

*Peer Review of the Scientific Findings in USFWS Species Status Assessment
Evaluating the Status of the North American Wolverine (Gulo gulo luscus)*

**Reviewer 4
December 2017**

Introductory Remarks

The Species Status Assessment (SSA) for the North American wolverine presents a complete, comprehensive, and well-organized and presented summary of the Species Description, Life History and Ecology, Biological Status-Current Condition, and Status – Future Conditions for the subspecies. The status and future temperature and snow conditions relative to climate change and winter snowpack change were particularly comprehensive, well thought out, and objectively presented. The road analyses and summary of current and ongoing research and wolverine monitoring were also up-to-date and provided useful insights. Further, the literature review was comprehensive and included relevant unpublished literature and personal communications. The authors should be commended for their completeness, well organized, and generally (with exceptions noted in subsequent sections) unbiased and scientifically based presentation of available information influencing the current and future status of the subspecies in the western U.S., central and western Canada, and Alaska.

That said, there are areas where the SSA has oversights or omissions (e.g., cumulative impacts of changing snow conditions); has not adequately identified the strength or limitations of available data (e.g., assumptions that reported road kills and incidental reports of trapping or illegal shooting of wolverines are complete and insignificant); where assumptions and methods in the report were not clearly and logically stated (e.g., the consideration of currently unoccupied but historically occupied habitat in California and Colorado, but omission of habitat in Minnesota, Wisconsin, Michigan, and Maine); where there seem to be demonstrable error in fact or interpretation (e.g., that wolverines can quickly change their pelage to respond to increasingly variable temperatures and that increasing temperatures during winter or summer would not stress wolverines); where uncertainty (e.g., uncertainty regarding viability of subpopulations important to persistence of the metapopulation, the role of increasing climate **variability**, and the role of human-induced mortalities on viability of small subpopulations of wolverines) has not been appropriately characterized; and where the SSA does not adequately address what the species needs to maintain redundancy and representation (e.g., are we considering the entire subpopulation or only currently occupied, high elevation habitats in the western mountainous U.S.?). Comments related to those primary issues are presented in the following section of this review.

Available Data:

1. Please identify any oversights or omissions of data or information, and their relevance to the assessment. Are there others sources of information or studies that were not included that are relevant to assessing the viability of this species and not repetitive of other information or studies already included? What are they and how are they relevant?

There is a general omission of data and discussion regarding the importance of unoccupied but potentially suitable habitats in California and Colorado, as well as virtually no discussion of reasons for extirpation in the Midwestern and extreme Northeastern U.S. The report exhibits bias towards well-performing populations in Canada and the U.S., as mentioned above, but seems to give little consideration to habitat identified by the Inman model as suitable and largely unoccupied in the western U.S. Further, we know that remnant populations of wide ranging and uncommon species do not adequately define the range of suitable habitats where the species may occur (i.e., underestimates the benchmark for species representation). For example, the Inman model is largely elevation-based, despite that the subspecies occupies lower elevation boreal forests, taiga, and tundra throughout its currently occupied range in Canada and Alaska. Further the species was extirpated from large areas of southern Ontario, virtually all

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of Quebec, and Labrador where elevation was not a detriment to human exploitation. How does the extirpated status in those regions affect current representation within potential suitable habitat in other regions of the U.S.? Is an elevation-based model really supported by the available data for the entire subspecies or is elevation merely a surrogate that explains where remnant population of wolverines persisted in mountainous regions of the western U.S. following a period of intense human exploitation? Elevation could also be correlated with snow and temperature limits for a species at the southern limit of its geographic range (as suggested by negative relationship between elevation at wolverine occurrences and latitude).

2. *Provide advice on the overall strengths and limitations of the scientific data used in the document. Is the information presented in the SSA report explicit about assumptions and limitations of, and concerns regarding, the data, and are these appropriately qualified or explained? Are there concerns that the Service did not identify, and if so, how relevant are these concerns to the assessment of the North American wolverine? Are there any inconsistencies in how the data are presented or assessed?*

2A) The general assumption that 100% of incidental harvests of wolverines are reported and, as such, shootings and incidental trapping are insignificant risks in the western U.S. seems unsubstantiated. Given the small population size, it appears that additional population viability modeling may be warranted to evaluate potential cumulative risks of incidental trapping (assuming sensitivity of population using available information and a range of assumed reporting rates), road kill (assuming a range of road mortality detection probabilities), and legal and illegal shooting (much of this is likely unreported) on the overall population (given a small effective population size), as well as the viability of small sub-populations.

2B) Although metapopulation processes are assumed in the SSA, the role and risks to subpopulations, as well as the significance to the larger metapopulation of largely unoccupied and isolated habitats in Colorado, California, and southeastern Wyoming are not addressed adequately. There seems to be a general assumption that because the species is mobile, and because individual animals have dispersed to Colorado and California, that the metapopulation is healthy and that the structure and population viability of the metapopulation is at low risk. Single animals do not represent a population, so those areas are effectively unoccupied from the standpoint of representation, resilience, and redundancy.

Analysis of Available Data:

3. *Have the assumptions and methods used in the SSA report been clearly and logically stated in light of the best available information? If not, please identify the specific assumptions and methods that are unclear or illogical.*

Methods used in the report are clearly and logically stated. Assumptions used to bridge from data presented or cited to conclusions regarding threats, particularly regarding the physical, physiological, and behavioral adaptations of wolverines in response to climate change are unclear. Assumptions regarding the conclusion that there is a lack of threat from incidental trapping, road kills, and legal and illegal shooting on the small subpopulations within the assumed metapopulation are unclear and inadequately documented.

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4. *Are there demonstrable errors of fact or interpretation? Have the authors of the SSA report provided reasonable and scientifically sound interpretations and syntheses from the scientific information presented in the report? Are there instances in the SSA report where a different but equally reasonable and sound interpretation might be reached that differs from that provided by the Service? If any instances are found where this is the case, please provide the specifics regarding those particular concerns.*

4A) The discussion of thermoneutrality in wolverines on pages 10 and 11 of the draft SSA is incomplete and presents an inaccurate picture of thermal stresses facing wolverines in the face of climate change. The assessment in the SSA is based primarily on wide ranges of **Lower** Critical Temperatures of wolverines during winter while in winter pelage compared to summer while in summer pelage. The authors provide weak support for the notion that the **Upper** Critical Temperature for wolverines will not be exceeded in summer because they are “good swimmers”, while ignoring uncertainty and the potential effect that increased temperature could have on a wolverine’s ability to be metabolically active in habitats (e.g., open area with sun exposure) with optimal foraging opportunities during summer. Particularly, the authors have ignored a significant body of literature suggesting that a combination of temperature and reflected solar radiation off snow can cause well insulated, northern mammals to exceed their **Upper** Critical Temperatures during relatively warm days (but well below 0°C) during winter when solar reflection off snow causes them to retreat to shaded habitats. As such, wolverines may not be able to remain metabolically active in optimal foraging habitats on below freezing but sunny days during winter when their dark coat is absorbing reflected solar radiation and their pelage is thick. The notion by the authors that wolverines have “rapid and seasonal adjustments of fur insulation (page 11, paragraph 6)”, despite only 1-2 seasonal molts (page 12, paragraph 2), is misleading and does not consider how increased temperatures during the >6 months when wolverines are in winter coat, as well as how increased variability in winter temperatures (i.e., cold periods requiring dense insulation intermingled with periods of high heat stresses) could affect the ability of wolverines to forage optimally and to reduce energy expenditure for cooling. Further the physiologic ability and costs to wolverines to quickly dissipate heat via energetically costly mechanisms of sweating and panting while in winter pelage has not been addressed.

A relevant example here was published by Parker and Gillingham (1990). They reported that the **Lower** Critical Temperature for mule deer in winter pelage was -19 degrees C (i.e., they are not as well insulated as wolverines). The drawback of that adaption to cold was that deer could exceed their **Upper** Critical Temperature at -25 degrees C with high solar radiation, reflective snow cover, and no wind. This shows how better insulated and cold adapted wolverines might be heat stressed with increased temperature variability and increased mean temperatures when in winter pelage. Thus, the premise of the conclusion of the SSA that wolverines have wide heat tolerances and will compensate behaviorally and physiologically to climate change effects seems without a sound scientific foundation and may be based on flawed logic.

4B) The discussion of “Snow Cover in an Ecological Context”, as summarized in Box 1 (page 29) is incomplete and is based solely on relatively old work by Formozov (1961, 1963). Issues related to changes in snow density (affects thermal environment for hibernating marmots and squirrels) and snow wetness (i.e., increased thermal heat loss to water evaporation and due to high specific heat of cold water), and changing snow depth, as well as these effects on snow interception in forested habitats associated with increased firnification (changing density and hardness due to wind, solar radiation, and freeze-thaw) have not been adequately addressed. The discussion of snow seems focused on discounting previously published work (see pages 30- 32), which suggested that den locations were correlated with late spring snow persistence. The SSA does not adequately consider other potential effects of climate warming on snow. Uncertainty related to effects of within-season variability in temperature, sun, and snow characteristics on wolverine foraging behavior, habitat selection, and spatial use is not adequately addressed. Also, effects of changing snow depth, persistence, and characteristics on competition (other

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carnivores) and overwinter survival of hibernating (e.g., ground squirrels and marmots) rodents has not been considered.

4C) The SSA goes to great lengths to discount the correlative relationships identified by Copeland et al. (2010) of persistent spring snow with den site locations, yet puts strong support behind correlative evidence from Webb et al. (2016) indicating that harvests of female wolverines (which likely represented many non-reproducing individuals) were not limited to areas of persistent snow. In fact, harvests by human may be biased to lower elevation areas with less snow. The SSA also does not include a recently published paper suggesting that patterns of occupancy of wolverines across a large region of Alberta were positively correlated with persistent spring snow (Heim et al. 2017). Further the authors of the SSA acknowledge the use of structures such as rocks and root masses for denning, as well as the altricial nature of wolverine kits at birth, but fail to acknowledge their earlier statements that temperatures of structures under snow would be 15°C warmer than without snow when kits are born?

I agree that there is great uncertainty regarding the direct effects of snow cover (e.g., versus correlative relationships with elevation or hibernating rodent prey) on wolverine reproductive success and there are certainly examples where wolverines occur and sometimes den in areas without persistent spring snow; however, it appears that the authors have made an inference that climate change is insignificant to wolverines and are going to great lengths to dismiss inconvenient truths. The wording of the text and the use of bold emphasis by authors on pages 30-32 exemplify my concerns with the objectivity of the authors regarding the importance of persistent snow. Alternative explanations (with data) to the observed and published relationships of wolverines to snow and elevation are needed if that relationship is to be discounted. Similar uncertainty regarding the wolverine's ability to deal energetically with elevated winter temperatures and an assumption that incidental trapping is inconsequential seem to be accepted by the authors as they seem to fall in line with their notion that the subspecies is not at risk. Thus, greater attention to equal and objective treatment of data uncertainty is warranted across all aspects of the report.

It is confusing that, after dismissing the relationships of persistent snow and reproduction, the authors go to great lengths to describe outcomes from a study funded by FWS that demonstrates significant areas of persistent snow in Glacier and Rocky Mountain Parks under potential future climate scenarios. These are encouraging and insightful results, but still seem to imply a lack of objectivity and an apparent effort to dismiss adverse climate effects. The fact that both parks have exceptionally high elevation (and presumably more persistent snow) in comparison to adjacent landscapes where wolverines are present leads to uncertainty regarding the generality of those findings, and those uncertainties seem to have been largely overlooked.

My concerns identified above are exemplified on page v of the Executive Summary. Which states (3: Resiliency: line 80-10) “... **based on available information we have no indication that this species is unable to adapt or adjust to changing (climate) conditions.**” This seems to ignore the fact that only 6% of occupied geographic range is south of the U.S. Canada border, that snow (+) and temperature (-) are strongly correlated with elevation, and that elevation of wolverine occurrences increases with decreasing latitude. Further, the climate evaluations all predict increasing temperatures and decreasing snow, yet effects on wolverines are concluded to be insignificant? There is contrary evidence and uncertainty that needs to be acknowledged here.

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5. *Provide feedback on the inclusion and portrayal of uncertainty in the SSA report. Have the scientific uncertainties presented and the analyses conducted been clearly identified and has the degree of uncertainty been appropriately characterized? If not, please identify any specific concerns.*

Refer to comments 2A, 3 and 4C. First, there is inadequate portrayal of uncertainty regarding effects of anthropogenic-related mortality on the metapopulation and subpopulation persistence. Secondly, there is inadequate portrayal of uncertainty that wolverines can respond behaviorally and physiologically to climate stressors and that there is little risk to wolverine persistence as a result of anticipated (and well documented in the SSA) changes in snow persistence and climate. Third, equal treatment of data uncertainty among studies regarding importance of snow persistence is warranted. Finally, further acknowledgment of uncertainty of the conclusion that there will be sufficient persistent snow cover throughout the range of wolverines based on FWS modeling in locally high-elevation national parks is needed.

6. *Does the SSA report adequately consider what the species needs to maintain viability in terms of resiliency, redundancy, and representation?*

6A) Is future population expansion into Colorado and California required to maintain adequate redundancy? If so, then those populations seem at high risk of extinction. If not, then why is the habitat in those areas included in the report given that it is largely unoccupied except by a couple of aberrant individuals? How are these areas important (or not) to maintain resiliency, redundancy, and representation?

6B) The SSA focuses on the western and northwestern U.S. and seems to ignore the language of the ESA relating to representation of a species in a significant portion of its geographic range. The report is unclear relative to the importance (vis a vis representation and redundancy) of wolverines in California, Colorado, the upper Midwestern U.S., and the extreme Northeastern U.S. (e.g., Maine). On page 15 (paragraph 3) the authors seem to dismiss the Midwestern U.S. as potential wolverine habitat based on a report that wolverines were historically present but “uncommon” in Wisconsin, despite that the same report states that several authenticated records of wolverines were reported along the Wisconsin-Minnesota border. Repeatedly, the SSA establishes that wolverines are uncommon within their currently occupied range and considers potential range in California and Colorado based on occurrence of a single individual in each state? Occurrence of a single individual in northern Michigan is dismissed, why? On page 15 (paragraph 1), the authors indicate that “Our intent....was to present an overall geographical depiction of the wolverine’s estimated range for only the west-northwestern United States...”. How was this geographic emphasis decided given that the SSA is for the entire geographic range of the sub-species? How does this decision affect inferences regarding redundancy and representation?

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General Comments

The SSA characterizes the wolverine as a food and habitat generalist restricted to boreal forests, tundra, taiga, and high-elevation meadows and boulder/talus. The report also (incorrectly I think) characterizes the wolverine as a species able to tolerate wide temperature extremes (but see comment #4A) and variable snow conditions. Thus, the report does not adequately explain why we are at the current southern range limit (6% of occupied range in coterminous U.S.) or why the geographic range of genus *Gulo* in North America has not included the warmer mixed and deciduous forest regions (e.g., present Appalachian Mountains) currently or since at least the late Pleistocene, despite high food availability? A significant northward shift in the distribution of a highly insulated, climate-restricted, large footed, and snow adapted carnivore like wolverine is certainly plausible under the climate change scenarios so eloquently presented by the authors. That possibility and degree of uncertainty does not come across in the Executive Summary, supporting text, and is in direct contradiction to the conclusions (see page 95, paragraph 2) of the SSA.

Literature Cited

This list includes only the two published studies that were cited above and which were not included in the SSA.

Gillingham, M. P., and K. L. Parker. 1990. Estimates of critical thermal environments for mule deer. *Journal of Range Management* 43:73-81.

Heim, N., J. T. Fisher, A. Clevenger, J. Paczkowski, and J. Volpe. 2017. Cumulative effects of climate and landscape change drive spatial distribution of Rocky Mountain wolverine (*Gulo gulo* L.). *Ecology and Evolution* 7:8903-8914.