

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

Reviewer 1
December 2017

Introductory Remarks

Overall, the SSA report is well written, thorough, and does an excellent job of synthesizing the available information and literature currently in existence for wolverines in the U.S., as well as the rest of the species' range. Below I have provided a number of comments that I hope will aid the USFWS in finalizing this report.

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?

Overall the SSA report provides a comprehensive review and synthesis of the available information on the ecology, biology, and management of wolverines, both within the U.S. but also across the species' range. This includes both the primary literature as well as many sources located within the gray literature and personal communications with wolverine experts. I am not aware of, nor did I find, any published studies that were omitted from the SSA report that provide novel information critical to the assessment of the viability of this species that was not covered to some degree in other sources. However, there are a few additional studies (relatively new studies) relevant to the SSA report that provide additional depth to a few key focal areas of the report.

Specifically, Rauset et al. (2013) tracked Eurasian lynx and wolverines in Sweden that were fitted with GPS collars to elucidate habitat selection and niche partitioning. Results of this study suggest wolverines avoid areas with higher human disturbance. Also, wolverines exhibited much higher individual variation in home range compositions than lynx, ranging from low elevations with large portions of coniferous forests, to higher elevations with large portions of bare rock and glaciers. Wolverines selected for habitats within their home range relative to their availability (i.e. no strong selection). In contrast, lynx had a stronger selection of particular habitats within their home range. Collectively, these data provide further support (with GPS data for which there are limited data available for wolverines) that wolverines are highly adaptable generalists.

Similarly, despite limitations to the study, given the paucity of data available on summer food items used by wolverines, inclusion of the results of Inman et al. (2015) would strengthen the food habits section of this SSA report, especially given that the data were collected in the U.S. Lastly, Ellis et al. (2013) used a simulation-based study to evaluate various sampling protocols to detect a decline in abundance of wolverines in the U.S. These simulation studies suggest most sampling schemes in the U.S. would only able to detect large declines in abundance (50% over 10 years) and small populations would require even more substantial changes to be able to detect a shift. While there are many limitations to this simulation study, the main point that monitoring changes in wolverine populations will require a large, and coordinated, effort is likely valid. Inclusion of this information/study is not essential to the report, but could aid in providing emphasis of the challenges and uncertainties associated with monitoring trends in wolverine populations.

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

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?*

Overall, this SSA report draws upon a broad range of materials available pertaining to wolverines, including peer-reviewed papers, reports, expert opinions, and other credible sources. As mentioned throughout the report, wolverines are an inherently challenging species to study, and research on this species, particularly in the U.S., is limited at this point. Thus, there are many aspects of wolverine biology, ecology, and management that are understudied, or largely unknown. The authors of the SSA report have done an excellent job synthesizing the available knowledge on wolverines relevant to the topics covered in this report, as well as emphasizing areas where the data are limited. I did not find any inconsistencies in how the data are presented or assessed. Below I have emphasized a few key topics discussed in the report where wolverine ecology is well established, areas where there are current gaps in knowledge, and a few areas where additional clarification in the SSA report could be warranted.

In general, there are several aspects of wolverine ecology that are relatively established, all of which are well characterized in this report with appropriate references. In particular, the available data consistently indicate wolverines are generalists in many aspects of their life history and thus able to exploit a range of habitats and food resources. However, there is consistent agreement that wolverines prefer rugged (high elevations in the U.S.), remote habitats and are typically associated with snow cover persisting late into spring. As highlighted in this report and the available data, there is general agreement wolverines prefer areas of persistent snow into spring, although it appears persistent snow is most critical for wolverine denning associated with rearing young. It also is clear that in most cases wolverines generally avoid areas with potentially greater mortality risk, such as areas with increased activity of predators or human activity (often harvest related). There also is widespread agreement wolverines require large territories and exhibit intrasex territoriality. Wolverines have been reported consuming a wide range of food items and thus require access to a wide variety of seasonally variable food resources, including carrion as wolverines scavenge extensively, especially during winter. All of these aspects of wolverine ecology have been well described in this report, and the authors have appropriately referenced the available literature and current state of knowledge on these topics.

While the aforementioned aspects of wolverine ecology are well recognized, there are many aspects of their ecology (especially in the U.S.) where the data are more limited or non-existent. Furthermore, there are numerous studies that have documented disparate findings (e.g., attraction vs. avoidance of areas of wolf activity), demonstrating the plasticity of the species. For example, although there is general agreement that wolverines prefer areas of persistent snow into spring associated with denning, some natal dens have been reported in areas with less persistent snow cover as well as areas outside modeled projections of snow cover. Thus, it is currently unknown whether wolverines require snow dens for successful reproduction and population viability. Furthermore, snow through May 15th may not be obligatory in wolverines (as suggested by Copeland et al. 2010) as some dens in their study had snow through 15 May in as little as 1 in 7 years (Magoun et al. 2017). It should be noted though that success of litters associated with those dens is unknown. It also is unknown whether females could shift reproductive phenology (given that delayed implantation occurs with this species) in the face of warming climate conditions to alter the timing of birth to better suit earlier snow melt in the future. Unfortunately there are no studies to date that have focused on many of these topics, particularly whether wolverines require persistent snow at the den site and whether this is tied to successful reproduction. Thus, there is a clear need for more information on denning activity, conditions contributing to den abandonment, and whether den type or abiotic/biotic conditions influence any

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

aspect of reproduction or young survival. These critical data limitations are highlighted in the SSA report.

As discussed throughout the report, there also are critical data gaps for many other aspects of wolverine ecology, such as population demography, vital rates, spatial ecology, population genetics, etc. In particular, there is considerable uncertainty regarding any potential impacts of reduced genetic diversity on U.S. wolverine populations. Much discussion is devoted to these topics in the SSA report. However, as discussed in responses to other questions (see below), the report would benefit from additional statements in the **Biological Status** or **Status-Future Conditions** sections to highlight these current data limitations, particularly genetic diversity in the face of potentially reduced population connectivity resulting from climate change.

Although food availability during denning is critical to both females (due to high energy demands associated with lactation) and their offspring, availability of summer forage should not be overlooked and could be equally important (Inman et al. 2012). In general the importance of summer forage is largely understudied, and would benefit from further research. During summer, young are rapidly growing and need steady food intake. Summer forage also may be critical to improving female body condition heading into winter (i.e. reproduction), although this does not appear to be well studied. This is mentioned in the report (under *diet and feeding* and briefly in *demography*), but only briefly and thus could be further emphasized, particularly under the section on *demography* to expand the current discussion on this topic on page 36.

Page 59, section on predation: Although predation is reported in the literature for wolverines, I would agree with the assessment that the best available data suggest predation does not represent a significant stressor to wolverines at the population level. However, at the individual level there are several studies that speculate wolverines avoid areas of potential predation risk from wolves (e.g., Scrafford et al. 2017). In fact, this is often one of the arguments given for wolverines selecting rugged terrain at high elevations, although there are several other studies that suggest wolverines can be associated with wolves and other predators, presumably to scavenge carcasses of their kills. This paragraph would benefit from the acknowledgement that indirect effects of predators could impact wolverine behavior (i.e. predator avoidance through habitat selection), although this is something that is not fully understood in the literature and the data are somewhat contradictory, suggesting this behavior may be influenced by a multitude of factors.

On page 64 it is stated that “In summary, overutilization does not represent a stressor to the wolverine in the contiguous U.S. at the individual, population, or species level”. However, as stated on page 61, Krebs et al. (2004) suggested harvest of wolverines could represent additive mortality. Although there currently is no wolverine harvest in the U.S., if harvest is reinstated any such harvest could thus provide an additional stressor to an already reduced population. However, as stated in (50 CFR Part 17) such harvest would likely be minimal and thus have limited impact. This SSA report would benefit from similar language as provided in 50 CFR Part 17 to better clarify that any future harvest of wolverine in Montana is likely to have minimal impact on the metapopulation.

Page 72, final sentence of the summary on this page. While these adaptations undoubtedly do allow wolverines to adapt to warming temperatures, other sub-lethal effects (e.g., impacts to reproduction) are not acknowledged here, which are currently unknown. Similarly, the summary on page 73 discusses shifts in vegetation associated with climate change but does not mention corresponding shifts in prey availability in response to changing habitat. It is possible increasing temperatures may favor production of small mammals and other small prey. In contrast, warming temperatures could reduce winter kill of ungulates, which wolverines likely utilize as a source of winter food.

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

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.*

After review I found the assumptions and methods used in the SSA report to be clearly and logically stated in light of the best available information with a few minor exceptions. On page 34 the authors introduce an evaluation of snow cover at previously recorded den sites. It is not clear where these den data are derived, or what area of the species distribution they are derived from. Similarly, in Table 9 it appears these same den sites might be used (although this is unclear). However, here only 14 dens are presented so please clarify why the remaining dens were not used, despite there being more than 14 dens presented in Table 3 between 2003 and 2007. These same dens seem to be referenced again on page 54 in the paragraph starting with “We also reviewed den site locations...”. It is unclear what dens were used in this analysis, as well as what analysis was performed to make the determination that “...wolverine dens are located in areas with minimal roads, including secondary roads...”. Furthermore, results of this analysis may simply reflect a correlation, and not causation. In other words, the wolverines using the dens incorporated in this analysis may simply occupy areas away from roads, rather than those individuals actually exhibiting an avoidance behavior of roads in terms of den selection within their home range. If GPS data are available for these individuals such a determination could be made to better qualify this statement.

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.*

I did not observe any demonstrable errors of fact or interpretation of the available literature on wolverines in this SSA report. I also found the author’s interpretations and syntheses of the available data to be reasonable and scientifically sound. During the initial proposed listing there was emphasis on habitat models generated by Copeland et al. (2010) and McKelvey et al. (2011). The strengths and limitations of the models produced in these studies have been reevaluated in this current SSA report. The current assessment appears to provide appropriate emphasis on both the strengths and limitations of these models, as well as the integration of new studies that are relevant to those prior determinations.

I did identify two aspects of wolverine populations covered in the SSA report that would benefit from additional detail or clarification to support the interpretations of the authors of the available data. In particular, the best available evidence indicates genetic diversity in U.S. wolverine populations is low and in the absence of augmentation (i.e. introductions) this is unlikely to change substantially in the foreseeable future. Furthermore, climate models suggest that while large tracts of wolverine habitat will remain in the future, populations will become increasingly isolated, and some populations could become isolated in terms of female immigration (Inman et al. 2013). Combined, this paints a rather troubling picture for wolverine populations in the future and suggests more active monitoring and management (including introductions) could be warranted. The best available data (which there are very few of) do not indicate wolverine populations are currently being negatively impacted (substantially) by the lack of genetic diversity present, and there is no evidence to suggest the U.S. population is declining. These topics are covered in the SSA report, but I was unable to find any discussion linking these issues under either the **Biological Status** section or the **Status-Future Conditions** section, where such discussion could be beneficial.

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

Additionally, under “other cumulative effects” on page 89 it is emphasized that a future warming climate could reduce season lengths for winter recreational activities, thus reducing the impact of this stressor. While likely true, it also is likely that given the future reduction in available snow pack there could be increasing overlap in areas used for winter recreation and wolverine activity. In particular, areas suitable for winter recreation could become more likely to encroach upon potential denning habitats if the availability of these habitats is reduced.

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.*

Overall there are a considerable number of uncertainties regarding the ecology of wolverine populations, particularly in the U.S., and importantly how future changes in climate/land use could impact populations. However, over the last several years (particularly since the initial proposed listing of the species by the USFWS), there has been a growing number of studies published attempting to address many outstanding questions regarding key ecological and biological attributes of wolverines in the U.S. Despite these additional studies, there remains a paucity of data regarding many aspects of wolverine ecology needed to better understand their ability to maintain viable populations in the face of a multitude of current and future threats, including global climate change. Throughout the SSA report I found the authors very clear in their inclusion and portrayal of uncertainty, particularly where aspects of the ecology of the species are unknown or understudied, and additional data necessary to better inform management decisions for this species. However, below I will highlight one topic in particular that would benefit from further emphasis within the report.

Wolverines currently do not appear to be declining in the U.S. and no impacts of loss of genetic diversity or small population sizes appear to have been documented thus far. Therefore, while genetic integrity and maintenance of robust and healthy populations are a concern for this species over the next century, particularly given the rate of climate change, there currently are insufficient data to suggest an immediate threat to wolverine populations, which is the conclusion stated in the SSA report. It is clear, however, that wolverine populations in the U.S. lack genetic diversity and several potential areas of wolverine habitat are marginally connected to existing populations. Thus, in the absence of population augmentation (i.e. introductions) this species is vulnerable to any factors that negatively impact populations, or connectivity among populations, including the projected reduction in habitat due to global climate change. Given current climate projections, it is possible populations could become smaller and more isolated, even further reducing the amount of genetic exchange (McKelvey et al. 2011, Inman et al. 2013). This likely will be less of a factor in terms of male dispersal, but could isolate core areas of habitat from female dispersal (Inman et al. 2013), and increase inbreeding potential. Small isolated populations also would be subject to high levels of demographic stochasticity. Given that wolverine populations in the U.S. appear to have reduced genetic diversity, any further reduction in connectivity could further impact the genetic integrity of the population. These are plausible scenarios and warrant careful consideration and evaluation moving forward. The lack of genetic data available for wolverines is highlighted in the SSA report, as well as the uncertainties associated with future climate change effects on population connectivity, although it could be beneficial to present these uncertainties together under either the **Biological Status** or the **Status-Future Conditions** sections.

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

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

The SSA report specifies the physical and ecological needs of wolverines to be 1) large territories in remote landscapes at high elevations, 2) access to a variety of seasonally variable food items, and 3) physical/structural features associated with denning. The report characterizes these needs relative to resiliency, redundancy, and representation of the species well, although below I emphasize a few areas where additional detail or clarification would be beneficial to the report.

In terms of resiliency, there is considerable uncertainty pertaining to many aspects of wolverine demography and population dynamics that require further data. However, as specified in the report, there is no information to suggest populations of wolverines in the U.S. are currently declining. The statement on page 93 that “population size, growth rate, and current population trends are unknown for wolverines...” would benefit from some clarification. Throughout the report there is reference to a population estimate of 318 individuals published by Inman et al. (2013), as well as statements indicating wolverine populations are neither increasing nor decreasing. Thus, there are population-level data available, but perhaps not at the spatial or temporal resolution needed. This should be clarified. This section on page 93 also would benefit from the acknowledgment that genetic diversity is undoubtedly an important attribute to the resiliency of wolverine populations, but it is currently unknown whether there are any impacts of loss of genetic diversity on wolverine populations in the U.S. Nearly a page of text (page 94) is devoted to highlighting aspects of adaptive responses of American pika to climate change effects. This information is relevant and valuable, but are there similar data available for other mustelids, such as marten or fisher that could be highlighted (e.g., Baltensperger et al. 2017, Zielinski et al. 2017)? The report also highlights several additional factors related to resiliency including viable population size and effects of climate change on wolverines through alteration of reproductive success or distribution. Few data are available to inform these aspects of resiliency, which is emphasized in the report.

In terms of redundancy the report states that wolverines are spread across a range of locations and habitats and thus are buffered from catastrophic events; populations in the U.S. also are connected to populations in Canada. However, it should be noted that future model projections suggest that although extensive contiguous areas of wolverine habitat are likely to persist in the next several decades, the available habitat could become more isolated, potentially subjecting smaller populations to increased demographic and genetic stochasticity (McKelvey et al. 2011, Inman et al. 2013). Thus, while the overall metapopulation could be robust to stochastic events, individual pockets of habitats containing wolverines could become increasingly vulnerable in the future. Such effects could be mitigated through active management such as population augmentation (i.e. translocations).

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

General Comments

In the SSA report the Western States Wolverine Conservation Project is referenced, as is the consideration of population augmentation through translocations. This study undoubtedly will produce a wealth of critical data to inform future management of this species. However, in general there does not seem to be any discussion to indicate under what scenarios future evidence could support further consideration of the listing of this species. This may not be appropriate for this report. But, if appropriate, such information could be valuable in providing benchmarks for future management action. For example, should evidence arise to suggest 1) wolverine populations are suffering from reduced genetic diversity, 2) wolverine reproduction is directly linked to available snow cover and individuals routinely exhibit reproductive failure in the absence of areas with sustained snowpack, 3) the U.S. population begins declining or retracting in range, or 4) that populations in the future could become sufficiently isolated to prevent the maintenance of a natural metapopulation structure, such data could provide sufficient evidence that additional action is needed to protect this species.

Minor Editorial Comments

Page v: under redundancy it is stated that “The wolverine occurs across the contiguous United States”. This should be reworded as the wolverine currently does not occur across the contiguous U.S. but rather is restricted to a handful of western states.

GLAC is not listed among the acronyms used.

Page 54: In the last paragraph it is stated that “...the **total** number of wolverine mortalities due to roads from 1972-2016...”. This should be changed to ...the **minimum** number of wolverine mortalities... as it cannot be certain that all road mortalities have been reported, which undoubtedly they haven't.

On page 91, add “in North America” after “The wolverine's current range”.

Literature Cited

- Baltensperger, A.P., J.M. Morton, and F. Huettmann. 2017. Expansion of American marten (*Martes americana*) distribution in response to climate and landscape change on the Kenai Peninsula, Alaska. *Journal of Mammalogy* 98:703-714.
- Copeland, J.P., K.S. McKelvey, K.B. Aubry, A. Landa, J. Persson, R.M. Inman, J. Krebs, E. Lofroth, H. Golden, J.R. Squires, A. Magoun, M.K. Schwartz, J. Wilmot, C.L. Copeland, R.E. Yates, I. Kojola, and R. May. 2010. The bioclimatic envelope of the wolverine (*Gulo gulo*): do climatic constraints limit its geographic distribution? *Canadian Journal of Zoology* 88:233–246.
- Ellis, M.M., J.S. Ivan, and M.K. Schwartz. 2013. 0. *Conservation Biology* 28:52-62.
- Inman, R.M., and M.L. Packila. 2015. Wolverine (*Gulo gulo*) food habits in Greater Yellowstone. *American Midland Naturalist* 173:156-161.

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

- Inman, R.M., A.J. Magoun, J. Persson, and J. Mattisson. 2012b. The wolverine's niche: linking reproductive chronology, caching, competition, and climate. *Journal of Mammalogy* 93(3):634–644.
- Inman, R.M., B.L. Brock, K.H. Inman, S.S. Sartious, 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 priorities for metapopulation conservation at the landscape scale: wolverines in the Western United States. *Biological Conservation* 166:276–286.
- Krebs, J., E. Lofroth, J. Copeland, V. Banci, D. Cooley, H. Golden, A. Magoun, R. Mulders, and B. Shults. 2004. Synthesis of survival rates and causes of mortality in North American wolverines. *Journal of Wildlife Management* 68(3):493–502.
- Magoun, A.J., M.D. Robards, M.L. Packila, and T.W. Glass. 2017. Detecting snow at the den-site scale in wolverine denning habitat. *Wildlife Society Bulletin* 41(2):381–387.
- McKelvey, K.S., J.P. Copeland, M.K. Schwartz, J.S. Littell, K.B. Aubry, J.R. Squires, S.A. Parks, M.M. Elsner, and G.S. Mauger. 2011. Climate change predicted to shift wolverine distributions, connectivity, and dispersal corridors. *Ecological Applications* 21(8):2882–2897.
- Rauset, G.R., J. Mattisson, H. Andren, G. Chapron, and J. Persson. 2013. When species' ranges meet: assessing differences in habitat selection between sympatric large carnivores. *Oecologia* 172:701–711.
- Saether, B.E., S. Engen, J. Persson, H. Broseth, A. Landa, and T. Willebrand. 2005. Management strategies for the wolverine in Scandinavia. *Journal of Wildlife Management* 69:1001–1014.
- Scrafford, M.A., T. Avgar, B. Abercrombie, J. Tigner, and M.S. Boyce. 2017. Wolverine habitat selection in response to anthropogenic disturbance in the western Canadian boreal forest. *Forest Ecology and Management*. 395: 27–36.
- Zielinski, W.J., J.M. Tucker, and K.M. Rennie. 2017. Niche overlap of competing carnivores across climatic gradients and the conservation implications of climate change at geographic range margins. *Biological Conservation* 209:533–545.