing determination and critical habitat designation are based on scientifically sound data, assumptions, and analyses. We have invited these peer reviewers to comment during this public comment period.

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We will consider all comments and information received during this comment period on this proposed rule during our preparation of a final determination. Accordingly, the final decision may differ from this proposal.

Required Determinations

Clarity of the Rule

Executive Order 12866 requires each agency to write regulations that are easy to understand. We invite your comments on how to make this rule easier to understand including answers to questions such as the following: (1) Are the requirements in the rule clearly stated? (2) Does the rule contain technical language or jargon that interferes with its clarity? (3) Does the format of the rule (grouping and order of sections, use of headings, paragraphing, etc.) aid or reduce its clarity? (4) Would the rule be easier to understand if it were divided into more (but shorter) sections? (5) Is the description of the rule in the **SUPPLEMENTARY INFORMATION** section of the preamble helpful in understanding the rule? What else could we do to make the rule easier to understand?

Send a copy of any comments that concern how we could make this rule easier to understand to Office of Regulatory Affairs, Department of the Interior, Room 7229, 1849 C Street, NW., Washington, DC 20240. You also may e-mail the comments to this address: *Exsec@ios.goi.gov*.

Paperwork Reduction Act of 1995 (44 U.S.C. 3501, et seq.)

This rule does not contain any new collections of information that require approval by Office of Management and Budget (OMB) under the Paperwork Reduction Act. This rule will not impose recordkeeping or reporting requirements on State or local governments, individuals, businesses, or organizations. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number.

National Environmental Policy Act (42 U.S.C. 4321 et seq.)

We have determined that environmental assessments and environmental impact statements, as defined under the authority of the National Environmental Policy Act of 1969, need not be prepared in connection with listing a species as an endangered or threatened species under the Endangered Species Act. We published a notice outlining our reasons for this determination in the **Federal Register** on October 25, 1983 (48 FR 49244).

References Cited

A complete list of all references cited in this proposed rule is available on the Internet at *http://www.regulations.gov* or upon request from the Field Supervisor, Montana Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT** section).

Authors

The primary authors of this proposed rule are the staff members of the Montana Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**).

List of Subjects in 50 CFR Part 17

Endangered and threatened species, Exports, Imports, Reporting and recordkeeping requirements, and Transportation.

Proposed Regulation Promulgation

Accordingly, we propose to amend part 17, subchapter B of chapter I, title 50 of the Code of Federal Regulations, as set forth below:

PART 17—[AMENDED]

1. The authority citation for part 17 continues to read as follows:

Authority: 16 U.S.C. 1361-1407; 1531-1544; and 4201-4245, unless otherwise noted.

2. In § 17.11(h) add entries for “Wolverine, North American” to the List of Endangered and Threatened Wildlife in alphabetical order under Mammals to read as set forth below:

§ 17.11 Endangered and threatened wildlife.

* * * * *

(h) * * *

Species

Historic range

Vertebrate population where endangered or threatened

Status

When listed

Critical habitat

Special rules

Common name

Scientific name

Mammals

* * * * * * *

Wolverine, North American

Gulo gulo luscus

U.S.A. (Alaska and northern contiguous States); Canada

Where found within contiguous U.S.A., except where listed as an experimental population

T

NA

17.40(a)

Wolverine, North American

Gulo gulo luscus

U.S.A. (Alaska and northern contiguous States); Canada

U.S.A. (specified portions of CO, NM, and WY; see 17.84(d))

XN

NA

17.84(d)

114

* * * * * * *

3. Amend § 17.40 by revising paragraph (a) to read as follows:

§ 17.40 Special rules—mammals.

(a) Wolverine, North American (*Gulo gulo luscus*).

(1) *Which populations of the North American wolverine are covered by this special rule?* This rule covers the distribution of this species in the contiguous United States.

(2) *What activities are prohibited?* Any activity where wolverines are attempted to be, or are intended to be, trapped, hunted, shot, captured, or collected, in the contiguous United States, will be prohibited. It will also be prohibited to incidentally trap, hunt, shoot, capture, pursue, or collect wolverines in the course of otherwise legal activities.

(3) *What activities are allowed?* Incidental take of wolverines will not be a violation of section 9 of the Act, if it occurs from any other otherwise legal activities involving wolverines and their habitat that are conducted in accordance with applicable State, Federal, tribal, and local laws and regulations. Such activities occurring in wolverine habitat include:

(i) Dispersed recreation such as snowmobiling, skiing, backpacking, and hunting for other species;

(ii) Management activities by Federal agencies and private landowners such as timber harvest, wildland firefighting, prescribed fire, and silviculture;

(iii) Transportation corridor and urban development;

(iv) Mining;

(v) Transportation and trade of legally possessed wolverine skins and skins from captive-bred wolverines within the United States.

* * * * *

Dated: 1/16/2013

/s/ Rowan W. Gould

Acting Director, U.S. Fish and Wildlife Service

Billing Code 4310–55–P

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

[FWS–R6–ES–2012–0107]

[4500030113]

RIN 1018–AY26

Endangered and Threatened Wildlife and Plants; Threatened Status for the Distinct Population Segment of the North American Wolverine Occurring in the Contiguous United States

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Proposed rule.

SUMMARY: We, the U.S. Fish and Wildlife Service, propose to list the distinct population segment of the North American wolverine occurring in the contiguous United States, as a threatened species under the Endangered Species Act. If we finalize this rule as proposed, it would extend the Act's protections to this species. The effect of this regulation is to add the distinct population segment of the North

American wolverine occurring in the contiguous United States to the List of Endangered and Threatened Wildlife (50 CFR 17.11). We also propose a special rule under section 4(d) of the Act to apply the specific prohibitions of the Act necessary to protect the wolverine. We find that critical habitat is not determinable at this time. The Service seeks data and comments from the public on this proposed listing rule, the proposed special rule under section 4(d) of the Act, and our finding that the designation of critical habitat for the species is not determinable at this time.

DATES: We will accept comments received or postmarked on or before [INSERT DATE 90 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER]. Comments submitted electronically using the Federal eRulemaking Portal (see **ADDRESSES** section, below) must be received by 11:59 p.m. Eastern Time on the closing date. We must receive requests for public hearings, in writing, at the address shown in the **ADDRESSES** section by [INSERT DATE 45 DAYS AFTER DATE OF PUBLICATION IN THE FEDERAL REGISTER].

Public Informational Sessions and Public Hearing: We will hold 3 public informational sessions and public hearings on this proposed rule. Public informational sessions will occur from 2:00 p.m. to 5:00 p.m. and public hearings will be held from 7:00 p.m. to 9:00 p.m. at each location. Public informational sessions and public hearings will occur in Boise, ID, on March 13, 2013, from 7:00 p.m. to 9:00 p.m.; in Lakewood, CO, on March 19, 2013, from 7:00 p.m. to 9:00 p.m.; and in Helena, MT, on March 27, 2013, from 7:00 p.m. to 9:00 p.m., all times local (see **ADDRESSES**). Registration for those providing testimony in the public hearings will begin at 6:00 p.m. at each location.

ADDRESSES: You may submit comments by one of the following methods:

(1) *Electronically*: Go to the Federal eRulemaking Portal: *http://www.regulations.gov*. In the Keyword box, enter Docket No. FWS–R6–ES–2012–0107, which is the docket number for this rulemaking. Then, in the Search panel on the left side of the screen, under the Document Type heading, click on the Proposed Rules link to locate this document. You may submit a comment by clicking on Comment Now!"

(2) *By hard copy*: Submit by U.S. mail or hand-delivery to: Public Comments Processing, Attn: FWS–R6–ES–2012–0107; Division of Policy and Directives Management; U.S. Fish and Wildlife Service; 4401 N. Fairfax Drive, MS 2042–PDM; Arlington, VA 22203.

(3) *At a public hearing*: We are holding three public hearings on this proposed rule (see **ADDRESSES** for location information). You may provide your comments at any of the three hearings.

We request that you send comments **only** by the methods described above. We will post all comments on *http://www.regulations.gov*. This generally means that we will post any personal information you provide us (see the **Public Comments** section below for more information).

Public Informational Sessions and Public Hearings: Public informational sessions and public hearings will be held on March 13, 2013, at the Boise Centre on the Grove, 850 West Front Street, Boise, ID 83702. The second is scheduled on March 19, 2013, at the Hampton Inn, 137 Union Boulevard, Lakewood, CO 80228. The third is scheduled on March 27, 2013, at the Red Lion Colonial Inn, 2301 Colonial Drive, Helena, MT 59601. At all three locations the public informational session will run from 2:00 p.m. to 5:00 p.m., followed by public speaker registration at 6:00 p.m., and then the public hearing for oral testimony from 7:00 p.m. to 9:00 p.m. People needing reasonable accommodations in order to attend and participate in the public hearing should contact Brent Esmoil,

Montana Ecological Services Field Office, as soon as possible (see **FOR FURTHER INFORMATION CONTACT**).

Any additional tools or supporting information that we may develop for this rulemaking will be available at http://www.fws.gov/mountain-prairie/species/mammals/wolverine/, at http://www.regulations.gov at Docket No. FWS–R6–ES–2012–0107, and at the Montana Field Office (see **FOR FURTHER INFORMATION CONTACT**).

FOR FURTHER INFORMATION CONTACT: Brent Esmoil, Field Supervisor (Acting), U.S. Fish and Wildlife Service, Montana Field Office, 585 Shepard Way, Helena, Montana 59601, by telephone (406) 449-5225. Persons who use a telecommunications device for the deaf (TDD) may call the Federal Information Relay Service (FIRS) at 800-877-8339.

SUPPLEMENTARY INFORMATION:

Executive Summary

Why we need to publish a rule. Under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) (Act or ESA), if a species is determined to be an endangered or threatened species throughout all or a significant portion of its range, we are required to promptly publish a proposal in the **Federal Register** and make a determination on our proposal within 1 year. Critical habitat shall be designated, to the maximum extent prudent and determinable, for any species determined to be an

endangered or threatened species under the Act. Listing a species as an endangered or threatened species and designations and revisions of critical habitat can only be completed by issuing a rule.

This rule consists of:

- A proposed rule to list the distinct population segment (DPS) of the North American wolverine occurring in the contiguous United States as a threatened species; and
- A proposed special rule under section 4(d) of the Act that outlines the prohibitions necessary and advisable for the conservation of the wolverine.

A proposed rule under section 10(j) of the Act to establish an experimental non-essential population of wolverine in Colorado is published concurrently in this issue of the **Federal Register**. Also, a draft Recovery Outline for the wolverine DPS is available on our website at http://www.fws.gov/mountain-prairie/species/mammals/wolverine/ or on http://www.regulations.gov.

The basis for our action. Under the Act, we can determine that a species is an endangered or threatened species based on any of five factors: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) Overutilization for commercial, recreational, scientific, or educational purposes; (C) Disease or predation; (D) The inadequacy of existing regulatory mechanisms; or (E) Other natural or manmade factors affecting its continued existence.

We have determined that habitat loss due to increasing temperatures and reduced late spring snowpack due to climate change is likely to have a significant negative population-level impact on wolverine populations in the contiguous United States. In the future, wolverine habitat is likely to be reduced to the point that the wolverine in the contiguous United States is in danger of extinction.

We will seek peer review. We are seeking comments from knowledgeable individuals with scientific expertise to review our analysis of the best available science and application of that science and to provide any additional scientific information to improve this proposed rule. Because we will consider all comments and information received during the comment period, our final determinations may differ from this proposal.

Information Requested

We intend that any final action resulting from this proposed rule will be based on the best scientific and commercial data available and be as accurate and as effective as possible. Therefore, we request comments or information from the public, other concerned governmental agencies, Native American tribes, the scientific community, industry, or any other interested parties concerning this proposed rule. We particularly seek comments concerning:

(1) Biological, commercial trade, or other relevant data concerning any threats (or lack thereof) to this species and regulations that may be addressing those threats.

(2) Additional information concerning the historical and current status, range, distribution, and population size of this species, including the locations of any additional populations of this species.

(3) Any information on the biological or ecological requirements of the species, and ongoing conservation measures for the species and its habitat.

(4) Current or planned activities in the areas occupied by the species and possible impacts of these activities on this species.

(5) The reasons why we should or should not designate habitat as “critical habitat” under section 4 of the Act (16 U.S.C. 1531 *et seq*.) including whether and how the wolverine may benefit from such a designation; whether there are threats to the species from human activity, the degree to which it can be expected to increase due to a critical habitat designation, and whether that increase in threat outweighs the benefit of designation such that the designation of critical habitat may not be prudent;

(6) Specific information on the amount and distribution of wolverine habitat,

(7) Information on the projected and reasonably likely impacts of climate change on the wolverine and its habitat;

(8) Suitability of the proposed 4(d) rule for the conservation, recovery, and management of the DPS of the North American wolverine occurring in the contiguous United States.

(9) Additional information concerning whether it is appropriate to prohibit incidental take of wolverine in the course of legal trapping activities directed at other species in the proposed 4(d) rule, including any information about State management plans related to trapping regulations and any

measures within those plans that may avoid or minimize the risk of wolverine mortality from incidental trapping for other species.

(10) Additional provisions the Service may wish to consider to conserve, recover, and manage the DPS of the North American wolverine occurring in the contiguous United States.

We will consider all comments and information received during the comment period on this proposed listing rule and special rule under section 4(d) of the Act during our preparation of a final determination. Accordingly, the final decision may differ from this proposal.

Please note that submissions merely stating support for or opposition to the action under consideration without providing supporting information, although noted, will not be considered in making a determination, as section 4(b)(1)(A) of the Act directs that determinations as to whether any species is an endangered or threatened species must be made "solely on the basis of the best scientific and commercial data available."

You may submit your comments and materials concerning this proposed rule by one of the methods listed in the **ADDRESSES** section. We request that you send comments **only** by the methods described in the **ADDRESSES** section.

If you submit information via *http://www.regulations.gov*, your entire submission—including any personal identifying information—will be posted on the website. If your submission is made via a hardcopy that includes personal identifying information, you may request at the top of your document

that we withhold this information from public review. However, we cannot guarantee that we will be able to do so. We will post all hardcopy submissions on *http://www.regulations.gov*. Please include sufficient information with your comments to allow us to verify any scientific or commercial information you include.

Comments and materials we receive, as well as supporting documentation we used in preparing this proposed rule, will be available for public inspection on *http://www.regulations.gov*, or by appointment, during normal business hours, at the U.S. Fish and Wildlife Service, Montana Field Office (see **FOR FURTHER INFORMATION CONTACT**).

Previous Federal Actions

On April 19, 1995, we published a finding (60 FR 19567) that a previous petition, dated August 3, 1994, submitted by the Predator Project (now named the Predator Conservation Alliance) and Biodiversity Legal Foundation to list the wolverine in the contiguous United States as an endangered or threatened species, did not provide substantial information indicating that listing the wolverine in the contiguous United States may be warranted.

On July 14, 2000, we received a petition dated July 11, 2000, submitted by the Biodiversity Legal Foundation, Predator Conservation Alliance, Defenders of Wildlife, Northwest Ecosystem Alliance, Friends of the Clearwater, and Superior Wilderness Action Network, to list the wolverine within the contiguous United States as an endangered or threatened species and designate critical habitat for the species.

On October 21, 2003, we published a 90-day finding that the petition failed to present substantial scientific and commercial information indicating that listing may be warranted (68 FR 60112).

On September 29, 2006, as a result of a complaint filed June 8, 2005 by Defenders of Wildlife and others alleging we used the wrong standards to assess the July 11, 2000, wolverine petition, the U.S. District Court, Montana District, ruled that our 90-day petition finding (68 FR 60112) was in error and ordered us to submit to the **Federal Register** a 12-month finding for the wolverine by September 29, 2007. On April 6, 2007, the deadline for this 12-month finding was extended to February 28, 2008.

On March 11, 2008, we published a 12-month finding of "not warranted" for the wolverine in the contiguous United States (73 FR 12929). In that finding we determined that the wolverine in the contiguous United States did not constitute a distinct population segment or a significant portion of the range of a listable entity of the wolverine in North America and so was not a listable entity under the Act.

On July 8, 2008 we received a Notice of Intent to Sue from Earthjustice alleging violations of the Act in our March 11, 2008, 12-month finding. On September 30, 2008, Earthjustice filed a complaint in the U.S. District Court, District of Montana, seeking to set aside and remand the 12-month finding back to the Service for reconsideration.

On March 6, 2009, the Service agreed to settle the case with Earthjustice by voluntarily remanding the 12-month finding and issuing a new 12-month finding by December 1, 2010. Following the settlement agreement, the court dismissed the case on June 15, 2009, and ordered the Service to comply with the settlement agreement.

On April 15, 2010, the Service published a Notice of Initiation of a 12-month finding for wolverines in the contiguous United States (75 FR 19591). That finding was published on December 14, 2010, and determined that the wolverine in the contiguous United States constituted a Distinct Population Segment and that the DPS warranted listing under the Act, but that listing was precluded by higher priority listing actions (75 FR 78030).

On September 9, 2011, we reached an agreement with plaintiffs in *Endangered Species Act Section 4 Deadline Litig.*, Misc. Action No. 10-377 (EGS), MDL Docket No. 2165 (D. D.C.) (known as the "MDL case") on a schedule to publish proposed rules or to withdraw warranted findings for the species on our list of candidate species. This agreement stipulated that we would submit for publication in the **Federal Register** a proposed listing rule for the wolverine, or withdraw the warranted 12-month finding, no later than the end of the 2013 Fiscal Year.

On April 13, 2012, several parties filed an action challenging the Service's December 14, 2010 warranted but precluded finding for wolverine. *Cottonwood Envtl. Law Ctr., et al. v. Salazar, et al.,* 9:12-cv-00057-DLC (D. Mont.) On September 20, 2012, the court granted the Service's motion to stay that litigation based on the Service's representation to the Court that it expected to submit this rule or withdraw the warranted finding to the **Federal Register** by January 18, 2013.

THREATENED STATUS FOR THE CONTIGUOUS UNITED STATES WOLVERINE DPS:

Background

It is our intent to discuss below only those topics directly relevant to the listing of the contiguous United States DPS of the North American wolverine as a threatened species in this section of the proposed rule.

Species Information

Taxonomy and Life History

The wolverine has a Holarctic (habitats found in the northern continents) distribution including northern portions of Europe, Asia, and North America. The currently accepted taxonomy classifies wolverines worldwide as a single species, *Gulo gulo*, with two subspecies. Old World wolverines are found in the Nordic countries of Europe, Russia, Mongolia, and Siberia and are part of the subspecies *Gulo gulo gulo*. New World wolverines occur in North America. The wolverines in the contiguous United States are a part of the New World subspecies, *G. g. luscus*: the North American wolverine (Kurten and Rausch 1959 p. 19; Pasitschniak-Arts and Lariviere 1995, p. 1). The species is known by several common names, including mountain devil, glutton, caracajou, quickhatch, gulon, skunk bear, as well as wolverine.

The wolverine is the largest terrestrial member of the family Mustelidae. Adult males weigh 12 to 18 kilograms (kg) (26 to 40 pounds (lb)), and adult females weigh 8 to 12 kg (17 to 26 lb) (Banci 1994, p. 99). The wolverine resembles a small bear with a bushy tail. It has a broad, rounded head; short, rounded ears; and small eyes. Each foot has five toes with curved, semi-retractile claws used for digging and climbing (Banci 1994, p. 99).

A large number of female wolverines (40 percent) are capable of giving birth at 2 years old, become pregnant most years, and produce average litter sizes of 1 to 2 kits. In one study of known-aged females, none reproduced at age 2; 3 of 10 first reproduced at age 3; and 2 did not reproduce until age 4. The average age at first reproduction was 3.4 years (Persson *et al*. 2006, pp. 76-77). Another study indicated that the average age at first reproduction is likely more than 3 years (Inman *et al*. 2007c, p. 70). Pregnant females commonly resorb or spontaneously abort litters prior to giving birth (Magoun 1985, pp. 30-31; Copeland 1996, p. 43; Persson *et al*. 2006, p. 77; Inman *et al*. 2007c, p. 70). This may in turn preserve resources to increase reproductive success in subsequent years (Persson 2005, p. 1456). By age 3, nearly all female wolverines become pregnant every year, but energetic constraints due to low food availability result in loss of pregnancy in about half of them each year. It is likely that, in many places in the range of wolverines, it takes 2 years of foraging for a female to store enough energy to successfully reproduce (Persson 2005, p. 1456). It is likely that, despite the high rate of initiation of pregnancy, due to the spontaneous abortion of litters resulting from resource limitation, actual rates of successful reproduction in wolverines are among the lowest known for mammals (Persson 2005, p. 1456).

Comment [O1]: Up to 29 in Petersburg Alaska; A. Magoun unpub. data

Comment [O2]: Wolverines do NOT have semi-retractile claws; don't know where this originally came from but it keeps getting repeated.

Comment [O3]: Incorrect statement; check your reference for this and put it here; Persson et al. 2006 does not state this; in fact no 2 year olds in his study gave birth; you may have gotten this from Inman 2007c instead, p. 70, but I'm not sure it is correct without reviewing the 3 papers that Inman cited. Suggest going to the original 3 papers for the correct information.

Comment [O4]: Reference? Cite the reference and the actual number, which I believe is an average litter size of 1.88 from Perrson

Comment [O5]: State whether this is average litter size based on placental scars or emerging from the den; this is low for placental scars

Comment [O6]: There is no way to know if this is a true statement; Magoun 1985 does NOT state this on pp. 30-31; Copeland 1996 also does not state this but only that Mead et al. 1993 (not the 1991 paper) found absorption of unimplanted blastocysts in mustelids (not woverines); Mead was never able to get wolverines to breed or become pregnant; Persson et al. (2006) also do NOT state this, rather they say that "young are lost during pregnancy, early after parturition, or both. Losses probably do not occur before implantation, because a unique feature of delayed implantation in mustelids is that there is minimal intrauterine death of embryos during the prolonged preimplantation period (Mead et al. 1993), and the number of corpora lutea approximates the number of unimplanted blastocysts (e.g., Liskop et al. 1981; Rausch and Pearson 1972). However, pregnancy failure at implantation might occur (Arthur and Krohn 1991)." Suggest that you check with the Mead et al. 1993 paper for the exact information. If any of the female wolverines conceived in their study (unknown), the embryos "either died during preimplantation, were resorbed during postimplantation, or the kits were eaten shortly after birth." Finally, Inman et al. 2007c does not refer to abortion of litters prior to birth. Check original citations that he cites. The fact is that no one knows why wolverines do not give birth in some years because any of these may occur: failure to breed, pseudopregnancy, failure to implant, absorption of implanted fetuses, stillbirth, death before den emergence, including infanticide.

Comment [O7]: What does this refer to? Persson 1985 does not say that resorbtion or abortion prior to birth preserves resources, rather ANY reason wolverines fail to reproduce in a given year (and this would include any of the above plus early death of kits after den emergence)

Comment [O8]: No scientific data to support this; just say failure to reproduce for unknown reasons

Supplemental feeding of females increases reproductive potential (Persson 2005, p. 1456). Food-supplemented females were also more successful at raising kits to the time of weaning, suggesting that wolverine reproduction and ultimately population growth rates and viability are food-limited. Female wolverines appear to use a complex strategy of food accumulation and caching to attain enough resources to successfully raise a litter (Inman *et al*. 2012b, pp. 640-641).

Breeding generally occurs from late spring to early fall (Magoun and Valkenburg 1983, p. 175; Mead *et al*. 1991, pp. 808-811). Females undergo delayed implantation until the following winter or spring, when active gestation lasts from 30 to 40 days (Rausch and Pearson 1972, pp. 254-257; Mead et al. 1993, Inman2012 (J of Mamm paper) = 45 days average). Litters are born from mid-February through March, containing one to five kits, with an average in North America of between one and two kits (Magoun 1985, pp. 28-31; Copeland 1996, p. 36; Krebs and Lewis 1999, p. 698; Copeland and Yates 2006, pp. 32-36; Inman *et al*. 2007c, p. 68).

Female wolverines use natal (birthing) dens that are excavated in snow. Persistent, stable snow greater than 1.5 meters (m) (5 feet (ft)) deep appears to be a requirement for natal denning, because it provides security for offspring and buffers cold winter temperatures (Pulliainen 1968, p. 342; Copeland 1996, pp. 92-97; Magoun and Copeland 1998, pp. 1317-1318; Banci 1994, pp. 109-110; Inman *et al*. 2007c, pp. 71-72; Copeland *et al*. 2010, pp. 240-242). Female wolverines go to great lengths to find secure den sites, suggesting that predation is a concern (Banci 1994, p. 107). Natal dens consist of tunnels that contain well-used runways and bed sites and may naturally incorporate shrubs, rocks, and downed logs as part of their structure (Magoun and Copeland 1998, pp. 1315-1316; Inman *et al*. 2007c, pp. 71-72). In Idaho, natal den sites occur above 2,500 m (8,200 ft) on rocky sites, such as north-facing

Comment [O9]: As early as January and as late as April (Inman et al. 2012 paper) and give peak parturition

Comment [O10]: Although 5 fetuses have been found, I know of no verified live births of 5 kits; give reference if you have one

Comment [O11]: Must state whether from examination of carcasses or from observed kits after leaving the den or dug from dens; most litters at birth probably have at least 2 kits, but one or both may die before they can be counted; an average litter of between 1 and 2 "AT BIRTH" is unmeasured and unknown for wild wolverines; only mean litter size at the time they are counted

Comment [O12]: Define terms

Comment [O13]: Not accurate; see lengthy discussion in Attachment A; snow ≥1 m and possibly less (e.g., 70 cm)

Comment [O14]: What does "great lengths" mean? there are often lots of potential den sites in a female's home range and the females are probably very familiar with them well before denning begins; this statement by Banci is opinion, not scientific fact; most carnivores find secure den sites because predation is almost always a concern

boulder talus or subalpine cirques (steep-walled semicircular basin carved by a glacier) in forest openings (Magoun and Copeland 1994, pp. 1315-1316). In Montana, natal dens occur above 2,400 m (7,874 ft) and are located on north aspects in avalanche debris, typically in alpine habitats near timberline (Inman *et al*. 2007c, pp. 71-72). Offspring are born from mid-February through March and the dens are typically used through late April or early May (Myrberget 1968, p. 115; Magoun and Copeland 1998, pp. 1314-1317; Inman *et al*. 2007b, pp. 55-59). Occupation of natal dens is variable, ranging from approximately 9 to 65 days (Magoun and Copeland 1998, pp. 1316-1317).

Comment [O15]: Born from January to mid-April but the peak of parturition is February to mid-March (Inman et al. 2012-J of Mamm. Vol. 93, p. 637-638

Comment [O16]: Use Inman et al. 2012- J of Mamm. Vol. 93, p. 637-638 for your reference here as it is comprehensive and includes the others listed here; also, Myrberget 1968 is not a good reference here because they did not know birth date

Females may move kits to multiple secondary (maternal) dens as they grow during the month of May (Pulliainen 1968, p. 343; Myrberget 1968, p. 115), although use of maternal dens may be minimal (Inman *et al*. 2007c, p. 69). Timing of den abandonment is related to accumulation of water in dens (due to snow melt), the maturation of offspring, disturbance, and geographic location (Myrberget 1968, p. 115; Magoun 1985, p. 73). After using natal and maternal dens, wolverines may also use rendezvous sites through early July. These sites are characterized by natural (unexcavated) cavities formed by large boulders, downed logs (avalanche debris), and snow (Inman *et al*. 2007c, pp. 55-56). Male wolverines likely mate with several females, and although they are not known to directly contribute to rearing young, they do tolerate subadult wolverines in their territories (usually their own offspring) until they reach maturity (Copeland 1996, p. 72).

Comment [O17]: Use Magoun and Copeland 1998 for reference; the two references cited here did not know birth date and therefore could not know if dens being used at the time the kits were dug out were natal, maternal, or rendezvous sites; although they mention moves, Pulliainen 1968 , p..343 stated it was due to disturbance; Myrberget 1968 (p. 115) also does not say they move kits to multiple dens; only that moves were observed and may have been influenced by disturbance from man---check your references.

Comment [O18]: "the thaw that has occurred" is more accurate (Myrberget 1968, p. 115; Magoun 1985, p. 1985 mentions "spring melt conditions"; neither observed accumulation of water in dens; spring melt conditions might include slumping of snow tunnels (Magoun, personal observation)

Comment [O19]: Not enough data on whether the subadults in a male's territory are their own offspring in all cases; they may tolerate unrelated subadults between ~1-2 years old in general; more information is needed on this topic; unrelated males do occur in the home ranges of other males (pers. observ., SE AK study)and there is not enough data on the social behavior of unrelated males

Habitat, Space, and Food

In North America, wolverines occur within a wide variety of alpine, boreal, and arctic habitats, including boreal forests, tundra, and western mountains throughout Alaska and Canada. The southern

portion of the species' range extends into the contiguous United States, including high-elevation alpine portions of Washington, Idaho, Montana, Wyoming, California, and Colorado (Wilson 1982, p. 644; Hash 1987, p. 576; Banci 1994, p. 102, Pasitschniak-Arts and Lariviere 1995, p. 499; Aubry *et al*. 2007, p. 2152; Moriarty *et al*. 2009, entire; Inman *et al*. 2009, pp. 22-25). Wolverines do not appear to specialize on specific vegetation or geological habitat aspects, but instead select areas that are cold and receive enough winter precipitation to reliably maintain deep persistent snow late into the warm season (Copeland *et al*. 2010, entire). The requirement of cold, snowy conditions means that, in the southern portion of the species' range where ambient temperatures are warmest, wolverine distribution is restricted to high elevations, while at more northerly latitudes, wolverines are present at lower elevations and even at sea level in the far north (Copeland *et al*. 2010, Figure 1).

Comment [O20]: Include Oregon if you are including California and Colorado based on Magoun et al. 2013 final report on the Wallowa study

Comment [O21]: So how are you defining the wolverine's range; looks as though you mean anywhere wolverines are occurring as residents even if there is no evidence of reproduction ???

Comment [O22]: Define terms

Comment [O23]: What is the "warm season"; be specific and use documented dates; see discussion in Attachment A

Comment [O24]: This is true if you are referring to the western US but not if you are referring to the entire N.A. population because wolverines at the southern extent of their range in eastern Canada do not have high elevation habitat

Comment [O25]: What is "far North"; wolverines occur at sea level in SE Alaska (Magoun et al. 2010) and in British Columbia (current research project by Canadian researchers; Aubry, pers. comm..)

In the contiguous United States, wolverines likely exist as a metapopulation (Aubry *et al*. 2007, p. 2147, Figures 1, 3). A population is a group of interbreeding individuals of the same species. A metapopulation is a population composed of a network of semi-isolated subpopulations, each occupying a suitable patch of habitat in a landscape of otherwise unsuitable habitat (Pulliam and Dunning 1997, pp. 212-214). Metapopulations require some level of regular or intermittent migration and gene flow among subpopulations, in which individual subpopulations support one-another by providing genetic and demographic enrichment through mutual exchange of individuals (Meffe and Carroll 1997, p. 678). Individual subpopulations may go extinct or lose genetic viability, but are then "rescued" by immigration from other subpopulations, thus ensuring the persistence of the metapopulation as a whole. If metapopulation dynamics break down, either due to changes within subpopulations or loss of connectivity, then the entire metapopulation may be jeopardized due to subpopulations becoming unable to persist in the face of inbreeding or demographic and environmental

stochasticity (Pulliam and Dunning 1997, pp. 221-222). The wolverine metapopulation in the DPS consists of a network of small subpopulations on mountain tops, some consisting of less than ten individuals. Persistence of subpopulations under these conditions requires movement between subpopulations across both suitable and unsuitable wolverine habitat. Wolverines prefer to move across suitable habitat (as defined by persistent spring snow cover) rather than to cross unsuitable habitats during dispersal movements (Schwartz et al. 2009, p. 3230). Therefore, we would expect that changes resulting in reduction of suitable habitat conditions would result in reduced movement rates between habitat patches if distances between them became greater. This could affect the metapopulation as a whole if movement rates became too low to ensure subpopulation demographic or genetic health.

Wolverines are opportunistic feeders and consume a variety of foods depending on availability. They primarily scavenge carrion, but also prey on small animals and birds, and eat fruits, berries, and insects (Hornocker and Hash 1981, p. 1290; Hash 1987, p. 579; Banci 1994, pp. 111-113). Wolverines have an excellent sense of smell that enables them to find food beneath deep snow (Hornocker and Hash 1981, p. 1297).

Wolverines require a lot of space; the availability and distribution of food is likely the primary factor in determining female wolverine movements and home range size (Hornocker and Hash 1981, p. 1298; Banci 1994, pp. 117-118). Male wolverine home range size and location is likely tied to the presence of active female home ranges and breeding opportunities (Copeland 1996, p. 74). Female wolverines forage close to den sites in early summer, progressively ranging further from dens as kits become more independent (May *et al*. 2010, p. 941). Wolverines travel long distances over rough

Comment [O26]: There are few documented accounts of wolverines eating fruits, berries, and insects; not probably a major part of their diet; not even listed in Banci 1994 or Hornocker and Hash 1290; Rausch and Pearson 1972 gives one of the only first-hand account of berries in the diet (p. 266); the emphasis should be on mice, ground squirrels, marmots, and hares, which are the primary small prey documented (multiple literature sources).

Comment [O27]: They also prey on large mammals to varying degrees; domestic sheep in Norway, semi-domesticated reindeer in Sweden; Dall sheep, personal observation; also Gill 1978-see Banci 1994, p. 113 for citations; moose (Magoun, poster paper reporting 3 accounts of wolverines killing moose—; see Banci 1994 for other species and citations; Haglund 1974)

Comment [O28]: Other instances of wolverines passing by bait at <300 m do not support this statement (Magoun pers. observation) and experiments I did with young wolverines indicated that their ability to smell bait at relatively close distance (~5) buried under moss was poor; there is no scientific data that support the supposition that wolverine's ability to smell is unusually keen for a carnivore; they do have good memories for where they have found food before or where they have cached food (pers. observ.) so maybe the "excellent" sense of smell is actually an "excellent" memory, similar to other animals that cache food like Clark's nutcracker (supported by research).

Comment [O29]: Do you mean rendezvous sites? Or do you mean in the denning season? I don't see where May actually states this on p. 941; he discusses foraging intensity and preferences, not distance

Comment [O30]: This is not what this reference actually says; especially when considering night-time movements; nothing about distance just elevation ; e.g., "In spring, wolverines showed restricted movement patterns around rendezvous sites at high elevations by day, whereas during the night animals were active at lower elevations." (see abstract)

terrain and deep snow, and adult males generally cover greater distances than females (Hornocker and Hash 1981, p. 1298; Banci 1994, pp. 117-118; Moriarty *et al*. 2009, entire; Inman *et al*. 2009, pp. 22-28; Brian 2010, p. 3; Copeland and Yates 2006, Figure 9). Home ranges of wolverines are large, and vary greatly in size depending on availability and distribution of food and gender and age of the animal. Home ranges of adult wolverines also vary in size depending on geographic location. Home ranges in Alaska were approximately 100 square kilometers (km^2) to over 900 km^2 (38.5 square miles (mi^2) to 348 mi^2) (Banci 1994, p. 117). Average home ranges of resident adult females in central Idaho were 384 km^2 (148 mi^2), and average home ranges of resident adult males were 1,522 km^2 (588 mi^2) (Copeland 1996, p. 50). Wolverines in Glacier National Park had average adult male home ranges of 496 km^2 (193 mi^2) and adult female home ranges of 141 km^2 (55 mi^2) (Copeland and Yates 2006, p. 25). Wolverines in the Greater Yellowstone Ecosystem had average adult male home ranges of 797 km^2 (311 mi^2), and average adult female home ranges of 329 km^2 (128 mi^2) (Inman *et al*. 2007a, p. 4). These home range sizes are large relative to the body size of wolverines, and may indicate that wolverines occupy a relatively unproductive niche in which they must forage over large areas to consume the amount of calories needed to meet their life-history requirements (Inman *et al*. 2007a, p. 11).

Comment [O31]: use published reference Inman et al. 2012 J of Mammalogy

Across their worldwide distribution, wolverines are dependent on persistent spring snow cover for successful reproduction (Pulliainen 1968, pp. 338-341; Myrberget 1968, p. 115; Copeland 1996, pp. 93-94; Magoun and Copeland 1998, pp. 1315-1319; Aubry *et al*. 2007, p. 2153; Inman *et al*. 2012a, p.785; Copeland *et al*. 2010, entire). No records exist of wolverines denning anywhere but in snow, despite the wide availability of snow-free denning opportunities within the species' geographic range. The snow tunnels and complex structure associated with dens are likely required to protect young from

Comment [O32]: few records; there are 1 or 2 but they may be unusual circumstances; see Pulliainen 1968 and Rausch and Pearson 1972

interspecific and intraspecific predation (Persson *et al*. 2003, pp. 25-26; Magoun and Copeland 1998, p. 1318). A layer of deep snow may also add crucial insulation from cold temperatures and wind prevalent in wolverine habitat (Pulliainen 1968, p. 342; Bjärvall *et al*. 1978, p. 24-25; Copeland 1996, p. 100; Magoun and Copeland 1998, p. 1318).

Female wolverines have been observed to abandon reproductive dens when temperatures warm and snow conditions become wet (Magoun and Copeland 1998, p. 1316); this response indicates that the condition of the snow is also important to successful reproduction, and that the onset of spring snowmelt forces female wolverines to move kits into alternate denning sites with better snow conditions, if they are available. These movements may be energetically costly and subject females and kits to predation risk. The deep, persistent spring snow layer in the Copeland et al. (2010) model captures all known wolverine den sites in the DPS; however, on average, most denning occurs at higher elevations within the area defined by the model. Female wolverines establish reproductive dens at elevations higher than average elevations used by nonreproductive wolverines (Copeland 1996, p. 94; Magoun and Copeland 1998, pp. 1315-1316; Inman *et al*. 2007c, p. 71), suggesting that females find the conditions necessary for successful denning in the upper portion of their home range where snow is most persistent and occurs in the heaviest accumulations.

Wolverine year-round habitat use also takes place almost entirely within the area defined by deep persistent spring snow (Copeland et al. 2010, pp. 242-243). Within the DPS, this area is generally centered on the alpine tree line (the maximum elevation beyond which tree growth is precluded and only low-growing vegetation is found). In the contiguous United States, wolverine year-round habitat is found at high elevations centered near the tree line in conifer forests (below tree line) and rocky

Comment [O33]: actually says when spring snow melt begins; dens were not actually excavated until ~ a week after the den was abandoned so we don't know if there was standing water at that time; slumping snow tunnels could be the reason for den abandonment

Comment [O34]: Copeland et al. 2010 did not measure depth nor used it to construct the snow model; no measurement of depth for the DPS provided in Copeland et al. 2010

Comment [O35]: Should note though that the authors state they did not attempt to fit the snow coverage to the data (i.e., actual locations of the dens against actual snow cover during the years the dens were used) and the snow coverage was based on snow cover in 1-7 years out of 7 years in only 2000-2006 (see Attachment A for more detailed discussion).

Comment [O36]: Cite page number

Comment [O37]: In the western US

Comment [O38]: Again, depth was not measured or used in Copeland et al. 2010

alpine habitat (above tree-line) and in cirque basins and avalanche chutes that have food sources such as marmots, voles, and carrion (Hornocker and Hash 1981, p. 1296; Copeland 1996, p. 124; Magoun and Copeland 1998, p. 1318; Copeland *et al*. 2007, p. 2211; Inman *et al*. 2007a, p. 11). In the southern portion of wolverine range in North America which includes the DPS, wolverines are constrained by their need for cold conditions and persistent spring snow to using only the coldest available landscapes (Copeland *et al*. 2010, Figure 6).

Mean seasonal elevations used by wolverines in the northern Rocky Mountains and North Cascades vary between 1,400 and 2,600 m (4,592 and 8,528 ft) depending on location, but are always relatively high on mountain slopes (Hornocker and Hash 1981, p. 1291; Copeland *et al*. 2007, p. 2207, Aubry *et al*. 2007, p. 2153; Inman et al. 2012, p.782). Elevation ranges used by historical wolverine populations in the Sierra Nevada and southern Rocky Mountains are unknown, but presumably wolverines used higher elevations, on average, than more northerly populations to compensate for the higher temperatures found at lower latitudes. In the contiguous United States, valley bottom habitat appears to be used only for dispersal movements and not for foraging or reproduction (Inman *et al*. 2009, pp. 22-28). Wolverine reproductive dens have been located in alpine, subalpine, taiga, or tundra habitat (Myrberget 1968, p. 115; Pulliainen 1968, pp. 338-341; Bjärvall 1982, p. 318; Lee and Niptanatiak 1996, p. 349; Landa *et al*. 1998, pp. 451-452; Magoun and Copeland 1998, pp. 1317-1318). Wolverines rarely, or never, den in lower elevation forested habitats, although they may occupy these habitats occasionally (Magoun and Copeland 1998, p. 1317).

Comment [O39]: Lowland boreal (Dawson et al. 2010)

Comment [O40]: They did NOT say that wolverines "occupy these habitats occasionally" rather that they "occupy these habitats" and in fact, they occupy quite a bit of this habitat in boreal Canada and are denning in lowland boreal in Sweden (see Attachment A); be careful to cite your references accurately

Comment [O41]: Magoun and Copeland 1998 did not say this; what they said was "rarely have dens been reported in low-elevation densely forested habitats.." p. 1317; they acknowledge that this could be an artifact of where researchers have searched for dens citing Banci 1994; the best available science now indicates that wolverines do den in lowland boreal forest (see Attachment A).

Wolverine Densities

Wolverines naturally occur in low densities with a reported range from one animal per 65 km^2 (25 mi^2), to one animal per 337 km^2 (130 mi^2) (Hornocker and Hash 1981, pp. 1292-1295; Hash 1987, p. 578; Copeland 1996, pp. 31-32; Copeland and Yates 2006, p. 27; Inman *et al*. 2007a, p. 10; Squires *et al*. 2007, p. 2218). No systematic population census exists over the entire current range of wolverines in the contiguous United States, so the current population level and trends are not known with certainty. However, based on our current knowledge of occupied wolverine habitat and wolverine densities in this habitat, it is reasonable to estimate that the wolverine population in the contiguous United States numbers approximately 250 to 300 individuals (Inman 2010b, pers. comm.). The bulk of the current population occurs in the northern Rocky Mountains, with a few individuals in the North Cascades and one known individual each in the Sierra Nevada and southern Rocky Mountains. Within the area known to currently have wolverine populations, relatively few wolverines can coexist due to their naturally low population densities, even if all areas were occupied at or near carrying capacity. Given the natural limitations on wolverine population density, it is likely that historical wolverine population numbers were also low (Inman et al. 2007a, Table 6). Because of these natural limitations, it is possible that densities and population levels in the northern Rocky Mountains and North Cascades where populations currently exist may not be substantially lower than population densities were in these areas prior to European settlement. However, historically, the contiguous United States population would likely have been larger than it is today due to the larger area occupied by populations when the southern Rocky Mountains, Bighorn Mountains, Sierra Nevada, and possibly also the Oregon Cascades and mountains of Utah, were occupied at full capacity.

Comment [O42]: Copeland and Yates 2006 do not report on density on p. 27

Comment [O43]: More recent and complete references include Inman et al. 2012 JWM 76:778-792 (Table 5)

Wolverine Status in Canada and Alaska

The bulk of the range of North American wolverines is found in Canada and Alaska, where wolverines inhabit alpine tundra, boreal forest, and arctic habitats (Slough 2007, p. 78). Wolverines in Canada have been divided into two populations for management by the Canadian Government: an eastern population in Labrador and Quebec, and a western population that extends from Ontario to the Pacific coast, and north to the Arctic Ocean. The eastern population is currently listed as endangered under the Species At Risk Act in Canada, and the western population is designated as a species of special concern (COSEWIC 2003, p. 8).

Comment [O44]: Mention that a new COSEWIC is currently under review (Graham Forbes, Univ. of New Brunswick, pers. comm..) and status could change

The current status of wolverines in eastern Canada is uncertain. Wolverines have not been confirmed to occur in Quebec since 1978 (Fortin *et al*. 2005, p. 4). Historical evidence of wolverine presence in eastern Canada is also suspect because no evidence exists to show that wolverine pelts attributed to Quebec or Labrador actually came from that region; animals were possibly trapped elsewhere and the pelts shipped through the eastern provinces (COSEWIC 2003, p. 20). Wolverines in eastern Canada may currently exist in an extremely low-density population, or may be extirpated. Wolverines in eastern Canada, both historically and currently, could represent migrants from western populations that never became resident animals (COSEWIC 2003, pp. 20-21). The Federal Government of Canada has completed a recovery plan for the eastern population with the goal of establishing a self-sustaining population through reintroduction and protection (Fortin *et al*. 2005, p. 16).

Comment [O45]: What historical evidence? Records of harvests? What do you consider historical?

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Comment [O46]: This statement is misleading because it suggests that wolverines may never have been present, but the COSEWIC 2003 report does not say that historical presence is suspect, only that harvests said to be from those provinces may not have been trapped there; there IS historical evidence of presence of wolverines in Labrador and Quebec; see Attachments Labrador; in addition see the Fortin et al. 2005 National Recovery Plan for the Wolverine (Eastern population) in your list of references, p. 4 ("Prior to the arrival of Europeans, wolverines were present throughout Labrador and Quebec (Kelsall 1981). The wolverine's historical distribution appears to have coincided with the distribution of caribou within the taiga ecoregion of the Canadian Shield (van Zyll de Jong 1972). However, the historical population size is not known. At the beginning of the 20th century, the geographic range of wolverine was thought to extend to the 66th parallel and perhaps beyond (de Puyjalon 1900)."

Comment [O47]: Again, this is a misleading statement, indicating that even historic occurrences of wolverines in eastern Canada may have been migrants and so giving the impression you are saying that wolverines never were established in eastern Canada and this is not true. This should be reworded with better information on on historic wolverine populations and references.

Wolverines in western Canada and Alaska inhabit a variety of habitats from sea level to high elevations (Slough 2007, pp. 77-78). They occur in Alaska, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, Yukon, Northwest Territories, and Nunavut (Slough 2007, pp. 77-78). Since

European colonization, a generally recognized range contraction has taken place in boreal Ontario and the aspen parklands of Manitoba, Saskatchewan, and Alberta (COSEWIC 2003, pp. 20-21; Slough 2007, p. 77). This range contraction occurred concurrently with a reduction in wolverine records for the Great Lakes region in the contiguous United States (Aubry *et al*. 2007, pp. 2155-2156). Causes of these changes are uncertain, but may be related to increased harvest, habitat modification, or climate change (COSEWIC 2003, pp. 20-21; Aubry *et al*. 2007, pp. 2155-2156; Slough 2007, pp. 77-78). Analysis supports climate change as a factor contributing to population declines in southern Ontario, because snow conditions necessary to support wolverines do not currently exist in the Great Lakes region of the contiguous United States, and are marginal in southern Ontario (Aubry *et al*. 2007, p. 2154). It is not known if these snow conditions existed historically in the Great Lakes of the contiguous United States; however, the small number of wolverine records from this area suggests that they did not. It is possible that suitable snow conditions did reach further south in eastern Canada in 1850 than they do today, making wolverine dispersal attempts from Canada to the Great Lakes region of the contiguous United States more likely than they are now. Wolverines occurred historically on Vancouver Island and have been given status as a separate subspecies by some (Hall 1981, p. 109). The Vancouver Island population is now regarded as possibly extirpated; no sightings have occurred since 1992 (COSEWIC 2003, p. 18).

Wolverines in western Canada and Alaska appear to persist everywhere that habitat and climate conditions are suitable (COSEWIC 2003, pp. 13-21; Aubry *et al*. 2007, pp. 2152-2155; Slough 2007, p. 79; Copeland *et al*. 2010, Figure 2). Throughout this area, wolverines are managed by regulated harvest at the Provincial and State level. Population estimates for Canada and Alaska are rough because no wolverine surveys have taken place at the State or Provincial scale. However, the population in western

Comment [O48]: It is not possible to tease apart the contribution of climate change from that of habitat conversion during human settlement, logging and railroad construction and the overharvest of ungulates that occurred all at the same time; information on historic snow depths is not available (Russ Brown, Climate Research Branch, Atmospheric Environment Service, Canada, pers. comm..) It seems you are using circular reasoning: saying changes in snow conditions may have led to declines in wolverines and then saying low number of wolverine records indicate that snow conditions were not able to support wolverines historically. Just say we don't know for sure what caused wolverines to disappear from the Great Lakes Region

Comment [O49]: Same comment as 047 above; also snow conditions in southern Ontario may be sufficient for denning but anthropogenic change may be at least one of the causes of retraction in wolverine range in Ontario in the south (possibly even more important than climate change); furthermore, Aubry et al. 2007 is inconclusive on the role of climate change on wolverine range in southern Ontario

Comment [O50]: Or that wolverines historically occurred in the extreme northern areas of Minnesota where they did not often encounter people and therefore not many records would be expected even if they occurred there; even today snow conditions around Lake Superior could be suitable snow cover for denning in some years (snow cover maps from the National Operational Hydrologic Remote Sensing Center).

Canada is estimated to include approximately 15,089 to 18,967 individuals (COSEWIC 2003, p. 22). The number of wolverines in Alaska is unknown, but they appear to exist at naturally low densities in suitable habitats throughout the state (Alaska Department of Fish and Game 2004, pp. 1-359). We have no information to indicate that wolverine populations have been reduced in numbers or geographic range in Alaska.

The Complexity of Geographic Range Delineation

Information on the nature of historical and current locations of wolverine is lacking for several reasons. Wolverines tend to live in remote and inhospitable places away from human settlements, where they are seldom encountered, documented, or studied. Wolverines naturally occur at low population densities and are rarely and unpredictably encountered where they do occur. Wolverines often move long distances in short periods of time; for example, when dispersing from natal ranges, wolverines may transit through habitats that are unsuitable for long-term survival (Aubry *et al*. 2007, p. 2147; Moriarty *et al*. 2009, entire; Inman *et al*. 2009, pp. 22-28; Brian 2010, p. 3). Such movements make it difficult to distinguish with certainty between occurrence records that represent established populations in suitable habitats and records that represent short-term occupancy or exploratory movements without the potential for establishment of home ranges, reproduction, or populations. These natural attributes of wolverines make it difficult to precisely determine their present range, or trends in range expansion or contraction, that may have occurred in the past. Therefore, we are cautious and use multiple lines of evidence when trying to determine where past wolverine populations occurred.

Throughout the remainder of this proposed rule, we focus on the use of verifiable and documented wolverine occurrence records to define historical and present range as we have determined that these records constitute the best scientific information available on the past and present distribution of wolverines (see Aubry *et al*. 2007, p. 2148; McKelvey *et al*. 2008, entire). Verifiable records are records supported by physical evidence such as museum specimens, harvested pelts, DNA samples, and diagnostic photographs. Documented records are those based on accounts of wolverines being killed or captured. Use of only verifiable and documented records avoids mistakes of misidentification often made in eyewitness accounts of visual encounters of unrestrained animals in the wild. Visual-encounter records often represent the majority of occurrence records for elusive forest carnivores, and they are subject to inherently high rates of misidentification of the species involved, including wolverines (McKelvey *et al*. 2008, pp. 551-552). These misidentifications can result in wildly inaccurate conclusions about species occurrence (McKelvey *et al*. 2008, pp. 550-553).

Aubry *et al*. (2007, entire) used only verifiable and documented records to investigate wolverine distribution through time. This paper is the only available comprehensive treatment of these distribution patterns that attempts to distinguish between records that represent resident animals versus animals that have dispersed outside of suitable habitat. For these reasons, we find that Aubry *et al.* (2007, entire) represents the best available summary of wolverine occurrence records in the contiguous United States at this time. Since the publication of Aubry *et al*. (2007, entire), verified records of wolverines have also been documented in Colorado and California, which we will describe in greater detail below.

Aubry *et al*. (2007, entire) used verifiable and documented records from museum collections, literature sources, and State and Federal institutions to trace changes in geographic distribution of wolverines in the historical record. They then used an overlay of suitable wolverine habitats to determine which records represent wolverines in habitats that may support residency, and, by extension, populations, and which records likely represent wolverines outside the range of suitable habitats, so called "extralimital" records. Aubry *et al*.'s (2007, entire) focus on verifiable and documented records corrected past overly broad approaches to wolverine range mapping (Nowak 1973, p. 22; Hall 1981, p. 1009; Wilson 1982, p. 644; Hash 1987, p. 576), which used a more inclusive but potentially misleading approach when dealing with occurrence records. Many of the extralimital records used in these publications represented individuals that dispersed from natal ranges but ended up in habitats that could not support wolverines. Use of these data to determine the historical geographic range of wolverines results in gross overestimation of the area that can actually be used successfully by wolverines for the establishment of populations. Subsequent to publication of Aubry *et al*. (2007, entire), two publications (Copeland *et al*. 2010, entire; Brock *et al*. 2007, entire) further refined our understanding of wolverine habitat needs and corroborated the approach of Aubry *et al*. (2007, entire). Thus, despite the paucity of verifiable records, we now have strong information on the areas that are currently suitable to be occupied by wolverine based on habitat and climate conditions.

We agree with Aubry *et al*. (2007, p. 2149) that the most appropriate method to determine the current and historical range of wolverines is to use a combination of occurrence records and habitat suitability, along with other information, such as documented successful reproduction events, indicating where reproductive and potentially self-sustaining populations may occur. We also generally agree with their conclusions about the historical and current range of the species. We find that the species' range is

the area that may support viable populations, and does not include extralimital occurrences outside of habitat that is likely to support wolverine life-history needs. Areas that can support wolverine populations may be referred to as potential "source" populations because they provide surplus individuals through reproduction beyond what is needed for replacement. Areas that have some of the habitat attributes of wolverine habitat but do not have enough habitat to support viable populations may be referred to as population "sinks" because wolverines may disperse to these areas and remain for some time, but will either die there without reproducing, leave the area in search of better habitat conditions, or may actually reproduce, but at a rate lower than that needed for replacement of individuals lost to mortality or emigration, leading to eventual population extinction.

For a widely dispersing species like the wolverine, we expect many locality records to represent dispersal attempts into sink habitats or nonhabitat. The value to the population (and thus the DPS) of dispersers in these areas is unclear; it is likely that most dispersers into sink habitats or nonhabitat will be lost to the population unless they are able to move back into source habitats. Therefore, it is our conclusion that population sink areas and areas of non-wolverine habitat, here defined as places where wolverines may be found but where habitat is not suitable for long-term occupancy and reproduction, do not represent part of the species historical range and have little conservation value for the DPS, other than possibly serving as temporary stop-overs for attempted dispersers as they search for suitable habitats. Compared with broader approaches to defining historical geographic range, this focused approach (1) results in reducing the bias of extralimital dispersers and (2) concentrates conservation attention on areas capable of maintaining populations.

Comment [O51]: This statement seems inconsistent with statements elsewhere regarding the need for dispersal habitat and genetic exchange

Aubry *et al*. (2007, pp. 2147-2148) divided records into "historical" (recorded prior to 1961), "recent" (recorded between 1961 and 1994), and "current" (recorded after 1994). Historical records occurred before systematic surveys. Historical records encompass the time during which wolverine numbers and distribution were hypothesized to be at their highest (prior to European settlement) and also at their lowest (early 20th century) (Wright and Thompson 1935; Grinnell *et al*. 1937; Allen 1942; Newby and Wright 1955, all as cited in Aubry *et al*. 2007, p. 2148). The recent time interval covers a hypothesized population expansion and rebound from the early 20th century low. Current records offer the most recent evidence available for wolverine occurrences and potential populations. All occurrence records must be individually analyzed in light of their context in terms of habitat conditions conducive to wolverine population establishment and whether or not they occur clustered with other records, which might indicate that populations have historically occurred in the area. The authors of Aubry *et al*. (2007) did such an analysis as they compiled their records.

Wolverine Distribution

We assessed the historical, recent, and current distribution data for each of the regions below to determine the likelihood of the presence of historical populations (rather than extralimital dispersers). Of 729 mappable records (those records with precise location information) compiled by Aubry *et al*. (2007, p. 2150), 188 were from the historical time interval (see Table 1). The discussion below draws heavily from both Aubry *et al*. (2007, entire) and Copeland *et al*. (2010, entire).

Table 1. Wolverine records from three time periods from Aubry *et al*. 2007. Numbers represent total documented and verifiable records with the subset of those records that were verifiable in parentheses.

□Historical (<1964)□Recent (1961-1994)□Current (>1994)□□Northeast □13 (1)□0□0□□Upper Midwest□4 (2)□0□0□□Great Lakes□36 (4)□1□0□□Central Great Plains□71* (2)□1□0□□Rocky Mountains□147 (45)□332 (283)□215 (210)□□Pacific Coast□89 (14)□23 (15)□7□□TOTALS□362 (68)□357 (298)□222 (210)□□* 35 records from a single source (the journals of Alexander Henry).

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Current (>1994)□□Northeast □13 (1)□0□0□□Upper Midwest□4 (2)□0□0□□Great Lakes□36 (4)□1□0□□Central Great Plains□71* (2)□1□0□□Rocky Mountains□147 (45)□332 (283)□215 (210)□□Pacific Coast□89 (14)□23 (15)□7□□TOTALS□362 (68)□357 (298)□222 (210)□□* 35 records from a single source (the journals of Alexander Henry).

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Northeast □13 (1)□0□0□□Upper Midwest□4 (2)□0□0□□Great Lakes□36 (4)□1□0□□Central Great Plains□71* (2)□1□0□□Rocky Mountains□147 (45)□332 (283)□215 (210)□□Pacific

Coast□89 (14)□23 (15)□7□□TOTALS□362 (68)□357 (298)□222 (210)□□* 35 records from a single source (the journals of Alexander Henry).

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71* (2)□1□0□□Rocky Mountains□147 (45)□332 (283)□215 (210)□□Pacific Coast□89 (14)□23 (15)□7□□TOTALS□362 (68)□357 (298)□222 (210)□□* 35 records from a single source (the journals of Alexander Henry).

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362 (68)□357 (298)□222 (210)□□* 35 records from a single source (the journals of Alexander Henry).

357 (298)□222 (210)□□* 35 records from a single source (the journals of Alexander Henry).

222 (210)□□* 35 records from a single source (the journals of Alexander Henry).

□* 35 records from a single source (the journals of Alexander Henry).

* 35 records from a single source (the journals of Alexander Henry).

Northeast and Upper Midwest—The low number of records and scattered nature of their distribution combined with a lack of suitable habitat indicate that wolverines were likely only occasional transients to the area and not present as a reproducing population after 1800.

Great Lakes—The lack of large numbers of verifiable records in this area of relatively high human population density and the lack of suitable habitat suggests that wolverines did not exist in this area as a viable population after 1900. Widely scattered records generally before 1900, along with occasional subsequent records suggest that if a reproducing population existed in the Great Lakes, it predated 1900, and that any post-1900 records represent dispersal from a receding Canadian population. Wolverine distribution in Ontario, Canada, appears to have receded north from the Great Lakes region since the 1800s, and currently wolverines occupy only the northern portion of the province, a distance of over 644 km (400 mi) from the United States border (COSEWIC 2003, p. 9). The distribution pattern of record illustrated in Aubry *et al*. (2007, p. 2152) is consistent with what would be expected if those records were of dispersing individuals from a Canadian population that receded progressively further north into Canada after 1800, possibly due to natural climate changes (COSEWIC 2003, p. 28).

Central Great Plains—The lack of precise locality records and suitable habitat from the Great Plains States leads us to conclude that reproducing populations of wolverines did not historically inhabit this area. Of thirty-six records from North Dakota, 35 are from the journals of a single fur trader (see Table 1), and it is not clear that the records represent actual collection localities or are localities where trades or shipments occurred (Aubry 2007, pers. comm.). Given the habitat relationships of wolverines (e.g., Copeland *et al*. 2010, Figure 1), it is unlikely that these records represent established wolverines or that this area served as wolverine habitat.

Rocky Mountains—Five Rocky Mountains States (Idaho, Montana, Wyoming, Colorado, and Utah) contained numerous wolverine records. Records with precise locality information appear to coalesce around several areas that may have been population centers, such as central Colorado, the greater Yellowstone region, and northern Idaho-northwestern Montana. The large number of verifiable and documented records for this region, along with the suggestion of population centers or strongholds, suggests that wolverines existed in reproducing populations throughout much of the Rocky Mountains during the historical time interval. The lack of records for Colorado and Utah after 1921 suggests that the southern Rocky Mountains population of wolverines was extirpated in the early 1900s, concurrent with widespread systematic predator control by government agencies and livestock interests. The northern Rocky Mountains population (north of Wyoming) was reduced to historical lows or possibly even extirpated during the early 1900s, and then increased dramatically in the second half of the 1900s (see Table 1) as predator control efforts subsided and trapping regulations became more restrictive (Aubry *et al*. 2007, p. 2151). This increase likely indicates a population rebound from historical lows in this period.

Wolverine records from 1995 to 2005 indicate that wolverine populations currently exist in the northern Rocky Mountains (see Table 1). Legal trapping in Montana in the recent past removed an average of 10.5 individuals from this population each year (Montana Department of Fish, Wildlife, and Parks 2007, p. 2), but harvest mortality has been reduced due to regulatory changes in 2008 (Montana Department of Fish, Wildlife and Parks 2008, p. 8). Populations in British Columbia and Alberta, Canada, are extant (COSEWIC 2003, pp. 18-19), and may have been a source of surplus wolverines to the contiguous United States population during population lows. Recently, a male wolverine moved on its own from the southern Greater Yellowstone Area of Wyoming into the southern Rocky Mountains of Colorado, where it still persisted as of November 2012 (Inman *et al*. 2009, pp. 22-26; Odell 2012, pers. comm.). This attempted dispersal event is the first verified wolverine occurrence in Colorado since 1919 and may represent a continuation of the wolverine expansion in the Rocky Mountains detailed above. It is possible that other wolverines have traveled to the southern Rocky Mountains and have remained undetected. There is no evidence that Colorado currently hosts a wolverine population or that female wolverines have made, or are likely to make, similar movements. Female dispersal movements tend to be much shorter than males, usually occupying home ranges adjacent to their natal range, and dispersal is documented only for lesser distances than males routinely travel (Hornocker and Hash 1981, p. 1290; Copeland 1996, p. 91; Kyle and Strobeck 2001, p. 338; Tomasik and Cook 2005, p. 390; Cegelski *et al.* 2006, p. 206, Inman *et al*. 2011, p. 7). The largest documented female movement occurred in 2010 in the North Cascades of Washington (Aubry *et al*. 2011, pp. 21-22). In that instance, a radio-collared female wolverine moved an air-line distance of approximately 233 km (145 mi) over a 44-day period. During this movement, her course generally stayed within suitable wolverine habitat (as defined by Copeland *et al*. (2010, p. 242)) and was never more than about 19 km (12 mi) from suitable wolverine habitat.

Comment [O52]: Distance of ~300 km (airline kilometers) for an ear-tagged young female wolverine in Alaska (Magoun 1985, p. 55-57); although the ear-tags were not retrieved from the trapper, there was no one else tagging wolverines in NW Alaska or anywhere in Alaska, especially not with yellow ear tags.

Comment [O53]: Mulders 2000 documented movement of 225 km, and 4 other movements of 69, 83, 97, and 189 so these should be stated here because you do not define the term "much shorter than males" and you state they usually occupy ranges adjacent to their natal area; what distances do Males "routinely travel"; Flagstand et al. 2004 stated that both sexes have the capacity to disperse 100-200 km

Comment [O54]: This is not how I interpret the path of this female on a map of the snow cover layer; much of her course was outside the snow cover layer of Copeland et al. 2010, even though the 15 May MODIS snow cover habitat was near enough that she could have selected it but didn't.

Pacific Coast—Historical records show that wolverines occurred in two population centers in the North Cascades Range and the Sierra Nevada. However, records do not show occurrences between these centers from southern Oregon to northern California, indicating that the historical distribution of wolverines in this area is best represented by two disjunct populations rather than a continuous peninsular extension from Canada. This conclusion is supported by genetic data indicating that the Sierra Nevada and Cascades wolverines were separated for at least 2,000 years prior to extirpation of the Sierra Nevada population (Schwartz *et al*. 2007, p. 2174).

Comment [O55]: Most recent scientific data invalidate this statement; McKelvey et al. in review (K. Aubry, pers. comm..)

Only one Sierra Nevada record exists after 1930, indicating that this population was likely extirpated in the first half of the 1900s, concurrent with widespread systematic predator control programs. In 2008, a male wolverine was discovered in the Sierra Nevada Range of California, the first verified record from California since 1922 (Moriarty *et al*. 2009, entire). Genetic testing revealed that this wolverine was not a descendant of the endemic Sierra Nevada wolverine population, but was likely derived from wolverines in the Rocky Mountains (Moriarty *et al*. 2009, p. 159). This attempted dispersal event may represent a continuation of the wolverine expansion in the contiguous United States as detailed above. Other wolverines may have travelled to the Sierra Nevada and remain undetected. There is no evidence that California currently hosts a wolverine population or that female wolverines have made, or are likely to make, similar dispersal movements.

Comment [O56]: Contradicts statement above about isolation for 2000 years; why would one accept that they were isolated for 2000 years but can now disperse there in a modern era with more anthropogenic "barriers to dispersal"; but see comment 052 above

Wolverines were likely extirpated from the North Cascades in the early 20th century and then recently recolonized from Canada. Currently, a small population persists in this area (Aubrey *et al*. 2011, entire). In 2012, reproduction was documented for the first time in the North Cascades (Aubry *et*

al. 2012, p. 2). Wolverines have also been documented in the southern portion of the North Cascades, near Mount Adams, since 2009 (Akins 2010, p. 4). The North Cascades population may be connected with, and is possibly dependent on, the larger Canadian population for future expansion and long-term persistence.

Comment [O57]: Should say "is connected" since some of the home ranges and dispersal movements of tagged wolverines span the border

Summary of Wolverine Distribution

Historical wolverine records were found across the northern tier of the contiguous United States, with convincing evidence of wolverine populations in the northern and southern Rocky Mountains, Sierra Nevada Mountains, and North Cascades Mountains (Aubry *et al*. 2007, p. 2152).

Currently, wolverines appear to be distributed as functioning populations in two regions in the contiguous United States: the North Cascades in Washington, and the northern Rocky Mountains in Idaho, Montana, and Wyoming (this area also includes the Wallowa Range in Oregon). Wolverines were likely extirpated, or nearly so, from the entire contiguous United States in the first half of the 20th century (Aubry *et al*. 2007, Table 1). Although the reasons for this extirpation are not known with certainty, unregulated trapping and widespread indiscriminant predator control likely contributed to population declines. The available evidence suggests that, in the second half of the 20th century and continuing into the present time, wolverine populations have expanded in the North Cascades and the northern Rocky Mountains from sources in Canada, but that populations have not been reestablished in the Sierra Nevada Range or the southern Rocky Mountains, despite the known movement of single individual males to each of these areas. We conclude that the current range of the species in the contiguous United States includes the North Cascades Mountains, the northern Rocky Mountains, the

southern Rocky Mountains, and the Sierra Nevada Mountains, but that reestablishment of populations in the southern Rocky Mountains and Sierra Nevada Mountains has not yet occurred.

We also conclude that wolverines either did not exist as established populations, or were extirpated prior to settlement and the compilation of historical records, in the Great Lakes region, possibly due to climate changes that occurred through the 1800s and 1900s. The Great Lakes region lacks suitable wolverine habitat, and suitable habitat does not appear to exist in adjacent Canada (Copeland *et al.* 2010, Figure 1). The widely scattered records from this region are consistent with dispersing individuals from a Canadian population that receded north early in the 1800s. We cannot rule out the possibility that wolverines existed as established populations prior to the onset of trapping in this area, but we have no evidence of this.

Comment [O58]: What evidence do you base this on that specifically indicates that snow conditions (depth and timing) for denning changed from historical times; I've tried to chase this down but haven't succeeded

Comment [O59]: Or expansion of humans, which happened concurrently with warming temperatures; unfortunately, there actually is no conclusive evidence of climate change [ie., decrease in snow depth in the denning season and duration in the 1800s and 1900s] that would explain the disappearance of wolverines any better than expansion of human developments; warming temperatures do not necessarily mean less winter snow (Russ Brown, climatologist, pers. comm..)

No evidence in the historical records indicates that wolverines were ever present as established populations in the Great Plains, Midwest, or Northeast.

Habitat Relationships and Wolverine Distribution

Deep, persistent, and reliable spring snow cover (April 15 to May 14) is the best overall predictor of wolverine occurrence in the contiguous United States (Aubry *et al*. 2007, pp. 2152-2156; Copeland *et al.* 2010, entire). Deep, persistent snow correlates well with wolverine year-round habitat use across wolverine distribution in North America and Eurasia at both regional and local scales (Copeland *et al*. 2010, entire; Inman *et al*. 2012a, p. 785). It is uncertain why spring snow cover so accurately predicts wolverine habitat use; however, it is likely related to wolverines' need for deep

Comment [O60]: Define terms

Comment [O61]: From Aubry not Copeland

Comment [O62]: I disagree; see Attachment A

Comment [O63]: Dates are 24 April to 15 May from Copeland

Comment [O64]: "Deep" has not been defined; Copeland did not use depth. And on p. 785 of the Inman et al. paper cited, Inman only states "deep snow exists during winter"; when defining year-round habitat, Inman used distance to snow of depth >2.5 cm (Inman et al. 2013, Paper III, p. 6); no definition of what depth is required so it remains a subjective statement (see Attachment A for further discussion)

snow during the denning period. In addition, wolverines appear to take advantage of a cold, low-productivity niche by using food caching in cold habitats to survive food-scarce winters that other carnivores cannot (Inman *et al*. 2012b, pp. 640-642). Wolverines' physiological requirement for year-round cold temperatures may also play a role in habitat use (Copeland *et al*. 2010, pp. 242-243). Snow cover during the denning period is essential for successful wolverine reproduction range-wide (Hatler 1989, p. iv; Magoun and Copeland 1998, p. 1317; Inman *et al*. 2007c, pp. 71-72; Persson 2007; Copeland *et al*. 2010, p. 244). Wolverine dens tend to be in areas of high structural diversity such as logs and boulders with deep snow (Magoun and Copeland 1998, p. 1317; Inman *et al*. 2007c, pp. 71-72; Persson 2007, entire). Reproductive females dig deep snow tunnels to reach the protective structure provided by logs and boulders. This behavior presumably protects the vulnerable kits from predation by large carnivores, including other wolverines (Pulliainen 1968, p. 342; Zyryanov 1989, pp. 3-12), but may also have physiological benefits for kits by buffering them from extreme cold, wind, and desiccation (Pullianen 1968, p. 342, Bjärvall *et al*. 1978, p. 23). Wolverines live in low-temperature conditions and appear to select habitats in part to avoid high summer temperatures (Copeland *et al*. 2010, p. 242). Wolverine distribution is likely affected by climatic conditions at two different scales. Wolverines require deep persistent snow for denning, and this likely determines where wolverine populations can be found at the grossest range-wide scale (Copeland *et al*. 2010, p. 244). At smaller scales, wolverines likely select habitats to avoid high summer temperatures. These cool habitats also tend to retain snow late into spring, leading to wolverines' year-round association with areas of persistent spring snow (Copeland *et al*. 2010, p. 244).

All of the areas in the contiguous United States for which good evidence of persistent wolverine populations (either present or historical) exists (i.e., North Cascades, Sierra Nevada, northern and

Comment [O65]: Inman et al. 2012 proposes other plausible explanations (J of Mamm. , Vol. 93) and could be the more proximate factors explaining spring snow cover relationships to wolverine habitat use; in other words, do wolverines use areas with spring snow cover because they have to den in snow, or do they den in snow because they use areas with spring snow cover because of the resources and nature of competition and predation risk that occur there.

Comment [O66]: Summer temperatures in the Rockies and WA Cascades can hardly be considered "cold"; be specific on what this means; (i.e, average MAXIMUM August temperatures <22 degrees C?); there is no measure of upper thermal limits for wolverines and may not be the reason for the southern limit of wolverine distribution. Copeland e al. cites upper therrmal limits for arctic foxes (in winter pelage) as 26-28 degrees C because they overlap on wolverine range, but the fox study also shows that red foxes have an upper thermal limit (summer and winter pelages tested) of 30-32 degrees C and this species actually overlaps on more of the wolverine distribution than do arctic foxes. In other studies the thermoneutral zone of arctic animals extends from +30 degrees C to -30 degrees C (e.g., arctic fox and husky pups). However, the more important point is that all these studies are testing the animals at rest (or nearly so) and do not consider ways that animals deal with heat (besides resting and panting); e.g., shedding the winter coat; seeking cool places to rest; swimming; drinking water; waiting until late in the day to move around; exposing the thinly-furred areas; etc. Average daily minimum temperatures may have been a better metric for matching with wolverine distribution.

Comment [O67]: In the DPS not in the tundra areas

Comment [O68]: Again, define; can be as little as 1 m (or even less); is that "deep"?

Comment [O69]: I don't know of any reference that states that snow dens protect kits from predation by other wolverines; other wolverines have been documented in dens that have later failed to produce kits (Magoun 1985) a nd infanticide may happen in dens (Swedish study)

Comment [O70]: See comment 060 above; the data were not clear on this in Copeland et al. and the "low-temperatures" in wolverine habitat may be selected for other reasons (Inman et al. 2012 J. Mamm.)

Comment [O71]: Define deep; again, Copeland does not consider depth of snow

Comment [O72]: Other reasons have been proposed (Inman et al. 2012, J. Mamm.)

Comment [O73]: I don't see this mentioned on p. 244 specifically

southern Rocky Mountains) contain large and well-distributed areas of deep snow cover that persists through the wolverine denning period (Inman *et al*. 2011, Fig. 3; Aubry *et al*. 2007, p. 2154; Copeland *et al*. 2010, Figure 1). The Great Plains, Great Lakes, Midwest, and Northeast lack the spring snow conditions and low summer temperatures thought to be required by wolverines for successful reproduction and year-round occupancy (Aubry *et al*. 2007, p. 2154; Copeland *et al*. 2010, Figure 1). The lack of persistent spring snow conditions in the Great Plains, Great Lakes, Midwest, and Northeast supports the exclusion of these areas from the current range of wolverines. Whether wolverines once existed as established populations in any of these regions is uncertain, but the current climate appears to preclude their presence as reproducing populations, and the sparse historical record of wolverine presence in this area makes historical occupation of these areas by wolverine populations doubtful. It is our conclusion that the ecosystem that supports wolverines does not exist in these areas currently, and may not have existed at the time of European settlement of these areas.

Comment [O74]: But what is "deep" and what is the "denning period"; see detailed discussion in Attachment A

Comment [O75]: Contradicts Aubry et al. 2007 for the Great Lakes region, p. 2155; i.e., the Great Lakes region probably was the southern extent of wolverine range

Large areas of habitat with characteristics suitable for wolverines still occur in the southern Rocky Mountains and Sierra Nevada, despite the extirpation of wolverines from those areas (Aubry *et al*. 2007, p. 2154, Inman et al. 2011, Fig. 4; Copeland *et al*. 2010, Figure 1). Wolverine extirpations in these areas were coincident with unregulated trapping and systematic predator eradication efforts in the early 1900s, which have been discontinued for many years. Each of these areas has received at least one and possibly more migrants from adjacent populations in the northern Rocky Mountains; however, there is no evidence that females have migrated to these areas or that populations of wolverines currently exist there (Aubry *et al*. 2007, *Table 1*; Moriarty *et al*. 2009, entire; Inman *et al*. 2009, entire).

We conclude that areas of wolverine historical occurrence can be placed in one of three categories: (1) Areas where wolverines are extant as reproducing and potentially self-sustaining populations (North Cascades, northern Rocky Mountains); (2) areas where wolverines historically existed as reproducing and potentially self-sustaining populations prior to human-induced extirpation, and where reestablishment of those populations is possible given current habitat conditions and management (the Sierra Nevada Mountains in California and southern Rocky Mountains in Colorado, New Mexico, Wyoming, Uinta Mountains and surrounding ranges in Utah, Bighorn Mountains in Wyoming, and possibly the Oregon Cascades Mountains); and (3) areas where historical presence of wolverines in reproducing and potentially self-sustaining populations is doubtful, and where the current habitat conditions preclude the establishment of populations (Great Plains, Midwest, Great Lakes, and Northeast). We, therefore, consider the current range of wolverines to include suitable habitat in the North Cascades of Washington, the northern Rocky Mountains of Idaho, Wyoming, Montana, and eastern Oregon, the southern Rocky Mountains of Colorado and Wyoming, and the Sierra Nevada of California. We here include the Sierra Nevada and southern Rocky Mountains in the current range of wolverines despite the probability that functional populations do not exist in these areas. They are included due to the known existence of one individual in each area and the possibility that more, as yet undetected, individuals inhabit these areas.

Distinct Population Segment

Pursuant to the Act, we must consider for listing any species, subspecies, or, for vertebrates, any Distinct Population Segment (DPS) of these taxa, if there is sufficient information to indicate that such action may be warranted. To interpret and implement the DPS provision of the Act and Congressional

guidance, the Service and the National Marine Fisheries Service published, on February 7, 1996, an interagency Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Act (61 FR 4722). This policy addresses the recognition of DPSs for potential listing actions. The policy allows for more refined application of the Act that better reflects the biological needs of the taxon being considered, and avoids the inclusion of entities that do not require its protective measures.

Under our DPS policy, three elements are considered in a decision regarding the status of a possible DPS as endangered or threatened under the Act. These are applied similarly for additions to the list of endangered and threatened species, reclassification, and removal from the list. They are: (1) Discreteness of the population segment in relation to the remainder of the taxon; (2) the biological or ecological significance of the population segment to the taxon to which it belongs; and (3) the population segment's conservation status in relation to the Act's standards for listing (i.e., whether the population segment is, when treated as if it were a species or subspecies, an endangered or threatened species). Discreteness refers to the degree of isolation of a population from other members of the species, and we evaluate this factor based on specific criteria. If a population segment is considered discrete, we must consider whether the discrete segment is "significant" to the taxon to which it belongs by using the best available scientific and commercial information. If we determine that a population segment is both discrete and significant, we then evaluate it for endangered or threatened species status based on the Act's standards. The DPS evaluation in this proposed rule concerns the segment of the wolverine species occurring within the contiguous 48 States, including the northern and southern Rocky Mountains, Sierra Nevada Range, and North Cascades Range.

Distinct Population Segment Analysis for Wolverine in the Contiguous United States

Analysis of Discreteness

Under our DPS Policy, a population segment of a vertebrate species may be considered discrete if it satisfies either one of the following conditions: (1) It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors (quantitative measures of genetic or morphological discontinuity may provide evidence of this separation); or (2) it is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of section 4(a)(1)(D) of the Act (inadequacy of existing regulatory mechanisms). The wolverine within the contiguous United States meets the second DPS discreteness condition because of differences in conservation status as delimited by the Canadian-United States international governmental boundary.

In our 12-month finding for the North American wolverine DPS (75 FR 78030) we conducted a complete analysis of the discreteness of the wolverine DPS that we incorporate here by reference. In that analysis we concluded that the international boundary between Canada and the United States currently leads to division of the control of exploitation and conservation status of the wolverine. This division is significant because it allows for potential extirpation of the species within the contiguous United States through loss of small populations and lack of demographic and genetic connectivity of the two populations. This difference in conservation status is likely to become more significant in light of threats discussed in the five factors analyzed below. Therefore, we find that the difference in the conservation statuses in Canada and the United States result in vulnerability to the significant threat

(discussed below) in the U.S. wolverine population but not for the Canadian population. Existing regulatory mechanisms are inadequate to ensure the continued existence of wolverines in the contiguous United States in the face of these threats. Therefore, it is our determination that the difference in conservation status between the two populations is significant in light of section 4(a)(1)(D) of the Act, because existing regulatory mechanisms appear sufficient to maintain the robust conservation status of the Canadian population, while existing regulatory mechanisms in the contiguous United States are insufficient to protect the wolverine from threats due to its depleted conservation status. As a result, the contiguous United States population of the wolverine meets the discreteness criterion in our DPS Policy (61 FR 4725). Consequently, we use the international border between the United States and Canada to define the northern boundary of the contiguous United States wolverine DPS.

Analysis for Significance

If we determine a population segment is discrete, its biological and ecological significance will then be considered in light of Congressional guidance that the authority to list DPSs be used sparingly while encouraging the conservation of genetic diversity. In carrying out this examination, we consider available scientific evidence of the population's importance to the taxon to which it belongs (i.e., the North American wolverine (*Gulo gulo luscus*)). Our DPS policy states that this consideration may include, but is not limited to: (1) Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon; (2) evidence that loss of the discrete population segment would result in a significant gap in the range of the taxon; (3) evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an

introduced population outside its historical range; or (4) evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

In our 12-month finding (75 FR 78030), we conducted an exhaustive analysis of the significance of the contiguous United States population of the North American wolverine that we incorporate here by reference. In that analysis we concluded that the wolverine population in the contiguous United States is significant because its loss would result in a significant gap in the range of the taxon.

Summary of the Distinct Population Segment Analysis

We conclude that the wolverine population in the contiguous United States is both discrete and significant under our DPS policy. The conservation status of wolverines in the contiguous United States is less secure than wolverines in adjacent Canada due to fragmented habitat, small population size, reduced genetic diversity, and their vulnerability to threats analyzed in this finding. Loss of the contiguous United States wolverines would result in a significant gap in the range of the taxon. Therefore, we determine that the population of wolverines in the contiguous 48 States, as currently described, meets both the discreteness and significance criteria of our DPS policy, and is a listable entity under the Act as a DPS.

Summary of Factors Affecting the Species

Section 4 of the Act (16 U.S.C. 1533), and its implementing regulations at 50 CFR part 424, set forth the procedures for adding species to the Federal Lists of Endangered and Threatened Wildlife and Plants. Under section 4(a)(1) of the Act, we may list a species based on any of the following five factors: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; and (E) other natural or manmade factors affecting its continued existence. Listing actions may be warranted based on any of the above threat factors, singly or in combination. Each of these factors is discussed below.

Factor A. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

Under Factor A we will discuss a variety of impacts to wolverine habitat including: (1) Climate change, (2) human use and disturbance, (3) dispersed recreational activities, (4) infrastructure development, (5) transportation corridors, and (6) land management. Many of these impact categories overlap or act in concert with each other to affect wolverine habitat. Climate change is discussed under Factor A because although climate change may affect wolverines directly by creating physiological stress, the primary impact of climate change on wolverines is expected to be through changes to the availability and distribution of wolverine habitat.

Two efforts to map wolverine habitat in the contiguous United States have been completed (Inman et al. 2012, entire; Copeland *et al*. 2010, entire). Both of these habitat models rely on snow as a primary input. The Copeland *et al*. (2010) model defines wolverine habitat as simply the area continuously covered by snow from mid-winter until mid-May. The Inman *et al*. (2012) model is based

Comment [O76]: No; it defines it as continuously cover by snow from 24 April (not mid winter) to mid-May in only 1 of 7 years from 2000-2006 as measured by MODIS (Version 4); and also states that the 15 May MODIS should be viewed as an "*approximation of underlying bioclimatic requirements*" (p. 244); see Attachment A

on snowpack and also incorporates other habitat variables, such as terrain ruggedness and some aspects of human development. The two models result in estimates of wolverine habitat that are very similar across most of the range of wolverines in the contiguous United States. Areas of significant departure between the models are the California Sierras and Oregon Cascades where the Copeland *et al*. (2010) model predicts significantly greater habitat area than does the Inman *et al*. (2012) model. Given the general agreement between the two models, we combined the areas depicted by them into a composite wolverine habitat model that includes all areas described by one or both of these models. This composite model serves as the basis for our estimates of wolverine habitat below. Within the four States that currently harbor wolverines (Montana, Idaho, Oregon (Wallowas) and Wyoming), an estimated 124,014 km^2 (47,882 mi^2) of wolverine habitat exists. Habitat in the North Cascades and Eastern Washington (Kettle Range and associated habitat) add approximately 20,356 km^2 (7859 mi^2). Ninety-four percent (135,396 km^2; 52,277 mi^2) of total wolverine habitat is in Federal ownership with most of that managed by the U.S. Forest Service (Forest Service).

Comment [O77]: None considered more important than another so snowpack should not be singled out

Comment [O78]: Primary /maternal habitat but not dispersal habitat; only Inman considers dispersal habitat

Comment [O79]: Not greater habitat area in general; just greater maternal habitat as it still has the same primary habitat for both models

Comment [O80]: State that these estimates do not include "dispersal habitat" as defined by Inman's map, or do they?

Reduction in Habitat due to Climate Change

Our analyses under the Act include consideration of ongoing and projected changes in climate. The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). "Climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007, p. 78). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability,

human activity, or both (IPCC 2007, p. 78). Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007, pp. 8–14, 18–19).

Comment [O81]: This would be a good place to mention what would be considered the timeframe for projecting climate effects on species; i.e., define "foreseeable future" as defined or used by the ESA

We recognize that there are scientific uncertainties on many aspects of climate change, including the role of natural variability in climate. In our analysis, we rely both on synthesis documents (e.g., IPCC 2007; Karl *et al*. 2009) that present the consensus view of a very large number of experts on climate change from around the world, and on five analyses that relate the effects of climate changes directly to wolverines (Gonzalez *et al*. 2008, entire; Brodie and Post 2009, entire; Peacock 2011, entire; McKelvey *et al*. 2011, entire, Johnston *et al*. 2012, entire). To date, McKelvey *et al*. (2011) is the most sophisticated analysis regarding climate change effects to wolverines. This report is based on data from global climate models including both temperature and precipitation, downscaled to reflect the regional climate patterns and topography found within the range of wolverines in the contiguous United States. For this reason we find that McKelvey *et al*. (2011, entire) represents the best scientific information available regarding the impacts of climate change to wolverine habitat.

Comment [O82]: I do not agree; See lengthy and detailed comments in Attachment A

Snowpack changes as well as concomitant changes to wolverine habitat suitability result from both changes in temperature (negative relationship) and changes in snowfall (positive relationship). Because many climate models predict higher precipitation levels associated with climate warming, the interaction between these two variables can be quite complex. Consequently, predictions about snow coverage that rely only on temperature projections are less reliable than those that rely on both

Comment [O83]: Changes in spring temperatures and their effect on NDVI may not all be negative; see Attachment A

temperature and precipitation. McKelvey *et al*. (2011, entire) report projections for wolverine habitat and dispersal routes through the time interval from 2070 to 2099.

Comment [O84]: Are these dates then considered to be "the foreseeable future" for projections of climate change on wolverine habitat; specifically, is "the foreseeable future" the end of the 21st"" century? McKelvey indicates that after that, projections are more uncertain

Climate Effects to Wolverines

Due to dependence of wolverines on deep snow that persists into late spring both for successful reproduction and for year-round habitat, and their restricted distribution to areas that maintain significant snow late into the spring season, we conclude that deep snow maintained through the denning period is required for wolverines to successfully live and reproduce. Reduction of this habitat feature would proportionally reduce wolverine habitat, or to an even greater extent if habitat reduction involved increasing fragmentation.

Comment [O85]: define

Comment [O86]: define

Comment [O87]: define, define, define, define

Comment [O88]: these two terms must be defined specifically, otherwise, it can be misinterpreted and there would be no way to determine when the conditions change because they were not defined from the start; strongly suggest a list of definitions of terms at the beginning of the document

Comment [O89]: probably not proportionally; some high elevation habitat not currently used by wolverines could become useable

Based on the information described above, we analyzed the effects of climate change on wolverines through three primary mechanisms: (1) Reduced snowpack and earlier spring runoff, which would reduce suitable habitat for wolverine denning; (2) increase in summer temperatures beyond the physiological tolerance of wolverines; and (3) ecosystem changes due to increased temperatures, which would move lower elevation ecosystems to higher elevations, thereby eliminating high-elevation ecosystems on which wolverines depend and increasing competitive interactions with species that currently inhabit lower elevations. These mechanisms would tend to push the narrow elevation band that wolverines use into higher elevation. Due to the conical structure of mountains, this upward shift would result in reduced overall suitable habitat for wolverines.

Comment [O90]: but over what time period; would this likely happen in the "foreseeable future" or beyond the 21st century when uncertainty increases concerning the effects of climate warming; my review of the literature does not show any evidence that a significant upward shift will occur in the foreseeable future; nor that an upward shift in tree line in mountain habitats will have a negative influence on wolverine habitat; your statement is supposition at this point and somewhat simplistic given the complexities of climate change in mountains and subsequent changes in mountain ecosystems; there is no indication at this point that wolverines will discontinue use of lower elevations

Reduced Snow Pack and Earlier Spring Runoff

Warmer winter temperatures are reducing snow pack in western North American mountains through a higher proportion of precipitation falling as rain and higher rates of snowmelt during winter (Hamlet and Lettenmaier 1999, p. 1609; Brown 2000, p. 2347; Mote 2003, p. 3-1; Christensen *et al*. 2004, p. 347; Knowles *et al*. 2006, pp. 4548-4549). This trend is expected to continue with future warming (Hamlet and Lettenmaier 1999, p. 1611; Christensen *et al*. 2004, p. 347; Mote *et al*. 2005, p. 48). Shifts in the initiation of spring runoff toward earlier dates are also well documented (Hamlet and Lettenmaier 1999, p. 1609; Brown 2000, p. 2347; Cayan *et al*. 2001, pp. 409-410; Christensen *et al*. 2004, p. 347; Mote *et al*. 2005, p. 41; Knowles *et al*. 2006, p. 4554). Earlier spring runoff leads to lack of snow or degraded snow conditions during April and May, the critical time period for wolverine reproductive denning. In addition, a feedback effect hastens the loss of snow cover due to the reflective nature of snow and the relative heat-absorbing properties of non-snow-covered ground. This effect leads to the highest magnitude of warming occurring at the interface of snow-covered and exposed areas, increasing the rate at which melting occurs in spring (Groisman *et al*. 1994a, pp. 1637-1648; Groisman *et al*. 1994b, pp. 198-200). Due to the importance of deep snow cover in spring for wolverine reproduction, currently suitable habitat that loses this feature would be rendered unsuitable for wolverines.

Ecosystem Changes Associated with Climate Change

Changes in temperature and rainfall patterns are expected to shift the distribution of ecosystems northward (IPCC 2007c, p. 230) and up mountain slopes (McDonald and Brown 1992, pp. 411-412; Danby and Hik 2007, pp. 358-359; IPCC 2007c, p. 232). As climate changes over a landscape, the

Comment [O91]: must define "winter"; a reduction in snowpack is not necessarily detrimental if it occurs late in the denning period and if reduction is not below what is required for wolverine denning; see Attachment A

Comment [O92]: not necessarily detrimental to wolverines see (Attachment A) or even perhaps to summer food items

Comment [O93]: I disagree that April and May comprise the "critical time period for wolverine reproductive denning"; see Attachment A; no evidence that May is critical

Comment [O94]: The definition of "deep" and "spring" is very important in this discussion because the data must show that the reduction in snow pack and melt must occur at a time and at a level that would affect wolverine denning and neither of these papers present evidence that this is likely to happen in the 21st century or perhaps longer; see Attachment A

Comment [O95]: It is very important when discussing reduction in snow pack and spring melt that the time periods and the amounts relative to wolverine denning are defined specifically; in other words, how much of a reduction in snow pack and when? How soon is the spring snow melt and how does it affect wolverines, either positively or negatively; see Attachment A; the general concensus of the papers that you cite and others that I have read indicates that there will be more snow in winter and an earlier spring melt and this is not necessarily detrimental to wolverines (Attachment A). Even more rain-on-snow events may not be detrimental because this is quite common in wolverine habitat in SE Alaska where we have documented one of the highest reported densities of wolverines

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Comment [O96]: The goal of McDonal and Brown 1992 was "not to make definitive predictions about future extinctions" but to present one model that could be used *"given certain assumptions"* and p. 411-412 is simply a list of the assumptions

Comment [O97]: Danby and Hik 2007 show that advancement of spruce did not occur on north-facing slopes, only density of the stands; an increase in elevation and density on south-facing slopes only in high mountain areas cannot be interpreted as a negative impact on wolverines without evidence of what the direct detrimental effects would be, or for that matter, possible beneficial effects such as nmore trees for cover, for more avalanche debris, fallen trees for den sites, etc.

Comment [O98]: Very important here to talk about the timeframe for these changes and at what level the change has to occur before it affects wolverines or the ecosystem features important to wolverines. As mentioned in the next sentence, there are time lags, so what are the projected time lags relative to the features of wolverine habitat that matter? Are they decades or centuries? And what is the timeframe relative to the certainty of the climate models? The cited literature does not indicate an imminent DEGREE OF change in ecosystems RELATIVE TO WOLVERINE HABITAT FEATURES THAT ARE LIKELY TO AFFECT ...

ecosystems that support wolverines are likely to move according to the change of temperature, but with a time lag depending on the ability of individual plant species to migrate (McDonald and Brown 1992, pp. 413-414; Hall and Fagre 2003, p. 138; Peterson 2003, p. 652). Wolverines are not dependent on any particular ecosystem in the sense that they do not appear to depend on a certain vegetative component or other biological ecosystem attribute; however, it is likely that wolverines would respond to similar climatic cues as other members of the alpine ecosystem such that changes in tree-line location up or down slope would predict a similar change in wolverine distribution. Because of their reliance on mountainous habitat, wolverines in the contiguous United States will most likely adjust to climate changes by using higher elevations on mountain slopes, not by shifting their latitudinal distribution. Along a latitudinal gradient through the historical distribution of wolverines, records tend to be found at higher elevations in southern latitudes (Aubry *et al*. 2007, p. 2153), suggesting that wolverines compensate for increased temperature at low latitudes by selecting higher elevations. Therefore, the regional availability of suitable habitat is not likely to significantly change (i.e., at least some wolverine habitat will continue to be available in all regions where wolverines currently occur), but within these landscapes, smaller areas will remain suitable for wolverines. Mountain ranges with maximum elevations within the elevation band that wolverines currently use, such as much of the wolverine habitat in central Idaho, may become entirely unsuitable for wolverines with the projected level of warming reported in McKelvey *et al*. (2011, Figure 3; see below for discussion).

Timing of Climate Effects

Unlike snow conditions, which respond directly to temperature change without a time lag, ecosystem responses to temperature change do lag, with the magnitude of the lag depending on

Comment [O99]: What is the time lag relative to wolverines not plant species???

Comment [O100]: The literature you cite and other papers indicate that effects of climate change on mountain habitat in the western states is not clear , either on snow or on vegetation, especially at regional or local scales; moreover, changes in tree-line in the foreseeable future are more related to changes in density of trees and changes in types of tree stands, not by appreciable advances in forest cover up-slope; again, without discussing the exact changes relative to what wolverines use now and the timeframe in which they are predicted to occur, the generalizations stated in this section are not elucidating relative to "Ecosystem Changes Associated with Climate Change" and you do not discuss ecosystem changes that could be positive (e.g. NDVI in spring; bigger trees that provide large down logs for dens or mor avalanche debris fields with larger trees, etc).

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Comment [O101]: This does not agree with Copeland et al. 2007 where elevations range to 3,279 m but use by wolverines was in a band up to 2,600 m

Comment [O102]: See Attachment A

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constituent species' individual migratory abilities. Wolverines are described as a "tree-line" species because they are most often found in an elevation band that is approximately centered on the alpine tree-line at any given locality within their range (Inman *et al*. 2012a, p. 785). Alpine tree lines are maintained by a complex set of climactic and biotic factors, of which temperature is significantly important (Cogbill and White 1991, p. 169; Hättenschwiler and Körner 1995, p. 367; Jobbágy and Jackson 2000, p. 259; Pellat *et al*. 2000, pp. 80-81). However, the conditions that favor tree establishment and lead to elevation advance in the tree line may exist only sporadically, increasing time lags associated with tree line response to warming beyond the species-specific generation time of the trees involved (Hessl and Baker 1997, p. 181; Klasner and Fagre 2002, p. 54). Within wolverine habitats, tree lines have advanced up mountain slopes since 1850, due to climate warming, and this trend is expected to continue into the future (Hessl and Baker 1997, p. 176; Hall and Fagre 2003, p. 138). We expect that species reliant on resources associated with this biome, such as wolverines, will need to shift accordingly, not necessarily due to their dependence on the specific vegetation conditions, but due to wolverines likely being keyed into similar climatic variables. Since wolverine association with tree-line location is likely coincident with their dependence on climatic conditions, and the fact that wolverines can move about in response to climate changes, it is not likely that wolverines would respond to climate changes with a similar time lag. More likely, wolverines would respond to climate changes in real time, shifting habitat use more rapidly than tree-line shifts would occur. Given the irregular nature of tree-line response to warming, tree-line migration is likely to lag behind the climate warming that causes it.

Magnitude of Climate Effects on Wolverine

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Comment [O103]: I see no reference to advance of tree line on p. 176 or in the body of the reference cited here; this study was for tree invasion in patch forest openings at treeline not advancement of treeline; furthermore, the study was equivocal on whether even this invasion, if climate driven, would continue; please be sure to use citations that support your statements

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Comment [O104]: This study concerns the melting of glaciers in Glacier National Park and the predicted change in vegetation; from Fig. 7 it is possible to conclude that a net increase in wolverine habitat should occur where before much of the area was covered in ice; since, as you state, there are no studies that indicate a particular vegetation type to which wolverines are tied, and presuming the snow depth will still be >1m in winter in this area, this paper does not appear to support a reduction in wolverine habitat, simply a revegetation of land that was once covered in ice and possibly an increase in wolverine habitat including denning habitat

Comment [O105]: Wolverines may increase use of more of the high elevation habitat with an upward shift in treeline, but that doesn't mean they will decrease the use of lower elevations that are currently forested, especially since no one has addressed why wolverines would stop using lower elevation habitats; no studies on changes in wolverine habitat due to climate warming are addressing the changes that occur at lower elevations (or even the present day use of lower elevation forests by wolverines); it is much too simplistic to assume that because wolverines have been defined by some as a "treeline" species, that any advance of treeline will will reduce wolverine habitat, since wolverines have also been described as a species that does not depend on any particular vegetation type

Comment [O106]: See Attachment A (entire) for detailed discussion of McKelvey et al. 2011 and the science on which they base their conclusions

Several studies relating the effects of climate changes on wolverines in the past, present, and future are now available (Brock and Inman Personal Communication 2007, entire; Gonzales *et al*. 2008, pp. 1-5; Brodie and Post 2010, entire; McKelvey *et al*. 2011, entire; Peacock 2011, entire; Johnston *et al*. 2012, entire). The Gonzalez *et al*. report and the report by Brock and Inman (Personal Communication 2007) were both preliminary attempts to analyze climate change impacts to wolverines, but are not currently considered the best available science because they did not consider the effects of both changes in temperature and precipitation that may affect the distribution of persistent spring snow cover (McKelvey 2011, entire). The analysis by Peacock (2011) is a sophisticated look at climate change impacts to wolverines, but suffers from the large-scale data presentation used. This large scale makes relating specific impacts to wolverines difficult, because the montane habitat inhabited by wolverines is climatologically complex on a small scale, and without significant downscaling of climate results, it is not possible to determine how much habitat may be left after climate change impacts have occurred. Both Brock and Inman (Personal Communication 2007) and Gonzalez *et al.* (2008) have been superseded by a more sophisticated analysis provided by McKelvey *et al.* (2011, entire). The course-grain scale of the analysis in Peacock (2011, entire) limits its use to that of supporting the conclusion that wolverine habitat is likely to decline. Likewise, the limited area analyzed by Johnston *et al*. (2012) also limits its use for this wide-ranging species. The McKelvey *et al.* (2011, entire) analysis includes climate projections at a local scale for wolverine habitats and analyzes the effects of both temperature changes and changes to precipitation patterns. Lack of accounting for changes in precipitation was a weakness of their own work cited by the authors of both Brock and Inman (Personal Communication 2007) and Gonzalez *et al.* (2008).

Brodie and Post (2010, entire) correlate the decline in wolverine populations in Canada over the past century with declining snowpack due to climate change over the same period. However, correlation does not infer causation; other factors could have caused the decline. The Brodie and Post (2010, entire) analysis used harvest data to infer population trends in addition to its reliance on correlation to infer causation (McKelvey *et al*. 2010a, entire); in this case, historic climate changes are inferred to have caused the declines in harvest returns, which are thought by the authors to reflect actual population declines. Due to the above-stated concerns, we view the analysis of Brodie and Post (2010, entire) with caution, although we do agree that the posited mechanism, of loss of snowpack affecting wolverine populations and distribution, likely has merit.

McKelvey *et al*. (2011, entire) used downscaled global climate models to project the impacts of changes in temperature and precipitation to wolverine habitat as modeled by Copeland *et al*. (2010, entire). The authors also present an alternative method for evaluating climate impacts on wolverine habitat, by merely projecting onset of spring snowmelt to occur 2 weeks earlier than it currently does. Based on this information, wolverine habitat in the contiguous United States, which supports approximately 250 to 300 wolverines, is shrinking and is likely to continue to shrink with increased climate warming (McKelvey *et al*. 2011, Figure 4). Habitat losses are likely to occur throughout the range of the DPS and are projected to be most severe in central Idaho. However, large areas of snow cover are likely to remain in the North Cascades, Greater Yellowstone Area (GYA), and the Glacier Park-Bob Marshall Wilderness of Montana (McKelvey *et al*. 2011 Figures 4, 13). The southern Rocky Mountains of Colorado retained significant high-elevation snow in some models but not others, and so may be another area that could support wolverine populations in the face of climate changes (McKelvey *et al*. 2011, p. 2889).

Comment [O107]: Based on erroneous biological assumptions about wolverine denning requirements; see full discussion in Attachment A

Overall, wolverine habitat in the contiguous United States is expected to get smaller and more highly fragmented as individual habitat islands become smaller and the intervening areas between wolverine habitats become larger (McKelvey *et al*. 2011, Figures 4, 13). McKelvey et al. (2011) predict that 31 percent of current wolverine habitat in the contiguous United States will be lost due to climate warming by the time interval centered on 2045 (2030-2059) (McKelvey *et al*. 2011, pp. 2887-2888). That loss expands to 63 percent of wolverine habitat by the time interval centered on 2085 (2070 to 2099). Estimates for the northern Rocky Mountain States (Montana, Idaho, and Wyoming) are similar, with an estimated 32 percent and 63 percent of persistent spring snow lost for the 2045 and 2085 intervals respectively. Central Idaho is predicted to be especially sensitive to climate change effects losing 43 percent and 78 percent of wolverine habitat for the 2045 and 2085 intervals respectively. Conversely, the mountains of Colorado appear to be slightly less sensitive to climate changes in their analysis losing 31 percent and 57 percent of habitat over the same intervals. Given the spatial needs of wolverines and the limited availability of suitable wolverine habitat in the contiguous United States, this projected gross loss of habitat area is likely to result in a loss of wolverine numbers that is greater than the overall loss of habitat area.

Comment [O108]: Predictions are questionable because the basis of the model (critical snow requirements) is in error; Appendix A

We expect wolverine populations to be negatively affected by changes in the spatial distribution of habitat patches as remaining habitat islands become progressively more isolated from each other due to climate changes (McKelvey *et al*. 2011, Figure 8). Currently, wolverine habitat in the contiguous United States can be described as a series of habitat islands. Some of these groups of islands are large and clumped closely together, such as in the North Cascades, Glacier Park-Bob Marshall Wilderness complex in Montana, and the GYA. Other islands are smaller and more isolated, such as the island

mountain ranges of central and southwestern Montana. Inbreeding and consequent loss of genetic diversity have occurred in the past within these smaller islands of habitat (Cegelski *et al*. 2006, p. 208), and genetic exchange between subpopulations is difficult to achieve (Schwartz *et al*. 2009, Figure 4). Climate change projections indicate that, as warming continues, large contiguous blocks of habitat will decrease in size and become isolated to the extent that their ability to support robust populations becomes questionable (McKelvey *et al*. 2010b, Figure 8). Under the moderate climate change scenarios analyzed by McKelvey *et al*. (2011, entire), the current wolverine stronghold in central Idaho begins to look similar to the current situation in the more isolated mountain ranges of southwestern Montana (McKelvey *et al*. 2011, Figure 4) where wolverines persist, but subpopulations are small. These subpopulations are essentially family groups, which require connectivity with other groups for genetic and possibly demographic enrichment. This habitat alteration would result in a high likelihood of reduced genetic diversity due to inbreeding within a few generations (Cegelski *et al*. 2006, p. 209). Further isolation of wolverines on small habitat islands with reduced connectivity to other subpopulations would also increase the likelihood of subpopulations loss due to demographic stochasticity, impairing the functionality of the wolverine metapopulation in the contiguous United States.

Comment [O109]: Based on erroneous assumptions about habitat requirements for wolverines in the denning and den abandonment seasons; see Attachment A

We find that McKelvey *et al*. (2011, entire) represents the best available science for projecting the future impacts of climate change on wolverine habitat for four primary reasons. First, their habitat projections are based on global climate models that are thought to be the most reliable predictors of future climate available (IPCC 2007a, p. 12). Second, they conducted downscaling analyses to infer geographic climate variation at a scale relevant to wolverine habitat. Third, they used a hydrologic model to predict snow coverage during the spring denning period (the strongest correlate with

wolverine reproductive success). Fourth, they used the habitat model developed by Copeland *et al.* (2010, entire), to relate projected climate changes to wolverine habitat. Based on our analysis of the methods and analysis used by the authors, we conclude it constitutes the best available information on the likely impact of climate change on wolverine distribution in the contiguous United States. Other analyses of climate change discussed above (Brock and Inman Personal Communication 2007, entire; Gonzales *et al*. 2008, entire; Brodie and Post 2010, entire; Peacock 2011, entire) all support the conclusion that climate changes caused by warming are likely to negatively affect wolverine habitat in the future. Based on the analysis presented, we conclude that climate changes are likely to result in permanent loss of a significant portion of wolverine habitat in the future. Additional impacts of climate change will be increased habitat fragmentation as habitat islands become smaller and intervening habitat disappears. Eventually, habitat fragmentation will likely lead to a breakdown of wolverine metapopulation dynamics, as subpopulations are no longer able to rescue each other after local extinctions due to a lack of connectivity. It is also likely that loss of genetic diversity resulting in lower fitness will occur as population isolation increases.

Comment [O110]: See comment 101 above

Summary of Impacts of Climate Changes

Wolverine habitat is projected to decrease in area and become more fragmented in the future as a result of climate changes that result in increasing temperatures, earlier spring snowmelt, and loss of deep, persistent, spring snowpack. These climate change impacts are expected to have direct and indirect effects to wolverine populations in the contiguous United States including reducing the number of wolverines that can be supported by available habitat and reducing the ability of wolverines to travel between patches of suitable habitat. This reduction in population size and connectivity is likely to

Comment [O111]: Predictions of increases in winter snow and an earlier spring melt in the mountains of the western United States do not support this conclusion for the period when wolverines den (Feb-April) (see detailed discussion in Attachment A)

affect metapopulation dynamics, making it more difficult for subpopulations to recolonize areas where wolverines have been extirpated and to bolster the genetics or demographics of adjacent subpopulations.

Habitat Impacts Due to Human Use and Disturbance

Because wolverine habitat is generally inhospitable to human use and occupation and most wolverine habitat is also federally managed in ways that must consider environmental impacts, wolverines are somewhat insulated from impacts of human disturbances from industry, agriculture, infrastructure development, or recreation. Human disturbance in wolverine habitat in the contiguous United States has likely resulted in the loss of some minor amount of wolverine habitat, although this loss has not yet been quantified. Sources of human disturbance to wolverines has been speculated to include winter and summer recreation, housing and industrial development, road corridors, and extractive industry, such as logging or mining. In the contiguous United States, these human activities and developments sometimes occur within or immediately adjacent to wolverine home ranges, such as in alpine or boreal forest environments at high elevations on mountain slopes. They can also occur in a broader range of habitats that are occasionally used by wolverines during dispersal or exploratory movements—habitats that are not suitable for the establishment of home ranges and reproduction.

Little is known about the behavioral responses of individual wolverines to human presence, or about the species' ability to tolerate and adapt to repeated human disturbance. Some speculate that disturbance may reduce the wolverine's ability to complete essential life-history activities, such as foraging, breeding, maternal care, routine travel, and dispersal (Packila *et al*. 2007, pp. 105-110).

However, wolverines have been documented to persist and reproduce in areas with high levels of human use and disturbance including developed alpine ski areas and areas with motorized use of snowmobiles (Heine~~n~~meyer 2012, entire). This suggests that wolverines can survive and reproduce in areas that experience human use and disturbance. How or whether effects of disturbance extend from individuals to characteristics of subpopulations and populations, such as vital rates (e.g., reproduction, survival, emigration, and immigration) and gene flow, and ultimately to wolverine population or metapopulation persistence, remains unknown at this time.

Wolverine habitat is characterized primarily by spring snowpack, but also by the absence of human presence and development (Hornocker and Hash 1981 p. 1299; Banci 1994, p. 114; Landa *et al*. 1998, p. 448; Rowland *et al*. 2003 p. 101; Copeland 1996, pp. 124-127; Krebs *et al*. 2007, pp. 2187-2190). This negative association with human presence is sometimes interpreted as active avoidance of human disturbance, but it may simply reflect the wolverine's preference for cold, snowy, and high-elevation habitat that humans avoid. In the contiguous United States, wolverine habitat is typically associated with high-elevation (e.g., 2,100 m to 2,600 m (6,888 ft to 8,528 ft)) subalpine forests that comprise the Hudsonian Life Zone (weather similar to that found in northern Canada), environments not typically used by people for housing, industry, agriculture, or transportation. However, a variety of activities associated with extractive industry, such as logging and mining, as well as recreational activities in both summer and winter are located in a small amount of occupied wolverine habitat.

For the purposes of this rulemaking, we analyze human disturbance in four categories: (1) Dispersed recreational activities with primary impacts to wolverines through direct disturbance (e.g., snowmobiling and heli-skiing); (2) disturbance associated with permanent infrastructure such as

Comment [O112]: Define "high levels" of human use; areas with motorized snowmobile use cannot be classified as high use relative to developed areas through which wolverines might have to disperse, especially since snowmobile use is usually daylight hours only compared to major highways and housing developments; perhaps better to say "periodic" high levels of use

Comment [O113]: I couldn't find anything in this reference to support this statement; do you mean Heinemeyer and Squires 2012

Comment [O114]: Results of this project are not finalized but in Heinemeyer and Squires 2012, the authors state that they have only a small sample of wolverines in areas exposed to highly recreated landscapes and that "one female we have monitored for 3 years in a highly recreated landscape attempted to den but failed in the first year and has not denned in the subsequent 2 years of monitoring." P. 17; they go on to say they need more data on females in highly recreated areas; this suggests there could be problems with these landscapes but it still has to be sorted out

Comment [O115]: Define; Copeland did not measure spring snowpack; Inman's model included many other factors

Comment [O116]: Add Inman 2013 papers

residential and commercial developments, mines, and campgrounds; (3) disturbance and mortality associated with transportation corridors; and (4) disturbance associated with land management activities such as forestry, or fire/fuels reduction activities. Overlap between these categories is extensive, and it is often difficult to distinguish effects of infrastructure from the dispersed activities associated with that infrastructure. However, we conclude that these categories account for most of the human activities that occur in occupied wolverine habitat.

Dispersed Recreational Activities

Dispersed recreational activities occurring in wolverine habitat include snowmobiling, heli-skiing, hiking, biking, off- and on-road motorized use, hunting, fishing, and other uses.

One study documented (in two reports) the extent that winter recreational activity spatially and temporally overlapped modeled wolverine denning habitat in the contiguous United States (Heinemeyer and Copeland 1999, pp. 1-17; Heinemeyer *et al*. 2001, pp. 1-35). This study took place in the Greater Yellowstone Area (GYA) in an area of high dispersed recreational use. The overlap of modeled wolverine denning habitat and dispersed recreational activities was extensive. Strong temporal overlap existed between snowmobile activity (February–April) and the wolverine denning period (February–May). During 2000, six of nine survey units, ranging from 3,500 to 13,600 (ha) (8,645 to 33,592 (ac)) in size, showed evidence of recent snowmobile use. Among the six survey units with snowmobile activity, the highest use covered 20 percent of the modeled denning habitat, and use ranged from 3 to 7 percent over the other survey units. Snowmobile activity was typically intensive where detected.

Three of nine survey units in this study showed evidence of skier activity (Heinemeyer and Copeland 1999, p. 10; Heinemeyer *et al*. 2001, p. 16). Among the three units with activity, skier use covered 3 to 19 percent of the survey unit. Skiers also intensively used the sites they visited. Combined skier and snowmobile use covered as much as 27 percent of potential denning habitat in one unit where no evidence of wolverine presence was detected. We conclude from this study that in some areas, high recreational use may coincide substantially with wolverine habitat. The authors of the study cited above chose the study area based on its unusually high level of motorized recreational use. Although we do not have information on the overlap of wolverine and winter recreation in the remaining part of the contiguous United States range, it is unlikely that any of the large areas of wolverine habitat such as the southern Rocky Mountains, Northern Rocky Mountains, GYA, or North Cascades get the high levels of recreational use seen in the portion of the GYA examined in this study across the entire landscape. Rather, each of these areas has small (relative to wolverine home range size) areas of intensive recreational use (ski resorts, motorized play areas) surrounded by a landscape that is used for more dispersed recreation such as backcountry skiing or snowmobile trail use.

Although we can demonstrate that recreational use of wolverine habitat is heavy in some areas, we do not have any information to suggest that these activities have negative effects on wolverines. No rigorous assessments of anthropogenic disturbance on wolverine den fidelity, food provisioning, or offspring survival have been conducted. Disturbance from foot and snowmobile traffic associated with historical wolverine control activities (Pulliainen 1968, p. 343), and field research activities, have been purported to cause maternal females to abandon natal dens and relocate kits to maternal dens (Myrberget 1968, p. 115; Magoun and Copeland 1998, p. 1316; Inman *et al*. 2007c, p. 71). However, this behavior appears to be rare, even under intense disturbance associated with capture of family

Comment [O117]: perhaps for natal dens, depending on type of disturbance, but not for maternal dens (e.g., Magoun and Copeland 1998 p. 1318)

groups at the den site (Persson et al. 2006, p. 76), and other causes of den abandonment may have acted in these cases. Preliminary results from an ongoing study on the potential impacts of winter recreation on wolverines in central Idaho indicate that wolverines are present and reproducing in this area in spite of heavy recreational use, including a developed ski area, dispersed winter and summer recreation, and dispersed snowmobile use (Heinemeyer *et al*. 2012, entire). The security of the den and the surrounding foraging areas (i.e., protection from predation by carnivores) is an important aspect of den site selection. Abandonment of natal and maternal dens may be a preemptive strategy that females use in the absence of predators (i.e. females may abandon dens without external stimuli), as this may confer an advantage to females if prolonged use of the same den makes that den more evident to predators. Evidence for effects to wolverines from den abandonment due to human disturbance is lacking. The best scientific information available does not substantiate dispersed recreational activities as a threat to wolverine.

Most roads in wolverine habitat are low-traffic volume dirt or gravel roads used for local access. Larger, high-volume roads are dealt with below in the section "transportation corridors. At both a site-specific and landscape scale, wolverine natal dens were located particularly distant from public (greater than 7.5 km (4.6 mi)) and private (greater than 3 km (1.9 mi)) roads (May 2007, p. 14-31; Dawson et al. 2010). Placement of dens away from public roads (and away from associated human-caused mortality) was also a positive influence on successful reproduction. It is not known if the detected correlation is due to the influence of the roads but we find it unlikely that wolverines avoid the type of low-use forest roads that generally occur in wolverine habitat. Other types of high-use roads are rare in wolverine habitat and are not likely to affect a significant amount of wolverine habitat (see transportation corridors section below).

Comment [O118]: Not sure what you mean here; Persson was not referring to capture of family groups at a den site in this case; just examining on the ground to verify a den; capture was later at rendezvous sites; digging young from dens almost always resulted in den abandonment (Magoun, personal observation and Persson, personal commun.)

Comment [O119]: I don't know of a reference that suggests females select *foraging areas* for security from predators, just dens

Comment [O120]: No references for this statement; doesn't explain why some females use the same den throughout the denning season; I doubt if this statement is true

Comment [O121]: But wolverines have been hit and killed on such roads, including forestry roads in Ontario and the pipeline haul road in northern Alaska

Comment [O122]: Doesn't this statement contradict the one above that states that natal dens are located away from roads? Generalization about roads is probably not advisable because avoidance of roads depends on the density of roads (and probably activity level); see Bowman et al. 2010. Roads, logging, and the large-mammal community of an eastern Canadian boreal forest. C. J. Zool. 88:454-467.

Infrastructure Development

Infrastructure includes all residential, industrial, and governmental developments such as buildings, houses, oil and gas wells, and ski areas. Infrastructure development on private lands in the Rocky Mountain West has been rapidly increasing in recent years and is expected to continue as people move to this area for its natural amenities (Hansen *et al*. 2002, p. 151). Infrastructure development may affect wildlife directly by eliminating habitats, or indirectly, by displacing animals from suitable habitats near developments.

Wolverine home ranges generally do not occur near human settlements, and this separation is largely due to differential habitat selection by wolverines and humans (May *et al*. 2006, pp. 289-292; Copeland *et al*. 2007, p. 2211). In one study, wolverines did not strongly avoid developed habitat within their home ranges (May *et al* 2006, p. 289). Wolverines may respond positively to human activity and developments that are a source of food. They scavenge food at dumps in and adjacent to urban areas, at trapper cabins, and at mines (LeResche and Hinman 1973 as cited in Banci 1994 p. 115; Banci 1994, p. 99). Based on the best available science, we conclude that wolverines do not avoid human development of the types that occur within suitable wolverine habitat.

There is no evidence that wolverine dispersal is affected by infrastructure development. Linkage zones are places where animals can find food, shelter, and security while moving across the landscape between suitable habitats. Wolverines prefer to travel in habitat that is most similar to habitat they use for home-range establishment, i.e., alpine habitats that maintain snow cover well into the

Comment [O123]: Or inhibiting dispersal

Comment [O124]: What does near mean? On the outskirts of town? Within 2, 5, or 10 km? doesn't it depend on how near the settlement is to wolverine habitat? And also what the surrounding area consists of? In wolverine habitat in Ontario, the effect is not due to differential habitat selection by wolverines and humans (they occur in the same habitat); also depends on whether wolverines are trapped in the area or not

Comment [O125]: Unlike your definition of infrastructure above, May differentiates between infrastructure and human development; i.e., "Within their home ranges wolverines used the available area *randomly with regard to infrastructure*. The available habitat within their home ranges tended to be used *non-randomly with regard to human development*"

Comment [O126]: doesn't this contradict your statement above that they do not occur near human settlements (generally)

Comment [O127]: what do you mean by "affected by"; the dispersing wolverine moving to Colorado avoided a small subdivision and moved around it; what would have been the effect if a much larger area was covered in subdivisions, etc.; would the dispersal not have happened through that area? Wouldn't that have affected dispersal? How would you prove that wolverines are not affected by infrastructure? You can't prove what you can't observe if wolverines are avoiding infrastructure (e.g., large towns).

Comment [O128]: if this is true, why did the young female wolverine Eowyn (Northern Cascades study) disperse through habitat that did not fall in the snow cover layer that Schwartz et al. 2009 states they should prefer during dispersal; this wolverine had areas defined by the Copeland snow layer <20 km to the east and west of where she dispersed, yet much of her dispersal appeared to be outside of the "preferred" habitat

spring (Schwartz *et al*. 2009, p. 3227). Wolverines may move large distances in an attempt to establish new home ranges, but the probability of making such movements decreases with increased distance between suitable habitat patches, and the degree to which the characteristics of the habitat to be traversed diverge from preferred habitat in terms of climatic conditions (Copeland *et al*. 2010, entire; Schwartz *et al*. 2009, p. 3230).

Comment [O129]: are you referring to mountains in western states here; because wolverines don't prefer alpine habitats in Ontario

Comment [O130]: and other conditions based on Inman's habitat model

The level of development in these linkage areas that wolverines can tolerate is unknown, but it appears that the current landscape does allow wolverine dispersal (Schwartz *et al*. 2009, Figures 4, 5; Moriarty *et al*. 2009, entire; Inman *et al*. 2009, pp. 22-28). For example, wolverine populations in the northern Rocky Mountains appear to be connected to each other at the present time through dispersal routes that correspond to habitat suitability (Schwartz *et al*. 2009, Figures 4, 5). However, gene flow between wolverine subpopulations in the contiguous United States may not be high enough to prevent genetic drift (Cegelski *et al*. 2006, p. 208). To ensure long-term genetic viability, each subpopulation within the contiguous United States would need an estimated 400 breeding pairs, or 1 to 2 effective migrants per generation (Cegelski *et al*. 2006, p. 209). Our current understanding of wolverine ecology suggests that no subpopulation historically or presently at carrying capacity would approach 400 breeding pairs within the contiguous United States (Brock *et al*. 2007, p. 26); nor is the habitat capable of supporting anywhere near this number. It is highly unlikely that 400 breeding pairs exist in the entire contiguous United States. Because no wolverine subpopulations are likely to be large enough to maintain genetic diversity over time on their own, long-term viability of wolverines in the contiguous United States requires exchange of individuals between subpopulations.

Wolverines are capable of long-distance movements through variable and anthropogenically altered terrain, crossing numerous transportation corridors (Moriarty *et al*. 2009, entire; Inman *et al*. 2009, pp. 22-28). Wolverines are able to successfully disperse between habitats, despite the level of development that is currently taking place in the current range of the DPS (Copeland 1996, p. 80; Copeland and Yates 2006, pp. 17-36; Inman *et al*. 2007a, pp. 9-10; Pakila *et al*. 2007, pp. 105-109; Schwartz *et al*. 2009, Figures 4, 5). Dispersal between populations is needed to avoid further reduction in genetic diversity; however, there is no evidence that human development and associated activities are preventing wolverine movements between suitable habitat patches. Rather, wolverine movement rates are limited by suitable habitat and proximity of suitable habitat patches, not the characteristics of the intervening unsuitable habitat (Schwartz *et al*. p. 3230).

Comment [O131]: unless the characteristics include transportation corridors; see next section

Transportation Corridors

Transportation corridors are places where transportation infrastructure and other forms of related infrastructure are concentrated together. Examples include interstate highways and high-volume secondary highways. These types of highway corridors often include railroads, retail, industrial, and residential development and also electrical and other types of energy transmission infrastructure. Transportation corridors may affect wolverines if located in wolverine habitat or between habitat patches. If located in wolverine habitat, transportation corridors result in direct loss of habitat. Direct mortality due to collisions with vehicles is also possible (Packila *et al*. 2007, Table 1).

The Trans Canada Highway at Kicking Horse Pass in southern British Columbia, an important travel corridor over the Continental Divide, has a negative effect on wolverine movement (Austin 1998,

p. 30). Wolverines partially avoided areas within 100 m (328 ft) of the highway, and preferred to use distant sites (greater than 1,100 m (3,608 ft)). Wolverines that approached the highway to cross repeatedly retreated, and successful crossing occurred in only half of the attempts (Austin 1998, p. 30). Highway-related mortality was not documented in the study. Where wolverines did successfully cross, they used the narrowest portions of the highway right-of-way. A railway with minimal human activity, adjacent to the highway, had little effect on wolverine movements. Wolverines did not avoid, and even preferred, compacted, lightly used ski trails in the area. The extent to which avoidance of the highway may have affected wolverine vital rates or life history was not measured.

In the tri-State area of Idaho, Montana, and Wyoming, most crossings of Federal or State highways were done by subadult wolverines making exploratory or dispersal movements (ranges of resident adults typically did not contain major roads) (Packila *et al*. 2007, p. 105). Roads in the study area, typically two-lane highways or roads with less improvement, were not absolute barriers to wolverine movement. The individual wolverine that moved to Colorado from Wyoming in 2008 successfully crossed Interstate 80 in southern Wyoming (Inman *et al*. 2008, Figure 6). Wolverines in Norway successfully cross deep valleys that contain light human developments such as railway lines, settlements, and roads (Landa *et al*. 1998, p. 454). Wolverines in central Idaho avoided portions of a study area that contained roads, although this was possibly an artifact of unequal distribution of roads that occurred at low elevations and peripheral to the study site (Copeland *et al*. 2007, p. 2211). Wolverines frequently used un-maintained roads for traveling during the winter, and did not avoid trails used infrequently by people or active campgrounds during the summer (Copeland *et al*. 2007, p. 2211).

At both a site-specific and landscape scale, wolverine natal dens were located particularly distant from public (greater than 7.5 km (4.6 mi)) and private (greater than 3 km (1.9 mi)) roads (May 2007, p. 14-31). Placement of dens away from public roads (and away from associated human-caused mortality) was a positive influence on successful reproduction (May 2007, p. 14-31). Predictive, broad-scale habitat models, developed using historical records of wolverine occurrence, indicated that roads were negatively associated with wolverine occurrence (Rowland *et al*. 2003, p. 101). Although wolverines appear to avoid transportation corridors in their daily movements, studies of the few areas where transportation corridors are located in wolverine habitat leads us to conclude that the effects are most likely local in scale. There are no studies that address potential effects of transportation corridors in linkage areas (i.e. outside of wolverine habitat). In the few documented long-distance movements by wolverines, the animals successfully crossed transportation corridors (Inman *et al*. 2009, Fig. 6). The available evidence indicates that dispersing wolverines can successfully cross transportation corridors.

Comment [O132]: some wolverines don't cross successfully and have been killed crossing transportation corridors; see Krebs et al. 2004, unpublished data used by Keith Aubry for his Aubry et al. 2007 paper; road in Kluane National Park in Canada and the pipeline haul road, P. Mickelson, pers. commun.; forestry roads in Ontarion (N. Dawson, pers. comm..), and these are only the ones we know about

Land Management

Few effects to wolverines from land management actions such as grazing, timber harvest, and prescribed fire have been documented. Wolverines in British Columbia used recently logged areas in the summer and moose winter ranges for foraging (Krebs *et al*. 2007, pp. 2189-2190). Males did not appear to be influenced strongly by the presence of roadless areas (Krebs *et al*. 2007, pp. 2189-2190). In Idaho, wolverines used recently burned areas despite the loss of canopy cover (Copeland 1996, p. 124).

Comment [O133]: not female wolverines in the Omineca Mountains, p. 2186

Comment [O134]: but females were, p. 2186

Intensive management activities such as timber harvest and prescribed fire do occur in wolverine habitat; however, for the most part, wolverine habitat tends to be located at high elevations and in rugged topography that is unsuitable for intensive timber management. Much of wolverine habitat is managed by the U.S. Forest Service or other Federal agencies and is protected from some practices or activities such as residential development. In addition, much of wolverine habitat within the contiguous United States is already in a management status such as wilderness or national park (see Factor D for more discussion) that provides some protection from management, industrial, and recreational activities. Wolverines are not thought to be dependent on specific vegetation or habitat features that might be manipulated by land management activities, nor is there evidence to suggest that land management activities are a threat to the conservation of the species.

Comment [O135]: state that you are talking about the western US because this is not true for wolverines in lowland boreal habitats

Comment [O136]: British Columbia logs in high elevation habitats where wolverines occur (Krebs et al. 2007, p. 2181)

Comment [O137]: In the DPS

Comment [O138]: Again, see Krebs et al. 2007 and Bowman et al. 2010

Summary of Factor A

The threat of current, and future impacts to wolverine habitat due to climate change occurs over the entire range of the contiguous United States population of the wolverine. This threat is likely to have already reduced the overall areal extent and distribution of wolverine suitable habitat. Determining whether or not wolverine populations have been impacted by this threat is complicated by the historical extirpation of wolverines in the early 20th century followed by recolonization and expansion. It is possible that expansion of wolverine populations through the second half of the 20th century has masked climate change effects that would have otherwise reduced populations had they existed at presettlement levels. Despite the lack of detectable population-level impacts, it is still likely that habitat is already reduced from historic levels due to this threat.

Comment [O139]: In what areas? Aubry et al. 2007 do not indicate habitat loss has occurred except perhaps for Great Lakes, and they suggest that area may not have been wolverine habitat even in the past but are equivocal on this point

Comment [O140]: I don't know what you are basing this on; reference or explanation is needed here

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Suitable wolverine habitat is projected to be reduced by 31 percent in the contiguous United States by 2045 and 63 percent by the time interval 2070 to 2099 due to climate warming. This reduction will likely result in suitable wolverine habitat shifting up mountain slopes, and becoming smaller and more isolated due to the conical structure of mountains. Because wolverine home ranges tend to be so large, some small mountain ranges are likely to lose the ability to support wolverine populations. We expect that the secondary effects of this habitat loss, such as increased habitat fragmentation and isolation, will intensify the overall impacts of habitat loss on wolverines.

Comment [O141]: Reference here; if this is based on McKelvey et al. 2011, see Attachment A

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Comment [O142]: This is speculation not based on any scientific evidence because we don't know what limits wolverine distribution in lower elevation forests. Moreover, you must state over what time frame this would happen relative to wolverine habitat requirements and what evidence there is that the lower slopes would not remain wolverine habitat.

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Deep snow that persists into the month of May is essential for wolverine reproduction. This life-history parameter for the species (reproductive rate) is likely to be most sensitive to climate changes. Wolverine are vulnerable to habitat modification (specifically, reduction in persistent spring snow cover) due to climate warming in the contiguous United States. Further, it is likely that year-round wolverine habitat, not just denning habitat, will also be significantly reduced due to the effects of climate warming. Reductions in habitat would result in greater habitat isolation, thereby likely reducing the frequency of dispersal between habitat patches and the likelihood of recolonization after local extinction events. This reduced dispersal ability, if not compensated for by higher population levels or assisted dispersal, is likely to result in loss of genetic diversity within remaining habitat patches and population loss due to demographic stochasticity. The contiguous United States population of wolverines is already very small and fragmented and is, therefore, particularly vulnerable to these impacts.

Comment [O143]: No evidence that this is true; see Attachment A; also define "deep"

Comment [O144]: Define "reproductive rate"; do you mean the proportion of females reproducing annually (e.g., Persson et al. 2006)? I don't think the proposed effects of climate change would necessarily change this parameter; just the total number of females reproducing, if that

Comment [O145]: Define persistent spring snow; if you are referring to the Copeland snow cover layer, then it is unlikely that earlier melting of snow cover on 15 May will reduce or modify wolverine habitat; see Attachment A

Comment [O146]: See Attachment A

Human activities, including dispersed recreation activities, infrastructure, and the presence of transportation corridors occur in occupied wolverine habitat. However, the alpine and subalpine

habitats preferred by wolverine typically receive little human use relative to lower elevation habitats. The majority of wolverine habitat (over 90 percent) occurs within Forest Service and National Park Service lands that are subject to activities, but usually not direct habitat loss to infrastructure development. The best available science leads us to determine that human activities and developments do not pose a current threat to wolverines in the contiguous United States.

Wolverines coexist with some modification of their environment, as wilderness characteristics such as complete lack of motorized use or any permanent human presence are likely not critical for maintenance of populations. It is clear that wolverines coexist with some level of human disturbance and habitat modification.

We know of no examples where human activities such as dispersed recreation have occurred at a scale that could render a large enough area unsuitable so that a wolverine home range would be likely to be rendered unsuitable or unproductive. Given the large size of home ranges used by wolverine, most human activities affect such a small portion that negative effects to individuals are unlikely. These activities do not occur at a scale that is likely to have population-level effects to wolverine.

Little scientific or commercial information exists regarding effects to wolverines from development or human disturbances associated with them. What little information does exist suggests that wolverines can adjust to moderate habitat modification, infrastructure development, and human disturbance. In addition, large amounts of wolverine habitat are protected from human disturbances and development, either legally through wilderness and National Park designation, or by being located at remote and high-elevation sites. Therefore, wolverines are afforded a relatively high degree of

protection from the effects of human activities by the nature of their habitat. Wolverines are known to successfully disperse long distances between habitats through human-dominated landscapes and across transportation corridors. The current level of residential, industrial, and transportation development in the western United States does not appear to have precluded the long-distance dispersal movements that wolverines require for maintenance of genetic diversity. We do not have information to suggest that future levels of residential, industrial, and transportation development would be a significant conservation concern for the DPS.

Comment [O147]: Does this apply to both male and female long-distance dispersal? is it possible that female wolverines might be more sensitive to this type of disturbance, as information on grizzly bear females suggests? How do you know that some wolverines have not been precluded from long-distance dispersal?

In summary, the best scientific and commercial information available indicates that only the projected decrease and fragmentation of wolverine habitat or range due to future climate change is a threat to the species now and in the future. The available scientific and commercial information does not indicate that other potential stressors such as land management, recreation, infrastructure development, and transportation corridors pose a threat to the DPS.

Comment [O148]: Restate this sentence because a "projected decrease and fragmentation" cannot be a threat currently

Comment [O149]: We know that wolverines have been killed on roads and railroads in the past and will probably continue to be; why isn't this considered a current threat to the DPS? How does one know how many wolverines are killed this way?

Factor B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Over much of recent history, trapping has been a primary cause of wolverine mortality (Banci 1994, p. 108; Krebs *et al*. 2004, p. 497; Lofroth and Ott 2007, pp. 2196-2197; Squires *et al*. 2007, p. 2217). Unregulated trapping is believed to have played a role in the historical decline of wolverines in North America in the late 1800s and early 1900s (Hash 1987, p. 580). Wolverines are especially vulnerable to targeted trapping and predator reduction campaigns due to their habit of ranging widely in search of carrion, bringing them into frequent contact with poison baits and traps (Copeland 1996, p. 78; Inman *et al*. 2007a, pp. 4-10; Packila *et al*. 2007, p. 105; Squires *et al*. 2007, p. 2219).

Human-caused mortality of wolverines is likely additive to natural mortality due to the low reproductive rate and relatively long life expectancy of wolverines (Krebs *et al*. 2004, p. 499; Lofroth and Ott 2007, pp. 2197-2198; Squires *et al*. 2007, pp. 2218-2219). This means that trapped subpopulations likely live at densities that are lower than carrying capacity, and may need to be reinforced by recruits from untrapped subpopulations to maintain population viability and persistence.

Comment [O150]: Some can be additive, and some compensatory; this is logical considering that a relatively large proportion of mortality in wolverines has been starvation (Krebs et al. 2004); a starving wolverine would be more likely to be trapped or hit by vehicles if moving around more in search of food; since it may have died from starvation anyway, this mortality could be compensatory under some circumstances (e,g,, in harvested populations)

A study in British Columbia determined that, under a regulated trapping regime, trapping mortality in 15 of 71 wolverine population units was unsustainable, and that populations in those unsustainable population units were dependent on immigration from neighboring populations or untrapped refugia (Lofroth and Ott 2007, pp. 2197-2198). Similarly, in southwestern Montana, legal trapping in isolated mountain ranges accounted for 64 percent of documented mortality and reduced the local wolverine subpopulation (Squires *et al*. 2007, pp. 2218-2219). The observed harvest levels, which included two pregnant females in a small mountain range, could have significant negative effects on a small subpopulation (Squires *et al*. 2007, p. 2219). Harvest refugia, such as jurisdictions with closed seasons, national parks, and large wilderness areas, are important to wolverine persistence on the landscape because they can serve as sources of surplus individuals to bolster trapped populations (Squires *et al*. 2007, p. 2219; Krebs and Ott 2004, p. 500). Due to their large space requirements, wolverine population refuges must be large enough to provide protection from harvest mortality; and complete protection is only available for wolverines whose entire home range occurs within protected areas. Glacier National Park, though an important refuge for a relatively robust population of wolverines, was still vulnerable to trapping because most resident wolverine home ranges extended into large areas outside the park (Squires *et al*. 2007, p. 2219). It is likely that the largerscale refuges

provided by the states of Idaho and Wyoming (which do not permit wolverine trapping) provide wolverine habitat that is fully protected from legal harvest in Montana; however, wolverines with home ranges that partially overlap Montana and dispersers that move into Montana would be vulnerable to harvest. Due to the restrictive, low level of harvest now allowed by Montana, the number of affected wolverines would be correspondingly small.

Despite the impacts of trapping on wolverines in the past, trapping is no longer a threat within most of the wolverine range in the contiguous United States. Montana is the only State where wolverine trapping is still legal. Before 2004, average wolverine harvest was 10.5 wolverines per year. Due to preliminary results of the study reported in Squires *et al*. (2007, pp. 2213-2220), the Montana Department of Fish, Wildlife, and Parks adopted new regulations for the 2004–2005 trapping season that divided the State into three units, with the goal of spreading the harvest more equitably throughout the State.

Comment [O151]: Why do you indicate "Most"; where is trapping still a threat? Reference? Are you referring to legal trapping or incidental take?

For the 2008–2009 trapping season, the Montana Department of Fish, Wildlife, and Parks adjusted its wolverine trapping regulations again to further increase the geographic control on harvest to prevent concentrated trapping in any single area, and to completely stop trapping in isolated mountain ranges where small populations are most vulnerable (Montana Department of Fish Wildlife and Parks 2010, pp. 8-11). Their new regulations spread harvest across three geographic units (the Northern Continental Divide area, the Greater Yellowstone area, and the Bitterroot Mountains), and established a statewide limit of five wolverines. In the four trapping seasons that have occurred since these rules were implemented, wolverine take averaged 3.25 wolverines annually (Montana Department of Fish Wildlife and Parks 2010, pp. 8-11; Brian Giddings Pers. Comm. August 30, 2012), with reduced

harvest being due to season closure rather than lack of wolverines. Under the current regulations, no more than three female wolverines can be legally harvested each year, and harvest in the more vulnerable isolated mountain ranges is prohibited. The size of the wolverine population subjected to trapping in this area is not known precisely but is likely not more than about 300 animals in states of Montana, Idaho, and Wyoming combined (Bob Inman pers. comm. 2010b).

The Montana Department of Fish, Wildlife, and Parks conduct yearly furbearer monitoring using track surveys. These surveys involve snowmobiling along transect routes under good tracking conditions and visually identifying all carnivore tracks encountered. The protocol does not use verification methods such as DNA collection or camera stations to confirm identifications. Consequently, misidentifications are likely to occur. Given the relative rarity of wolverines and the relative abundance of other species with which they may be confused, such as bobcats (*Lynx rufus*), Canada lynx (*Lynx canadensis*), and mountain lions (*Felis concolor*), lack of certainty of identifications of tracks makes it highly likely that the rare species is overrepresented in unverified tracking records (McKelvey *et al*. 2008, entire). The Montana Department of Fish, Wildlife, and Parks wolverine track survey information does not meet our standard for reliability described in the geographic distribution section, and we have not relied on this information in this finding.

Montana wolverine populations have rebounded from historic lows in the early 1900s while at the same time being subjected to regulated trapping (Aubry *et al*. 2007, p. 2151; Montana Department of Fish, Wildlife, and Parks 2007, p. 1). In fact, much of the wolverine expansion that we have described above took place under less-restrictive (i.e., higher harvest levels) harvest regulations than are in place today. The extent to which wolverine population growth has occurred in Montana as a result of

within-Montana population growth, versus population growth attributable to surrounding states where wolverines are not trapped, i.e., population growth driven by the entire metapopulation versus just the portion of the metapopulation found in Montana, is unknown.

Current levels of incidental trapping (i.e., capture in traps set for species other than wolverine) have been suggested by the petitioners to be a threat to wolverines. In the 2008–2009 trapping season, two wolverines were incidentally killed in traps set for other species in Beaverhead and Granite Counties, Montana (Montana Fish, Wildlife, and Parks 2010, p. 2). These two mortalities occurred within the portion of southwestern Montana that is currently closed to legal wolverine trapping to ensure that wolverines are not unsustainably harvested in this area of small, relatively isolated mountain ranges. Four cases of incidental wolverine trapping have occurred in Idaho in recent years. One wolverine was trapped by a coyote/bobcat trapper in 2006 and was collared and released after all of its toes and a portion of its left front foot were amputated (Inman et al. 2008, p. 1). That animal (a female) survived and successfully reproduced after release. The Department of Agriculture Wildlife Services trapped three wolverines (one each in 2004, 2005, and 2010) incidental to trapping wolves involved in livestock depredations. One of these sustained severe injuries and was euthanized. The other two were released without visible injury. Another wolverine was trapped in Wyoming in 2006. This animal was released unharmed (Inman 2012, pers. comm.). The three documented mortalities are possibly locally significant for wolverines in these areas because local populations in each of the mountain ranges are small and relatively isolated from nearby source populations.

Summary of Factor B

Legal wolverine harvest occurs in one state, Montana, within the range of the DPS. The extent to which this harvest affects populations occurring outside of Montana is unknown. However, the State of Montana contains most of the habitat and wolverines that exist in the current range of the DPS, and regulates trapping to reduce the impact of harvest on wolverine populations. Incidental harvest also occurs within the range of the DPS; however, the level of mortality from incidental trapping appears to be low. Harvest,when combined with the likely effects of climate change, may contribute to the likelihood that the wolverine will become extirpated in the future. This may occur by increasing the speed with which small populations of wolverine are lost from isolated habitats, and also by increasing mortality levels for dispersing wolverines, with the result of reducing dispersal rates. Regular dispersal and exchange of genetic material are required to maintain the genetics and demographics of wolverine subpopulations in the contiguous United States.

The current known level of incidental trapping mortality is low. We note that it is unknown whether or not increased trapping of wolves associated with wolf trapping regulations recently approved by the states of Idaho and Montana would be likely to result in increased incidental trapping of wolverines. Idaho began its wolf trapping program in the winter of 2011–2012, and Montana began theirs in the winter of 2012–2013. These wolf trapping activities are relatively new in the DPS area, and we do not yet have reliable information on the level of incidental take of wolverines that may result from them.

Based on the best scientific and commercial information available, we conclude that trapping, including known rates of incidental trapping in Montana and Idaho, result in a small number of wolverine mortalities each year and that this level of mortality by itself would not be a threat to the

wolverine DPS. However, by working in concert with habitat loss resulting from climate change, mortality due to harvest and incidental trapping may contribute to population declines. Therefore, we conclude that trapping, when considered cumulatively with habitat loss resulting from climate change, is likely to become a threat to the DPS (see discussion under Synergistic Interactions Between Threat Factors, below).

Factor C. Disease or Predation

No information is currently available on the potential effects of disease on wild wolverine populations. Wolverines are sometimes killed by wolves (*Canis lupus*), black bears (*Ursus americanus*), and mountain lion (White et al. Can. Field nat. 116:132-134;Burkholder 1962, p. 264; Hornocker and Hash 1981, p. 1296; Copeland 1996, p. 44-46; Inman *et al*. 2007d, p. 89). In addition, wolverine reproductive dens are likely subject to predation, although so few dens have been discovered in North America that determining the intensity of this predation is not possible.

Comment [O152]: Add this reference

Comment [O153]: Dens are not subject to predation, kits are??. Are you including intraspecific predation by other wolverines?

Summary of Factor C

We have no information to suggest that wolverine mortality from predation and disease is above natural or sustainable levels. The best scientific and commercial information available indicates that disease or predation is not a threat to the species now or likely to become so in the future.

Factor D. Inadequacy of Existing Regulatory Mechanisms

Based on our calculations using a composite map showing the coverage of both the Copeland *et al*. (2010, entire) and Inman et al. (2012, entire) wolverine habitat models, the majority (94 percent) of wolverine habitat currently occupied by wolverine populations in the lower contiguous United States is Federally owned and managed, mostly by the U.S. Forest Service. An estimated 144,371 km^2 (49,258 mi^2) of wolverine habitat occurs in the occupied area in Montana, Idaho, Oregon (Wallowa Range), and Wyoming. Of that, 135,396 km^2 (46,332 mi^2) is in Federal ownership. Additionally, 47,150 km^2 (12,973 mi^2) (32.7 percent) occurs in designated wilderness, and 23,062 km^2 (1,630 mi^2) (16.0 percent) occurs in inventoried roadless areas. An additional 13,784 km^2 (3,288 mi^2) (9.5 percent) are within national parks.

None of the existing Federal or State regulatory mechanisms were designed to address the threat of modification of wolverine habitat due to the loss of snowpack associated with climate change. Several existing regulatory mechanisms protect wolverine from other forms of disturbance and from overutilization from harvesting; these are described in more detail below.

Federal Laws and Regulations

The Wilderness Act

The Forest Service and National Park Service both manage lands designated as wilderness areas under the Wilderness Act of 1964 (16 U.S.C. 1131-1136). Within these areas, the Wilderness Act states the following: (1) New or temporary roads cannot be built; (2) there can be no use of motor vehicles, motorized equipment, or motorboats; (3) there can be no landing of aircraft; (4) there can be no other

form of mechanical transport; and (5) no structure or installation may be built. A large amount of suitable wolverine habitat, about 28 percent for the states of Montana, Idaho, and Wyoming, occurs within Federal wilderness areas in the United States (Inman personal communication 2007b). As such, a large proportion of existing wolverine habitat is protected from direct loss or degradation by the prohibitions of the Wilderness Act.

National Environmental Policy Act

All Federal agencies are required to adhere to the National Environmental Policy Act (NEPA) of 1970 (42 U.S.C. 4321 *et seq.*) for projects they fund, authorize, or carry out. The Council on Environmental Quality's regulations for implementing NEPA (40 CFR 1500–1518) state that agencies shall include a discussion on the environmental impacts of the various project alternatives (including the proposed action), any adverse environmental effects which cannot be avoided, and any irreversible or irretrievable commitments of resources involved (40 CFR 1502). The NEPA itself is a disclosure law, and does not require subsequent minimization or mitigation measures by the Federal agency involved. Although Federal agencies may include conservation measures for wolverines as a result of the NEPA process, any such measures are typically voluntary in nature and are not required by the statute. Additionally, activities on non-Federal lands are subject to NEPA if there is a Federal action.

For example, wolverines are designated as a sensitive species by the Forest Service, which requires that effects to wolverines be considered in documentation completed under NEPA. NEPA does not itself regulate activities that might affect wolverines, but it does require full evaluation and

disclosure of information regarding the effects of contemplated Federal actions on sensitive species and their habitats.

National Forest Management Act

Under the National Forest Management Act of 1976, as amended (16 U.S.C. 1600–1614), the Forest Service shall strive to provide for a diversity of plant and animal communities when managing national forest lands. Individual national forests may identify species of concern that are significant to each forest's biodiversity. Outside of designated wilderness but still on Forest Service-managed lands, wolverines occur mainly in alpine areas. Their habitat is generally offered more protections from timber harvest than would otherwise be the case in lowland areas due to the difficulty of accessing wolverine habitat, especially in areas where motorized access is limited or absent, such as most National Forest land and all designated wilderness areas.

National Park Service Organic Act

The NPS Organic Act of 1916 (16 U.S.C. 1 *et seq.*), as amended, states that the NPS ''shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations to conserve the scenery and the national and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.'' Where wolverines occur in National Parks, they and their habitats are protected from large-scale loss or degradation due to the Park Service's mandate

to ‘‘...conserve scenery... and wildlife...[by leaving] them unimpaired.’’ Wolverine harvest and trapping of other furbearers is also prohibited in National Parks.

Clean Air Act of 1970

On December 15, 2009, the Environmental Protection Agency (EPA) published in the Federal Register (74 FR 66496) a rule titled, “Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act.” In this rule, the EPA Administrator found that the current and projected concentrations of the six long-lived and directly emitted greenhouse gases (GHGs)—carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride—in the atmosphere threaten the public health and welfare of current and future generations; and that the combined emissions of these GHGs from new motor vehicles and new motor vehicle engines contribute to the GHG pollution that threatens public health and welfare (74 FR 66496). In effect, the EPA has concluded that the GHGs linked to climate change are pollutants, whose emissions can now be subject to the Clean Air Act (42 U.S.C. 7401 *et seq.*) (see 74 FR 66496). However, specific regulations to limit GHG emissions were only proposed in 2010 and, therefore, cannot be considered an existing regulatory mechanism. At present, we have no basis to conclude that implementation of the Clean Air Act in the future (40 years, based on global climate projections) will substantially reduce the current rate of global climate change through regulation of GHG emissions. Thus, we conclude the Clean Air Act is not designed to address the primary threat to wolverine of the loss of snowpack due to the effects of climate change.

State Laws and Regulations

State Comprehensive Wildlife Conservation Strategies and State Environmental Policy and Protection Acts

The wolverine is listed as State Endangered in Washington, California, and Colorado. In Idaho and Wyoming it is designated as a protected nongame species (Idaho Department of Fish and Game 2010, p. 4; Wyoming Game and Fish 2005, p. 2). Oregon, while currently not considered to have any individuals other than possible unsuccessful dispersers, has a closed season on trapping of wolverines. These designations largely protect the wolverine from mortality due to hunting and trapping. In Montana, the wolverine is classified as a regulated furbearer (Montana Fish, Wildlife, and Parks 2010, p. 8). Montana is the only State in the contiguous United States where wolverine trapping is still legal.

Wolverines receive some protection under State laws in Washington, California, Idaho, Montana, Wyoming, and Colorado. Each State's fish and wildlife agency has some version of a State Comprehensive Wildlife Conservation Strategy (CWCS) in place. These strategies, while not State or Federal legislation, can help prioritize conservation actions within each State. Named species and habitats within each CWCS may receive focused attention during State Environmental Protection Act (SEPA) reviews as a result of being included in a State's CWCS. However, only Washington, California, and Montana appear to have SEPA-type regulations in place. In addition, each State's fish and wildlife agency often specifically names or implies protection of wolverines in its hunting and trapping regulations. Only the State of Montana currently allows wolverine harvest (see discussion under Factor B).

Before 2004, the Montana Department of Fish, Wildlife, and Parks regulated wolverine harvest through the licensing of trappers, a bag limit of one wolverine per year per trapper, and no statewide limit. Under this management, average wolverine harvest was 10.5 wolverines per year. Due to preliminary results of the study reported in Squires *et al*. (2007, pp. 2213-2220), Montana Department of Fish, Wildlife, and Parks adopted new regulations for the 2004–2005 trapping season that divided the State into three units with the goal of spreading the harvest more equitably among available habitat. In 2008, Montana Department of Fish, Wildlife, and Parks further refined their regulations to prohibit trapping in isolated mountain ranges, and reduced the overall statewide harvest to five wolverines with a statewide female harvest limit of three. Under factor B, above, we concluded that trapping, including known rates of incidental trapping in Montana, by itself, is not a threat to the wolverine DPS, but that by working in concert with the primary threat of climate change, the trapping program may contribute to population declines (see Synergistic Interactions Between Threat Factors, below).

Summary of Factor D

The existing regulatory mechanisms appear to protect wolverine from several of the factors described in Factors A and B above. Specifically, State regulations for wolverine harvest appear to be sufficient to prohibit range–wide overutilization from hunting and trapping in the absence of other threats. However, given that climate change impacts are expected to reduce wolverine populations and fragment habitat, the impact of harvest to wolverine would be expected to increase if harvest levels were maintained at current levels. Federal ownership of much of occupied wolverine habitat protects the species from direct losses of habitat and provides further protection from many of the forms of disturbance described above. Wolverines use habitats affected by human disturbance, and additional

protection is afforded wolverines by the large area of their range that occurs in designated wilderness and national parks. The current regulatory regime does not address the potential impacts of dispersed winter recreation outside of protected areas; however, at this time the available information does not suggest that dispersed winter recreation is a threat to the DPS.

Our review of the regulatory mechanisms in place at the national and State level demonstrates that the short-term, site-specific threats to wolverine from direct loss of habitat, disturbance by humans, and direct mortality from hunting and trapping are, for the most part, adequately addressed through State and Federal regulatory mechanisms. However, as described under Factor A, the primary threat with the greatest severity and magnitude of impact to the species is loss of habitat due to continuing climate warming. The existing regulatory mechanisms currently in place at the national level were not designed to address the threat to wolverine habitat from climate change.

Comment [O154]: See Attachment A

Factor E. Other Natural or Manmade Factors Affecting its Continued Existence

Small Population Size

Population ecologists use the concept of a population's "effective" size as a measure of the proportion of the actual population that contributes to future generations (for a review of effective population size, see Schwartz *et al*. 1998, entire). In a population where all of the individuals contribute offspring equally, effective population size would equal true population size, referred to as the population census size. For populations where contribution to the next generations is often unequal, effective population size will be smaller than the census size. The smaller the effective population size,

the more reproduction in each generation is dominated by a few individuals in each generation. For wolverines it is likely that high-quality home ranges are limited, and individuals occupying them are better able to reproduce. Therefore, mature males and females that are successful at acquiring and defending a territory may dominate reproduction. Another contributing factor that reduces effective population size is the tendency in wolverines for a few males to monopolize the reproduction of several females, reducing reproductive opportunities for other males. Although this monopolization is a natural feature of wolverine life history strategy, it can lead to lower effective population size and reduce population viability by reducing genetic diversity. The effective population is not static, members of the effective population in 1 year may lose this status in the following year and possibly regain it again later depending on their reproductive success. When members of the effective population are lost, it is likely that their territories are quickly filled by younger individuals who may not have been able to secure a productive territory previously.

Effective population size is important because it determines rates of loss of genetic variation and the rate of inbreeding. Populations with small effective population sizes show reductions in population growth rates and increases in extinction probabilities when genetic diversity is low enough to lead to inbreeding depression (Leberg 1990, p. 194; Jimenez *et al*. 1994, pp. 272-273; Newman and Pilson 1997, p. 360; Saccheri *et al*. 1998, p. 492; Reed and Bryant 2000, p. 11; Schwartz and Mills 2005, p. 419; Hogg *et al*. 2006, p. 1495, 1498; Allendorf and Luikart 2007, pp. 338-342). Franklin (1980, as cited in Allendorf and Luikart 2007, p. 359) proposed an empirically based rule suggesting that for short-term (a few generations) maintenance of genetic diversity, effective population size should not be less than 50. For long-term (hundreds of generations) maintenance of genetic diversity, effective population size should not be less than 500 (for appropriate use of this rule and its limitations

see Allendorf and Luikart 2007, pp. 359-360). Others suggest that even higher numbers are required to ensure that populations remain viable, suggesting that long-term connectivity to the reservoir of genetic resources in the Canadian population of wolverines will be required for the long-term genetic health of the DPS (Traill *et al.* 2010, p. 32). All evidence suggests that no habitat area within the contiguous United States is large enough to support a wolverine population with an effective population size of 500 animals. Given the life history of wolverines that includes high inequality of reproductive success and a metapopulation of semi-isolated subpopulations, effective population sizes would likely never reach even 100 individuals at full habitat occupancy as this would suggest a census population of over 1,000. In this case, population connectivity exchange with the larger Canadian/Alaskan population would likely be required for long-term viability.

Wolverine effective population size in the northern Rocky Mountains, which is the largest extant population in the contiguous United States, is exceptionally low and is below what is thought necessary for short-term maintenance of genetic diversity. Estimates for effective population size for wolverines in the northern Rocky Mountains averaged 35 (credible limits = 28–52) (Schwartz *et al*. 2009, p. 3226). This study excluded the small population from the Crazy and Belt Mountains (hereafter "CrazyBelts") as they may be an isolated population, which could bias the estimate using the methods of Tallmon *et al*. (2007, entire). Measures of the effective population sizes of the other populations in the contiguous United States have not been completed, but given their small census sizes, their effective sizes are expected to be smaller than for the northern Rocky Mountains population. Thus, wolverine effective population sizes are very low. For comparison, estimates of wolverine effective population size are bracketed by critically endangered species, such as the black-footed ferret (*Mustela nigripes*) (4.10) (Wisely *et al*. 2007, p. 3) and the ocelot (*Leopardus pardalis*) (2.9 to 13.9) (Janecka *et al*. 2007,

p. 1), but are substantially smaller than estimates for the Yellowstone grizzly bear (*Ursus arctos*) (greater than 100), which has reached the level of recovery under the Act (Miller and Waits 2003, p. 4338). Therefore, we conclude that effective population size estimates for wolverines do not suggest that populations are currently critically endangered, but they do suggest that populations are low enough that they could be vulnerable to loss of genetic diversity, and may require intervention in the future to remain viable. To date, no adverse effects of the lower genetic diversity of the contiguous United States wolverines have been documented.

Wolverines in the contiguous United States are thought to be derived from a recent recolonization event after they were extirpated from the area in the early 20th century (Aubry *et al.* 2007, Table 1). Consequently, wolverine populations in the contiguous United States have reduced genetic diversity relative to larger Canadian populations as a result of founder effects or inbreeding (Schwartz *et al.* 2009, pp. 3228-3230). Wolverine effective population size in the northern Rocky Mountains was estimated to be 35 (Schwartz et al. 2009, p. 3226) and is below what is thought to be adequate for short-term maintenance of genetic diversity. Loss of genetic diversity can lead to inbreeding depression and is associated with increased risk of extinction (Allendorf and Luikart 2007, pp. 338-343). Small effective population sizes are caused by small actual population size (census size), or by other factors that limit the genetic contribution of portions of the population, such as polygamous mating systems. Populations may increase their effective size by increasing census size or by the regular exchange of genetic material with other populations through interpopulation mating.

Comment [O155]: Aubry stated "extirpated, or nearly so" as did the references they cited; the genetics paper in review by McKelvey et al. may support extirpation but that is not published yet

The concern with the low effective population size was highlighted in a recent analysis that determined that, without immigration from other wolverine populations, at least 400 breeding pairs

would be necessary to sustain the long-term genetic viability of the northern Rocky Mountains wolverine population (Cegelski *et al*. 2006, p. 197). However, the entire population is likely only 250 to 300 (Inman 2010b, pers. comm.), with a substantial number of these being unsuccessful breeders or nonbreeding subadults (i.e., part of the census population, but not part of the effective population).

Genetic studies demonstrate the essential role that genetic exchange plays in maintaining genetic diversity in small wolverine populations. The concern that low effective population size would result in negative effects is already being realized for the contiguous United States population of wolverine. Genetic drift has already occurred in subpopulations of the contiguous United States: Wolverines here contained 3 of 13 haplotypes found in Canadian populations (Kyle and Strobeck 2001, p. 343; Cegelski *et al*. 2003, pp. 2914-2915; Cegelski *et al*. 2006, p. 208; Schwartz *et al*. 2007, p. 2176; Schwartz *et al*. 2009, p. 3229). The haplotypes found in these subpopulations were a subset of those in the larger Canadian population, indicating that genetic drift had caused a loss of genetic diversity. One study found that a single haplotype dominated the northern Rocky Mountain wolverine population, with 71 of 73 wolverines sampled expressing that haplotype (Schwartz *et al*. 2007, p. 2176). The reduced number of haplotypes indicates not only that genetic drift has occurred but also some level of genetic separation; if these populations were freely interbreeding, they would share more haplotypes (Schwartz *et al*. 2009, p. 3229). The reduction of haplotypes is likely a result of the fragmented nature of wolverine habitat in the United States and is consistent with an emerging pattern of reduced genetic variation at the southern edge of the range documented in a suite of boreal forest carnivores (Schwartz *et al*. 2007, p. 2177).

Immigration of wolverines from Canada is not likely to bolster the genetic diversity of wolverines in the contiguous United States. There is an apparent lack of connectivity between wolverine populations in Canada and the United States based on genetic data (Schwartz *et al.* 2009, pp. 3228-3230). The apparent loss of connectivity between wolverines in the northern Rocky Mountains and Canada prevents the influx of genetic material needed to maintain or increase the genetic diversity in the contiguous United States. The continued loss of genetic diversity may lead to inbreeding depression, potentially reducing the species' ability to persist through reduced reproductive output or reduced survival. Currently, the cause for this lack of connectivity is uncertain. Wolverine habitat appears to be well-connected across the border region (Copeland *et al.* 2010, Figure 2) and there are few manmade obstructions such as transportation corridors or alpine developments. However, this lack of genetically detectable connectivity may be related to harvest management in southern Canada.

Comment [O156]: In what way do you mean this? Are you suggesting that harvest is removing so many wolverines in Canada that there are none to disperse into the U.S.? or are you suggesting that trapping in Canada is opening up home ranges that then absorb the potential dispersers? Copeland and Yates 2008 study suggests wolverine habitat in Glacier National Park is saturated based on the home range maps; wolverines to the north of the park may disperse into trapped areas rather than into GNP; if this were the case, even a trapping closure immediately north of the border with Canada would not necessarily increase dispersal into GNP because a saturated population in GNP could still pose a "barrier" to dispersers if this sociobiological phenomenon exists; see dispersal route of Eowyn outside the home ranges of resident wolverines in Washington and the new male from this past field season. Both may have dispersed around the home ranges of resident wolverines, although Jens Persson has GPS data that shows dispersers going through resident home ranges (unpublished data) but there they may have no other option.

Summary of Factor E

Small population size and resulting inbreeding depression are potential, though as-yet undocumented, threats to wolverines in the contiguous United States. There is good evidence that genetic diversity is lower in wolverines in the DPS than it is in the more contiguous habitat in Canada and Alaska. The significance of this lower genetic diversity to wolverine conservation is unknown. We do not discount the possibility that loss of genetic diversity could be negatively affecting wolverines now and continue to do so in the future. It is important to point out, however, that wolverine populations in the DPS area are thought to be the result of colonization events that have occurred since the 1930s. Such recent colonizations by relatively few individuals and subsequent population growth are likely to have resulted in founder effects, which could contribute to low genetic diversity. The

effect of small population sizes and low genetic diversity may become more significant if populations become smaller and more isolated, as predicted due to climate changes.

Based on the best scientific and commercial information available we conclude that demographic stochasticity and loss of genetic diversity due to small effective population sizes, by itself, is not a threat to the wolverine DPS. However, by working in concert with the primary threat of habitat loss due to climate change, this may contribute to the cumulative effect of population declines. Therefore, we conclude that demographic stochasticity and loss of genetic diversity due to small effective population sizes is a threat to wolverines when considered cumulatively with habitat loss due to climate change (see discussion under Synergistic Interactions Between Threat Factors).

Synergistic Interactions Between Threat Factors

We have evaluated individual threats to the distinct population segment of the North American Wolverine throughout its range in the contiguous United States. The wolverine DPS faces one primary threat that is likely to drive its conservation status in the future: habitat change and loss due to climate change. This factor alone is enough to determine that the species should be proposed for listing under the Act. Other factors, though not as severe or geographically comprehensive as the potential habitat effects from climate change may, when considered in the context of changes likely to occur due to climate change, become threats due to the cumulative effects they have on wolverine populations. For wolverines, the only such threat factors found in our analysis to have a basis of support as threats to wolverines were the effects of small subpopulation sizes and subpopulation isolation on wolverine genetic and demographic health, and the subsequent potential future influence of trapping.

Comment [O157]: Not supported by the best available science; see Attachment A

Comment [O158]: If these are factors, then certainly an increasing human footprint (infrastructure, perhaps even increased recreation beyond the levels that now occur) at some threshold level must also be a threat, especially in the intervening areas between current wolverine habitat islands, which already threaten dispersal/survival to some unknown extent

As discussed in our analysis of the effects on wolverine habitat from climate change under Factor A, wolverine habitat in the contiguous United States is likely to become smaller overall, and remaining habitat is likely to be more fragmented and fragments more isolated from one another than they are today (McKelvey *et al*. 2011, Figure 8). Given that wolverine subpopulations in the DPS are already so small, and movement between subpopulations so restricted, inbreeding has become likely (Kyle and Strobeck 2001, p. 343; Cegelski *et al*. 2003, pp. 2914-2915; Cegelski *et al*. 2006, p. 208; Schwartz *et al*. 2007, p. 2176; Schwartz *et al*. 2009, p. 3229). The longterm maintenance of wolverines in the DPS will require continued connectivity between subpopulations within the DPS, and with populations to the north in Canada. To the extent that wolverine habitat becomes more fragmented, and fragments become more isolated due habitat loss resulting from climate change, these factors will become more significant to wolverine conservation. The risk factor of small population size, including measures of effective population size and their consequent effects on maintenance of genetic diversity, is a threat to the North American wolverine DPS when considered cumulatively with habitat loss resulting from climate change.

Comment [O159]: I disagree, at least as far as "the foreseeable future" is concerned; See Attachment A

Comment [O160]: And if habitat loss and fragmentation due to climate warming is not a factor in the foreseeable future, the increasing human footprint in areas where wolverines need to disperse would be the overriding conservation issue; i.e., the need for dispsersal corridors exists today

Wolverine populations have been expanding in the DPS area since the early 20th century, when they were likely at or near zero (Aubry *et al*. 2007, p. 2151). Most of this expansion has occurred under trapping regulations that allowed a higher level of trapping than currently occurs (see Montana Department of Fish, Wildlife, and Parks 2007, p. 1). Therefore, it might be argued that wolverine trapping is not occurring at levels that would significantly affect conservation of the DPS. However, future habitat changes due to climate change are predicted to reduce habitat connectivity and extent. As described above, these changes are likely to exacerbate the problem of loss of genetic diversity and

Comment [O161]: See Attacment A

demographic stability caused by low effective population size and insufficient movement between populations, leading to inbreeding. Given these likely secondary effects of climate change, human-caused mortality due to harvest is likely to become more significant to the wolvereine population as connectivity needs increase and connectivity simultaneously becomes more difficult. As habitats become smaller and more isolated from one another, more wolverines will be needed to attempt to move between subpopulations to maintain population viability. Harvest currently removes up to five wolverines from the population every year, reducing the number of animals available for dispersal. In addition, incidental trapping of wolverines removes still more. For these reasons, we find that harvest and incidental trapping, when considered cumulatively with habitat loss resulting from climate change, are likely to become threats to the DPS due to the likely synergistic effects they may have on the population as habitat becomes smaller and more fragmented.

Comment [O162]: As will increasing human footprint in areas between wolverine habitat islands, perhaps more so than incidental take

Comment [O163]: And if habitat is not affected by climate warming in the foreseeable future, it could be argued that harvest and incidental trapping are less of a threat than increasing human developments in areas between wolverine habitat islands

Proposed Determination

We have carefully assessed the best scientific and commercial information available regarding the past, present, and future threats to the wolverine DPS. We have identified threats to the contiguous United States population of the North American wolverine attributable to Factors A, B, and E. The primary threat to the DPS is from habitat and range loss due to climate warming (Factor A). Wolverines require habitats with near-arctic conditions wherever they occur. In the contiguous United States, wolverine habitat is restricted to high-elevation areas in the West. Wolverines are dependent on deep persistent snow cover for successful denning, and they concentrate their year-round activities in areas that maintain deep snow into spring and cool temperatures throughout summer. Wolverines in the contiguous United States exist as small and semi-isolated subpopulations in a larger metapopulation

Comment [O164]: Define what this means

Comment [O165]: Define specifically so that it can be tested now and in the future

Comment [O166]: Define specifically here so that it can be tested now and in the future

that requires regular dispersal of wolverines between habitat patches to maintain itself. These dispersers achieve both genetic enrichment and demographic support of recipient populations. Climate changes are predicted to reduce wolverine habitat and range by 31 percent over the next 30 years and 63 percent over the next 75 years, rendering remaining wolverine habitat significantly smaller and more fragmented. We anticipate that, by 2045, maintenance of the contiguous United States wolverine population in the currently occupied area may require human intervention to facilitate genetic exchange and possibly also to facilitate metapopulation dynamics by moving individuals between habitat patches if they are no longer accessed regularly by dispersers, or risk loss of the population.

Comment [O167]: Not supported by the best available science; Appendix A

Other threats are minor in comparison to the driving primary threat of climate change; however, cumulatively, they could become significant when working in concert with climate change if they further suppress an already stressed population. These secondary threats include harvest (including incidental harvest) (Factor B) and demographic stochasticity and loss of genetic diversity due to small effective population sizes (Factor E). All of these factors affect wolverines across their current range in the contiguous United States.

Comment [O168]: Downplaying the significance of the effects of continued growth of the human population and expansion into areas between wolverine habitat islands seems counterproductive for wolverine conservations initiatives especially following the statement just above that states "Wolverines in the contiguous United States exist as small and semi-isolated subpopulations in a larger metapopulation that requires regular dispersal of wolverines between habitat patches to maintain itself."

The Act defines an endangered species as any species that is "in danger of extinction throughout all or a significant portion of its range" and a threatened species as any species "that is likely to become endangered throughout all or a significant portion of its range within the foreseeable future." We find that the contiguous United States wolverine DPS presently meets the definition of a threatened species due to the likelihood of habitat loss caused by climate change resulting in population decline leading to breakdown of metapopulation dynamics. Breakdown in metapopulation dynamics would make the DPS vulnerable to further loss of genetic diversity through inbreeding, and likely vulnerable to

demographic endangerment as small subpopulations could no longer rely on demographic rescue from nearby populations. At that point wolverine populations would meet the definition of an endangered species under the Act. We base this determination on the immediacy, severity, and scope of the threats described above. Therefore, on the basis of the best available scientific and commercial information, we propose listing the contiguous United State DPS of the North American wolverine as a threatened species in accordance with sections 3(6) and 4(a)(1) of the Act.

Under the Act and our implementing regulations, a species may warrant listing if it meets the definition of an endangered or threatened species throughout all or a significant portion of its range. The contiguous United States DPS of the North American wolverine proposed for listing in this rule is wide-ranging and the threats occur throughout its range. Therefore, we assessed the status of the DPS throughout its entire range. The threats to the survival of the species occur throughout the species' range and are not restricted to any particular significant portion of that range. Accordingly, our assessment and proposed determination applies to the DPS throughout its entire range.

Available Conservation Measures

Conservation measures provided to species listed as an endangered or threatened species under the Act include recognition, recovery actions, requirements for Federal protection, and prohibitions against certain practices. Recognition through listing results in public awareness and conservation by Federal, State, Tribal, and local agencies, private organizations, and individuals. The Act encourages cooperation with the States and requires that recovery actions be carried out for all listed species. The

protection required by Federal agencies and the prohibitions against certain activities are discussed, in part, below.

The primary purpose of the Act is the conservation of endangered and threatened species and the ecosystems upon which they depend. The ultimate goal of such conservation efforts is the recovery of these listed species, so that they no longer need the protective measures of the Act. Subsection 4(f) of the Act requires the Service to develop and implement recovery plans for the conservation of endangered and threatened species. The recovery planning process involves the identification of actions that are necessary to halt or reverse the species' decline by addressing the threats to its survival and recovery. The goal of this process is to restore listed species to a point where they are secure, self-sustaining, and functioning components of their ecosystems.

Recovery planning includes the development of a recovery outline shortly after a species is listed, preparation of a draft and final recovery plan, and revisions to the plan as significant new information becomes available. The recovery outline guides the immediate implementation of urgent recovery actions and describes the process to be used to develop a recovery plan. The recovery plan identifies site-specific management actions that will achieve recovery of the species, measurable criteria that determine when a species may be downlisted or delisted, and methods for monitoring recovery progress. Recovery plans also establish a framework for agencies to coordinate their recovery efforts and provide estimates of the cost of implementing recovery tasks. Recovery teams (composed of species experts, Federal and State agencies, nongovernmental organizations, and stakeholders) are often established to develop recovery plans. The recovery outline is available on our website at http://www.fws.gov/mountain-prairie/species/mammals/wolverine/ and

on http://www.regulations.gov concurrently with the publication of this proposed rule. When completed, the draft recovery plan and the final recovery plan will be available on our website or from our Montana Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**).

Implementation of recovery actions generally requires the participation of a broad range of partners, including other Federal agencies, States, Tribal, nongovernmental organizations, businesses, and private landowners. Examples of recovery actions include habitat restoration (e.g., restoration of native vegetation), research, captive propagation and reintroduction, and outreach and education. The recovery of many listed species cannot be accomplished solely on Federal lands because their range may occur primarily or solely on non-Federal lands. To achieve recovery of these species requires cooperative conservation efforts on private, State, and Tribal lands.

If this species is listed, funding for recovery actions will be available from a variety of sources, including Federal budgets, State programs, and cost share grants for nonfederal landowners, the academic community, and nongovernmental organizations. In addition, pursuant to section 6 of the Act, the States inhabited by wolverines or uninhabited states with suitable habitat would be eligible for Federal funds to implement management actions that promote the protection and recovery of wolverines. Information on our grant programs that are available to aid species recovery can be found at: *http://www.fws.gov/grants*.

Although the wolverine DPS is only proposed for listing under the Act at this time, please let us know if you are interested in participating in recovery efforts for this species. Additionally, we invite

you to submit any new information on this species whenever it becomes available and any information you may have for recovery planning purposes (see **FOR FURTHER INFORMATION CONTACT**).

Section 7(a) of the Act requires Federal agencies to evaluate their actions with respect to any species that is proposed or listed as endangered or threatened and with respect to its critical habitat, if any is designated. Regulations implementing this interagency cooperation provision of the Act are codified at 50 CFR part 402. Section 7(a)(4) of the Act requires Federal agencies to confer with the Service on any action that is likely to jeopardize the continued existence of a species proposed for listing or result in destruction or adverse modification of proposed critical habitat. If a species is listed subsequently, section 7(a)(2) of the Act requires Federal agencies to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of the species or destroy or adversely modify its critical habitat. If a Federal action may affect a listed species or its critical habitat, the responsible Federal agency must enter into formal consultation with the Service.

Federal agency actions within the species habitat that may require conference or consultation or both as described in the preceding paragraph include management and any other landscape altering activities on Federal lands in suitable wolverine habitat within the range of the species administered by the Department of Defense, U.S. Fish and Wildlife Service, Bureau of Land Management, National Park Service, and U.S. Forest Service; construction and management of gas pipeline and power line rights-of-way in suitable wolverine habitat by the Federal Energy Regulatory Commission; construction and maintenance of roads or highways by the Federal Highway Administration in suitable wolverine habitat; and permitting of infrastructure development in suitable wolverine habitat for recreation, oil

and gas development, or residential development by the U.S. Forest Service, National Park Service, Bureau of Land Management, U.S. Fish and Wildlife Service, or Department of Defense.

The Act and its implementing regulations set forth a series of general prohibitions and exceptions that apply to all endangered wildlife. The prohibitions of section 9(a)(2) of the Act, codified at 50 CFR 17.21 for endangered wildlife, in part, make it illegal for any person subject to the jurisdiction of the United States to take (includes harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect; or to attempt any of these), import, export, ship in interstate commerce in the course of commercial activity, or sell or offer for sale in interstate or foreign commerce any listed species. Under the Lacey Act (18 U.S.C. 42–43; 16 U.S.C. 3371–3378), it is also illegal to possess, sell, deliver, carry, transport, or ship any such wildlife that has been taken illegally. Certain exceptions apply to agents of the Service and State conservation agencies.

We may issue permits to carry out otherwise prohibited activities involving endangered and threatened wildlife species under certain circumstances. Regulations governing permits are codified at 50 CFR 17.22 for endangered species, and at 17.32 for threatened species. With regard to endangered wildlife, a permit must be issued for the following purposes: for scientific purposes, to enhance the propagation or survival of the species, and for incidental take in connection with otherwise lawful activities.

It is our policy, as published in the **Federal Register** on July 1, 1994 (59 FR 34272), to identify to the maximum extent practicable at the time a species is listed, those activities that would or would not constitute a violation of section 9 of the Act. The intent of this policy is to increase public

awareness of the effect of a proposed listing on proposed and ongoing activities within the range of species proposed for listing. The following activities could potentially result in a violation of section 9 of the Act; this list is not comprehensive:

Unauthorized collecting, handling, possessing, selling, delivering, carrying, or transporting of the species, including import or export across State lines and international boundaries, except for properly documented antique specimens of these taxa at least 100 years old, as defined by section 10(h)(1) of the Act.

Questions regarding whether specific activities would constitute a violation of section 9 of the Act should be directed to the Montana Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**). Requests for copies of the regulations concerning listed animals and general inquiries regarding prohibitions and permits may be addressed to the U.S. Fish and Wildlife Service, Endangered Species Permits, 134 Union Boulevard, Suite 650, Lakewood, CO 80228; Telephone 303-236-4265.

A determination to list the contiguous United States DPS of the North American wolverine as a threatened species under the Act, if we ultimately determine that listing is warranted, will not regulate greenhouse gas emissions. Rather, it will reflect a determination that the DPS meets the definition of a threatened species under the Act, thereby establishing certain protections for them under the ESA. While we acknowledge that listing will not have a direct impact on the loss of deep, persistent, late spring snowpack or the reduction of greenhouse gases, we expect that it will indirectly enhance national and international cooperation and coordination of conservation efforts, enhance research programs, and

encourage the development of mitigation measures that could help slow habitat loss and population declines. In addition, the development of a recovery plan will guide efforts intended to ensure the long-term survival and eventual recovery of the lower 48 states DPS of the wolverine.

Special Rule Under Section 4(d) of the Act

Whenever a species is listed as a threatened species under the Act, the Secretary may specify regulations that he deems necessary and advisable to provide for the conservation of that species under the authorization of section 4(d) of the Act. These rules, commonly referred to as ''special rules,'' are found in part 17 of title 50 of the Code of Federal Regulations (CFR) in §§ 17.40–17.48. This special rule for § 17.40 would prohibit take of any wolverine in the contiguous United States when associated with or related to trapping, hunting, shooting, collection, capturing, pursuing, wounding, killing, and trade. In this context, any activity where wolverines are attempted to be, or are intended to be, trapped, hunted, shot, captured, or collected, in the contiguous United States, will be prohibited. It will also be prohibited to incidentally trap, hunt, shoot, capture, pursue, or collect wolverines in the course of otherwise legal activities. All otherwise legal activities involving wolverines and their habitat that are conducted in accordance with applicable State, Federal, tribal, and local laws and regulations are not considered to be take under this regulation. This includes activities that occur in and may modify wolverine habitat such as those described below.

In this proposed listing rule, we identified several risk factors for the wolverine DPS that, in concert with climate change, may result in reduced habitat value for the species. These risk factors include human activities like dispersed recreation, land management activities by Federal agencies and

private landowners, and infrastructure development. However, the scale at which these activities occur is relatively small compared to the average size of wolverine's home range, between 300 and 500 km^2 (186 and 310 mi^2). For example, ski resorts constitute the largest developments in wolverine habitats. In Colorado, the state with the most ski resorts in the range of the wolverine, ski resort developments cover only 0.6 percent of available wolverine habitat (Colorado Division of Wildlife 2010, p. 16). Other developments are more localized still, such as mines and small infrastructure. It is possible that these forms of habitat alteration may affect individual wolverines, by causing the temporary movement of a few individuals within or outside of their home ranges during or shortly after construction. However, due to the small scale of the habitat alteration involved in these sorts of activities, we conclude that the overall impact of these activities is not significant to the conservation of the species. Dispersed recreation like snowmobiling and back country skiing, and warm season activities like backpacking and hunting, occur over larger scales; however, there is little evidence to suggest that these activities may affect wolverines significantly or have a significant effect on conservation of the DPS. Preliminary evidence suggests that wolverines can coexist amid high levels of dispersed motorized and nonmotorized use (Heinenmeyer *et al*. 2012, entire), possibly shifting activity to avoid the most heavily used areas within their home ranges.

Transportation corridors and urban development in valley bottoms between patches of wolverine habitat may inhibit individual wolverines' movement between habitat patches; however, wolverines have made several long-distance movements in the recent past that indicates they are able to navigate current landscapes as they search for new home ranges. As described above, we have no evidence to suggest that current levels of transportation infrastructure development or residential development are a threat to the DPS or will become one in the future.

Comment [O169]: May be better evidence that infrastructure development and residential development between habitat islands is more of a threat than an earlier spring melt of just 2 weeks over the remainder of the 21st century; there is no way to know how much transportation infrastructure etc. already has affected wolverines or will in the near and foreseeable future; "no evidence" does not guarantee "no effect"

Land management activities (principally timber harvest, wildland firefighting, prescribed fire, and silviculture) can modify wolverine habitat, but this generalist species appears to be little affected by changes to the vegetative characteristics of its habitat. In addition, most wolverine habitat occurs at high elevations in rugged terrain that is not conducive to intensive forms of silviculture and timber harvest. Therefore, we anticipate that habitat modifications resulting from these types of land management activities would not significantly affect the conservation of the DPS, as we described above.

The proposed special rule under section 4(d) of the Act will provide for the possession and take of wolverines that are (1) legally held at the time of listing (2) legally imported pursuant to applicable Federal and state statutes, or (3) captively bred without a permit. The special rule will also allow the continuation of the export of captive-bred wolverines provided applicable Federal and state laws are followed, and provide for the transportation of wolverine skins in commerce within the United States. The export skins from wolverines documented as captive-bred will be permitted. Legally possessed skins may be transported in interstate trade without permits.

Comment [O170]: I'm confused; does this affect possession and take of legally harvested wolverines in Alaska? Because it refers to wolverines "legally held at the time of listing"

In this proposed rule, we include a prohibition against incidental take of wolverine in the course of legal trapping activities directed at other species. However, documented take of wolverine from incidental trapping has been low. In the 2008–2009 trapping season, two wolverines were incidentally killed in traps set for other species in Beaverhead and Granite Counties, Montana (Montana Fish, Wildlife, and Parks 2010, p. 2). In Idaho, the U.S. Department of Agriculture Wildlife Services trapped three wolverines (one each in 2004, 2005, and 2010) incidental to trapping wolves involved in livestock

Comment [O171]: Where? In the DPS only?

depredations. One of these sustained severe injuries and was euthanized. We are requesting the public, Federal agencies, and the affected State fish and wildlife agencies to submit public comments on this issue, including any State management plans related to trapping regulations and any measures within those plans that may avoid or minimize the risk of wolverine mortality from incidental trapping for other species.

Comment [O172]: There are a number of methods that can be used to minimize incidental take while trapping other species

CRITICAL HABITAT

Section 3(5)(A) of the Act defines critical habitat as "(i) the specific areas within the geographical area occupied by the species, at the time it is listed...on which are found those physical or biological features (I) Essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed...upon a determination by the Secretaries of Commerce and Interior that such areas are essential for the conservation of the species." Section 3(3) of the Act (16 U.S.C. 1532(3)) also defines the terms "conserve," "conserving," and "conservation" to mean "to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this chapter are no longer necessary."

Section 4(a)(3) of the Act and implementing regulations (50 CFR 424.12) require that, to the maximum extent prudent and determinable, we designate critical habitat at the time a species is determined to be an endangered or threatened species. Critical habitat may only be designated within the jurisdiction of the United States, and may not be designated for jurisdictions outside of the United States (50 CFR 424(h)). Our regulations (50 CFR 424.12(a)(1)) state that designation of critical habitat

is not prudent when one or both of the following situations exist: (1) The species is threatened by taking or other activity and the identification of critical habitat can be expected to increase the degree of threat to the species; or (2) such designation of critical habitat would not be beneficial to the species. Our regulations (50 CFR 424.12(a)(2)) further state that critical habitat is not determinable when one or both of the following situations exists: (1) Information sufficient to perform required analysis of the impacts of the designation is lacking; or (2) the biological needs of the species are not sufficiently well known to permit identification of an area as critical habitat.

Delineation of critical habitat requires, within the geographical area occupied by the DPS of the North American wolverine in the contiguous United States, identification of the physical and biological features essential to the conservation of the species. In general terms, physical and biological features essential to the wolverine may include (1) Areas defined by persistent spring snowpack and (2) areas with avalanche debris (bottom of avalanche chutes where large trees, rocks, and other debris are swept) and talus slopes or boulder fields (debris piles of large rocks, trees, and branches) in which females can construct dens which provide security from large predators and buffer against wind and low temperatures.

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Comment [O173]: Include dispersal habitat that may have neither snowpack or avalanche debris and wildlife corridors outside of wolverine habitat

Information regarding the wolverine's life functions and habitats associated with these functions has expanded greatly in recent years. We need additional time to assess the potential impact of a critical habitat designation, including whether there will be any benefit to wolverine from such a designation. A careful assessment of the habitats that may qualify for designation as critical habitat will require a thorough assessment in light of projected climate change and other threats. At this time, we also need more time to analyze the comprehensive data to identify specific areas appropriate for critical

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habitat designation. Accordingly, we find designation of critical habitat to be "not determinable" at this time.

Comment [O174]: Particularly because the best science available indicates that erroneous assumptions about wolverine habitat requirements (deep snow until 15 May) led to incorrect evaluation of the threat of climate warming to wolverine habitat in the DPS (Attachment A)

Peer Review

In accordance with our joint policy on peer review published in the **Federal Register** on July 1, 1994 (59 FR 34270), we will seek the expert opinions of at least three appropriate and independent specialists regarding this proposed rule. The purpose of peer review is to ensure that our listing determination and critical habitat designation are based on scientifically sound data, assumptions, and analyses. We have invited these peer reviewers to comment during this public comment period.

We will consider all comments and information received during this comment period on this proposed rule during our preparation of a final determination. Accordingly, the final decision may differ from this proposal.

Required Determinations

Clarity of the Rule

Executive Order 12866 requires each agency to write regulations that are easy to understand. We invite your comments on how to make this rule easier to understand including answers to questions such as the following: (1) Are the requirements in the rule clearly stated? (2) Does the rule contain technical language or jargon that interferes with its clarity? (3) Does the format of the rule (grouping and order of sections, use of headings, paragraphing, etc.) aid or reduce its clarity? (4) Would the rule

be easier to understand if it were divided into more (but shorter) sections? (5) Is the description of the rule in the **SUPPLEMENTARY INFORMATION** section of the preamble helpful in understanding the rule? What else could we do to make the rule easier to understand?

Send a copy of any comments that concern how we could make this rule easier to understand to Office of Regulatory Affairs, Department of the Interior, Room 7229, 1849 C Street, NW., Washington, DC 20240. You also may e-mail the comments to this address: *Exsec@ios.goi.gov*.

Paperwork Reduction Act of 1995 (44 U.S.C. 3501, et seq.)

This rule does not contain any new collections of information that require approval by Office of Management and Budget (OMB) under the Paperwork Reduction Act. This rule will not impose recordkeeping or reporting requirements on State or local governments, individuals, businesses, or organizations. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number.

National Environmental Policy Act (42 U.S.C. 4321 et seq.)

We have determined that environmental assessments and environmental impact statements, as defined under the authority of the National Environmental Policy Act of 1969, need not be prepared in connection with listing a species as an endangered or threatened species under the Endangered Species Act. We published a notice outlining our reasons for this determination in the **Federal Register** on October 25, 1983 (48 FR 49244).

References Cited

A complete list of all references cited in this proposed rule is available on the Internet at *http://www.regulations.gov* or upon request from the Field Supervisor, Montana Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT** section).

Authors

The primary authors of this proposed rule are the staff members of the Montana Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**).

List of Subjects in 50 CFR Part 17

Endangered and threatened species, Exports, Imports, Reporting and recordkeeping requirements, and Transportation.

Proposed Regulation Promulgation

Accordingly, we propose to amend part 17, subchapter B of chapter I, title 50 of the Code of Federal Regulations, as set forth below:

PART 17—[AMENDED]

1. The authority citation for part 17 continues to read as follows:

Authority: 16 U.S.C. 1361-1407; 1531-1544; and 4201-4245, unless otherwise noted.

2. In § 17.11(h) add entries for “Wolverine, North American” to the List of Endangered and Threatened Wildlife in alphabetical order under Mammals to read as set forth below:

§ 17.11 Endangered and threatened wildlife.

* * * * *

(h) * * *

Species□Historic range□Vertebrate population where endangered or threatened□Status□When listed□Critical habitat□Special rules□□Common name□Scientific name□□□□□□□□□

Historic range□Vertebrate population where endangered or threatened□Status□When listed□Critical habitat□Special rules□□Common name□Scientific name□□□□□□□□

Vertebrate population where endangered or threatened□Status□When listed□Critical habitat□Special rules□□Common name□Scientific name□□□□□□□□

Status□When listed□Critical habitat□Special rules□□Common name□Scientific name□□□□□□□□

When listed□Critical habitat□Special rules□□Common name□Scientific name□□□□□□□□

Critical habitat□Special rules□□Common name□Scientific name□□□□□□□□

Special rules□□Common name□Scientific name□□□□□□□□

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Mammals

* * * * * * *

□□Wolverine, North American

□Wolverine, North American

Wolverine, North American

□*Gulo gulo luscus* □U.S.A. (Alaska and northern contiguous States); Canada□Where found within contiguous U.S.A., except where listed as an experimental population□T□□NA□17.40(a)

Gulo gulo luscus □U.S.A. (Alaska and northern contiguous States); Canada□Where found within contiguous U.S.A., except where listed as an experimental population□T□□NA□17.40(a)

U.S.A. (Alaska and northern contiguous States); Canada□Where found within contiguous U.S.A., except where listed as an experimental population□T□□NA□17.40(a)

Where found within contiguous U.S.A., except where listed as an experimental population□T□□NA□17.40(a)

T□□NA□17.40(a)

□NA□17.40(a)

NA□17.40(a)

17.40(a)

□□Wolverine, North American□*Gulo gulo luscus*□U.S.A. (Alaska and northern contiguous States); Canada□U.S.A. (specified portions of CO, NM, and WY; see 17.84(d))□XN□□NA□17.84(d)□□

□Wolverine, North American□*Gulo gulo luscus*□U.S.A. (Alaska and northern contiguous States); Canada□U.S.A. (specified portions of CO, NM, and WY; see 17.84(d))□XN□□NA□17.84(d)□□

Wolverine, North American□*Gulo gulo luscus*□U.S.A. (Alaska and northern contiguous States); Canada□U.S.A. (specified portions of CO, NM, and WY; see 17.84(d))□XN□□NA□17.84(d)□□

Gulo gulo luscus□U.S.A. (Alaska and northern contiguous States); Canada□U.S.A. (specified portions of CO, NM, and WY; see 17.84(d))□XN□□NA□17.84(d)□□

U.S.A. (Alaska and northern contiguous States); Canada□U.S.A. (specified portions of CO, NM, and WY; see 17.84(d))□XN□□NA□17.84(d)□□

U.S.A. (specified portions of CO, NM, and WY; see 17.84(d))□XN□□NA□17.84(d)□□

XN□□NA□17.84(d)□□

□NA□17.84(d)□□

NA□17.84(d)□□

17.84(d)□□

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* * * * * * *□□

□

3. Amend § 17.40 by revising paragraph (a) to read as follows:

§ 17.40 Special rules—mammals.

(a) Wolverine, North American (*Gulo gulo luscus*).

(1) *Which populations of the North American wolverine are covered by this special rule?* This rule covers the distribution of this species in the contiguous United States.

(2) *What activities are prohibited?* Any activity where wolverines are attempted to be, or are intended to be, trapped, hunted, shot, captured, or collected, in the contiguous United States, will be prohibited. It will also be prohibited to incidentally trap, hunt, shoot, capture, pursue, or collect wolverines in the course of otherwise legal activities.

(3) *What activities are allowed?* Incidental take of wolverines will not be a violation of section 9 of the Act, if it occurs from any other otherwise legal activities involving wolverines and their habitat that are conducted in accordance with applicable State, Federal, tribal, and local laws and regulations. Such activities occurring in wolverine habitat include:

(i) Dispersed recreation such as snowmobiling, skiing, backpacking, and hunting for other species;

(ii) Management activities by Federal agencies and private landowners such as timber harvest, wildland firefighting, prescribed fire, and silviculture;

(iii) Transportation corridor and urban development;

(iv) Mining;

(v) Transportation and trade of legally possessed wolverine skins and skins from captive-bred wolverines within the United States.

* * * * *

Dated: 1/16/2013

/s/ Rowan W. Gould

Acting Director, U.S. Fish and Wildlife Service

Billing Code 4310–55–P

From:	Grizzle, Betty
To:	Shoemaker, Justin; John Guinotte
Cc:	Bush, Jodi
Subject:	Fwd: Final Report for the Wolverine-Winter Recreation Project
Date:	Sunday, December 17, 2017 12:57:46 PM
Attachments:	Wolverine Winter Recreation Final Report 15Dec17.pdf

---

FYI - See attached report.

---------- Forwarded message ----------
From: **Kimberly Heinemeyer** <kim@roundriver.org>
Date: Fri, Dec 15, 2017 at 8:52 AM
Subject: Final Report for the Wolverine-Winter Recreation Project
To: June -FS Galloway <jgalloway02@fs.fed.us>, Lisa Nutt <lnutt@fs.fed.us>, Robin Garwood <rgarwood@fs.fed.us>, nyorgason@fs.fed.us, Kerry M -FS Murphy <kmmurphy02@fs.fed.us>, Gary Hanvey <ghanvey@fs.fed.us>, Tammy -FS Fletcher <tammyfletcher@fs.fed.us>, Randy Scarlett <rscarlett@fs.fed.us>, "Dewey, Sarah" <sarah_dewey@nps.gov>, Betty_Grizzle@fws.gov, Diane Evans Mack <diane.evansmack@idfg.idaho.gov>, Alyson Courtemanch <alyson.courtemanch@wyo.gov>, "Egnew, Ana E -FS" <aeegnew@fs.fed.us>, Rebecca Watters <watters.rj@gmail.com>, Sandra Mitchel <smitchel@alscott.com>, Rob Cavallaro <rob.cavallaro@idfg.idaho.gov>, Dennis Sizemore <sizemore@roundriver.com>, Kathleen Wilson <kathleen@roundriver.org>
Cc: John Squires <jsquires@fs.fed.us>, Mark Hebblewhite <Mark.Hebblewhite@umontana.edu>, Julia Smith <julia@roundriver.org>, jholbrook03@gmail.com, Jeff P Copeland <jcopeland224@gmail.com>

Dear Project Collaborators,

John Squires (Rocky Mountain Research Station) and I am pleased to provide the Final Report for the Wolverine – Winter Recreation Research Project. Over the 6 years of extensive field efforts and these last two years of intensive data analyses, you have been supportive and critical to the success of the project. We hope you find the attached Final Report informative and helpful. Please feel free to share this with your colleagues, and do not hesitate to contact us if you have questions about the project and the information provided in the Final Report. I am sure that we will be talking with many of you in the New Year, and I would like to offer to provide a presentation on the project and these results, if your team would find that useful.

Thank you,

Kim Heinemeyer

****

Kimberly Heinemeyer, PhD
Project Lead Scientist
Wolverine – Winter Recreation Research Project
Round River Conservation Studies

Project led by the USFS Rocky Mountain Research Station

--

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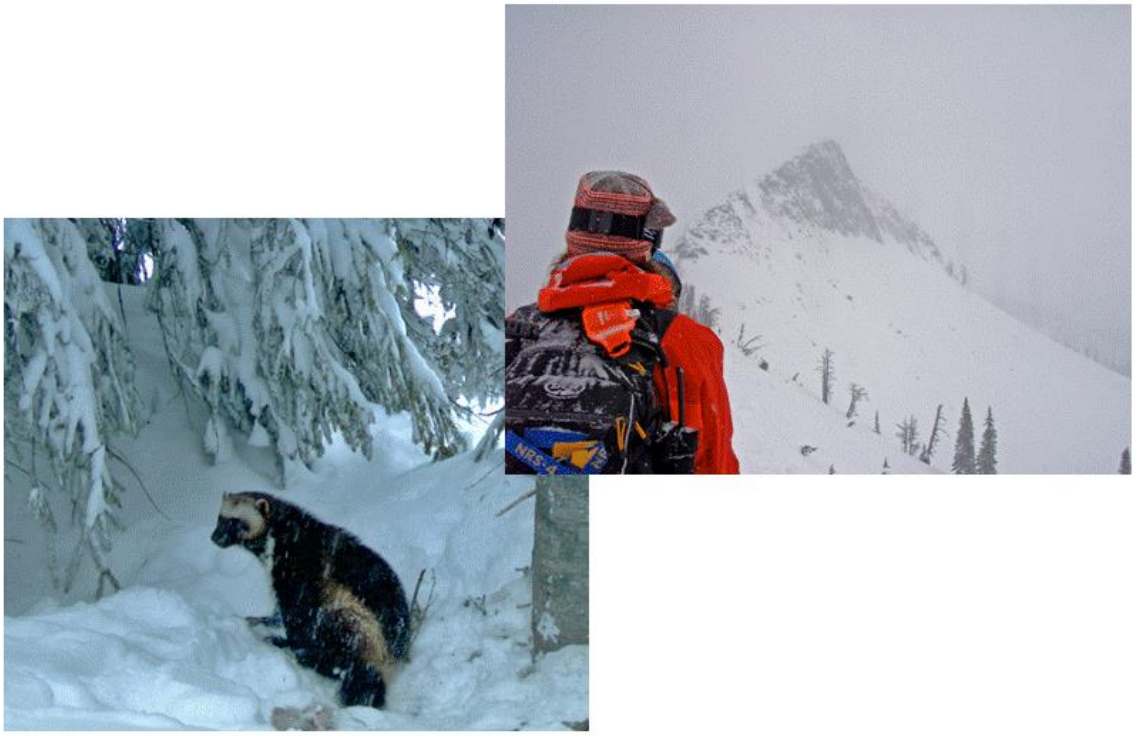
WOLVERINE – WINTER RECREATION RESEARCH PROJECT:
INVESTIGATING THE INTERACTIONS BETWEEN WOLVERINES AND WINTER RECREATION

FINAL REPORT



DECEMBER 15, 2017

HEINEMEYER, KIMBERLY S.[1], JOHN R. SQUIRES[2], MARK HEBBLEWHITE[3], JULIA S. SMITH[1], JOSEPH D. HOLBROOK[2], AND JEFFREY P. COPELAND[2,4]

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WOLVERINE – WINTER RECREATION RESEARCH PROJECT:
INVESTIGATING THE INTERACTIONS BETWEEN WOLVERINES AND WINTER RECREATION

FINAL REPORT

DECEMBER 15, 2017

HEINEMEYER, KIMBERLY S.[1], JOHN R. SQUIRES[2], MARK HEBBLEWHITE[3], JULIA S. SMITH[1], JOSEPH D. HOLBROOK[2], AND JEFFREY P. COPELAND[2,4]

WITH THE SUPPORT OF PROJECT PARTNERS AND COLLABORATORS INCLUDING:

BOISE, BRIDGER-TETON, CARIBOU-TARGHEE, PAYETTE AND SAWTOOTH NATIONAL FORESTS
IDAHO DEPARTMENT OF FISH AND GAME
LIZ CLAIBORNE ART ORTENBERG FOUNDATION
THE WOLVERINE FOUNDATION
UNIVERSITY OF MONTANA
GRAND TETON NATIONAL PARK
WYOMING DEPARTMENT OF GAME AND FISH
US FISH AND WILDLIFE SERVICE
IDAHO STATE SNOWMOBILE ASSOCIATION
BRUNDAGE MOUNTAIN RESORT
GRAND TARGHEE RESORT
JACKSON HOLE MOUNTAIN RESORT
CENTRAL IDAHO RECREATION COALITION
DEFENDERS OF WILDLIFE
THE SAWTOOTH SOCIETY
THE WINTER RECREATION COMMUNITIES OF CENTRAL IDAHO AND WESTERN YELLOWSTONE.

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The project would not have been possible without individuals within our partnering agencies who tirelessly assisted the project in numerous ways. In particular, we thank Diane Evans Mack and Rob Cavallaro (IDFG), Tammy Fletcher (Caribou-Targhee National Forest), Ana Egnew (Payette NF), Lisa Nutt and Joe Foust (Boise NF), Robin Garwood (Sawtooth NF), Gary Hanvey and Kerry Murphy (Bridger-Teton NF) and Aly Courtemanch (Wyoming Game and Fish) for diligently ensuring the success of the project. We also want to thank Mark Drew, veterinarian at IDFG for supporting safe handling of wolverines. Many additional agency personnel assisted us – we thank you for your assistance and support. A large amount of effort is invested behind the scenes in personnel, project and financial management, and we are grateful to Kathleen Wilson at Round River Conservation Studies for always cheerfully handling these often thankless but critical tasks. We thank Lucretia Olson and Dennis Sizemore for advising and commenting on earlier versions of this report.

The backbone of the research is high quality data collection under sometimes challenging conditions, and we are indebted to our hard-working field crew, many of whom worked multiple winters on the project: Blakeley Adkins, Matt Amick, Isaac Babcock, Anne Blackwood, Kristina Boyd, Grace Carpenter, Llona Ney Clausen, Drew Chambers, Chris Cole, Jeff Copeland, Jim Corbet, John Councilman, Katie Coyle, Ross Dorendorf, Danielle Fagre, Tony Folsom, Gary Gadwa, Tom Glass, Erica Goad, Sierra Groves, Jessica Haas, Dylan Hopkins, Brooklyn Hudson, Zack Huling, Lindsay Jones, Rollie Jones, Shannon Jones, Suzanne Johnston, Tyler Kaebisch, Matt Kasprzak, Chris Klingler, Kyle Krapster, Tulley Mackey, Scott Martin, Alex May, Madison McConnell, Cy McCullough, Josh Metten, Nick Miller, Ryan Mong, Celina Moreno, Katy Nelson, Zoe Nelson, Ben Rooney, Rachel Rubin, Joel Ruprecht, Toni Ruth, Kristen Sellmer, Molly Shuman-Goodier, Will Tyson, Carson White, and Jarrod Zweigart. Your commitment, professionalism and good humor made the project not only successful, but also good fun.

We thank the thousands of recreationists who agreed to carry funny little orange data loggers while out having fun and who took the time to return them to us. Your contribution provides a critical foundation to the project. Finally, we thank the wolverines who also carried funny, little data loggers for us, and who have taught us so much.

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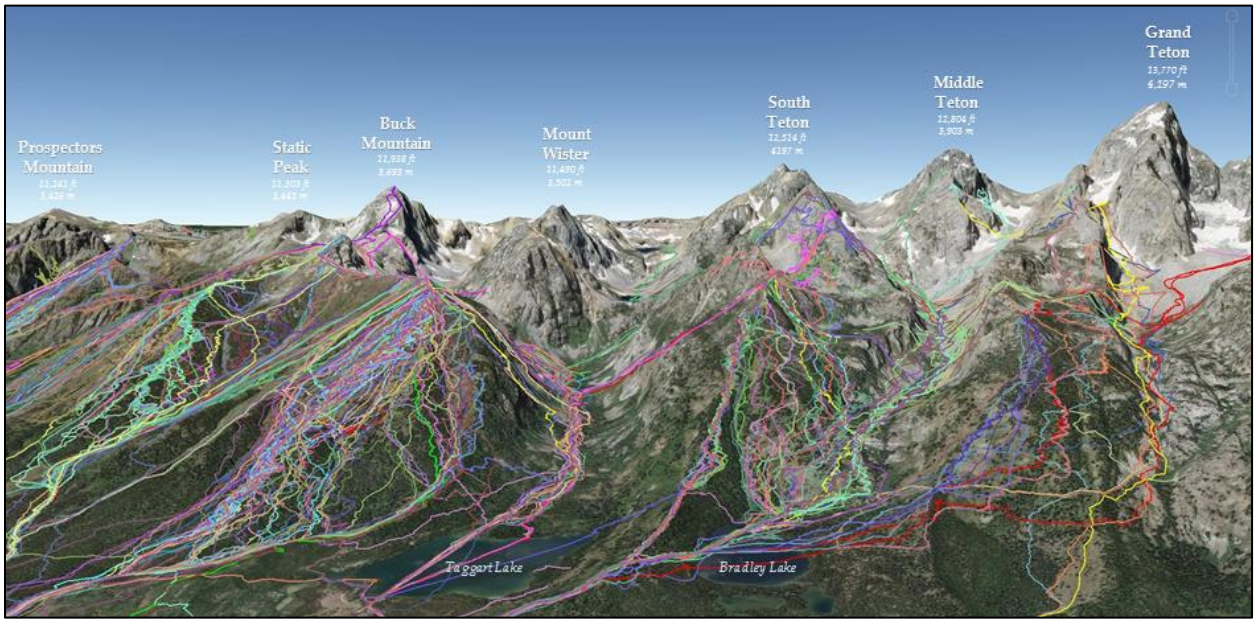

Backcountry ski and snowboard Global Positions System (GPS) tracks collected during the winter of 2014 by volunteer recreationists.

Executive Summary

Outdoor recreation provides opportunities for people to connect to nature, and is a critical economic driver and part of the cultural fabric of some rural communities. Outdoor recreation is also increasingly recognized to have potentially important impacts on nature and wildlife, and we need to understand these potential effects. In recent years, technological advancements in over-snow equipment including 'powder snowmobiles' and lightweight backcountry ski gear provide opportunity for backcountry enthusiasts to access previously remote landscapes for winter recreation activities. Wolverines may be vulnerable to direct and indirect impacts of recreation during winter, as they remain active through the winter, naturally occur at low densities, have low reproductive rates, and enter reproductive dens within deep snowpack during the winter recreation season. The Rocky Mountains represent the southern extent of wolverine distribution and in this region they are limited to high elevation habitat, which overlaps the same types of mountainous terrain sought by backcountry winter recreationists.

Over 6 winters (2010 – 2015) and four study areas, we GPS collared 24 individual wolverines over 39 animal-years to collect >54,000 GPS locations, one of the largest GPS datasets collected on wolverines in the lower 48 states. These wolverines were exposed to a diversity of winter recreation activities across our study areas spanning >1.1 million ha in Idaho, Wyoming and Montana. Simultaneously, we monitored and sampled winter recreation, collecting 5,899 GPS tracks from backcountry winter recreationists representing >198,000km of recreation activity, in the most intensive and extensive backcountry winter recreation monitoring effort that we know of to date. Backcountry winter recreation information was also collected through trail use counts and aerial-based recreation surveys, and the combination of data allowed us to create maps of backcountry winter recreation portraying the extent and relative intensity of motorized recreation and non-motorized recreation within wolverine home ranges. From locations of 18 wolverines (25 animal-years, >53,000 locations), we modelled habitat selection of male and female wolverines within home ranges using resource selection functions and used remaining wolverine data to validate these models. We characterized the habitat selection responses of wolverines to varying winter recreation patterns, and assessed the potential for indirect habitat loss from avoidance of recreated areas. Replicating this across multiple study areas allowed us to evaluate functional responses of wolverines to differing levels and types of recreation, providing further insights into wolverine responses to winter recreation.

Wolverines exhibited selection for specific habitat characteristics within home ranges, with female selection differed in some important ways from males. Female wolverines, which were represented by both denning and non-denning females in our sample, selected for talus and for snowier and colder habitats when compared to males, and we suggest these may represent denning affiliations similar to those found in other studies. Both males and females selected for drainage bottoms and avoided steep slopes. Both male and female wolverines selected for fir-associated conifer forest, avoided open areas but selected for areas close to forest edges. Unlike females, males were found closer to roads than expected; these roads were primarily unmaintained, snow-covered secondary roads with little human use during winter.

Wolverines maintained multi-year home ranges within landscapes that support relatively intensive levels of winter recreation, suggesting that wolverines tolerate winter recreation at some scales. Individual wolverine exposure to winter recreation varied notably across study areas and animals, a key aspect of our study design. Variation in the spatial extent of motorized

recreation ranged from <1% to 51% within home ranges, while non-motorized recreation tended to have smaller footprint areas covering an average of <5%, and ranging from <1% to 9.3% within home ranges. Wolverines responded negatively to increasing intensity of winter recreation, with off-road or dispersed recreation eliciting a stronger response than recreation concentrated on access routes. Indirect habitat loss from winter recreation reduced the quality of 2 – 28% of available habitat within home ranges. Female wolverines exhibited strong avoidance of off-road motorized recreation and were more vulnerable to higher levels of indirect habitat loss than males who appeared to be less sensitive to disturbance. While non-motorized recreation covered a relatively small proportion of home ranges, these areas were also avoided by male and female wolverines. The avoidance of areas of linear access used by winter recreationists was not as strong as estimated for dispersed recreation and wolverines may be less sensitive to predictable patterns of human use.

The strength of wolverine negative responses to dispersed motorized and non-motorized recreation increased with increasing levels of the recreation within the home range. This functional response of wolverines to recreation intensity suggests that potentially important indirect habitat loss may occur when a notable portion of an animal's home range receives recreation use, as it is exactly those animals exposed to higher levels of recreation that are most strongly displaced from these areas. The functional response also suggests that limited exposure may mute the indirect habitat loss, and some of our animals were exposed to relatively low levels of winter recreation. Our ability to understand wolverine responses to non-motorized recreation is hindered by having few wolverines exposed to higher levels of this recreation type.

Currently, exposure to winter recreation is highly variable within home ranges and across individuals indicating further work is needed to understand population-level effects. We suggest significant habitat degradation to reproductive females during denning season should be of concern within landscapes with higher levels of winter recreation. We speculate that the potential for backcountry winter recreation to affect wolverines may increase under climate change due to reduced snow pack and snow season that may concentrate winter recreationists spatially and temporally in these high elevation habitats during a season when these species face increased energetic stressors and females enter reproductive dens. We recommend that solutions to finding a balanced approach to sustaining the diverse values of these wild landscapes requires creative approaches and collaborations between land managers, stakeholders and wildlife professionals.

Cite as: Heinemeyer, K. S., J. R. Squires, M. Hebblewhite, J. S. Smith, J. D. Holbrook, J. P. Copeland. 2017. Wolverine – Winter Recreation Research Project: Investigating the interactions between wolverines and winter recreation. Final Report, December 15, 2017. 71pp. Available at: www.roundriver.org/wolverine.

Introduction

Fostering societal appreciation for nature conservation partly relies upon individuals connecting to nature during leisure activities including participating in outdoor recreation activities. Winter snow-based recreation is an important component of the outdoor recreation industry, and includes backcountry sports in undeveloped landscapes. In recent years, technological advancements in over-snow equipment including 'powder snowmobiles' and lightweight backcountry ski gear provide opportunity to access previously remote landscapes. Not only are backcountry recreationists potentially important advocates for the landscapes they visit (Teisl and O'Brien 2003, Gifford and Nilsson 2014), but the winter recreation is important economically and culturally for many small communities (e.g., (Scott et al. 2008).

While maintaining societal values for nature partly depends on supporting interactions with natural landscapes, the potential impacts of this use needs to be understood (Boyle and Samson 1985, Knight and Gutzwiller 1995, Taylor and Knight 2003). There have been an increasing number of studies highlighting a diversity of recreation-based impacts on habitats and wildlife species (Steven et al. 2011, Sato et al. 2013, Larson et al. 2016, Ewacha et al. 2017). The most commonly recorded wildlife responses include both behavioral and physiological stressors on individual animals, including increased avoidance of the disturbance, elevated stress hormones and displacement from preferred areas (Harris et al. 2014, Arlettaz et al. 2015, Larson et al. 2016). Recreation that results in the avoidance of disturbed areas leads to indirect habitat loss (Patthey et al. 2008, Polfus et al. 2011, Coppes et al. 2017b). The importance of disturbance and particularly indirect habitat loss from winter recreation may be elevated if animals face increased energetic demands for thermoregulation and travel over snow while food may be less abundant or of lower quality (Telfer and Kelsall 1979, Parker et al. 1984, Neumann et al. 2009).

Habitat displacement and indirect habitat loss from winter recreation activities have been documented in a diverse array of montane and alpine species. In Europe, for example, high elevation forest grouse (*Tetrao* sp.) are negatively impacted by backcountry winter recreation including habitat displacement as well as energetic and physiological effects (Patthey et al. 2008, Braunisch et al. 2011, Arlettaz et al. 2015, Coppes et al. 2017b). Many species of large herbivore (e.g., red deer (*Cervus elaphus*), mountain caribou (*Rangifer tarandus caribou*), bighorn sheep (*Ovis canadensis*), mountain goat (*Oreamnos americanus*), and moose (*Alces alces*)) have exhibited negative physiological or behavioral responses including indirect habitat loss through avoidance associated with motorized and non-motorized winter recreation (Seip et al. 2007, Neumann et al. 2009, Courtemanch 2014, Richard and Cote 2016, Coppes et al. 2017a, Lesmerises et al. 2018). As backcountry winter recreation grows in intensity and spatial extent coupled with the potential concentration of activities due to climate change, there is a growing need to understand the potential effects on wildlife species particularly those that are sensitive, snow-associated, and occupy alpine habitats.

Large carnivores are globally threatened and declining, and have experienced negative effects of human-caused habitat fragmentation and loss throughout their range (Ripple et al. 2014). In North America, the Rocky Mountains represent a large carnivore hotspot (Noss et al. 1996, Laliberte and Ripple 2004), where some species are restricted to high elevation habitat. The wolverine (*Gulo gulo*) is limited to northern latitudes across its circumpolar distribution, is closely associated with snow and subalpine or alpine habitats throughout the winter and reproductive denning, and is a species of conservation concern. Indeed, there is high potential for overlap and interactions between wolverines and backcountry winter recreationists because they both occupy similar areas. Wolverines may be vulnerable to direct and indirect impacts of

recreation during winter, as they naturally occur at low densities, have low reproductive rates, and remain active through the winter (Hash 1987). There has been no effort focused on understanding wolverine responses to winter recreation, though research suggests they are sensitive to human activities and infrastructure (May et al. 2006, Krebs et al. 2007, Stewart et al. 2016, Heim et al. 2017). Females enter reproductive dens within deep snowpack in during the winter recreation season with kits born in mid-Feb to early March and they occupy these dens through late April or mid-May (Hash 1987, Magoun and Copeland 1998). The potential impact of backcountry winter recreation to denning females is of primary concern (Carroll et al. 2001, May et al. 2006, Copeland et al. 2007, Krebs et al. 2007). In Canada, wolverine status was changed to 'Special Concern' in 2014 with increased winter recreation use combined with sensitivity of denning females among the considerations (www.cosewic.gc.ca). In the United States, wolverines are being considered for listing under the Endangered Species Act, with the most recent status review (Service 2013) indicating a lack of evidence to assess potential effects of winter recreation.

Understanding the responses of elusive, low-density wildlife species to relatively novel human uses such as backcountry winter recreation require committed and innovative approaches that capture the temporal and spatial variability inherent in the human use patterns and in the responses of animals to this disturbance (Tablado and Lukas 2017, Squires et al. 2018). Previous studies on the effects of winter recreation on wildlife species have been limited spatially and temporally, and most were focused within a single study area and on a single form of winter recreation (Larson et al. 2016). Over six years, we monitored the movements and habitat use of wolverines in four different study areas in the Rocky Mountains of Idaho, Wyoming and Montana. We simultaneously tracked and monitored winter recreation to characterize the spatial

extent and relative intensity of activities across the landscape. We hypothesized that wolverine responses to winter recreation would be influenced by the type of winter recreation, as well as the spatial extent and intensity of the recreation. We developed resources selection analyses to both understand wolverine habitat use within home ranges and to test wolverine responses to type, spatial extent and the relative intensity of winter recreation. These analyses allowed us to evaluate the potential for indirect habitat loss due to winter recreation (Johnson et al. 2005, Polfus et al. 2011, Hebblewhite et al. 2014). While resource selection analyses provide an estimate of average responses, they tell us little about how wolverine responses may change based on the level of exposure to winter recreation (Mysterud and Ims 1998, Hebblewhite and Merrill 2008). Functional responses can include such important effects as habituation and threshold effects (Hebblewhite and Merrill 2008, Moreau et al. 2012, Holbrook et al. 2017). For example, Hebblewhite and Merrill (2008) found that wolves showed no response to humans in areas of low human activity, but as the amount of human activity increased, they displayed heighted avoidance. We tested for functional responses in habitat use of wolverines by evaluating how wolverine use of recreated areas changes with changing availability (Holbrook et al. 2017). The goals of our research were three-fold: 1) characterize fine-scale (i.e., third-order home range scale, Johnson 1980) habitat use and selection of male and female wolverines; 2) assess the importance of motorized and non-motorized winter recreation in influencing wolverine habitat use and habitat quality; and 3) test if the responses of wolverines to winter recreation were dependent upon the spatial extent and relative intensity of the recreation within individual home ranges.

Methods

To understand wolverine responses to winter recreation disturbance, we fit Global Position System (GPS) collars on wolverines to monitor movements and habitat use in mid and late winter, and concurrently sampled and monitored winter recreation. We developed wolverine resource selection functions (RSF) at the third order (within home range scale, Johnson 1980) with a use:availability design to estimate the relative probability of selection (Manly et al. 2002, Johnson et al. 2006, McDonald 2013). We developed maps of different types of winter recreation and included these as covariates in RSFs to test hypotheses concerning the effect of winter recreation on wolverine habitat selection. Based on the selected models, we evaluated indirect habitat loss from winter recreation, as measured by the loss in predicted habitat quality with the inclusion of winter recreation covariates in the RSF, with habitat quality classified by relative probability of use (i.e., Polfus et al. 2011). Finally, we tested if wolverines showed functional responses to winter recreation based on the relative intensity of winter recreation to which they were exposed. We used ArcGIS (ArcGIS Desktop: Release 10.1 – 10.5, Redlands, CA: Environmental Systems Research Institute) and R (R Core Team 2016) for data management and analyses.

Study Area

Our research included four broad study areas spanning >1.1 million ha in Idaho, Wyoming and Montana (Figure 1) which we refer to as: McCall study area (Payette NF, northern Boise NF); Sawtooth study area (including portions of the Sawtooth NF, southern Boise NF); West Yellowstone study area (including portions of the Caribou-Targhee NF, Custer-Gallatin, NF and Beaverhead-Deerlodge NF), and the Tetons study area (including portions of the Caribou-Targhee NF, Bridger-Teton NF and the Grand Teton National Park). Each study area

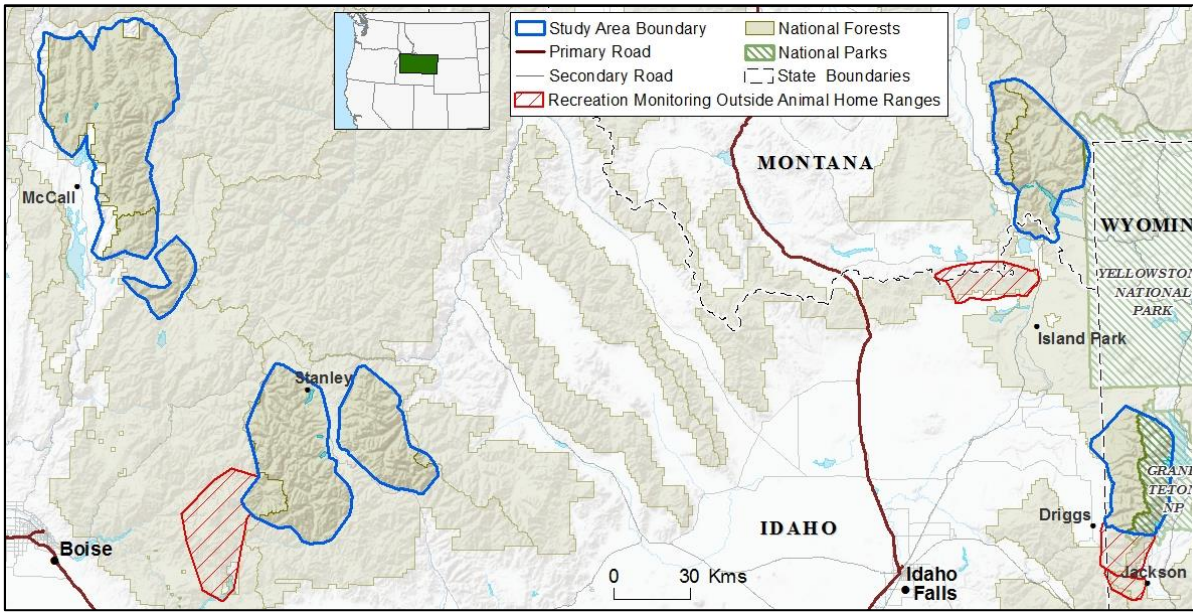

Figure 1. Four broad study areas (McCall, Sawtooth, West Yellowstone and Tetons) for examining effects of winter recreation on wolverines (*Gulo gulo*) in Idaho, Montana, and Wyoming, USA, years 2010-2015. The study area boundaries in blue identify the outer extent of wolverine home ranges monitored during the study, while the red hatched areas indicate additional areas where camera and live-trapping for wolverines occurred without the identification of wolverine presence. Winter recreation sampling occurred in all study areas.

was a popular backcountry winter recreation destination with backcountry snowmobiling, skiing or both occurring in the range of wolverines, but also large areas without intense winter human activity. Study areas were primarily National Forest System lands, but also contained a mix of other state and federal land designations. Topography was mountainous with alpine dominated by rock, ice and low-growing herbaceous vegetation, transitioning into more open conifers with open rocky or subalpine shrub, grass and herbaceous vegetation. Mid-elevation vegetation was dominated by coniferous forests, with interspersed deciduous tree and shrub communities. The lower boundaries of the study areas were defined by the lower limits of wolverine use, typically near the lower limit of forested habitats, with rare agricultural and sagebrush steppe near these margins.

Infrastructure supporting backcountry recreation varied across the study areas. All study areas maintained parking areas for backcountry access at trailheads or along plowed roads, and some study areas had a network of groomed snowmobile trails. Within wolverine home ranges, roads were almost exclusively secondary roads that were not plowed for vehicle travel though some were groomed for snowmobile use. Plowed roads occurred along the periphery or in close proximity outside of home range boundaries. All roads were snow-covered during our study, and motorized and non-motorized recreation use was allowed on the majority of roads regardless of whether they were groomed for recreation use. Winter recreation activities varied in the number of recreationists and types of recreation, and each study area had a unique combination of backcountry recreation including snowmobile, ski (including snowboards), snowmobile-accessed ski/board (hybrid), cat-ski, heli-ski and yurt-supported ski. The McCall, Sawtooth and Teton study areas also had developed ski resorts which allowed for backcountry or out-of-bounds skiing.

Wolverine capture and monitoring

Between 2010 – 2015 we captured wolverines from early January through April using modified box traps built from logs (Lofroth et al. 2008) baited with road-kill deer or trapper-caught beaver and a skunk-based lure. Each trap was equipped with a satellite-device that notified us when the trap was triggered (Vectronics trap transmitters TT2, TT3; Vetronic Aerospace GmbH, Berlin, Germany), as well as a VHF-based trap trigger (Telonics trapsite transmitters, TBT series; Telonics, Inc, Mesa, AZ, USA); traps were visited immediately if triggered, and maintained every 3 – 5 days (see Appendix A for additional details). Traps were closed late February to late March to avoid capturing a reproducing female, and re-opened in late March through April for collar removal. Wolverines were anesthetized using a 10 mg/kg

ketamine hydrocholoride and 0.075 mg/kg medetomidine mixture (Fahlman et al. 2008) delivered by a jab stick. A GPS collar (either WildCellSL collar from Lotek Wireless, Newmarket, Ontario, Canada or Quantum 4000 collar from Telemetry Solutions, Concord, CA, USA) was attached and programmed to collect a location every 20 minutes on weekends (Saturday, Sunday) and mid-week (Tuesday, Wednesday), which we expected to differ in intensity of human use. Collars were modified with a cotton strip designed to rot away within 4 – 6 months if we were unable to recapture the animal. Trapping and handling procedures were approved through the University of Montana Institutional Animal Care and Use Committee (IACUC; Permit #055-10MHECS-113010) and the National Park Service IACUC under a research permit (GRTE-2015-SCI-0003). We also obtained research permits through Idaho Department of Fish and Game (IDFG) and Wyoming Game and Fish (WGF). We monitored the status of wolverines through aerial telemetry flights, including identifying potentially denning females (Appendix A).

Resource Selection Function Analyses

Resource selection functions (RSF) compare covariate characteristics at used GPS locations with random locations (putatively available) to identify covariates that are used disproportionately more (i.e., selected) or less than (i.e., avoided) available (Manly et al. 2002). We used general linear mixed-effects models with a logit link function (GLMM) and animal-year as a random effect to control for repeated sampling of individuals (Gillies et al. 2006). The mixed-effects RSF model therefore takes the form:

$$w(x) = \beta_1 x_{1ij} + \beta_2 x_{2ij} + \beta_3 x_{3ij} + \cdots + \beta_n x_{nij} + \gamma_{0j} + \varepsilon_{ij} \quad (1)$$

where x_n are covariate values for location i of animal-year j with the fixed regression coefficient β_n; γ_{0j} is the random intercept for animal-year j and is ε_{ij} is the residual variance within each

animal-year. Logistic regression (Hosmer et al. 2013) is used to fit the exponential approximation to an inhomogeneous spatial-point process model, but without the intercept because in used-available designs, the true amount of non-use is unknown (McDonald 2013). Thus, the resultant probability is best considered a relative probability of selection or use (Lele et al. 2013). Animal and random (available) locations were attributed with the environmental and winter recreation covariates (see below), which were then standardized to support model fitting and allow for comparisons between model coefficients (Hosmer et al. 2013).

Location data and home range analyses

We defined available habitat by estimating home range boundaries using a local convex hull (LoCoH) non-parametric kernel method (Getz et al. 2007) with a fixed 'k' number of nearest neighbors (Appendix A). We buffered calculated polygons by the sex-specific median step length (331 m for females, 441 m for males) to account for habitat immediately available to the animal. We included individual wolverine animal-years with ≥5 weeks of GPS monitoring in that winter in model development. Data for individuals monitored for <5 weeks, or subadults with exploratory behaviors, were withheld for model validation. Within each home range, we estimated available habitat with random locations generated at a ratio of 2:1 random:use with random locations forced to be ≥30m apart.

Wolverine spent time under snow and structures that resulted in low GPS fix-rates and potential behavioral or habitat-induced bias (Frair et al. 2004, Nielson et al. 2009). To account for behavior-based missed locations, we developed a modification of Knopff et al. (2009) to identify clusters of wolverine locations based on their spatial (within 25m of each other) and temporal (within 24 hours of each other) proximity. Missed locations were associated with a known cluster site if the location before or after the failed GPS attempt was within a cluster, and

the cluster centroid was imputed for their location (Frair et al. 2004). Locations <100 m of an active trap site were censored given the effect of baited traps.

Environmental variables

We evaluated land cover, topographic, snow, climate and anthropogenic covariates (Appendix B) that may be important predictors of wolverine resource selection at the third-order. First, we identified the spatial scale most strongly selected by wolverines (DeCesare et al. 2012; Appendix B). Second, we screened covariates for collinearity (|r| >= 0.6), and the covariate with the lowest univariate AIC was retained (Hosmer et al. 2013). Finally, we evaluated covariates for potential nonlinear relationships using general additive models (Hilbe 2015) and by testing potential non-linear models, keeping the form of the covariate with the lowest AIC (Hosmer et al. 2013). This resulted in slope being included in a quadratic form.

Winter recreation sampling and models

We developed spatially-explicit maps of winter recreation by sampling backcountry recreation using three methods: GPS tracking of volunteer recreationists (*sensu* Olson et al. 2017), infra-red trail use counters, and aerial surveys. We combined spatial information from GPS tracks with the amount of recreational use from trail counters to develop maps of winter recreation intensity of all recreation combined as well as by motorized or non-motorized recreation type. We used the aerial surveys to validate recreation maps (Appendix C).

To collect GPS tracks of recreation, we sampled recreationists at known recreation access points during mid-week (Tuesday, Wednesday) and weekend (Saturday-Sunday) days from mid-January through mid-April. We sampled recreation systematically, not in proportion to recreation use at access points or across study areas. We asked recreation groups to carry one GPS unit (Qstarz International Co., Ltd., model BT-Q1300, 1 location/5 seconds, position accuracy < 10

m) per ≤4 people in the group, and we recorded the type of winter recreation and the group size per GPS unit. We also distributed GPS units to backcountry guide, heli-ski and cat-ski operations, with guides carrying the GPS units and recording their group size. To estimate the number of recreationists accessing each study area, we installed infra-red trail counters (Trafx Research Ltd, Canmore, Alberta, Canada) at constriction points on backcountry snowmobile and ski/snowboard access routes. If the access route was used by both out-going and incoming recreationists, the counts were divided by two to estimate the one-way traffic.

We developed maps of winter recreation, including linear travel or access routes and the relative intensity of dispersed use based on the GPS tracks. To account for differences in overall use within and between study areas, we weighted each GPS track based on the proportion of the estimated total recreation use it represented from each trailhead or access point, with total use estimated from the trail use counters associated with the access point:

$$w_i = \left({Trail\ count_j} \Big/ {\sum Groups_j} \right) \times GPS\ Group_i \qquad (2)$$

where i = individual GPS track, j = trailhead (or group of clustered trailheads), *Trail count* = the estimated total recreationists accessing from trailhead$_j$, $Groups_j$ = the total number of people sampled as the sum across all groups carrying GPS units at trailhead j, and GPS Group$_i$ = the number of people associated with GPS track i.

The GPS tracks of recreationists that use motorized access (e.g., snowmobile, cat-ski, heli-ski) to undertake non-motorized activities were split into their motorized and non-motorized components. For heli-ski GPS tracks, we used only the non-motorized portions of GPS tracks and discarded the track associated with the helicopter transport. To test for wolverine responses to spatial pattern and intensity of winter recreation, we developed maps of recreation: 1) the recreation footprint as a binomial characterization of recreation extent that includes linear and

dispersed recreation; 2) recreation access routes (recreated roads and groomed trails); 3) the relative intensity of all winter recreation; 4) the relative intensity of off-road or dispersed recreation (tracks >30m from a road or groomed route) for all recreation and 5) the relative intensity of motorized and non-motorized recreation separately (see details in Appendix C).

Model Selection

To test our hypotheses of wolverine responses to winter recreation, we first developed RSFs (habitat models) based on environmental covariates not including recreation, which predicts 'potential' habitat quality in the absence of receation, based on relative probability of use (Polfus et al. 2011, Trainor and Schmitz 2014). Then, we added winter recreation covariates to the potential habitat model(s) to test for responses of wolverines to different aspects of winter recreation (e.g., spatial extent, relative intensity, recreation type) and to identify the best model to predict 'realized' habitat quality accounting for effects of winter recreation on wolverine habitat selection. We followed a two-step process to identify the environmental predictors of wolverine habitat use for all animals combined (global model), for females (female model) and for males (male model). We used fixed-effect least absolute shrinkage and operator selection (LASSO) logistic regression (Tibshirani 1996, Reineking and Schröder 2006) implemented using the 'glmnet' package in R (Friedman et al. 2010) to identify the most predictive of the potential covariates (penalty strength set within one standard error of the minimum cross-validated error; Friedman et al. 2010). In the second step, we developed RSF global, female and male models using GLMM with animal-year as a random effect using the 'lme4' package in R (Bates et al. 2015). We compared the summed AIC scores of the male and female RSF models to the global RSF AIC to determine if a single global model or separate sex-based models were supported (Burnham and Anderson 1998). To include winter recreation effects, we then developed five

additional RSF models that included the potential habitat RSF covariates and five winter recreation covariates from our winter recreation maps. We selected the model with the lowest ΔAIC to best represent realized wolverine habitat use in areas that also have winter recreation. For the selected models of potential habitat and realized habitat, we used 10-fold cross validation to assess the goodness of model fit (Boyce et al. 2002). We also validated the models using out-of-sample GPS location data from wolverine animal-years not used in the development of habitat models to determine how our models predicted the frequency of wolverine use (e.g., DeCesare et al. 2012, Holbrook et al. 2017).

Comparing potential and realized habitat quality

We estimated the amount of predicted change in wolverine habitat quality that may occur in the presence of winter recreation by calculating the reduction in habitat quality between the potential habitat and realized habitat models (Johnson et al. 2005, Nielsen et al. 2010, Polfus et al. 2011, Hebblewhite et al. 2014). Given we did not measure habitat use in the absence of winter recreation, we assume that the influence of winter recreation is independent of environmental variables and evaluated this assumption by comparing the standardized model selection coefficients of environment covariates between the potential and realized models (Hosmer and Lemeshow 2008). If model coefficients were 'stable' in the potential and realized models, this suggests that recreation and other covariates were not confounded, thus enabling our ability to predict additive effects of 'adding' or 'removing' recreation.

Each model was then mapped at a 30 m^2 resolution and mapped values were binned into 10 quantiles from low to high quality or relative probability of use. We classified habitat quality by classifying the top 30% of the area (bins 8 – 10) as 'high quality habitat', the next 30% (bins 5 – 7) as 'moderate quality habitat' and the lowest 40% of habitat values (bins 1 – 4) as 'low

quality habitat'. We did not include areas where gaps in winter recreation monitoring information did not allow us to predict the probability of use. Indirect habitat loss was calculated as the spatially-explicit reduction in habitat class when comparing the realized habitat model to the potential habitat model (Johnson et al. 2005, Polfus et al. 2011). We summarized the amount of change across the study areas as well as area within individual home ranges. We calculated the degree of habitat degradation by the number of classes reduced, with the most severe degradation indicated by high quality habitat that is degraded by two classes to low quality habitat.

Functional responses to winter recreation

We tested if wolverines exhibited a functional response to the relative intensity of motorized and non-motorized dispersed winter recreation by evaluating how habitat use of recreated areas changes with availability of these areas. If there is no functional response, habitat use of recreation changes in proportion to availability (Holbrook et al. 2017), while deviations from proportional use indicate a functional response. We calculated habitat use and availability of the relative motorized and non-motorized recreation intensity by computing the mean recreation intensity at used and available locations for each animal-year home range. We then analyzed these data using the following model:

$$U_{R\mathrm{i}} = \beta_0 + \beta_R\,(A_{R\mathrm{i}}) \qquad (3)$$

where R indicates the recreation type (motorized or nonmotorized); $U_{R\mathrm{i}}$ = the average recreation intensity at used locations of each animal-year i; β_0 = y-intercept, β_R = slope of the functional response; and $A_{R\mathrm{i}}$ = the average recreation intensity at available locations within the home range of animal-year i. The null hypothesis is $\beta_R = 1$ (proportional use), while $\beta_R < 1$ indicates decreasing use and $\beta_R > 1$ indicates increasing use as availability increases.

Results

In this Final Report, we focus primarily on modeling and analytical results as the key final products of this multi-year research effort. We have presented field-based results throughout the life of the research effort within Annual Progress Reports including data collection efforts and data summaries, and we recommend reviewing the progress reports for these details, available at www.roundriver.org/wolverine.

Wolverine trapping and location data

We captured 24 individual wolverines over five years of live-trapping, with two years spent within most individual study areas though the McCall study area had four years of trapping efforts (Appendix A). We did not successfully identify the presence of wolverines in either the Trinity Mtns (part of the Sawtooth study area) or the Centennial Mtns (part of the West Yellowstone study area), and we did not identify or capture any female wolverines in the Tetons Mtns or any wolverines in the southern portion of the Tetons, despite ≥2 years of high effort in each area (Appendix A). We radio-collared the 24 wolverines (11 females, 13 males), and recaptured 11 of these animals for 2 – 4 years for a total of 39 animal-years. We obtained >5 weeks of data from 18 (10 females, 8 males) animals and 25 animal-years, averaging 2101 locations/animal-year between mid-Jan and end of March (see Appendix A). An additional nine animal-years (5 female animal-years with 6,841 locations and 4 male animal-years with 9,954 male locations) were used for model validation and four collared animals either slipped their collar or otherwise could not be found and no data were collected. Raw fix-rates were 75.8%, yet 78% of failed GPS attempts were associated with clustered behavior and were thus imputed. After correcting for missed locations, our corrected fix-rate was 94.7%, providing 53,301

Table 1. Summary of the male and female wolverines (*Gulo gulo*) GPS collar locations and home range estimates during winter seasons (2010-2015) in Idaho, Wyoming and Montana as part of research examining wolverine responses to winter recreation. Home range areas were estimated using a local convex hull non-parametric kernel method (Getz et al. 2007).

	Individuals	**Animal-Years[1]**	**Ave # locations ± SD**	**Location count range (min – max)**	**Ave home range (km^2) + SD**	**Min – Max of home range sizes (km^2)**
Males	8	12	2590 ± 677	806 - 3778	1273 ± 471	401 – 2158
Females	10	13	1894 ± 547	1247 - 3079	289 ± 92	126 – 420

[1] Animal-years indicates the total number of winter seasons cumulatively monitored accounting for multiple seasons of monitoring of some individual animals

locations used in the spatial modeling and >10,000 for model validation. The average size of female winter home ranges was smaller than male winter home ranges (Table 1, Appendix A).

Recreation Monitoring

Every study area had at least one year of GPS-based recreation tracking, infra-red trail use counts and aerial surveys, with most study areas having two years of recreation monitoring. We recorded 5,899 GPS tracks of combined length of 198,019km (Table 2). While we recorded a diversity of backcountry recreation types (Appendix C), snowmobiling was the most popular motorized backcountry recreation while skiing was the most popular non-motorized recreation. More non-motorized recreation tracks were collected (3,125) than motorized (2,956) and hybrid types of recreation were limited (237 tracks). The vast majority of non-motorized recreation tracks were collected in the Teton study area, with localized areas of non-motorized recreation in other study areas (Table 2). Snowmobile tracks were longer (average of 60km) than ski tracks (average of 10km) and snowmobile tracks constituted 82% of our total track length. Snowmobiling was a common recreation activity across all of our study areas. Heli-ski only occurred within our Sawtooth study area and cat-ski recreation was only present in the McCall

Table 2. The number (%) of motorized and non-motorized recreation GPS tracks collected in our study areas, the annual average number of recreationists sampled (carrying or in a group with a GPS), the average annual trail use counts from infra-red trail use counters, and the estimated proportion of total use that we sampled (total people represented by GPS tracks/total use).

Recreation Type	McCall	Sawtooths	West Yellowstone	Tetons
GPS tracks, motorized	1620 (93%)	755 (54%)	386 (98%)	195 (8%)
GPS tracks, non-motorized	118 (7%)	613 (46%)	9 (2%)	2385 (92%)
Ave annual number of recreationists represented by GPS tracks	4,125	2,596	1,389	3,568
Average annual recreation visits	16,173	6,149	7,215	23,387
Sampling effort	25.5%	42.2%	19.3%	15.3%

study area. We established trail use counters at 25 sites, with most sites monitored for two years. The total number of recreation visits varied considerably across our study areas, reflecting the relative popularity of each study area as a destination for recreationists traveling from other areas (Table 2). The Teton and the McCall study areas received the highest use with >23,000 and >16,000 visits annually, respectively. The proportion of recreationist sampled using GPS tracking also varied based partly on the total recreation use but also based on localized access patterns, from 42% in the Sawtooth study area to 15% in the Tetons study area (Table 2).

Winter recreation occurred in 12.5% of our study area, and the spatial extent and relative intensity of both motorized and non-motorized winter recreation varied notably within and across study areas (Table 3, Figures 2 - 5). In the McCall study area (Table 3, Figure 2), the most widespread and intense recreation occurred in the north (covering approximately 16% of the Payette NF portion of the study area), and included extensive motorized recreation adjacent to a developed ski area and backcountry cat-ski activities. The lowest overall levels of winter recreation occurred across much of our Sawtooth study area with <5% disturbance from each of motorized and non-motorized recreation activities (Table 3) though recreation did have areas of

high localized intensity, and the Trinity Mtns had extensive motorized recreation covering 32% of the area (Figure 3). The Sawtooth area also included an area used for heli-ski. Relatively high levels of winter recreation levels were recorded in the West Yellowstone area (Table 3, Figure 4), with 50% of the Centennial Mtn portion of the study area within the motorized recreation footprint. One male wolverine home range extended north of our recreation monitoring area and into the southern Madison Mtns; portions of this northern area had extensive motorized recreation based on our aerial surveys resulting in a significant data gap (Figure 4). The Teton study area included a diverse array of winter recreation (Table 3, Figure 5). Motorized recreation was absent from the Grand Teton National Park, but non-motorized recreation occurred in 14% of the monitored Park area. The areas west of the Park, within the Caribou-Targhee NF support both motorized and non-motorized use including developed and out-of-bounds skiing associated with the Grand Targhee Resort. We were unable to adequately sample motorized recreation in portions of this area and based on our aerial recreation surveys (Figure 5) it is more widespread and intense than suggested by our recreation covariates. The highest overall winter recreation levels were in the southern Tetons including the Teton Pass area of the Caribou-Targhee and Bridger-Teton NFs (Table 3, Figure 5). We recorded >50% of this area with winter recreation, primarily as non-motorized winter recreation (47%), this also areas of motorized recreation as well as the developed and out-of-bounds skiing associated with the Jackson Hole Ski Resort (Figure 5).

The spatial extent and relative intensity of backcountry winter recreation also varied within and across wolverine home ranges. Motorized recreation, on average, occurred in 22% and 14% of female and male home ranges, respectively, but varied greatly from a low of <1% to a high of 50%. In general, non-motorized winter recreation has a smaller footprint in most of our

study areas covering <5% of home ranges on average, and two females were not exposed to non-motorized recreation. The Tetons study area had more non-motorized recreation than other study areas (Table 3, Figure 5) and the male wolverine residing there was exposed to higher non-motorized winter recreation levels covering 10% of his home range. Average recreation intensity of motorized recreation ranged from 0.00025 – 0.422 within home ranges. Given the smaller footprint of non-motorized recreation, it is not unexpected that the maximum average non-motorized recreation intensity value is lower, with a range of values of 0.001 – 0.093 within home ranges.

Table 3. Summary of the recreation footprint by study area, broken out by Administrative area or by distinct mountain ranges (see Figures 1); the proportion of each area in the motorized recreation footprint and in the non-motorized recreation footprint are estimated by our GPS track-based recreation maps.

Study Area[1]	**Study Area (km^2)**	**Area (%) Motorized Recreation (km^2)**	**Area (%) Non-motorized Recreation (km^2)**
McCall			
Payette NF	2,553	419 (16%)	47 (2%)
Boise NF	620	37 (6%)	1 (<1%)
Sawtooth			
Sawtooth NF	2,776	125 (5%)	72 (3%)
Sawtooth NRA	2,142	99 (5%)	54 (3%)
Trinity Mtns (BNF)	385	124 (32%)	0
West Yellowstone			
Henry Mtns (CTFN, CGNF)	250	50 (20%)	6 (2%)
Centennial Mtns (CTFN, CGNF)	395	196 (50%)	0
Tetons			
Teton National Park	477	0	67 (14%)
Northwest Tetons (CTFN)	588	41 (7%)	37 (6%)
South Tetons/Pass (CTFN, BTNF)	240	12 (5%)	113 (47%)
Mosquito Cr (CTFN, BTNF)	92	23 (25%)	0

[1] CTFN: Caribou-Targhee NF, CGNF: Custer-Gallatin NF; BTNF: Bridger-Teton NF

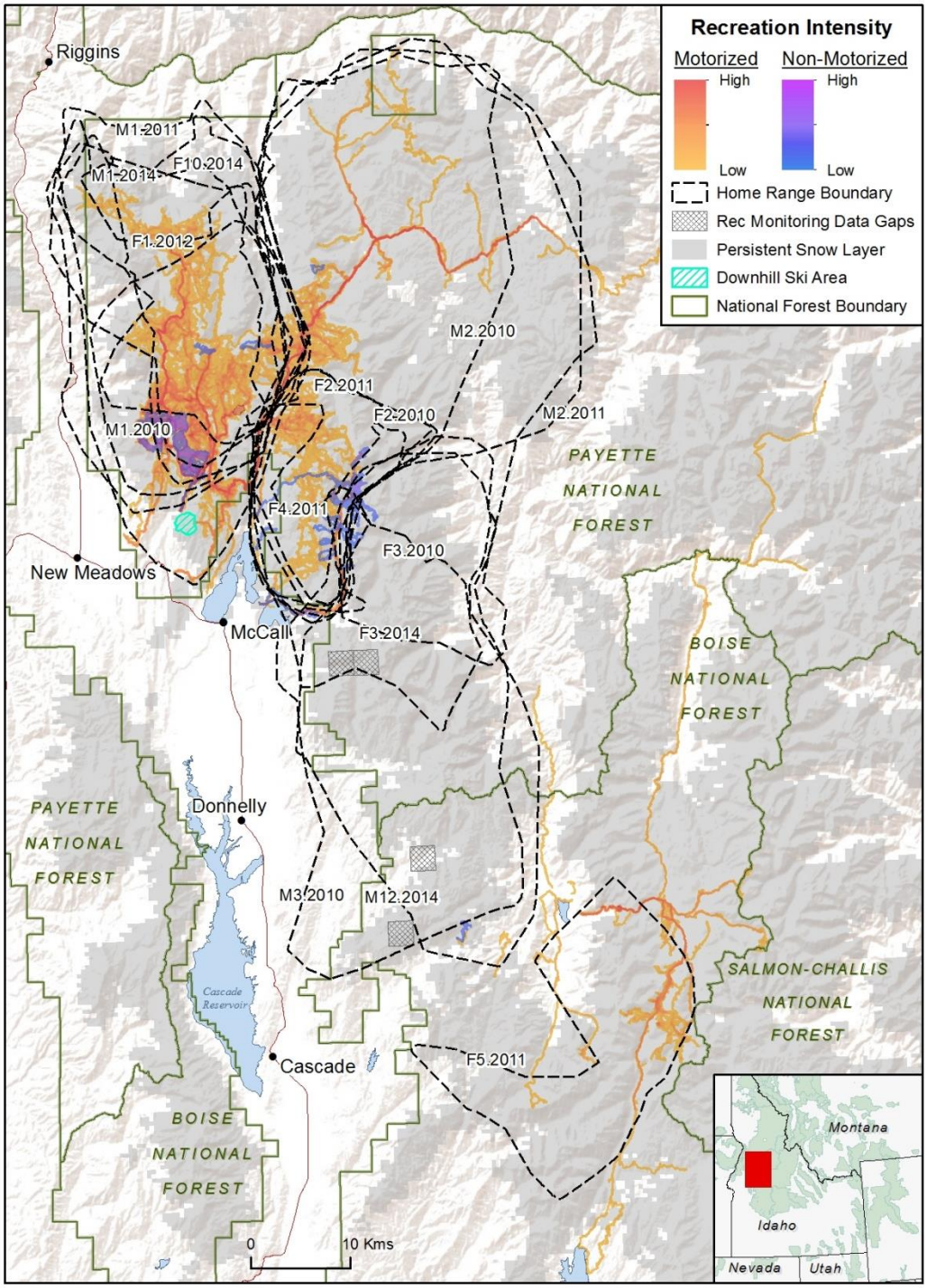

Figure 2. Map of wolverine (*Gulo gulo*) winter home ranges (2010-2014) and estimated backcountry winter recreation relative intensity in the McCall, Idaho study area as estimated based on GPS tracks collected from volunteer recreationists (2010-11) and used to develop recreation maps. Square or rectangular hatched areas indicate areas where we had gaps in GPS track sampling based on aerial recreation surveys.

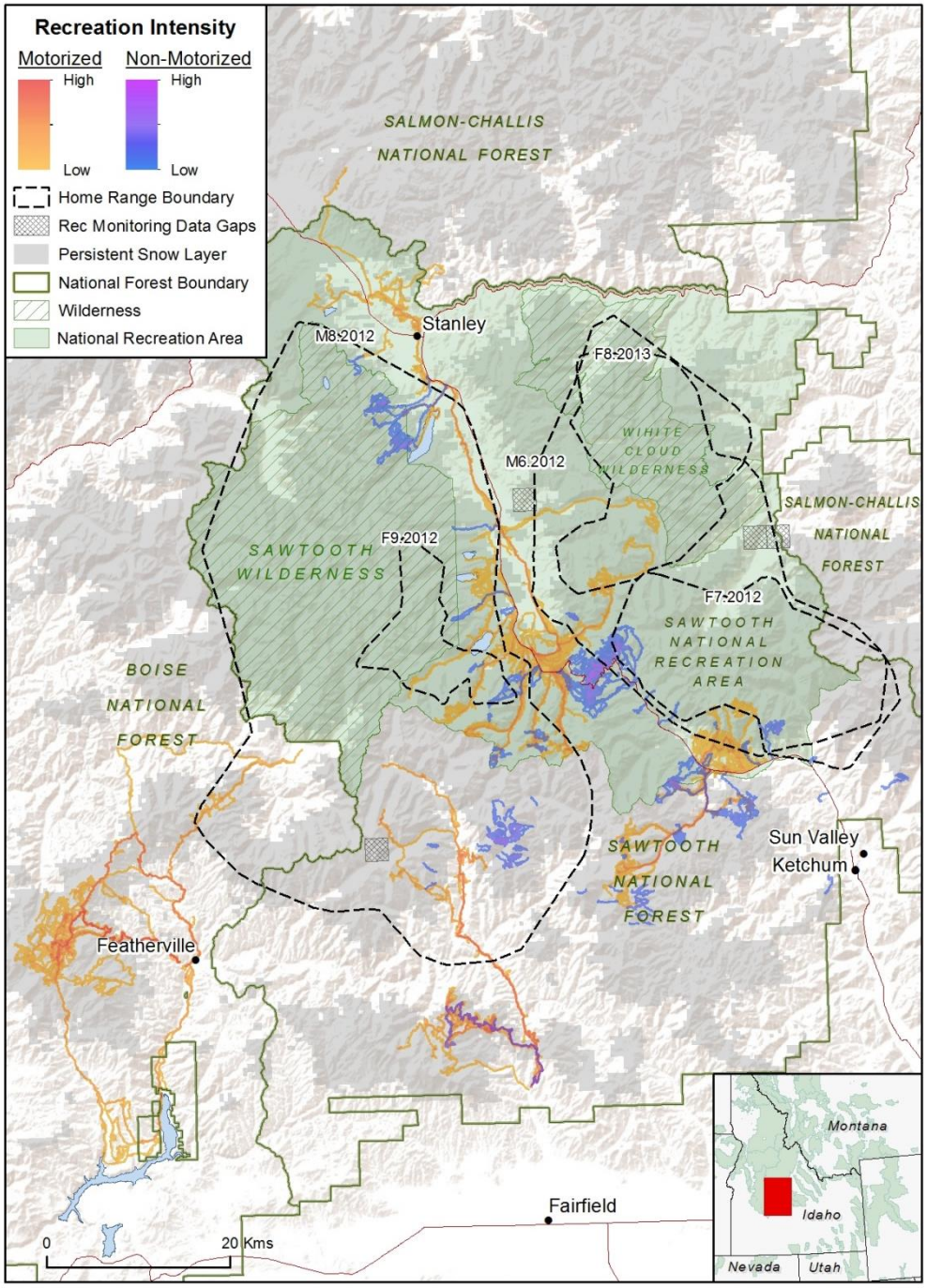

Figure 3. Map of wolverine (*Gulo gulo*) winter home ranges (2012-2013) and estimated backcountry winter recreation relative intensity in the Sawtooth study area as estimated based on GPS tracks collected from volunteer recreationists (2012-13) and used to develop recreation maps. Square or rectangular hatched areas indicate areas where we had gaps in GPS track sampling based on aerial recreation surveys.

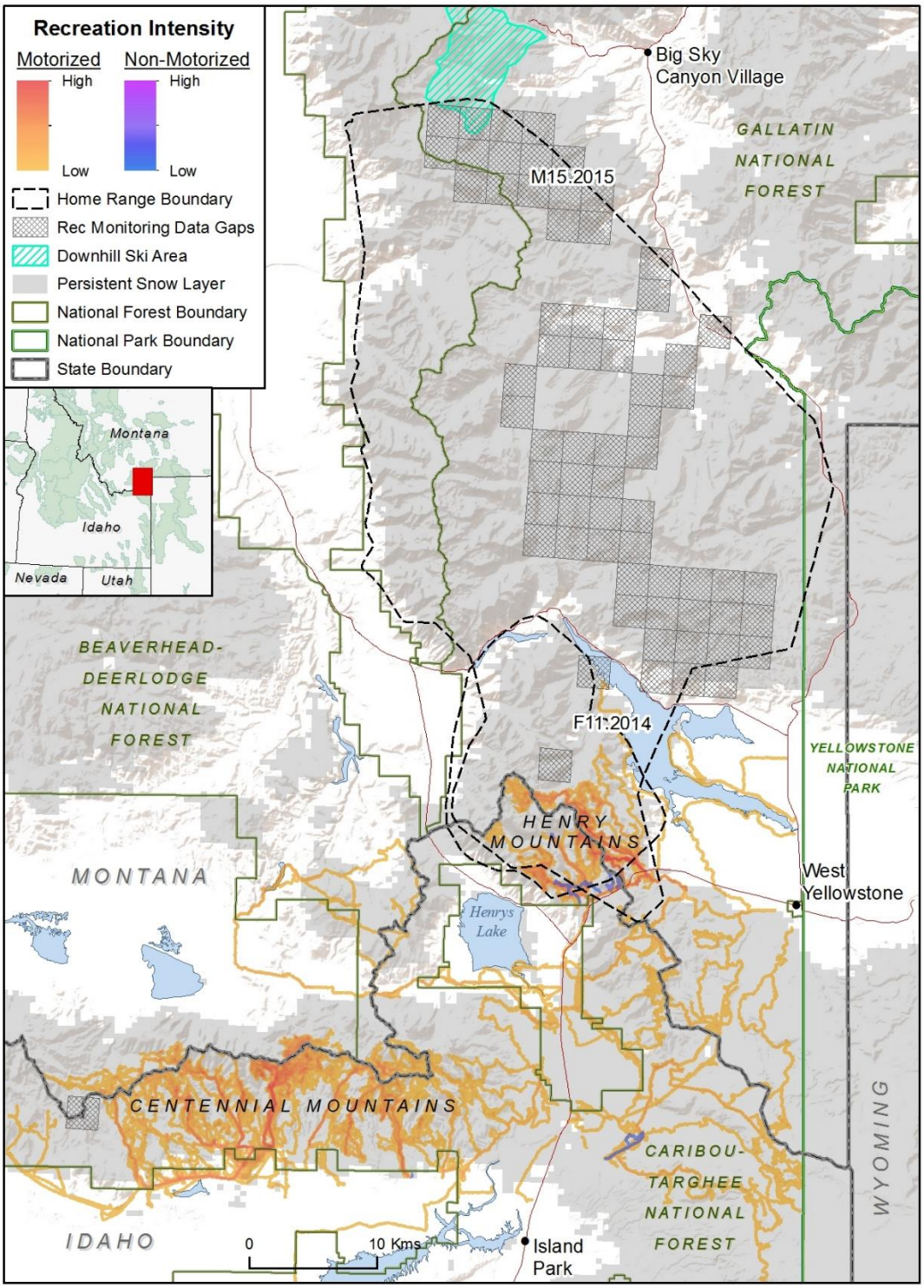

Figure 4. Map of wolverine (*Gulo gulo*) winter home ranges (2014-2015) and estimated backcountry winter recreation relative intensity in the West Yellowstone study area as estimated based on GPS tracks collected from volunteer recreationists (2014-15) and used to develop recreation maps. Square or rectangular hatched areas indicate areas where we had gaps in GPS track sampling based on aerial recreation surveys.

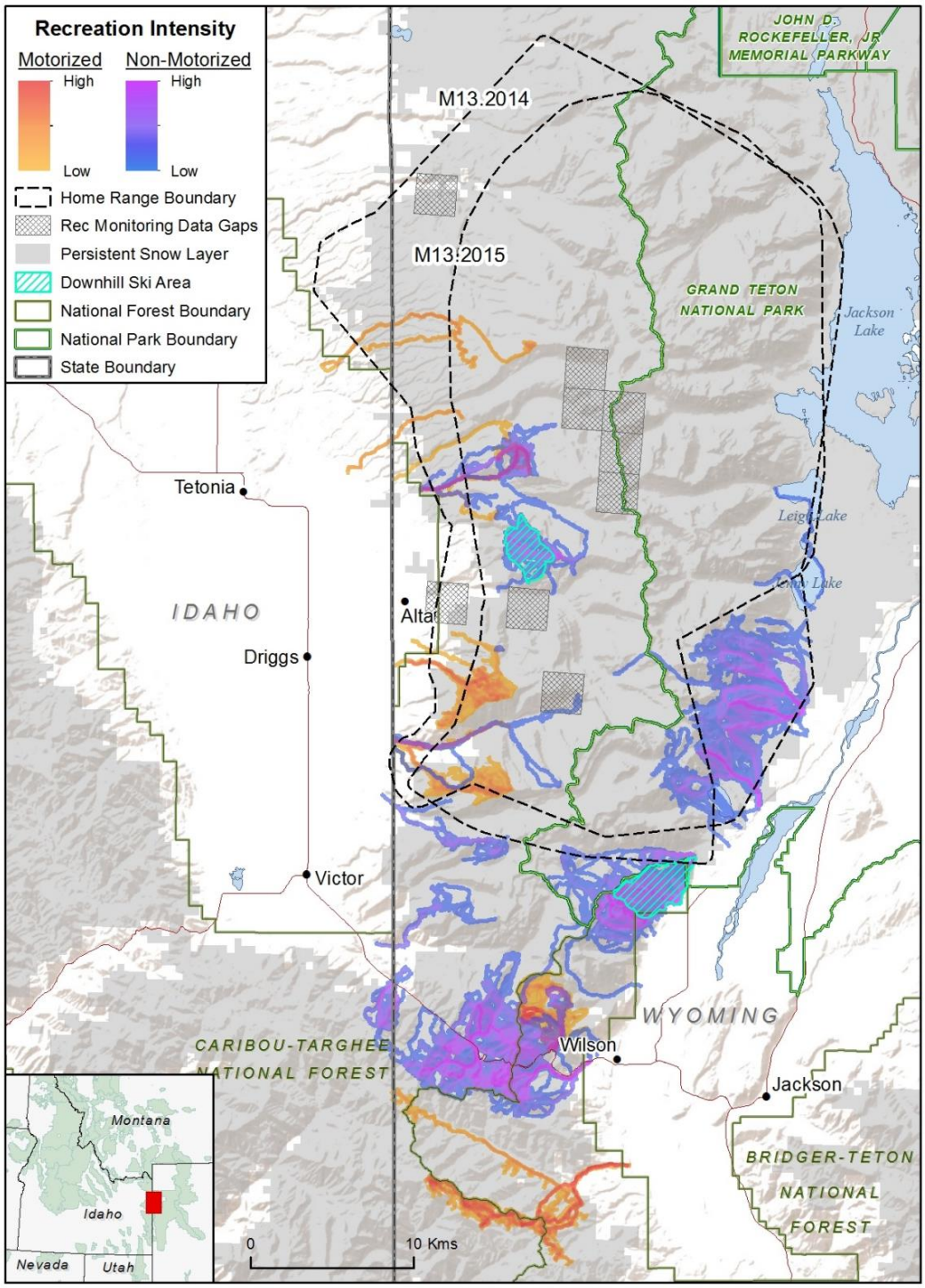

Figure 5. Map of wolverine (*Gulo gulo*) winter home ranges (2014-2015) and estimated backcountry winter recreation relative intensity in the Teton study area as estimated based on GPS tracks collected from volunteer recreationists (2014-15) and used to develop recreation maps. Square or rectangular hatched areas indicate areas where we had gaps in GPS track sampling based on aerial recreation surveys.

Environment resource selection function

The summed AIC score of the male and female environment-only models (i.e., potential habitat models) was notably lower than the AIC of the global with ΔAIC of 1,669, suggesting that resource selection by males and female differed significantly, thereby justifying separate treatment. The male wolverine model showed that resource selection was best characterized by nine environmental variables, while female wolverine habitat selection was best characterized by ten covariates. The male model uniquely included covariates for distance to roads and the proportion of lower elevation grass and shrub land cover types. Alternatively, the female model included talus, persistent spring snow cover and forest edge:area covariates, which were not identified as important predictors of male habitat use. All covariates were statistically significant (Table 4). The models shared several covariates including topographic position index, quadratic form of slope, distance to forest edge, solar insulation and the percent cover of forest, riparian and montane open cover types.

Model coefficients were standardized, allowing for within-model comparison and ranking of β coefficients for relative importance. Both sexes showed strong selection (ranked first in β coefficient importance) for drainage or valley bottom topography (β_{female} = -0.31, SE = 0.01; β_{male} = -0.42, SE = 0.01) as indicated by the negative coefficient for TPI (Table 4), and this is combined with the avoidance of steep slopes indicated by the negative coefficient of slope^2 (β_{female} = -0.27, SE = 0.01; β_{male} = -0.17, SE = 0.01). Selection for fir-dominated forests by males (β_{male} = 0.37, SE = 0.01) ranked second in coefficient importance. While females also selected for fir dominated forests (β_{female} = 0.05, SE = 0.01), this selection coefficient ranked second to last in importance (Table 4). Both sexes show a selection for areas near forest edge (β_{female} = -

Table 4. Standardized model coefficients betas and standard errors for environment RSF models for wolverines (*Gulo gulo*) monitored in Idaho, Wyoming and Montana (2010-2015), with the random effect standard deviation also included. Blank cells indicate covariates not identified for inclusion in the specified model. Negative Beta values indicate selection for lower values of the covariate.

	Female Model			**Male Model**		
	Beta	Beta St. Error	Rank	Beta	Beta St. Error	Rank
Distance to edge	-0.21	0.01	3	-0.16	0.01	6
Distance to roads				-0.21	0.01	4
Fir forest	0.05	0.01	10	0.37	0.01	2
Foothill shrub & grass				-0.06	0.01	10
Forest edge:area	0.12	0.01	6			
Montane shrub & grass	-0.09	0.01	7	-0.06	0.01	9
Riparian	0.07	0.01	9	0.11	0.01	8
Slope	-0.02	0.01	11	0.25	0.01	3
Slope2	-0.27	0.01	2	-0.17	0.01	5
Solar insolation	-0.15	0.01	4	0.13	0.01	7
Spring snow	0.09	0.01	8			
Talus	0.13	0.01	5			
TPI	-0.31	0.01	1	-0.42	0.01	1
Intercept	0.20	0.04		0.07	0.03	
Random effect		0.13			0.11	

0.21, SE = 0.01; β_{male} = -0.16, SE = 0.01), while they avoid montane shrub and grass land cover (β_{female} = -0.09, SE = 0.01; β_{male} = -0.06, SE = 0.01), and select for riparian areas (β_{female} = 0.07, SE = 0.01; β_{male} = 0.11, SE = 0.01).

Wolverines displayed some notable differences in their resource selection patterns between sexes (Table 4). Males selected areas close to secondary roads (indicated by a negative scaled RSF coefficient: β_{male} = -0.2, SE = 0.01) and avoided (indicated by a negative coefficient) foothill open areas (β_{male} = -0.06, SE = 0.01). Alternatively, females selected for talus (β_{female} = 0.13, SE = 0.01), for higher forest patch edge:area ratios (β_{female} = 0.12, SE = 0.01) indicating smaller, more fragmented forest patches and for areas with persistent spring snow (β_{female} = 0.09,

Table 5. Resource selection function models developed for wolverines (*Gulo gulo*) monitored in Idaho, Wyoming and Montana as part of research investigating wolverine responses to winter recreation (2010-2015). Model 1 for male and female are the environment only models. Models 2-6 use the environment covariates identified in Model 1 and winter recreation covariates to test hypotheses about the responses of wolverines to different characteristics of winter recreation. Models 2 – 6 were developed separately for males and females.

Models	**Variables**	**Male ΔAIC**	**Female ΔAIC**
Model 1: Female Potential Model	TPI + slope + slope^2+ fir forest + distance to edge + talus + riparian + montane shrub & grass + solar insulation + forest edge:area + spring snow	-	537.79
Model 1: Male Potential Model	TPI + slope + slope^2+ fir forest + distance to edge + distance to roads + riparian + montane shrub & grass + foothill open + solar insulation	41.71	-
Model 2: Potential Model + Rec 1	Model 1 + winter recreation footprint	43.2	286.96
Model 3: Potential Model + Rec 2	Model 1 + distance to linear recreation + dispersed motorized footprint + dispersed non-motorized footprint	355.71	266.1
Model 4: Potential Model + Rec 3	Model 1 + relative intensity of all winter recreation	0	181.44
Model 5: Potential Model + Rec 4	Model 1 + distance to linear recreation + relative intensity dispersed recreation	283.5	60.82
Model 6: Potential Model + Rec 5	Model 1 + distance to linear recreation + relative intensity of dispersed motorized recreation + relative intensity of dispersed non-motorized recreation	249.55	0

SE = 0.01). Areas of high solar insolation were avoided by females (β_{female} = -0.15, SE = 0.01) but selected by males (β_{male} = 0.13, SE = 0.01). Cross-validation of female and male environmental models had similar Spearman rank correlations (r_s) of 0.92 and 0.91, respectively. Out-of-sample data validation similarly showed strong validation (female r_s = 0.86, male r_s = 0.95).

Environment and winter recreation resource selection functions

Of the six models developed for male wolverines (Table 5; Appendix D), Model 4 (combined recreation intensity) had the lowest ΔAIC (Appendix D) and defined our realized

habitat model for male wolverines. The next ranked models were the environment-only model (Model 1) and the recreation footprint model (Model 2) with ΔAIC of 41.7 and 43.2, respectively (Table 5). There was a significant avoidance of areas with higher recreation intensity (β_{male} = -0.06, SE = 0.01) though the overall importance of this was relatively low (ranked 9 out of 12 covariates) compared to other coefficients in Model 4 (Table 6). Ten-fold cross-validation of this model showed high support for the model (r_s = 0.91), and the out-of-sample male locations also validated very well (r_s = 0.90).

The best-supported habitat model for female wolverines was Model 6 (Table 5, Appendix D), with covariates for distance to linear recreation and intensity of motorized and non-motorized recreation; all covariates were significant (p-value < 0.01). The second-ranked female model (ΔAIC = 11.8) included the distance to linear recreation and a combined relative intensity dispersed recreation (both motorized and non-motorized). Beta coefficients of Model 6 show females strongly avoided dispersed motorized winter recreation (β_{female} = -0.31, SE = 0.02) as the intensity of the recreation increased and this covariate is the second ranked covariate predicting female resource selection (Table 6). Females also strongly avoided areas of higher intensity dispersed non-motorized winter recreation (β_{female} = -0.19, SE = 0.01), with this predictor ranked fifth. Females avoided areas near recreated roads and groomed routes as indicated by the positive coefficient (β_{female} = 0.08, SE = 0.01), and this covariate ranked 10 out 14. Similar to the male model, both the cross validation and out-of-sample model validation showed strong support (rs = 0.91, rs = 0.83), respectively.

Model 6 did not provide the best overall predictor of male resource selection (Model 4 had the lowest ΔAIC) but it allowed us to compare male response to female responses (Model 6) and to evaluate the differential effects of recreation type on male wolverine responses (Table 6).

Table 6. Standardized model coefficients betas, standard errors and importance rank for male and female wolverine (*Gulo gulo*) RSF models including environment and winter recreation covariates, based on wolverine GPS collar data collected in Idaho, Wyoming and Montana (2010-2015). Female Model 6 and Male Model 4 were identified as the best models based on AIC values, while Male Model 6 provides male responses to specific recreation types. The random effect standard deviation is shown. Blank cells indicate covariates not identified for inclusion in the specified model. The ranked importance of each covariate indicated based on the absolute value of the standardized coefficient. Negative Beta values indicate selection for lower values of the covariate.

	Female Model 6			**Male Model 4**			**Male Model 6**		
	β	SE	Rank	β	SE	Rank	β	SE	Rank
Distance to edge	-0.21	0.01	4	-0.16	0.01	6	-0.16	0.01	4
Distance to roads				-0.22	0.01	4	-0.10	0.01	9
Fir forest	0.05	0.01	14	0.36	0.01	2	0.41	0.01	2
Foothill shrub & grass				-0.06	0.01	11	-0.05	0.01	11
Forest edge:area	0.12	0.01	9						
Montane shrub & grass	-0.06	0.01	13	-0.06	0.01	10	-0.04	0.01	12
Riparian	0.08	0.01	11	0.11	0.01	8	0.11	0.01	8
Slope	-0.07	0.01	12	0.25	0.01	3	0.22	0.01	3
Slope^2	-0.25	0.01	3	-0.16	0.01	5	-0.16	0.01	5
Solar insolation	-0.15	0.01	6	0.13	0.01	7	0.13	0.01	7
Spring snow	0.14	0.01	7						
Talus	0.13	0.01	8						
TPI	-0.32	0.01	1	-0.42	0.01	1	-0.41	0.01	1
Distance to recreated roads	0.08	0.01	10				0.02	0.01	13
Intensity of all recreation				-0.06	0.01	9			
Dispersed motorized recreation intensity	-0.31	0.02	2				-0.07	0.01	10
Dispersed non-motorized recreation intensity	-0.19	0.01	5				-0.15	0.02	6
Intercept	0.17	0.04		0.07	0.03		0.07	0.03	
Random effect		0.13			0.11			0.11	

All covariates in Model 6 were significant (or nearly so) in predicting male wolverine habitat use (Table 6). Similar to females, males avoided areas of higher intensity dispersed motorized recreation (β_{male} = -0.07, SE = 0.01), higher intensity non-motorized dispersed recreation (β_{male} = -0.15, SE = 0.02) and areas close to recreated roads and groomed routes (β_{male} = 0.02, SE = 0.01). But the relative importance of winter recreation to males was more muted than for females. The importance of motorized dispersed winter recreation to male wolverine resource

selection ranked 10 out of 13, while avoidance of non-motorized dispersed winter recreation was similar to females at a rank of 6. Avoidance of linear recreation by male wolverines was marginally insignificant ($p = 0.056$) and this predictor was ranked of lowest relative importance (Table 6).

Potential and realized habitats

The selection coefficients for environmental covariates were nearly identical between the environment-only (potential) habitat model and the selected model including winter recreation (realized habitat model) for both males and females (Tables 4 and 6). This indicated that wolverine selection for these environmental characteristics were stable and relatively independent of human recreation. Across the study area, the classification of potential habitat quality resulted in the prediction of 30% high, 30% moderate, and 40% low quality habitat, with 84% of animal locations found in moderate (28%) and high (56%) quality habitats. Winter recreation resulted in indirect habitat loss of moderate and high quality wolverine habitats as measured by areas transitioning to a lower class when comparing the realized habitat map to the potential habitat map (Figures 6). On average, 14% of female habitat and 11% of male habitat was degraded to lower habitat classes across the study area; calculated as proportions of available moderate and high quality indicates loss of these higher quality habitats range from <10% to >70% within individual home ranges (Appendix D). Both the amount and severity of indirect habitat loss varies across home ranges and is related to the average relative intensity of winter recreation within home ranges (Figure 7a, Appendix D). The incremental effects of winter recreation are high across home ranges with relatively low winter recreation levels, but the rate of indirect habitat loss tend to plateau across home ranges with the highest levels of recreation use (Figure 7a). Female wolverines experienced a higher degree of degradation to high quality

habitat (Figure 7b), represented by high quality habitat reduced to low quality habitat (change of 2 classes; Appendix D); an average of 9.6% of available female high quality habitat but only 0.2% of available male high quality habitat was degraded to low quality across the study area.

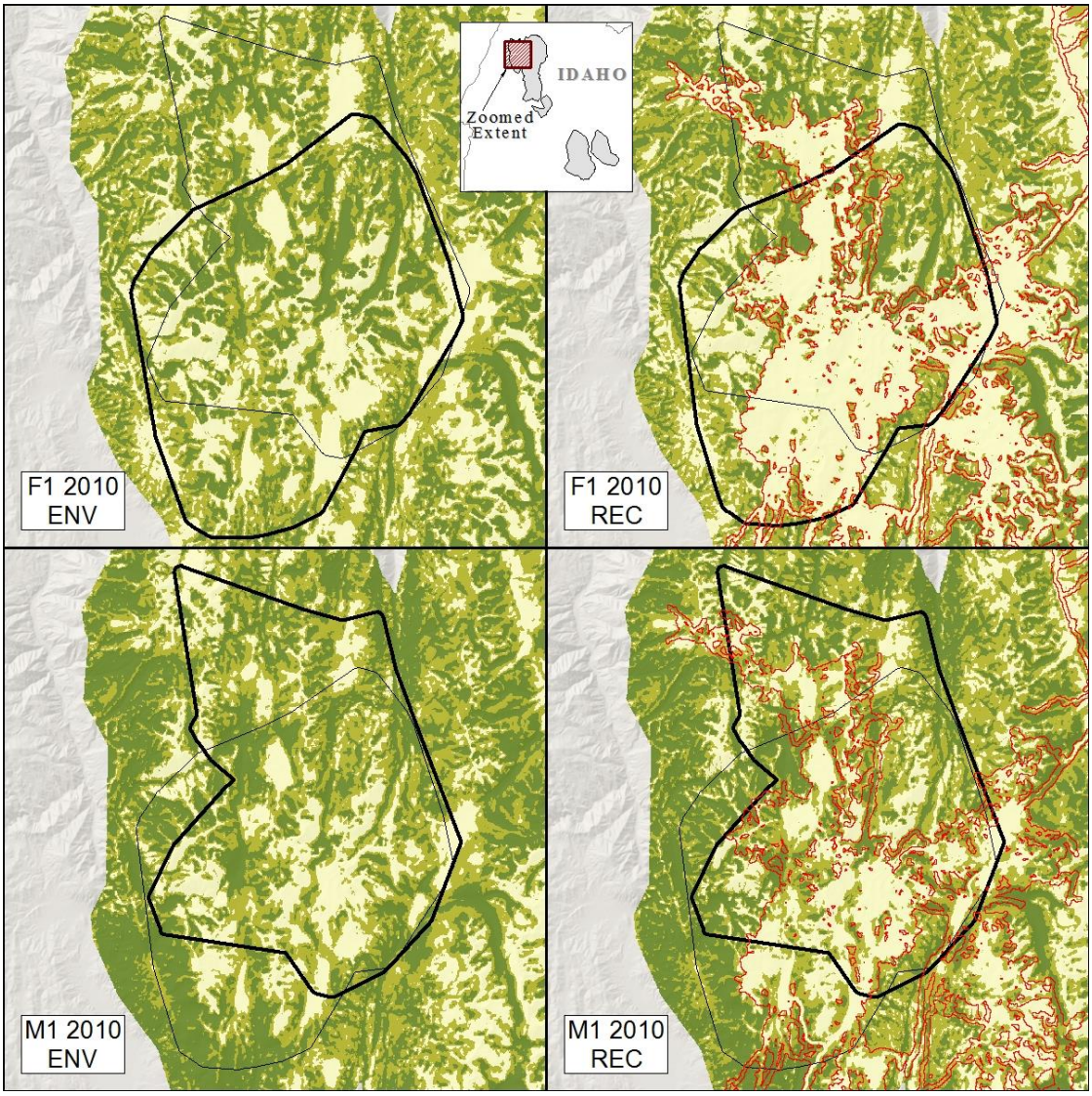

Figure 6. Example maps of potential winter wolverine (Gulo gulo) habitat predicted by the environment only model in the left-hand panels for females (top) and males (bottom) in a portion of the McCall, Idaho study area. The right-hand panel maps the realized habitat models that include winter recreation, and show the change in habitat quality. Three classes of habitat are shown: high quality in dark green, moderate quality in light green and low quality habitat in beige. The bold black lines are the home range boundaries for the animal-year indicated and the thinner black line identifying the overlapping animal of the other sex to facilitate comparing between the upper and lower panels. The red lines indicate the outline of the winter recreation footprint.

These responses translated into more pronounced indirect habitat loss for females compared to males within the same landscapes. For example, a male and female that resided in the same landscape had similar average recreation intensity within their respective home ranges of 0.37 and 0.34 and recreation footprints that covered 47% and 35% of their home ranges (Figure 6). The female experienced predicted indirect habitat losses of 36% and 38% of her high and moderate quality habitats, and 21% of the high-quality habitat was predicted to be degraded to low quality habitat. In contrast, the male experienced predicted habitat degradation to 20% of high and moderate quality habitats, with only 0.9% of high quality habitats predicted to be degraded to low quality habitat.

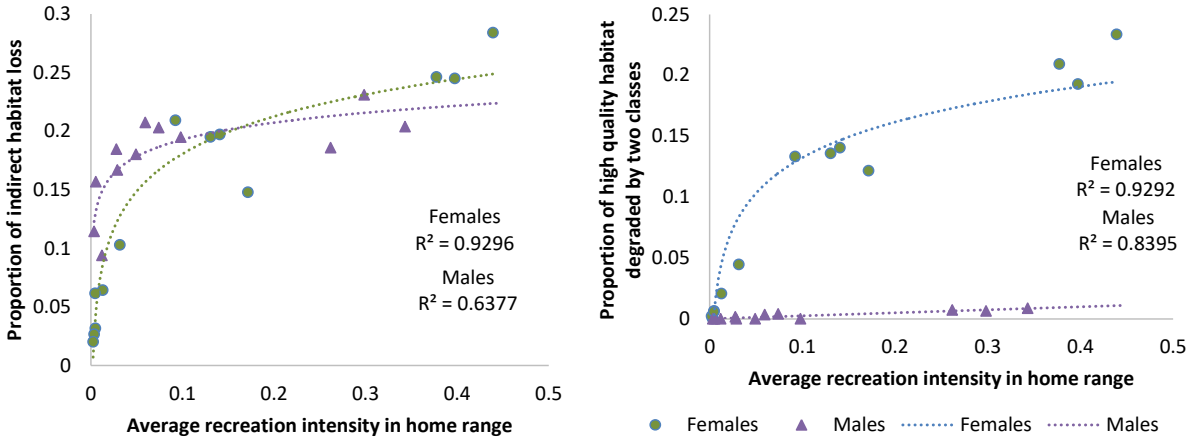

Figure 7. The percent of habitat degraded (left panel) and the severity of that degradation (right panel) across home ranges of wolverines with varying levels of winter recreation intensity. Degradation is defined by the percent of high and moderate quality habitat that degrades by at least 1 class, while severity of the degradation is measured by the proportion of the degradation that is high quality habitat dropping 2 classes to low quality habitat.

Functional Responses to Winter Recreation

The availability of motorized and non-motorized recreation as defined by the mean recreation intensity within home ranges varied notably. The mean motorized recreation intensity ranged from 0.00025 – 0.422 within home ranges. Non-motorized recreation occurred generally within smaller areas and at lower intensity, with a range of values of 0.001 – 0.093 within home ranges. Wolverines displayed negative functional responses in habitat use related to the average relative intensity of both motorized and non-motorized winter recreation (Table 7, Figure 8). Habitat use of areas with motorized recreation decreased as the availability of these areas increased within male and female home ranges, with slopes of 0.22 (R^2 = 0.4) and 0.38 (R^2 = 0.72), respectively. Similarly, both males and females showed negative functional responses to non-motorized winter recreation, even at the relatively lower average intensities this recreation occurred at. Habitat use of areas with non-motorized recreation declined as the availability of these areas increased within their home ranges, with slopes significantly <1: 0.32 (R^2 = 0.80) and 0.10 (R^2=0.13) for males and females, respectively. The male functional response was driven by the high average intensity of non-motorized recreation that one male experienced (2 animal-years) in the Tetons. If the Teton animal is removed, male wolverines do not show a significant functional response to non-motorized winter recreation (Table 7). Additionally, the low R^2 of the female functional response to non-motorized recreation indicates high variation and therefore a weak effect.

Table 7. Functional responses of wolverines (*Gulo gulo*) to dispersed motorized and non-motorized winter recreation measured as the proportional use of recreation intensity compared to the average recreation intensity across home ranges of individual animals. Null hypothesis is: H_0: $\beta_R = 1$, with $\beta_R < 1$ indicating increasing avoidance of recreation with increasing availability and $\beta_R > 1$ indicating increasing selection with increasing availability.

Model	Male β_0	Male β_R (95% CI)	R^2	Female β_0	Female β_R (95% CI)	R^2
Motorized	0.02	0.22 (0.05 – 0.40)	0.40	0.01	0.38 (0.24 – 0.51)	0.72
Non-motorized	0.00	0.32 (0.25 – 0.39)	0.89	0.00	0.10 (-0.05 – 0.24)	0.13
Non-motorized, removing the Teton male	0.001	0.06 (0.17 - -0.05)	0.07	-	-	-

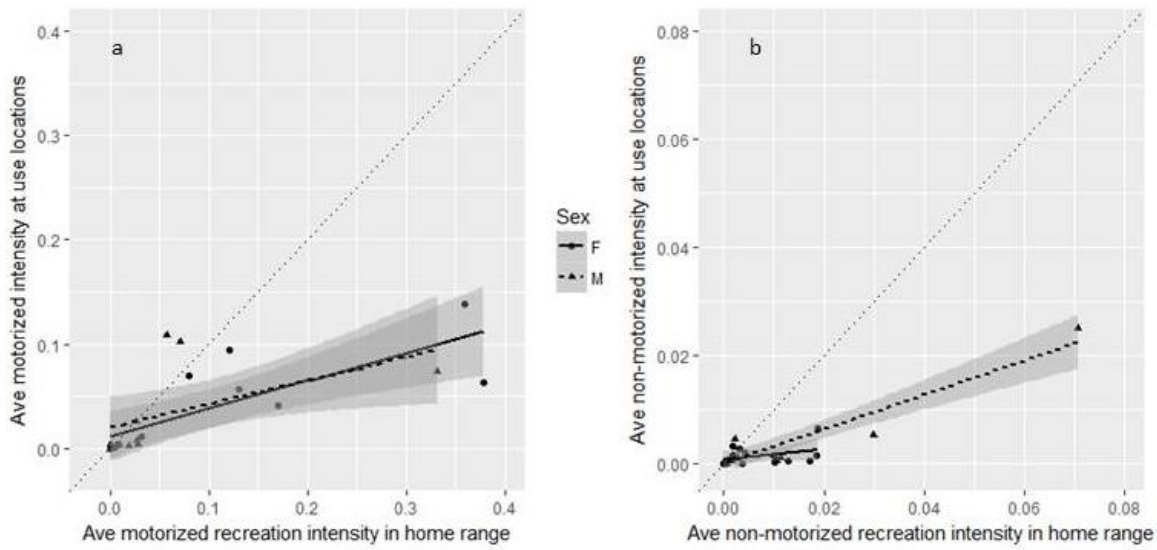

Figure 8. Functional responses of male and female wolverines (*Gulo gulo*) habitat use to the available relative intensity of (a) motorized and (b) non-motorized winter recreation in individual home ranges. The y-axis shows the average relative intensity of recreation at wolverine locations for each monitored wolverine and x-axis shows the average recreation intensity within the animal home range. The dotted 1:1 slope line indicates the null hypothesis expectation and slope if no functional response were present. Responses below the 1:1 line indicate that use is lower than expected based on availability.

Discussion

We found that male and female wolverines showed some notable differences in the selection for environmental covariates, and that their selection for these covariates was independent of the potential effects of winter recreation. The RSF defining the realized habitat models that included winter recreation covariates showed that both males and females responded negatively to increasing intensity of winter recreation within home ranges. Dispersed recreation activities elicited a stronger response than recreation along roads and groomed routes, with females showing more sensitivity to disturbance than males. The functional responses to dispersed recreation, particularly to motorized dispersed recreation, suggests that avoidance results in potentially important indirect habitat loss when a significant portion of an animal's home range receives recreation use, as it is exactly those animals exposed to higher levels of recreation that are most strongly displaced from these areas. Other wolverines were exposed to winter recreation within only a relatively small portion of their large home ranges, and the functional responses also suggest that this limited exposure may mute the indirect habitat loss. The weak avoidance of areas near linear access used by winter recreationists suggests wolverines may be less sensitive to these linear disturbances.

Wolverine habitat selection

Wolverine occur at low densities in northern latitudes and generally in areas with limited human use and infrastructure, creating a multitude of logistical hurdles in conducting detailed research and monitoring of this species. Prior habitat analyses in the Rocky Mountain portion of the North American wolverine distribution have been primarily at the first or second-order landscape scales (Aubry et al. 2007, Copeland et al. 2007, Copeland et al. 2010, Fisher et al. 2013, Inman et al. 2013), identifying characteristics that predict the distribution or presence of

wolverines, though Krebs et al. (2007) provides a multi-scale analyses of habitat selection. These efforts have indicated that wolverine are found at higher elevations (Copeland et al. 2007, Krebs et al. 2007, Copeland et al. 2010, Inman et al. 2013), in areas associated with late spring snowpack (Aubry et al. 2007, Copeland et al. 2010, Inman et al. 2013), alpine and subalpine habitats (Aubry et al. 2007) or with higher topographic ruggedness (Krebs et al. 2007, Fisher et al. 2013, Inman et al. 2013) compared to the broader landscape. In contrast to the broader association to more rugged terrain, our work demonstrated wolverines select less extreme topography characterized by concave or drainage bottom type topography (negative coefficient of TPI and slope covariates) and forested landscapes (similar to May et al. 2006, Copeland et al. 2007). We also found an avoidance of open alpine and subalpine areas, but that wolverines are found close to these areas as indicated by their selection for areas near forest edges. Within the winter season, wolverines use lower elevations than in the summer including subalpine and mid-elevation forest types (Copeland et al. 2007, Krebs et al. 2007), which is similar to our result of a selection for fir-associated conifer forests and riparian habitat during winter. Drainage bottom, riparian and forested edge habitats may represent good travel paths or more productive habitats (Scrafford et al. 2017) within a generally low productivity, high elevation landscape.

Prior analyses have also consistently identified the presence of spring snow as an important predictor of wolverine distribution, particularly in the southern portion of the species range in North America (Aubry et al. 2007, Copeland et al. 2010, Inman et al. 2013). We found persistent spring snow was moderately important for predicting female habitat use at the third-order of selection (importance rank of 7 out of 14 covariates). In addition, females also selected for cold areas (negative solar insulation covariate), which also would support the selection for areas with persistent snow. We expect that the selection patterns of our females reflect

reproductive denning which has been linked to deep and persistent snowpack (Magoun and Copeland 1998), as 7 of 13 female animal-years represented denning females. Female reproductive dens in Idaho were also associated with high structure such as talus boulders (Magoun and Copeland 1998), which may partially explain our finding that females select for talus, but this covariate was not important for predicting male habitat use. At broader scales, talus selection by wolverines was associated with elevation (Copeland et al. 2007), but we found females selected talus at finest spatial scale tested (Appendix B) and believe this reflects selection for this land cover itself within home ranges. We found that female habitat selection is complex, including characteristics that may be linked to some of the coldest and snowiest habitats as well as characteristics that may represent some of the more productive areas. This complexity in female habitat selection was also described by Krebs et al. (2007) who proposed female selection was driven by a combination of factors including food, predator and human avoidance, while males may also be food-motivated but less risk-averse than females. Copeland et al. (2017) suggest that while food resource availability and distribution are the primary factors shaping female territories, males work toward developing a positive association with females through territory defense and male parental care.

Influence of winter recreation on wolverine habitat selection

Wolverines maintained multi-year home ranges within landscapes that support winter recreation, and some resident animals had >40% of their home range within the footprint of winter recreation suggesting that at some scales wolverines tolerate winter recreation disturbance. Exposure to winter recreation varied notably across study areas and animals despite the focus of this research on areas where backcountry winter recreation is popular. Most animals were exposed to winter recreation within a relatively limited portion of their home ranges, likely

due to recreation use being linked to access such as roads and trails (Olson et al. 2017) combined with the large home ranges of wolverines. In some of the highest recreated landscapes, we did not successfully identify wolverines. Our research highlights the previously unrecognized and unrecorded spatial extent and intensity of backcountry winter recreation in remote landscapes. We expect the patterns of backcountry winter recreation across the extent of wolverine distribution in the western United States to be similar to our findings that some individual animals reside in highly disturbed winter landscapes while others are exposed to relatively low levels of winter recreation. While wolverine home ranges may be notably large, they still represent the minimum spatial requirement necessary to provide for needs of the individual as well as offspring and kin as expressed by the resource dispersion hypothesis (Macdonald and Johnson 2015, Copeland et al. 2017).

Harris et al. (2014) found that the total area disturbed by winter recreation is more important than the intensity of recreation use for northern ungulates. As measured in our study areas, these two metrics are correlated, and it would be difficult to disentangle the responses of wolverines to each independently. Still, models including relative intensity of winter recreation were selected over those models that characterized the footprint of winter recreation, and both within home range and across landscapes wolverines avoid areas with higher intensity winter recreation. The amount of indirect habitat loss is also related to the relative intensity of winter recreation within the home range. Habitat displacement and indirect habitat loss from winter recreation activities have been documented in a diverse array of montane and alpine species. High elevation forest grouse (*Tetrao* sp.) are impacted by backcountry winter recreation including habitat displacement as well as energetic and physiological effects (Patthey et al. 2008, Braunisch et al. 2011, Arlettaz et al. 2015, Coppes et al. 2017b). Endangered mountain caribou

in southern British Columbia have been displaced from high quality winter habitat due to high levels of snowmobile recreation (Seip et al. 2007). In the Teton Mountains of Wyoming, backcountry ski recreation resulted in a 30% loss of high quality winter habitat to bighorn sheep (Courtemanch 2014). Mountain goats avoided otherwise high quality habitat associated with a developed ski area near Banff, Alberta (Richard and Cote 2016). The negative functional responses of wolverines to increasing intensity of winter recreation indicate that individual animals that have the most extensive portions of their home range affected by recreation are also the animals with the strongest avoidance of these areas. Alternatively, we would expect a more muted response by wolverines in areas with low levels of winter recreation as compared to the population average response. As backcountry winter recreation grows in numbers of participants as well as in localized intensity of use and overall footprint, we need to understand the potential effects on wildlife species, particularly on sensitive, special-status or rare species.

Female wolverines appeared to discriminate between different types of winter recreation with the best supported female model containing separate predictors for linear recreation travel, dispersed motorized recreation and dispersed non-motorized recreation. Females avoid all three forms of winter recreation but the relative importance of each is different. Females show a strong avoidance of areas with dispersed non-motorized recreation (importance rank of 5 of 11), though these areas are limited within home ranges (<5% of home ranges affected by non-motorized recreation on average). Motorized dispersed winter recreation is the second most important predictor of female habitat selection (topographic position is the most important), indicating that this disturbance has a strong influence on female wolverine habitat selection in areas where motorized recreation occurs. This strong avoidance combined with the potential for motorized recreation to cover larger areas may lead to important indirect habitat loss for female wolverines.

Krebs et al (2007) also found that female wolverines avoided areas of winter recreation and argued this supports the hypothesis that female habitat selection is consistent with a risk-averse pattern. In contrast to females, male wolverines do not appear as sensitive to winter recreation in general, with the winter recreation covariate of lower importance (rank of 9 of 11 standardized covariates) in predicting male wolverine habitat selection. Krebs et al (2007) also found that human disturbance was less important for males than females in that 3 of 4 top ranking male habitat models did not include human disturbance and they suggested that male wolverine were less risk-averse than female wolverine.

Despite concerted efforts to identify and trap wolverines in the Tetons, we only captured a single male, estimated age of 13 years based on prior research handling as a subadult. We recorded the highest and most extensive backcountry non-motorized winter recreation in the Teton study area and this animal was exposed to higher levels of non-motorized recreation than other wolverines in our study. He exhibited strong avoidance of non-motorized recreation, but we are cautious in our interpretation of this given our limited information on wolverines exposed to higher levels of non-motorized recreation. Still, the response of this wolverine reinforces our suggestions that the strength of avoidance exhibited by wolverines to non-motorized recreation depends on the intensity of recreation within their home ranges, similar to the functional response of wolverines to motorized recreation. As expected, the removal of the Teton animal from the functional response analysis strongly influenced our results and limited our ability to conclude a negative functional response of male wolverines to non-motorized recreation (Table 7). Thus, it would be useful to perform additional monitoring of male (and female) wolverines that are exposed to higher levels of non-motorized winter recreation such as we recorded in the Teton study area.

Roads and linear winter access

Males were found closer to roads than expected and these roads were identified as an important predictor of male habitat selection but not female selection (suggesting females do not strongly respond to the proximity of roads). In our study, these roads were snow-covered and most were not plowed or maintained for winter use. Research examining wolverine responses to human infrastructure has suggested wolverines avoid roads, roaded areas and development (May et al. 2006, Fisher et al. 2013, Inman et al. 2013, Stewart et al. 2016, Heim et al. 2017). At a landscape scale, the negative association may be partially confounded by the fact that wolverines are naturally not found in lower elevation valley habitats where human infrastructure is higher. We found that within home ranges during winter, human use of roads may be important than the existence of the road itself in determining wolverine responses. Male wolverines were found closer than expected to unused roads but both male and female wolverines avoided areas near roads and groomed routes with winter recreation use, though male avoidance was of low importance (rank 13 of 13). Recent research in northern Canada also found that both males and female wolverines avoided active winter roads, though they may select for some other types of human infrastructure associated with roads that provide potential foraging opportunities (Scrafford et al. 2017). Roads accessible by hunters in the fall may be associated with ungulate gut piles or wounding mortalities that are potential scavenging opportunities for wolverines (Mattisson et al. 2016); many of these roads are not used by people in winter and foraging opportunities may partially explain male attraction to areas close to these unused roads. While both males and females avoided areas near actively recreated roads, this avoidance was not as important as avoidance of dispersed motorized and dispersed non-motorized recreation, suggesting that spatially predictable recreation travel patterns may be perceived by wolverines as

less risky. (Harris et al. 2014) also found higher disturbance to northern ungulates from recreation that is unpredictable in space or time than from road-based recreation.

Cumulative impacts of climate change and winter recreation

Both wolverines and backcountry winter recreation are expected to be affected by climate change, potentially resulting in an increased overlap between winter recreation and wolverine distribution as they both respond to declining snow extent, depth and the snow season. In the southern portion of their North American range, wolverines appear to be tightly linked to the area defined by the presence of persistent spring snow (Aubry et al. 2007, Copeland et al. 2010, Inman et al. 2013). The underlying ecological requirements that drive this close relationship may include denning requirements (Magoun and Copeland 1998, Copeland et al. 2010) and a dependence on scavenging large ungulate carcasses effectively preserved within and under the snowpack (Mattisson et al. 2016). Additional potential factors contributing to wolverine association with areas supporting persistent spring snow may include caching food under snow and associated cold micro-climates (Inman et al. 2012) and competitor or predator avoidance (Mattisson et al. 2016). Heim et al. (2017) suggested that the association of wolverines to persistent spring snow makes them vulnerable to climate changes and McKelvey et al. (2011) predicted a 67% loss of wolverine habitat in the western United States by 2059 due to loss of snowpack.

The demonstrated loss of snow pack and reduced winter length (Mote et al. 2005) will also have profound impacts for winter recreation in the future (Bowker et al. 2012, White et al. 2016, Wobus et al. 2017). While the reductions in winter length are predicted to cause a decline in per capita participation in winter recreation, human population growth counters these declines and most projections of winter recreation are stable or increasing (Bowker et al. 2012, White et

al. 2016, Wobus et al. 2017). Winter recreationists will likely need to adapt when and where they recreate to adjust to shortened snow season and reduction of winter recreation areas due to snow loss (Dawson et al. 2013, Rutty et al. 2015). This would result in winter recreation becoming more concentrated and intense in space and time (Dawson et al. 2013, Rutty et al. 2015), especially during the mid to late winter period when snowpack is predicted to be the most consistent (Mote et al. 2005). This is also the time period when female wolverines are entering reproductive dens. Predictions of winter recreation distribution and intensity would likely suggest even more severe indirect habitat loss than our current assessment indicates. Thus, managers must consider growth of the recreation industry concurrent with declining 'habitat' for winter recreation, which will potentially exacerbate conflicts between recreation and wildlife.

Conclusion

Outdoor recreation provides avenues for people to connect with nature and is an important economic and cultural component of the small communities that serve as gateways to some of our larger natural areas. Balancing the many positive benefits of encouraging outdoor recreation with the impacts it may have on these natural systems is a growing field of study. Our research into the potential effects of winter recreation on wolverines represents information at spatial and temporal scales rarely achieved in other disturbance research. Clearly, at some point, displacement from high quality habitats would affect the reproductive and survival fitness of animals. Given the low density and fragmented nature of wolverines in the contiguous United States, impacts to the relatively few reproductive females should be minimized. We found that the effects of winter recreation on wolverine habitat are dependent upon the relative intensity of recreation and that winter recreation patterns are highly variable at the scale of wolverine home ranges. Some animals may be exposed to important levels of indirect habitat loss due to

avoidance of areas with winter recreation while adjacent animals have relatively little exposure. We recommend that additional research is needed to understand winter recreation distribution and relative intensity within potential wolverine habitats across the western United States and elsewhere where backcountry winter recreation activities are popular. Approaches to documenting and monitoring the extent and relative intensity of backcountry winter recreation in an efficient and effective manner needs additional development, and we suggest approaches that combine modeling the potential for recreation (e.g. Olson et al. 2017) with field efforts to identify the realized extent of existing recreation, such as the standardized aerial surveys we undertook.

Our results suggest that winter recreation should be considered when assessing wolverine habitat suitability, cumulative effects and conservation. Our research provides land managers with a more detailed understanding of important habitat characteristics used by wolverines within home ranges and should inform management of wolverine habitats across the large landscapes they require. Further, it shows that female wolverines are sensitive to dispersed winter recreation which results in indirect habitat loss during the critical denning season. The functional responses to dispersed winter recreation provide insight into these negative effects, and suggest that lower levels of dispersed recreation will have less effect on wolverines than more widespread and intense recreation. We also found that recreation use of roads and groomed routes has low influence on male and female wolverine habitat use. Our research also shows that males are less sensitive to dispersed recreation, and therefore may be a lower management priority. While extremely challenging with a rare species residing in remote landscapes, research is needed that links population-level metrics to habitat and habitat conditions. These backcountry landscapes represent critical habitats for wolverines, important and highly valued areas for

people to connect with nature, and are economic drivers for the small communities that surround them. Solutions to finding a balanced approach to sustaining the diverse values of these wild landscapes requires creative approaches and collaboration between land managers, stakeholders and wildlife professionals.

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Appendix A: Wolverine capture and monitoring

This appendix provides additional details about the collection and processing of wolverine location information.

Trapping and handling

We attempted to confirm the presence of wolverines within each of our study areas through pre-baiting with remote cameras using road-killed deer or elk and a skunk-based lure. In study areas where we successfully identified and captured wolverines, we live-trapped, collared and monitored wolverines for a minimum of two years. In the Centennial Mtns, we live-trapped and/or camera trapped for 3 years (2014-2016) without evidence of wolverine presence; in the Trinity Mtns (2012-2015), we or the USFS collaborators camera trapped for three years without evidence of wolverine presence. In the Teton Mtns, we live-trapped and camera trapped for 3 years (2014-2016) and only captured one male wolverine estimated to be 13 years old based on prior research handling when he was estimated to be a subadult.

We built log-based box traps on-site using existing downed logs or cutting trees if permitted within the specific study area. In the West Yellowstone and Teton study areas, we refurbished log traps built by the Wildlife Conservation Society personnel for an earlier research effort, and in the Grand Teton National Park we either also refurbished existing traps or brought in lumber to build traps (Lofroth et al. 2008) that were removed at the end of the trapping season. New trap locations across all study areas was based primarily on evidence of wolverine presence, including prior remote camera surveys done as part of our preparations or by prior survey effort. Nearly all traps required snowmobiles to access, except in the Tetons where ski or snowshoe-based access was used for traps with the Grand Teton National Park. We attempted to pre-bait all

trap sites using road-killed deer by mid-December depending upon access, and opened traps in early January. In the first year (2010), traps were remotely monitored 2-3 times/daily using VHF based trap transmitters (Telonics trapsite transmitters, TBT series; Telonics, Inc, Mesa, AZ, USA), and starting the second year (2011) all traps were equipped with the satellite-based trap transmitters (Vectronics trap transmitters TT2, TT3; Vetronic Aerospace GmbH, Berlin, Germany) that notified us immediately when a trap door closed. We limited visits to traps primarily to daylight hours for safety except during the recapture efforts in late March-April when we checked traps when they closed regardless of time to minimize the capture time of any lactating female. If any new or unidentified wolverine was captured during the recapture period, we collected a hair and/or saliva sample and released it, and only anesthetized animals to remove collars.

Aerial telemetry monitoring and identification of denning females

We flew telemetry flights intermittently throughout the duration of the winter season to confirm the functioning collars and presence of collared animals. Starting in mid-February, we increased our aerial monitoring of collared females to every 2-3 days to identify localized behavior and potential reproductive dens. The Telemetry Solution collars (Quantum 4000 collar from Telemetry Solutions, Concord, CA, USA) provided the ability to remotely download data through a UHF connection, which we used to confirm localized behaviors. We continued to monitor potentially denning females primarily from the air but occasionally it was also possible to use a near-by ridge or other discreet ground-based location to confirm continued occupancy for dens. Confirmation of denning was both through the intensive GPS location monitoring as well as identification of swollen teats and milk in females recaptured for collar removal (Table

A1.1). Field crews also visited den sites after abandonment in the following summer to document latrines, prey remains and characteristics of the den site itself.

Wolverine GPS location data and home range summary

Table A. 1. Summary of wolverine location data including assessed denning status, start and end dates for GPS monitoring, the k parameter used in the LoCoH home range estimate and the area of the resulting home ranges.

Animal-year	Study Area	GPS N	Denning Status	Start Date	End Date	LoCoH k	Km^2	Mi^2
F11.2014	Henry Mtns	2067	Not denning	1/19/2014	4/9/2014	46	250	96
M15.2015	Henry Mtns	2881	Male	1/25/2015	5/5/2015	71	1485	573
F1.2010	McCall	1247	Denning	1/30/2010	3/31/2010	62	397	153
F1.2012	McCall	1757	Not denning	1/15/2012	3/10/2012	82	336	130
F10.2014	McCall	3079	Denning	1/14/2014	4/19/2014	93	420	162
F2.2010	McCall	1844	Denning	1/30/2010	3/21/2010	64	228	88
F2.2011	McCall	2632	Not denning	1/25/2011	4/10/2011	92	248	96
F3.2010	McCall	1372	Denning	2/20/2010	4/3/2010	44	239	92
F3.2014	McCall	2496	Not denning	1/4/2014	3/24/2014	148	281	108
F4.2011	McCall	1386	Not denning	1/22/2011	3/16/2011	102	153	59
F5.2011	McCall	1677	Denning	1/30/2011	4/2/2011	96	377	146
M1.2010	McCall	806	Male	2/2/2010	3/10/2010	32	401	155
M1.2011	McCall	1974	Male	1/18/2011	3/15/2011	77	779	301
M1.2014	McCall	2947	Male	1/25/2014	4/13/2014	104	791	306
M12.2014	McCall	3778	Male	1/11/2014	5/27/2014	121	2158	833
M2.2010	McCall	2648	Male	2/5/2010	4/20/2010	64	994	384
M2.2011	McCall	2059	Male	2/10/2011	4/3/2011	56	1334	515
M3.2010	McCall	1340	Male	2/11/2010	4/26/2010	44	934	361
F7.2012	Stanley	1489	Not denning	2/5/2012	3/12/2012	89	375	145
F8.2013	Stanley	1943	Denning	2/2/2013	3/31/2013	80	328	126
F9.2012	Stanley	1627	Denning	2/10/2012	4/26/2012	86	126	49
M6.2012	Stanley	1896	Male	1/17/2012	3/11/2012	107	1087	420
M8.2012	Stanley	2618	Male	1/17/2012	3/24/2012	107	1988	767
M13.2014	Tetons	2766	Male	2/22/2014	7/18/2014	147	1094	422
M13.2015	Tetons	2972	Male	1/14/2015	4/3/2015	159	867	335

Appendix B: Description of Environment Covariates

This appendix provides additional detailed descriptions of the environment covariates acquired or developed to support the spatial analyses

Identification of environment covariates

Table B. 1. Environmental and winter recreation covariates identified for consideration in the wolverine winter resource selection function (RSF) models to understand wolverine responses to winter recreation in Idaho, Wyoming and Montana, 2010-2015. The native resolution indicated the finest resolution spatial information available, while the selected resolution is based on analyses following DeCesare et al. (2012). We provide information regarding the source of the data or derivation methods, and if and why the covariate was removed from the analyses.

Covariate	Native scale	Selected Scale (m)	Source	Description
Environment covariates				
Elevation	30	30	USGS National Elevation data	Collinear with multiple other covariates, removed
Slope	30	500	Derived from USGS National Elevation data	Slope (degrees), input as quadratic (Slope + Slope^2)
Aspect	30	Variable	Derived from USGS National Elevation data	Assessed categorical; high AIC relative to solar insolation, removed
Terrain ruggedness	30	100	Riley et al. (1999)	Topographic complexity; collinear with slope, removed
Topographic position index (TPI)	30	300	Weiss (2001)	Measure of landscape concavity or convexity
Solar Insolation	30	50	ESRI Area Solar Radiation tool	Index of solar insolation
Edge:area forest patch ratio	30	1000	Helzer and Jelinski (1999), using 30m resampled talus-forest cover classification of 2015 NAIP Imagery	Calculated as the length of edge/area of forest areas
Distance to forest edge	Vector	N/A	Derived from 30 m resampled talus-forest cover classification of 2015 NAIP Imagery	2D distance to forest edge, both from inside and outside the forest
Spring snow model	500	1000	MODIS Snow Cover Daily L3 Global 500m Grid, created based on methods of Copeland et al. 2010	Calculated persistent snow layer for 2009-2015
Riparian	30	100	Derived from USGS LANDFIRE Existing Vegetation Type layer. (2013, June). Available: http://landfire.cr.usgs.gov/viewer/	Mesic forested and non-forested types associated with waterways (Appendix B)
Montane Shrub-Grass	30	300	Derived from USGS LANDFIRE EVT Class v1.3,	Percent mid- to upper elevation shrub and grass types (Appendix B)
Foothill Shrub-Grass	30	30	Derived from USGS LANDFIRE EVT v1.3	Percent shrub or grass in lower elevation types (Appendix B)

Covariate	Native scale	Selected Scale (m)	Source	Description
Montane-Alpine Sparse	30	300	Derived from USGS LANDFIRE EVT v1.3	Percent sparse vegetation in upper elevation areas (Appendix B)
Fir forest	30	500	Derived from USGS LANDFIRE EVT v1.3	Percent Douglas fir, subalpine fir and associated fir forest types (Appendix B)
Ponderosa pine	30	2000	Derived from USGS LANDFIRE EVT v1.3	Not significant in univariate logistic regression
Lodgepole pine	30	3000		Not selected in LASSO
Talus	1	30	1 m classification of 2015 NAIP Imagery, mapped outputs use 30-m resampled	Percent talus cover
Winter recreation covariates				
Dist. to recreated roads	Vector	N/A	Derived from USFS & USGS roads and recreation tracks	Secondary roads and groomed routes with GPS tracks traveling parallel
Dist. to non-recreated secondary roads	Vector	N/A	Derived from USFS & USGS roads and recreation tracks	Secondary roads without GPS tracks traveling parallel
All winter recreation intensity layer	30	125	See methods and Appendix C	Linear and off-road winter recreation weighted track density
Winter recreation footprint	125	-	See methods and Appendix C	Transformed intensity values>0 to '1' to create binomial layer
Motorized winter recreation intensity layer	30	125	See methods and Appendix C	Motorized off-road winter recreation weighted track density
Non-motorized winter recreation intensity layer	30	125	See methods and Appendix C	Non-motorized off-road winter recreation weighted track density

Additional details of the covariates are provided below.

Topographic covariates. We used 30m digital elevation models (DEMs) from the National Elevation dataset from the USGS for elevation, slope and aspect. In addition, we also calculated the terrain roughness (TRI), topographic position index (TPI), vector ruggedness measure (VRM), and solar insolation. The TPI (Weiss 2001) looks at the position of a pixel relative to the surrounding pixels in a given neighborhood size in an attempt to classify the landscape into slope position and landform categories. The calculation produces either positive (higher

positions, i.e. ridges) or negative (lower positions, i.e. valleys) values as its output. The size of the neighborhood that best captures TPI depends on the landscape, for this analysis we generated it at the same spatial scales as for other covariates (30, 50, 100, 150, 300, 500, 700, 1000, 2000, 3000m radii) and classified rasters according to the recommendations of Weiss (2001). The TRI (Riley 1999) measures local variations about a central pixel in a 3-pixel neighborhood (8 surrounding neighborhoods) using the minimum and maximum values of the local neighborhood. We calculated solar insulation from the DEM, which aims to identify areas with less sun exposure where snow may be more likely to accumulate. Solar radiation was calculated separately for each band of latitude in the study area using ERSI's Area Solar Radiation tool. The output rasters were mosaicked together with a mean operator to provide wall-to-wall coverage.

Persistent Spring Snow. Spatially-explicit data summarizing persistent spring snow was created for the years 2009-2015 by following the same methods as Copeland et al (2010). MODIS data were projected and downloaded from the 'reverb.echo' NASA web portal and assimilated according to the steps outlined by Copeland et al (2010) and detailed by Copeland (pers. comm. 2015). This resulted in a 500 m resolution raster with values of 0-7, representing the number of years that pixel was consistently snow covered from April 24 – May 15 of each year. Additional snow data was downloaded from the SNOWDAS dataset for January – April of each year of the study. Daily variables at 1 km were compiled and mosaicked together to produce continuous rasters of the minimum, maximum, mean, range, and standard deviation of the following variables: depth (m), snow water equivalent (SWE, m), snow melt runoff at the base of the snow pack (m), and solid precipitation (kg/m^2).

Roads and groomed winter recreation routes. The best available road, trail and groomed routes data were collected from each of the seven National Forests (Boise, Bridger-Teton, Caribou-Targhee, Gallatin, Payette, Sawtooth, Beaverhead-Deer Lodge NFs) and from Grand Teton National Park. Gaps in the data were filled in with USGS Transport data. Euclidean distance was calculated to all roads, major roads (either delineated in the attributes of the assimilated data or designated by local knowledge), and winter routes or groomed routes. Winter routes were rarely designated in the attributes of the USFS-supplied spatial data, and we digitized these from the USFS Winter Recreation Maps, available for all Forests.

Land cover. We used LANDFIRE data downloaded from USGS, and developed a simplified land cover classification based on the National Vegetation Classification System Physiognomic Class (EVT_CLASS), as summarized in Table B.1. An additional land cover model specific to talus and rock habitats was produced at 1m resolution to more accurately identify talus land cover. This model predicts talus habitats at 67% accuracy, and combined talus/rock habitats at 87% accuracy. This classification also provided a higher resolution classification for conifer forests, and we used this resampled to 30m to calculate distance to forest edge as a covariate in the analyses. We also used this forest cover data to generate forest edge:area as the length of edge/forest area at the suite of spatial scales other covariates were assessed at (30, 50, 100, 150, 300, 500, 700, 1000, 2000, 3000m). See details of the land cover classification in Smith and Heinemeyer (2016).

Table B. 1. Land cover groupings were developed based on LANDFIRE National Vegetation Classification System Physiognomic Class, reducing 68 unique cover types to six broad classes for purposes of habitat modeling.

EVT Class (LANDFIRE, June 2013)	Land cover type
Northern Rocky Mountain Subalpine Woodland and Parkland	Fir Mixed Forest
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	Fir Mixed Forest
Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland	Fir Mixed Forest
Dry-mesic Montane Douglas-fir Forest	Fir Mixed Forest
Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland	Fir Mixed Forest
Mesic Montane Douglas-fir Forest	Fir Mixed Forest
Middle Rocky Mountain Montane Douglas-fir Forest and Woodland	Fir Mixed Forest
Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	Fir Mixed Forest
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest	Fir Mixed Forest
Rocky Mountain Aspen Forest and Woodland	Fir Mixed Forest
Subalpine Douglas-fir Forest	Fir Mixed Forest
Subalpine Western Larch Forest	Fir Mixed Forest
Xeric Montane Douglas-fir Forest	Fir Mixed Forest
Artemisia tridentata ssp. vaseyana Shrubland Alliance	Foothill Shrub and Grass
Columbia Plateau Low Sagebrush Steppe	Foothill Shrub and Grass
Inter-Mountain Basins Big Sagebrush Steppe	Foothill Shrub and Grass
Introduced Upland Vegetation-Perennial Grassland and Forbland	Foothill Shrub and Grass
Northern Rocky Mountain Lower Montane-Foothill-Valley Grassland	Foothill Shrub and Grass
Rocky Mountain Lodgepole Pine Forest	Lodgepole Pine
Rocky Mountain Poor-Site Lodgepole Pine Forest	Lodgepole Pine
Inter-Mountain Basins Montane Sagebrush Steppe	Montane Shrub and Grass
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	Montane Shrub and Grass
Northern Rocky Mountain Subalpine-Upper Montane Grassland	Montane Shrub and Grass
Northern Rocky Mountain Subalpine Deciduous Shrubland	Montane Shrub and Grass
Rocky Mountain Subalpine-Montane Mesic Meadow	Montane Shrub and Grass
Inter-Mountain Basins Sparsely Vegetated Systems	Montane-Alpine Sparse
Rocky Mountain Alpine Dwarf-Shrubland	Montane-Alpine Sparse
Rocky Mountain Alpine Turf	Montane-Alpine Sparse
Rocky Mountain Alpine/Montane Sparsely Vegetated Systems	Montane-Alpine Sparse
Barren	Other
Columbia Basin Foothill and Canyon Dry Grassland	Other
Columbia Basin Palouse Prairie	Other
Columbia Plateau Steppe and Grassland	Other
Developed-Low Intensity	Other
Developed-Medium Intensity	Other
Developed-Roads	Other
Dry-mesic Montane Western Larch Forest	Other
Great Basin Xeric Mixed Sagebrush Shrubland	Other

EVT Class (LANDFIRE, June 2013)	Land cover type
Inter-Mountain Basins Big Sagebrush Shrubland	Other
Inter-Mountain Basins Mixed Salt Desert Scrub	Other
Inter-Mountain Basins Semi-Desert Shrub-Steppe	Other
Introduced Upland Vegetation-Annual Grassland	Other
Mesic Montane Western Larch Forest	Other
Northern Rocky Mountain Avalanche Chute Shrubland	Other
Open Water	Other
Rocky Mountain Foothill Limber Pine-Juniper Woodland	Other
Snow-Ice	Other
Western Cool Temperate Close Grown Crop	Other
Western Cool Temperate Developed Ruderal Evergreen Forest	Other
Western Cool Temperate Developed Ruderal Grassland	Other
Western Cool Temperate Developed Ruderal Shrubland	Other
Western Cool Temperate Pasture and Hayland	Other
Western Cool Temperate Undeveloped Ruderal Grassland	Other
Western Cool Temperate Undeveloped Ruderal Shrubland	Other
Western Cool Temperate Urban Deciduous Forest	Other
Western Cool Temperate Urban Evergreen Forest	Other
Western Cool Temperate Urban Herbaceous	Other
Western Cool Temperate Urban Mixed Forest	Other
Western Cool Temperate Urban Shrubland	Other
Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	Ponderosa Pine
Inter-Mountain Basins Montane Riparian Forest and Woodland	Riparian
Northern Rocky Mountain Conifer Swamp	Riparian
Rocky Mountain Montane Riparian Forest and Woodland	Riparian
Rocky Mountain Montane Riparian Shrubland	Riparian
Rocky Mountain Subalpine/Upper Montane Riparian Forest and Woodland	Riparian
Rocky Mountain Subalpine/Upper Montane Riparian Shrubland	Riparian
Rocky Mountain Wetland-Herbaceous	Riparian

Spatial scaling of covariates

We generated each covariate at multiple spatial scales to identify the scale most strongly selected by wolverines. We used moving windows in ArcGIS at 8 radii (50, 100, 200, 500, 700, 1000, 2000, 3000m), with the finest resolution determined by the native resolution of the covariate data. For categorical variables such as the land cover classification, we calculated the percentage of that class at each window radii. Animal and available locations were attributed

with the scaled covariates, and univariate logistic regressions were fit at spatial resolution with the scale having lowest Akaike Information Criteria (AIC; Akaike 1974) selected for further analyses. Wolverines most strongly selected environmental covariates at broadly differing scales ranging from coarser resolutions of 1000 m for forest edge:area ratio to fine-scale selection at our original 30m scale for other covariates such as talus cover (Table B.1).

Appendix C: Winter recreation sampling and analyses

This Appendix provides additional information on winter recreation mapping, on winter recreation aerial surveys, and winter recreation map validation using the aerial recreation surveys.

Development of winter recreation spatially-explicit models

We used the weighted GPS tracks collected from volunteer recreationists to develop spatially-explicit models and map representing winter recreation within our study areas. These spatial depictions include identification of the network of roads and groomed routes used by recreationists within the study area to access backcountry areas (linear recreation), and estimating the relative intensity as the weighted track density of all recreation (road and dispersed combined), motorized dispersed recreation and non-motorized dispersed recreation. We also developed a simple footprint depiction of winter recreation. These models were used as covariates in the development of wolverine RSF models.

Linear recreation. We used the vector-based recreation track data to identify roads or groomed routes that had recreation tracks traveling within 30m classified as a 'linear recreation route'. Recreation GPS tracks simply crossing an otherwise unused road were ignored in these classifications, and secondary roads without documented winter recreation travel were classified

as such. In areas with multiple years of GPS recreation track information, we combined years to identify recreation routes. We calculated the straight-line distance to the linear recreation as a potential predictor of wolverine habitat use in our analyses.

Relative intensity of recreation. We developed spatial layers depicting the relative intensity of recreation use calculated as the weighted density of recreation tracks:

Recreation Intensity = $\sum_i^N (w_i \ l_i \ )/Area$

where l_i is the length of each GPS track within the selected Area, generated through moving window analyses in ArcGIS, and w_i is defined in equation (1). For areas with multiple years of GPS data, we generated annual recreation intensity layers and averaged the weighted density across years.

We generated recreation intensity grids for all recreation tracks, as well as separate intensity layers for off-road or dispersed motorized recreation and for dispersed non-motorized recreation. For the motorized and non-motorized spatial layers, the proportion of GPS units handed out to each recreation type was used to estimate the proportion of total use representing that recreation type in the *w* calculations.

To determine the most appropriate scale to depict the recreation intensity layers, we generated each recreation layer at multiple moving windows from 50-5000m (DeCesare et al. 2012). Animal and available locations were attributed with the scaled covariates, and univariate logistic regressions were fit at spatial resolution with the scale having lowest Akaike Information Criteria (AIC; Akaike 1974) selected for further analyses. The relative intensity scores averaged a moving window radii of 125m had the lowest AIC for all recreation combined, motorized

dispersed recreation and non-motorized dispersed recreation, and we used this spatial scale for all subsequent analyses.

Recreation footprint. The spatial extent or footprint of recreation was estimated from the scaled recreation intensity layers for all recreation combined by converting any relative intensity score > 0 to a '1' to create a binomial predictor.

Winter recreation aerial surveys to validate recreation maps

We validated our winter recreation models using aerial surveys that independently documented winter recreation type, extent and relative intensity within our study areas. Aerial surveys in fixed-wing aircraft were completed 1-4 times in each study area each year. Visually evaluating recreation levels or intensity during aerial surveys is challenging to standardize across observers, study areas and time, so we used a presence-absence survey approach to avoid observer bias. The area was systematically flown along transects spaced 2 km apart. Sequential 20-second presence-absence observations were recorded by two observers with each observer recording from one side of the plane, with presence, type (snowmobile, ski, both) and spatial pattern (linear, dispersed, both) recorded for each sample. The 20-sec interval allowed for a new field of view between samples. Transects formed the boundaries of 1 km^2 grid cells, and scores for each survey grid quadrat ($500m^2$) were calculated as the total number of positives/total samples taken. Aerial survey information was used in-season to identify gaps in GPS sampling such as trailhead access points not being sampled, allowing us to adjust GPS distributions to ensure comprehensive sampling. It was also used to validate and identify any spatial gaps in recreation covariates developed for analyses, and identify changes in recreation distribution in years following the collection of the GPS-based recreation data.

The aerial recreation survey data were used to validate the GPS-based recreation maps. The GPS track-based recreation footprint was compared to aerial survey cells scoring positive for winter recreation and percent overlap was calculated. We also generated an all-track recreation intensity layer at 500m^2 resolution to match the resolution of the aerial surveys and used binned values to compute the correlation with the coarser resolution scores of the aerial surveys. At the level of individual aerial survey grid cells, we identified 'gaps' in our ground-based recreation monitoring data, as indicated by the absence of GPS track information where aerial surveys indicated consistent or wide-spread use. We undertook additional validation of the recreation layers when using them in analyses of animals monitored in years subsequent to the recreation GPS tracking data collection. In these instances, we used aerial survey data collected concurrent with animal monitoring to identify potential spatial shifts in winter recreation compared to the GPS track-based layers. Animal and random locations falling in aerial grid cells in areas of notable mismatch between aerial survey and the recreation covariate layers were not included in further analyses. The maps of RSF models including winter recreation relative intensity covariates are not extrapolated into these areas of data gaps.

We completed 9 aerial recreation surveys. The correlation between the aerial survey scores and the recreation intensity layer classes was 0.80, suggesting high concurrence in the relative intensity of recreation as estimated between the two independent methods. The footprints were also very similar, with the aerial recreation surveys suggesting a larger footprint in 13% of the area, while the recreation intensity layer suggested a larger recreation footprint in 15% of the area. Animal and random locations falling within gaps in our recreation intensity models were removed from further analyses, including one female animal-year and 232 animal locations and 1875 random locations across nine additional animal-years.

Backcountry winter recreation types and patterns

Table C. 1. Summary the types of backcountry winter recreation monitored through volunteer recreationists carrying GPS units in Idaho, Wyoming and Montana (2010-2015) as part of the research examining wolverine responses to winter recreation. Each type of recreation was subsequently classified as motorized, non-motorized while recreationists partaking in both motorized and non-motorized activities (e.g., using a snowmobile to access areas for skiing) were identified and their tracks split into the component types.

Recreation Type	No. of tracks	Total km	Avg km	Classified
Snowmobile	2772	161,699	60.42	Motorized
ATV	2	75	37.50	Motorized
Motorbike	1	16	16.41	Motorized
Snowbike	1	6	6.38	Non-motorized
Ski	2485	24814	9.99	Non-motorized
Snowboard	377	3919	10.40	Non-motorized
Snowshoe	24	148	6.15	Non-motorized
Snowmobile –ski/snowboard	139	4351	31.30	Split
Cat-Ski	45	2432	54.05	Split
Heli-Ski	53	559	10.54	Non-motorized portion only
Total	**5899**[1]	**178438**	**32.57**	

[1] This is the raw track count; the snowmobile-ski/snowboard tracks were split into their component motorized and non-motorized sections.

Appendix D: Wolverine habitat models and indirect habitat loss

This Appendix provides additional details on indirect habitat loss calculated for individual wolverines. It also displays small format maps of the RSF wolverine habitat models developed using environmental and winter recreation covariates to predict relative wolverine probability of use based on GPS monitoring of wolverines 2010-2015 across four study areas in Idaho, Wyoming and Montana (Figures D.1 – D.4). Large format maps of the final RSF habitat models are available at www.roundriver.org/wolverine

Table D.1. Indirect habitat loss calculated[1] from winter recreation within individual wolverine (*Gulo gulo*) home ranges based on spatially-explicit transitions to lower habitat classes when comparing potential and realized habitat models developed for wolverines monitored 2010-2015 across study area in Idaho, Wyoming and Montana (see Figures 2-5).

	Overall Degraded	Moderate to Low	High to Moderate	High to Low
F1_2010	28.4%	44.5%	19.9%	23.4%
F1_2012	24.6%	38.4%	15.4%	20.9%
F10_2014	24.5%	37.6%	15.1%	19.3%
F11_2014	14.8%	24.9%	12.1%	12.2%
F2_2010	19.5%	29.7%	15.7%	13.6%
F2_2011	19.7%	28.3%	17.2%	14.1%
F3_2010	6.4%	5.4%	9.1%	2.1%
F3_2014	3.2%	2.8%	5.5%	0.6%
F4_2011	20.9%	28.3%	23.4%	13.3%
F5_2011	10.3%	10.7%	15.1%	4.5%
F7_2017	2.7%	4.0%	6.0%	0.0%
F8_2103	2.0%	2.5%	4.5%	0.2%
F9_2012	6.2%	7.2%	10.8%	0.6%
Female Average	14.1%	20.3%	13.1%	9.6%
M1_2010	16.2%	21.6%	24.1%	0.7%
M1_2011	14.3%	18.1%	18.2%	0.7%
M1_2014	16.1%	19.6%	20.1%	0.9%
M12_2014	12.3%	18.4%	18.3%	0.2%
M13_2014	9.3%	19.4%	19.5%	0.0%
M13_2015	7.7%	19.4%	16.4%	0.0%
M15_2015	11.2%	16.1%	17.2%	0.0%
M2_2010	14.3%	19.9%	20.3%	0.4%
M2_2011	13.8%	21.1%	20.1%	0.3%
M2_2012	5.5%	11.3%	11.6%	0.0%
M3_2010	11.2%	14.5%	16.6%	0.0%
M6_2012	4.8%	9.9%	8.9%	0.0%
M8_2012	5.5%	11.3%	11.6%	0.0%
Male Average	10.9%	17.0%	17.2%	0.2%

[1] Calculations: 'overall degradation' = ha degraded/total ha; 'moderate to low' = moderate degraded/total moderate available, 'high to moderate' = high degraded to moderate/high available; 'high to low' = high degraded to low/high available

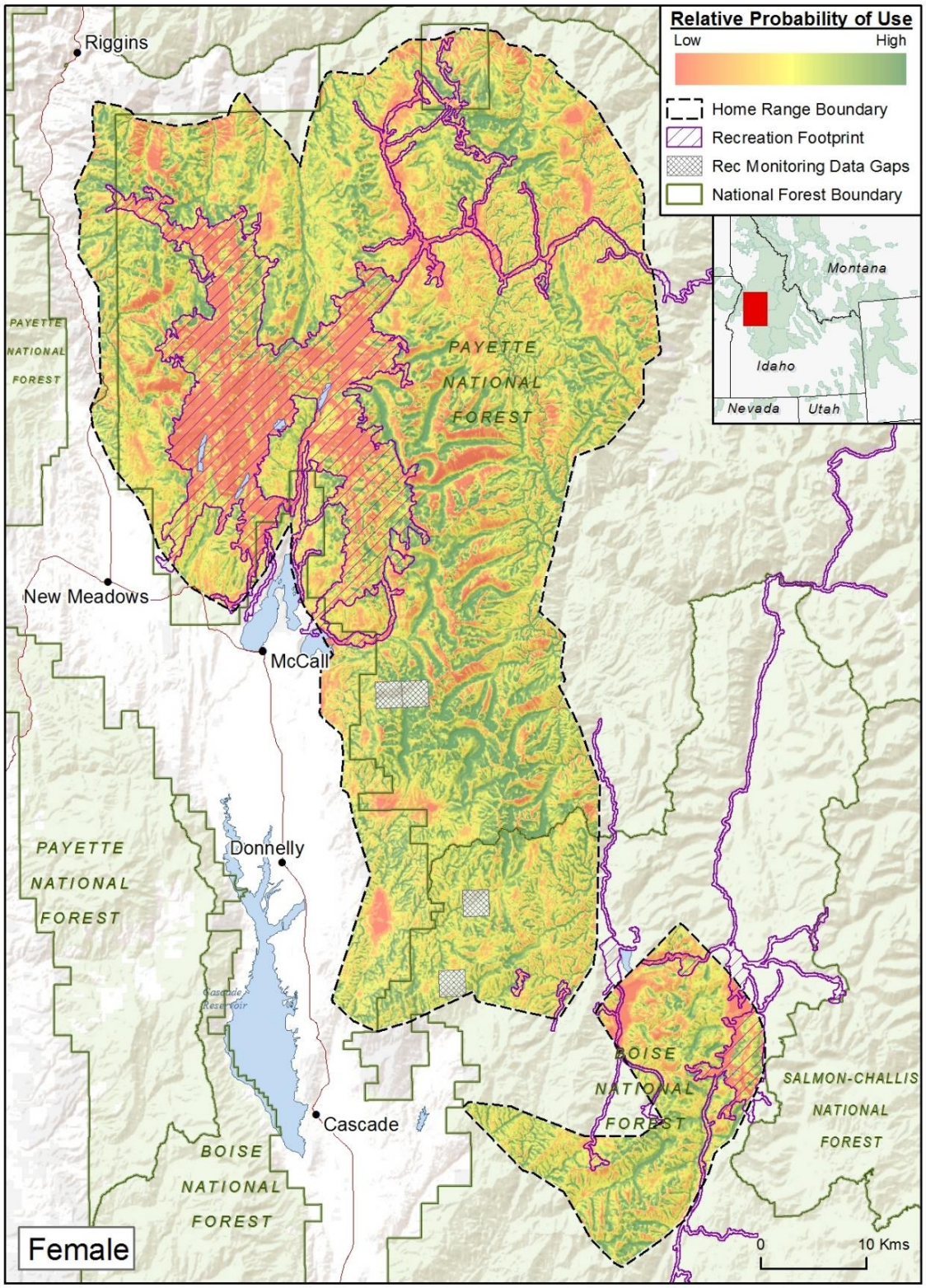

Figure D.1. Resource selection function habitat model for female wolverines (*Gulo gulo*) in the McCall study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

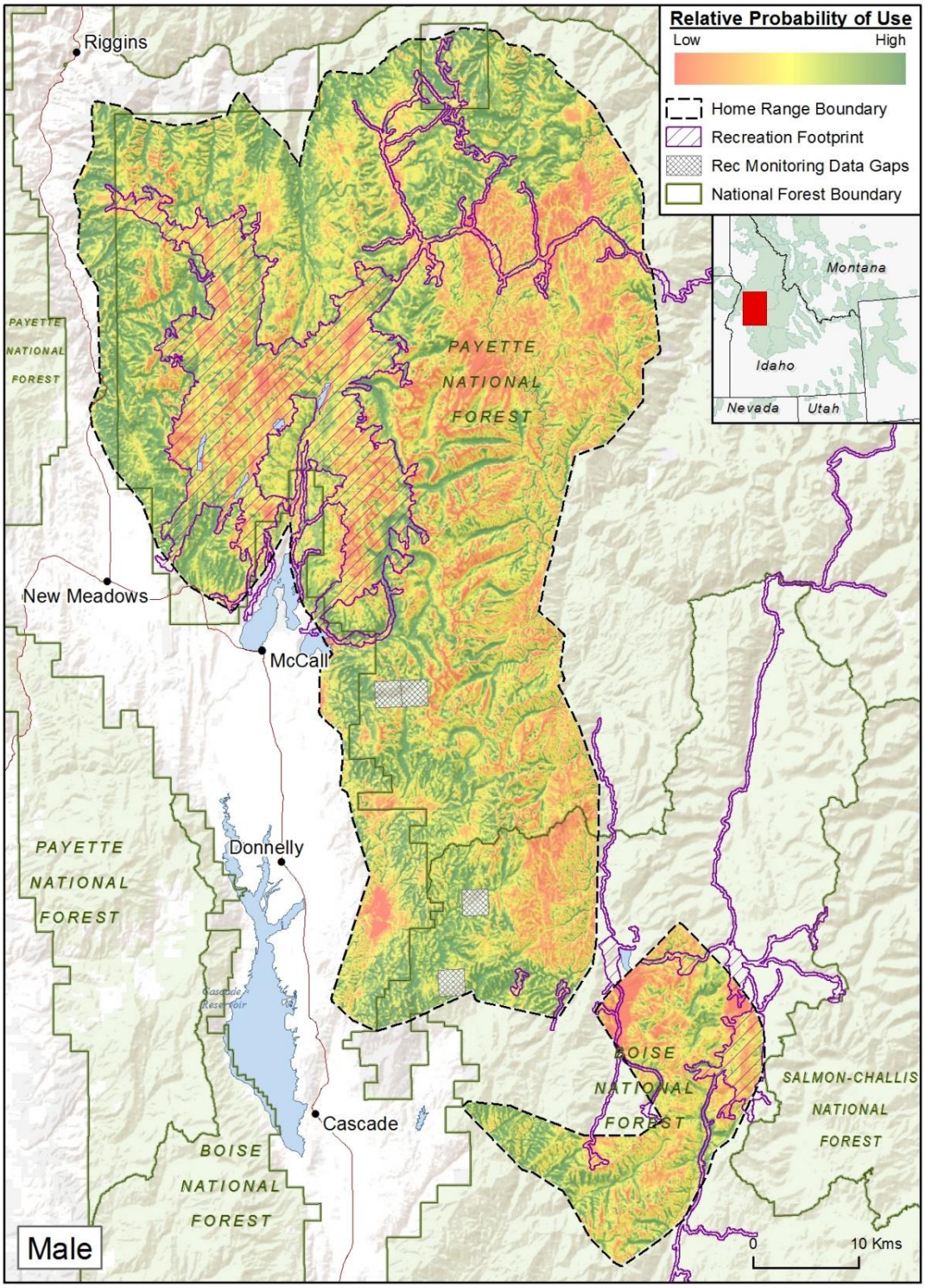

Figure D.2. Resource selection function habitat model for male wolverines (*Gulo gulo*) in the McCall study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

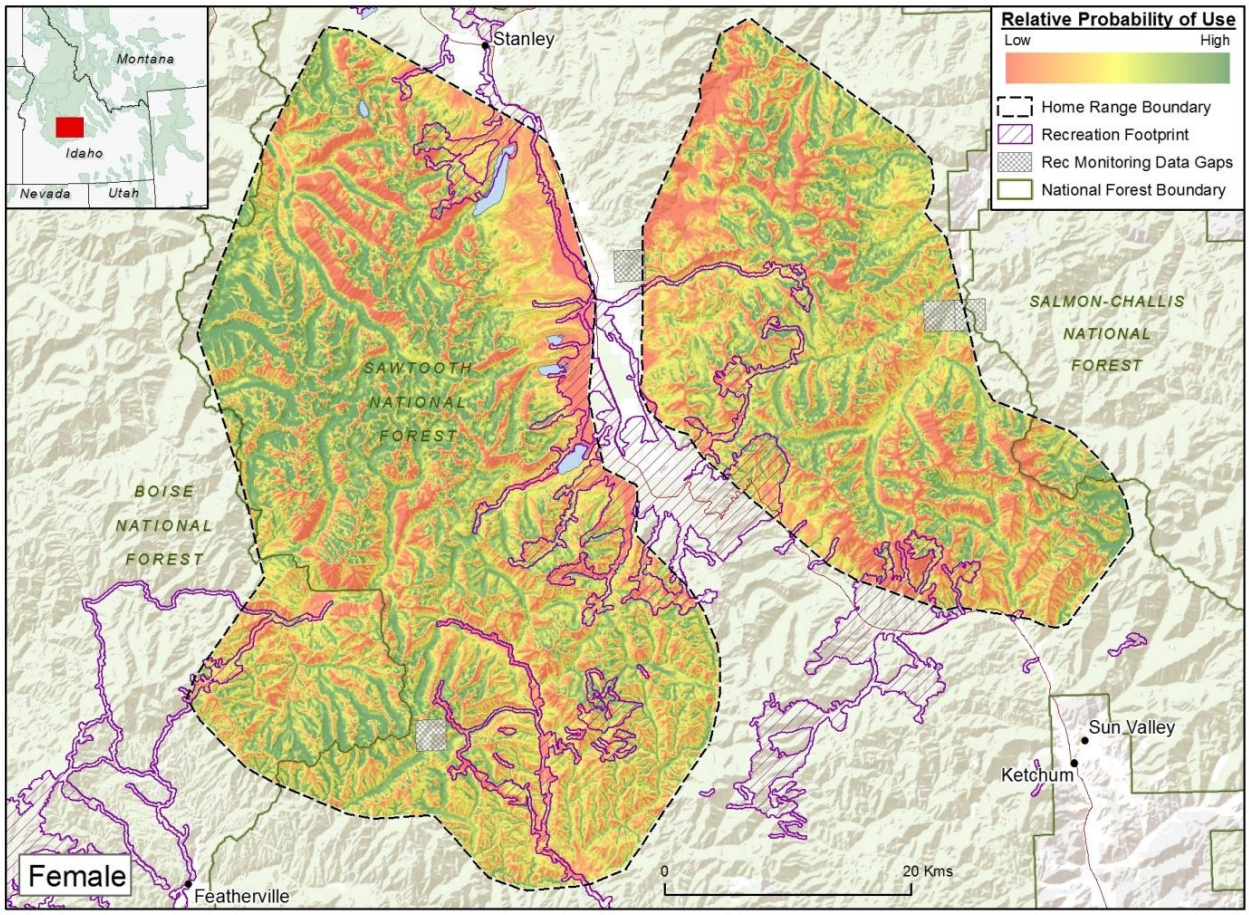

Figure D.3. Resource selection function habitat model for female wolverines (*Gulo gulo*) in the Sawtooth study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

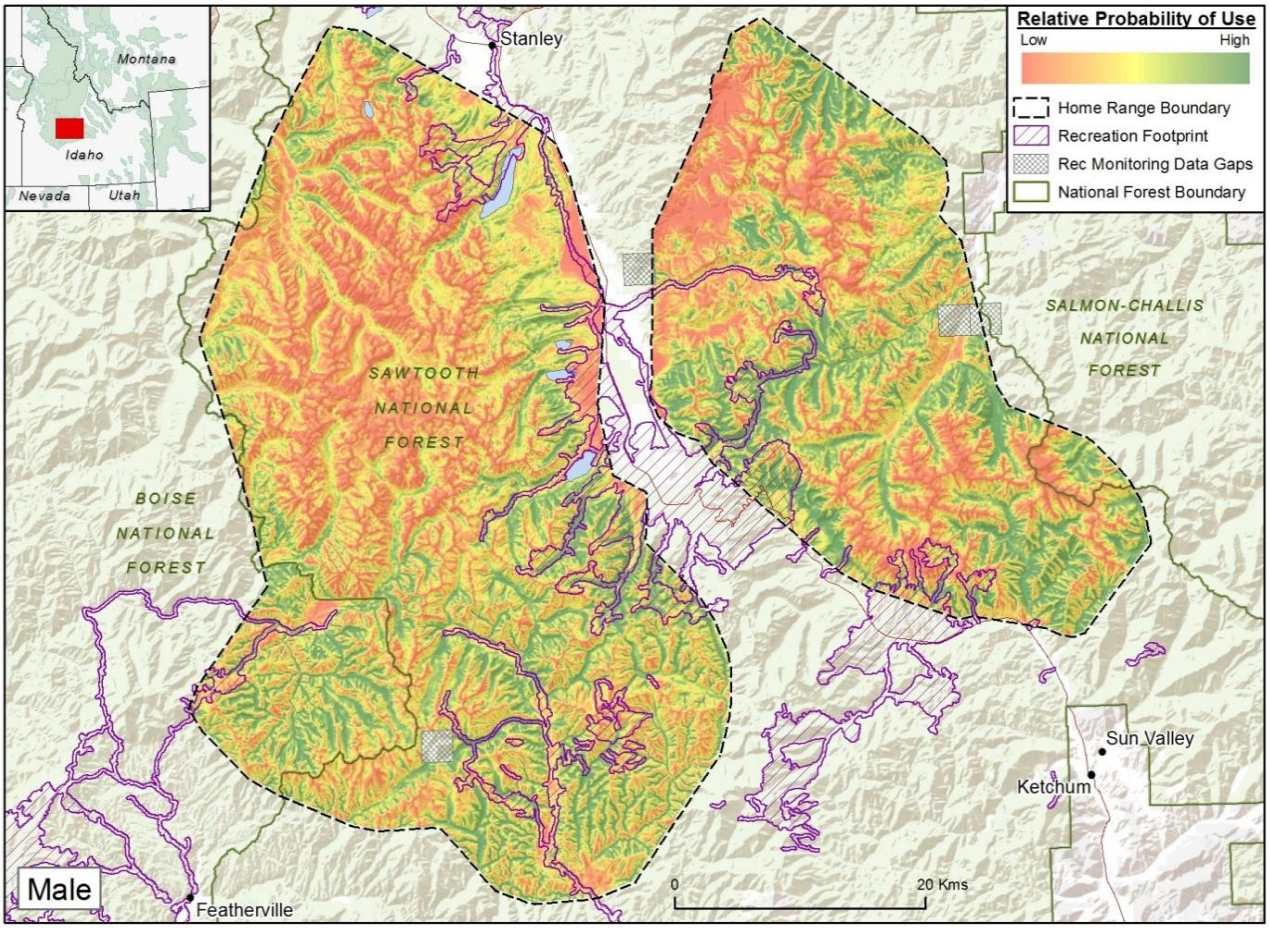

Figure D.4. Resource selection function habitat model for male wolverines (*Gulo gulo*) in the Sawtooth study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

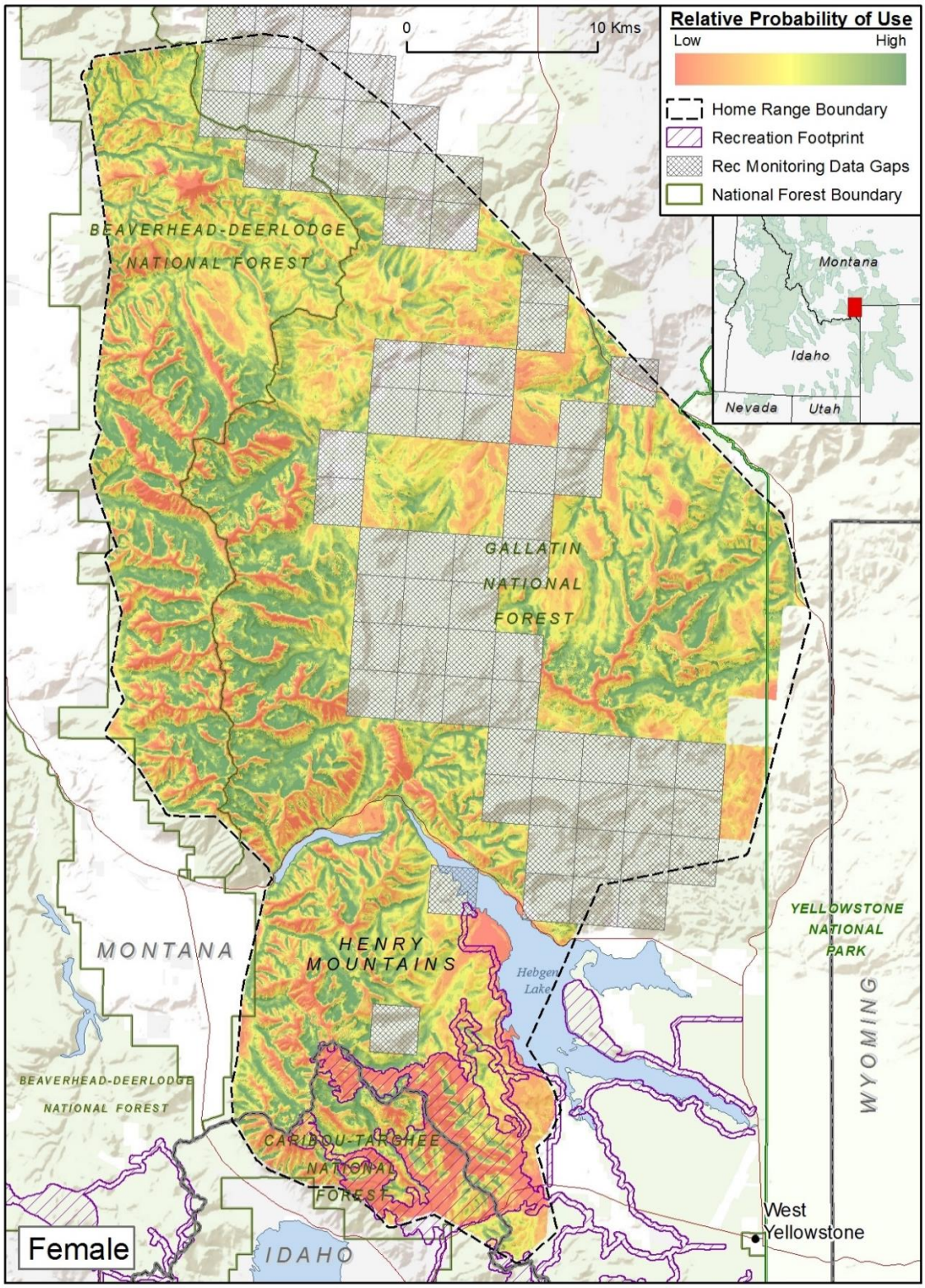

Figure D.5. Resource selection function habitat model for female wolverines (*Gulo gulo*) in the West Yellowstone study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

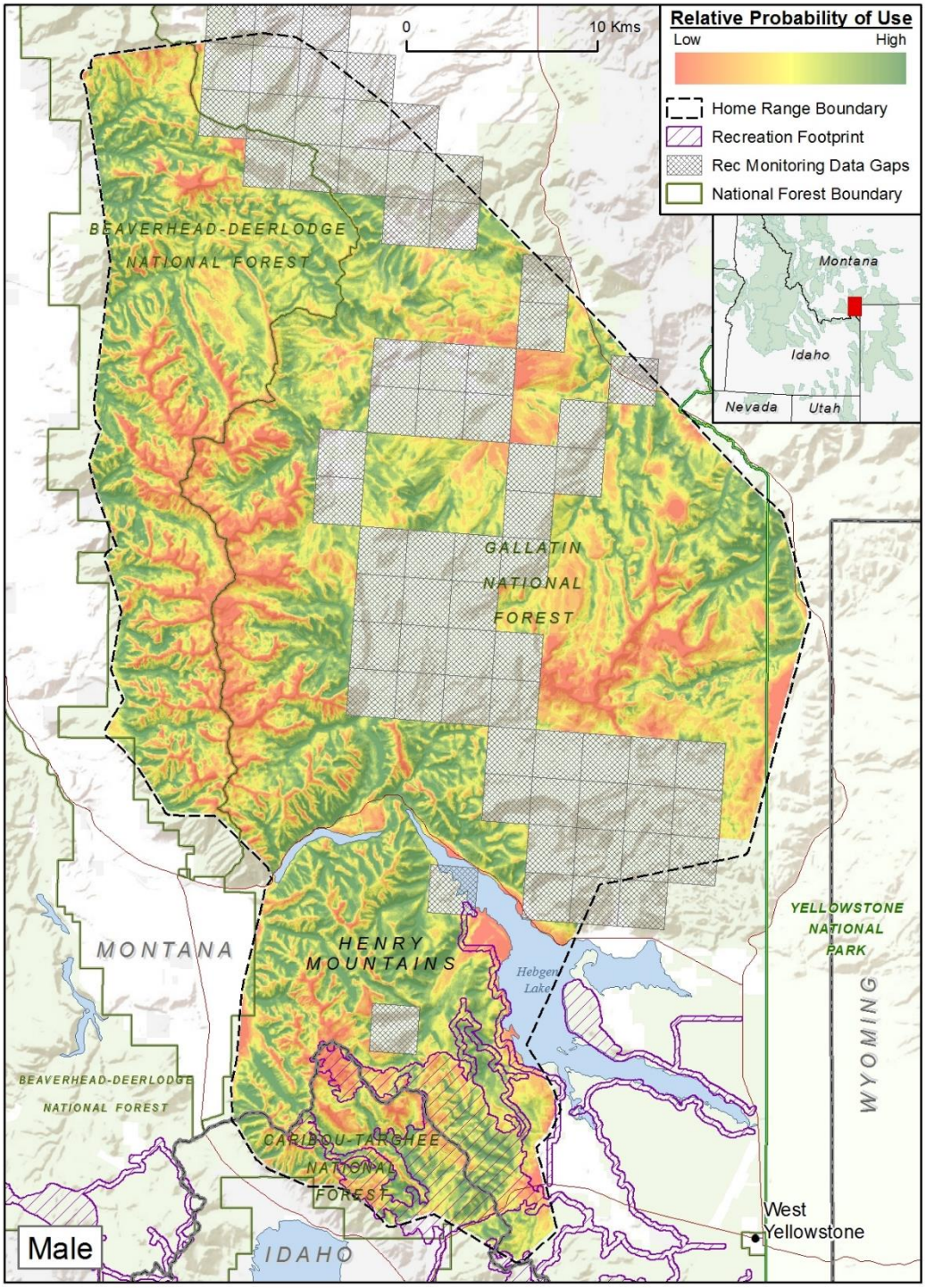

Figure D.6. Resource selection function habitat model for male wolverines (*Gulo gulo*) in the West Yellowstone study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

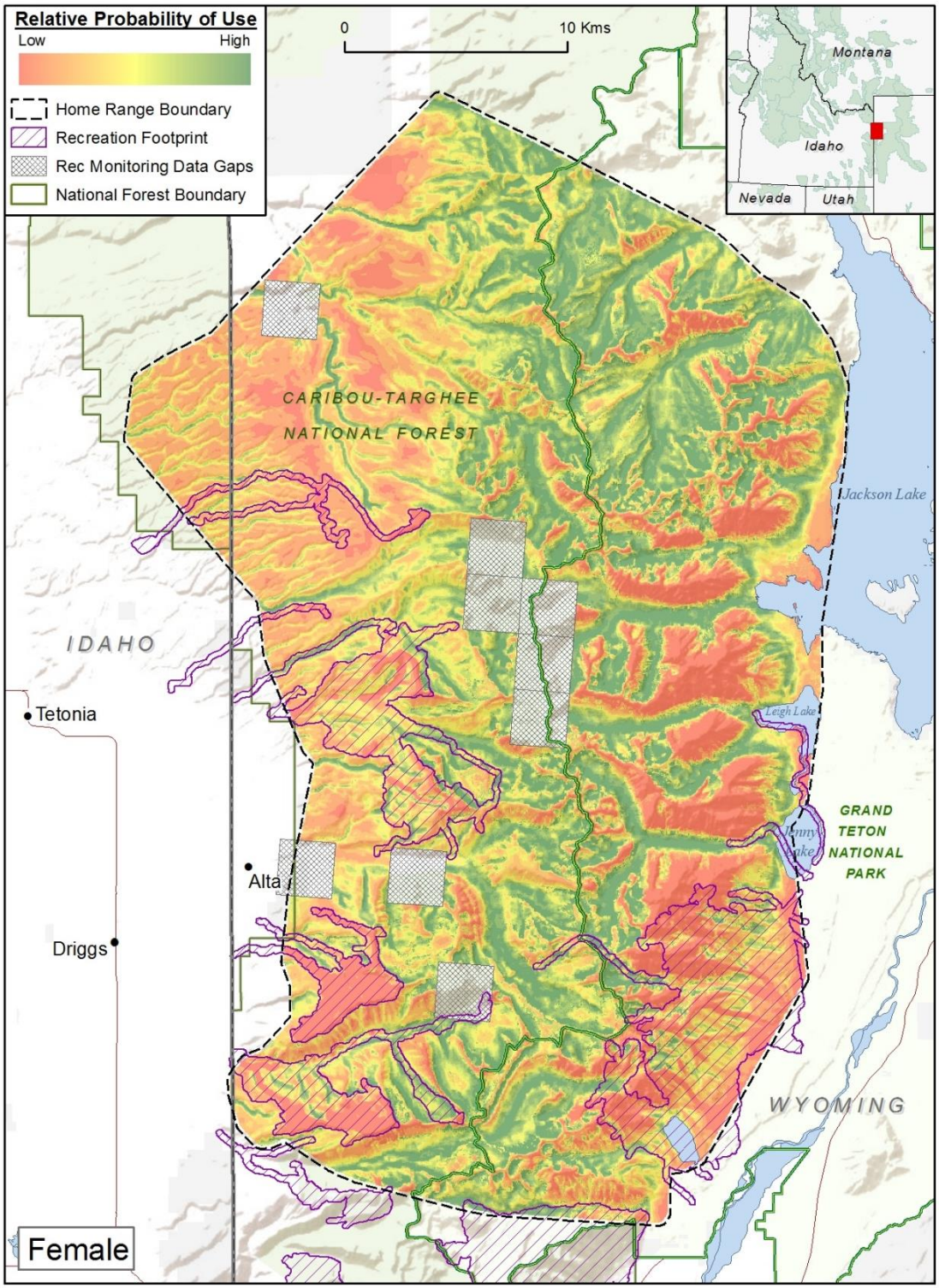

Figure D.7. Resource selection function habitat model for female wolverines (*Gulo gulo*) in the Teton study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

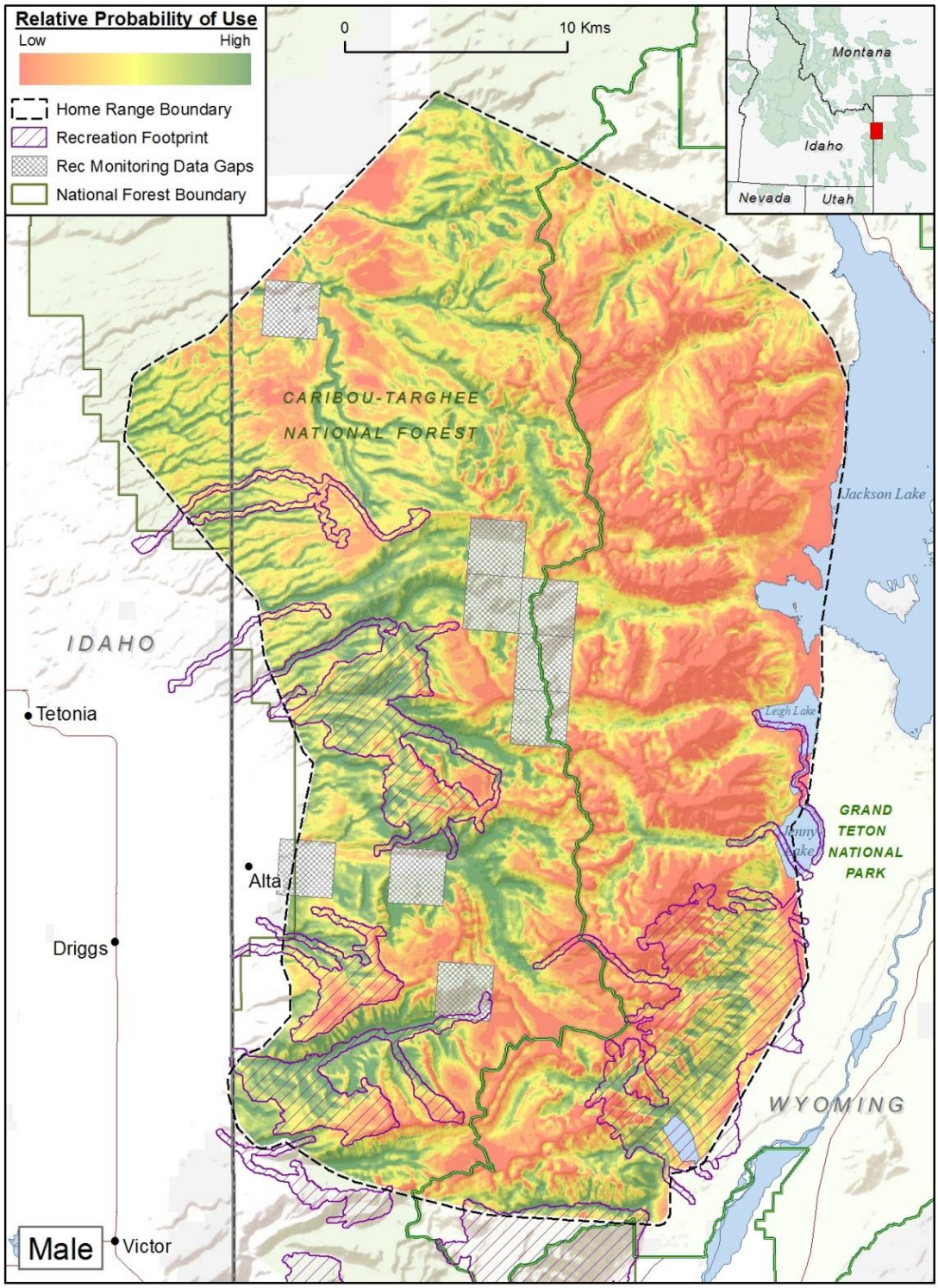

Figure D.8. Resource selection function habitat model for male wolverines (*Gulo gulo*) in the Teton study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

From: Grizzle, Betty
To: Kimberly Heinemeyer
Subject: Re: Question and request for data in winter recreation research project report
Date: Monday, December 18, 2017 2:02:35 PM

Thanks, Kim, very much appreciated. I believe you were going to check with your co-PIs about releasing this information when we spoke earlier this year.

We will keep this information protected (that is, if someone requests these type of data from us, we refer them to the original source).

On Mon, Dec 18, 2017 at 12:49 PM, Kimberly Heinemeyer <kim@roundriver.org> wrote:

> Hi Betty,
>
> That seems odd that you didn't receive those den locations. It must have been a miscommunication or an oversight. Here you go. As before, these are provided in the strictest confidence – do not share location information due to the vulnerability of the site and the animal to disturbance.
>
> Also, note that F11.2015 den site (8th female, 7 female listed in Final Report) is a confirmed den site in that she occupied it showing classic wolverine denning behavior, but GPS collar failed prior to being able to download location data for the female (e.g., develop a home range and include her in the habitat analyses) so this year and therefore this den is not included Table A.1 of the Final Report.
>
> Cheers,
>
> Kim
>
> **From:** Grizzle, Betty [mailto:betty_grizzle@fws.gov]
> **Sent:** Monday, December 18, 2017 12:37 PM
> **To:** Kimberly Heinemeyer
> **Subject:** Re: Question and request for data in winter recreation research project report
>
> Thanks Kim. I only received den locations from Jeff Copeland for Glacier NP (2003-2007) and Sawtooth Mtns (1990s), not directly from you (though I did ask for these when I spoke to you in January).
>
> On Mon, Dec 18, 2017 at 11:06 AM, Kimberly Heinemeyer <kim@roundriver.org> wrote:
>
> Hi Betty,
>
> GPS N is the number of GPS collar locations collected. Sorry, that is not real clear! I can extract the elevation and latitude of the dens, though I believe you would have the actual data, as provided in

the GPS locations of dens you/USFWS requested last year.

From: Grizzle, Betty [mailto:betty_grizzle@fws.gov]
Sent: Monday, December 18, 2017 11:59 AM
To: kim@roundriver.org
Subject: Question and request for data in winter recreation research project report

Hi Kim - In Table A, page 52, there is a column labeled GPS N. Is this elevation (in meters?) and, if so, how does this value relate to location of home ranges (e.g., center point or other position)?

Also, for the denning females listed in that table, if available, can you provide our agency with the elevation and latitude of dens?

Thanks.

--

Betty J. Grizzle, D.Env.

Fish and Wildlife Biologist

U.S. Fish and Wildlife Service

Carlsbad Fish and Wildlife Office

2177 Salk Ave, Suite 250

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760-431-9440, ext. 215

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From: Grizzle, Betty
To: Turner, Ed
Subject: Re: Question and request for data in winter recreation research project report
Date: Monday, December 18, 2017 3:46:53 PM
Attachments: Wolverine Winter Recreation Final Report 15Dec17.pdf

---

Here is her information, but I am also attaching the publication for their study so you can put that in your files.

Kimberly Heinemeyer. Affiliation: Round River Conservation Studies (Bozeman, Montana)

On Mon, Dec 18, 2017 at 2:42 PM, Turner, Ed <ed_turner@fws.gov> wrote:

> Betty, Can you give me more information on Kimberly. Did she work with Diane Evans at IDFG on the winter study? I need to get the source information so we can combine the data and I can get it in a format that I will need back from John.
>
> I list:
>
> Observer - - I'll use her name
> Source_Agency - - If you have this it will help.
>
> Thanks, Ed
>
> On Mon, Dec 18, 2017 at 1:04 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
>
>> Hi Ed - Here are the den locations with message from Kim (including protection of data). Let me know when you have a chance to look it over and we can discuss.
>>
>> ---------- Forwarded message ----------
>> From: **Kimberly Heinemeyer** <kim@roundriver.org>
>> Date: Mon, Dec 18, 2017 at 12:49 PM
>> Subject: RE: Question and request for data in winter recreation research project report
>> To: "Grizzle, Betty" <betty_grizzle@fws.gov>
>>
>> Hi Betty,
>>
>> That seems odd that you didn't receive those den locations. It must have been a miscommunication or an oversight. Here you go. As before, these are provided in the strictest confidence – do not share location information due to the vulnerability of the site and the animal to disturbance.
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Cheers,

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Thanks.

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Edwin Turner, Geographer
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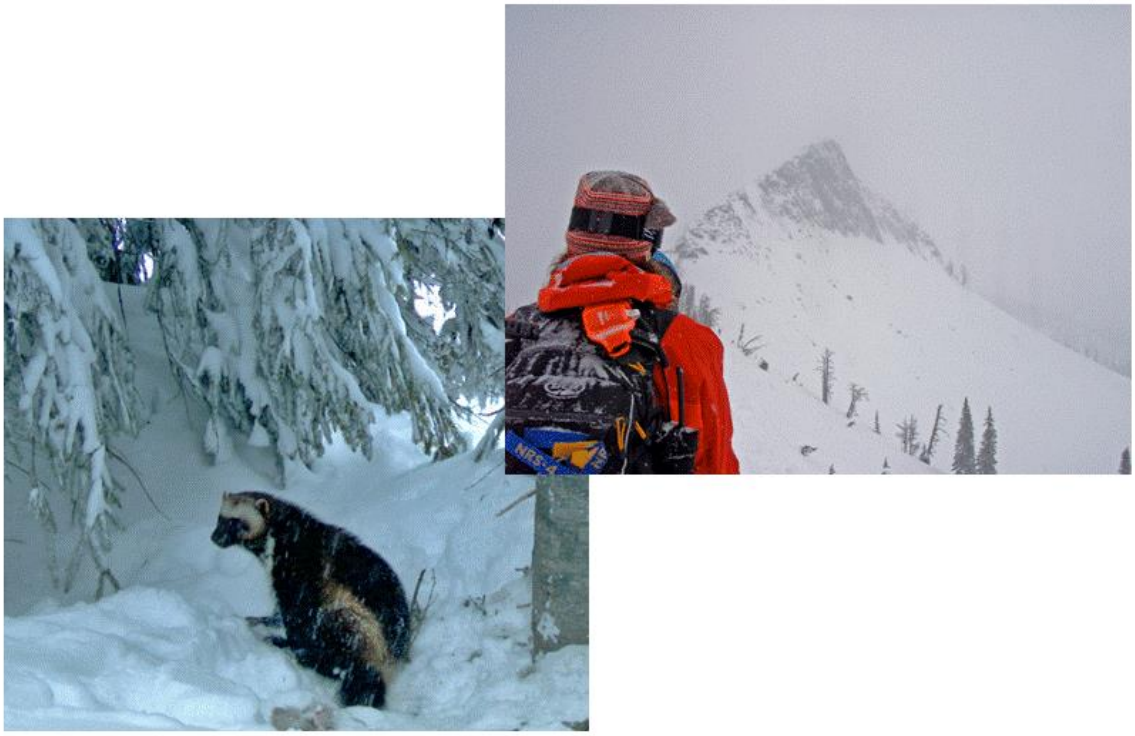
WOLVERINE – WINTER RECREATION RESEARCH PROJECT:
INVESTIGATING THE INTERACTIONS BETWEEN WOLVERINES AND WINTER RECREATION

FINAL REPORT



DECEMBER 15, 2017

HEINEMEYER, KIMBERLY S.[1], JOHN R. SQUIRES[2], MARK HEBBLEWHITE[3], JULIA S. SMITH[1], JOSEPH D. HOLBROOK[2], AND JEFFREY P. COPELAND[2,4]

[1] *Round River Conservation Studies, 104 E. Main St, Bozeman, MT 59715*
[2] *Rocky Mountain Research Station, United States Forest Service, Missoula, MT 59802*
[3] *Wildlife Biology Program, Department of Ecosystem and Conservation Sciences, W. A. Franke College of Forestry and Conservation, University of Montana, Missoula, MT, 59812*
[4] *Current affiliation: The Wolverine Foundation, 4444 Packsaddle Rd, Tetonia, ID 83452*

WOLVERINE – WINTER RECREATION RESEARCH PROJECT:
INVESTIGATING THE INTERACTIONS BETWEEN WOLVERINES AND WINTER RECREATION

FINAL REPORT

DECEMBER 15, 2017

HEINEMEYER, KIMBERLY S.[1], JOHN R. SQUIRES[2], MARK HEBBLEWHITE[3], JULIA S. SMITH[1], JOSEPH D. HOLBROOK[2], AND JEFFREY P. COPELAND[2,4]

WITH THE SUPPORT OF PROJECT PARTNERS AND COLLABORATORS INCLUDING:

BOISE, BRIDGER-TETON, CARIBOU-TARGHEE, PAYETTE AND SAWTOOTH NATIONAL FORESTS
IDAHO DEPARTMENT OF FISH AND GAME
LIZ CLAIBORNE ART ORTENBERG FOUNDATION
THE WOLVERINE FOUNDATION
UNIVERSITY OF MONTANA
GRAND TETON NATIONAL PARK
WYOMING DEPARTMENT OF GAME AND FISH
US FISH AND WILDLIFE SERVICE
IDAHO STATE SNOWMOBILE ASSOCIATION
BRUNDAGE MOUNTAIN RESORT
GRAND TARGHEE RESORT
JACKSON HOLE MOUNTAIN RESORT
CENTRAL IDAHO RECREATION COALITION
DEFENDERS OF WILDLIFE
THE SAWTOOTH SOCIETY
THE WINTER RECREATION COMMUNITIES OF CENTRAL IDAHO AND WESTERN YELLOWSTONE.

[1] *Round River Conservation Studies, 104 E. Main St, Bozeman, MT 59715*
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We are grateful to our multiple partners and collaborators who have assisted the project in numerous ways. Funding, equipment and logistical support for the project has been contributed by the US Forest Service, Liz Claiborne Art Ortenberg Foundation, Round River Conservation Studies, Idaho Department of Fish and Game, The Wolverine Foundation, Wyoming Department of Game and Fish, Idaho State Snowmobile Association, Sawtooth Society, the Nez Perce Tribe and the University of Montana. Several additional organizations have supported the project through assisting with the hand out of GPS units to winter recreationists including: Brundage Mountain Resort, Jackson Hole Mountain Resort, Grand Targhee Resort, Sun Valley Heli Ski, Teton Backcountry Guides and numerous local businesses in the towns of Cascade, Driggs, Fairfield, Island Park, McCall, Stanley, Sun Valley and Victor in Idaho and Jackson, Wyoming.

The project would not have been possible without individuals within our partnering agencies who tirelessly assisted the project in numerous ways. In particular, we thank Diane Evans Mack and Rob Cavallaro (IDFG), Tammy Fletcher (Caribou-Targhee National Forest), Ana Egnew (Payette NF), Lisa Nutt and Joe Foust (Boise NF), Robin Garwood (Sawtooth NF), Gary Hanvey and Kerry Murphy (Bridger-Teton NF) and Aly Courtemanch (Wyoming Game and Fish) for diligently ensuring the success of the project. We also want to thank Mark Drew, veterinarian at IDFG for supporting safe handling of wolverines. Many additional agency personnel assisted us – we thank you for your assistance and support. A large amount of effort is invested behind the scenes in personnel, project and financial management, and we are grateful to Kathleen Wilson at Round River Conservation Studies for always cheerfully handling these often thankless but critical tasks. We thank Lucretia Olson and Dennis Sizemore for advising and commenting on earlier versions of this report.

The backbone of the research is high quality data collection under sometimes challenging conditions, and we are indebted to our hard-working field crew, many of whom worked multiple winters on the project: Blakeley Adkins, Matt Amick, Isaac Babcock, Anne Blackwood, Kristina Boyd, Grace Carpenter, Llona Ney Clausen, Drew Chambers, Chris Cole, Jeff Copeland, Jim Corbet, John Councilman, Katie Coyle, Ross Dorendorf, Danielle Fagre, Tony Folsom, Gary Gadwa, Tom Glass, Erica Goad, Sierra Groves, Jessica Haas, Dylan Hopkins, Brooklyn Hudson, Zack Huling, Lindsay Jones, Rollie Jones, Shannon Jones, Suzanne Johnston, Tyler Kaebisch, Matt Kasprzak, Chris Klingler, Kyle Krapster, Tulley Mackey, Scott Martin, Alex May, Madison McConnell, Cy McCullough, Josh Metten, Nick Miller, Ryan Mong, Celina Moreno, Katy Nelson, Zoe Nelson, Ben Rooney, Rachel Rubin, Joel Ruprecht, Toni Ruth, Kristen Sellmer, Molly Shuman-Goodier, Will Tyson, Carson White, and Jarrod Zweigart. Your commitment, professionalism and good humor made the project not only successful, but also good fun.

We thank the thousands of recreationists who agreed to carry funny little orange data loggers while out having fun and who took the time to return them to us. Your contribution provides a critical foundation to the project. Finally, we thank the wolverines who also carried funny, little data loggers for us, and who have taught us so much.

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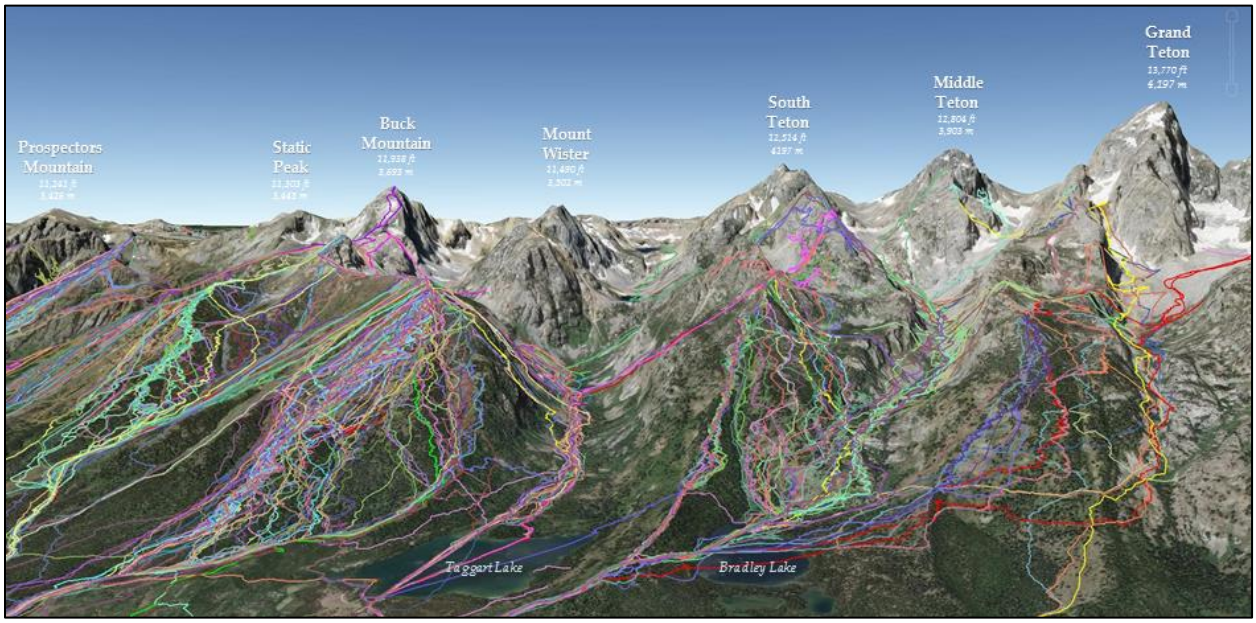

Backcountry ski and snowboard Global Positions System (GPS) tracks collected during the winter of 2014 by volunteer recreationists.

Executive Summary

Outdoor recreation provides opportunities for people to connect to nature, and is a critical economic driver and part of the cultural fabric of some rural communities. Outdoor recreation is also increasingly recognized to have potentially important impacts on nature and wildlife, and we need to understand these potential effects. In recent years, technological advancements in over-snow equipment including 'powder snowmobiles' and lightweight backcountry ski gear provide opportunity for backcountry enthusiasts to access previously remote landscapes for winter recreation activities. Wolverines may be vulnerable to direct and indirect impacts of recreation during winter, as they remain active through the winter, naturally occur at low densities, have low reproductive rates, and enter reproductive dens within deep snowpack during the winter recreation season. The Rocky Mountains represent the southern extent of wolverine distribution and in this region they are limited to high elevation habitat, which overlaps the same types of mountainous terrain sought by backcountry winter recreationists.

Over 6 winters (2010 – 2015) and four study areas, we GPS collared 24 individual wolverines over 39 animal-years to collect >54,000 GPS locations, one of the largest GPS datasets collected on wolverines in the lower 48 states. These wolverines were exposed to a diversity of winter recreation activities across our study areas spanning >1.1 million ha in Idaho, Wyoming and Montana. Simultaneously, we monitored and sampled winter recreation, collecting 5,899 GPS tracks from backcountry winter recreationists representing >198,000km of recreation activity, in the most intensive and extensive backcountry winter recreation monitoring effort that we know of to date. Backcountry winter recreation information was also collected through trail use counts and aerial-based recreation surveys, and the combination of data allowed us to create maps of backcountry winter recreation portraying the extent and relative intensity of motorized recreation and non-motorized recreation within wolverine home ranges. From locations of 18 wolverines (25 animal-years, >53,000 locations), we modelled habitat selection of male and female wolverines within home ranges using resource selection functions and used remaining wolverine data to validate these models. We characterized the habitat selection responses of wolverines to varying winter recreation patterns, and assessed the potential for indirect habitat loss from avoidance of recreated areas. Replicating this across multiple study areas allowed us to evaluate functional responses of wolverines to differing levels and types of recreation, providing further insights into wolverine responses to winter recreation.

Wolverines exhibited selection for specific habitat characteristics within home ranges, with female selection differed in some important ways from males. Female wolverines, which were represented by both denning and non-denning females in our sample, selected for talus and for snowier and colder habitats when compared to males, and we suggest these may represent denning affiliations similar to those found in other studies. Both males and females selected for drainage bottoms and avoided steep slopes. Both male and female wolverines selected for fir-associated conifer forest, avoided open areas but selected for areas close to forest edges. Unlike females, males were found closer to roads than expected; these roads were primarily unmaintained, snow-covered secondary roads with little human use during winter.

Wolverines maintained multi-year home ranges within landscapes that support relatively intensive levels of winter recreation, suggesting that wolverines tolerate winter recreation at some scales. Individual wolverine exposure to winter recreation varied notably across study areas and animals, a key aspect of our study design. Variation in the spatial extent of motorized

recreation ranged from <1% to 51% within home ranges, while non-motorized recreation tended to have smaller footprint areas covering an average of <5%, and ranging from <1% to 9.3% within home ranges. Wolverines responded negatively to increasing intensity of winter recreation, with off-road or dispersed recreation eliciting a stronger response than recreation concentrated on access routes. Indirect habitat loss from winter recreation reduced the quality of 2 – 28% of available habitat within home ranges. Female wolverines exhibited strong avoidance of off-road motorized recreation and were more vulnerable to higher levels of indirect habitat loss than males who appeared to be less sensitive to disturbance. While non-motorized recreation covered a relatively small proportion of home ranges, these areas were also avoided by male and female wolverines. The avoidance of areas of linear access used by winter recreationists was not as strong as estimated for dispersed recreation and wolverines may be less sensitive to predictable patterns of human use.

The strength of wolverine negative responses to dispersed motorized and non-motorized recreation increased with increasing levels of the recreation within the home range. This functional response of wolverines to recreation intensity suggests that potentially important indirect habitat loss may occur when a notable portion of an animal's home range receives recreation use, as it is exactly those animals exposed to higher levels of recreation that are most strongly displaced from these areas. The functional response also suggests that limited exposure may mute the indirect habitat loss, and some of our animals were exposed to relatively low levels of winter recreation. Our ability to understand wolverine responses to non-motorized recreation is hindered by having few wolverines exposed to higher levels of this recreation type.

Currently, exposure to winter recreation is highly variable within home ranges and across individuals indicating further work is needed to understand population-level effects. We suggest significant habitat degradation to reproductive females during denning season should be of concern within landscapes with higher levels of winter recreation. We speculate that the potential for backcountry winter recreation to affect wolverines may increase under climate change due to reduced snow pack and snow season that may concentrate winter recreationists spatially and temporally in these high elevation habitats during a season when these species face increased energetic stressors and females enter reproductive dens. We recommend that solutions to finding a balanced approach to sustaining the diverse values of these wild landscapes requires creative approaches and collaborations between land managers, stakeholders and wildlife professionals.

Cite as: Heinemeyer, K. S., J. R. Squires, M. Hebblewhite, J. S. Smith, J. D. Holbrook, J. P. Copeland. 2017. Wolverine – Winter Recreation Research Project: Investigating the interactions between wolverines and winter recreation. Final Report, December 15, 2017. 71pp. Available at: www.roundriver.org/wolverine.

Introduction

Fostering societal appreciation for nature conservation partly relies upon individuals connecting to nature during leisure activities including participating in outdoor recreation activities. Winter snow-based recreation is an important component of the outdoor recreation industry, and includes backcountry sports in undeveloped landscapes. In recent years, technological advancements in over-snow equipment including 'powder snowmobiles' and lightweight backcountry ski gear provide opportunity to access previously remote landscapes. Not only are backcountry recreationists potentially important advocates for the landscapes they visit (Teisl and O'Brien 2003, Gifford and Nilsson 2014), but the winter recreation is important economically and culturally for many small communities (e.g., (Scott et al. 2008).

While maintaining societal values for nature partly depends on supporting interactions with natural landscapes, the potential impacts of this use needs to be understood (Boyle and Samson 1985, Knight and Gutzwiller 1995, Taylor and Knight 2003). There have been an increasing number of studies highlighting a diversity of recreation-based impacts on habitats and wildlife species (Steven et al. 2011, Sato et al. 2013, Larson et al. 2016, Ewacha et al. 2017). The most commonly recorded wildlife responses include both behavioral and physiological stressors on individual animals, including increased avoidance of the disturbance, elevated stress hormones and displacement from preferred areas (Harris et al. 2014, Arlettaz et al. 2015, Larson et al. 2016). Recreation that results in the avoidance of disturbed areas leads to indirect habitat loss (Patthey et al. 2008, Polfus et al. 2011, Coppes et al. 2017b). The importance of disturbance and particularly indirect habitat loss from winter recreation may be elevated if animals face increased energetic demands for thermoregulation and travel over snow while food may be less abundant or of lower quality (Telfer and Kelsall 1979, Parker et al. 1984, Neumann et al. 2009).

Habitat displacement and indirect habitat loss from winter recreation activities have been documented in a diverse array of montane and alpine species. In Europe, for example, high elevation forest grouse (*Tetrao* sp.) are negatively impacted by backcountry winter recreation including habitat displacement as well as energetic and physiological effects (Patthey et al. 2008, Braunisch et al. 2011, Arlettaz et al. 2015, Coppes et al. 2017b). Many species of large herbivore (e.g., red deer (*Cervus elaphus*), mountain caribou (*Rangifer tarandus caribou*), bighorn sheep (*Ovis canadensis*), mountain goat (*Oreamnos americanus*), and moose (*Alces alces*)) have exhibited negative physiological or behavioral responses including indirect habitat loss through avoidance associated with motorized and non-motorized winter recreation (Seip et al. 2007, Neumann et al. 2009, Courtemanch 2014, Richard and Cote 2016, Coppes et al. 2017a, Lesmerises et al. 2018). As backcountry winter recreation grows in intensity and spatial extent coupled with the potential concentration of activities due to climate change, there is a growing need to understand the potential effects on wildlife species particularly those that are sensitive, snow-associated, and occupy alpine habitats.

Large carnivores are globally threatened and declining, and have experienced negative effects of human-caused habitat fragmentation and loss throughout their range (Ripple et al. 2014). In North America, the Rocky Mountains represent a large carnivore hotspot (Noss et al. 1996, Laliberte and Ripple 2004), where some species are restricted to high elevation habitat. The wolverine (*Gulo gulo*) is limited to northern latitudes across its circumpolar distribution, is closely associated with snow and subalpine or alpine habitats throughout the winter and reproductive denning, and is a species of conservation concern. Indeed, there is high potential for overlap and interactions between wolverines and backcountry winter recreationists because they both occupy similar areas. Wolverines may be vulnerable to direct and indirect impacts of

recreation during winter, as they naturally occur at low densities, have low reproductive rates, and remain active through the winter (Hash 1987). There has been no effort focused on understanding wolverine responses to winter recreation, though research suggests they are sensitive to human activities and infrastructure (May et al. 2006, Krebs et al. 2007, Stewart et al. 2016, Heim et al. 2017). Females enter reproductive dens within deep snowpack in during the winter recreation season with kits born in mid-Feb to early March and they occupy these dens through late April or mid-May (Hash 1987, Magoun and Copeland 1998). The potential impact of backcountry winter recreation to denning females is of primary concern (Carroll et al. 2001, May et al. 2006, Copeland et al. 2007, Krebs et al. 2007). In Canada, wolverine status was changed to 'Special Concern' in 2014 with increased winter recreation use combined with sensitivity of denning females among the considerations (www.cosewic.gc.ca). In the United States, wolverines are being considered for listing under the Endangered Species Act, with the most recent status review (Service 2013) indicating a lack of evidence to assess potential effects of winter recreation.

Understanding the responses of elusive, low-density wildlife species to relatively novel human uses such as backcountry winter recreation require committed and innovative approaches that capture the temporal and spatial variability inherent in the human use patterns and in the responses of animals to this disturbance (Tablado and Lukas 2017, Squires et al. 2018). Previous studies on the effects of winter recreation on wildlife species have been limited spatially and temporally, and most were focused within a single study area and on a single form of winter recreation (Larson et al. 2016). Over six years, we monitored the movements and habitat use of wolverines in four different study areas in the Rocky Mountains of Idaho, Wyoming and Montana. We simultaneously tracked and monitored winter recreation to characterize the spatial

extent and relative intensity of activities across the landscape. We hypothesized that wolverine responses to winter recreation would be influenced by the type of winter recreation, as well as the spatial extent and intensity of the recreation. We developed resources selection analyses to both understand wolverine habitat use within home ranges and to test wolverine responses to type, spatial extent and the relative intensity of winter recreation. These analyses allowed us to evaluate the potential for indirect habitat loss due to winter recreation (Johnson et al. 2005, Polfus et al. 2011, Hebblewhite et al. 2014). While resource selection analyses provide an estimate of average responses, they tell us little about how wolverine responses may change based on the level of exposure to winter recreation (Mysterud and Ims 1998, Hebblewhite and Merrill 2008). Functional responses can include such important effects as habituation and threshold effects (Hebblewhite and Merrill 2008, Moreau et al. 2012, Holbrook et al. 2017). For example, Hebblewhite and Merrill (2008) found that wolves showed no response to humans in areas of low human activity, but as the amount of human activity increased, they displayed heighted avoidance. We tested for functional responses in habitat use of wolverines by evaluating how wolverine use of recreated areas changes with changing availability (Holbrook et al. 2017). The goals of our research were three-fold: 1) characterize fine-scale (i.e., third-order home range scale, Johnson 1980) habitat use and selection of male and female wolverines; 2) assess the importance of motorized and non-motorized winter recreation in influencing wolverine habitat use and habitat quality; and 3) test if the responses of wolverines to winter recreation were dependent upon the spatial extent and relative intensity of the recreation within individual home ranges.

Methods

To understand wolverine responses to winter recreation disturbance, we fit Global Position System (GPS) collars on wolverines to monitor movements and habitat use in mid and late winter, and concurrently sampled and monitored winter recreation. We developed wolverine resource selection functions (RSF) at the third order (within home range scale, Johnson 1980) with a use:availability design to estimate the relative probability of selection (Manly et al. 2002, Johnson et al. 2006, McDonald 2013). We developed maps of different types of winter recreation and included these as covariates in RSFs to test hypotheses concerning the effect of winter recreation on wolverine habitat selection. Based on the selected models, we evaluated indirect habitat loss from winter recreation, as measured by the loss in predicted habitat quality with the inclusion of winter recreation covariates in the RSF, with habitat quality classified by relative probability of use (i.e., Polfus et al. 2011). Finally, we tested if wolverines showed functional responses to winter recreation based on the relative intensity of winter recreation to which they were exposed. We used ArcGIS (ArcGIS Desktop: Release 10.1 – 10.5, Redlands, CA: Environmental Systems Research Institute) and R (R Core Team 2016) for data management and analyses.

Study Area

Our research included four broad study areas spanning >1.1 million ha in Idaho, Wyoming and Montana (Figure 1) which we refer to as: McCall study area (Payette NF, northern Boise NF); Sawtooth study area (including portions of the Sawtooth NF, southern Boise NF); West Yellowstone study area (including portions of the Caribou-Targhee NF, Custer-Gallatin, NF and Beaverhead-Deerlodge NF), and the Tetons study area (including portions of the Caribou-Targhee NF, Bridger-Teton NF and the Grand Teton National Park). Each study area

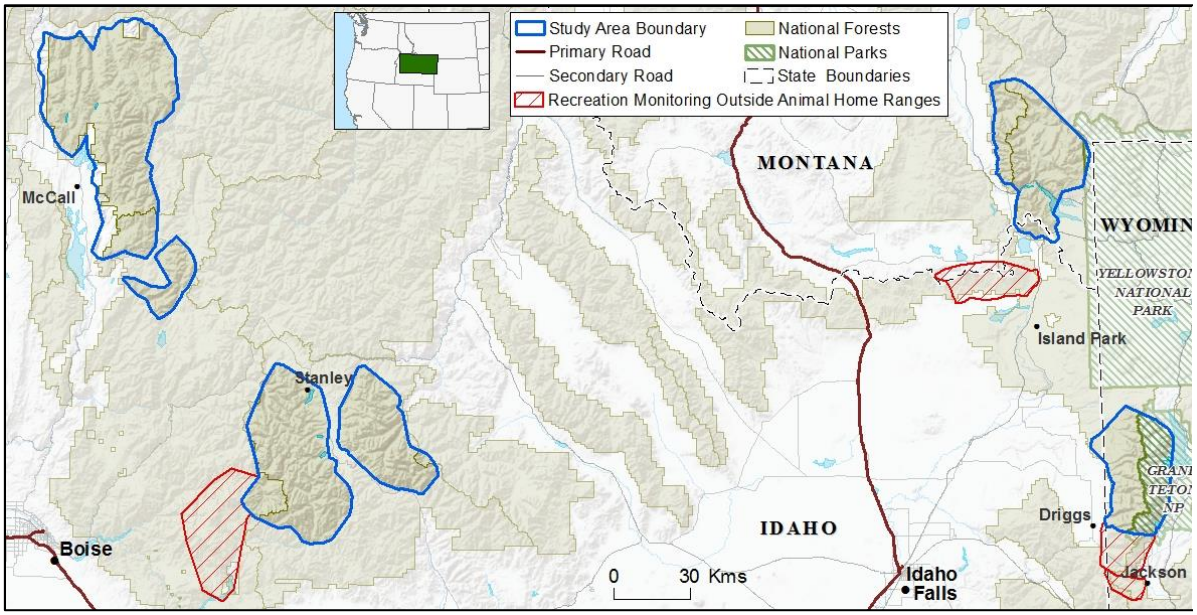

Figure 1. Four broad study areas (McCall, Sawtooth, West Yellowstone and Tetons) for examining effects of winter recreation on wolverines (*Gulo gulo*) in Idaho, Montana, and Wyoming, USA, years 2010-2015. The study area boundaries in blue identify the outer extent of wolverine home ranges monitored during the study, while the red hatched areas indicate additional areas where camera and live-trapping for wolverines occurred without the identification of wolverine presence. Winter recreation sampling occurred in all study areas.

was a popular backcountry winter recreation destination with backcountry snowmobiling, skiing or both occurring in the range of wolverines, but also large areas without intense winter human activity. Study areas were primarily National Forest System lands, but also contained a mix of other state and federal land designations. Topography was mountainous with alpine dominated by rock, ice and low-growing herbaceous vegetation, transitioning into more open conifers with open rocky or subalpine shrub, grass and herbaceous vegetation. Mid-elevation vegetation was dominated by coniferous forests, with interspersed deciduous tree and shrub communities. The lower boundaries of the study areas were defined by the lower limits of wolverine use, typically near the lower limit of forested habitats, with rare agricultural and sagebrush steppe near these margins.

Infrastructure supporting backcountry recreation varied across the study areas. All study areas maintained parking areas for backcountry access at trailheads or along plowed roads, and some study areas had a network of groomed snowmobile trails. Within wolverine home ranges, roads were almost exclusively secondary roads that were not plowed for vehicle travel though some were groomed for snowmobile use. Plowed roads occurred along the periphery or in close proximity outside of home range boundaries. All roads were snow-covered during our study, and motorized and non-motorized recreation use was allowed on the majority of roads regardless of whether they were groomed for recreation use. Winter recreation activities varied in the number of recreationists and types of recreation, and each study area had a unique combination of backcountry recreation including snowmobile, ski (including snowboards), snowmobile-accessed ski/board (hybrid), cat-ski, heli-ski and yurt-supported ski. The McCall, Sawtooth and Teton study areas also had developed ski resorts which allowed for backcountry or out-of-bounds skiing.

Wolverine capture and monitoring

Between 2010 – 2015 we captured wolverines from early January through April using modified box traps built from logs (Lofroth et al. 2008) baited with road-kill deer or trapper-caught beaver and a skunk-based lure. Each trap was equipped with a satellite-device that notified us when the trap was triggered (Vectronics trap transmitters TT2, TT3; Vetronic Aerospace GmbH, Berlin, Germany), as well as a VHF-based trap trigger (Telonics trapsite transmitters, TBT series; Telonics, Inc, Mesa, AZ, USA); traps were visited immediately if triggered, and maintained every 3 – 5 days (see Appendix A for additional details). Traps were closed late February to late March to avoid capturing a reproducing female, and re-opened in late March through April for collar removal. Wolverines were anesthetized using a 10 mg/kg

ketamine hydrocholoride and 0.075 mg/kg medetomidine mixture (Fahlman et al. 2008) delivered by a jab stick. A GPS collar (either WildCellSL collar from Lotek Wireless, Newmarket, Ontario, Canada or Quantum 4000 collar from Telemetry Solutions, Concord, CA, USA) was attached and programmed to collect a location every 20 minutes on weekends (Saturday, Sunday) and mid-week (Tuesday, Wednesday), which we expected to differ in intensity of human use. Collars were modified with a cotton strip designed to rot away within 4 – 6 months if we were unable to recapture the animal. Trapping and handling procedures were approved through the University of Montana Institutional Animal Care and Use Committee (IACUC; Permit #055-10MHECS-113010) and the National Park Service IACUC under a research permit (GRTE-2015-SCI-0003). We also obtained research permits through Idaho Department of Fish and Game (IDFG) and Wyoming Game and Fish (WGF). We monitored the status of wolverines through aerial telemetry flights, including identifying potentially denning females (Appendix A).

Resource Selection Function Analyses

Resource selection functions (RSF) compare covariate characteristics at used GPS locations with random locations (putatively available) to identify covariates that are used disproportionately more (i.e., selected) or less than (i.e., avoided) available (Manly et al. 2002). We used general linear mixed-effects models with a logit link function (GLMM) and animal-year as a random effect to control for repeated sampling of individuals (Gillies et al. 2006). The mixed-effects RSF model therefore takes the form:

$$w(x) = \beta_1 x_{1ij} + \beta_2 x_{2ij} + \beta_3 x_{3ij} + \cdots + \beta_n x_{nij} + \gamma_{0j} + \varepsilon_{ij} \quad (1)$$

where x_n are covariate values for location i of animal-year j with the fixed regression coefficient β_n; γ_{0j} is the random intercept for animal-year j and is ε_{ij} is the residual variance within each

animal-year. Logistic regression (Hosmer et al. 2013) is used to fit the exponential approximation to an inhomogeneous spatial-point process model, but without the intercept because in used-available designs, the true amount of non-use is unknown (McDonald 2013). Thus, the resultant probability is best considered a relative probability of selection or use (Lele et al. 2013). Animal and random (available) locations were attributed with the environmental and winter recreation covariates (see below), which were then standardized to support model fitting and allow for comparisons between model coefficients (Hosmer et al. 2013).

Location data and home range analyses

We defined available habitat by estimating home range boundaries using a local convex hull (LoCoH) non-parametric kernel method (Getz et al. 2007) with a fixed 'k' number of nearest neighbors (Appendix A). We buffered calculated polygons by the sex-specific median step length (331 m for females, 441 m for males) to account for habitat immediately available to the animal. We included individual wolverine animal-years with ≥5 weeks of GPS monitoring in that winter in model development. Data for individuals monitored for <5 weeks, or subadults with exploratory behaviors, were withheld for model validation. Within each home range, we estimated available habitat with random locations generated at a ratio of 2:1 random:use with random locations forced to be ≥30m apart.

Wolverine spent time under snow and structures that resulted in low GPS fix-rates and potential behavioral or habitat-induced bias (Frair et al. 2004, Nielson et al. 2009). To account for behavior-based missed locations, we developed a modification of Knopff et al. (2009) to identify clusters of wolverine locations based on their spatial (within 25m of each other) and temporal (within 24 hours of each other) proximity. Missed locations were associated with a known cluster site if the location before or after the failed GPS attempt was within a cluster, and

the cluster centroid was imputed for their location (Frair et al. 2004). Locations <100 m of an active trap site were censored given the effect of baited traps.

Environmental variables

We evaluated land cover, topographic, snow, climate and anthropogenic covariates (Appendix B) that may be important predictors of wolverine resource selection at the third-order. First, we identified the spatial scale most strongly selected by wolverines (DeCesare et al. 2012; Appendix B). Second, we screened covariates for collinearity (|r| >= 0.6), and the covariate with the lowest univariate AIC was retained (Hosmer et al. 2013). Finally, we evaluated covariates for potential nonlinear relationships using general additive models (Hilbe 2015) and by testing potential non-linear models, keeping the form of the covariate with the lowest AIC (Hosmer et al. 2013). This resulted in slope being included in a quadratic form.

Winter recreation sampling and models

We developed spatially-explicit maps of winter recreation by sampling backcountry recreation using three methods: GPS tracking of volunteer recreationists (*sensu* Olson et al. 2017), infra-red trail use counters, and aerial surveys. We combined spatial information from GPS tracks with the amount of recreational use from trail counters to develop maps of winter recreation intensity of all recreation combined as well as by motorized or non-motorized recreation type. We used the aerial surveys to validate recreation maps (Appendix C).

To collect GPS tracks of recreation, we sampled recreationists at known recreation access points during mid-week (Tuesday, Wednesday) and weekend (Saturday-Sunday) days from mid-January through mid-April. We sampled recreation systematically, not in proportion to recreation use at access points or across study areas. We asked recreation groups to carry one GPS unit (Qstarz International Co., Ltd., model BT-Q1300, 1 location/5 seconds, position accuracy < 10

m) per ≤4 people in the group, and we recorded the type of winter recreation and the group size per GPS unit. We also distributed GPS units to backcountry guide, heli-ski and cat-ski operations, with guides carrying the GPS units and recording their group size. To estimate the number of recreationists accessing each study area, we installed infra-red trail counters (Trafx Research Ltd, Canmore, Alberta, Canada) at constriction points on backcountry snowmobile and ski/snowboard access routes. If the access route was used by both out-going and incoming recreationists, the counts were divided by two to estimate the one-way traffic.

We developed maps of winter recreation, including linear travel or access routes and the relative intensity of dispersed use based on the GPS tracks. To account for differences in overall use within and between study areas, we weighted each GPS track based on the proportion of the estimated total recreation use it represented from each trailhead or access point, with total use estimated from the trail use counters associated with the access point:

$$w_i = \left({Trail\ count_j} \Big/ {\sum Groups_j} \right) \times GPS\ Group_i \qquad (2)$$

where i = individual GPS track, j = trailhead (or group of clustered trailheads), *Trail count* = the estimated total recreationists accessing from trailhead$_j$, $Groups_j$ = the total number of people sampled as the sum across all groups carrying GPS units at trailhead j, and GPS Group$_i$ = the number of people associated with GPS track i.

The GPS tracks of recreationists that use motorized access (e.g., snowmobile, cat-ski, heli-ski) to undertake non-motorized activities were split into their motorized and non-motorized components. For heli-ski GPS tracks, we used only the non-motorized portions of GPS tracks and discarded the track associated with the helicopter transport. To test for wolverine responses to spatial pattern and intensity of winter recreation, we developed maps of recreation: 1) the recreation footprint as a binomial characterization of recreation extent that includes linear and

dispersed recreation; 2) recreation access routes (recreated roads and groomed trails); 3) the relative intensity of all winter recreation; 4) the relative intensity of off-road or dispersed recreation (tracks >30m from a road or groomed route) for all recreation and 5) the relative intensity of motorized and non-motorized recreation separately (see details in Appendix C).

Model Selection

To test our hypotheses of wolverine responses to winter recreation, we first developed RSFs (habitat models) based on environmental covariates not including recreation, which predicts 'potential' habitat quality in the absence of receation, based on relative probability of use (Polfus et al. 2011, Trainor and Schmitz 2014). Then, we added winter recreation covariates to the potential habitat model(s) to test for responses of wolverines to different aspects of winter recreation (e.g., spatial extent, relative intensity, recreation type) and to identify the best model to predict 'realized' habitat quality accounting for effects of winter recreation on wolverine habitat selection. We followed a two-step process to identify the environmental predictors of wolverine habitat use for all animals combined (global model), for females (female model) and for males (male model). We used fixed-effect least absolute shrinkage and operator selection (LASSO) logistic regression (Tibshirani 1996, Reineking and Schröder 2006) implemented using the 'glmnet' package in R (Friedman et al. 2010) to identify the most predictive of the potential covariates (penalty strength set within one standard error of the minimum cross-validated error; Friedman et al. 2010). In the second step, we developed RSF global, female and male models using GLMM with animal-year as a random effect using the 'lme4' package in R (Bates et al. 2015). We compared the summed AIC scores of the male and female RSF models to the global RSF AIC to determine if a single global model or separate sex-based models were supported (Burnham and Anderson 1998). To include winter recreation effects, we then developed five

additional RSF models that included the potential habitat RSF covariates and five winter recreation covariates from our winter recreation maps. We selected the model with the lowest ΔAIC to best represent realized wolverine habitat use in areas that also have winter recreation. For the selected models of potential habitat and realized habitat, we used 10-fold cross validation to assess the goodness of model fit (Boyce et al. 2002). We also validated the models using out-of-sample GPS location data from wolverine animal-years not used in the development of habitat models to determine how our models predicted the frequency of wolverine use (e.g., DeCesare et al. 2012, Holbrook et al. 2017).

Comparing potential and realized habitat quality

We estimated the amount of predicted change in wolverine habitat quality that may occur in the presence of winter recreation by calculating the reduction in habitat quality between the potential habitat and realized habitat models (Johnson et al. 2005, Nielsen et al. 2010, Polfus et al. 2011, Hebblewhite et al. 2014). Given we did not measure habitat use in the absence of winter recreation, we assume that the influence of winter recreation is independent of environmental variables and evaluated this assumption by comparing the standardized model selection coefficients of environment covariates between the potential and realized models (Hosmer and Lemeshow 2008). If model coefficients were 'stable' in the potential and realized models, this suggests that recreation and other covariates were not confounded, thus enabling our ability to predict additive effects of 'adding' or 'removing' recreation.

Each model was then mapped at a 30 m^2 resolution and mapped values were binned into 10 quantiles from low to high quality or relative probability of use. We classified habitat quality by classifying the top 30% of the area (bins 8 – 10) as 'high quality habitat', the next 30% (bins 5 – 7) as 'moderate quality habitat' and the lowest 40% of habitat values (bins 1 – 4) as 'low

quality habitat'. We did not include areas where gaps in winter recreation monitoring information did not allow us to predict the probability of use. Indirect habitat loss was calculated as the spatially-explicit reduction in habitat class when comparing the realized habitat model to the potential habitat model (Johnson et al. 2005, Polfus et al. 2011). We summarized the amount of change across the study areas as well as area within individual home ranges. We calculated the degree of habitat degradation by the number of classes reduced, with the most severe degradation indicated by high quality habitat that is degraded by two classes to low quality habitat.

Functional responses to winter recreation

We tested if wolverines exhibited a functional response to the relative intensity of motorized and non-motorized dispersed winter recreation by evaluating how habitat use of recreated areas changes with availability of these areas. If there is no functional response, habitat use of recreation changes in proportion to availability (Holbrook et al. 2017), while deviations from proportional use indicate a functional response. We calculated habitat use and availability of the relative motorized and non-motorized recreation intensity by computing the mean recreation intensity at used and available locations for each animal-year home range. We then analyzed these data using the following model:

$$U_{R\mathrm{i}} = \beta_0 + \beta_R\,(A_{R\mathrm{i}}) \qquad (3)$$

where R indicates the recreation type (motorized or nonmotorized); $U_{R\mathrm{i}}$ = the average recreation intensity at used locations of each animal-year i; β_0 = y-intercept, β_R = slope of the functional response; and $A_{R\mathrm{i}}$ = the average recreation intensity at available locations within the home range of animal-year i. The null hypothesis is $\beta_R = 1$ (proportional use), while $\beta_R < 1$ indicates decreasing use and $\beta_R > 1$ indicates increasing use as availability increases.

Results

In this Final Report, we focus primarily on modeling and analytical results as the key final products of this multi-year research effort. We have presented field-based results throughout the life of the research effort within Annual Progress Reports including data collection efforts and data summaries, and we recommend reviewing the progress reports for these details, available at www.roundriver.org/wolverine.

Wolverine trapping and location data

We captured 24 individual wolverines over five years of live-trapping, with two years spent within most individual study areas though the McCall study area had four years of trapping efforts (Appendix A). We did not successfully identify the presence of wolverines in either the Trinity Mtns (part of the Sawtooth study area) or the Centennial Mtns (part of the West Yellowstone study area), and we did not identify or capture any female wolverines in the Tetons Mtns or any wolverines in the southern portion of the Tetons, despite ≥2 years of high effort in each area (Appendix A). We radio-collared the 24 wolverines (11 females, 13 males), and recaptured 11 of these animals for 2 – 4 years for a total of 39 animal-years. We obtained >5 weeks of data from 18 (10 females, 8 males) animals and 25 animal-years, averaging 2101 locations/animal-year between mid-Jan and end of March (see Appendix A). An additional nine animal-years (5 female animal-years with 6,841 locations and 4 male animal-years with 9,954 male locations) were used for model validation and four collared animals either slipped their collar or otherwise could not be found and no data were collected. Raw fix-rates were 75.8%, yet 78% of failed GPS attempts were associated with clustered behavior and were thus imputed. After correcting for missed locations, our corrected fix-rate was 94.7%, providing 53,301

Table 1. Summary of the male and female wolverines (*Gulo gulo*) GPS collar locations and home range estimates during winter seasons (2010-2015) in Idaho, Wyoming and Montana as part of research examining wolverine responses to winter recreation. Home range areas were estimated using a local convex hull non-parametric kernel method (Getz et al. 2007).

	Individuals	**Animal-Years[1]**	**Ave # locations ± SD**	**Location count range (min – max)**	**Ave home range (km^2) + SD**	**Min – Max of home range sizes (km^2)**
Males	8	12	2590 ± 677	806 - 3778	1273 ± 471	401 – 2158
Females	10	13	1894 ± 547	1247 - 3079	289 ± 92	126 – 420

[1] Animal-years indicates the total number of winter seasons cumulatively monitored accounting for multiple seasons of monitoring of some individual animals

locations used in the spatial modeling and >10,000 for model validation. The average size of female winter home ranges was smaller than male winter home ranges (Table 1, Appendix A).

Recreation Monitoring

Every study area had at least one year of GPS-based recreation tracking, infra-red trail use counts and aerial surveys, with most study areas having two years of recreation monitoring. We recorded 5,899 GPS tracks of combined length of 198,019km (Table 2). While we recorded a diversity of backcountry recreation types (Appendix C), snowmobiling was the most popular motorized backcountry recreation while skiing was the most popular non-motorized recreation. More non-motorized recreation tracks were collected (3,125) than motorized (2,956) and hybrid types of recreation were limited (237 tracks). The vast majority of non-motorized recreation tracks were collected in the Teton study area, with localized areas of non-motorized recreation in other study areas (Table 2). Snowmobile tracks were longer (average of 60km) than ski tracks (average of 10km) and snowmobile tracks constituted 82% of our total track length. Snowmobiling was a common recreation activity across all of our study areas. Heli-ski only occurred within our Sawtooth study area and cat-ski recreation was only present in the McCall

Table 2. The number (%) of motorized and non-motorized recreation GPS tracks collected in our study areas, the annual average number of recreationists sampled (carrying or in a group with a GPS), the average annual trail use counts from infra-red trail use counters, and the estimated proportion of total use that we sampled (total people represented by GPS tracks/total use).

Recreation Type	McCall	Sawtooths	West Yellowstone	Tetons
GPS tracks, motorized	1620 (93%)	755 (54%)	386 (98%)	195 (8%)
GPS tracks, non-motorized	118 (7%)	613 (46%)	9 (2%)	2385 (92%)
Ave annual number of recreationists represented by GPS tracks	4,125	2,596	1,389	3,568
Average annual recreation visits	16,173	6,149	7,215	23,387
Sampling effort	25.5%	42.2%	19.3%	15.3%

study area. We established trail use counters at 25 sites, with most sites monitored for two years. The total number of recreation visits varied considerably across our study areas, reflecting the relative popularity of each study area as a destination for recreationists traveling from other areas (Table 2). The Teton and the McCall study areas received the highest use with >23,000 and >16,000 visits annually, respectively. The proportion of recreationist sampled using GPS tracking also varied based partly on the total recreation use but also based on localized access patterns, from 42% in the Sawtooth study area to 15% in the Tetons study area (Table 2).

Winter recreation occurred in 12.5% of our study area, and the spatial extent and relative intensity of both motorized and non-motorized winter recreation varied notably within and across study areas (Table 3, Figures 2 - 5). In the McCall study area (Table 3, Figure 2), the most widespread and intense recreation occurred in the north (covering approximately 16% of the Payette NF portion of the study area), and included extensive motorized recreation adjacent to a developed ski area and backcountry cat-ski activities. The lowest overall levels of winter recreation occurred across much of our Sawtooth study area with <5% disturbance from each of motorized and non-motorized recreation activities (Table 3) though recreation did have areas of

high localized intensity, and the Trinity Mtns had extensive motorized recreation covering 32% of the area (Figure 3). The Sawtooth area also included an area used for heli-ski. Relatively high levels of winter recreation levels were recorded in the West Yellowstone area (Table 3, Figure 4), with 50% of the Centennial Mtn portion of the study area within the motorized recreation footprint. One male wolverine home range extended north of our recreation monitoring area and into the southern Madison Mtns; portions of this northern area had extensive motorized recreation based on our aerial surveys resulting in a significant data gap (Figure 4). The Teton study area included a diverse array of winter recreation (Table 3, Figure 5). Motorized recreation was absent from the Grand Teton National Park, but non-motorized recreation occurred in 14% of the monitored Park area. The areas west of the Park, within the Caribou-Targhee NF support both motorized and non-motorized use including developed and out-of-bounds skiing associated with the Grand Targhee Resort. We were unable to adequately sample motorized recreation in portions of this area and based on our aerial recreation surveys (Figure 5) it is more widespread and intense than suggested by our recreation covariates. The highest overall winter recreation levels were in the southern Tetons including the Teton Pass area of the Caribou-Targhee and Bridger-Teton NFs (Table 3, Figure 5). We recorded >50% of this area with winter recreation, primarily as non-motorized winter recreation (47%), this also areas of motorized recreation as well as the developed and out-of-bounds skiing associated with the Jackson Hole Ski Resort (Figure 5).

The spatial extent and relative intensity of backcountry winter recreation also varied within and across wolverine home ranges. Motorized recreation, on average, occurred in 22% and 14% of female and male home ranges, respectively, but varied greatly from a low of <1% to a high of 50%. In general, non-motorized winter recreation has a smaller footprint in most of our

study areas covering <5% of home ranges on average, and two females were not exposed to non-motorized recreation. The Tetons study area had more non-motorized recreation than other study areas (Table 3, Figure 5) and the male wolverine residing there was exposed to higher non-motorized winter recreation levels covering 10% of his home range. Average recreation intensity of motorized recreation ranged from 0.00025 – 0.422 within home ranges. Given the smaller footprint of non-motorized recreation, it is not unexpected that the maximum average non-motorized recreation intensity value is lower, with a range of values of 0.001 – 0.093 within home ranges.

Table 3. Summary of the recreation footprint by study area, broken out by Administrative area or by distinct mountain ranges (see Figures 1); the proportion of each area in the motorized recreation footprint and in the non-motorized recreation footprint are estimated by our GPS track-based recreation maps.

Study Area[1]	**Study Area (km^2)**	**Area (%) Motorized Recreation (km^2)**	**Area (%) Non-motorized Recreation (km^2)**
McCall			
Payette NF	2,553	419 (16%)	47 (2%)
Boise NF	620	37 (6%)	1 (<1%)
Sawtooth			
Sawtooth NF	2,776	125 (5%)	72 (3%)
Sawtooth NRA	2,142	99 (5%)	54 (3%)
Trinity Mtns (BNF)	385	124 (32%)	0
West Yellowstone			
Henry Mtns (CTFN, CGNF)	250	50 (20%)	6 (2%)
Centennial Mtns (CTFN, CGNF)	395	196 (50%)	0
Tetons			
Teton National Park	477	0	67 (14%)
Northwest Tetons (CTFN)	588	41 (7%)	37 (6%)
South Tetons/Pass (CTFN, BTNF)	240	12 (5%)	113 (47%)
Mosquito Cr (CTFN, BTNF)	92	23 (25%)	0

[1] CTFN: Caribou-Targhee NF, CGNF: Custer-Gallatin NF; BTNF: Bridger-Teton NF

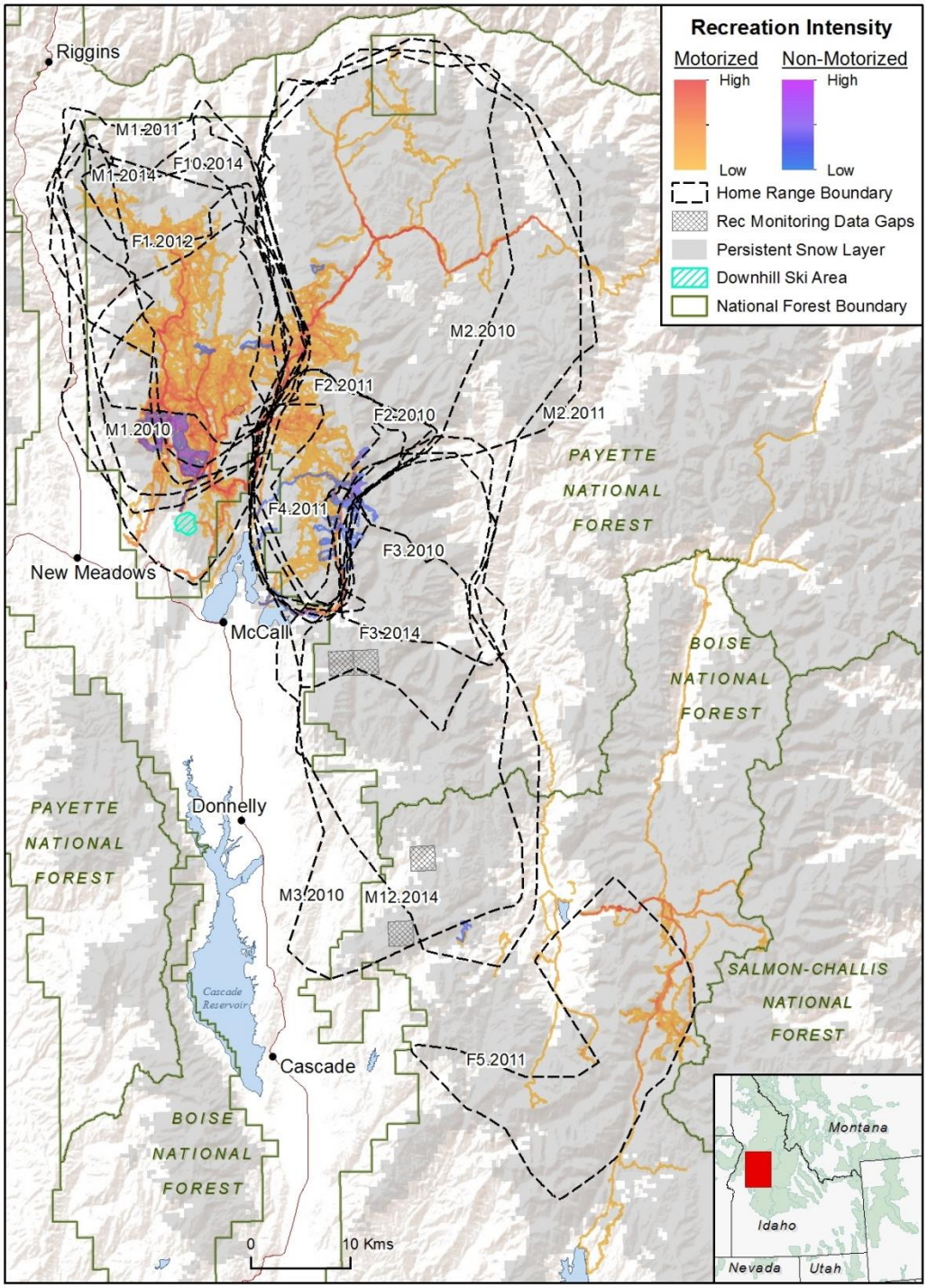

Figure 2. Map of wolverine (*Gulo gulo*) winter home ranges (2010-2014) and estimated backcountry winter recreation relative intensity in the McCall, Idaho study area as estimated based on GPS tracks collected from volunteer recreationists (2010-11) and used to develop recreation maps. Square or rectangular hatched areas indicate areas where we had gaps in GPS track sampling based on aerial recreation surveys.

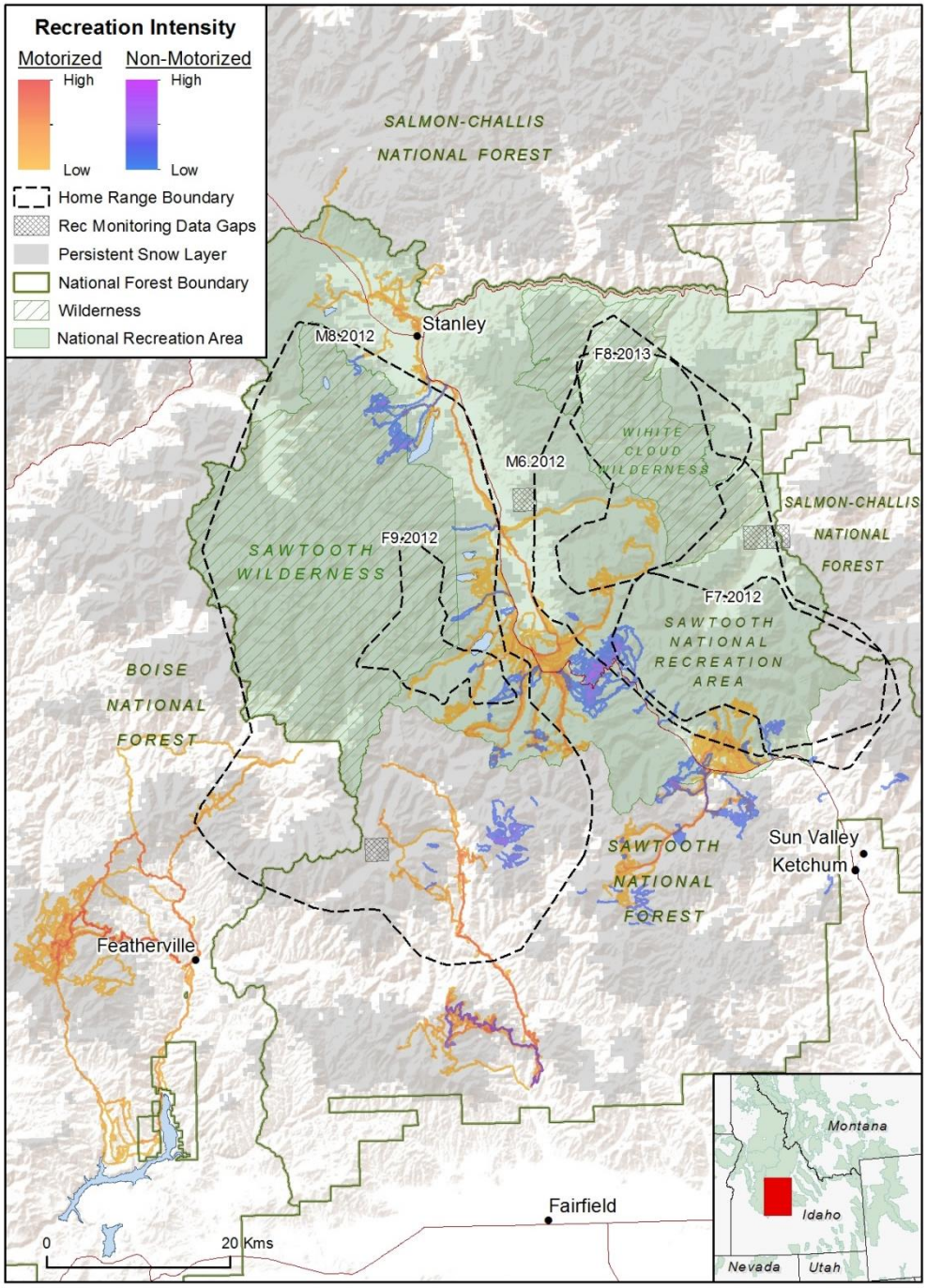

Figure 3. Map of wolverine (*Gulo gulo*) winter home ranges (2012-2013) and estimated backcountry winter recreation relative intensity in the Sawtooth study area as estimated based on GPS tracks collected from volunteer recreationists (2012-13) and used to develop recreation maps. Square or rectangular hatched areas indicate areas where we had gaps in GPS track sampling based on aerial recreation surveys.

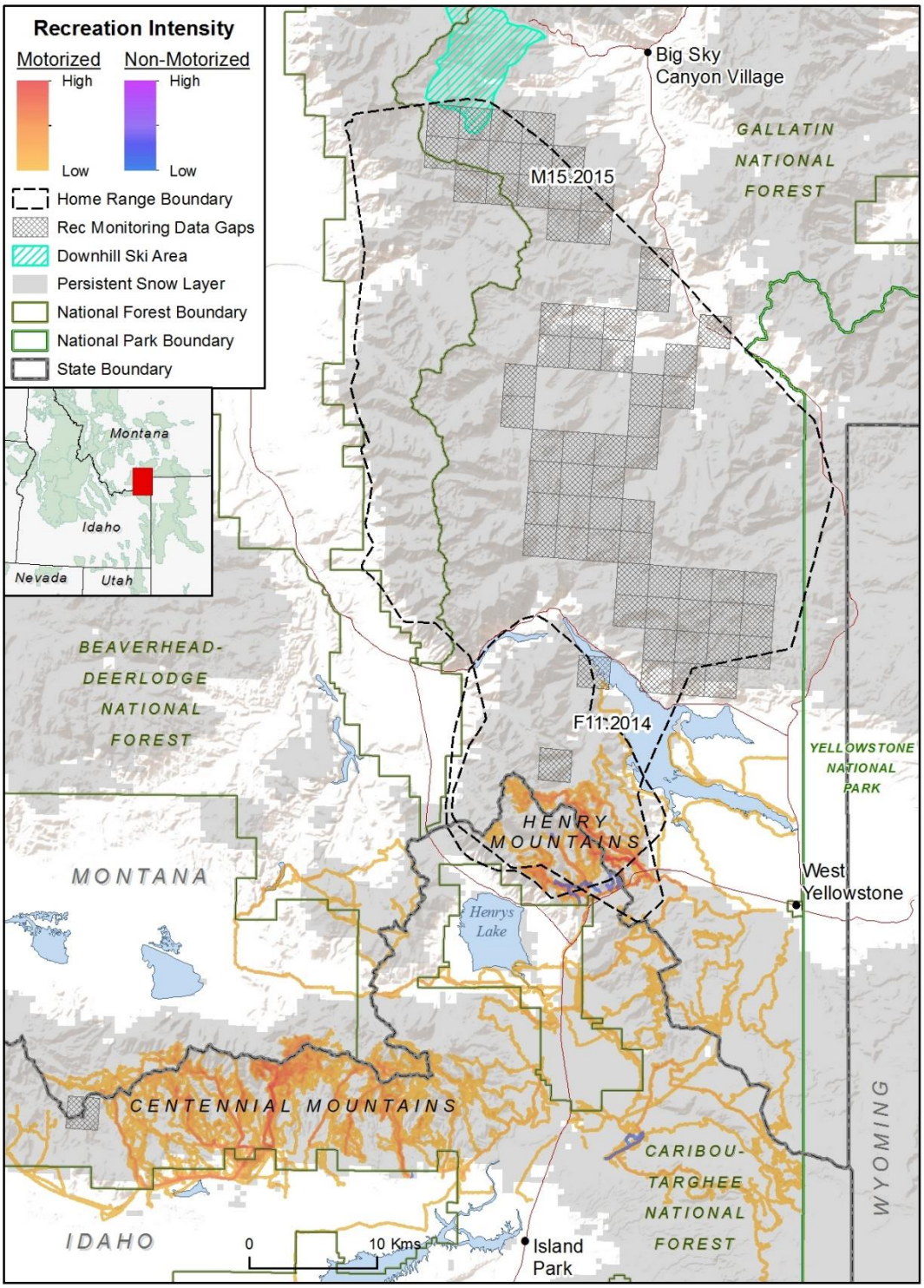

Figure 4. Map of wolverine (*Gulo gulo*) winter home ranges (2014-2015) and estimated backcountry winter recreation relative intensity in the West Yellowstone study area as estimated based on GPS tracks collected from volunteer recreationists (2014-15) and used to develop recreation maps. Square or rectangular hatched areas indicate areas where we had gaps in GPS track sampling based on aerial recreation surveys.

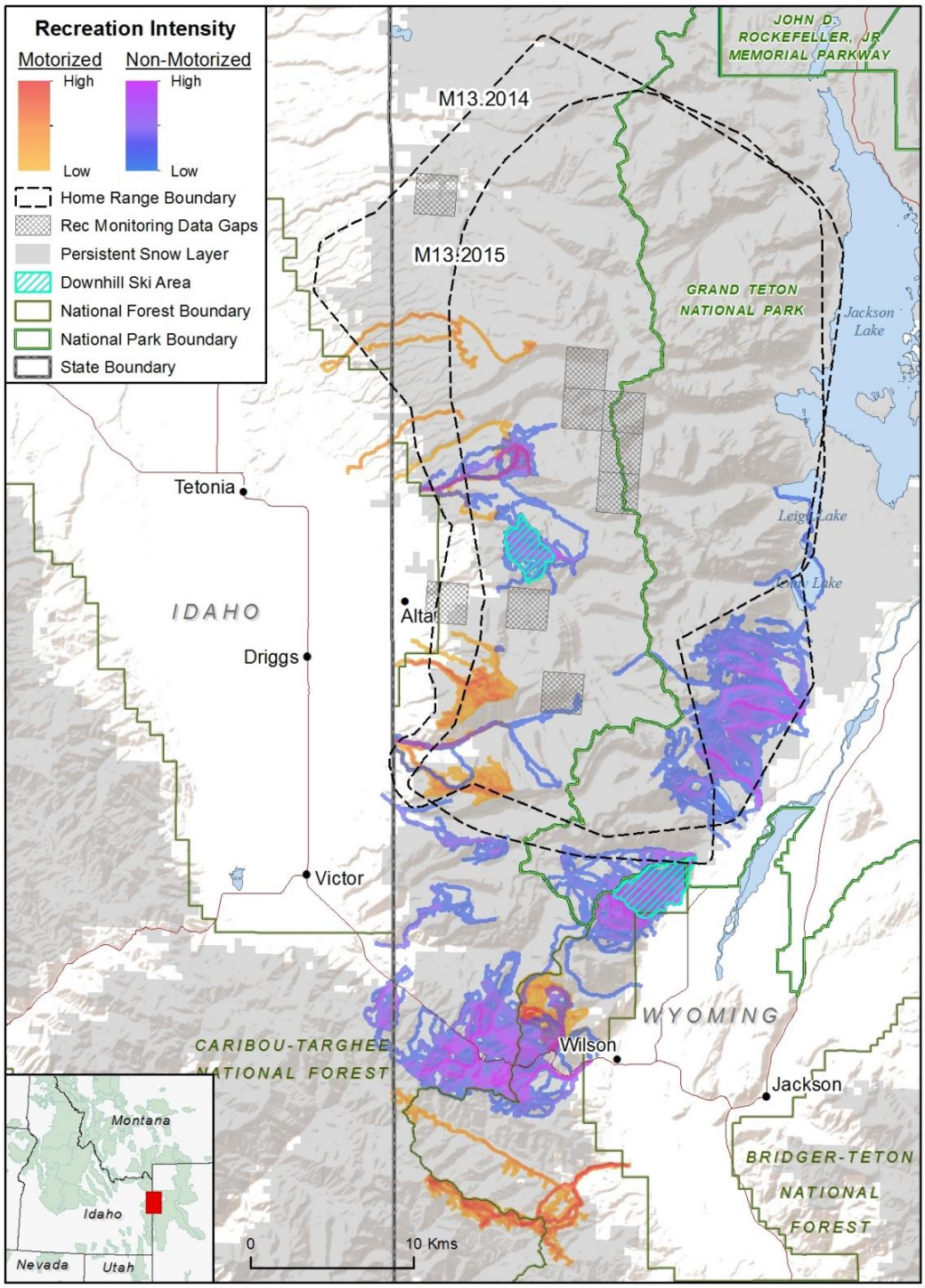

Figure 5. Map of wolverine (*Gulo gulo*) winter home ranges (2014-2015) and estimated backcountry winter recreation relative intensity in the Teton study area as estimated based on GPS tracks collected from volunteer recreationists (2014-15) and used to develop recreation maps. Square or rectangular hatched areas indicate areas where we had gaps in GPS track sampling based on aerial recreation surveys.

Environment resource selection function

The summed AIC score of the male and female environment-only models (i.e., potential habitat models) was notably lower than the AIC of the global with ΔAIC of 1,669, suggesting that resource selection by males and female differed significantly, thereby justifying separate treatment. The male wolverine model showed that resource selection was best characterized by nine environmental variables, while female wolverine habitat selection was best characterized by ten covariates. The male model uniquely included covariates for distance to roads and the proportion of lower elevation grass and shrub land cover types. Alternatively, the female model included talus, persistent spring snow cover and forest edge:area covariates, which were not identified as important predictors of male habitat use. All covariates were statistically significant (Table 4). The models shared several covariates including topographic position index, quadratic form of slope, distance to forest edge, solar insulation and the percent cover of forest, riparian and montane open cover types.

Model coefficients were standardized, allowing for within-model comparison and ranking of β coefficients for relative importance. Both sexes showed strong selection (ranked first in β coefficient importance) for drainage or valley bottom topography (β_{female} = -0.31, SE = 0.01; β_{male} = -0.42, SE = 0.01) as indicated by the negative coefficient for TPI (Table 4), and this is combined with the avoidance of steep slopes indicated by the negative coefficient of slope^2 (β_{female} = -0.27, SE = 0.01; β_{male} = -0.17, SE = 0.01). Selection for fir-dominated forests by males (β_{male} = 0.37, SE = 0.01) ranked second in coefficient importance. While females also selected for fir dominated forests (β_{female} = 0.05, SE = 0.01), this selection coefficient ranked second to last in importance (Table 4). Both sexes show a selection for areas near forest edge (β_{female} = -

Table 4. Standardized model coefficients betas and standard errors for environment RSF models for wolverines (*Gulo gulo*) monitored in Idaho, Wyoming and Montana (2010-2015), with the random effect standard deviation also included. Blank cells indicate covariates not identified for inclusion in the specified model. Negative Beta values indicate selection for lower values of the covariate.

	Female Model			**Male Model**		
	Beta	Beta St. Error	Rank	Beta	Beta St. Error	Rank
Distance to edge	-0.21	0.01	3	-0.16	0.01	6
Distance to roads				-0.21	0.01	4
Fir forest	0.05	0.01	10	0.37	0.01	2
Foothill shrub & grass				-0.06	0.01	10
Forest edge:area	0.12	0.01	6			
Montane shrub & grass	-0.09	0.01	7	-0.06	0.01	9
Riparian	0.07	0.01	9	0.11	0.01	8
Slope	-0.02	0.01	11	0.25	0.01	3
Slope2	-0.27	0.01	2	-0.17	0.01	5
Solar insolation	-0.15	0.01	4	0.13	0.01	7
Spring snow	0.09	0.01	8			
Talus	0.13	0.01	5			
TPI	-0.31	0.01	1	-0.42	0.01	1
Intercept	0.20	0.04		0.07	0.03	
Random effect		0.13			0.11	

0.21, SE = 0.01; β_{male} = -0.16, SE = 0.01), while they avoid montane shrub and grass land cover (β_{female} = -0.09, SE = 0.01; β_{male} = -0.06, SE = 0.01), and select for riparian areas (β_{female} = 0.07, SE = 0.01; β_{male} = 0.11, SE = 0.01).

Wolverines displayed some notable differences in their resource selection patterns between sexes (Table 4). Males selected areas close to secondary roads (indicated by a negative scaled RSF coefficient: β_{male} = -0.2, SE = 0.01) and avoided (indicated by a negative coefficient) foothill open areas (β_{male} = -0.06, SE = 0.01). Alternatively, females selected for talus (β_{female} = 0.13, SE = 0.01), for higher forest patch edge:area ratios (β_{female} = 0.12, SE = 0.01) indicating smaller, more fragmented forest patches and for areas with persistent spring snow (β_{female} = 0.09,

Table 5. Resource selection function models developed for wolverines (*Gulo gulo*) monitored in Idaho, Wyoming and Montana as part of research investigating wolverine responses to winter recreation (2010-2015). Model 1 for male and female are the environment only models. Models 2-6 use the environment covariates identified in Model 1 and winter recreation covariates to test hypotheses about the responses of wolverines to different characteristics of winter recreation. Models 2 – 6 were developed separately for males and females.

Models	**Variables**	**Male ΔAIC**	**Female ΔAIC**
Model 1: Female Potential Model	TPI + slope + slope^2+ fir forest + distance to edge + talus + riparian + montane shrub & grass + solar insulation + forest edge:area + spring snow	-	537.79
Model 1: Male Potential Model	TPI + slope + slope^2+ fir forest + distance to edge + distance to roads + riparian + montane shrub & grass + foothill open + solar insulation	41.71	-
Model 2: Potential Model + Rec 1	Model 1 + winter recreation footprint	43.2	286.96
Model 3: Potential Model + Rec 2	Model 1 + distance to linear recreation + dispersed motorized footprint + dispersed non-motorized footprint	355.71	266.1
Model 4: Potential Model + Rec 3	Model 1 + relative intensity of all winter recreation	0	181.44
Model 5: Potential Model + Rec 4	Model 1 + distance to linear recreation + relative intensity dispersed recreation	283.5	60.82
Model 6: Potential Model + Rec 5	Model 1 + distance to linear recreation + relative intensity of dispersed motorized recreation + relative intensity of dispersed non-motorized recreation	249.55	0

SE = 0.01). Areas of high solar insolation were avoided by females (β_{female} = -0.15, SE = 0.01) but selected by males (β_{male} = 0.13, SE = 0.01). Cross-validation of female and male environmental models had similar Spearman rank correlations (r_s) of 0.92 and 0.91, respectively. Out-of-sample data validation similarly showed strong validation (female r_s = 0.86, male r_s = 0.95).

Environment and winter recreation resource selection functions

Of the six models developed for male wolverines (Table 5; Appendix D), Model 4 (combined recreation intensity) had the lowest ΔAIC (Appendix D) and defined our realized

habitat model for male wolverines. The next ranked models were the environment-only model (Model 1) and the recreation footprint model (Model 2) with ΔAIC of 41.7 and 43.2, respectively (Table 5). There was a significant avoidance of areas with higher recreation intensity (β_{male} = -0.06, SE = 0.01) though the overall importance of this was relatively low (ranked 9 out of 12 covariates) compared to other coefficients in Model 4 (Table 6). Ten-fold cross-validation of this model showed high support for the model (r_s = 0.91), and the out-of-sample male locations also validated very well (r_s = 0.90).

The best-supported habitat model for female wolverines was Model 6 (Table 5, Appendix D), with covariates for distance to linear recreation and intensity of motorized and non-motorized recreation; all covariates were significant (p-value < 0.01). The second-ranked female model (ΔAIC = 11.8) included the distance to linear recreation and a combined relative intensity dispersed recreation (both motorized and non-motorized). Beta coefficients of Model 6 show females strongly avoided dispersed motorized winter recreation (β_{female} = -0.31, SE = 0.02) as the intensity of the recreation increased and this covariate is the second ranked covariate predicting female resource selection (Table 6). Females also strongly avoided areas of higher intensity dispersed non-motorized winter recreation (β_{female} = -0.19, SE = 0.01), with this predictor ranked fifth. Females avoided areas near recreated roads and groomed routes as indicated by the positive coefficient (β_{female} = 0.08, SE = 0.01), and this covariate ranked 10 out 14. Similar to the male model, both the cross validation and out-of-sample model validation showed strong support (rs = 0.91, rs = 0.83), respectively.

Model 6 did not provide the best overall predictor of male resource selection (Model 4 had the lowest ΔAIC) but it allowed us to compare male response to female responses (Model 6) and to evaluate the differential effects of recreation type on male wolverine responses (Table 6).

Table 6. Standardized model coefficients betas, standard errors and importance rank for male and female wolverine (*Gulo gulo*) RSF models including environment and winter recreation covariates, based on wolverine GPS collar data collected in Idaho, Wyoming and Montana (2010-2015). Female Model 6 and Male Model 4 were identified as the best models based on AIC values, while Male Model 6 provides male responses to specific recreation types. The random effect standard deviation is shown. Blank cells indicate covariates not identified for inclusion in the specified model. The ranked importance of each covariate indicated based on the absolute value of the standardized coefficient. Negative Beta values indicate selection for lower values of the covariate.

	Female Model 6			**Male Model 4**			**Male Model 6**		
	β	SE	Rank	β	SE	Rank	β	SE	Rank
Distance to edge	-0.21	0.01	4	-0.16	0.01	6	-0.16	0.01	4
Distance to roads				-0.22	0.01	4	-0.10	0.01	9
Fir forest	0.05	0.01	14	0.36	0.01	2	0.41	0.01	2
Foothill shrub & grass				-0.06	0.01	11	-0.05	0.01	11
Forest edge:area	0.12	0.01	9						
Montane shrub & grass	-0.06	0.01	13	-0.06	0.01	10	-0.04	0.01	12
Riparian	0.08	0.01	11	0.11	0.01	8	0.11	0.01	8
Slope	-0.07	0.01	12	0.25	0.01	3	0.22	0.01	3
Slope^2	-0.25	0.01	3	-0.16	0.01	5	-0.16	0.01	5
Solar insolation	-0.15	0.01	6	0.13	0.01	7	0.13	0.01	7
Spring snow	0.14	0.01	7						
Talus	0.13	0.01	8						
TPI	-0.32	0.01	1	-0.42	0.01	1	-0.41	0.01	1
Distance to recreated roads	0.08	0.01	10				0.02	0.01	13
Intensity of all recreation				-0.06	0.01	9			
Dispersed motorized recreation intensity	-0.31	0.02	2				-0.07	0.01	10
Dispersed non-motorized recreation intensity	-0.19	0.01	5				-0.15	0.02	6
Intercept	0.17	0.04		0.07	0.03		0.07	0.03	
Random effect		0.13			0.11			0.11	

All covariates in Model 6 were significant (or nearly so) in predicting male wolverine habitat use (Table 6). Similar to females, males avoided areas of higher intensity dispersed motorized recreation (β_{male} = -0.07, SE = 0.01), higher intensity non-motorized dispersed recreation (β_{male} = -0.15, SE = 0.02) and areas close to recreated roads and groomed routes (β_{male} = 0.02, SE = 0.01). But the relative importance of winter recreation to males was more muted than for females. The importance of motorized dispersed winter recreation to male wolverine resource

selection ranked 10 out of 13, while avoidance of non-motorized dispersed winter recreation was similar to females at a rank of 6. Avoidance of linear recreation by male wolverines was marginally insignificant ($p = 0.056$) and this predictor was ranked of lowest relative importance (Table 6).

Potential and realized habitats

The selection coefficients for environmental covariates were nearly identical between the environment-only (potential) habitat model and the selected model including winter recreation (realized habitat model) for both males and females (Tables 4 and 6). This indicated that wolverine selection for these environmental characteristics were stable and relatively independent of human recreation. Across the study area, the classification of potential habitat quality resulted in the prediction of 30% high, 30% moderate, and 40% low quality habitat, with 84% of animal locations found in moderate (28%) and high (56%) quality habitats. Winter recreation resulted in indirect habitat loss of moderate and high quality wolverine habitats as measured by areas transitioning to a lower class when comparing the realized habitat map to the potential habitat map (Figures 6). On average, 14% of female habitat and 11% of male habitat was degraded to lower habitat classes across the study area; calculated as proportions of available moderate and high quality indicates loss of these higher quality habitats range from <10% to >70% within individual home ranges (Appendix D). Both the amount and severity of indirect habitat loss varies across home ranges and is related to the average relative intensity of winter recreation within home ranges (Figure 7a, Appendix D). The incremental effects of winter recreation are high across home ranges with relatively low winter recreation levels, but the rate of indirect habitat loss tend to plateau across home ranges with the highest levels of recreation use (Figure 7a). Female wolverines experienced a higher degree of degradation to high quality

habitat (Figure 7b), represented by high quality habitat reduced to low quality habitat (change of 2 classes; Appendix D); an average of 9.6% of available female high quality habitat but only 0.2% of available male high quality habitat was degraded to low quality across the study area.

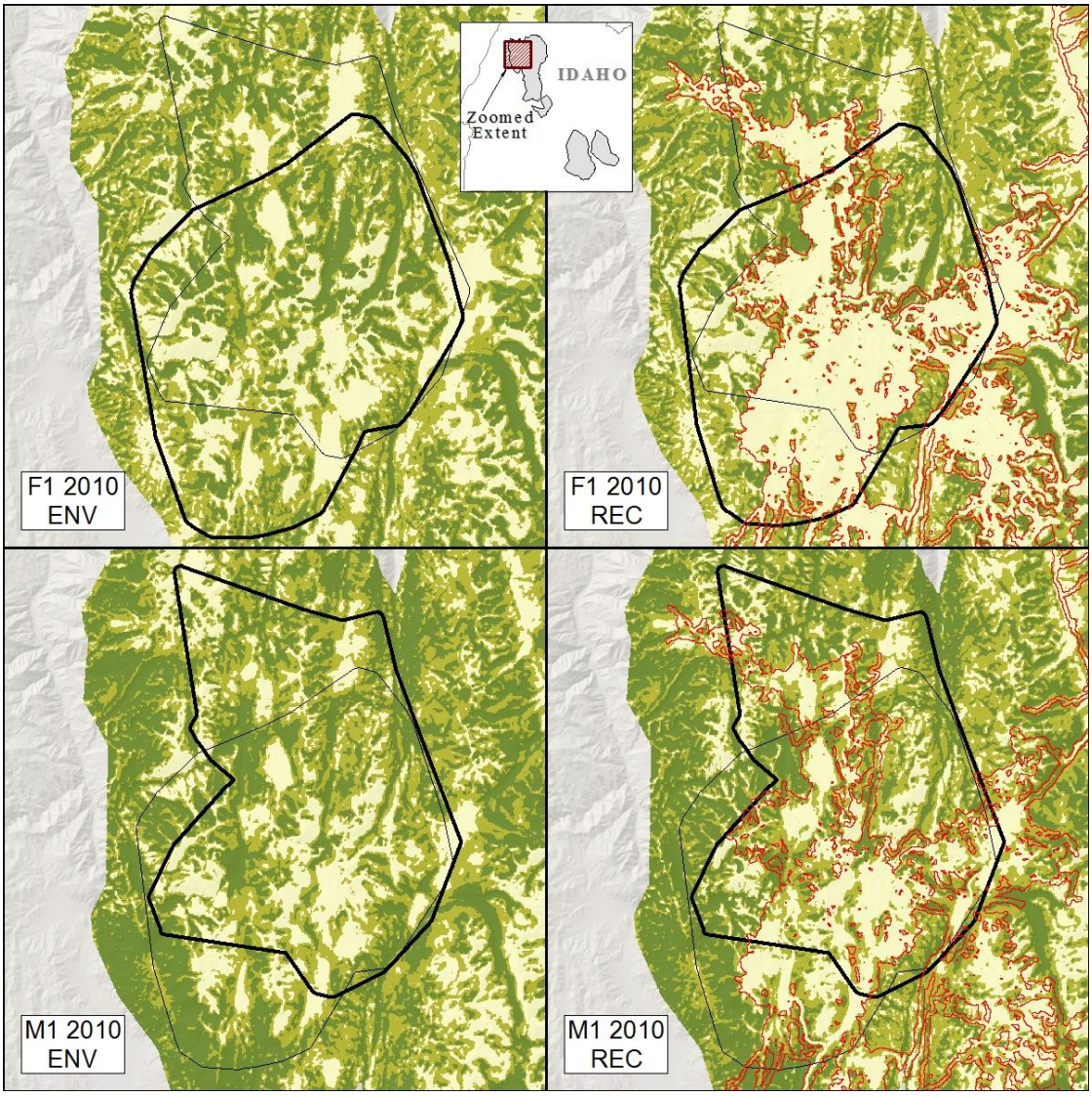

Figure 6. Example maps of potential winter wolverine (Gulo gulo) habitat predicted by the environment only model in the left-hand panels for females (top) and males (bottom) in a portion of the McCall, Idaho study area. The right-hand panel maps the realized habitat models that include winter recreation, and show the change in habitat quality. Three classes of habitat are shown: high quality in dark green, moderate quality in light green and low quality habitat in beige. The bold black lines are the home range boundaries for the animal-year indicated and the thinner black line identifying the overlapping animal of the other sex to facilitate comparing between the upper and lower panels. The red lines indicate the outline of the winter recreation footprint.

These responses translated into more pronounced indirect habitat loss for females compared to males within the same landscapes. For example, a male and female that resided in the same landscape had similar average recreation intensity within their respective home ranges of 0.37 and 0.34 and recreation footprints that covered 47% and 35% of their home ranges (Figure 6). The female experienced predicted indirect habitat losses of 36% and 38% of her high and moderate quality habitats, and 21% of the high-quality habitat was predicted to be degraded to low quality habitat. In contrast, the male experienced predicted habitat degradation to 20% of high and moderate quality habitats, with only 0.9% of high quality habitats predicted to be degraded to low quality habitat.

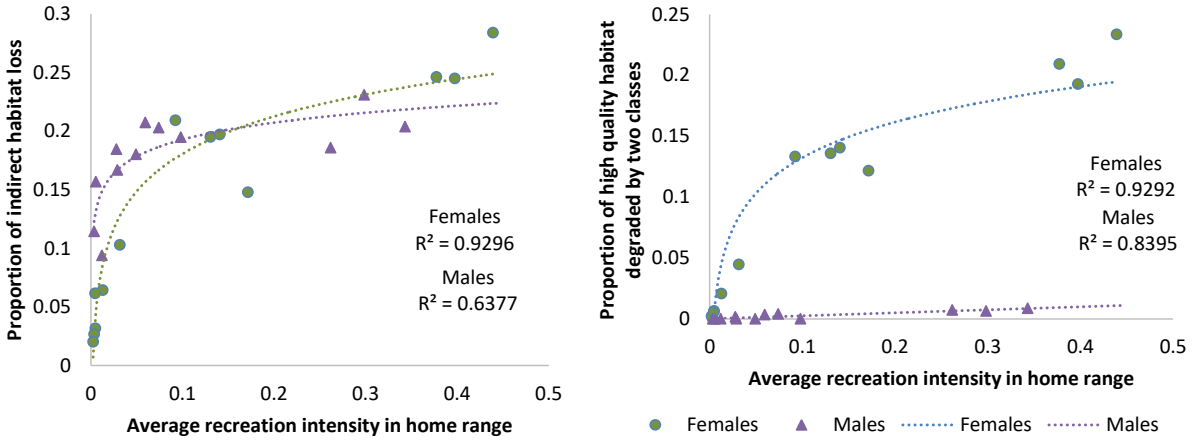

Figure 7. The percent of habitat degraded (left panel) and the severity of that degradation (right panel) across home ranges of wolverines with varying levels of winter recreation intensity. Degradation is defined by the percent of high and moderate quality habitat that degrades by at least 1 class, while severity of the degradation is measured by the proportion of the degradation that is high quality habitat dropping 2 classes to low quality habitat.

Functional Responses to Winter Recreation

The availability of motorized and non-motorized recreation as defined by the mean recreation intensity within home ranges varied notably. The mean motorized recreation intensity ranged from 0.00025 – 0.422 within home ranges. Non-motorized recreation occurred generally within smaller areas and at lower intensity, with a range of values of 0.001 – 0.093 within home ranges. Wolverines displayed negative functional responses in habitat use related to the average relative intensity of both motorized and non-motorized winter recreation (Table 7, Figure 8). Habitat use of areas with motorized recreation decreased as the availability of these areas increased within male and female home ranges, with slopes of 0.22 (R^2 = 0.4) and 0.38 (R^2 = 0.72), respectively. Similarly, both males and females showed negative functional responses to non-motorized winter recreation, even at the relatively lower average intensities this recreation occurred at. Habitat use of areas with non-motorized recreation declined as the availability of these areas increased within their home ranges, with slopes significantly <1: 0.32 (R^2 = 0.80) and 0.10 (R^2=0.13) for males and females, respectively. The male functional response was driven by the high average intensity of non-motorized recreation that one male experienced (2 animal-years) in the Tetons. If the Teton animal is removed, male wolverines do not show a significant functional response to non-motorized winter recreation (Table 7). Additionally, the low R^2 of the female functional response to non-motorized recreation indicates high variation and therefore a weak effect.

Table 7. Functional responses of wolverines (*Gulo gulo*) to dispersed motorized and non-motorized winter recreation measured as the proportional use of recreation intensity compared to the average recreation intensity across home ranges of individual animals. Null hypothesis is: H_0: $\beta_R = 1$, with $\beta_R < 1$ indicating increasing avoidance of recreation with increasing availability and $\beta_R > 1$ indicating increasing selection with increasing availability.

Model	Male β_0	Male β_R (95% CI)	R^2	Female β_0	Female β_R (95% CI)	R^2
Motorized	0.02	0.22 (0.05 – 0.40)	0.40	0.01	0.38 (0.24 – 0.51)	0.72
Non-motorized	0.00	0.32 (0.25 – 0.39)	0.89	0.00	0.10 (-0.05 – 0.24)	0.13
Non-motorized, removing the Teton male	0.001	0.06 (0.17 - -0.05)	0.07	-	-	-

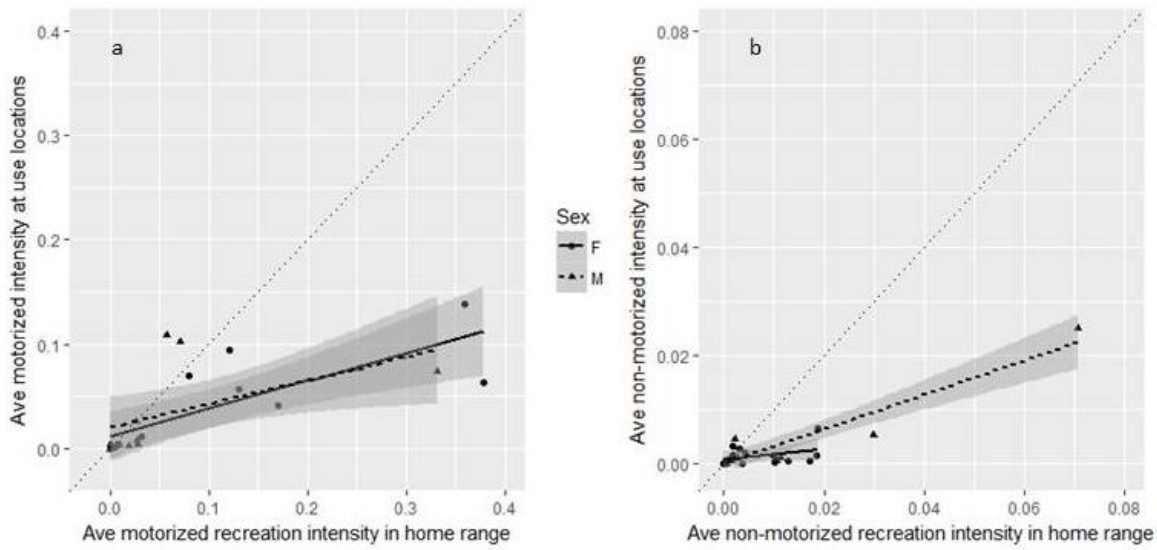

Figure 8. Functional responses of male and female wolverines (*Gulo gulo*) habitat use to the available relative intensity of (a) motorized and (b) non-motorized winter recreation in individual home ranges. The y-axis shows the average relative intensity of recreation at wolverine locations for each monitored wolverine and x-axis shows the average recreation intensity within the animal home range. The dotted 1:1 slope line indicates the null hypothesis expectation and slope if no functional response were present. Responses below the 1:1 line indicate that use is lower than expected based on availability.

Discussion

We found that male and female wolverines showed some notable differences in the selection for environmental covariates, and that their selection for these covariates was independent of the potential effects of winter recreation. The RSF defining the realized habitat models that included winter recreation covariates showed that both males and females responded negatively to increasing intensity of winter recreation within home ranges. Dispersed recreation activities elicited a stronger response than recreation along roads and groomed routes, with females showing more sensitivity to disturbance than males. The functional responses to dispersed recreation, particularly to motorized dispersed recreation, suggests that avoidance results in potentially important indirect habitat loss when a significant portion of an animal's home range receives recreation use, as it is exactly those animals exposed to higher levels of recreation that are most strongly displaced from these areas. Other wolverines were exposed to winter recreation within only a relatively small portion of their large home ranges, and the functional responses also suggest that this limited exposure may mute the indirect habitat loss. The weak avoidance of areas near linear access used by winter recreationists suggests wolverines may be less sensitive to these linear disturbances.

Wolverine habitat selection

Wolverine occur at low densities in northern latitudes and generally in areas with limited human use and infrastructure, creating a multitude of logistical hurdles in conducting detailed research and monitoring of this species. Prior habitat analyses in the Rocky Mountain portion of the North American wolverine distribution have been primarily at the first or second-order landscape scales (Aubry et al. 2007, Copeland et al. 2007, Copeland et al. 2010, Fisher et al. 2013, Inman et al. 2013), identifying characteristics that predict the distribution or presence of

wolverines, though Krebs et al. (2007) provides a multi-scale analyses of habitat selection. These efforts have indicated that wolverine are found at higher elevations (Copeland et al. 2007, Krebs et al. 2007, Copeland et al. 2010, Inman et al. 2013), in areas associated with late spring snowpack (Aubry et al. 2007, Copeland et al. 2010, Inman et al. 2013), alpine and subalpine habitats (Aubry et al. 2007) or with higher topographic ruggedness (Krebs et al. 2007, Fisher et al. 2013, Inman et al. 2013) compared to the broader landscape. In contrast to the broader association to more rugged terrain, our work demonstrated wolverines select less extreme topography characterized by concave or drainage bottom type topography (negative coefficient of TPI and slope covariates) and forested landscapes (similar to May et al. 2006, Copeland et al. 2007). We also found an avoidance of open alpine and subalpine areas, but that wolverines are found close to these areas as indicated by their selection for areas near forest edges. Within the winter season, wolverines use lower elevations than in the summer including subalpine and mid-elevation forest types (Copeland et al. 2007, Krebs et al. 2007), which is similar to our result of a selection for fir-associated conifer forests and riparian habitat during winter. Drainage bottom, riparian and forested edge habitats may represent good travel paths or more productive habitats (Scrafford et al. 2017) within a generally low productivity, high elevation landscape.

Prior analyses have also consistently identified the presence of spring snow as an important predictor of wolverine distribution, particularly in the southern portion of the species range in North America (Aubry et al. 2007, Copeland et al. 2010, Inman et al. 2013). We found persistent spring snow was moderately important for predicting female habitat use at the third-order of selection (importance rank of 7 out of 14 covariates). In addition, females also selected for cold areas (negative solar insulation covariate), which also would support the selection for areas with persistent snow. We expect that the selection patterns of our females reflect

reproductive denning which has been linked to deep and persistent snowpack (Magoun and Copeland 1998), as 7 of 13 female animal-years represented denning females. Female reproductive dens in Idaho were also associated with high structure such as talus boulders (Magoun and Copeland 1998), which may partially explain our finding that females select for talus, but this covariate was not important for predicting male habitat use. At broader scales, talus selection by wolverines was associated with elevation (Copeland et al. 2007), but we found females selected talus at finest spatial scale tested (Appendix B) and believe this reflects selection for this land cover itself within home ranges. We found that female habitat selection is complex, including characteristics that may be linked to some of the coldest and snowiest habitats as well as characteristics that may represent some of the more productive areas. This complexity in female habitat selection was also described by Krebs et al. (2007) who proposed female selection was driven by a combination of factors including food, predator and human avoidance, while males may also be food-motivated but less risk-averse than females. Copeland et al. (2017) suggest that while food resource availability and distribution are the primary factors shaping female territories, males work toward developing a positive association with females through territory defense and male parental care.

Influence of winter recreation on wolverine habitat selection

Wolverines maintained multi-year home ranges within landscapes that support winter recreation, and some resident animals had >40% of their home range within the footprint of winter recreation suggesting that at some scales wolverines tolerate winter recreation disturbance. Exposure to winter recreation varied notably across study areas and animals despite the focus of this research on areas where backcountry winter recreation is popular. Most animals were exposed to winter recreation within a relatively limited portion of their home ranges, likely

due to recreation use being linked to access such as roads and trails (Olson et al. 2017) combined with the large home ranges of wolverines. In some of the highest recreated landscapes, we did not successfully identify wolverines. Our research highlights the previously unrecognized and unrecorded spatial extent and intensity of backcountry winter recreation in remote landscapes. We expect the patterns of backcountry winter recreation across the extent of wolverine distribution in the western United States to be similar to our findings that some individual animals reside in highly disturbed winter landscapes while others are exposed to relatively low levels of winter recreation. While wolverine home ranges may be notably large, they still represent the minimum spatial requirement necessary to provide for needs of the individual as well as offspring and kin as expressed by the resource dispersion hypothesis (Macdonald and Johnson 2015, Copeland et al. 2017).

Harris et al. (2014) found that the total area disturbed by winter recreation is more important than the intensity of recreation use for northern ungulates. As measured in our study areas, these two metrics are correlated, and it would be difficult to disentangle the responses of wolverines to each independently. Still, models including relative intensity of winter recreation were selected over those models that characterized the footprint of winter recreation, and both within home range and across landscapes wolverines avoid areas with higher intensity winter recreation. The amount of indirect habitat loss is also related to the relative intensity of winter recreation within the home range. Habitat displacement and indirect habitat loss from winter recreation activities have been documented in a diverse array of montane and alpine species. High elevation forest grouse (*Tetrao* sp.) are impacted by backcountry winter recreation including habitat displacement as well as energetic and physiological effects (Patthey et al. 2008, Braunisch et al. 2011, Arlettaz et al. 2015, Coppes et al. 2017b). Endangered mountain caribou

in southern British Columbia have been displaced from high quality winter habitat due to high levels of snowmobile recreation (Seip et al. 2007). In the Teton Mountains of Wyoming, backcountry ski recreation resulted in a 30% loss of high quality winter habitat to bighorn sheep (Courtemanch 2014). Mountain goats avoided otherwise high quality habitat associated with a developed ski area near Banff, Alberta (Richard and Cote 2016). The negative functional responses of wolverines to increasing intensity of winter recreation indicate that individual animals that have the most extensive portions of their home range affected by recreation are also the animals with the strongest avoidance of these areas. Alternatively, we would expect a more muted response by wolverines in areas with low levels of winter recreation as compared to the population average response. As backcountry winter recreation grows in numbers of participants as well as in localized intensity of use and overall footprint, we need to understand the potential effects on wildlife species, particularly on sensitive, special-status or rare species.

Female wolverines appeared to discriminate between different types of winter recreation with the best supported female model containing separate predictors for linear recreation travel, dispersed motorized recreation and dispersed non-motorized recreation. Females avoid all three forms of winter recreation but the relative importance of each is different. Females show a strong avoidance of areas with dispersed non-motorized recreation (importance rank of 5 of 11), though these areas are limited within home ranges (<5% of home ranges affected by non-motorized recreation on average). Motorized dispersed winter recreation is the second most important predictor of female habitat selection (topographic position is the most important), indicating that this disturbance has a strong influence on female wolverine habitat selection in areas where motorized recreation occurs. This strong avoidance combined with the potential for motorized recreation to cover larger areas may lead to important indirect habitat loss for female wolverines.

Krebs et al (2007) also found that female wolverines avoided areas of winter recreation and argued this supports the hypothesis that female habitat selection is consistent with a risk-averse pattern. In contrast to females, male wolverines do not appear as sensitive to winter recreation in general, with the winter recreation covariate of lower importance (rank of 9 of 11 standardized covariates) in predicting male wolverine habitat selection. Krebs et al (2007) also found that human disturbance was less important for males than females in that 3 of 4 top ranking male habitat models did not include human disturbance and they suggested that male wolverine were less risk-averse than female wolverine.

Despite concerted efforts to identify and trap wolverines in the Tetons, we only captured a single male, estimated age of 13 years based on prior research handling as a subadult. We recorded the highest and most extensive backcountry non-motorized winter recreation in the Teton study area and this animal was exposed to higher levels of non-motorized recreation than other wolverines in our study. He exhibited strong avoidance of non-motorized recreation, but we are cautious in our interpretation of this given our limited information on wolverines exposed to higher levels of non-motorized recreation. Still, the response of this wolverine reinforces our suggestions that the strength of avoidance exhibited by wolverines to non-motorized recreation depends on the intensity of recreation within their home ranges, similar to the functional response of wolverines to motorized recreation. As expected, the removal of the Teton animal from the functional response analysis strongly influenced our results and limited our ability to conclude a negative functional response of male wolverines to non-motorized recreation (Table 7). Thus, it would be useful to perform additional monitoring of male (and female) wolverines that are exposed to higher levels of non-motorized winter recreation such as we recorded in the Teton study area.

Roads and linear winter access

Males were found closer to roads than expected and these roads were identified as an important predictor of male habitat selection but not female selection (suggesting females do not strongly respond to the proximity of roads). In our study, these roads were snow-covered and most were not plowed or maintained for winter use. Research examining wolverine responses to human infrastructure has suggested wolverines avoid roads, roaded areas and development (May et al. 2006, Fisher et al. 2013, Inman et al. 2013, Stewart et al. 2016, Heim et al. 2017). At a landscape scale, the negative association may be partially confounded by the fact that wolverines are naturally not found in lower elevation valley habitats where human infrastructure is higher. We found that within home ranges during winter, human use of roads may be important than the existence of the road itself in determining wolverine responses. Male wolverines were found closer than expected to unused roads but both male and female wolverines avoided areas near roads and groomed routes with winter recreation use, though male avoidance was of low importance (rank 13 of 13). Recent research in northern Canada also found that both males and female wolverines avoided active winter roads, though they may select for some other types of human infrastructure associated with roads that provide potential foraging opportunities (Scrafford et al. 2017). Roads accessible by hunters in the fall may be associated with ungulate gut piles or wounding mortalities that are potential scavenging opportunities for wolverines (Mattisson et al. 2016); many of these roads are not used by people in winter and foraging opportunities may partially explain male attraction to areas close to these unused roads. While both males and females avoided areas near actively recreated roads, this avoidance was not as important as avoidance of dispersed motorized and dispersed non-motorized recreation, suggesting that spatially predictable recreation travel patterns may be perceived by wolverines as

less risky. (Harris et al. 2014) also found higher disturbance to northern ungulates from recreation that is unpredictable in space or time than from road-based recreation.

Cumulative impacts of climate change and winter recreation

Both wolverines and backcountry winter recreation are expected to be affected by climate change, potentially resulting in an increased overlap between winter recreation and wolverine distribution as they both respond to declining snow extent, depth and the snow season. In the southern portion of their North American range, wolverines appear to be tightly linked to the area defined by the presence of persistent spring snow (Aubry et al. 2007, Copeland et al. 2010, Inman et al. 2013). The underlying ecological requirements that drive this close relationship may include denning requirements (Magoun and Copeland 1998, Copeland et al. 2010) and a dependence on scavenging large ungulate carcasses effectively preserved within and under the snowpack (Mattisson et al. 2016). Additional potential factors contributing to wolverine association with areas supporting persistent spring snow may include caching food under snow and associated cold micro-climates (Inman et al. 2012) and competitor or predator avoidance (Mattisson et al. 2016). Heim et al. (2017) suggested that the association of wolverines to persistent spring snow makes them vulnerable to climate changes and McKelvey et al. (2011) predicted a 67% loss of wolverine habitat in the western United States by 2059 due to loss of snowpack.

The demonstrated loss of snow pack and reduced winter length (Mote et al. 2005) will also have profound impacts for winter recreation in the future (Bowker et al. 2012, White et al. 2016, Wobus et al. 2017). While the reductions in winter length are predicted to cause a decline in per capita participation in winter recreation, human population growth counters these declines and most projections of winter recreation are stable or increasing (Bowker et al. 2012, White et

al. 2016, Wobus et al. 2017). Winter recreationists will likely need to adapt when and where they recreate to adjust to shortened snow season and reduction of winter recreation areas due to snow loss (Dawson et al. 2013, Rutty et al. 2015). This would result in winter recreation becoming more concentrated and intense in space and time (Dawson et al. 2013, Rutty et al. 2015), especially during the mid to late winter period when snowpack is predicted to be the most consistent (Mote et al. 2005). This is also the time period when female wolverines are entering reproductive dens. Predictions of winter recreation distribution and intensity would likely suggest even more severe indirect habitat loss than our current assessment indicates. Thus, managers must consider growth of the recreation industry concurrent with declining 'habitat' for winter recreation, which will potentially exacerbate conflicts between recreation and wildlife.

Conclusion

Outdoor recreation provides avenues for people to connect with nature and is an important economic and cultural component of the small communities that serve as gateways to some of our larger natural areas. Balancing the many positive benefits of encouraging outdoor recreation with the impacts it may have on these natural systems is a growing field of study. Our research into the potential effects of winter recreation on wolverines represents information at spatial and temporal scales rarely achieved in other disturbance research. Clearly, at some point, displacement from high quality habitats would affect the reproductive and survival fitness of animals. Given the low density and fragmented nature of wolverines in the contiguous United States, impacts to the relatively few reproductive females should be minimized. We found that the effects of winter recreation on wolverine habitat are dependent upon the relative intensity of recreation and that winter recreation patterns are highly variable at the scale of wolverine home ranges. Some animals may be exposed to important levels of indirect habitat loss due to

avoidance of areas with winter recreation while adjacent animals have relatively little exposure. We recommend that additional research is needed to understand winter recreation distribution and relative intensity within potential wolverine habitats across the western United States and elsewhere where backcountry winter recreation activities are popular. Approaches to documenting and monitoring the extent and relative intensity of backcountry winter recreation in an efficient and effective manner needs additional development, and we suggest approaches that combine modeling the potential for recreation (e.g. Olson et al. 2017) with field efforts to identify the realized extent of existing recreation, such as the standardized aerial surveys we undertook.

Our results suggest that winter recreation should be considered when assessing wolverine habitat suitability, cumulative effects and conservation. Our research provides land managers with a more detailed understanding of important habitat characteristics used by wolverines within home ranges and should inform management of wolverine habitats across the large landscapes they require. Further, it shows that female wolverines are sensitive to dispersed winter recreation which results in indirect habitat loss during the critical denning season. The functional responses to dispersed winter recreation provide insight into these negative effects, and suggest that lower levels of dispersed recreation will have less effect on wolverines than more widespread and intense recreation. We also found that recreation use of roads and groomed routes has low influence on male and female wolverine habitat use. Our research also shows that males are less sensitive to dispersed recreation, and therefore may be a lower management priority. While extremely challenging with a rare species residing in remote landscapes, research is needed that links population-level metrics to habitat and habitat conditions. These backcountry landscapes represent critical habitats for wolverines, important and highly valued areas for

people to connect with nature, and are economic drivers for the small communities that surround them. Solutions to finding a balanced approach to sustaining the diverse values of these wild landscapes requires creative approaches and collaboration between land managers, stakeholders and wildlife professionals.

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Appendix A: Wolverine capture and monitoring

This appendix provides additional details about the collection and processing of wolverine location information.

Trapping and handling

We attempted to confirm the presence of wolverines within each of our study areas through pre-baiting with remote cameras using road-killed deer or elk and a skunk-based lure. In study areas where we successfully identified and captured wolverines, we live-trapped, collared and monitored wolverines for a minimum of two years. In the Centennial Mtns, we live-trapped and/or camera trapped for 3 years (2014-2016) without evidence of wolverine presence; in the Trinity Mtns (2012-2015), we or the USFS collaborators camera trapped for three years without evidence of wolverine presence. In the Teton Mtns, we live-trapped and camera trapped for 3 years (2014-2016) and only captured one male wolverine estimated to be 13 years old based on prior research handling when he was estimated to be a subadult.

We built log-based box traps on-site using existing downed logs or cutting trees if permitted within the specific study area. In the West Yellowstone and Teton study areas, we refurbished log traps built by the Wildlife Conservation Society personnel for an earlier research effort, and in the Grand Teton National Park we either also refurbished existing traps or brought in lumber to build traps (Lofroth et al. 2008) that were removed at the end of the trapping season. New trap locations across all study areas was based primarily on evidence of wolverine presence, including prior remote camera surveys done as part of our preparations or by prior survey effort. Nearly all traps required snowmobiles to access, except in the Tetons where ski or snowshoe-based access was used for traps with the Grand Teton National Park. We attempted to pre-bait all

trap sites using road-killed deer by mid-December depending upon access, and opened traps in early January. In the first year (2010), traps were remotely monitored 2-3 times/daily using VHF based trap transmitters (Telonics trapsite transmitters, TBT series; Telonics, Inc, Mesa, AZ, USA), and starting the second year (2011) all traps were equipped with the satellite-based trap transmitters (Vectronics trap transmitters TT2, TT3; Vetronic Aerospace GmbH, Berlin, Germany) that notified us immediately when a trap door closed. We limited visits to traps primarily to daylight hours for safety except during the recapture efforts in late March-April when we checked traps when they closed regardless of time to minimize the capture time of any lactating female. If any new or unidentified wolverine was captured during the recapture period, we collected a hair and/or saliva sample and released it, and only anesthetized animals to remove collars.

Aerial telemetry monitoring and identification of denning females

We flew telemetry flights intermittently throughout the duration of the winter season to confirm the functioning collars and presence of collared animals. Starting in mid-February, we increased our aerial monitoring of collared females to every 2-3 days to identify localized behavior and potential reproductive dens. The Telemetry Solution collars (Quantum 4000 collar from Telemetry Solutions, Concord, CA, USA) provided the ability to remotely download data through a UHF connection, which we used to confirm localized behaviors. We continued to monitor potentially denning females primarily from the air but occasionally it was also possible to use a near-by ridge or other discreet ground-based location to confirm continued occupancy for dens. Confirmation of denning was both through the intensive GPS location monitoring as well as identification of swollen teats and milk in females recaptured for collar removal (Table

A1.1). Field crews also visited den sites after abandonment in the following summer to document latrines, prey remains and characteristics of the den site itself.

Wolverine GPS location data and home range summary

Table A. 1. Summary of wolverine location data including assessed denning status, start and end dates for GPS monitoring, the k parameter used in the LoCoH home range estimate and the area of the resulting home ranges.

Animal-year	Study Area	GPS N	Denning Status	Start Date	End Date	LoCoH k	Km^2	Mi^2
F11.2014	Henry Mtns	2067	Not denning	1/19/2014	4/9/2014	46	250	96
M15.2015	Henry Mtns	2881	Male	1/25/2015	5/5/2015	71	1485	573
F1.2010	McCall	1247	Denning	1/30/2010	3/31/2010	62	397	153
F1.2012	McCall	1757	Not denning	1/15/2012	3/10/2012	82	336	130
F10.2014	McCall	3079	Denning	1/14/2014	4/19/2014	93	420	162
F2.2010	McCall	1844	Denning	1/30/2010	3/21/2010	64	228	88
F2.2011	McCall	2632	Not denning	1/25/2011	4/10/2011	92	248	96
F3.2010	McCall	1372	Denning	2/20/2010	4/3/2010	44	239	92
F3.2014	McCall	2496	Not denning	1/4/2014	3/24/2014	148	281	108
F4.2011	McCall	1386	Not denning	1/22/2011	3/16/2011	102	153	59
F5.2011	McCall	1677	Denning	1/30/2011	4/2/2011	96	377	146
M1.2010	McCall	806	Male	2/2/2010	3/10/2010	32	401	155
M1.2011	McCall	1974	Male	1/18/2011	3/15/2011	77	779	301
M1.2014	McCall	2947	Male	1/25/2014	4/13/2014	104	791	306
M12.2014	McCall	3778	Male	1/11/2014	5/27/2014	121	2158	833
M2.2010	McCall	2648	Male	2/5/2010	4/20/2010	64	994	384
M2.2011	McCall	2059	Male	2/10/2011	4/3/2011	56	1334	515
M3.2010	McCall	1340	Male	2/11/2010	4/26/2010	44	934	361
F7.2012	Stanley	1489	Not denning	2/5/2012	3/12/2012	89	375	145
F8.2013	Stanley	1943	Denning	2/2/2013	3/31/2013	80	328	126
F9.2012	Stanley	1627	Denning	2/10/2012	4/26/2012	86	126	49
M6.2012	Stanley	1896	Male	1/17/2012	3/11/2012	107	1087	420
M8.2012	Stanley	2618	Male	1/17/2012	3/24/2012	107	1988	767
M13.2014	Tetons	2766	Male	2/22/2014	7/18/2014	147	1094	422
M13.2015	Tetons	2972	Male	1/14/2015	4/3/2015	159	867	335

Appendix B: Description of Environment Covariates

This appendix provides additional detailed descriptions of the environment covariates acquired or developed to support the spatial analyses

Identification of environment covariates

Table B. 1. Environmental and winter recreation covariates identified for consideration in the wolverine winter resource selection function (RSF) models to understand wolverine responses to winter recreation in Idaho, Wyoming and Montana, 2010-2015. The native resolution indicated the finest resolution spatial information available, while the selected resolution is based on analyses following DeCesare et al. (2012). We provide information regarding the source of the data or derivation methods, and if and why the covariate was removed from the analyses.

Covariate	Native scale	Selected Scale (m)	Source	Description
Environment covariates				
Elevation	30	30	USGS National Elevation data	Collinear with multiple other covariates, removed
Slope	30	500	Derived from USGS National Elevation data	Slope (degrees), input as quadratic (Slope + Slope^2)
Aspect	30	Variable	Derived from USGS National Elevation data	Assessed categorical; high AIC relative to solar insolation, removed
Terrain ruggedness	30	100	Riley et al. (1999)	Topographic complexity; collinear with slope, removed
Topographic position index (TPI)	30	300	Weiss (2001)	Measure of landscape concavity or convexity
Solar Insolation	30	50	ESRI Area Solar Radiation tool	Index of solar insolation
Edge:area forest patch ratio	30	1000	Helzer and Jelinski (1999), using 30m resampled talus-forest cover classification of 2015 NAIP Imagery	Calculated as the length of edge/area of forest areas
Distance to forest edge	Vector	N/A	Derived from 30 m resampled talus-forest cover classification of 2015 NAIP Imagery	2D distance to forest edge, both from inside and outside the forest
Spring snow model	500	1000	MODIS Snow Cover Daily L3 Global 500m Grid, created based on methods of Copeland et al. 2010	Calculated persistent snow layer for 2009-2015
Riparian	30	100	Derived from USGS LANDFIRE Existing Vegetation Type layer. (2013, June). Available: http://landfire.cr.usgs.gov/viewer/	Mesic forested and non-forested types associated with waterways (Appendix B)
Montane Shrub-Grass	30	300	Derived from USGS LANDFIRE EVT Class v1.3,	Percent mid- to upper elevation shrub and grass types (Appendix B)
Foothill Shrub-Grass	30	30	Derived from USGS LANDFIRE EVT v1.3	Percent shrub or grass in lower elevation types (Appendix B)

Covariate	Native scale	Selected Scale (m)	Source	Description
Montane-Alpine Sparse	30	300	Derived from USGS LANDFIRE EVT v1.3	Percent sparse vegetation in upper elevation areas (Appendix B)
Fir forest	30	500	Derived from USGS LANDFIRE EVT v1.3	Percent Douglas fir, subalpine fir and associated fir forest types (Appendix B)
Ponderosa pine	30	2000	Derived from USGS LANDFIRE EVT v1.3	Not significant in univariate logistic regression
Lodgepole pine	30	3000		Not selected in LASSO
Talus	1	30	1 m classification of 2015 NAIP Imagery, mapped outputs use 30-m resampled	Percent talus cover
Winter recreation covariates				
Dist. to recreated roads	Vector	N/A	Derived from USFS & USGS roads and recreation tracks	Secondary roads and groomed routes with GPS tracks traveling parallel
Dist. to non-recreated secondary roads	Vector	N/A	Derived from USFS & USGS roads and recreation tracks	Secondary roads without GPS tracks traveling parallel
All winter recreation intensity layer	30	125	See methods and Appendix C	Linear and off-road winter recreation weighted track density
Winter recreation footprint	125	-	See methods and Appendix C	Transformed intensity values>0 to '1' to create binomial layer
Motorized winter recreation intensity layer	30	125	See methods and Appendix C	Motorized off-road winter recreation weighted track density
Non-motorized winter recreation intensity layer	30	125	See methods and Appendix C	Non-motorized off-road winter recreation weighted track density

Additional details of the covariates are provided below.

Topographic covariates. We used 30m digital elevation models (DEMs) from the National Elevation dataset from the USGS for elevation, slope and aspect. In addition, we also calculated the terrain roughness (TRI), topographic position index (TPI), vector ruggedness measure (VRM), and solar insolation. The TPI (Weiss 2001) looks at the position of a pixel relative to the surrounding pixels in a given neighborhood size in an attempt to classify the landscape into slope position and landform categories. The calculation produces either positive (higher

positions, i.e. ridges) or negative (lower positions, i.e. valleys) values as its output. The size of the neighborhood that best captures TPI depends on the landscape, for this analysis we generated it at the same spatial scales as for other covariates (30, 50, 100, 150, 300, 500, 700, 1000, 2000, 3000m radii) and classified rasters according to the recommendations of Weiss (2001). The TRI (Riley 1999) measures local variations about a central pixel in a 3-pixel neighborhood (8 surrounding neighborhoods) using the minimum and maximum values of the local neighborhood. We calculated solar insulation from the DEM, which aims to identify areas with less sun exposure where snow may be more likely to accumulate. Solar radiation was calculated separately for each band of latitude in the study area using ERSI's Area Solar Radiation tool. The output rasters were mosaicked together with a mean operator to provide wall-to-wall coverage.

Persistent Spring Snow. Spatially-explicit data summarizing persistent spring snow was created for the years 2009-2015 by following the same methods as Copeland et al (2010). MODIS data were projected and downloaded from the 'reverb.echo' NASA web portal and assimilated according to the steps outlined by Copeland et al (2010) and detailed by Copeland (pers. comm. 2015). This resulted in a 500 m resolution raster with values of 0-7, representing the number of years that pixel was consistently snow covered from April 24 – May 15 of each year. Additional snow data was downloaded from the SNOWDAS dataset for January – April of each year of the study. Daily variables at 1 km were compiled and mosaicked together to produce continuous rasters of the minimum, maximum, mean, range, and standard deviation of the following variables: depth (m), snow water equivalent (SWE, m), snow melt runoff at the base of the snow pack (m), and solid precipitation (kg/m^2).

Roads and groomed winter recreation routes. The best available road, trail and groomed routes data were collected from each of the seven National Forests (Boise, Bridger-Teton, Caribou-Targhee, Gallatin, Payette, Sawtooth, Beaverhead-Deer Lodge NFs) and from Grand Teton National Park. Gaps in the data were filled in with USGS Transport data. Euclidean distance was calculated to all roads, major roads (either delineated in the attributes of the assimilated data or designated by local knowledge), and winter routes or groomed routes. Winter routes were rarely designated in the attributes of the USFS-supplied spatial data, and we digitized these from the USFS Winter Recreation Maps, available for all Forests.

Land cover. We used LANDFIRE data downloaded from USGS, and developed a simplified land cover classification based on the National Vegetation Classification System Physiognomic Class (EVT_CLASS), as summarized in Table B.1. An additional land cover model specific to talus and rock habitats was produced at 1m resolution to more accurately identify talus land cover. This model predicts talus habitats at 67% accuracy, and combined talus/rock habitats at 87% accuracy. This classification also provided a higher resolution classification for conifer forests, and we used this resampled to 30m to calculate distance to forest edge as a covariate in the analyses. We also used this forest cover data to generate forest edge:area as the length of edge/forest area at the suite of spatial scales other covariates were assessed at (30, 50, 100, 150, 300, 500, 700, 1000, 2000, 3000m). See details of the land cover classification in Smith and Heinemeyer (2016).

Table B. 1. Land cover groupings were developed based on LANDFIRE National Vegetation Classification System Physiognomic Class, reducing 68 unique cover types to six broad classes for purposes of habitat modeling.

EVT Class (LANDFIRE, June 2013)	Land cover type
Northern Rocky Mountain Subalpine Woodland and Parkland	Fir Mixed Forest
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	Fir Mixed Forest
Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland	Fir Mixed Forest
Dry-mesic Montane Douglas-fir Forest	Fir Mixed Forest
Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland	Fir Mixed Forest
Mesic Montane Douglas-fir Forest	Fir Mixed Forest
Middle Rocky Mountain Montane Douglas-fir Forest and Woodland	Fir Mixed Forest
Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	Fir Mixed Forest
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest	Fir Mixed Forest
Rocky Mountain Aspen Forest and Woodland	Fir Mixed Forest
Subalpine Douglas-fir Forest	Fir Mixed Forest
Subalpine Western Larch Forest	Fir Mixed Forest
Xeric Montane Douglas-fir Forest	Fir Mixed Forest
Artemisia tridentata ssp. vaseyana Shrubland Alliance	Foothill Shrub and Grass
Columbia Plateau Low Sagebrush Steppe	Foothill Shrub and Grass
Inter-Mountain Basins Big Sagebrush Steppe	Foothill Shrub and Grass
Introduced Upland Vegetation-Perennial Grassland and Forbland	Foothill Shrub and Grass
Northern Rocky Mountain Lower Montane-Foothill-Valley Grassland	Foothill Shrub and Grass
Rocky Mountain Lodgepole Pine Forest	Lodgepole Pine
Rocky Mountain Poor-Site Lodgepole Pine Forest	Lodgepole Pine
Inter-Mountain Basins Montane Sagebrush Steppe	Montane Shrub and Grass
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	Montane Shrub and Grass
Northern Rocky Mountain Subalpine-Upper Montane Grassland	Montane Shrub and Grass
Northern Rocky Mountain Subalpine Deciduous Shrubland	Montane Shrub and Grass
Rocky Mountain Subalpine-Montane Mesic Meadow	Montane Shrub and Grass
Inter-Mountain Basins Sparsely Vegetated Systems	Montane-Alpine Sparse
Rocky Mountain Alpine Dwarf-Shrubland	Montane-Alpine Sparse
Rocky Mountain Alpine Turf	Montane-Alpine Sparse
Rocky Mountain Alpine/Montane Sparsely Vegetated Systems	Montane-Alpine Sparse
Barren	Other
Columbia Basin Foothill and Canyon Dry Grassland	Other
Columbia Basin Palouse Prairie	Other
Columbia Plateau Steppe and Grassland	Other
Developed-Low Intensity	Other
Developed-Medium Intensity	Other
Developed-Roads	Other
Dry-mesic Montane Western Larch Forest	Other
Great Basin Xeric Mixed Sagebrush Shrubland	Other

EVT Class (LANDFIRE, June 2013)	Land cover type
Inter-Mountain Basins Big Sagebrush Shrubland	Other
Inter-Mountain Basins Mixed Salt Desert Scrub	Other
Inter-Mountain Basins Semi-Desert Shrub-Steppe	Other
Introduced Upland Vegetation-Annual Grassland	Other
Mesic Montane Western Larch Forest	Other
Northern Rocky Mountain Avalanche Chute Shrubland	Other
Open Water	Other
Rocky Mountain Foothill Limber Pine-Juniper Woodland	Other
Snow-Ice	Other
Western Cool Temperate Close Grown Crop	Other
Western Cool Temperate Developed Ruderal Evergreen Forest	Other
Western Cool Temperate Developed Ruderal Grassland	Other
Western Cool Temperate Developed Ruderal Shrubland	Other
Western Cool Temperate Pasture and Hayland	Other
Western Cool Temperate Undeveloped Ruderal Grassland	Other
Western Cool Temperate Undeveloped Ruderal Shrubland	Other
Western Cool Temperate Urban Deciduous Forest	Other
Western Cool Temperate Urban Evergreen Forest	Other
Western Cool Temperate Urban Herbaceous	Other
Western Cool Temperate Urban Mixed Forest	Other
Western Cool Temperate Urban Shrubland	Other
Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	Ponderosa Pine
Inter-Mountain Basins Montane Riparian Forest and Woodland	Riparian
Northern Rocky Mountain Conifer Swamp	Riparian
Rocky Mountain Montane Riparian Forest and Woodland	Riparian
Rocky Mountain Montane Riparian Shrubland	Riparian
Rocky Mountain Subalpine/Upper Montane Riparian Forest and Woodland	Riparian
Rocky Mountain Subalpine/Upper Montane Riparian Shrubland	Riparian
Rocky Mountain Wetland-Herbaceous	Riparian

Spatial scaling of covariates

We generated each covariate at multiple spatial scales to identify the scale most strongly selected by wolverines. We used moving windows in ArcGIS at 8 radii (50, 100, 200, 500, 700, 1000, 2000, 3000m), with the finest resolution determined by the native resolution of the covariate data. For categorical variables such as the land cover classification, we calculated the percentage of that class at each window radii. Animal and available locations were attributed

with the scaled covariates, and univariate logistic regressions were fit at spatial resolution with the scale having lowest Akaike Information Criteria (AIC; Akaike 1974) selected for further analyses. Wolverines most strongly selected environmental covariates at broadly differing scales ranging from coarser resolutions of 1000 m for forest edge:area ratio to fine-scale selection at our original 30m scale for other covariates such as talus cover (Table B.1).

Appendix C: Winter recreation sampling and analyses

This Appendix provides additional information on winter recreation mapping, on winter recreation aerial surveys, and winter recreation map validation using the aerial recreation surveys.

Development of winter recreation spatially-explicit models

We used the weighted GPS tracks collected from volunteer recreationists to develop spatially-explicit models and map representing winter recreation within our study areas. These spatial depictions include identification of the network of roads and groomed routes used by recreationists within the study area to access backcountry areas (linear recreation), and estimating the relative intensity as the weighted track density of all recreation (road and dispersed combined), motorized dispersed recreation and non-motorized dispersed recreation. We also developed a simple footprint depiction of winter recreation. These models were used as covariates in the development of wolverine RSF models.

Linear recreation. We used the vector-based recreation track data to identify roads or groomed routes that had recreation tracks traveling within 30m classified as a 'linear recreation route'. Recreation GPS tracks simply crossing an otherwise unused road were ignored in these classifications, and secondary roads without documented winter recreation travel were classified

as such. In areas with multiple years of GPS recreation track information, we combined years to identify recreation routes. We calculated the straight-line distance to the linear recreation as a potential predictor of wolverine habitat use in our analyses.

Relative intensity of recreation. We developed spatial layers depicting the relative intensity of recreation use calculated as the weighted density of recreation tracks:

Recreation Intensity = $\sum_i^N (w_i \ l_i \ )/Area$

where l_i is the length of each GPS track within the selected Area, generated through moving window analyses in ArcGIS, and w_i is defined in equation (1). For areas with multiple years of GPS data, we generated annual recreation intensity layers and averaged the weighted density across years.

We generated recreation intensity grids for all recreation tracks, as well as separate intensity layers for off-road or dispersed motorized recreation and for dispersed non-motorized recreation. For the motorized and non-motorized spatial layers, the proportion of GPS units handed out to each recreation type was used to estimate the proportion of total use representing that recreation type in the *w* calculations.

To determine the most appropriate scale to depict the recreation intensity layers, we generated each recreation layer at multiple moving windows from 50-5000m (DeCesare et al. 2012). Animal and available locations were attributed with the scaled covariates, and univariate logistic regressions were fit at spatial resolution with the scale having lowest Akaike Information Criteria (AIC; Akaike 1974) selected for further analyses. The relative intensity scores averaged a moving window radii of 125m had the lowest AIC for all recreation combined, motorized

dispersed recreation and non-motorized dispersed recreation, and we used this spatial scale for all subsequent analyses.

Recreation footprint. The spatial extent or footprint of recreation was estimated from the scaled recreation intensity layers for all recreation combined by converting any relative intensity score > 0 to a '1' to create a binomial predictor.

Winter recreation aerial surveys to validate recreation maps

We validated our winter recreation models using aerial surveys that independently documented winter recreation type, extent and relative intensity within our study areas. Aerial surveys in fixed-wing aircraft were completed 1-4 times in each study area each year. Visually evaluating recreation levels or intensity during aerial surveys is challenging to standardize across observers, study areas and time, so we used a presence-absence survey approach to avoid observer bias. The area was systematically flown along transects spaced 2 km apart. Sequential 20-second presence-absence observations were recorded by two observers with each observer recording from one side of the plane, with presence, type (snowmobile, ski, both) and spatial pattern (linear, dispersed, both) recorded for each sample. The 20-sec interval allowed for a new field of view between samples. Transects formed the boundaries of 1 km^2 grid cells, and scores for each survey grid quadrat ($500m^2$) were calculated as the total number of positives/total samples taken. Aerial survey information was used in-season to identify gaps in GPS sampling such as trailhead access points not being sampled, allowing us to adjust GPS distributions to ensure comprehensive sampling. It was also used to validate and identify any spatial gaps in recreation covariates developed for analyses, and identify changes in recreation distribution in years following the collection of the GPS-based recreation data.

The aerial recreation survey data were used to validate the GPS-based recreation maps. The GPS track-based recreation footprint was compared to aerial survey cells scoring positive for winter recreation and percent overlap was calculated. We also generated an all-track recreation intensity layer at 500m^2 resolution to match the resolution of the aerial surveys and used binned values to compute the correlation with the coarser resolution scores of the aerial surveys. At the level of individual aerial survey grid cells, we identified 'gaps' in our ground-based recreation monitoring data, as indicated by the absence of GPS track information where aerial surveys indicated consistent or wide-spread use. We undertook additional validation of the recreation layers when using them in analyses of animals monitored in years subsequent to the recreation GPS tracking data collection. In these instances, we used aerial survey data collected concurrent with animal monitoring to identify potential spatial shifts in winter recreation compared to the GPS track-based layers. Animal and random locations falling in aerial grid cells in areas of notable mismatch between aerial survey and the recreation covariate layers were not included in further analyses. The maps of RSF models including winter recreation relative intensity covariates are not extrapolated into these areas of data gaps.

We completed 9 aerial recreation surveys. The correlation between the aerial survey scores and the recreation intensity layer classes was 0.80, suggesting high concurrence in the relative intensity of recreation as estimated between the two independent methods. The footprints were also very similar, with the aerial recreation surveys suggesting a larger footprint in 13% of the area, while the recreation intensity layer suggested a larger recreation footprint in 15% of the area. Animal and random locations falling within gaps in our recreation intensity models were removed from further analyses, including one female animal-year and 232 animal locations and 1875 random locations across nine additional animal-years.

Backcountry winter recreation types and patterns

Table C. 1. Summary the types of backcountry winter recreation monitored through volunteer recreationists carrying GPS units in Idaho, Wyoming and Montana (2010-2015) as part of the research examining wolverine responses to winter recreation. Each type of recreation was subsequently classified as motorized, non-motorized while recreationists partaking in both motorized and non-motorized activities (e.g., using a snowmobile to access areas for skiing) were identified and their tracks split into the component types.

Recreation Type	No. of tracks	Total km	Avg km	Classified
Snowmobile	2772	161,699	60.42	Motorized
ATV	2	75	37.50	Motorized
Motorbike	1	16	16.41	Motorized
Snowbike	1	6	6.38	Non-motorized
Ski	2485	24814	9.99	Non-motorized
Snowboard	377	3919	10.40	Non-motorized
Snowshoe	24	148	6.15	Non-motorized
Snowmobile –ski/snowboard	139	4351	31.30	Split
Cat-Ski	45	2432	54.05	Split
Heli-Ski	53	559	10.54	Non-motorized portion only
Total	**5899**[1]	**178438**	**32.57**	

[1] This is the raw track count; the snowmobile-ski/snowboard tracks were split into their component motorized and non-motorized sections.

Appendix D: Wolverine habitat models and indirect habitat loss

This Appendix provides additional details on indirect habitat loss calculated for individual wolverines. It also displays small format maps of the RSF wolverine habitat models developed using environmental and winter recreation covariates to predict relative wolverine probability of use based on GPS monitoring of wolverines 2010-2015 across four study areas in Idaho, Wyoming and Montana (Figures D.1 – D.4). Large format maps of the final RSF habitat models are available at www.roundriver.org/wolverine

Table D.1. Indirect habitat loss calculated[1] from winter recreation within individual wolverine (*Gulo gulo*) home ranges based on spatially-explicit transitions to lower habitat classes when comparing potential and realized habitat models developed for wolverines monitored 2010-2015 across study area in Idaho, Wyoming and Montana (see Figures 2-5).

	Overall Degraded	Moderate to Low	High to Moderate	High to Low
F1_2010	28.4%	44.5%	19.9%	23.4%
F1_2012	24.6%	38.4%	15.4%	20.9%
F10_2014	24.5%	37.6%	15.1%	19.3%
F11_2014	14.8%	24.9%	12.1%	12.2%
F2_2010	19.5%	29.7%	15.7%	13.6%
F2_2011	19.7%	28.3%	17.2%	14.1%
F3_2010	6.4%	5.4%	9.1%	2.1%
F3_2014	3.2%	2.8%	5.5%	0.6%
F4_2011	20.9%	28.3%	23.4%	13.3%
F5_2011	10.3%	10.7%	15.1%	4.5%
F7_2017	2.7%	4.0%	6.0%	0.0%
F8_2103	2.0%	2.5%	4.5%	0.2%
F9_2012	6.2%	7.2%	10.8%	0.6%
Female Average	14.1%	20.3%	13.1%	9.6%
M1_2010	16.2%	21.6%	24.1%	0.7%
M1_2011	14.3%	18.1%	18.2%	0.7%
M1_2014	16.1%	19.6%	20.1%	0.9%
M12_2014	12.3%	18.4%	18.3%	0.2%
M13_2014	9.3%	19.4%	19.5%	0.0%
M13_2015	7.7%	19.4%	16.4%	0.0%
M15_2015	11.2%	16.1%	17.2%	0.0%
M2_2010	14.3%	19.9%	20.3%	0.4%
M2_2011	13.8%	21.1%	20.1%	0.3%
M2_2012	5.5%	11.3%	11.6%	0.0%
M3_2010	11.2%	14.5%	16.6%	0.0%
M6_2012	4.8%	9.9%	8.9%	0.0%
M8_2012	5.5%	11.3%	11.6%	0.0%
Male Average	10.9%	17.0%	17.2%	0.2%

[1] Calculations: 'overall degradation' = ha degraded/total ha; 'moderate to low' = moderate degraded/total moderate available, 'high to moderate' = high degraded to moderate/high available; 'high to low' = high degraded to low/high available

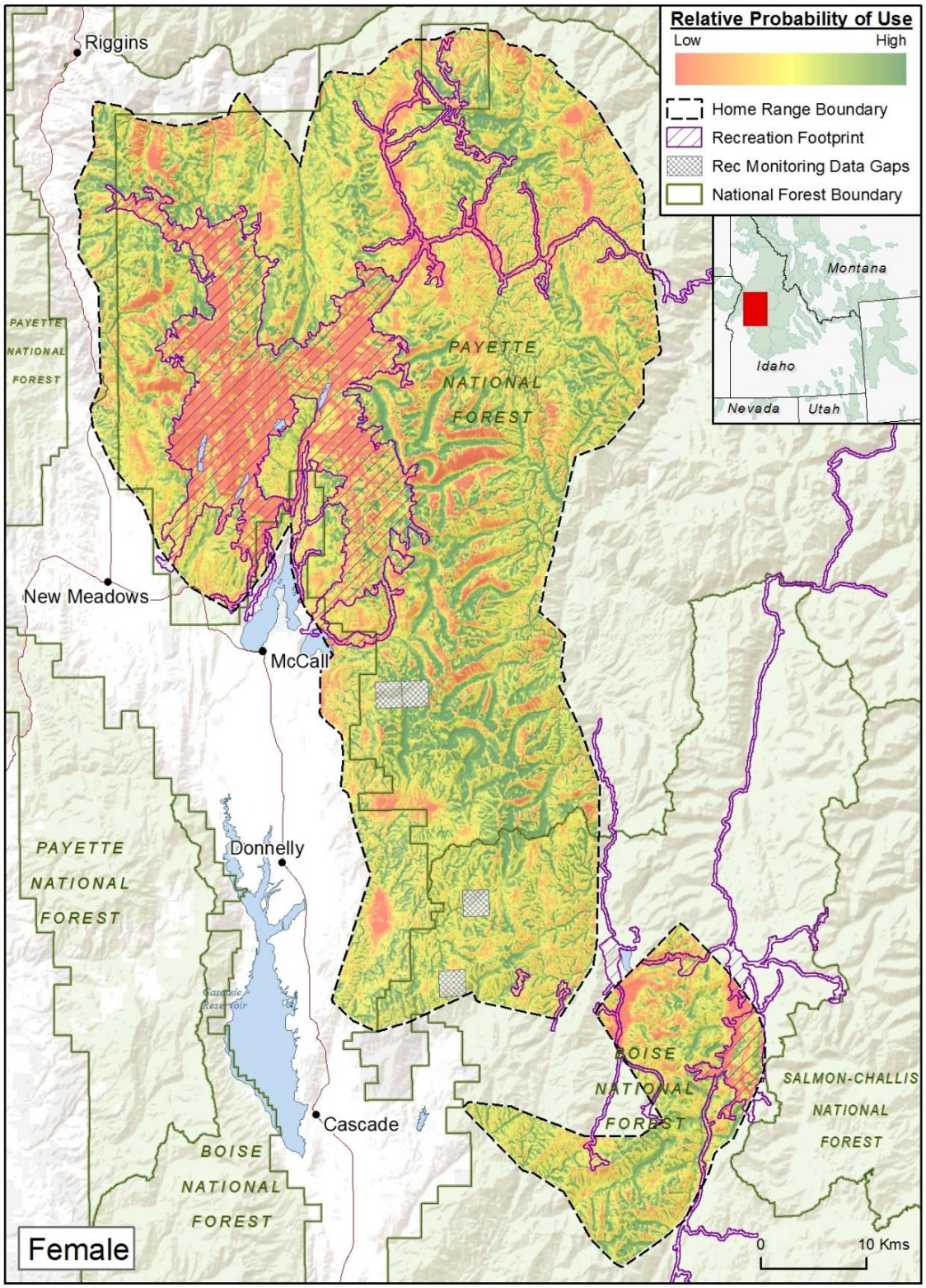

Figure D.1. Resource selection function habitat model for female wolverines (*Gulo gulo*) in the McCall study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

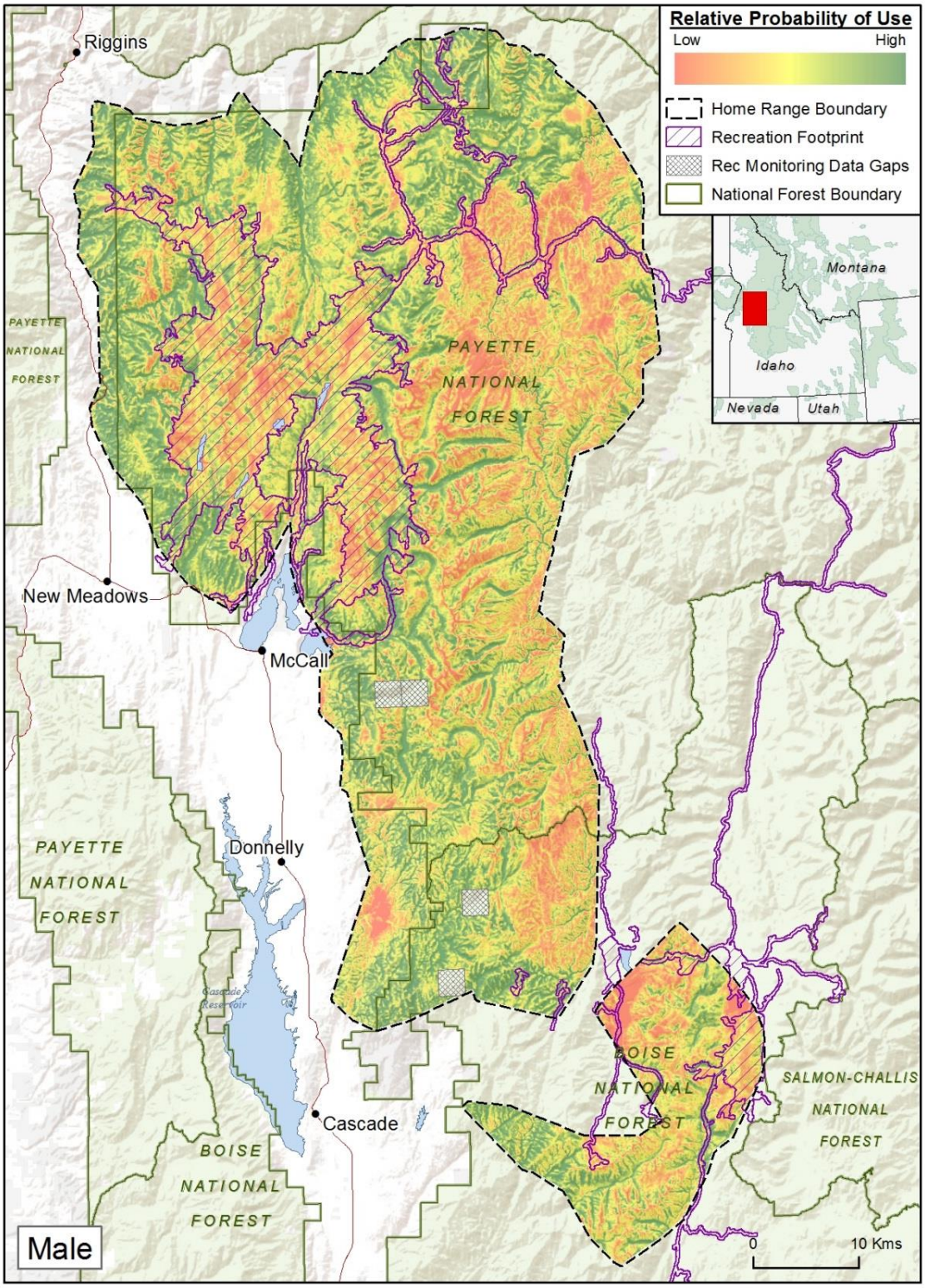

Figure D.2. Resource selection function habitat model for male wolverines (*Gulo gulo*) in the McCall study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

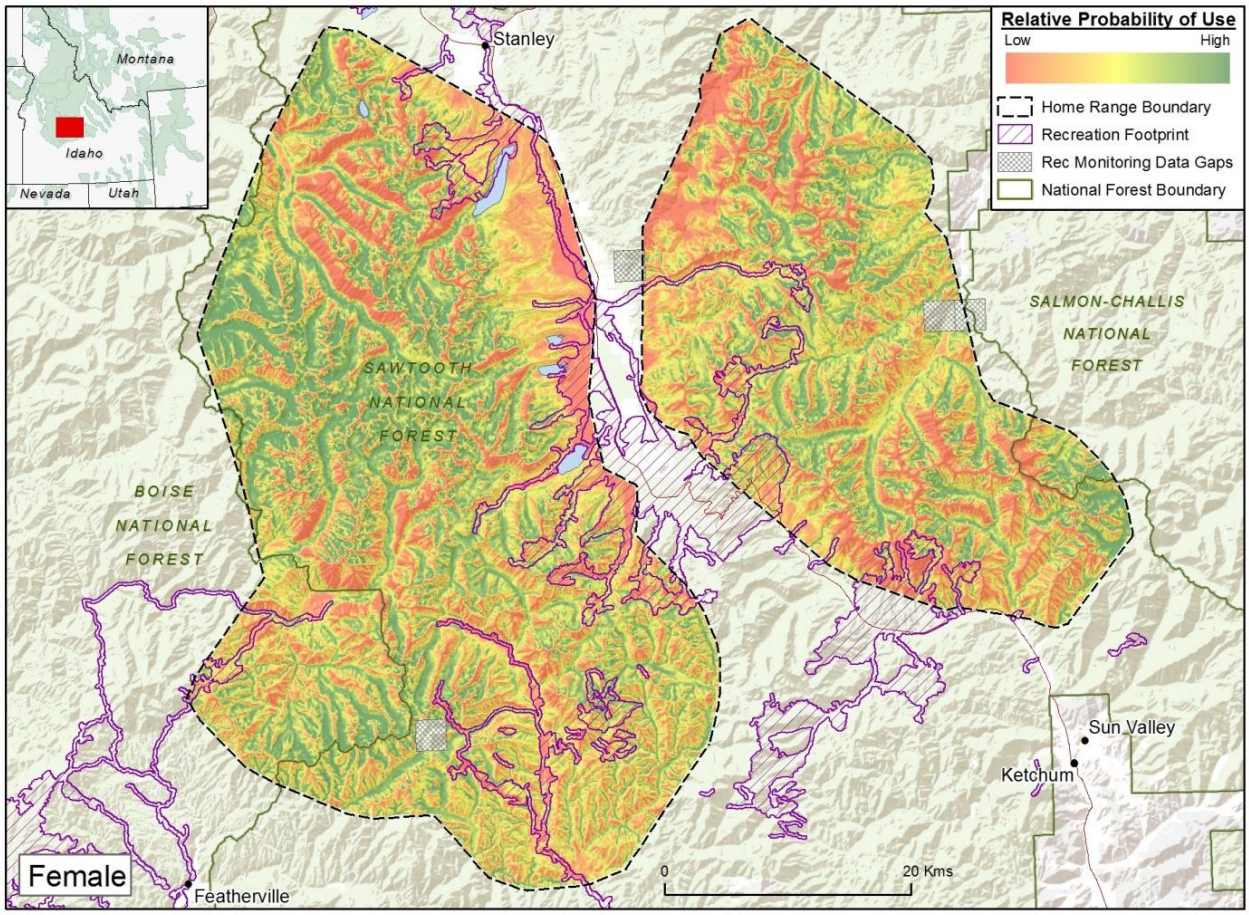

Figure D.3. Resource selection function habitat model for female wolverines (*Gulo gulo*) in the Sawtooth study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

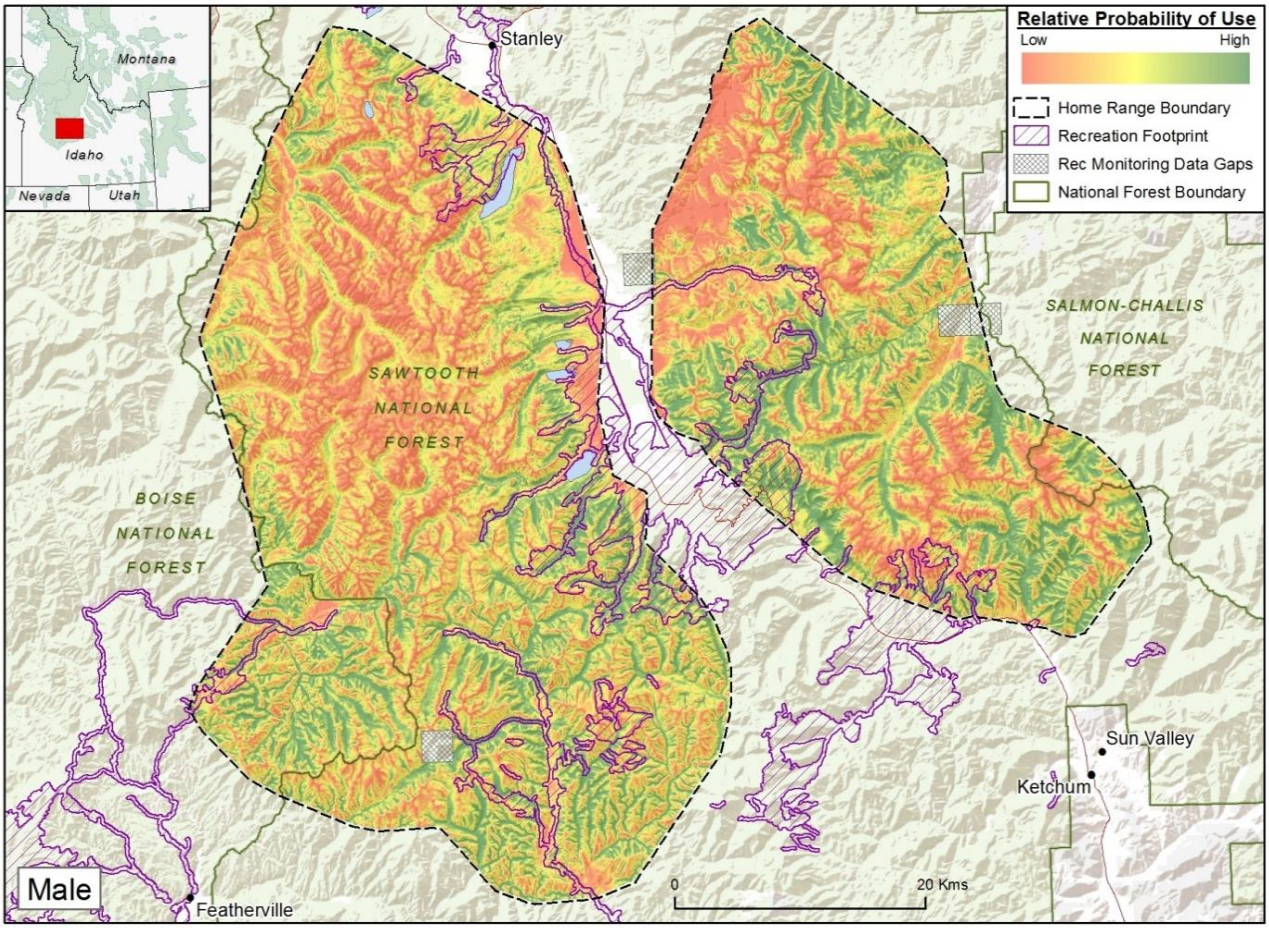

Figure D.4. Resource selection function habitat model for male wolverines (*Gulo gulo*) in the Sawtooth study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

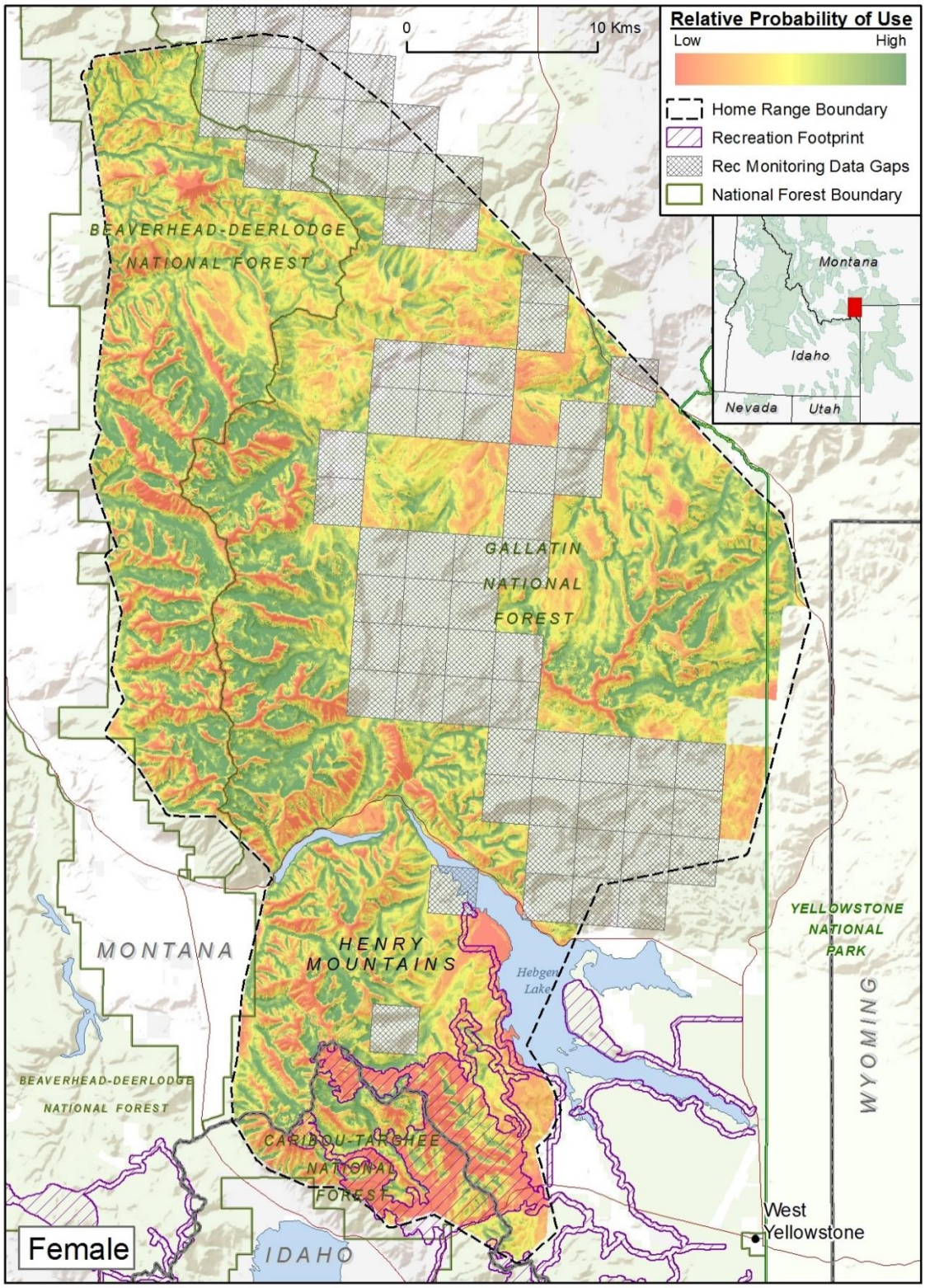

Figure D.5. Resource selection function habitat model for female wolverines (*Gulo gulo*) in the West Yellowstone study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

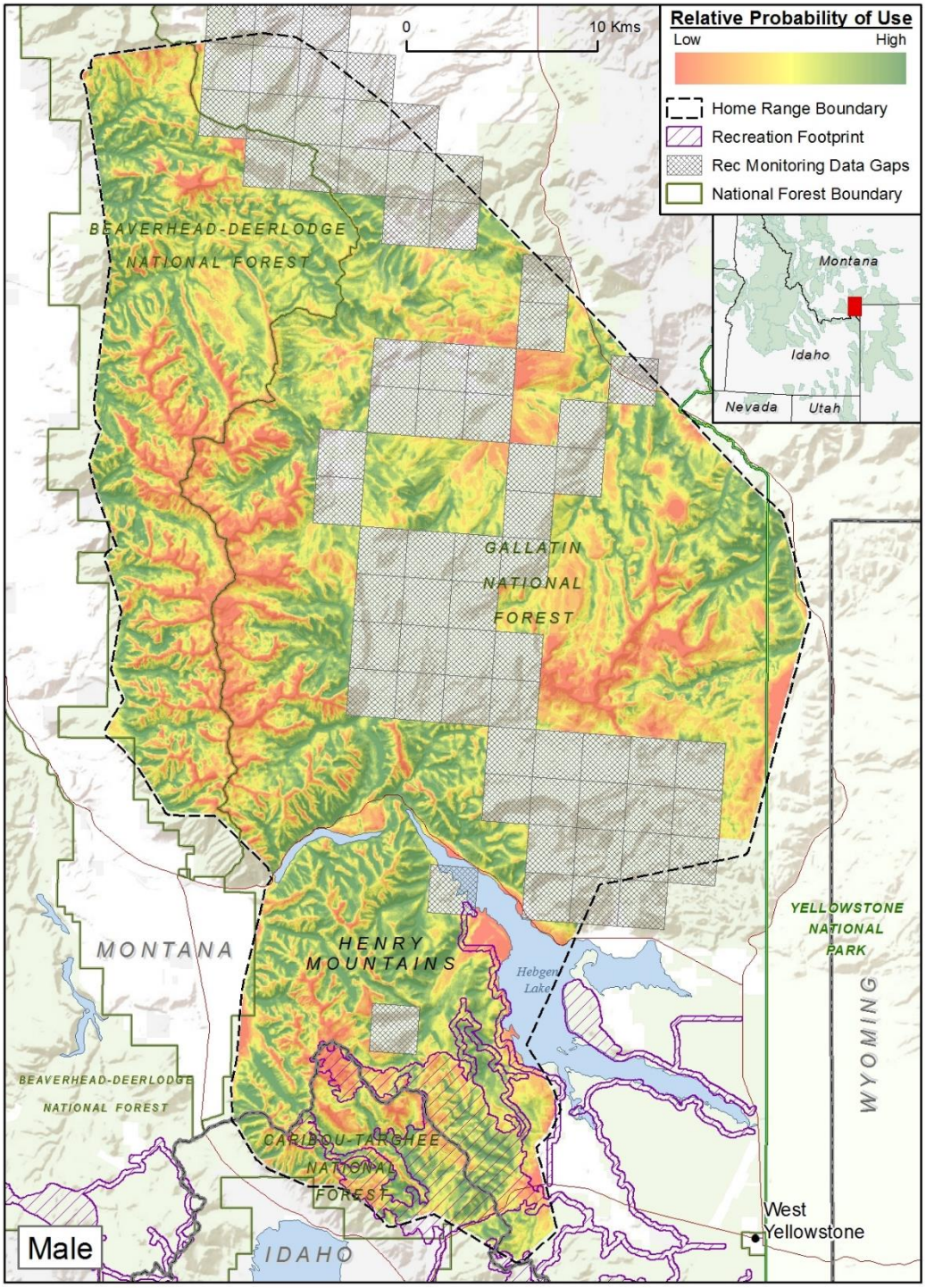

Figure D.6. Resource selection function habitat model for male wolverines (*Gulo gulo*) in the West Yellowstone study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

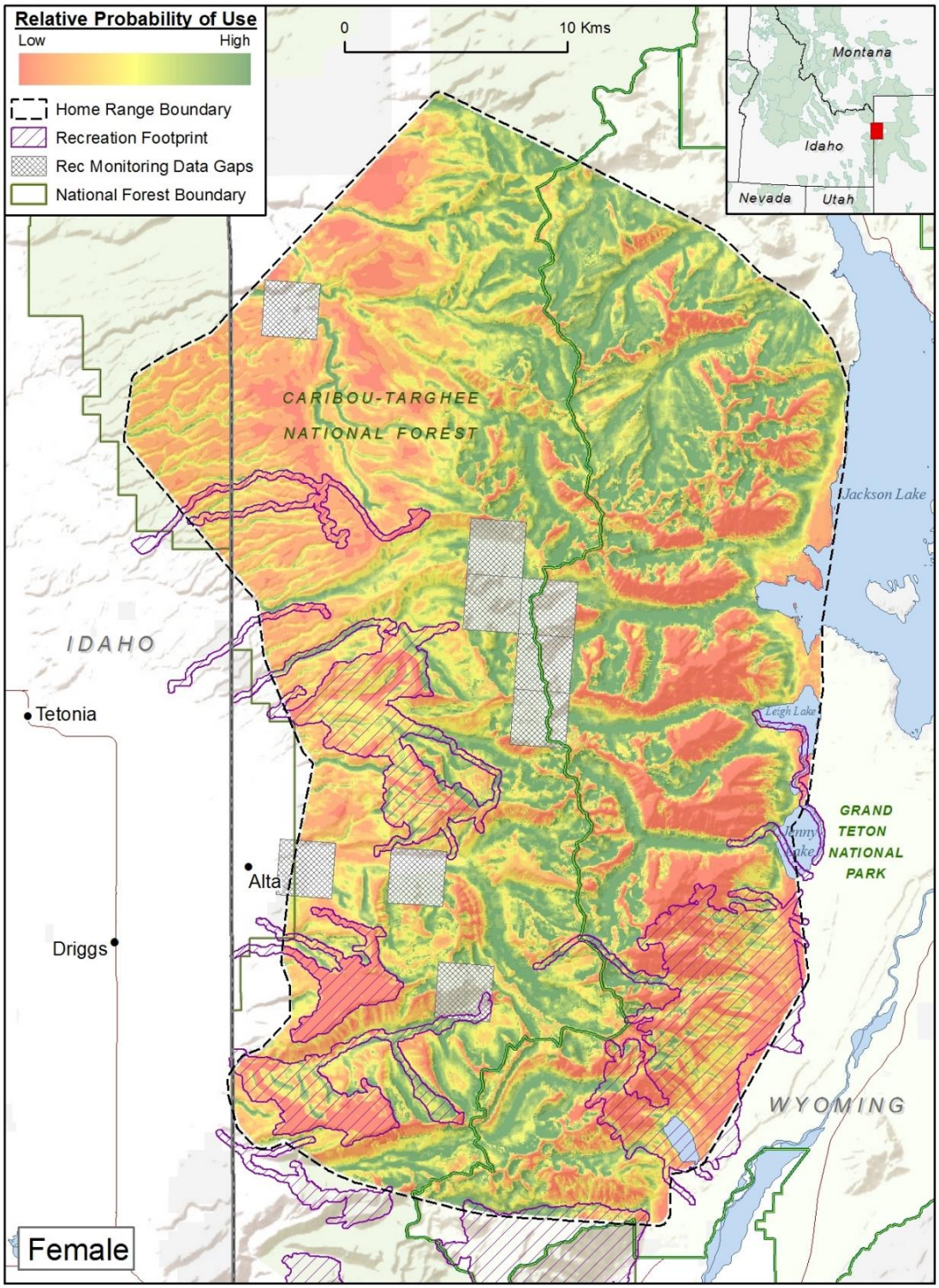

Figure D.7. Resource selection function habitat model for female wolverines (*Gulo gulo*) in the Teton study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

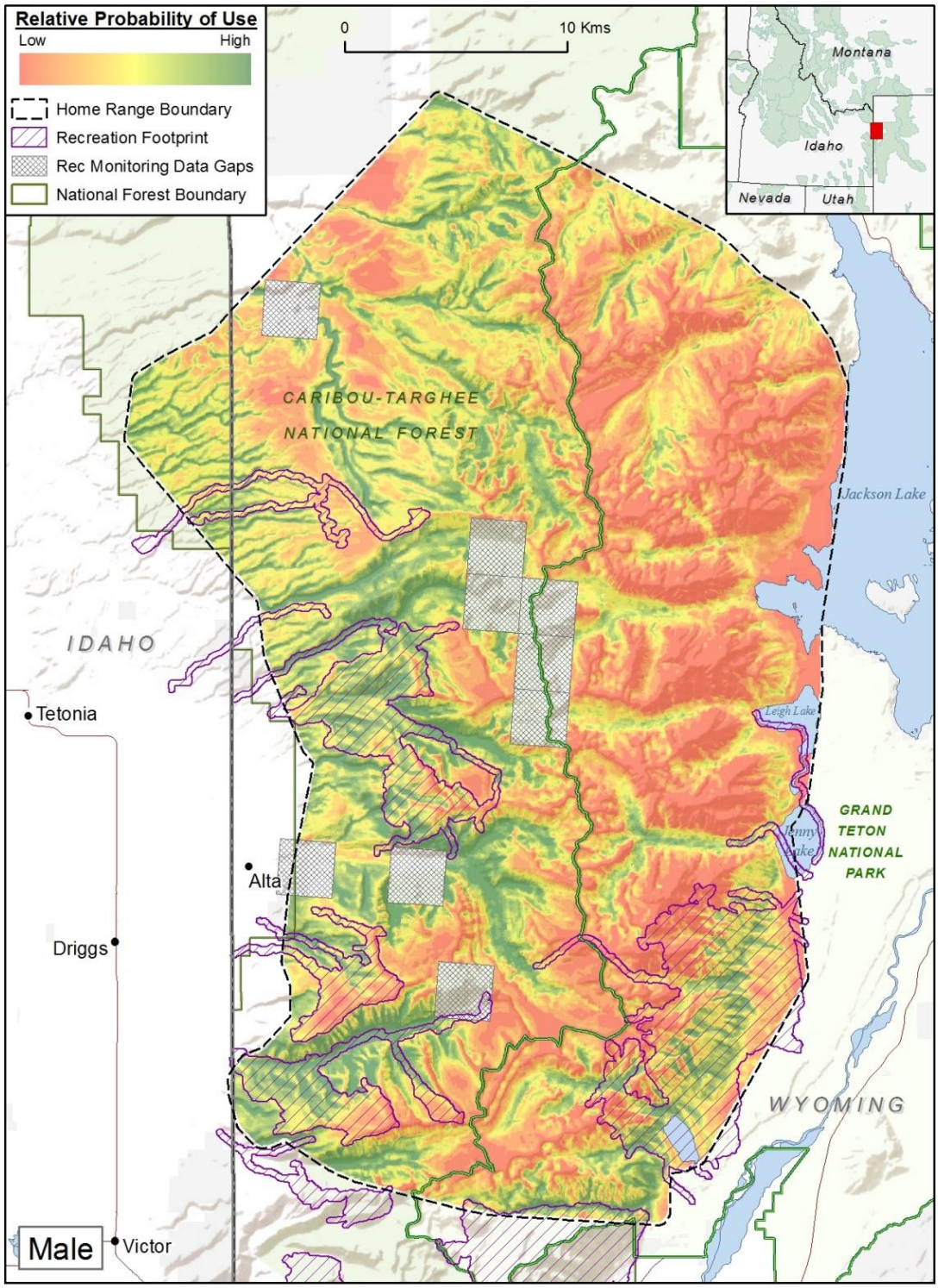

Figure D.8. Resource selection function habitat model for male wolverines (*Gulo gulo*) in the Teton study area, including environmental and winter recreation covariates to predict relative probability of use based on GPS locations of wolverines monitored 2010-2015.

From:	Andrea Ray - NOAA Federal
To:	Steve Torbit; John Guinotte; Joseph Barsugli
Subject:	Fwd: getting ahead of publicity about wolverine work Re: Please review AGU wolverine poster
Date:	Thursday, December 21, 2017 6:00:29 PM

Steve and John, I've sent a message to Theo Stein and Katy Human (now CIRES public affairs, fmr Denver Post & Daily Camera reporter, and NOAA public affairs) asking to talk to them early in the new year about getting ready for possible press inquiries. I know Steve and Theo know each other, and we'd coordinate with FWS anyway, you're the lead on this.

Is it OK to share the report with them? Or let me know when it is. I did send them our posters (I think Katy saw them at AGU), but told them to keep them close hold.

I'll be in tomorrow, then off, but don't hesitate to call me or joe next week if you need to.

have a good holiday! Andrea

---------- Forwarded message ----------
From: **Andrea Ray - NOAA Federal** <andrea.ray@noaa.gov>
Date: Thu, Dec 21, 2017 at 5:35 PM
Subject: getting ahead of publicity about wolverine work Re: Please review AGU wolverine poster
To: Stephen Torbit <Stephen_Torbit@fws.gov>
Cc: Joseph Barsugli <joseph.barsugli@noaa.gov>, John Guinotte <john_guinotte@fws.gov>, Ben Livneh <ben.livneh@colorado.edu>, Aaron Joseph Heldmyer <Aaron.Heldmyer@colorado.edu>, Imtiaz Rangwala <imtiaz.rangwala@noaa.gov>, Candida Dewes - NOAA Affiliate <candida.dewes@noaa.gov>, "Jenna.R.Stewart@Colorado.EDU" <Jenna.R.Stewart@colorado.edu>

Hi Steve and all, none of us caught that word when Aaron sent out the abstract for a read before submitting in late July. In the upcoming months, we all need to be mindful of language and our respective roles in this project -- we did the science, and not towards any particular result. "preservation" could be interpreted as aiming towards listing or not. I'm sure there are other potential mis-interpretations we want to avoid. We'll likely respond to some questions by referring them to FWS because some parts of this are beyond the purview of our work, and are the role of FWS.

Aaron -- as discussed in a previous email, please do no post an e-poster of your AGU presentation. I'm not either. We'll be able to post other places later, and in the meantime, if someone wants a copy, check with Joe and I first. I did have a reporter at my poster -- if you did, would you let me know who?

Probably in late January (date not known yet), the Species Status Assessment will be public and we may get press inquiries. We need to be ready for that. I'll be reaching out to Theo Stein and Katy Human (NOAA & CIRES public affairs people respectively) offline about having a message ready and how we'll talk about it, and ask Theo in particular to coordinate with FWS, because they'll have the lead. I'll get back to all of you in the new year after I've talked with them. We should go over best practices for talking to the press, and decide who the primary

project spokespersons are for CIRES, and me for NOAA. I plan to work with Theo and Katy to get ready for this.Theo used to work at FWS so he's already familiar with ESA issues and sensitivities, so he'll be really helpful.

In the meantime, if any of you get press requests, please remember that you don't have to and shouldn't respond immediately (a standard "best practice" in dealing with the media). Get their contact info and find out what their deadline is, and tell them that someone from the project will get back to them. Then check in with Joe and I and we'll decide what to do. We shouldn't respond to anything before FWS is ready.

Thank you in advance for your cooperation and patience!

Andrea

On Tue, Dec 19, 2017 at 1:37 PM, Stephen Torbit <Stephen_Torbit@fws.gov> wrote:

> I just looked at Aaron's and although his is more model oriented, I think we need to wait until after the decision meeting to put this on the web. And, in the future, lets not use the word "preservation" when we talk about the purpose of undertaking the study.
>
> Thanks
>
> ST
>
> Stephen C. Torbit
>
> Assistant Regional Director
>
> Science Applications
>
> U.S. Fish and Wildlife Service
>
> 134 Union Blvd.
>
> Lakewood, Colorado 80228
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> 303-236-4602 – Office
>
> 720-626-7504 – Cell
>
> **From:** Andrea Ray - NOAA Federal [mailto:andrea.ray@noaa.gov]
> **Sent:** Tuesday, December 19, 2017 1:17 PM
> **To:** Stephen Torbit

Cc: Joseph Barsugli; John Guinotte; Ben Livneh; Aaron Joseph Heldmyer; Imtiaz Rangwala; Candida Dewes - NOAA Affiliate; Jenna.R.Stewart@Colorado.EDU
Subject: Re: Please review AGU wolverine poster

Hi Steve, I'm fine with holding off on posting this. It's a "nice to do" thing to post an e-poster for AGU, but more important that your process plays out as needed. Anyone who sees the abstract or saw one of the posters always has the option to email us if they're interested. We can post it later (after the SSA release or when we agree) on our own webpages and places like ResearchGate.

So -- should Aaron also hold off on posting? He sent his poster after I did.

FYI, I'm here this week, but out next week. I wont be monitoring email much, but if anything comes up short turn around, feel free to call my cell.

I'll catch up with Joe on what happened last week.

thanks, Andrea

On Tue, Dec 19, 2017 at 12:48 PM, Stephen Torbit <Stephen_Torbit@fws.gov> wrote:

Hi Andrea, thanks for sharing your poster with us. We are in the middle of our review of the wolverine SSA and its gotten pretty tough. As we told Joe last week, we have gotten some pretty good but tough feedback and then some other feedback that borders on unprofessional. We will be having our decision meeting in late January. I suggest that we may want to work on the poster a bit and delay any publication on the web until after our decision is finalized. Happy to discuss if this causes you any heartburn, but we have to be sensitive to all that is going to be happening soon with the decision process.

Steve

Stephen C. Torbit

Assistant Regional Director

Science Applications

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720-626-7504 – Cell

From: Andrea Ray - NOAA Federal [mailto:andrea.ray@noaa.gov]
Sent: Monday, December 18, 2017 5:28 PM
To: Steve Torbit; Joseph Barsugli; John Guinotte; Ben Livneh; Aaron Joseph Heldmyer; Imtiaz Rangwala; Candida Dewes - NOAA Affiliate; Jenna.R.Stewart@Colorado.EDU
Subject: Please review AGU wolverine poster

Hi All,

Attached is the poster I gave last week at AGU. WE've got the opportunity to post it as an "e-poster," but I'd like to give you a chance to edit before I do that. Robin Webb, PSD director, also asked that I print a copy to post in the hall here (Steve, we can print one for you if you like). Steve and John -- if you don't want this posted as an e-poster, let me know. I don't think it gives away anything -- its more about the co-production process, but I'll understand if you don't want it out there.

The session was well attended, I talked for most of the two hours I was there -- and we did a "lightening poster" walk around that attracted a number of people to the poster. A student who was blogging for AGU stopped by, and reporter who writes for both Science and High Country News (Emily Underwood). I promised the reporter that I'd let her know when the SSA package is out and this is public.

in addition to giving it a close(r) read for typos, I also want to revise the line that we "engaged" McKelvey, Copeland, and Littell -- Jeremy was in my session and said that all he really did was provide data. So I'll edit that.

I have until Dec 31st to post it, but I'd like to have your inputs by Thursday or Friday morning, bc I'll be on leave next week, and I'd like to wrap it up before I go. If you can't do it by then, let me know when you can.

Remember -- this wasn't intended as a science results poster, it was in a session about co-production of science for policy and management. So its light on results. it's attached, and also posted in the google drive with abstracts and presentations: https://drive.google.com/drive/folders/0B6ksrl3lWQI4Q2NITlo1eTdQSG8. Powerpoint doesnt have a track changes feature, so if you have comments, highlight or use a different color, or just call/send me a message depending on how involved it is.

Andrea

--

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From: Grizzle, Betty
To: Shoemaker, Justin
Cc: Guinotte, John; Stephen Torbit
Subject: Re: Wolverine peer review comments table - updated
Date: Tuesday, January 2, 2018 8:21:15 AM

Thanks Justin. Will take a look before the call, though I expect not too many people will be available today.

On Tue, Jan 2, 2018 at 5:36 AM, Shoemaker, Justin <justin_shoemaker@fws.gov> wrote:

> Betty,
>
> Attached is a revised comments table with some categories added (4 categories: range, mapping; snow, climate; trapping; genetics). Hopefully this can help in addressing comments more efficiently. The range, mapping stuff is probably addressed already w/ your recent revisions to the range map and any associated text in the report. The snow, climate comments may be largely addressed by the response to commenter #2 that Steve and John are working on.
>
> And I've categorized where I thought each comment should be addressed, either in the report or record, or dismiss. Feel free to revise any of that if you think something might be better addressed in the record vs the report, or simply dismissed altogether.
>
> We could also share this table w/ the group for today's call, just let me know.
>
> Justin Shoemaker
> Classification and Recovery Biologist
> U.S. Fish and Wildlife Service, Region 6
> Phone: 309-757-5800 x214
> Email: justin_shoemaker@fws.gov

--

Betty J. Grizzle, D.Env.
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2177 Salk Ave, Suite 250
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From: Inman, Bob
To: A J; Grizzle, Betty
Subject: RE: Female wolverine data
Date: Tuesday, January 2, 2018 11:23:27 AM

I have not read through the recreation report in detail. Glad you have.

Our 2012 spatial ecology paper has a figure with GPS collar movements of 5 females. One (F121) was denning. So there is some data, but it is limited. We also did flights where we recorded snowmobile and ski tracks on the landscape. Lots of flights.

Our study design was more focused on wilderness females and non-wilderness females. I wanted to compare movement rates and activity patterns between those in W (no motorized rec) and not. Also to look at space use (potential for avoidance) for those with rec in their home range.

Do wolverines with rec in their home range avoid it?

Or do they use the same areas but change activity pattern - Is the activity pattern of wolverines with rec in their home range different than those without rec?

Are movement rates of wolverines with rec in their home range different than those without rec in their home range?

Still could be done. The data is just sitting there.

-Bob Inman

Robert M. Inman, PhD
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bobinman@mt.gov

-----Original Message-----
From: A J [mailto:222wsheridan@gmail.com]
Sent: Saturday, December 30, 2017 4:02 PM
To: Inman, Bob <bobinman@mt.gov>
Subject: Female wolverine data

Hi Bob
Hope all is well and you had a good holiday season. I've been wasting my time "analyzing" the recreation report. I have a question for you. In your 2007 GYWP report, on page 8, Fig. 3, you show movements of males broken down in weekly segments. Do you have similar data analyzed that way for females? I seem to remember seeing it but maybe I'm remembering wrong. Can you let me know. The only female wolverines with appreciable amounts of recreation in the recreation report were 3 denning females (F1, F2 both denning in 2010 and F10 in 2014). The 2010 progress report shows movements for F1 and F2 those years relative to recreation, but no info on F10 is available in the progress report or final report, and no info on all 3 in their non-denning years. I would like to see how movements change by week over the pre-denning and denning period but that is not available. But I hope you have that kind of data???? And maybe some indication of where snow machines played in their home ranges.

As I mentioned in my email to Betty, I'm rather disappointed in the recreation report. After waiting 7 years for it to

come out, it was essentially a modeling exercise with all the inherent problems with modeling and very little actual biological and behavioral data.

Give all the family hugs from me.
Happy New Year.
Audrey

Sent from my iPhone,

From: Grizzle, Betty
To: A J
Subject: Re: recreation report
Date: Tuesday, January 2, 2018 4:33:16 PM

Thanks Audrey for your insights. It would have been helpful if other scenarios/model runs were evaluated and to have a better description of their methods (and assumptions).
I will let you know when the report is available.

On Tue, Jan 2, 2018 at 3:11 PM, A J <222wsheridan@gmail.com> wrote:

> Hi Betty
> Excuse me for going on about the RSF modeling used for the recreation report. I just find that RSFs often lead to erroneous assumptions about habitat use because animal behavior is rarely taken into consideration when choosing variables or selecting the best fitting model. I would very much like to see a RSF run for the recreationists in that study. I am guessing that the "best model" would show that recreationists chose habitats that would not be selected by wolverines. For example, I guess that recreationists "select" habitats relative to how close they are to access points, roads and groomed trails, and usually select open areas rather than forested areas or rugged terrain with cliff habitats or talus. Wolverines often avoid open areas in many situations where there are no recreationists so the wolverines may not be avoiding the recreation landscape because there is recreation there.Also, they could if they wanted: consider that they have about 16 hours of every 24-hour period to go into recreated areas when the recreationists have gone home
>
> The other thing that occurred to me was how the authors used the wolverine telemetry points for selected habitats. There is not enough information in the methods to determine if they used all the locations at den sites as evidence of selection for talus, likewise all locations at clusters that might be feeding sites at carcasses as selection for the habitat the carcass was in. If they did this, it would be a strong bias toward talus or the habitat that the clusters occurred in. Consider, a wolverine selects talus when it initiates a den; from then on, it is not selecting talus, but rather selecting the den. Same thing for habitat where a carcass occurs. They select the habitat the first time they locate a carcass and from then on, select the carcass. For F1 in 2010, she had a den and at least 3 large clusters that accounted for lots of her telemetry points (not to mention that she had to travel to and from these sites, which also biases selection of habitat to some degree). Moreover, there was no differentiation between denning females and non-denning females, and the authors recognized that this could lead to bias for talus, but did not address that. Finally, females with dens must return to the dens limiting the choices of where and what they choose for travel.
>
> Before I could accept the conclusions in that report, I would have to be convinced that the habitats selected by recreationists were similar to habitat that wolverines

would have selected if recreationists had not been there. It seems to me that the availability of "wolverine habitat" as described by the RSF is not likely to occur over much of the area under the recreated footprint (and the wolverines probably know that).

I guess I'll stop thinking about this now.
Please let me know when the SSA is available.
All the best
Audrey

On Tue, Jan 2, 2018 at 6:35 AM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:

> Thanks Audrey for your review and comments. Yes, my first impression was similar - this was primarily a presentation of modeling results.
>
> I did take some time off to visit family in Park City, UT, but didn't make it up to Bozeman - weather did not cooperate for driving.
> Happy New Year to you as well!
>
> On Fri, Dec 29, 2017 at 6:18 PM, A J <222wsheridan@gmail.com> wrote:
>
>> Hi Betty
>> I hope you had a good Christmas and took some time off. I used the holidays to study the recreation report, brush up a bit on RSF models, and AIC etc., and also go over the previous progress reports. The more I got into everything, the more questions I developed regarding the final report and the conclusions. I really am disappointed that the final report is only a modeling exercise with little on-the-ground observations. When I looked through the material presented in the progress reports and compared it to the conclusions from the modeling exercise in the final report, I see a number of things that are contradictory. Furthermore, I think the interpretation of the model by the authors may not be the only interpretation that makes sense. I have so many questions and points I would make that if I were a reviewer of the report (submitted as a potential publication), I would recommend major revisions. Too many points to address in this email. I'll just conclude with my opinion that the data collected over the 5 years of the field study indicate to me that there is not enough information on the levels of recreation (or wolverines exposed to recreation) to conclude that recreation is now having an affect on wolverines, and nothing that indicates that recreation will increase appreciably in the future into new areas or higher intensities. In fact, I wonder if, with earlier spring melt, recreation will end earlier, leaving the area without recreation disturbance during the entire April period. Recreation was not monitored after April 15, which I assumed was because snow conditions at access points was no longer amenable to recreation activity after mid AprI.
>>
>> I find the term "indirect habitat loss" unfortunate because the disturbance is temporary in nature (if indeed wolverines are actually avoiding recreated

areas) and I believe you will soon see people stating that the winter recreation is causing wolverines to lose up to 50% of their habitat in the Payette and other areas and this percentage will increase in the future with climate warming.

I also don't like the term "avoided" in presenting the results of the modeling exercise because it insinuates that there is something negative about the "avoided" areas, when in fact, it may simply not be "selected" in winter period for various reasons. I would prefer "selected" or "not selected." There are only 3 denning females that were exposed to relatively high recreation, and movements for those females overlaid on recreation is only available for F1 and F2 (attached: "D" marks the den; F10's den in 2014 was just east of F1's 2010 den) from the 2010 progress report. One does not know if these females would have had these same movements and locations even if there had been no recreation in their home range. Their apparent "avoidance" of a lot of the recreated area may not have been due to recreation but to some other factor, since wolverine movements often are quite different in the denning period than in the rest of the year. However, the attached maps show that they used portions of the recreated area, even denning in recreated areas when un-recreated areas were nearby.

I can only hope that additional data analyses will be forthcoming from the recreation study that will not be focused on modeling, but actual observations of wolverines and recreationists and how the interacted.

I assume you are getting close to being done with the SSA and can move on to other things.

Hope you have a Happy New Year!

--

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From:	Guinotte, John
To:	Betty Grizzle
Subject:	Fwd: Memo on some key methodological issues. WITH DATA!
Date:	Wednesday, January 3, 2018 4:03:43 PM
Attachments:	12DEC_Memo_to_FWS.docx Snowcourse_GLAC_ROMO_12DEC2017.xlsx

---

Hi Betty, Have a look at the third paragraph in the word doc re 00-13 time series.

---------- Forwarded message ----------
From: **Joe Barsugli** <joseph.barsugli@colorado.edu>
Date: Wed, Dec 13, 2017 at 4:26 PM
Subject: Memo on some key methodological issues. WITH DATA!
To: Stephen Torbit <Stephen_Torbit@fws.gov>, "Guinotte, John" <john_guinotte@fws.gov>, Andrea Ray <Andrea.Ray@noaa.gov>

Steve, John

I'm re-sending this with the Excel spreadsheet of the data, just for completeness.

One thing to keep in mind in interpreting this data is that the recent period has been warmer due at least in part to the climate change signal. (Attribution of the temperature signal to climate change has only been done formally for the larger region of the western US). This supports using the more recent baseline, particularly considering that the den sites were surveyed during the recent period. However it is clear that one cannot rule multidecadal wet and dry periods in the future, but it would likely be warmer than the one in the 1950's - 1970's.

Yours,

Joe

--
Joseph Barsugli, Research Scientist III
CIRES, UCB216
University of Colorado Boulder
Boulder CO 80309
303-497-6042
PSD Science Board and
Attribution and Predictability Assessments Team Member

Memo to Stephen Torbit and John Guinotte, December 12, 2017.

Joseph Barsugli, CIRES, University of Colorado, affiliated with NOAA/ Earth System Research Laboratory/Physical Sciences Division.

Summary of some key methodological issues that are addressed in the "snow persistence" report.

How representative is the 0.5 meter threshold modeled snow depth of snow at den sites?

As stated in the report, the DHSVM model has limitations due to its spatial scale and unresolved snowpack physical processes. Even though the study breaks new ground by running the DHSVM model at 250 meters resolution for a landscape-scale study, it does not model certain key processes that result in variations in snow depth within a model gridcell. For example, wind and avalanche redistribution of snow are not modeled, nor are small-scale topographic variations such as stream channels where drifting may occur. As a result of these unresolved processes certain sites within the grid would have deeper snowpack than others. When the model indicates 0.5 meters of snow for the entire grid, it is likely that wolverines would have available sites within that grid with greater than 0.5 meters of snow. Therefore we interpret the modeled area covered by snow greater than 0.5 m depth as an "index" or "indicator" of snow availability for potential den sites rather than a precise model of snow depth at the den sites.

Was modeled snow depth validated?

Snow depth was not an output variable of the DHSVM model. Snow Water Equivalent (SWE) was validated against SNOTEL station data (and MODIS snow cover extent, for the Rocky Mountain NP regional domain) as described in Section 5 of the report. Snow depth was then derived from the SWE outputs using empirically derived ratios of depth to SWE (or, equivalently, the inverse of bulk snow density). We considered three sources of information to come up with typical springtime values of snow density: SNOTEL station observations, SNODAS spatial snow estimates, and the VIC model output that was used by McKelvey et al. 2011. McKelvey notes that SWE and snow depth are extremely highly correlated in the VIC model output that they used, further supporting the use of this bulk conversion formula. Given the other uncertainties associated with the spatial scale of modeling (above), the overall results are not critically dependent on the precise value of snow density that was inferred.

How representative is the 2000-2013 baseline period in terms of the longer record of snow?

The baseline period of 2000-2013 was chosen for concordance with the availability of the MODIS satellite remote sensed snow product and availability of the Livneh (2014) gridded meteorology dataset. In section 3 we discuss the larger historical context by showing the percentile rankings for temperature and precipitation compared to a longer (1951-2013) gridded dataset (Tables 3-3 and 3-4) and a scatterplot of the data (Figure 3-5). For GLAC, October-May was typically warmer and drier during 2000-2013 than the long term average. For ROMO, the October – May precipitation was typical, though with higher temperatures. One might infer that the Spring snowpack would therefore be lower in our baseline period than in the prior decades. Further investigation into three long-established May 1 snow course (manual measurements) in the GLAC and ROMO regions (Figs. 1 and 2, not shown in the report) shows that, while this is true, the longer record dating back to 1922 in GLAC and 1936 in ROMO indicates a period of relatively low snowpack prior to the 1950's.

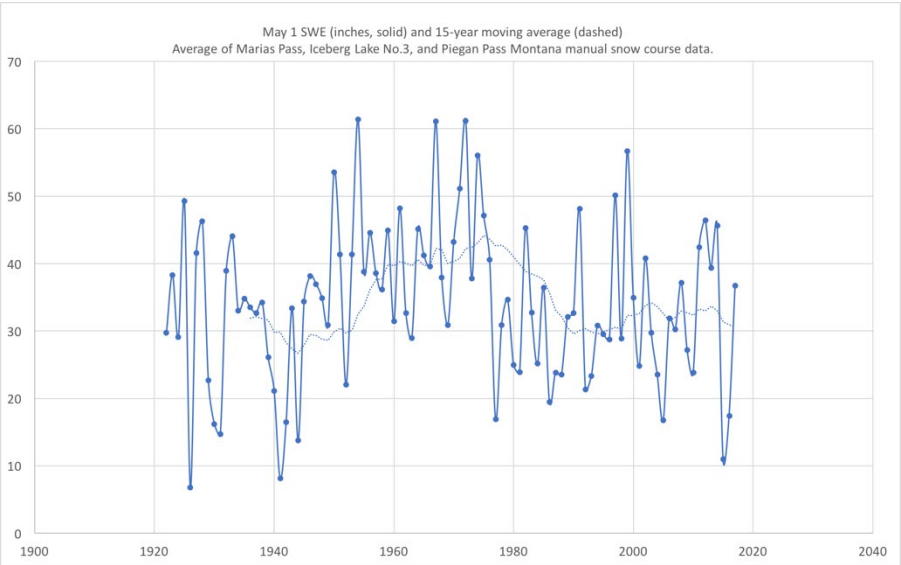


Fig. 1 Snow Water Equivalent on May 1 (inches). Average of three snow course sites in the GLAC region (solid) and 15-year lagging moving average (dashed).

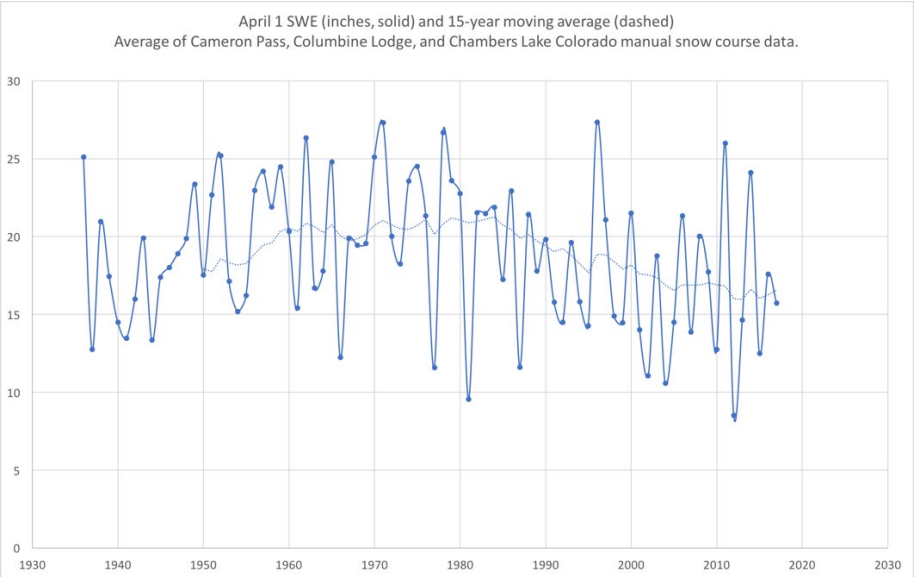


Fig. 2 Snow Water Equivalent on April 1 (inches). Average of three snow course sites in the ROMO region (solid) and 15-year lagging moving average (dashed). April 1 snow course data was chosen for analysis because it is more complete than May 1 data for Colorado, while still indicative of Spring snowpack.

GLAC area snow course data: Sites chosen with longest period of record and good data cover

		Mount Allen			
		Depth (in)	SWE (in)		
1922	1-May	72	30	1922	8-May
1923	7-May	98	48.6	1923	8-May
1924	7-May	78	36	1924	8-May
1925	7-May	121	59.1	1925	8-May
1926	5-May	24	13.1	1926	6-May
1927	6-May	127	53.4	1927	6-May
1928	4-May	119	50.7	1928	5-May
1929	5-May	67	25.3	1929	6-May
1930	5-May	49	20	1930	6-May
1931	5-May	70	19.8	1931	6-May
1932	5-May	98	46.5	1932	6-May
1933	5-May	113	52.5	1933	6-May
1934	4-May	74	39	1934	6-May
1935	6-May	88	44.7	1935	7-May
1936	4-May	89	46.1	1936	5-May
1937	4-May	90	41.4	1937	5-May
1938	4-May	101	45	1938	6-May
1939	4-May	79	41	1939	5-May
1940	2-May	67	27.6	1940	3-May
1941	5-May	39	16.5	1941	6-May
1942	4-May	61	25.6	1942	5-May
1943	5-May	88	43	1943	6-May
1944	4-May	47	21.7	1944	5-May
1945	3-May	100	41.8	1945	4-May
1946	2-May	105	51.3	1946	3-May
1947	2-May	100	50	1947	3-May
1948	4-May	104	45.8	1948	5-May
1949	4-May	85	39.8	1949	5-May
1950	6-May	139	62.9	1950	5-May
1951	4-May	112	54.2	1951	5-May
1952	6-May	63	31.9	1952	5-May
1953	5-May	112	50.4	1953	6-May
1954	4-May	169	72.1	1954	6-May
1955	3-May	108	46.3	1955	4-May
1956	1-May	128	49.4	1956	2-May
1957	1-May	101	48.3	1957	2-May
1958	30-Apr	95	44.3	1958	1-May
1959	30-Apr	118	54.6	1959	1-May
1960	3-May	95	38.1	1960	4-May
1961	2-May	121	59.2	1961	3-May

1962	1-May	101	40.5	1962	2-May
1963	30-Apr	84	34.8	1963	1-May
1964	29-Apr	111	50.8	1964	30-Apr
1965	3-May	96	45.6	1965	4-May
1966	3-May	97	47.8	1966	4-May
1967	2-May	150	72.9	1967	3-May
1968	30-Apr	98	46.7	1968	1-May
1969	1-May	78	38	1969	30-Apr
1970	5-May	111	50.1	1970	6-May
1971	28-Apr	124	60	1971	29-Apr
1972	2-May	134	68.1	1972	3-May
1973	1-May	98	43.3	1973	2-May
1974	30-Apr	137	67	1974	1-May
1975	29-Apr	122	52.1	1975	30-Apr
1976	28-Apr	107	46.1	1976	29-Apr
1977	27-Apr	51	21.4	1977	28-Apr
1978	2-May	81	38.4	1978	3-May
1979	1-May	92	39.6	1979	1-May
1980	29-Apr	72	31.1	1980	30-Apr
1981	28-Apr	76	31.3	1981	29-Apr
1982	27-Apr	125	53.8	1982	28-Apr
1983	26-Apr	92	40.1	1983	27-Apr
1984	26-Apr	87	32.7	1984	25-Apr
1985	24-Apr	113	42.1	1985	25-Apr
1986	29-Apr	67	25.6	1986	30-Apr
1987	28-Apr	68	31.4	1987	29-Apr
1988	26-Apr	72	29.9	1988	27-Apr
1989	25-Apr	92	37.7	1989	26-Apr
1990	25-Apr	82	37.2	1990	24-Apr
1991	24-Apr	119	54.7	1991	25-Apr
1992	29-Apr	51	24.6	1992	1-Sep
1993	30-Apr	61	28.5	1993	29-Apr
1994	27-Apr	76	35	1994	28-Apr
1995	27-Apr	76	34.9	1995	28-Apr
1996	25-Apr	85	35.6	1996	26-Apr
1997	25-Apr	128	57	1997	28-Apr
1998	30-Apr	72	34.3	1998	1-May
1999	29-Apr	137	69	1999	30-Apr
2000	26-Apr	102	47.5	2000	27-Apr
2001	25-Apr	74	27.4	2001	26-Apr
2002	29-Apr	102	44.3	2002	30-Apr
2003	30-Apr	81	35.5	2003	1-May
2004	28-Apr	61	25.6	2004	29-Apr

2005	27-Apr	54	22		2005	26-Apr
2006	2-May	84	36.6		2006	3-May
2007	26-Apr	68	33.8		2007	27-Apr
2008	30-Apr	92	40.9		2008	29-Apr
2009	4-May	71	25.4		2009	5-May
2010	27-Apr	67	28.7		2010	26-Apr
2011	27-Apr	137	44.3		2011	28-Apr
2012	26-Apr	119	55.9		2012	26-Apr
2013	29-Apr	100	41.7		2013	
2014	29-Apr	113	45.2		2014	
2015	29-Apr	33	15.5		2015	30-Apr
2016	27-Apr	40	18		2016	26-Apr
2017	27-Apr	96	40		2017	26-Apr

rage in time

	Iceberg Lake No. 3				Piegan Pass	
Depth (in)	SWE (in)			Depth (in)	SWE (in)	
67	28.6	1922	1-May	66	30.5	
57	28.2	1923	7-May	79	38	
45	21.9	1924	7-May	63	29.3	
77	36.8	1925	7-May	108	51.8	
0	0	1926	5-May	13	7.3	
75	29.4	1927	6-May	107	42	
76	33.1	1928	4-May	111	55.1	
50	18.8	1929	5-May	60	23.9	
33	14	1930	5-May	36	14.6	
27	8.6	1931	5-May	56	15.6	
64	31	1932	5-May	88	39.2	
89	40.4	1933	5-May	84	39.3	
45	24.1	1934	4-May	67	36	
57	21.8	1935	6-May	79	37.8	
42	20	1936	4-May	69	34.4	
53	25.3	1937	4-May	75	31.3	
68	25.3	1938	4-May	72	32.3	
21	10.4	1939	4-May	55	26.8	
36	15.7	1940	2-May	47	20	
10	2.1	1941	5-May	13	5.7	
16	6.6	1942	4-May	41	17.3	
53	24.5	1943	5-May	68	32.5	
15	6.8	1944	4-May	29	12.8	
62	26.4	1945	3-May	84	35	
43	21.9	1946	2-May	86	41.3	
53	27.2	1947	2-May	69	33.7	
60	25.7	1948	4-May	79	33	
45	21.7	1949	4-May	67	31.1	
90	39.9	1950	6-May	131	57.8	
62	30.4	1951	4-May	86	39.4	
20	10.3	1952	6-May	47	23.9	
69	32.7	1953	5-May	95	41	
116	46.2	1954	4-May	146	65.8	
65	28	1955	3-May	91	42	
97	38.8	1956	1-May	115	45.4	
56	26.2	1957	1-May	84	41.3	
58	26.4	1958	30-Apr	80	37.8	
72	33.5	1959	30-Apr	99	46.7	
55	24.6	1960	3-May	75	31.6	
76	37.4	1961	2-May	98	48	

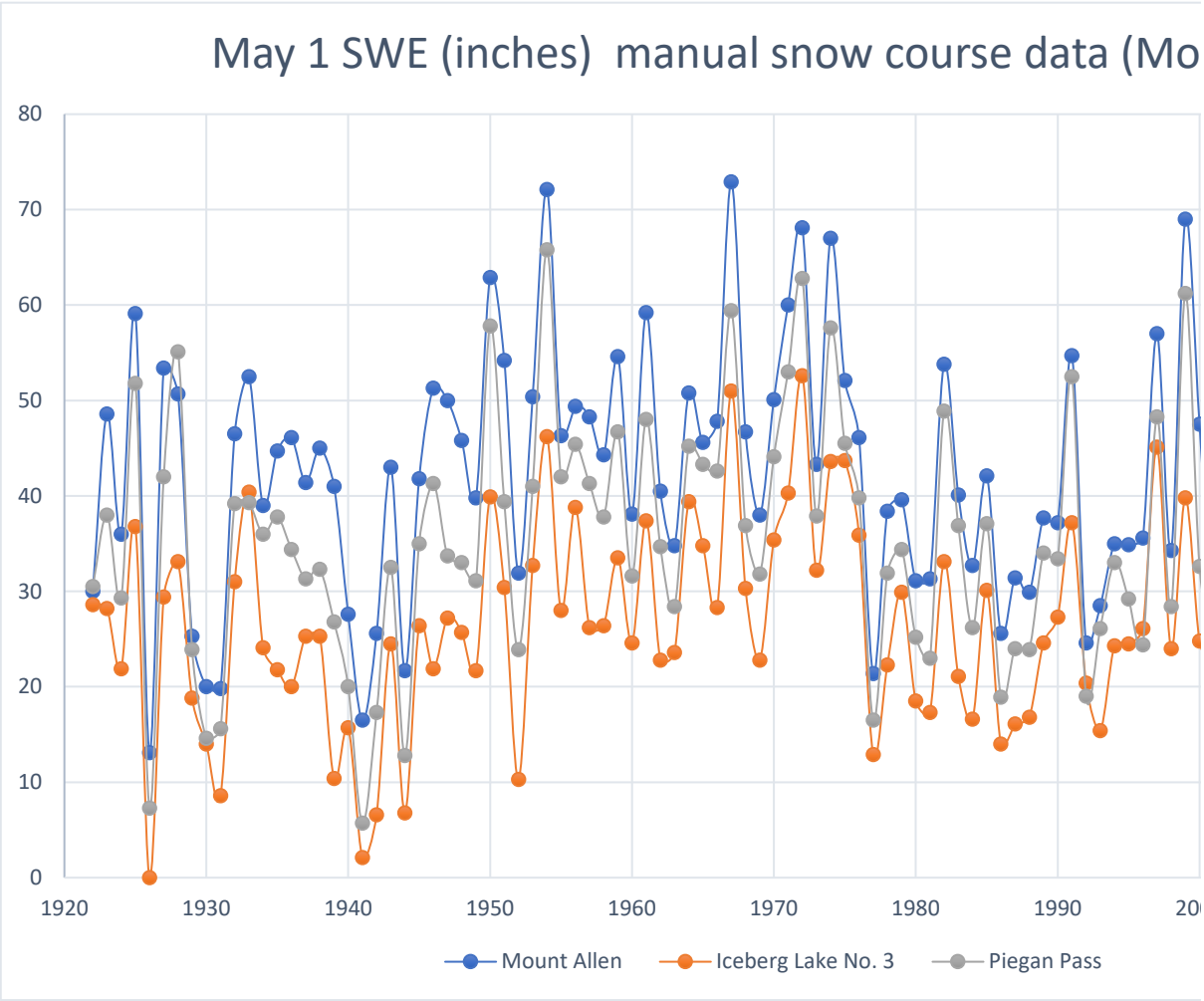
48	22.8	1962	1-May	82	34.7
54	23.6	1963	30-Apr	66	28.4
80	39.4	1964	29-Apr	93	45.2
69	34.8	1965	3-May	86	43.3
52	28.3	1966	3-May	80	42.6
114	51	1967	2-May	135	59.4
59	30.3	1968	30-Apr	77	36.9
46	22.8	1969	1-May	64	31.8
77	35.4	1970	5-May	95	44.1
86	40.3	1971	28-Apr	110	53
99	52.6	1972	2-May	121	62.8
71	32.2	1973	1-May	86	37.9
90	43.6	1974	30-Apr	117	57.6
100	43.7	1975	29-Apr	103	45.5
84	35.9	1976	28-Apr	92	39.8
28	12.9	1977	27-Apr	41	16.5
47	22.3	1978	2-May	65	31.9
63	29.9	1979	1-May	76	34.4
41	18.5	1980	29-Apr	58	25.2
40	17.3	1981	28-Apr	56	23
81	33.1	1982	27-Apr	109	48.9
54	21.1	1983	26-Apr	83	36.9
44	16.6	1984	26-Apr	70	26.2
78	30.1	1985	24-Apr	101	37.1
34	14	1986	29-Apr	50	18.9
35	16.1	1987	28-Apr	51	24
39	16.8	1988	26-Apr	57	23.9
58	24.6	1989	25-Apr	86	34
53	27.3	1990	25-Apr	73	33.4
83	37.2	1991	24-Apr	114	52.5
	20.4	1992	29-Apr	40	19
34	15.4	1993	30-Apr	58	26.1
57	24.3	1994	27-Apr	71	33
55	24.5	1995	27-Apr	64	29.2
62	26.1	1996	25-Apr	61	24.4
97	45.1	1997	25-Apr	107	48.3
46	24	1998	30-Apr	61	28.4
92	39.8	1999	29-Apr	122	61.2
52	24.8	2000	26-Apr	75	32.6
58	22.4	2001	25-Apr	67	24.6
84	37.2	2002	29-Apr	91	40.8
50	23.2	2003	30-Apr	69	30.6
53	20.8	2004	28-Apr	61	24.1

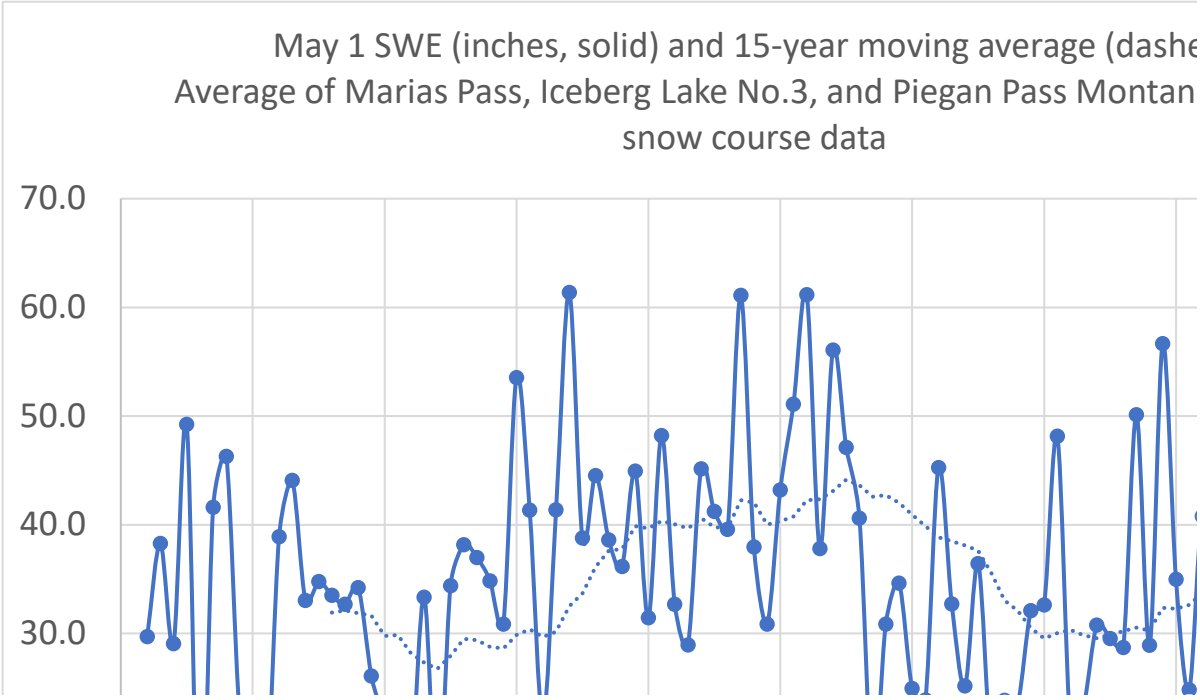
32	12.1	2005	27-Apr	43	16.2
58	25.2	2006	2-May	76	33.9
52	26.3	2007	26-Apr	61	30.5
69	32.1	2008	30-Apr	85	38.4
63	27.6	2009	4-May	65	28.4
44	20.9	2010	27-Apr	52	21.8
117	44.6	2011	27-Apr	124	38.3
76	36.3	2012	26-Apr	101	47
		2013	29-Apr	83	37
		2014	29-Apr	104	46.1
22	9.1	2015	29-Apr	19	8.3
33	15.2	2016	27-Apr	40	18.9
78	31.6	2017	27-Apr	87	38.5

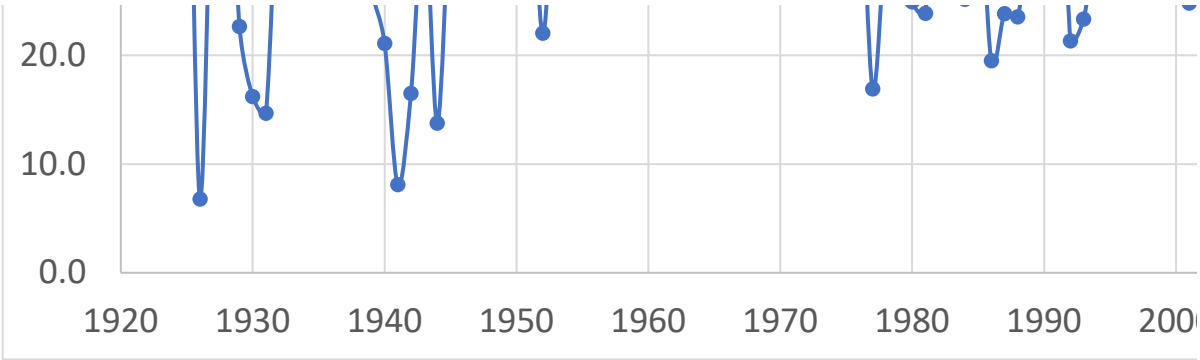
Year	Mount Allen	Iceberg Lake	Piegan Pass	Year	Average
1922	30	28.6	30.5	1922	29.7
1923	48.6	28.2	38	1923	38.3
1924	36	21.9	29.3	1924	29.1
1925	59.1	36.8	51.8	1925	49.2
1926	13.1	0	7.3	1926	6.8
1927	53.4	29.4	42	1927	41.6
1928	50.7	33.1	55.1	1928	46.3
1929	25.3	18.8	23.9	1929	22.7
1930	20	14	14.6	1930	16.2
1931	19.8	8.6	15.6	1931	14.7
1932	46.5	31	39.2	1932	38.9
1933	52.5	40.4	39.3	1933	44.1
1934	39	24.1	36	1934	33.0
1935	44.7	21.8	37.8	1935	34.8
1936	46.1	20	34.4	1936	33.5
1937	41.4	25.3	31.3	1937	32.7
1938	45	25.3	32.3	1938	34.2
1939	41	10.4	26.8	1939	26.1
1940	27.6	15.7	20	1940	21.1
1941	16.5	2.1	5.7	1941	8.1
1942	25.6	6.6	17.3	1942	16.5
1943	43	24.5	32.5	1943	33.3
1944	21.7	6.8	12.8	1944	13.8
1945	41.8	26.4	35	1945	34.4
1946	51.3	21.9	41.3	1946	38.2
1947	50	27.2	33.7	1947	37.0
1948	45.8	25.7	33	1948	34.8
1949	39.8	21.7	31.1	1949	30.9
1950	62.9	39.9	57.8	1950	53.5
1951	54.2	30.4	39.4	1951	41.3
1952	31.9	10.3	23.9	1952	22.0
1953	50.4	32.7	41	1953	41.4
1954	72.1	46.2	65.8	1954	61.4
1955	46.3	28	42	1955	38.8
1956	49.4	38.8	45.4	1956	44.5
1957	48.3	26.2	41.3	1957	38.6
1958	44.3	26.4	37.8	1958	36.2
1959	54.6	33.5	46.7	1959	44.9
1960	38.1	24.6	31.6	1960	31.4
1961	59.2	37.4	48	1961	48.2
1962	40.5	22.8	34.7	1962	32.7

1963	34.8	23.6	28.4	1963	28.9
1964	50.8	39.4	45.2	1964	45.1
1965	45.6	34.8	43.3	1965	41.2
1966	47.8	28.3	42.6	1966	39.6
1967	72.9	51	59.4	1967	61.1
1968	46.7	30.3	36.9	1968	38.0
1969	38	22.8	31.8	1969	30.9
1970	50.1	35.4	44.1	1970	43.2
1971	60	40.3	53	1971	51.1
1972	68.1	52.6	62.8	1972	61.2
1973	43.3	32.2	37.9	1973	37.8
1974	67	43.6	57.6	1974	56.1
1975	52.1	43.7	45.5	1975	47.1
1976	46.1	35.9	39.8	1976	40.6
1977	21.4	12.9	16.5	1977	16.9
1978	38.4	22.3	31.9	1978	30.9
1979	39.6	29.9	34.4	1979	34.6
1980	31.1	18.5	25.2	1980	24.9
1981	31.3	17.3	23	1981	23.9
1982	53.8	33.1	48.9	1982	45.3
1983	40.1	21.1	36.9	1983	32.7
1984	32.7	16.6	26.2	1984	25.2
1985	42.1	30.1	37.1	1985	36.4
1986	25.6	14	18.9	1986	19.5
1987	31.4	16.1	24	1987	23.8
1988	29.9	16.8	23.9	1988	23.5
1989	37.7	24.6	34	1989	32.1
1990	37.2	27.3	33.4	1990	32.6
1991	54.7	37.2	52.5	1991	48.1
1992	24.6	20.4	19	1992	21.3
1993	28.5	15.4	26.1	1993	23.3
1994	35	24.3	33	1994	30.8
1995	34.9	24.5	29.2	1995	29.5
1996	35.6	26.1	24.4	1996	28.7
1997	57	45.1	48.3	1997	50.1
1998	34.3	24	28.4	1998	28.9
1999	69	39.8	61.2	1999	56.7
2000	47.5	24.8	32.6	2000	35.0
2001	27.4	22.4	24.6	2001	24.8
2002	44.3	37.2	40.8	2002	40.8
2003	35.5	23.2	30.6	2003	29.8
2004	25.6	20.8	24.1	2004	23.5
2005	22	12.1	16.2	2005	16.8

2006	36.6	25.2	33.9	2006	31.9
2007	33.8	26.3	30.5	2007	30.2
2008	40.9	32.1	38.4	2008	37.1
2009	25.4	27.6	28.4	2009	27.1
2010	28.7	20.9	21.8	2010	23.8
2011	44.3	44.6	38.3	2011	42.4
2012	55.9	36.3	47	2012	46.4
2013	41.7		37	2013	39.4
2014	45.2		46.1	2014	45.7
2015	15.5	9.1	8.3	2015	11.0
2016	18	15.2	18.9	2016	17.4
2017	40	31.6	38.5	2017	36.7


May 1 SWE (inches) manual snow course data (Mo
80
70
60
50
40
30
20
10
0
1920
1930
1940
1950
1960
1970
1980
1990
20
Mount Allen
Iceberg Lake No. 3
Piegan Pass


May 1 SWE (inches, solid) and 15-year moving average (dashe
Average of Marias Pass, Iceberg Lake No.3, and Piegan Pass Montan
snow course data
70.0
60.0
50.0
40.0
30.0


20.0
10.0
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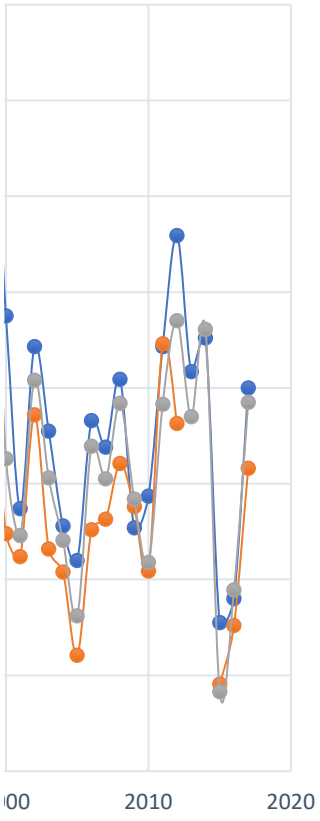
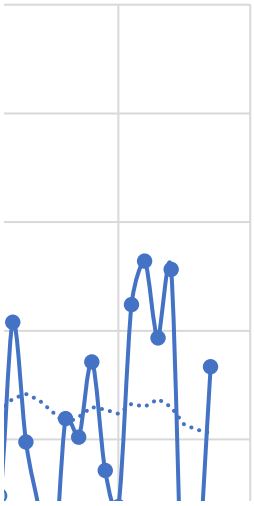
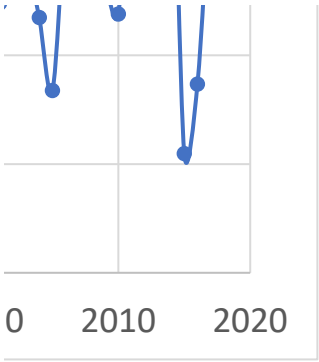
1920
1930
1940
1950
1960
1970
1980
1990
200

ntana)



ed)
a manual




0
2010
2020

From: Guinotte, John
To: Grizzle, Betty
Subject: Re: Memo on some key methodological issues. WITH DATA!
Date: Wednesday, January 3, 2018 4:15:04 PM

I will look now

John Guinotte
Spatial Ecologist
Ecological Services
U.S. Fish and Wildlife Service
Mountain Prairie Region 6
134 Union Blvd., Lakewood, CO 80228
303-236-4264
john_guinotte@fws.gov

On Wed, Jan 3, 2018 at 4:13 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:

> Thanks. I should be able to summarize this. Do you know if there are there specific pages in the report we can refer to as well?
>
> On Wed, Jan 3, 2018 at 3:03 PM, Guinotte, John <john_guinotte@fws.gov> wrote:
>
> > Hi Betty, Have a look at the third paragraph in the word doc re 00-13 time series.
> >
> > ---------- Forwarded message ----------
> > From: **Joe Barsugli** <joseph.barsugli@colorado.edu>
> > Date: Wed, Dec 13, 2017 at 4:26 PM
> > Subject: Memo on some key methodological issues. WITH DATA!
> > To: Stephen Torbit <Stephen_Torbit@fws.gov>, "Guinotte, John" <john_guinotte@fws.gov>, Andrea Ray <Andrea.Ray@noaa.gov>
> >
> > Steve, John
> >
> > I'm re-sending this with the Excel spreadsheet of the data, just for completeness.
> >
> > One thing to keep in mind in interpreting this data is that the recent period has been warmer due at least in part to the climate change signal. (Attribution of the temperature signal to climate change has only been done formally for the larger region of the western US). This supports using the more recent baseline, particularly considering that the den sites were surveyed during the recent period. However it is clear that one cannot rule multidecadal wet and dry periods in the future, but it would likely be warmer than the one in the 1950's - 1970's.
> >
> > Yours,
> >
> > Joe
> >
> > --
> > Joseph Barsugli, Research Scientist III

CIRES, UCB216
University of Colorado Boulder
Boulder CO 80309
303-497-6042
PSD Science Board and
Attribution and Predictability Assessments Team Member

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

From: Guinotte, John
To: Grizzle, Betty
Subject: Re: Memo on some key methodological issues. WITH DATA!
Date: Wednesday, January 3, 2018 4:18:47 PM

---

pages 18-20 in Noaa report, Section 3.4 The Study Period in the Longer Climate Record.

John Guinotte
Spatial Ecologist
Ecological Services
U.S. Fish and Wildlife Service
Mountain Prairie Region 6
134 Union Blvd., Lakewood, CO 80228
303-236-4264
john_guinotte@fws.gov

On Wed, Jan 3, 2018 at 4:13 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:

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>
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> >
> > ---------- Forwarded message ----------
> > From: **Joe Barsugli** <joseph.barsugli@colorado.edu>
> > Date: Wed, Dec 13, 2017 at 4:26 PM
> > Subject: Memo on some key methodological issues. WITH DATA!
> > To: Stephen Torbit <Stephen_Torbit@fws.gov>, "Guinotte, John" <john_guinotte@fws.gov>, Andrea Ray <Andrea.Ray@noaa.gov>
> >
> > Steve, John
> >
> > I'm re-sending this with the Excel spreadsheet of the data, just for completeness.
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> >
> > Yours,
> >
> > Joe
> >
> > --
> > Joseph Barsugli, Research Scientist III

CIRES, UCB216
University of Colorado Boulder
Boulder CO 80309
303-497-6042
PSD Science Board and
Attribution and Predictability Assessments Team Member

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

From: Shoemaker, Justin
To: Norman, Kate; Craig Hansen
Subject: Wolverine score sheet
Date: Friday, January 5, 2018 8:25:23 AM
Attachments: Recommendation Meeting_Exercises_Wolverine_working draft.xlsx

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Kate,

Attached is a scoring sheet we plan to use in the wolverine Recommendation Team Meeting, to facilitate discussion only. We've used this process for several of these meetings lately. We're calling it the modified Delphi approach, if that's technically accurate I don't know. We can discuss on our call perhaps.

Justin Shoemaker
Classification and Recovery Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

Instructions: Given what you know about wolve
information in the SSA Report, distribute 100 pc
alternatives based on the "degree of belief" tha
defensible.

Provide bulleted rationale

**** Scoring is to facilitate conversation ONLY anc**

Round 1

Alterna
1. The wolverine is in danger of extinction in a significant portion of its range
#NUM!

Round 2

Alterna
1. The wolverine is in danger of extinction in a significant portion of its range
#NUM!

Round 3

Alterna
1. The wolverine is in danger of extinction in a significant portion of its range
#NUM!

erines, SPR policy, and the
oints between the 2
at the alternative is the most

d does not represent a decision

tives
2. The wolverine is NOT in danger of extinction in a significant portion of its range
#NUM!

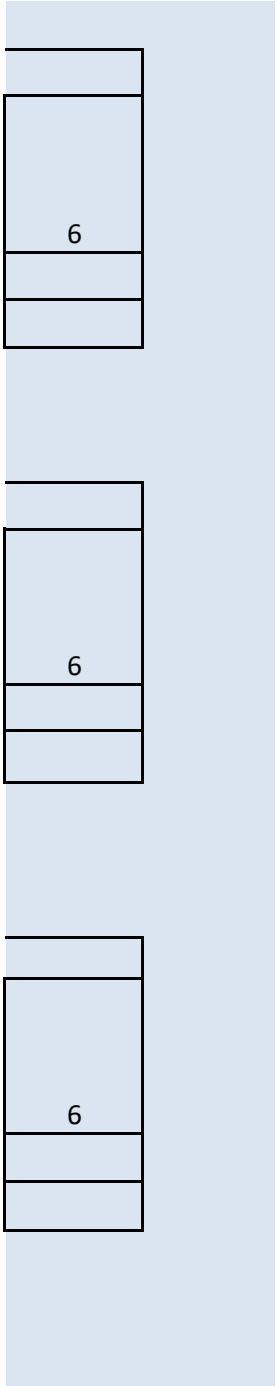
	Decision Maker				
	1	2	3	4	5
Alt. 1					
Alt. 2					

tives
2. The wolverine is NOT in danger of extinction in a significant portion of its range
#NUM!

	Decision Maker				
	1	2	3	4	5
Alt. 1					
Alt. 2					

tives
2. The wolverine is NOT in danger of extinction in a significant portion of its range
#NUM!

	Decision Maker				
	1	2	3	4	5
Alt. 1					
Alt. 2					


6
6
6

From: Inman, Bob
To: Grizzle, Betty
Subject: FW: wolverine genetics
Date: Friday, January 5, 2018 11:52:11 AM

Will let you know what I hear back.

-Bob Inman

Robert M. Inman, PhD
Carnivore-Furbearer Coordinator
Montana Fish, Wildlife and Parks
1420 East 6th Ave., PO Box 200701,
Helena, MT 59620-0701
406-444-0042 (o)
406-570-5326 (c)
bobinman@mt.gov

From: Inman, Bob
Sent: Friday, January 05, 2018 11:35 AM
To: Stephen Torbit (stephen_torbit@fws.gov) <stephen_torbit@fws.gov>; Gude, Justin <Jgude@mt.gov>; Schwartz, Michael K -FS <michaelkschwartz@fs.fed.us>; dpaetkau@wildlifegenetics.ca
Cc: Bob Lanka (bob.lanka@wyo.gov) <bob.lanka@wyo.gov>; Zack Walker <zack.walker@wyo.gov>; Sallabanks,Rex <rex.sallabanks@idfg.idaho.gov>; Jeff Lewis <jeffrey.lewis@dfw.wa.gov>
Subject: wolverine genetics

Hello,

Just wondering about the progress/status of the work?

-Bob Inman

Robert M. Inman, PhD
Carnivore-Furbearer Coordinator
Montana Fish, Wildlife and Parks
1420 East 6th Ave., PO Box 200701,
Helena, MT 59620-0701
406-444-0042 (o)
406-570-5326 (c)
bobinman@mt.gov

From:	Turner, Ed
To:	Betty Grizzle
Subject:	CPE Roads Maps
Date:	Friday, January 5, 2018 3:39:39 PM
Attachments:	Wolverine_CPE_Roads_ElevRange2.pdf Wolverine_CPE_Roads_ElevRange.pdf

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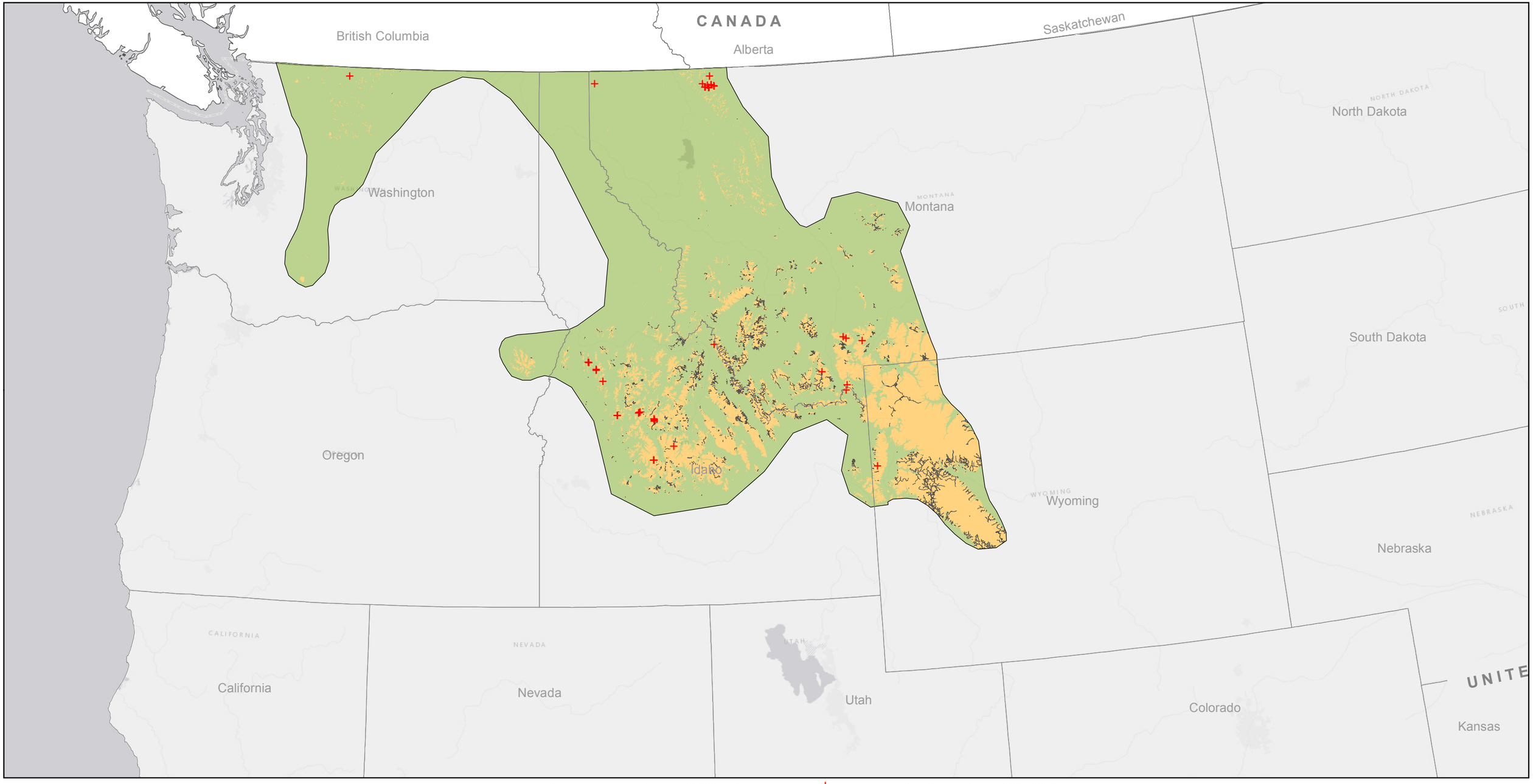
--

Edwin Turner, Geographer
GIS Mapping and Analysis Branch

DOI-R8-CFWO
USFWS Carlsbad Fish and Wildlife Office
2177 Salk Ave. Suite 250
Carlsbad, CA 92008
760.431.9440 x266

Ed_Turner@fws.gov
760.431.9440 x266



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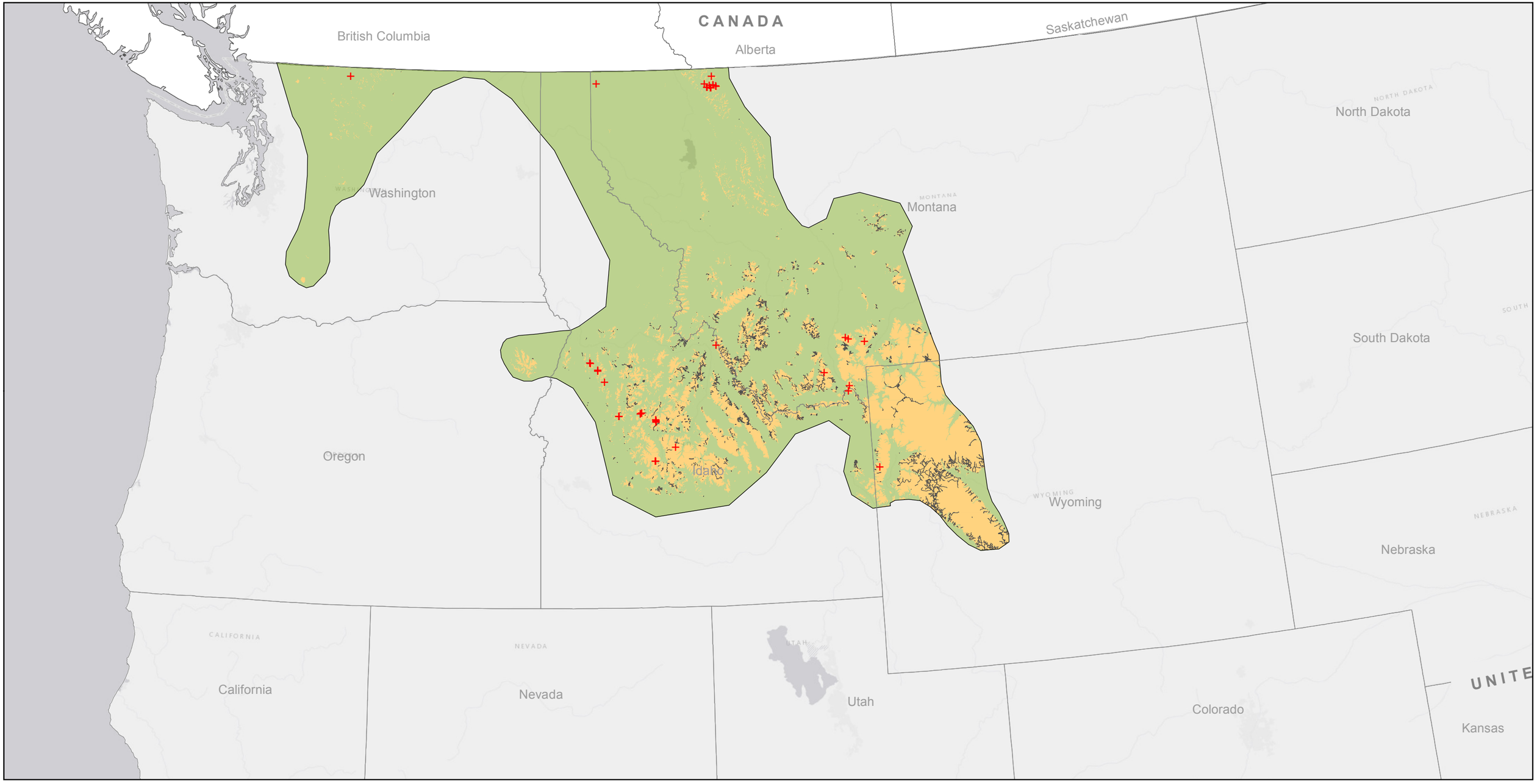
North American Wolverine (*Gulo gulo luscus*) Current Potential Extent



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North American Wolverine (*Gulo gulo luscus*) Current Potential Extent

Elevations => 2,300 meters

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Local Roads where Elevations => 2,300 meters

From: Shoemaker, Justin
To: Grizzle, Betty
Subject: Re: Wolverine SSA Report - second draft for review
Date: Monday, January 8, 2018 9:16:21 AM
Attachments: 20180105_Final Draft Wolverine SSA Report_JS.docx

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Very nice work Betty! Here's my review.

I will be working on getting materials together here to transmit the SSA Report to the RD's office on 1/10. They require a briefing memo and surname folder and other stuff, so I'll get all that together and wait for a final version from you to print for our RD later this week. And I'll have the same materials sent to the other regions.

Justin Shoemaker
Classification and Recovery Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

On Fri, Jan 5, 2018 at 4:47 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:

> Hi all - This is still a bit rough. Lots and lots of comments to address, and several new references, so you might want to read with Track Changes OFF first. I have not yet formatted this as I am still working in Track Changes; I will update Table of Contents, and relabel figures with final formatting. There are also places where (for some reason) the spell-checker is off, so I still need to proofread this for those misspelled words, etc. Also, several figures were replaced or revised (we had to redo several analyses), but these will not show up in Track Changes given the growing size of this already very large Word file.
>
> Please review the yellow highlighted sentences and comment bubbles. Since the States provided the most useful comments, I focused on those first and then the peer reviewers. I ask that you please review those 4 reviewer comment documents again relative to this new draft to see if I missed anything.
>
> As you know, this is due to Recommendation Management Team (and Core Team) next Wednesday so I will need your comments back quickly (please use track changes or comment bubbles) so I can pull all of your individual comments together in one document, accept changes, and then do final formatting.
>
> Let me know if you have any questions and THANK YOU all for your help with this.
> Betty
>
> --
>
> Betty J. Grizzle, D.Env.
> Fish and Wildlife Biologist
> U.S. Fish and Wildlife Service
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FINAL DRAFT
SPECIES STATUS ASSESSMENT
FOR THE
NORTH AMERICAN WOLVERINE
(*Gulo gulo luscus*)

Wolverines in southwestern Montana. *Photo credit: Mark Packila; used with permission.*

U.S. Fish and Wildlife Service

Version 1.1
January , 2018

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Suggested citation:

U.S. Fish and Wildlife Service. 2017. Species status assessment report for the North American wolverine (*Gulo gulo luscus*). Version 1.1. January 2018. U.S. Fish and Wildlife Service, Mountain-Prairie Region, Lakewood, CO.

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Executive Summary

The North American wolverine (*Gulo gulo luscus*; wolverine) is a medium-sized carnivore found within the west-northwestern contiguous United States, Alaska, and Canada. Systematic monitoring across the wolverine's North American range has not been conducted given the difficulty in surveying this highly mobile species, and its occupancy within large and relatively inaccessible areas. A multi-state effort to determine wolverine occupancy in Montana, Idaho, and Washington was conducted in winter of 2016–2017 and in Wyoming for the winters of 2015–2016 and 2016–2017. Results from this study are still being analyzed, but photographic detections of wolverines were found across all surveyed States, including areas where wolverines have not recently been observed. In Canada, the population is estimated to exceed 10,000 mature individuals and has been stable over the last two decades. Recent density estimates indicate no declining trend for wolverines in Alaska. Wolverine populations in Alaska are considered to be continuous with populations in the Yukon and British Columbia provinces of Canada. Wolverines that occupy the North Cascades region are known to move from Washington into British Columbia.

Wolverines are highly mobile, capable of moving and dispersing over great distances over short periods of time. Wolverine populations are also characterized by naturally low densities in North America. The species is highly territorial, with very little overlap between same-sex adults. Wolverines occupy a variety of habitats, but generally select habitat in locations away from human settlements. Wolverines consume a variety of food resources and seasonal switching of prey is commonly observed with other mammals, including Arctic mammals, wolverines have the ability to adapt to both cold and warm ambient temperatures through vasodilation and increase in skin temperature, and rapid and seasonal adjustments in fur insulation. Wolverines can also adapt behaviorally to both cold and warm ambient temperatures by movement and, relatedly, micro- and macro-habitat selection.

Wolverine reproduction includes the following characteristics: polygamous behavior (i.e., male mates with more than one female each year), delayed implantation (up to 6 months), a short gestation period (30–40 days), denning behavior, and an extended period of maternal care. The reproductive behavior in wolverines is temporally adapted to take advantage of the availability of food resources, limited interspecific competition, and snow cover in the winter.

Since the publication of the Service's 2013 proposed rule to list the distinct population segment of the North American wolverine in the contiguous United States (78 FR 7864; February 4, 2013), several new wolverine studies have been published, which has added to our understanding of wolverine biology while also highlighting new insights into identifying key species' needs and their interactions with both abiotic and biotic factors. In particular, wolverine populations and wolverine dens have been observed outside previously modeled projections of spring snow cover. Our evaluation of snow cover at previously recorded natal den site locations in the western United States indicated that 'melt-out' dates at these locations extend well past the May 15 date used in persistent spring snow cover models.

Overall, the best available information indicates that within the contiguous United States the wolverine's physical and ecological needs include:

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(1) large territories in relatively inaccessible landscapes; at high elevation (1,800 to 3,500 meters (5,906 to 11,483 feet));
(2) access to a variety of food resources, that varies with seasons; and
(3) physical/structural features (e.g., talus slopes, rugged terrain) linked to reproductive behavioral patterns.

In this Species Status Assessment (SSA) Report, we provide a discussion of the ecological needs of the wolverine, its current conditions, and projected future conditions. We evaluate potential stressors to the species, with a particular focus on the impacts associated with projected effects of climate change.

In our analysis, we applied the conservation biology principles of redundancy, resiliency, and representation (collectively known as the "3Rs") to evaluate the current and projected future condition of the wolverine and its ability to sustain itself (as one or more populations) in the wild over time (Carroll *et al.* 1996, entire; Wolf *et al.* 2015, entire). This evaluation considers the demographic, distribution, and diversity characteristics unique to the species. After applying the framework of the 3Rs, we determined the following:

(1) Redundancy: The wolverine occurs in the contiguous United States within a metapopulation structure. The best available information indicates that the species continues to expand into historical, previously occupied areas in the contiguous United States following decades of unregulated hunting and trapping, and poisoning at bait stations.
(2) Representation: The wolverine is currently found in the west-northwestern United States, as well as much of Canada, and Alaska. The best available information indicates that the species is found in Arctic, boreal, and subalpine habitats. We estimated a Current Potential Extent area for the wolverine in the contiguous United States of approximately 280,316 square kilometers (km^2) (69,267,592 acres (ac)).
(3) Resiliency: The wolverine appears resilient within its contiguous United States range. The species exhibits physiological (e.g., seasonal changes in fur) and behavioral plasticity in its life history (e.g., reproduction, feeding, movement and use of habitat). Estimated population size and growth rates across its North American range are uncertain, but the best available information does not suggest that abundance is declining in the contiguous United States, or in North America. The most significant stressor currently and in the future appears to be the effects of climate change, such as warming temperatures and loss of snowpack. However, we have no information to indicate that this species is unable to adapt or adjust to changing conditions.

Demographic risks to the species from either known or most likely potential stressors (i.e., effects from roads, disturbance due to winter recreational activities, effects of wildland fire, and overutilization) are low based on our evaluation of the best available information as it applies to current and potential future conditions for the wolverine and in the context of the attributes that affect its viability. We analyzed the potential effects of climate change to wolverine habitat, including snow persistence in the Northern and Southern Rocky Mountains. The future timeframe evaluated in this analysis is approximately 40 to 50 years. This range represents our best professional judgment of the projected future conditions related to climate change, wildland

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fire conditions, or other potential cumulative impacts. While population information is lacking for this subspecies in some parts of its range, the best available information does not indicate that, winter recreational activities, infrastructure features, mortality from road crossings or trapping (authorized and incidental), currently or in the future will result in a decline in the subspecies across its range. Our evaluation of climate change indicates that snow cover is projected to decline in response to warming temperatures and changing precipitation patterns, but this varies by elevation, topography, and by geographic region. In general, models indicate higher elevations will retain more snow cover than lower elevations, particularly in early spring (April 30/May1). Further, significant snow persistence (greater than 0.5 meters (20 inches)) is projected at high elevations.

Legal protections include State listing in California and Oregon (as threatened), as endangered in Colorado, as a candidate species in Washington, and protection as a non-game species in Idaho and Wyoming, and protected from collection, importation, and possession in Utah. In Canada, provincial designations range from endangered to threatened in eastern provinces, and sensitive/special concern to no ranking in other provinces. Legal trapping or hunting of wolverines is currently prohibited in the contiguous United States. Trapping effort along the U.S.–Canada border does not represent a barrier to wolverine movement and dispersal along the international border.

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Within the contiguous United States, approximately 72 percent of the Current Potential Extent of the wolverine is located on Federal lands, with 18 percent located in designated wilderness areas. Management actions, including State Wildlife Action Plans, the Idaho Wolverine Conservation Plan, and USDA Forest Service Land and Resource Management Plans, and other Federal and Tribal partners, include winter road closures, fire management, land acquisition or conservation easements. The Western Association of Fish and Wildlife Agencies (WAFWA), in coordination with Tribal partners, have formed a multi-state, multi-agency working group (Western States Wolverine Working Group) to design and implement the Western States Wolverine Conservation Project (WSWCP)–Coordinated Occupancy Survey. In addition, a WAFWA Wildlife Chiefs Wolverine Subcommittee is working collaboratively with each other and with the Service, Tribes, and other partners to conserve wolverines in the western United States; to date, approximately $1.5 million of funding has been applied towards conservation and management actions.

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Abbreviations and Acronyms Used

ADF&G = Alaska Department of Fish and Game
BLM = Bureau of Land Management
°C = degrees Celsius
CEC = Commission for Environmental Cooperation
CDFW = California Department of Fish and Wildlife
CNDDB = California Natural Diversity Database
COSEWIC = Committee on the Status of Endangered Wildlife in Canada
cm = centimeter
DNA = deoxyribonucleic acid
EIS = Environmental Impact Statement
EPA = U.S. Environmental Protection Agency
°F = degrees Fahrenheit
ft = feet
GCMs = Global Climate Models
GHG = Greenhouse gas
GLAC = Glacier National Park
GPS = Global Positioning System
IDFG = Idaho Department of Fish and Game
in = inch
IPCC = Intergovernmental Panel on Climate Change
IUCN = International Union for Conservation of Nature and Natural Resources
kg = kilogram
km = kilometer
lb = pound
m = meter
mi = mile
MODIS = Moderate-Resolution Imaging Spectroradiometer
Montana FWP = Montana Fish, Wildlife, & Parks
NDSI = Normalized Difference Snow Index
NRC = National Research Council
NRIS = Natural Resource Information System
ODFW = Oregon Department of Fish and Wildlife
RCPs = Representative Concentration Pathways
ROMO = Rocky Mountain National Park
Service = U.S. Fish and Wildlife Service
SSA = Species Status Assessment
SCA = Snowcovered Area
SGCN = Species of Greatest Conservation Need
SWCC = Southwestern Crown of the Continent
SWE = Snow Water Equivalent
UDNR = Utah Division of Natural Resources
WAFWA = Western Association of Fish and Wildlife Agencies
WDFW = Washington Department of Fish and Wildlife
WGFD = Wyoming Game and Fish Department

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WRCC = Western Regional Climate Center
WSWCP = Western States Wolverine Conservation Project
YBP = Years Before Present

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Introduction

The wolverine (*Gulo gulo*) is the largest terrestrial member of the Mustelidae family (weasels, fisher, mink, marten, and others) and resembles a small bear with a bushy tail (Hash 1987, p. 575). Wolverines have a Holarctic distribution that includes the northern portions of Europe, Asia, and North America. In North America, they are found in Alaska, much of Canada, and the western-northwestern United States. The wolverine is important to the culture of Native Americans and Aboriginal Peoples in North America, as is its conservation status in aboriginal territory (Cardinal 2004, p. iv; Edmo 2016; pers. comm.; Miles 2017, pers. comm.).

Wolverines possess a number of morphological and physiological adaptations that allow them to travel long distances and they maintain large territories in remote areas (Pasitschniak-Arts and Larivière 1995, p. 6). They have been described as curious, intelligent, and playful, but cautious animals (e.g., Krott 1958, p. 241; Krott 1960, pp. 25–26; Magoun 1985, p. 94; Cardinal 2004, p. 7–8; Woodford 2014, entire), though their social behavior and social organization has not been well-studied.

During the late 1800s and early 1900s, the wolverine population declined or was extirpated in much of the conterminous United States (lower 48 States), which has been attributed to unregulated trapping and habitat degradation (Hash 1987, p. 583). Similar range reductions and extirpations of some wolverine populations were observed in parts of Canada during this time period (van Zyll de Jong 1975, entire; Committee on the Status of Endangered Wildlife in Canada (COSEWIC) 2014, p. iv), attributed largely to human exploitation and availability of food (e.g., decline in caribou (*Rangifer tarandus*)), not climate or habitat changes (van Zyll de Jong 1975, pp. 434, 436). Wolverine numbers have recovered to some extent from this decline (e.g., Aubry *et al*., 2007, p. 2,151; Aubry *et al*., 2012, entire; Aubry *et al*. 2016, pp. 14–15; Magoun *et al*. 2013, p. 27). In the United States, wolverines are currently found in parts of Washington, Oregon, Idaho, Montana, Wyoming, California (single male) and Alaska. Known reproducing wolverine populations are found in Washington, Idaho, Montana, and Wyoming.

Species Status Assessment Methodology

In preparing the Species Status Assessment (SSA) Report for the wolverine, we reviewed available reports and peer-reviewed literature, incorporated survey information, and contacted species experts to collect additional unpublished information for the North American subspecies (*Gulo gulo luscus*), including Canada and Alaska. We identified uncertainties and data gaps in our assessment of the current and future status of the species. We also evaluated the appropriate analytical tools to address these gaps and conducted discussions with species experts and prepared updated maps of the known species' range and denning areas in North America. In some instances, we used publications and other reports (primarily from Fenno-Scandinavia) of the Eurasian subspecies (*Gulo gulo gulo*) in completing this assessment.

Importantly, we note here that, since the publication of the 2013 proposed listing rule (78 FR 7864; February 4, 2013), many new wolverine studies have been published, which has added to our understanding of wolverine biology while also highlighting new insights into identifying key

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species' needs and their interactions with both abiotic and biotic factors. This is particularly relevant for a difficult to study animal like the wolverine.

Using the species, individual, and population needs identified for the wolverine and location results from surveys and studies, we conducted a geospatial analysis to estimate the Current Potential Extent of the North American wolverine in the contiguous United States. We then evaluated this area and previous estimates of potentially suitable habitat in the west-northwestern United States to assess the species' current conditions within that region. Our future condition analysis includes the potential conditions that the species or its habitat may face, that is, the most probable scenario if those conditions are realized in the future. This most probable scenario includes consideration of the sources that have the potential to most likely impact the species at the population or rangewide scales in the future, including potential cumulative impacts. Potential future impacts associated with climate change (probabilistic estimates for temperature and precipitation) were based on downscaled climate model projections, including a detailed study of two regions in the western United States (Glacier National Park (currently occupied) and Rocky Mountain National Park (not currently occupied).

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For the purpose of this assessment, we generally define viability as "consisting of self-sustaining populations that are well distributed throughout the species' range," and where "[s]elf-sustaining populations are those that are sufficiently abundant and have sufficient genetic diversity to display the array of life history strategies and forms that will provide for their persistence and adaptability in the planning area over time" (Committee of Scientists 1999, p. 38). We use a timeframe of approximately 40 to 50 years because it is within the range of the available modeling efforts related to climate change. We believe this is a reasonable timeframe to consider as it includes the potential for observing these effects over several generations of the wolverine.

Using the SSA framework (Figure 1), we consider what the species needs to maintain viability by characterizing the status of the species in terms of resiliency, redundancy, and representation (Wolf *et al*. 2015, entire).

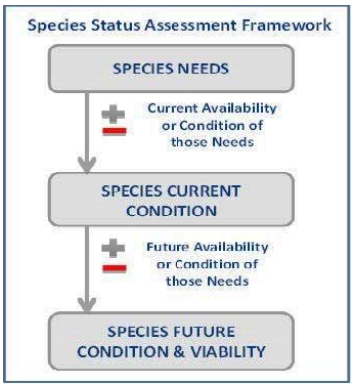

Figure 1. Species Status Assessment Framework.

- **Resiliency** is having sufficiently large populations for the species to withstand stochastic events (arising from random factors). We can measure resiliency based on metrics of population health; for example, birth versus death rates and population size. Resilient populations are better able to withstand disturbances such as random fluctuations in birth rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the effects of anthropogenic activities.
- **Redundancy** is having a sufficient number of populations for the species to withstand catastrophic events (such as a rare destructive natural event or episode involving many

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populations). Redundancy is about spreading the risk and can be measured through the duplication and distribution of populations across the range of the species. The greater the number of populations a species has distributed over a larger landscape, the better it can withstand catastrophic events.

- **Representation** is having the breadth of genetic makeup of the species to adapt to changing environmental conditions. Representation can be measured through the genetic diversity within and among populations and the ecological diversity (also called environmental variation or diversity) of populations across the species' range. The more representation, or diversity, a species has, the more it is capable of adapting to changes (natural or human caused) in its environment. In the absence of species-specific genetic and ecological diversity information, we evaluate representation based on the extent and variability of habitat characteristics within the geographical range.

Species Description

Taxonomy

The taxonomic relationship between North American and Eurasian wolverines has been a debated topic (Pasitschniak-Arts and Larivière 1995, p. 1). Most authorities consider all wolverines to belong to a single species, *Gulo gulo* (Rausch 1953, p. 114; Kurten and Rausch 1959, p. 19; Wozencraft 2008 [in *Wilson and Reeder's Mammal Species of the World*, online publication]). Some also further consider the New World and Old World wolverines to be two subspecies, *Gulo gulo luscus* and *G. g. gulo,* respectively, based on morphological measurements. Degerbøl (1935, pp. 35–43) noted slight color differences and very slight, if any, cranium differences, based on 10 North American (Hudson Bay) specimens examined, and regarded the North American and Old World wolverines as conspecific, but identified two subspecies. This reference also cites Coues (1877, p. 43), who, based on observations of a slight similar cranium difference, had posited that the wolverines of the Old World and New World were the same species (Degerbøl 1935, p. 35).

In their *Checklist of Palaearctic and Indian Mammals* (1st and 2nd editions) Ellerman and Morrison-Scott (1951, p. 251; 1966, p. 251) identified one species of wolverine, but listed several subspecies. A comparative analysis of various measurements from 1 wolverine skull collected from the northern Ural Mountains to 41 Alaskan skulls by Rausch (1953, entire) reported "no appreciable differences," noting the highly variable skull characteristics for the Alaskan specimens. Additionally, Krott (1960, p. 20) found no distinct differences between Old World and New World wolverines, and that pelt size and quality were not distinguishable. However, using biometric measurements of both newly collected and previously published cranial measurements (e.g., Degerbøl 1935; Rausch 1953), Kurtén and Rausch (1959, p. 19) reported that the North American and European wolverine were significantly different in several quantitative characters related to the size and shape of the skull and teeth. They concluded that the two wolverine populations represented two distinct subspecies, but were the same species, *Gulo gulo*.

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The International Union for Conservation of Nature and Natural Resources (IUCN) states that "Most recent accounts [citing Jones *et al*. 1992, Pasitschniak-Arts and Larivière 1995,

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Wozencraft 2005] treat *luscus* as a subspecies of *Gulo gulo*, following Degerbøl (1935) and Kurtén and Rausch (1959)" (Abramov 2016, p. 1). We reviewed the references cited by IUCN. Jones *et al*. (1992, p. 17) only considers *Gulo gulo*. Pasitschniak-Arts and Larivière (1995, p. 1) state there are differences in the taxonomic treatment, and that, while *Gulo gulo* is now considered by most to be the extant *species*, others (including the above-cited Kurtén and Rausch (1959) and Rausch (1953)) have considered two *subspecies*. The Wozencraft (2005) citation is from Wilson and Reeder's previous 2005 publication, which was updated as of 2008. That account lists several "offspring" of *Gulo gulo*, but does not provide citations for the subspecies identified there, and at least two of those listed are not considered to be subspecific entities (e.g., *G. g. vancouverensis* and *G. g. luteus* (see Banci 1982, p. ii; Banci 1994, p. 104)). Finally, the COSEWIC Assessment and Status Report on the Wolverine (*Gulo gulo*) in Canada indicated that taxonomists recognize only a single subspecies (*Gulo gulo luscus*) in North America *or* consider *G. gulo* as single Holarctic taxon (COSEWIC 2014, p. 4).

Genetic analyses for the North American wolverine populations have primarily focused on genetic structure and variation of wolverine populations or subpopulations (see Kyle and Strobeck 2001; Kyle and Strobeck 2002; Zigouris *et al*. 2012, Zigouris *et al*. 2013). However, Frances' (2008, pp. 20–21) assessment of wolverine spatial genetic structure and demographic history (using mitochondrial DNA) indicated incomplete lineage sorting between North American and Eurasian populations, though comprehensive sampling has not been conducted for some areas (e.g., eastern Asia). A study by Tomasik and Cook (2005, entire) also concluded that reciprocal monophyly (i.e., distinct *species*) had not been attained between Eurasian and North American wolverine populations. Until additional studies are published, including robust genetic analyses in conjunction with additional sampling, the Service recognizes the North American wolverine as *G. g. luscus*.

Physical Appearance

Detailed descriptions of the wolverine are described in Novikov (1962, pp. 196–202), Hash (1987, p. 575), Pasitschniak-Arts and Larivière (1995, pp. 1–2), and Wilson (1982, pp. 644–646), among others. Key distinguishing features are summarized here.

Wolverines are a medium-sized (about 1 meter (m) (3.3 feet (ft)) in length) carnivore, with a large head, broad forehead, and short neck (Pasitschniak-Arts and Larivière 1995, p. 1). Males are larger than females (Hall 1981, p. 1,007; Banci 1987, p. 35). Wolverines have heavy musculature and relatively short legs, and large feet with strong, curved claws for digging and climbing (Hash 1987, p. 575). Their feet are well-adapted for travel through deep snow and, during the winter, dense, stiff, bristle-type hairs are found between the toes and around the foot pad (Grinnell *et al*. 1937, pp. 265–266; Hash 1987, p. 575); this characteristic becomes diminished in the summer (Hash 1987, p. 575).

Adult wolverines are sexually dimorphic, with females weighing from 7 to 13 kilogram (kg) (15.4 to 29 pounds (lbs)) and males weighing between 10 to 18 kg (22 to 40 lbs) (North America) (Rausch and Pearson 1972, p. 264; Magoun 1985, pp. 19–21; Banci 1994, p. 99; Copeland 1996, p. 20; Cardinal 2004, p. 8; Lofroth 2001, p. 11; Inman 2013, pers. comm.; Magoun 2013, pers. comm.; Aubry *et al*. 2016, pp. 17–18). The skulls of wolverine are large and

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heavy, and the strong jaw structure allows animals to feed on frozen flesh and crush bone (Haglund 1966, p. 269; Hash 1987, p. 575). Some geographic variation and sexual differences in skull morphology have been reported (Pasitschniak-Arts and Larivière 1995, p. 2). Wolverines have small, wide-set eyes, and are reported to have excellent hearing (Grinnell *et al*. 1937, p. 265; Krott 1960, p. 25; Bevanger 1992, p. 8).

Wolverine fur is short, thick, and uniform in thickness on the head and becomes longer towards the rear of the body (Hash 1987, p. 1). The coat consists of dense, woolly underfur (2-3 centimeters (cm) (0.8-1.2 inches (in) long) and coarse, stiff guard hairs, 6-10 cm (2.4-4 in) in length (Hash 1987, p. 1). The rich glossy coat can vary from medium brown to black (Banci 1994, p. 99; Pasitschniak-Arts and Larivière 1995, p. 1). Seasonal and individual variation in pelt color has been described (Degerbøl 1935, pp. 38–42; Grinnell *et al*. 1937, p. 252). In general, the head, tail, and legs are darker than the face (Pasitschniak-Arts and Larivière 1995, p. 1). An upper body stripe, which varies from creamy, pale buff to light brown or reddish in color (Pasitschniak-Arts and Larivière 1995, p. 1), extends from the nape of the neck, along the sides of the body, to the base of the bushy tail (Banci 1994, p. 99). White or orange patches are commonly found on the throat or chest (Pasitschniak-Arts and Larivière 1995, p. 1; Magoun *et al*. 2008, p. 24; Figure 14). The unique property of wolverine fur to shed frost (Hardy 1948, p. 330; Quick 1952, pp. 492–493), along with its rarity, has made wolverine pelts valuable for trade (Hash 1987, p. 575).

Various accounts state that wolverines have a strong sense of smell (Grinnell *et al*. 1937, p. 265; Bevanger 1992, p. 8) that allows them to locate carrion from great distances (Hornocker and Hash 1981, p. 1,297; *in litt.* Bevanger 1992, p. 8, citing Røskaft 1990; Copeland 1996, p. 100; Cardinal 2004, p. 8); however, experiments with young wolverines indicated a poor sense of smell, and that wolverines may locate food (areas where previously located or cached) based on their memory skills (Magoun 2013, pers. comm.) or learning abilities (e.g., Krott 1958, p. 241).

Scent-marking is used by mammalian carnivores for chemical communication (Hutchings and White 2000, p. 160). For wolverines, this behavior commonly includes urination (e.g., trees, stumps, snow) (Copeland 1996, p. 115; Magoun 1985, p. 105), but also includes scat, and scratches and bites on trees (Haglund 1966, pp. 225, 277; Copeland 1996, p. 115). Scent rubbing (see review by Rieger 1979) of the ventral (abdomen/stomach) area and anal rubbing have also been observed in wolverines (Pulliainen and Oyaskainen 1975, pp. 268–269; Rieger 1979, p. 22, *in litt.* Goethe 1964; Magoun 1985, p. 105). Scent marking by wolverines may also be an important chemical communication signal for potential wolverine prey. Field experiments conducted by Sullivan *et al*. (1985, pp. 928, 930) and Sullivan (1986, p. 388) found that black-tailed deer (*Odocoileus hemionus columbianus*) and snowshoe hares (*Lepus americanus*) avoided feeding on seedlings that were marked with wolverine urine.

Life History and Ecology

In this section we provide a summary of the individual and population needs (collective, species needs), including its life history, physiology and behavior, resource functions necessary for each life stage (i.e., breeding, feeding, sheltering, dispersal), demographic information (abundance and distribution) and ecological setting.

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Overview

Wolverines are active year-round and have been considered as primarily nocturnal (Iversen 1972b, p. 319; Pasitschniak-Arts and Larivière 1995, p. 7, and references cited therein). In his observational studies, Krott (1958, p. 168; 1960, p. 25) described periods of 3-4 hours of activity followed by 3-4 hours of sleep for wolverines in Scandinavia, a pattern also observed in Idaho (Copeland 1996, p. 77).

A study of body temperatures of caged wolverines, along with direct observations of animals obtained from Alaska and Sweden and previous studied animals (Alaska), suggested that wolverines were a day-active species, being very active in the morning, with periods of sleep during the night, a pattern that persisted in both winter and summer (Folk *et al*. 1977, p. 233). However, crepuscular activity (period just after dawn and just before sunset) may be a more accurate description for wolverine behavior (McCue *et al*. 2007, pp. 98–99). Others have remarked that wolverines exhibit a plasticity in their behavior (i.e., different behavior under different conditions) (Krott 1960, p. 26), a result attributed, in part, to their being a scavenging carnivore covering large areas (Stewart *et al*. 2016, pp. 1,495, 1,497). Several aspects of this plasticity are described below.

Wolverines are wide-ranging animals and known for traveling great distances in a short period of time (Krott 1960, p. 21; Gardner *et al*. 1986, p. 603; Woodford 2014, entire) (see Movement section below). This is due, in part, to their unique body structure. As described by Krott (1960, p. 20), they are "lumbrosacrally overbuilt" with heavy musculature and legs that are acutely angled when walking. Wolverine gait is characterized as either a 2X pattern (when patterns of two footprints repeat), used primarily in deep snow, and the more common 3X lopes (patterns of three footprints), for covering long distances over more compacted snow (Halfpenny *et al*. 1995, p. 104). The latter is described as a bouncing gait where all four feet may leave the ground at the same time (Halfpenny *et al*. 1995, p. 104).

As noted in our Species Description section above, in winter, the dense hairs on the foot pad and its body structure supports a low foot load, which has been estimated at 22 gram/cm^2 (Knorre 1959, p. 26) and 27–35 gram/cm^2 (Novikov 1962, pp. 22–23 (citing Dulkeit 1953)). This foot loading is believed to provide an advantage for wolverines preying on ungulates and other large mammals whose movements become restricted in deep snow (Knorre 1959, p. 26; Formozov 1963, pp. 40–41; van Zyll de Jong 1975, p. 435; Banci 1994, p. 113). However, a study of wolverines in boreal forest habitat in Canada present a differing interpretation of the wolverine foot adaptation based on tracking wolverines in snow over three winters (Wright and Ernst 2004a, pp. 58–59), in which they observed wolverines in their study area continuously selected for a path of least snow cover, where practicable, and only traveled in upland areas (Wright and Ernst 2004a, p. 59). They concluded that the low foot load is advantageous when snow crusts form, but, in deep snow, wolverines shift to an inefficient walking gait or lunge, which increases energy demand (Wright and Ernst 2004a, p. 59). They hypothesized that traveling in deep snow during winter in search of food may increase the risk of starvation due to the greater energy expenditure (Wright and Ernst 2004a, p. 59).

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Physiology

The wolverine is a snow-adapted, cold climate animal in its physiology, morphology (Telfer and Kelsall 1984, p. 1,830), behavior, and habits. Wolverines have been classified as a "chionphile" or those animals with adaptations for snow (e.g., increased surface area on feet, pelt characteristics) (see definitions in Pruitt 1959, p. 172; Cathcart 2014, p. 22).

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In general, mustelids weighing more than 1 kilogram (kg) (2.2 pounds (lbs)) have a basal metabolism (defined as the minimum metabolic rate for maintaining a comfortable warm temperature; Irving 1972, p. 121) that is about 20 percent higher than other mammals (Iversen 1972a, p. 343). For the wolverine, Young *et al*. (2012, p. 222) estimated a basal metabolic rate for a 15 kg (33 lbs) adult at 669.4 kcal/day, using Iversen's derived equation [Metabolic rate (M)=84.6*Weight (W, in kg)$^{(0.78)}$ ± 0.15] (Iversen 1972a, p. 343). By comparison, the estimated basal metabolic rate for a 53 g (1.9 ounce (oz)) least weasel (*Mustela nivalis*) is about 40 kcal/day, and approximately 250 kcal/day for a 3.8–5.5 kg (8.4–12 lbs) Arctic fox (*Vulpes lagopus*) (both sampled from Barrow, Alaska) (Irving 1972, p. 115; Figure 9.1).

Experimental studies by Iversen (1972, pp. 320–321; Figure 4) found that during their first 2.5 months, the basal metabolic rate for young wolverines was substantially higher than rates reported for other mammals ($W^{1.41}$ vs. $W^{1.0}$), then declined after 3 months, and declined again after 8 months. Because the early period coincides with weaning, Wilson (1982, p. 646) suggested that the observed peak may be related to changes in food consumed as well as improved thermoregulation since the mother is leaving the young for longer periods of time.

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Energy expenditure during pregnancy is relatively low for mustelids (Oftedal and Gittleman 1989, p. 374); however, energy requirements for lactation in mammals can be over 4 to 7 times basal metabolic rates (Allen and Ullrey 2004, p. 478). Thus, estimates of energetic requirements (e.g., less than 1 kg prey/day annually) may be too low to support reproductive activity (Young *et al*. 2012, p. 226). Wolverines are known to consume a variety of food resources and seasonal switching of prey likely allows for adjustment for nutritional needs depending on life history stage (e.g., lactating females) (Krebs *et al*. 2007, p. 2,187 (Canada); Koskela *et al*. 2013a, pp. 103–104 (Finland); Yates and Copeland 2017, *in prep* (Montana)). Additional details on diet and feeding behavior for wolverines are provided below.

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Relatedly, Casey *et al*. (1979, p. 335) evaluated metabolic and respiratory responses of eight terrestrial Arctic mammals to ambient temperature during summer months. For wolverines, they found that the frequency of respiration was generally constant (15-20 per minute), but their tidal volume (air moved per breath) increased nearly constantly with *decreasing* ambient temperature, unlike Canada lynx (*Lynx canadiensis*), which is similar in body mass (Casey *et al*. 1979, p. 335). The researchers inferred that the increased ventilation of wolverines at low ambient temperatures was the result of an increased energy metabolism (Casey *et al*. 1979, p. 336). ¶

Thermal neutrality (or thermoneutrality) is the temperature range at which resting metabolism is at minimum (Barnett and Mount 1967, p. 468) and animals produce heat at a minimum rate in a thermal neutral environment (Barnett and Mount 1967, p. 413). For a resting mammal at thermal neutrality, body temperature is primarily maintained by "physical thermoregulation," that is, control of circulation in the skin and by sweating (Barnett and Mount 1967, p. 413). The body temperature of wolverine (measured by an implanted temperature transducer) at thermoneutrality has been reported at 38°C (100.4°F) (Folk *et al*; 1977, p. 231; Casey *et al*. 1979, pp. 332–333). The lower and upper bounds of the thermoneutral zone are established by the lower and upper critical temperatures (Monahan 2009, p. 5), which are related to physiological and behavioral adaptive responses. Because the critical temperature is the point at which the metabolic rate starts to rise, animals with lower critical temperatures are able to better conserve their energy expenditure (Barnett and Mount 1967, p. 413). Arctic mammals, including wolverine, Arctic fox,

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and wolf (*Canis lupus*), have a (lower) threshold of thermoneutrality of between −30°C to −40°C (–22°F to –40°F) (Iversen 1972b, p. 322; citing studies by Scholander *et al*. (1950b) and Hart (1956)).

With increasing ambient temperatures, mammals, including Arctic mammals, have the ability to dissipate heat through vasodilation and rise of skin temperature (Scholander *et al*. 1950a, p. 251). Casey *et al*. (1979, p. 340) estimated a critical (upper) temperature for wolverine (14 kg (31 lb)) in summer pelage of 5°C (41°F) based on an observed increase in oxygen uptake at air temperatures below this temperature. For comparison, measurements of metabolic rates for the red fox (*Vulpes vulpes alascensis*) (Alaska) observed critical temperatures of 8°C (46°F) in summer (Irving *et al*. 1955, p. 184).

Arctic mammals, particularly small mammals, also adapt behaviorally to cold temperatures by creating burrows and building nest sites under the snow. Wolverines are known to dig holes in snow for shelter (Pruitt 2005, p. 120), and wolverine reproductive den sites located under deep snow may provide a thermoneutrality advantage for newborn wolverines (cubs or kits) (Magoun and Copeland 1998, p. 1,313). This topic is discussed in more detail below under Use of Dens and Denning Behavior.

Wolverines can also adapt to changes in ambient temperature and solar radiation by movement and micro- and macro-habitat selection (e.g., movemement to higher elevations in summer, shaded areas, and water sources). For example, wolverines are good swimmers, easily crossing lakes and rivers, and have been observed near and in lakes and other water bodies (Seton 1909, p. 950; Krott 1960, p. 23; Magoun 2017a, pers. comm.). They likely use these areas more frequently during warmer months both for cooling and hydration, and possibly for hygienic reasons (Krott 1960, p. 23).

Seasonal adjustments of fur insulation also provides an additional mechanism for mammals to overcome large seasonal changes in temperature (Casey *et al*. 1979, p. 340) and have been described for wolverine and other mammals in Alaska (Henshaw 1970, p. 522). An evaluation of the seasonal change in the insulation of fur of wolverine (pelts from Canada) found a 41.2 percent change in mean insulation values (measured as °C/cal/m^2/hr) from winter to summer (Hart 1956, p. 56). Relatedly, a single annual molting (between August and December) was noted in Grinnell *et al*. (1937, p. 251) (California), but twice yearly was described by Novikov (1962, p. 201) (Russia). The reported seasonal decrease in wolverine fur thickness also correlates with experimental results of Casey *et al*. (1979, p. 337) who indicated that a seasonal shift in oxygen consumption below critical temperature was likely due to an increased rate of heat loss in summer.

Physiological responses (e.g., changes in respiration rate, heart rate, skin temperature, or endocrine (hormone) functions) to changes in ambient temperature or solar radiation are also observed in mammalian species (e.g., Norris and Kunz 2012, p. 207). In a study to evaluate metabolic and respiratory responses of eight terrestrial Arctic mammals to ambient temperature during summer months, Casey *et al*. (1979, pp. 335, 338; Figure 7) found that, for wolverines, the frequency of respiration was generally constant (15-20 per minute) for air temperatures ranging from −20°C to +20°C (−4 to 68°F). However, with decreasing ambient temperature, the

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Arctic mammals, including wolverine, Arctic fox, and wolf (*Canis lupus*), have a threshold of thermoneutrality of between −30°C to −40°C (–22°F to –40°F) (Iversen 1972b, p. 322; citing studies by Scholander *et al*. (1950b) and Hart (1956)). Relatedly,

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Changes in endocrine (hormone) function can also represent a physiological adaptation to cold by acting on organs to generate energy (Barnett and Mount 1967, p. 428). The best available information does not indicate that these functions have been evaluated in wolverines.

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Similarly, an

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tidal volume (air moved per breath) of wolverines exhibited a constant increase (Casey *et al*. 1979, p. 335). The researchers inferred that the increased ventilation of wolverines at low ambient temperatures was the result of an increased energy metabolism (Casey *et al*. 1979, p. 336). One veterinarian reported an enlarged thyroid in a wolverine during a necropsy procedure (Copeland 2017, pers. comm.), which is suggestive of a high metabolism.

Beyond these cited observational and laboratory/field studies, the best available information indicates that behavioral, morphological, or physiological responses of wolverines relative to increases in either colder or warmer temperatures have not been evaluated (e.g., thermal imaging studies combined with biophysical models (McCafferty *et al*. 2011, entire), or physiological niche models).

Range and Habitat Use

Historical Range and Distribution

Phylogeography/Phylogenetics

Results from a molecular study of phylogenetic relationships of the Mustelidae family suggest at least six radiation episodes within this family since the Early Eocene Epoch (approximately 50 million years before present (YBP)) (Marmi *et al*. 2004, pp. 488, 492). The split of the marten (*Martes*, *Gulo*) and weasel (*Mustela*) lineages occurred in the Early Middle Miocene Epoch (14 to 11 million YBP), with the separation of Old World and New World lineages (*Martes*, *Gulo*) occurring in the Late Miocene Epoch (8.6 to 5.8 million YBP) (Marmi *et al*. 2004, p. 488). The *Gulo* genus appears in the fossil record in the mid-Pleistocene in both Europe and North America (Bryant 1987, p. 659).

The dispersal of *Gulo* across Beringia (land mass that extended from Siberia into interior Alaska during the Pleistocene) is believed to have produced contemporaneous records for the species in Europe and North America (Bryant 1987, p. 659). Genomic data was examined using a molecular dating technique to estimate an approximate age of the *G. gulo* ancestor (Malyarchuk *et al*. 2015, entire). The researchers estimated a relatively recent origin of the species *Gulo gulo* at about 181,000 to 234,000 YBP (Malyarchuk *et al*. 2015, pp. 1,115–1,116). They note that this latter time period corresponds to the Riss glaciation period (187,000 to 230,000 YBP), a time of genetic divergence of amphi-Beringian (both sides of Beringia) species and speciation events (Hope *et al*. 2013, p. 426). Their results, along with fossil information, also indicate the divergence of the *Gulo* branch and the other *Martes* taxa occurred during the Late Miocene-Early Pliocene (5.6 million YBP), and lends support for strong evolutionary processes in the northern Siberian ecosystems in the Pliocene and Pleistocene Epochs (Malyarchuk *et al*. 2015, pp. 1,116–1,117).

An evolutionary trend was described in which *Gulo* increased in size from the mid- to late-Pleistocene, with a subsequent reduction in size post glaciation, as well as small changes in selected teeth, and a possible shift to colder habitats (Bryant 1987, p. 660). The Late Pleistocene and the Pleistocene-Holocene transition represent the end of prolonged period that was characterized by climate fluctuations followed by rapid warming (Post 2013, p. 28). This

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analysis also indicated that both the mid-Pleistocene European *Gulo schlosseri* and the early North American *Gulo* appear to be adapted to a warmer climatic environment, but are likely to have also occupied colder climates (Bryant 1987, p. 660). Other factors such as competition (Guilday 1971, p. 237), predator avoidance, and prey abundance may also have been important in creating significant shifts in geographic ranges for certain species during glacial cycles.

Wolverines are believed to have migrated to North America during the late Pleistocene, although fossil evidence from the Pleistocene Epoch for wolverine is limited (Anderson 1977, p. 15; Bryant 1987, p. 660), and most fossil material is either cranial or dental fragments (Bryant 1987, p. 660). A summary of records for both Pleistocene and extant *Gulo* (Bryant 1987, p. 659; Table 3) includes findings in the United States from Colorado, Idaho (e.g., White *et al*. 1984, p. 248 (lava tubes)), Alaska, Maryland, and Pennsylvania, and Canada (primarily the Yukon region) ranging from the Irvingtonian Age (1.8–2.4 million YBP) to Late Wisconsinan-Holocene (15,000 YBP to present day).

Genetic studies can provide an understanding of the postglacial recolonization of wolverines following the Last Glacial Maximum, a period of rapid cooling, and movement patterns due to changed climatic conditions (Frances 2008; Zigouris *et al*. 2013; McKelvey *et al*. 2014). During the late Wisconsin period (10,000 to 25,000 YBP), approximately 60 percent of North America was covered by glacial ice (Rogers *et al*. 1991, p. 624). However, several ice-free refugia existed at that time including the Beringian refugium, which included eastern Siberia, most of Alaska, areas of northwestern Canada, and areas of the Bering Sea shelf that were exposed by lower sea levels, and this refugium harbored a number of mammalian species including wolverine (Rogers *et al*. 1991, pp. 624, 626). Analyses by Frances (2008, entire) and Zigouris *et al*. (2013, entire) supported a wolverine colonization of North America in which individuals "followed retreating glaciers" (Zigouris *et al*. 2013, pp. 10–11), beginning about 21,000 YBP, following the Last Glacial Maximum, when a period of rapid warming occurred that resulted in additional extinction events, particularly large mammalian megafauna (Post 2013, p. 29)

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A phylogeographic analysis presented by McKelvey *et al*. (2014, p. 331) proposed that a unique haplotype (Cali 1) observed in historical wolverine samples from California was reflective of an independent evolutionary history resulting from isolation (i.e., southern ice-free refugium) of wolverines during glacial retreat. However, Zigouris *et al*. (2013, p. 10, Supplemental Table S5) found the Cali 1 haplotype described by Schwartz *et al*. (2007, p. 2,173; Tables 2 and 4) (relabeled as Haplotype 21) also occurred in historical wolverine samples from the eastern region of Canada (Quebec-Labrador). In addition, as noted by Zigouris (2014, pp. 232–233) the historical samples analyzed by McKelvey *et al*. (2014, p. 327; Table 1) were primarily those from locations at the southwestern edge of the wolverine's North American range (e.g., California, Colorado, Idaho, Montana, Wyoming, Utah, Washington). Without additional sampling, it is unclear if this particular haplotype distribution from two of the most peripheral North American wolverine populations is a reflection of a skewed dispersal after post-glacial colonization, or was a more widely distributed haplotype that declined or was lost due to hunting and unregulated trapping pressures (beginning in 18th century) or fragmentation (late-20th century) (Zigouris *et al*. 2013, p. 10).

Additional discussion of our current understanding of wolverine genetic structure and diversity is provided in the *Population Structure* section below.

Historical Range

In North America, wolverines were historically distributed in much of the northern portion of the continent, extending southward to the northernmost region of the United States (Maine to Washington) or approximately north of the 38th parallel (Hash 1987, p. 576; Banci 1994, p. 102). An estimate of wolverine observations and distribution in the contiguous United States was prepared by compiling 901 verifiable or documented records of wolverine occurrence dating from 1801 to 2005 from 24 states in the contiguous United States (Aubry *et al*. 2007, entire). This included a total of 809 verifiable or documented records for the Rocky Mountain and Pacific Coast mountains (west-northwestern United States) for this time period (Aubry *et al*. 2007, p. 2,151).

The historical population size of wolverines in Canada is not known (Fortin 2005, p. 4). Its historical distribution, as depicted by Seton (1909, p. 947; Map 51) and also later by van Zyll de Jong (1975, p. 435; Figure 9) shows a broad range across much of Canada. Examples of early descriptive accounts include de Puyjalon (1900, pp. 126–144), who described wolverines as inhabiting Labrador, Canada (de Puyjalon, p. 101), and extending in range to the 66th parallel and perhaps further (de Puyjalon 1900, p. 144); reports of both trapped and live wolverines in Labrador in the late 1700s (Townsend (ed.), 1911, pp. 73, 93, 228, 255); and reports of wolverines as "common" in Canada's Nunavut Territory (Hudson Bay region) during a 1920s Danish excursion (the Fifth Thule Expedition) to Arctic North America (Freuchen 1935, p. 101). The 2014 COSEWIC report presents a historic range distribution for Canada based on personal accounts and interpretation of the fur trade (COSEWIC 2014, pp. 12–13; Figure 3).

Maximum Extent of Occurrences

We created a map to depict the Maximum Extent of Occurrences (similar to a historic range map) of the North American wolverine (Figure 2). This map represents the area defined by circumscribing all known localities of a species, or the perimeter of the outermost geographic limits based on occurrence records from survey reports, literature, natural heritage databases, and citizen sightings (Service 2017), and is similar to the map presented in Seton (1909, p. 947; Map 51). For defining this area in Canada and Alaska, we used the map (in digital format) presented in COSEWIC (2014, p. 12; Figure 3). For the western United States, we used relevant forested areas identified in the U. S. Environmental Protection Agency's (EPA) ecological regions map (Level 2) (Commission for Environmental Cooperation (CEC) 1997, EPA 2010; see Appendix A for complete North American map). The Maximum Extent of Occurrences area shown in Figure 2 encompasses about 12,966,221 km^2 (3,204,022,986 ac) (using North American Lambert projection). Of this total, about 88 percent (11,363,639 km^2 (2,808,016,350 ac)) is found north of the U.S.–Canada border.

We then requested all available wolverine observations for the west-northwestern United States from State agencies (e.g., wildlife agencies, natural heritage programs) and the Forest Service Natural Resource Information System (NRIS) Wildlife Database. The NRIS Wildlife Database

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records represent data that have been quality checked ("passed") by the Forest Service. For the Midwest and eastern United States, we incorporated observations from Aubrey *et al*. (2007; pp. 2,151–2,152; Figure 1). We also located additional historical records in the western United States that do not appear in Aubry *et al*. (2007, p. 2,151); for example, Nead *et al*. (1985, entire) identified several positive and probable reports of wolverines in Colorado in the late 1970s and a wolverine was reported from the Squaw Valley region of California in the summer of 1953 (Ruth 1954, pp. 594–595). Wolverine observations for the contiguous United States are included in Figure 2, and illustrate the close correlation with the Ecoregions boundaries.

Current Potential Extent

Using the best available information, we created maps to describe an area of Current Potential Extent for the western-northwestern contiguous United States (Figure 4). Current Potential Extent represents the Maximum Extent of Occurrences minus those areas where we believe the species has been extirpated. For the wolverine, this map was developed from the current distribution of breeding populations defined by Inman *et al*. (2013, p. 282; Figure 3). We then incorporated records from Forest Service (NRIS Wildlife Database) from 2004 to early 2017, based on an average male life expectancy of about 13 years (Jung and Kukka 2013, pp. 8, 12). We also incorporated more recent observations (e.g., telemetry, camera traps, and/or mortality reports) reported from California, Washington, Colorado, Wyoming, Utah (2014, 2016), Oregon (2016, 2017), Michigan (2004-2010) and North Dakota (2016). Sources include California Department of Fish and Wildlife; Idaho Department of Fish and Game; Michigan Department of Natural Resources; Utah Division of Wildlife Resources; Wyoming Game and Fish Department, Magoun *et al*. 2013, p. 27; Magoun 2017b, pers. comm.), and additional observations from 2016-2017 winter surveys (i.e., WAFWA's Coordinated Occupancy Survey) (Montana Fish Wildlife & Parks (FWP) 2017, pers. comm.)). This Current Potential Extent map is illustrated in Figure 3. This map also identifies individual wolverine observations outside these boundaries, including a current resident wolverine in California, the tracking locations of a dispersing male (M56) that traveled from northwest Wyoming into Colorado and then to North Dakota where it was legally shot in 2016 (Packila *et al*. 2017, entire), and three observations from experienced observers in Colorado (2015) and one from Wyoming Game and Fish Department (January 2016). We placed a question mark on this map for the Uinta Moutains region of Utah since the last detection was a female wolverine found killed along a highway in July 2016 (Rich County) (Hersey 2017, pers. comm.). The Current Potential Extent area identified in Figure 3 encompasses approximately 280,316 km^2 (69,267,592 ac) (North American Lambert projection). We also prepared a Current Potent Extent map for all of North America, including Canada and Alaska, shown in Figure 4, using map presented in the 2014 COSEWIC Status Assessment and Status Report on the wolverine in Canada (COSEWIC 2014, p. 12; Figure 3), for a total estimated Current Potential Extent of 8,114,878 km^2 (2,005,230,024 ac) (North American Lambert projection). The Current Potential Extent area in the contiguous United States represents approximately 3.45 percent of the total Current Potential Extent of wovlerines in North America.

We recognize that this depiction does not necessarily represent current areas where reproducing populations of wolverines are found, nor does it capture unverified accounts from New Mexico, described in Frey (2006, pp. 20–21) for the Sangre de Cristo Range, and visual observations

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Deleted: Figure 2 presents a map of these compiled observations, overlaid with the habitat suitability model results presented by Inman *et al*. (2013, p. 281). We acknowledge that some of these records may be in error or inaccurately located, and although wolverines have been reported from the Central Great Plains, Great Lakes region, Upper Midwest, or Northeast (Wilson 1982, p. 650), we did not create a historical range for these regions given the very low number (92) reported by Aubry *et al*. (2007, p. 2,151) from the 1880s to 2005, and to present day, and an incomplete historical record of trapping. We also found a few additional historical records that do not appear in Aubry *et al*. (2007, p. 2,151). For example, Nead *et al*. (1985, entire) identified several positive and probable reports of wolverines in Colorado in the late 1970s. A wolverine was reported from the Squaw Valley region of California in the summer of 1953 (Ruth 1954, pp. 594–595). Our intent in creating this map was to present an overall geographical depiction of the wolverine's estimated range only for the west-northwestern United States, and is not intended to represent an estimate of population numbers.

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reported by two individuals (2005 and 2016) in response to our *Federal Register* notice (81 FR71670; October 18, 2016) requesting information for our status review.

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Habitat loss (historical vs. current range) for the North American wolverine (i.e., Canada and United States) has been estimated at 37 percent (Laliberte and Ripple 2004, p. 126), using "historic" and "current" range maps, an estimatation of "human footprint," North American biomes, and a digital elevation model (Laliberte and Ripple 2004, p. 126). Similarly, comparing our estimated North American Maximum Extent of Occurrences map to our estimated Current Potential Extent map for the wolverine also indicates a 37 percent change. However, as noted in Laliberte and Ripple (2004, pp. 125–126), we recommend caution in interpreting this value given the coarse scale used to define dynamic range boundaries.

We provide a discussion of wolverine population abundance and distribution in more detail in the *Biological Status–Current Condition* section below.

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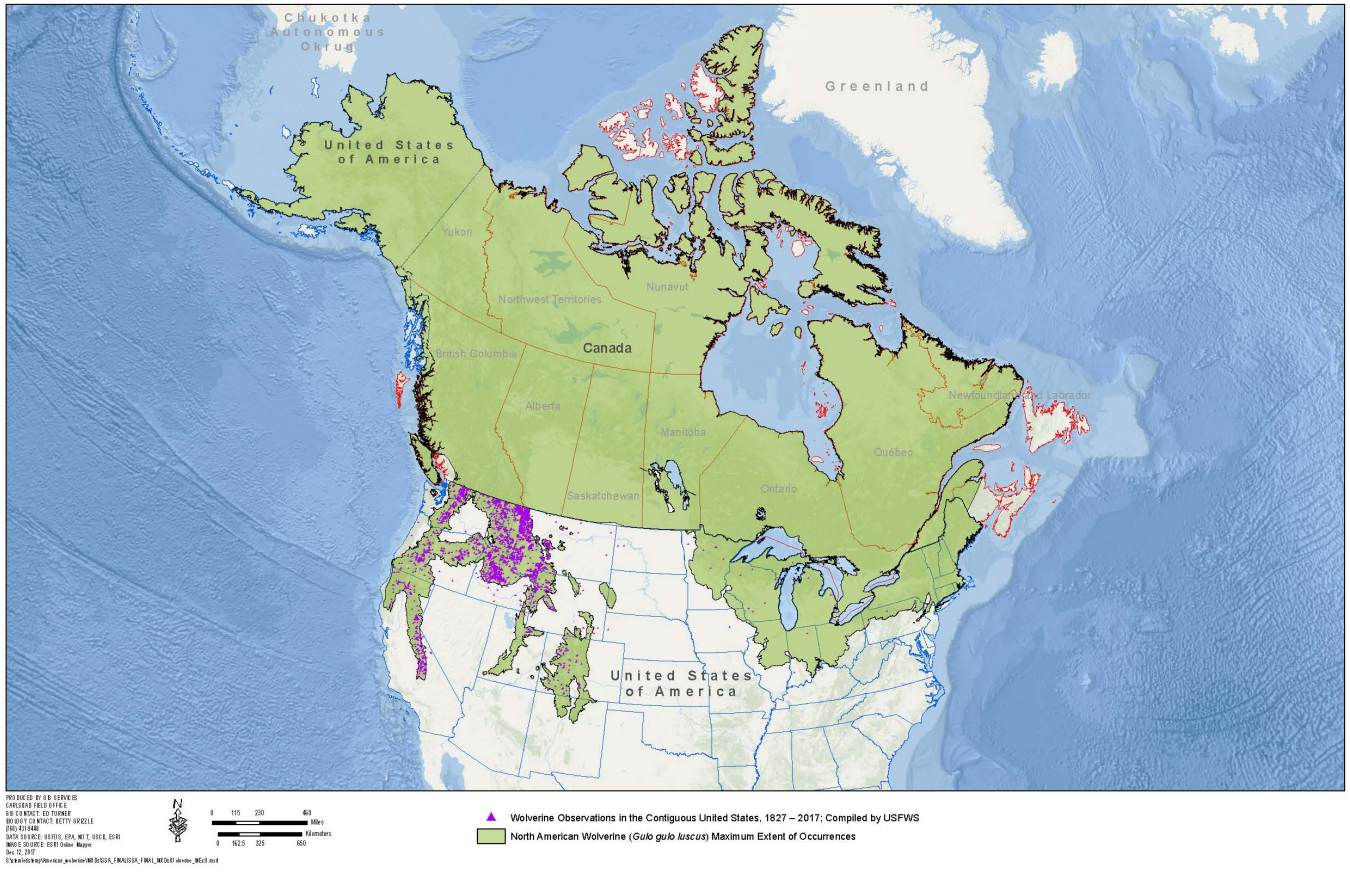

Figure 2. Maximum Extent of Occurences for the North America wolverine shown with observations (1800s to 2017) within the contiguous United States. Boundaries based on COSEWIC (2014) (for Canada and Alaska) and North American Ecological Regions (CEC 1997, EPA 2010) (for contiguous United States).

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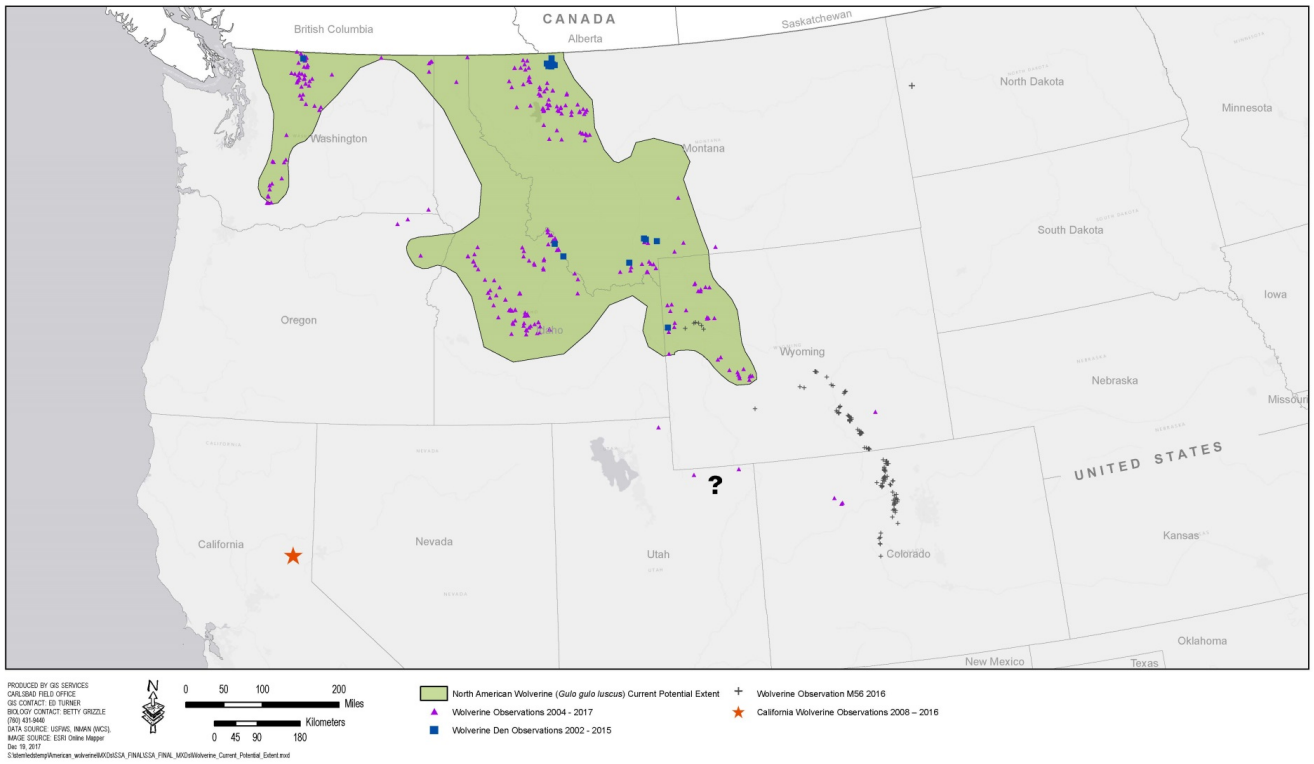

Figure 3. Current Potential Extent of the North American wolverine, western United States. Adapted from Inman *et al.* (2013) and records from California Department of Fish and Wildlife; Forest Service NRIS; Idaho Department of Fish and Game; Magoun *et al.* (2013); Magoun 2017b pers. comm.; Michigan Department of Natural Resources; Montana Fish Wildlife & Parks; Utah Division of Wildlife Resources; Wyoming Game and Fish Department; and den records from Copeland, Heinemeyer, and Inman.

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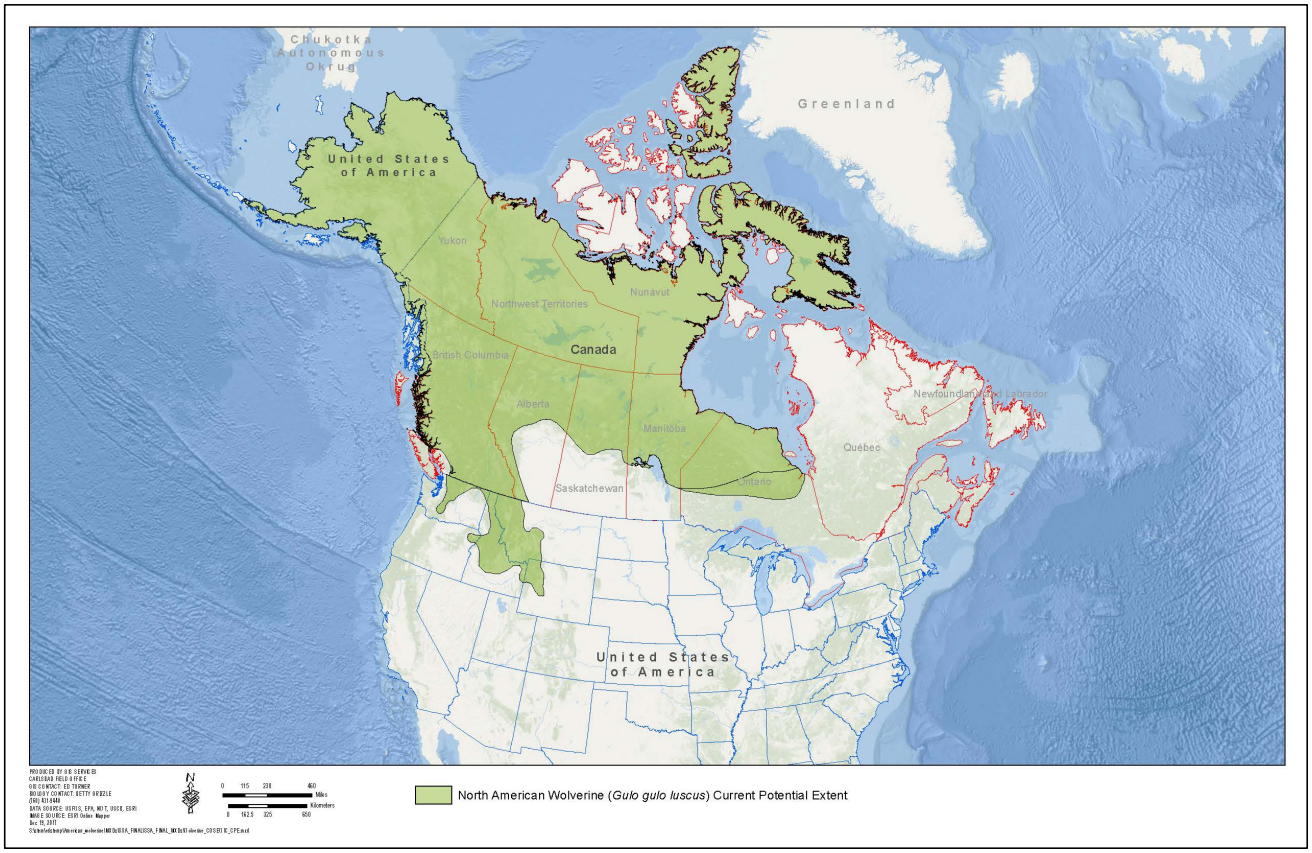

Figure 4. Current Potential Extent of the North American wolverine, North America. Adapted from COSEWIC (2014), and records from Forest Service NRIS; Idaho Department of Fish and Game; Magoun *et al*. (2013); Magoun 2017b pers. comm.; Montana Fish Wildlife & Parks; Utah Division of Wildlife Resources; Wyoming Game and Fish Department; and den records from Copeland, Heinemeyer, and Inman.

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Habitat Use

Wolverines occupy a variety of habitats within North America, including Arctic tundra, subarctic-alpine tundra, boreal forest, mixed forest, redwood forest, and coniferous forest (Banci 1994, p. 114). However, these broad, landscape-scale vegetation associations can obscure other habitat variables important for wolverines, including features found within peripherally occupied areas or areas of high elevation (Banci 1994, p. 114). In Canada, wolverines use a wide variety of forested and tundra vegetation, at all elevations (COSEWIC 2014, p. 18).

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When viewed by ecological region (see EPA 2010), in general, wolverine observations found within our Current Potential Extent of wolverines in the contiguous United States are most commonly found in the Northwestern Forested Mountains ecological region. All North American ecological regions are presented in the map in **Appendix A**.

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Studies of wolverines in central Idaho found that montane coniferous forests comprised two-thirds of available habitat (Copeland 1996, p. 120). Wolverines in this region also exhibited a seasonal preference, with subalpine rock habitats used in summer and montane coniferous forests used most often in winter (Copeland 1996, p. 120). In addition, individuals within this study population commonly crossed natural openings and those areas with little cover, including burn areas, meadows, or open mountain-top areas (Copeland 1996, p. 124).

Observations of summer movements of wolverines in northwestern Montana indicated that both males and females moved to higher, cooler elevations and remained there throughout the summer (Hornocker and Hash 1981, p. 1,299). In the Greater Yellowstone Ecosystem, wolverines selected areas that contained steep terrain with tree cover, high elevation meadows, boulder or talus fields, and avalanche chutes (Inman *et al*. 2012a, p. 785). In this region, wolverines selected elevations at and above the treeline during summer, moved slightly lower during winter, but avoided low-elevation winter ranges occupied by potential prey (e.g., elk) or areas with little human activity (Inman *et al*. 2012a, p. 785). The avoidance of these areas may be the result of lack of tree or talus field cover at these low elevations, in combination with presence of potential predators (e.g., wolf, mountain lion (*Puma concolor*) or competitors (e.g., coyote (*Canis latrans*), bobcat (*Lynx rufus*) (Inman *et al*. 2012a, p. 785).

Several habitat association-type models have been developed for both North American and European wolverines. In the northern Rockies (including Canada and the United States), Carroll *et al*. (2001, p. 975) found that elevation and north-facing cirque habitat variables (i.e., alpine areas), when incorporated into empirical habitat models, were significantly correlated with wolverine occurrence (Carroll *et al*. 2001, pp. 971, 973–974). Copeland *et al*. (2007, entire) also evaluated habitat associations for wolverines in central Idaho. Wolverines were found to be associated with high elevations (2,200 to 2,600 m (7,218 to 8,530 ft)) with a slight downward shift in summer (Copeland *et al*. 2007, p. 2,207). These movements correspond with a shift in cover types, from high-elevation whitebark pine (*Pinus albicaulis*) communities in summer to mid-elevation Douglas fir (*Pseudotsuga menziezii*) and lodgepole pine (*Pinus contorta*) in winter (Copeland *et al*. 2007, pp. 2,207–2,208). Results from a study of wolverines in Scandinavia suggested that topography may be important in providing refugia from predators and may

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therefore facilitate the co-existence of wolverines with larger carnivores such as wolves (Khalil *et al*. 2014, p. 636).

In interior Alaska, wolverines were also found to be positively associated with high elevations (Gardner *et al*. 2010, p. 1,901). The authors concluded that wolverines avoided human influences based on observations that both elevation and human influence were found to have significant effects on wolverine occurrence probabilities, but were not correlated (Gardner *et al*. 2010, p. 1,901). However, they indicate that their sampling design was not able to determine which human activities influenced wolverine behaviors; a combination of intensity of development and harvest activities was suggested (Gardner *et al*. 2010, p. 1,901). Current studies are underway in the North Slope region of Alaska to evaluate fine-scale habitat selection of wolverines related to denning, caching, day bed use, and snow holes (Dorendorf 2016, p. 6). Day beds were also described by Haglund (1966, p. 268) for wolverines studied in Sweden.

A study also found that habitat associations, at least for females, are more complex, and include combinations of several modeled variables that supported hypotheses related to food (prey distribution), predation risk (based on a ruggedness index), or human disturbance (winter recreation activity, roads, and forest harvesting) for both summer and winter in two study areas located in northcentral and southeast British Columbia (Krebs *et al*. 2007, pp. 2,186–2,187). Wolverines in the Rocky Mountains of Alberta, Canada, were found to more likely occupy areas with increasingly rugged terrain (Fisher *et al*. 2013, pp. 710–712).

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Camera trapping was used to study wolverine behavior in varying habitat in the Rocky Mountains of Alberta, Canada (Stewart *et al*. 2016, entire). That study found that wolverine behavior differed in landscapes that had been significantly modified by human activities as compared to those with light modifications or in protected areas (Stewart *et al*. 2016, p. 1,499). They concluded that wolverine occurrence in their study areas varied more strongly with linear features (seismic lines created from oil and gas exploration, pipelines, transmission lines, roads, and rail lines) than with the degree of snowpack, and supports the idea of human "footprint" as a driver of habitat suitability for wolverines; that is, if snowpack conditions was the only driver for suitable habitat, then a behavioral signal (e.g., latency time for detection or tree climbing at bait station) would not be expected (Stewart *et al*. 2016, p. 1,501).

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Aboriginal knowledge holders (Aboriginal Peoples that have accumulated knowledge about wildlife species and their environment) in Canada have reported that while wolverines appear to avoid human habitation and developed areas, some wolverine will visit these areas if they do not appear to be threatened or if development activities cease (Cardinal 2004, p. 22). Wolverines have also been described as occupying deserted snow huts (Nunavut Territory, Canada) during winter months (Freuchen 1935, p. 98).

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A negative association with roads and wolverine (and caribou) occurrence in boreal forest habitat was reported in northwestern Ontario, Canada, and wolverines in that study area avoided deciduous forests (Bowman *et al*. 2010, p. 464). However, a study of wolverines in upland boreal forests of Canada found that wolverines followed open linear corridors that offered compact snow conditions, including winter roads, recent seismic lines, snowmobile trails, and all-terrain vehicle tire tracks for travel of distances up to 3 kilometers (km) (1.86 miles (mi)) (Wright and

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Ernst 2004b, p. 59). In central Idaho, wolverines were reported using snowmobile winter access (unmaintained) roads for travel (Copeland *et al*. 2007, p. 2,210).

A study of wolverine selection patterns in boreal forests in northwestern Alberta using resource selection function (RSF) modeling techniques[1] and data from telemetered wolverines found that, for the winter season, both male and female wolverines selected for streams, forested areas (broadleaf, coniferous, and mixed) and bogs or fens, while avoiding active oil and gas well sites and low-traffic winter roads (Scrafford *et al*. 2017, pp. 31, 32). That study also found that wolverines did not avoid older seismic lines, likely due to the intermediate stage of regeneration found in their study area as well as availability of small prey in conjunction with minimal risk of human or wolf presence (Scrafford *et al*. 2017, p. 34).

RSF-based modeling was used to quantify the relationship between the observed distribution of the wolverine and variables representative of habitats and human disturbance in the taiga and tundra ecoregions (see ecological regions map in **Appendix A**) of the Canadian central Arctic (Nunavut and Northwest Territories) (Johnson *et al*. 2005, p. 10). Using a range defined by previous studies of collared wolverines, researchers identified two seasons for wolverines, based on presence or absence of barren-ground caribou (*Rangifer tarandus groenlandicus*) (Johnson *et al*. 2005, p. 8). They found that, in winter, the occurrence of wolverines was correlated with patches of heath rock and rock association, and areas dominated by sedge (Johnson *et al*. 2005, pp. 23–25). Results for models for summer season were less clear, but models that included grizzly bear (*Ursus arctos*), caribou, and wolf were found to be positively associated with wolverine, likely due to the scavenging opportunities and hunting of caribou provided by these other carnivores (Johnson *et al*. 2005, p. 24). In Finland, the presence of wolves was found to be one of the most important variables influencing habitat selection of wolverines (Koskela 2013, p. 35) likely due to the increased scavenging opportunities provided by wolf kills (Koskela 2013, p. 36).

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A RSF model was also used to develop a predictive map of wolverine habitat for the western United States (Inman *et al*. (2013, p. 281), as shown in the background of our Figure 3. Their best fit model found that, in general, wolverine were most likely to be distributed at high elevations, with steeper terrain, more snow, fewer roads, and reduced human activity, but also in proximity to high elevation talus, tree cover, and areas that had snow cover on April 1 (Inman *et al*. 2013, pp. 280–281). Primary habitat for the wolverine in the western United States was estimated at 164,125 km^2 (63,369 mi^2) (Inman *et al*. 2013, p. 281). Additional information related to the results of this modeling effort is discussed in the *Population Distribution and Abundance* section below.

[1] RSF is any mathematical function that is proportional to the probability of use of a resource unit (Manly *et al*. 2002, p. 15). A RSF contains several coefficients that quantify the selection for or avoidance of an environmental feature, and the sign/strength of those coefficients represents a differential variation in the distribution of each environmental feature measured at a sample of locations to a comparable set of random sites. Thus, when an animal's observed use of a resource is greater than those random sites, selection of that feature is inferred (Johnson *et al*. 2005, p. 10).

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Movement

Wolverine movements are related to both territoriality (within home ranges) and dispersal (adults and young). Movement within home ranges by adult male and female wolverines is extensive. For example, wolverines monitored in the Greater Yellowstone Ecosystem traveled a distance that was equivalent to their average home range diameter in less than 2 days, which is also about the size of their home range circumference in less than 1 week (Inman *et al*. 2012a, pp. 782–783). This study also found that, for a 24-hour period, the average minimum distance traveled was 15.5 (km) (9.63 (mi) for males and 7.5 km (4.66 mi) for females (Inman *et al*. 2012a, p. 783). Telemetry studies of wolverines in south-central Alaska indicate an average distance traveled per day of approximately 12 km (7.46 mi) for females and 8–21 km (4.97–13 mi) for males (Woodford 2014, no page number). Observations from snow tracking studies have found instances where two individual wolverines traveled together (Wright and Ernst 2004b, p. 63).

A study of female Fennoscandinavian wolverines found that most (86 percent) females remained stationary in their established territories, with 8 percent vacating and 6 percent expanding their territory (Aronsson 2017, p. 40). In addition, this study of 42 female wolverines in 122 territories reported that females with established territories only moved to available territories that were higher than average in quality (Aronsson 2017, p. 41). In central Norway, a study of spatial and temporal patterns in wolverines using noninvasive genetic sampling methods also found that individuals tended to stay in the same general area from one year to the next (Bischof *et al*.'s 2016, p. 1,533).

A number of factors can affect wolverine movements within territories, such as availability of food, temperature, and breeding activity. Seasonal shifts in elevation have also been observed for wolverines in the contiguous United States. An ecological study of wolverines in southcentral Alaska found significant movement up in elevation during late winter and early spring as well as significant movement down in elevation during the late fall and winter (Gardner 1985, p. 21). Wolverines were also observed moving to and occupying higher and presumably cooler elevations in summer months in northwestern Montana (Hornocker and Hash 1981, p. 1,299). In Central Idaho, wolverines exhibited a preference for higher elevation areas containing rock and talus cover in summer months, but moved to lower elevations in winter; this was likely the result of an increase in availability of carrion related to the fall hunting season (Copeland 1996, p. iv). Two aboriginal knowledge holders in the Kivalliq region (Nunavut, Canada) reported that wolverines will move closer to communities during caribou migration in the fall, likely attracted by the large number of caribou carcasses left by hunters (Cardinal 2004, p. 22).

A study of wolverine movement in boreal forest habitat in Canada (northwestern Alberta and northeastern British Columbia) during winter months found that wolverines chose the most direct travel route with the least snow cover (Wright and Ernst 2004a, pp. 58–59). Woodford's (2014, no page number) account of wolverine observations from studies in Alaska indicated that, when pursued, wolverines will run uphill, which may represent a predator-avoidance adaptive behavior.

As discussed in more detail below (*Diet and Feeding*), several studies have shown that wolverines exhibit a seasonal shift in diet, and Hornocker and Hash (1981, p. 1298) concluded

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that food availability was the primary factor determining both movements and home ranges for wolverines studied in northwestern Montana. Movement patterns of adult males during the summer months are also likely influenced by breeding activity (Magoun 1985, p. 66).

Males and females maintain large territories with very little overlap between same-sex adults (Magoun 1985, p. 38; Banci 1994, p. 118; Inman *et al*. 2012a, p. 783; Bischof *et al*. 2016, pp. 1,532–1,533; Regehr and Lacroix 2016, p. 249), but breeding pairs have overlapping territories (Copeland 1996, pp. 55–61; Hedmark *et al*. 2007, p. 19; Dawson *et al*. 2010, p. 413; Persson 2010, p. 52; Inman *et al*. 2012a, p. 787). However, ranges of young males, that have not yet dispersed, can overlap with resident adult male home ranges (Alaska) (Magoun 1985, p. 64). Studies of wolverines in the Greater Yellowstone Ecosystem found a mean percent overlap of 12.7 percent for same sex, adult–sub-adult pairs and about 24 percent for opposite sex, adult–sub-adult pairs (Inman *et al*. 2012a, p. 787). In addition, Inman *et al*. (2012a, p. 783) found that when a resident adult wolverine died, same-sex adults (not known to be located within the dead wolverine's home range) would begin using (within 3–7 weeks) areas of the unoccupied home range, or same-sex subadults would expand into and then occupy most or all of the dead wolverine's former home range. A study of territoriality of wolverines in central Norway (using scat analysis) indicated that within their study population, wolverines were also more likely to choose a home range area that was previously used by a neighboring same sex individual after that individual's death (Bischof *et al*. 2016, p. 1,533).

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Table 1 below presents a summary of annual home ranges of resident wolverines.

Table 1. Annual Home Range Size for Adult, Resident Wolverines.

Region	Female, km^2 (mi^2)	Male, km^2 (mi^2)	Reference
Central Idaho	384 (148)	1,582 (610)	Copeland 1996
Central Idaho / Yellowstone Region	357 (138)	1,138 (439)	Heinemeyer and Squires 2015
Greater Yellowstone Ecosystem	303 (117)	797 (308)	Inman *et al*. 2012a
Glacier National Park (MT)	139 (54)	521 (201)	Copeland and Yates 2008
Alaska (Northwestern)	53-232 (20-89.6)	488-917 (188-354)	Magoun 1985
Canada Northwest Ontario	50-400 (19-154) 423 (163)	230-1,580 (89-610) 2,563 (990)	COSEWIC 2014 Dawson *et al*. 2010
Central Norway	331 (128)	757 (292)	Bischof *et al*. 2016
Southern Norway	274 (106)	663 (256)	Landa *et al*. 1998
Northern Sweden	170 (66)	669 (258)	Persson *et al*. 2010

Home range use is smaller for female wolverines during the reproductive period. For a parturient (about to bear young) female, estimates of home range size in the Greater Yellowstone region were significantly smaller, with a minimum of 100–150 km^2 (39–58 mi^2) (i.e., during year raising young) (Inman *et al*. 2012a, p. 782). The average home range size for lactating females

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rearing young was estimated at 70 km^2 (27 mi^2) from March through August (Alaska) (Magoun 1985, p. 36). In northwestern Ontario, researchers reported a home range of 262 km^2 (101 mi^2) for a lactating female (Dawson *et al*. 2010, pp. 141–142). In general, the distance traveled by female wolverines depends on the location of the reproductive den site within the home range, the areas used for locating food/prey, and the territory border (Myhr 2017, no page number).

In summary, habitat diversity, food availability, and competition for resources can collectively or individually influence home range sizes of wolverines (Magoun 1985, p. 63; Inman *et al*. 2012a, p. 785), which affects wolverine densities and population structure. Home range sizes of male wolverines are likely influenced by the density and reproductive condition of female wolverines (Magoun 1985, p. 63).

Dispersal relates to the successful establishment of a breeding territory, generally by juveniles, at a location removed from the natal denning area, and can be confused with long-range movements of wolverines and other carnivores (Ruggiero *et al*. 1994, pp. 4–5).

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Based on telemetry studies, wolverines have been observed to disperse over very long distances. Both male and females can move long distances (Flagstad *et al*. 2004, pp. 684–686), but young (yearling) females tend to establish home ranges closer to their natal ranges than do young males (COSEWIC 2014, p. 24), which supports a male-biased dispersal pattern (from natal range) for wolverine populations. Vangen *et al*. (2001, p. 1,647) indicated that dispersal patterns of females were likely determined by competition for resources (that is, high quality territories) while male dispersal patterns were likely determined by competition for mates.

As noted above, wolverines readily cross water bodies such as rivers, and can cross rugged terrain (COSEWIC 2014, p. 24; Woodford 2014, entire). Dispersing wolverines in Idaho traveled over 200 km (124 mi) following routes across isolated subalpine habitat (Copeland 1996, p. 130). Inman *et al*. (2012a, p. 784) recorded dispersal-related movements of wolverines in the Greater Yellowstone Ecosystem and found that the maximum dispersal distance of subadults from the home range of their mothers was 170 km (106 mi) for males and 173 km (108 mi) for females, with an average maximum distance per dispersal movement of 102 km (63 mi) for males and 57 km (35 mi) for females (Inman *et al*. 2012a, p. 784). In the Ontario, Canada, region a juvenile male reportedly dispersed 100 km (62 mi) (COSEWIC 2014, p. 24, citing unpublished data from Dawson *et al*. 2013).

Several examples illustrate the extensive dispersal capability of wolverines. A male wolverine apparently dispersed (2008 or earlier) from the western edge of the Rocky Mountain region to the Sierra Nevada region of California (Moriarty *et al*. 2009, p. 160). Another male wolverine (designated as M56), whose natal area was the Greater Yellowstone Ecosystem (northwest Wyoming), moved south to Colorado (about 500 miles), where it remained for about 3 years (2009–2012), when its tracking signal was lost (Packila *et al*. 2017, p. 402). In April 2016, M56 was legally shot and killed by a rancher in western North Dakota, or about 1,288 km (800 mi) from its last know location (Packila et al. 2017, p. 404). A female wolverine was also observed over several years (2004–2010) in the lower peninsula of Michigan, and genetic testing after her death in 2010 suggested she was more closely associated with eastern Canada wolverine populations (i.e., Manitoba and Ontario) (*in litt* Zigouris 2013, pers. comm.). It's unclear how

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this individual came to occupy this region, but given the long distance movements reported for this species (e.g., male wolverine that traveled from Wyoming into Colorado and then back to North Dakota (Packila *et al*. 2017, entire), dispersal from Canada is plausible. Wilson (1982, p. 650) reported that wolverines on occasion may enter Minnesota from Canada. Jackson (1961, pp. 359–360) also reported several authentic records of wolverine in Wisconsin and in areas in Minnesota, along the Wisconsin-Minnesota border. However, the wolverine was likely never abundant in Wisconsin, even before widespread and unregulated (Anglo) hunting in the late 19th and early 20th centuries (Jackson 1961, p. 359).

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Additional discussion of population distribution and density estimates is provided below (see Biological Status–Current Conditions).

Reproduction and Growth

Wolverine reproduction includes the following characteristics: polygamous behavior (i.e., a male mates with more than one female each year), delayed implantation (up to 6 months), short gestation period (30–40 days), denning behavior, and an extended period of maternal care (Rausch and Pearson 1972, pp. 255–256; Pasitschniak-Arts and Larivière 1995, p. 5; Magoun and Copeland 1998, pp. 1,315–1,316; Hedmark *et al*. 2007, p. 19; Persson *et al*. 2017, *in prep*).

Table 2 below presents a summary of wolverine reproductive chronology (extent and peak of reproductive events) based on a review of the literature and personal knowledge from field studies (Inman *et al*. 2012b, entire), and studies from Scandinavia (Aronsson 2017; Persson *et al*. 2017, *in prep*).

Table 2. Chronology of wolverine reproductive events (adapted from Inman *et al*. 2012b).

Reproductive Biology Event	Time Interval
Mating Season	May – August; *peak in June*
Nidation (implantation of embryo)	November – March; *peak in late December–early February*
Gestation	November – April; *peak in January–mid-March*
Parturition (birth of young)	late January – mid-April; *peak in February–mid-March* (Sweden: *peak in mid-February*, range from end of January to early March)[a]
Reproductive Den Use	late January – end of June; most commonly, *early February–mid-May*
Lactation	About 10 weeks; generally February–June
Weaning	April – June; most commonly, *late April–May*
Rendezvous Sites[b]	April – June; peak in *early May*
Independence	August – January; *peak in September–December*
Dispersal	Peak period at *10–15 months of age*; February–mid-April

[a] Persson *et al*. (2017, *in prep*); [b] Described below.

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Wolverine mating is generally assumed to occur in May, June, and July (Pulliainen 1968, p. 341; Rausch and Pearson 1972, p. 249). A review of both the literature and personal observations by Inman *et al*. (2012, p. 636) indicated that June represented the peak in a wolverine mating season, but began in at least May and extended into early August. Female wolverines have been reported as not breeding in their first summer (under 1 year of age) based on examination of

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reproductive tracts from wolverine carcasses obtained from trappers (Yukon) (Banci and Harestad 1988, p. 268) and ages of pregnant female wolverines were estimated at 1 to 11-plus years of age (Banci and Harestad 1988, p. 266). In another study of wolverine carcasses (also in Yukon), some female wolverines were said to be mature at about 1 year (about 15 months), but first litters were not produced until 2 years of age (Rausch and Pearson 1972, p. 253). In Scandinavia, the mean age of first reproduction for female wolverines was 3.4 years, based on monitoring of telemetered animals (Persson *et al*. 2006, p. 76). Breeding ages were reported at 2 to 13 years of age for wolverines in Sweden (mean age of first birth was 3.4, range of 2 to 5 years), based on monitoring/observations of female wolverines (Rauset *et al*. 2015, p. 3,157).

A genetic-based wolverine study in Scandinavia found that "females often reproduced with the same male in subsequent breeding years" (Hedmark *et al*. 2007, p. 18). However, this study also found (with some assumptions regarding sampling and paternity) that 8 of 13 female wolverines bred with different males, and, based on telemetry results, 2 females bred with a new male even though their previous breeding partner was still alive (Hedmark *et al*. 2007, p. 18). This shift in partners may have resulted from a change in the resident male wolverine in the area (Hedmark *et al*. 2007, p. 19).

The reproductive rate of wolverines is relatively low. An early study of 31 wolverine dens in Finland, as reported by hunters, found an average of 2 young per den (range 1–4) (Pulliainen 1968, pp. 338–341). Average litter size for northern Europe (161 litters) was 2.5 (range 1–4) (Pulliainen 1968, p. 343). In Alaska, average litter size was reported as 1.75 young, with a reproductive rate of 0.69 young per adult female per year (Magoun 1985, p. 28). A summary of average litter size for earlier studies of New World and Old World wolverines, based on method of determination, was presented in Magoun (1985, p. 29), indicating a range of 2.2 to 3.5. Anderson and Aune (2008, entire) evaluated pregnancy rates based on presence of corpora lutea (CL) and fetuses in trapper-harvested wolverines from western Montana. That study found median CL counts for pregnant adults ranging from 1.6 to 3.0, depending on the subpopulation (Anderson and Aune 2008, p. 22), with a mean litter size based on number of fetuses for pregnant adult females of 2.6 (Anderson and Aune 2008, p. 23). Studies of telemetered female wolverine in Scandinavia, from 1993 to 2002, reported a mean litter size of 1.88, with a range of 1 to 4 young, with a mean annual birth rate of 0.74 young per female (Persson *et al*. 2006, pp. 76–77). More recently, the average number of young per female per year reported for wolverines in Sweden was 0.84 (range 0–3); however, for those animals with recorded denning behavior, this value increased to 1.38 (range 0–3) (Rauset *et al*. 2015, p. 3,157).

Results from studies of telemetered female wolverines indicate that studies of wolverine reproductive tracts are likely to overestimate wolverine productivity (Persson *et al*. 2006, p. 77). Their findings suggest that young are either lost during pregnancy, early after parturition, or both; the losses likely do not occur before implantation (Persson 2006, p. 77). However, the factors that contribute to the observations that female wolverines do not give birth during some years are not well understood, and could be due to failure to breed, pseudo-pregnancy (as demonstrated by Mead *et al*. 1993, entire), failure of a fetus to implant, absorption of implanted fetus, stillbirth, or mortality before emerging from den (e.g. infanticide, etc.) (Magoun 2013, pers. comm.).

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Carnivorous mammals generally have altricial young (poorly developed and dependent young (Derrickson 1992, p. 58)), and prepare shelter in dens where the mother can feed their young and keep them warm (Irving 1972, p. 174). Young wolverines (kits or cubs) weigh about 0.1 kg (3.5 oz) at birth and are blind until about 4 weeks of age (Krott 1960, p. 23). Newborns are covered with whitish to yellow hair (Krott 1958, p. 87; Mehrer 1976, p. 570), 4.5 millimeters (mm) (0.18 in) in length (Shilo and Tamarovskaya 1981, p. 147), with unerupted teeth (Mehrer 1976, p. 570; Pasitschniak-Arts and Larivière 1995, p. 5) and closed ear canals (Shilo and Tamarovskaya 1981, p. 147).

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Mustelids, in general, have a short period of growth (Iversen 1972b, p. 317). As noted above, the metabolism of young wolverines is highest during the first 2.5 months, and individuals are almost two-thirds grown by the fall (at about 6 months) (Krott 1960, p. 25). As described by Shilo and Tamarovskaya (1981, p. 146), 45-50 day old wolverines (Norway) have woolly coats, are muddy grey in color, with teeth beginning to erupt at this age. At about 150 days, all permanent teeth have been established (Shilo and Tamaovskaya 1981, p. 147). After 2.5 months, young wolverines replace their juvenile coat with the adult summer coat (Shilo and Tamarovskaya 1981, p. 147). With growth ending at about 8 months (Iversen 1972b, p. 320; Magoun 1985, p. 23), wolverines are generally full grown by October or November.

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Use of Dens and Denning Behavior

Dens and breeding burrows of animals are, in general, carefully constructed, well-camouflaged, and located in areas not easily accessible (Novikov 1962, p. 25). Wolverines use both natal dens (used for birthing) and maternal dens (used subsequent to natal den and before weaning) for rearing young (Magoun and Copeland 1998, p. 1,314). They are generally not left alone at the den during the first 3-4 weeks (Krott 1958, pp. 88, 108). The young remain at the natal den site for 6 to 8 weeks (Krott 1960, p. 24), and are weaned at 9 to 10 weeks (Copeland 1996, p. iv (Central Idaho); Koskela *et al*. 2013a, p. 101 (Finland)) (*cf*. 7 to 8 weeks reported by Myhre and Myrberget, 1975, p. 754 (Norway)). After weaning, the young are dependent on the mother and begin to travel with her by late April (Koskela *et al*. 2013a, p. 101 (Finland)). Observations of wolverines in central Idaho reported that females traveled up to 17.9 km (11 mi) from maternal dens to forage (Copeland 1996, p. 97). A study of telemetered wolverines in Scandinavia found that, on average, a female wolverine spends most of her time within 1,000 m (3,281 ft) of the reproductive den during the denning period (Myhr 2017, no page number). The average relocation distance to maternal den sites for active wolverine den sites studied in Norway was 268 m (879 ft) (95% confidence interval: 40–497 m (131–1,631 ft)) (May *et al*. 2012, p. 199).

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The exact timing of when females abandon natal dens and begin using maternal dens is difficult to establish (Inman *et al*. 2012b, p. 638). In general, studies have found that den abandonment (natal) occurs before May (Magoun and Copeland 1998, p. 1,315; Table 1; Inman *et al*. 2012b, p. 637; Figure 2). A study by Aubry *et al*. (2016, p. 24) reported that a female wolverine moved her single young (estimated to be at least 9 weeks old) from a natal den in *late April* in the North Cascades region of Washington. More recently, a comprehensive study of wolverines in Scandinavia found that females begin to shift den locations more frequently beginning in *late April* as young are more mobile and are more reliant on solid food brought to them by the mother (Aronsson 2017, p. 46). Natal den abandonment in Alaska and Idaho reportedly "coincided with

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a period when maximum daily temperatures rose above freezing for a number of days for the first time since denning commenced" (Magoun and Copeland 1998, p. 1,316). Factors other than temperature can influence shifts in the locations of these dens, including intraspecific predation, parasites, or other disturbances (Inman *et al*. 2012b, p. 638). In central Idaho, Copeland (1996, p. iv) concluded that human disturbance at maternal den sites resulted in den abandonment, but not abandonment *of young*.

Rendezvous sites are locations in which the female leaves young while she hunts for food, and from which they will not leave without her (Magoun 1985, pp. 16, 77). These areas provide security to young (Copeland 1996, p. 94) and serve as locations at which females bring food to the young, or from which she will guide them to a food source (Inman *et al*. 2012b, p. 638). Rendezvous sites of wolverines studied in central Idaho consisted of large boulder talus or riparian areas associated with mature overstory and dense timber deadfall (Copeland 1996, p. iv). Magoun (1985, p. 76) reported that rock caves and hilltops containing boulders without large snowdrifts were used as rendezvous sites in Alaska. Females may move their young to new rendezvous sites several times over a two month period (Magoun 1985, p. 73), and distances between consecutives sites have been reported as far away as 8.5 km (5.3 mi) (Magoun 1985, p. 76).

Studies of adult female wolverines in Scandinavia (northern Sweden) have provided additional details regarding the temporal patterns of reproductive behavior and den site use. Aronsson (2017, p. 45) (see also Persson *et al*. 2017, *in prep*) found that, in general, most births occurred in mid-February. Females spend very little time outside the natal den for the first 2 weeks (Aronsson 2017, p. 45). During the first period of den site use, or approximately 2 to 2.5 months from mid-February (when females generally give birth and are lactating), females will move short distances and do not need to bring food to young (Aronsson 2017, p. 46). This time period generally coincides with snow cover and favorable conditions for food caching, and dens offer protection from predators and the environment (Aronsson 2017, p. 46). In addition, during the first 1.5 months of the denning period, females rarely changed den sites, but begin to move outside the den in early March (Aronsson 2017, p. 45). In the later denning period (after April 15), females begin to move more frequently and at greater distances between den sites (Aronsson 2017, p. 45). By late April, the young are more active and also begin to rely more on solid food that is brought back to them by their mother (Aronsson 2017, p. 46). This also corresponds to a time period when prey are more available (e.g., reindeer migration and calving period in Sweden and emergence of hibernating rodents in the spring (Yates and Copeland 2017, *in prep*) and expected shorter distance movements by the mother back to denning or rendezvous sites (Aronsson 2017, p. 46). These observations are consistent with Inman *et al*.'s (2012b, entire) proposed cold, low productivity niche for wolverines based on studies of wolverines in the Greater Yellowstone Ecosystem. That is, reproductive chronology in wolverines is considered to be adapted to take advantage of the availability of food resources, limited interspecific competition, and snow cover in the winter (Inman *et al*. 2012b, p. 635).

In summary, as described by Inman *et al*. (2012b, entire) and Persson *et al*. (2017, *in prep*), reproductive behavior of wolverines reflect seasonal shifts in resource abundance within the wolverine's range; that is, adaptation that matches the time of birth and development of young to changes in the availability of resources and foraging strategies (Persson *et al*. 2017, *in prep*). We

present in Figure 4 a visual summary of wolverine feeding strategies relative to resource availability from time of birth to post-weaning.

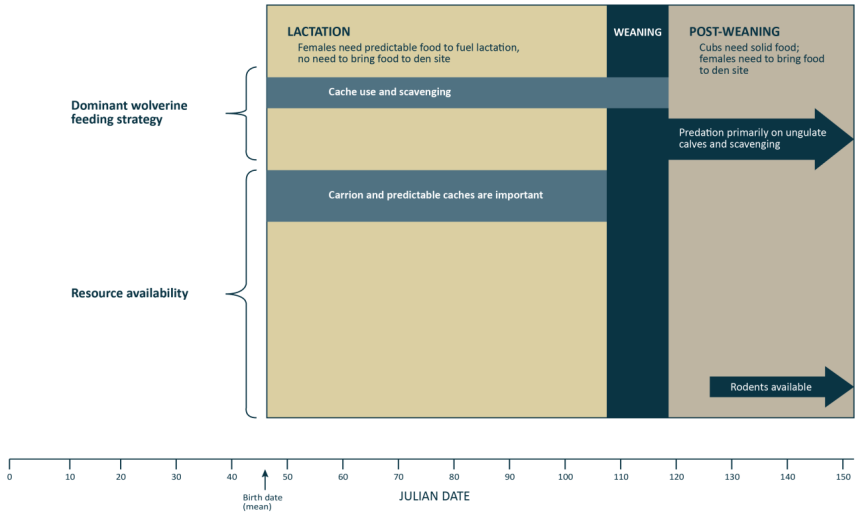

Figure 5. Wolverine feeding strategies relative to resource availability. Adapted from Persson *et al*. 2017, *in prep*.

Denning Habitat

Given the wolverine's observed association with snow, we provide in **Box 1** a summary of the importance of snow, in general, for ecological systems. This summary provides a detailed perspective of how various physical properties of snow can influence ecological systems occupied by snow-adapted wildlife, including insulating properties, differences in snow cover in mountainous vs. forested habitat, and changes in snow cover due to wind and slope/aspect.

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Commented [SJ14]: I lean towards keeping it. Shows that not all snow is equal, and it varis within habitats, important to keep inmind when considering snow as it reltates to wolverines. Some of it is common sense, but good to attribute it to a citation a least.

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Box 1. Snow Cover in an Ecological Context

Formozov (1961; 1963) prepared comprehensive reviews of the unique properties of snow in the context of its role in the ecology of animals and plants in Russia. In his 1963 review (translated from the 1946 original), he identified two important factors attributed to snow cover — nastization (the thickness of the crust on the surface of mature snow cover) and firnization (process of snow compaction) — relative to its ecological influence (Formozov 1963, p. 8). Snow cover provides not only a substrate that allows some animals to move across the landscape, it also provides a matrix within which other animals can create tunnels and build nests (Formozov 1963, p. 8). Additional fundamental concepts described in this study are provided below:

- Snow has very low thermal conductivity which promotes cooling at the surface while at the same time protects the deeper layers from chilling; but this property varies by region, by depth, by season, and by year (e.g., the more continuous the snow cover during winter, the greater the warming effect); as snow changes to ice (through compaction and melting), the thermal conductivity decreases (Formozov 1963, pp. 7, 8, 108)
- Snow therefore creates a thermo-insulating layer, which allows for a unique temperature regime on the surface and underneath; as an example, soil temperatures measured in January (near Saint Petersburg, Russia) averaged 15°C higher with snow cover than without snow cover, with up to a 32°C difference, depending on the day and depth measured (Formozov 1963, p. 109)
    - At 20–25 cm snow cover, the insulative effect is particularly important for winter nesting of small mammals (Formozov 1963, p. 110)
- Snow cover in mountains:
    - Depth of snow cover and its duration increases with elevation; even minor elevation differences are noticeable (Formozov 1963, p. 123)
    - This spotty distribution is also affected by unequal distribution of snow precipitation on slopes with different exposures, transport of snow by wind, melting of snow on sun-exposed slopes, avalanche or rolling down of snow from steeper areas, and vegetation (Formozov 1963, p. 123)
    - Snow cover areas near Arctic limits and at treeline in mountain regions is more strongly influenced by wind (which compacts and re-works snow cover) (Formozov 1963, p. 29)
- Snow cover in forests:
    - The maximum depth, density, duration and date of melting, thickness of snow surface crust are all much different in forested areas as compared to open treeless areas (Formozov 1963, p. 19)
    - Snow accumulates slowly under trees and is generally thicker the further away from the forest than within the forest; thus, the compaction and settling of snow under a forest canopy is less than tundra or open fields (with a less icy crust), so for some vertebrates, forested areas can provide a more preferable place to winter or migrate (Formozov 1963, pp. 24, 26)
    - Snow cover in forested areas also melts slower than open fields and clearings (Formozov 1963, p. 28)
- Snow cover also plays an important role in the overwintering conditions for insect eggs, caterpillars, pupae, and adult insects in litter and soil (Formozov 1963, p. 121)

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Wolverine denning habitat varies over its Holarctic range and is dependent on regional environmental conditions. For example, in southcentral Norway, wolverine dens were snow tunnels dug into deep snow at the tree line (elevation 1,100 m (3,609 ft)), but most of the tunnel systems extended down to boulder fields, talus slopes, or rock crevices such that young could crawl around within these structures (May *et al*. 2012, p. 201). Snow tunnels are also reported for wolverine natal dens in Alaska (Magoun 1985, pp. 84, 185, 190). However, reproductive dens are not always excavated in deep snow. In Canada, female wolverines are said to give birth in dens where snow cover persists at least until April, and can den under snow-covered rocks, logs, or within snow tunnels (COSEWIC 2014, p. v). As an example, in northwestern Ontario, den site habitat for a female in lower Boreal Forest habitat (elevation 250 to 500 m (820 to 1,640 ft), 51°N) included large boulders and downed trees, similar to dens described for wolverines in montane ecosystems (Dawson *et al*. 2010, p. 139). Large diameter, downed trees can also provide structure for den sites. In Finland, Pulliainen (1968, p. 340) reported a den site (January) at the base of a tree and not covered in snow, and also described other structural features such as rocks, fallen trees, and deep ravines as denning habitat (likely both natal and maternal dens) (Pullianinen 1968, pp. 338–341). In Russia, where wolverine habitat has been described as located far from human-inhabited areas within boreal forests and, to some extent, tundra, and taiga (Novikov 1962, pp. 199, 200), den locations were described as "clefts in rocks, among stones, and under roots of upturned trees" (Novikov 1962, p. 200). A study from northwestern Ontario noted that, because lowland boreal forest habitat in this region does not support deep, wind-hardened snowdrifts, other structural elements within snow layers such as trees and boulders can be important components of wolverine denning habitat (Dawson *et al*. 2010, p. 142).

Although it has been assumed that wolverines have an obligate relationship with snow for natal denning, including persistent spring snow cover, the key elements or combination of elements that define this relationship have not been empirically analyzed. Limited studies to date have evaluated the importance of denning habitat to reproductive success, or the key physiological and ecological characteristics, including avoidance and/or protection from predators, prey availability, availability of caching habitat, that define denning behavior and den site selection. Population density, trapping pressure, population genetics, and other measures of habitat quality may also influence wolverine fecundity (Anderson and Aune 2008, p. 28). Habitat features that facilitate caching (e.g., restricted access and cold temperatures) are also likely to be important for wolverine reproduction (Inman *et al*. 2012b, p. 640). Studies of wolverine denning activity have not reported the condition of the natal or maternal den location following abandonment; that is, what is the persistence and/or depth of snow at the natal den at the end of the denning season, and how does this affect survival of young? In addition, previous accounts of den site locations for North America have been biased to tundra regions where dens are more readily observed and located (Banci 1994, p. 110). In Scandinavia, snow cover also had been found to be a poor technique for tracking female wolverines during the time when they give birth and initiate denning (Aronsson and Persson 2016, p. 266).

As noted above, adult wolverines have a wide range of thermoneutrality. However, newborns, who are born with lighter, less dense fur are likely to have a more limited ability to control their internal temperature, though huddling (a thermotactic behavior) of small mammals in dens can

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Another key element related to den location is the protection that dens provide to a nursing female and her young. Because wolverines are known to den in a variety of structures, it is unclear if the apparent relationship to snow cover is based on selecting den locations in remote, high elevation areas to avoid predators. Bare rock and boulders at den sites can offer dry and secure cavities and enhance the ruggedness of the landscape (May *et al*. 2012, p. 198). "Ruggedness," a measure derived from elevational changes and irregularity of land surface (density of contour lines) traversing a given area (Beasom *et al*. 1983, p. 1,163) has been found to be an important variable (i.e., secure habitat from predation risk) for female wolverines in winter (British Columbia, Canada) (Krebs *et al*. 2007, p. 2,188) and for den site selection at site-specific, home range, and landscape scales (southcentral Norway) (May *et al*. 2012, pp. 200–201). ¶

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conserve heat (Barnett and Mount 1967, p. 439). Relatedly, basal metabolic production of heat is the source of heat that maintains bodily warmth, and is not easily modifiable unlike the flexibility of insulation (Irving 1972, p. 121). Metabolic heat above an animal's basal rate for preservation of warmth is restricted by its limited capacity for metabolic production of heat, but also by food availability and the time and opportunity for nourishment (Irving 1972, p. 121). In general, metabolic production of heat is costly to animals, but variable insulation represents a conservative strategy (Irving 1972, p. 121).

A bioclimatic model was used by Copeland *et al*. (2010, p. 234) to test the following hypothesis: "…wolverine distribution at the broadest spatial scale is constrained within a climatic envelope defined by an obligate association with persistent spring snow cover and by an upper limit of thermoneutrality." This hypothesis was based on the premise "If persistence of wolverine populations is linked to the availability of suitable reproductive den sites ([citing] Banci 1994), snow cover that persists throughout the denning period may be a critical habitat component that limits the wolverine's geographic distribution" (Copeland *et al*. 2010, p. 234). The authors tested this hypothesis by "comparing and correlating the locations of wolverine reproductive dens from throughout their circumboreal range, and telemetry locations from 10 recent wolverine studies in western North America and Scandinavia, with spatial models representing the distribution of spring snow cover and average maximum August temperatures" (Copeland *et al*. 2010, p. 234).

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Bioclimatic models "use associations between aspects of climate and known occurrences of species across landscapes of interest to define sets of conditions under which species are likely to maintain viable populations" (Araújo and Peterson 2012, p. 1,527). They are correlational by nature and are often applied to study a variety of conservation issues, including forecasting potential climate change effects on species' distributions (Araújo and Peterson 2012, p. 1,527). These types of correlational models have received some criticisms and require careful framing to avoid misapplication (Sieck *et al*. 2011, p. 6; review by Araújo and Peterson 2012, entire). They generally represent a first step for evaluating current and future species distributions, and, when coupled with climate change scenarios, results are presented at a coarse scale that may not accurately project shifts in species distribution at a smaller scale (Sieck *et al*. 2011, p. 6). In particular, when used to estimate extinction risk, these types of models provide only an estimate of the empirical relationships between a species' current distribution and climate variables and then use inferred relationships to identify potential areas where the species is distributed under future climate scenarios (Araújo and Peterson 2012, p. 1,553). Extinction risk is not represented in the model's input data and therefore is not the targeted parameter of the model; thus, a bioclimatic model's usefulness may be limited in these types of applications given that it only offers partial explanatory evidence for reasons for potential extinction related to the shifts in climate suitability within the time frame being modeled (Araújo and Peterson 2012, p. 1,533 and citations therein). In addition, climate niche projections generally do not incorporate factors such as competition, dispersal, and evolutionary capacity, which also influence range boundaries (Michalak *et al*. 2017, p. 370). Thus, these types of models are more applicable at broad scales in which the effects of fine-scaled topography and biological interactions play a more limited role (Michalak *et al*. 2017, p. 370); however, both of those factors are important for wolverine, particularly at the den-site scale.

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As noted above, Copeland *et al*. (2010, entire), used a bioclimatic model to evaluate an assumed association not at the den site scale, but at a broad scale. The results presented in Copeland *et al*. (2010, entire) were based not on the condition of snow cover at a particular den site at the time of denning, but rather their evaluation of snow persistence (April 24 to May 15) was based on satellite images summed over a 7-year period (2000 to 2006) for the den locations. The spatial resolution of the snow measurement used to detect daily snow cover was 500 m by 500 m (1,640 ft by 1,640 ft), using Moderate-Resolution Imaging Spectroradiometer (MODIS). If persistent snow cover was observed in any one year, it was included in the bioclimatic model regardless of whether denning occurred during that particular year.

In addition, although the study found that 69 percent of dens for North American wolverines were located within satellite images (pixels) in areas that had snow cover for 6 or 7 years, out of 7 years, one-third (31 percent) of the identified den locations were located in areas that were identified as having spring snow cover 5 years or less, out of 7 years (from April 24 to May 15). However, snow depth was not defined in Copeland *et al*. (2010). Also, the den location attributes (e.g., den structure, how long it was used) were not recorded relative to the observed persistent snow cover and some of the 562 dens (e.g., Norway) were identified by snow tracking rather than direct observation.

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In summary the results presented by Copeland *et al*. (2010, entire) provided a fairly accurate, albeit broad, assessment at that time of where wolverine populations are expected to be observed, but did not evaluate (model) snow persistence at the den site scale based on location and denning period.

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Since the 2013 (78 FR 7864; February 4, 2013) proposed listing rule and 2014 (79 FR 47522; August 13, 2014) withdrawal of the proposed listing rule for the wolverine, several publications have presented additional study results related to wolverine distribution and snow cover. In Alberta, Canada, Webb *et al*. (2016, entire) found that, based on wolverine harvest data, wolverine occurrence (but not reproductive den sites) relative to spring snow cover (percent of area covered, with greater than 75 percent snow coverage, on April 1 and 15) varied based on the different regions of Alberta. This study used meterological data from 2009 to 2015, in northern Alberta (north of 54°N) and differentiated between spring snow cover that persisted in ≥ 1 of 7 years and more frequently (≥4 of 7 yr) (Webb *et al*. 2016, pp. 1462–1464). Although the study found an overall positive trend of more frequent wolverine harvests in those areas expected to have spring snow cover, the study did not find consistent large differences between these areas, and did not typically detect significant relationships with frequent spring snow cover (4–7 years) in all regions (Webb *et al*. 2016, p. 6). The Rocky Mountains region was the only region in which wolverines were reported in areas with more frequent spring snow cover (4–7 years) (Webb *et al*. 2016, p. 5). This region, which is located along the western border of Alberta, contains montane, subalpine and alpine habitat, with elevations from 1,000 m (3,281 ft) to 3,700 m (12,139 ft) (Webb *et al*. 2016, p. 9). Conversely, the study found that in the Boreal Forest region of Alberta (i.e., wetland habitat interspersed with coniferous, mixed wood, and deciduous forests, with elevations between 1,500 m (4,921 ft) to 1,100 m (3,609 ft)), a female wolverine denned under large boulders and downed trees (Webb *et al*. 2016, p. 8). Further, the study reported that all female wolverines that were positively identified from camera trapping

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(including five lactating females) were found in townships where no spring snow cover was predicted (Webb *et al*. 2016, p. 1,461).

Results from another recent Alberta study (Heim *et al*. 2017, entire) evaluated cumulative effects of climate and landscape change, using species distribution models, relative to the spatial distribution of the wolverine. Persistent spring snowpack was a significant predictor for wolverine distribution as was anthropogenic landscape changes (Heim et al. 2017, p. 8,908; Table 2). The study found that a cumulative effects model provided the best support for predicting wolverine frequency, which suggests that no single factor explains wolverine distribution (Heim *et al*. 2017, p. 8,908).

The study presented in Webb *et al*. noted that wolverine den locations within low elevation, forest habitats have not been well-described (Webb *et al*. 2016, p. 8). In boreal forested habitat in Russia, Novikov (1962, p. 200) reported wolverines denning in rock areas and in tree root structures. A similar finding was reported in Sweden, where a majority of dens (n=49) were in boulder areas located within mature, mixed coniferous forests (i.e., not alpine or tundra habitat) (Makkonen 2015, p. 14). A recently published study reported two wolverine natal dens in logged areas (cutblocks) in northern Alberta, Canada; specifically, within a slash pile and log deck (Scrafford *et al*. 2017, p. 35).

A study of wolverine populations and distribution in Sweden observed that wolverine populations were found outside areas with persistent spring snow cover (mean snow depth and proportion of years with snow cover on March 15; 1961–1990) and expanding into boreal forest habitat located to the east and south of alpine areas (Aronsson and Persson 2016, p. 266). This southern and eastern expansion (from 1996 to 2014) indicates recolonization of their historical distribution in Sweden, and is thought to be the result of an increase in population, with more dispersers colonizing forest habitat, and an increase in year-round scavenging opportunities due to an increase in Scandinavian wolf packs (Aronsson and Persson 2016, p. 266; Aronsson 2017, pp. 43–44). As of the spring of 2017, over 80 reproductive dens have been observed outside the boundary of the snow model presented in Copeland *et al*. (2010) (Persson 2017, pers. comm.).

Another key element related to den location is the protection that dens provide to a nursing female and her young. Because wolverines are known to den in a variety of structures, it is unclear if the apparent relationship to snow cover is based on selecting den locations in relatively inaccessible, high elevation areas to avoid predators. Bare rock and boulders at den sites can offer dry and secure cavities and enhance the ruggedness of the landscape (May *et al*. 2012, p. 198). "Ruggedness," a measure derived from elevational changes and irregularity of land surface (density of contour lines) traversing a given area (Beasom *et al*. 1983, p. 1,163) has been found to be an important variable (i.e., secure habitat from predation risk) for female wolverines in winter (British Columbia, Canada) (Krebs *et al*. 2007, p. 2,188) and for den site selection at site-specific, home range, and landscape scales (southcentral Norway) (May *et al*. 2012, pp. 200–201).

Snow depth can be affected at a local level by terrain, ruggedness, slope and aspect as well as wind and vegetation cover. For example, slope and aspect together will affect the exposure to snow accumulation (May *et al*. 2012, p. 198). In an effort to document and compare snow persistence at the wolverine den-site scale, Magoun *et al*. (2017, entire) evaluated the use of low-altitude aerial photography during late May 2016 in areas within the Rocky Mountains (Idaho

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and Montana) and northwestern Alaska. In Idaho and Montana, flight lines were established along transects through the long axis of previously documented home ranges of denning female wolverines and, in Alaska, known den sites (from 2016) were visited by helicopter and remaining snow was photographed (Magoun *et al*. 2017, p. 383). Transect segments in the Rocky Mountain study areas documented snow on May 31 in all but one segment, with 82 percent classified in low to heavy snow retention categories, and 58 percent considered as moderate to heavy (Magoun *et al*. 2017, p. 383). In the Alaska study area, photographs documented widely scattered patches of snow on May 29, with remnant snowdrifts observed at all four wolverine den sites (Magoun *et al*. 2017, p. 383). The documentation of the existence of scattered patches of snow in the Rocky Mountains persisting into late May in areas previously detected to be bare of snow on May 29 (MODIS persistent spring snow cover, McKelvey *et al*. 2011, p. 2,889, Figure 4D; Magoun *et al*. 2017, p. 384, Figures 2b and 2d) suggests that persistent spring cover may not always be detectable at the den-site scale using remote sensing methods (Magoun *et al*. 2017, p. 384).

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To evaluate, at a finer scale, snow cover at previously recorded den site locations in the western United States, we reviewed natal, maternal, and known den sites relative to derived 'melt-out' dates using MODIS/Terra Snow Cover, 8-day series (Hall and Riggs 2016). Melt-out dates represent the first day of the 8-day composite series when the cell in which the den was located switches from "snow" to "no snow." Snow cover was identified using the Normalized Difference Snow Index (NDSI), on a scale of 0 to 1.0, where NDSI greater than 0.1 is considered "snow." The spatial resolution for these data is 500 m by 500 m (1,640 ft by 1,640 ft). Because MODIS data was only available from the years 2000 to present, we were only able to evaluate 34 of the 47 den sites documented in our records. As shown in Table 3, the earliest melt-out date was May 14 (2006) and the latest was July 12 (2002).

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Table 3. Wolverine Den Site Melt-Out Dates, 2002–2015.

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Den #	Den Type	Melt-out Date	Elevation, meters (feet)	Structure	State
1	Unknown	7/12/2002	1,814 m (5,951 ft)	None Listed	WA
2	**Natal**	5/25/2003	1,928 m (6,326 ft)	Log Complex	MT
3	Maternal	5/25/2003	1,995 m (6,545 ft)	Log Complex	MT
4	**Natal**	6/4/2004	1,807 m (5,923 ft)	Log Complex	MT
5	**Natal**	6/9/2004	2,399 m (7,871 ft)	None Listed	WY
6	**Natal**	6/17/2004	2,487 m (8,160 ft)	None Listed	MT
7	Maternal	6/29/2004	1,823 m (5,981 ft)	Downed Log	MT
8	Maternal	6/29/2004	1,893 m (6,211 ft)	Log/Boulder	MT
9	Maternal	6/11/2005	1,912 m (6,273 ft)	Spider Tree	MT
10	Maternal	6/11/2005	1,973 m (6,473 ft)	Spider Tree	MT
11	**Natal**	6/11/2005	1,977 m (6,486 ft)	Spider Tree	MT
12	**Natal**	7/12/2005	2,693 m (8,835 ft)	None Listed	MT
13	Unknown	5/14/2006	1,514 m (4,967 ft)	Log Complex	MT
14	Unknown	5/25/2006	2,093 m (6,867 ft)	None Listed	MT
15	Maternal	5/31/2006	1,851 m (6,073 ft)	Log Complex	MT
16	**Natal**	5/31/2006	1,843 m (6,047 ft)	Log Complex	MT

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17	Unknown	6/7/2006	2,252 m (7,389 ft)	None Listed	MT
18	**Natal**	6/18/2006	2,695 m (8,842 ft)	None Listed	MT
19	**Natal**	5/25/2007	2,820 m (9,252 ft)	None Listed	MT
20	**Natal**	6/4/2007	1,922 m (6,306 ft)	Log/Boulder	MT
21	Unknown	7/3/2008	2,505 m (8,219 ft)	None Listed	ID
22	**Natal**	6/26/2010	2,276 m (7,466 ft)	Boulder/Downed Log	ID
23	**Natal**	6/18/2010	2,216 m (7,270 ft)	Boulder	ID
24	**Natal**	6/26/2010	2,223 m (7,293 ft)	Boulder/Talus Field	ID
25	Unknown	6/26/2010	2,402 m (7,882 ft)	Boulder	ID
26	**Natal**	7/4/2011	2,167 m (7,110 ft)	Tree Complex	ID
27	Unknown	7/4/2011	2,130 m (6,989 ft)	Tree Complex	ID
28	Unknown	7/4/2011	2,147 m (7,043 ft)	Tree Complex	ID
29	**Natal**	6/9/2012	2,311 m (7,582 ft)	Log Complex	ID
30	Unknown	6/25/2012	2,318 m (7,604 ft)	Downed Log Complex	ID
31	Unknown	6/9/2012	2,350 m (7,711 ft)	Downed Log Complex	ID
32	**Natal**	6/10/2013	2,911 m (9,552 ft)	Boulder Field	ID
33	**Natal**	6/26/2014	2,218 m (7,278 ft)	Boulder Field	ID
34	**Natal**	6/10/2015	2,713 m (8,901 ft)	Boulder Field	MT

For *natal* den sites only, the range for melt-out dates was May 25 to July 12. All of these sites indicate a melt-out date that is past the May 15 date used for the persistent spring snow cover model presented in Copeland *et al*. (2010), which suggests that snow is persistent at these locations past the time when young begin moving out of natal dens (i.e., late April; see Use of Dens and Denning Behavior section).

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Other physical or biotic variables are also likely to be important for wolverine den site locations. Elevation affects snow depth and persistence at the landscape scale (May *et al*. 2012, p. 198). Inman *et al*. (2012a, p. 782) found that wolverines (12 females and 6 males) monitored in the Greater Yellowstone Ecosystem selected, on an annual basis, areas above 2,600 m (8,530 ft) latitude-adjusted elevation. In central Idaho, natal dens were also found in secluded, high elevation (above 2,500 m (8,202 ft)) cirque basins (Copeland 1996, p. 94).

We evaluated 47 den sites in the lower United States using a linear regression model to evaluate whether the elevation of wolverine den sites is related to latitude. We note here that not all of these dens were characterized as to whether they were natal or maternal dens, a few records were not verified through tracking of females or direct observations, and these den locations may not be representative of all current or potential wolverine den sites in the western-northwestern United States. Given these caveats, our examination of these records indicated that, in general, wolverine dens at lower latitudes (36 to 38°N) occur at higher elevations (range: 2,688 to 3,562 m) (8,819 to 11,686 ft) while the converse is seen for those dens at higher latitudes, or approximately 44 to 49°N (range: 1,514 to 2,911 m) (4,967 to 9,552 ft). Given our assumptions (small sample size, test of normality), we used linear regression (R Software; R Development

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Core Team, 2014) to test this association. We found a moderately significant association with elevation and latitude [adjusted R^2 = 0.68.56, F = 101.3, df=45; *p-value* = 4.23 x 10^{-13}], such that dens found at lower elevations were located at more northerly latitudes. These results suggest that other potential explanatory variables or interactions between variables should be considered using multiple regression techniques.

The steep slopes found at higher elevations also provide conditions conducive to avalanches, which result in debris and talus/boulder piles that provide structure for dens (Inman 2013, pers. comm.). Steep slopes and the availability of rocks were found to be important to wolverine den site selection for wolverines studied in Norway (May *et al*. 2012, p. 200). These areas also offer either exclusive or higher frequencies of maternal food sources during the high energy demands for reproducing females, such as marmot emerging from hibernation and neonatal or avalanche-killed ungulates (Inman 2013, pers. comm.) (see *Diet and Feeding* discussion below).

In summary, wolverines select den sites for different characteristics depending on location. Dens located under snow cover may be related to wolverine distribution based on other life history traits, including morphological, demographic, and behavioral adaptations that allow them to successfully compete for food resources (Inman 2013, pers. comm.). Structure (e.g., uprooted trees, boulders and talus fields) appears to be important for natal den sites with or without snow cover. Sensitivity to human disturbance and predator avoidance are also likely important factors in selecting both natal and maternal den sites. However, reproductive success of wolverines has not been evaluated relative to the depth and persistence of snow cover, or in combination with these or other important characteristics, including prey availability and predator avoidance. Based on their study of wolverines in Alberta, Canada, Webb *et al*. (2016, p. 1,468) concluded that wolverines appear to be are adaptable and do not require large areas of deep spring snowpack for successful reproduction. They suggest that "wolverines may select small areas covered with deep snow at a finer scale than can be detected using satellite imagery, but the amount of snow needed over what portion of the denning duration remains uncertain" (Webb *et al*. 2016, p. 1,468, citations omitted). They add that temperature may play a more important role in determing the distribution of wolverines and restricting the wolverine's niche to cooler environments where wolverines have the competitive edge (citing Aubry et al. 2007, Copeland et al. 2010, Inman et al. 2012) (Webb *et al*. 2016, p. 1,468). Additional studies are needed to further document wolverine den structure, snow conditions at dens, and how long dens are used, particularly for those locations outside of areas expected to have spring snow cover, to better understand the relationship of wolverines and snow cover (Webb *et al*. 2016, p. 8; Magoun *et al*. 2017, pp. 6–7).

Demography

The lifespan of the wolverine is variable. Jackson (1961, p. 361) reported an upper range of 8–10 years in the wild and potentially up to 18 years in captivity. Based on trapper-submitted carcasses from the Yukon, an upper age of 11.9 years for a male wolverine and 12.9 years for (pregnant) female was reported (Jung and Kukka 2013, pp. 8, 12). Inman *et al*. (2012a, p. 781) classified wolverines less than 1 year old as juveniles (or kits/cubs), those 1 to 2 years old as subadults, and those at least 3 years old as adults. Generation time for wolverines has been estimated at 7.5 years (COSEWIC 2014, p. 23).

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Survival of adult female wolverines is considered to be an important demographic parameter in the wolverine's life history (Sæther *et al*. 2005, entire). As noted by Aronsson (2017, p. 13), because most polygamous species display a dispersal pattern that is sex-based, their population distribution is generally limited by the dispersal behavior of the sex that is more philopatric (the tendency of a species to remain within or return to its birth area). Thus, the distribution of wolverine populations and colonization is generally limited by dispersal of female wolverines (Aronsson *et al*. 2017, p. 2).

Stochastic factors (both demographic and environmental) also strongly influence the population dynamics of the wolverine (Sæther *et al*. 2005, p. 1,011–1,012). Given the rapid maturity of young wolverines, survival of female wolverines with young is likely dependent on the availability and distribution of food sources during the "snow-free season" (late spring and summer) (Banci 1994, p. 114). For example, a study of wolverines in Norway found that survival of young was primarily influenced by the abundance of small rodents (Landa *et al*. 1997, p. 1,293).

Evaluating how variations in demographic rates are influenced by the interactions between costs of reproduction, individual quality (e.g., breeding status), and environmental factors can provide a better understanding of the dynamics and viability of animal populations (Robert *et al*. 2012; p. entire; Rauset *et al*. 2015, entire). The interactions between individual age, environmental resources, and reproductive costs of wolverines in Sweden were recently examined (Rauset *et al*. 2015, entire). The results of this study provide important details regarding the influences on wolverine reproduction productivity. The study found that age-related variation in reproductive output for female wolverines is driven by the interactions between age, reproductive costs, and availability of resources (Rauset *et al*. 2015, p. 3,160). As an example, female wolverines were found to be more likely to give birth and nurse young in home ranges with greater food resource abundance at the time of fetal development (Rauset *et al*. 2015, p. 3,158). The study also concluded that a favorable reproductive strategy for female wolverines is a conservative one, wherein older female wolverines do not "trade" current reproduction against their own survival (Rauset *et al*. 2015, p. 3,161).

Intraspecific predation of wolverines is another important influence on wolverine population dynamics (Persson *et al*. 2003, p. 26). The altricial life history stage (early May to end of July) is likely a period of high juvenile mortality in solitary carnivores, such as the wolverine, since females are balancing the energetic demands of lactation (Sadleir 1984, pp. 179–180) and providing protection to young (Persson *et al*. 2003, p. 22). Young (juveniles) wolverines are vulnerable to predation during the time period when left unattended in the natal den (generally March-April) and when they first exit the natal or maternal den and are left at rendezvous sites, or around May-early July (Magoun 1985, pp. 49, 73, 77). An additional vulnerability occurs when juvenile wolverines are required to become nutritionally independent and begin exploratory movements away from their mother's protection, generally August-September (Vangen *et al*. 2001, p. 1,644).

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Mortality

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There are a few natural predators of wolverines, but interactions with wolves can lead to severe injury and death (Burkholder 1962, p. 264; Banci 1987, pp. 81, 91; White *et al*. 2002, p. 132). Predation deaths from interactions with American black bears (*Ursus americanus*) have been documented (Inman *et al*. 2007, p. 89). Mountain lions are suspected of killing wolverines (Copeland 1996, p. 46; Krebs *et al*. 2004, p. 497; Aubry *et al*. 2016, pp. 27, 32). Starvation has also been identified as a cause of mortality in wolverines (Hornocker and Hash 1981, p. 1,296; Banci 1987, pp. 91, 110; Krebs *et al*. 2004, p. 497). Intraspecific predation also contributes to wolverine deaths. Persson *et al*. (2003, p. 25) found that juvenile survival rates tended to be lower during the altricial period (May–July), and intraspecific predation was the most common cause of mortality, occurring either as infanticide or after independence. Avalanches have also been documented as a cause of wolverine deaths (Inman *et al*. 2007, p. 89).

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In North America, anthropogenic causes of mortality for wolverine populations include hunting, trapping, and road kill. Discussion of the effects of hunting, trapping, and human development is provided below (see Biological Status–Current Condition section).

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Diet and Feeding

Wolverines have been described as opportunistic foragers (Inman *et al*. 2012b, p. 639) and as a "seasonal scavenger on the fringe of the food web" (Larsen 1980, p. 399). They are both scavengers and predators, with a diet that varies between seasons and years, and switching between food sources depending on availability (Magoun 1987, p. 396; Cardinal 2004, pp. 19–22; Mattisson *et al*. 2016, p. 9). The term "polyphagous" was used by Landa *et al*. (1997, p. 1,292) to describe the switching of food sources depending on prey availability by wolverines. Regional variations in diet have also been observed for wolverine populations (Nunavut, Canada) (Awan and Szor 2012, p. 9). The availability of ungulate carrion is believed to be more important than a particular habitat type for wolverines (Cardinal 2004, p. 20).

Early studies from northwestern Montana using scat analysis found that carrion (deer or elk) was an important component of wolverine diet (Hornocker and Hash 1981, p. 1,297). However, during winter, hoary marmots (*Marmota caligata*) were also important food items consumed and, in the spring, Columbian ground squirrels (*Urocitellus columbianus*) were heavily preyed upon (Hornocker and Hash 1981, p. 1,298). As reported by Cardinal (2004, pp. 20–21), wolverines in Canada have a large and varying diet based on reports from aboriginal traditional knowledge holders; in addition to large animals as prey or carrion, wolverine diet includes rabbits and ptarmigans (*Lagopus* sp.), porcupine (*Erethizon dorsatum*), mice, beaver (*Castor canadensis*), fish, ducks, seals, gulls and gull eggs, and lemmings, as well as antlers, bones, and skulls. Native mountain goats (*Oreamnos americanus*) and bighorn sheep (*Ovis canadensis*), that occupy high elevation winter ranges in portions of North America, have also been suggested as important components of wolverine winter diet, particularly during the reproductive denning period (Buell Environmental 2016, pers. comm.). Snowshoe hares may also be an important food item for wolverines in parts of Canada (Jung and Kukka 2013, p. 20).

In northwestern Alaska, analyses of wolverine winter diet using carcasses collected from hunters (1996–2002) within the migratory range of the Western Arctic Caribou Herd found that caribou represented the most common food item, likely through scavenging behavior, followed by moose

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(*Alces alces*), and to a lesser degree, microtine rodents, Arctic ground squirrels (*Spermophilus parryii*), porcupines, wolverines, red fox (*Vulpes vulpes*), sheep and ptarmigan (Dalerum *et al*. 2009, p. 249). One study found stomach contents contained a large portion of muskoxen (*Ovibos moschatus*) and Dall's sheep (*Ovis dalli*) (Dalerum *et al*. 2009, p. 249). Wolverine diets in winter (scat analysis) and summer (primarily direct observation) were evaluated by Magoun (1987, entire) in northwestern Alaska. Results from that study indicate a large number of Arctic ground squirrels were eaten in summer, while the winter diet consisted primarily of caribou and Arctic ground squirrels (Magoun 1987, p. 393). Scavenging was found to be an important feeding strategy in winter, including remnants of buried caribou carcasses or bone/hide in the tundra (Magoun 1987, p. 396).

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Food habits of wolverines from 2002 to 2007 in Glacier National Park were evaluated by Yates and Copeland (2017, *in prep*) by reviewing prey remains and scat samples, or direct observations of feeding behavior. Their scat analysis found that 72 percent of samples contained more than one prey species, and 89 percent contained plant material, primarily conifer needles (Yates and Copeland 2017, *in prep*). The latter may be related to scent-marking behavior of territories, either by defecation after chewing on twigs/shrubs or terpenes released during urination (Wood *et al*. 2009, p. 574), or the result of stomach contents found within their consumed herbivorous prey (Yates and Copeland 2017, *in prep*). Overall, deer and elk represented the most frequent prey item (37 percent), but hibernating rodents were also common in scats (36 percent). Other prey items included mice, voles, lemmings, bovids (e.g., bighorn sheep, mountain goat), birds, and hares (Yates and Copeland 2017, *in prep*). Temporal differences in the occurrence of prey were also observed.

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Snow tracking in Montana found that wolverines hunted in brush piles, log jams, and heavy cover, and routinely entered "tree wells," areas immediately under dense, low growing conifers where snow does not accumulate, that provide easy access to small, ground-dwelling mammals (Hornocker and Hash 1981, p. 1298). Wolverines have been described as moving and lifting large stones in order to access human-cached meat (Freuchen 1935, p. 98).

Several foraging strategies have been described for wolverines. Predation behavior on reindeer (Sweden) was detailed by Haglund (1966, p. 275). A study of elk in Siberia, Russia, noted that, in most instances, wolverines will attack young, pregnant females, young of the year, and wounded or sick animals (Knorre 1959, p. 27). Elk were chased, sometimes by two wolverines during periods of heavy snow (Knorre 1959, pp. 10, 27) and wolverines have been observed feeding in groups on large animal carcasses (Cardinal 2004, p.21). However, wolverines have been described as neither an effective predator of large game animals, nor a serious competitor with other predators (Cardinal 2004, p. 21).

Based on studies in Alaska, Dalerum *et al*. (2009, p. 251) suggested that wolverines occupying this region are large ungulate specialists, but use a generalist feeding strategy by switching between ungulate food sources (e.g., caribou and moose) depending on their availability. Thus, during periods of low caribou abundance, wolverines can switch from caribou (migratory) to moose (non-migratory) while still maintaining their ecological role as a scavenger on ungulate carcasses (Dalerum *et al*. 2009, p. 251).

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Wolverines were found to be the main predator of caribou calves (less than 14 days of age) in northern British Columbia, Canada (Gustine *et al*. (2006, pp. 13–14). As noted in the study, the calving areas were located in wolverine denning habitat (Gustine *et al*. 2006, p. 19); thus, this food resource may be especially important to female wolverines and their young in this region.

A study of wolverine diet using scat samples in Finland found that breeding female wolverines opportunistically used carrion and hunted less on small prey as compared to males and non-breeding females (Koskela 2013, p. 35). In addition, in areas with low densities of mid-size ungulates, smaller prey and carcasses may be important in the wolverine diet (Koskela 2013, p. 35). These results supported an optimal foraging theory; that is, wolverines will opportunistically use foods that are the most energy-efficiently available (Koskela 2013, p. 41). In other words, hunting ungulates or smaller prey (rabbits, birds) may incur greater energetic costs than scavenging for food, but searching for wolf- or human-killed carcasses will take more time (Koskela 2013, p. 41).

Finally, diet and feeding strategies of wolverines were evaluated in Scandinavia (Mattisson *et al*. 2016, entire). Wolverine feeding strategies were found to be flexible and temporarily shifted from scavenging to predation and heavily influenced by seasonal dependent responses to availability of prey and the supply of carrion (Mattisson *et al*. 2016, p. 9). Predictable anthropogenic food sources (i.e., remains from hunted ungulates) also influenced wolverine feeding strategies in their study area by increasing scavenging behavior relative to predation (Mattisson *et al*. 2016, p. 10).

Aboriginal traditional knowledge holders in Canada have reported wolverines as being largely dependent on wolves or another large predator to obtain large mammal carrion such as caribou, but also scavenge off polar bear (*Ursus maritimus*) and grizzly bear (summer) kills (Cardinal 2004, p. 20). Wolverines were observed following the tracks of Eurasian lynx (*Lynx lynx*) and then scavenging on prey left behind from lynx kills (Haglund 1966, pp. 272–273). Myhre and Myrberget (1975, p. 756) noted that the hunting abilities of wolverine and Eurasian lynx are not the same and that the two animals use the meat of their prey differently, which, together, may allow the two carnivores to coexist in the same environment.

In Sweden, Mattisson *et al*.'s (2011b, p. 1,326) study of Global Positioning System (GPS)-collared wolverines found that they spent three times longer scavenging ungulate carrion as compared to feeding on wolverine-killed prey, and more than half of the reindeer carcasses scavenged by wolverines were killed by Eurasian lynx. That study concluded that lynx can increase the availability of food for wolverines and other scavengers and that lynx behavior around kill sites minimizes potential encounter conflicts (Mattisson *et al*. 2011b, p. 1,328). In their study area, Eurasian lynx do not appear to pose a significant threat to wolverines, neither by exclusion in space or time (Mattisson *et al*. 2011a, p. 79) nor from mortality (Persson *et al*. 2009, p. 327). We are not aware of similar evaluations for North American populations of wolverines and Canada lynx. This lack of study on interspecific processes in the more predator-diverse North American landscape is an important gap in our understanding of wolverine distribution (Fisher *et al*. 2013, p. 712).

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Large carnivores can act as "sympatric ungulate predators" (Dalerum *et al*. 2009, p. 251), generating carrion at kill sites, particularly during winter months, but also as competitors and potential sources of mortality (White *et al*. 2002, p. 132; Krebs *et al*. 2004, p. 497; Koskela *et al*. 2013b, p. 221). Wolverines apparently balance their exposure to the risk of predation with foraging opportunities (Scrafford *et al.* (2017, p. 32). Thus, even though wolverines may not be dependent on lynx or other sympatric predators for their survival or reproduction, an increase in the availability of carrion and skeletal remains such as bones left by other predators (Yates and Copeland 2017, *in prep*) likely has a positive influence on the reproductive rate (e.g., number of offspring) in wolverine populations (Mattisson *et al*. 2011b, p. 1,328).

Caching of food is an important behavior of wolverines and is a key component of wolverine population dynamics (Hornocker and Hash 1981, p. 1,297; Inman *et al*. 2012b, p. 640). Food is cached in both summer and winter, by both sexes, and allows for food to be available past the peak periods of mortality and predation (Inman *et al*. 2012b, p. 639). Wolverines will typically move between carcasses and cache sites and are able to remove large parts of a carcass in a short time (Mattisson *et al*. 2011b, p. 1,327). Caching behavior in Sweden was reported most commonly in snow, as well as crevices in rock piles, and found that wolverines carried food to cache sites over long distances (8 and 10 km (5 and 6 mi)) (Haglund 1966, p. 274). As an example, Bjärvall (1982, p. 319) reported a female wolverine carried a reindeer head (with antlers) about 22 km (13.67 mi) back to a den site in Sweden. In northwestern Alaska, wolverines fed on cached ground squirrels during winter (Magoun 1987, p. 395).

A study of wolverine caching behavior in boreal forest habitat in Canada reported that cache sites varied from simple caches, a single feeding site or excavation, to cache complexes, which included feeding stations, latrines, resting sites, and climbing trees dispersed over varying spatial landscapes (Wright and Ernst 2004b, pp. 61–62). All cache sites included bones and hides of moose, which were likely scavenged from wolf kills (Wright and Ernst 2004b, p. 62). Cache sites were often excavated in snow, but also in the ground under boughs of large spruce (*Picea* spp.) trees (Wright and Ernst, 2004b, p. 62) and in peat bogs (Krott 1960, p. 23; Kimmy 2013, no page number). Wolverines also appeared to select cache sites and resting areas that offered good visibility of approaching competitors or predators (Wright and Ernst 2004b, pp. 63–64).

Wolverine energetic demands and food requirements are related to their foraging strategies. Caching provides important energy for female wolverines during the lactation period and helps ensure survival of newborns (Inman *et al*. 2012b, p. 640). Wolverines were found to have high energetic needs compared to other mammalian carnivores (Young *et al*. (2012, p. 2,252), similar to results previously presented by Iversen (1972a, p. 343), who concluded the basal metabolism of mustelids weighing over 1 kg (2.2 lbs) is approximately 20 percent higher than for other mammals. A study by Andrén *et al*. (2011, p. 36) estimated a 1.2 kg/day (2.65 lbs/day) (range: 1.0–1.4 kg/day (2.2–3 lbs/day)) food requirement for wolverines, while Young *et al*. (2012, p. 223) estimated a male wolverine would require an average of 0.85 kg (1.87 lb) of prey/day in winter and 0.95 kg/day (2.1 lbs/day) in "snow-free" periods (i.e., two 182-day seasons). Based on energy equivalent value of various prey sources, Young *et al*. (2012, pp. 223, 225) estimated that a winter diet for a male wolverine would include the equivalent of 1.8 ungulates (i.e., mule deer (*Odocoileus hemionus*)), 70.7 sciurids (squirrels), 20.6 lagomorphs (rabbits), and 832.7

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small mammals, while in snow free season this would include the equivalent of 0.9 ungulates, 122.9 sciurids, and 3362.1 small mammals.

The study by Young *et al*. (2012, p. 225) concluded that wolverines consume 0.1 kg (0.22 lb) of prey per day more outside winter season, but that prey expected to be consumed in winter had a higher caloric content than other seasons; thus, the mass requirement is lower. As an example, they cite the higher proportion of ungulates consumed in winter, which provide about 1.3 times more energy (kilojoules per kilogram) than squirrels (Young *et al*. 2012, p. 225). Other researchers have also noted that food during the summer is just as important as the availability of cached ungulate food in the winter (e.g., during the energy demanding lactation period) (Inman *et al*. 2012b, pp. 640–642). The post-weaning growth period (May–August) was identified as a high energetic demand for food by a wolverine family group (Inman *et al*. 2012b, p. 640). Taken together with the lactation period, the calories available to wolverines therefore likely reach a maximum from March to August (Inman *et al*. 2012b, p. 640).

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Population Structure

As discussed above, wolverines recolonized much of North America after periods of glaciation and then experienced heavy human persecution in much of their historic range. As shown in our Current Potential Extent maps (Figures 3 and 4) and described below in our *Population Abundance and Distribution* section, wolverines occur across a broad expanse of North America, where the contiguous United States represents the southern extent of the species' range. However, no comprehensive studies have been conducted across the western-northwestern United States to provide a reliable population estimate of wolverine populations or population structure.

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A number of biological factors can affect wolverine populations, including the species' low intrinsic rate of population increase, naturally low densities, and need for large, intra-sexual home ranges (Banci and Proulx 1999, p. 180). Their extensive dispersal abilities make possible the recolonization of individuals into vacant habitats (Vangen *et al*. 2001, p; 1,647; Aronsson 2017, p. 43), though not necessarily establishment of a successful reproducing population. As noted above (*Diet and Feeding*), interactions with sympatric predators and the availability of prey and carrion can also directly and indirectly affect wolverine populations.

Wolverines in the contiguous United States are considered to represent a metapopulation (set of local or subpopulations within a larger area and where migration is possible between patches (Hanski and Simberloff 1997, p. 11)) (Inman *et al*. 2013, p. 277) and occupy habitat in high alpine patches at low densities, dispersing into suitable areas (Inman *et al*. 2012a, pp. 782–784). Wolverines in Canada are considered to occur as a single large group as they are easily able to move between areas of good habitat and because wolverine habitat is relatively contiguous (Harrower 2017, pers. comm.).Wolverine populations in Alaska are considered to be continuous with populations in the Yukon and British Columbia provinces of Canada based on genetic studies (COSEWIC 2014, p. 37).

Studies of wolverines in the North Cascades region have documented movement of wolverines from Washington into British Columbia (Aubry *et al*. 2016, pp. 16, 20). The 2014 COSEWIC

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Report indicated that rescue (immigration from another population) of Canadian wolverine populations along the Canada-Alaska international boundary was likely (based on nuclear DNA evidence), but was negligible *from* the contiguous United States (COSEWIC 2014, p. 37). Based on mitochondrial DNA studies, Tomasik and Cook (2005, p. 390) concluded the gene flow in wolverines in northwestern North America is likely male-mediated, and is primarily due to long distance dispersal between low-density populations. Genetic studies of North American wolverines conducted by Kyle and Strobeck (2002, entire) found high levels of gene flow across northern populations (Canada and Alaska).

Commented [SJ23]: Are we saying that rescue from the US wolverines moving into Canada was negligible?

Genetics

The geographical genetic structure of wolverines is believed to be largely structured around the strong female philopatry characteristic of this species (Rico *et al*. 2015, p. 2), and, given the species' polygamous behavior, wolverine population distributions (at least in Scandinavia) are considered to be primarily limited by dispersal of the more philopatric sex (females) (Aronsson 2017, p. 13). However, the extensive and often asymmetrical movement of male wolverines from core populations to the periphery of their range can result in the addition of nuclear genetic material to these edges (Zigouris *et al*. 2012, p. 1,553). Thus, the dispersal pattern for male wolverines may help explain why allelic richness (i.e., nuclear DNA) can be similar across regions, but haplotype richness (mitochondrial DNA) is lower at the periphery of the species' range (Zigouris *et al*. 2012, p. 1,553). Additionally, the extensive dispersal movements of both male and female wolverines can produce gene flow among diverged populations, making it difficult to distinguish, without additional sampling and analysis, between long-distance dispersal and fragmentation based on the patchy distribution of some haplotypes (Zigouris *et al*. 2013, p.10).

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Studies evaluating the genetic structure of wolverines, primarily within its core range in North America, were presented in Chappell *et al*. (2004) and Kyle and Strobeck (2001, 2002). Using microsatellite markers, Kyle and Strobeck (2002) and Zigouris *et al*. (2012) found a greater genetic structure of wolverines toward their eastern and southern peripheries of their North American distribution, likely due to a west-to-east recolonization during the Holocene (Zigouris *et al*. 2013, p. 9). Similarly, based on mitochondria DNA, McKelvey *et al*. (2014, p. 330) concluded that modern wolverine populations in the contiguous United States are the result of recolonization (following persecution during a period of unregulated hunting and trapping and poisoning) from the north.

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Genetic diversity and population genetic structure of a larger sample size of wolverines were examined by Cegelski *et al*. (2006, entire) for the southern extent of their North American range using both microsatellite markers and mitochondrial DNA. They concluded that the wolverine populations in the contiguous United States were not sources for dispersing individuals into Canada (Cegelski *et al*. 2006, p. 208). They found that there was significant differentiation between most of the populations in Canada and the United States (Cegelski *et al*. 2006, p. 208). However, they cautioned that their statistical analysis may not have been able to detect "effective migrants" and that sample size can affect the detection of dispersers (Cegelski *et al*. 2006, p. 208). They concluded that some migration of wolverines was occurring between the Rocky Mountain Front region (northwestern Montana) and Canada as well as among wolverine

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populations in the United States, with the exception of Idaho (Cegelski *et al*. 2006, p. 208). In addition, results from testing of allelic differences among the populations were interpreted by the authors as likely inadequate to counter the effects of genetic drift due to low numbers of migrants (Cegelski *et al*. 2006, p. 208). They estimated that, based on genetic diversity observed at that time, two effective migrants from either Canada or Wyoming into the Rocky Mountain Front population would be needed to maintain the levels of genetic diversity in that population, and one effective migrant was needed to maintain levels of diversity in the Gallatin, Crazybelt, or Idaho populations (Cegelski *et al*. 2006, p. 209). The authors concluded that migration is essential for maintaining diversity in wolverine populations in the contiguous United States since effective population size may never be reached due to the naturally low population densities of wolverines (Cegelski *et al*. 2006, p. 209).

Commented [SJ24]: I don't remember this from Cegelski, at least the "due to low numbers of migrants" part. I thought their main conclusion was that US pops are by themselves not large enough to counter gentic drift without migrants from Canada. And below you describe how few migrants they think are needed.

Commented [SJ25]: I thought they said something like a pop sizes would need to be 400+ individuals to be large enough to maintain genetic diversity w/out migrants. But maybe that's more detail than neeed here. ?

Effective population size (N_e) (see **Box 2**) is defined as "the size of an idealized population that would experience the same amount of genetic drift and inbreeding as the population of interest. In popular terms, N_e is the number of individuals in a population that contribute offspring to the next generation" (Hoffman *et al*. 2017, p. 507). It represents a metric for quantifying rates of inbreeding and genetic drift and is often used in conservation management to set genetic viability targets (Olsson *et al*. 2017, p. 1). It is not the same as the more commonly used metric, census population size (*N*), but is often assumed to represent the genetically effective population size.

Commented [BJG26]: Peer reviewer recommended different reference but it is a book that I do not have. I will request through interlibrary loan, but will take time to get to me.

Commented [SJ27]: Ok, we can add it in later if needed.

An effective population size analysis for wolverines in the contiguous United States was presented in Schwartz *et al*. (2009, p. 3,225) using wolverine samples from the main part of the Rocky Mountains populations (e.g., central and eastern Idaho, Montana, northwestern Wyoming). Excluded in this analysis, were subpopulations from the Crazy and Belt Mountains in Montana (based on suggestion by Cegelski *et al*. (2003) that they represented separate groups) (Schwartz *et al*. 2009, p. 3,225). Samples were divided into three time frames and the computer program ONeSAMP was used to estimate effective population size in each time frame [sample size appears to be between 142 and 210]. The summed effective population size was estimated at 35, with credible limits from 28–52, and the summed values for the three time frames was reported as follows: $N_{e\ 1989–1994} = 33$, credible limits 27–43; $N_{e\ 1995–2000} = 35$, credible limits 28–57; $N_{e\ 2001–2006} = 38$, credible limits 33–59 (Schwartz *et al*. 2009, p. 3,226).

However, Cegelski *et al*.'s (2006, p. 203) evaluation of nuclear DNA population structure in wolverines in Canada (sample size of 101) and the contiguous United States (sample size of 116), as depicted by a principle component analysis plot and dendrogram, found that all of the Canadian wolverine populations clustered together. In the contiguous United States, the Rocky Mountain Front subpopulation clustered with the Wyoming subpopulation, the Crazy and Belt Mountains area subpopulation clustered with the Gallatin (Montana) population, and the Idaho population was highly differentiated (Cegelski *et al*. 2006, p. 203). However, the sample size used for evaluating the Idaho population was small (n=15) and limited to central Idaho. That study concluded that some exchange of migrants is occurring between the Gallatin and Crazybelt wolverine populations (Cegelski *et al*. 2006, p. 207).

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In addition, the map presented in Schwartz *et al*. (2009, p. 3,223) depicting the locations of the wolverine samples used in preparing their effective population size estimate shows significant gaps within the wolverine's range in Idaho and parts of Montana (e.g., interior of the Bob

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Marshall Wilderness area). Thus, other wolverine subpopulations and/or individuals were likely missed for this analysis. Studies within the Southwestern Crown of the Continent (SWCC) in northwestern Montana have detected cross-valley movements of wolverines, which researchers believe is an indication of good connectivity in this region (SWCC Wildlife Working Group 2016, pers. comm.). Current efforts to collect additional wolverine hair samples for genetic analyses are underway through a multi-state occupancy survey project (see *Population Abundance and Distribution* section below).

Another evaluation of mitochondrial DNA was conducted by Francis (2008), who found an overall lack of regional (geographic) genetic structure for North American wolverines, but noted that a few populations (the Crazy and Belt Mountains (Montana), Southeast Alaska, Nunavut (Canada), and Kenai Peninsula) appeared to be isolated from the others (Francis 2008, p. 12). However, statistical testing did not identify any genetically defined sampling localities (Francis 2008, p. 13). Minimal differences were found between core and peripheral wolverine populations, as grouped in that analysis (Francis 2008, p. 21; Table 4). Conversely, the study by Zigouris *et al*. (2012, p. 1,554; Table 5) did find support for genetic clusters for wolverine populations in Canada, and Zigouris *et al*. (2013, p. 5; Table 3) identified several worldwide regional genetic groups. In addition, an analysis of estimated population growth found signals of population expansion in several wolverine populations (Francis 2008, p. 13; Table 5) including Rocky Mountain Front, Wyoming, Central, South, and Northwestern Alaska, British Columbia, Northwest Territories, and Nunavut.

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Box 2. Effective Population Size and Genetic Variation

The concept of effective population size (N_e) (see review by Wang *et al*. 2016) and, relatedly, minimum viable population, has been a topic of debate, particularly the 50/500 rule, which was developed over 30 years ago. As noted by Laikre *et al*. (2016, p. 280), the concept and guidelines for *genetically* effective population size were developed for single, isolated populations, but it's unclear which of the various N_e metrics was referenced in the original concept proposed by Franklin (1980) (i.e., inbreeding effective size, realized effective size, total inbreeding effective size of a metapopulation, or eigenvalue effective size (Laikre *et al*. 2016, p. 288)).

There are differing interpretations of the values proposed for effective population size. For example, should the minimum viable effective population size be derived genetically to set a threshold for a minimum viable population? Here, the rule is interpreted as 50 being the short-term number (for inbreeding depression) and 500 as the long-term number (for retention of genetic variation). Or should the N_e value of 500 be interpreted as a long-term goal for maintaining a healthy, genetically robust population, and not a threshold trigger that predicts extinction risk? In addition, some view the 500 value to be a global reference value rather than a local value, and that it may not be necessary to maintain a local N_e of 500 as long as there is some gene flow into a population (Jamieson and Allendorf 2012, p. 580).

Finally, others have recommended changes to the 50/500 rule. Laikre *et al*. (2016, entire) presented an analysis of the metapopulation effective size for the Fennoscandian wolf population and recommended that long-term conservation genetic target for metapopulations (N_{eMeta}) ≥ 500, but also a realized effective size of *each subpopulation* (N_{eRx}) ≥ 500. Frankham *et al*. (2014, p. 59) have recommended modifying the 50/500 rule to 100/1000.

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It can be difficult to make inferences about the relationship between population size and point estimates of genetic diversity without continued genetic monitoring and an understanding of the demographic history of a species' population (Hoffman *et al*. 2017, p. 507), including factors that have influenced movement patterns and connectivity. Additionally, the extensive dispersal movements of both male and female wolverines can produce gene flow among diverged populations, making it difficult to distinguish, without additional sampling and analysis, between long-distance dispersal and fragmentation based on the patchy distribution of some haplotypes (Zigouris *et al*. 2013, p.10).

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Genetic diversity can be a reflection of favorable adaptations (natural selection) and is necessary for species to locally adapt to environmental stressors or to facilitate range shifts (Zigouris *et al*. 2012, p. 1,544). Genetic distinctiveness in peripheral populations may play a role in both maintaining and generating biological diversity for a species (Zigouris *et al*. 2012, p. 1,544; citing results presented in Channell and Lomolino 2000, p. 84). Genetic variation that is adaptive is a better predictor of the long-term success of populations as compared to overall genetic variation (Hoffman *et al*. 2017, p. 510). The challenge is to be able to determine whether genetic variation is adaptive and is a reflection of remnants of high genetic diversity from ancestral populations, or whether that variation is a reflection of accumulated deleterious, nonadaptive genes due to genetic drift in small populations (Hoffman *et al*. 2017, p. 509).

In summary, the currently known spatial distribution of genetic variability in wolverines in North America appears to be a reflection of a complex history where population abundance has fluctuated since the time of the last glaciation, and insufficient time has passed since human persecution for a full recovery of wolverine densities (Cardinal 2004, pp. 23–24; Zigouris *et al*. 2012, p. 1,554). Zigouris *et al*. (2012, p.1,545) noted that the genetic diversity reported in Cegelski *et al*. (2006) and Kyle and Strobeck (2001, 2002) for the southwestern edge of the North American range represented only part of the diversity in the northern populations of wolverines. Zigouris *et al*. (2012, p. 1,545) posit that the irregular distribution of wolverines in the southwestern periphery and the genetic diversity observed in those analyses is a result of population bottlenecks that were caused by range contractions from a panmictic (random mating) northern core population approximately 150 years ago coinciding with human persecution. Demographic studies as well as additional genetic analyses from contemporaneous wolverines currently occupying the contiguous United States are needed to evaluate the current status of wolverine populations in North America. In addition, ecological, phenotypical, and environmental information should be used to complement genomic data when interpreting the strength of conclusions or inferences of spatial patterns of adaptation or for adaptively divergent populations (Jamieson and Allendorf 2012, p. 492).

Summary

In this SSA report, we have incorporated information from several new studies related to the wolverine published since our 2013 proposed rule (e.g., Magoun *et al*. 2017) and previous studies that were not considered. We have also reviewed new publications and publications in preparation from wolverine researchers in Scandinavia (e.g., Aronsson 2017; Bischof *et al*. 2016; Makkonen 2015; Mattisson *et al*. 2016; Myhr 2015; Persson *et al*. 2017, *in prep*). This information informs our assessment of the most current information regarding the description of

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the wolverine and its life history and ecology across its North American range. We have included in this SSA Report detailed discussions of wolverine physiology, and spatial and temporal patterns and trends related to reproduction and diet/feeding. We also prepared a revised Current Potential Extent map (see Figure 3) based on information we received from Federal, State, and wolverine researchers.

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A species' current and future conditions and overall viability (in terms of resiliency, redundancy, and representation), are largely impacted by the availability of what the species needs at the individual, population, and species level. The needs described below are necessary for wolverines to have resources for the basic requirements of life (breeding, feeding, and sheltering) at all levels. Overall, the best available information indicates that within the contiguous United States the wolverine's physical and ecological needs include:

(1) large territories in relatively inaccessible landscapes; at high elevation (1,800 to 3,500 meters (5,906 to 11,483 feet))
(2) access to a variety of food resources, that varies with seasons; and
(3) physical/structural features (e.g., talus slopes, rugged terrain) linked to reproductive behavioral patterns.

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Biological Status – Current Condition

This section provides an overview of the wolverine's current condition, including those stressors that may be impacting the species or its habitat. In this SSA Report, we have identified stressors based on impacts that may negatively affect the physical and ecological needs of the species, including temporary or permanent impacts to habitat features that the species relies on for survival and reproduction.

Population Abundance and Distribution

As shown in Figure 2, wolverines occupy areas in the west-northwestern United States, and have recently dispersed into historically occupied areas, including California, Utah, Colorado, and Oregon; verified reproducing wolverine populations are found in Idaho, Washington (Northern Cascades), Montana, and northwest Wyoming. Demographic data collected in the contiguous United States is primarily presence/absence data, which makes it difficult to develop reliable population estimates or population trends. Since our 2013 proposed rule, an updated Canadian status review for the wolverine has been prepared (COSEWIC 2014, entire) and additional studies have also been published related to wolverine populations in British Columbia and Alberta (e.g., Regehr and Lacroix 2016; Stewart *et al*. 2016; Webb *et al*. 2016). As noted above, we developed a Current Potential Extent map for the North American wolverine in the contiguous United States and North America (see Figures 3 and 4) based on several resources, including Inman *et al*. (2013), EPA ecological region mapping (2010), Forest Service NRIS data, and information received from State agencies. The 2014 COSEWIC Assessment and Status Report presents an estimated current range map for Canada and Alaska, and includes the Yukon, Northwest Territories, Nunavut, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec, Newfoundland, and Labrador (COSEWIC 2014, p. vii).

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Contiguous United States

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Areas in the western contiguous United States were identified by Inman *et al*. (2013, entire) as suitable for wolverine survival (long-term survival; used by resident adults), or primary habitat (Inman *et al*. 2013, p. 279), reproduction (used by reproductive females), and dispersal (female and male) of wolverines (see methodology in Inman *et al*. 2013, pp. 279–280; Figure 2). From these results, the researchers estimated potential and current distribution and abundance of wolverines in the western contiguous United States (Inman *et al*. 2013, p. 282). They estimated current population size of wolverines to be 318 (range 249–626) located within the Northern Continental Divide (Montana) and areas within the following ecoregions: Salmon-Selway (Idaho, portion of eastern Oregon), Central Linkage (primarily Idaho, Montana), Greater Yellowstone (Montana, Idaho, Wyoming), and Northern Cascades (Washington) (Inman *et al*. 2013, p. 282). Potential wolverine population capacity based on their RSF habitat modeling was estimated to be 644 (range: 506–1881) (Inman *et al*. 2013, p. 282). However, these estimates did not consider spatial characteristics related to behavior, such as territoriality, of wolverine populations.

The discussion below provides a summary of recent studies of wolverine detections and observations in the western United States; however, no comprehensive surveys have been conducted across the entire area defined as the species' Maximum Extent of Occurrence (Figure 2) or Current Potential Extent (Figure 3) in the contiguous United States.

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In the northern Cascades region of Washington and Canada, researchers tracked activity areas for 14 wolverines via satellite telemetry from 2007 through 2015 (Aubry *et al*. 2016, entire). This study demonstrated that the region supports a resident population, with 9 of 11 study animals documented primarily within Washington (Aubry *et al*. 2016, p. 40).

Wolverines have been detected in the Eagle Cap Wilderness Area in the Wallowa Mountains of northeastern Oregon 2011–2012, 2016, and 2017 (Magoun *et al*. 2013, p. 17; Magoun 2017b, pers. comm.). Surveys conducted in the Northern Cascades of Oregon in 2012–2014 did not detect any wolverines (McFadden-Hiller and Hiller 2015, p. 107).

Deleted: The Oregon Department of Fish and Wildlife (ODFW) reports that wolverines have been found in the Oregon Cascades on Three-fingered Jack (glaciated volcano) in Linn County, on the Steens Mountain in Harney County, and Broken Top Mountain in Deschutes County

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In California, camera trap data indicate the continued presence of a single male wolverine in the Truckee area, as of March 2017 (Shufelberger 2017, pers. comm.). The California Department of Fish and Wildlife (CDFW) has received reports of wolverine detections from the public over the past several years, particularly the region near Carson Pass, as well as near Meeks Bay, Lake Tahoe (Stermer 2017, pers. comm.). The CDFW has conducted systematic surveys in these areas and has installed baited camera traps in the Carson Pass area, but no wolverines have been detected (CDFW 2017, pers. comm.). CDFW researchers are conducting multi-species predator surveys, targeting the potential occurrence of Sierra Nevada red fox and wolverine using camera trapping with hair snares in an effort to determine occupancy, detection probability, distribution, and habitat associations (Stermer 2017, pers. comm.).

Since 2010, the Idaho Department of Fish and Game (IDFG) has directed a multi-species forest carnivore monitoring program in the Idaho Panhandle and adjoining areas of Washington, Montana, and British Columbia, Canada (Lucid *et al*. 2016; Lucid *et al*. 2017). From 2010–2014,

497 forest carnivore bait stations were used to survey the study area using a 5 by 5 km (3 by 3 mi) grid (Robinson *et al*. 2016, pp. 6,827–6,828). Wolverines were detected at 13 sites in 13 different cells, and genetic analysis identified 3 individual males (Lucid *et al*. 2016, p. 154). One male was detected on 6 occasions in the Selkirk Mountains from 2010–2013, and was determined to be resident of the area (Lucid *et al*. 2016, p. 161). This male (LS11) was also detected in British Columbia, north of Canadian Highway 3 (Lucid *et al*. 2016, p. 184), which some consider to be a barrier to wildlife passage (IDFG 2017, pers. comm.). LS11 was most recently detected in Idaho, on March 6, 2013 (Lucid *et al*. 2016, p. 175). From 2015–2016, a more focused monitoring effort in the region was conducted and resulted in the detection of two new male wolverines in the Purcell and Saint Joe Mountains, but not the three previously detected males (Lucid *et al*. 2017, p. 12). The 2017 summary report also noted one likely wolverine den in the Saint Joe Mountains (Lucid *et al*. 2017, p. 12).

A pilot study to evaluate wolverine occupancy was conducted in Wyoming from February through June in 2015 (Inman *et al*. 2015, entire). Results from that survey (hair snares and camera traps in 18 stations across 5 mountain ranges) indicated at least three individual wolverines (at five stations) with at least one individual in the Gros Ventre and Wind River mountain ranges, and at least two individuals in the Southern Absaroka mountain range (Inman *et al*. 2015, p. 9). Occupancy modeling estimated a probability of occupancy for sampled sites of 62.9 percent (Inman *et al*. 2015, p. 8).

Building on the results of the Wyoming pilot study, the Western Association of Fish and Wildlife Agencies (WAFWA), in coordination with Tribal partners, formed a multi-state, multi-agency working group (Western States Wolverine Working Group) to design and implement the Western States Wolverine Conservation Project (WSWCP)–Coordinated Occupancy Survey (see Western States Wolverine Working Group 2016 for details of protocol). The primary objectives of the WSWCP include: 1) implement a monitoring program to define a baseline wolverine distribution and genetic characteristics of the metapopulation across Montana, Idaho, Wyoming, and Washington, 2) model and maintain the connectivity of the wolverine metapopulation in western United States, and 3) develop policies to address socio-political needs to assist wolverine population expansion as a conservation tool, including translocation of wolverines (IDFG 2016, pers. comm.; Montana FWP 2016, pers. comm.; WGFD 2016, pers. comm.).

The WGFD began implementation of the survey in Wyoming in the Greater Yellowstone Ecosystem region and the Bighorn Mountains (25 grid cells) in the winter of 2015–2016 (WGFD 2016, pers. comm.). That initial survey detected, based on unique fur markings, at least three unique wolverines in the Wind River and southern Absaroka Mountain Ranges (WGFD 2016, pers. comm.). The WGFD reported 26 independent wolverine visits (defined as a photo of a wolverine greater or equal to 60 minutes from the previous photo of a wolverine), and detections at least once within their study area during each of the four sampling periods (December 2015 through March 2016) (Bjornlie *et al*. 2017, pp. 4–5). As part of this effort, the WGFD collaborated with the Eastern Shoshone and Arapaho Tribes in Wyoming to conduct surveys on Tribal lands in 2015, and plans to continue this collaboration in the winter of 2017–2018 to monitor wolverines on the Wind River Reservation (WGFD 2017, pers. comm.).

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The monitoring effort was expanded in the winter of 2016–2017 to 185 cells (cell area of 225 km^2 (87 mi^2)) in four States (Washington, Idaho, Montana, and Wyoming). **Appendix B** contains a map illustrating these preliminary detections. Wolverines were detected in 59 cells (22,461 detections) and volunteers detected wolverines in another 36 cells for a total of 95 cells (Montana FWP 2017, pers. comm.). Photographic detections of wolverine (both survey and volunteer cells include 22 from Idaho, 48 in Montana (including detection of wolverines in all 10 cells surveyed in the SWCC region (Davis 2017, pers. comm.)), 10 in Washington, including detections south of Interstate 90 (Davis 2017, pers. comm.), and 6 in Wyoming (for 2015–2016 and 2016–2017); genetic analyses, to date, have reported a total of 157 wolverine samples (Montana FWP 2017, pers. comm.; WGFD 2017, pers. comm.). It has not yet been determined from the camera-trap images and hair samples how many of these detections are the same individual and genetic analyses of collected hair samples, including sex and individual identification are ongoing. A detailed summary of the occupancy survey design and results is presented in **Appendix C** (McDonald (on behalf of WAFWA Wolverine Subcommittee) 2017, pers. comm.).

We also requested and received additional wolverine observations from State and Federal agencies in northwestern Wyoming. A wolverine was detected by camera in northern Grand Teton National Park (Dewey 2017, pers. comm.), and a member of the public reported wolverine tracks in southwestern Grand Teton National Park while skiing (Walker pers. comm. 2017), which was confirmed by a Forest Service biologist (WGFD 2017, pers. comm.). Both of these observations occurred in March 2017. South of this area in the Wyoming Range (about 4 miles east of Alpine, Wyoming), a wolverine was detected by camera in May 2017 (Walker 2017, pers. comm.).

Alaska

The ADF&G Trapper Questionnaire Annual Reports include estimates of relative abundance and trends of wolverines and other furbearers as reported by trappers (Parr 2016, p. 38). Table 4 below provides a summary of abundance and trends from 2010–2016 of those reports by region.

Table 4. Relative Abundance and Trend of Wolverine Populations, Alaska (as reported by trappers), 2010-2016.* For Trend, + indicates increase, − indicates declining/decrease, and n/c indicates no change. N/A (Not Applicable) indicates no value for that year due to changes in how the regions were defined. Sources: ADF&G 2012, 2013a, 2013b; Parr 2016.

Region	Relative Abundance				Trend			
	2010-2011	2011-2012	2012-2013	2015-2016	2010-2011	2011-2012	2012-2013	2015-2016
Region I – Southeast Alaska	scarce	scarce	scarce	scarce	n/c	n/c	n/c	−
Region II – Southcentral Alaska	scarce	scarce	scarce	scarce	n/c	n/c	n/c	−

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Deleted: We therefore requested additional information from State and Federal agencies regarding the most recent wolverine detections in the Winter Recreation Project study areas of Idaho and Wyoming. In the Teton Mountains region, two wolverines were detected in March 2017, in two different areas (Dewey 2017, pers. comm.). In addition, at least one wolverine was detected on the east side of the Teton Mountains during the winter of 2016-2017, as part of the Western States Wolverine Conservation Project–Coordinated Occupancy Survey monitoring and occupancy study, and a member of the public reported wolverine tracks within Grand Teton National Park in March 2017, while skiing (Walker 2017, pers. comm.). In Idaho, IDFG reported 5 wolverine detections in the Salmon Mountains in Central Idaho in the winter of 2016 (Mack 2017a and 2017b, pers. comm.). These recent detections are displayed in **Appendix C** relative to the study areas of the Winter Recreation Project study areas for the McCall, Idaho, and Teton Mountains. A wolverine was also detected in the winter of 2016-2017 in the Gravelly Range in southwestern Montana about 25 km (15.5 mi) north of the Centennial Mountains area surveyed during the winter recreation project (Inman 2017b, pers. comm.).

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Region III – Interior Alaska	scarce	scarce	scarce	scarce	n/c	n/c	n/c	–
Region IV – Central and Southwest Alaska	N/A	N/A	N/A	scarce	N/A	N/A	N/A	–
Region V - Northwest	N/A	N/A	N/A	scarce	N/A	N/A	N/A	–
Southwest	common	scarce	scarce	N/A	n/c	–	n/c	N/A
Arctic and Western	common	common	scarce	N/A	n/c	n/c	n/c	N/A

*No reports written for years 2009-2010, 2013-2015.

However, relying exclusively on trapping reports is likely to present an incomplete assessment of wolverine populations. The accuracy of information provided in the most recent report is dependent on how many trappers reply to the annual survey; for 2016, the response rate was only 11.7 percent (Parr 2016, p. 3). Trapping effort was reported to have increased by some trappers (45 percent of those reporting) during the 2015–2016 season, and 80 percent of those who increased their efforts reported an increase in their overall catch (Parr 2016, p. 15). However, this assessment does not consider how this increased trapper effort relates to harvest levels for wolverine, nor does it account for an unknown and unreported number of wolverines taken for subsistence purposes (Gardner *et al*. 2010, p. 1,894). Estimates of density, described below, provide a better depiction of wolverine population status in Alaska.

Canada

Similar to Alaska, determining wolverine population abundance and trends in Canada is difficult as numbers are developed from harvest activity (COSEWIC 2014, p. 25). Wolverine harvest trends are also difficult to estimate given the temporal and spatial variability in trapping effort and reporting of harvest, and not all regions use mandatory pelt sealing, compulsory reporting, or fur export permits/fur dealer records (COSEWIC 2014, p. 26).

According to the most recent COSEWIC Assessment and Status Report on the Wolverine, *Gulo gulo* in Canada (COSEWIC 2014, entire), Canada's western subpopulation has been estimated at 15,688 to 23,830 adults, though this value is based on several assumptions (consistent trapping effort and uniform densities across the species' range); the eastern population (Québec and Labrador) is estimated at less than 100 individuals or may be extirpated (COSEWIC 2014, p. 36). Population trends across all of Canada are not known, but wolverine populations have been stable over areas within the country's northern range for the last three generations (22.5 years) (COSEWIC 2014, p. v).

In northern Manitoba and Ontario, wolverines may be increasing in number as aerial surveys in northern Ontario have indicated an eastward reoccupation of its former range (towards James Bay and Québec) (COSEWIC 2014, p. v). However, although observations of wolverines continue to be reported within Québec and Labrador, there have been no verifiable observations since 1978, and wolverines are likely extirpated from much of southeastern Canada (COSEWIC 2014, p. v). In addition, declines in the southern regions (within parts of British Columbia and Alberta) may be occurring (COSEWIC 2014, p. 36). Table 5 presents a summary of estimated wolverine populations in Canada; study references for regional estimates are presented in COSEWIC (2014, pp. 26–36).

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Table 5. Wolverine Population Estimates for Canadian Territories. Source: COSEWIC, 2014.

Territory	Number of wolverines
Yukon Territory	3,500–4,500
Northwest Territories	3,430–7,325 (with an additional 220–470 juveniles)
Nunavut	Estimated at 2,000–2,500
British Columbia	2,700–4,760
Alberta	Estimated at 1,500–2,000
Saskatchewan	Less than 1,000
Manitoba	1,100–1,600
Ontario	458–645
Québec	Very rare, at non-detectable level, or extirpated
Labrador (including mainland Newfoundland)	Very rare or extirpated

In addition to the 2014 COSEWIC summary, Cardinal 2004 (entire) prepared a complimentary summary report of wolverine trends in Canada based on Aboriginal traditional knowledge. Trends reported indicate: (1) high, relatively stable levels of wolverines in the Yukon; (2) high levels of wolverines in the North Slave region of the Northwest Territories, though population levels are estimated to be stable to decreasing; (3) high levels of wolverine along forested areas in the northern portions of the mainland within the Inuvialuit Settlement Region (ISR) (located in the northwest corner of the Northwest Territories) and Kitikmeot region of Nunavut; (4) an increase in wolverines in the Kivalliq region of Nunavut, but at lower levels than populations in the Boreal and North Mountain ecological areas; and (5) least abundant in the northeastern corner of Nunavut and the Arctic Islands (Cardinal 2004, pp. 22–29). In sum, the majority of traditional knowledge holders in Nunavut, Northwest Territory, and Yukon Territory describe wolverine populations as either stable or increasing in northern Canada and is now found in areas where they occurred in the past; however, they are still considered naturally uncommon; only in Yellowknife did people report that wolverines might be decreasing (Cardinal 2004, pp. iii– iv, 10, 23).

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Other inventory and occupancy studies include an inventory of wolverines conducted by Regehr and Lacroix (2016, entire) in the winter of 2012 on the east side of the Coast Mountains in British Columbia using a multi-method approach. They identified six individuals using genetic analysis, and one additional individual by photography, which was higher than expected as compared to model predictions of density and habitat quality (Regehr and Lacroix 2016, pp. 248–249). Estimates of wolverine occupancy were also evaluated for the Canadian Crown of the Continent ecosystem (central and southern Canadian Rockies) (Clevenger *et al*. 2016, entire). Occupancy estimates were found to vary from year-to-year and exhibited a north-south gradient, likely due to the differences in habitat quality among areas that were sampled by year (Clevenger *et al*. 2016, p. 4). For 2016, estimated wolverine occupancy probability was 0.40 for their British Columbia Rockies study area, with a declining pattern from north to south (Clevenger *et al*. 2016, p. 4). In general, their research has found that wolverines are more abundant in rugged, remote areas that have minimal human activity and landscape disturbance (Clevenger *et al*. 2016, p. 5). This study projected an expected number of wolverines in their study area of about 28 (Clevenger *et al*. 2017, p. 6). To the south, in the Southwestern Crown of the Continent (SWCC) region, northwestern Montana, wolverine surveys (snow tracking, bait stations/hair snares) have been conducted since 2012 (SWCC Wildlife Working Group 2016, pers. comm.). These survey

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efforts have detected 22 unique wolverines (11 males, 11 females) within three U.S. Forest Service districts, and they reported an increase in the frequency of detections from 2012 to 2015 (SWCC Wildlife Working Group 2016, pers. comm.).

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In the Kootenay Region of southern British Columbia, a non-invasive genetic study of wolverines, including collection of trapper carcasses, was initiated in the southern Columbia Mountains in 2012 (Hausleitner and Kortello 2016, entire). The 2016 report estimated a population size of 9 (7-12) individuals, less than half of the expected population size of 24 (17-36), with a 64 percent estimate of occupancy for the central Purcell Mountains, which was higher than the south Purcell Mountains (38 percent) and south Selkirk Moutains (55 percent), but lower than the Valhalla (70 percent) and central Selkirk Mountains (71 percent) (estimates of detectability were found to be within the range of previous years and other studies) (Hausleitner and Kortello 2016, p. 2; Figures 1 and 2). Although the study results suggest that dispersal events are still occurring among ranges and subranges, they also found three distinct subpopulations in their genetic analyses, which they believe is indicative of limited gene flow (Hausleitner and Kortello 2016, p. 21).

The 2014 COSEWIC report indicates that trends in wolverine populations in the northern range, while uncertain, appear to be stable or increasing, but also notes that there is some concern for populations in the southern areas of British Columbia and parts of the northern United States (COSEWIC 2014, p. 22, citing personal communication from Richard Weir, Carnivore Conservation Specialist, Ministry of the Environment, British Columbia, and Wolverine Science Panel Workshop Report (Wolverine Science Panel 2014)). In British Columbia, researchers are currently conducting a multi-phase project using landscape genetic analyses to identify and delineate functional populations of wolverines and provide an estimate of size and sustainable harvest within each functional population (Weir 2017a, pers. comm.).

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Estimates of Density

Wolverine densities vary across North America, and have been described as "naturally low" (van Zyll de Jong 1975, p. 434) and "naturally uncommon" (Cardinal 2004, p. iii) given the species' large home range, wide-ranging movements, and solitary characteristics. The most recent estimates (at that time) of density (number of wolverines per 1,000 km^2 (386 mi^2)) for North America were prepared by Inman *et al*. (2012a, p. 789; Table 5). In the contiguous United States, density estimates ranged from 3.5 for the Greater Yellowstone region (2001–2008) (areas above 2,150 m (7,054 ft) (latitude-adjusted elevation), 4.5 for central Idaho (1992–1995), to 15.4 for northwestern Montana (1972–1977).

In Alaska and Yukon, density estimates presented by Inman *et al*. (2012a, p. 789) range from 3 to about 14 wolverines per 1000 km^2 (386 mi^2), using a number of methods. For example, Royle *et al*. (2011, p. 609) estimated wolverine densities for southeastern Alaska (Tongass National Forest; 2008) from 8.2 to 9.7 per 1000 km^2 (386 mi^2) (using mark-recapture), where the higher estimate incorporates a positive, trap-specific behavioral response. Density of wolverines were recently reported as an estimated 5–10 wolverines per 1000 km^2 (386 mi^2) (based on snow tracking) for southcentral Alaska, and approximately 10 per 1000 km^2 (386 mi^2) (based on DNA mark-recapture methods) for southeast Alaska (Golden 2017, pers. comm.). A wolverine

occupancy study in 2015 within an area of central Alaska reported a density estimate of 9.48 wolverines per 1,000 km^2 (386 mi^2) (ADF&G 2015a, p. 7).

Wolverine density estimates for Canada varies across regions, from 5 to 10 per 1000 km^2 (386 mi^2) in northern mountain and boreal regions to 1 to 4 per 1000 km^2 (386 mi^2) in southern boreal areas (COSEWIC 2014, p. 27). More recently, Clevenger *et al*. (2017, entire) presented a density estimate (using spatial capture/recapture models) for the Kootenay region of British Columbia of 0.78 wolverines per 1000 km^2 (386 mi^2), for 3 study years (2014–2016), which they reported as lower than expected (Clevenger *et al*. 2017, p. 6).

Stressors – Causes and Effects

We reviewed the best available information to identify current conditions and potential stressors that may be affecting wolverine populations or its habitat. These include roads and other infrastructure, recreational activity and other human disturbances, wildland fire, disease or predation, and overutilization for commercial, recreational, scientific, or educational purposes. Because wolverines in North America move between both borders of Canada (i.e., contiguous United States, Alaska), we included in our evaluation stressors identified for wolverines in Canada and Alaska that are also relevant for wolverine populations in the contiguous United States.

As an initial step, we reviewed the land ownership of the area defined as Current Potential Extent in the contiguous United States (Figure 3), and determined that 72.4 percent is located on Federal land (using Albers Projection) (see **Appendix D**). Lands managed by the Forest Service represent the largest portion of Federal lands (62 percent) within this area.

Effects from Roads

Roads and rail lines can be a cause of mortality to wolverines and habitat models have identified road density as an important association (avoidance) for selection of habitat (e.g., Rowland *et al*. 2003; Bowman *et al*. 2010; Inman *et al*. 2013). Road density has been listed as a threat to wolverines occupying the boreal/western mountain regions of Canada (Canadian Boreal Forest Agreement 2014, p. 2). In the wolverine's southern Canadian range, roads may be facilitating direct mortality along transportation corridors and may facilitate indirect mortality through improved motorized access for hunters, trappers and recreational users into remote areas (COSEWIC 2014, p. 21).

In their review of 12 radio-telemetry studies (1972 to 2001) of wolverines in North America, Krebs *et al*. (2004, p. 497) reported 3 mortalities of wolverines from road-rail kills. In addition, a female wolverine was killed on Highway 20 in northwestern Washington in May 1997 (specimen at Burke Museum; Bradley 2017, pers. comm.). More recently, road mortalities have been recorded in Idaho (1 confirmed in 2014) (IDFG 2017a); three in Montana (2004, 2007) (Kociolek *et al*. 2016, p. 68; Yates 2017, pers. comm.); one in Utah (2016) (Hersey 2017, pers. comm.). Two additional wolverine road-rail fatalities in Montana were reported in 2015 (Inman 2017a, pers. comm.).

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In Canada, anthropogenic causes of mortality for wolverine populations also include road kill (COSEWSIC 2014, p. v). One road mortality of a male wolverine was reported in a lowland boreal forest region of Ontario, Canada (Dawson *et al*. (2010, p. 142). More recently, Scrafford *et al*. (2017, p. 34) described a report in which 9 wolverines were struck and killed by vehicles in the Hay-Zama region of northwestern Alberta, Canada (2013–2015), and 1 road mortality occurred within the town of Rainbow Lake in Alberta.

Roads also may affect den site selection (May *et al*. 2012, p. 202), particularly areas within their range where they cannot select for high elevation habitat (e.g., central lowland forests of Canada) (Dawson *et al*. 2010, p. 143). In Norway, May *et al*. (2012, p 202) found that wolverine dens were generally located far from infrastructure (public roads and private roads and/or recreational cabins). The authors reported a minimum threshold in den site selection relative to infrastructure of 1.4 km (0.87 mi) from private roads and 7.5 km (4.7 mi) from public roads (May *et al*. 2012, p. 202). However, they found that wolverines in their study area had a wide tolerance range at the home-range scale (1.0–2.75 km (0.62–1.7 mi) for private roads and 6.0–11.0 (3.7–6.8 mi) for public roads) (May *et al*. 2012, p. 201; Figure 4), supporting conclusions from other studies that have found that, once a general area is used, it appears to be re-used in subsequent years including by successive individuals colonizing the sites (May *et al*. 2012, p. 202).

Wolverine road crossings were evaluated in the western Greater Yellowstone region through telemetered animals and visual observations of snow tracks, direct observations of crossings, and road-kill mortality (Packila *et al*. 2007, entire). That study documented 43 crossings of U.S. and State highways by 12 wolverines (Packila *et al*. 2007, p. 105). Within the Big Sky, Montana, area, they documented 67 crossings of MT64/Jack Creek Road by 4 wolverines (Packila *et al*. 2007, p. 105). Most (76%) road crossings were made by subadult wolverines, dispersing or otherwise exploring new areas (Packila *et al*. 2007, p. 105). One road-caused mortality was observed and the authors report two others from additional sources during their study period (Inman *et al*. 2007, p. 89). The study results indicate that roads do not act as absolute barriers to movement by wolverines, but they can directly affect individuals (road kill) and may have secondary effects at the population level (Packila *et al*. 2007, p. 105).

In an effort to evaluate the potential impact of major roads to wolverine (individuals and populations), we conducted a spatial analysis of roads[2] found within our Current Potential Extent for the wolverine in the contiguous United States, as measured by number of kilometers (miles). In our analysis, we identified several road classes: Interstate Highway, U.S. Highway, State Highway, roads identified by Federal agency, County highways, County roads, and local roads. Our analysis found approximately 248,966 km (154,700 mi) of roads within the Current Potential Extent area, with local roads representing 83 percent (209,719 km (128,449 mi)) of all roads within our Current Potential Extent area.

We then evaluated the type of roads at high elevation within our estimated Current Potential Extent area (Figure 3). Using the 2,300 m (7,546 ft) elevation as a benchmark (based on its use as a predictor variable for wolverine occurrence in Inman *et al*. 2013, and results from predictive

[2] Using U.S. Geological Survey National Transportation Dataset Downloadable Data Collection based on TIGER/Line data provided through U.S. Census Bureau and supplemented with 'HERE' road data to create tile cache base maps.

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models presented in Copeland *et al*. 2007, p. 2,205), we evaluated the length of roads above and below this elevation, and also the type of roads at or above 2,300 m (7,546 ft). The results are illustrated in **Appendix E**. Overall, we found that approximately 95 percent of all roads were below 2,300 m (7,546 ft). Of the roads located at or above 2,300 m (7,546 ft), 85 percent are local roads.

Using the same dataset, we evaluated road density (km/km^2) based on regional blocks of primary wolverine habitat in the western United States delineated by Inman *et al*. (2013; Figure 3). Those results are shown in Table 6. With the exception of the Southern Rockies (at 0.47 km/km^2), the mean road densities at elevations equal to or greater than 2,300 m (7,546 ft) are very low.

Table 6. Mean Road Density in Wolverine Primary Habitat.

Geographic Region‡	Mean density (km/km^2), all roads	Mean density (km/km^2), all roads ≥ 2,300 m (7,546 ft)
Northern Cascade	0.54	0.00
North Continental Divide	0.54	0.00
Salmon-Selway	0.70	0.03
Central Linkage	0.84	0.06
Greater Yellowstone	0.24	0.06
Southern Rockies	0.55	0.47
Sierra Nevada	0.09	0.03
Uinta	0.15	0.12
Bighorn	0.00	0.00
Great Basin	0.06	0.03
Oregon Cascade	0.72	0.00

‡Regions defined in Inman *et al*. (2013; Figure 3).

We also reviewed den site locations (natal, maternal, or unknown dens) within our database relative to roads (see map in **Appendix E**). Our results indicate that wolverine dens in the contiguous United States are located in areas with minimal roads, including local roads; however, we caution that this analysis is based on a limited den site dataset and should be viewed in the context of other abiotic and biotic variables including landscape features at the den site scale and availability of food. Additionally, most den locations in much of the wolverine's range in the contiguous United States are at high elevations and roads in these areas would likely be impassable or closed entirely to vehicles during the time of denning (January–March).

In summary, wolverines are associated with habitat found in high elevation areas, but are known to disperse over great distances. Major highways can present mortality risks to dispersing individuals and affect immigration to open territories, but roads do not represent absolute barriers to wolverine movements. Wolverines den during winter months in locations that are often inaccessible or restricted to motorized vehicles, though, secondary roads and trails are used for winter recreational activity. Although we recognize there are likely additional events that have not been reported, we estimated the total number of wolverine mortalities due to roads from 1972 to 2016 (44 years) in North America was 20, at least 11 of which are from Canada (see citations above). As discussed above, we calculated a low proportion of major highways in both modeled primary habitat and female dispersal habitat, and a low mean density of roads at high elevations where wolverines have been observed, with the exception of the southern Rocky Mountains.

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Roads present a low stressor to wolverines at the individual and population level in most of its current contiguous United States range.

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Disturbance due to Winter Recreational Activity

Wolverine behavior patterns, such as denning, rearing of young, movement and dispersal, and foraging/scavenging, may be affected by recreational activities (COSEWIC 2014, p. 42), though several wolverines have been captured for research on or near ski areas (e.g., Teton Mountains) (Montana FWP 2017, pers. comm.) As noted above, in Norway, May *et al*. (2012, p. 201) found, at the home range scale, a minimal threshold distance of approximately 1.5 km (0.93 mi) for wolverine den sites from private roads and/or recreational cabins. Krebs *et al*. (2007, entire) evaluated habitat use associations for wolverines in two multiple use areas in British Columbia, Canada. Using logistic regression models, the authors found that in an area of active recreation (Columbia Mountains), female wolverines were negatively associated with helicopter and backcountry skiing in their winter models (Krebs *et al*. 2007, pp. 2,187–2,188). However, in summer months, Copeland *et al*. (2007, p. 2,210) reported that wolverines in their study area of central Idaho were not uncommonly found near maintained trails and active campgrounds.

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The Wolverine–Winter Recreation Study represents an on-going project to evaluate the potential effects of backcountry winter recreation (e.g., backcountry skiers, heli-skiers, cat-skiers, snowmobilers) on wolverines (Heinemeyer 2016, pers. comm.). The multiyear study areas include central Idaho and areas in the western Yellowstone region (Island Park and Teton Mountains) (Heinemeyer and Squires 2015, p. 3). The study has been monitoring wolverines using GPS collars using movement rates and percent of time active (vs. resting) as indicators of potential responses of wolverines to winter recreation activities (Heinemeyer 2013, pers. comm.). Backcountry winter recreation activities are monitored through GPS units voluntarily carried by recreationists (Heinemeyer 2016, pers. comm.). Early analysis of the data suggest that wolverines demonstrate a behavioral response to recreation activities, such as increased movement rates and a reduction in resting periods in areas of high recreation activity, especially high recreation days (Saturday and Sunday) (Heinemeyer and Squires 2013, pp. 5, 7–8).

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However, this research has also found that wolverines maintained their home ranges within areas with relatively high winter recreation activity over several years of monitoring, including some areas found to contain the highest recreational activities (Heimemeyer 2016, pers. comm.). The study has not been able to determine whether these resident wolverines are reproductively successful due to the limited monitoring information available for reproductive females (Heinemeyer 2016, pers. comm.).

A final Winter Recreation Study report was prepared by Heinemeyer *et al*. in December 2017. The study presented results from a RSF model in an effort to characterize habitat selection responses of wolverines to winter recreation patterns. The study found that wolverines maintained multi-year home ranges in areas that support relatively intensive winter recreation, suggesting that wolverines are able to tolerate winter recreation at some scales (Heinemeyer *et al*. 2017, p. iv). They also reported that wolverines responded negatively to increasing intensity of winter recreation, with off-road and dispersed recreation having a greater effect than recreation that was concentrated on access routes (Heinemeyer *et al*. 2017, p. 34). In addition,

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wolverine avoidance of roads and groomed areas used by winter recreationists was less than estimated for dispersed recreation, suggesting that wolverines may be less sensitive to predictable winter recreation use patterns (Heinemeyer *et al*. 2017, p. 40). The authors also described habitat selection in females evaluated in the mutli-year study as complex, and likely driven by a combination abiotic (snow, cold) and biotic factors (predator avoidance, food availability) (Heinemeyer *et al*. 2017, p. 36).

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Conservation measures currently being implemented that address the effects of roads in the Teton Mountains include winter closures in certain areas (generally from November 1 through May 1), including road closures in the Bridger-Teton and Caribou-Targhee National Forests and in Grand Teton National Park as shown in **Appendix F** (additional details for Grand Teton National Park are described in Superintendent's Compendium (National Park Service (NPS) 2017; pp. 8–9); see also maps at https://jhalliance.org/campaigns/dont-poach-the-powder/ Jackson Hole Conservation Alliance 2017). These closures are being implemented to help minimize disturbance to wildlife (e.g., migration pathways).

State Wildlife Action Plans prepared for individual western States identify recreation management strategies within wolverine habitats. For example, in Oregon, the ODFW Conservation Strategy identifies management of winter recreation use in order to avoid impacts to wolverines (ODFW 2016). In Montana's State Wildlife Action Plan, conservation actions are identified for addressing potential impacts from recreation, such as consideration of seasonal closures during denning season (Montana FWP 2015, p. 63). The IDFG *Management Plan for the Conservation of Wolverines in Idaho* also includes conservation strategies related to winter recreation (e.g., characterizing wolverine response to recreational activities (IDFG 2014, p. 35)), and the State continues to support the Wolverine-Winter Recreation Study. **Appendix G** provides additional details on individual State conservation strategies.

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In summary, wolverine behavior (movement) can be affected by winter recreational activity. Results from one long-term study in parts of the wolverine's range in the contiguous United States have found that wolverines can maintain residency in high winter recreational use areas. Wolverines have recently been detected in areas that experience winter recreational activity. Conservation strategies and actions have been identified in several western States' Wildlife Action Plan to address potential impacts of this stressor to wolverines. Based on the best available scientific and commercial information, the effect of winter recreational activity represents a low stressor to wolverines in the contiguous United States at the individual and population level.

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Other Human Disturbance

Infrastructure, such as pipelines, active logging or clearcuts, seismic lines, and activities associated with mining (e.g., producing mines, mines under development, mineral exploration areas), may also affect individual wolverine behavior (e.g., avoidance) or loss or modification of wolverine habitat. As discussed above (see Habitat Use section), Johnson *et al*. (2005, entire) evaluated habitat relationships for the wolverine and other arctic wildlife, including the cumulative effects of human activities and associated infrastructure on the distribution of wolverines in the Canadian central Arctic using RSF modeling. However, because human

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disturbance factors (i.e., major developments, mineral explorations, seasonal outfitter camps) were mostly absent from the range of monitored wolverines, the researchers were not able to reliably model their effects (Johnson *et al*. 2005, p. 23).

The 2014 COSEWIC status review identified several potential stressors to wolverines and their habitat in Canadian territories. They indicated potential permanent, temporary, and functional losses to wolverine habitat from forestry; oil, gas, and mineral exploration and development; and large hydroelectric reservoirs (COSEWIC 2014, p. 21). As discussed above, Scrafford *et al*. (2017, entire) evaluated habitat selection of wolverines in response to human disturbance in the western Canadian boreal forest in both winter and summer months. Their analysis found that wolverines were attracted to some industrial infrastructure (older seismic lines exhibiting latter stages of regeneration) and disturbance (areas of active logging), likely related to foraging opportunities (e.g., small prey), but avoided interior areas of intermediate-aged cutblocks (areas authorized for logging) (Scrafford *et al*. 2017, pp. 32–34). Their results found evidence of road avoidance, but wolverines were attracted to all-season road sections with borrow pits, which they suggest was related to foraging opportunities at these pits (e.g., presence of beavers in water-filled pits) and less predation risk, since wolves avoid these roads (Scrafford *et al*. 2017, p. 34). In sum, these authors concluded that wolverine selection patterns relative to industrial activity and infrastructure in their study area represent a balance between exposure to predators and foraging opportunities (Scrafford *et al*. 2017, p. 32).

Additional studies of wolverine behaviors related to the effects of disturbance due to infrastructure and other human activities are needed. Based on the best available scientific and commercial information, these effects are small or narrow in scope and scale and appear to represent a trade-off between foraging opportunities in areas that provide minimal risk of predation and avoidance of open areas and/or higher predation risk (Scrafford *et al*. 2017, pp. 33–34).

Effects from Wildland Fire

Wildland fire can produce both direct and indirect effects to wildlife. Direct effects include injury and mortality as well as escape or emigration movement away from fires (Lyon *et al*. 2000, pp. 17–21). Small mammals will generally find refuge underground or within sheltered places within the burning area, while larger mammals will move to safe areas in unburned patches or outside the burn (Lyon *et al*. 2000, p. 18). For animals that emigrate during fire events, the length of time before they return is dependent on the degree to which fire has altered habitat structure and food supply (Lyon *et al*. 2000, p. 20).

We are unaware of any studies evaluating direct effects of wildland fire to wolverines. Wildland fire is likely to temporarily displace wolverines, which could affect home range dynamics. Given that wolverines can travel long distances in a short period of time, individuals would be expected to move away from fire and smoke (Luensmann 2008, p. 14). In addition, because young are born during winter months, fire risk at that critical life stage is very low (Luensmann 2008, p. 14).

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Indirect effects of wildland fire can include habitat-related effects or effects to prey and competitors/predators; however, we are unaware of empirical studies evaluating these potential effects as they relate to wolverines. In a study area within the Yukon (Canada), wolverines were reported occupying regenerating forested habitat that contained remnants of mature timber which had burned 30 years prior (Slough and Mowat 1996, p. 948). Additionally, fire suppression in conjunction with logging activities in boreal forests (northwestern Ontario) can increase the prevalence of deciduous tree habitats, at least at a regional level, which is negatively associated with wolverine occurrence (Bowman *et al*. 2010, p. 464).

A study in northern Idaho of the effects of multiple wildland fires over several years, including very large fires, to forest habitat occupied by another mustelid, the American marten (*Martes americana*) found that fire events had created a mosaic of vegetation that supported a diverse assemblage of cover and food resources that was favorable to this species (Koehler and Hornocker 1977, p. 503). Similar to wolverines, the summer and fall diet of the American marten is represented by diverse prey, and wildland fire events can create and maintain forest openings for ground squirrels and voles (Koehler and Hornocker 1977, p. 504). The development of these types of mosaic forest communities following certain wildland fire events also provides discontinuous fuel loads, which in turn should result in smaller and cooler wildland fires, with less replacement of marten habitat (Koehler and Hornocker 1977, p. 504). However, large, uniform burns would be expected to result in more severe impacts to American marten habitat (Lyon *et al*. 2000, p. 21).

Studies of the effects of wildland fire to a key prey species for the wolverine in parts of its North American range, the caribou, was reviewed by Klein (1982, entire). This review highlighted the importance of separating short-term effects of wildland fire in boreal forests to caribou ecology from long-term effects (Klein 1982, p. 393). Given that long-term benefits to the species' ecology can be disproportionate to the short-term detrimental effects on populations and herds, (including the species' lack of reproductive plasticity), caribou may be more appropriately considered as fire-influenced, rather than fire-adapted (Klein 1982, p. 393). Other ungulate prey species respond more positively to fire. An increase in spring and summer grasses following fall burns can provide forage for elk and deer, and sprouting of deciduous trees, such as aspen, birch and willow, following burns provides forage for moose (Luensmann 2008, p. 18).

Management measures to address this potential stressor are identified in USDA Forest Service National Forest Land Management Plans. Examples of these goals and objectives are described in **Appendix G**. In addition, the Idaho State Wildlife Action Plan includes measures to address fire threats to the wolverine and its habitat, including removal of perceived barriers to allow more prescribed natural fire on State and private forest lands and promoting/facilitating the use of prescribed fire as a habitat restoration tool, on both public and private lands where appropriate, and leaving fire-killed trees standing as wildlife habitat if they pose no safety hazard, all in an effort to restore a more natural fire interval that allows for return to historical forest conditions (IDFG 2017b, pp. 91, 134, 180).

Given the diversity of habitats occupied by wolverines, their occupancy of high elevations, and extensive mobility, wildland fire represents a limited stressor, in scope and scale, to wolverine habitat and its prey in the contiguous United States range.

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Disease or Predation

Disease

We are unaware of comprehensive surveys evaluating the prevalence of diseases in wolverines in the contiguous United States. Early accounts of endoparasites species and their prevalence in wolverines include a review by Erickson (1946, p. 503), and a report by Rausch (1959, entire), who documented 7 species of helminth parasites in 86 percent of wolverines examined from trapper-supplied carcasses in Alaska. In 1994, Copeland (1996, p. 26) collected a single specimen of the parasite *Toxascaris* sp. from wolverine scat in Idaho. In Alaska, carcasses sampled (during necropsy or predator control activities) in 2012–2014 to determine the prevalence of *Trichinella* and its genotypes reported one wolverine with *Trichinella* T6 genotype in that single sample (ADF&G 2015b, p. 8). Results from Alaska trapper questionnaires for the prevalence of ectoparasites on wolverines were either scarce or not present across all reporting regions in 2015–2016 (Parr 2016, p. 21).

Rabies is endemic to Alaska in Arctic and red fox along north and west coasts of Alaska (ADF&G 2013c). Under the ADF&G enhanced rabies surveillance program, the agency confirmed rabies in one wolverine (out of 49 sampled) in 2012, a female found dead in the North Slope region (Woodford and Beckman 2012). This was the first confirmed case of rabies in wolverines in North America (Woodford and Beckham 2012).

The 2014 COSEWIC Assessment and Status Report for the wolverine presented a summary of reported parasitic species observed in wolverines in Canada (COSEWIC 2014, p. 25). These observations included: parasitic nematode roundworms (*Trichinella* spp.) in 88 percent of wolverine samples tested from Nunavut and 26 percent from the lower MacKenzie region; helminth parasites (trematodes, cestodes and nematodes) in wolverine digestive tracts from the lower Mackenzie River valley; and, from the Nunavut region, protozoan parasites infections including *Sacrosystis* spp. (80 percent) and *Toxoplasma gondii* (41 percent) (citations omitted). Banci (1987, pp. 81, 110) reported parasitic pneumonia as a cause of mortality in southwest Yukon Territory, a female thought be nutritionally-stressed following the raising of young.

An evaluation of trapper-submitted wolverine carcasses harvested was conducted for the Yukon Territory in the fur trapping seasons 2005–2006 through 2011–2012 (Jung and Kukka 2013, entire). No samples tested positive for rabies (Jung and Kukka 2013, p. 17). Another study of intestinal parasites of wolverine carcasses from both the Yukon and Northwest Territories reported *Trichinella* spp. in 74 percent of carcasses and several intestinal parasites, including cestodes (parasitic flatworms) such as *Taenia* spp. (Luck *et al*. 2016, no page number).

In summary, other than a parasitic pneumonia mortality event and the single rabies case, we are not aware of any other studies documenting impacts of disease to wolverines in North America. At this time, based on the best available scientific and commercial information, we do not find that disease is a population or species level stressor to the wolverine in the contiguous United States.

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Predation

As discussed above (*Diet and Feeding* section), a number of potential natural predators have been identified for wolverines within its North American range, including intraspecific predation. However, we have no information that suggests this predation represents a significant stressor to the wolverine at the population level. At the individual level, we recognize that wolverines likely avoid areas of potential predation risk from wolves (Scrafford et al. 2017, p. 34) and other potential predators. Thus, indirect effects of predators may result in predator avoidance behavior of individual wolverines through habitat selection.

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In summary, the best scientific and commercial information available indicates that disease or predation is not a stressor for the wolverine. We are unaware of any management or conservation measures currently in place to reduce potential impacts associated with disease or predation.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

There is currently no allowable trapping or harvesting of wolverines in the contiguous United States, though incidental trapping mortalities have been documented as we reported in our proposed rule (78 FR 7881; February 4, 2013). Two mortality events from shootings of wolverines were documented in Idaho (2001, 2007) (Idaho Department of Fish and Game (IDFG) 2014, p. 26).

In Montana, wolverines were a legally harvested furbearer in Montana up until 2012. As noted in **Appendix G**, beginning in 2008, the State shifted harvest units and quotas to emphasize proetection in smaller mountain ranges, closing 40 percent of the State to harvest and the trapping season is currently suspended with a zero statewide quota (Montana Natural Heritage Program and Montana FWP 2017). Montana FWP also adopted mandatory trapping education in August 2017, which begins in 2018, which will emphasize avoidance of incidental captures and modern equipment in order to minimize injury (Montana FWP 2017, pers. comm.). There is, however, no evidence to suggest that the harvest of wolverines in Montana at historical rates (about 10 animals per year) was detrimental to wolverine populations, and since 2005, the rates and spatial arrangement of wolverine harvest have been much more conservative than the historical rates (Montana FWP 2017, pers. comm.) (see **Appendix G**).

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Unlike populations in Eurasia, wolverines rarely prey on livestock in North America (*cf.* domestic sheep predation in Wyoming reported (Mead 2013, pers. comm.)) and therefore they are not directly targeted for predator control (COSEWIC 2014, p. 41). However, incidental trapping can result in the capture of non-target species such as wolverine. In Idaho, the IDFG has a mandatory furtaker harvest report that requests all live incidental catches be reported by species and any wolverine catch that results in mortality is required to be reported (IDFG 2013, pers. comm.). Since 1965, over a period of just over 50 years, 17 incidentally-trapped wolverines were reported during the State's furbearing seasons, with 6 animals known to be released alive and 6 mortalities (IDFG 2013, pers. comm.; IDFG 2016, pers. comm.; IDFG 2017, pers. comm.). This total includes four wolverines caught during the 2013-2014 furbearer season, with three released alive and one mortality (IDFG 2014, p. 26), and one animal in 2016, who released itself prior to

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discovery (identified through DNA testing). Though the fate of that animal is unknown there was no obvious sign of injury (IDFG 2017, pers. comm.).

The State of Utah maintains a highly regulated trapping program, including mandatory trap check intervals (Utah Department of Natural Resources (UDNR) 2017, pers. comm.). Any incidentally trapped wolverines must be released and any mortality must be reported to the Division of Wildlife Resources within 48 hours; there are no records of incidental captures (UDNR 2017, pers. comm.). Within the State of Wyoming, there are two confirmed reports of incidental take, one in 1996 (Mead 2013, pers. comm.) one in 2006. The 2006 animal was released unharmed (Inman 2012, pers. comm.). In Montana, since the closing of the trapping season for wolverine in 2013 (2013 through 2016), four wolverines have been incidentally trapped, one in 2013 and three in 2014 (Inman 2017c, pers. comm.). The 2013 capture was released unharmed and the three caught in 2014 were all mortalities (Inman 2017c, pers. comm.).

Predator control programs targeting wolves, including poison and incidental trapping, can result in incidental losses of wolverines (COSEWIC 2014, p. 41). Specific to wolf control for livestock protection in Idaho, three wolverines have been trapped incidental to authorized wolf control activities since 1995, with two released alive and one animal euthanized (IDFG 2014, p. 26). Preventive measures have been adopted to reduce these incidental captures, including implementation of educational programs to minimize incidental capture of wolverines during trapping seasons (IDFG 2014, p. 27). Licensed wolf trappers are required to complete a Wolf Trapper Education course with specific instruction for reducing incidental trapping of wolverine, Canada lynx, and other non-target species (IDFG 2014, p. 27). In addition, the U.S. Department of Agriculture Wildlife Services (Wildlife Services) agency has also temporarily stopped (as of April 2017) using cyanide predator control devices in the State of Idaho (Moeller 2017). Wildlife Services has also agreed to not use, or fund the use of, M-44 cyanide devices on public lands in Colorado pending issuance of an Environmental Assessment (Civil Action No. 17-cv-00891-WYD) and has agreed to interim measures, including not using EPA-labeled pesticides targeting mammalian species, in the Northern District of California, pending environmental analsysis (Case No. 3:17-cv-3564-WHA) .

In Alaska, wolverine trapping and hunting is controlled by seasons and bag limits, with about 550 animals harvested each year (Alaska Department of Fish and Game (ADF&G) 2017a). For the 2015–2016 reporting period, wolverine harvest, based on furbearer sealing records,[3] totaled 527 animals (Parr 2016, p. 42). This level of harvest has been fairly consistent since 2010, as shown in Table 7 below.

Table 7. Number of wolverines harvested in Alaska, as reported from regulatory year sealing records, 2010–2015. Adapted from Parr (2016, p. 42; Table 10).

[3] Wolverines taken in Alaska are required to be sealed by an authorized department representative before pelts are shipped to an out-of-state buyer or auction house (Parr 2016, p. 44). For those species that require sealing, the number of animals sealed represents the best information regarding the statewide harvest (Parr 2016, p. 41).

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Alaska Region	2010	2011	2012	2013	2014	2015
I	25	20	25	31	14	15
II	25	29	50	31	16	37
III	233	235	261	358	268	214
IV	180	160	170	158	99	150
V	140	110	135	133	109	111
Total	603	554	641	711	506	527

Trapping and harvesting of wolverines occurs over much of the range in Canada, as summarized in the 2014 COSEWIC wolverine status review (COSEWIC 2014, pp. 10, 29–35). Specifically, wolverines are harvested in the northern and western territories–Manitoba, Saskatchewan, Alberta, British Columbia, Yukon, Northwest Territories, and Nunavut (COSEWIC 2014, p. 43). Non-aboriginal harvest of wolverines has not been permitted since 2001–2002 in Québec and Labrador (COSEWIC 2014, p. 43). Trapping is closed in Ontario (except through treaty rights), though incidental trapping results in 1 to 4 mortalities per year (Bowman *et al*. 2010, p. 465). Harvest levels in western provinces have remained relatively stable since 1992 (COSEWIC 2014, p. 38; Table 1). An earlier assessment of the sustainability of wolverine harvest in British Columbia was presented in Lofroth and Ott (2007, entire). That study found that the trapping and hunting harvest of British Columbia's wolverine population was likely sustainable at a provincial scale from 1985 to 2004, with wolverine harvest in 15 of 71 population units were likely unsustainable during this period (Lofroth and Ott 2007, p. 2,197).

The management of wolverine harvest in Canada incorporates spatial and temporal elements such as season length, quotas, limited entry, and trapline management by trappers (reviewed by Slough *et al*. 1987). Wolverine harvest levels in Canada are monitored using mandatory pelt sealing, annual harvest reporting, or through monitoring of fur exports (COSEWIC 2014, p. 43). In some northern communities, wolverine pelts are used locally and harvests are monitored through carcass collection programs (COSEWIC 2014, p. 43).

The COSEWIC Assessment and Status Report for the wolverine also noted that range contraction and habitat trends of wolverines in Canada are not solely the result of habitat or trapping pressure (COSEWIC 2014, p. 20). Reductions in ungulate (e.g., caribou) populations, which provide an important winter food resource, were also likely an important factor in range contractions of wolverines in its northern range (COSEWIC 2014, p. 20), and likely continue to influence populations today. Snowmobiles have allowed for better access for hunters and trappers and may be increasing the number of wolverine harvested in its northern North America range; however, the areas of exploitation are still relatively small concentrated areas, and large areas of refugia continue to be found (Cardinal 2004, p. 31).

As described in the 2014 COSEWIC report, trends in wolverine populations in the northern range, while uncertain, appear to be stable or increasing, with some concern for populations in the southern areas of British Columbia and parts of the northern United States (COSEWIC 2014, p. 22, and references cited therein). Similarly, in Alaska, over the past 6 years, on average, 590 wolverines are taken each year (see Table 7). The consistent harvest levels in these regions suggest relatively stable wolverine populations.

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We evaluated trapping of wolverines in British Columbia and Alberta regions of Canada in an effort to document potential impacts to dispersing wolverines along the U.S.–Canada border. As described above (*Population Abundance and Distribution*), the population of wolverines in British Columbia is estimated to be 2,700–4,760 and 1,500–2,000 animals in Alberta (COSEWIC 2014, p 36). We obtained 9 years (2007–2015) of harvest data for southern BC wildlife management units from the British Columbia Ministry of Environment, Ecosystems Branch for our analysis (Weir 2017b, pers. comm.). Twenty seven years (1989–2015) of harvest data was obtained for Alberta in addition to locations of wolverines from a 2012–2015 study and other sources (Webb *et al*. 2016, p. 1,465; Webb 2017, pers. comm.).

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Figure 6 presents the results from our spatial analysis and indicates a total of 77 wolverines were trapped in British Columbia wildlife management units within 110 km (68.35 mi) of the U.S.–Canada border from 2007–2015 (average of 8.5 animals per year) (Note: the gray areas depicted for British Columbia represent management units with zero harvest). We used this distance since it's similar to both the average maximum distance per dispersal movement of 102 km (63 mi) for male wolverines reported by Inman *et al*. (2012a, p. 784) for the Greater Yellowstone region of Montana, and a reported 100 km (62 mi) dispersal distance for a juvenile male for Ontario, Canada (COSEWIC 2014, p. 24, citing unpublished data from Dawson *et al*. 2013). As shown below, one management area contains nearly one-third (23 individuals) of this total number. The other management units along the international border indicate very few animals harvested over this 8-year period (i.e., areas on map identified as zero). There is no open trapping season or hunting season on wolverines in the management units in the Okanagan (Region 8) (north of Washington State) or South Coast (Region 2) (southwest corner of British Columbia) with a trapping season for wolverines only in the Kootenay (Region 4, the eastern half of the southern part of the province) (Weir 2017c, pers. comm.). In addition, there has not been an open trapping season in Region 2 since at least 1985 and since 1993 in the Okanagan region (Weir 2017d, pers. comm.). For Alberta, we identified a total of 15 wolverines harvested by trappers and data presented in other studies within 110 km (68.35 mi) of the U.S.–Canada border from 1989–2014 (average of less than 1.0 animal per year). Researchers in Canada are currently conducting a landscape level analysis to estimate the size and sustainable harvest for wolverine populations within British Columbia (Weir 2017a, pers. comm.). We also requested information related to incidental trapping along the southern Alberta- U.S. border. Only one registered trapline is located 10 km north of the border with Montana and no wolverines have been reported as this is primarily grassland habitat (Webb 2018, pers. comm.). In addition, in Canada, if wolverines are trapped outside of a registered trapline, trappers are required to register that event; however, fur harvest records for southern Alberta do not indicate any trapped wolverines (Webb 2018, pers. comm.).

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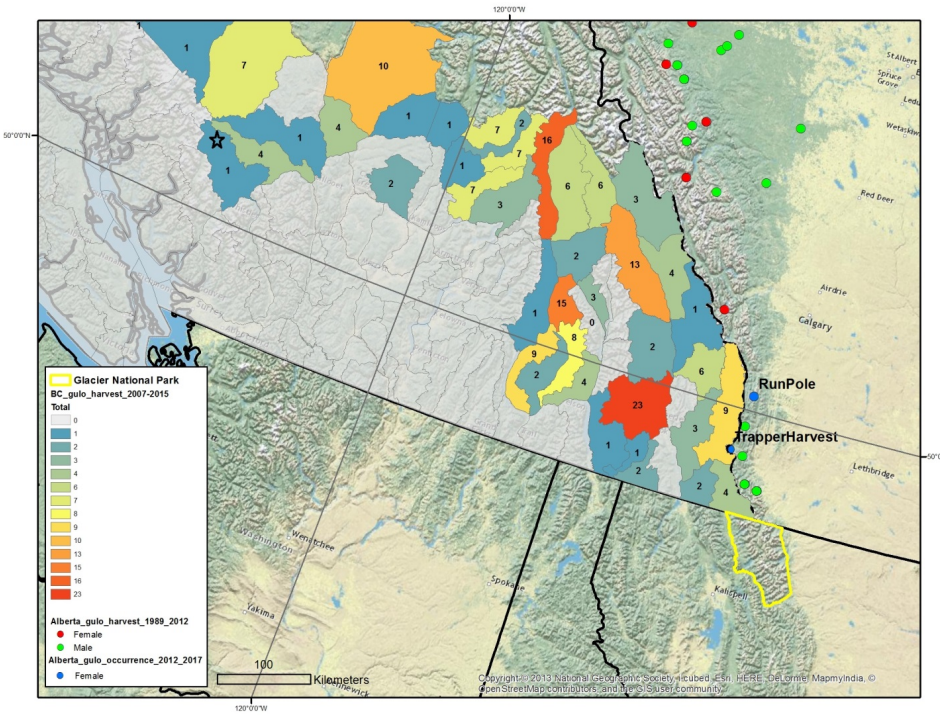

Figure 64. Numbers of wolverines harvested in British Columbia and Alberta, Canada. Sources: Weir 2017a, pers. comm.; Webb *et al.* 2016; Webb 2017, pers. comm.

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Based on this analysis, trapping effort along the U.S.–Canada border does not represent a barrier to wolverine movement and dispersal along the international border. As noted above, Regehr and Lacroix's (2016, entire) multi-method inventory of wolverines within an area located in the eastern side of the Coast Mountains of British Columbia (see black star in Figure 6 above) found unexpectedly high numbers of wolverines, which may have been the result of the rugged landscape features in this mountainous area and abundant food resources (both winter and summer) (Regehr and Lacroix 2016, pp. 249–250).

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Legal Status/Protection

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In the western United States, the wolverine status is as follows: a state-threatened species in Oregon (ODFW 2016) and California (CDFW 2017a); state-endangered species in Colorado (Colorado Parks and Wildlife 2015a) ; a candidate species in Washington (Washington Department of Fish and Wildlife (WDFW) 2013); a protected nongame species and species of greatest conservation need in Idaho (IDFG 2014); a protected animal and species of greatest conservation need in Wyoming (WGFD 2017); protected from collection, possession, and importation (Utah Administrative Rule R-657-3-24) and a species of greatest conservation need in Utah (Utah Wildlife Action Plan Joint Team 2015); a furbearer and species of concern in

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Montana (Montana Natural Heritage Program and Montana FWP 2017); and, in Nevada, the Nevada Administrative Code lists wolverines as a protected mammal (NAC 503.030), which provides full legal protection. There is no protected status for wolverines in the State of Alaska. The State of New Mexico Department of Game and Fish does not recognize the wolverine as a native mammal. Additional discussion regarding State regulatory mechanisms that provide protections for wolverines is provided in **Appendix G**.

The Idaho Department of Fish and Game issues permits allowing live capture, handling, and release of wolverines for scientific studies, which usually involved log box-traps that do not cause physical injury to the captured animals (IDFG 2014, p. 27). The agency also issues scientific collection permits to various agencies and organizations and to IDFG biologists that can include the capture, chemical immobilization, and placement of radio-collars/radio-markers on wolverines (IDFG 2014, p. 27). These permittees (and IDFG staff) are required to comply with animal trapping and handling protocols approved by IDFG's Wildlife Health/Forensic Laboratory and other animal welfare and research institutions. This same process is followed by the State of Montana (Montana FWP 2017, pers. comm.). Over the past 20 years, there have been two documented wolverine deaths due to live capture activities in Idaho (IDFG 2014, p. 27), and one handling-related mortaliy in Montana (Montana FWP 2017, pers. comm).

In Wyoming, the Wyoming Game and Fish Commission (Commission) Regulation Chapter 52, Nongame Wildlife, authorizes 'take' of wolverine only for scientific or educational purposes as regulated by Commission Regulation Chapter 33 (Regulation Governing Issuance of Scientific, Research, Educational, or Special Purpose Permits). As of November 2017, the WGFD has issued five different Chapter 33 permis for research activities; four of the five are for live capture and one for camera trapping surveys (WGFD 2017, pers. comm.). No incidental take has been reported from permits issued, and no permits allowing for the take of wolverine hve been issued in Wyoming (WGFD 2017, pers. comm.).

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In California, research permits for State-listed, State-candidate, and fully protected species in California are issued as a Memorandum of Understanding (MOU). Currently, there are no active MOUs for research on wolverine in California (Burkett 2017, pers. comm.).

In Canada, provincial designations for the wolverine include Endangered in Labrador, and Threatened in Ontario and Québec ('Threatened' is equivalent to Endangered in Québec), with the remaining provincial designations ranging from no ranking to Sensitive or Special Concern and the Vancouver Island population designated as Imperilled (COSEWIC 2014, p. 44). Recovery planning for the wolverine is focused on the eastern population (Canadian Boreal Forest Agreement Secretariat 2015, p. 3).

In summary, overutilization does not currently represent a stressor to the wolverine in the contiguous United States at the individual, population, or species level. Wolverine populations in the contiguous United States are currently protected under several State laws and regulations. Hunting and trapping activities for wolverines are currently suspended or closed entirely for animals within the contiguous United States, though occasional incidental trapping can occur. Trapping in Montana, Alaska, and Canada has been and appears to be sustainable. Trapping or harvesting of wolverines along the contiguous U.S.–Canada border does not represent a stressor

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to wolverines migrating into the contiguous United States at the individual or population level. In addition, wolverine populations along the Alaska–Canada border are continuous with the Yukon region of Canada, which suggests a rescue effect for Canadian populations along this international boundary (COSEWIC 2014, p. 37).

Summary of Current Conditions

Wolverine populations in much of North America are still recovering from large losses of individuals from intensive hunting and unregulated persecution pressures in the late 1880s into the mid-20th century. The distribution of wolverines within suitable habitat provides a better method for estimating population status than using abundance of animals, although there is limited rangewide survey information. Based on the best available information, wolverines continue to be detected within suitable habitat within the west-northwestern contiguous United States including Washington, Oregon, Idaho, Montana, and Wyoming (e.g., Aubry *et al*. 2016, pp. 14–15; Magoun *et al*. 2013, p. 27; Montana FWP 2017, pers. comm.). Studies are currently underway to estimate the species' current distribution and genetic characteristics of these populations. In Canada, the total wolverine population is estimated at over 10,000 adults (COSEWIC 2014, p. 47). In Alaska, estimates of populations are not available and are best evaluated based on density (Parr 2017, pers.comm.), which are naturally low for this species. Recent density estimates range from 5 to 10 wolverines per 1000 km^2 (386 mi^2) for Alaska (Parr 2017, pers. comm). The best available information does not indicate wolverine populations are currently negatively impacted by the lack of genetic diversity and there is no evidence that the population in the contiguous United States is declining.

We prepared a Current Potential Extent map to illustrate the species' current distribution in the contiguous United States (Figure 3). We estimated this area represents approximately 3.5 percent of the wolverine's North American range.

We determined that 72 percent of our Curent Potential Extent of the wolverine in the contiguous United States is found on lands owned or managed by the Federal government (see **Appendix D**) We also evaluated Inman *et al*.'s (2013) previously modeled wolverine primary habitat in the contiguous United States and estimated that 96 percent of that area is owned or managed by Federal agencies and 41 percent is located in designated wilderness areas. **Appendix G**, *Regulatory Mechanisms and Conservation Measures*, provides a more detailed summary of management actions.

We evaluated several potential stressors that may be affecting wolverine populations or its habitat, including effects from roads, disturbance due to winter recreation and other activities, effects from wildland fire, disease and predation, and overutilization for (primarily) commercial purposes. We determined that the effects of roads (evaluated by number of miles, density, and location) and disturbance represent low level stressors to the wolverine in the contiguous United States. Wildland fire was determined to be a short-term stressor to wolverine habitat and its prey. Disease and predation are not considered stressors to the wolverine.

Legal trapping or hunting of wolverines is currently prohibited in the contiguous United States. Incidental trapping of wolverines is infrequent in the contiguous United States, and, in Idaho and

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Montana, education programs are being implemented to reduce this stressor. In Alaska, the level of harvest of wolverines has been fairly consistent since 2010, and, as noted above, density estimates indicate no declining trend in wolverine populations.

Wolverines are harvested in several Canadian provinces with management and monitoring oversight based on spatial and temporal elements. We reviewed trapping information from Canada (within 110 km (68.35 mi) of the contiguous U.S.–Canada border) to assess potential impacts to dispersing wolverines into the United States. We found that, in Alberta, 15 wolverines were harvest over a 25 year period (average of less than 1.0 animal per year), and, for British Columbia, we found an average of 8.5 animals per year, though one management area contained nearly one-third (23 individuals) of this total (Weir 2017b, pers. comm.). Researchers in Canada are currently conducting a landscape level analysis to estimate the size and sustainable harvest for wolverine populations within British Columbia (Weir 2017a, pers. comm.). Based on the best available commercial and scientific information, overutilization does not represent a stressor to the wolverine in the contiguous United States.

Status – Future Conditions

The future timeframe evaluated in our analysis is approximately 40 to 50 years, which captures our best professional judgment of the projected future conditions related to trapping/harvesting, climate change, or other potential cumulative impacts. We note here that evaluations of future conditions for species have an inherent level of uncertainty relative to demographic risks, particularly those related to climate change projection.

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After considering the current conditions for the wolverine and its habitat, we describe here the most likely future scenario to potentially have an effect on wolverine at the population level in the contiguous United States:

- Climate change effects (i.e., significantly elevated temperatures resulting in decline in snowpack) may modify suitable habitat (including reproductive denning habitat), which could also change the scope of the wildland fire stressor.

Based on our review of the best available information, we determined that there were no other plausible scenarios that were likely to have population level impacts to wolverine in the contiguous United States. We expect that the effects of trapping and roads, human disturbance, effects of wildland fire to continue to be at low levels in the future. We have no information that indicates that mortality from roads or disease would increase within the range of wolverine in the contiguous United States in the future.

Climate Change Effects

In this section, we consider climate changes that may affect environmental conditions that the wolverine relies on. As defined by the Intergovernmental Panel on Climate Change (IPCC), the term "climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2013a, p. 1,450). The term "climate change" thus refers to a change in the mean or the variability of relevant properties, which persists for an extended

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period, typically decades or longer, due to natural conditions (e.g., solar cycles) or human-caused changes in the composition of atmosphere or in land use (IPCC 2013a, p. 1,450).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring. In particular, warming of the climate system is unequivocal and many of the observed changes in the last 60 years are unprecedented over decades to millennia (IPCC 2013b, p. 4). The change in temperature reported in the Northern Hemisphere in recent history (past 150 years) at +0.6°C (1.08°F) is twice the change reported for the Southern Hemisphere (+0.3°C (0.54°F)) and there is much year-to-year variation (Post 2013, p. 4). With regard to precipitation over land, there has been a decline in global total annual precipitation, but the variability between years in total precipitation has increased since about the 1970s (Post 2013, p. 9). The Palmer Drought Severity Index (PDSI) compares the actual amount of precipitation received in an area during a certain time period with the normal or average amount expected during that same period (National Weather Service (NWS) 2015) and is generally used as a measure of water stress. Time series analysis of the PDSI indicates worsening persistent drought-like or drought-potential conditions across the globe since 1980, a reflection of the influence of temperature on atmospheric dynamics (Post 2013, pp. 10–11).

Comprehensive assessments of other observed and projected changes in climate and associated effects and risks, and the basis for them, are provided for global and regional scales in recent reports issued by the IPCC (2013c, 2014), and similar types of information for the United States and regions within it can be found in the National Climate Assessment (Melillo *et al*. 2014, entire). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate and is "extremely likely" (defined by the IPCC as 95 to 100 percent likelihood) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from fossil fuel use (IPCC 2013b, p. 17 and related citations).

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions. Model results yield very similar projections of average global warming until about 2030, and thereafter the magnitude and rate of warming vary through the end of the century depending on the assumptions about human population levels, emissions of GHGs, and other factors that influence climate change. Thus, absent extremely rapid stabilization of GHGs at a global level, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by human actions regarding GHG emissions (IPCC 2013b, 2014; entire).

Global climate projections are informative, and, in some cases, the only or the best scientific information available. However, projected changes in climate and related impacts can vary substantially across and, as noted above, within different regions and hemispheres (e.g., IPCC 2013c, 2014; entire) and within the United States (Melillo *et al*. 2014, entire). Therefore, we use "downscaled" projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is

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more relevant to spatial scales used for analyses of a given species (see Glick *et al*. 2011, pp. 58–61, for a discussion of downscaling). We note here that multiple lines of evidence, not just projections derived from quantitative models, should be examined when conducting climate vulnerability assessments (Michalak *et al*. 2017, entire). Thus, we provide below projected effects from climate change in the western United States relative to both abiotic (e.g., temperature, precipitation, snow cover) and biotic (e.g., phenology, behavior) factors.

Abiotic Factors

California

Regional temperature and precipitation observations for assessing climate change are often used as an indicator of how climate is changing. For evaluating climate trends in California, the Western Regional Climate Center (WRCC) has defined 11 climate regions (Abatzoglou *et al*. 2009, p. 1,535). The relevant region for our assessment is the north/north-central Sierra Nevada region (Tahoe National Forest), currently occupied by a male wolverine, or the northeast region as defined in Abatzoglou *et al*. (2009, p. 1,535) .

Two indicators of temperature, the increase in mean temperature and the increase in maximum temperature, are important for evaluating trends in climate change in California. For the climate region that encompasses the Tahoe National Forest region, the 100-year linear trends provided by the WRCC indicate an increase in mean temperatures (Jan–Dec) of approximately 0.92°C/100 yr (± 0.29°C/100 yr) (1.66°F ± 0.53°F/100 yr) since 1895 from present day; 1.55°C/100 yr (± 0.67°C/100 yr) (2.79°F ± 1.21°F/100 yr) since 1949 to present day; and 2.41°C/100 yr (±1.54°C/100 yr) (4.33°F ± 2.78°F/100 yr) since 1975 to present day (WRCC 2017). Thus, the increase in mean temperature has not been constant—the rate of increase over the past 42 years in this region has been 2.6 times higher than the past 122 years. We assume the rate of temperature increase for this region is higher for the second and third time periods (since 1949 and 1975, respectively) than for the first time period (since 1895) due to the increased use of fossil fuels in the later part of the 20th and early 21st century.

Although these observed trends provide information as to how climate has changed in the past, climate models can be used to simulate and develop future climate projections. Both state-wide and regional probabilistic estimates of temperature and precipitation changes for California (by the 2060s) using downscaled data from 16 global circulation models and 3 nested regional climate models were presented by Pierce *et al*. (2013, entire). The study looked at a historical (1985–1994) and a future (2060–2069) time period using the IPCC Special Report on Emission Scenarios A2 (Pierce *et al*. 2013, p. 841), which is an IPCC-defined scenario used for the IPCCs Third and Fourth Assessment reports, and is based on a global population growth scenario and economic conditions that result in a relatively high level of atmospheric GHGs by 2100 (IPCC 2000, pp. 4–5; see Stocker *et al*. 2013, pp. 60–68, and Walsh *et al*. 2014, pp. 25–28, for discussions and comparisons of the prior and current IPCC approaches and outcomes). Importantly, the projections by Pierce *et al*. (2013, pp. 852–853) include daily distributions and natural internal climate variability.

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Simulations using these downscaling methods project an increase in *yearly* temperature for the area that encompasses the Tahoe National Forest (Sierra Nevada) ranging from 2.1°C (3.78°F) to 3.2°C (5.76°F) by the 2060s time period (Pierce *et al*. 2013, p. 844), compared to 1985–1994. The simulations indicated a yearly upper temperature increase of 2.5°C (4.5°F) from 1985–1994 to 2060–2069 (averaged across models) for this area, and an increase of 1.9°C (3.42°F) for the December–February period (Pierce *et al*. 2013, p. 842).

Beginning in 2012 and continuing into 2016, California experienced a severe drought throughout most of the state (Griffin and Anchukaitis 2014, p. 9,020). Although three-year droughts in California are not unusual when evaluated over the past 1000 years, the severity of these drought conditions during this period was demonstrated in the 2014 summer PDSI, which was estimated to be the lowest on record (1901–2014) (Williams *et al*. 2015, p. 6,823). An evaluation of how unusual this drought event was in the context of the last millennium using blue oak (*Quercus douglasii*) tree ring data from four sampling sites (with additional tree sampling following the 2014 growth season) was conducted by Griffin and Anchukaitis (2014, entire). Their paleoclimate drought and precipitation reconstructions for Central and Southern California show that, although the precipitation during this drought has not been anomalously low, it was not outside the range of variability (Griffin and Anchukaitis 2014, p. 9,017). However, the 2014 drought was the worst single drought year of at least the last 1,200 years in California and the 2012–2014 drought was the most severe of three consecutive drought years, based on three events found in the record for the last 1,200 years (Griffin and Anchukaitis 2014, pp. 9,020–9,021). The study concluded that low precipitation combined with high temperatures was responsible for creating this worst short-term drought episode (Griffin and Anchukaitis 2014, pp. 9,021–9,022).

A study by Williams *et al.* (2015, entire) estimated the anthropogenic contribution to California's drought during 2012–2014. They found that the intensifying effect of high potential evapotranspiration on this drought event (measured by summer PDSI) was almost entirely the result of high temperatures (18–27 percent in 2012–2014; 20–26 percent in 2014) (Williams *et al*. 2015, p. 6,825). Another study evaluating the influence of temperature on the drought in water year 2014 in California found that, although the low level of precipitation was the primary driver for the drought conditions, temperature was an important factor in exacerbating the drought, noting that the water year 2014 was the third year of the multiyear drought event and therefore conditions were drier than normal at the beginning of the water year (Shukla *et al*. 2015, p. 4,392).

In sum, these projections indicate that increased temperatures are likely to occur in the Tahoe National Forest region by the 2060s due to the effects of climate change.

Precipitation patterns can also be used as an indicator of potential climate change. We obtained yearly snowfall data for the Tahoe City station located in the northern Sierra Nevada region from the WRCC (https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca8758) since that dataset was the most complete for the area. We then conducted a nonparametric correlation test, the Mann-Kendall statistical test (Hipel and McLeod 1994, pp. 63–64, 856–858), which is commonly used for analyzing climatic time series (e.g., Ahmad *et al*. 2015, entire), to evaluate trends in snowfall over time. This analysis was conducted using the R and R Studio software programs (Version

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3.1.2; R Development Core Team, 2014) with the "Kendall" package (Version 2.2) (McLeod 2011). We found that annual snowfall amounts showed no statistically significant trend (increasing or decreasing) from 1909–2017 (tau = –0.0289, two-sided *p*-value of 0.6705) for the Tahoe City station.

State-wide and regional probabilistic estimates of precipitation changes for California were also evaluated by Pierce *et al*. (2013, entire). When averaged across all models and downscaling methods, small annual mean decreases in precipitation were found for the Sierra Nevada region of California (by the 2060s), but that study also found an increase in precipitation for the December through February period (wetter winters) (Pierce *et al*. 2013, pp. 849, 855). There was significant disagreement across the models, with percent changes ranging from a 12 percent decrease to a 9 percent increase (Pierce *et al*. 2013, p. 851), and the projected changes in seasonal-mean precipitation were generally small when compared to natural internal climate variability (Pierce *et al*. 2013, p. 850; Figure 9).

Columbia River Basin Region

This region covers a large area within Washington, Oregon, and Idaho, and parts of British Columbia, Canada, and includes portions of the Current Potential Extent area of the wolverine. Rupp *et al*. (2017, entire) used simulations from 35 Global Climate Models (GCMs) to provide projections of climate in the Columbia River Basin into the 2080s under two emissions scenarios, Representative Concentration Pathways (RCP) (RCP 4.5, which represents moderate reduction in GHG emissions ("intermediate emissions"), and RCP 8.5, which represents a continued increase in GHG emission "high emission"). The results of their multi-model ensemble for the RCP 4.5 scenario indicate mean annual temperature increases (above Bonneville Dam), above the 1970–1999 baseline average, of 1.3°C (2.34°F) for the 2010–2039 period, 2.3°C (4.14°F) for the 2040–2069 period, and 2.8°C (5.04°F), for the 2070–2099 future period (Rupp *et al*. 2017, p. 1,788). By season, the winter period (December–February) mean change result indicates an increase of 1.1°C (2.52°F) for 2010–2039, 2.2°C (3.96°F) for 2040-2069, and 2.7°C (4.86°F) for 2070–2099, as compared to the 1970–1999 baseline average (Rupp et al. 2017, p. 1,788).

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For the RCP 8.5 scenario, the multi-model ensemble projections indicate mean annual temperature increases, above the 1970–1999 baseline average, of 1.4°C (2.34°F) for the 2010–2039 period, 3.1°C (5.58°F) for the 2040–2069 period, and 5.0°C (9.0°F), for the 2070–2099 period (Rupp *et al*. 2017, p. 1,788). For the winter season (December–February) mean change increase of 1.4°C (2.34 °F) for 2010–2039, 2.9°C (5.22°F) for 2040-2069, and 4.7°C (8.46°F) for 2070–2099, as compared to the 1970–1999 baseline average (Rupp *et al*. 2017, p. 1,788). The anthropogenic-forced (human caused or influenced) change for these projections is higher than the annual variability; thus, by the year 2050, it is very unlikely that the temperature for this year or any year following during this century would be as low as the historical average (Rupp *et al*. 2017, p. 1,788).

Precipitation projections were much less robust; the multi-model ensemble mean precipitation projections indicate an increase above baseline of up to 8 percent by 2099 for RCP 8.5 and slightly less for RCP 4.5 (Rupp *et al*. 2017, p. 1,788). When viewed seasonally, for the winter

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season, the ensemble projections indicate increases in precipitation for all three future time periods for both the RCP 4.5 and RCP 8.5 scenarios (ranging from 3 to 14 percent) as compared to the baseline period (1970–1999) (Rupp *et al*. 2017, p. 1,788). The projections of anthropogenic-forced increases in precipitation are lower than the interannual variability; however, despite these increases, the authors indicate that years of anomalously low precipitation relative to baseline would be expected with high frequency throughout the 21st century (Rupp *et al*. 2017, p. 1,788).

Within three subregions of the Pacific Northwest within the Current Potential Extent of the wolverine, Sheehan *et al*. (2015, p. 20; Table 4) also found that, when compared to a historical baseline (1971–2000), all future climate projections (RCP scenarios 4.5 and 8.5; 2036–2066, 2071–2100) indicate a rise in both minimum and maximum monthly temperatures, and a generally positive change in mean annual precipitation, though the latter results varied across projections.

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Upper Snake River Basin

The Upper Snake River Tribe Foundation and its Tribal members prepared a climate change vulnerability assessment for the Upper Snake River Watershed (Petersen *et al*. 2017, entire). The assessment covers large areas of southern Idaho and eastern Oregon, and small areas of northern Nevada, northern Utah, and western Wyoming (Petersen *et al*. 2017, p. 15). Within three geographic/model domains of this larger region, downscaled climate projections were created from 20 GCMs run with two emissions scenarios (RCPs 4.5 and 8.5) and these outputs were then used to calculate potential future changes in temperature and precipitation (Petersen *et al*. 2017, pp. 15–16). The projections were analyzed in reference to a baseline period (1950-2005) for three future time periods—the 2030s (2020–2049), the 2050s (2040–2069), and the 2080s (2070–2099) (Petersen *et al*. 2017, p. 16).

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For temperature, their projections indicated an increase in average annual temperatures in both future emission scenarios and across all time periods. Under RCP 8.5 (high emissions scenario), the ensemble mean temperature increase was about 6.11°C (11ºF), and 2.78°C (5ºF) under the RCP 4.5 intermediate emissions scenario across all three geographic/model domains (Petersen *et al*. 2017, Appendix A, p. 2). For the North and East domains (areas with greater topographical variability), there was some indication of a small increase in total annual precipitation by the end of the century, though there was less agreement among the models (Petersen *et al*. 2017, Appendix A, p. 2).

For all geographic/model domains, the average temperature is projected to increase under both emissions scenarios for all seasons (Petersen *et al*. 2017, Appendix A, p. 2). For the winter months (December, January, February), for RCP 4.5, the average seasonal temperature is projected to increase by 3.89 to 5°C (7 to 9ºF) by the end of the century, and an increase of approximately 2.22 to 3.33°C (4 to 6ºF) for the other seasons (Petersen *et al*. 2017, Appendix A, pp. 2, 6). The winter season projections for RCP 8.5 add an additional 1.67 to 2.22°C (3 to 4ºF) by the end of the century (Petersen *et al*. 2017, Appendix A, pp. 2, 6).

Rocky Mountain Region (Colorado)

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A report by Lukas *et al*. (2014, entire) presented an assessment of observed and future projections of climate change effects for Colorado. They reported that, statewide, annual average temperatures have increased by 1.1°C (2.0°F) over the past 30 years, and 1.4°C (2.5°F) over the past 50 years (Lukas *et al*. 2014, p. 11). These warming trends have been observed in much of the State (Lukas *et al*. 2014, p. 11). They report no significant long-term trends in annual precipitation (30-, 50-, and 100-year trends) through 2012, but they indicate an observed trend towards more severe soil-moisture drought conditions in Colorado, based on the PDSI, over the past 30 years (Lukas *et al*. 2014, pp. 12, 21).

This report also presents results from climate change modeling using an ensemble of CMIP5 model projections, run with RCP 4.5 and 8.5 scenarios (Lukas *et al*. 2014; Section 5). The results indicate future warming in Colorado for all of the climate model projections (Lukas *et al*. 2014, p. 59). By 2050, for the RCP 4.5 (intermediate) emissions scenario, the statewide average annual temperatures are projected to increase by 1.4 to 2.8°C (2.5 to 5°F) (relative to a 1971–2000 baseline), and increase by 1.9 to 3.6°C (3.5 to 6.5°F) under the RCP 8.5 (high) emissions scenario (Lukas *et al*. 2014, p. 59). For precipitation, they report that climate model projections show less agreement regarding future precipitation change for Colorado, but most projections indicate increasing winter precipitation by 2050 (Lukas *et al*. 2014, p. 59).

Summary

Observed trends and future climate model projections indicate warming temperatures for much of the western United States, including areas within the Current Potential Extent of the wolverine. The degree of future warming varies by region and is dependent upon the future emission scenario used during the modeling process. Future precipitation trends are less certain for many regions, in part, due to naturally high, inter-annual variability; some regions are projected to experience greater winter precipitation. Wolverines have been found to have a wide range in critical temperature depending on season, and undergo seasonal changes in fur insulation to adapt to warmer temperatures in summer. Wolverines also exhibit changes in behavior, such as moving to higher elevations in summer months. Wolverines continue to occupy areas that have exhibited increases in temperature (e.g., California, parts of Montana and Washington); however, no empirical studies have evaluated these physiological and behavioral adaptations, including sub-lethal effects, relative to warming temperatures .

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Biotic Factors

In addition to evaluating changes in these abiotic factors, biotic interactions should be considered in evaluating species' response to climate change (reviewed by Post 2013). Although abiotic changes drive ecological processes, the alterations in biotic interactions (e.g., competition among conspecifics, interactions with competitors, resources, and predators) represent the ecological responses that result from those changes (Post 2013, p 1). Changes in certain abiotic factors, such as snow and ice cover, should also be considered in an ecological context since they represent habitat for many species (Post 2013, p. 11).

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Ecological studies evaluating the effects of climate change often evaluate phenology, the timing of life history events and how they vary in space and time, generally at the population or site-specific level, though phenological variation at the individual level may also be important (Post 2013, p. 54). Previous meta-analyses of the rate of phenological advancement have suggested advances of between 2–5 days per decade, across taxa, and between low-mid to mid-high latitudes (Post 2013, p. 59). A more recent meta-analysis from Cohen *et al*. (2017, p. 4) found, on average, significant advancement in the phenology of animals since 1950, advancing by about 2.88 days per decade and 3.08 days per degree Celsius.

Within the Pacific Northwest region, Ford *et al*. 2016 (entire) modeled the timing of growth initiation in coast Douglas-fir trees (*Pseudotsuga menziezii* var. *menziezii*) within the species' range in Washington and Oregon to evaluate its ability to track changes in climate with changes in phenology. This study found that, for high latitudes and elevations, growth initiation was predicted to occur earlier in the year, which allows trees to track the beginning of favorable growing conditions, without exposure to frost risk (i.e., adaptive phenological response) (Ford *et al*. 2016, pp. 3718, 3,721). Conversely, their model predicted that at lower latitudes and elevations, growth initiation will lag behind climate change shifts due to reduced chilling with lower productivity, which suggested that coast Douglas-fir has an obligate chilling requirement for height (but not diameter growth initiation) (Ford *et al*. 2016, pp. 3,717–3,719).

Another study reported on the effects of encroachment of woody plants (willows (*Salix* sp.)) in alpine environments to alpine wildflowers and their pollinators due to temporal overlap in flowering phenology, which may result in establishment of plant species with broader environmental tolerance in high alpine ecosystems (Kettenbach *et al*. 2017, p. 6,969). Similarly, in Sweden, Wilson and Nilsson (2009, entire) reported on encroachment of woody vegetation in arctic-mountain habitat, though primarily at lower elevations in response to observed temperature increase of 2.0°C (3.6°F) over 20 years, though this increase in cover was observed primarily at lower elevations (Wilson and Nilsson 2009, p. 1,682).

A high-latitude, North American study evaluated the effect of weather and broad-scale climate variables and vegetation productivity on the timing of spring and fall migrations of migratory caribou herds in northern Québec and Labrador, Canada (Le Corre *et al*. 2017, entire). That study found that, since 2000, except for the spring arrival, migrations occurred earlier, and were affected by resource availability, likely through intraspecific competition factors (Le Corre *et al*. 2017, p. 266).

In addition to phenological changes related to habitat variables or reproduction patterns, the effects of climate change may affect food resources important to wolverine, either directly (e.g., survival) or indirectly (e.g., effects to their habitat). An early study by Wang *et al*. (2002, p. 217) projected a potential increase in ungulate populations in Rocky Mountain National Park (Colorado) under future climate scenarios due to enhanced survival and recruitment of juvenile animals in response to less severe winters. The authors note that their results should be interpreted qualitatively given the uncertainties in applying climate change scenarios based on global models to ecological systems at the local scale (Wang *et al*. 2002, p. 217). In addition, they report that vegetation response (e.g., succession) to climate change effects may result in changes to ungulate habitat (Wang *et al*. 2002, p. 219). Overall, the study concluded that their

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results were consistent with those reported in other studies that have evaluated the relationships between the effect of weather and density dependence and ungulate population dynamics (Wang *et al*. 2002, p. 219).

Summary

The results presented above indicate biotic effects resulting from climate change, varying from phenological changes to shifts in vegetation and vegetation succession. We are unaware of studies that have directly evaluated these types of effects to the North American wolverine or its habitat. Given the extensive range and varied habitats occupied by wolverines in the contiguous United States, the shifts in vegetation are likely to be relatively narrow in scope and scale. Furthermore, we have no information to suggest that wolverines selectively use any specific vegetation type and some changes in vegetation may actually be advantageous for wolverine prey.

Climate Change and Potential for Cumulative Effects

Threats can work in concert with one another to cumulatively create conditions that may impact the wolverine or its habitat beyond the scope of each individual threat. Given an expected increase in temperature in the western United States, the best available information indicates that, if there are any cumulative impacts in the future, the most likely to have population level effects on wolverine in the contiguous United States could be: 1) changes in snowpack from the combination of increased temperature and changes in precipitation patterns, or 2) changes in snowpack and increase in wildland fire potential.

Snowpack/Snow Cover

Upper Snake River Watershed (Pacific Northwest region)

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The Upper Snake River Tribal Foundation assessment (discussed above) included projected changes in snowpack for three locations in the Upper Snake River watershed, including areas located within our estimated Current Potential Extent of the wolverine (from Climate Impacts Group Pacific Northwest (PNW) Hydroclimate Scenarios Project (2860); http://warm.atmos.washington.edu/2860/products/sites/). Model results, based on snow water equivalent (SWE) (the water content of snowpack, expressed as depth), indicate a projected loss in April 1st snowpack of 36 percent for the 2030–2059 period and 64 percent for the 2070–2099 period for the *Salmon River at White Bird* location (average of percent change across all models relative to the long-term average for 1916–2006 ("historical period")). For the *Snake River at Brownlee Dam* location, the projected loss is 37 percent for the 2030–2059 period and 64 percent for the 2070–2099 period (summary presented in Petersen *et al*. 2017, p. 20). These projected changes were found to be consistent with overall changes projected for the Columbia River Basin snowpack in an earlier study. Hamlet *et al*. (2013, p. 404; Figure 7) found that, relative to the long-term average for 1916 to 2006, the April 1st snowpack in the Columbia River Basin is projected to decline by 29% for the 30-year period spanning 2030-2059 and decline by 52% for the period spanning 2070-2099 for the A1B emissions scenario. [Note: the A1B emission

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scenario represents a more balanced energy portfolio than RCP 8.5, with GHG emissions leveling off by the middle of the 21st century].

Sierra Nevada

Walton *et al*. (2017, entire) developed snow cover projections for the Sierra Nevada region in California, incorporating snow albedo feedback using a hybrid downscaling approach to develop future climate projections. This feedback loop is known to be important for regional climate change (Thackeray and Fletcher 2016, p. 395) and occurs when warming causes snow pack to shrink at margins and the exposed ground absorbs more sunlight than snow, which enhances the warming, resulting in more melting of snow (Walton *et al*. 2017, p. 1,417). This study (using 3 km (1.86 mi) resolution) found that, by the end of the 21st century (2081–2100), warming and loss of snow cover is expected to occur, though the degree varies depending on the GHG scenario (Walton *et al*. 2017, p. 1,430). Under the RCP 8.5 (high emissions) scenario, the study found that the total area covered by snow during the typical month of April decreases by 48 percent, as compared to historical average (1981–2000) (using ensemble mean) (Walton *et al*. 2017, p. 1,432). Under the RCP 4.5 (moderate emissions) scenario, snow cover losses were projected at about half of those for RCP 8.5 (Walton *et al*. 2017, p. 1,434; Figure 13). The effects of warming were more pronounced at lower elevations and were most severe in May and June (Walton *et al*. 2017, p. 1,431; Figure 12). For the months of March and April, the highest elevations were found to have nearly complete snow cover (measured as snow covered fraction) for all GCM simulations (Walton *et al*. 2017, p. 1,431; Figure 12).

Northern and Southern Rocky Mountains–Glacier and Rocky Mountain National Parks

The effects of climate change on snow persistence has been suggested as an important negative impact on wolverine habitat and populations by the mid-21st century (McKelvey *et al*., 2011, entire). The Service therefore pursued a refined methodology to provide insights into the potential impacts of climate change on snow persistence.

The Service engaged the National Oceanic and Atmospheric Administration (NOAA) laboratories and University of Colorado in Boulder, Colorado (CU) to evaluate and model fine scale persistence of snow in occupied and potential wolverine habitat in the contiguous United States. Those discussions revealed significant progress in fine scale modeling approaches since the early 2000s. The Service provided funding for an assessment of snow extent and depth to assess the effects of climate change on snow persistence in two areas of the western United States, Rocky Mountain and Glacier National Parks (Ray *et al*. 2017, entire). The primary objective of this study was to refine the spatial and temporal scale of snow modeling efforts and improve the scientific understanding of the extent of spring snow retention currently and into the future under a changing climate (Ray *et al*. 2017, p. 9). The objectives of the study included (Ray *et al*. 2017, p. 10):

- Use of fine-scale models to analyze the topographic effects of snow, including slope and aspect (compass direction that slope faces)
- Use of a range of plausible future climate change scenarios to assess snow persistence

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- Analysis of extremes and year-to-year variability by selecting representative wet, dry, and near normal years (using observed conditions) and then modeling changes for those base years under several future climate scenarios
- Assessment of changes in snow persistence by elevation

The study was designed to parallel as much as possible and thereby refine the previous assessment of snow cover persistence in the western United States presented in McKelvey *et al*. (2011). However, an exact replication of the McKelvey *et al* (2011) study was not possible given the time, funding, and computational constraints needed to develop a fine-scale assessment. The current study was limited to two study areas (approximately 1,500 to 3,000 km^2 (579 to 1,158 mi^2) each) in the northern and southern Rocky Mountains (see **Appendix H** for maps). The two study areas were selected because they encompass the latitude and elevational range of wolverines within the contiguous United States. Glacier National Park (GLAC) is representative of a high latitude and relatively low elevation area currently occupied by wolverines. The Rocky Mountain National Park region (ROMO) is a lower latitude and higher elevation area within the wolverine's historical range, which was recently occupied by a wolverine from 2009 to at least 2012.

Methods: We provide here a brief summary of the methods used in this study. Additional details are contained in the full report authored by Ray *et al*. (2017). The initial step of the analysis was a review of the observed climate and variability to provide context for trends and year-to-year variability. Next, historical snow cover extent and variability were analyzed using satellite remote sensing (MODIS) data from 2000 to 2016 to calculate a snow disappearance date for each year at each pixel. Summary statistics include total snow covered area (total area covered by snow), representation of snow pack by aspect (percent of land areas covered by snow for each of the 17 years in the historical record by topographic aspect based on compass direction that the slope faces), and elevation dependence for wet, near-normal, and dry years (with median of all years used as reference). Future snow pack projections were then generated using the Distributed Hydrology Soil Vegetation Model (DHSVM), for the historical period 1998-2013, and then validated against SNOTEL observing stations and MODIS satellite data.

Both Ray *et al*. (2017) and McKelvey *et al*. (2011) used the delta method to estimate future snow persistence. The NOAA-DHSVM delta method uses historical observed weather (1998–2013) as the baseline and applies future changes in temperature and precipitation from the chosen GCMs (approximately Year 2055) to estimate future snow persistence on the landscape. This time period was chosen for concordance with the availability of the MODIS satellite remote sensed snow product and availability of the meteorology dataset used for the study. For GLAC, October–May was typically warmer and drier during 2000–2013 than the long term average, while, for ROMO, the October–May precipitation was typical, though with higher temperatures. Although one might assume that the Spring snowpack would therefore be lower in the baseline period than in prior decades, an assessment of three long-established May 1 snow course (manual measurements) in the GLAC and ROMO regions, indicates that, while this is true, the longer record dating back to 1922 in GLAC and 1936 in ROMO indicates a period of relatively low snowpack prior to the 1950's (see Ray *et al*. 2017, pp. 18–20). Five future scenarios (GCMs) were selected from CMIP5 global climate model projections to capture variability in temperature and precipitation, using the RCP 4.5 (moderate) and RCP 8.5 (high) emissions scenarios.

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Representative wet, near normal, and dry years were analyzed for the historical simulations and evaluated for the five future scenarios. The number of years (out of 16) with snow depth greater than 0.5 m (20 in) was also analyzed as was the change in Snowcovered Area (SCA) (area with depth greater than 0.5 m (20 in)). This snow depth was selected based on an analysis of the depth of snow at documented wolverine den sites in Glacier National Park (Ray *et al*. 2017; Table 5-2). Results were reported for "light snow cover" (snow depth greater than 1.25 cm (0.5 in)) and "significant" snow (snow depth > 0.5 m (20 in)) for April 15, May 1, and May 15 for previously defined representative years. These dates were selected based on studies indicating den site abandonment generally occurs before May 1 (see Use of Dens and Denning Behavior discussion above in *Reproduction and Growth* section). The term "light snow cover" was incorporated as the most directly comparable parameter to McKelvey *et al*.'s "light" snow cover. The average change in SCA and SWE was analyzed as a function for both study areas of elevation and was overlaid with the elevations of documented wolverine den sites (2003–2007) in GLAC. As noted earlier, snow depth was not defined in Copeland *et al*. (2010).

Comparison with McKelvey *et al*. (2011): Although the methods used in this study have similarities with those presented in McKelvey *et al*. (2011), there are several key differences. Ray *et al*. (2017) used a finer spatial resolution model (DHSVM) than McKelvey *et al*. (2011) (0.0625 km^2 vs. 35 km^2) that incorporated slope and aspect. The grid cells represented in McKelvey *et al*. (2011) were assumed to be flat (i.e., north-facing slopes treated as identical to south-facing slopes). McKelvey *et al*. (2011) focused on May 1st snow depth as a proxy for May 15th snow disappearance, while Ray *et al*. (2017) focused directly on May 15th snow disappearance and produced results for the presence or absence of deeper snow (nominally greater than or equal to 0.5 m (20 in) depth) on May 1st and April 15th.[4] Because of the increased resolution of this study, Ray *et al*. (2017) were able to consider whether any areas of snow with depth greater than 0.5 m (20 in) will persist in these areas. Additional comparisons are outlined below in Table 8 and in Ray *et al*. (2017, p. 6). However, the May 15th date does not represent a meaningful biological significance for wolverines relative to the presence or lack of snow.

Table 8. Comparison of Methods, Ray *et al*. (2017) vs. Copeland *et al*. (2010) and McKelvey *et al*. (2011)

Feature	Ray *et al*. (2017)	Copeland *et al*. (2010) and McKelvey *et al*. (2011)
Spatial Resolution	250 m x 250 m = 62,500 m^2 or 0.0625 km^2 (0.24 mi^2)	0.125 degrees (~5 km x 7 km; 37 km^2 (14.29 mi^2))
Geographic Area	Glacier and Rocky Mountain National Parks, 300 m below treeline and above	Western United States, except California and Great Basin
Topography	Slope, aspect, and shading were used	Slope and aspect were not used
Validation	SNOTEL (in-situ observations) and MODIS (satellite remote sensing)	None specific to the snow dataset used
Future Scenario Method	Delta Method, used to project 2000-2013 conditions out to Year 2055 (average of 2041–2070)	Delta Method (Years: 2045 (2030–2059), 2085 (2070-2099)

[4] Ray *et al*. (2017) originally focused on May 15th to compare to the McKelvey *et al*. (2011) study, and June 1st to bracket the snowmelt season. However, April 15 and April 30 dates were added to the evaluation of snowcovered areas to align with temporal reproductive patterns of the wolverine (see Use of Dens and Denning Behavior discussion in *Reproduction and Growth* section above).

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Future Scenarios (GCMs)	*miroc*, *giss*, *fio, cnrm* (both study areas); *canesm* (Glacier National Park only) *hadgem2* (Rocky Mountain National Park only)	Ensemble mean of 10 GCMs, *pcm1*, and *miroc 3.2*
Time-related Results	Long-term means and year-to-year variability (i.e., wet, near normal, and dry years)	Changes in long-term mean snowpack only
Snow Detection and Measurements	Snow presence: 1.25 cm (0.5 in) snow depth threshold on May 15. "Significant snow": snow depth (0.5 meter (20 in) threshold. Snow depth determined by conversion from Snow Water Equivalent using bulk snow density.	Snow presence (13 cm (5.12 in) snow depth threshold on May 1). Snow depth determined by VIC model.
Number of Years of MODIS Data	17 (2000-2016)	7 (2000-2006)
Snow Model	DHSVM (University of Washington)	VIC (University of Washington)
Snow Cover Dates Analyzed	April 15, May 1, and May 15	May 15 (derived from May 1), May 29 (derived from May 1)

Results: While there are challenges in comparing the results from McKelvey *et al*. (2011) directly to the Ray *et al*. (2017) study due to differences in methodology and focus, the qualitative picture can be summarized as follows: projected warming has a larger effect at lower elevations whereas projected precipitation changes may dominate the springtime snowpack in the high country. We present below a summary of the main results from Ray *et al*. (2017).

MODIS Observed Historical Snowpack Variability Analysis:

- In GLAC, Snowcovered Area (SCA) varies considerably by year, including wet years such as 2011 with very persistent snow, years with strong melt in early May, such as 2012, or in late May (2009, 2001), and dry years (2004, 2005) (Ray *et al*. 2017, Section 4.3).
- Even in dry years, northeast-facing slopes in GLAC tend to hold more snow and melt later in the season.
- More than 80 percent of the GLAC study area above approximately 2,000 m (6,562 ft) elevation on May 1 has snow cover during dry years, and more than 95 percent has snow cover above approximately 1,200 m (3,937 ft) during wet years.
- In ROMO, the SCA also varies considerably by year.
- The northwest-facing slopes in ROMO tend to hold more snow even during dry years. In very dry years, snow cover peaks at intermediate elevations, suggesting that the high-altitude snowpack may be particularly vulnerable in this region under warm/dry conditions.

Future Snowpack Projections: The area-wide SCA results include snow cover changes in both forested and above-treeline (alpine) terrain, which may have different implications for wolverine biology.

Glacier National Park (GLAC):

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- Projections for April 15th, May 1st, and May 15th SCA and area with snow depth greater than 0.5 m (20 in) show declines on average in all scenarios, compared to the 2000–2013 historical average, except for small increases in the Warm/Wet scenario and for almost all years.
    - For April 15th, light SCA area is reduced by 3–23 percent and significant snow cover (greater than 0.5 m (20 in)) declines by 7–44 percent.
    - For May 15th, light SCA is reduced by 10–36 percent, and the area with significant snow cover declines by 13–50 percent.
- All projections show declines in the number of years with significant snow (equal to or greater than 0.5 m (20 in)), which varies by scenario (e.g., Figure 5-14 in Ray *et al*. 2017). Areas with frequent availability (at least 14 out of 16 years) of significant snow become concentrated in smaller high elevation areas. Lower elevation areas had the largest decreases in the number of years with significant snow cover.
- Most of the known den sites are located between 1,800 m (5,906 ft) and 2,000 m (6,562 ft) in GLAC. Below that elevation band, large snow losses are predicted (40 to 70 percent decrease for two of the scenarios, 16–20 percent for the other three). Above that elevation band, there is little change in SCA for four of the five scenarios (2–8 percent) except in maximum warming scenario (decline of 40 percent (Ray *et al*. 2017; Figure 5-22). In the 1,800–2,000 m (5,906–6,562 ft) band, the snowpack change is sensitive to elevation and to the future climate scenario used.
- For representative wet years, for May 15th, the higher elevations of the study areas experience only 2–7 percent loss of snowpack under the scenarios with "least" change and the "moderate" change, although for the dry years, losses range from 18–57 percent.
    - The implication is that the wet, cold climate of the GLAC study area could act as a "buffer" to change in areas with of 0.5 m (20 in) of (significant) snow on May 1st, at least for elevations above 1,800 m (5,906 ft).

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Rocky Mountain National Park (ROMO):

- Projections of May 15th SCA in ROMO decline on average in all scenarios, except for small increases in the Warm/Wet scenario, and for almost all years.
    - For April 15th, light SCA (depth ≥ 5 mm (0.2 in)) declines by 3–18 percent and significant SCA (depth > 0.5 m (20 in)) changes from −1– +16 percent for the five scenarios considered (compared to the 2000-2013 historical average).
    - For May 15th, the area with light snow cover declines 8–35 percent and the area with significant snow cover declines 6–38 percent.
- All projections show declines in the number of years with significant snow (equal to or greater than 0.5 (20 in), which varies by scenario (e.g., Figure 5-21in Ray *et al*. 2017). The areas with frequent availability (at least 14 out of 16 years) of significant snow become concentrated in smaller high elevation areas. In contrast, lower elevation areas had the largest decreases in the number of years with significant snow cover.
- Although no dens have been documented in ROMO, the elevation band for denning, modeled by regression analysis, is estimated at 2,700 to 3,600 m (8,858 to 11,811 ft). On May 1st, modest declines in SWE of about 15 percent and less for areas at 3,400 m (11,155 ft) or above result in losses of only about 10 percent snow cover.

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- The implication is that the wet, cold climate of the higher parts of the ROMO study area could also act as a "buffer" to change in the area of 0.5 m (20 in) deep snow on May 1st.

Elevation Dependence of Change: In general, and supported by the literature, the snowpack in the higher elevations of both areas is more responsive to precipitation change, while lower elevations are more responsive to temperature change. For GLAC, most of the observed den sites are located within the zone where temperature dominates the future effects of change. For the elevation of den sites in GLAC (i.e., above 1800 m (5,906 ft)), loss of SCA on May 1st spans the range of 5–40 percent, with a 70 percent decrease for the Hot/Wet (*miroc* GCM) scenario. Above 2,200 m (7,218 ft), the losses are less than 5 percent for all but the Hot/Wet scenario.

Current results may be a reasonable estimate for the high mountain ranges within the Rockies that lie between GLAC and ROMO. However, without further study, we cannot reasonably extend these results to say whether or not snow refugia will persist in the Central Rockies below our study elevations (approximately 1,000 m (3,281 ft)). These lower elevations are where McKelvey *et al*. (2011) predicted the greatest losses in snowpack. The NOAA/CU results also cannot be extrapolated to mountain ranges outside of the Rockies (i.e. the Cascade Range) that have different climates (temperature and precipitation). We note here that we have no documented wolverine den sites in the contiguous United States below 1,500 m (4,921 ft) elevation; that is, no documented den locations in the areas where McKelvey *et al*. (2011) predicted the greatest loss in snowpack.

Interpretation and additional analysis relative to wolverine den site scale: The Service was interested in exploring the question, "If snow cover is required for wolverine denning, will there be a sufficient amount of significant snow cover in the future in areas wolverines have historically used for denning in the contiguous United States?" The Service integrated future DHSVM projections (2000–2013 averages) of snow covered area (greater than 0.5 m (20 in) depth) on May 1st for GLAC and ROMO with new information obtained from a spatial analysis of documented den sites in the contiguous United States. This spatial analysis indicated 31 of 34 documented den sites in the contiguous United States were located in areas with slope less than 25 degrees. Avalanche risk increases significantly in areas with slope greater than 25 degrees (Scott 2017, pers. comm.) and wolverines may avoid these areas for denning due to this risk.

Using the projections prepared by Ray *et al*. (2017), we present in Figures 7–14 the spatial distribution of significant snow covered area with slopes less than 25 degrees and within the elevation bands indicated above for three future scenarios in each study area. The three scenarios for GLAC (*miroc*, *cnrm*, and *giss*) and for ROMO (*hadgem2*, *fio*, and *giss*) were chosen to span the range of GCM uncertainty regarding temperature and precipitation, and by extension significant SCA (see Figure 7 and Figure 8). We found that large portions of the study areas meet all three criteria—greater than 0.5 m (20 in) snow depth on May 1st, at elevation 1,514–2,252 m (4,967–7,389 ft) for GLAC or 2,700 to 3,600 m (8,858 to 11,811 ft) for ROMO, and with a slope less than 25 degrees—across both study sites in the future.

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The GLAC *miroc* simulation shows the greatest decrease in future snow covered area in the elevation band historically used for denning (orange line in Figure 7). Figure 9 shows the spatial distribution of significant SCA with slope less than 25 degrees and elevation of 1,514–2,252 m

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(4,967–7,389 ft) for the *miroc* simulation on May 1st (approximately Year 2055). Approximately 494 km^2 (191 mi^2) of area meet the three criteria with an additional 803 km^2 (310 mi^2) of area retaining significant snow covered area, primarily at higher elevations. Moreover, we determined that large tracts of significant SCA are projected in close proximity to documented historical den sites across all three scenarios (Figures 9–11). Because we have model projections that fall within wolverine denning areas within for Glacier National Park, we used those den locations to evaluate wolverine distances to snow relative to future snow covered area projections for GLAC. As shown in Table 9, wolverines would not have to travel far, or at all, relative to either distance or elevation to reach areas with significant snow covered area in the future.

A similar analysis was performed for the ROMO study area and the results indicate that large portions of the study area meet all three criteria identified above. The *hadgem2* (Figure 12) and *cnrm* scenarios were found to have the greatest decrease in significant snow covered area of the five scenarios analyzed. Figure 12 (*hadgem2* simulation) shows the spatial distribution of significant SCA (greater than 0.5 m (20 in) depth), elevation of 2,700–3,600 m (8,858–11,811 ft), and slopes less than 25 degrees where denning would be expected to occur. Total area meeting these three criteria was 339 km^2 (131 mi^2) (dark blue in Figure 12), with an additional 446 km^2 (172 mi^2) with snow depth greater than 0.5 m (20 in) (light blue in Figure 12), mostly at higher elevations. Figures 13 (*fio* scenario) and Figure 14 (*giss* scenario) show a similar distribution, albeit larger areas of significant snow retention in the future (see map legends in Figures 13 and 14 for area estimates).

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Table 9. Distance of historical GLAC dens (Years 2003–2007) from projected significant snow covered area in the future (approximately Year 2055) (using 2000–2013 average).

A 0 (zero) value indicates the den site location meets all three criteria in the future (greater than 0.5 m (20 in) snow depth on May 1st, at elevation 1,514–2,252 m (4,967–7,389 ft), and with a slope less than 25 degrees).

Den Site[a]	Elevation, m (ft)	Distance from den site to nearest model cell, m (ft)		
		GCM scenario		
		miroc	*cnrm*	*giss*
1	2,252 (7,389 ft)	0	0	0
2	2,093 (6,867 ft)	0	0	0
3	1,995 (6,545 ft)	0	0	0
4	1,977 (6,486 ft)	210 (689 ft)	0	0
5	1,973 (6,473 ft)	208 (682 ft)	0	0
6	1,928 (6,326 ft)	0	0	0
7	1,922 (6,306 ft)	9 (29.5 ft)	8 (26 ft)	8 (26 ft)
8	1,912 (6,273 ft)	170 (558 ft)	0	0
9	1,893 (6,211 ft)	110 (361 ft)	0	0
10	1,851 (6,073 ft)	87 (285 ft)	0	0
11	1,843 (6,047 ft)	74 (243 ft)	0	0
12	1,823 (5,981 ft)	56 (184 ft)	0	0
13	1,807 (5,929 ft)	0	0	0
14	1,514 (4,967 ft)	574 (1,883 ft)	571(1,873 ft)	296 (971 ft)

[a]Glacier National Park

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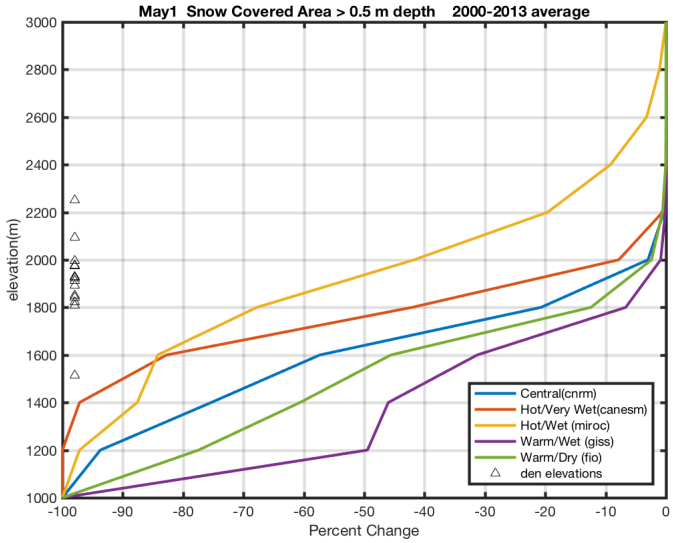

Figure 7. Average Snow Covered Area (depth ≥ 0.5 m (20 in)) percent change at elevation bands for GLAC for five future scenarios on May 1.

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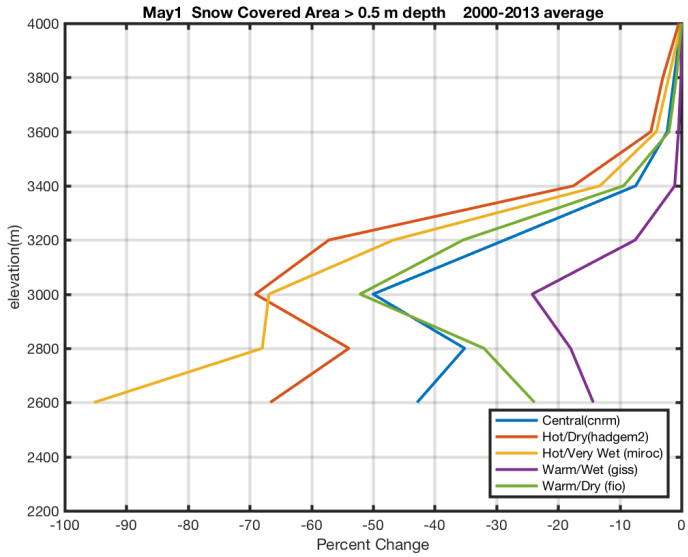

Figure 8. Average Snow Covered Area (depth ≥ 0.5 m (20 in)) percent change at elevation bands for ROMO for five future scenarios on May 1.

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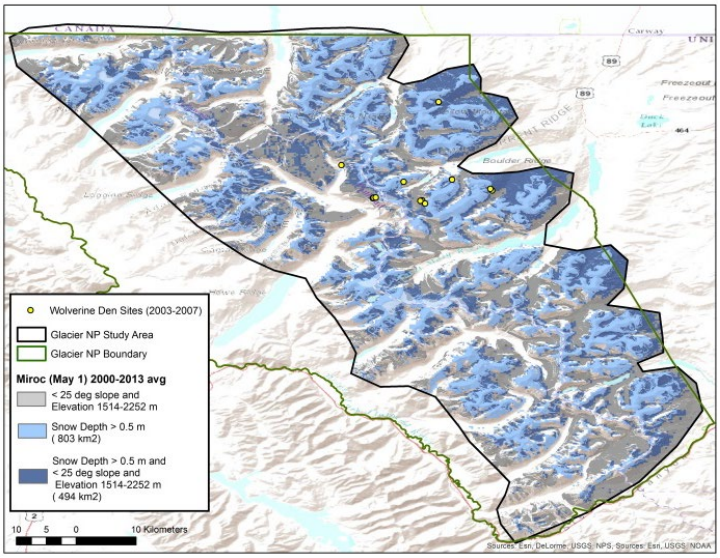

Figure 9. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *miroc* (Hot/Wet) scenario in Glacier National Park study area. Map legend shows where slopes are less than 25 degrees and elevations of 1,514–2,252 m (4,968–7,389 ft) (where dens have been documented).

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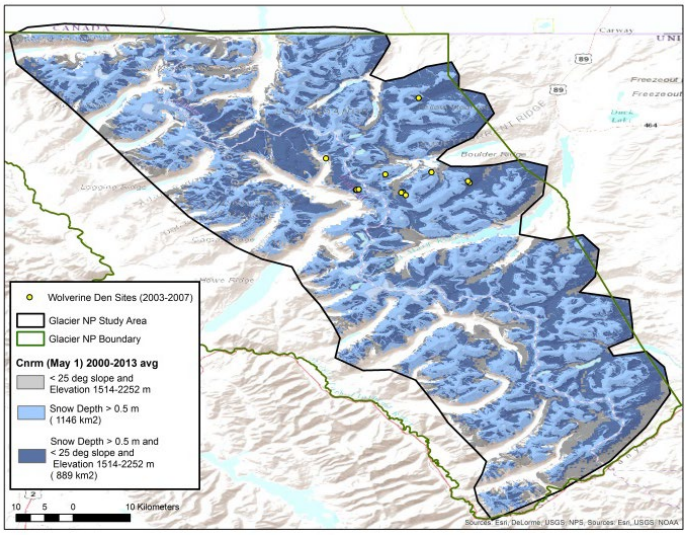

Figure 10. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *cnrm* (Central) scenario in Glacier National Park study area. Map legend shows where slopes are less than 25 degrees and elevations 1514–2252 m (4,968–7,389 ft) (where dens have been documented).

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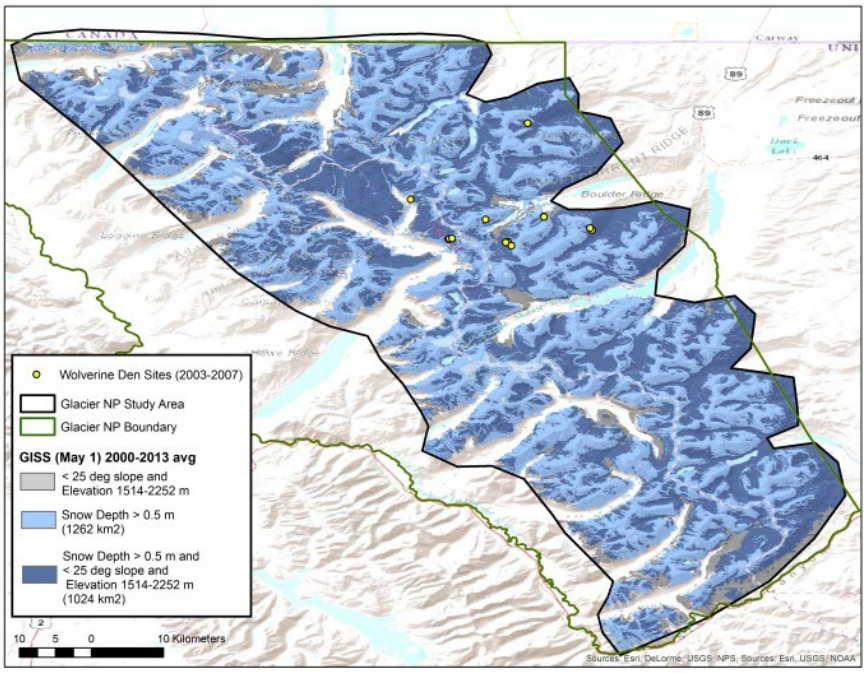

Figure 11. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *giss* (Warm/Wet) scenario in Glacier National Park study area. Map legend shows where slopes are less than 25 degrees and elevations 1,514–2,252 m (4,968–7,389 ft) (where dens have been documented).

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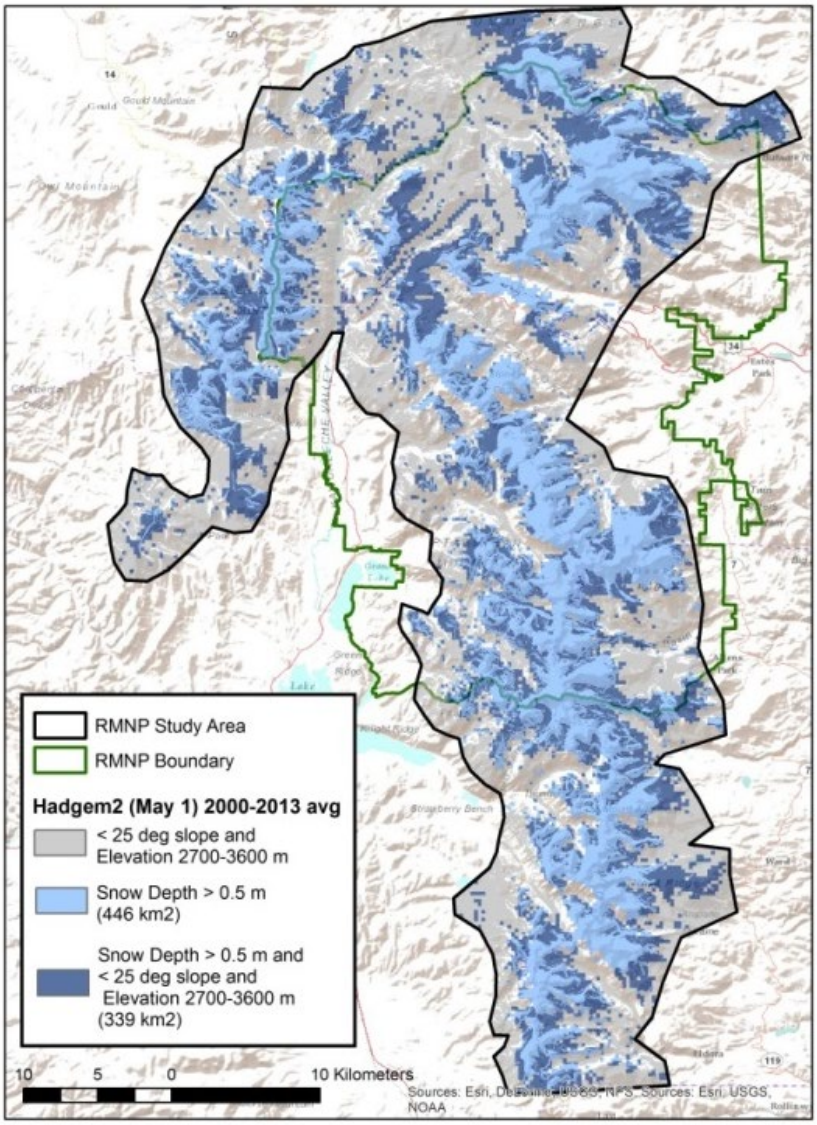

Figure 12. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *hadgem2* (Hot/Dry) scenario in Rocky Mountain National Park study area. Map legend shows where slopes are less than 25 degrees and elevations 2,700–3,600 m (8,858–11,811 ft) (inferred elevations where dens would be expected if occupied).

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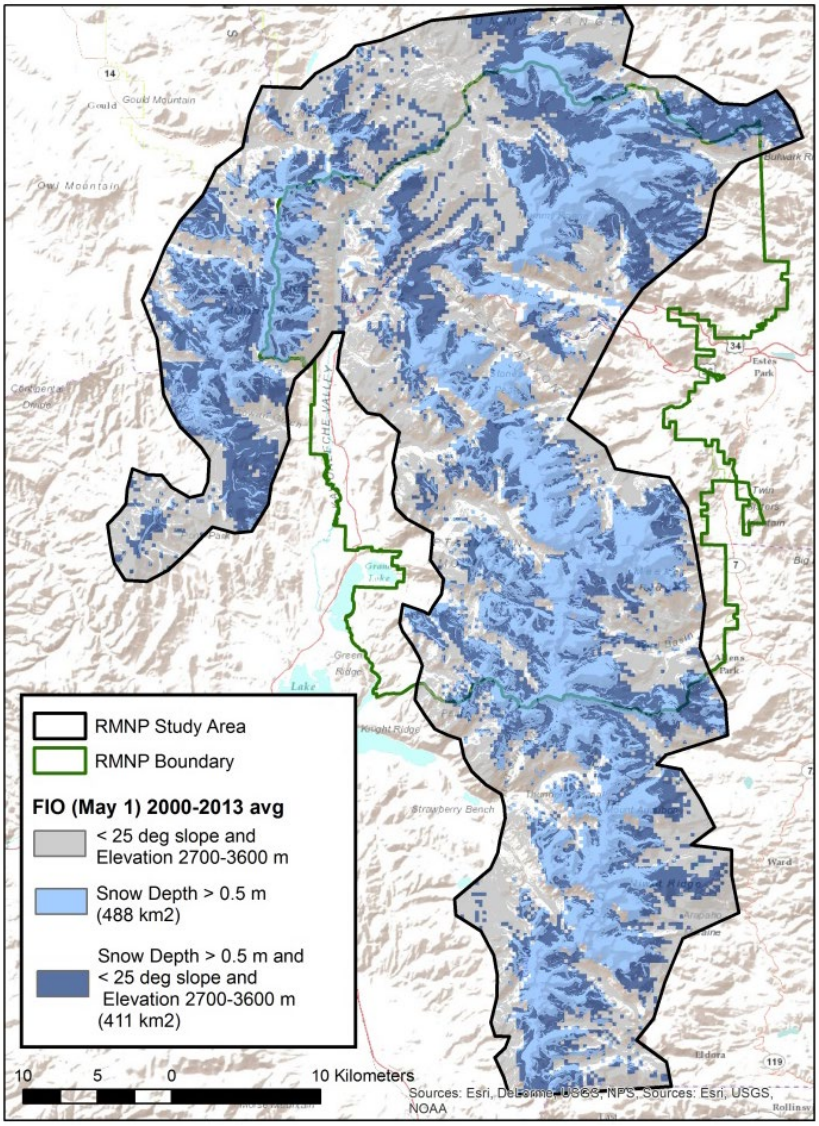

Figure 13. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *fio* (Warm/Dry) scenario in Rocky Mountain National Park study area. Map legend shows where slopes are less than 25 degrees and elevations 2,700-3,600 m (8,858–11,811 ft) (inferred elevations where dens would be expected if occupied).

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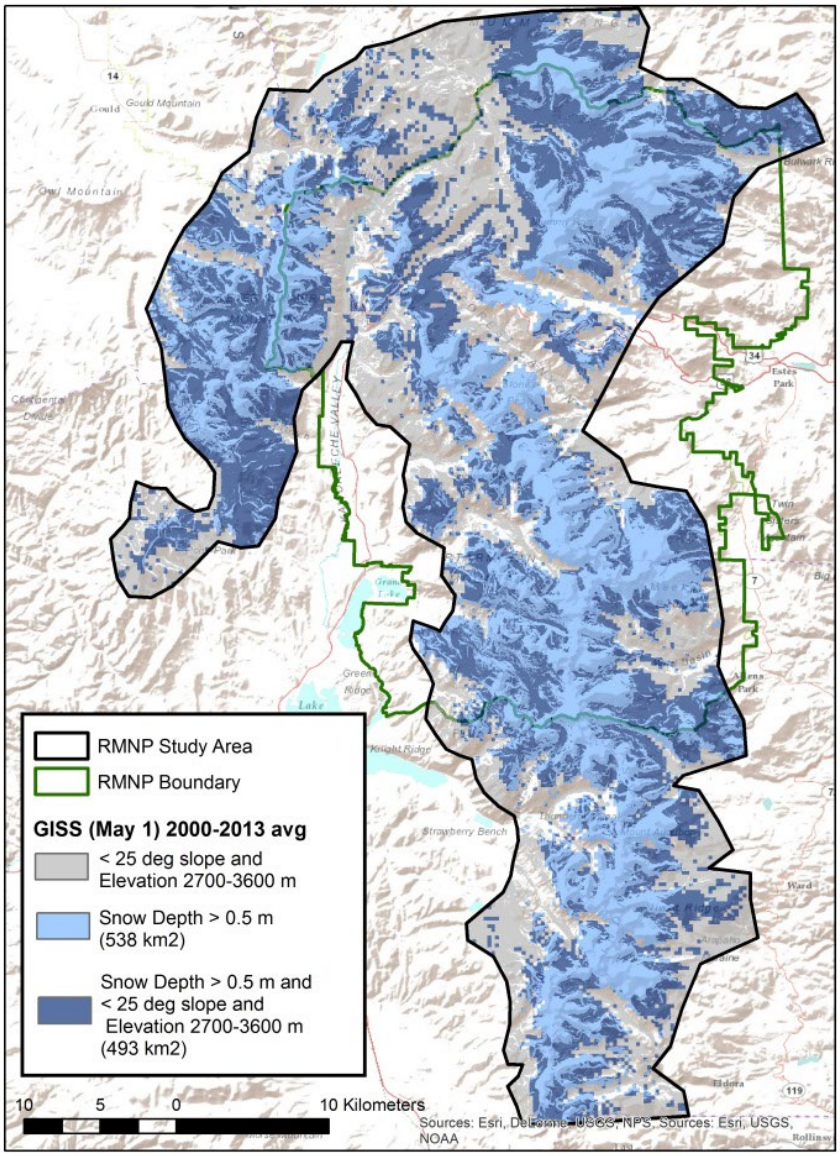

Figure 14. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *giss* (Warm/Wet) scenario in Rocky Mountain National Park study area. Map legend shows where slopes are less than 25 degrees and elevations 2,700-3,600 m (8,858–11,811 ft) (inferred elevations where dens would be expected if occupied).

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Montana Climate Assessment

Another recent assessment of snowpack was conducted for the State of Montana (Whitlock *et al*. 2017, no page number). The report analyzed recent climate trends in Montana and assessed how climate is projected to change in the future (2040–2069). The study found that snowpack that accumulates at high elevations tends to be more stable and persists longer than at low elevations, due largely to the colder temperatures at high elevations. The largest projected changes in snowpack appear to be in areas located west of the Continental Divide, given their exposure to relatively warm Pacific air masses. Overall, the assessment found that declines in snowpack volume are likely in the future in the basins studied.

Wildland Fire

California

Keeley and Syphard (2016, entire) analyzed fire-climate relationships relative to predicting future fire regimes in California. Their review concluded that: (1) Climate is not a major determinant of fire activity across all landscapes; (2) hotter and drier conditions for areas at lower elevations and lower latitude were found to have little or no increase in fire activity as vegetation types in these regions are ignition limited; (3) increasing annual temperatures by themselves are not good predictors of increased fire activity; seasonality, especially spring and summer temperatures, are more important; and (4) fire-climate models need to be scaled to vegetation types; broad-scale models may produce over-predictions of the total increase in future fire regimes (Keeley and Syphard 2016, pp. 1, 10). Additionally, drought is a key factor in defining fire regimes and annual precipitation is the primary driver of drought variability (Williams *et al*. 2015, p. 6,819), but, at the present time, it is difficult to separate current droughts in California from natural cycles of drought (Keeley and Syphard 2016, p. 6).

Pacific Northwest

Sheehan *et al*. (2015, entire) used downscaled CMIP5 projections to model vegetation and fire changes, with and without fire suppression, within three subregions of the Pacific Northwest. Emission scenarios RCP 4.5 and 8.5 were used for future climate projections (2011–2100). The resulting trends varied by geographic region. In the Western Northwest subregion (from the crest of the Cascade Mountains west), the mean fire interval (MFI) averaged over all climate projections decreased by up to 48 percent, an increase in annual percent area burned (PAB), and the predominant conifer forest is replaced by mixed forest under future climate under both RCP scenarios, with and without fire suppression; thus, climate, rather than fire was found to be the primary influence in this subregion (Sheehan *et al*. 2015, pp. 22–26). In the Eastern Northwest Mountains (ENWM) subregion (mountainous areas east of the Cascade Mountains), the MFI (averaged across all climate projections) decreased by up to 81 percent, there was a projected increase in mean annual PAB, and, while subalpine communities are projected to be lost, conifer forests were projected to continue to dominate this subregion (Sheehan *et al*. 2015, pp. 22–24). When modeled using a without fire suppression regime, the future projections for ENWM indicated a lower MFI and higher mean annual PAB as compared to the with fire suppression regime (Sheehan *et al*. 2015, p. 22; Table 5). However, the eastern portion of the ENWM

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subregion was found to show a differing response based on elevation; that is, higher elevations were found to have a higher MFI and a lower mean annual PAB during the 20th century as compared to lower elevations (Sheehan *et al*. 2015, p. 23).

Gergel *et al*. (2017, entire) evaluated the effects of climate change on snowpack, and soil moisture and fuel moisture (fire potential) in the western United States. This study used a statistical downscaling approach, using an ensemble of 10 GCMs across several mountainous regions known to be occupied by wolverines, with a 6.25 km (3.88 mi) spatial resolution hydrologic model. Simulations were run for three future periods: 2020s (2010–2039), 2050s (2040–2069), and 2080s (2070–2099) (Gergel *et al*. 2017, p. 291). Significant declines in snowpack (measured as SWE) were found in all mountain ranges for all future scenarios (using RCPs 4.5 and 8.5) and GCMs (Gergel *et al*. 2017, p. 295). This study found that spring snowpack in mountains along the Pacific Coast is quite sensitive to warmer temperatures, but in the continental mountain ranges (Northern and Southern Rocky Mountains) spring snowpack is more sensitive to changes in precipitation (Gergel *et al*. 2017, p. 295). Differences were observed based on elevation (Gergel *et al*. 2017, p. 292). The study reported on future projected declines of summer soil moisture in forested areas (e.g., Northern Rockies) and the likelihood of increased risk of drought and therefore an increase in wildland fire risk for forested areas (e.g., Northern Rocky Mountains), though they recognize there is significant uncertainty in these future projections in high-elevation areas (Gergel *et al*. 2017, pp. 295–296).

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In summary, based on these projections, wildland fire risk is likely to increase in the western United States, but future patterns and trends of wildland fire are dependent on several factors (e.g., degree of warming and drought conditions, fuel and soil moisture, wildland fire management practices, elevation) and geographic region. Based on the best available information, the cumulative effects of these two stressors will continue to represent a low impact to the wolverine and its habitat into the mid-21st century, based on climate change projections.

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Other Cumulative Effects

Commented [BJG44]: Should we include other cumulative effects such as trapping, etc?

Commented [SJ45]: I imagine Dana would say Yes. So I'd suggest we at least touch on the others even if we just think they would have little effect on wolverine in the future cumulatively.

We will certainly need cumulative effects discussion in the eventual decision document, so the more that we have in the SSA report, the better.

We could just briefly state the effect of trapping, roads, etc, is not expected to act cumulatively w/ effects of climate change in the future and those stressors are expected to remain low level impacts into the futre. Something like that.

Finally, we note here that the effects of climate change on snowpack are projected to negatively affect the season lengths for winter recreational activities, such as skiing and snowmobiling (Wobus *et al*. 2017, entire), thus, potentially reducing this stressor to the wolverine in the future. Wobus *et al*. (2017) modeled potential changes in snowpack at locations across the contiguous United States using output from five GCMs, two representative pathways (RCPs) that represent a future scenario with continued high emissions growth with limited efforts to reduce GHGs (RCP 8.5) and a future scenario with global GHG mitigation (RCP 4.5), and two future time periods (2050 and 2090) (Wobus *et al*. 2017, pp. 2, 5). Although there was some inter-annual variability in 2050 for some model projections, in general, the Rocky Mountains and Sierra Nevada regions had smaller reductions in season length than other locations due to higher elevation, though for the RCP 8.5 scenario coupled with the 2090 future time period, the smallest projected reduction in season length was 15 percent (Wobus *et al*. 2017, p. 9).

An evaluation of the potential future role of federal lands in the United States (including Alaska and Hawaii) relative to providing outdoor recreation opportunities was prepared in 2014 by the Federal Interagency Council of Outdoor Recreation (White *et al*. 2014, entire). The study used

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projection models developed for the 2010 Resources Planning Act Assessment (http://www.fs.fed.us/research/rpa/) in conjunction with external projections of relevant factors, including demographic, economic, land use, and climate factors, to simulate future recreation participation (White *et al*. 2014, p. 4). Both motorized (snow mobiling) and non-motorized (developed and undeveloped skiing) winter outdoor activities were evaluated. The study found that for winter motorized activities, projected trends from 2008 to 2030, per capita participation rates would decline by 10 percent, with days per participant also declining, but at a much lower percentage than the participation rate (White *et al*. 2014, p. 7; Table 3). Snowmobilers still average about 7 days per year on the snow in 2030 (White *et al*. 2014, p. 9).

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For non-motorized winter activities, projected trends for developed skiing (downhill skiing and snowboarding) indicated an increase in both per capita participation (6 to 7 percent) and days per participant (3 percent) by 2030 (White *et al*. 2014, p. 9). Undeveloped skiing (cross-country skiing and snowshoeing) has the lowest participation rate for any of the activity groups (approximately 3 percent of the population), and, although little change is expected in per capita participation, the days per participant are projected to increase slightly due to a positive correlation with mean population age (White *et al*. 2014, p. 9).

Summary of Future Conditions

Models represent tools to describe basic physical and biological behaviors using the best available science, and, by presenting a range of plausible future outcomes, they can help generate hypotheses while also identifying knowledge gaps where greater accuracy is needed (Batchelet *et al*. 2016, p. 23). Detecting a species' response to climate change in a single population, and sometimes multiple populations, may not always indicate the response throughout its range given the variation in annual mean surface temperatures over the past century (Post 2013, p. 5). In addition, inter-annual variability in temperature can be as important to a species' ecological needs as the actual temperature itself (Post 2013, p. 7).

Climate change model projections for the range of the wolverine within the contiguous United States indicate increases in temperature by the mid-21st century as compared to early to mid-20th century values. Precipitation patterns into the future are less clear as the climate models show significant disagreement in their many regional projections. Although drought conditions in the western United States are not unusual, drought duration and intensity have the potential to be exacerbated by projected temperature increases. Projected temperature and precipitation changes will affect future snow cover and the persistence of snow on the landscape. We note here that a male wolverine occupied (and continues to occupy) the Sierra Nevada Mountain region of California through over 4 years of severe drought with reduced snowpack/snow cover conditions.

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Snow cover is projected to decline in response to warming temperatures and changing precipitation patterns, but this varies by elevation, topography, and by geographic region. Simulations of natural snow accumulation at winter recreation locations have found that, overall, higher elevation areas (e.g., Rocky Mountains, Sierra Nevada Mountains) are more resilient to projected changes in temperature and precipitation as compared to lower elevations (Wobus *et al*. 2017, p. 12). In general, models indicate higher elevations will retain more snow cover than

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lower elevations, particularly in early spring (April 30/May1). We present results (above) from several recent climate models projecting snowpack declines in the western United States. More specifically, we reviewed a new analysis from NOAA/CU that modeled future snow persistence for Glacier and Rocky Mountain National Parks (areas that encompass the latitudinal and elevational range of the wolverine in the contiguous United States) at high spatial resolution (Ray *et al*. 2017, entire). Their results indicate significant areas (several hundred square kilometers (miles) for each site) of future snow (greater than 0.5 m (20 in) in depth) will persist on May 1st at elevations currently used by wolverines for denning. This is true, on average, across the range of climate models used out to approximately Year 2055.

As described above (see *Life History and Ecology* section), within their North American range, wolverines are found in a variety of habitats within primarily high elevation areas of the western-northwestern United States, and exhibit wide-ranging movements. As discussed above (Denning Habitat), wolverines select den sites for differing characteristics depending on location and natal dens locations are generally associated with snow cover; however, natal dens have been observed outside of the boundary of the snow model presented in Copeland *et al*. (2010). In addition, very few studies to date have evaluated the importance of denning habitat to reproductive success, or the key physiological and ecological characteristics, including avoidance and/or protection from predators, prey availability, availability of food caching habitat, that define denning behavior and den site selection.

We also considered temperature and precipitation projections from climate change models in conjunction with wildland fire risk. This risk is likely to increase across the western United States, but patterns and trends are dependent on several factors (e.g., degree of warming and drought conditions, fuel and soil moisture) and geographic region.

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Overall Assessment

The wolverine's current potential extent includes the west-northwestern United States, large areas of Canada, and Alaska (see Figure 4). In the contiguous United States, potentially suitable habitat (i.e., primary habitat), as determined by the physical and ecological features and the ecological needs of the wolverine, has been estimated at 164,125 km^2 (63,369 mi^2) (Inman *et al*. 2013, p. 281). The species is found in a variety of habitats, but generally occurs in high elevation, relatively inaccessible locations.

In the contiguous United States, the structure of the wolverine population is represented as a metapopulation, although its genetic structure relative to its entire North American range has not been comprehensively evaluated. Wolverine populations in Alaska are considered to be continuous with populations in the Yukon and British Columbia provinces of Canada based on genetic studies (COSEWIC 2014, p. 37). Similarly, studies of wolverines in the North Cascades region have documented recent movement of wolverines from Washington into British Columbia (Aubry *et al*. 2016, pp. 16, 20) and from Idaho (Lucid *et al*. 2016, p. 184) to British Columbia, and earlier from Montana to British Columbia and Alberta (e.g., Newby and Wright 1955, p. 252).

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Based on the best available information, wolverines select den sites for different characteristics depending on location. Dens located under snow cover may be related to wolverine distribution based on other life history traits, including morphological, demographic, and behavioral adaptations that allow them to successfully compete for food resources (Inman 2013, pers. comm.). Structure (e.g., uprooted trees, boulders and talus fields) appears to be essential for natal den sites. However, reproductive success of wolverines has not been evaluated relative to the depth and persistence of snow cover, or in combination with these or other important characteristics, including prey availability and predator avoidance. Recent studies of wolverine populations and distribution in Sweden have observed wolverine populations and reproductive den sites outside areas with persistent spring snow cover (Aronsson and Persson 2016; Persson 2017, pers. comm.). The study presented in Webb *et al*. (2016, p. 1,468) (Alberta) concluded that wolverines appear to be adaptable and do not require large areas of deep spring snowpack for successful reproduction, and may select small areas covered with deep snow at a finer scale than can be detected using satellite imagery.

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We identified several potential stressors that may be affecting the species' and its habitat currently or in the future, including impacts associated with climate change effects. We recognize there is limited information available for the wolverine, including population estimates and abundance trends. Based on the best available information, demographic risks to the species from either known or most likely potential stressors (i.e., effects from roads, disturbance due to winter recreational activities, effects of wildland fire, and overutilization) are low based on our evaluation of the best available information as it applies to current and potential future conditions for the wolverine and in the context of the attributes that affect the needs of the species.

Climate change model projections for the range of the wolverine within the contiguous United States indicate increases in temperature by the mid-21st century as compared to early to mid-20th century values. Our evaluation of climate change indicates that snow cover is projected to decline in response to warming temperatures and changing precipitation patterns, but this varies by elevation, topography, and by geographic region. In general, models indicate higher elevations will retain more snow cover than lower elevations, particularly in early spring (April 30/May1). Although the persistence of spring snow has not yet been evaluated as critical to wolverine survival in North America, our review of projected snow persistence (to approximately Year 2055) within the Northern and Southern Rocky Mountains, indicates that several hundred kilometers (miles) of deep snow will persist on May 1st at elevations used by the wolverine for denning.

Legal protections include State listing in California and Oregon (as threatened), endangered in Colorado, as a candidate species in Washington, and protection as a non-game species in Idaho and Wyoming, and protected from collection, importation, and possession in Utah. In Canada, provincial designations range from endangered to threatened in eastern provinces, and sensitive/special concern to no ranking in other provinces. Legal trapping or hunting of wolverines is currently prohibited in the contiguous United States. Trapping effort along the U.S.–Canada border does not represent a barrier to wolverine movement and dispersal along the international border.

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Our estimate of Current Potential Extent in the contiguous United States (Figure 3) encompasses approximately 18 percent of designated wilderness areas. Approximately 96 percent of previously modeled wolverine primary habitat (Inman *et al*. 2013) in the contiguous United States is located on Federal lands, with 41 percent located in designated wilderness areas. Management actions for conservation of the wolverine and its habitat are included within State Wildlife Action Plans, the *Management Plan for the Conservation of Wolverines in Idaho* (IDFG 2014), and USDA Forest Service Land and Resource Management Plans (see **Appendix G**). Various provisions of these plans include, but are not limited to, winter road closures, fire management, and land acquisition or conservation easements. These management measures, currently and in the future, will alleviate effects associated with potential impacts related to stressors discussed in this report. In addition, the WAFWA Wildlife Chiefs Wolverine Subcommittee is providing a forum for western States to work collaboratively with each other and with the Service and other partners for conserving wolverines where they are found in the west-northwestern United States, and, to date, approximately $1.5 million of funding has been applied towards conservation and management actions (e.g., Western States Wolverine Conservation Project) (McDonald 2017, pers. comm.).

Based on our review of available relevant literature for similar species, we identified the physical and ecological needs of the species as follows: large territories in relatively inaccessible landscapes; at high elevation (1,800 to 3,500 meters (5,906 to 11,483 feet)) within the contiguous United States; access to a variety of food resources, that varies with seasons; and reproductive behavior linked to both temporal and physical features. These needs are currently met for wolverines in the contiguous United States and are expected to be met in the future (i.e., 40–50 years).

Risk Assessment

In order to characterize a species' viability and demographic risks, we consider the concepts of resilience, representation, and redundancy. We also consider known and potential stressors that may negatively impact the physical and biological features that the species needs for survival and reproduction. Stressors are expressed as risks to its demographic features such as abundance, population and spatial structure, and genetic or ecological diversity. We consider the level of impact a stressor may have on a species along with the consideration of demographic factors (e.g., whether a species has stable, increasing, or decreasing trends in abundance, population growth rates, diversity of populations, and loss or degradation of habitat).

Wolverine populations in much of North America are still recovering from large losses of individuals from unregulated hunting and persecution pressures in the late 1880s into the mid-20th century. Surveys conducted in the winter of 2015–2016, and 2016–2017 continue to document its presence within its "historical" range in the western contiguous United States (representation).

Redundancy, the ability to rebound after stochastic pertrubation, can be characterized by the distribution and connectivity of populations. In considering wolverine in the contiguous United States, individuals are found in alpine, boreal, and subalpine habitats, with breeding populations in four western States. Additionally, wolverines in the contiguous United States appear to be

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connected to wolverine populations in Canada, also contributing to current and future redundancy.

Resiliency, the ability to withstand stochastic events, can be characterized by numbers of individuals and abundance trends. As indicated above, population size, growth rate, and current population trends are unknown for the wolverine due to the lack of abundance information. The Current Potential Extent range of the wolverine occurs within a large area of northern North America (see Figure 3). The most recent estimate for Canada indicates over 10,000 adult wolverines, as well as expansion of wolverines into historically occupied areas in both Canada and the contiguous United States with movement across both international borders. The 2014 COSEWIC report concluded that a climate-driven decline in wolverine populations in North America is not evident at this time in much of its range (COSEWIC 2014, p. 22). Wolverine populations in Canada are considered stable. Density estimates indicate no declining trend in wolverine populations in Alaska. We recognize that there is limited information on populations (representation) or genetic diversity (resiliency and representation) for the wolverine in the contiguous United States, and no comprehensive studies to indicate what a viable (or minimal) wolverine population size should be across its North American range. However, the best available information does not indicate either increasing or declining numbers of the wolverine in North America, including the contiguous United States. Further, at this time, the best available information does not indicate that the species' abundance is significantly impacted by human-caused stressors and this is unlikely to change in the future, supporting current and future resiliency.

As discussed above (Status–Future Conditions), both direct and cumulative effects of climate change (e.g., higher temperatures, loss of snow cover, wildland fire) may affect the resilience of the wolverine by creating an environment that is less favorable to its physiological and ecological needs. We are unaware of studies of the wolverine that have formally evaluated the species' responses (e.g., reproductive success) to warming temperatures or other climate change effects. Recent studies of behavioral responses to climate change effects of the American pika (*Ochotona princeps*; pika) (Beever *et al*. 2017, entire; Jeffress *et al*. 2017, entire; Stewart *et al*., 2017, entire) highlight the need for monitoring programs for animals, such as the wolverine, that are found in relatively inaccessible locations, in naturally low densities, and the importance of evaluating occupancy at multiple scales (Jeffress *et al*. 2017, p. 266) and the potential for geographical variation and habitat structure in adaptation to climate change effects.

As described in this SSA Report, the best available information indicates confirmed observations of wolverines denning in areas with patchy snow cover in Alaska, Canada, and Scandinavia. Given their high rate of movement, large dispersal, and other observed life history traits (e.g., behavioral plasticity) observed in wolverines, we do not predict a significant loss of individual and population resiliency to the species in the future (i.e., 40–50 years) within its North America range, including the contiguous United States.

Currently, we are unaware of any documented specific risks for the wolverine related to a substantial change or loss of diversity in life history traits, population demographics, morphology, behavior, or genetic characteristics which can be used to characterize species representation (the ability to adapt to change). Rates of dispersal or gene flow are not known to

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Deleted: However, a recent evaluation of behavioral plasticity, as an adaptive response to climate change effects, was presented for another mammal considered to be sensitive to climate change effects—the American pika (*Ochotona princeps*; pika) (Beever et al. 2017, entire). As with the wolverine, this species is known to use several behavioral responses to variability in climate including changes in foraging strategies, use of habitat, and thermoregulation (Beever *et al*. 2017, p. 302). The pika was recently detected in heavily shaded rainforest habitat adjacent to talus patches at lower elevation (Columbia River Gorge) not typical of the talus-type habitats commonly used in many alpine areas of the western United States (Beever *et al*. 2017, p. 302). The authors suggest that, in the Columbia River Gorge region, this species is selecting microclimates in nearby shaded forests that provide insulation from warm summer temperatures (Beever *et al*. 2017, p. 302).This study also included results from a review of available literature related to behavior as a response to changing environmental conditions for several taxonomic groups. They found that behavioral responses to climate change effects were most commonly observed in longer-lived species, and the most common response, across all taxa, was a change in reproductive behavior, followed by dispersal or migration (Beever *et al*. 2017, p. 300). Most of the studies they evaluated identified temperature as the climate metric that was responsible for, or correlated with, changes in behavior; however, about 14 percent of the examined literature included responses to indirect (biotic) factors, such as changes in food resources (Beever *et al*. 2017, p. 300). ¶
¶
The authors also note that there are tradeoffs (e.g., reduction in time for foraging due to sheltering) that may impact long-term persistence and population viability (Beever *et al*. 2017, pp. 301–302), and the pika's flexibility in habitat selection has not been observed in populations in the Great Basin (Beever *et al*. 2017, p. 302), where some populations have been extirpated (Beever *et al*. 2016, p. 1,498; Table 1). A recent study concluded that the pika has been extirpated from an interior portion of its geographic distribution in the Sierra Nevada region (California) due to climate effects (i.e., increase in temperature, decline in snowpack), and although sites surrounding this core area still harbor the species, the net effect has been fragmentation of habitat and species distribution (Stewart *et al*., 2017, entire). ¶
¶
However, the pika continues to be found at sites that are outside of areas contained within bioclimatic envelop models (Jeffress *et al*. p. 253). The study found previously undocumented extant populations of the American pika in a region of the Great Basin (northwestern Nevada) that has been described as extirpated (Jeffress *et al*. 2017, entire). Relative to wolverine, the authors note that these results

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have changed. Additionally, there is no currently available information to indicate that the current abundance of the wolverine across its Current Potential Extent in the contiguous United States is at a level that is causing inbreeding depression or loss of genetic variation that would affect representation. Nor is there any information to indicate that this species is unable to adapt or adjust to changing conditions (e.g., potential reduction in snow cover). We do not expect a reduction in representation of the wolverines in the contiguous United States in the future.

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Commented [SJ52]: Don't we also have info that only a few migrants per generation (Cegelski) would be necessary to maintain the long term genetic health in the US, and we don't think anything is preventing migration from Canada, therefor… But maybe that would be better stated in the previous section.

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¶
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Appendices

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Appendix A – Ecological regions of North America
(Source: CEC 1997; EPA 2010)

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Appendix B – Wolverine Detections, Multi-State Wolverinec Occupancy Survey and Volunteer/Incidental Sightings, Winters 2015–2016 (Wyoming only) and 2016–2017
Source: WAFWA Wolverine Subcommittee 2017.

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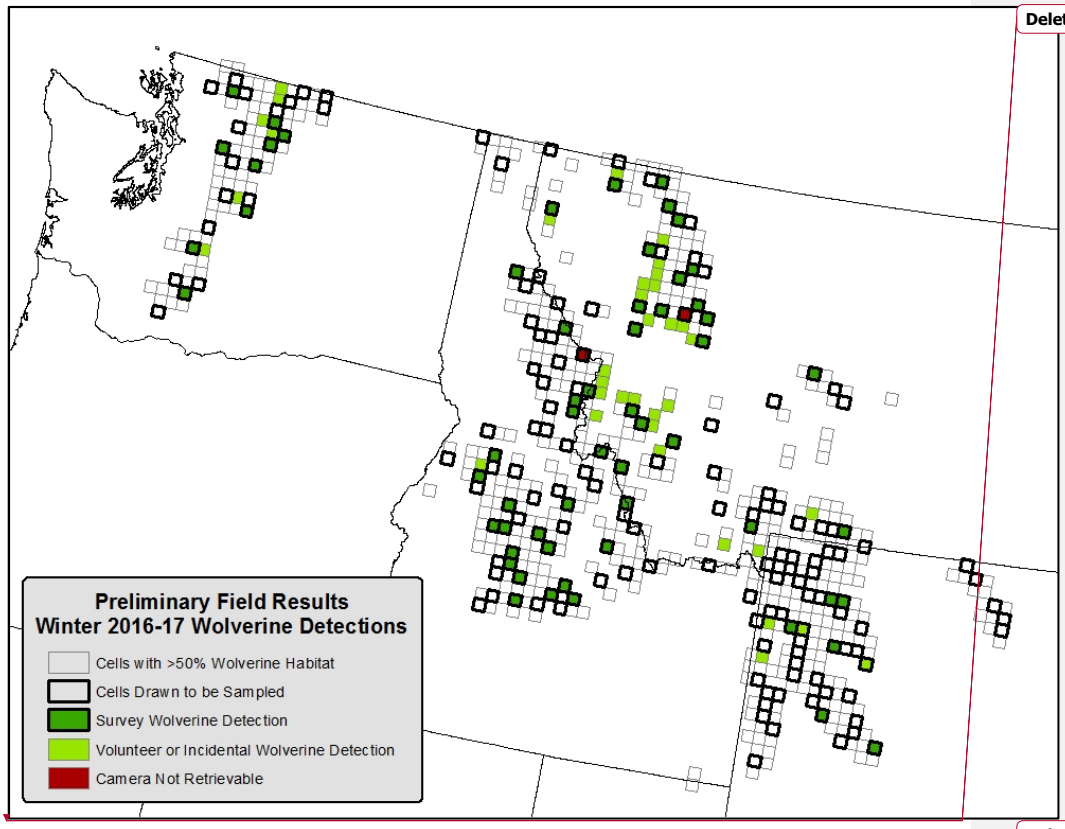

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Appendix C – Summary of Multi-State Wolverine Occupancy Survey

Provided by Montana FWP 2017, pers. comm.

"*Wolverines are a naturally uncommon and rarely encountered species that resides in remote, high-elevation areas of the western United States. Proactive conservation measures are needed for this inherently small population that exists as a metapopulation across the region. One key component of a wolverine conservation strategy is development of a population monitoring program – up to now, records of wolverine occurrence have been rare and collected in an uncoordinated and opportunistic fashion, which makes it difficult to assess the species distribution, status and trend. The continued absence of a monitoring program jeopardizes the ability of agencies to allocate resources effectively among wolverines and other conservation priorities. State wildlife agencies in WA, ID, MT, and WY, along with federal, tribal, and NGO partners, developed a collaborative monitoring program that can be implemented in a coordinated fashion across the species range in the western U.S. The foundation for this monitoring program is a coordinated camera survey to obtain baseline information on distribution, genetics, and occupancy of wolverines. When repeated over time, trends in occupancy and distribution can be evaluated.*

We developed a sampling frame based on existing models of wolverine habitat. The sampling frame consisted of 633 15x15 km grid cells. We selected 185 cells to sample from the frame using a GRTS sampling method. A single remotely triggered camera was placed in likely wolverine habitat within each selected cell along with a bait or scent attractant. Sampling occurred across a four-state area (ID, MT, WA, WY) during the winters of 2015-16 and 2016-17.

We obtained data from 183 sites and detected wolverines at 59 of the sampled cells. Detection rate was exceptionally high (p=0.92), and did not differ between sites that were baited and revisited multiple times vs. sites that were scented only and visited less frequently. The average estimated probability of wolverine occupancy during our study was 0.42 (95% credible interval 0.29-0.55) suggesting that wolverines used nearly half of all sites during the study period. Wolverine occupancy varied across the region with highest occupancy in the Northern Continental Divide Ecosystem and lower on the southern and eastern periphery of the study area (Figure 1).

The multi-state wolverine survey produced several important outcomes. First, it provided a rigorous and previously unavailable evaluation of wolverine distribution for the first time since the species was extirpated from the contiguous U.S. a century ago. This evaluation confirms the broad distribution of wolverines across the region and that recovery has progressed substantially since historical lows. The effort also demonstrates that occupancy probability varies throughout the region. The variability may be due to differences in habitat quality, differences in wolverine survival, or could be due to the time required to recover from historical absence. Perhaps most importantly, the regional occupancy estimates provide a baseline for future evaluations of change in wolverine distribution through time, including the possibility of detecting any influences due to climate change. In addition, the high detection rate and equal performance of stations visited less frequently indicates the potential for substantial cost savings during future surveys. The effort also demonstrated strong and fruitful collaboration among state, federal and tribal agencies at the scale of a species range, and the results provide management-level guidance on where to direct wolverine conservation in the future. For instance, information on occupancy may be used to inform criteria for translocation, should some states pursue that as a means for enhancing the conservation status of wolverines."

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Commented [SJ54]: I think its fine as is, but maybe just say up front that it is language taken directly from the working group and not use italics.

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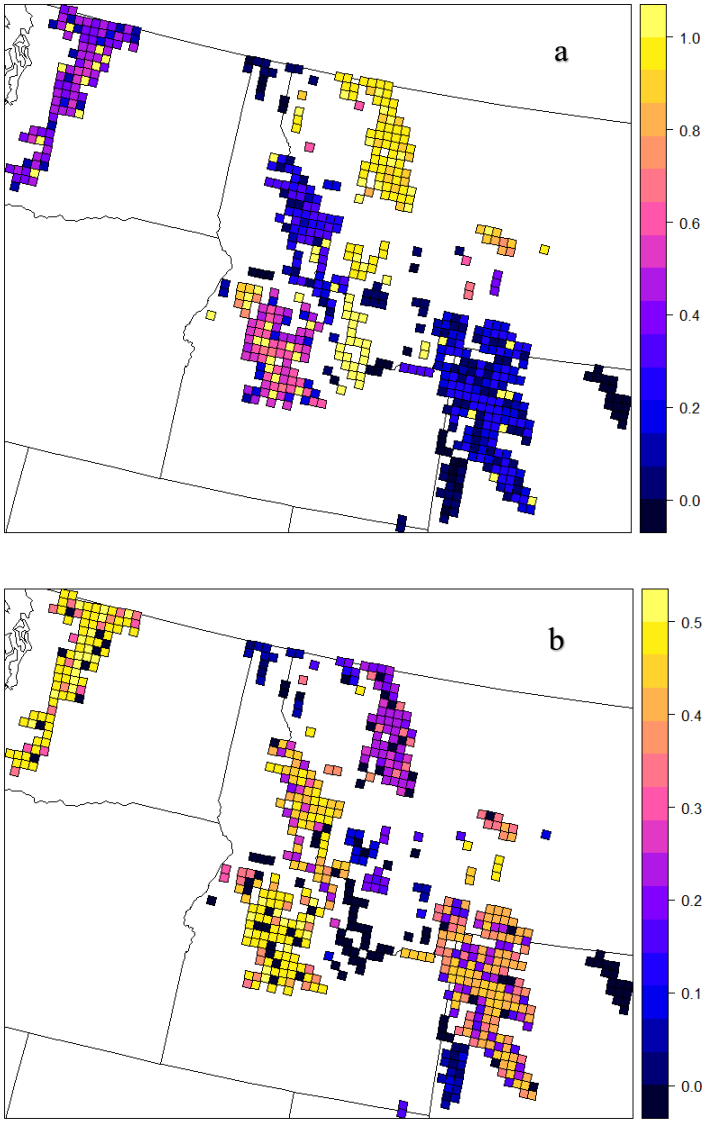
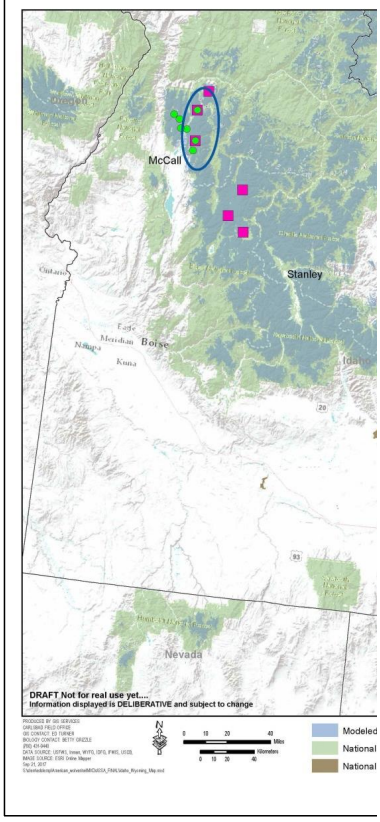
Figure 1. Predicted wolverine occupancy (a) and standard errors (b) for the multistate wolverine survey in Winters 2015–2016 and 2016–2017.



Appendix D – Land Ownership of Current Potential Extent of the Current Potential Extent of Wolverine in the Contiguous United States
(based on Albers Projection; see Figure 3)

Ownership (% of total)	Agency or other Entity	Total (acres)	Total (square kilometers)
Federal Lands	Bureau of Indian Affairs	2,108,012	8,531
	Bureau of Land Management	4,236,779	17,146
	Bureau of Reclamation	137,567	557
	Forest Service	45,217,891	182,990
	U.S. Fish and Wildlife Service	115,184	466
	National Park Service	4,429,682	17,926
	Other U.S. Department of Agriculture	17,449	71
	Other Federal	76,152	308
Total Federal (72.4%)		**56,338,714**	**227,995**
State Lands (4.3%)	Idaho, Montana, Oregon, Washington, Wyoming	**3,337,474**	**13,506**
Local Government (0.01%)		**9,249**	**37**
Private Lands (22.8%)		**17,771,270**	**71,918**
No Code ("99") (0.24%)		**187,625**	**759**
Undetermined (0.24%)		**184,767**	**748**
Total (100%)		**77,829,099**	**314,963**

Note: Numbers may not total to 100 percent due to rounding.



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Appendix E – Results from Spatial Analysis of Roads within Current Potential Extent of Wolverine

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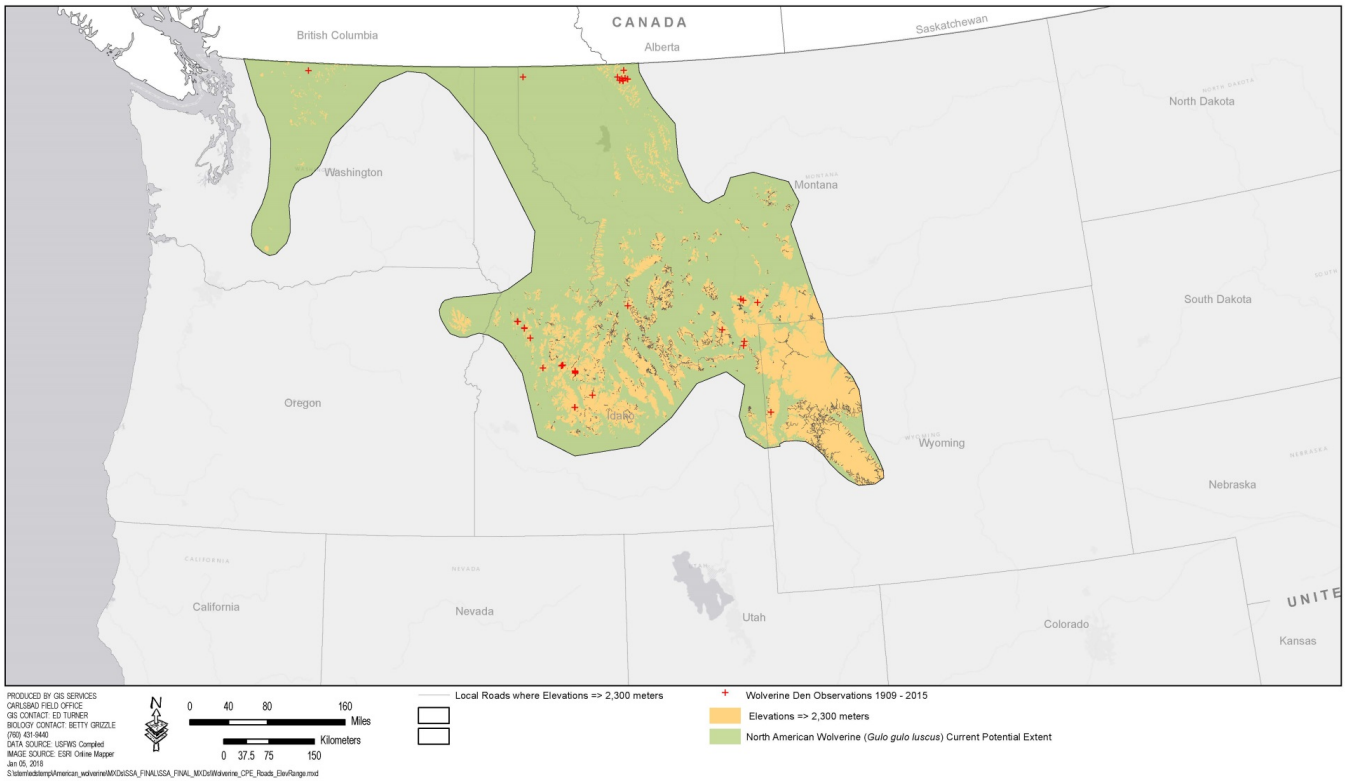

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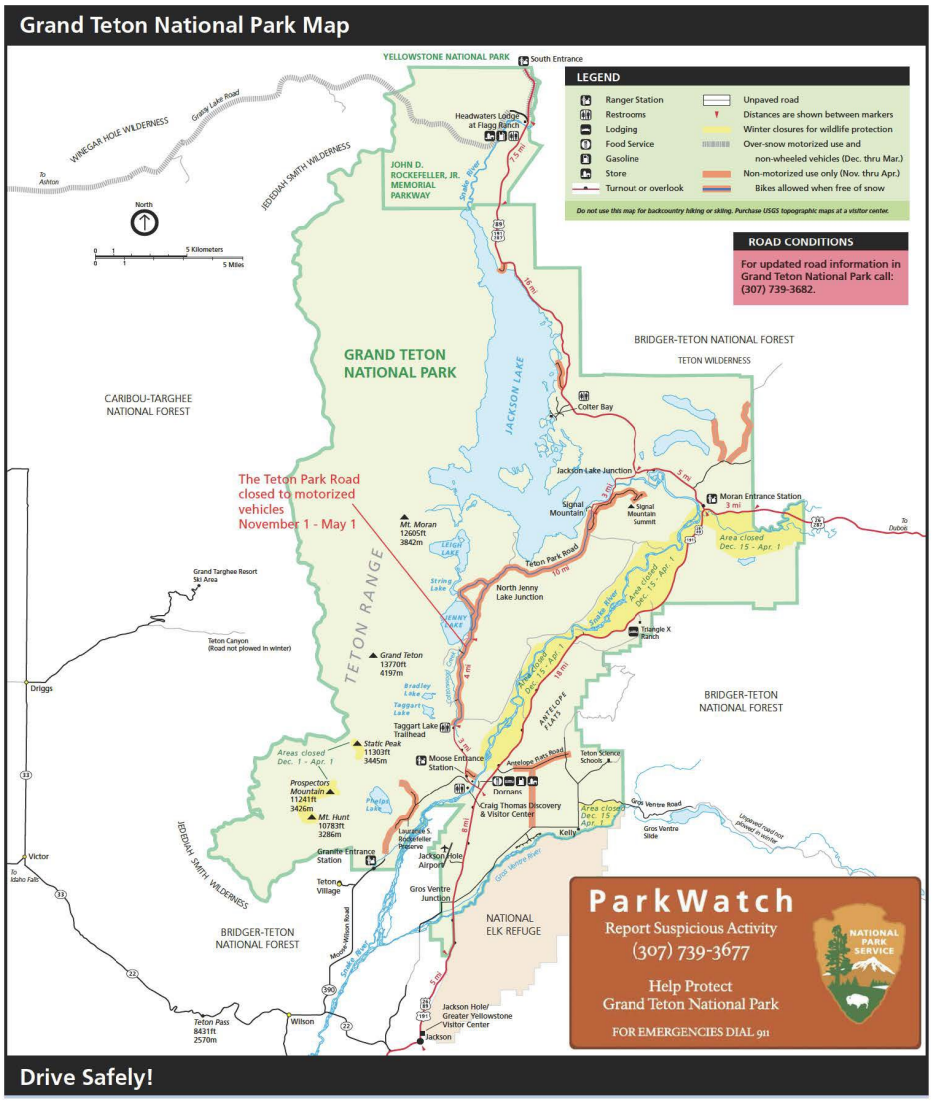
Appendix F – Road Closure Map, Grand Teton National Park
Retrieved from: https://2v9usu38jb9t3l8big1ialsn-wpengine.netdna-ssl.com/wp-content/uploads/2015/11/GTNP-closure-map.pdf



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Appendix G – Existing Regulatory Mechanisms and Voluntary Conservation Measures

Federal Mechanisms

Organic Administration Act of 1897 and the Multiple–Use, Sustained–Yield Act of 1960

The USFS Organic Act of 1897 (16 U.S.C. § 475–482) established general guidelines for administration of timber on USFS lands, which was followed by the Multiple–Use, Sustained–Yield Act (MUSY) of 1960 (16 U.S.C. § 528–531), which broadened the management of USFS lands to include outdoor recreation, range, watershed, and wildlife and fish purposes.

National Forest Management Act

The National Forest Management Act (NFMA) (16 U.S.C. § 1600 *et seq*.) requires the Forest Service to develop a planning rule under the principles of the MUSY of 1960 (16 U.S.C. § 528–531). The NFMA outlines the process for the development and revision of the land management plans and their guidelines and standards (16 U.S.C. § 1604(g)).

A new National Forest System (NFS) land management planning rule (Planning Rule) was adopted by the U.S. Department of Agriculture Forest Service (Forest Service) in 2012 (77 FR 21162; April 9, 2012). The new Planning Rule guides the development, amendment, and revision of land management plans for all units of the NFS to maintain and restore NFS land and water ecosystems while providing for ecosystem services and multiple uses. Land management plans (also called Forest Plans) are designed to: (1) Provide for the sustainability of ecosystems and resources; (2) meet the need for forest restoration and conservation, watershed protection, and species diversity and conservation; and (3) assist the Forest Service in providing a sustainable flow of benefits, services, and uses of NFS lands that provide jobs and contribute to the economic and social sustainability of communities (77 FR 21261, April 9, 2012). A land management plan does not authorize projects or activities, but projects and activities must be consistent with the plan (77 FR 21261; April 9, 2012). The plan must provide for the diversity of plant and animal communities including species-specific plan components in which a determination is made as to whether the plan provides the "ecological conditions necessary to…contribute to the recovery of federally listed threatened and endangered species…" (77 FR 21265; April 9, 2012).

The Record of Decision for the final Planning Rule was based on the analyses presented in the *Final Programmatic Environmental Impact Statement, National Forest System Land Management Planning* (77 FR 21162–21276; April 9, 2012), which was prepared in accordance with the requirements of the National Environmental Policy Act (NEPA) (discussed below). In addition, the NFMA requires land management plans to be developed in accordance with the procedural requirements of NEPA, with a similar effect as zoning requirements or regulations as these plans control activities on the national forests and are judicially enforceable until properly revised (Coggins *et al.* 2001, p. 720).

A Species of Conservation Concern (SCC) is defined in the 2012 Planning Rule and in regulation (36 CFR 219.9(c)), as "a species, other than federally recognized threatened,

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endangered, proposed, or candidate species, that is known to occur in the plan area and for which the regional forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area." The 2012 Planning Rule requires Regional Foresters to identify SCC for plan revision, and, when identified for a National Forest, monitoring plans are changed as needed (77 FR 21250, 21267; April 9, 2012). Wolverine is considered a SCC in the Rocky Mountain Region (Region 2). It is considered a Sensitive Species in the Intermountain Region (Region 4) and Northern Region (Region 1).

Within our estimated Current Potential Extent of the wolverine in the contiguous United States (see Figure 3), we identified 22 National Forests. These areas are contained within four Forest Service Regions across the western United States.

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National Forest Land Management Plans (Forest Plans)

We reviewed several Forest Plans or related planning documents in an effort to describe how these plans provide conservation management for the wolverine and its habitat, including wildland fire management practices. The sections below are, in most cases, taken directly from relevant documents. However, this discussion is not intended to be inclusive of all NFS management strategies and activities across the entire Current Potential Extent of the wolverine in the contiguous United States.

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Sierra Nevada Forest Plan Implementation

The 2004 Sierra Nevada Forest Plan Amendment (referred to as the Sierra Nevada Framework) amended the Land and Resource Management Plans (LRMP) for the eleven National Forests in the Sierra Nevada range to improve protection of old forests, wildlife habitats, watersheds and communities in the Sierra Nevada Mountains and Modoc Plateau. This amendment applies to the Tahoe National Forest, which has been occupied by a single male wolverine since at least 2008 (Moriarty *et al*. 2009, p. 150). The emphasis of the 2004 Sierra Nevada Framework is to adopt an integrated strategy for vegetation management that is aggressive enough to reduce the risk of wildfire to communities in the wildland urban interface, while modifying fire behavior over the broader landscape. Direction is provided as management goals and strategies, desired conditions, management intents and objectives, and management standards and guidelines. The 2004 Framework addressed five problem areas: old forest ecosystems and associated species; aquatic, riparian and meadow ecosystems and associated species; fire and fuels management; noxious weeds; and lower west side hardwood ecosystems (Forest Service 2013, p. 2–3).

Kootenai National Forest

The Kootenai National Forest is located in the northwest corner of Montana along the Canadian border and includes about 2.2 million acres of public land (Forest Service 2015, p. 7). The Forest Service published a Revised Land Management Plan for the Kootenai National Forest in 2015 that identifies forestwide direction, including goals, desired conditions, objectives, standards, and guidelines for physical and biological elements including wildlife such as management activities that promote connectivity and avoiding or minimizing disturbance at known active denning sites

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for sensitive, proposed, threatened, or endangered species not covered under other forestwide guidelines. It also outlines objectives and guidelines related to the use of fire to maintain or improve habitat and maintaining unlogged conditions in some portions of areas burned by wildfires for 5 years post-fire (Forest Service 2015, pp. 28–32).

The Kootenai National Forest Land Management Plan also identifies *proposed or possible* actions for wildlife management that includes establishing and maintaining the vegetation diversity necessary to provide food, cover, and security for wildlife species native to the Kootenai National Forest in cooperation with federal, state, and other organizations. For wolverine, those management activities might include maintaining, managing, and protecting lands known or suspected to contribute to landscape linkages for wolverine (and other carnivores) in order to promote genetic dispersal and healthy populations (Forest Service 2015, p. 128).

Beaverhead-Deerlodge National Forest

The Beaverhead-Deerlodge National Forest covers 3.38 million acres in southwest Montana (Forest Service 2009, p. 2). The Beaverhead-Deerlodge National Forest Land and Resource Management Plan identifies goals, objectives, and standards for wildlife management (Forest Service 2009, pp. 45–49). Of relevance to the wolverine, wildlife security management goals include securing areas and connectivity for ungulates and large carnivores and managing the density of open motorized roads and trails by landscape region (Forest Service 2009, p. 45). Objectives include management of habitat conditions for elk security and winter habitat integrity for wolverine and mountain goat relative to changes in abundance of these Management Indicator Species (Forest Service 2009, p. 47). Monitoring elements are defined in the Land and Resource Management Plan that link goals and objectives to elements of the National Monitoring and Evaluation Framework (Forest Service 2009, pp. 273–280). For wildlife security, three performance measures relative to determining whether management activities are effectively protecting high elevation winter habitats for wolverines and mountain goats are defined: (1) presence or absence of wolverines in high elevation habitats, (2) populations of mountain goats (from Montana Fish Wildlife & Parks), and (3) number of snowmobile entries into non-motorized high elevation units protected for wolverines and mountain goats (Forest Service 2009, p. 277). In addition, in order to evaluate objectives related to road and trail densities, a performance measure related to changes in open motorized road and trail density for both seasons by landscape is included (Forest Service 2009, p. 277).

The Forest Service is monitoring the Mount Jefferson Recommended Wilderness boundary for illegal snowmobile intrusions into the wolverine habitat closure; that is, illegal use will be monitored and recorded (number and distance of intrusions) during the period open to snowmobiles December 2 to May 15 and any other time of the year snow conditions make snowmobiling possible (Forest Service 2009, p. 277). A reassessment of the decision to allow snowmobile use will be triggered if: (1) illegal intrusions are documented throughout the closure period; (2) illegal intrusions into the closed area, or (3) illegal intrusions that extend as far as the Bureau of Land Management (BLM) Wilderness Study Area (Forest Service 2009, p. 277).

Flathead National Forest

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The Flathead National Forest is located in the northern Rocky Mountains in western Montana and includes approximately 2.4 million acres of public land (Forest Service 2016a, p. 3). This National Forest is surrounded by the Kootenai, Lewis and Clark, and Lolo National Forests, Glacier National Park, and Canada and includes large areas of designated wilderness (e.g., Bob Marshall Wilderness Complex, Mission Mountains Wilderness), Crown of the Continent Ecosystem, and wild and scenic river systems (Forest Service 2016a, pp. 3–4).

A Draft Revised Forest Plan was prepared for the Flathead National Forest in 2016 (Forest Service 2016b, entire). The Draft Revised Forest Plan identifies components to guide future projects and activities and the plan monitoring program, though these components are not commitments or final decisions approving projects or activities (Forest Service 2016b, p. 3). These components include desired conditions, objectives, standards, guidelines, suitability, and monitoring questions and monitoring indicators (Forest Service 2016b, p. 3). [A *desired condition* is a description of specific social, economic, and/or ecological characteristics of the plan area, or a portion of the plan area, toward which management of the land and resources should be directed, while an *objective* a concise, measurable, and time-specific statement of a desired rate of progress toward a desired condition or conditions (Forest Service 2016b, p. 4). A *standard* is a mandatory constraint on project and activity decision making, established to help achieve or maintain the desired condition or conditions, and a *guideline* is a constraint on project and activity decision-making that allows for departure from its terms, and are established to help achieve or maintain a desired condition or conditions, to avoid or mitigate undesirable effects, or to meet applicable legal requirements (Forest Service 2016b, pp. 4–5).]

Relative to wolverine, plan components for the revised forest plan include two guidelines that are protective of wolverine habitat; one that would protect modeled wolverine maternal denning habitat with respect to new projects or activity authorizations involving helicopter use and one that stipulates no net increase in the percentage of modeled wolverine maternal denning habitat where motorized over-snow vehicle use would be suitable on National Forest System lands. Additionally, as described in the Final EIS, management area allocations for Alternatives A, B modified and C include recommended wilderness areas that would add to existing wilderness. Desired conditions related to maintaining connectivity for wolverine and other wildlife are also identified within several geographic areas (Kuennen 2017, pers. comm.).

Federal Land Policy and Management Act (FLPMA) of 1976

FLMPA (43 U.S.C. 1711-1712) represents the BLM's "organic act" for public lands management under the principles of multiple use and sustained yield. Its implementing regulations give BLM regulatory authority over activities for protection of the environment, including mining claims. Under FLPMA and BLM policy, public lands must be managed so as to protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archaeological values (BLM 2005, p. 1).

Land Use and Resource Management Plans

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BLM land use planning requirements are established by Sections 201 and 202 of FLMPA and regulations at 43 CFR 1600 (BLM 2005, p. 1). A *Land Use Planning Handbook* (BLM 2005, entire) provides guidance for implementing land use planning requirements established under FLMPA and implementing regulations. Land use plans prepared by BLM include resource management plans (RMPs) and management framework plans (BLM 2005, p. 1). The RMPs establish the basis for actions and approved uses on the public lands and are prepared for areas of public lands, called planning areas (BLM 2005, pp. 1, 14). These plans are periodically evaluated and revised in response to changed conditions and resource demands (BLM 2005, pp. 33–34).

National Environmental Policy Act (NEPA)

All Federal agencies are required to adhere to the NEPA of 1970 (42 U.S.C. 4321 et seq.) for projects they fund, authorize, or carry out. Prior to implementation of such projects with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. The Council on Environmental Quality's regulations for implementing NEPA state that agencies shall include a discussion on the environmental impacts of the various project alternatives (including the proposed action), any adverse environmental effects that cannot be avoided, and any irreversible or irretrievable commitments of resources involved (40 CFR part 1502). The public notice provisions of NEPA provide an opportunity for the Service and other interested parties to review proposed actions and provide recommendations to the implementing agency. NEPA does not impose substantive environmental obligations on Federal agencies—it merely prohibits an uninformed agency action. However, if an Environmental Impact Statement is prepared for an agency action, the agency must take a "hard look" at the consequences of this action and must consider all potentially significant environmental impacts. Federal agencies may include mitigation measures in the final Environmental Impact Statement as a result of the NEPA process that may help to conserve the wolverine and its habitat.

Although NEPA requires full evaluation and disclosure of information regarding the effects of contemplated Federal actions on sensitive species and their habitats, it does not by itself regulate activities that might affect the wolverine; that is, effects to the subspecies and its habitat would receive the same scrutiny as other plant and wildlife resources during the NEPA process and associated analyses of a project's potential impacts to the human environment. The Service receives notification letters for Draft and Final Environmental Impact Statements prepared by the Forest Service, BLM and other Federal agencies pursuant to NEPA for specific proposed projects including those within National Forests or National Parks, and preparation of Forest Service Land and Resource Management Plans, as discussed above.

Wilderness Act

The Wilderness Act of 1964 (16 U.S.C. 1131–1136) provides protection of habitat from most forms of development, though no single agency is responsible for administration of lands provided this designation, which are designated (or modified) by Congress. The Wilderness Act prohibits commercial enterprises and permanent roads within wilderness area and restricts temporary roads, motorized and mechanical transport, and structures, but does not prohibit all commercial uses (e.g., grazing). Within the portion of our estimated Current Potential Extent of

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the wolverine in the contiguous United States and Alaska, approximately 18 percent is designated as wilderness areas under the Wilderness Act. We also evaluated wilderness contained within modeled wolverine primary habitat from Inman *et al*. (2013). We found 41 percent of this suitable habitat was designated as wilderness areas.

State Mechanisms

California

As noted above, the wolverine is a threatened species under the California Endangered Species Act or CESA, which prohibits the take of any species of wildlife designated by the California Fish and Game Commission as endangered, threatened, or candidate species (CDFW 2017b). CDFW may authorize the take of any such species if certain conditions are met through the issuance of permits (e.g., Incidental Take Permits) (CDFW 2017b). The wolverine is also a fully protected mammal in California, a designation that provides it with the most restrictive protection regarding take (i.e., may not be taken or possessed at any time) (CDFG Game Code, Division 4, Part 3 (Mammals), Chapter 8 (Fully Protected Mammals) § 4700(a)(1)).

The wolverine is also a Species of Greatest Conservation Need (SGCN) in the State's Wildlife Action Plan[5] and is a focal species of conservation strategies for conservation targets in the Southern Cascades and Sierra Nevada Ecoregions, and in the Mono Ecoregion of the Deserts Province section (Big Sagebrush Scrub (CDFW 2015, pp. 5.2-16, 5.4-23, 5.6-19).

In 2011, the CDFW (formerly California Department of Fish and Game) prepared an assessment/briefing document, *California Wolverine Population Augmentation Considerations*, in response to a *Feasibility Assessment and Implementation Plan for Population Augmentation of Wolverines in California* (November 2010) submitted to the Department by the Institute for Wildlife Studies (California Department of Fish and Game (CDFG) 2011). As of August 2017, no action has been taken by CDFW toward implementation of augmentation of wolverines in California.

Oregon

The wolverine has been listed as threatened species in Oregon since 1975, under the Oregon Endangered Species Act, and is fully protected under management authority of the ODFW (Anglin 2013, pers. comm.).

A Conservation Strategy for conserving the State's fish and wildlife has been prepared by the ODFW. The Conservation Strategy identifies 294 Strategy Species, which are Oregon's SGCN, (including wolverine) and are defined as those species having small or declining populations, are

[5] The U.S. Congress created the State Wildlife Grant (SWG) funding program in 2000 (Title IX, Public Law 106-553 and Title 1, Public Law 107-63). SWG funds are to be used "…for the planning and implementation of [States and territories] wildlife conservation and restoration program and wildlife conservation strategy, including wildlife conservation, wildlife conservation education, and wildlife-associated recreation projects." Congress stipulated that each State or territory applying for this funding program must develop a wildlife conservation strategy (**State Wildlife Action Plan** (SWAP)) by October 1, 2005. All 56 states and territories submitted SWAPs by 2005 and made commitments to review and/or revise their SWAP at least every 10 years.

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at-risk, and/or are of management concern (ODFW 2016). For each of the Strategy Species, the Conservation Strategy identifies information on the special needs, limiting factors, data gaps, and conservation actions. For wolverine, conservation actions include management of recreational use to avoid impacts to the species (ODFW 2016). Other Strategy Species identified in the State's Conservation Strategy are prey species important to wolverine, including the Rocky Mountain bighorn sheep and Columbian white-tailed deer (ODFW 2016).

Washington

The wolverine is a candidate species for listing in the State of Washington and, since 2006, the Washington Department of Fish and Wildlife (WDFW) has been collaborating with wolverine researchers in the Cascades of northern Washington and southern British Columbia to better understand the status, distribution, and general ecology of wolverines in this region (WDFW 2013). It is also considered a SGCN, and is identified as a species whose population is in critical condition (WDFW 2013, pp. 3-7).

Washington's State Wildlife Action Plan (updated in 2015) identifies several major conservation strategies to address the conservation of fish and wildlife habitat and biodiversity in Washington, on both public and private lands (WDFW 2015, pp. 2-12–2-28). The wolverine is included in several identified ecological systems of concern such as alpine scrub, forb meadow, and grassland vegetation, cliff, scree and rock vegetation, and temperate forests (WDFW 2015, pp. 4-19, 4-27, 4-98). The State's *Wildlife Action Plan* identifies major stressors and key actions needed to maintain habitat quality for each of these ecological systems.

Of relevance to wolverine, the WDFW and its partners have been targeting land acquisition and conservation easements with high habitat or biodiversity values such as mixed-conifer forests as well as areas that support winter range and connectivity for wolverine and other carnivores (e.g., Methow River and Okanogan River Watersheds projects) (WDFW 2015, pp. 2-15–2-17). Other landscape conservation efforts highlighted in the State's Wildlife Action Plan include a Federal-State partnership with Washington's Department of Transportation to implement the Interstate-90 Snoqualmie Pass East Project to enhance wildlife connectivity that includes wildlife underpasses under the highway along creeks and rivers and two 150-foot wide wildlife bridges over the highway (WDFW 2015, p. 2-26).

Idaho

In Idaho, the wolverine is a protected nongame species and SGCN in Idaho (IDFG 2014). The *Idaho State Wildlife Action Plan, 2015* is a statewide plan for conserving and managing Idaho's fish and wildlife and their habitats, and provides a framework for conserving Idaho's 205 SGCN and their habitats, which includes the wolverine (IDFG 2017b, pp. xv–xviii). The wolverine is identified as a Tier 1 SGCN, which indicates it represents a species of most critical conservation need (IDFG 2017b, p. xvi). The statewide plan presents a species assessment for each SGCN and ecological section plans. Each of the ecological section plans presents a conservation target (e.g., habitat, species assemblage) that summarizes its viability as well as prioritized threats and strategies (IDFG 2017b, p. xv). A section outlining species designation, planning, and monitoring is also provided. The wolverine is included in three of the defined conservation

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targets—forested lowlands, subalpine-high montane conifer forest, and low density forest carnivores (IDFG 2017b, p. 76). Along with objectives and strategies, these summaries identify actions for the SGCNs included in the defined conservation targets. Examples include: develop and implement a long-term multi-taxa monitoring program; determine high risk areas for wildlife crossings; construct highway over- and underpasses; promote and/or facilitate the use of prescribed fire as a habitat restoration tool, on both public and private lands where appropriate; determine best management practices to maintain cool microsites and benefit cool air associated species; and implement strategies to minimize disturbance from winter recreation activities as outlined in the *Management Plan for the Conservation of Wolverines in Idaho, 2014–2019* (IDFG 2017b, pp. 79, 80, 91, 94, 110).

The *Management Plan for the Conservation of Wolverines in Idaho, 2014–2019* (Management Plan) (IDFG 2014, entire) represents a framework for proactive efforts to ensure the long-term persistence and viability of wolverine populations in Idaho (IDFG 2016, pers. comm.). The Management Plan is described as a voluntary guidance document to lead conservation efforts at the State and local level, as well as to facilitate communication and collaboration efforts among wildlife and land managers (IDFG 2014, p. v).

Conservation issues and management actions are described in the Management Plan and the appropriate section plans of the *Idaho State Wildlife Action Plan*. The recommended strategies include development of finer-scale climate projections, research regarding wolverine-snow relationships, characterizing wolverine response to recreational activities, developing predictions of the potential overlap of wolverine and high levels of snow-sports recreation, and educating trappers to minimize incidental trapping of nontarget species, including the wolverine (IDFG 2014, pp. 32–39; IDFG 2017b, p. 1058). Seven conservation and management objectives are outlined in the Management Plan (IDFG 2014, pp. 32–39) and, as outlined in a November 2016 response letter, there has been progress on all of these objectives (IDFG 2016, pers. comm.). As an example, the agency (under the Multi-species Baseline Initiative) has developed and implemented a baseline micro-climate monitoring protocol for collecting environmental parameters in an effort to identify areas that serve as cool-air refugia (IDFG 2016, pers. comm.). As described above (*Overutilization for Commercial, Recreational, Scientific, or Educational Purposes*), the IDFG has prepared educational materials to promote best management practices for minimizing non-target wolverine captures and continues to educate trappers under a legislative mandate passed in 2016 (State of Idaho House Bill 378) (IDFG 2016, pers. comm.).

In addition, management of prey species important to the wolverine diet is outlined in the Idaho Elk Management Plan 2014-2024 (IDFG 2014a), the Mule Deer Management Plan 2008-2017 (2008) and the Bighorn Sheep Management Plan (2010).

Montana

In the State of Montana, the wolverine is classified as a furbearer and species of concern. Since 2013, there has been a zero quota for trapping or harvest of wolverine and trappers that capture a wolverine must notify a designated Montana FWP employee within the relevant trapping district within 24 hours for collection if the animal cannot be released uninjured (Montana FWP 2016, pers. comm.).

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There are two broad-scale wildlife conservation efforts that provide conservation benefits to the wolverine. *Montana's State Wildlife Action Plan* (updated and revised in 2015) identifies the wolverine as one of 128 SGCN (Montana FWP 2015, Appendix N). The State's Wildlife Action Plan identifies priority community types, focal Areas, and species to help informing Montana FWP's priorities and decisions and to assist other agencies and organizations in making decisions as to where to focus their conservation efforts (Montana FWP 2015, p. 2). Community types and focal areas are designed to identify and direct attention to specific geographical areas in the State that have the greatest conservation need (Montana FWP 2015, p. 5). For the wolverine, *Montana's State Wildlife Action Plan* identifies wolverine habitats in seven community types, all designate Tier I (or those with greatest conservation need), and in all focal areas (also Tier I) within those community types (Montana FWP 2016, pers. comm.). For each community type, impacts, threats, and corresponding conservation actions are identified, as well as specific impacts and threats such as habitat fragmentation (e.g., prioritize land acquisition, provide wildlife under- and overpasses), land management (e.g., management to address altered fire regimes), recreation (e.g., consider seasonal closures during breeding season), and climate change (e.g., collection of baseline data to document shifting range limits of SGCN and Community Types of Greatest Conservation Need) (Montana FWP 2015, pp. 59–63).

The second conservation effort in the State of Montana is a Crucial Area Assessment to identify crucial areas and fish and wildlife corridors, and development of a Crucial Areas Planning System (URL: http://fwp.mt.gov/fishAndWildlife/conservationInAction/crucialAreas.html). This is a Montana FWP mapping application and planning tool designed to assist in future planning of development and conservation (Montana FWP 2016, pers. comm.).

The State of Montana is also conserving wildlife habitat through land acquisition and conservation easements (Montana FWP 2016, pers. comm.) using a landscape scale collaborative approach with other agencies (Montana FWP 2016, pers. comm.; Montana FWP 2017, pers. comm.). In western Montana, including areas known to be occupied by the wolverine, 425 properties for a total 310,523 ha (767,320 ac) have been either acquired (e.g., State Parks, Wildlife Management Areas) or protected by conservation easements, as of November 2016, as shown in the figure below (Montana FWP 2016, pers. comm.). In addition, beginning in 2008, the agency shifted harvest units and quotoas to emphasize protection in smaller mountain ranges (closing 40 percent of the State to harvest), and to provide protection in places where reproduction is occurring in-between large ecosystems, to ensure dispersal and genetic exchange (Montana FWP 2017, pers. comm.).

Other regulatory mechanisms implemented by the State include rules and regulations promulgated by the Montana Fish and Wildlife Commission and codified in State Statute (MCA 87-1-201), and have been in place since 1921. All furbearer regulations are reviewed on an annual basis.

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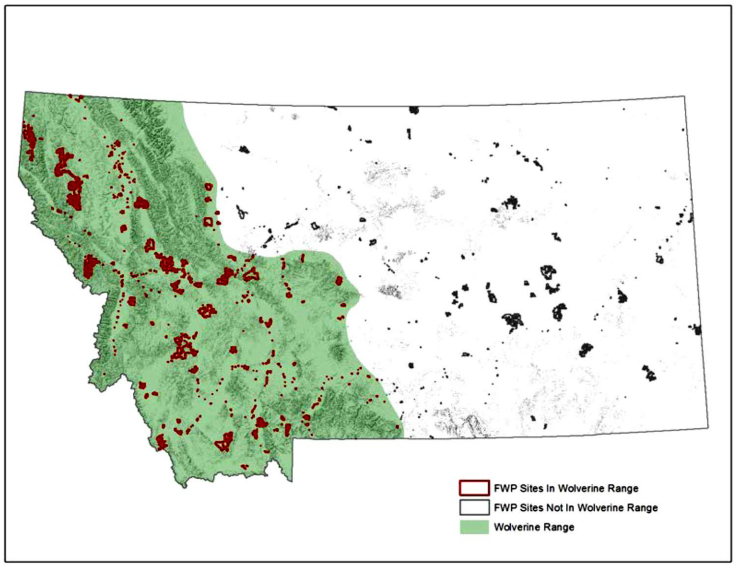

Wyoming

The wolverine is a protected animal and SGCN in Wyoming (WGFD 2017). The *Wyoming Game and Fish Department State Wildlife Action Plan* directs the activities of the WGFD and serves to guide in conserving Wyoming's SGCN through the combined efforts of government agencies, conservation organizations, academia, tribes, and others (WGFD 2017, p. I–1-1). As noted above, the wolverine is identified as a SGCN, a designation intended to identify species whose conservation status warrants increased management attention and funding, and consideration in conservation, land use, and development planning in the State (WGFD 2017, p. IV– i-1). The *State Wildlife Action Plan* incorporates the wolverine as a SGCN in several terrestrial habitat types or ecological systems, including cliffs, canyons, and rock outcrops, montane and subalpine forests, and mountain grasslands and alpine tundra (WGFD 2017, pp. III–2-5, III–5-7, III–6-5).

In 2015, Wyoming funded a pilot project (through The Wolverine Initiative) to evaluate wolverine detection and monitoring of the species in the State and is a contributing collaborator in the Multistate Wolverine Working Group implementing a monitoring strategy (the WSWCP) in the winter of 2016–2017 across four western states (WGFD 2017, p. IV–5-357). Results of those studies (e.g., Inman *et al*. 2015) are summarized above (*Population Abundance and Distribution*). The WSWCP is also updating and refining connectivity models for the wolverine in an effort to focus and prioritize habitat conservation and management (WGFD 2016, pers. comm.).

Utah

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The wolverine is protected from collection, importation, and possession in Utah. It is identified as a SGCN in the *Utah Wildlife Action Plan* (UDNR 2015). The plan's threat assessment lists the wolverine as a Level 3 threat based on natural rarity, with a high threat impact (severity x scope) (UDNR 2015, p. 149). As a SGCN, wolverine conservation and management projects are eligible for State Wildlife Grant funding, including landscape-level conservation efforts (UDNR 2017, pers. comm.). The wolverine is also identified in the *Utah Wildlife Action Plan* as a species with a data gap relative to an inadequate understanding of distribution or range (UDNR 2015, p. 174).

Although the State of Utah is not a formal partner in the WAFWA Western States Wolverine Conservation Project (WSWCP)–Coordinated Occupancy Survey, the Division of Wildlife Resources selected grid cells for monitoring wolverines with remote cameras in accordance with the WAFWA protocol. Cameras were placed in potential wolverine habiat in the Unita and Bear River mountain areas from 2014–2017, and the State intends to continue camera monitoring for wolverines (UDNR 2017, pers. comm.).

Colorado

The wolverine is a state-endangered species in Colorado (Colorado Parks and Wildlife 2015a); however, there is no known current resident or reproducing wolverine population.

The *Colorado State Action Plan* (Colorado Parks and Wildlife 2015b) provides a blueprint for a collaborative effort to conserve Colorado's at-risk wildlife and their habitats, with a primary goal for securing wildlife populations in order to avoid protections implemented so that they do not require protection via federal or state listing regulations (Colorado Parks and Wildlife 2015b, p. 1). The wolverine is designated as a Tier 1 (highest conservation priority; up from Tier 2) SGCN (Colorado Parks and Wildlife 2015b, p. 19). The primary conservation action for wolverine described in the 2015 State Action Plan is to continue discussions among wildlife managers, conservation partners and stakeholders of the social and political aspects regarding reintroduction of wolverine populations into the southern Rocky Mountains (Colorado Parks and Wildlife 2015b, p. 186). The State has not yet prepared a potential restoration program for the species (Broscheid 2016, pers. comm.).

Western Association of Fish and Wildlife Agencies (WAFWA) – Western States Wolverine Working Group

The WAFWA, in coordination with Tribal partners, have formed a multi-state, multi-agency working group (Western States Wolverine Working Group) to design and implement the Western States Wolverine Conservation Project (WSWCP)–Coordinated Occupancy Survey. In addition, a WAFWA Wildlife Chiefs Wolverine Subcommittee provides a forum for western States to work collaboratively with each other and with the Service, Tribes, and other partners, for conserving wolverines across the western United States; to date, approximately $1.5 million of funding has been applied towards conservation and management actions, including the WSWCP (McDonald 2017, pers. comm.).

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Other Conservation Mechanisms

Tribes

Nez Perce Tribe

Wolverines are found within the aboriginal territory of the Nez Perce Tribe in north-central Idaho, and conservation and restoration of the species within the Nez Perce homeland is important to the Nez Perce Tribe (Miles 2017, pers. comm.). The Nez Perce Tribe is currently preparing an Integrated Resource Management Plan (IRMP), a Plant and Wildlife Conservation Strategy, and a Forest Management plan with the wolverine defined as a species of conservation concern in all three draft plans (Miles 2017, pers. comm.). The planning area for the IRMP, which is being prepared in partnership with the Bureau of Indian Affairs, incorporates the approximately 311,608 ha (770,000 ac) Nez Perce Reservation, located within portions of Nez Perce, Lewis, Clearwater, Latah, and Idaho Counties in north-central Idaho (http://www.nezperce.org/irmp/; accessed August 24, 2017). The preparation of the IRMP is currently at the scoping stage in the NEPA process for development of a Programmatic Environmental Impact Statement (http://www.nezperce.org/irmp/; accessed August 24, 2017).

The Shoshone-Bannock Tribes

The Shoshone-Bannock Tribes are currently conducting climate change modeling for the Northern Rocky Mountains as part of its preparation of a Climate Change Adaptation Plan (Edmo 2016, pers. comm.). The Upper Snake River Tribes Foundation (USRT), which is comprised of four member tribes—the Burns Paiute Tribe, Fort McDermitt Paiute-Shoshone Tribe, Shoshone-Bannock Tribes of the Fort Hall Reservation, and Shoshone-Paiute Tribes of the Duck Valley Reservation—within the Upper Snake River Watershed region, prepared a *Climate Change Vulnerability Assessment* in February 2017 (Petersen *et al*. 2017, entire). The assessment is the first of three steps the USRT and its member tribes plan activities over the next several years as part of a comprehensive climate change effort, and will include an Adaptation Plan (expected to be completed in 2017–2018), and, depending on future funding, a process for development of Implementing Adaptation Actions and Monitoring (Petersen *et al*. 2017, p. 7).

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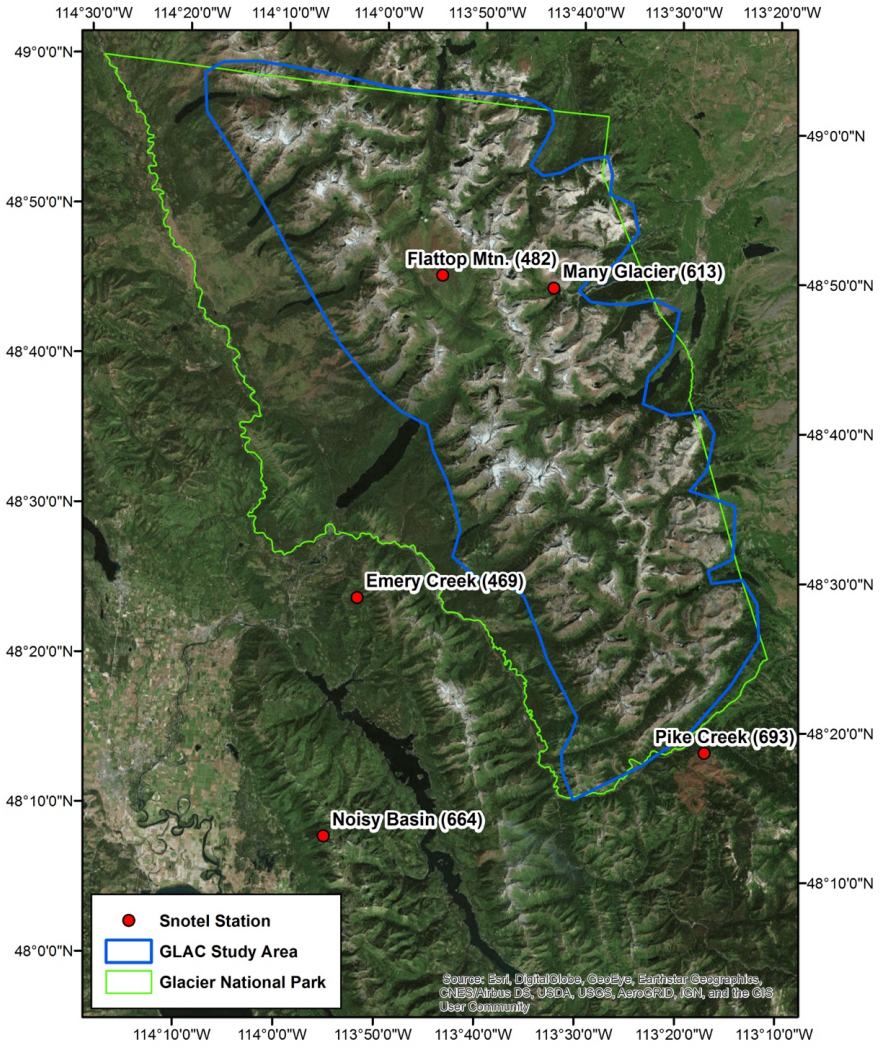
Appendix H–NOAA/CU Study Areas Used to Evaluate Future Snow Persistence (from Ray et al., 2017)

Glacier National Park Study Area



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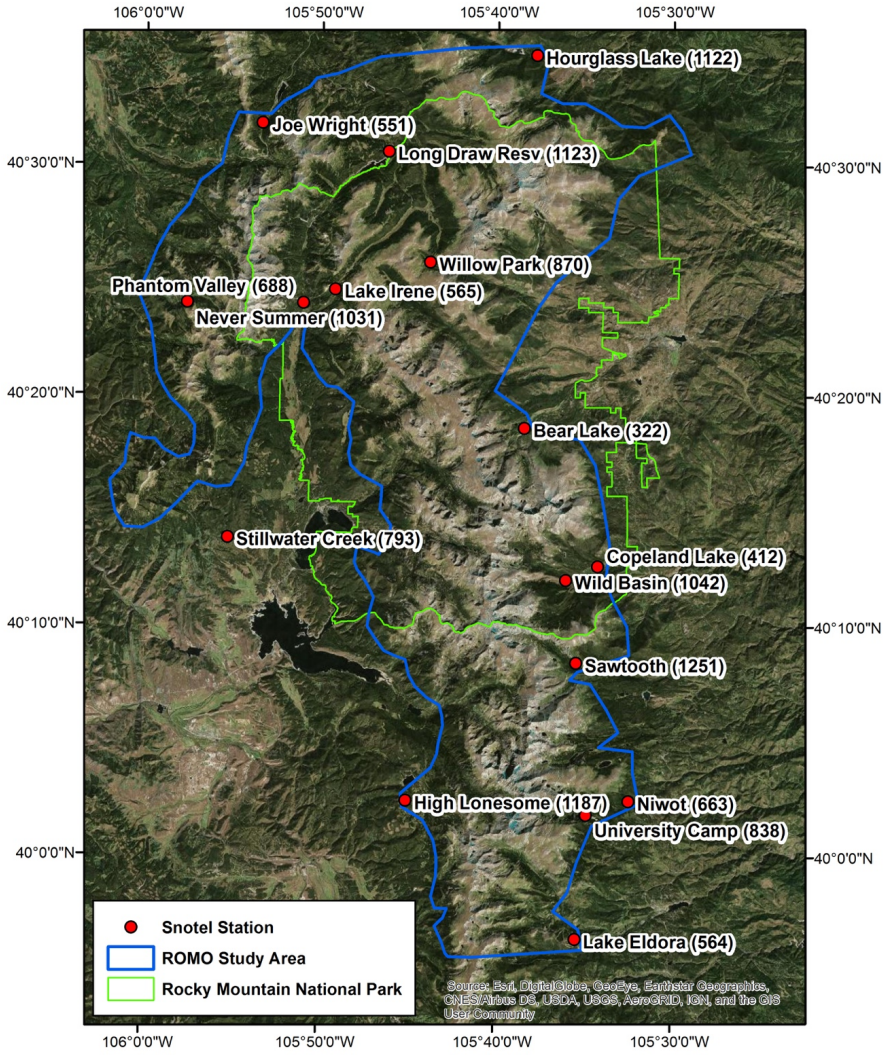
Rocky Mountain National Park Study Area



From: Grizzle, Betty
To: Bush, Jodi
Cc: Shoemaker, Justin
Subject: Re: Wolverine Decision Meeting
Date: Monday, January 8, 2018 12:08:26 PM

Thanks Justin! Let's hope for decent (no blizzard) weather.

On Mon, Jan 8, 2018 at 10:55 AM, Bush, Jodi <jodi_bush@fws.gov> wrote:

> Sounds good. JB
>
> Jodi L. Bush
> Office Supervisor
> Montana State Ecological Services Office
> 585 Shepard Way, Suite 1
> Helena, MT 59601
> (406) 449-5225, ext.205
>
> On Mon, Jan 8, 2018 at 11:44 AM, Shoemaker, Justin <justin_shoemaker@fws.gov> wrote:
>
> > I should have room for both of you. My flight gets there at 10:30 AM. Return flight on Thursday at 4:20 PM.
> >
> > Justin Shoemaker
> > Classification and Recovery Biologist
> > U.S. Fish and Wildlife Service, Region 6
> > Phone: 309-757-5800 x214
> > Email: justin_shoemaker@fws.gov
> >
> > On Mon, Jan 8, 2018 at 11:37 AM, Bush, Jodi <jodi_bush@fws.gov> wrote:
> >
> > > I will be arriving in Denver on Jan 23 at 910 AM. If you have room, would love a ride.
> > >
> > > My flight out on Thursday is at 7PM. Thanks . JB
> > >
> > > Jodi L. Bush
> > > Office Supervisor
> > > Montana State Ecological Services Office
> > > 585 Shepard Way, Suite 1
> > > Helena, MT 59601
> > > (406) 449-5225, ext.205

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Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist

U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

From: Nelson, Marjorie
To: Backsen, Sarah
Cc: Shoemaker, Justin; Kurt Broderdorp
Subject: Re: Wolverine - transmittal of SSA to RDs/ARDs?
Date: Monday, January 8, 2018 12:40:57 PM

Yes, they should not be reviewing the SSA.

Marjorie Nelson
Chief, Division of Ecological Services
Mountain-Prairie Region
U.S. Fish and Wildlife Service
303-236-4258 direct
720-582-3524 cell

On Mon, Jan 8, 2018 at 9:31 AM, Backsen, Sarah <sarah_backsen@fws.gov> wrote:

> I think for mine she only reviewed the briefing paper, not the SSA Report. I submitted that as a PDF to make it clear it was not for editing at that point.
>
> Sarah Backsen
> Classification Biologist
> U.S. Fish and Wildlife Service, Region 6
> 134 Union Blvd., Suite 670
> Lakewood, Colorado 80228
> 303-236-4388
> sarah_backsen@fws.gov
>
> On Mon, Jan 8, 2018 at 9:28 AM, Shoemaker, Justin <justin_shoemaker@fws.gov> wrote:
>
>> Did Trina have to review it (the SSA report) in order for the RD's office to accept the package? That would slow us down. Its going to be close even getting a final draft of the report done by Wed (the 2 wk out date).
>>
>> Justin Shoemaker
>> Classification and Recovery Biologist
>> U.S. Fish and Wildlife Service, Region 6
>> Phone: 309-757-5800 x214
>> Email: justin_shoemaker@fws.gov
>>
>> On Mon, Jan 8, 2018 at 10:06 AM, Nelson, Marjorie <marjorie_nelson@fws.gov> wrote:
>>
>>> Go with what Sarah did and, yes, the peer/partner reviews should be included.
>>>
>>> I think period issue is only for FR docs?
>>> thanks!
>>>
>>> Marjorie Nelson
>>> Chief, Division of Ecological Services
>>> Mountain-Prairie Region
>>> U.S. Fish and Wildlife Service
>>> 303-236-4258 direct
>>> 720-582-3524 cell
>>>
>>> On Mon, Jan 8, 2018 at 8:38 AM, Backsen, Sarah <sarah_backsen@fws.gov> wrote:
>>>
>>>> I did one of these back in November for Chapin Mesa milkvetch, and yes, it was in a

surname folder with a "transmittal" briefing paper, note to reviewer, etc. If it helps, you can look at all the briefing paper and other materials that went in the folder for that one. Here's where they are on the I drive:

I:\5. Plants\Chapin Mesa milkvetch\Chapin Mesa milkvetch SSA transmittal to RD

We didn't include the actual peer/partner reviews, but I don't see why you couldn't for wolverine. Not sure about the 2 spaces after a period question - that's not something I checked for, and nobody seems to have objected!

After the hard copy SSA Report went to the RD's office, I think I emailed the PDF version to the rest of the meeting participants (ARD, Project Leaders).

Sarah Backsen
Classification Biologist
U.S. Fish and Wildlife Service, Region 6
134 Union Blvd., Suite 670
Lakewood, Colorado 80228
303-236-4388
sarah_backsen@fws.gov

On Sun, Jan 7, 2018 at 6:43 AM, Shoemaker, Justin <justin_shoemaker@fws.gov> wrote:

> Marj and Sarah,
>
> We are hoping to get a "final" SSA report to everyone on Wed, 2 wks ahead of the RTM. Its been a while since I sent a 2 wk out SSA report to the RDs office and I'm not up on the latest procedure. I'm assuming there are hoops that we need to jump through and simply emailing it to the group won't suffice? Do I need a BP? Does the SSA report have to have 2 spaces after periods? Is it ok to include peer reviews also? What about state/partner reviews? In a surname folder?
>
> Justin Shoemaker
> Classification and Recovery Biologist
> U.S. Fish and Wildlife Service, Region 6
> Phone: 309-757-5800 x214
> Email: justin_shoemaker@fws.gov

From: Shoemaker, Justin
To: Stephanie Potter; Marjorie Nelson; Norman, Kate
Subject: Fwd: R8 at the wolverine meeting
Date: Monday, January 8, 2018 1:07:21 PM

FYI - Looks like R8 has settled on Mike Fris attending the wolverine meeting.

Justin Shoemaker
Classification and Recovery Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

---------- Forwarded message ----------
From: **Russell, Daniel** <daniel_russell@fws.gov>
Date: Mon, Jan 8, 2018 at 2:06 PM
Subject: Re: R8 at the wolverine meeting
To: "Shoemaker, Justin" <justin_shoemaker@fws.gov>

Hi Justin,
Final answer is now in...ARD Mike Fris will be representing R8 at the wolverine meeting.
Dan

****
Daniel Russell - Regional Listing Coordinator
Pacific Southwest Regional Office, Region 8
U.S. Fish and Wildlife Service
2800 Cottage Way, Room W-2606
Sacramento, CA 95825
Office (916) 978-6191
Cell (916) 335-9060
****

On Wed, Jan 3, 2018 at 3:53 PM, Russell, Daniel <daniel_russell@fws.gov> wrote:

> Hey again,
> the answer I've gotten so far is that our RD, Paul Souza, has it on his calendar to attend the RTM. But our ARD, Mike Fris, may end up going in his place.
>
> So at the moment, it appears we will have someone in person at the RTM.
> Dan
>
> **********
> Daniel Russell - Regional Listing Coordinator
> Pacific Southwest Regional Office, Region 8
> U.S. Fish and Wildlife Service
> 2800 Cottage Way, Room W-2606
> Sacramento, CA 95825
> Office (916) 978-6191
> Cell (916) 335-9060
> **********
>
> On Wed, Jan 3, 2018 at 11:17 AM, Shoemaker, Justin <justin_shoemaker@fws.gov> wrote:
>
>

I think the only R6 PL participating will be from the lead FO, MT, in-person. We don't generally invite all PLs.

Justin Shoemaker
Classification and Recovery Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

On Wed, Jan 3, 2018 at 1:01 PM, Russell, Daniel <daniel_russell@fws.gov> wrote:

> Hey Justin,
> do you know if all the other R6 PLs are going to participate in the RTM? And in-person or by phone?
> Thanks,
> Dan
>
> **********
> Daniel Russell - Regional Listing Coordinator
> Pacific Southwest Regional Office, Region 8
> U.S. Fish and Wildlife Service
> 2800 Cottage Way, Room W-2606
> Sacramento, CA 95825
> Office (916) 978-6191
> Cell (916) 335-9060
> **********
>
> On Tue, Jan 2, 2018 at 1:53 PM, Shoemaker, Justin <justin_shoemaker@fws.gov> wrote:
>
>> Josh or Dan,
>>
>> Do either of you know who will be representing R8 (in a decision maker capacity) at the wolverine recommendation team meeting? Are they planning to attend in person? It is at the R6 RO on Jan 24-25.
>>
>> Justin Shoemaker
>> Classification and Recovery Biologist
>> U.S. Fish and Wildlife Service, Region 6
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From: Shoemaker, Justin
To: Grizzle, Betty
Subject: Re: Wolverine SSA Report - second draft for review
Date: Monday, January 8, 2018 9:17:49 AM
Attachments: 20180105_Final Draft Wolverine SSA Report_JS.docx

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Very nice work Betty! Here's my review.

I will be working on getting materials together here to transmit the SSA Report to the RD's office on 1/10. They require a briefing memo and surname folder and other stuff, so I'll get all that together and wait for a final version from you to print for our RD later this week. And I'll have the same materials sent to the other regions.

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On Fri, Jan 5, 2018 at 4:47 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:

> Hi all - This is still a bit rough. Lots and lots of comments to address, and several new references, so you might want to read with Track Changes OFF first. I have not yet formatted this as I am still working in Track Changes; I will update Table of Contents, and relabel figures with final formatting. There are also places where (for some reason) the spell-checker is off, so I still need to proofread this for those misspelled words, etc. Also, several figures were replaced or revised (we had to redo several analyses), but these will not show up in Track Changes given the growing size of this already very large Word file.
>
> Please review the yellow highlighted sentences and comment bubbles. Since the States provided the most useful comments, I focused on those first and then the peer reviewers. I ask that you please review those 4 reviewer comment documents again relative to this new draft to see if I missed anything.
>
> As you know, this is due to Recommendation Management Team (and Core Team) next Wednesday so I will need your comments back quickly (please use track changes or comment bubbles) so I can pull all of your individual comments together in one document, accept changes, and then do final formatting.
>
> Let me know if you have any questions and THANK YOU all for your help with this.
> Betty
>
> --
>
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FINAL DRAFT
SPECIES STATUS ASSESSMENT
FOR THE
NORTH AMERICAN WOLVERINE
(*Gulo gulo luscus*)

Wolverines in southwestern Montana. *Photo credit: Mark Packila; used with permission.*

U.S. Fish and Wildlife Service

Version 1.~~0~~1
~~October~~ January ~~23~~, ~~2017~~ 2018

Suggested citation:

U.S. Fish and Wildlife Service. 2017. Species status assessment report for the North American wolverine (*Gulo gulo luscus*). Version 1.~~0~~1. January 2018~~October 2017~~. U.S. Fish and Wildlife Service, Mountain-Prairie Region, Lakewood, CO.

Executive Summary

The North American wolverine (*Gulo gulo luscus*; wolverine) is a medium-sized carnivore found within~~across~~ the west-northwestern contiguous United States, Alaska, and Canada. Systematic monitoring across the wolverine's North American range has not been conducted given the difficulty in surveying this highly mobile species, and its occupancy within large and relatively inaccessible areas. ~~The most recent estimate of wolverine populations in the contiguous United States based on resource function modeling is 318 individuals, with a range from 249 to 949; however, systematic monitoring across the wolverine's North American range has not been conducted given the difficulty in surveying this highly mobile species, and its occupation across large and remote areas.~~ A multi-state effort to determine wolverine occupancy in Montana, Idaho, and Washington was conducted in winter of 2016–2017 and in Wyoming for the winters of 2015–2016 and 2016–2017. Results from this study are still being analyzed, but photographic detections of wolverines were found across all surveyed States, including areas where wolverines have not recently been observed. In Canada, the population is estimated to exceed 10,000 mature individuals and has been stable over the last two decades. Recent density estimates indicate no declining trend for wolverines in Alaska. Wolverine populations in Alaska are considered to be continuous with populations in the Yukon and British Columbia provinces of Canada. Wolverines that occupy the North Cascades region are known to move from Washington into British Columbia.

Wolverines are highly mobile, capable of moving and dispersing over great distances over short periods of time. Wolverine populations are also characterized by naturally low densities in North America. The species is highly territorial, with very little overlap between same-sex adults. Wolverines occupy a variety of habitats, but ~~are~~ generally select ~~found in remote~~ habitat in locations~~,~~ away from human settlements. Wolverines consume a variety of food resources and seasonal switching of prey is commonly observed ~~likely allows for adjustment for nutritional needs throughout their life history. As observed in~~with other mammals, including ~~a~~Arctic mammals, wolverines have the ability to adapt to both cold and warm ambient temperatures through ~~dissipate body heat to balance the heat loss from 30°C to −40°C (86°F to −40°F), due in large part to~~ vasodila~~ta~~tion and increase in ~~rise of~~ skin temperature, and rapid and seasonal adjustments in fur insulation. Wolverines can also adapt behaviorally to both cold and warm ambient temperatures by movement and, relatedly, micro- and macro-habitat selection. ~~Further, wolverines have been observed near and in lakes and other water bodies.~~

Commented [SJ1]: Run-on sentence.

Wolverine reproduction includes the following characteristics: polygamous behavior (i.e., male mates with more than one female each year), delayed implantation (up to 6 months), a short gestation period (30–40 days), denning behavior, and an extended period of maternal care ~~(3.5 months)~~. The reproductive behavior in wolverines is temporally adapted to take advantage of the availability of food resources, limited interspecific competition, and snow cover in the winter.

Since the publication of the Service's 2013 proposed rule to list the distinct population segment of the North American wolverine in the contiguous United States (78 FR 7864; February 4, 2013), several new wolverine studies have been published, which has added to our understanding of wolverine biology while also highlighting new insights into identifying key species' needs and their interactions with both abiotic and biotic factors. In particular, wolverine populations and

wolverine dens have been observed outside previously modeled projections of spring snow cover. Our evaluation of snow cover at previously recorded natal den site locations in the western United States indicated that 'melt-out' dates at these locations extend well past the May 15 date used in persistent spring snow cover models.

Overall, the best available information indicates that within the contiguous United States the wolverine's physical and ecological needs include:

(1) large territories in relatively inaccessible~~remote~~ landscapes; at high elevation (1,800 to 3,500 meters (5,906 to 11,483 feet));
(2) access to a variety of food resources, that varies with seasons; and
(3) physical/structural features (e.g., talus slopes, rugged terrain) linked to reproductive behavioral patterns.

In this Species Status Assessment (SSA) Report, we provide a discussion of the ecological needs of the wolverine, its current conditions, and projected future conditions. We evaluate potential stressors to the species, with a particular focus on the impacts associated with projected effects of climate change.

In our analysis, we applied the conservation biology principles of redundancy, resiliency, and representation (collectively known as the "3Rs") to evaluate the current and projected future condition of the wolverine and its ability to sustain itself (as one or more populations) in the wild over time (Carroll *et al.* 1996, entire; Wolf *et al.* 2015, entire). This evaluation considers the ~~unique~~ demographic, distribution, and diversity characteristics unique to the species. After applying the framework of the 3Rs, we determined the following:

(1) Redundancy: The wolverine occurs in ~~across~~ the contiguous United States within a metapopulation structure. The best available information indicates that the species continues to expand into historical, previously occupied areas in the contiguous United States following decades of unregulated hunting and trapping, and poisoning at bait stations.
(2) Representation: The wolverine is currently found ~~across the~~in the west-northwestern United States, as well as much of Canada, and Alaska. The best available information indicates that the species is found in ~~across a wide range of~~ Arctic, boreal, and subalpine habitats. We estimated a Current Potential Extent area for the wolverine in the contiguous United States of approximately 280,316 square kilometers (km^2) (69,267,592 acres (ac)). ~~Modeled primary habitat for the wolverine in the contiguous United States has been estimated at 164,125 square kilometers (km^2) (63,369 square miles (mi^2).~~
(3) Resiliency: The wolverine appears resilient within its contiguous United States range. The species exhibits physiological (e.g., seasonal changes in fur) and behavioral plasticity in its life history (e.g., reproduction, feeding, movement and use of habitat). Estimated population size and growth rates across its North American range are uncertain, but the best available information does not suggest that abundance is declining in the contiguous United States, or in North America. The most significant stressor currently and in the future appears to be the effects of climate change, such as warming temperatures and loss of snowpack. However, ~~based on the best available~~

Commented [SJ2]: Necessary?

Commented [BJG3]: Added per Peer Reviewer 2, p. 7.

~~information,~~ we have no information to indicate ~~indication~~ that this species is unable to adapt or adjust to changing conditions.

Commented [BJG4]: Please review relative to final paragraphs (see Peer Reviewer 4, page 6).

Demographic risks to the species from either known or most likely potential stressors (i.e., effects from roads, disturbance due to winter recreational activities, effects of wildland fire, and overutilization) are low based on our evaluation of the best available information as it applies to current and potential future conditions for the wolverine and in the context of the attributes that affect its viability. We analyzed the potential effects of climate change to wolverine habitat, including snow persistence in the Northern and Southern Rocky Mountains. The future timeframe evaluated in this analysis is approximately 40 to 50 years. This range ~~, which captures the range of time periods for proposed projects within the species range, as well as~~represents ~~-~~our best professional judgment of the projected future conditions related to climate change, wildland fire conditions, or other potential cumulative impacts. While population information is lacking for this subspecies in some parts of its range, the best available information does not indicate that, winter recreational activities, infrastructure features, mortality from road crossings or trapping (authorized and incidental), currently or in the future will result in a decline in the subspecies across its range. Our evaluation of climate change indicates that snow cover is projected to decline in response to warming temperatures and changing precipitation patterns, but this varies by elevation, topography, and by geographic region. In general, models indicate higher elevations will retain more snow cover than lower elevations, particularly in early spring (April 30/May1). Further, significant snow persistence (greater than 0.5 meters (20 inches)) is projected at high elevations.

Legal protections include State listing in California and Oregon (as threatened), as endangered in Colorado, as a candidate species in Washington, and protection as a non-game species in Idaho and Wyoming, and protected from collection, importation, and possession in Utah. In Canada, provincial designations range from endangered to threatened in eastern provinces, and sensitive/special concern to no ranking in other provinces. Legal trapping or hunting of wolverines is currently prohibited in the contiguous United States. Trapping effort along the U.S.–Canada border does not represent a ~~significant~~ barrier to wolverine movement and dispersal along the international border.

Within the contiguous United States, approximately ~~96~~ 72 percent of ~~modeled wolverine primary~~ the Current Potential Extent of the wolverine ~~habitat~~ is located on Federal lands, with ~~41~~ 18 percent located in designated wilderness areas. Management actions, including State Wildlife Action Plans, the Idaho Wolverine Conservation Plan, and USDA Forest Service Land and Resource Management Plans, and other Federal and Tribal partners, include winter road closures, fire management, land acquisition or conservation easements. The Western Association of Fish and Wildlife Agencies (WAFWA), in coordination with Tribal partners, have formed a multi-state, multi-agency working group (Western States Wolverine Working Group) to design and implement the Western States Wolverine Conservation Project (WSWCP)–Coordinated Occupancy Survey. In addition, a WAFWA Wildlife Chiefs Wolverine Subcommittee is working collaboratively with each other and with the Service, Tribes, and other partners to conserve wolverines in the western United States; to date, approximately $1.5 million of funding has been applied towards conservation and management actions.

Commented [SJ5]: How about adding a short paragraph at the end of the Exec summary indicating the report has been through peer and partner review?

Abbreviations and Acronyms Used

ADF&G = Alaska Department of Fish and Game
BLM = Bureau of Land Management
°C = degrees Celsius
CEC = Commission for Environmental Cooperation
CDFW = California Department of Fish and Wildlife
CNDDB = California Natural Diversity Database
COSEWIC = Committee on the Status of Endangered Wildlife in Canada
cm = centimeter
DNA = deoxyribonucleic acid
EIS = Environmental Impact Statement
EPA = U.S. Environmental Protection Agency
°F = degrees Fahrenheit
ft = feet
GCMs = Global Climate Models
GHG = Greenhouse gas
GLAC = Glacier National Park
GPS = Global Positioning System
IDFG = Idaho Department of Fish and Game
in = inch
IPCC = Intergovernmental Panel on Climate Change
IUCN = International Union for Conservation of Nature and Natural Resources
kg = kilogram
km = kilometer
lb = pound
m = meter
mi = mile
MODIS = Moderate-Resolution Imaging Spectroradiometer
Montana FWP = Montana Fish, Wildlife, & Parks
NDSI = Normalized Difference Snow Index
NRC = National Research Council
NRIS = Natural Resource Information System
ODFW = Oregon Department of Fish and Wildlife
RCPs = Representative Concentration Pathways
ROMO = Rocky Mountain National Park
Service = U.S. Fish and Wildlife Service
SSA = Species Status Assessment
SCA = Snow~~c~~ ~~C~~overed Area
SGCN = Species of Greatest Conservation Need
SWCC = Southwestern Crown of the Continent
SWE = Snow Water Equivalent
UDNR = Utah Division of Natural Resources
WAFWA = Western Association of Fish and Wildlife Agencies
WDFW = Washington Department of Fish and Wildlife
WGFD = Wyoming Game and Fish Department

WRCC = Western Regional Climate Center
WSWCP = Western States Wolverine Conservation Project
YBP = Years Before Present

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Introduction

The wolverine (*Gulo gulo*) is the largest terrestrial member of the Mustelidae family (weasels, fisher, mink, marten, and others) and resembles a small bear with a bushy tail (Hash 1987, p. 575). Wolverines have a Holarctic distribution that includes the northern portions of Europe, Asia, and North America. In North America, they are found in Alaska, much of Canada, and the western-northwestern United States. The wolverine is important to the culture of Native Americans and Aboriginal Peoples in North America, as is its conservation status in aboriginal territory (Cardinal 2004, p. iv; Edmo 2016; pers. comm.; Miles 2017, pers. comm.).

Wolverines possess a number of morphological and physiological adaptations that allow them to travel long distances and they maintain large territories in remote areas (Pasitschniak-Arts and Larivière 1995, p. 6). They have been described as curious, intelligent, and playful, but cautious animals (e.g., Krott 1958, p. 241; Krott 1960, pp. 25–26; Magoun 1985, p. 94; Cardinal 2004, p. 7–8; Woodford 2014,~~;~~ entire), though their social behavior and social organization has not been well-studied.

During the late 1800s and early 1900s, the wolverine population declined or was extirpated in much of the conterminous United States (lower 48 States), which has been attributed to unregulated trapping~~over-trapping~~ and habitat degradation (Hash 1987, p. 583). Similar range reductions and extirpations of some wolverine populations were observed in parts of Canada during this time period (van Zyll de Jong 1975, entire; Committee on the Status of Endangered Wildlife in Canada (COSEWIC) 2014, p. iv), attributed largely to human exploitation and availability of food (e.g., decline in caribou (*Rangifer tarandus*)), not climate or habitat changes (van Zyll de Jong 1975, pp. 434, 436). ~~Habitat loss (historic vs. current range) for the North American wolverine (i.e., Canada and United States) has been estimated at 37 percent (Laliberte and Ripple 2004, p. 126).~~ Wolverine numbers have recovered to some extent from this decline (e.g., Aubry *et al*., 2007, p. 2,151; Aubry *et al*., 2012, entire; Aubry *et al*. 2016, pp. 14–15; Magoun *et al*. 2013, p. 27). I~~; i~~n the United States, wolverines are currently found in parts of Washington, Oregon, Idaho, Montana, Wyoming, ~~and~~ California (single male)~~,~~ and Alaska. ~~, as recently as 2012 in Colorado and 2016 in Utah, though not all of these areas contain resident, reproductive populations.~~ Known reproducing wolverine populations are found in Washington, Idaho, Montana, and Wyoming.

Species Status Assessment Methodology

In preparing the Species Status Assessment (SSA) Report for the wolverine, we reviewed available reports and peer-reviewed literature, incorporated survey information, and contacted species experts to collect additional unpublished information for the North American subspecies (*Gulo gulo luscus*), including Canada and Alaska. We identified uncertainties and data gaps in our assessment of the current and future status of the species. We also evaluated the appropriate analytical tools to address these gaps and conducted discussions with species experts and prepared updated maps of the known species' range and denning areas in ~~across~~ North America. In some instances, we used publications and other reports (primarily from Fenno-Scandinavia) of the Eurasian subspecies (*Gulo gulo gulo*) in completing this assessment.

Importantly, we note here that, since the publication of the 2013 proposed listing rule (78 FR 7864; February 4, 2013), many new wolverine studies have been published, which has added to our understanding of wolverine biology while also highlighting new insights into identifying key species' needs and their interactions with both abiotic and biotic factors. This is particularly relevant for a difficult to study animal like the wolverine.

Using the species, individual, and population needs identified for the wolverine and location results from surveys and studies, we conducted a geospatial analysis to estimate the Current Potential Extent of the North American wolverine in the contiguous United States'~~s current range~~. We then evaluated this ~~range~~ area and previous estimates of potentially suitable habitat in the west-northwestern United States to assess the species' current conditions within that region. Our future condition analysis includes the potential conditions that the species or its habitat may face, that is, the most probable scenario if those conditions are realized in the future. This most probable scenario includes consideration of the sources that have the potential to most likely impact the species at the population or rangewide scales in the future, including potential cumulative impacts. Potential future impacts associated with climate change (probabilistic estimates for temperature and precipitation) were based on downscaled climate model projections, including a detailed study of two regions in the western United States (Glacier National Park (currently occupied) and Rocky Mountain National Park (not currently occupied).

For the purpose of this assessment, we generally define viability as "consisting of self-sustaining populations that are well distributed throughout the species' range," and where "[s]elf-sustaining populations are those that are sufficiently abundant and have sufficient genetic diversity to display the array of life history strategies and forms that will provide for their persistence and adaptability in the planning area over time" (Committee of Scientists 1999, p. 38). We use a timeframe of approximately 40 to 50 years because it is within the range of the available modeling efforts related to climate change. We believe this is a reasonable timeframe to consider as it includes the potential for observing these effects over several generations of the wolverine.

Using the SSA framework (Figure 1), we consider what the species needs to maintain viability by characterizing the status of the species in terms of resiliency, redundancy, and representation (Wolf *et al*. 2015, entire).

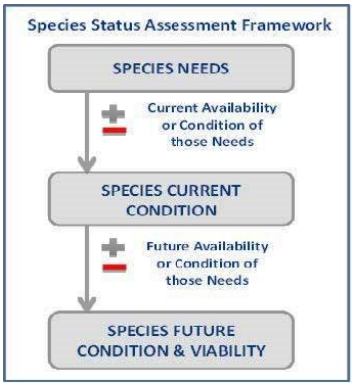

Figure 1. Species Status Assessment Framework.

- **Resiliency** is having sufficiently large populations for the species to withstand stochastic events (arising from random factors). We can measure resiliency based on metrics of population health; for example, birth versus death rates and population size. Resilient populations are better able to withstand disturbances such as random fluctuations in birth rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the effects

of anthropogenic activities.

- **Redundancy** is having a sufficient number of populations for the species to withstand catastrophic events (such as a rare destructive natural event or episode involving many populations). Redundancy is about spreading the risk and can be measured through the duplication and distribution of populations across the range of the species. The greater the number of populations a species has distributed over a larger landscape, the better it can withstand catastrophic events.
- **Representation** is having the breadth of genetic makeup of the species to adapt to changing environmental conditions. Representation can be measured through the genetic diversity within and among populations and the ecological diversity (also called environmental variation or diversity) of populations across the species' range. The more representation, or diversity, a species has, the more it is capable of adapting to changes (natural or human caused) in its environment. In the absence of species-specific genetic and ecological diversity information, we evaluate representation based on the extent and variability of habitat characteristics within the geographical range.

Species Description

Taxonomy

The taxonomic relationship between North American and Eurasian wolverines has been a debated topic (Pasitschniak-Arts and Larivière 1995, p. 1). Most authorities consider all wolverines to belong to a single species, *Gulo gulo* (Rausch 1953, p. 114; Kurten and Rausch 1959, p. 19; Wozencraft 2008 [in *Wilson and Reeder's Mammal Species of the World*, online publication]). Some also further consider the New World and Old World wolverines to be two subspecies, *Gulo gulo luscus* and *G. g. gulo,* respectively, based on morphological measurements. Degerbøl (1935, pp. 35–43) noted slight color differences and very slight, if any, cranium differences, based on 10 North American (Hudson Bay) specimens examined, and regarded the North American and Old World wolverines as conspecific, but identified two subspecies. This reference also cites Coues (1877, p. 43), who, based on observations of a slight similar cranium difference, had posited that the wolverines of the Old World and New World were the same species (Degerbøl 1935, p. 35).

In their *Checklist of Palaearctic and Indian Mammals* (1st and 2nd editions) Ellerman and Morrison-Scott (1951, p. 251; 1966, p. 251) identified one species of wolverine, but listed several subspecies. A comparative analysis of various measurements from 1 wolverine skull collected from the northern Ural Mountains to 41 Alaskan skulls by Rausch (1953, entire) reported "no appreciable differences," noting the highly variable skull characteristics for the Alaskan specimens. Additionally, Krott (1960, p. 20) found no distinct differences between Old World and New World wolverines, and that pelt size and quality were not distinguishable. However, using biometric measurements of both newly collected and previously published cranial measurements (e.g., Degerbøl 1935; Rausch 1953), Kurtén and Rausch (1959, p. 19) reported that the North American and European wolverine were significantly different in several quantitative characters related to the size and shape of the skull ~~size~~ and teeth ~~size~~. They concluded that the two wolverine populations represented two distinct subspecies, but were the same species, *Gulo gulo*.

The International Union for Conservation of Nature and Natural Resources (IUCN) states that "Most recent accounts [citing Jones *et al*. 1992, Pasitschniak-Arts and Larivière 1995, Wozencraft 2005] treat *luscus* as a subspecies of *Gulo gulo*, following Degerbøl (1935) and Kurtén and Rausch (1959)" (Abramov 2016, p. 1). We reviewed the references cited by IUCN. Jones *et al*. (1992, p. 17) only considers *Gulo gulo*. Pasitschniak-Arts and Larivière (1995, p. 1) state there are differences in the taxonomic treatment, and that, while *Gulo gulo* is now considered by most to be the extant *species*, others (including the above-cited Kurtén and Rausch (1959) and Rausch (1953)) have considered two *subspecies*. The Wozencraft (2005) citation is from Wilson and Reeder's previous 2005 publication, which was updated as of 2008. That account lists several "offspring" of *Gulo gulo*, but does not provide citations for the subspecies identified there, and at least two of those listed are not considered to be subspecific entities (e.g., *G. g. vancouverensis* and *G. g. luteus* (see Banci 1982, p. ii; Banci 1994, p. 104)). Finally, the COSEWIC Assessment and Status Report on the Wolverine (*Gulo gulo*) in Canada indicated that taxonomists recognize only a single subspecies (*Gulo gulo luscus*) in North America *or* consider *G. gulo* as single Holarctic taxon (COSEWIC 2014, p. 4).

Genetic analyses for the North American wolverine populations have primarily focused on genetic structure and variation of wolverine populations or subpopulations (see Kyle and Strobeck 2001; Kyle and Strobeck 2002; Zigouris *et al*. 2012, Zigouris *et al*. 2013). However, Frances' (2008, pp. 20–21) assessment of wolverine spatial genetic structure and demographic history (using mitochondrial DNA) indicated incomplete lineage sorting between North American and Eurasian populations, though comprehensive sampling has not been conducted for some areas (e.g., eastern Asia). A study by Tomasik and Cook (2005, entire) also concluded that reciprocal monophyly (i.e., distinct *species*) had not been attained between Eurasian and North American wolverine populations. Until additional studies are published, including robust genetic analyses in conjunction with additional sampling, the Service recognizes the North American wolverine as *G. g. luscus*.

Physical Appearance

Detailed descriptions of the wolverine are described in Novikov (1962, pp. 196–202), Hash (1987, p. 575), Pasitschniak-Arts and Larivière (1995, pp. 1–2), and Wilson (1982, pp. 644–646), among others. Key distinguishing features are summarized here.

Wolverines are a medium-sized (about 1 meter (m) (3.3 feet (ft)) in length) carnivore, with a large head, broad forehead, and short neck (Pasitschniak-Arts and Larivière 1995, p. 1). Males are larger than females (Hall 1981, p. 1,007; Banci 1987, p. 35). Wolverines have heavy musculature and relatively short legs, and large feet with strong, curved claws for digging and climbing (Hash 1987, p. 575). Their feet are well-adapted for travel through deep snow and, during the winter, dense, stiff, bristle-type hairs are found between the toes and around the foot pad (Grinnell *et al*. 1937, pp. 265–266; Hash 1987, p. 575); this characteristic becomes diminished in the summer (Hash 1987, p. 575).

Adult wolverines are sexually dimorphic, with females weighing from 7 to 13 kilogram (kg) (15.4 to 29 pounds (lbs)) and males weighing between 10 to 18 kg (22 to 40 lbs) (North

America) (Rausch and Pearson 1972, p. 264; Magoun 1985, pp. 19–21; Banci 1994, p. 99; Copeland 1996, p. 20; Cardinal 2004, p. 8; Lofroth 2001, p. 11; Inman 2013, pers. comm.; Magoun 2013, pers. comm.; Aubry *et al*. 2016, pp. 17–18). The skulls of wolverine are large and heavy, and the strong jaw structure allows animals to feed on frozen flesh and crush bone (Haglund 1966, p. 269; Hash 1987, p. 575). Some geographic variation and sexual differences in skull morphology have been reported (Pasitschniak-Arts and Larivière 1995, p. 2). Wolverines have small, wide-set eyes, and are reported to have excellent hearing (Grinnell *et al*. 1937, p. 265; Krott 1960, p. 25; Bevanger 1992, p. 8).

Wolverine fur is short, thick, and uniform in thickness on the head and becomes longer towards the rear of the body (Hash 1987, p. 1). The coat consists of dense, woolly underfur (2-3 centimeters (cm) (0.8-1.2 inches (in) long) and coarse, stiff guard hairs, 6-10 cm (2.4-4 in) in length (Hash 1987, p. 1). The rich glossy coat can vary from medium brown to black (Banci 1994, p. 99; Pasitschniak-Arts and Larivière 1995, p. 1). Seasonal and individual variation in pelt color has been described (Degerbøl 1935, pp. 38–42; Grinnell *et al*. 1937, p. 252). In general, the head, tail, and legs are darker than the face (Pasitschniak-Arts and Larivière 1995, p. 1). An upper body stripe, which varies from creamy, pale buff to light brown or reddish in color (Pasitschniak-Arts and Larivière 1995, p. 1), extends from the nape of the neck, along the sides of the body, to the base of the bushy tail (Banci 1994, p. 99). White or orange patches are commonly found on the throat or chest (Pasitschniak-Arts and Larivière 1995, p. 1; Magoun *et al*. 2008, p. 24; Figure 14). The unique property of wolverine fur to shed frost (Hardy 1948, p. 330; Quick 1952, pp. 492–493), along with its rarity, has made wolverine pelts valuable for trade (Hash 1987, p. 575).

Various accounts state that wolverines have a strong sense of smell (Grinnell *et al*. 1937, p. 265; Bevanger 1992, p. 8) that allows them to locate carrion from great distances (Hornocker and Hash 1981, p. 1,297; *in litt.* Bevanger 1992, p. 8, citing Røskaft 1990; Copeland 1996, p. 100; Cardinal 2004, p. 8); however, experiments with young wolverines indicated a poor sense of smell, and that wolverines may locate food (areas where previously located or cached) based on their memory skills (Magoun 2013, pers. comm.) or learning abilities (e.g., Krott 1958, p. 241).

Scent-marking is used by mammalian carnivores for chemical communication (Hutchings and White 2000, p. 160). For wolverines, this behavior commonly includes urination (e.g., trees, stumps, snow) (Copeland 1996, p. 115; Magoun 1985, p. 105), but also includes scat, and scratches and bites on trees (Haglund 1966, pp. 225, 277; Copeland 1996, p. 115). Scent rubbing (see review by Rieger 1979) of the ventral (abdomen/stomach) area and anal rubbing have also been observed in wolverines (Pulliainen and Oyaskainen 1975, pp. 268–269; Rieger 1979, p. 22, *in litt.* Goethe 1964; Magoun 1985, p. 105). Scent marking by wolverines may also be an important chemical communication signal for potential wolverine prey. Field experiments conducted by Sullivan *et al*. (1985, pp. 928, 930) and Sullivan (1986, p. 388) found that black-tailed deer (*Odocoileus hemionus columbianus*) and snowshoe hares (*Lepus americanus*) avoided feeding on seedlings that were marked with wolverine urine.

Life History and Ecology

In this section we provide a summary of the individual and population needs (collective, species needs), including its life history, physiology and behavior, resource functions necessary for each life stage (i.e., breeding, feeding, sheltering, dispersal), demographic information (abundance and distribution) and ecological setting.

Overview

Wolverines are active year-round and have been considered as primarily nocturnal (Iversen 1972b, p. 319; Pasitschniak-Arts and Larivière 1995, p. 7, and references cited therein). In his observational studies, Krott (1958, p. 168; 1960, p. 25) described periods of 3-4 hours of activity followed by 3-4 hours of sleep for wolverines in Scandinavia, a pattern also observed in Idaho (Copeland 1996, p. 77).

A study of body temperatures of caged wolverines, along with direct observations of animals obtained from Alaska and Sweden and previous studied animals (Alaska), suggested that wolverines were a day-active species, being very active in the morning, with periods of sleep during the night, a pattern that persisted in both winter and summer (Folk *et al*. 1977, p. 233). However, crepuscular activity (period just after dawn and just before sunset) may be a more accurate description for wolverine behavior (McCue *et al*. 2007, pp. 98–99). Others have remarked that wolverines exhibit a plasticity in their behavior (i.e., different behavior under different conditions) (Krott 1960, p. 26), a result attributed, in part, to their being a scavenging carnivore covering large areas (Stewart *et al*. 2016, pp. 1,495, 1,497). Several aspects of this plasticity are described below.

Wolverines are wide-ranging animals and known for traveling great distances in a short period of time (Krott 1960, p. 21; Gardner *et al*. 1986, p. 603; Woodford 2014, entire) (see Movement section below). This is due, in part, to their unique body structure. As described by Krott (1960, p. 20), they are "lumbrosacrally overbuilt" with heavy musculature and legs that are acutely angled when walking. Wolverine gait is characterized as either a 2X pattern (when patterns of two footprints repeat), used primarily in deep snow, and the more common 3X lopes (patterns of three footprints), for covering long distances over more compacted snow (Halfpenny *et al*. 1995, p. 104). The latter is described as a bouncing gait where all four feet may leave the ground at the same time (Halfpenny *et al*. 1995, p. 104).

As noted in our Species Description section above, in winter, the dense hairs on the foot pad and its body structure supports a low foot load, which has been estimated at 22 gram/cm^2 (Knorre 1959, p. 26) and 27–35 gram/cm^2 (Novikov 1962, pp. 22–23 (citing Dulkeit 1953)). This foot loading is believed to provide an advantage for wolverines preying on ungulates and other large mammals whose movements become restricted in deep snow (Knorre 1959, p. 26; Formozov 1963, pp. 40–41; van Zyll de Jong 1975, p. 435; Banci 1994, p. 113). However, a study of wolverines in boreal forest habitat in Canada present a differing interpretation of the wolverine foot adaptation based on tracking wolverines in snow over three winters (Wright and Ernst 2004a, pp. 58–59), in which they observed wolverines in their study area continuously selected for a path of least snow cover, where practicable, and only traveled in upland areas (Wright and Ernst 2004a, p. 59). They concluded that the low foot load is advantageous when snow crusts form, but, in deep snow, wolverines shift to an inefficient walking gait or lunge, which increases

energy demand (Wright and Ernst 2004a, p. 59). They hypothesized that traveling in deep snow during winter in search of food may increase the risk of starvation due to the greater energy expenditure (Wright and Ernst 2004a, p. 59).

Physiology

The wolverine is a snow-adapted, cold climate animal in its physiology, morphology (Telfer and Kelsall 1984, p. 1,830), behavior, and habits. ~~The wolverine was considered by Formozov (1963, p. 65) as one of several "chioneuphores," or those vertebrates who tolerate snow but have no special adaptations; however,~~ W~~w~~olverines ~~could~~ have been ~~also be considered~~classified as a "chionphile" or those animals with adaptations for snow (e.g., increased surface area on feet, pelt characteristics) (see definitions in Pruitt 1959, p. 172; Cathcart 2014, p. 22).

In general, mustelids weighing more than 1 kilogram (kg) (2.2 pounds (lbs)) have a basal metabolism (defined as the minimum metabolic rate for maintaining a comfortable warm temperature; Irving 1972, p. 121) that is about 20 percent higher than other mammals (Iversen 1972a, p. 343). For the wolverine, Young *et al*. (2012, p. 222) estimated a basal metabolic rate for a 15 kg (33 lbs) adult at 669.4 kcal/day, using Iversen's derived equation [Metabolic rate (M)=84.6*Weight (W, in kg)$^{(0.78)}$ ± 0.15] (Iversen 1972a, p. 343). By comparison, the estimated basal metabolic rate for a 53 g (1.9 ounce (oz)) least weasel (*Mustela nivalis*) is about 40 kcal/day, and approximately 250 kcal/day for a 3.8–5.5 kg (8.4–12 lbs) Arctic fox (*Vulpes lagopus*) (both sampled from Barrow, Alaska) (Irving 1972, p. 115; Figure 9.1).

Experimental studies by Iversen (1972, pp. 320–321; Figure 4) found that during their first 2.5~~2½~~ months, the basal metabolic rate for young wolverines was substantially higher than rates reported for other mammals ($W^{1.41}$ vs. $W^{1.0}$), then declined after 3 months, and declined again after 8 months. Because the early period coincides with weaning, Wilson (1982, p. 646) suggested that the observed peak may be related to changes in food consumed as well as improved thermoregulation since the mother is leaving the young for longer periods of time.

Energy expenditure during pregnancy is relatively low for mustelids (Oftedal and Gittleman 1989, p. 374); however, energy requirements for lactation in mammals can be over 4 to 7 times basal metabolic rates (Allen and Ullrey 2004, p. 478). Thus, estimates of energetic requirements (e.g., less than 1 kg prey/day annually) may be too low to support reproductive activity (Young *et al*. 2012, p. 226). Wolverines are known to consume a variety of food resources and seasonal switching of prey likely allows for adjustment for nutritional needs depending on life history stage (e.g., lactating females)~~throughout their life history~~ (Krebs *et al*. 2007, p. 2,187 (Canada); Koskela *et al*. 2013a, pp. 103–104 (Finland); Yates and Copeland 2017, *in prep* (Montana)). Additional details on diet and feeding behavior for wolverines are provided below.

~~Relatedly, Casey *et al*. (1979, p. 335) evaluated metabolic and respiratory responses of eight terrestrial Arctic mammals to ambient temperature during summer months. For wolverines, they found that the frequency of respiration was generally constant (15-20 per minute), but their tidal volume (air moved per breath) increased nearly constantly with *decreasing* ambient temperature, unlike Canada lynx (*Lynx canadiensis*), which is similar in body mass (Casey *et al*. 1979, p.~~

~~335). The researchers inferred that the increased ventilation of wolverines at low ambient temperatures was the result of an increased energy metabolism (Casey *et al*. 1979, p. 336).~~

Thermal neutrality (or thermoneutrality) is the temperature range at which resting metabolism is at minimum (Barnett and Mount 1967, p. 468) and animals produce heat at a minimum rate in a thermal neutral environment (Barnett and Mount 1967, p. 413). For a resting mammal at thermal neutrality, body temperature is primarily maintained by "physical thermoregulation," that is, control of circulation in the skin and by sweating (Barnett and Mount 1967, p. 413). The body temperature of wolverine (measured by an implanted temperature transducer) at thermoneutrality has been reported at 38°C (100.4°F) (Folk *et al*; 1977, p. 231; Casey *et al*. 1979, pp. 332–333). The lower and upper bounds of the thermoneutral zone are established by the lower and upper critical temperatures (Monahan 2009, p. 5), which are related to physiological and behavioral adaptive responses. Because the ~~The~~ critical temperature is the point at which the metabolic rate starts to rise~~; thus~~, animals with lower critical temperatures are able to better conserve their energy expenditure (Barnett and Mount 1967, p. 413). Arctic mammals, including wolverine, Arctic fox, and wolf (*Canis lupus*), have a (lower) threshold of thermoneutrality of between −30°C to −40°C (–22°F to –40°F) (Iversen 1972b, p. 322; citing studies by Scholander *et al*. (1950b) and Hart (1956)).

With increasing ambient temperatures, mammals, including Arctic mammals, have the ability to dissipate heat through vasodilation and rise of skin temperature (Scholander *et al*. 1950a, p. 251). ~~Studies of arctic mammals defined a zone of thermoneutrality in Eskimo dogs (*Canis lupus familiaris*) and Arctic foxes that extended to at least −40°C (−40°F), with an estimated critical temperature between −45°C (−49°F) and −50°C (−58°F) (Scholander *et al*. 1950a, p. 254).~~

~~Arctic mammals, including wolverine, Arctic fox, and wolf (*Canis lupus*), have a threshold of thermoneutrality of between −30°C to −40°C (−22°F to −40°F) (Iversen 1972b, p. 322; citing studies by Scholander *et al*. (1950b) and Hart (1956)). Relatedly,~~ Casey *et al*. (1979, p. 340) estimated a critical (upper) temperature for wolverine (14 kg (31 lb)) in summer pelage of 5°C (41°F) based on an observed increase in oxygen uptake at air temperatures below this temperature. For comparison, measurements of metabolic rates for the red fox (*Vulpes vulpes alascensis*) (Alaska) observed critical temperatures of 8°C (46°F) in summer (Irving *et al*. 1955, p. 184). ~~These Arctic mammals therefore have the ability to dissipate heat to balance the heat loss from 30°C to −40°C (86°F to −40°F), due in large part to vasodilatation and rise of skin temperature (Scholander *et al*. 1950a, p. 251).~~

Arctic mammals, particularly small mammals, also adapt behaviorally to cold temperatures by creating burrows and building nest sites under the snow. Wolverines are known to dig holes in snow for shelter (Pruitt 2005, p. 120), and wolverine reproductive den sites located under deep snow may provide a thermoneutrality advantage for newborn wolverines (cubs or kits)~~cubs~~ (Magoun and Copeland 1998, p. 1,313). This topic is discussed in more detail below under Use of Dens and Denning Behavior.

Wolverines can also adapt to changes in ambient temperature ~~both cold and warm temperatures~~ and solar radiation by movement and~~, relatedly,~~ micro- and macro-habitat selection (e.g., movemement to higher elevations in summer, shaded areas, and water sources). For example,

w~~W~~olverines are good swimmers, easily crossing lakes and rivers, and have been observed near and in lakes and other water bodies~~ and are good swimmers, easily crossing lakes and rivers~~ (Seton 1909, p. 950; Krott 1960, p. 23; Magoun 2017a, pers. comm.). They likely use these areas more frequently during warmer months both for cooling and hydration, and~~or~~ possibly for hygienic reasons (Krott 1960, p. 23).

~~Changes in endocrine (hormone) function can also represent a physiological adaptation to cold by acting on organs to generate energy (Barnett and Mount 1967, p. 428). The best available information does not indicate that these functions have been evaluated in wolverines. However, one veterinarian reported an enlarged thyroid in a wolverine during a necropsy procedure (Copeland 2017, pers. comm.), which is suggestive of a high metabolism.~~

~~In addition to these physiological processes, rapid and~~ ~~S~~seasonal adjustments of fur insulation also provides an additional mechanism for mammals to overcome large seasonal changes in temperature (Casey *et al*. 1979, p. 340) and have been described for wolverine and other mammals in Alaska (Henshaw 1970, p. 522). ~~The seasonal increase in fur depth for captive wolverines was reported to be 65 percent (Henshaw 1970, p. 522). That study identified a metric termed seasonal insulative advantage (or SIA) as a measure of the degree to which insulative compensation changes seasonally in response to ambient temperature (Henshaw 1970, p. 522). For wolverines, this advantage was found to be less than unity; that is, the increase in fur did not fully compensate for average winter cold, and therefore other compensating mechanisms were needed (Henshaw 1970, p. 522).~~

~~Similarly, an~~An evaluation of the seasonal change in the insulation of fur of wolverine (pelts from Canada) found a 41.2 percent change in mean insulation values (measured as °C/cal/m^2/hr) from winter to summer (Hart 1956, p. 56). Relatedly, a~~A~~ single annual molting (between August and December) was noted in Grinnell *et al*. (1937, p. 251) (California), but twice yearly was described by Novikov (1962, p. 201) (Russia). ~~The large seasonal change in insulation observed for wolverine and other larger mammals is, in large part, due to changes in fur depth, and can be interpreted as an adaptation to both high summer temperatures and low winter temperatures (Hart 1956, p. 57).~~ The reported seasonal decrease in wolverine fur thickness also correlates with experimental results of Casey *et al*. (1979, p. 337) who indicated that a seasonal shift in oxygen consumption below critical temperature was likely due to an increased rate of heat loss in summer.

Physiological responses (e.g., changes in respiration rate, heart rate, skin temperature, or endocrine (hormone) functions) to changes in ambient temperature or solar radiation are also observed in mammalian species (e.g., Norris and Kunz 2012, p. 207). In a study to evaluate metabolic and respiratory responses of eight terrestrial Arctic mammals to ambient temperature during summer months, Casey *et al*. (1979, pp. 335, 338; Figure 7) found that, for wolverines, the frequency of respiration was generally constant (15-20 per minute) for air temperatures ranging from −20°C to +20°C (−4 to 68°F). However, with decreasing ambient temperature, the tidal volume (air moved per breath) of wolverines exhibited a constant increase (Casey *et al*. 1979, p. 335). The researchers inferred that the increased ventilation of wolverines at low ambient temperatures was the result of an increased energy metabolism (Casey *et al*. 1979, p.

336). One veterinarian reported an enlarged thyroid in a wolverine during a necropsy procedure (Copeland 2017, pers. comm.), which is suggestive of a high metabolism.

Beyond these cited observational and laboratory/field studies, the best available information indicates that behavioral, morphological, or physiological responses of wolverines relative to increases in either colder or warmer temperatures have not been evaluated (e.g., thermal imaging studies combined with biophysical models (McCafferty *et al*. 2011, entire), or physiological niche models).

Range and Habitat Use

Historical Range and Distribution

Phylogeography/Phylogenetics

Results from a molecular study of phylogenetic relationships of the Mustelidae family suggest at least six radiation episodes within this family since the Early Eocene Epoch (approximately 50 million years before present (YBP)) (Marmi *et al*. 2004, pp. 488, 492). The split of the marten (*Martes*, *Gulo*) and weasel (*Mustela*) lineages occurred in the Early Middle Miocene Epoch (14 to 11 million YBP), with the separation of Old World and New World lineages (*Martes*, *Gulo*) occurring in the Late Miocene Epoch (8.6 to 5.8 million YBP) (Marmi *et al*. 2004, p. 488). The *Gulo* genus appears in the fossil record in the mid-Pleistocene in both Europe and North America (Bryant 1987, p. 659).

The dispersal of *Gulo* across Beringia (land mass that extended from Siberia into interior Alaska during the Pleistocene) is believed to have produced contemporaneous records for the species in Europe and North America (Bryant 1987, p. 659). Genomic data was examined using a molecular dating technique to estimate an approximate age of the *G. gulo* ancestor (Malyarchuk *et al*. 2015, entire). The researchers estimated a relatively recent origin of the species *Gulo gulo* at about 181,000 to 234,000 YBP (Malyarchuk *et al*. 2015, pp. 1,115–1,116). They note that this latter time period corresponds to the Riss glaciation period (187,000 to 230,000 YBP), a time of genetic divergence of amphi-Beringian (both sides of Beringia) species and speciation events (Hope *et al*. 2013, p. 426). Their results, along with fossil information, also indicate the divergence of the *Gulo* branch and the other *Martes* taxa occurred during the Late Miocene-Early Pliocene (5.6 million YBP), and lends support for strong evolutionary processes in the northern Siberian ecosystems in the Pliocene and Pleistocene Epochs (Malyarchuk *et al*. 2015, pp. 1,116–1,117).

An evolutionary trend was described in which *Gulo* increased in size from the mid- to late-Pleistocene, with a subsequent reduction in size post glaciation, as well as small changes in selected teeth, and a possible shift to colder habitats (Bryant 1987, p. 660). The Late Pleistocene and the Pleistocene-Holocene transition represent the end of prolonged period that was characterized by climate fluctuations followed by rapid warming (Post 2013, p. 28). This analysis also indicated that both the mid-Pleistocene European *Gulo schlosseri* and the early North American *Gulo* appear to be adapted to a warmer climatic environment, but are likely to have also occupied colder climates (Bryant 1987, p. 660). Other factors such as competition

(Guilday 1971, p. 237), predator avoidance, and prey abundance may also have been important in creating significant shifts in geographic ranges for certain species during glacial cycles.

Wolverines are believed to have migrated to North America during the late Pleistocene, although fossil evidence from the Pleistocene Epoch for wolverine is limited (Anderson 1977, p. 15; Bryant 1987, p. 660), and most fossil material is either cranial or dental fragments (Bryant 1987, p. 660). A summary of records for both Pleistocene and extant *Gulo* (Bryant 1987, p. 659; Table 3) includes findings in the United States from Colorado, Idaho (e.g., White *et al*. 1984, p. 248 (lava tubes)), Alaska, Maryland, and Pennsylvania, and Canada (primarily the Yukon region) ranging from the Irvingtonian Age (1.8–2.4 million YBP) to Late Wisconsinan-Holocene (15,000 YBP to present day).

Genetic studies can provide an understanding of the postglacial recolonization of wolverines following the Last Glacial Maximum, a period of rapid cooling, and movement patterns due to changed climatic conditions (Frances 2008; Zigouris *et al*. 2013; McKelvey *et al*. 2014). ~~Following the Last Glacial Maximum, beginning about 21,000 YBP, was a period of rapid warming, resulting in a second wave of extinction events, particularly of large mammalian megafauna that were cold-adapted (Post 2013, pp. 29, 31).~~

During the late Wisconsin period (10,000 to 25,000 YBP), approximately 60 percent of North America was covered by glacial ice (Rogers *et al*. 1991, p. 624). However, several ice-free refugia existed at that time including the Beringian refugium, which included eastern Siberia, most of Alaska, areas of northwestern Canada, and areas of the Bering Sea shelf that were exposed by lower sea levels, and this refugium harbored a number of mammalian species including wolverine (Rogers *et al*. 1991, pp. 624, 626). Analyses by Frances (2008, entire) and Zigouris *et al*. (2013, entire) supported a wolverine colonization of North America in which individuals "followed retreating glaciers" (Zigouris *et al*. 2013, pp. 10–11), beginning about 21,000 YBP, following the Last Glacial Maximum, when a period of rapid warming occurred that resulted in additional extinction events, particularly large mammalian megafauna (Post 2013, p. 29)

A phylogeographic analysis presented by McKelvey *et al*. (2014, p. 331) proposed that a unique haplotype (Cali 1) observed in historical wolverine samples from California was reflective of an independent evolutionary history resulting from isolation (i.e., southern ice-free refugium) of wolverines during glacial retreat. However, Zigouris *et al*. (2013, p. 10, Supplemental Table S5) found the Cali 1 haplotype described by Schwartz *et al*. (2007, p. 2,173; Tables 2 and 4) (relabeled as Haplotype 21) also occurred in historical wolverine samples from the eastern region of Canada (Quebec-Labrador). In addition, as noted by Zigouris (2014, pp. 232–233) the historical samples analyzed by McKelvey *et al*. (2014, p. 327; Table 1) were primarily those from locations at the southwestern edge of the wolverine's North American range (e.g., California, Colorado, Idaho, Montana, Wyoming, Utah, Washington). Without additional sampling, it is unclear if this particular haplotype distribution from two of the most peripheral North American wolverine populations is a reflection of a skewed dispersal after post-glacial colonization, or was a more widely distributed haplotype that declined or was lost due to hunting and unregulated trapping pressures (beginning in 18th century) or fragmentation (late-20th century) (Zigouris *et al*. 2013, p. 10).

Additional discussion of our current understanding of wolverine genetic structure and diversity is provided in the *Population Structure* section below.

Historical Range

In North America, wolverines were historically distributed in much of the northern portion of the continent, extending southward to the northernmost region of the United States (Maine to Washington) or approximately north of the 38th parallel (Hash 1987, p. 576; Banci 1994, p. 102).

An estimate of wolverine observations and distribution in the contiguous United States was prepared by compiling 901 verifiable or documented records of wolverine occurrence dating from 1801 to 2005 from 24 states in the contiguous United States (Aubry *et al*. 2007, entire). This included a total of 809 verifiable or documented records for the Rocky Mountain and Pacific Coast mountains (west-northwestern United States) for this time period (Aubry *et al*. 2007, p. 2,151).

Commented [SJ6]: Should we be referring to one of our maps here? Or see below at least?

The historical population size of wolverines in Canada is not known (Fortin 2005, p. 4). Its historical distribution, as depicted by Seton (1909, p. 947; Map 51) and also later by van Zyll de Jong (1975, p. 435; Figure 9) shows a broad range across much of Canada. Examples of early descriptive accounts include de Puyjalon (1900, pp. 126–144), who described wolverines as inhabiting Labrador, Canada (de Puyjalon, p. 101), and extending in range to the 66th parallel and perhaps further (de Puyjalon 1900, p. 144); reports of both trapped and live wolverines in Labrador in the late 1700s (Townsend (ed.), 1911, pp. 73, 93, 228, 255); and reports of wolverines as "common" in Canada's Nunavut Territory (Hudson Bay region) during a 1920s Danish excursion (the Fifth Thule Expedition) to Arctic North America (Freuchen 1935, p. 101). The 2014 COSEWIC report presents a historic~~al~~ range distribution for Canada based on personal accounts and interpretation of the fur trade (COSEWIC 2014, pp. 12–13; Figure 3).

~~Current Range~~Maximum Extent of Occurrences

We created a map to depict the Maximum Extent of Occurrences (similar to a historic range map) of the North American wolverine (Figure 2). This map represents the area defined by circumscribing all known localities of a species, or the perimeter of the outermost geographic limits based on occurrence records from survey reports, literature, natural heritage databases, and citizen sightings (Service 2017), and is similar to the map presented in Seton (1909, p. 947; Map 51). For defining this area in Canada and Alaska, we used the map (in digital format) presented in COSEWIC (2014, p. 12; Figure 3). For the western United States, we used relevant forested areas identified in the U. S. Environmental Protection Agency's (EPA) ecological regions map (Level 2) (Commission for Environmental Cooperation (CEC) 1997, EPA 2010; see Appendix A for complete North American map). The Maximum Extent of Occurrences area shown in Figure 2 encompasses about 12,966,221 km^2 (3,204,022,986 ac) (using North American Lambert projection). Of this total, about 88 percent (11,363,639 km^2 (2,808,016,350 ac)) is found north of the U.S.–Canada border.~~depicting~~

Commented [SJ7]: I fear if we say this, people are going to just call it a historic "range map". Needed?

Commented [SJ8]: True for wolverine, or just these maps in general? We focus on verifiable records, right?

We then requested all available wolverine observations for the west-northwestern United States ~~by requesting all available wolverine records~~ from State agencies (e.g., wildlife agencies, natural heritage programs) and the Forest Service Natural Resource Information System (NRIS) Wildlife Database. The NRIS Wildlife Database records represent data that have been quality checked ("passed") by the Forest Service. For the Midwest and eastern United States, we incorporated observations from Aubrey *et al*. (2007; pp. 2,151–2,152; Figure 1).~~We found a total of 4,215 records (1800s to 2017) for this portion of the United States (*cf*. 809 records from Aubrey *et al*. 2007; Table 1)~~, We also located additional historical records in the western United States that do not appear in Aubry *et al*. (2007, p. 2,151); for example, Nead *et al*. (1985, entire) identified several positive and probable reports of wolverines in Colorado in the late 1970s and a wolverine was reported from the Squaw Valley region of California in the summer of 1953 (Ruth 1954, pp. 594–595). Wolverine observations for the contiguous United States are included in Figure 2, and illustrate the close correlation with the Ecoregions boundaries. ~~Figure 2 presents a map of these compiled observations, overlaid with the habitat suitability model results presented by Inman *et al*. (2013, p. 281). We acknowledge that some of these records may be in error or inaccurately located, and although wolverines have been reported from the Central Great Plains, Great Lakes region, Upper Midwest, or Northeast (Wilson 1982, p. 650), we did not create a historical range for these regions given the very low number (92) reported by Aubry *et al*. (2007, p. 2,151) from the 1880s to 2005, and to present day, and an incomplete historical record of trapping. We also found a few additional historical records that do not appear in Aubry *et al*. (2007, p. 2,151). For example, Nead *et al*. (1985, entire) identified several positive and probable reports of wolverines in Colorado in the late 1970s. A wolverine was reported from the Squaw Valley region of California in the summer of 1953 (Ruth 1954, pp. 594–595). Our intent in creating this map was to present an overall geographical depiction of the wolverine's estimated range only for the west-northwestern United States, and is not intended to represent an estimate of population numbers.~~

Current Potential Extent

Using the best available information, we ~~also~~ created maps to describe an area of Current Potential Extent for the western-northwestern contiguous United States (Figure 4). Current Potential Extent represents the Maximum Extent of Occurrences minus those areas where we believe the species has been extirpated. For the wolverine, this map was developed from the current distribution of breeding populations defined by Inman *et al*. (2013, p. 282; Figure 3). We then incorporated records from Forest Service (NRIS Wildlife Database) from 2004 to early 2017, based on an average male life expectancy of about 13 years (Jung and Kukka 2013, pp. 8, 12). We also incorporated more recent observations (e.g., telemetry, camera traps, and/or mortality reports) reported from California, Washington, Colorado, Wyoming, Utah (2014, 2016), Oregon (2016, 2017), Michigan (2004-2010) and North Dakota (2016). Sources include California Department of Fish and Wildlife; Idaho Department of Fish and Game; Michigan Department of Natural Resources; Utah Division of Wildlife Resources; Wyoming Game and Fish Department, Magoun *et al*. 2013, p. 27; Magoun 2017b, pers. comm.), and additional observations from 2016-2017 winter surveys (i.e., WAFWA's Coordinated Occupancy Survey) (Montana Fish Wildlife & Parks (FWP) 2017, pers. comm.)). ~~current North American range based on results presented by COSEWIC (2014, p. 12) for Canada and Alaska, Forest Service NRIS data, and more recent observations (e.g., telemetry, camera traps, mortality reports)~~

~~reported from California, Washington, Colorado, Wyoming, Utah, and North Dakota (e.g., California Natural Diversity Database (CNDDB); Forest Service NRIS; Idaho Department of Fish and Game; Utah Division of Wildlife; Wyoming Game and Fish Department).~~ This Current Potential Extent map ~~is range~~ is illustrated in Figure 3. -This map also identifies individual wolverine observations outside these boundaries, including a current resident wolverine in California, the tracking locations of a dispersing male (M56) that traveled from northwest Wyoming into Colorado and then to North Dakota where it was legally shot in 2016 (Packila *et al*. 2017, entire), and three observations from experienced observers in Colorado (2015) and one from Wyoming Game and Fish Department (January 2016). We placed a question mark on this map for the Uinta Moutains region of Utah since the last detection was a female wolverine found killed along a highway in July 2016 (Rich County) (Hersey 2017, pers. comm.). The Current Potential Extent area identified in Figure 3 encompasses approximately 280,316 km^2 (69,267,592 ac) (North American Lambert projection). We also prepared a Current Potent Extent map for all of North America, including Canada and Alaska, shown in Figure 4, using map presented in the 2014 COSEWIC Status Assessment and Status Report on the wolverine in Canada (COSEWIC 2014, p. 12; Figure 3), for a total estimated Current Potential Extent of 8,114,878 km^2 (2,005,230,024 ac) (North American Lambert projection). The Current Potential Extent area in the contiguous United States represents approximately 3.45 percent of the total Current Potential Extent of wovlerines in North America.

Commented [SJ9]: a map? Or maps?

We recognize that this depiction does not necessarily represent current areas where reproducing populations of wolverines are found, nor does it capture unverified accounts from New Mexico, described in Frey (2006, pp. 20–21) for the Sangre de Cristo Range, and visual observations reported by two individuals (2005 and 2016) in response to our *Federal Register* notice (81 FR71670; October 18, 2016) requesting information for our status review. ~~In addition, we did not incorporate the Central Great Plains, Great Lakes region, Upper Midwest, or Northeast. However, we note here that a female wolverine was observed over several years (2004–2010) in the lower peninsula of Michigan, and genetic testing after her death in 2010 suggested she was more closely associated with eastern Canada wolverine populations (i.e., Manitoba and Ontario) (*in litt* Zigouris 2013, pers. comm.). It's unclear how this individual came to occupy this region, but given the long distant movements reported for this species (e.g., male wolverine that traveled from Wyoming into Colorado and then back to North Dakota), dispersal from Canada is plausible. Wilson (1982, p. 650) reported that wolverines on occasion may enter Minnesota from Canada. Jackson (1961, pp. 359–360) also reported several authentic records of wolverine in Wisconsin and in areas in Minnesota, along the Wisconsin-Minnesota border. However, the wolverine was likely never abundant in Wisconsin, even before trapping and hunting in the late 19th and early 20th centuries (Jackson 1961, p. 359).~~

Habitat loss (historical vs. current range) for the North American wolverine (i.e., Canada and United States) has been estimated at 37 percent (Laliberte and Ripple 2004, p. 126), using "historic" and "current" range maps, an estimatation of "human footprint," North American biomes, and a digital elevation model (Laliberte and Ripple 2004, p. 126). Similarly, comparing our estimated North American Maximum Extent of Occurrences map to our estimated Current Potential Extent map for the wolverine also indicates a 37 percent change. However, as noted in Laliberte and Ripple (2004, pp. 125–126), we recommend caution in interpreting this value given the coarse scale used to define dynamic range boundaries.

We provide a discussion of wolverine population abundance and distribution in more detail in the *Biological Status–Current Condition* section below.

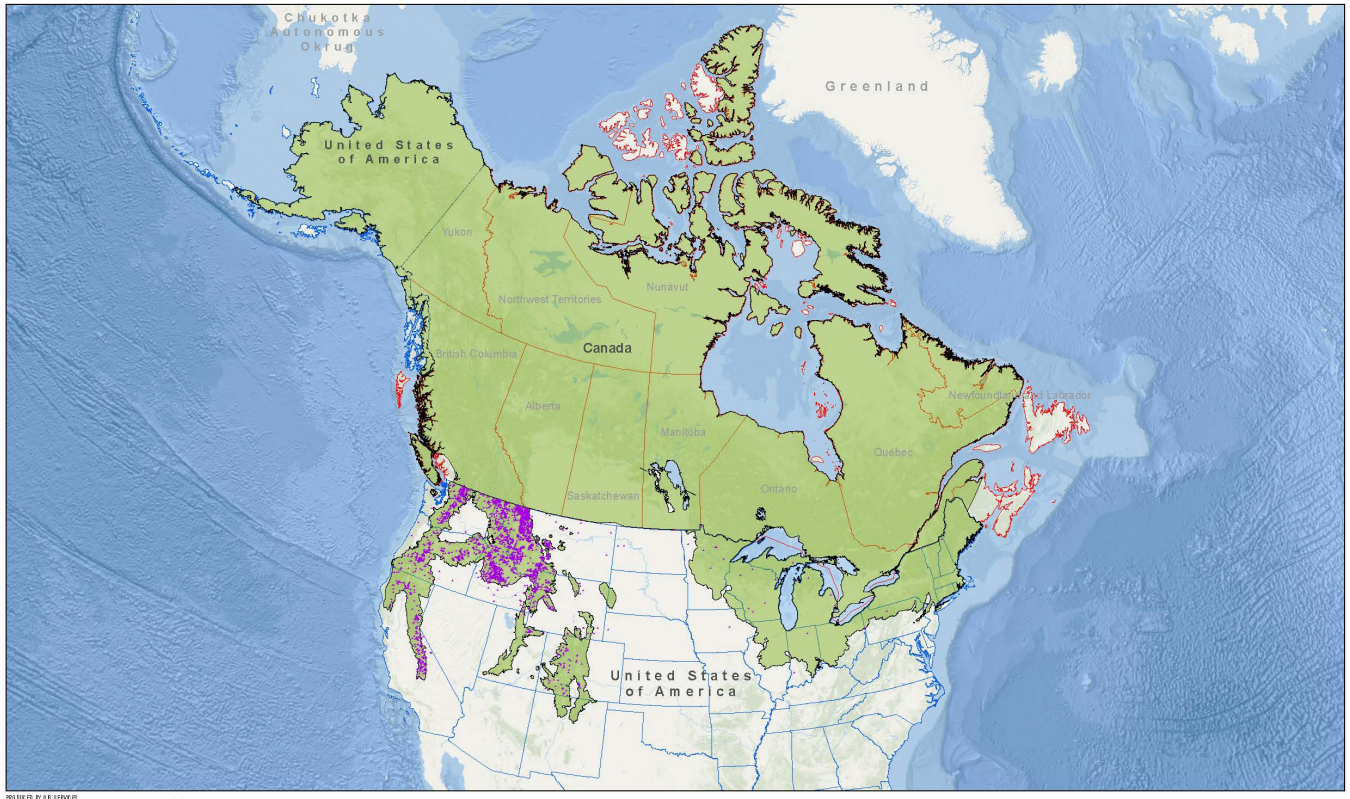

Figure 2. Maximum Extent of Occurences for the North America wolverine shown with observations (1800s to 2017) within the ~~west-northwestern~~contiguous United States ~~(1800s to 2017)~~. Boundaries based on COSEWIC (2014) (for Canada and Alaska) and North American Ecological Regions (CEC 1997, EPA 2010) (for contiguous United States)~~; shown with Inman *et al.* (2013) modeled habitat~~.

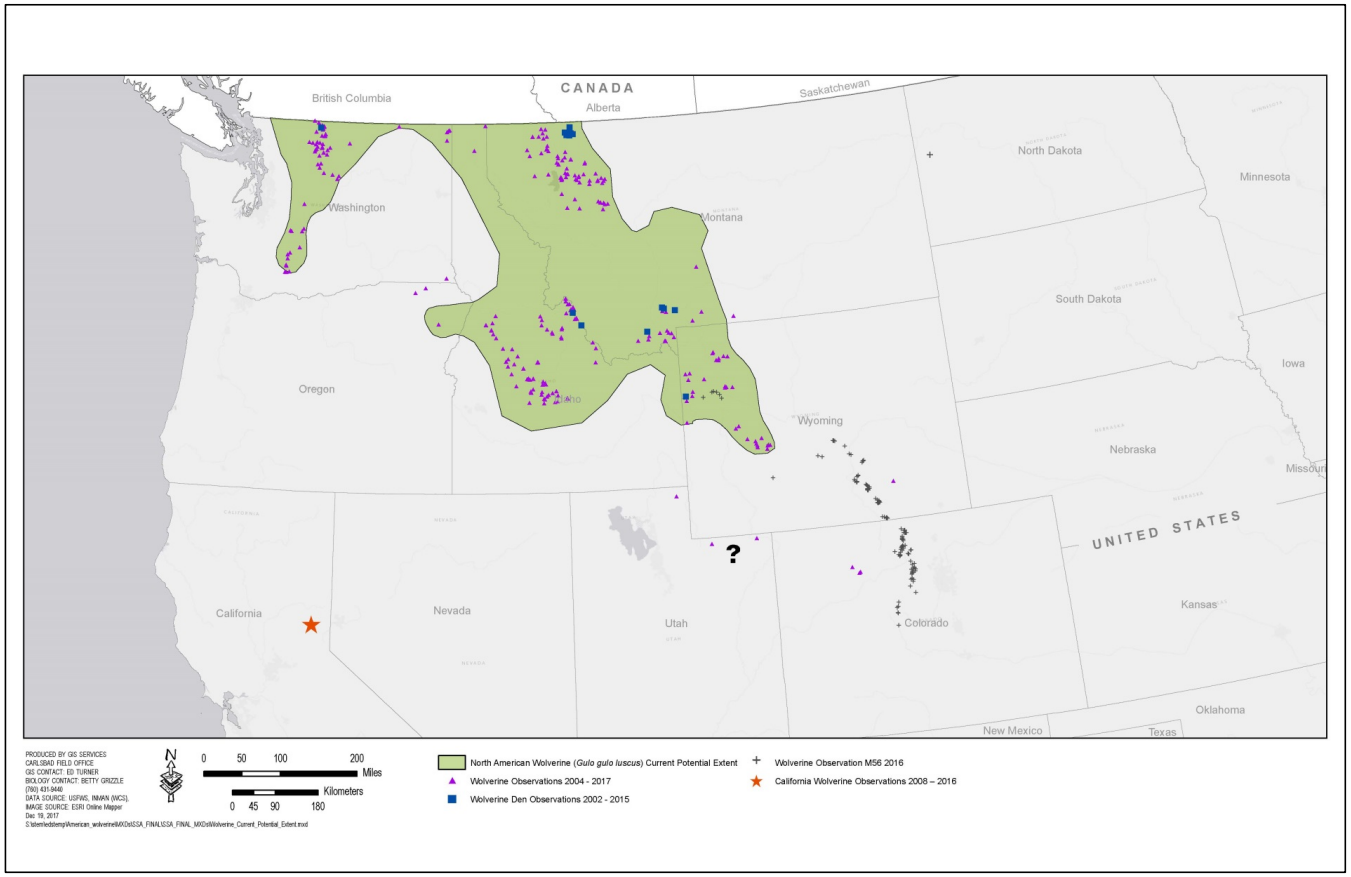

Figure 3. Current Potential Extent ~~range of~~of the North American wolverine, western United States. -Adapted from ~~COSEWIC (2014), EPA (2010),~~ Inman *et al*. (2013) and ~~,~~records from ~~CNDDB~~California Department of Fish and Wildlife; Forest Service NRIS; Idaho Department of Fish and Game; Magoun *et al*. (2013); Magoun 2017b pers. comm.; Michigan Department of Natural Resources; Montana Fish Wildlife & Parks; Utah Division of Wildlife Resources; Wyoming Game and Fish Department;~~,~~ and den records from ~~CNDDB, Inman,~~ ~~and~~ Copeland, Heinemeyer, and Inman.

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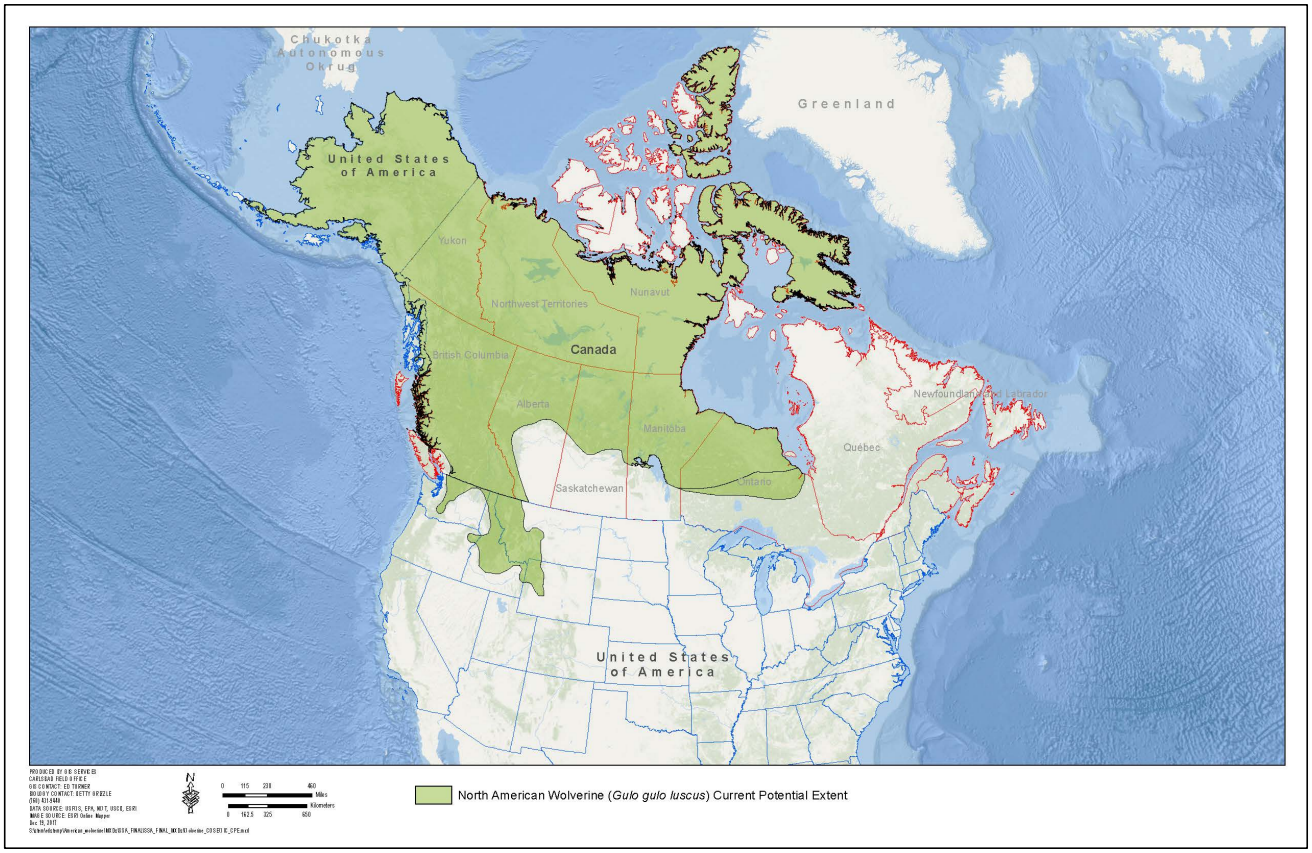

Figure 4. Current Potential Extent of the North American wolverine, North America. Adapted from COSEWIC (2014), and records from Forest Service NRIS; Idaho Department of Fish and Game; Magoun *et al*. (2013); Magoun 2017b pers. comm.; Montana Fish Wildlife & Parks; Utah Division of Wildlife Resources; Wyoming Game and Fish Department; and den records from Copeland, Heinemeyer, and Inman.

Habitat Use

Wolverines occupy a variety of habitats within their current rangeNorth America, including Arctic tundra, subarctic-alpine tundra, boreal forest, mixed forest, redwood forest, and coniferous forest (Banci 1994, p. 114). However, these broad, landscape-scale vegetation associations can obscure other habitat variables important for wolverines, including features found within peripherally occupied areas or areas of high elevation (Banci 1994, p. 114). In Canada, wolverines use a wide variety of forested and tundra vegetation, at all elevations (COSEWIC 2014, p. 18).

When viewed by ecological region (U.S. Environmental Protection Agency (see EPA) 2010), in general, wolverine observations found within our Current Potential Extent of wolverines in the contiguous United States are most commonly found in the Northwestern Forested Mountains ecological region. In Canada, our estimate of current range includes Northwestern Forested Mountains, Northern Forests, Marine West Coast Forest, Hudson Plain, Taiga (Boreal Forest), Tundra, and parts of the Arctic Cordillera (northeastern fringe of Nunavut and northern Labrador); in Alaska, Marine West Coast Forest, Northwestern Forested Mountains, Taiga, and Tundra are represented. All North American ecological regions are presented in the map in **Appendix A** provides an illustration of these ecoregions of North America in relationship to our Current Range map presented in Figure 3.

Studies of wolverines in central Idaho found that montane coniferous forests comprised two-thirds of available habitat (Copeland 1996, p. 120). Wolverines in this region also exhibited a seasonal preference, with subalpine rock habitats used in summer and montane coniferous forests used most often in winter (Copeland 1996, p. 120). In addition, individuals within this study population commonly crossed natural openings and those areas with little cover, including burn areas, meadows, or open mountain-top areas (Copeland 1996, p. 124).

Observations of summer movements of wolverines in northwestern Montana indicated that both males and females moved to higher, cooler elevations and remained there throughout the summer (Hornocker and Hash 1981, p. 1,299). In the Greater Yellowstone Ecosystem, wolverines selected areas that contained steep terrain with tree cover, high elevation meadows, boulder or talus fields, and avalanche chutes (Inman *et al*. 2012a, p. 785). In this region, wolverines selected elevations at and above the treeline during summer, moved slightly lower during winter, but avoided low-elevation winter ranges occupied by potential prey (e.g., elk) or areas with little human activity (Inman *et al*. 2012a, p. 785). The avoidance of these areas may be the result of lack of tree or talus field cover at these low elevations, in combination with presence of potential predators (e.g., wolf, mountain lion (*Puma concolor*) or competitors (e.g., coyote (*Canis latrans*), bobcat (*Lynx rufus*) (Inman *et al*. 2012a, p. 785).

Several habitat association-type models have been developed for both North American and European wolverines. In the northern Rockies (including Canada and the United States), Carroll *et al*. (2001, p. 975) found that elevation and north-facing cirque habitat variables (i.e., alpine areas), when incorporated into empirical habitat models, were significantly correlated with wolverine occurrence ; however, results from multiple regression analyses of these and other

~~habitat variables indicated a high degree of unexplained variance for predicting wolverine habitat relationships, and underscores the inherent difficulty in identifying appropriate metrics to represent difficult to measure underlying factors, or other unrecognized limiting variables~~ (Carroll *et al*. 2001, pp. 971, 973–974). Copeland *et al*. (2007, entire) also evaluated habitat associations for wolverines in central Idaho. Wolverines were found to be associated with high elevations (2,200 to 2,600 m (7,218 to 8,530 ft)) with a slight downward shift in summer (Copeland *et al*. 2007, p. 2,207). These movements correspond with a shift in cover types, from high-elevation whitebark pine (*Pinus albicaulis*) communities in summer to mid-elevation Douglas fir (*Pseudotsuga menziezii*) and lodgepole pine (*Pinus contorta*) in winter (Copeland *et al*. 2007, pp. 2,207–2,208). Results from a study of wolverines in Scandinavia suggested that topography may be important in providing refugia from predators and may therefore facilitate the co-existence of wolverines with larger carnivores such as wolves (Khalil *et al*. 2014, p. 636).

In interior Alaska, wolverines were also found to be positively associated with high elevations (Gardner *et al*. 2010, p. 1,901). The authors concluded that wolverines avoided human influences based on observations that both elevation and human influence were found to have significant effects on wolverine occurrence probabilities, but were not correlated (Gardner *et al*. 2010, p. 1,901). However, they indicate that their sampling design was not able to determine which human activities influenced wolverine behaviors; a combination of intensity of development and harvest activities was suggested (Gardner *et al*. 2010, p. 1,901). Current studies are underway in the North Slope region of Alaska to evaluate fine-scale habitat selection of wolverines related to denning, caching, day bed use, and snow holes (Dorendorf 2016, p. 6). Day beds were also described by Haglund (1966, p. 268) for wolverines studied in Sweden.

A study also found that habitat associations, at least for females, are more complex, and include combinations of several modeled variables that supported hypotheses related to food (prey distribution), predation risk (based on a ruggedness index), or human disturbance (winter recreation activity, roads, and forest harvesting) for both summer and winter in two study areas located in northcentral and southeast British Columbia (Krebs *et al*. 2007, pp. 2,186–2,187). Wolverines in the Rocky Mountains of Alberta, Canada, were found to more likely occupy areas with increasingly rugged terrain (Fisher *et al*. ~~(~~2013, pp. 710–712).

Camera trapping was used to study wolverine behavior in varying habitat in the Rocky Mountains of Alberta, Canada (Stewart *et al*. 2016, entire). That study found that wolverine behavior differed in landscapes that had been significantly modified by human activities as compared to those with light modifications or in protected areas (Stewart *et al*. 2016, p. 1,499). They concluded that wolverine occurrence in their study areas varied more strongly with linear features (seismic lines created from oil and gas exploration, pipelines, transmission lines, roads, and rail lines) than with the degree of snowpack, and supports the idea ~~that~~ of human "footprint" as a driver of habitat suitability for wolverines; that is, if snowpack conditions was the only driver for suitable habitat, then a behavioral signal (e.g., latency time for detection or tree climbing at bait station) would not be expected (Stewart *et al*. 2016, p. 1,501).

Aboriginal knowledge holders (~~the knowledge~~ Aboriginal Peoples that have accumulated knowledge about wildlife species and their environment) in Canada have reported that while wolverines appear to avoid human habitation and developed areas, some wolverine will visit

these areas if they do not appear to be threatened or if development activities cease (Cardinal 2004, p. 22). Wolverines have also been described as occupying deserted snow huts (Nunavut Territory, Canada) during winter months (Freuchen 1935, p. 98).

A negative association with roads and wolverine (and caribou) occurrence in boreal forest habitat was reported in northwestern Ontario, Canada, and wolverines in that study area avoided deciduous forests (Bowman *et al*. 2010, p. 464). However, a study of wolverines in upland boreal forests of Canada found that wolverines followed open linear corridors that offered compact snow conditions, including winter roads, recent seismic lines, snowmobile trails, and all-terrain vehicle tire tracks for travel of distances up to 3 kilometers (km) (1.86 miles (mi)) (Wright and Ernst 2004b, p. 59). In central Idaho, wolverines were reported using snowmobile winter access (unmaintained) roads for travel (Copeland *et al*. 2007, p. 2,210).

A study of wolverine selection patterns in boreal forests in northwestern Alberta using resource selection function (RSF) modeling techniques[1] and data from telemetered wolverines found that, for the winter season, both male and female wolverines selected for streams, forested areas (broadleaf, coniferous, and mixed) and bogs or fens, while avoiding active oil and gas well sites and low-traffic winter roads (Scrafford *et al*. 2017, pp. 31, 32). That study also found that wolverines did not avoid older seismic lines, likely due to the intermediate stage of regeneration found in their study area as well as availability of small prey in conjunction with minimal risk of human or wolf presence (Scrafford *et al*. 2017, p. 34).

RSF-based modeling was used to quantify the relationship between the observed distribution of the wolverine and variables representative of habitats and human disturbance in the taiga and tundra ecoregions (~~shown in~~see ecological regions map in **Appendix A**) of the Canadian central Arctic (Nunavut and Northwest Territories) (Johnson *et al*. 2005, p. 10). Using a range defined by previous studies of collared wolverines, researchers identified two seasons for wolverines, based on presence or absence of barren-ground caribou (*Rangifer tarandus groenlandicus*) (Johnson *et al*. 2005, p. 8). They found that, in winter, the occurrence of wolverines was correlated with patches of heath rock and rock association, and areas dominated by sedge (Johnson *et al*. 2005, pp. 23–25). Results for models for summer season were less clear, but models that included grizzly bear (*Ursus arctos*), caribou, and wolf were found to be positively associated with wolverine, likely due to the scavenging opportunities and hunting of caribou provided by these other carnivores (Johnson *et al*. 2005, p. 24). In Finland, the presence of wolves was found to be one of the most important variables influencing habitat selection of wolverines (Koskela 2013, p. 35) likely due to the increased scavenging opportunities provided by wolf kills (Koskela 2013, p. 36).

A RSF model was also used to develop a predictive map of wolverine habitat for the western United States (Inman *et al*. (2013, p. 281), as shown in the background of our Figure 3. Their

[1] RSF is any mathematical function that is proportional to the probability of use of a resource unit (Manly *et al*. 2002, p. 15). A RSF contains several coefficients that quantify the selection for or avoidance of an environmental feature, and the sign/strength of those coefficients represents a differential variation in the distribution of each environmental feature measured at a sample of locations to a comparable set of random sites. Thus, when an animal's observed use of a resource is greater than those random sites, selection of that feature is inferred (Johnson *et al*. 2005, p. 10).

best fit model found that, in general, wolverine were most likely to be distributed at high elevations, with steeper terrain, more snow, fewer roads, and reduced human activity, but also in proximity to high elevation talus, tree cover, and areas that had snow cover on April 1 (Inman *et al*. 2013, pp. 280–281). Primary habitat for the wolverine in the western United States was estimated at 164,125 km^2 (63,369 mi^2) (Inman *et al*. 2013, p. 281). Additional information related to the results of this modeling effort is discussed in the *Population Distribution and Abundance* section below.

Movement

Wolverine movements are related to both territoriality (within home ranges) and dispersal (adults and young). Movement within home ranges by adult male and female wolverines is extensive. For example, wolverines monitored in the Greater Yellowstone Ecosystem traveled a distance that was equivalent to their average home range diameter in less than 2 days, which is also about the size of their home range circumference in less than 1 week (Inman *et al*. 2012a, pp. 782–783). This study also found that, for a 24-hour period, the average minimum distance traveled was 15.5 (km) (9.63 (mi) for males and 7.5 km (4.66 mi) for females (Inman *et al*. 2012a, p. 783). Telemetry studies of wolverines in south-central Alaska indicate an average distance traveled per day of approximately 12 km (7.46 mi) for females and 8–21 km (4.97–13 mi) for males (Woodford 2014, no page number). Observations from snow tracking studies have found instances where two individual wolverines traveled together (Wright and Ernst 2004b, p. 63).

A study of female Fennoscandinavian wolverines found that most (86 percent) females remained stationary in their established territories, with 8 percent vacating and 6 percent expanding their territory (Aronsson 2017, p. 40). In addition, this study of 42 female wolverines in 122 territories reported that females with established territories only moved to available territories that were higher than average in quality (Aronsson 2017, p. 41). In central Norway, a study of spatial and temporal patterns in wolverines using noninvasive genetic sampling methods also found that individuals tended to stay in the same general area from one year to the next (Bischof *et al*.'s 2016, p. 1,533).

A number of factors can affect wolverine movements within territories, such as availability of food, temperature, and breeding activity. Seasonal shifts in elevation have also been observed for wolverines in the contiguous United States. An ecological study of wolverines in southcentral Alaska found significant movement up in elevation during late winter and early spring as well as significant movement down in elevation during the late fall and winter (Gardner 1985, p. 21). Wolverines were also observed moving to and occupying higher and presumably cooler elevations in summer months in northwestern Montana (Hornocker and Hash 1981, p. 1,299). In Central Idaho, wolverines exhibited a preference for higher elevation areas containing rock and talus cover in summer months, but moved to lower elevations in winter; this was likely the result of an increase in availability of carrion related to the fall hunting season (Copeland 1996, p. iv). Two aboriginal knowledge holders in the Kivalliq region (Nunavut, Canada) reported that wolverines will move closer to communities during caribou migration in the fall, likely attracted by the large number of caribou carcasses left by hunters (Cardinal 2004, p. 22).

A study of wolverine movement in boreal forest habitat in Canada (northwestern Alberta and northeastern British Columbia) during winter months found that wolverines chose the most direct travel route with the least snow cover (Wright and Ernst 2004a, pp. 58–59). Woodford's (2014, no page number) account of wolverine observations from studies in Alaska indicated that, when pursued, wolverines will run uphill, which may represent a predator-avoidance adaptive behavior.

As discussed in more detail below (*Diet and Feeding*), several studies have shown that wolverines exhibit a seasonal shift in diet, and Hornocker and Hash (1981, p. 1298) concluded that food availability was the primary factor determining both movements and home ranges for wolverines studied in northwestern Montana. Movement patterns of adult males during the summer months are also likely influenced by breeding activity (Magoun 1985, p. 66).

Males and females maintain large territories with very little overlap between same-sex adults (Magoun 1985, p. 38; Banci 1994, p. 118; Inman *et al*. 2012a, p. 783; Bischof *et al*. 2016, pp. 1,532–1,533; Regehr and Lacroix 2016, p. 249), but breeding pairs have overlapping territories (Copeland 1996, pp. 55–61; Hedmark *et al*. 2007, p. 19; Dawson *et al*. 2010, p. 413; Persson 2010, p. 52; Inman *et al*. 2012a, p. 787). However, ranges of young males, that~~who~~ have not yet dispersed, can overlap with resident adult male home ranges (Alaska) (Magoun 1985, p. 64). Studies of wolverines in the Greater Yellowstone Ecosystem found a mean percent overlap of 12.7 percent for same sex, adult–sub-adult pairs and about 24 percent for opposite sex, adult–sub-adult pairs (Inman *et al*. 2012a, p. 787). In addition, Inman *et al*. (2012a, p. 783) found that when a resident adult wolverine died, same-sex adults (not known to be located within the dead wolverine's home range) would begin using (within 3–7 weeks) areas of the unoccupied home range, or same-sex subadults would expand into and then occupy most or all of the dead wolverine's former home range. A study of territoriality of wolverines in central Norway (using scat analysis) indicated that within their study population, wolverines were also more likely to choose a home range area that was previously used by a neighboring same sex individual after that individual's death (Bischof *et al*. 2016, p. 1,533).

Table 1 below presents a summary of annual home ranges of resident wolverines.

Table 1. Annual Home Range Size for Adult, Resident Wolverines.

Region	Female, km^2 (mi^2)	Male, km^2 (mi^2)	Reference
Central Idaho	384 (148)	1,582 (610)	Copeland 1996
Central Idaho / Yellowstone Region	357 (138)	1,138 (439)	Heinemeyer and Squires 2015
Greater Yellowstone Ecosystem	303 (117)	797 (308)	Inman *et al*. 2012a
Glacier National Park (MT)	139 (54)	521 (201)	Copeland and Yates 2008
Alaska (Northwestern)	53-232 (20-89.6)	488-917 (188-354)	Magoun 1985
Canada Northwest Ontario	50-400 (19-154) 423 (163)	230-1,580 (89-610) 2,563 (990)	COSEWIC 2014 Dawson *et al*. 2010

Central Norway	331 (128)	757 (292)	Bischof *et al*. 2016
Southern Norway	274 (106)	663 (256)	Landa *et al*. 1998
Northern Sweden	170 (66)	669 (258)	Persson *et al*. 2010

Home range use is smaller for female wolverines during the reproductive period. For a parturient (about to bear young) female, estimates of home range size in the Greater Yellowstone region were significantly smaller, with a minimum of 100–150 km^2 (39–58 mi^2) (i.e., during year raising young) (Inman *et al*. 2012a, p. 782). The average home range size for lactating females rearing young was estimated at 70 km^2 (27 mi^2) from March through August (Alaska) (Magoun 1985, p. 36). In northwestern Ontario, researchers reported a home range of 262 km^2 (101 mi^2) for a lactating female (Dawson *et al*. 2010, pp. 141–142). In general, the distance traveled by female wolverines depends on the location of the reproductive den site within the home range, the areas used for locating food/prey, and the territory border (Myhr 2017, no page number).

In summary, habitat diversity, food availability, and competition for resources can collectively or individually influence home range sizes of wolverines (Magoun 1985, p. 63; Inman *et al*. 2012a, p. 785), which affects wolverine densities and population structure. Home range sizes of male wolverines are likely influenced by the density and reproductive condition of female wolverines (Magoun 1985, p. 63).

Dispersal relates to the successful establishment of a breeding territory, generally by juveniles, at a location removed from the natal denning area, and can be confused with long-range movements of wolverines and other carnivores (Ruggiero *et al*. 1994, pp. 4–5).

Commented [SJ11]: I'm not sure what we're saying here. Dispersal is one thing, long-range movement is another?

Based on telemetry studies, wolverines have been observed to disperse over very long distances. Both male and females can move long distances (Flagstad *et al*. 2004, pp. 684–686), but young (yearling) females tend to establish home ranges closer to their natal ranges than do young males (COSEWIC 2014, p. 24), which supports a male-biased dispersal pattern (from natal range) for wolverine populations. Vangen *et al*. (2001, p. 1,647) indicated that dispersal patterns of females were likely determined by competition for resources (that is, high quality territories) while male dispersal patterns were likely determined by competition for mates.

As noted above, wolverines readily cross water bodies such as rivers, and can cross rugged terrain (COSEWIC 2014, p. 24; Woodford 2014, entire). Dispersing wolverines in Idaho traveled over 200 km (124 mi) following routes across isolated subalpine habitat (Copeland 1996, p. 130). Inman *et al*. (2012a, p. 784) recorded dispersal-related movements of wolverines in the Greater Yellowstone Ecosystem and found that the maximum dispersal distance of subadults from the home range of their mothers was 170 km (106 mi) for males and 173 km (108 mi) for females, with an average maximum distance per dispersal movement of 102 km (63 mi) for males and 57 km (35 mi) for females (Inman *et al*. 2012a, p. 784). In the Ontario, Canada, region a juvenile male reportedly dispersed 100 km (62 mi) (COSEWIC 2014, p. 24, citing unpublished data from Dawson *et al*. 2013).

~~Two recent~~Several examples illustrate the extensive dispersal capability of wolverines. A male wolverine apparently dispersed (2008 or earlier) from the western edge of the Rocky Mountain

region to the Sierra Nevada region of California (Moriarty *et al*. 2009, p. 160). Another male wolverine (designated as M56), whose natal area was the Greater Yellowstone Ecosystem (northwest Wyoming), moved south to Colorado (about 500 miles), where it remained for about 3 years (2009–2012), when its tracking signal was lost (Packila *et al*. 2017, p. 402). In April 2016, M56 was legally shot and killed by a rancher in western North Dakota, or about ~~1126.5~~1,288 km (800~~700~~ mi) from ~~where~~ its ~~was last seen~~last know location (~~Wyoming Game and Fish Department (WGFD) 2016, pers. comm~~Packila et al. 2017, p. 404). A female wolverine was also observed over several years (2004–2010) in the lower peninsula of Michigan, and genetic testing after her death in 2010 suggested she was more closely associated with eastern Canada wolverine populations (i.e., Manitoba and Ontario) (*in litt* Zigouris 2013, pers. comm.). It's unclear how this individual came to occupy this region, but given the long distance movements reported for this species (e.g., male wolverine that traveled from Wyoming into Colorado and then back to North Dakota (Packila *et al*. 2017, entire), dispersal from Canada is plausible. Wilson (1982, p. 650) reported that wolverines on occasion may enter Minnesota from Canada. Jackson (1961, pp. 359–360) also reported several authentic records of wolverine in Wisconsin and in areas in Minnesota, along the Wisconsin-Minnesota border. However, the wolverine was likely never abundant in Wisconsin, even before widespread and unregulated (Anglo) hunting in the late 19th and early 20th centuries (Jackson 1961, p. 359).

Additional discussion of population distribution and density estimates is provided below (see Biological Status–Current Conditions).

Reproduction and Growth

Wolverine reproduction includes the following characteristics: polygamous behavior (i.e., a male mates with more than one female each year), delayed implantation (up to 6 months), short gestation period (30–40 days), denning behavior, and an extended period of maternal care (Rausch and Pearson 1972, pp. 255–256; Pasitschniak-Arts and Larivière 1995, p. 5; Magoun and Copeland 1998, pp. 1,315–1,316; Hedmark *et al*. 2007, p. 19; Persson *et al*. 2017, *in prep*).

Table 2 below presents a summary of wolverine reproductive chronology (extent and peak of reproductive events) based on a review of the literature and personal knowledge from field studies (Inman *et al*. 2012b, entire), and studies from Scandinavia (Aronsson 2017; Persson *et al*. 2017, *in prep*).

Table 2. Chronology of wolverine reproductive events (adapted from Inman *et al*. 2012b).

Reproductive Biology Event	Time Interval
Mating Season	May – August; *peak in June*
Nidation (implantation of embryo)	November – March; *peak in late December–early February*
Gestation ~~(45 days)~~	November – April; *peak in January–mid-March*
Parturition (birth of young)	late January – mid-April; *peak in February–mid-March* (Sweden: *peak in mid-February*, range from end of January to early March)[a]
Reproductive Den Use	late January – end of June; most commonly, *early February–mid-May*

Lactation	About 10 weeks; generally February–June
Weaning	April – June; most commonly, *late April–May*
Rendezvous Sites[b]	April – June; peak in *early May*
Independence	August – January; *peak in September–December*
Dispersal	Peak period at *10–15 months of age*; February–mid-April

[a] Persson *et al*. (2017, *in prep*); [b] Described below.

Wolverine mating is generally assumed to occur in May, June, and July (Pulliainen 1968, p. 341; Rausch and Pearson 1972, p. 249). A review of both the literature and personal observations by Inman *et al*. (2012, p. 636) indicated that June represented the peak in a wolverine mating season, but began in at least May and extended into early August. Female wolverines have been reported as not breeding in their first summer (under 1 year of age) based on examination of reproductive tracts from wolverine carcasses obtained from trappers (Yukon) (Banci and Harestad 1988, p. 268) and ages of pregnant female wolverines were estimated at 1 to 11-plus years of age (Banci and Harestad 1988, p. 266). In another study of wolverine carcasses (also in Yukon), some female wolverines were said to be mature at about 1 year (about 15 months), but first litters were not produced until 2 years of age (Rausch and Pearson 1972, p. 253). In Scandinavia, the mean age of first reproduction for female wolverines was 3.4 years, based on monitoring of telemetered animals (Persson *et al*. 2006, p. 76). Breeding ages were reported at 2 to 13 years of age for wolverines in Sweden (mean age of first birth was 3.4, range of 2 to 5 years), based on monitoring/observations of female wolverines (Rauset *et al*. 2015, p. 3,157).

A genetic-based wolverine study in Scandinavia found that "females often reproduced with the same male in subsequent breeding years" (Hedmark *et al*. 2007, p. 18). However, this study also found (with some assumptions regarding sampling and paternity) that 8 of 13 female wolverines bred with different males, and, based on telemetry results, 2 females bred with a new male even though their previous breeding partner was still alive (Hedmark *et al*. 2007, p. 18). This shift in partners may have resulted from a change in the resident male wolverine in the area (Hedmark *et al*. 2007, p. 19).

The reproductive rate of wolverines is relatively low. An early study of 31 wolverine dens in Finland, as reported by hunters, found an average of 2 young per den (range 1–4) (Pulliainen 1968, pp. 338–341). Average litter size for northern Europe (161 litters) was 2.5 (range 1–4) (Pulliainen 1968, p. 343). In Alaska, average litter size was reported as 1.75 young, with a reproductive rate of 0.69 young per adult female per year (Magoun 1985, p. 28). A summary of average litter size for earlier studies of New World and Old World wolverines, based on method of determination, was presented in Magoun (1985, p. 29), indicating a range of 2.2 to 3.5. Anderson and Aune (2008, entire) evaluated pregnancy rates based on presence of corpora lutea (CL) and fetuses in trapper-harvested wolverines from western Montana. That study found median CL counts for pregnant adults ranging from 1.6 to 3.0, depending on the subpopulation (Anderson and Aune 2008, p. 22), with a mean litter size based on number of fetuses for pregnant adult females of 2.6 (Anderson and Aune 2008, p. 23). Studies of telemetered female wolverine in Scandinavia, from 1993 to 2002, reported a mean litter size of 1.88, with a range of 1 to 4 young, with a mean annual birth rate of 0.74 young per female (Persson *et al*. 2006, pp. 76–77). More recently, the average number of young per female per year reported for wolverines in Sweden was 0.84 (range 0–3); however, for those animals with recorded denning behavior, this value increased to 1.38 (range 0–3) (Rauset *et al*. 2015, p. 3,157).

Results from studies of telemetered female wolverines indicate that studies of wolverine reproductive tracts are likely to overestimate wolverine productivity (Persson *et al*. 2006, p. 77). Their findings suggest that young are either lost during pregnancy, early after parturition, or both; the losses likely do not occur before implantation (Persson 2006, p. 77). ~~and/or shortly after birth, and are not likely to occur before implantation due, in part, to presumed delayed implantation (Persson 2006, p. 77). Delayed implantation (or reabsorption) of fetuses has been observed in other mustelids, including mink (Hansson 1947, p. 62; and references cited therein, pp. 65–66).~~ However, the factors that contribute to the observations that female wolverines do not give birth during some years are not well understood, and could be due to failure to breed, pseudo-pregnancy (as demonstrated by Mead *et al*. 1993, entire), failure of a fetus to implant, absorption of implanted fetus, stillbirth, or mortality before emerging from den (e.g. infanticide, etc.) (Magoun 2013, pers. comm.).

Carnivorous mammals generally have altricial young (poorly developed and dependent young (Derrickson 1992, p. 58)), and prepare shelter in dens where the mother can feed their young and keep them warm (Irving 1972, p. 174). Young wolverines (kits or cubs) weigh about 0.1 kg (3.5 oz) at birth and are blind until about 4 weeks of age (Krott 1960, p. 23). Newborns are covered with whitish to yellow hair (Krott 1958, p. 87; Mehrer 1976, p. 570), 4.5 millimeters (mm) (0.18 in) in length (Shilo and Tamarovskaya 1981, p. 147), with unerupted teeth (Mehrer 1976, p. 570; Pasitschniak-Arts and Larivière 1995, p. 5) and closed ear canals (Shilo and Tamarovskaya 1981, p. 147). ~~They are generally not left alone at the den during the first 3-4 weeks (Krott 1958, pp. 88, 108). A study of telemetered wolverines in Scandinavia found that, on average, a female wolverine spends most of her time within 1,000 m (3,281 ft) of the reproductive den during the denning period (Myhr 2017, no page number).~~

Mustelids, in general, have a short period of growth (Iversen 1972b, p. 317). As noted above, the metabolism of young wolverines is highest during the first 2.5 months, and individuals are almost two-thirds grown by the fall (at about 6 months) (Krott 1960, p. 25). As described by Shilo and Tamarovskaya (1981, p. 146), 45-50 day old wolverines~~cubs~~ (Norway) have woolly coats, are muddy grey in color, with teeth beginning to erupt at this age. At about 150 days, all permanent teeth have been established (Shilo and Tamaovskaya 1981, p. 147). After 2.5 months, young wolverines replace their juvenile coat with the adult summer coat (Shilo and Tamarovskaya 1981, p. 147). With growth ending at about 8 months (Iversen 1972b, p. 320; Magoun 1985, p. 23), wolverines~~cubs~~ are generally full grown by October or November.

Use of Dens and Denning Behavior

Dens and breeding burrows of animals are, in general, carefully constructed, well-camouflaged, and located in areas not easily accessible (Novikov 1962, p. 25). Wolverines use both natal dens (used for birthing) and maternal dens (used subsequent to natal den and before weaning) for rearing young (Magoun and Copeland 1998, p. 1,314). They are generally not left alone at the den during the first 3-4 weeks (Krott 1958, pp. 88, 108). ~~The average relocation distance to maternal den sites for active wolverine den sites studied in Norway was 268 m (879 ft) (95% confidence interval: 40–497 m (131–1,631 ft)) (May *et al*. 2012, p. 199).~~ The young remain at the natal den site for 6 to 8 weeks (Krott 1960, p. 24), and are weaned at 9 to 10 weeks

(Copeland 1996, p. iv (Central Idaho); Koskela *et al*. 2013a, p. 101 (Finland)) (*cf*. 7 to 8 weeks reported by Myhre and Myrberget, 1975, p. 754 (Norway)). After weaning, the young are dependent on the mother and begin to travel with her by late April (Koskela *et al*. 2013a, p. 101 (Finland)). Observations of wolverines in central Idaho reported that females traveled up to 17.9 km (11 mi) from maternal dens to forage (Copeland 1996, p. 97). A study of telemetered wolverines in Scandinavia found that, on average, a female wolverine spends most of her time within 1,000 m (3,281 ft) of the reproductive den during the denning period (Myhr 2017, no page number). The average relocation distance to maternal den sites for active wolverine den sites studied in Norway was 268 m (879 ft) (95% confidence interval: 40–497 m (131–1,631 ft)) (May *et al*. 2012, p. 199).

The exact timing of when females abandon natal dens and begin using maternal dens is difficult to establish (Inman *et al*. 2012b, p. 638). In general, studies have found that den abandonment (natal) occurs before May (Magoun and Copeland 1998, p. 1,315; Table 1; Inman *et al*. 2012b, p. 637; Figure 2). A study by Aubry *et al*. (2016, p. 24) reported that a female wolverine moved her single young (estimated to be at least 9 weeks old) from a natal den in *late April* in the North Cascades region of Washington. More recently, a comprehensive study of wolverines in Scandinavia found that females begin to shift den locations more frequently beginning in *late April* as young are more mobile and are more reliant on solid food brought to them by the mother (Aronsson 2017, p. 46). Natal den abandonment in Alaska and Idaho reportedly "coincided with a period when maximum daily temperatures rose above freezing for a number of days for the first time since denning commenced" (Magoun and Copeland 1998, p. 1,316). Factors other than temperature can influence shifts in the locations of these dens, including intraspecific predation, parasites, or other disturbances (Inman *et al*. 2012b, p. 638). In central Idaho, Copeland (1996, p. iv) concluded that human disturbance at maternal den sites resulted in den abandonment, but not abandonment *of young*.

Rendezvous sites are locations in which the female leaves young while she hunts for food, and from which they will not leave without her (Magoun 1985, pp. 16, 77). These areas provide security to young (Copeland 1996, p. 94) and serve as locations at which females bring food to the young, or from which she will guide them to a food source (Inman *et al*. 2012b, p. 638). Rendezvous sites of wolverines studied in central Idaho consisted of large boulder talus or riparian areas associated with mature overstory and dense timber deadfall (Copeland 1996, p. iv). Magoun (1985, p. 76) reported that rock caves and hilltops containing boulders without large snowdrifts were used as rendezvous sites in Alaska. Females may move their young to new rendezvous sites several times over a two month period (Magoun 1985, p. 73), and distances between consecutives sites have been reported as far away as 8.5 km (5.3 mi) (Magoun 1985, p. 76).

Studies of adult female wolverines in Scandinavia (northern Sweden) have provided additional details regarding the temporal patterns of reproductive behavior and den site use. Aronsson (2017, p. 45) (see also Persson *et al*. 2017, *in prep*) found that, in general, most births occurred in mid-February. Females spend very little time outside the natal den for the first 2 weeks (Aronsson 2017, p. 45). During the first period of den site use, or approximately 2 to 2.5 months from mid-February (when females generally give birth and are lactating), females will move short distances and do not need to bring food to young (Aronsson 2017, p. 46). This time period

generally coincides with snow cover and favorable conditions for food caching, and dens offer protection from predators and the environment (Aronsson 2017, p. 46). In addition, during the first 1.5 months of the denning period, females rarely changed den sites, but begin to move outside the den in early March (Aronsson 2017, p. 45). In the later denning period (after April 15), females begin to move more frequently and at greater distances between den sites (Aronsson 2017, p. 45). By late April, the young are more active and also begin to rely more on solid food that is brought back to them by their mother (Aronsson 2017, p. 46). This also corresponds to a time period when prey are more available (e.g., reindeer migration and calving period in Sweden and emergence of hibernating rodents in the spring (Yates and Copeland 2017, *in prep*) and expected shorter distance movements by the mother back to denning or rendezvous sites (Aronsson 2017, p. 46). These observations are consistent with Inman *et al*.'s (2012b, entire) proposed cold, low productivity niche for wolverines based on studies of wolverines in the Greater Yellowstone Ecosystem. That is, reproductive chronology in wolverines is considered to be adapted to take advantage of the availability of food resources, limited interspecific competition, and snow cover in the winter (Inman *et al*. 2012b, p. 635).

In summary, as described by Inman *et al*. (2012b, entire) and Persson *et al*. (2017, *in prep*), reproductive behavior of wolverines reflect seasonal shifts in resource abundance within the wolverine's range; that is, adaptation that matches the time of birth and development of young to changes in the availability of resources and foraging strategies (Persson *et al*. 2017, *in prep*). We present in Figure 4 a visual summary of wolverine feeding strategies relative to resource availability from time of birth to post-weaning.

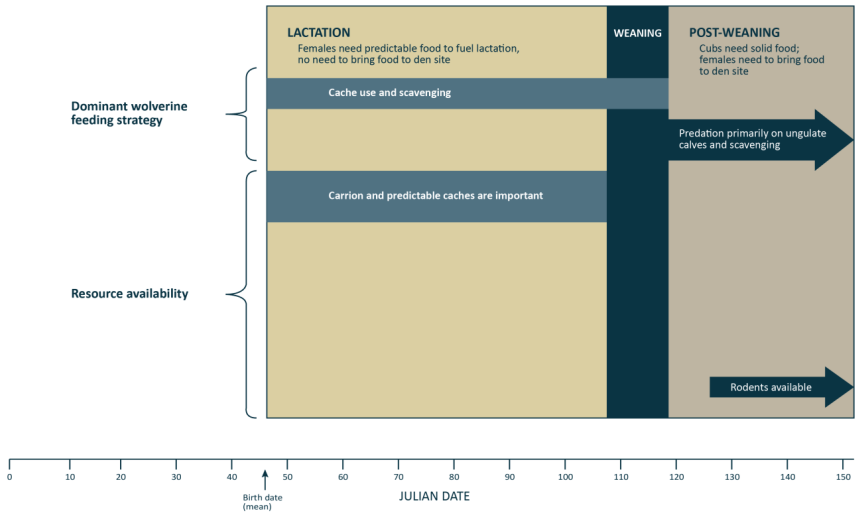

Figure ~~4~~5. Wolverine feeding strategies relative to resource availability. Adapted from Persson *et al*. 2017, *in prep*.

Denning Habitat

Given the wolverine's observed association with snow, we provide in **Box 1** a summary of the importance of snow, in general, for ecological systems. This summary provides a detailed perspective of how various physical properties of snow can influence ecological systems occupied by snow-adapted wildlife, including insulating properties, differences in snow cover in mountainous vs. forested habitat, and changes in snow cover due to wind and slope/aspect. ~~However, we also emphasize here that there have been limited comprehensive studies of wolverine behavior, or its physical and ecological requirements outside of the winter months in North America (*cf.* Banci 1987 (Yukon); Hornocker and Hash 1981 (Montana); Gardner 1985 (Alaska); Magoun 1985 (Alaska); Copeland 1996 (Idaho); Krebs *et al.* 2007 (Canada); Inman *et al.* 2013 (Greater Yellowstone Ecosystem)) due, in part, to the difficulty in tracking animals when snow cover is absent and their ability to move great distances across rugged terrain. In addition, den site locations for North America reported in the past have been biased to tundra regions where dens are more readily observed and located (Banci 1994, p. 110). In Scandinavia, snow cover has also been found to be a poor technique for tracking female wolverines during the time when they give birth and initiate denning (Aronsson and Persson 2016, p. 266).~~

Commented [BJG12]: Much of this section rearranged.

Commented [BJG13]: Do we want to keep this box? If so, I would move it and the reference to it after the second sentence of next (revised) paragraph – see below. (FYI – although some did not like the use of older studies, no one provided more current references)

Commented [SJ14]: I lean towards keeping it. Shows that not all snow is equal, and it varis within habitats, important to keep inmind when considering snow as it reltates to wolverines. Some of it is common sense, but good to attribute it to a citation a least.

Box 1. Snow Cover in an Ecological Context

Formozov (1961; 1963) prepared comprehensive reviews of the unique properties of snow in the context of its role in the ecology of animals and plants in Russia. In his 1963 review (translated from the 1946 original), he identified two important factors attributed to snow cover — nastization (the thickness of the crust on the surface of mature snow cover) and firnization (process of snow compaction) — relative to its ecological influence (Formozov 1963, p. 8). Snow cover provides not only a substrate that allows some animals to move across the landscape, it also provides a matrix within which other animals can create tunnels and build nests (Formozov 1963, p. 8). Additional fundamental concepts described in this study are provided below:

- Snow has very low thermal conductivity which promotes cooling at the surface while at the same time protects the deeper layers from chilling; but this property varies by region, by depth, by season, and by year (e.g., the more continuous the snow cover during winter, the greater the warming effect); as snow changes to ice (through compaction and melting), the thermal conductivity decreases (Formozov 1963, pp. 7, 8, 108)
- Snow therefore creates a thermo-insulating layer, which allows for a unique temperature regime on the surface and underneath; as an example, soil temperatures measured in January (near Saint Petersburg, Russia) averaged 15°C higher with snow cover than without snow cover, with up to a 32°C difference, depending on the day and depth measured (Formozov 1963, p. 109)
    - At 20–25 cm snow cover, the insulative effect is particularly important for winter nesting of small mammals (Formozov 1963, p. 110)
- Snow cover in mountains:
    - Depth of snow cover and its duration increases with elevation; even minor elevation differences are noticeable (Formozov 1963, p. 123)
    - This spotty distribution is also affected by unequal distribution of snow precipitation on slopes with different exposures, transport of snow by wind, melting of snow on sun-exposed slopes, avalanche or rolling down of snow from steeper areas, and vegetation (Formozov 1963, p. 123)
    - Snow cover areas near Arctic limits and at treeline in mountain regions is more strongly influenced by wind (which compacts and re-works snow cover) (Formozov 1963, p. 29)
- Snow cover in forests:
    - The maximum depth, density, duration and date of melting, thickness of snow surface crust are all much different in forested areas as compared to open treeless areas (Formozov 1963, p. 19)
    - Snow accumulates slowly under trees and is generally thicker the further away from the forest than within the forest; thus, the compaction and settling of snow under a forest canopy is less than tundra or open fields (with a less icy crust), so for some vertebrates, forested areas can provide a more preferable place to winter or migrate (Formozov 1963, pp. 24, 26)
    - Snow cover in forested areas also melts slower than open fields and clearings (Formozov 1963, p. 28)
- Snow cover also plays an important role in the overwintering conditions for insect eggs, caterpillars, pupae, and adult insects in litter and soil ~~, and some plants~~ (Formozov 1963,

~~Although it has been assumed that wolverines have an obligate relationship with snow for natal denning, including persistent spring snow cover, the key elements or combination of elements that define this relationship have not been empirically analyzed. As noted above, adult wolverines have a wide range of thermoneutrality. However, newborns, who are born with lighter, less dense fur are likely to have a more limited ability to control their internal temperature, though huddling (a thermotactic behavior) of small mammals in dens can conserve heat (Barnett and Mount 1967, p. 439). Relatedly, basal metabolic production of heat is the source of heat that maintains bodily warmth, and is not easily modifiable unlike the flexibility of insulation (Irving 1972, p. 121). However, metabolic heat above an animal's basal rate for preservation of warmth is restricted by its limited capacity for metabolic production of heat, but also by food availability and the time and opportunity for nourishment (Irving 1972, p. 121). In general, metabolic production of heat is costly to animals, but variable insulation represents a conservative strategy (Irving 1972, p. 121).~~

~~Another key element related to den location is the protection that dens provide to a nursing female and her young. Because wolverines are known to den in a variety of structures, it is unclear if the apparent relationship to snow cover is based on selecting den locations in remote, high elevation areas to avoid predators. Bare rock and boulders at den sites can offer dry and secure cavities and enhance the ruggedness of the landscape (May *et al*. 2012, p. 198). "Ruggedness," a measure derived from elevational changes and irregularity of land surface (density of contour lines) traversing a given area (Beasom *et al*. 1983, p. 1,163) has been found to be an important variable (i.e., secure habitat from predation risk) for female wolverines in winter (British Columbia, Canada) (Krebs *et al*. 2007, p. 2,188) and for den site selection at site-specific, home range, and landscape scales (southcentral Norway) (May *et al*. 2012, pp. 200–201).~~

Wolverine denning habitat varies over ~~across~~ its Holarctic range and is dependent on regional environmental conditions. For example, in southcentral Norway, wolverine dens were snow tunnels dug into deep snow at the tree line (elevation 1,100 m (3,609 ft)), but most of the tunnel systems extended down to boulder fields, talus slopes, or rock crevices such that young could crawl around within these structures (May *et al*. 2012, p. 201). Snow tunnels are also reported for wolverine natal dens in Alaska (Magoun 1985, pp. 84, 185, 190). However, reproductive dens are not always excavated in deep snow. In Canada, female wolverines are said to give birth in dens where snow cover persists at least until April, and can den under snow-covered rocks, logs, or within snow tunnels (COSEWIC 2014, p. v). As an example, in northwestern Ontario, den site habitat for a female in lower Boreal Forest habitat (elevation 250 to 500 m (820 to 1,640 ft), 51°N) included large boulders and downed trees, similar to dens described for wolverines in montane ecosystems (Dawson *et al*. 2010, p. 139). Large diameter, downed trees can also provide structure for den sites. In Finland, Pulliainen (1968, p. 340) reported a den site (January) at the base of a tree and not covered in snow, and also described other structural features such as rocks, fallen trees, and deep ravines as denning habitat (likely both natal and maternal dens) (Pullianinen 1968, pp. 338–341). In Russia, where wolverine habitat has been described as located far from human-inhabited areas within boreal forests and, to some extent, tundra, and taiga (Novikov 1962, pp. 199, 200), den locations were described as "clefts in rocks, among stones, and under roots of upturned trees" (Novikov 1962, p. 200). A study from northwestern Ontario noted that, because lowland boreal forest habitat in this region does not support deep,

wind-hardened snowdrifts, other structural elements within snow layers such as trees and boulders can be important components of wolverine denning habitat (Dawson *et al*. 2010, p. 142).

Although it has been assumed that wolverines have an obligate relationship with snow for natal denning, including persistent spring snow cover, the key elements or combination of elements that define this relationship have not been empirically analyzed. Limited studies to date have evaluated the importance of denning habitat to reproductive success, or the key physiological and ecological characteristics, including avoidance and/or protection from predators, prey availability, availability of caching habitat, that define denning behavior and den site selection. Population density, trapping pressure, population genetics, and other measures of habitat quality may also influence wolverine fecundity (Anderson and Aune 2008, p. 28). Habitat features that facilitate caching (e.g., restricted access and cold temperatures) are also likely to be important for wolverine reproduction (Inman *et al*. 2012b, p. 640). ~~In addition, s~~Studies of wolverine denning activity have not reported the condition of the natal or maternal den location following abandonment; that is, what is the persistence and/or depth of snow at the natal den at the end of the denning season, and how does this affect survival of young? In addition, previous accounts of den site locations for North America have been biased to tundra regions where dens are more readily observed and located (Banci 1994, p. 110). In Scandinavia, snow cover also had been found to be a poor technique for tracking female wolverines during the time when they give birth and initiate denning (Aronsson and Persson 2016, p. 266).

As noted above, adult wolverines have a wide range of thermoneutrality. However, newborns, who are born with lighter, less dense fur are likely to have a more limited ability to control their internal temperature, though huddling (a thermotactic behavior) of small mammals in dens can conserve heat (Barnett and Mount 1967, p. 439). Relatedly, basal metabolic production of heat is the source of heat that maintains bodily warmth, and is not easily modifiable unlike the flexibility of insulation (Irving 1972, p. 121). Metabolic heat above an animal's basal rate for preservation of warmth is restricted by its limited capacity for metabolic production of heat, but also by food availability and the time and opportunity for nourishment (Irving 1972, p. 121). In general, metabolic production of heat is costly to animals, but variable insulation represents a conservative strategy (Irving 1972, p. 121).

A bioclimatic model was used by Copeland *et al*. (2010, p. 234) to test the following hypothesis: "…wolverine distribution at the broadest spatial scale is constrained within a climatic envelope defined by an obligate association with persistent spring snow cover and by an upper limit of thermoneutrality." ~~However,~~ T~~t~~his hypothesis was based on the premise "If persistence of wolverine populations is linked to the availability of suitable reproductive den sites ([citing] Banci 1994), snow cover that persists throughout the denning period may be a critical habitat component that limits the wolverine's geographic distribution" (Copeland *et al*. 2010, p. 234). The authors tested this hypothesis by "comparing and correlating the locations of wolverine reproductive dens from throughout their circumboreal range, and telemetry locations from 10 recent wolverine studies in western North America and Scandinavia, with spatial models representing the distribution of spring snow cover and average maximum August temperatures" (Copeland *et al*. 2010, p. 234).

Bioclimatic models "use associations between aspects of climate and known occurrences of species across landscapes of interest to define sets of conditions under which species are likely to maintain viable populations" (Araújo and Peterson 2012, p. 1,527). They are correlational by nature and are often applied to study a variety of conservation issues, including forecasting potential climate change effects on species' distributions (Araújo and Peterson 2012, p. 1,527). ~~However, these~~These types of correlational models have received some criticisms and require careful framing to avoid misapplication (Sieck *et al*. 2011, p. 6; review by Araújo and Peterson 2012, entire). They generally represent a first step for evaluating current and future species distributions, and, when coupled with climate change scenarios, results are presented at a coarse scale that may not accurately project shifts in species distribution at a smaller scale (Sieck *et al*. 2011, p. 6). In particular, when used to estimate extinction risk, these types of models provide only an estimate of the empirical relationships between a species' current distribution and climate variables and then use inferred relationships to identify potential areas where the species is distributed under future climate scenarios (Araújo and Peterson 2012, p. 1,553). Extinction risk is not represented in the model's input data and therefore is not the targeted parameter of the model; thus, a bioclimatic model's usefulness may be limited in these types of applications given that it only offers partial explanatory evidence for reasons for potential extinction related to the shifts in climate suitability within the time frame being modeled (Araújo and Peterson 2012, p. 1,533 and citations therein). In addition, climate niche projections generally do not incorporate factors such as competition, dispersal, and evolutionary capacity, which also influence range boundaries (Michalak *et al*. 2017, p. 370). Thus, these types of models are more applicable at broad scales in which the effects of fine-scaled topography and biological interactions play a more limited role (Michalak *et al*. 2017, p. 370); however, both of those factors are important for wolverine, particularly at the den-site scale.

Commented [SJ15]: Not sure I get the wording here. Are we saying that broad scale models, like Copeland, do not reflect/explain fine-scaled topography and biological interactions?

~~Finally, Post (2013, p. 50) suggested that the niche conservatism approach may not be appropriate in predicting changes to species' distributions under future climate change scenarios. He concluded that, based on redistribution patterns of flora and fauna throughout the Pleistocene epoch, but particularly the Late Pleistocene period of rapid warming, species movement is not always predictable in directions or rates based simply on their association with the more predictably changing environmental/abiotic measures.~~

Commented [SJ16]: Why'd we take this out?

As noted above, Copeland *et al*. (2010, entire), used a bioclimatic model to evaluate an assumed association not at the den site scale, but at a broad scale. The results presented in Copeland *et al*. (2010, entire) were based not on the condition of snow cover at a particular den site at the time of denning, but rather their evaluation of snow persistence (April 24 to May 15) was based on satellite images summed over a 7-year period (2000 to 2006) for the den locations. The spatial resolution of the snow measurement used to detect daily snow cover was 500 m by 500 m (1,640 ft by 1,640 ft), using Moderate-Resolution Imaging Spectroradiometer (MODIS). If persistent snow cover was observed in any one year, it was included in the bioclimatic model regardless of whether denning occurred during that particular year.

In addition, although the study found that 69 percent of dens for North American wolverines were located within satellite images (pixels) in areas that had snow cover for 6 or 7 years, out of ~~–~~7 years, ~~just over~~ one-third (31 percent) of the identified den locations were located in areas that

were identified as having spring snow cover 5 years or less, out of 7 years (from April 24 to May 15). However, snow depth was not defined in Copeland *et al*. (2010). Also, the den location attributes (e.g., den structure, how long it was used) were not recorded relative to the observed persistent snow cover and some of the ~~560~~ 562 dens (e.g., Norway) were identified by snow tracking rather than direct observation.

In ~~essence,~~summary the results presented by Copeland *et al*. (2010, entire) provided a fairly accurate, albeit broad, ~~, though preliminary,~~ assessment at that time of where wolverine populations are expected to be observed, but did not evaluate (model) snow persistence at the den site scale based on location and denning period.

Commented [SJ17]: Yea or nay?

~~We also note here that results from group scoring exercises using modified (no consensus) Delphi techniques (i.e., group discussions followed by group scoring exercises with points allocated for beliefs on wolverine habitat needs and behavior, as well as uncertainty in allocation of points) of a panel of scientists convened by the Service in April 2014 (Wolverine Science Panel Workshop), indicated that most panelists allocated points to an obligate relationship of wolverines with deep snow at the den-site scale, but there was a wide range of scores from the panel as to whether contiguous snow was limiting at the home-range or species-range scales (Wolverine Science Panel Workshop Report 2014, pp. 9–11).~~

Since the 2013 (78 FR 7864; February 4, 2013) proposed listing rule and 2014 (79 FR 47522; August 13, 2014) withdrawal of the proposed listing rule ~~proposed rules~~ for the wolverine, several publications have presented additional study results related to wolverine distribution and snow cover. In Alberta, Canada, Webb *et al*. (2016, entire) found that, based on wolverine harvest data, wolverine occurrence (but not reproductive den sites) relative to spring snow cover (percent of area covered, with greater than 75 percent snow coverage, on April 1 and 15) varied based on the different regions of Alberta. This study used meterological data from 2009 to 2015, in northern Alberta (north of 54°N) and differentiated between spring snow cover that persisted in ≥ 1 of 7 years and more frequently (≥4 of 7 yr) (Webb *et al*. 2016, pp. 1462–1464). Although the study found an overall positive trend of more frequent wolverine harvests in those areas expected to have spring snow cover, the study did not find consistent large differences between these areas, and did not typically detect significant relationships with frequent spring snow cover (4–7 years) in all regions (Webb *et al*. 2016, p. 6). The Rocky Mountains region was the only region in which wolverines were reported in areas with more frequent spring snow cover (4–7 years) (Webb *et al*. 2016, p. 5). This region, which is located along the western border of Alberta, contains montane, subalpine and alpine habitat, with elevations from 1,000 m (3,281 ft) to 3,700 m (12,139 ft) (Webb *et al*. 2016, p. 9). Conversely, the study found that in the Boreal Forest region of Alberta (i.e., wetland habitat interspersed with coniferous, mixed wood, and deciduous forests, with elevations between 1,500 m (4,921 ft) to 1,100 m (3,609 ft)), a female wolverine denned under large boulders and downed trees (Webb *et al*. 2016, p. 8). Further, the study reported that all female wolverines that were positively identified from camera trapping (including five lactating females) were found in townships where no spring snow cover was predicted (Webb *et al*. 2016, p. 1,461).

Results from another recent Alberta study (Heim *et al*. 2017, entire) evaluated cumulative effects of climate and landscape change, using species distribution models, relative to the spatial distribution of the wolverine. Persistent spring snowpack was a significant predictor for

wolverine distribution as was anthropogenic landscape changes (Heim et al. 2017, p. 8,908; Table 2). The study found that a cumulative effects model provided the best support for predicting wolverine frequency, which suggests that no single factor explains wolverine distribution (Heim *et al*. 2017, p. 8,908).

The study presented in Webb *et al*. authors noted that wolverine den locations within low elevation, forest habitats have not been well-described (Webb *et al*. 2016, p. 8). As noted above (Novikov 1962, p. 200), iIn boreal forested habitat in Russia, Novikov (1962, p. 200) reported wolverines denning in rock areas and in tree root structures. A similar finding was reported in Sweden, where a majority of dens (n=49) were in boulder areas located within mature, mixed coniferous forests (i.e., not alpine or tundra habitat) (Makkonen 2015, p. 14); all den sites provided cover for young *without snow* (Makkonen 2015, p. 17). A recently published study reported two wolverine natal dens in logged areas (cutblocks) in northern Alberta, Canada; specifically, within a slash pile and log deck (Scrafford *et al*. 2017, p. 35).

A study of wolverine populations and distribution in Sweden observed that wolverine populations were found outside areas with persistent spring snow cover (mean snow depth and proportion of years with snow cover on March 15; 1961–1990) and expanding into boreal forest habitat located to the east and south of alpine areas (Aronsson and Persson 2016, p. 266). This southern and eastern expansion (from 1996 to 2014) indicates recolonization of their historical distribution in Sweden, and is thought to be the result of an increase in population, with more dispersers colonizing forest habitat, and an increase in year-round scavenging opportunities due to an increase in Scandinavian wolf packs (Aronsson and Persson 2016, p. 266; Aronsson 2017, pp. 43–44). As of the spring of 2017, over 80 reproductive dens have been observed outside the boundary of the snow model presented in Copeland *et al*. (2010) (Persson 2017, pers. comm.). Similarly, in Finland, Koskela (2013, p. 38) found that 10 observed wolverine dens observed were determined to be "snow dens," but 8 of the 10 dens were located in areas outside the Copeland *et al*. (2010) modeled, satellite-based spring snow cover area.

Another key element related to den location is the protection that dens provide to a nursing female and her young. Because wolverines are known to den in a variety of structures, it is unclear if the apparent relationship to snow cover is based on selecting den locations in relatively inaccessible, high elevation areas to avoid predators. Bare rock and boulders at den sites can offer dry and secure cavities and enhance the ruggedness of the landscape (May *et al*. 2012, p. 198). "Ruggedness," a measure derived from elevational changes and irregularity of land surface (density of contour lines) traversing a given area (Beasom *et al*. 1983, p. 1,163) has been found to be an important variable (i.e., secure habitat from predation risk) for female wolverines in winter (British Columbia, Canada) (Krebs *et al*. 2007, p. 2,188) and for den site selection at site-specific, home range, and landscape scales (southcentral Norway) (May *et al*. 2012, pp. 200–201).

Snow depth can be affected at a local level by terrain, ruggedness, slope and aspect as well as wind and vegetation cover. For example, ; slope and aspect together will affect the exposure to snow accumulation (May *et al*. 2012, p. 198). In an effort to document and compare snow persistence at the wolverine den-site scale, Magoun *et al*. (2017, entire) evaluated the use of low-altitude aerial photography during late May 2016 in areas within the Rocky Mountains (Idaho and Montana) and northwestern Alaska. In Idaho and Montana, flight lines were established along transects through the long axis of previously documented home ranges of denning female

wolverines and, in Alaska, known den sites (from 2016) were visited by helicopter and remaining snow was photographed (Magoun *et al*. 2017, p. 383). Transect segments in the Rocky Mountain study areas documented snow on May 31 in all but one segment, with 82 percent classified in low to heavy snow retention categories, and 58 percent considered as moderate to heavy (Magoun *et al*. 2017, p. 383). In the Alaska study area, photographs documented widely scattered patches of snow on May 29, with remnant snowdrifts observed at all four wolverine den sites (Magoun *et al*. 2017, p. 383). The documentation of the existence of scattered patches of snow in the Rocky Mountains persisting into late May in areas previously detected to be bare of snow on May 29 (MODIS persistent spring snow cover, McKelvey *et al*. 2011, p. 2,889, Figure 4D; Magoun *et al*. 2017, p. 384, Figures 2b and 2d) suggests that persistent spring cover may not always be detectable at the den-site scale using remote sensing methods (Magoun *et al*. 2017, p. 384)~~, and is affected by terrain, ruggedness, slope, and aspect~~.

Commented [SJ18]: …such as those used in Copeland, etc.?

To evaluate, at a finer scale, -snow cover at previously recorded den site locations in the western United States, we reviewed natal, maternal, and known den sites relative to derived 'melt-out' dates using MODIS/Terra Snow Cover, 8-day series (Hall and Riggs 2016). Melt-out dates represent the first day of the 8-day composite series when the cell in which the den was located switches from "snow" to "no snow." Snow cover was identified using the Normalized Difference Snow Index (NDSI), on a scale of 0 to 1.0, where NDSI greater than 0.1 is considered "snow." The spatial resolution for these data is 500 m by 500 m (1,640 ft by 1,640 ft). Because MODIS data was only available from the years 2000 to present, we were only able to evaluate 34~~21~~ of the 47~~34~~ den sites documented in our records. As shown in Table 3, the earliest melt-out date was May 14 (2006) and the latest was July 12 (2002).

Table 3. Wolverine Den Site Melt-Out Dates, 2002–~~2008~~2015.

Den #	Den Type	Melt-out Date	Elevation, meters (feet)	Structure	State
1	Unknown	7/12/2002	1,814 m (5,951 ft)	None Listed	WA
2	**Natal**	5/25/2003	1,928 m (6,326 ft)	Log Complex	MT
3	Maternal	5/25/2003	1,995 m (6,545 ft)	Log Complex	MT
4	**Natal**	6/4/2004	1,807 m (5,923 ft)	Log Complex	MT
5	**Natal**	6/9/2004	2,399 m (7,871 ft)	None Listed	WY
6	**Natal**	6/17/2004	2,487 m (8,160 ft)	None Listed	MT
7	Maternal	6/29/2004	1,823 m (5,981 ft)	Downed Log	MT
8	Maternal	6/29/2004	1,893 m (6,211 ft)	Log/Boulder	MT
9	Maternal	6/11/2005	1,912 m (6,273 ft)	Spider Tree	MT
10	Maternal	6/11/2005	1,973 m (6,473 ft)	Spider Tree	MT
11	**Natal**	6/11/2005	1,977 m (6,486 ft)	Spider Tree	MT
12	**Natal**	7/12/2005	2,693 m (8,835 ft)	None Listed	MT
13	Unknown	5/14/2006	1,514 m (4,967 ft)	Log Complex	MT
14	Unknown	5/25/2006	2,093 m (6,867 ft)	None Listed	MT
15	Maternal	5/31/2006	1,851 m (6,073 ft)	Log Complex	MT
16	**Natal**	5/31/2006	1,843 m (6,047 ft)	Log Complex	MT
17	Unknown	6/7/2006	2,252 m (7,389 ft)	None Listed	MT

18	**Natal**	6/18/2006	2,695 m (8,842 ft)	None Listed	MT
19	**Natal**	5/25/2007	2,820 m (9,252 ft)	None Listed	MT
20	**Natal**	6/4/2007	1,922 m (6,306 ft)	Log/Boulder	MT
21	Unknown	7/3/2008	2,505 m (8,219 ft)	None Listed	ID
22	**Natal**	6/26/2010	2,276 m (7,466 ft)	Boulder/Downed Log	ID
23	**Natal**	6/18/2010	2,216 m (7,270 ft)	Boulder	ID
24	**Natal**	6/26/2010	2,223 m (7,293 ft)	Boulder/Talus Field	ID
25	Unknown	6/26/2010	2,402 m (7,882 ft)	Boulder	ID
26	**Natal**	7/4/2011	2,167 m (7,110 ft)	Tree Complex	ID
27	Unknown	7/4/2011	2,130 m (6,989 ft)	Tree Complex	ID
28	Unknown	7/4/2011	2,147 m (7,043 ft)	Tree Complex	ID
29	**Natal**	6/9/2012	2,311 m (7,582 ft)	Log Complex	ID
30	Unknown	6/25/2012	2,318 m (7,604 ft)	Downed Log Complex	ID
31	Unknown	6/9/2012	2,350 m (7,711 ft)	Downed Log Complex	ID
32	**Natal**	6/10/2013	2,911 m (9,552 ft)	Boulder Field	ID
33	**Natal**	6/26/2014	2,218 m (7,278 ft)	Boulder Field	ID
34	**Natal**	6/10/2015	2,713 m (8,901 ft)	Boulder Field	MT

For *natal* den sites only, the range for melt-out dates was May 25 to July 12. All of these sites indicate a melt-out date that is past the May 15 date used for the persistent spring snow cover model presented in Copeland *et al*. (2010), which suggests that snow is persistent at these locations past the time when young begin moving out of natal dens (i.e., late April; see Use of Dens and Denning Behavior section). ~~Additional studies are needed to further document wolverine den structure, snow conditions at dens, and how long dens are used, particularly for those locations outside of areas expected to have spring snow cover, to better understand the relationship of wolverines and snow cover (Webb *et al*. 2016, p. 8; Magoun *et al*. 2017, pp. 6–7).~~

Commented [SJ19]: But what does this mean? What are we getting at here?

Other physical or biotic variables are also likely to be important for wolverine den site locations. Elevation affects snow depth and persistence at the landscape scale (May *et al*. 2012, p. 198). Inman *et al*. (2012a, p. 782) found that wolverines (12 females and 6 males) monitored in the Greater Yellowstone Ecosystem selected, on an annual basis, areas above 2,600 m (8,530 ft) latitude-adjusted elevation. In central Idaho, natal dens were also found in secluded, high elevation (above 2,500 m (8,202 ft)) cirque basins (Copeland 1996, p. 94).

We evaluated ~~34~~ 47 den sites in the lower United States using a linear regression model to evaluate whether the elevation of wolverine den sites is related to latitude. We note here that not all of these dens were characterized as to whether they were natal or maternal dens, ~~and~~ a few records were not verified through tracking of females or direct observations, and these den locations may not be representative of all current or potential wolverine den sites in the western-northwestern United States. Given these caveats, our examination of these records indicated that, in general, wolverine dens at lower latitudes (36 to 38°N) occur at higher elevations (range: 2,688 to 3,562 m) (8,819 to 11,686 ft) while the converse is seen for those dens at higher

latitudes, or approximately 44 to 49°N (range: 1,514 to 2,911~~2,820~~ m) (4,967 to 9,552~~252~~ ft). Given our assumptions (small sample size, test of normality~~ (i.e., Shapiro test for elevation is just met)~~), we used linear regression (R Software; R Development Core Team, 2014) to test this association. We found a moderately significant association with elevation and latitude [adjusted R^2 = 0.~~76~~68.56, *F* = ~~108.1~~101.3, *df*~~=32~~45; *p-value* = ~~8.24 x10~~4.23 x 10^{-12}~~13~~], such that dens found at lower elevations were located at ~~were associated with~~ more northerly~~higher~~ latitudes. ~~However, t~~These results ~~of this simple model indicate that 76 percent of the elevation for this sample is explained by latitude; thus,~~suggest that other potential explanatory variables or interactions between variables should be considered using multiple regression techniques.

Commented [SJ20]: Explanatory variables for den site selection? Wolverine distribution?

The steep slopes found at higher elevations also provide conditions conducive to avalanches, which result in debris and talus/boulder piles that provide structure for dens (Inman 2013, pers. comm.). Steep slopes and the availability of rocks were found to be important to wolverine den site selection for wolverines studied in Norway (May *et al*. 2012, p. 200). These areas also offer either exclusive or higher frequencies of maternal food sources during the high energy demands for reproducing females, such as marmot emerging from hibernation and neonatal or avalanche-killed ungulates (Inman 2013, pers. comm.) (see *Diet and Feeding* discussion below).

In summary, wolverines select den sites for different characteristics depending on location. Dens located under snow cover may be related to wolverine distribution based on other life history traits, including morphological, demographic, and behavioral adaptations that allow them to successfully compete for food resources (Inman 2013, pers. comm.). Structure (e.g., uprooted trees, boulders and talus fields) appears to be ~~essential~~ important for natal den sites with or without snow cover. Sensitivity to human disturbance and predator avoidance are also likely important factors in selecting both natal and maternal den sites. However, reproductive success of wolverines has not been evaluated relative to the depth and persistence of snow cover, or in combination with these or other important characteristics, including prey availability and predator avoidance. Based on their study of wolverines in Alberta, Canada, Webb *et al*. (2016, p. 1,468) concluded that wolverines appear to be are adaptable and do not require large areas of deep spring snowpack for successful reproduction. They suggest that "wolverines may select small areas covered with deep snow at a finer scale than can be detected using satellite imagery, but the amount of snow needed over what portion of the denning duration remains uncertain" (Webb *et al*. 2016, p. 1,468, citations omitted). They add that temperature may play a more important role in determing the distribution of wolverines and restricting the wolverine's niche to cooler environments where wolverines have the competitive edge (citing Aubry et al. 2007, Copeland et al. 2010, Inman et al. 2012) (Webb *et al*. 2016, p. 1,468). Additional studies are needed to further document wolverine den structure, snow conditions at dens, and how long dens are used, particularly for those locations outside of areas expected to have spring snow cover, to better understand the relationship of wolverines and snow cover (Webb *et al*. 2016, p. 8; Magoun *et al*. 2017, pp. 6–7).

Commented [SJ21]: ?

Demography

The lifespan of the wolverine is variable. Jackson (1961, p. 361) reported an upper range of 8–10 years in the wild and potentially up to 18 years in captivity. Based on trapper-submitted carcasses from the Yukon, an upper age of 11.9 years for a male wolverine and 12.9 years for

(pregnant) female was reported (Jung and Kukka 2013, pp. 8, 12). Inman *et al*. (2012a, p. 781) classified wolverines less than 1 year old as juveniles (or kits/cubs), those 1 to 2 years old as subadults, and those at least 3 years old as adults. Generation time for wolverines has been estimated at 7.5 years (COSEWIC 2014, p. 23).

Survival of adult female wolverines is considered to be an important demographic parameter in the wolverine's life history (Sæther *et al*. 2005, entire). As noted by Aronsson (2017, p. 13), because most polygamous species display a dispersal pattern that is sex-based, their population distribution is generally limited by the dispersal behavior of the sex that is more philopatric (the tendency of a species to remain within or return to its birth area). Thus, the distribution of wolverine populations and colonization is generally limited by dispersal of female wolverines (Aronsson *et al*. 2017, p. 2).

Stochastic factors (both demographic and environmental) also strongly influence the population dynamics of the wolverine (Sæther *et al*. 2005, p. 1,011–1,012). Given the rapid maturity of young wolverines, survival of female wolverines with young is likely dependent on the availability and distribution of food sources during the "snow-free season" (late spring and summer) (Banci 1994, p. 114). For example, a study of wolverines in Norway found that survival of young was primarily influenced by the abundance of small rodents (Landa *et al*. 1997, p. 1,293).

Evaluating how variations in demographic rates are influenced by the interactions between costs of reproduction, individual quality (e.g., breeding status), and environmental factors can provide a better understanding of the dynamics and viability of animal populations (Robert *et al*. 2012; p. entire; Rauset *et al*. 2015, entire). The interactions between individual age, environmental resources, and reproductive costs of wolverines in Sweden were recently examined (Rauset *et al*. 2015, entire). The results of this study provide important details regarding the influences on wolverine reproduction productivity. The study found that age-related variation in reproductive output for female wolverines is driven by the interactions between age, reproductive costs, and availability of resources (Rauset *et al*. 2015, p. 3,160). As an example, female wolverines were found to be more likely to give birth and nurse young in home ranges with greater food resource abundance at the time of fetal development (Rauset *et al*. 2015, p. 3,158). The study also concluded that a favorable reproductive strategy for female wolverines is a conservative one, wherein older female wolverines do not "trade" current reproduction against their own survival (Rauset *et al*. 2015, p. 3,161).

Intraspecific predation of wolverines is another important influence on wolverine population dynamics (Persson *et al*. 2003, p. 26). The altricial life history stage (early May to end of July) is likely a period of high juvenile mortality in solitary carnivores, such as the wolverine, since females are balancing the energetic demands of lactation (Sadleir 1984, pp. 179–180) and providing protection to young (Persson *et al*. 2003, p. 22). Young (juveniles) wolverines are vulnerable to predation during the time period when left unattended in the natal den (generally March-April) and when they first exit the natal or maternal den and are left at rendezvous sites, or around May-early July~~June~~ (Magoun 1985, pp. 49, 73, 77). An additional vulnerability occurs when juvenile wolverines are required to become nutritionally independent and begin

exploratory movements away from their mother's protection, generally August-September (Vangen *et al*. 2001, p. 1,644).

Mortality

There are a few natural predators of wolverines, but interactions with wolves can lead to severe injury and death (Burkholder 1962, p. 264; Banci 1987, pp. 81, 91; White *et al*. 2002, p. 132). Predation deaths from interactions with American black bears (*Ursus americanus*) have ~~also~~ been documented (Inman *et al*. 2007, p. 89). Mountain lions are suspected of killing wolverines (Copeland 1996, p. 46; Krebs *et al*. 2004, p. 497; Aubry *et al*. 2016, pp. 27, 32). Starvation has also been identified as a cause of mortality in wolverines (Hornocker and Hash 1981, p. 1,296; Banci 1987, pp. 91, 110; Krebs *et al*. 2004, p. 497). Intraspecific predation also contributes to wolverine deaths. Persson *et al*. (2003, p. 25) found that juvenile survival rates tended to be lower during the altricial period (May–July), and intraspecific predation was the most common cause of mortality, occurring either as infanticide or after independence. Avalanches have also been documented as a cause of wolverine deaths (Inman *et al*. 2007, p. 89).

In North America, anthropogenic causes of mortality for wolverine populations include hunting, trapping, and road kill. Discussion of the effects of hunting, trapping, and human development is provided below (see Biological Status–Current Condition section).

Commented [SJ22]: …(including roads)?

Diet and Feeding

Wolverines have been described as opportunistic foragers (Inman *et al*. 2012b, p. 639) and as a "seasonal scavenger on the fringe of the food web" (Larsen 1980, p. 399). They are both scavengers and predators, with a diet that varies between seasons and years, and switching between food sources depending on availability (Magoun 1987, p. 396; Cardinal 2004, pp. 19–22; Mattisson *et al*. 2016, p. 9). The term "polyphagous" was used by Landa *et al*. (1997, p. 1,292) to describe the switching of food sources depending on prey availability by wolverines. Regional variations in diet have also been observed for wolverine populations (Nunavut, Canada) (Awan and Szor 2012, p. 9). The availability of ungulate carrion is believed to be more important than a particular habitat type for wolverines (Cardinal 2004, p. 20).

Early studies from northwestern Montana using scat analysis found that carrion (deer or elk) was an important component of wolverine diet (Hornocker and Hash 1981, p. 1,297). However, during winter, hoary marmots (*Marmota caligata*) were also important food items consumed and, in the spring, Columbian ground squirrels (*Urocitellus columbianus*) were heavily preyed upon (Hornocker and Hash 1981, p. 1,298). As reported by Cardinal (2004, pp. 20–21), wolverines in Canada have a large and varying diet based on reports from aboriginal traditional knowledge holders; in addition to large animals as prey or carrion, wolverine diet includes rabbits and ptarmigans (*Lagopus* sp.), porcupine (*Erethizon dorsatum*), mice, beaver (*Castor canadensis*), fish, ducks, seals, gulls and gull eggs, and lemmings, as well as antlers, bones, and skulls. Native mountain goats (*Oreamnos americanus*) and bighorn sheep (*Ovis canadensis*), that occupy high elevation winter ranges in portions of North America, have also been suggested as important components of wolverine winter diet, particularly during the reproductive denning

period (Buell Environmental 2016, pers. comm.). Snowshoe hares may also be an important food item for wolverines in parts of Canada (Jung and Kukka 2013, p. 20).

In northwestern Alaska, analyses of wolverine winter diet using carcasses collected from hunters (1996–2002) within the migratory range of the Western Arctic Caribou Herd found that caribou represented the most common food item, likely through scavenging behavior, followed by moose (*Alces alces*), and to a lesser degree, microtine rodents, Arctic ground squirrels (*Spermophilus parryii*), porcupines, wolverines, red fox (*Vulpes vulpes*), sheep and ptarmigan (Dalerum *et al*. 2009, p. 249). One study ~~year~~ found stomach contents contained a large portion of muskoxen (*Ovibos moschatus*) and Dall's sheep (*Ovis dalli*) (Dalerum *et al*. 2009, p. 249). ~~Wolverines were found to be the main predator of caribou calves (less than 14 days of age) in northern British Columbia, Canada (Gustine *et al*. (2006, pp. 13–14).~~ Wolverine diets in winter (scat analysis) and summer (primarily direct observation) were evaluated by Magoun (1987, entire) in northwestern Alaska. Results from that study indicate a large number of Arctic ground squirrels were eaten in summer, while the winter diet consisted primarily of caribou and Arctic ground squirrels (Magoun 1987, p. 393). Scavenging was found to be an important feeding strategy in winter, including remnants of buried caribou carcasses or bone/hide in the tundra (Magoun 1987, p. 396).

Food habits of wolverines from 2002 to 2007 in Glacier National Park were evaluated by Yates and Copeland (2017, *in prep*) by reviewing prey remains and scat samples, or direct observations of feeding behavior. Their scat analysis found that 72 percent of samples contained more than one prey species, and 89 percent contained plant material, primarily conifer needles (Yates and Copeland 2017, *in prep*). The latter may be related to scent-marking behavior of territories, either by defecation after chewing on twigs/shrubs or terpenes released during urination (Wood *et al*. 2009, p. 574), or the result of stomach contents found within their consumed herbivorous prey (Yates and Copeland 2017, *in prep*). Overall, deer and elk represented the most frequent prey item (37 percent), but hibernating rodents were also common in scats (36 percent). Other prey items included mice, voles, lemmings, bovids (e.g., bighorn sheep, mountain goat), birds, and hares (Yates and Copeland 2017, *in prep*). Temporal differences in the occurrence of prey were also observed.

Snow tracking in Montana found that wolverines hunted in brush piles, log jams, and heavy cover, and routinely entered "tree wells," areas immediately under dense, low growing conifers where snow does not accumulate, that provide easy access to small, ground-dwelling mammals (Hornocker and Hash 1981, p. 1298). Wolverines have been described as moving and lifting large stones in order to access human-cached meat (Freuchen 1935, p. 98).

Several foraging strategies have been described for wolverines. Predation behavior on reindeer (Sweden) was detailed by Haglund (1966, p. 275). A study of elk in Siberia, Russia, noted that, in most instances, wolverines will attack young, pregnant females, young of the year, and wounded or sick animals (Knorre 1959, p. 27). Elk were chased, sometimes by two wolverines during periods of heavy snow (Knorre 1959, pp. 10, 27) and wolverines have been observed feeding in groups on large animal carcasses (Cardinal 2004, p.21). However, wolverines have

been described as neither an effective predator of large game animals, nor a serious competitor with other predators (Cardinal 2004, p. 21).

Based on studies in Alaska, Dalerum *et al*. (2009, p. 251) suggested that wolverines occupying this region are large ungulate specialists, but use a generalist feeding strategy by switching between ungulate food sources (e.g., caribou and moose) depending on their availability. Thus, during periods of low caribou abundance, wolverines can switch from caribou (migratory) to moose (non-migratory) while still maintaining their ecological role as a scavenger on ungulate carcasses (Dalerum *et al*. 2009, p. 251).

Wolverines were found to be the main predator of caribou calves (less than 14 days of age) in northern British Columbia, Canada (Gustine *et al*. (2006, pp. 13–14). As noted in the study, the calving areas were located in wolverine denning habitat (Gustine *et al*. 2006, p. 19); thus, this food resource may be especially important to female wolverines and their young in this region.

A study of wolverine diet using scat samples in Finland found that breeding female wolverines opportunistically used carrion and hunted less on small prey as compared to males and non-breeding females (Koskela 2013, p. 35). In addition, in areas with low densities of mid-size ungulates, smaller prey and carcasses may be important in the wolverine diet (Koskela 2013, p. 35). These results supported an optimal foraging theory; that is, wolverines will opportunistically use foods that are the most energy-efficiently available (Koskela 2013, p. 41). In other words, hunting ungulates or smaller prey (rabbits, birds) may incur greater energetic costs than scavenging for food, but searching for wolf- or human-killed carcasses will take more time (Koskela 2013, p. 41).

Finally, diet and feeding strategies of wolverines were evaluated in Scandinavia (Mattisson *et al*. 2016, entire). Wolverine feeding strategies were found to be flexible and temporarily shifted from scavenging to predation and heavily influenced by seasonal dependent responses to availability of prey and the supply of carrion (Mattisson *et al*. 2016, p. 9). Predictable anthropogenic food sources (i.e., remains from hunted ungulates) also influenced wolverine feeding strategies in their study area by increasing scavenging behavior relative to predation (Mattisson *et al*. 2016, p. 10).

Aboriginal traditional knowledge holders in Canada have reported wolverines as being largely dependent on wolves or another large predator to obtain large mammal carrion such as caribou, but also scavenge off polar bear (*Ursus maritimus*) and grizzly bear (summer) kills (Cardinal 2004, p. 20). Wolverines were observed following the tracks of Eurasian lynx (*Lynx lynx*) and then scavenging on prey left behind from lynx kills (Haglund 1966, pp. 272–273). Myhre and Myrberget (1975, p. 756) noted that the hunting abilities of wolverine and Eurasian lynx are not the same and that the two animals use the meat of their prey differently, which, together, may allow the two carnivores to coexist in the same environment.

In Sweden, Mattisson *et al*.'s (2011b, p. 1,326) study of Global Positioning System (GPS)-collared wolverines found that they spent three times longer scavenging ungulate carrion as compared to feeding on wolverine-killed prey, and more than half of the reindeer carcasses scavenged by wolverines were killed by Eurasian lynx. That study concluded that lynx can

increase the availability of food for wolverines and other scavengers and that lynx behavior around kill sites minimizes potential encounter conflicts (Mattisson *et al*. 2011b, p. 1,328). In their study area, Eurasian lynx do not appear to pose a significant threat to wolverines, neither by exclusion in space or time (Mattisson *et al*. 2011a, p. 79) nor from mortality (Persson *et al*. 2009, p. 327). We are not aware of similar evaluations for North American populations of wolverines and Canada lynx. This lack of study on interspecific processes in the more predator-diverse North American landscape is an important gap in our understanding of wolverine distribution (Fisher *et al*. 2013, p. 712).

Large carnivores can act as "sympatric ungulate predators" (Dalerum *et al*. 2009, p. 251), generating carrion at kill sites, particularly during winter months, but also as competitors and potential sources of mortality (White *et al*. 2002, p. 132; Krebs *et al*. 2004, p. 497; Koskela *et al*. 2013b, p. 221). Wolverines apparently balance their exposure to the risk of predation with foraging opportunities (Scrafford *et al.* (2017, p. 32). Thus, even though wolverines may not be dependent on lynx or other sympatric predators for their survival or reproduction, an increase in the availability of carrion and skeletal remains such as bones left by other predators (Yates and Copeland 2017, *in prep*) likely has a positive influence on the reproductive rate (e.g., number of offspring) in wolverine populations (Mattisson *et al*. 2011b, p. 1,328).

Caching of food is an important behavior of wolverines and is a key component of wolverine population dynamics (Hornocker and Hash 1981, p. 1,297; Inman *et al*. 2012b, p. 640). Food is cached in both summer and winter, by both sexes, and allows for food to be available past the peak periods of mortality and predation (Inman *et al*. 2012b, p. 639). Wolverines will typically move between carcasses and cache sites and are able to remove large parts of a carcass in a short time (Mattisson *et al*. 2011b, p. 1,327). Caching behavior in Sweden was reported most commonly in snow, as well as crevices in rock piles, and found that wolverines carried food to cache sites over long distances (8 and 10 km (5 and 6 mi)) (Haglund 1966, p. 274). As an example, Bjärvall (1982, p. 319) reported a female wolverine carried a reindeer head (with antlers) about 22 km (13.67 mi) back to a den site in Sweden. In northwestern Alaska, wolverines fed on cached ground squirrels during winter (Magoun 1987, p. 395).

A study of wolverine caching behavior in boreal forest habitat in Canada reported that cache sites varied from simple caches, a single feeding site or excavation, to cache complexes, which included feeding stations, latrines, resting sites, and climbing trees dispersed over varying spatial landscapes (Wright and Ernst 2004b, pp. 61–62). All cache sites included bones and hides of moose, which were likely scavenged from wolf kills (Wright and Ernst 2004b, p. 62). Cache sites were often excavated in snow, but also in the ground under boughs of large spruce (*Picea* spp.) trees (Wright and Ernst, 2004b, p. 62) and in peat bogs (Krott 1960, p. 23; Kimmy 2013, no page number). Wolverines also appeared to select cache sites and resting areas that offered good visibility of approaching competitors or predators (Wright and Ernst 2004b, pp. 63–64).

Wolverine energetic demands and food requirements are related to their foraging strategies. Caching provides important energy for female wolverines during the lactation period and helps ensure survival of newborns (Inman *et al*. 2012b, p. 640). Wolverines were found to have high energetic needs compared to other mammalian carnivores (Young *et al*. (2012, p. 2,252), similar to results previously presented by Iversen (1972a, p. 343), who concluded the basal metabolism

of mustelids weighing over 1 kg (2.2 lbs) is approximately 20 percent higher than for other mammals. A study by Andrén *et al*. (2011, p. 36) estimated a 1.2 kg/day (2.65 lbs/day) (range: 1.0–1.4 kg/day (2.2–3 lbs/day)) food requirement for wolverines, while Young *et al*. (2012, p. 223) estimated a male wolverine would require an average of 0.85 kg (1.87 lb) of prey/day in winter and 0.95 kg/day (2.1 lbs/day) in "snow-free" periods ~~.~~ (i.e., two 182-day seasons). Based on energy equivalent value of various prey sources, Young *et al*. (2012, pp. 223, 225) estimated that a winter diet for a male wolverine would include the equivalent of 1.8 ungulates (i.e., mule deer (*Odocoileus hemionus*)), 70.7 sciurids (squirrels), 20.6 lagomorphs (rabbits), and 832.7 small mammals, while in snow free season this would include the equivalent of 0.9 ungulates, 122.9 sciurids, and 3362.1 small mammals.

The study by Young *et al*. (2012, p. 225) concluded that wolverines consume 0.1 kg (0.22 lb) of prey per day more outside winter season, but that prey expected to be consumed in winter had a higher caloric content than other seasons; thus, the mass requirement is lower. As an example, they cite the higher proportion of ungulates consumed in winter, which provide about 1.3 times more energy (kilojoules per kilogram) than squirrels (Young *et al*. 2012, p. 225). Other researchers have also noted that food during the summer is just as important as the availability of cached ungulate food in the winter (e.g., during the energy demanding lactation period) (Inman *et al*. 2012b, pp. 640–642). The post-weaning growth period (May–August) was identified as a high energetic demand for food by a wolverine family group (Inman *et al*. 2012b, p. 640). Taken together with the lactation period, the calories available to wolverines therefore likely reach~~es~~ a maximum from March to ~~April~~August (Inman *et al*. 2012b, p. 640).

Population Structure

As discussed above, wolverines recolonized much of North America after periods of glaciation and then experienced heavy human persecution in much of their historic range. As shown in our Current Potential Extent ~~current range~~ maps (Figures 3 and 4) and described below in our *Population Abundance and Distribution* section, wolverines occur across a broad expanse of North America, where the contiguous United States represents the southern extent of the species' range. However, no comprehensive studies have been conducted across the western-northwestern United States to provide a reliable population estimate of wolverine populations or population structure.

A number of biological factors can affect wolverine populations, including the species' low intrinsic rate of population increase, naturally low densities, and need for large, intra-sexual home ranges (Banci and Proulx 1999, p. 180). Their extensive dispersal abilities make possible the recolonization of individuals into vacant habitats (Vangen *et al*. 2001, p; 1,647; Aronsson 2017, p. 43), though not necessarily establishment of a successful reproducing population. As noted above (*Diet and Feeding*), interactions with sympatric predators and the availability of prey and carrion can also directly and indirectly affect wolverine populations.

Wolverines in the contiguous United States are considered to represent a metapopulation (set of local or subpopulations within a larger area and where migration is possible between patches (Hanski and Simberloff 1997, p. 11)) (Inman *et al*. 2013, p. 277) and occupy habitat in high alpine patches at low densities, dispersing into suitable areas (Inman *et al*. 2012a, pp. 782–784).

Wolverines in Canada are considered to occur as a single large group as they are easily able to move between areas of good habitat and because wolverine habitat is relatively contiguous (Harrower 2017, pers. comm.).Wolverine populations in Alaska are considered to be continuous with populations in the Yukon and British Columbia provinces of Canada based on genetic studies (COSEWIC 2014, p. 37).

Studies of wolverines in the North Cascades region have documented movement of wolverines from Washington into British Columbia (Aubry *et al*. 2016, pp. 16, 20). The 2014 COSEWIC Report indicated that rescue (immigration from another population) of Canadian wolverine populations along the Canada-Alaska international boundary was likely (based on nuclear DNA evidence), but was negligible *from* the contiguous United States (COSEWIC 2014, p. 37). Based on mitochondrial DNA studies, Tomasik and Cook (2005, p. 390) concluded the gene flow in wolverines in northwestern North America is likely male-mediated, and is primarily due to long distance dispersal between low-density populations. Genetic studies of North American wolverines conducted by Kyle and Strobeck (2002, entire) found high levels of gene flow across northern populations (Canada and Alaska).

Commented [SJ23]: Are we saying that rescue from the US wolverines moving into Canada was negligible?

Genetics

~~Evaluation of genetic material can provide an understanding of population dynamics (Cegelski *et al*. 2006, p. 209).~~ The geographical genetic structure of wolverines is believed to be largely structured around the strong female philopatry characteristic of this species (Rico *et al*. 2015, p. 2), and, given the species' polygamous behavior, wolverine population distributions (at least in Scandinavia) are considered to be primarily limited by dispersal of the more philopatric sex (females) (Aronsson 2017, p. 13). However, the extensive and often asymmetrical movement of male wolverines from core populations to the periphery of their range can result in the addition of nuclear genetic material to these edges (Zigouris *et al*. 2012, p. 1,553). Thus, the dispersal pattern for male wolverines may help explain why allelic richness (i.e., nuclear DNA) can be similar across regions, but haplotype richness (mitochondrial DNA) is lower at the periphery of the species' range (Zigouris *et al*. 2012, p. 1,553). Additionally, the extensive dispersal movements of both male and female wolverines can produce gene flow among diverged populations, making it difficult to distinguish, without additional sampling and analysis, between long-distance dispersal and fragmentation based on the patchy distribution of some haplotypes (Zigouris *et al*. 2013, p.10).

Studies evaluating the genetic structure of wolverines, primarily within its core range in North America, were presented in Chappell *et al*. (2004) and Kyle and Strobeck (2001, 2002). Using microsatellite markers, Kyle and Strobeck (2002) and Zigouris *et al*. (2012) found a greater genetic structure of wolverines toward their eastern and southern peripheries of their North American distribution, likely due to a west-to-east recolonization during the Holocene (Zigouris *et al*. 2013, p. 9). Similarly, based on mitochondria DNA, McKelvey *et al*. (2014, p. 330) concluded that modern wolverine populations in the contiguous United States are the result of recolonization (following persecution during a period of unregulated ~~from~~ hunting and trapping and poisoning) from the north.

Genetic diversity and population genetic structure of a larger sample size of wolverines were examined by Cegelski *et al*. (2006, entire) for the southern extent of their North American range using both microsatellite markers and mitochondrial DNA. They concluded that the wolverine populations in the contiguous United States were not sources for dispersing individuals into Canada (Cegelski *et al*. 2006, p. 208). They found that there was significant differentiation between most of the populations in Canada and the United States (Cegelski *et al*. 2006, p. 208). However, they cautioned that their statistical analysis may not have been able to detect "effective migrants" and that sample size can affect the detection of dispersers (Cegelski *et al*. 2006, p. 208). They concluded that some migration of wolverines was occurring between the Rocky Mountain Front region (northwestern Montana) and Canada as well as among wolverine populations in the United States, with the exception of Idaho (Cegelski *et al*. 2006, p. 208). In addition, results from testing of allelic differences among the populations were interpreted by the authors as likely inadequate to counter the effects of genetic drift due to low numbers of migrants (Cegelski *et al*. 2006, p. 208). They estimated that, based on genetic diversity observed at that time, two effective migrants from either Canada or Wyoming into the Rocky Mountain Front population would be needed to maintain the levels of genetic diversity in that population, and one effective migrant was needed to maintain levels of diversity in the Gallatin, Crazybelt, or Idaho populations (Cegelski *et al*. 2006, p. 209). The authors concluded that migration is essential for maintaining diversity in wolverine populations in the contiguous United States since effective population size may never be reached due to the naturally low population densities of wolverines (Cegelski *et al*. 2006, p. 209).

Effective population size (N_e) (see **Box 2**) is defined as "the size of an idealized population that would experience the same amount of genetic drift and inbreeding as the population of interest. In popular terms, N_e is the number of individuals in a population that contribute offspring to the next generation" (Hoffman *et al*. 2017, p. 507). It represents a metric for quantifying rates of inbreeding and genetic drift and is often used in conservation management to set genetic viability targets (Olsson *et al*. 2017, p. 1). It is not the same as the more commonly used metric, census population size (*N*), but is often assumed to represent the genetically effective population size.

An effective population size analysis for wolverines in the contiguous United States was presented in Schwartz *et al*. (2009, p. 3,225) using wolverine samples from the main part of the Rocky Mountains populations (e.g., central and eastern Idaho, Montana, northwestern Wyoming). Excluded in this analysis, were subpopulations from the Crazy and Belt Mountains in Montana (based on suggestion by Cegelski *et al*. (2003) that they represented separate groups) (Schwartz *et al*. 2009, p. 3,225). Samples were divided into three time frames and the computer program ONeSAMP was used to estimate effective population size in each time frame [sample size appears to be between 142 and 210]. The summed effective population size was estimated at 35, with credible limits from 28–52, and the summed values for the three time frames was reported as follows: $N_{e\ 1989–1994} = 33$, credible limits 27–43; $N_{e\ 1995–2000} = 35$, credible limits 28–57; $N_{e\ 2001–2006} = 38$, credible limits 33–59 (Schwartz *et al*. 2009, p. 3,226).

However, Cegelski *et al*.'s (2006, p. 203) evaluation of nuclear DNA population structure in wolverines in Canada (sample size of 101) and the contiguous United States (sample size of 116), as depicted by a principle component analysis plot and dendrogram, found that all of the Canadian wolverine populations clustered together. In the contiguous United States, the Rocky

Commented [SJ24]: I don't remember this from Cegelski, at least the "due to low numbers of migrants" part. I thought their main conclusion was that US pops are by themselves not large enough to counter gentic drift without migrants from Canada. And below you describe how few migrants they think are needed.

Commented [SJ25]: I thought they said something like a pop sizes would need to be 400+ individuals to be large enough to maintain genetic diversity w/out migrants. But maybe that's more detail than neeed here. ?

Commented [BJG26]: Peer reviewer recommended different reference but it is a book that I do not have. I will request through interlibrary loan, but will take time to get to me.

Commented [SJ27]: Ok, we can add it in later if needed.

Mountain Front subpopulation clustered with the Wyoming subpopulation, the Crazy and Belt~~belt~~ Mountains~~'~~ area subpopulation clustered with the Gallatin (Montana) population, and the Idaho population was highly differentiated (Cegelski *et al*. 2006, p. 203). However, the sample size used for evaluating the Idaho population was small (n=15) and limited to central Idaho. That study concluded that some exchange of migrants is occurring between the Gallatin and Crazybelt wolverine populations (Cegelski *et al*. 2006, p. 207)~~, but noted that this grouping is more genetically differentiated and isolated from the other populations they sampled when compared to the Rocky Mountain Front population (Cegelski *et al*. 2003).~~

In addition, the map presented in Schwartz *et al*. (2009, p. 3,223) depicting the locations of the wolverine samples used in preparing their effective population size estimate shows significant gaps within the wolverine's range in Idaho and parts of Montana (e.g., interior of the Bob Marshall Wilderness area). Thus, other wolverine subpopulations and/or individuals were likely missed for this analysis. Studies within the Southwestern Crown of the Continent (SWCC) in northwestern Montana have detected cross-valley movements of wolverines, which researchers believe is an indication of good connectivity in this region (SWCC Wildlife Working Group 2016, pers. comm.). Current efforts to collect additional wolverine hair samples for genetic analyses are underway through a multi-state occupancy survey project (see *Population Abundance and Distribution* section below).

Another evaluation of mitochondrial DNA was conducted by Francis (2008), who found an overall lack of regional (geographic) genetic structure for North American wolverines, but noted that a few populations ~~-~~(the Crazy and Belt Mountains~~belts~~ (Montana), Southeast Alaska, Nunavut (Canada), and Kenai Peninsula) appeared to be isolated from the others (Francis 2008, p. 12). However, statistical testing did not identify any genetically defined sampling localities (Francis 2008, p. 13). Minimal differences were found between core and peripheral wolverine populations, as grouped in that analysis (Francis 2008, p. 21; Table 4). Conversely, the study by Zigouris *et al*. (2012, p. 1,554; Table 5) did find support for genetic clusters for wolverine populations in Canada, and Zigouris *et al*. (2013, p. 5; Table 3) identified several worldwide regional genetic groups. In addition, an analysis of estimated population growth found signals of population expansion in several wolverine populations (Francis 2008, p. 13; Table 5) including Rocky Mountain Front, Wyoming, Central, South, and Northwestern Alaska, British Columbia, Northwest Territories, and Nunavut.

Box 2. Effective Population Size and Genetic Variation

The concept of effective population size (N_e) (see review by Wang *et al*. 2016) and, relatedly, minimum viable population, has been a topic of debate, particularly the 50/500 rule, which was developed over 30 years ago. As noted by Laikre *et al*. (2016, p. 280), the concept and guidelines for *genetically* effective population size were developed for single, isolated populations, but it's unclear which of the various N_e metrics was referenced in the original concept proposed by Franklin (1980) (i.e., inbreeding effective size, realized effective size, total inbreeding effective size of a metapopulation, or eigenvalue effective size (Laikre *et al*. 2016, p. 288)).

There are differing interpretations of the values proposed for effective population size. For example, should the minimum viable effective population size be derived genetically to set a threshold for a minimum viable population? Here, the rule is interpreted as 50 being the short-term number (for inbreeding depression) and 500 as the long-term number (for retention of genetic variation). Or should the N_e value of 500 be interpreted as a long-term goal for maintaining a healthy, genetically robust population, and not a threshold trigger that predicts extinction risk? In addition, some view the 500 value to be a global reference value rather than a local value, and that it may not be necessary to maintain a local N_e of 500 as long as there is some gene flow into a population (Jamieson and Allendorf 2012, p. 580).

Finally, others have recommended changes to the 50/500 rule. Laikre *et al*. (2016, entire) presented an analysis of the metapopulation effective size for the Fennoscandian wolf population and recommended that long-term conservation genetic target for metapopulations (N_{eMeta}) ≥ 500, but also a realized effective size of *each subpopulation* (N_{eRx}) ≥ 500. Frankham *et al*. (2014, p. 59) have recommended modifying the 50/500 rule to 100/1000.

It can be difficult to make inferences about the relationship between population size and point estimates of genetic diversity without continued genetic monitoring and an understanding of the demographic history of a species' population (Hoffman *et al*. 2017, p. 507), including factors that have influenced movement patterns and connectivity. Additionally, the extensive dispersal movements of both male and female wolverines can produce gene flow among diverged populations, making it difficult to distinguish, without additional sampling and analysis, between long-distance dispersal and fragmentation based on the patchy distribution of some haplotypes (Zigouris *et al*. 2013, p.10). ~~It's also important to note that g~~

Genetic diversity can be a reflection of favorable adaptations (natural selection) and is necessary for species to locally adapt to environmental stressors or to facilitate range shifts (Zigouris *et al*. 2012, p. 1,544). Genetic distinctiveness in peripheral populations may play a role in both maintaining and generating biological diversity for a species (Zigouris *et al*. 2012, p. 1,544; citing results presented in Channell and Lomolino 2000, p. 84). Genetic variation that is adaptive is a better predictor of the long-term success of populations as compared to overall genetic variation (Hoffman *et al*. 2017, p. 510). The challenge is to be able to determine whether genetic variation is adaptive and is a reflection of remnants of high genetic diversity from ancestral populations, or whether that variation is a reflection of accumulated deleterious, nonadaptive genes due to genetic drift in small populations (Hoffman *et al*. 2017, p. 509).

In summary, the currently known spatial distribution of genetic variability in wolverines in North America appears to be a reflection of a complex history where population abundance has fluctuated since the time of the last glaciation, and insufficient time has passed since human

persecution for a full recovery of wolverine densities (Cardinal 2004, pp. 23–24; Zigouris *et al*. 2012, p. 1,554). Zigouris *et al*. (2012, p.1,545) noted that the genetic diversity reported in Cegelski *et al*. (2006) and Kyle and Strobeck (2001, 2002) for the southwestern edge of the North American range represented only part of the diversity in the northern populations of wolverines. Zigouris *et al*. (2012, p. 1,545) posit that the irregular distribution of wolverines in the southwestern periphery and the genetic diversity observed in those analyses is a result of population bottlenecks that were caused by range contractions from a panmictic (random mating) northern core population approximately 150 years ago coinciding with human persecution. Demographic studies as well as additional genetic analyses from contemporaneous wolverines currently occupying the contiguous United States are needed to evaluate the current status of wolverine populations in North America. In addition, ecological, phenotypical, and environmental information should be used to complement genomic data when interpreting the strength of conclusions or inferences of spatial patterns of adaptation or for adaptively divergent populations (Jamieson and Allendorf 2012, p. 492).

Summary

In this SSA report, we have incorporated information from several new studies related to the wolverine published since our 2013 proposed rule (e.g., Magoun *et al*. 2017) and previous studies that were not considered ~~(e.g., Magoun *et al*. 2017)~~. We have also reviewed new publications and publications in preparation from wolverine researchers in Scandinavia (e.g., Aronsson 2017; Bischof *et al*. 2016; Makkonen 2015; Mattisson *et al*. 2016; Myhr 2015; Persson *et al*. 2017, *in prep*). This information informs our assessment of the most current information regarding the description of the wolverine and its life history and ecology across its North American range. We have included in this SSA Report detailed discussions of wolverine physiology, and spatial and temporal patterns and trends related to reproduction and diet/feeding. We also prepared a revised ~~current range~~Current Potential Extent map (see Figure 3) based on information we received from Federal, State, and ~~other~~ wolverine researchers~~, including Canada~~.

A species' current and future conditions and overall viability (in terms of resiliency, redundancy, and representation), are largely impacted by the availability of what the species needs at the individual, population, and species level. The needs described below are necessary for wolverines to have resources for the basic requirements of life (breeding, feeding, and sheltering) at all levels. Overall, the best available information indicates that within the contiguous United States the wolverine's physical and ecological needs include:

(1) large territories in relatively inaccessible ~~remote~~ landscapes; at high elevation (1,800 to 3,500 meters (5,906 to 11,483 feet))
(2) access to a variety of food resources, that varies with seasons; and
(3) physical/structural features (e.g., talus slopes, rugged terrain) linked to reproductive behavioral patterns.

Biological Status – Current Condition

This section provides an overview of the wolverine's current condition, including those stressors that may be impacting the species or its habitat. In this SSA Report, we have identified stressors based on impacts that may negatively affect the physical and ecological needs of the species,

including temporary or permanent impacts to habitat features that the species relies on for survival and reproduction.

Population Abundance and Distribution

As shown in Figure 2, wolverines occupy areas in the west-northwestern United States, and have recently dispersed into historically occupied areas, including California, Utah, Colorado, and Oregon; verified reproducing wolverine populations are found in Idaho, Washington (Northern Cascades), Montana, and northwest Wyoming. Demographic data collected in the contiguous United States is primarily presence/absence data, which makes it difficult to develop reliable population estimates or population trends. Since our 2013 proposed rule, ~~we have received additional reports of wolverine observations including Utah, Colorado, and Oregon, and~~ an updated Canadian status review for the wolverine has been prepared (COSEWIC 2014, entire) and ~~. A~~additional studies have also been published related to wolverine populations in British Columbia and Alberta (e.g., Regehr and Lacroix 2016; Stewart *et al*. 2016; Webb *et al*. 2016). As noted above, we developed a Current Potential Extent ~~Range~~ map for the North American wolverine in the contiguous United States and North America (see Figures 3 and 4) ~~. For the conterminous United States, this map was~~ based on several resources, including ~~the primary habitat model developed by~~ Inman *et al*. (2013), EPA ~~Eco~~ecological region mapping (2010), Forest Service NRIS data, and information received from State agencies. ~~We used the~~The 2014 COSEWIC Assessment and Status Report~~'s~~ presents an estimated current range map for Canada and Alaska, and ~~. For Canada, the range of occurrence~~ includes the Yukon, Northwest Territories, Nunavut, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec, Newfoundland, and Labrador (COSEWIC 2014, p. vii).

Contiguous United States

Commented [SJ28]: I feel like we at least need to acknowledge that wolverines have intermittently occurred (hiostorically?) in Midwest and East States. Some reveiwers pointed this out as a shortcoming of the report.

Areas in the western contiguous United States were identified by Inman *et al*. (2013, entire) as suitable for wolverine survival (long-term survival; used by resident adults), or primary habitat (Inman *et al*. 2013, p. 279), reproduction (used by reproductive females), and dispersal (female and male) of wolverines (see methodology in Inman *et al*. 2013, pp. 279–280; Figure 2). From these results, the researchers estimated potential and current distribution and abundance of wolverines in the western contiguous United States (Inman *et al*. 2013, p. 282). They estimated current population size of wolverines to be 318 (range 249–626) located within the Northern Continental Divide (Montana) and areas within the following ecoregions: Salmon-Selway (Idaho, portion of eastern Oregon), Central Linkage (primarily Idaho, Montana), Greater Yellowstone (Montana, Idaho, Wyoming), and Northern Cascades (Washington) (Inman *et al*. 2013, p. 282). Potential wolverine population capacity based on their RSF habitat modeling was estimated to be 644 (range: 506–1881) (Inman *et al*. 2013, p. 282). However, these estimates did not consider spatial characteristics related to behavior, such as territoriality, of wolverine populations.

The discussion below provides a summary of recent studies of wolverine detections and observations in the western United States; however, no comprehensive surveys have been conducted across the entire area defined as the species' ~~entire~~ Maximum Extent of Occurrence (Figure 2) or Current Potential Extent (Figure 3) in the contiguous United States~~range~~.

In the northern Cascades region of Washington and Canada, researchers tracked activity areas for 14 wolverines via satellite telemetry from 2007 through 2015 (Aubry *et al*. 2016, entire). This study demonstrated that the region supports a resident population, with 9 of 11 study animals documented primarily within Washington (Aubry *et al*. 2016, p. 40).

~~The Oregon Department of Fish and Wildlife (ODFW) reports that wolverines have been found in the Oregon Cascades on Three-fingered Jack (glaciated volcano) in Linn County, on the Steens Mountain in Harney County, and Broken Top Mountain in Deschutes County~~Wolverines have been detected ~~,~~ in the Eagle Cap Wilderness Area in the Wallowa Mountains of northeastern Oregon 2011–2012, 2016, and 2017 (~~, and, more recently (2012), in Wallowa County, northeast Oregon (ODFW 2017, no page number~~Magoun *et al*. 2013, p. 17; Magoun 2017b, pers. comm.). Surveys conducted in the Northern Cascades of Oregon in 2012–2014 did not detect any wolverines (McFadden-Hiller and Hiller 2015, p. 107).

In California, camera trap data indicate the continued presence of a single male wolverine in the Truckee area, as of March 2017 (Shufelberger 2017, pers. comm.). The California Department of Fish and Wildlife (CDFW) has received reports of wolverine detections from the public over the past several years, particularly the region near Carson Pass, as well as near Meeks Bay, Lake Tahoe (Stermer 2017, pers. comm.). The CDFW has conducted systematic surveys in these areas and has installed baited camera traps in the Carson Pass area, but no wolverines have been detected (CDFW 2017, pers. comm.). CDFW researchers are conducting multi-species predator surveys, targeting the potential occurrence of Sierra Nevada red fox and wolverine using camera trapping with hair snares in an effort to determine occupancy, detection probability, distribution, and habitat associations (Stermer 2017, pers. comm.).

Since 2010, the Idaho Department of Fish and Game (IDFG) has directed a multi-species forest carnivore monitoring program in the Idaho Panhandle and adjoining areas of Washington, Montana, and British Columbia, Canada (Lucid *et al*. 2016; Lucid *et al*. 2017). From 2010–2014, 497 forest carnivore bait stations were used to survey the study area using a 5 by 5 km (3 by 3 mi) grid (Robinson *et al*. 2016, pp. 6,827–6,828). Wolverines were detected ~~wolverines~~ at 13 sites in 13 different cells, and genetic analysis identified 3 individual males (Lucid *et al*. 2016, p. 154). One male was detected on 6 occasions in the Selkirk Mountains from 2010–2013, and was determined to be resident of the area (Lucid *et al*. 2016, p. 161). This male (LS11) was also detected in British Columbia, north of Canadian Highway 3 (Lucid *et al*. 2016, p. 184), which some consider to be a barrier to wildlife passage (IDFG 2017, pers. comm.). LS11 was most recently detected in Idaho, on March 6, 2013 (Lucid *et al*. 2016, p. 175). From 2015–2016, a more focused monitoring effort in the region was conducted and resulted in the detection of two new male wolverines in the Purcell and Saint Joe Mountains, but not the three previously detected males (Lucid *et al*. 2017, p. 12). The 2017 summary report also noted one likely wolverine den in the Saint Joe Mountains (Lucid *et al*. 2017, p. 12).

A pilot study to evaluate wolverine occupancy was conducted in Wyoming from February through June in 2015 (Inman *et al*. 2015, entire). Results from that survey (hair snares and camera traps in 18 stations across 5 mountain ranges) indicated at least three individual wolverines (at five stations) with at least one individual in the Gros Ventre and Wind River

mountain ranges, and at least two individuals in the Southern Absaroka mountain range (Inman *et al*. 2015, p. 9). Occupancy modeling estimated a probability of occupancy for sampled sites of 62.9 percent (Inman *et al*. 2015, p. 8).

Building on the results of the Wyoming pilot study~~In an effort to assess wolverine occupancy in the western United States~~, the Western Association of Fish and Wildlife Agencies (WAFWA), in coordination with Tribal partners, ~~have~~ formed a multi-state, multi-agency working group (Western States Wolverine Working Group) to design and implement the Western States Wolverine Conservation Project (WSWCP)–Coordinated Occupancy Survey (~~see Bjornlie *et al.* 2017~~see Western States Wolverine Working Group 2016 for details of protocol). The primary objectives of the WSWCP include: 1) implement a monitoring program to define a baseline wolverine distribution and genetic characteristics of the metapopulation across Montana, Idaho, Wyoming, and Washington, 2) model and maintain the connectivity of the wolverine metapopulation in western United States, and 3) develop policies to address socio-political needs to assist wolverine population expansion as a conservation tool, including translocation of wolverines (IDFG 2016, pers. comm.; Montana FWP 2016, pers. comm.; WGFD 2016, pers. comm.).

The WGFD began implementation of the survey in Wyoming in the Greater Yellowstone Ecosystem region and the Bighorn Mountains (25 grid cells) in the winter of 2015–2016 (WGFD 2016, pers. comm.). That initial survey detected, based on unique fur markings, at least ~~two~~ three unique wolverines in the Wind River and southern Absaroka Mountain Ranges (WGFD 2016, pers. comm.). The WGFD reported 26 independent wolverine visits (defined as a photo of a wolverine greater or equal to 60 minutes from the previous photo of a wolverine), and detections at least once within their study area during each of the four sampling periods (December 2015 through March 2016) (Bjornlie *et al*. 2017, pp. 4–5). As part of this effort, the WGFD collaborated with the Eastern Shoshone and Arapaho Tribes in Wyoming to conduct surveys on Tribal lands in 2015, and plans to continue this collaboration in the winter of 2017–2018 to monitor wolverines on the Wind River Reservation (WGFD 2017, pers. comm.). ~~Genetic analyses of collected hair samples, including sex and individual identification, are underway.~~

The monitoring effort was expanded in the winter of 2016–2017 to 185~~7~~ cells (cell area of 225 km^2 (87 mi^2)) in ~~across~~ four ~~states~~ States (Washington, Idaho, Montana, and Wyoming). **Appendix B** contains a map illustrating these preliminary detections. Wolverines were detected in 59 cells (22,461 detections) and volunteers detected wolverines in another 36 cells for a total of 95 cells (Montana FWP 2017, pers. comm.)~~Preliminary results for the 2016–2017 winter detected wolverines in 85 survey cells (WAFWA 2017)~~. Photographic detections of wolverine (both survey and volunteer cells include ~~18~~ 22 from Idaho, 48 in Montana (including detection of wolverines in all 10 cells surveyed in the SWCC region (Davis 2017, pers. comm.)), 10 in Washington, including detections south of Interstate 90 (Davis 2017, pers. comm.), and ~~9~~ 6 in Wyoming (for 2015–2016 and 2016–2017); genetic analyses, to date, have reported a total of 157 wolverine samples (Montana FWP 2017, pers. comm.; WGFD 2017, pers. comm.)~~WAFWA 2017~~). It has not yet been determined from the camera-trap images and hair samples how many of these detections are the same individual and genetic analyses of collected hair samples, including sex and individual identification are ongoing. ~~**Appendix B** contains a map illustrating these preliminary detections (as of July 2017).~~ A detailed summary of the occupancy survey

design and results is presented in **Appendix C** (McDonald (on behalf of WAFWA Wolverine Subcommittee) 2017, pers. comm.).

We also requested and received additional wolverine observations from State and Federal agencies in northwestern Wyoming. A wolverine was detected by camera in northern Grand Teton National Park (Dewey 2017, pers. comm.), and a member of the public reported wolverine tracks in southwestern Grand Teton National Park while skiing (Walker pers. comm. 2017), which was confirmed by a Forest Service biologist (WGFD 2017, pers. comm.). Both of these observations occurred in March 2017. South of this area in the Wyoming Range (about 4 miles east of Alpine, Wyoming), a wolverine was detected by camera in May 2017 (Walker 2017, pers. comm.).

~~Based on a 6-year study of monitoring resident wolverines (live trapping and camera stations) in central Idaho (Centennial, Smoky, and Salmon Mountains) and the western Yellowstone region (Teton Mountains), Heinemeyer (2016, pers. comm.) suggested that subpopulations of the species at this southern periphery of their North American range are still unstable with low rates of recruitment.~~

~~We therefore requested additional information from State and Federal agencies regarding the most recent wolverine detections in the Winter Recreation Project study areas of Idaho and Wyoming. In the Teton Mountains region, two wolverines were detected in March 2017, in two different areas (Dewey 2017, pers. comm.). In addition, at least one wolverine was detected on the east side of the Teton Mountains during the winter of 2016-2017, as part of the Western States Wolverine Conservation Project–Coordinated Occupancy Survey monitoring and occupancy study, and a member of the public reported wolverine tracks within Grand Teton National Park in March 2017, while skiing (Walker 2017, pers. comm.). In Idaho, IDFG reported 5 wolverine detections in the Salmon Mountains in Central Idaho in the winter of 2016 (Mack 2017a and 2017b, pers. comm.). These recent detections are displayed in **Appendix C** relative to the study areas of the Winter Recreation Project study areas for the McCall, Idaho, and Teton Mountains. A wolverine was also detected in the winter of 2016-2017 in the Gravelly Range in southwestern Montana about 25 km (15.5 mi) north of the Centennial Mountains area surveyed during the winter recreation project (Inman 2017b, pers. comm.).~~

Alaska

The ADF&G Trapper Questionnaire Annual Reports include estimates of relative abundance and trends of wolverines and other furbearers as reported by trappers (Parr 2016, p. 38). Table 4 below provides a summary of abundance and trends from 2010–2016 of those reports by region.

Table 4. Relative Abundance and Trend of Wolverine Populations, Alaska (as reported by trappers), 2010-2016.* -For Trend, + indicates increase, − indicates declining/decrease, and n/c indicates no change. N/A (Not Applicable) indicates no value for that year due to changes in how the regions were defined. Sources: ADF&G 2012, 2013a, 2013b; Parr 2016.

Region	Relative Abundance				Trend			
	2010-2011	2011-2012	2012-2013	2015-2016	2010-2011	2011-2012	2012-2013	2015-2016

Region I – Southeast Alaska	scarce	scarce	scarce	scarce	n/c	n/c	n/c	–
Region II – Southcentral Alaska	scarce	scarce	scarce	scarce	n/c	n/c	n/c	–
Region III – Interior Alaska	scarce	scarce	scarce	scarce	n/c	n/c	n/c	–
Region IV – Central and Southwest Alaska	N/A	N/A	N/A	scarce	N/A	N/A	N/A	–
Region V - Northwest	N/A	N/A	N/A	scarce	N/A	N/A	N/A	–
Southwest	common	scarce	scarce	N/A	n/c	–	n/c	N/A
Arctic and Western	common	common	scarce	N/A	n/c	n/c	n/c	N/A

*No reports written for years 2009-2010, 2013-2015.

However, relying exclusively on trapping reports is likely to present an incomplete assessment of wolverine populations. The accuracy of information provided in the most recent report is dependent on how many trappers reply to the annual survey; for 2016, the response rate was only 11.7 percent (Parr 2016, p. 3). Trapping effort was reported to have increased by some trappers (45 percent of those reporting) during the 2015–2016 season, and 80 percent of those who increased their efforts reported an increase in their overall catch (Parr 2016, p. 15). However, this assessment does not consider how this increased trapper effort relates to harvest levels for wolverine, nor does it account for an unknown and unreported number of wolverines taken for subsistence purposes (Gardner *et al*. 2010, p. 1,894). Estimates of density, described below, provide a better depiction of wolverine population status in Alaska.

Canada

Similar to Alaska, determining wolverine population abundance and trends in Canada is difficult as numbers are developed from harvest activity (COSEWIC 2014, p. 25). Wolverine harvest trends are also difficult to estimate given the temporal and spatial variability in trapping effort and reporting of harvest, and not all regions use mandatory pelt sealing, compulsory reporting, or fur export permits/fur dealer records (COSEWIC 2014, p. 26).

According to the most recent COSEWIC Assessment and Status Report on the Wolverine, *Gulo gulo* in Canada (COSEWIC 2014, entire), Canada's western subpopulation has been estimated at 15,688 to 23,830 adults, though this value is based on several assumptions (consistent trapping effort and uniform densities across the species' range); the eastern population (Québec and Labrador) is estimated at less than 100 individuals or may be extirpated (COSEWIC 2014, p. 36). Population trends across all of Canada are not known, but wolverine populations have been stable over areas within the country's northern range for the last three generations (22.5 years) (COSEWIC 2014, p. v).

In northern Manitoba and Ontario, wolverines may be increasing in number as aerial surveys in northern Ontario have indicated an eastward reoccupation of its former range (towards James Bay and Québec) (COSEWIC 2014, p. v). However, although observations of wolverines continue to be reported within Québec and Labrador ~~(the eastern sub-population)~~, there have been no verifiable observations since 1978, and wolverines are likely extirpated from much of southeastern Canada (COSEWIC 2014, p. v). In addition, declines in the southern regions

(within parts of British Columbia and Alberta) may be occurring (COSEWIC 2014, p. 36). Table 5 presents a ~~more detailed~~ summary of estimated wolverine populations in Canada; study references for regional estimates are presented in COSEWIC (2014, pp. 26–36).

Table 5. Wolverine Population Estimates for Canadian Territories. Source: COSEWIC, 2014.

Territory	Number of wolverines
Yukon Territory	3,500–4,500
Northwest Territories	3,430–7,325 (with an additional 220–470 juveniles)
Nunavut	Estimated at 2,000–2,500
British Columbia	2,700–4,760
Alberta	Estimated at 1,500–2,000
Saskatchewan	Less than 1,000
Manitoba	1,100–1,600
Ontario	458–645
Québec	Very rare, at non-detectable level, or extirpated
Labrador (including mainland Newfoundland)	Very rare or extirpated

In addition to the 2014 COSEWIC summary, Cardinal 2004 (entire) prepared a complimentary summary report of wolverine trends in Canada based on Aboriginal traditional knowledge. Trends reported indicate: (1) high, relatively stable levels of wolverines in the Yukon; (2) high levels of wolverines in the North Slave region of the Northwest Territories, though population levels are estimated to be stable to decreasing; (3) high levels of wolverine along forested areas in the northern portions of the mainland within the Inuvialuit Settlement Region (ISR) (located in the northwest corner of the Northwest Territories) and Kitikmeot region of Nunavut; (4) an increase in wolverines in the Kivalliq region of Nunavut, but at lower levels than populations in the Boreal and North Mountain ecological areas; and (5) least abundant in the northeastern corner of Nunavut and the Arctic Islands (Cardinal 2004, pp. 22–29). In sum, the majority of traditional knowledge holders in Nunavut, Northwest Territory, and Yukon Territory describe wolverine populations as either stable or increasing in northern Canada and is now found in areas where they occurred in the past; however, they are still considered naturally uncommon; only in Yellowknife did people report that wolverines might be decreasing (Cardinal 2004, pp. iii– iv, 10, -23).

Other inventory and occupancy studies include an inventory of wolverines conducted by Regehr and Lacroix (2016, entire) in the winter of 2012 on the east side of the Coast Mountains in British Columbia using a multi-method approach. They identified six individuals using genetic analysis, and one additional individual by photography, which was higher than expected as compared to model predictions of density and habitat quality (Regehr and Lacroix 2016, pp. 248–249). Estimates of wolverine occupancy were also evaluated for the Canadian Crown of the Continent ecosystem (central and southern Canadian Rockies) (Clevenger *et al*. 2016, entire). Occupancy estimates were found to vary from year-to-year and exhibited a north-south gradient, likely due to the differences in habitat quality among areas that were sampled by year (Clevenger *et al*. 2016, p. 4). For 2016, estimated wolverine occupancy probability was 0.40 for their British Columbia Rockies study area, with a declining pattern from north to south (Clevenger *et al*. 2016, p. 4). In general, their research has found that wolverines are more abundant in rugged, remote areas that have minimal human activity and landscape disturbance (Clevenger *et al*. 2016,

p. 5). This study projected an expected number of wolverines in their study area of about 28 (Clevenger *et al*. ~~(~~2017, p. 6). To the south, in the Southwestern Crown of the Continent (SWCC) region, ~~-~~ ~~(~~northwestern Montana~~, approximately 1.5 million acres)~~, wolverine surveys (snow tracking, bait stations/hair snares) have been conducted since 2012 (SWCC Wildlife Working Group 2016, pers. comm.). These survey efforts have detected 22 unique wolverines (11 males, 11 females) within~~across~~ three U.S. Forest Service districts, and they reported an increase in the frequency of detections from 2012 to 2015 (SWCC Wildlife Working Group 2016, pers. comm.).

In the Kootenay Region of southern British Columbia, a non-invasive genetic study of wolverines, including collection of trapper carcasses, was initiated in the southern Columbia Mountains in 2012 (Hausleitner and Kortello 2016, entire). The 2016 report estimated a population size of 9 (7-12) individuals, less than half of the expected population size of 24 (17-36), with a 64 percent estimate of occupancy for the central Purcell Mountains, which was higher than the south Purcell Mountains (38 percent) and south Selkirk Moutains (55 percent), but lower than the Valhalla (70 percent) and central Selkirk Mountains (71 percent) (estimates of detectability were found to be within the range of previous years and other studies) (Hausleitner and Kortello 2016, p. 2; Figures 1 and 2). Although the study results suggest that dispersal events are still occurring among ranges and subranges, they also found three distinct subpopulations in their genetic analyses, which they believe is indicative of limited gene flow (Hausleitner and Kortello 2016, p. 21).

The 2014 COSEWIC report indicates that trends in wolverine populations in the northern range, while uncertain, appear to be stable or increasing, but also notes that there is some concern for populations in the southern areas of British Columbia and parts of the northern United States (COSEWIC 2014, p. 22, citing personal communication from Richard Weir, Carnivore Conservation Specialist, Ministry of the Environment, British Columbia, and Wolverine Science Panel Workshop Report (Wolverine Science Panel 2014)~~and references cited therein~~). In British Columbia, researchers are currently conducting a multi-phase project using landscape genetic analyses to identify and delineate functional populations of wolverines and provide an estimate of size and sustainable harvest within each functional population (Weir 2017a, pers. comm.).

Estimates of Density

Wolverine densities vary across North America, and have been described as "naturally low" (van Zyll de Jong 1975, p. 434) and "naturally uncommon" (Cardinal 2004, p. iii) given the species' large home range, wide-ranging movements, and solitary characteristics. The most recent estimates (at that time) of density (number of wolverines per 1,000 km^2 (386 mi^2)) for North America were prepared by Inman *et al*. (2012a, p. 789; Table 5). In the contiguous United States, density estimates ranged from 3.5 for the Greater Yellowstone region (2001–2008) (areas above 2,150 m (7,054 ft) (latitude-adjusted elevation), 4.5 for central Idaho (1992–1995), to 15.4 for northwestern Montana (1972–1977).

In Alaska and Yukon, density estimates presented by Inman *et al*. (2012a, p. 789) range from 3 to about 14 wolverines per 1000 km^2 (386 mi^2), using a number of methods. For example, Royle *et al*. (2011, p. 609) estimated wolverine densities for southeastern Alaska (Tongass National

Forest; 2008) from 8.2 to 9.7 per 1000 km^2 (386 mi^2) (using mark-recapture), where the higher estimate incorporates a positive, trap-specific behavioral response. Density of wolverines were recently reported as an estimated 5–10 wolverines per 1000 km^2 (386 mi^2) (based on snow tracking) for southcentral Alaska, and approximately 10 per 1000 km^2 (386 mi^2) (based on DNA mark-recapture methods) for southeast Alaska (Golden 2017, pers. comm.). A wolverine occupancy study in 2015 within an area of central Alaska reported a density estimate of 9.48 wolverines per 1,000 km^2 (386 mi^2) (ADF&G 2015a, p. 7).

Wolverine density estimates for Canada varies across regions, from 5 to 10 per 1000 km^2 (386 mi^2) in northern mountain and boreal regions to 1 to 4 per 1000 km^2 (386 mi^2) in southern boreal areas (COSEWIC 2014, p. 27). More recently, Clevenger *et al*. (2017, entire) presented a density estimate (using spatial capture/recapture models) for the Kootenay region of British Columbia of 0.78 wolverines per 1000 km^2 (386 mi^2), for 3 study years (2014–2016), which they reported as lower than expected (Clevenger *et al*. 2017, p. 6).

Stressors – Causes and Effects

We reviewed the best available information to identify current conditions and potential stressors that may be affecting wolverine populations or its habitat. These include roads and other infrastructure, recreational activity and other human disturbances, wildland fire, disease or predation, and overutilization for commercial, recreational, scientific, or educational purposes. Because wolverines in North America move between both borders of Canada (i.e., contiguous United States, Alaska), we included in our evaluation stressors identified for wolverines in Canada and Alaska that are also relevant for wolverine populations in the contiguous United States.

As an initial step, we reviewed the land ownership of the area defined ~~as primary habitat by Inman *et al*. (2013, entire)~~as Current Potential Extent in the contiguous United States (Figure 3), and determined that 72.4~~96~~ percent ~~of that modeled habitat~~ is located on Federal land (using Albers Projection) (see **Appendix D**). ~~L~~Lands managed by the Forest Service represent the largest portion of Federal lands (~~89~~ 62 percent) within this ~~modeled primary habitat~~area.

Effects from Roads

Roads and rail lines can be a cause of mortality to wolverines and habitat models have identified road density as an important association (avoidance) for selection of habitat (e.g., Rowland *et al*. 2003; Bowman *et al*. 2010; Inman *et al*. 2013). Road density has been listed as a threat to wolverines occupying the boreal/western mountain regions of Canada (Canadian Boreal Forest Agreement 2014, p. 2). In the wolverine's southern Canadian range, roads may be facilitating direct mortality along transportation corridors ~~by improving motorized access of hunters, trappers,~~ and may facilitate indirect mortality through improved motorized access for hunters, trappers and recreational users into remote areas (COSEWIC 2014, p. 21).

In their review of 12 radio-telemetry studies (1972 to 2001) of wolverines in North America, Krebs *et al*. (2004, p. 497) reported 3 mortalities of wolverines from road-rail kills. In addition, a female wolverine was killed on Highway 20 in northwestern Washington in May 1997

(specimen at Burke Museum; Bradley 2017, pers. comm.). More recently, road mortalities have been recorded in Idaho (1 confirmed in 2014) (IDFG 2017a); ~~and 2~~three in Montana (2004, 2007) (Kociolek *et al*. 2016, p. 68; Yates 2017, pers. comm.); one in Utah (2016) (Hersey 2017, pers. comm.). ~~; and t~~Two additional~~other~~ wolverine road-rail fatalities in Montana were reported in 2015 (Inman 2017a, pers. comm.).

In Canada, anthropogenic causes of mortality for wolverine populations also include road kill (COSEWSIC 2014, p. v). One road mortality of a male wolverine was reported in a lowland boreal forest region of Ontario, Canada (Dawson *et al*. (2010, p. 142). More recently, Scrafford *et al*. (2017, p. 34) described a report in which 9 wolverines were struck and killed by vehicles in the Hay-Zama region of northwestern Alberta, Canada (2013–2015), and 1 road mortality occurred within the town of Rainbow Lake in Alberta.

Roads also may ~~also~~ affect den site selection (May *et al*. 2012, p. 202), particularly areas within their range where they cannot select for high elevation habitat (e.g., central lowland forests of Canada) (Dawson *et al*. 2010, p. 143). In Norway, May *et al*. (2012, p 202) found that wolverine dens were generally located far from infrastructure (public roads and private roads and/or recreational cabins). The authors reported a minimum threshold in den site selection relative to infrastructure of 1.4 km (0.87 mi) from private roads and 7.5 km (4.7 mi) from public roads (May *et al*. 2012, p. 202). However, they found that wolverines in their study area had a wide tolerance range at the home-range scale (1.0–2.75 km (0.62–1.7 mi) for private roads and 6.0–11.0 (3.7–6.8 mi) for public roads) (May *et al*. 2012, p. 201; Figure 4), supporting conclusions from other studies that have found that, once a general area is used, it appears to be re-used in subsequent years including by successive individuals colonizing the sites (May *et al*. 2012, p. 202).

Wolverine road crossings were evaluated in the western Greater Yellowstone region through telemetered animals and visual observations of snow tracks, direct observations of crossings, and road-kill mortality (Packila *et al*. 2007, entire). That study documented 43 crossings of U.S. and State highways by 12 wolverines (Packila *et al*. 2007, p. 105). Within the Big Sky, Montana, area, they documented 67 crossings of MT64/Jack Creek Road by 4 wolverines (Packila *et al*. 2007, p. 105). Most (76%) road crossings were made by subadult wolverines, dispersing or otherwise exploring new areas (Packila *et al*. 2007, p. 105). One road-caused mortality was observed and the authors report two others from additional sources during their study period (Inman *et al*. 2007, p. 89). The study results indicate that roads do not act as absolute barriers to movement by wolverines, but they can directly affect individuals (road kill) and may have secondary effects at the population level (Packila *et al*. 2007, p. 105).

In an effort to evaluate the potential impact of major roads to wolverine (individuals and populations), we conducted a spatial analysis of roads[2] found within our Current Potential Extent for the wolverine in the contiguous United States~~Inman *et al*.'s (2013, p. 281) primary wolverine habitat and female wolverine dispersal habitat in the western United States~~, as measured by number of kilometers (miles). In our analysis, we identified several~~four~~ road classes: Interstate

[2] Using U.S. Geological Survey National Transportation Dataset Downloadable Data Collection based on TIGER/Line data provided through U.S. Census Bureau and supplemented with 'HERE' road data to create tile cache base maps.

Highway, U.S. Highway, State Highway, roads identified by Federal agency, County highways, County roads, and ~~secondary~~ local roads. ~~Secondary roads encompassed all roads not included in any of the first three categories and include paved and unpaved roads, including Forest Service roads, and are generally likely to have less traffic volume than major highways in the regions evaluated.~~ Our analysis found approximately 248,966 km (154,700 mi) of roads within the Current Potential Extent area, with local roads representing ~~that secondary roads represented~~ ~~97~~ 83 percent (~~29,892~~209,719 km (~~18,574~~128,449 mi)) of all roads ~~(30,805 km (19,141 mi))~~ within our Current Potential Extent area~~modeled primary habitat, and 97.5 percent (144,279 km (89,650 mi)) of all roads (148,029 km (91,980 mi)) within modeled female dispersal habitat~~.

We then evaluated the type of roads at high elevation within our estimated Current Potential Extent area~~Range~~ (~~shown in~~ Figure 3). Using the 2,300 m (7,546 ft) elevation as a benchmark (based on its use as a predictor variable for wolverine occurrence in Inman *et al*. 2013, and results from predictive models presented in Copeland *et al*. 2007, p. 2,205), we evaluated the length of roads above and below this elevation, and also the type of roads at or above 2,300 m (7,546 ft). The results are illustrated in **Appendix E**. Overall, we found that approximately ~~85~~ 95 percent of all roads were below 2,300 m (7,546 ft). Of the roads located at or above 2,300 m (7,546 ft), ~~95~~ 85 percent are ~~secondary~~ local roads ~~(see charts in **Appendix E**)~~.

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Using the same dataset, we evaluated road density (km/km^2) based on regional blocks of primary wolverine habitat in the western United States delineated by Inman *et al*. (2013; Figure 3). Those results are shown in Table 6. With the exception of the Southern Rockies (at 0.47 km/km^2), the mean road densities at elevations equal to or greater than 2,300 m (7,546 ft) are very low.

Table 6. Mean Road Density in Wolverine Primary Habitat.

Geographic Region‡	Mean density (km/km^2), all roads	Mean density (km/km^2), all roads ≥ 2,300 m (7,546 ft)
Northern Cascade	0.54	0.00
North Continental Divide	0.54	0.00
Salmon-Selway	0.70	0.03
Central Linkage	0.84	0.06
Greater Yellowstone	0.24	0.06
Southern Rockies	0.55	0.47
Sierra Nevada	0.09	0.03
Uinta	0.15	0.12
Bighorn	0.00	0.00
Great Basin	0.06	0.03
Oregon Cascade	0.72	0.00

‡Regions defined in Inman *et al*. (2013; Figure 3).

We also reviewed den site locations (natal, maternal, or unknown dens) within our database relative to roads (see map in **Appendix E**). Our results indicate that wolverine dens in the contiguous United States are located in areas with minimal roads, including ~~secondary~~ local roads; however, we caution that this analysis is based on a limited den site dataset and should be viewed in the context of other abiotic and biotic variables including landscape features at the den site scale and availability of food. Additionally, most den locations in much of the wolverine's

range in the contiguous United States are at high elevations and roads in these areas would likely be impassable or closed entirely to vehicles during the time of denning (January–March).

In summary, wolverines are associated with habitat found in high elevation areas, but are known to disperse over~~across~~ great distances. Major highways can present mortality risks to dispersing individuals and affect immigration to open territories, but roads do not represent absolute barriers to wolverine movements. Wolverines den during winter months in ~~remote~~ locations that are often inaccessible or restricted to motorized vehicles, though, secondary roads and trails are used for winter recreational activity. Although we recognize there are likely additional events that have not been reported, we estimated the total number of wolverine mortalities due to roads from 1972 to 2016 (44 years) in North America was 20, at least 11 of which are from Canada (see citations above). As discussed above, we calculated a low proportion of major highways in both modeled primary habitat and female dispersal habitat, and a low mean density of roads at high elevations where wolverines have been observed, with the exception of the southern Rocky Mountains. Roads present a low stressor to wolverines at the individual and population level in most of its current contiguous United States range.

Disturbance due to Winter Recreational Activity

Wolverine behavior patterns, such as denning, rearing of young, movement and dispersal, and foraging/scavenging, may be affected by recreational activities (COSEWIC 2014, p. 42~~).~~), though several wolverines have been captured for research on or near ski areas (e.g., Teton Mountains) (Montana FWP 2017, pers. comm.) As noted above, in Norway, May *et al*. (2012, p. 201) found, at the home range scale, a minimal threshold distance of approximately 1.5 km (0.93 mi) for wolverine den sites from private roads and/or recreational cabins. Krebs *et al*. (2007, entire) evaluated habitat use associations for wolverines in two multiple use areas in British Columbia, Canada. Using logistic regression models, the authors found that in an area of active recreation (Columbia Mountains), female wolverines were negatively associated with helicopter and backcountry skiing in their winter models (Krebs *et al*. 2007, pp. 2,187–2,188). However, in summer months, Copeland *et al*. (2007, p. 2,210) reported that wolverines in their study area of central Idaho were not uncommonly found near maintained trails and active campgrounds.

The Wolverine–Winter Recreation Study represents an on-going project to evaluate the potential effects of backcountry winter recreation (e.g., backcountry skiers, heli-skiers, cat-skiers, snowmobilers) on wolverines (Heinemeyer 2016, pers. comm.). The multiyear study areas include central Idaho and areas in the western Yellowstone region (~~'~~Island Park~~'~~ and Teton Mountains) (Heinemeyer and Squires 2015, p. 3). The study has been monitoring wolverines using GPS collars using movement rates and percent of time active (vs. resting) as indicators of potential responses of wolverines to winter recreation activities (Heinemeyer 2013, pers. comm.). Backcountry winter recreation activities are monitored through GPS units voluntarily carried by recreationists (Heinemeyer 2016, pers. comm.). Early analysis of the data suggest that wolverines demonstrate a behavioral response to recreation activities, such as increased movement rates and a reduction in resting periods in areas of high recreation activity, especially high recreation days (Saturday and Sunday) (Heinemeyer and Squires 2013, pp. 5, 7–8).

However, this research has also found that wolverines maintained their home ranges within areas with relatively high winter recreation activity over several years of monitoring, including some areas found to contain the highest recreational activities (Heimemeyer 2016, pers. comm.). The study has not been able to determine whether these resident wolverines are reproductively successful due to the limited monitoring information available for reproductive females (Heinemeyer 2016, pers. comm.).

A final Winter Recreation Study report was prepared by Heinemeyer *et al*. in December 2017. The study presented results from a RSF model in an effort to characterize habitat selection responses of wolverines to winter recreation patterns. The study found that wolverines maintained multi-year home ranges in areas that support relatively intensive winter recreation, suggesting that wolverines are able to tolerate winter recreation at some scales (Heinemeyer *et al*. 2017, p. iv). They also reported that wolverines responded negatively to increasing intensity of winter recreation, with off-road and dispersed recreation having a greater effect than recreation that was concentrated on access routes (Heinemeyer *et al*. 2017, p. 34). In addition, wolverine avoidance of roads and groomed areas used by winter recreationists was less than estimated for dispersed recreation, suggesting that wolverines may be less sensitive to predictable winter recreation use patterns (Heinemeyer *et al*. 2017, p. 40). The authors also described habitat selection in females evaluated in the mutli-year study as complex, and likely driven by a combination abiotic (snow, cold) and biotic factors (predator avoidance, food availability) (Heinemeyer *et al*. 2017, p. 36).

Conservation measures currently being implemented that address the effects of roads in the Teton Mountains include winter closures in certain areas (generally from November 1 through May 1), including road closures in the Bridger-Teton and Caribou-Targhee National Forests and in Grand Teton National Park as shown in **Appendix F** (additional details for Grand Teton National Park are described in Superintendent's Compendium (National Park Service (NPS) 2017; pp. 8–9); see also maps at https://jhalliance.org/campaigns/dont-poach-the-powder/ Jackson Hole Conservation Alliance 2017). These closures are being implemented to help minimize disturbance to wildlife (e.g., migration pathways).

State Wildlife Action Plans prepared for individual western States identify recreation management strategies within wolverine habitats. For example, in ~~the State of~~ Oregon, the ODFW Conservation Strategy identifies management of winter recreation use in order to avoid impacts to wolverines (ODFW 2016). In Montana's State Wildlife Action Plan, conservation actions are identified for addressing potential impacts from recreation, such as consideration of seasonal closures during denning~~breeding~~ season (Montana FWP 2015, p. 63). The IDFG *Management Plan for the Conservation of Wolverines in Idaho* also includes conservation strategies related to winter recreation (e.g., characterizing wolverine response to recreational activities (IDFG 2014, p. 35)), and the State continues to support the Wolverine-Winter Recreation Study. **Appendix ~~F~~ G** provides additional details on individual State conservation strategies.

In summary, wolverine behavior (movement) can be affected by winter recreational activity. Results from one long-term study in parts of the wolverine's range in the contiguous United States have found that wolverines can maintain residency in high winter recreational use areas.

Wolverines have recently been detected in areas that experience winter recreational activity. Conservation strategies and actions have been identified in several western States' Wildlife Action Plan to address potential impacts of this stressor to wolverines. Based on the best available scientific and commercial information, the effect of winter recreational activity represents a low stressor to wolverines in the contiguous United States at the individual and population level.

Commented [SJ30]: Plans?

Other Human Disturbance

Infrastructure, such as pipelines, active logging or clearcuts, seismic lines, and activities associated with mining (e.g., producing mines, mines under development, mineral exploration areas), may also affect individual wolverine behavior (e.g., avoidance) or loss or modification of wolverine habitat. As discussed above (see Habitat Use section), Johnson *et al*. (2005, entire) evaluated habitat relationships for the wolverine and other arctic wildlife, including the cumulative effects of human activities and associated infrastructure on the distribution of wolverines in the Canadian central Arctic using RSF modeling. However, because human disturbance factors (i.e., major developments, mineral explorations, seasonal outfitter camps) were mostly absent from the range of monitored wolverines, the researchers were not able to reliably model their effects (Johnson *et al*. 2005, p. 23).

The 2014 COSEWIC status review identified several potential stressors to wolverines and their habitat in Canadian territories. They indicated potential permanent, temporary, and functional losses to wolverine habitat from forestry; oil, gas, and mineral exploration and development; and large hydroelectric reservoirs (COSEWIC 2014, p. 21). As discussed above, Scrafford *et al*. (2017, entire) evaluated habitat selection of wolverines in response to human disturbance in the western Canadian boreal forest in both winter and summer months. Their analysis found that wolverines were attracted to some industrial infrastructure (older seismic lines exhibiting latter stages of regeneration) and disturbance (areas of active logging), likely related to foraging opportunities (e.g., small prey), but avoided interior areas of intermediate-aged cutblocks (areas authorized for logging) (Scrafford *et al*. 2017, pp. 32–34). Their results found evidence of road avoidance, but wolverines were attracted to all-season road sections with borrow pits, which they suggest was related to foraging opportunities at these pits (e.g., presence of beavers in water-filled pits) and less predation risk, since wolves avoid these roads (Scrafford *et al*. 2017, p. 34). In sum, these authors concluded that wolverine selection patterns relative to industrial activity and infrastructure in their study area represent a balance between exposure to predators and foraging opportunities (Scrafford *et al*. 2017, p. 32).

Additional studies of wolverine behaviors related to the effects of disturbance due to infrastructure and other human activities are needed. Based on the best available scientific and commercial information, these effects are small or narrow in scope and scale and appear to represent a trade-off between foraging opportunities in areas that provide minimal risk of predation and avoidance of open areas and/or higher predation risk (Scrafford *et al*. 2017, pp. 33–34).

Effects from Wildland Fire

Wildland fire can produce both direct and indirect effects to wildlife. Direct effects include injury and mortality as well as escape or emigration movement away from fires (Lyon *et al*. 2000, pp. 17–21). Small mammals will generally find refuge underground or within sheltered places within the burning area, while larger mammals will move to safe areas in unburned patches or outside the burn (Lyon *et al*. 2000, p. 18). For animals that emigrate during fire events, the length of time before they return is dependent on the degree to which fire has altered habitat structure and food supply (Lyon *et al*. 2000, p. 20).

We are unaware of any studies evaluating direct effects of wildland fire to wolverines. Wildland fire is likely to temporarily displace wolverines, which could affect home range dynamics. Given that wolverines can travel long distances in a short period of time, individuals would be expected to move away from fire and smoke (Luensmann 2008, p. 14). In addition, because young are born during winter months, fire risk at that critical life stage is very low (Luensmann 2008, p. 14).

Indirect effects of wildland fire can include habitat-related effects or effects to prey and competitors/predators; however, we are unaware of empirical studies evaluating these potential effects as they relate to wolverines. In a study area within the Yukon (Canada), wolverines were reported occupying regenerating forested habitat that contained remnants of mature timber which had burned 30 years prior (Slough and Mowat 1996, p. 948). Additionally, fire suppression in conjunction with logging activities in boreal forests (northwestern Ontario) can increase the prevalence of deciduous tree habitats, at least at a regional level, which is negatively associated with wolverine occurrence (Bowman *et al*. 2010, p. 464).

A study in northern Idaho of the effects of multiple wildland fires over several years, including very large fires, to forest habitat occupied by another mustelid, the American marten (*Martes americana*) found that fire events had created a mosaic of vegetation that supported a diverse assemblage of cover and food resources that was favorable to this species (Koehler and Hornocker 1977, p. 503). Similar to wolverines, the summer and fall diet of the American marten is represented by diverse prey, and wildland fire events can create and maintain forest openings for ground squirrels and voles (Koehler and Hornocker 1977, p. 504). The development of these types of mosaic forest communities following certain wildland fire events also provides discontinuous fuel loads, which in turn should result in smaller and cooler wildland fires, with less replacement of marten habitat (Koehler and Hornocker 1977, p. 504). However, large, uniform burns would be expected to result in more severe impacts to American marten habitat (Lyon *et al*. 2000, p. 21).

Studies of the effects of wildland fire to a key prey species for the wolverine in parts of its North American range, the caribou, was reviewed by Klein (1982, entire). This review highlighted the importance of separating short-term effects of wildland fire in boreal forests to caribou ecology from long-term effects (Klein 1982, p. 393). Given that long-term benefits to the species' ecology can be disproportionate to the short-term detrimental effects on populations and herds, (including the species' lack of reproductive plasticity), caribou may be more appropriately considered as fire-influenced, rather than fire-adapted (Klein 1982, p. 393). Other ungulate prey species respond more positively to fire. An increase in spring and summer grasses following fall

burns can provide forage for elk and deer, and sprouting of deciduous trees, such as aspen, birch and willow, following burns provides forage for moose (Luensmann 2008, p. 18).

Management measures to address this potential stressor are identified in USDA Forest Service National Forest Land Management Plans. Examples of these goals and objectives are described in **Appendix G**. In addition, the Idaho State Wildlife Action Plan includes measures to address fire threats to the wolverine and its habitat, including removal of perceived barriers to allow more prescribed natural fire on State and private forest lands and promoting/facilitating the use of prescribed fire as a habitat restoration tool, on both public and private lands where appropriate, and leaving fire-killed trees standing as wildlife habitat if they pose no safety hazard, all in an effort to restore a more natural fire interval that allows for return to historical forest conditions (IDFG 2017b, pp. 91, 134, 180).

Given the diversity of habitats occupied by wolverines, their occupancy of high elevations, and extensive mobility, wildland fire represents a limited stressor, in scope and scale, to wolverine habitat and its prey in the contiguous United States range.

Disease or Predation

Disease

We are unaware of comprehensive surveys evaluating the prevalence of diseases in wolverines in the contiguous United States. Early accounts of endoparasites species and their prevalence in wolverines include a review by Erickson (1946, p. 503), and a report by Rausch (1959, entire), who documented 7 species of helminth parasites in 86 percent of wolverines examined from trapper-supplied carcasses in Alaska. In 1994, Copeland (1996, p. 26) collected a single specimen of the parasite *Toxascaris* sp. from wolverine scat in Idaho. In Alaska, carcasses sampled (during necropsy or predator control activities) in 2012–2014 to determine the prevalence of *Trichinella* and its genotypes reported one wolverine with *Trichinella* T6 genotype in that single sample (ADF&G 2015b, p. 8). Results from Alaska trapper questionnaires for the prevalence of ectoparasites on wolverines were either scarce or not present across all reporting regions in 2015–2016 (Parr 2016, p. 21).

Rabies is endemic to Alaska in Arctic and red fox along north and west coasts of Alaska (ADF&G 2013c). Under the ADF&G enhanced rabies surveillance program, the agency confirmed rabies in one wolverine (out of 49 sampled) in 2012, a female found dead in the North Slope region (Woodford and Beckman 2012). This was the first confirmed case of rabies in wolverines in North America (Woodford and Beckham 2012).

The 2014 COSEWIC Assessment and Status Report for the wolverine presented a summary of reported parasitic species observed in wolverines in Canada (COSEWIC 2014, p. 25). These observations included: parasitic nematode roundworms (*Trichinella* spp.) in 88 percent of wolverine samples tested from Nunavut and 26 percent from the lower MacKenzie region; helminth parasites (trematodes, cestodes and nematodes) in wolverine digestive tracts from the lower Mackenzie River valley; and, from the Nunavut region, protozoan parasites infections including *Sacrosystis* spp. (80 percent) and *Toxoplasma gondii* (41 percent) (citations omitted).

Banci (1987, pp. 81, 110) reported parasitic pneumonia as a cause of mortality in southwest Yukon Territory, a female thought be nutritionally-stressed following the raising of young.

An evaluation of trapper-submitted wolverine carcasses harvested was conducted for the Yukon Territory in the fur trapping seasons 2005–2006 through 2011–2012 (Jung and Kukka 2013, entire). No samples tested positive for rabies (Jung and Kukka 2013, p. 17). Another study of intestinal parasites of wolverine carcasses from both the Yukon and Northwest Territories reported *Trichinella* spp. in 74 percent of carcasses and several intestinal parasites, including cestodes (parasitic flatworms) such as *Taenia* spp. (Luck *et al*. 2016, no page number).

In summary, other than a parasitic pneumonia mortality event and the single rabies case, we are not aware of any other studies documenting impacts of disease to wolverines in North America. At this time, based on the best available scientific and commercial information, we do not find that disease is a population or species level stressor to the wolverine in the contiguous United States.

Predation

As discussed above (*Diet and Feeding* section), a number of potential natural predators have been identified for wolverines within~~across~~ its North American range, including intraspecific predation. However, we have no information that suggests this predation represents a significant stressor to the wolverine at ~~either an individual or~~the population level. At the individual level, we recognize that wolverines likely avoid areas of potential predation risk from wolves (Scrafford et al. 2017, p. 34) and other potential predators. Thus, indirect effects of predators may result in predator avoidance behavior of individual wolverines through habitat selection.

Commented [BJG31]: Added – Peer Reviewer 1, page 3.

In summary, the best scientific and commercial information available indicates that disease or predation is not a stressor for the wolverine. We are unaware of any management or conservation measures currently in place to reduce potential impacts associated with disease or predation.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

There is currently no allowable trapping or harvesting of wolverines in the contiguous United States, though incidental trapping mortalities have been documented as we reported in our proposed rule (78 FR 7881; February 4, 2013). Two mortality events from shootings of wolverines were documented in Idaho (2001, 2007) (Idaho Department of Fish and Game (IDFG) 2014, p. 26).

In Montana, wolverines were a legally harvested furbearer in Montana up until 2012. ~~; however,~~ As noted in **Appendix G**, beginning in 2008, the State shifted harvest units and quotas to emphasize proetection ~~i~~in smaller mountain ranges, closing 40 percent of the State to harvest and the trapping season is currently suspended with a zero statewide quota (Montana Natural Heritage Program and Montana FWP 2017). Montana FWP also adopted mandatory trapping education in August 2017, which begins in 2018, which will emphasize avoidance of incidental captures and modern equipment in order to minimize injury (Montana FWP 2017, pers. comm.). There is, however, no evidence to suggest that the harvest of wolverines in Montana at historical

rates (about 10 animals per year) was detrimental to wolverine populations, and since 2005, the rates and spatial arrangement of wolverine harvest have been much more conservative than the historical rates (Montana FWP 2017, pers. comm.) (see **Appendix G**).

Commented [BJG32]: Added per request of MT FWP.

Unlike populations in Eurasia, wolverines rarely prey on livestock in North America (*cf.* domestic sheep predation in Wyoming reported (Mead 2013, pers. comm.)) and therefore they are not directly targeted for predator control (COSEWIC 2014, p. 41). However, incidental trapping can result in the capture of non-target species such as wolverine. In Idaho, the IDFG has a mandatory furtaker harvest report that requests all live incidental catches be reported by species and any wolverine catch that results in mortality is required to be reported (IDFG 2013, pers. comm.). Since 1965, over a period of just over 50 years, ~~16~~ 17 incidentally-trapped wolverines were reported during the State's furbearing seasons, with 6 animals known to be released alive and 6 mortalities (IDFG 2013, pers. comm.; IDFG 2016, pers. comm.; IDFG 2017, pers. comm.). This total includes four wolverines caught during the 2013-2014 furbearer season, with three released alive and one mortality (IDFG 2014, p. 26), and one animal in 2016, who released itself prior to discovery (identified through DNA testing). Though the fate of that animal is unknown there was no obvious sign of injury (IDFG 2017, pers. comm.).

The State of Utah maintains a highly regulated trapping program, including mandatory trap check intervals (Utah Department of Natural Resources (UDNR) 2017, pers. comm.). Any incidentally trapped wolverines must be released and any mortality must be reported to the Division of Wildlife Resources within 48 hours; there are no records of incidental captures (UDNR 2017, pers. comm.). Within the State of Wyoming, there are two confirmed reports of incidental take, one in 1996 (Mead 2013, pers. comm.) one in 2006. The 2006 animal was released unharmed (Inman 2012, pers. comm.). In Montana, since the closing of the trapping season for wolverine in 2013 (2013 through 2016), four wolverines have been incidentally trapped, one in 2013 and three in 2014 (Inman 2017c, pers. comm.). The 2013 capture was released unharmed and the three caught in 2014 were all mortalities (Inman 2017c, pers. comm.).

Predator control programs targeting wolves, including poison and incidental trapping, can result in incidental losses of wolverines (COSEWIC 2014, p. 41). Specific to wolf control for livestock protection in Idaho, three wolverines have been trapped incidental to authorized wolf control activities since 1995, with two released alive and one animal euthanized (IDFG 2014, p. 26). Preventive measures have been adopted to reduce these incidental captures, including implementation of educational programs to minimize incidental capture of wolverines during trapping seasons (IDFG 2014, p. 27). Licensed wolf trappers are required to complete a Wolf Trapper Education course with specific instruction for reducing incidental trapping of wolverine, Canada lynx, and other non-target species (IDFG 2014, p. 27). In addition, the U.S. Department of Agriculture Wildlife Services (Wildlife Services) agency has also temporarily stopped (as of April 2017) using cyanide predator control devices in the State of Idaho (Moeller 2017). Wildlife Services has also agreed to not use, or fund the use of, M-44 cyanide devices on public lands in Colorado pending issuance of an Environmental Assessment (Civil Action No. 17-cv-00891-WYD) and has agreed to interim measures, including not using EPA-labeled pesticides targeting mammalian species, in the Northern District of California, pending environmental analsysis (Case No. 3:17-cv-3564-WHA) .

In Alaska, wolverine trapping and hunting is controlled by seasons and bag limits, with about 550 animals harvested each year (Alaska Department of Fish and Game (ADF&G) 2017a). For the 2015–2016 reporting period, wolverine harvest, based on furbearer sealing records,[3] totaled 527 animals (Parr 2016, p. 42). This level of harvest has been fairly consistent since 2010, as shown in Table 7 below.

Table 7. Number of wolverines harvested in Alaska, as reported from regulatory year sealing records, 2010–2015. Adapted from Parr (2016, p. 42; Table 10).

Alaska Region	2010	2011	2012	2013	2014	2015
I	25	20	25	31	14	15
II	25	29	50	31	16	37
III	233	235	261	358	268	214
IV	180	160	170	158	99	150
V	140	110	135	133	109	111
Total	603	554	641	711	506	527

Trapping and harvesting of wolverines occurs over much of the range in Canada, as summarized in the 2014 COSEWIC wolverine status review (COSEWIC 2014, pp. 10, 29–35). Specifically, wolverines are harvested in the northern and western territories–Manitoba, Saskatchewan, Alberta, British Columbia, Yukon, Northwest Territories, and Nunavut (COSEWIC 2014, p. 43). Non-aboriginal harvest of wolverines has not been permitted since 2001–2002 in Québec and Labrador (COSEWIC 2014, p. 43). Trapping is closed in Ontario (except through treaty rights), though incidental trapping results in 1 to 4 mortalities per year (Bowman *et al*. 2010, p. 465). Harvest levels in western provinces have remained relatively stable since 1992 (COSEWIC 2014, p. 38; Table 1). An earlier assessment of the sustainability of wolverine harvest in British Columbia was presented in Lofroth and Ott (2007, entire). That study found that the trapping and hunting harvest of British Columbia's wolverine population was likely sustainable at a provincial scale from 1985 to 2004, with wolverine harvest in 15 of 71 population units were likely unsustainable during this period (Lofroth and Ott 2007, p. 2,197).

The management of wolverine harvest in Canada incorporates spatial and temporal elements such as season length, quotas, limited entry, and trapline management by trappers (reviewed by Slough *et al*. 1987). Wolverine harvest levels in Canada are monitored using mandatory pelt sealing, annual harvest reporting, or through monitoring of fur exports (COSEWIC 2014, p. 43). In some northern communities, wolverine pelts are used locally and harvests are monitored through carcass collection programs (COSEWIC 2014, p. 43).

The COSEWIC Assessment and Status Report for the wolverine also noted that range contraction and habitat trends of wolverines in Canada are not solely the result of habitat or trapping pressure (COSEWIC 2014, p. 20). Reductions in ungulate (e.g., caribou) populations,

[3] Wolverines taken in Alaska are required to be sealed by an authorized department representative before pelts are shipped to an out-of-state buyer or auction house (Parr 2016, p. 44). For those species that require sealing, the number of animals sealed represents the best information regarding the statewide harvest (Parr 2016, p. 41).

which provide an important winter food resource, were also likely an important factor in range contractions of wolverines in its northern range (COSEWIC 2014, p. 20), and likely continue to influence populations today. Snowmobiles have allowed for better access for hunters and trappers and may be increasing the number of wolverine harvested in its northern North America range; however, the areas of exploitation are still relatively small concentrated areas, and large areas of refugia continue to be found (Cardinal 2004, p. 31).

~~Population growth rate scenarios for North American wolverines were modeled by Krebs *et al.* (2004, p. 499), including trapped and untrapped populations. Of note, at the time of this study, wolverines were considered furbearer or game animals and trapped or hunted in 8 of their 12 study areas in North America, including Montana (Krebs *et al*. 2004, p. 495; Table 1). Estimated (logistic) rates of population growth (λ) were found to be lower for trapped populations (λ = 0.878) as compared to untrapped populations (λ = 1.064) (Krebs *et al*. 2004, p. 499). Based on their analysis, harvesting was considered to be an "additive mortality" in the populations studied and is likely sustained by dispersal from untrapped areas that provide refugia (Krebs *et al*. 2004, pp. 499–500). However,~~ A~~a~~s described in the 2014 COSEWIC report, trends in wolverine populations in the northern range, while uncertain, appear to be stable or increasing, with some concern for populations in the southern areas of British Columbia and parts of the northern United States (COSEWIC 2014, p. 22, and references cited therein). Similarly, in Alaska, over the past 6 years, on average, 590 wolverines are taken each year (see Table 7). The consistent harvest levels in these regions suggest relatively stable wolverine populations.

We evaluated trapping of wolverines in British Columbia and Alberta regions of Canada in an effort to document potential impacts to dispersing wolverines along the U.S.–Canada border. As described above (*Population Abundance and Distribution*), the population of wolverines in British Columbia is estimated to be 2,700–4,760 and 1,500–2,000 animals in Alberta (COSEWIC 2014, p 36). We obtained 9 years (2007–~~-~~2015) of harvest data for southern BC wildlife management units from the British Columbia Ministry of Environment, Ecosystems Branch for our analysis (Weir 2017b, pers. comm.). Twenty seven years (1989–2015) of harvest data was obtained for Alberta in addition to locations of wolverines from a 2012–2015 study and other sources (Webb *et al*. 2016, p. 1,465; Webb 2017, pers. comm.).

Figure 6~~5~~ presents the results from our spatial analysis and indicates a total of 77 wolverines were trapped in British Columbia wildlife management units within 110 km (68.35 mi) of the U.S.–Canada border from 2007–2015 (average of 8.5 animals per year) (Note: the gray areas depicted for British Columbia represent management units with zero harvest). We used this distance since it's similar to both the average maximum distance per dispersal movement of 102 km (63 mi) for male wolverines reported by Inman *et al*. (2012a, p. 784) for the Greater Yellowstone region of Montana, and a reported 100 km (62 mi) dispersal distance for a juvenile male for Ontario, Canada (COSEWIC 2014, p. 24, citing unpublished data from Dawson *et al*. 2013). As shown below, one management area contains nearly one-third (23 individuals) of this total number. The other management units along the international border indicate very few animals harvested over this 8-year period (i.e., areas on map identified as zero). There is no open trapping season or hunting season on wolverines in the management units in the Okanagan (Region 8) (north of Washington State) or South Coast (Region 2) (southwest corner of British Columbia) with a trapping season for wolverines only in the Kootenay (Region 4, the eastern half of the southern

part of the province) (Weir ~~2017b~~2017c, pers. comm.). In addition, there has not been an open trapping season in Region 2 since at least 1985 and since 1993 in the Okanagan region (Weir ~~2017c~~2017d, pers. comm.). For Alberta, we identified a total of 15 wolverines harvested by trappers and data presented in other studies within 110 km (68.35 mi) of the U.S.–Canada border from 1989–2014 (average of less than 1.0 animal per year). Researchers in Canada are currently conducting a landscape level analysis to estimate the size and sustainable harvest for wolverine populations within British Columbia (Weir 2017a, pers. comm.). We also requested information related to incidental trapping along the southern Alberta- U.S. border. Only one registered trapline is located 10 km north of the border with Montana and no wolverines have been reported as this is primarily grassland habitat (Webb 2018, pers. comm.). In addition, in Canada, if wolverines are trapped outside of a registered trapline, trappers are required to ~~be~~ register that event; however, fur harvest records for southern Alberta do not indicate any trapped wolverines (Webb 2018, pers. comm.).

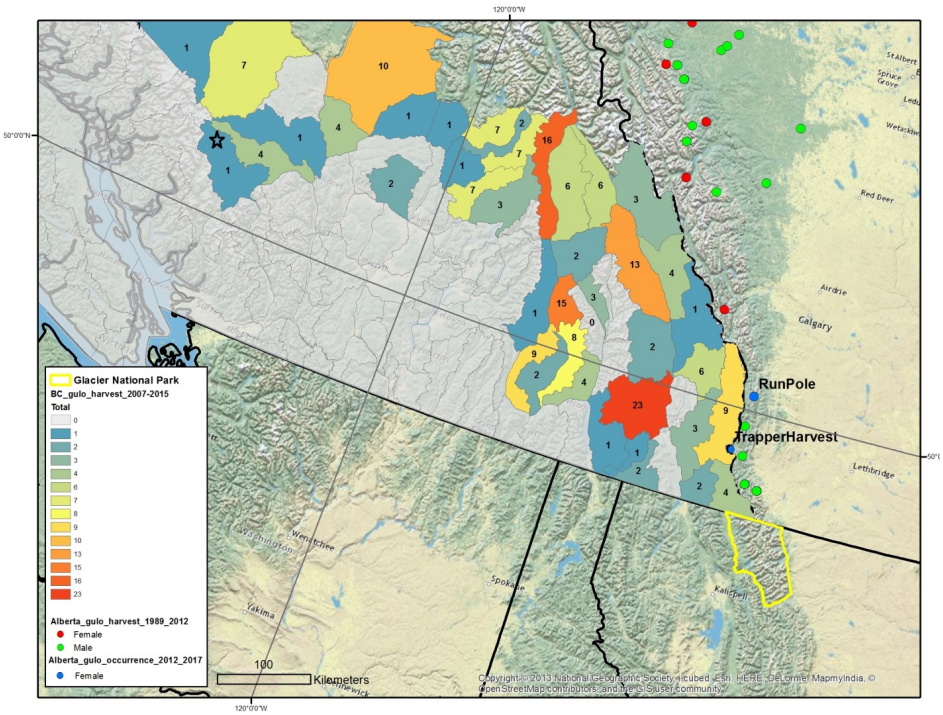

Figure 64. Numbers of wolverines harvested in British Columbia and Alberta, Canada. Sources: Weir 2017a, pers. comm.~~British Columbia Ministry of Environment~~; Webb *et al*. 2016; Webb 2017, pers. comm.

Commented [SJ33]: 6?

Based on this analysis, trapping effort along the U.S.–Canada border does not represent a ~~significant~~ barrier to wolverine movement and dispersal along the international border. As noted above, Regehr and Lacroix's (2016, entire) multi-method inventory of wolverines within an area located in the eastern side of the Coast Mountains of British Columbia (see black star in Figure

6~~5~~ above) found unexpectedly high numbers of wolverines, which may have been the result of the rugged landscape features in this mountainous area and abundant food resources (both winter and summer) (Regehr and Lacroix 2016, pp. 249–250).

Commented [SJ34]: Seems out of place here?

Legal Status/Protection

Commented [SJ35]: What about Alaska?

In the western United States, the wolverine status is as follows: a state-threatened species in Oregon (ODFW 2016) and California (CDFW 2017a); state-endangered species in Colorado (Colorado Parks and Wildlife 2015a) ; a candidate species in Washington (Washington Department of Fish and Wildlife (WDFW) 2013); a protected nongame species and species of greatest conservation need in Idaho (IDFG 2014); a protected animal and species of greatest conservation need in Wyoming (WGFD 2017); ~~a~~ protected from collection, possession, and importation (Utah Administrative Rule R-657-3-24) and a species of greatest conservation need in Utah (Utah Wildlife Action Plan Joint Team 2015); a furbearer and species of concern in Montana (Montana Natural Heritage Program and Montana FWP 2017); and, in Nevada, the Nevada Administrative Code lists wolverines as a protected mammal (NAC 503.030), which provides full legal protection. There is no protected status for wolverines in the State of Alaska. The State of New Mexico Department of Game and Fish does not recognize the wolverine as a native mammal. Additional discussion regarding State regulatory mechanisms that provide protections for wolverines is provided in **Appendix G**.

The Idaho Department of Fish and Game issues permits allowing live capture, handling, and release of wolverines for scientific studies, which usually involved log box-traps that do not cause physical injury to the captured animals (IDFG 2014, p. 27). The agency also issues scientific collection permits to various agencies and organizations and to IDFG biologists that can include the capture, chemical immobilization, and placement of radio-collars/radio-markers on wolverines (IDFG 2014, p. 27). These permittees (and IDFG staff) are required to comply with animal trapping and handling protocols approved by IDFG's Wildlife Health/Forensic Laboratory and other animal welfare and research institutions. This same process is followed by the State of Montana (Montana FWP 2017, pers. comm.). Over the past 20 years, there have been two documented wolverine deaths due to live capture activities in Idaho (IDFG 2014, p. 27), and one handling-related mortaliy in Montana (Montana FWP 2017, pers. comm).

In Wyoming, the Wyoming Game and Fish Commission (Commission) Regulation Chapter 52, Nongame Wildlife, authorizes 'take' of wolverine only for scientific or educational purposes as regulated by Commission Regulation Chapter 33 (Regulation Governing Issuance of Scientific, Research, Educational, or Special Purpose Permits). As of November 2017, the WGFD has issued five different Chapter 33 permis for research activities; four of the five are for live capture and one for camera trapping surveys (WGFD 2017, pers. comm.). No incidental take has been reported from permits issued, and no permits allowing for the take of wolverine hve been issued in Wyoming (WGFD 2017, pers. comm.). ~~We received information from the State of Wyoming indicating that a search of electronic records of Chapter 33 permits (issued since 1997) found (as of May 2013) three permits have been issued for scientific purposes to further understanding of wolverine ecology in Wyoming (Mead 2013, pers. comm.).~~

In California, research permits for State-listed, State-candidate, and fully protected species in California are issued as a Memorandum of Understanding (MOU). Currently, there are no active MOUs for research on wolverine in California (Burkett 2017, pers. comm.).

In Canada, provincial designations for the wolverine include Endangered in Labrador, and Threatened in Ontario and Québec ('Threatened' is equivalent to Endangered in Québec), with the remaining provincial designations ranging from no ranking to Sensitive or Special Concern and the Vancouver Island population designated as Imperilled (COSEWIC 2014, p. 44). Recovery planning for the wolverine is focused on the eastern population (Canadian Boreal Forest Agreement Secretariat 2015, p. 3).

In summary, overutilization does not currently represent a stressor to the wolverine in the contiguous United States at the individual, population, or species level. Wolverine populations in the contiguous United States are currently protected under several State laws and regulations. Hunting and trapping activities for wolverines are currently suspended or closed entirely for animals within the contiguous United States, though occasional incidental trapping can occur. Trapping in Montana, Alaska, and Canada has been and appears to be sustainable~~ given large areas of available refugia in these regions~~. Trapping or harvesting of wolverines along the contiguous U.S.–Canada border does not represent a stressor to wolverines migrating into the contiguous United States at the individual or population level. In addition, wolverine populations along the Alaska–Canada border are continuous with the Yukon region of Canada, which suggests a rescue effect for Canadian populations along this international boundary (COSEWIC 2014, p. 37).

Summary of Current Conditions

Wolverine populations in much of North America are still recovering from large losses of individuals from intensive hunting and unregulated persecution pressures in the late 1880s into the mid-20th century.~~ Although there is limited rangewide survey information,~~ The distribution of wolverines within suitable habitat provides a better method for estimating population status than using abundance of animals, although there is limited rangewide survey information. B~~b~~ased on the best available information, wolverines continue to be detected within ~~across~~ suitable habitat within the west-northwestern contiguous United States including Washington, Oregon, Idaho, Montana, and Wyoming (e.g., Aubry *et al*. 2016, pp. 14–15; Magoun *et al*. 2013, p. 27; Montana FWP 2017, pers. comm.). Studies are currently underway to estimate the species' current distribution and genetic characteristics of these populations~~ metapopulation across Montana, Idaho, Wyoming, and Washington~~. In Canada, the total wolverine population is estimated at over 10,000 adults (COSEWIC 2014, p. 47). In Alaska, estimates of populations are not available and are best evaluated based on density (Parr 2017, pers.comm.), which are naturally low for this species. Recent density estimates range from 5 to 10 wolverines per 1000 km^2 (386 mi^2) for Alaska (Parr 2017, pers. comm). The best available information does not indicate wolverine populations are currently negatively impacted by the lack of genetic diversity and there is no evidence that the population in the contiguous United States is declining.

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~~Based on our collection of observations and detections of wolverines in the contiguous United States and the 2014 status review for Canada, we~~We prepared a Current Potential Extent ~~Range~~ map to illustrate the species' ~~North American range~~current distribution in the contiguous United States (Figure 3). We estimated ~~that the proportion of~~ this area ~~e current North American range of the wolverine encompassed within the contiguous United States~~ represents ~~is~~ approximately 3.5 ~~6~~ percent of the wolverine's North American range.

~~We determined that 96 percent of the previously modeled primary habitat (Inman *et al*. 2013) in the lower United States is considered to be lands owned or managed by the Federal government (see **Appendix D**).~~ We determined that 72 percent of our Curent Potential Extent of the wolverine in the contiguous United States is found on lands owned or managed by the Federal government (see **Appendix D**) We also evaluated Inman *et al*.'s (2013) previously modeled wolverine primary habitat in the contiguous United States and estimated that 96 percent ~~are~~of that area is owned or managed by Federal agencies and 41 percent ~~of this modeled primary habitat~~ is located in designated wilderness areas. **Appendix G**, *Regulatory Mechanisms and Conservation Measures*, provides a more detailed summary of management actions.

We evaluated several potential stressors that may be affecting wolverine populations or its habitat, including effects from roads, disturbance due to winter recreation and other activities, effects from wildland fire, disease and predation, and overutilization for (primarily) commercial purposes. We determined that the effects of roads (evaluated by number of miles, density, and location) and disturbance represent low level stressors to the wolverine in the contiguous United States. Wildland fire was determined to be a short-term stressor to wolverine habitat and its prey. Disease and predation are not considered stressors to the wolverine.

Legal trapping or hunting of wolverines is currently prohibited in the contiguous United States. Incidental trapping of wolverines is infrequent in the contiguous United States, and, in Idaho and Montana, education programs are being implemented to reduce this stressor. In Alaska, the level of harvest of wolverines has been fairly consistent since 2010, and, as noted above, density estimates indicate no declining trend in wolverine populations.

Wolverines are harvested in several Canadian provinces with management and monitoring oversight based on spatial and temporal elements. We reviewed trapping information from Canada (within 110 km (68.35 mi) of the contiguous U.S.–Canada border) to assess potential impacts to dispersing wolverines into the United States. We found that, in Alberta, 15 wolverines were harvest over a 25 year period (average of less than 1.0 animal per year), and, for British Columbia, we found an average of 8.5 animals per year, though one management area contained nearly one-third (23 individuals) of this total (Weir 2017b, pers. comm.). Researchers in Canada are currently conducting a landscape level analysis to estimate the size and sustainable harvest for wolverine populations within British Columbia (Weir 2017a, pers. comm.). Based on the best available commercial and scientific information, overutilization does not represent a stressor to the wolverine in the contiguous United States.

Status – Future Conditions

The future timeframe evaluated in our analysis is approximately 40 to 50 years, which captures ~~the range of time periods for proposed projects within the species' range, as well as~~ our best professional judgment of the projected future conditions related to trapping/harvesting, climate change, or other potential cumulative impacts. We note here that evaluations of future conditions for species have an inherent level of uncertainty relative to demographic risks, particularly those related to climate change projection.

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After considering the current conditions for the wolverine and its habitat, we describe here the most likely future scenario to potentially have an effect on wolverine at the population level in the contiguous United States:

- Climate change effects (i.e., significantly elevated temperatures resulting in decline in snowpack) may modify suitable habitat (including reproductive denning habitat), which could also change the scope of the wildland fire stressor.

Based on our review of the best available information, we determined that there were no other plausible scenarios that were likely to have population level impacts to wolverine in the contiguous United States. We expect that the effects of trapping and roads, human disturbance, effects of wildland fire to continue to be at low levels in the future. We have no information that indicates that mortality from roads or disease would increase within the range of wolverine in the contiguous United States in the future.

Climate Change Effects

In this section, we consider climate changes that may affect environmental conditions that the wolverine relies on. As defined by the Intergovernmental Panel on Climate Change (IPCC), the term "climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2013a, p. 1,450). The term "climate change" thus refers to a change in the mean or the variability of relevant properties, which persists for an extended period, typically decades or longer, due to natural conditions (e.g., solar cycles) or human-caused changes in the composition of atmosphere or in land use (IPCC 2013a, p. 1,450).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring. In particular, warming of the climate system is unequivocal and many of the observed changes in the last 60 years are unprecedented over decades to millennia (IPCC 2013b, p. 4). The change in temperature reported in the Northern Hemisphere in recent history (past 150 years) at +0.6°C (1.08°F) is twice the change reported for the Southern Hemisphere (+0.3°C (0.54°F)) and there is much year-to-year variation (Post 2013, p. 4). With regard to precipitation over land, there has been a decline in global total annual precipitation, but the variability between years in total precipitation has increased since about the 1970s (Post 2013, p. 9). The Palmer Drought Severity Index (PDSI) compares the actual amount of precipitation received in an area during a certain time period with the normal or average amount expected during that same period (National Weather Service (NWS) 2015) and is generally used as a measure of water stress. Time series analysis of the PDSI indicates worsening persistent drought-like or drought-potential

conditions across the globe since 1980, a reflection of the influence of temperature on atmospheric dynamics (Post 2013, pp. 10–11).

Comprehensive assessments of other observed and projected changes in climate and associated effects and risks, and the basis for them, are provided for global and regional scales in recent reports issued by the IPCC (2013c, 2014), and similar types of information for the United States and regions within it can be found in the National Climate Assessment (Melillo *et al*. 2014, entire). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate and is "extremely likely" (defined by the IPCC as 95 to 100 percent likelihood) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from fossil fuel use (IPCC 2013b, p. 17 and related citations).

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions. Model results yield very similar projections of average global warming until about 2030, and thereafter the magnitude and rate of warming vary through the end of the century depending on the assumptions about human population levels, emissions of GHGs, and other factors that influence climate change. Thus, absent extremely rapid stabilization of GHGs at a global level, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by human actions regarding GHG emissions (IPCC 2013b, 2014; entire).

Global climate projections are informative, and, in some cases, the only or the best scientific information available. However, projected changes in climate and related impacts can vary substantially across and, as noted above, within different regions and hemispheres (e.g., IPCC 2013c, 2014; entire) and within the United States (Melillo *et al*. 2014, entire). Therefore, we use "downscaled" projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species (see Glick *et al*. 2011, pp. 58–61, for a discussion of downscaling). We note here that multiple lines of evidence, not just projections derived from quantitative models, should be examined when conducting climate vulnerability assessments (Michalak *et al*. 2017, entire). Thus, we provide below projected effects from climate change in the western United States relative to both abiotic (e.g., temperature, precipitation, snow cover) and biotic (e.g., phenology, behavior) factors.

Abiotic Factors

California

Regional temperature and precipitation observations for assessing climate change are often used as an indicator of how climate is changing. For evaluating climate trends in California, the Western Regional Climate Center (WRCC) has defined 11 climate regions (Abatzoglou *et al*. 2009, p. 1,535). The relevant region for our assessment is the north/north-central Sierra Nevada

region (Tahoe National Forest), currently occupied by a male wolverine, or the northeast region as defined in Abatzoglou *et al*. (2009, p. 1,535) .

Two indicators of temperature, the increase in mean temperature and the increase in maximum temperature, are important for evaluating trends in climate change in California. For the climate region that encompasses the Tahoe National Forest region, the 100-year linear trends provided by the WRCC indicate an increase in mean temperatures (Jan–Dec) of approximately 0.92°C/100 yr (± 0.29°C/100 yr) (1.66°F ± 0.53°F/100 yr) since 1895 from present day; 1.55°C/100 yr (± 0.67°C/100 yr) (2.79°F ± 1.21°F/100 yr) since 1949 to present day; and 2.41°C/100 yr (±1.54°C/100 yr) (4.33°F ± 2.78°F/100 yr) since 1975 to present day (WRCC 2017). Thus, the increase in mean temperature has not been constant—the rate of increase over the past 42 years in this region has been 2.6 times higher than the past 122 years. We assume the rate of temperature increase for this region is higher for the second and third time periods (since 1949 and 1975, respectively) than for the first time period (since 1895) due to the increased use of fossil fuels in the later part of the 20th and early 21st century.

Although these observed trends provide information as to how climate has changed in the past, climate models can be used to simulate and develop future climate projections. Both state-wide and regional probabilistic estimates of temperature and precipitation changes for California (by the 2060s) using downscaled data from 16 global circulation models and 3 nested regional climate models were presented by Pierce *et al*. (2013, entire). The study looked at a historical (1985–1994) and a future (2060–2069) time period using the IPCC Special Report on Emission Scenarios A2 (Pierce *et al*. 2013, p. 841), which is an IPCC-defined scenario used for the IPCCs Third and Fourth Assessment reports, and is based on a global population growth scenario and economic conditions that result in a relatively high level of atmospheric GHGs by 2100 (IPCC 2000, pp. 4–5; see Stocker *et al*. 2013, pp. 60–68, and Walsh *et al*. 2014, pp. 25–28, for discussions and comparisons of the prior and current IPCC approaches and outcomes). Importantly, the projections by Pierce *et al*. (2013, pp. 852–853) include daily distributions and natural internal climate variability.

Simulations using these downscaling methods project an increase in *yearly* temperature for the area that encompasses the Tahoe National Forest (Sierra Nevada) ranging from 2.1°C (3.78°F) to 3.2°C (5.76°F) by the 2060s time period (Pierce *et al*. 2013, p. 844), compared to 1985–1994. The simulations indicated a yearly upper temperature increase of 2.5°C (4.5°F) from 1985–1994 to 2060–2069 (averaged across models) for this area, and an increase of 1.9°C (3.42°F) for the December–February period (Pierce *et al*. 2013, p. 842).

Beginning in 2012 and continuing into 2016, California experienced a severe drought throughout most of the state (Griffin and Anchukaitis 2014, p. 9,020). Although three-year droughts in California are not unusual when evaluated over the past 1000 years, the severity of these drought conditions during this period was demonstrated in the 2014 summer PDSI, which was estimated to be the lowest on record (1901–2014) (Williams *et al*. 2015, p. 6,823). An evaluation of how unusual this drought event was in the context of the last millennium using blue oak (*Quercus douglasii*) tree ring data from four sampling sites (with additional tree sampling following the 2014 growth season) was conducted by Griffin and Anchukaitis (2014, entire). Their paleoclimate drought and precipitation reconstructions for Central and Southern California

show that, although the precipitation during this drought has not been anomalously low, it was not outside the range of variability (Griffin and Anchukaitis 2014, p. 9,017). However, the 2014 drought was the worst single drought year of at least the last 1,200 years in California and the 2012–2014 drought was the most severe of three consecutive drought years, based on three events found in the record for the last 1,200 years (Griffin and Anchukaitis 2014, pp. 9,020–9,021). The study concluded that low precipitation combined with high temperatures was responsible for creating this worst short-term drought episode (Griffin and Anchukaitis 2014, pp. 9,021–9,022).

A study by Williams *et al.* (2015, entire) estimated the anthropogenic contribution to California's drought during 2012–2014. They found that the intensifying effect of high potential evapotranspiration on this drought event (measured by summer PDSI) was almost entirely the result of high temperatures (18–27 percent in 2012–2014; 20–26 percent in 2014) (Williams *et al*. 2015, p. 6,825). Another study evaluating the influence of temperature on the drought in water year 2014 in California found that, although the low level of precipitation was the primary driver for the drought conditions, temperature was an important factor in exacerbating the drought, noting that the water year 2014 was the third year of the multiyear drought event and therefore conditions were drier than normal at the beginning of the water year (Shukla *et al*. 2015, p. 4,392).

In sum, these projections indicate that increased temperatures are likely to occur in the Tahoe National Forest region by the 2060s due to the effects of climate change.

Precipitation patterns can also be used as an indicator of potential climate change. We obtained yearly snowfall data for the Tahoe City station located in the northern Sierra Nevada region from the WRCC (https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca8758) since that dataset was the most complete for the area. We then conducted a nonparametric correlation test, the Mann-Kendall statistical test (Hipel and McLeod 1994, pp. 63–64, 856–858), which is commonly used for analyzing climatic time series (e.g., Ahmad *et al*. 2015, entire), to evaluate trends in snowfall over time. This analysis was conducted using the R and R Studio software programs (Version 3.1.2; R Development Core Team, 2014) with the "Kendall" package (Version 2.2) (McLeod 2011). We found that annual snowfall amounts showed no statistically significant trend (increasing or decreasing) from 1909–2017 (tau = –0.0289, two-sided *p*-value of 0.6705) for the Tahoe City station.

State-wide and regional probabilistic estimates of precipitation changes for California were also evaluated by Pierce *et al*. (2013, entire). When averaged across all models and downscaling methods, small annual mean decreases in precipitation were found for the Sierra Nevada region of California (by the 2060s), but that study also found an increase in precipitation for the December through February period (wetter winters) (Pierce *et al*. 2013, pp. 849, 855). There was significant disagreement across the models, with percent changes ranging from a 12 percent decrease to a 9 percent increase (Pierce *et al*. 2013, p. 851), and the projected changes in seasonal-mean precipitation were generally small when compared to natural internal climate variability (Pierce *et al*. 2013, p. 850; Figure 9).

Columbia River Basin Region

This region covers a large area within Washington, Oregon, and Idaho, and parts of British Columbia, Canada, and includes portions of the Current Potential Extent area~~current range~~ of the wolverine. Rupp *et al*. (2017, entire) used simulations from 35 Global Climate Models (GCMs) to provide projections of climate in the Columbia River Basin into the 2080s under two emissions scenarios, Representative Concentration Pathways (RCP) (RCP 4.5, which represents moderate reduction in GHG emissions ("intermediate emissions"), and RCP 8.5, which represents a continued increase in GHG emission "high emission"). The results of their multi-model ensemble for the RCP 4.5 scenario indicate mean annual temperature increases (above Bonneville Dam), above the 1970–1999 baseline average, of 1.3°C (2.34°F) for the 2010–2039 period, 2.3°C (4.14°F) for the 2040–2069 period, and 2.8°C (5.04°F), for the 2070–2099 future period (Rupp *et al*. 2017, p. 1,788). By season, the winter period (December–February) mean change result indicates an increase of 1.1°C (2.52°F) for 2010–2039, 2.2°C (3.96°F) for 2040-2069, and 2.7°C (4.86°F) for 2070–2099, as compared to the 1970–1999 baseline average (Rupp et al. 2017, p. 1,788).

For the RCP 8.5 scenario, the multi-model ensemble projections indicate mean annual temperature increases, above the 1970–1999 baseline average, of 1.4°C (2.34°F) for the 2010–2039 period, 3.1°C (5.58°F) for the 2040–2069 period, and 5.0°C (9.0°F), for the 2070–2099 period (Rupp *et al*. 2017, p. 1,788). For the winter season (December–February) mean change increase of 1.4°C (2.34 °F) for 2010–2039, 2.9°C (5.22°F) for 2040-2069, and 4.7°C (8.46°F) for 2070–2099, as compared to the 1970–1999 baseline average (Rupp *et al*. 2017, p. 1,788). The anthropogenic-forced (human caused or influenced) change for these projections is higher than the annual variability; thus, by the year 2050, it is very unlikely that the temperature for this year or any year following during this century would be as low as the historical average (Rupp *et al*. 2017, p. 1,788).

Precipitation projections were much less robust; the multi-model ensemble mean precipitation projections indicate an increase above baseline of up to 8 percent by 2099 for RCP 8.5 and slightly less for RCP 4.5 (Rupp *et al*. 2017, p. 1,788). When viewed seasonally, for the winter season, the ensemble projections indicate increases in precipitation for all three future time periods for both the RCP 4.5 and RCP 8.5 scenarios (ranging from 3 to 14 percent) as compared to the baseline period (1970–1999) (Rupp *et al*. 2017, p. 1,788). The projections of anthropogenic-forced increases in precipitation are lower than the interannual variability; however, despite these increases, the authors indicate that years of anomalously low precipitation relative to baseline would be expected with high frequency throughout the 21st century (Rupp *et al*. 2017, p. 1,788).

Within three subregions of the Pacific Northwest within the Current Potential Extent ~~current range~~ of the wolverine, Sheehan *et al*. (2015, p. 20; Table 4) also found that, when compared to a historical baseline (1971–2000), all future climate projections (RCP scenarios 4.5 and 8.5; 2036–2066, 2071–2100) indicate a rise in both minimum and maximum monthly temperatures, and a generally positive change in mean annual precipitation, though the latter results varied across projections.

Upper Snake River Basin

The Upper Snake River Tribe Foundation and its Tribal members prepared a climate change vulnerability assessment for the Upper Snake River Watershed (Petersen *et al*. 2017, entire). The assessment covers large areas of southern Idaho and eastern Oregon, and small areas of northern Nevada, northern Utah, and western Wyoming (Petersen *et al*. 2017, p. 15). Within three geographic/model domains of this larger region, downscaled climate projections were created from 20 GCMs run with two emissions scenarios (RCPs 4.5 and 8.5) and these outputs were then used to calculate potential future changes in temperature and precipitation (Petersen *et al*. 2017, pp. 15–16). The projections were analyzed in reference to a baseline period (1950-2005) for three future time periods—the 2030s (2020–2049), the 2050s (2040–2069), and the 2080s (2070–2099) (Petersen *et al*. 2017, p. 16).

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For temperature, their projections indicated an increase in average annual temperatures in both future emission scenarios and across all time periods. Under RCP 8.5 (high emissions scenario), the ensemble mean temperature increase was about 6.11°C (11ºF), and 2.78°C (5ºF) under the RCP 4.5 intermediate emissions scenario across all three geographic/model domains (Petersen *et al*. 2017, Appendix A, p. 2). For the North and East domains (areas with greater topographical variability), there was some indication of a small increase in total annual precipitation by the end of the century, though there was less agreement among the models (Petersen *et al*. 2017, Appendix A, p. 2).

For all geographic/model domains, the average temperature is projected to increase under both emissions scenarios for all seasons (Petersen *et al*. 2017, Appendix A, p. 2). For the winter months (December, January, February), for RCP 4.5, the average seasonal temperature is projected to increase by 3.89 to 5°C (7 to 9ºF) by the end of the century, and an increase of approximately 2.22 to 3.33°C (4 to 6ºF) for the other seasons (Petersen *et al*. 2017, Appendix A, pp. 2, 6). The winter season projections for RCP 8.5 add an additional 1.67 to 2.22°C (3 to 4ºF) by the end of the century (Petersen *et al*. 2017, Appendix A, pp. 2, 6).

Rocky Mountain Region (Colorado)

A report by Lukas *et al*. (2014, entire) presented an assessment of observed and future projections of climate change effects for Colorado. They reported that, statewide, annual average temperatures have increased by 1.1°C (2.0°F) over the past 30 years, and 1.4°C (2.5°F) over the past 50 years (Lukas *et al*. 2014, p. 11). These warming trends have been observed in much of the State (Lukas *et al*. 2014, p. 11). They report no significant long-term trends in annual precipitation (30-, 50-, and 100-year trends) through 2012, but they indicate an observed trend towards more severe soil-moisture drought conditions in Colorado, based on the PDSI, over the past 30 years (Lukas *et al*. 2014, pp. 12, 21).

This report also presents results from climate change modeling using an ensemble of CMIP5 model projections, run with RCP 4.5 and 8.5 scenarios (Lukas *et al*. 2014; Section 5). The results indicate future warming in Colorado for all of the climate model projections (Lukas *et al*. 2014, p. 59). By 2050, for the RCP 4.5 (intermediate) emissions scenario, the statewide average annual temperatures are projected to increase by 1.4 to 2.8°C (2.5 to 5°F) (relative to a 1971–2000 baseline), and increase by 1.9 to 3.6°C (3.5 to 6.5°F) under the RCP 8.5 (high) emissions

scenario (Lukas *et al*. 2014, p. 59). For precipitation, they report that climate model projections show less agreement regarding future precipitation change for Colorado, but most projections indicate increasing winter precipitation by 2050 (Lukas *et al*. 2014, p. 59).

Summary

Observed trends and future climate model projections indicate warming temperatures for much of the western United States, including areas within the Current Potential Extent~~current range~~ of the wolverine. The degree of future warming varies by region and is dependent upon the future emission scenario used during the modeling process. Future precipitation trends are less certain for many regions, in part, due to naturally high, inter-annual variability; some regions are projected to experience greater winter precipitation. Wolverines have been found to have a wide range in critical temperature depending on season, and undergo seasonal changes in fur insulation to adapt to warmer temperatures in summer. Wolverines also exhibit changes in behavior, such as moving to ~~water bodies or~~ higher elevations in summer months. Wolverines continue to occupy areas that have exhibited increases in temperature (e.g., California, parts of Montana and Washington); however, no empirical studies have evaluated these~~These~~ physiological and behavioral adaptations, including sub-lethal effects, relative to warming temperatures . ~~allow wolverines to adapt to warming temperatures.~~

Biotic Factors

In addition to evaluating changes in these abiotic factors, biotic interactions should be considered in evaluating species' response to climate change (reviewed by Post 2013). Although abiotic changes drive ecological processes, the alterations in biotic interactions (e.g., competition among conspecifics, interactions with competitors, resources, and predators) represent the ecological responses that result from those changes (Post 2013, p 1). Changes in certain abiotic factors, such as snow and ice cover, should also be considered in an ecological context since they represent habitat for many species (Post 2013, p. 11).

Ecological studies evaluating the effects of climate change often evaluate phenology, the timing of life history events and how they vary in space and time, generally at the population or site-specific level, though phenological variation at the individual level may also be important (Post 2013, p. 54). Previous meta-analyses of the rate of phenological advancement have suggested advances of between 2–5 days per decade, across taxa, and between low-mid to mid-high latitudes (Post 2013, p. 59). A more recent meta-analysis from Cohen *et al*. (2017, p. 4) found, on average, significant advancement in the phenology of animals since 1950, advancing by about 2.88 days per decade and 3.08 days per degree Celsius.

Within the Pacific Northwest region, Ford *et al*. 2016 (entire) modeled the timing of growth initiation in coast Douglas-fir trees (*Pseudotsuga menziezii* var. *menziezii*) within the species' range in Washington and Oregon to evaluate its ability to track changes in climate with changes in phenology. This study found that, for high latitudes and elevations, growth initiation was predicted to occur earlier in the year, which allows trees to track the beginning of favorable growing conditions, without exposure to frost risk (i.e., adaptive phenological response) (Ford *et al*. 2016, pp. 3718, 3,721). Conversely, their model predicted that at lower latitudes and

elevations, growth initiation will lag behind climate change shifts due to reduced chilling with lower productivity, which suggested that coast Douglas-fir has an obligate chilling requirement for height (but not diameter growth initiation) (Ford *et al*. 2016, pp. 3,717–3,719).

Another study reported on the effects of encroachment of woody plants (willows (*Salix* sp.)) in alpine environments to alpine wildflowers and their pollinators due to temporal overlap in flowering phenology, which may result in establishment of plant species with broader environmental tolerance in high alpine ecosystems (Kettenbach *et al*. 2017, p. 6,969). Similarly, in Sweden, Wilson and Nilsson (2009, entire) reported on encroachment of woody vegetation in arctic-mountain habitat, though primarily at lower elevations in response to observed temperature increase of 2.0°C (3.6°F) over 20 years, though this increase in cover was observed primarily at lower elevations (Wilson and Nilsson 2009, p. 1,682).

A high-latitude, North American study evaluated the effect of weather and broad-scale climate variables and vegetation productivity on the timing of spring and fall migrations of migratory caribou herds in northern Québec and Labrador, Canada (Le Corre *et al*. 2017, entire). That study found that, since 2000, except for the spring arrival, migrations occurred earlier, and were affected by resource availability, likely through intraspecific competition factors (Le Corre *et al*. 2017, p. 266).

In addition to phenological changes related to habitat variables or reproduction patterns, the effects of climate change may affect food resources important to wolverine, either directly (e.g., survival) or indirectly (e.g., effects to their habitat). An early study by Wang *et al*. (2002, p. 217) projected a potential increase in ungulate populations in Rocky Mountain National Park (Colorado) under future climate scenarios due to enhanced survival and recruitment of juvenile animals in response to less severe winters. The authors note that their results should be interpreted qualitatively given the uncertainties in applying climate change scenarios based on global models to ecological systems at the local scale (Wang *et al*. 2002, p. 217). In addition, they report that vegetation response (e.g., succession) to climate change effects may result in changes to ungulate habitat (Wang *et al*. 2002, p. 219). Overall, the study concluded that their results were consistent with those reported in other studies that have evaluated the relationships between the effect of weather and density dependence and ungulate population dynamics (Wang *et al*. 2002, p. 219).

Summary

The results presented above indicate biotic effects resulting from climate change, varying from phenological changes to shifts in vegetation and vegetation succession. We are unaware of studies that have directly evaluated these types of effects to the North American wolverine or its habitat. Given the extensive range and varied habitats occupied by wolverines in the contiguous United States, the shifts in vegetation are likely to be relatively narrow in scope and scale. Furthermore, we have no information to suggest that wolverines selectively use any specific vegetation type and some changes in vegetation may actually be advantageous for wolverine prey.

Climate Change and Potential for Cumulative Effects

Threats can work in concert with one another to cumulatively create conditions that may impact the wolverine or its habitat beyond the scope of each individual threat. Given an expected increase in temperature in the western United States, the best available information indicates that, if there are any cumulative impacts in the future, the most likely to have population level effects on wolverine in the contiguous United States could be: 1) changes in snowpack from the combination of increased temperature and changes in precipitation patterns, or 2) changes in snowpack and increase in wildland fire potential.

Snowpack/Snow Cover

Upper Snake River Watershed (Pacific Northwest region)

The Upper Snake River Tribal Foundation assessment (discussed above) included projected changes in snowpack for three locations in the Upper Snake River watershed, including areas located within our estimated Current Potential Extent~~Range~~ of the wolverine (from Climate Impacts Group Pacific Northwest (PNW) Hydroclimate Scenarios Project (2860); http://warm.atmos.washington.edu/2860/products/sites/). Model results, based on snow water equivalent (SWE) (the water content of snowpack, expressed as depth), indicate a projected loss in April 1st snowpack of 36 percent for the 2030–2059 period and 64 percent for the 2070–2099 period for the *Salmon River at White Bird* location (average of percent change across all models relative to the long-term average for 1916–2006 ("historical period")). For the *Snake River at Brownlee Dam* location, the projected loss is 37 percent for the 2030–2059 period and 64 percent for the 2070–2099 period (summary presented in Petersen *et al*. 2017, p. 20). These projected changes were found to be consistent with overall changes projected for the Columbia River Basin snowpack in an earlier study. Hamlet *et al*. (2013, p. 404; Figure 7) found that, relative to the long-term average for 1916 to 2006, the April 1st snowpack in the Columbia River Basin is projected to decline by 29% for the 30-year period spanning 2030-2059 and decline by 52% for the period spanning 2070-2099 for the A1B emissions scenario. [Note: the A1B emission scenario represents a more balanced energy portfolio than RCP 8.5, with GHG emissions leveling off by the middle of the 21st century].

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Sierra Nevada

Walton *et al*. (2017, entire) developed snow cover projections for the Sierra Nevada region in California, incorporating snow albedo feedback using a hybrid downscaling approach to develop future climate projections. This feedback loop is known to be important for regional climate change (Thackeray and Fletcher 2016, p. 395) and occurs when warming causes snow pack to shrink at margins and the exposed ground absorbs more sunlight than snow, which enhances the warming, resulting in more melting of snow (Walton *et al*. 2017, p. 1,417). This study (using 3 km (1.86 mi) resolution) found that, by the end of the 21st century (2081–2100), warming and loss of snow cover is expected to occur, though the degree varies depending on the GHG scenario (Walton *et al*. 2017, p. 1,430). Under the RCP 8.5 (high emissions) scenario, the study found that the total area covered by snow during the typical month of April decreases by 48 percent, as compared to historical average (1981–2000) (using ensemble mean) (Walton *et al*.

2017, p. 1,432). Under the RCP 4.5 (moderate emissions) scenario, snow cover losses were projected at about half of those for RCP 8.5 (Walton *et al*. 2017, p. 1,434; Figure 13). The effects of warming were more pronounced at lower elevations and were most severe in May and June (Walton *et al*. 2017, p. 1,431; Figure 12). For the months of March and April, the highest elevations were found to have nearly complete snow cover (measured as snow covered fraction) for all GCM simulations (Walton *et al*. 2017, p. 1,431; Figure 12).

Northern and Southern Rocky Mountains–Glacier and Rocky Mountain National Parks

The effects of climate change on snow persistence has been suggested as an important negative impact on wolverine habitat and populations by the mid-21st century (McKelvey *et al*., 2011, entire). The Service therefore pursued a refined methodology to provide insights into the potential impacts of climate change on snow persistence.

The Service engaged the National Oceanic and Atmospheric Administration (NOAA) laboratories and University of Colorado in Boulder, Colorado (CU) to evaluate and model fine scale persistence of snow in occupied and potential wolverine habitat in the contiguous United States. Those discussions revealed significant progress in fine scale modeling approaches since the early 2000s. The Service provided funding for an assessment of snow extent and depth to assess the effects of climate change on snow persistence in two areas of the western United States, Rocky Mountain and Glacier National Parks (Ray *et al*. 2017, entire). The primary objective of this study was to refine the spatial and temporal scale of snow modeling efforts and improve the scientific understanding of the extent of spring snow retention currently and into the future under a changing climate (Ray *et al*. 2017, p. 9). The objectives of the study included (Ray *et al*. 2017, p. 10):

- Use of fine-scale models to analyze the topographic effects of snow, including slope and aspect (compass direction that slope faces)
- Use of a range of plausible future climate change scenarios to assess snow persistence
- Analysis of extremes and year-to-year variability by selecting representative wet, dry, and near normal years (using observed conditions) and then modeling changes for those base years under several future climate scenarios
- Assessment of changes in snow persistence by elevation

The study was designed to parallel as much as possible and thereby refine the previous assessment of snow cover persistence in the western United States presented in McKelvey *et al*. (2011). However, an exact replication of the McKelvey *et al* (2011) study was not possible given the time, funding, and computational constraints needed to develop a fine-scale assessment. The current study was limited to two study areas (approximately 1,500 to 3,000 km^2 (579 to 1,158 mi^2) each) in the northern and southern Rocky Mountains (see **Appendix H** for maps). The two study areas were selected because they encompass the latitude and elevational range of wolverines within the contiguous United States. Glacier National Park (GLAC) is representative of a high latitude and relatively low elevation area currently occupied by wolverines. The Rocky Mountain National Park region (ROMO) is a lower latitude and higher elevation area within the wolverine's historical range, which was recently occupied by a wolverine from 2009 to at least 2012.

Methods: We provide here a brief summary of the methods used in this study. Additional details are contained in the full report authored by Ray *et al*. (2017). The initial step of the analysis was a review of the observed climate and variability to provide context for trends and year-to-year variability. Next, historical snow cover extent and variability were analyzed using satellite remote sensing (MODIS) data from 2000 to 2016 to calculate a snow disappearance date for each year at each pixel. Summary statistics include total snow covered area (total area covered by snow), representation of snow pack by aspect (percent of land areas covered by snow for each of the 17 years in the historical record by topographic aspect based on compass direction that the slope faces), and elevation dependence for wet, near-normal, and dry years (with median of all years used as reference). Future snow pack projections were then generated using the Distributed Hydrology Soil Vegetation Model (DHSVM), for the historical period 1998-2013, and then validated against SNOTEL observing stations and MODIS satellite data.

Both Ray *et al*. (2017) and McKelvey *et al*. (2011) used the delta method to estimate future snow persistence. The NOAA-DHSVM delta method uses historical observed weather (1998–2013) as the baseline and applies future changes in temperature and precipitation from the chosen GCMs (approximately Year 2055) to estimate future snow persistence on the landscape. This time period was chosen for concordance with the availability of the MODIS satellite remote sensed snow product and availability of the meteorology dataset used for the study. For GLAC, October–May was typically warmer and drier during 2000–2013 than the long term average, while, for ROMO, the October–May precipitation was typical, though with higher temperatures. Although one might assume that the Spring snowpack would therefore be lower in the baseline period than in prior decades, an assessment of three long-established May 1 snow course (manual measurements) in the GLAC and ROMO regions, indicates that, while this is true, the longer record dating back to 1922 in GLAC and 1936 in ROMO indicates a period of relatively low snowpack prior to the 1950's (see Ray *et al*. 2017, pp. 18–20). Five future scenarios (GCMs) were selected from CMIP5 global climate model projections to capture variability in temperature and precipitation, using the RCP 4.5 (moderate) and RCP 8.5 (high) emissions scenarios. Representative wet, near normal, and dry years were analyzed for the historical simulations and evaluated for the five future scenarios. The number of years (out of 16) with snow depth greater than 0.5 m (20 in) was also analyzed as was the change in Snowcovered Area (SCA) (area with depth greater than 0.5 m (20 in)). This snow depth was selected based on an analysis of the depth of snow at documented wolverine den sites in Glacier National Park (Ray *et al*. 2017; Table 5-2). Results were reported for "light snow cover" (snow depth greater than 1.25 cm (0.5 in)) and "significant" snow (snow depth > 0.5 m (20 in)) for April 15, May 1, and May 15 for previously defined representative years. These dates were selected based on studies indicating den site abandonment generally occurs before May 1 (see Use of Dens and Denning Behavior discussion above in *Reproduction and Growth* section). The term "light snow cover" was incorporated as the most directly comparable parameter to McKelvey *et al*.'s "light" snow cover. The average change in SCA and SWE was analyzed as a function for both study areas of elevation and was overlaid with the elevations of documented wolverine den sites (2003–2007) in GLAC. As noted earlier, snow depth was not defined in Copeland *et al*. (2010).

Comparison with McKelvey *et al*. (2011): Although the methods used in this study have similarities with those presented in McKelvey *et al*. (2011), there are several key differences.

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Ray *et al*. (2017) used a finer spatial resolution model (DHSVM) than McKelvey *et al*. (2011) (0.0625 km^2 vs. 35 km^2) that incorporated slope and aspect. The grid cells represented in McKelvey *et al*. (2011) were assumed to be flat (i.e., north-facing slopes treated as identical to south-facing slopes). McKelvey *et al*. (2011) focused on May 1st snow depth as a proxy for May 15th snow disappearance, while Ray *et al*. (2017) focused directly on May 15th snow disappearance and produced results for the presence or absence of deeper snow (nominally greater than or equal to 0.5 m (20 in) depth) on May 1st and April 15th.[4] Because of the increased resolution of this study, Ray *et al*. (2017) were able to consider whether any areas of snow with depth greater than 0.5 m (20 in) will persist in these areas. Additional comparisons are outlined below in Table 8 and in Ray *et al*. (2017, p. 6). However, the May 15th date does not represent a meaningful biological significance for wolverines relative to the presence or lack of snow.

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Table 8. Comparison of Methods, Ray *et al*. (2017) vs. Copeland *et al*. (2010) and McKelvey *et al*. (2011)

Feature	Ray *et al*. (2017)	Copeland *et al*. (2010) and McKelvey *et al*. (2011)
Spatial Resolution	250 m x 250 m = 62,500 m^2 or 0.0625 km^2 (0.24 mi^2)	0.125 degrees (~5 km x 7 km; 37 km^2 (14.29 mi^2))
Geographic Area	Glacier and Rocky Mountain National Parks, 300 m below treeline and above	Western United States, except California and Great Basin
Topography	Slope, aspect, and shading were used	Slope and aspect were not used
Validation	SNOTEL (in-situ observations) and MODIS (satellite remote sensing)	None specific to the snow dataset used
Future Scenario Method	Delta Method, used to project 2000-2013 conditions out to Year 2055 (average of 2041–2070)	Delta Method (Years: 2045 (2030–2059), 2085 (2070-2099)
Future Scenarios (GCMs)	*miroc*, *giss*, *fio, cnrm* (both study areas); *canesm* (Glacier National Park only) *hadgem2* (Rocky Mountain National Park only)	Ensemble mean of 10 GCMs, *pcm1*, and *miroc 3.2*
Time-related Results	Long-term means and year-to-year variability (i.e., wet, near normal, and dry years)	Changes in long-term mean snowpack only
Snow Detection and Measurements	Snow presence: 1.25 cm (0.5 in) snow depth threshold on May 15. "Significant snow": snow depth (0.5 meter (20 in) threshold. Snow depth determined by conversion from Snow Water Equivalent using bulk snow density.	Snow presence (13 cm (5.12 in) snow depth threshold on May 1). Snow depth determined by VIC model.
Number of Years of MODIS Data	17 (2000-2016)	7 (2000-2006)
Snow Model	DHSVM (University of Washington)	VIC (University of Washington)
Snow Cover Dates Analyzed	April 15, May 1, and May 15	May 15 (derived from May 1), May 29 (derived from May 1)

Results: While there are challenges in comparing the results from McKelvey *et al*. (2011) directly to the Ray *et al*. (2017) study due to differences in methodology and focus, the

[4] Ray *et al*. (2017) originally focused on May 15th to compare to the McKelvey *et al*. (2011) study, and June 1st to bracket the snowmelt season. However, April 15 and April 30 dates were added to the evaluation of snowcovered areas to align with temporal reproductive patterns of the wolverine (see Use of Dens and Denning Behavior discussion in *Reproduction and Growth* section above).

qualitative picture can be summarized as follows: projected warming has a larger effect at lower elevations whereas projected precipitation changes may dominate the springtime snowpack in the high country. We present below a summary of the main results from Ray *et al*. (2017).

MODIS Observed Historical Snowpack Variability Analysis:

- In GLAC, Snowcovered Area (SCA) varies considerably by year, including wet years such as 2011 with very persistent snow, years with strong melt in early May, such as 2012, or in late May (2009, 2001), and dry years (2004, 2005) (Ray *et al*. 2017, Section 4.3).
- Even in dry years, northeast-facing slopes in GLAC tend to hold more snow and melt later in the season.
- More than 80 percent of the GLAC study area above approximately 2,000 m (6,562 ft) elevation on May 1 has snow cover during dry years, and more than 95 percent has snow cover above approximately 1,200 m (3,937 ft) during wet years.
- In ROMO, the SCA also varies considerably by year.
- The northwest-facing slopes in ROMO tend to hold more snow even during dry years. In very dry years, snow cover peaks at intermediate elevations, suggesting that the high-altitude snowpack may be particularly vulnerable in this region under warm/dry conditions.

Future Snowpack Projections: The area-wide SCA results include snow cover changes in both forested and above-treeline (alpine) terrain, which may have different implications for wolverine biology.

Glacier National Park (GLAC):

- Projections for April 15th, May 1st, and May 15th SCA and area with snow depth greater than 0.5 m (20 in) show declines on average in all scenarios, compared to the 2000–2013 historical average, except for small increases in the Warm/Wet scenario and for almost all years.
    - For April 15th, light SCA area is reduced by 3–23 percent and significant snow cover (greater than 0.5 m (20 in)) declines by 7–44 percent.
    - For May 15th, light SCA is reduced by 10–36 percent, and the area with significant snow cover declines by 13–50 percent.
- All projections show declines in the number of years with significant snow (equal to or greater than 0.5 m (20 in)), which varies by scenario (e.g., Figure 5-14 in Ray *et al*. 2017). Areas with frequent availability (at least 14 out of 16 years) of significant snow become concentrated in smaller high elevation areas. Lower elevation areas had the largest decreases in the number of years with significant snow cover.
- Most of the known den sites are located between 1,800 m (5,906 ft) and 2,000 m (6,562 ft) in GLAC. Below that elevation band, large snow losses are predicted (40 to 70 percent decrease for two of the scenarios, 16–20 percent for the other three). Above that elevation

band, there is little change in SCA for four of the five scenarios (2–8 percent) except in maximum warming scenario (decline of 40 percent (Ray *et al*. 2017; Figure 5-22). In the 1,800–2,000 m (5,906–6,562 ft) band, the snowpack change is sensitive to elevation and to the future climate scenario used.

- For representative wet years, for May 15th, the higher elevations of the study areas experience only 2–7 percent loss of snowpack under the scenarios with "least" change and the "moderate" change, although for the dry years, losses range from 18–57 percent.
    - The implication is that the wet, cold climate of the GLAC study area could act as a "buffer" to change in areas with of 0.5 m (20 in) of ~~deep~~ (significant) snow on May 1st, at least for elevations above 1,800 m (5,906 ft).

Rocky Mountain National Park (ROMO):

- Projections of May 15th SCA in ROMO decline on average in all scenarios, except for small increases in the Warm/Wet scenario, and for almost all years.
    - For April 15th, light SCA (depth ≥ 5 mm (0.2 in)) declines by 3–18 percent and significant SCA (depth > 0.5 m (20 in)) changes from −1– +16 percent for the five scenarios considered (compared to the 2000-2013 historical average).
    - For May 15th, the area with light snow cover declines 8–35 percent and the area with significant snow cover declines 6–38 percent.
- All projections show declines in the number of years with significant snow (equal to or greater than 0.5 (20 in), which varies by scenario (e.g., Figure 5-21in Ray *et al*. 2017). The areas with frequent availability (at least 14 out of 16 years) of significant snow become concentrated in smaller high elevation areas. In contrast, lower elevation areas had the largest decreases in the number of years with significant snow cover.
- Although no dens have been documented in ROMO, the elevation band for denning, modeled by regression analysis, is estimated at 2,700 to 3,600 m (8,858 to 11,811 ft). On May 1st, modest declines in SWE of about 15 percent and less for areas at 3,400 m (11,155 ft) or above result in losses of only about 10 percent snow cover.
    - The implication is that the wet, cold climate of the higher parts of the ROMO study area could also act as a "buffer" to change in the area of 0.5 m (20 in) deep snow on May 1st.

Elevation Dependence of Change: In general, and supported by the literature, the snowpack in the higher elevations of both areas is more responsive to precipitation change, while lower elevations are more responsive to temperature change. For GLAC, most of the observed den sites are located within the zone where temperature dominates the future effects of change. For the elevation of den sites in GLAC (i.e., above 1800 m (5,906 ft)), loss of SCA on May 1st spans the range of 5–40 percent, with a 70 percent decrease for the Hot/Wet (*miroc* GCM) scenario. Above 2,200 m (7,218 ft), the losses are less than 5 percent for all but the Hot/Wet scenario.

Current results may be a reasonable estimate for the high mountain ranges within the Rockies that lie between GLAC and ROMO. However, without further study, we cannot reasonably extend these results to say whether or not snow refugia will persist in the Central Rockies below our study elevations (approximately 1,000 m (3,281 ft)). These lower elevations are where McKelvey *et al*. (2011) predicted the greatest losses in snowpack. The NOAA/CU results also

cannot be extrapolated to mountain ranges outside of the Rockies (i.e. the Cascade Range) that have different climates (temperature and precipitation). We note here that we have no documented wolverine den sites in the contiguous United States below 1,500 m (4,921 ft) elevation; that is, no documented den locations in the areas where McKelvey *et al*. (2011) predicted the greatest loss in snowpack.

Interpretation and additional analysis relative to wolverine den site scale: The Service was interested in exploring the question, "If snow cover is required for wolverine denning, will there be a sufficient amount of significant snow cover in the future in areas wolverines have historically used for denning in the contiguous United States?" The Service integrated future DHSVM projections (2000–2013 averages) of snow covered area (greater than 0.5 m (20 in) depth) on May 1st for GLAC and ROMO with new information obtained from a spatial analysis of documented den sites in the contiguous United States. This spatial analysis indicated 31 of 34 documented den sites in the contiguous United States were located in areas with slope less than 25 degrees. Avalanche risk increases significantly in areas with slope greater than 25 degrees (Scott 2017, pers. comm.) and wolverines may avoid these areas for denning due to this risk.

Using the projections prepared by Ray *et al*. (2017), we present in Figures ~~6~~7 ~~13~~ 14 the spatial distribution of significant snow covered area with slopes less than 25 degrees and within the elevation bands indicated above for three future scenarios in each study area. The three scenarios for GLAC (*miroc*, *cnrm*, and *giss*) and for ROMO (*hadgem2*, *fio*, and *giss*) were chosen to span the range of GCM uncertainty regarding temperature and precipitation, and by extension significant SCA (see Figure ~~6~~ 7 and Figure ~~7~~8). We found that large portions of the study areas meet all three criteria—greater than 0.5 m (20 in) snow depth on May 1st, at elevation 1,514–2,252 m (4,967–7,389 ft) for GLAC or 2,700 to 3,600 m (8,858 to 11,811 ft) for ROMO, and with a slope less than 25 degrees—across both study sites in the future.

The GLAC *miroc* simulation shows the greatest decrease in future snow covered area in the elevation band historically used for denning (orange line in Figure 7~~6~~). Figure ~~8~~ 9 shows the spatial distribution of significant SCA with slope less than 25 degrees and elevation of 1,514–2,252 m (4,967–7,389 ft) for the *miroc* simulation on May 1st (approximately Year 2055). Approximately 494 km^2 (191 mi^2) of area meet the three criteria with an additional 803 km^2 (310 mi^2) of area retaining significant snow covered area, primarily at higher elevations. Moreover, we determined that large tracts of significant SCA are projected in close proximity to documented historical den sites across all three scenarios (Figures 9~~8~~–11~~10~~). Because we have model projections that fall within wolverine denning areas within for Glacier National Park, we used those den locations to evaluate wolverine distances to snow relative to future snow covered area projections for GLAC. As shown in Table 9, wolverines would not have to travel far, or at all, relative to either distance or elevation to reach areas with significant snow covered area in the future.

A similar analysis was performed for the ROMO study area and the results indicate that large portions of the study area meet all three criteria identified above. The *hadgem2* (Figure 12~~11~~) and *cnrm* scenarios were found to have the greatest decrease in significant snow covered area of the five scenarios analyzed. Figure ~~11~~ 12 (*hadgem2* simulation) shows the spatial distribution of significant SCA (greater than 0.5 m (20 in) depth), elevation of 2,700–3,600 m (8,858–11,811 ft), and slopes less than 25 degrees where denning would be expected to occur. Total area

meeting these three criteria was 339 km^2 (131 mi^2) (dark blue in Figure ~~11~~12), with an additional 446 km^2 (172 mi^2) with snow depth greater than 0.5 m (20 in) (light blue in Figure ~~11~~12), mostly at higher elevations. Figures ~~12~~ 13 (*fio* scenario) and Figure ~~13~~ 14 (*giss* scenario) show a similar distribution, albeit larger areas of significant snow retention in the future (see map legends in Figures ~~12~~ 13 and ~~13~~ 14 for area estimates).

Table 9. Distance of historical GLAC dens (Years 2003–2007) from projected significant snow covered area in the future (approximately Year 2055) (using 2000–2013 average).

A 0 (zero) value indicates the den site location meets all three criteria in the future (greater than 0.5 m (20 in) snow depth on May 1st, at elevation 1,514–2,252 m (4,967–7,389 ft), and with a slope less than 25 degrees).

Den Site[a]	Elevation, m (ft)	Distance from den site to nearest model cell, m (ft)		
		GCM scenario		
		miroc	*cnrm*	*giss*
1	2,252 (7,389 ft)	0	0	0
2	2,093 (6,867 ft)	0	0	0
3	1,995 (6,545 ft)	0	0	0
4	1,977 (6,486 ft)	210 (689 ft)	0	0
5	1,973 (6,473 ft)	208 (682 ft)	0	0
6	1,928 (6,326 ft)	0	0	0
7	1,922 (6,306 ft)	9 (29.5 ft)	8 (26 ft)	8 (26 ft)
8	1,912 (6,273 ft)	170 (558 ft)	0	0
9	1,893 (6,211 ft)	110 (361 ft)	0	0
10	1,851 (6,073 ft)	87 (285 ft)	0	0
11	1,843 (6,047 ft)	74 (243 ft)	0	0
12	1,823 (5,981 ft)	56 (184 ft)	0	0
13	1,807 (5,929 ft)	0	0	0
14	1,514 (4,967 ft)	574 (1,883 ft)	571(1,873 ft)	296 (971 ft)

[a]Glacier National Park

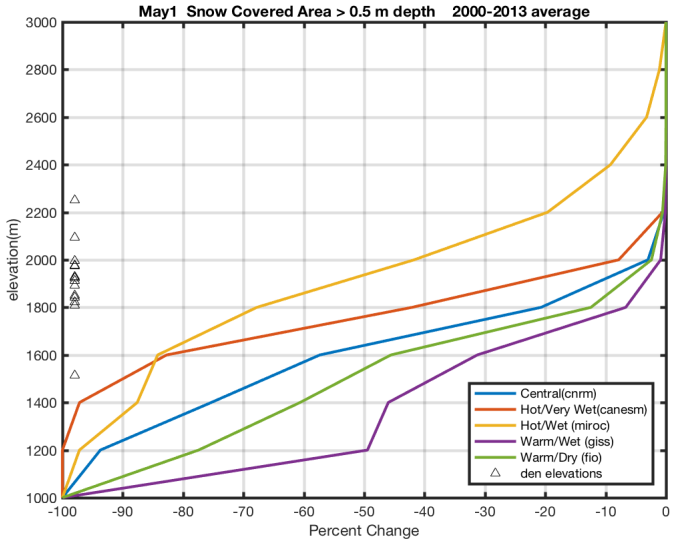

Figure ~~6~~7. Average Snow Covered Area (depth ≥ 0.5 m (20 in)) percent change at elevation bands for GLAC for five future scenarios on May 1.

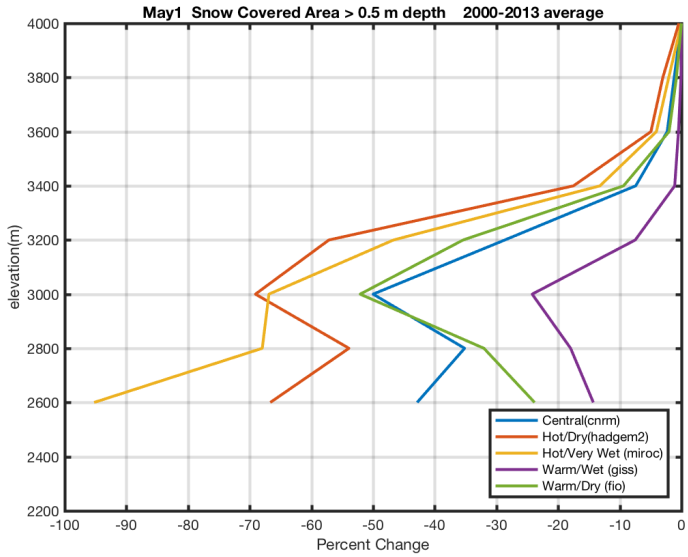

Figure ~~8~~7. Average Snow Covered Area (depth ≥ 0.5 m (20 in)) percent change at elevation bands for ROMO for five future scenarios on May 1.

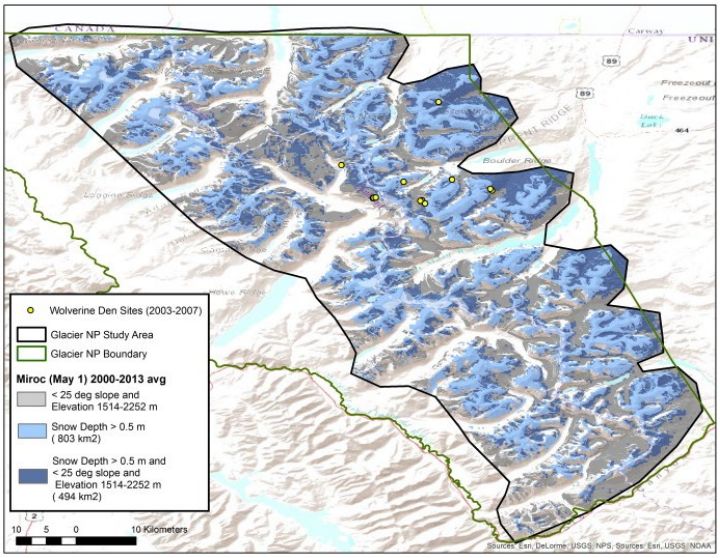

Figure ~~8~~9. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *miroc* (Hot/Wet) scenario in Glacier National Park study area. Map legend shows where slopes are less than 25 degrees and elevations of 1,514–2,252 m (4,968–7,389 ft) (where dens have been documented).

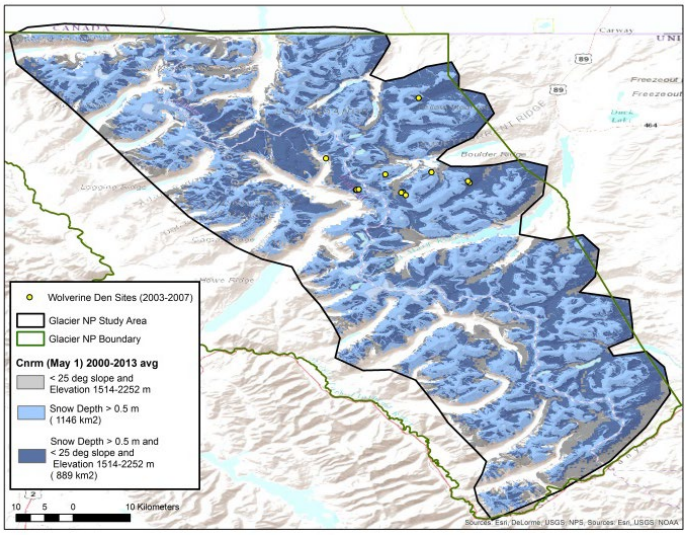

Figure ~~9~~10. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *cnrm* (Central) scenario in Glacier National Park study area. Map legend shows where slopes are less than 25 degrees and elevations 1514–2252 m (4,968–7,389 ft) (where dens have been documented).

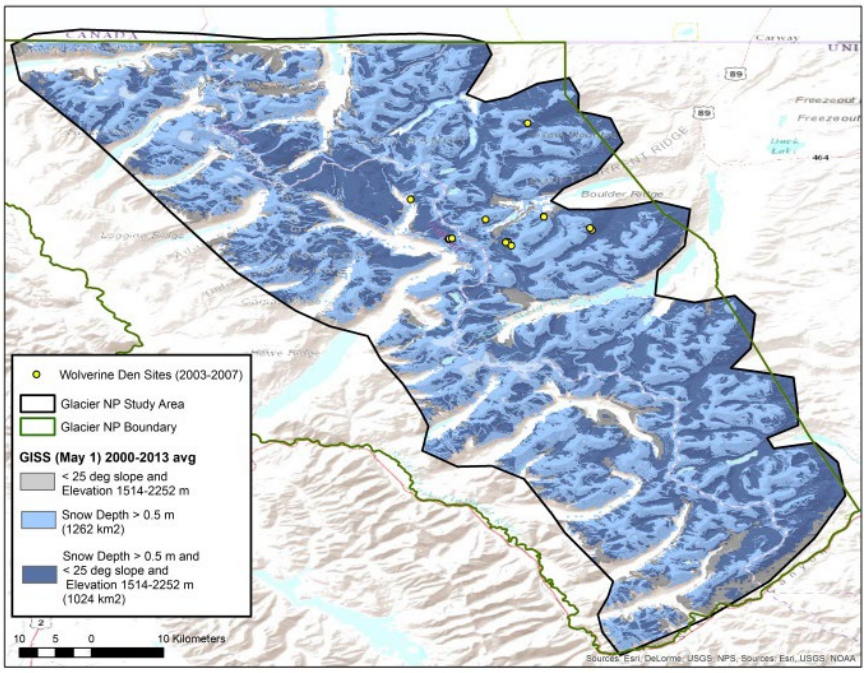

Figure 11~~10~~. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *giss* (Warm/Wet) scenario in Glacier National Park study area. Map legend shows where slopes are less than 25 degrees and elevations 1,514–2,252 m (4,968–7,389 ft) (where dens have been documented).

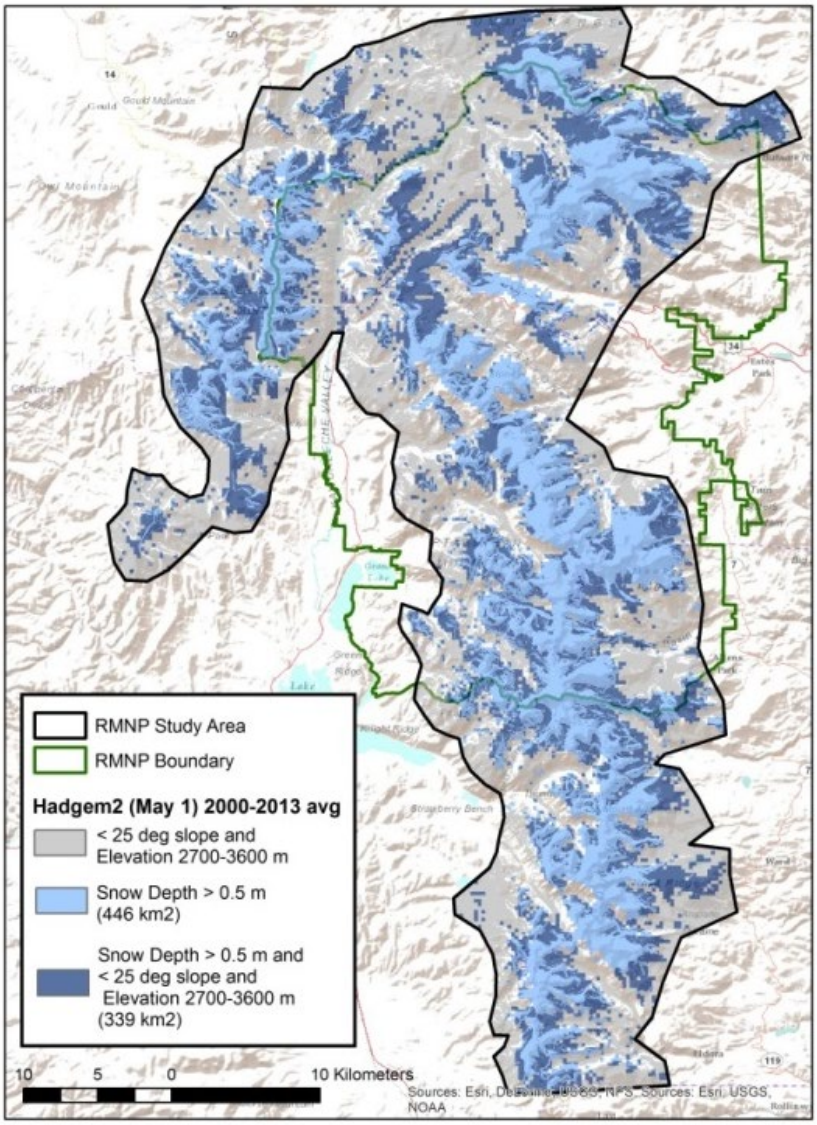

Figure ~~11~~12. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *hadgem2* (Hot/Dry) scenario in Rocky Mountain National Park study area. Map legend shows where slopes are less than 25 degrees and elevations 2,700–3,600 m (8,858–11,811 ft) (inferred elevations where dens would be expected if occupied).

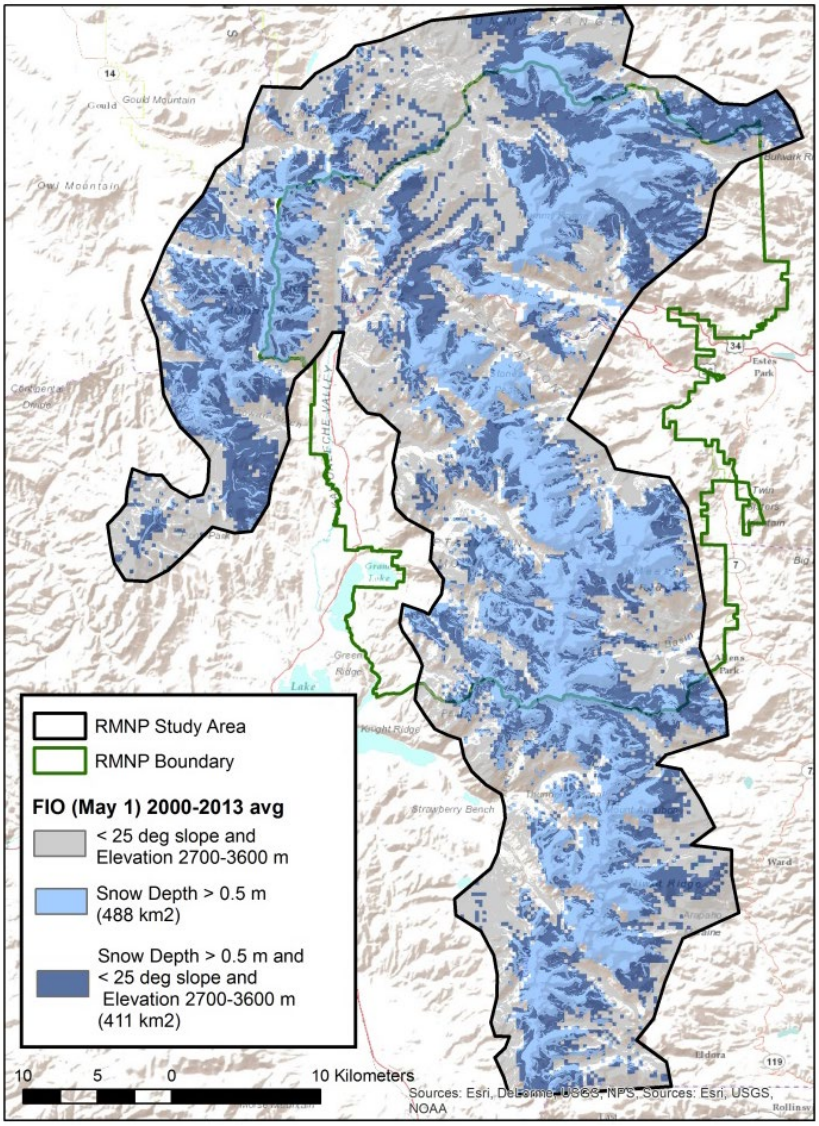

Figure ~~12~~ 13. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *fio* (Warm/Dry) scenario in Rocky Mountain National Park study area. Map legend shows where slopes are less than 25 degrees and elevations 2,700-3,600 m (8,858–11,811 ft) (inferred elevations where dens would be expected if occupied).

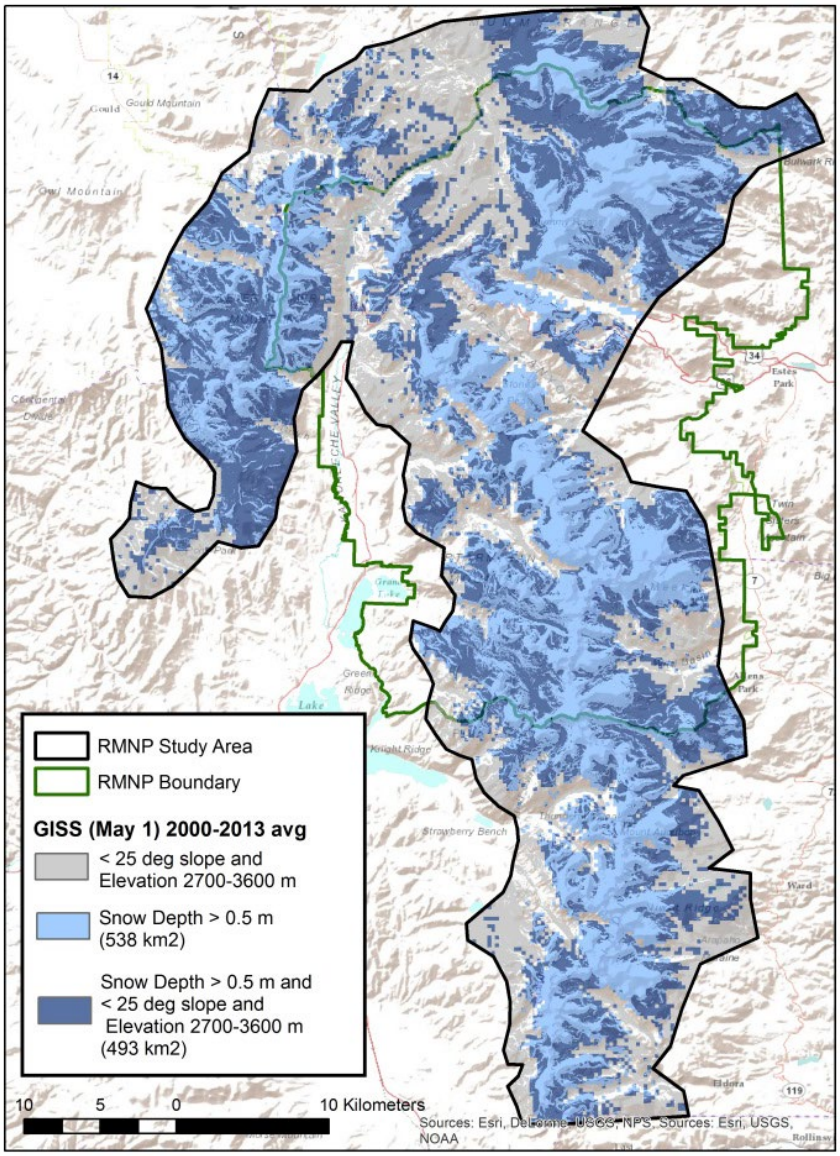

Figure 14~~13~~. Spatial distribution of averaged (2000-2013) projected snow covered area (depth ≥ 0.5 m (20 in)) for May 1 under the *giss* (Warm/Wet) scenario in Rocky Mountain National Park study area. Map legend shows where slopes are less than 25 degrees and elevations 2,700-3,600 m (8,858–11,811 ft) (inferred elevations where dens would be expected if occupied).

Montana Climate Assessment

Another recent assessment of snowpack was conducted for the State of Montana (Whitlock *et al*. 2017, no page number). The report analyzed recent climate trends in Montana and assessed how climate is projected to change in the future (2040–2069). The study found that snowpack that accumulates at high elevations tends to be more stable and persists longer than at low elevations, due largely to the colder temperatures at high elevations. The largest projected changes in snowpack appear to be in areas located west of the Continental Divide, given their exposure to relatively warm Pacific air masses. Overall, the assessment found that declines in snowpack volume are likely in the future in the basins studied.

Wildland Fire

California

Keeley and Syphard (2016, entire) analyzed fire-climate relationships relative to predicting future fire regimes in California. Their review concluded that: (1) Climate is not a major determinant of fire activity across all landscapes; (2) hotter and drier conditions for areas at lower elevations and lower latitude were found to have little or no increase in fire activity as vegetation types in these regions are ignition limited; (3) increasing annual temperatures by themselves are not good predictors of increased fire activity; seasonality, especially spring and summer temperatures, are more important; and (4) fire-climate models need to be scaled to vegetation types; broad-scale models may produce over-predictions of the total increase in future fire regimes (Keeley and Syphard 2016, pp. 1, 10). Additionally, drought is a key factor in defining fire regimes and annual precipitation is the primary driver of drought variability (Williams *et al*. 2015, p. 6,819), but, at the present time, it is difficult to separate current droughts in California from natural cycles of drought (Keeley and Syphard 2016, p. 6).

Pacific Northwest

Sheehan *et al*. (2015, entire) used downscaled CMIP5 projections to model vegetation and fire changes, with and without fire suppression, within three subregions of the Pacific Northwest. Emission scenarios RCP 4.5 and 8.5 were used for future climate projections (2011–2100). The resulting trends varied by geographic region. In the Western Northwest subregion (from the crest of the Cascade Mountains west), the mean fire interval (MFI) averaged over all climate projections decreased by up to 48 percent, an increase in annual percent area burned (PAB), and the predominant conifer forest is replaced by mixed forest under future climate under both RCP scenarios, with and without fire suppression; thus, climate, rather than fire was found to be the primary influence in this subregion (Sheehan *et al*. 2015, pp. 22–26). In the Eastern Northwest Mountains (ENWM) subregion (mountainous areas east of the Cascade Mountains), the MFI (averaged across all climate projections) decreased by up to 81 percent, there was a projected increase in mean annual PAB, and, while subalpine communities are projected to be lost, conifer forests were projected to continue to dominate this subregion (Sheehan *et al*. 2015, pp. 22–24). When modeled using a without fire suppression regime, the future projections for ENWM indicated a lower MFI and higher mean annual PAB as compared to the with fire suppression regime (Sheehan *et al*. 2015, p. 22; Table 5). However, the eastern portion of the ENWM

subregion was found to show a differing response based on elevation; that is, higher elevations were found to have a higher MFI and a lower mean annual PAB during the 20th century as compared to lower elevations (Sheehan *et al*. 2015, p. 23).

Gergel *et al*. (2017, entire) evaluated the effects of climate change on snowpack, and soil moisture and fuel moisture (fire potential) in the western United States. This study used a statistical downscaling approach, using an ensemble of 10 GCMs across several mountainous regions known to be occupied by wolverines, with a 6.25 km (3.88 mi) spatial resolution hydrologic model. Simulations were run for three future periods: 2020s (2010–2039), 2050s (2040–2069), and 2080s (2070–2099) (Gergel *et al*. 2017, p. 291). ~~The authors report s~~Significant declines in snowpack (measured as SWE) were found in all mountain ranges for all future scenarios (using RCPs 4.5 and 8.5) and GCMs (Gergel *et al*. 2017, p. 295). This study found that spring snowpack in mountains along the Pacific Coast is quite sensitive to warmer temperatures, but in the continental mountain ranges (Northern and Southern Rocky Mountains) spring snowpack is more sensitive to changes in precipitation (Gergel *et al*. 2017, p. 295). Differences were observed based on elevation (Gergel *et al*. 2017, p. 292). The study reported on future projected declines of summer soil moisture in forested areas (e.g., Northern Rockies) and the likelihood of increased risk of drought and therefore an increase in wildland fire risk for forested areas (e.g., Northern Rocky Mountains), though they recognize there is significant uncertainty in these future projections in high-elevation areas (Gergel *et al*. 2017, pp. 295–296).

In summary, based on these projections, wildland fire risk is likely to increase in~~across~~ the western United States, but future patterns and trends of wildland fire are dependent on several factors (e.g., degree of warming and drought conditions, fuel and soil moisture, wildland fire management practices, elevation) and geographic region. Based on the best available information, the cumulative effects of these two stressors will continue to represent a low impact to the wolverine and its habitat into the mid-21st century, based on climate change projections.

Commented [SJ43]: What two?

Other Cumulative Effects

Commented [BJG44]: Should we include other cumulative effects such as trapping, etc?

Commented [SJ45]: I imagine Dana would say Yes. So I'd suggest we at least touch on the others even if we just think they would have little effect on wolverine in the future cumulatively.

We will certainly need cumulative effects discussion in the eventual decision document, so the more that we have in the SSA report, the better.

We could just briefly state the effect of trapping, roads, etc, is not expected to act cumulatively w/ effects of climate change in the future and those stressors are expected to remain low level impacts into the futre. Something like that.

Finally, we note here that the effects of climate change on snowpack are projected to negatively affect the season lengths for winter recreational activities, such as skiing and snowmobiling (Wobus *et al*. 2017, entire), thus, potentially reducing this stressor to the wolverine in the future. Wobus *et al*. (2017) modeled potential changes in snowpack at locations across the contiguous United States using output from five GCMs, two representative pathways (RCPs) that represent a future scenario with continued high emissions growth with limited efforts to reduce GHGs (RCP 8.5) and a future scenario with global GHG mitigation (RCP 4.5), and two future time periods (2050 and 2090) (Wobus *et al*. 2017, pp. 2, 5). Although there was some inter-annual variability in 2050 for some model projections, in general, the Rocky Mountains and Sierra Nevada regions had smaller reductions in season length than other locations due to higher elevation, though for the RCP 8.5 scenario coupled with the 2090 future time period, the smallest projected reduction in season length was 15 percent (Wobus *et al*. 2017, p. 9).

An evaluation of the potential future role of federal lands in the United States (including Alaska and Hawaii) relative to providing ~~supplying~~ outdoor recreation opportunities was prepared in 2014 by the Federal Interagency Council of Outdoor Recreation (White *et al*. 2014, entire). The

Commented [BJG46]: This is new. May need to include a sentence or two of these results in summary of future conditions paragraph directly below.

study used projection models developed for the 2010 Resources Planning Act Assessment (http://www.fs.fed.us/research/rpa/) in conjunction with external projections of relevant factors, including demographic, economic, land use, and climate factors, to simulate future recreation participation (White *et al*. 2014, p. 4). Both motorized (snow mobiling) and non-motorized (developed and undeveloped skiing) winter outdoor activities were evaluated. The study found that for winter motorized activities, projected trends from 2008 to 2030, per capita participation rates would decline by 10 percent, with days per participant also declining~~e~~, but at a much lower percentage than the participation rate (White *et al*. 2014, p. 7; Table 3). Snowmobilers still average about 7 days per year on the snow in 2030 (White *et al*. 2014, p. 9).

For non-motorized winter activities, projected trends for developed skiing (downhill skiing and snowboarding) indicated an increase in both per capita participation (6 to 7 percent) and days per participant (3 percent) by 2030 (White *et al*. 2014, p. 9). Undeveloped skiing (cross-country skiing and snowshoeing) has the lowest participation rate for any of the activity groups (approximately 3 percent of the population), and, although little change is expected in per capita participation, the days per participant are projected to increase slightly due to a positive correlation with mean population age (White *et al*. 2014, p. 9).

Summary of Future Conditions

Models represent tools to describe basic physical and biological behaviors using the best available science, and, by presenting a range of plausible future outcomes, they can help generate hypotheses while also identifying knowledge gaps where greater accuracy is needed (Batchelet *et al*. 2016, p. 23). Detecting a species' response to climate change in a single population, and sometimes multiple populations, may not always indicate the response throughout its range given the variation in annual mean surface temperatures over the past century (Post 2013, p. 5). In addition, inter-annual variability in temperature can be as important to a species' ecological needs as the actual temperature itself (Post 2013, p. 7).

Climate change model projections for the range of the wolverine within the contiguous United States indicate increases in temperature by the mid-21st century as compared to early to mid-20th century values. Precipitation patterns into the future are less clear as the climate models show significant disagreement in their many regional projections. Although drought conditions in the western United States are not unusual, drought duration and intensity have the potential to be exacerbated by projected temperature increases. Projected temperature and precipitation changes will affect future snow cover and the persistence of snow on the landscape. We note here that a male wolverine occupied (and continues to occupy) the Sierra Nevada Mountain region of California through over 4 years of severe drought with reduced snowpack/snow cover conditions.

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Snow cover is projected to decline in response to warming temperatures and changing precipitation patterns, but this varies by elevation, topography, and by geographic region. Simulations of natural snow accumulation at winter recreation locations have found that, overall, higher elevation areas (e.g., Rocky Mountains, Sierra Nevada Mountains) are more resilient to projected changes in temperature and precipitation as compared to lower elevations (Wobus *et al*. 2017, p. 12). In general, models indicate higher elevations will retain more snow cover than

lower elevations, particularly in early spring (April 30/May1). We present results (above) from several recent climate models projecting snowpack declines in the western United States. More specifically, we reviewed a new analysis from NOAA/CU that modeled future snow persistence for Glacier and Rocky Mountain National Parks (areas that encompass the latitudinal and elevational range of the wolverine in the contiguous United States) at high spatial resolution (Ray *et al*. 2017, entire). Their results indicate significant areas (several hundred square kilometers (miles) for each site) of future snow (greater than 0.5 m (20 in) in depth) will persist on May 1st at elevations currently used by wolverines for denning. This is true, on average, across the range of climate models used out to approximately Year 2055.

As described above (see *Life History and Ecology* section), within their North American range, wolverines are found in a variety of habitats within primarily high elevation areas of the western-northwestern United States, and exhibit wide-ranging movements. ~~Although it has been assumed that wolverines have an obligate relationship with snow for natal denning, the key variables or combination of variables, that defined this relationship have not been empirically analyzed. As discussed above (**Box 1**), depth of snow cover and its duration increases with elevation; even minor elevation differences are noticeable (Formozov 1963, p. 123). The spotty distribution of snow cover is also affected by unequal distribution of snow precipitation on slopes with different exposures, transport of snow by wind, melting of snow on sun-exposed slopes, avalanche or rolling down of snow from steeper areas, and vegetation (Formozov 1963, p. 123).~~ As discussed above (Denning Habitat), wolverines select den sites for differing characteristics depending on location and natal dens locations are generally associated with snow cover; however, ~~and wolverine (~~natal ~~)~~ dens have been observed outside of the boundary of the snow model presented in Copeland *et al*. (2010). In addition, very few studies to date have evaluated the importance of denning habitat to reproductive success, or the key physiological and ecological characteristics, including avoidance and/or protection from predators, prey availability, availability of food caching habitat, that define denning behavior and den site selection.

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Commented [SJ47]: Have *any* studies evaluated this? I thought not.

We also considered temperature and precipitation projections from climate change models in conjunction with wildland fire risk. This risk is likely to increase across the western United States, but patterns and trends are dependent on several factors (e.g., degree of warming and drought conditions, fuel and soil moisture) and geographic region.

~~As described above (see *Life History and Ecology* section), across their North American range, wolverines are found in a number of habitats, and exhibit wide-ranging movements. In conjunction with behavioral responses (e.g., dispersal over great distances, prey switching), physiological adaptations, including observed seasonal changes in the insulative capacity of fur, allow wolverines to occupy a variety of habitats throughout the year. Physiological adaptations at the cellular and biochemical level are also important in adapting to projected increases in temperature due to climate changes, though we are unaware of studies evaluating these types of responses in wolverines.~~

Overall Assessment

The wolverine's current potential extent ~~range extends across~~includes the west-northwestern United States, large areas of Canada, and Alaska (see Figure 4). In the contiguous United States, potentially suitable habitat (i.e., primary habitat), as determined by the physical and ecological features and the ecological needs of the wolverine, has been estimated at 164,125 km^2 (63,369 mi^2) (Inman *et al*. 2013, p. 281). The species is found in a variety of habitats, but generally occurs in high elevation, relatively inaccessible~~remote~~ locations.

In the contiguous United States, the structure of the wolverine population is represented as a metapopulation, although its genetic structure relative to its entire North American range has not been comprehensively evaluated. Wolverine populations in Alaska are considered to be continuous with populations in the Yukon and British Columbia provinces of Canada based on genetic studies (COSEWIC 2014, p. 37). Similarly, studies of wolverines in the North Cascades region have documented recent movement of wolverines from Washington into British Columbia (Aubry *et al*. 2016, pp. 16, 20) and from Idaho (Lucid *et al*. 2016, p. 184) to British Columbia, and earlier from Montana to British Columbia and Alberta (e.g., Newby and Wright 1955, p. 252).

Based on the best available information, wolverines select den sites for different characteristics depending on location. Dens located under snow cover may be related to wolverine distribution based on other life history traits, including morphological, demographic, and behavioral adaptations that allow them to successfully compete for food resources (Inman 2013, pers. comm.). Structure (e.g., uprooted trees, boulders and talus fields) appears to be essential for natal den sites. However, reproductive success of wolverines has not been evaluated relative to the depth and persistence of snow cover, or in combination with these or other important characteristics, including prey availability and predator avoidance. Recent studies of wolverine populations and distribution in Sweden have observed wolverine populations and reproductive den sites outside areas with persistent spring snow cover (Aronsson and Persson 2016; Persson 2017, pers. comm.). The study presented in Webb *et al*. (2016, p. 1,468) (Alberta) concluded that wolverines appear to be ~~are~~ adaptable and do not require large areas of deep spring snowpack for successful reproduction, and may select small areas covered with deep snow at a finer scale than can be detected using satellite imagery.

We identified several potential stressors that may be affecting the species' and its habitat currently or in the future, including impacts associated with climate change effects. We recognize there is limited information available for the wolverine, including population estimates and abundance trends. Based on the best available information, demographic risks to the species from either known or most likely potential stressors (i.e., effects from roads, disturbance due to winter recreational activities, effects of wildland fire, and overutilization) are low based on our evaluation of the best available information as it applies to current and potential future conditions for the wolverine and in the context of the attributes that affect the needs of the species.

Climate change model projections for the range of the wolverine within the contiguous United States indicate increases in temperature by the mid-21st century as compared to early to mid-20th century values. Our evaluation of climate change indicates that snow cover is projected to decline in response to warming temperatures and changing precipitation patterns, but this varies by elevation, topography, and by geographic region. In general, models indicate higher

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elevations will retain more snow cover than lower elevations, particularly in early spring (April 30/May1). Although the persistence of spring snow has not yet been evaluated as critical to wolverine survival in North America, our review of projected snow persistence (to approximately Year 2055) within the Northern and Southern Rocky Mountains, indicates that several hundred kilometers (miles) of deep snow will persist on May 1st at elevations used by the wolverine for denning.

Legal protections include State listing in California and Oregon (as threatened), endangered in Colorado, as a candidate species in Washington, and protection as a non-game species in Idaho and Wyoming, and protected from collection, importation, and possession in Utah. In Canada, provincial designations range from endangered to threatened in eastern provinces, and sensitive/special concern to no ranking in other provinces. Legal trapping or hunting of wolverines is currently prohibited in the contiguous United States. Trapping effort along the U.S.–Canada border does not represent a ~~significant~~ barrier to wolverine movement and dispersal along the international border.

~~Approximately 96 percent of modeled wolverine primary habitat in the contiguous United States is located on Federal lands, with 41 percent located in designated wilderness areas.~~Our estimate of Current Potential Extent in the contiguous United States (Figure 3) encompasses approximately 18 percent of designated wilderness areas. Approximately 96 percent of previously modeled wolverine primary habitat (Inman *et al*. 2013) in the contiguous United States is located on Federal lands, with 41 percent located in designated wilderness areas. Management actions for conservation of the wolverine and its habitat are included within State Wildlife Action Plans, the *Management Plan for the Conservation of Wolverines in Idaho* ~~Wolverine Conservation Plan~~ (IDFG 2014), and USDA Forest Service Land and Resource Management Plans (see **Appendix G**). Various provisions of these plans include, but are not limited to, winter road closures, fire management, and land acquisition or conservation easements. These management measures, currently and in the future, will alleviate effects associated with potential impacts related to stressors discussed in this report. ~~-~~In addition, the WAFWA Wildlife Chiefs Wolverine Subcommittee is providing a forum for western States to work collaboratively with each other and with the Service and other partners for conserving wolverines where they are found in the west-northwestern United States, and, to date, approximately $1.5 million of funding has been applied towards conservation and management actions (e.g., Western States Wolverine Conservation Project) (McDonald 2017, pers. comm.).

Based on our review of available relevant literature for similar species, we identified the physical and ecological needs of the species as follows: large territories in relatively inaccessible~~remote~~ landscapes; at high elevation (1,800 to 3,500 meters (5,906 to 11,483 feet)) within the contiguous United States; access to a variety of food resources, that varies with seasons; and reproductive behavior linked to both temporal and physical features. These needs are currently met for wolverines in the contiguous United States and are expected to be met in the future (i.e., 40–50 years).

Risk Assessment

In order to characterize a species' viability and demographic risks, we consider the concepts of resilience, representation, and redundancy. We also consider known and potential stressors that may negatively impact the physical and biological features that the species needs for survival and reproduction. Stressors are expressed as risks to its demographic features such as abundance, population and spatial structure, and genetic or ecological diversity. We consider the level of impact a stressor may have on a species along with the consideration of demographic factors (e.g., whether a species has stable, increasing, or decreasing trends in abundance, population growth rates, diversity of populations, and loss or degradation of habitat).

Wolverine populations in much of North America are still recovering from large losses of individuals from unregulated~~intensively~~ hunting and persecution pressures in the late 1880s into the mid-20th century. Surveys conducted in the winter of 2015–2016, and 2016–2017 continue to document its presence ~~(representation)~~ within~~across~~ its "historical" range in the western contiguous United States (representation). ~~These surveys have recorded 85 observations, including in locations where they have not been recently detected (e.g., south of Interstate 90 in Washington, Teton Mountain Range/Grand Teton National Park). Thus, based on the best available information, wolverines continue to be detected across suitable habitat within the contiguous United States.~~

Redundancy, the ability to rebound after stochastic pertrubation~~withstand catastrophic events~~, can be characterized by the distribution and connectivity of populations. In considering wolverine in the contiguous United States, individuals are ~~spread across~~found in alpine, boreal, and subalpine ~~a wide range of locations and connected~~ habitats, with breeding populations in four western States ~~affording protection to withstand catastrophic events.~~ Additionally, wolverines in the contiguous United States appear to be connected to wolverine populations in Canada, also contributing to current and future redundancy.

Resiliency, the ability to withstand stochastic events, can be characterized by numbers of individuals and abundance trends. As indicated above, population size, growth rate, and current population trends are unknown for the wolverine due to the lack of abundance information. The Current Potential Extent range of the wolverine occurs within a large area of northern North America (see Figure 3). The most recent estimate for Canada indicates over 10,000 adult wolverines, as well as expansion of wolverines into historically occupied areas in both Canada and the contiguous United States with movement across both international borders. The 2014 COSEWIC report concluded that a climate-driven decline in wolverine populations in North America is not evident at this time in much of its range (COSEWIC 2014, p. 22). Wolverine populations in Canada are considered stable. Density estimates indicate no declining trend in wolverine populations in Alaska. We recognize that there is limited information on populations (representation) or genetic diversity (resiliency and representation) ~~sizes~~ for the wolverine in the contiguous United States, and no comprehensive studies to indicate what a viable (or minimal) wolverine population size should be across its North American range. However, the best available information does not indicate either increasing or declining numbers of the wolverine in North America, including the contiguous United States. Further, at this time, the best available information does not indicate that the species' abundance is significantly impacted by human-caused stressors and this is unlikely to change in the future, supporting current and future resiliency.

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Commented [SJ51]:

As discussed above (Status–Future Conditions), both direct and cumulative effects of climate change (e.g., higher temperatures, loss of snow cover, wildland fire) may affect the resilience of the wolverine by creating an environment that is less favorable to its physiological and ecological needs. We are unaware of studies of the wolverine that have formally evaluated the species' responses (e.g., reproductive success) to warming temperatures or other climate change effects. ~~However, a recent evaluation of behavioral plasticity, as an adaptive response to climate change effects, was presented for another mammal considered to be sensitive to climate change effects—the American pika (*Ochotona princeps*; pika) (Beever et al. 2017, entire). As with the wolverine, this species is known to use several behavioral responses to variability in climate including changes in foraging strategies, use of habitat, and thermoregulation (Beever *et al*. 2017, p. 302). The pika was recently detected in heavily shaded rainforest habitat adjacent to talus patches at lower elevation (Columbia River Gorge) not typical of the talus-type habitats commonly used in many alpine areas of the western United States (Beever *et al*. 2017, p. 302). The authors suggest that, in the Columbia River Gorge region, this species is selecting microclimates in nearby shaded forests that provide insulation from warm summer temperatures (Beever *et al*. 2017, p. 302).This study also included results from a review of available literature related to behavior as a response to changing environmental conditions for several taxonomic groups. They found that behavioral responses to climate change effects were most commonly observed in longer-lived species, and the most common response, across all taxa, was a change in reproductive behavior, followed by dispersal or migration (Beever *et al*. 2017, p. 300). Most of the studies they evaluated identified temperature as the climate metric that was responsible for, or correlated with, changes in behavior; however, about 14 percent of the examined literature included responses to indirect (biotic) factors, such as changes in food resources (Beever *et al*. 2017, p. 300).~~

~~The authors also note that there are tradeoffs (e.g., reduction in time for foraging due to sheltering) that may impact long-term persistence and population viability (Beever *et al*. 2017, pp. 301–302), and the pika's flexibility in habitat selection has not been observed in populations in the Great Basin (Beever *et al*. 2017, p. 302), where some populations have been extirpated (Beever *et al*. 2016, p. 1,498; Table 1). A recent study concluded that the pika has been extirpated from an interior portion of its geographic distribution in the Sierra Nevada region (California) due to climate effects (i.e., increase in temperature, decline in snowpack), and although sites surrounding this core area still harbor the species, the net effect has been fragmentation of habitat and species distribution (Stewart *et al*., 2017, entire).~~

~~However, the pika continues to be found at sites that are outside of areas contained within bioclimatic envelop models (Jeffress *et al*. p. 253). The study found previously undocumented extant populations of the American pika in a region of the Great Basin (northwestern Nevada) that has been described as extirpated (Jeffress *et al*. 2017, entire). Relative to wolverine, the authors note that these results~~ Recent studies of behavioral responses to climate change effects of the American pika (*Ochotona princeps*; pika) (Beever *et al*. 2017, entire; Jeffress *et al*. 2017, entire; Stewart *et al*., 2017, entire) highlight the need for monitoring programs for animals, such as the wolverine, that are found in~~, particularly at remote~~ relatively inaccessible ~~and isolated~~ locations, in naturally low densities, and the importance of evaluating occupancy at multiple scales (Jeffress *et al*. 2017, p. 266) and the potential for geographical variation and habitat

structure in adaptation to climate change effects. ~~In addition, the study noted the inconsistency of modeled climate factors in explaining occupied/unoccupied sites, and the likely importance of the pika's talus (micro) habitat as well as the scale in which environmental variables are examined (Jeffress *et al*. 2017, p, 264). Resilience of pika populations is therefore likely related to these types of landforms, which act to decouple surface temperatures, with the talus rock habitat providing cool refugia (Jeffress *et al*. 2017, pp. 253, 264–265), but additional microsite data is needed as well as analyses of physiological variables to develop predictions of persistence (Jeffress *et al*. 2017, pp. 265–266). In sum, these studies indicate that small mammals exhibit adaptive responses to changing climate provided that refugia are available to support life history requirements. These studies also highlight the importance of continued monitoring and surveillance for difficult to study animals such as the wolverine, who are found in remote areas in naturally low densities, as well as the potential for geographical variation and habitat structure in adaptation to climate change effects.~~

As described in this SSA Report, the best available information indicates confirmed observations of wolverines denning in areas with patchy snow cover in Alaska, Canada, and Scandinavia. Given their high rate of movement, large dispersal, and other observed life history traits (e.g., behavioral plasticity) observed in wolverines, we do not predict a significant loss of individual and population resiliency to the species in the future (i.e., 40–50 years) within its North America range, including the contiguous United States.

Currently, we are unaware of any documented specific risks for the wolverine related to a substantial change or loss of diversity in life history traits, population demographics, morphology, behavior, or genetic characteristics which can be used to characterize species representation (the ability to adapt to change). Rates of dispersal or gene flow are not known to have changed. Additionally, there is no currently available information to indicate that the current abundance of the wolverine across its Current Potential Extent in the contiguous United States~~current range~~ is at a level that is causing inbreeding depression or loss of genetic variation that would affect representation. Nor is there any information to indicate that this species is unable to adapt or adjust to changing conditions (e.g., potential reduction in snow cover). We do not expect a reduction in representation of the wolverines in the contiguous United States in the future.

Commented [SJ52]: Don't we also have info that only a few migrants per generation (Cegelski) would be necessary to maintain the long term genetic health in the US, and we don't think anything is preventing migration from Canada, therefor… But maybe that would be better stated in the previous section.

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~~[**Add reviewer names, agency, Tribal Nations**]~~
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~~Oregon State Agency~~
~~Idaho State Agency~~
~~Montana State Agency~~
~~Wyoming State Agency~~
~~Tribal Nations~~

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Weir, R. 2017b. Electronic mail message from Richard Weir, Carnivore Conservation Specialist, Ministry of Environment, British Columbia, Canada, re wolverine harvest data, to John Guinotte, U.S. Fish and Wildlife Service, Mountain Prairie Regional Office. August 17, 2017.

Weir, R. ~~2017b~~2017c. Electronic mail message from Richard Weir, Carnivore Conservation Specialist, Ministry of Environment, British Columbia, Canada, re wolverine trapping by region, to Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. October 6, 2017.

Weir, R. ~~2017c~~2017d. Electronic mail message from Richard Weir, Carnivore Conservation Specialist, Ministry of Environment, British Columbia, Canada, re wolverine trapping, to Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. October 10, 2017.

[WGFD] Wyoming Game and Fish Department. 2016. Letter received from Wyoming Game and Fish Department in response to proposed rule reopening of comment period and request for information for North American wolverine (81 FR 71670; October 18, 2016). November 3, 2016.

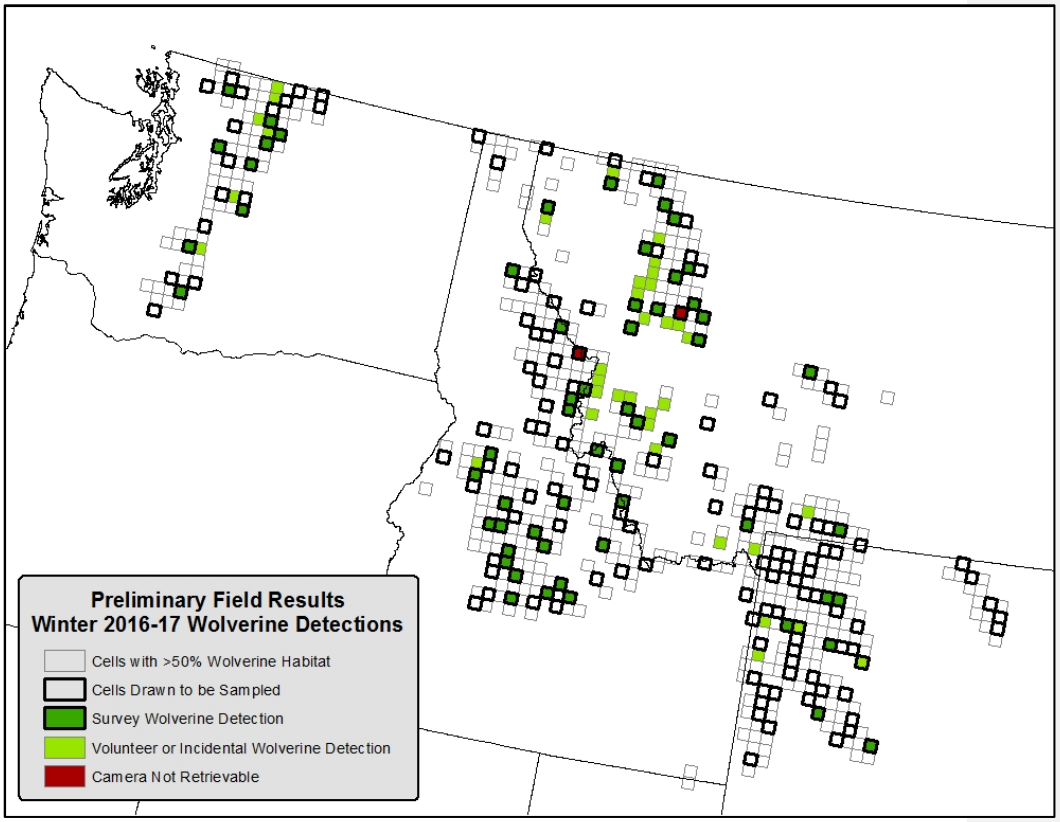
_____. 2017. Comment letter received from Wyoming Game and Fish Department, regarding review of Draft North American wolverine Species Status Assessment, version 1.0. November 27, 2017.

Yates, R.E. 2017. Comments received from Rick Yates, Wildlife Biologist, USDA Forst Service, Flathead National Forest, regarding review of Draft North American wolverine Species Status Assessment, version 1.0. Received December 1, 2017.

Appendices

Appendix A – Ecological regions of North America~~n within Estimated Current Range of North American Wolverine~~
(Source: CEC 1997; ~~Adapted from U.S.~~ EPA ~~1997,~~ 2010)

Appendix B – Wolverine Detections, Multi-State Wolverinec Occupancy Survey and Volunteer/Incidental Sightings, Winters 2015–2016 (Wyoming only) and 2016–2017 ~~(as of July 2017)~~
Source: ~~Inman 2017b, pers. comm~~WAFWA Wolverine Subcommittee 2017.



Appendix C – ~~Recent Wolverine Detections, Idaho and Wyoming~~Summary of Multi-State Wolverine Occupancy Survey

~~Source~~Provided by Montana FWP 2017, pers. comm~~. s: Dewey 2017, pers. comm.; Evans Mack 2017a and 2017b, pers. comm.; Walker 2017, pers. comm.~~

Commented [BJG53]: This is new (replacing previous Appendix) and was requested by several states for inclusion. Let me know if this should be paraphrased, as it's direct language from the working group.

Commented [SJ54]: I think its fine as is, but maybe just say up front that it is language taken directly from the working group and not use italics.

"*Wolverines are a naturally uncommon and rarely encountered species that resides in remote, high-elevation areas of the western United States. Proactive conservation measures are needed for this inherently small population that exists as a metapopulation across the region. One key component of a wolverine conservation strategy is development of a population monitoring program – up to now, records of wolverine occurrence have been rare and collected in an uncoordinated and opportunistic fashion, which makes it difficult to assess the species distribution, status and trend. The continued absence of a monitoring program jeopardizes the ability of agencies to allocate resources effectively among wolverines and other conservation priorities. State wildlife agencies in WA, ID, MT, and WY, along with federal, tribal, and NGO partners, developed a collaborative monitoring program that can be implemented in a coordinated fashion across the species range in the western U.S. The foundation for this monitoring program is a coordinated camera survey to obtain baseline information on distribution, genetics, and occupancy of wolverines. When repeated over time, trends in occupancy and distribution can be evaluated.*

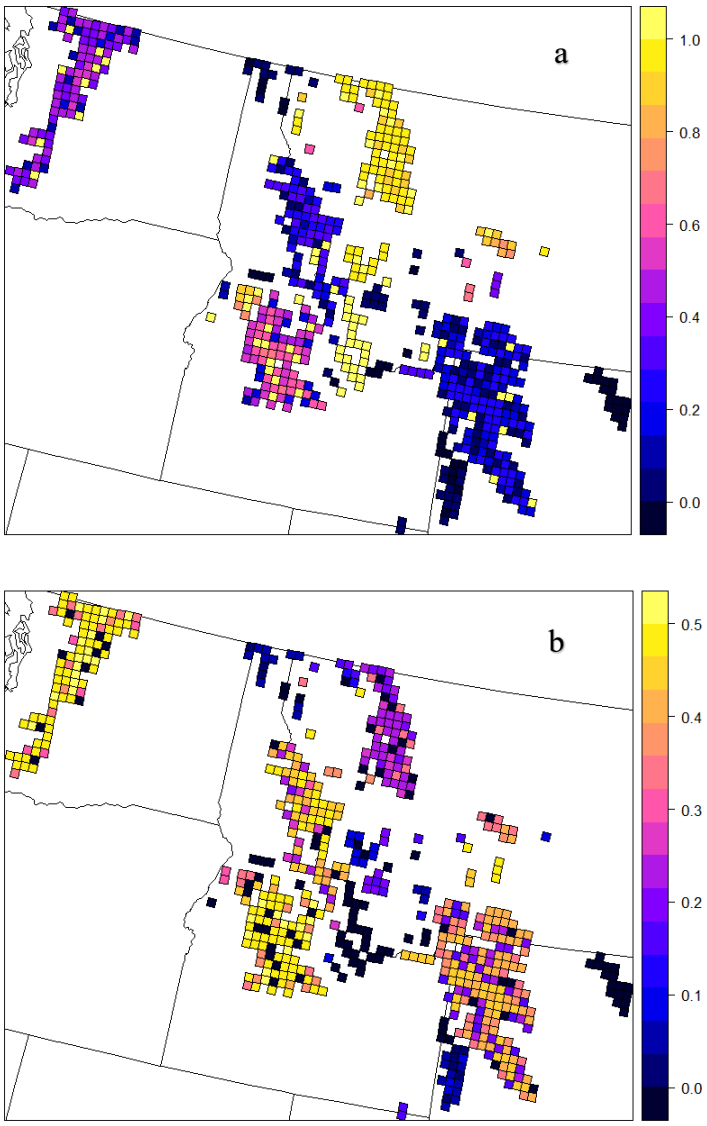
We developed a sampling frame based on existing models of wolverine habitat. The sampling frame consisted of 633 15x15 km grid cells. We selected 185 cells to sample from the frame using a GRTS sampling method. A single remotely triggered camera was placed in likely wolverine habitat within each selected cell along with a bait or scent attractant. Sampling occurred across a four-state area (ID, MT, WA, WY) during the winters of 2015-16 and 2016-17.

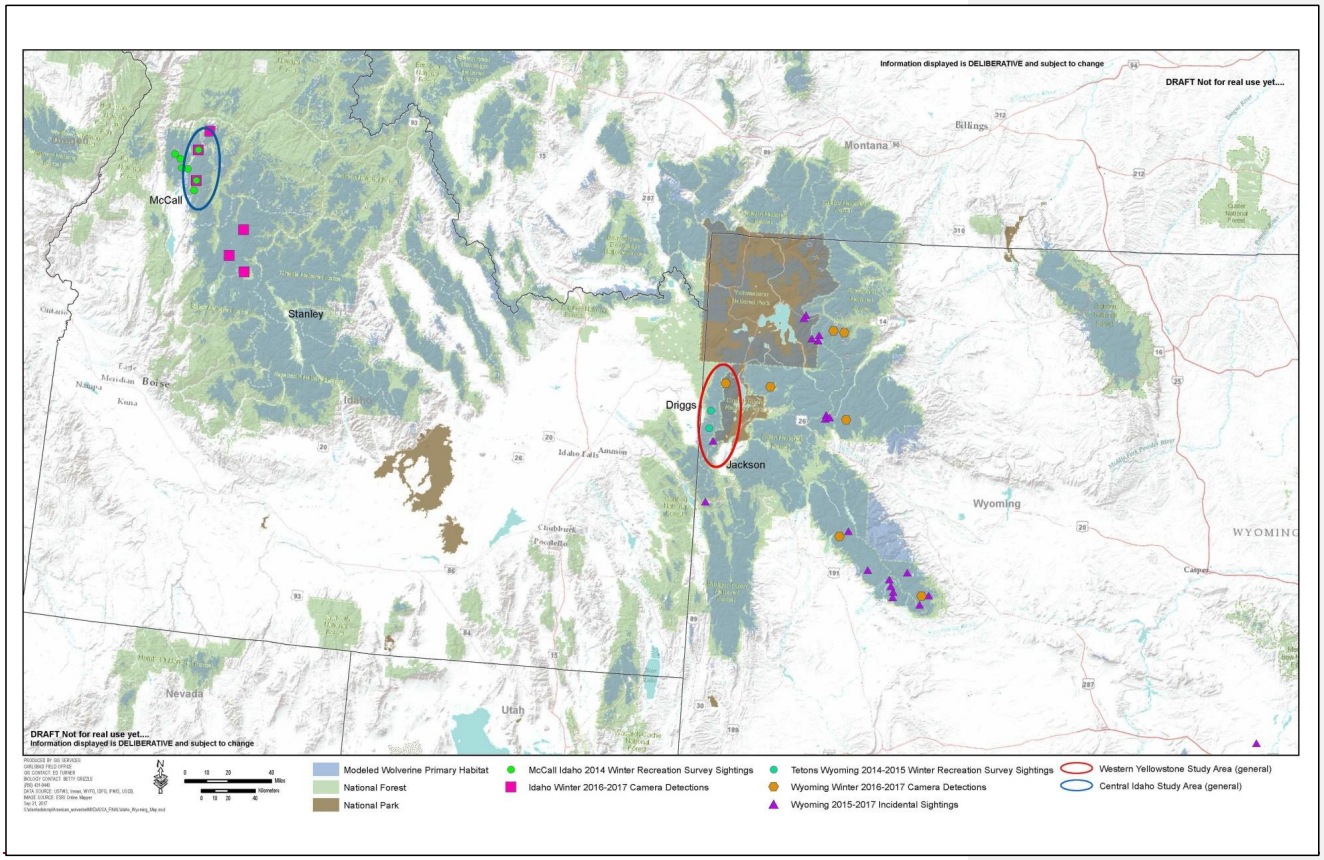
We obtained data from 183 sites and detected wolverines at 59 of the sampled cells. Detection rate was exceptionally high (p=0.92), and did not differ between sites that were baited and revisited multiple times vs. sites that were scented only and visited less frequently. The average estimated probability of wolverine occupancy during our study was 0.42 (95% credible interval 0.29-0.55) suggesting that wolverines used nearly half of all sites during the study period. Wolverine occupancy varied across the region with highest occupancy in the Northern Continental Divide Ecosystem and lower on the southern and eastern periphery of the study area (Figure 1).

The multi-state wolverine survey produced several important outcomes. First, it provided a rigorous and previously unavailable evaluation of wolverine distribution for the first time since the species was extirpated from the contiguous U.S. a century ago. This evaluation confirms the broad distribution of wolverines across the region and that recovery has progressed substantially since historical lows. The effort also demonstrates that occupancy probability varies throughout the region. The variability may be due to differences in habitat quality, differences in wolverine survival, or could be due to the time required to recover from historical absence. Perhaps most importantly, the regional occupancy estimates provide a baseline for future evaluations of change in wolverine distribution through time, including the possibility of detecting any influences due to climate change. In addition, the high detection rate and equal performance of stations visited less frequently indicates the potential for substantial cost savings during future surveys. The effort also demonstrated strong and fruitful collaboration among state, federal and tribal agencies at the scale of a species range, and the results provide management-level guidance on where to direct wolverine conservation in the future. For instance, information on occupancy may be used to inform criteria for

translocation, should some states pursue that as a means for enhancing the conservation status of wolverines."

Figure 1. Predicted wolverine occupancy (a) and standard errors (b) for the multistate wolverine survey in Winters 2015–2016 and 2016–2017.




Information displayed is DELIBERATIVE and subject to change
DRAFT Not for real use yet....
Montana
Billings
McCall
Stanley
Idaho
Boise
Meridian
Nampa
Kuna
Caldwell
Driggs
Jackson
Idaho Falls
Ammon
Chubbuck
Pocatello
Wyoming
WYOMING
Casper
Nevada
Utah
DRAFT Not for real use yet....
Information displayed is DELIBERATIVE and subject to change
Modeled Wolverine Primary Habitat
National Forest
National Park
McCall Idaho 2014 Winter Recreation Survey Sightings
Idaho Winter 2016-2017 Camera Detections
Tetons Wyoming 2014-2015 Winter Recreation Survey Sightings
Wyoming Winter 2016-2017 Camera Detections
Wyoming 2015-2017 Incidental Sightings
Western Yellowstone Study Area (general)
Central Idaho Study Area (general)

Appendix D – Land Ownership of ~~Modeled Wolverine Primary Habitat~~Current Potential Extent of the Current Potential Extent of Wolverine in the Contiguous United States
(based on- Albers Projection; see Figure 3)~~model from Inman *et al.* 2013)~~

Commented [SJ55]: Redundant?

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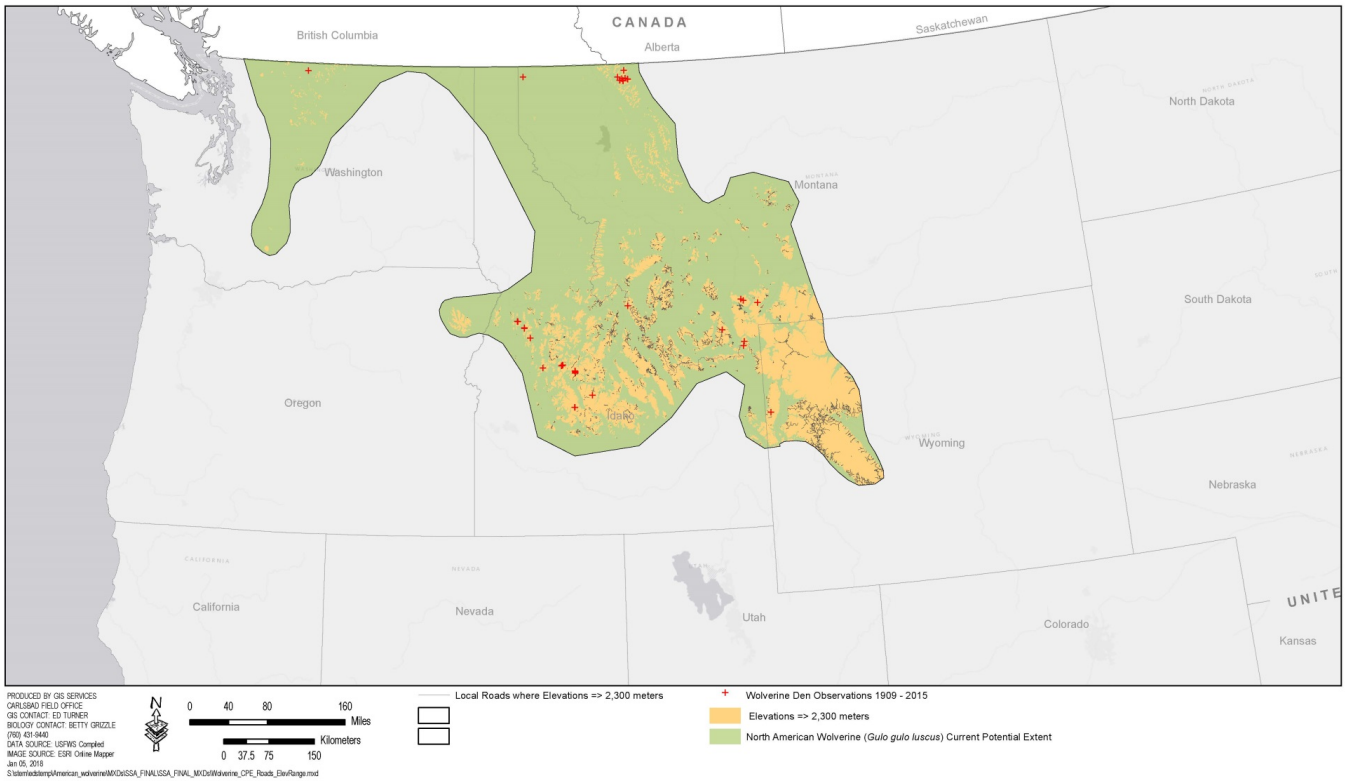
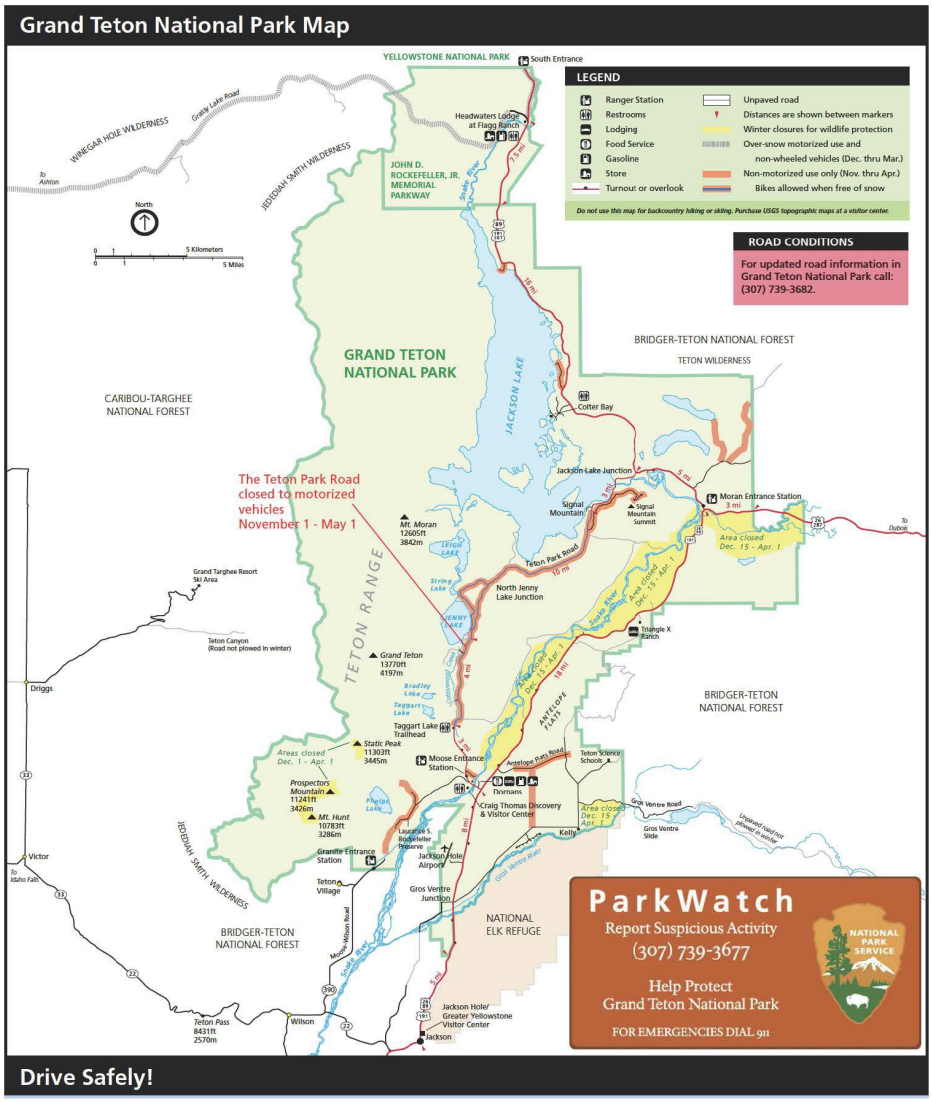
Ownership (% of total)	**Agency or other Entity**	**Total (acres)**	**Total (~~hectares~~square kilometers)**
Federal Lands	Bureau of Indian Affairs	~~453,866~~2,108,012	8,531~~183,673~~
	Bureau of Land Management	~~498,977~~4,236,779	17,146~~201,929~~
	Bureau of Reclamation	~~1,868~~137,567	557~~756~~
	Forest Service	~~34,331,515~~45,217,891	182,990~~13,893,471~~
	U.S. Fish and Wildlife Service	~~5,528~~115,184	466~~2,237~~
	National Park Service	~~3,791,491~~4,429,682	17,926~~1,534,362~~
	Other U.S. Department of Agriculture	~~13,312~~17,449	71~~5,387~~
	Other Federal	~~0.05~~76,152	308~~0.02~~
Total Federal (~~96~~72.4%)		**~~39,096,557~~56,338,714**	**227,995~~15,821,815~~**
State Lands (~~0.68%)~~4.3%)	~~Arizona, California, Colorado,~~ Idaho, Montana, ~~Nevada, New Mexico,~~ Oregon, ~~Utah,~~ Washington, Wyoming	**~~277,181~~3,337,474**	**13,506~~112,171~~**
Local Government (0.~~12~~01%)		**~~49,464~~9,249**	**37~~20,017~~**
Private Lands (~~2.63~~22.8%)		**~~1,064,858~~17,771,270**	**71,918~~430,933~~**
No Code ("99") (0.~~15~~24%)		**~~60,380~~187,625**	**759~~24,435~~**
Undetermined (0.~~02~~24%)		**~~7,598~~184,767**	**748~~3,075~~**
Total (100%)		**~~40,556,038~~77,829,099**	**~~16,412,446~~314,963**

Note: Numbers may not total to 100 percent due to rounding.

Appendix E – Results from Spatial Analysis of Roads within Current Potential Extent~~Range~~ of Wolverine



Appendix F – Road Closure Map, Grand Teton National Park
Retrieved from: https://2v9usu38jb9t3l8big1ialsn-wpengine.netdna-ssl.com/wp-content/uploads/2015/11/GTNP-closure-map.pdf



Appendix G – Existing Regulatory Mechanisms and Voluntary Conservation Measures

Federal Mechanisms

Organic Administration Act of 1897 and the Multiple–Use, Sustained–Yield Act of 1960

The USFS Organic Act of 1897 (16 U.S.C. § 475–482) established general guidelines for administration of timber on USFS lands, which was followed by the Multiple–Use, Sustained–Yield Act (MUSY) of 1960 (16 U.S.C. § 528–531), which broadened the management of USFS lands to include outdoor recreation, range, watershed, and wildlife and fish purposes.

National Forest Management Act

The National Forest Management Act (NFMA) (16 U.S.C. § 1600 *et seq*.) requires the Forest Service to develop a planning rule under the principles of the MUSY of 1960 (16 U.S.C. § 528–531). The NFMA outlines the process for the development and revision of the land management plans and their guidelines and standards (16 U.S.C. § 1604(g)).

A new National Forest System (NFS) land management planning rule (Planning Rule) was adopted by the U.S. Department of Agriculture Forest Service (Forest Service) in 2012 (77 FR 21162; April 9, 2012). The new Planning Rule guides the development, amendment, and revision of land management plans for all units of the NFS to maintain and restore NFS land and water ecosystems while providing for ecosystem services and multiple uses. Land management plans (also called Forest Plans) are designed to: (1) Provide for the sustainability of ecosystems and resources; (2) meet the need for forest restoration and conservation, watershed protection, and species diversity and conservation; and (3) assist the Forest Service in providing a sustainable flow of benefits, services, and uses of NFS lands that provide jobs and contribute to the economic and social sustainability of communities (77 FR 21261, April 9, 2012). A land management plan does not authorize projects or activities, but projects and activities must be consistent with the plan (77 FR 21261; April 9, 2012). The plan must provide for the diversity of plant and animal communities including species-specific plan components in which a determination is made as to whether the plan provides the "ecological conditions necessary to…contribute to the recovery of federally listed threatened and endangered species…" (77 FR 21265; April 9, 2012).

The Record of Decision for the final Planning Rule was based on the analyses presented in the *Final Programmatic Environmental Impact Statement, National Forest System Land Management Planning* (77 FR 21162–21276; April 9, 2012), which was prepared in accordance with the requirements of the National Environmental Policy Act (NEPA) (discussed below). In addition, the NFMA requires land management plans to be developed in accordance with the procedural requirements of NEPA, with a similar effect as zoning requirements or regulations as these plans control activities on the national forests and are judicially enforceable until properly revised (Coggins *et al.* 2001, p. 720).

A Species of Conservation Concern (SCC) is defined in the 2012 Planning Rule and in regulation (36 CFR 219.9(c)), as "a species, other than federally recognized threatened,

endangered, proposed, or candidate species, that is known to occur in the plan area and for which the regional forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area." The 2012 Planning Rule requires Regional Foresters to identify SCC for plan revision, and, when identified for a National Forest, monitoring plans are changed as needed (77 FR 21250, 21267; April 9, 2012). Wolverine is considered a SCC in the Rocky Mountain Region (Region 2). It is considered a Sensitive Species in the Intermountain Region (Region 4) and Northern Region (Region 1).

Within our estimated Current Potential Extent ~~Range~~ of the wolverine in the contiguous United States (see Figure 3), we identified ~~49~~ 22 National Forests~~ or Scenic Recreation Areas in the contiguous United States, and 2 within the State of Alaska~~. These areas are contained within four~~6~~ Forest Service Regions across the western United States~~ and Alaska~~.

National Forest Land Management Plans (Forest Plans)

We reviewed several Forest Plans or related planning documents in an effort to describe how these plans provide conservation management for the wolverine and its habitat, including wildland fire management practices. The sections below are, in most cases, taken directly from relevant documents. However, this discussion is not intended to be inclusive of all NFS management strategies and activities across the entire Current Potential Extent~~Range~~ of the wolverine in the contiguous United States.

Sierra Nevada Forest Plan Implementation

The 2004 Sierra Nevada Forest Plan Amendment (referred to as the Sierra Nevada Framework) amended the Land and Resource Management Plans (LRMP) for the eleven National Forests in the Sierra Nevada range to improve protection of old forests, wildlife habitats, watersheds and communities in the Sierra Nevada Mountains and Modoc Plateau. This amendment applies to the Tahoe National Forest, which has been occupied by a single male wolverine since at least 2008 (Moriarty *et al*. 2009, p. 150). The emphasis of the 2004 Sierra Nevada Framework is to adopt an integrated strategy for vegetation management that is aggressive enough to reduce the risk of wildfire to communities in the wildland urban interface, while modifying fire behavior over the broader landscape. Direction is provided as management goals and strategies, desired conditions, management intents and objectives, and management standards and guidelines. The 2004 Framework addressed five problem areas: old forest ecosystems and associated species; aquatic, riparian and meadow ecosystems and associated species; fire and fuels management; noxious weeds; and lower west side hardwood ecosystems (Forest Service 2013, p. 2–3).

Kootenai National Forest

The Kootenai National Forest is located in the northwest corner of Montana along the Canadian border and includes about 2.2 million acres of public land (Forest Service 2015, p. 7). The Forest Service published a Revised Land Management Plan for the Kootenai National Forest in 2015 that identifies forestwide direction, including goals, desired conditions, objectives, standards, and guidelines for physical and biological elements including wildlife such as management activities

that promote connectivity and avoiding or minimizing disturbance at known active denning sites for sensitive, proposed, threatened, or endangered species not covered under other forestwide guidelines. It also outlines objectives and guidelines related to the use of fire to maintain or improve habitat and maintaining unlogged conditions in some portions of areas burned by wildfires for 5 years post-fire (Forest Service 2015, pp. 28–32).

The Kootenai National Forest Land Management Plan also identifies *proposed or possible* actions for wildlife management that includes establishing and maintaining the vegetation diversity necessary to provide food, cover, and security for wildlife species native to the Kootenai National Forest in cooperation with federal, state, and other organizations. For wolverine, those management activities might include maintaining, managing, and protecting lands known or suspected to contribute to landscape linkages for wolverine (and other carnivores) in order to promote genetic dispersal and healthy populations (Forest Service 2015, p. 128).

Beaverhead-Deerlodge National Forest

The Beaverhead-Deerlodge National Forest covers 3.38 million acres in southwest Montana (Forest Service 2009, p. 2). The Beaverhead-Deerlodge National Forest Land and Resource Management Plan identifies goals, objectives, and standards for wildlife management (Forest Service 2009, pp. 45–49). Of relevance to the wolverine, wildlife security management goals include securing areas and connectivity for ungulates and large carnivores and managing the density of open motorized roads and trails by landscape region (Forest Service 2009, p. 45). Objectives include management of habitat conditions for elk security and winter habitat integrity for wolverine and mountain goat relative to changes in abundance of these Management Indicator Species (Forest Service 2009, p. 47). Monitoring elements are defined in the Land and Resource Management Plan that link goals and objectives to elements of the National Monitoring and Evaluation Framework (Forest Service 2009, pp. 273–280). For wildlife security, three performance measures relative to determining whether management activities are effectively protecting high elevation winter habitats for wolverines and mountain goats are defined: (1) presence or absence of wolverines in high elevation habitats, (2) populations of mountain goats (from Montana Fish Wildlife & Parks), and (3) number of snowmobile entries into non-motorized high elevation units protected for wolverines and mountain goats (Forest Service 2009, p. 277). In addition, in order to evaluate objectives related to road and trail densities, a performance measure related to changes in open motorized road and trail density for both seasons by landscape is included (Forest Service 2009, p. 277).

The Forest Service is monitoring the Mount Jefferson Recommended Wilderness boundary for illegal snowmobile intrusions into the wolverine habitat closure; that is, illegal use will be monitored and recorded (number and distance of intrusions) during the period open to snowmobiles December 2 to May 15 and any other time of the year snow conditions make snowmobiling possible (Forest Service 2009, p. 277). A reassessment of the decision to allow snowmobile use will be triggered if: (1) illegal intrusions are documented throughout the closure period; (2) illegal intrusions into the closed area, or (3) illegal intrusions that extend as far as the Bureau of Land Management (BLM) Wilderness Study Area (Forest Service 2009, p. 277).

Flathead National Forest

The Flathead National Forest is located in the northern Rocky Mountains in western Montana and includes approximately 2.4 million acres of public land (Forest Service 2016a, p. 3). This National Forest is surrounded by the Kootenai, Lewis and Clark, and Lolo National Forests, Glacier National Park, and Canada and includes large areas of designated wilderness (e.g., Bob Marshall Wilderness Complex, Mission Mountains Wilderness), Crown of the Continent Ecosystem, and wild and scenic river systems (Forest Service 2016a, pp. 3–4).

A Draft Revised Forest Plan was prepared for the Flathead National Forest in 2016 (Forest Service 2016b, entire). The Draft Revised Forest Plan identifies components to guide future projects and activities and the plan monitoring program, though these components are not commitments or final decisions approving projects or activities (Forest Service 2016b, p. 3). These components include desired conditions, objectives, standards, guidelines, suitability, and monitoring questions and monitoring indicators (Forest Service 2016b, p. 3). [A *desired condition* is a description of specific social, economic, and/or ecological characteristics of the plan area, or a portion of the plan area, toward which management of the land and resources should be directed, while an *objective* a concise, measurable, and time-specific statement of a desired rate of progress toward a desired condition or conditions (Forest Service 2016b, p. 4). A *standard* is a mandatory constraint on project and activity decision making, established to help achieve or maintain the desired condition or conditions, and a *guideline* is a constraint on project and activity decision-making that allows for departure from its terms, and are established to help achieve or maintain a desired condition or conditions, to avoid or mitigate undesirable effects, or to meet applicable legal requirements (Forest Service 2016b, pp. 4–5).]

Relative to wolverine, plan components for the revised forest plan include two guidelines that are protective of wolverine habitat; one that would protect modeled wolverine maternal denning habitat with respect to new projects or activity authorizations involving helicopter use and one that stipulates no net increase in the percentage of modeled wolverine maternal denning habitat where motorized over-snow vehicle use would be suitable on National Forest System lands. Additionally, as described in the Final EIS, management area allocations for Alternatives A, B modified and C include recommended wilderness areas that would add to existing wilderness. Desired conditions related to maintaining connectivity for wolverine and other wildlife are also identified within several geographic areas (Kuennen 2017, pers. comm.).

Federal Land Policy and Management Act (FLPMA) of 1976

FLMPA (43 U.S.C. 1711-1712) represents the BLM's "organic act" for public lands management under the principles of multiple use and sustained yield. Its implementing regulations give BLM regulatory authority over activities for protection of the environment, including mining claims. Under FLPMA and BLM policy, public lands must be managed so as to protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archaeological values (BLM 2005, p. 1).

Land Use and Resource Management Plans

BLM land use planning requirements are established by Sections 201 and 202 of FLMPA and regulations at 43 CFR 1600 (BLM 2005, p. 1). A *Land Use Planning Handbook* (BLM 2005, entire) provides guidance for implementing land use planning requirements established under FLMPA and implementing regulations. Land use plans prepared by BLM include resource management plans (RMPs) and management framework plans (BLM 2005, p. 1). The RMPs establish the basis for actions and approved uses on the public lands and are prepared for areas of public lands, called planning areas (BLM 2005, pp. 1, 14). These plans are periodically evaluated and revised in response to changed conditions and resource demands (BLM 2005, pp. 33–34).

National Environmental Policy Act (NEPA)

All Federal agencies are required to adhere to the NEPA of 1970 (42 U.S.C. 4321 et seq.) for projects they fund, authorize, or carry out. Prior to implementation of such projects with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. The Council on Environmental Quality's regulations for implementing NEPA state that agencies shall include a discussion on the environmental impacts of the various project alternatives (including the proposed action), any adverse environmental effects that cannot be avoided, and any irreversible or irretrievable commitments of resources involved (40 CFR part 1502). The public notice provisions of NEPA provide an opportunity for the Service and other interested parties to review proposed actions and provide recommendations to the implementing agency. NEPA does not impose substantive environmental obligations on Federal agencies—it merely prohibits an uninformed agency action. However, if an Environmental Impact Statement is prepared for an agency action, the agency must take a "hard look" at the consequences of this action and must consider all potentially significant environmental impacts. Federal agencies may include mitigation measures in the final Environmental Impact Statement as a result of the NEPA process that may help to conserve the wolverine and its habitat.

Although NEPA requires full evaluation and disclosure of information regarding the effects of contemplated Federal actions on sensitive species and their habitats, it does not by itself regulate activities that might affect the wolverine; that is, effects to the subspecies and its habitat would receive the same scrutiny as other plant and wildlife resources during the NEPA process and associated analyses of a project's potential impacts to the human environment. The Service receives notification letters for Draft and Final Environmental Impact Statements prepared by the Forest Service, BLM and other Federal agencies pursuant to NEPA for specific proposed projects including those within National Forests or National Parks, and preparation of Forest Service Land and Resource Management Plans, as discussed above.

Wilderness Act

The Wilderness Act of 1964 (16 U.S.C. 1131–1136) provides protection of habitat from most forms of development, though no single agency is responsible for administration of lands provided this designation, which are designated (or modified) by Congress. The Wilderness Act prohibits commercial enterprises and permanent roads within wilderness area and restricts temporary roads, motorized and mechanical transport, and structures, but does not prohibit all commercial uses (e.g., grazing). Within the portion of our estimated Current Potential Extent

~~Range~~ of the wolverine in the contiguous United States and Alaska, approximately ~~15~~ 18 percent is designated as wilderness areas under the Wilderness Act. We also evaluated wilderness contained within modeled wolverine primary habitat from Inman *et al*. (2013). We found 41 percent of this suitable habitat was designated as wilderness areas.

State Mechanisms

California

As noted above, the wolverine is a threatened species under the California Endangered Species Act or CESA, which prohibits the take of any species of wildlife designated by the California Fish and Game Commission as endangered, threatened, or candidate species (CDFW 2017b). CDFW may authorize the take of any such species if certain conditions are met through the issuance of permits (e.g., Incidental Take Permits) (CDFW 2017b). The wolverine is also a fully protected mammal in California, a designation that provides it with the most restrictive protection regarding take (i.e., may not be taken or possessed at any time) (CDFG Game Code, Division 4, Part 3 (Mammals), Chapter 8 (Fully Protected Mammals) § 4700(a)(1)).

The wolverine is also a Species of Greatest Conservation Need (SGCN) in the State's Wildlife Action Plan[5] and is a focal species of conservation strategies for conservation targets in the Southern Cascades and Sierra Nevada Ecoregions, and in the Mono Ecoregion of the Deserts Province section (Big Sagebrush Scrub (CDFW 2015, pp. 5.2-16, 5.4-23, 5.6-19).

In 2011, the CDFW (formerly California Department of Fish and Game) prepared an assessment/briefing document, *California Wolverine Population Augmentation Considerations*, in response to a *Feasibility Assessment and Implementation Plan for Population Augmentation of Wolverines in California* (November 2010) submitted to the Department by the Institute for Wildlife Studies (California Department of Fish and Game (CDFG) 2011). As of August 2017, no action has been taken by CDFW toward implementation of augmentation of wolverines in California.

Oregon

The wolverine has been listed as threatened species in Oregon since 1975, under the Oregon Endangered Species Act, and is fully protected under management authority of the ODFW (Anglin 2013, pers. comm.).

A Conservation Strategy for conserving the State's fish and wildlife has been prepared by the ODFW. The Conservation Strategy identifies 294 Strategy Species, which are Oregon's SGCN, (including wolverine) and are defined as those species having small or declining populations, are

[5] The U.S. Congress created the State Wildlife Grant (SWG) funding program in 2000 (Title IX, Public Law 106-553 and Title 1, Public Law 107-63). SWG funds are to be used "…for the planning and implementation of [States and territories] wildlife conservation and restoration program and wildlife conservation strategy, including wildlife conservation, wildlife conservation education, and wildlife-associated recreation projects." Congress stipulated that each State or territory applying for this funding program must develop a wildlife conservation strategy (**State Wildlife Action Plan** (SWAP)) by October 1, 2005. All 56 states and territories submitted SWAPs by 2005 and made commitments to review and/or revise their SWAP at least every 10 years.

at-risk, and/or are of management concern (ODFW 2016). For each of the Strategy Species, the Conservation Strategy identifies information on the special needs, limiting factors, data gaps, and conservation actions. For wolverine, conservation actions include management of recreational use to avoid impacts to the species (ODFW 2016). Other Strategy Species identified in the State's Conservation Strategy are prey species important to wolverine, including the Rocky Mountain bighorn sheep and Columbian white-tailed deer (ODFW 2016).

Washington

The wolverine is a candidate species for listing in the State of Washington and, since 2006, the Washington Department of Fish and Wildlife (WDFW) has been collaborating with wolverine researchers in the Cascades of northern Washington and southern British Columbia to better understand the status, distribution, and general ecology of wolverines in this region (WDFW 2013). It is also considered a SGCN, and is identified as a species whose population is in critical condition (WDFW 2013, pp. 3-7).

Washington's State Wildlife Action Plan (updated in 2015) identifies several major conservation strategies to address the conservation of fish and wildlife habitat and biodiversity in Washington, on both public and private lands (WDFW 2015, pp. 2-12–2-28). The wolverine is included in several identified ecological systems of concern such as alpine scrub, forb meadow, and grassland vegetation, cliff, scree and rock vegetation, and temperate forests (WDFW 2015, pp. 4-19, 4-27, 4-98). The State's *Wildlife Action Plan* identifies major stressors and key actions needed to maintain habitat quality for each of these ecological systems.

Of relevance to wolverine, the WDFW and its partners have been targeting land acquisition and conservation easements with high habitat or biodiversity values such as mixed-conifer forests as well as areas that support winter range and connectivity for wolverine and other carnivores (e.g., Methow River and Okanogan River Watersheds projects) (WDFW 2015, pp. 2-15–2-17). Other landscape conservation efforts highlighted in the State's Wildlife Action Plan include a Federal-State partnership with Washington's Department of Transportation to implement the Interstate-90 Snoqualmie Pass East Project to enhance wildlife connectivity that includes wildlife underpasses under the highway along creeks and rivers and two 150-foot wide wildlife bridges over the highway (WDFW 2015, p. 2-26).

Idaho

In Idaho, the wolverine is a protected nongame species and SGCN in Idaho (IDFG 2014). The *Idaho State Wildlife Action Plan, 2015* is a statewide plan for conserving and managing Idaho's fish and wildlife and their habitats, and provides a framework for conserving Idaho's 205 SGCN and their habitats, which includes the wolverine (IDFG 2017b, pp. xv–xviii). The wolverine is identified as a Tier 1 SGCN, which indicates it represents a species of most critical conservation need (IDFG 2017b, p. xvi). The statewide plan presents a species assessment for each SGCN and ecological section plans. Each of the ecological section plans presents a conservation target (e.g., habitat, species assemblage) that summarizes its viability as well as prioritized threats and strategies (IDFG 2017b, p. xv). A section outlining species designation, planning, and monitoring is also provided. The wolverine is included in three of the defined conservation

targets—forested lowlands, subalpine-high montane conifer forest, and low density forest carnivores (IDFG 2017b, p. 76). Along with objectives and strategies, these summaries identify actions for the SGCNs included in the defined conservation targets. Examples include: develop and implement a long-term multi-taxa monitoring program; determine high risk areas for wildlife crossings; construct highway over- and underpasses; promote and/or facilitate the use of prescribed fire as a habitat restoration tool, on both public and private lands where appropriate; determine best management practices to maintain cool microsites and benefit cool air associated species; and implement strategies to minimize disturbance from winter recreation activities as outlined in the *Management Plan for the Conservation of Wolverines in Idaho, 2014–2019* (IDFG 2017b, pp. 79, 80, 91, 94, 110).

The *Management Plan for the Conservation of Wolverines in Idaho, 2014–2019* (Management Plan) (IDFG 2014, entire) represents a framework for proactive efforts to ensure the long-term persistence and viability of wolverine populations in Idaho (IDFG 2016, pers. comm.). The Management Plan is described as a voluntary guidance document to lead conservation efforts at the State and local level, as well as to facilitate communication and collaboration efforts among wildlife and land managers (IDFG 2014, p. v).

Conservation issues and management actions are described in the Management Plan and the appropriate section plans of the *Idaho State Wildlife Action Plan*. The recommended strategies include development of finer-scale climate projections, research regarding wolverine-snow relationships, characterizing wolverine response to recreational activities, developing predictions of the potential overlap of wolverine and high levels of snow-sports recreation, and educating trappers to minimize incidental trapping of nontarget species, including the wolverine (IDFG 2014, pp. 32–39; IDFG 2017b, p. 1058). Seven conservation and management objectives are outlined in the Management Plan (IDFG 2014, pp. 32–39) and, as outlined in a November 2016 response letter, there has been progress on all of these objectives (IDFG 2016, pers. comm.). As an example, the agency (under the Multi-species Baseline Initiative) has developed and implemented a baseline micro-climate monitoring protocol for collecting environmental parameters in an effort to identify areas that serve as cool-air refugia (IDFG 2016, pers. comm.). As described above (*Overutilization for Commercial, Recreational, Scientific, or Educational Purposes*), the IDFG has prepared educational materials to promote best management practices for minimizing non-target wolverine captures and continues to educate trappers under a legislative mandate passed in 2016 (State of Idaho House Bill 378) (IDFG 2016, pers. comm.).

In addition, management of prey species important to the wolverine diet is outlined in the Idaho Elk Management Plan 2014-2024 (IDFG 2014a), the Mule Deer Management Plan 2008-2017 (2008) and the Bighorn Sheep Management Plan (2010).

Montana

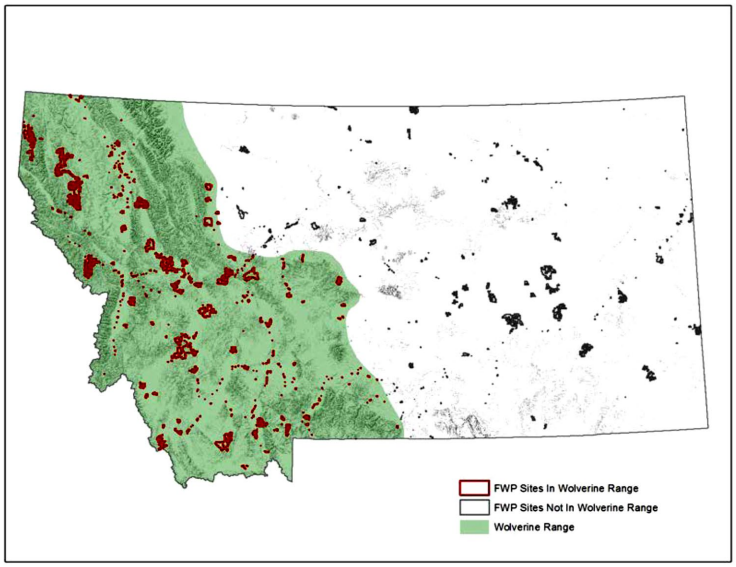
In the State of Montana, the wolverine is classified as a furbearer and species of concern. Since 2013, there has been a zero quota for trapping or harvest of wolverine and trappers that capture a wolverine must notify a designated Montana FWP employee within the relevant trapping district within 24 hours for collection if the animal cannot be released uninjured (Montana FWP 2016, pers. comm.).

There are two broad-scale wildlife conservation efforts that provide conservation benefits to the wolverine. *Montana's State Wildlife Action Plan* (updated and revised in 2015) identifies the wolverine as one of 128 SGCN (Montana FWP 2015, Appendix N). The State's Wildlife Action Plan identifies priority community types, focal Areas, and species to help informing Montana FWP's priorities and decisions and to assist other agencies and organizations in making decisions as to where to focus their conservation efforts (Montana FWP 2015, p. 2). Community types and focal areas are designed to identify and direct attention to specific geographical areas in the State that have the greatest conservation need (Montana FWP 2015, p. 5). For the wolverine, *Montana's State Wildlife Action Plan* identifies wolverine habitats in seven community types, all designate Tier I (or those with greatest conservation need), and in all focal areas (also Tier I) within those community types (Montana FWP 2016, pers. comm.). For each community type, impacts, threats, and corresponding conservation actions are identified, as well as specific impacts and threats such as habitat fragmentation (e.g., prioritize land acquisition, provide wildlife under- and overpasses), land management (e.g., management to address altered fire regimes), recreation (e.g., consider seasonal closures during breeding season), and climate change (e.g., collection of baseline data to document shifting range limits of SGCN and Community Types of Greatest Conservation Need) (Montana FWP 2015, pp. 59–63).

The second conservation effort in the State of Montana is a Crucial Area Assessment to identify crucial areas and fish and wildlife corridors, and development of a Crucial Areas Planning System (URL: http://fwp.mt.gov/fishAndWildlife/conservationInAction/crucialAreas.html). This is a Montana FWP mapping application and planning tool designed to assist in future planning of development and conservation (Montana FWP 2016, pers. comm.).

The State of Montana is also conserving wildlife habitat through land acquisition and conservation easements (Montana FWP 2016, pers. comm.) using a landscape scale collaborative approach with other agencies (Montana FWP 2016, pers. comm.; Montana FWP 2017, pers. comm.). In western Montana, including areas known to be occupied by the wolverine, 425 properties for a total 310,523 ha (767,320 ac) have been either acquired (e.g., State Parks, Wildlife Management Areas) or protected by conservation easements, as of November 2016, as shown in the figure below (Montana FWP 2016, pers. comm.). In addition, beginning in 2008, the agency shifted harvest units and quotoas to emphasize protection in smaller mountain ranges (closing 40 percent of the State to harvest), and to provide protection in places where reproduction is occurring in-between large ecosystems, to ensure dispersal and genetic exchange (Montana FWP 2017, pers. comm.).

Other regulatory mechanisms implemented by the State include rules and regulations promulgated by the Montana Fish and Wildlife Commission and codified in State Statute (MCA 87-1-201), and have been in place since 1921. All furbearer regulations are reviewed on an annual basis.



Wyoming

The wolverine is a protected animal and SGCN in Wyoming (WGFD 2017). The *Wyoming Game and Fish Department State Wildlife Action Plan* directs the activities of the WGFD and serves to guide in conserving Wyoming's SGCN through the combined efforts of government agencies, conservation organizations, academia, tribes, and others (WGFD 2017, p. I–1-1). As noted above, the wolverine is identified as a SGCN, a designation intended to identify species whose conservation status warrants increased management attention and funding, and consideration in conservation, land use, and development planning in the State (WGFD 2017, p. IV– i-1). The *State Wildlife Action Plan* incorporates the wolverine as a SGCN in several terrestrial habitat types or ecological systems, including cliffs, canyons, and rock outcrops, montane and subalpine forests, and mountain grasslands and alpine tundra (WGFD 2017, pp. III–2-5, III–5-7, III–6-5).

In 2015, Wyoming funded a pilot project (through The Wolverine Initiative) to evaluate wolverine detection and monitoring of the species in the State and is a contributing collaborator in the Multistate Wolverine Working Group implementing a monitoring strategy (the WSWCP) in the winter of 2016–2017 across four western states (WGFD 2017, p. IV–5-357). Results of those studies (e.g., Inman *et al*. 2015) are summarized above (*Population Abundance and Distribution*). The WSWCP is also updating and refining connectivity models for the wolverine in an effort to focus and prioritize habitat conservation and management (WGFD 2016, pers. comm.).

Utah

The wolverine is protected from collection, importation, and possession in Utah. It is identified as a SGCN in the *Utah Wildlife Action Plan* (UDNR 2015). The plan's threat assessment lists the wolverine as a Level 3 threat based on natural rarity, with a high threat impact (severity x scope) (UDNR 2015, p. 149). As a SGCN, wolverine conservation and management projects are eligible for State Wildlife Grant funding, including landscape-level conservation efforts (UDNR 2017, pers. comm.). The wolverine is also identified in the *Utah Wildlife Action Plan* as a species with a data gap relative to an inadequate understanding of distribution or range (UDNR 2015, p. 174).

Although the State of Utah is not a formal partner in the WAFWA Western States Wolverine Conservation Project (WSWCP)–Coordinated Occupancy Survey, the Division of Wildlife Resources selected grid cells for monitoring wolverines with remote cameras in accordance with the WAFWA protocol. Cameras were placed in potential wolverine habiat in the Unita and Bear River mountain areas from 2014–2017, and the State intends to continue camera monitoring for wolverines (UDNR 2017, pers. comm.).

Colorado

The wolverine is a state-endangered species in Colorado (Colorado Parks and Wildlife 2015a); however, there is no known current resident or reproducing wolverine population.

The *Colorado State Action Plan* (Colorado Parks and Wildlife 2015b) provides a blueprint for a collaborative effort to conserve Colorado's at-risk wildlife and their habitats, with a primary goal for securing wildlife populations in order to avoid protections implemented so that they do not require protection via federal or state listing regulations (Colorado Parks and Wildlife 2015b, p. 1). The wolverine is designated as a Tier 1 (highest conservation priority; up from Tier 2) SGCN (Colorado Parks and Wildlife 2015b, p. 19). The primary conservation action for wolverine described in the 2015 State Action Plan is to continue discussions among wildlife managers, conservation partners and stakeholders of the social and political aspects regarding reintroduction of wolverine populations into the southern Rocky Mountains (Colorado Parks and Wildlife 2015b, p. 186). The State has not yet prepared a potential restoration program for the species (Broscheid 2016, pers. comm.).

Western Association of Fish and Wildlife Agencies (WAFWA) – Western States Wolverine Working Group

The WAFWA, in coordination with Tribal partners, have formed a multi-state, multi-agency working group (Western States Wolverine Working Group) to design and implement the Western States Wolverine Conservation Project (WSWCP)–Coordinated Occupancy Survey. In addition, a WAFWA Wildlife Chiefs Wolverine Subcommittee provides a forum for western States to work collaboratively with each other and with the Service, Tribes, and other partners, for conserving wolverines across the western United States; to date, approximately $1.5 million of funding has been applied towards conservation and management actions, including the WSWCP (McDonald 2017, pers. comm.).

Other Conservation Mechanisms

Tribes

Nez Perce Tribe

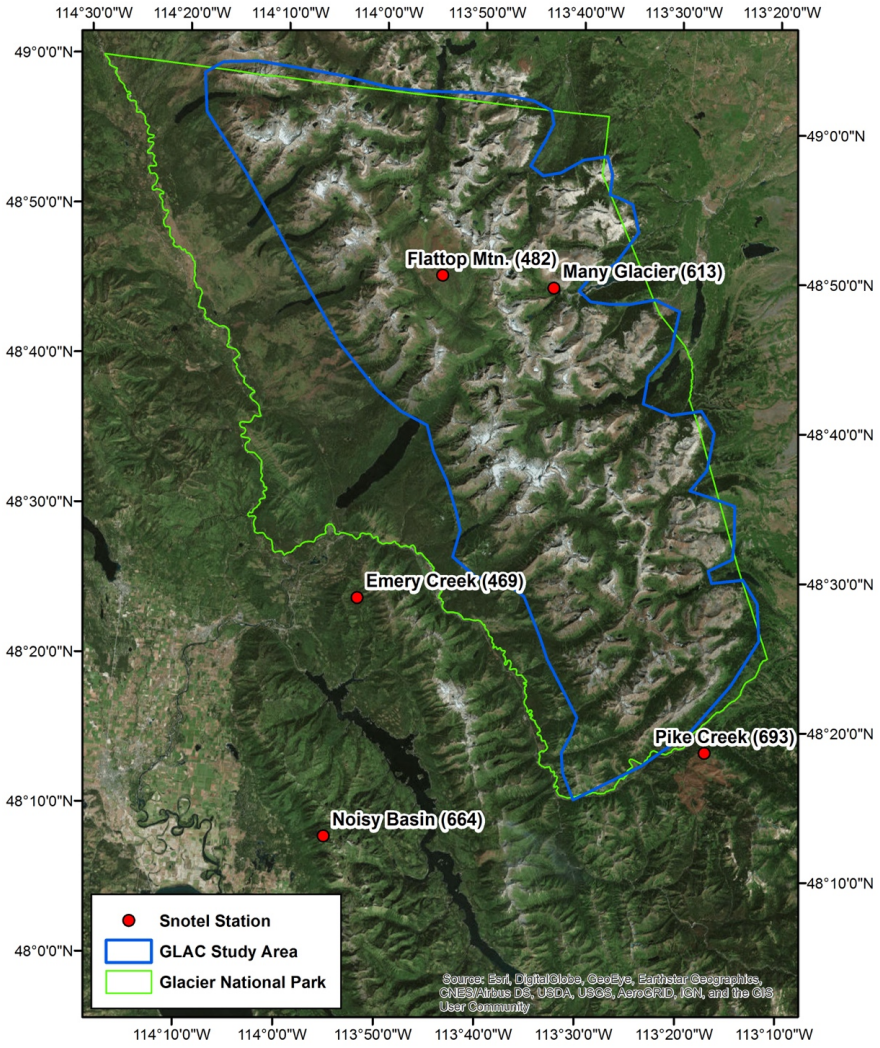
Wolverines are found within the aboriginal territory of the Nez Perce Tribe in north-central Idaho, and conservation and restoration of the species within the Nez Perce homeland is important to the Nez Perce Tribe (Miles 2017, pers. comm.). The Nez Perce Tribe is currently preparing an Integrated Resource Management Plan (IRMP), a Plant and Wildlife Conservation Strategy, and a Forest Management plan with the wolverine defined as a species of conservation concern in all three draft plans (Miles 2017, pers. comm.). The planning area for the IRMP, which is being prepared in partnership with the Bureau of Indian Affairs, incorporates the approximately 311,608 ha (770,000 ac) Nez Perce Reservation, located within portions of Nez Perce, Lewis, Clearwater, Latah, and Idaho Counties in north-central Idaho (http://www.nezperce.org/irmp/; accessed August 24, 2017). The preparation of the IRMP is currently at the scoping stage in the NEPA process for development of a Programmatic Environmental Impact Statement (http://www.nezperce.org/irmp/; accessed August 24, 2017).

The Shoshone-Bannock Tribes

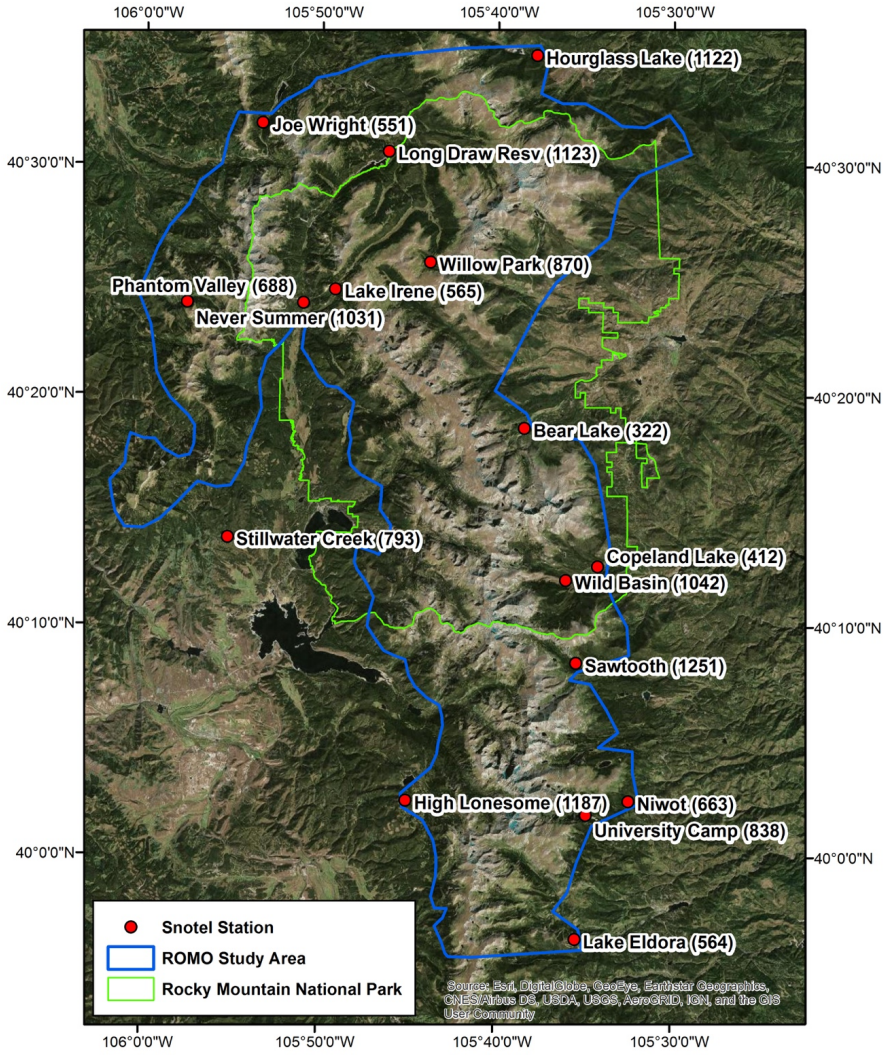
The Shoshone-Bannock Tribes are currently conducting climate change modeling for the Northern Rocky Mountains as part of its preparation of a Climate Change Adaptation Plan (Edmo 2016, pers. comm.). The Upper Snake River Tribes Foundation (USRT), which is comprised of four member tribes—the Burns Paiute Tribe, Fort McDermitt Paiute-Shoshone Tribe, Shoshone-Bannock Tribes of the Fort Hall Reservation, and Shoshone-Paiute Tribes of the Duck Valley Reservation—within the Upper Snake River Watershed region, prepared a *Climate Change Vulnerability Assessment* in February 2017 (Petersen *et al*. 2017, entire). The assessment is the first of three steps the USRT and its member tribes plan activities over the next several years as part of a comprehensive climate change effort, and will include an Adaptation Plan (expected to be completed in 2017–2018), and, depending on future funding, a process for development of Implementing Adaptation Actions and Monitoring (Petersen *et al*. 2017, p. 7).

Appendix H–NOAA/CU Study Areas Used to Evaluate Future Snow Persistence (from Ray et al., 2017)

Glacier National Park Study Area



Rocky Mountain National Park Study Area



From: Grizzle, Betty
To: Shoemaker, Justin
Subject: Re: Wolverine SSA Report - second draft for review
Date: Monday, January 8, 2018 9:21:33 AM

Thanks Justin. I'll do my best to pull this together by Wednesday after getting the other reviews (have only heard from you as of this morning). I will also work revising the PowerPoint this week.

On Mon, Jan 8, 2018 at 8:16 AM, Shoemaker, Justin <justin_shoemaker@fws.gov> wrote:

> Very nice work Betty! Here's my review.
>
> I will be working on getting materials together here to transmit the SSA Report to the RD's office on 1/10. They require a briefing memo and surname folder and other stuff, so I'll get all that together and wait for a final version from you to print for our RD later this week. And I'll have the same materials sent to the other regions.
>
> Justin Shoemaker
> Classification and Recovery Biologist
> U.S. Fish and Wildlife Service, Region 6
> Phone: 309-757-5800 x214
> Email: justin_shoemaker@fws.gov
>
> On Fri, Jan 5, 2018 at 4:47 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
>
>> Hi all - This is still a bit rough. Lots and lots of comments to address, and several new references, so you might want to read with Track Changes OFF first. I have not yet formatted this as I am still working in Track Changes; I will update Table of Contents, and relabel figures with final formatting. There are also places where (for some reason) the spell-checker is off, so I still need to proofread this for those misspelled words, etc. Also, several figures were replaced or revised (we had to redo several analyses), but these will not show up in Track Changes given the growing size of this already very large Word file.
>>
>> Please review the yellow highlighted sentences and comment bubbles. Since the States provided the most useful comments, I focused on those first and then the peer reviewers. I ask that you please review those 4 reviewer comment documents again relative to this new draft to see if I missed anything.
>>
>> As you know, this is due to Recommendation Management Team (and Core Team) next Wednesday so I will need your comments back quickly (please use track changes or comment bubbles) so I can pull all of your individual comments together in one document, accept changes, and then do final formatting.
>>
>> Let me know if you have any questions and THANK YOU all for your help with this.
>> Betty
>>
>> --
>>
>> Betty J. Grizzle, D.Env.
>> Fish and Wildlife Biologist
>> U.S. Fish and Wildlife Service
>> Carlsbad Fish and Wildlife Office

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760-431-9440, ext. 215
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From: Grizzle, Betty
To: Bush, Jodi
Subject: Re: Wolverine SSA Report - second draft for review
Date: Monday, January 8, 2018 3:55:15 PM

Thanks Jodi. I received comments from Justin this morning, but still waiting for review from John (and maybe Steve).

On Mon, Jan 8, 2018 at 2:50 PM, Bush, Jodi <jodi_bush@fws.gov> wrote:

> here is my review. I did a quick look through and have some general comments. Its looking good. JB
>
> Jodi L. Bush
> Office Supervisor
> Montana State Ecological Services Office
> 585 Shepard Way, Suite 1
> Helena, MT 59601
> (406) 449-5225, ext.205
>
> On Mon, Jan 8, 2018 at 3:31 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
>
> > It's due to the managers (for review prior to the recommendation team meeting) this Wednesday, Jan 10th.
> >
> > On Mon, Jan 8, 2018 at 2:23 PM, Bush, Jodi <jodi_bush@fws.gov> wrote:
> >
> > > what is your due date on this? Is the document due to reviewers on the 10th? JB
> > >
> > > Jodi L. Bush
> > > Office Supervisor
> > > Montana State Ecological Services Office
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> > > On Fri, Jan 5, 2018 at 3:47 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
> > >
> > > > Hi all - This is still a bit rough. Lots and lots of comments to address, and several new references, so you might want to read with Track Changes OFF first. I have not yet formatted this as I am still working in Track Changes; I will update Table of Contents, and relabel figures with final formatting. There are also places where (for some reason) the spell-checker is off, so I still need to proofread this for those misspelled words, etc. Also, several figures were replaced or revised (we had to redo several analyses), but these will not show up in Track Changes given the growing size of this already very large Word file.
> > > >
> > > > Please review the yellow highlighted sentences and comment bubbles. Since the States provided the most useful comments, I focused on those first and then the peer reviewers. I ask that you please review those 4 reviewer comment documents again relative to this new draft to see if I missed anything.

As you know, this is due to Recommendation Management Team (and Core Team) next Wednesday so I will need your comments back quickly (please use track changes or comment bubbles) so I can pull all of your individual comments together in one document, accept changes, and then do final formatting.

Let me know if you have any questions and THANK YOU all for your help with this.
Betty

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