

Wolverine denning ecology and Ontario's "Forest Management Guide for Conserving Biodiversity at the Stand and Site Scales"



Photo: Liam Cowan

FAQ and Recommendations



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A wolverine den site in slash pile in Red Lake, Ontario. The wolverine's low reproductive potential and expansive space needs result in low population densities in all habitats. We have detected ≥ 53 wolverines in a 5,500 km² area in Red Lake between 2018 and 2022. Of these, only 18 are females, with about half at reproductive age when they were live trapped.

Photo: Jacob Seguin/WCS Canada

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WCS Canada has carried out extensive research on wolverines in Ontario, including a telemetry project for wolverines in Red Lake from 2003-2005, a survey of northern Ontario for wolverine tracks in the snow from 2003-2012 and a major GPS collaring project during which the WCS team tracked 53 wolverines with GPS collars and found 12 wolverine den sites. Above: Anna Machowicz and Jacob Seguin from the WCS wolverine team assess a wolverine near Red Lake, Ontario.

Photo: Matt Scrafford/WCS Canada

Summary of Recommendations

Recommendation #1: Monitor for female wolverine reuse of the denning area rather than the den site, allowing the female to use a different den site in subsequent denning periods but still show evidence of reuse of the larger area. This strategy also allows protections to stay in place if a different female reuses the denning area.

Recommendation #2: Human activity associated with finding a den site, as well as other natural factors, might negatively affect the likelihood of female reuse of the den site, furthering the need for monitoring wolverine reuse of the denning areas rather than den site.

Recommendation #3: Maintain a 4 km radius AOC around den sites and the AOC should be the spatial area to monitor for future wolverine reuse.

Recommendation #4: A run pole and camera should be set up within the AOC to document wolverine reuse.

Recommendation #5: Monitor the AOC for wolverine reuse over a five-year period.

Recommendation #6: Monitor the AOC for wolverine reuse from January through April.

Recommendation #7: There should be no commercial harvest within an AOC and an AOC should include a minimum-forested area of ~50 km² (roughly the area of a 4 km radius circle). Whenever possible, the AOC should be maintained as a 4 km circle to buffer the den site from edge effects associated with human disturbance.

Recommendation #8: There should be enhanced efforts to track cumulative disturbances at landscape scales, including the implementation and study of effective road decommissioning

Recommendation #9: Slash piles should be left in cutblocks to provide habitat for wolverines and other species, and be placed and created in a way that wolverines might find suitable.

Recommendation #10: Harvest timing restrictions are a poor tool to mitigate impacts to wolverine dens as any human development within the AOC is likely to have long-term negative effects on wolverine habitat quality. In some situations, timing restrictions can be used to remove previously cut wood on established roads.

Recommendation #11: If there are multiple den sites discovered within a single denning period within 4 km of each other, form an AOC based on a point equidistant between the den sites but use discretion to expand the AOC to include important landscape features. Maintain the same AOC if new den sites are found in subsequent years within the AOC, but create a new AOC if dens are found outside of the AOC.

Recommendation #12: Because den sites are almost impossible to identify without radio-collared animals, female wolverine habitat management should simply focus on protecting habitats where females are confirmed to be present.

Recommendation #13: Wolverine habitat is best managed at a landscape scale that matches wolverine space needs. The DCHS currently does a poor job in managing large roadless areas important to wolverines and caribou.

Recommendation #14: Other forms of human disturbance, not just forestry, should be mitigated within AOCs. Trap line owners should be informed of the location of the AOC and develop guidelines to reduce the incidental harvest of wolverines.



The entrance of a wolverine den located in a fallen tree in Red Lake, Ontario.

Photo: Matt Scrafford/WCS Canada



Wolverine F10 in Red Lake, Ontario.

Photo: Liam Cowan

BACKGROUND

Since the spring of 2018, WCS Canada has engaged with the Ministry of Environment and Climate Change (MECP) and Ministry of Northern Development, Mines, Natural Resources and Forestry (NDMNEF) and the forestry industry on habitat management associated with wolverine den sites¹ we have found over the course of our wolverine GPS collaring project in Red Lake, Ontario. A number of questions have repeatedly come up through these discussions about how our growing knowledge of wolverine denning ecology can inform current government policies. This document contains our responses to these frequently asked questions (FAQ) accompanied by recommendations. We intend for these comments to inform future den site management plans (DSMP), revisions to the “*Forest Management Guide for Conserving Biodiversity at the Stand and Site Scales*” (SSG), and the “*Boreal Landscape Guide*”.

We base our comments and recommendations on our collective knowledge of wolverine ecology acquired through both our field experiences and our understanding of the scientific literature. WCS Canada co-led a telemetry project for wolverines in Red Lake from 2003-2005 during which time a reproductive denning area² was found with multiple den sites (Dawson et al. 2010). WCS Canada also surveyed northern Ontario for wolverine tracks in the snow from 2003-2012 to better understand wolverine distribution in the province (Ray et al. 2018). The bulk of our insights come from two major GPS collaring projects led by Dr. Scrafford. The first project was in the lowland boreal forest of Rainbow Lake, Alberta from 2013-2016 during which time Dr. Scrafford (then a Ph.D. student) and his team tracked 45 wolverines with GPS collars and found five wolverine den sites. The second project was in Red Lake from 2018-2022 when Dr. Scrafford (as a scientist with WCS Canada) and his team tracked 53 wolverines with GPS collars and found 12 wolverine den sites (Scrafford et al. 2021; unpublished field data). Besides gaining insights into wolverine denning ecology through this field research, we also have gained additional knowledge on female wolverine abundance, movement, habitat use, sources of mortality and foraging.

Wolverine reproductive ecology

Wolverines have low reproductive potential compared to other large carnivores including grizzly bears, mountain lions and wolves (Weaver et al. 1996). Female wolverines will generally mate during the summer of their third year and deliver kits the following February or March. There is variability in how many kits females have each year and how many survive into adulthood, with age and food availability as contributing factors, but in general, females will give birth to one or two kits every other year from age three and begin senescence at age seven (Persson et al. 2006; Rauset et al. 2015). As a result, a female might only have two female kits in her lifetime (Weaver et al. 1996).

The wolverine’s low reproductive potential and expansive space needs result in low population densities in all habitats. We have detected approximately 53 wolverines in a 5,500 km² area in Red Lake between 2018 and 2022; of these, only 18 are females, with about half at reproductive age when they were live trapped. The low number of reproductive females and the unbalanced sex ratio means that protecting females and the habitats they use for reproduction is likely critical to the persistence of wolverine populations in the Red Lake area.

Wolverines spend time close to the den site from parturition through weaning. Females will use a single or multiple den sites within the denning period³ (Magoun and Copeland 1988) with movement between den sites likely dependent on security and conditions near or within the den site (Heeres 2021). Wolverine den

1 Den site = the actual structure that a wolverine is using to house the kits during the denning period

2 Denning area = the larger areas around a den site

3 Denning period = the period from kit birth (~February) to weaning (~ May)

sites provide kits with protection from both weather and predators and often include an earth structure (e.g., tree, rock) covered by snow or moss (Copeland et al. 2010). Wolverine den sites in Red Lake included downed trees with snow caves, snow tunnels, and root balls ($n=5$), rocky caves or cracks with snow tunnels and caves ($n=3$, including the den site found in the 2003-2005 study in Dawson et al. 2010), and forestry slash piles ($n=4$). Wolverine den sites in Rainbow Lake were found in downed trees with snow caves, excavated middens and root balls ($n=2$) as well as in a beaver lodge ($n=1$), log deck ($n=1$), and slash pile ($n=1$).

The larger landscapes where den sites are found are generally secure or isolated from human and predator activity (May et al. 2012) and might provide proximal foraging opportunities for small prey like snowshoe hare and grouse. Forestry does not promote high-quality denning habitat because associated road development increases the risk to wolverines from fur harvest, vehicle collisions and encounters with wolves – with roads decreasing wolverine survival long after the cutting is finished (Krebs et al. 2004; Perrson et al. 2009; Scrafford et al. 2017). Forestry also reduces wolverine habitat availability through clear cuts (Hornocker and Hash 1982; Krebs et al. 2007; Scrafford et al. 2017). As a result, high-quality wolverine habitat tends to be relatively intact, i.e., roadless or with few roads and other human developments (COSEWIC 2014).

Forestry also might reduce the availability of den sites because harvest activity results in a higher prevalence of younger forests at the landscape scale. The structures wolverines use for den sites – often over-turned trees with thick moss – are likely less prevalent in young and mature forests than in older post-succession forests. In today's landscapes, the latter are often only available in forestry buffers along lakes, streams and wetlands or within interior residual bypass from forest-harvest activities.

The SSG requires establishment of a 4 km Area of Concern (AOC) around known wolverine den sites to protect the den site and denning area from commercial forestry. The NDMNRF delineates the AOC and applies associated rules that limit human disturbance in a Den Site Management Plan (DSMP). The DSMP/AOC is in effect for 10 years unless the den site is unoccupied by a wolverine for more than three consecutive years. Below we discuss frequently asked questions (FAQs) related to wolverine AOCs and DSMPs, and associated management recommendations. While the policy context is particular to Ontario, many of the questions and our recommendations are relevant to wolverine management in boreal forests in general.

Frequently Asked Questions

1. Do wolverines reuse their den sites or denning areas?

Recommendation #1: Monitor for female wolverine reuse of the denning area rather than the den site, allowing the female to use a different den site in subsequent denning periods but still show evidence of reuse of the larger area. This strategy also allows protections to stay in place if a different female reuses the denning area.

It is largely unknown whether the same or different female wolverines reuse specific den sites (e.g., the same root ball). Part of this uncertainty stems from a lack of long-term monitoring of individual wolverines across multiple reproductive events – wolverine GPS collars need to be small so they often run out of battery within a year. Moreover, wolverines are adept at getting collars off because their neck and head are very similar in size. An older synthesis of North American studies (Magoun and Copeland 1998) documented one instance of the same female reusing a den site in three consecutive years, but all other females ($n=4$) used den sites that had not been previously documented.

Researchers in Scandinavia have collected some of the best data to address the question of wolverine reuse of den sites as well as larger denning areas. They count the number of active wolverine den sites on the landscape to estimate the minimum population of breeding females. Their monitoring program involves both aerial and ground surveys during the denning period where they revisit 500 m² denning areas where females have historically established den sites and look for new den sites (Saether et al. 2005). They report that breeding females reuse ~ 50% of 500 m² denning areas each year and they also find reuse of smaller 50 m² areas within the 500 m² denning areas. However, there is poor information available on whether the same den sites (e.g., rock structure) are reused within the 50 m² area and whether it is the same exact female that is using them (personal communication with John Linnell, Henrik Broseth, and Jenny Mattison, Norwegian Institute of Nature Research). For example, there is evidence that female offspring will use a portion of their mother's range as their own which might include denning areas (Aronsson and Persson 2018).

We have not monitored any wolverines in Red Lake or Rainbow Lake that have reused den sites. However, there is some evidence for reuse of denning areas. Wolverine F08 in Rainbow Lake had two den sites in two different years that were ~ 5 km apart. In Red Lake, F01 had three den sites in three different years that were 0.5 – 2 km apart and F05 had two den sites in two different years that were 1 – 3 km apart. Conversely, F07 had two den sites in two different years that were ~ 17 km apart. Within a denning period, F10 in 2022 had two den sites that were 1.2 km apart and F05 in 2022 had two den sites that were 1 km apart.

The SSG indicates that the den site is the value that requires a management plan and therefore the den site requires evidence of reuse by wolverines for continued protection. The SSG does not require verification that the same female that initially used the den site needs to continue using it for protections to stay in place. However, our summary of the available evidence suggests that wolverines more often reuse denning areas rather than specific den sites. Therefore, we suggest that denning areas instead of den sites be monitored for reuse by any female wolverine. If there is no ability to determine whether a wolverine reusing a denning area is a male or female, then protections should stay in place if any wolverine uses the denning area.

2. Does human activity at a den site affect its probability of reuse?

Recommendation #2: Human activity associated with finding a den site, as well as other natural factors, might negatively affect the likelihood of female reuse of the den site, furthering the need for monitoring wolverine reuse of the denning areas rather than den site.



Tracking a female wolverine in Red Lake, Ontario.
Photo: Matt Scrafford/WCS Canada

Most wolverine den sites in forested areas are found by tracking females on the ground to the den site to verify the type of structure used (e.g., tree root, rock) and whether there are kits inside. Our wolverine field data suggest that wolverines will sometimes move their den site within weeks after researchers approached the den site. Although human disturbance may have played a role, we also do not know the extent to which other factors, such as conditions within the den site, natural movement, or nearby predators were important (e.g., Heeres 2021). For example, we never visited F05's den site while she was actively using it, but her GPS data indicated she moved the den site two weeks after establishment, likely because warm temperatures rotted the snow she was using for structure.

As stated previously, there also is evidence from Norway that wolverines reuse 50 m² areas across years, regardless of whether researchers approached these areas, but we do not know the timeline of this reuse and whether it is the same female and structure. Ultimately, human disturbance likely affects the probability of detecting female reuse of a den site and provides further reason for the NDMNRF to monitor denning areas rather than specific den sites for reuse.

3. Is a 4 km radius circle the right size for an AOC?

Recommendation #3: Maintain a 4 km radius AOC around den sites and the AOC should be the spatial area to monitor for future wolverine reuse.

Within the DSMP, the AOC protects or buffers the den site from disturbances in the larger area. The NDMNRF's starting point for creating a wolverine AOC is to draw a 4 km radius circle around the den site. We suggest that a 4 km radius circle is a suitable distance to buffer den sites based on previously reported data on wolverine den placement relative to human disturbance. In alpine areas of Norway, den sites were 7.5 (SE = 0.5 km) from public roads and 1.4 (SE = 0.1 km) from smaller private roads (May et al. 2012). However, one needs to be cautious in interpreting these numbers because alpine areas where wolverines have den sites are often poor places to build roads, making it difficult to discern whether this is evidence of avoidance behaviour by the female or an artifact of road availability. In the lowland boreal forest of Alberta, where roads are much more abundant within wolverine habitats, den sites ($n = 5$) were 2.5 (SD = 1.7 km) from major roads (highways and all-season roads) and 0.9 (1.2 km) from smaller industrial roads. In Ontario, den sites ($n = 12$) were 4.8 (SD = 2.4 km) from major roads and 1.0 (1.2 km) from smaller industrial roads (averaging distance to road within and then between individuals).

In addition to safeguarding the den site, the AOC can provide protection for nearby areas the female uses for foraging and movement. The average euclidean distance a female moved (when she did leave the den

site and registered a GPS point) from her current or active den in Rainbow Lake was 3,618 (2,165 m) and in Red Lake was 4,391 (SD = 1,942 m). We created this average by averaging distance to den for each female's denning period and then averaging these values across females. These data further suggest a 4 km AOC would help protect important foraging and movement areas during denning.

The 4 km AOC radius also is important for protecting areas a female might move to establish den sites within or between years (data presented in FAQ #1).

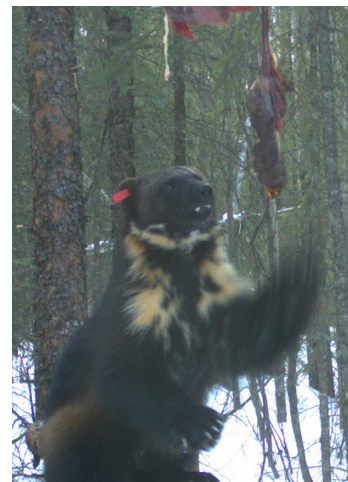
In summary, the available information supports the idea that a 4 km radius AOC would help to preserve the conditions that might have initially attracted a female to establish a den site in a specific area. We consider the AOC as a surrogate for the denning area and the spatial area to monitor for future reuse.

4. What are the best methods to monitor wolverine reuse of AOCs?

Recommendation #4: A run pole and camera should be set up within the AOC to document wolverine reuse.

Scientists use baited run poles to conduct non-invasive surveys for wolverine use of an area (Magoun et al. 2011) which could be set up within AOCs to document wolverine reuse. Run poles provide identification by sex or individual depending on field methods. We suspect that human activity associated with monitoring within the AOC will have minimal affect on female detection probability relative to human activity at den sites.

If the government decides to monitor the den site for reuse, we caution that cameras at den-site entrances will often provide a poor picture of the wolverine's chest pattern for individual identification. We also note that den sites often have multiple entrances that are not always apparent without wolverine tracks in the snow. Nonetheless, cameras will provide some evidence that a wolverine is reusing the den site. As mentioned in FAQ #2, field visits and cameras might affect the probability of detecting wolverine reuse at the den site.



Wolverine on a run pole in Rainbow Lake, Alberta. Photo: WCS Canada

5. Is three years enough time to document reuse of an AOC?

Recommendation #5: Monitor the AOC for wolverine reuse over a five-year period.

Wolverines generally give birth every other year after age three, although it can be variable depending on food availability and body condition (Persson et al. 2006). Therefore, if an AOC is monitored for three years after the initial den site is found, there might only be one opportunity (second year) for the resident female to have kits before the AOC is lifted.

We suggest that the appropriate duration for monitoring for wolverine reuse of the AOC should align with wolverine biology as well as land-management timelines. Although FMP plans cover a 10-year period, the audit and plan review cycle often occur at five-year intervals. Aligning AOC monitoring with the five-year FMP audit cycle offers more opportunity for the female to have kits again and might increase the likelihood that the government incorporates AOCs into FMPs and other landscape-level management programs such as the Dynamic Caribou Habitat Schedule.

6. When should monitoring of the AOC occur within each year?

Recommendation #6: Monitor the AOC for wolverine reuse from January through April.

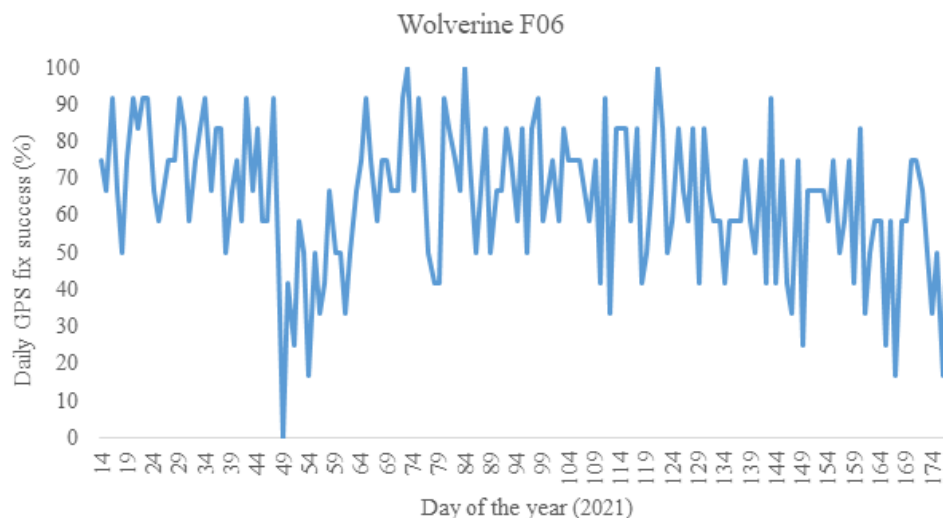


A wolverine leaving a den site in Red Lake, Ontario. Photo: WCS Canada

The most obvious time for monitoring of wolverine reuse of an AOC would be during the denning period (February-April). However, we caution that females spend time within and close to the den site after giving birth, which reduces their detection probability in the AOC. For example, the collar on wolverine F06 in Red Lake was often unable to acquire GPS fixes when she started denning (around the 49th day of the year) likely because she was in a den and the collar could not track satellites (Fig. 1). Therefore, detection probability will be low for females within AOCs during the denning period, and particularly during

the first one-third to one-half of the denning period when kits are small and require more care. We suggest that monitoring for reuse within the denning period should start before denning (January) while also leaving time for detection later in the denning period (late-March and April).

Figure 1. Daily GPS fix success (% of successful fixes out of 12 total attempts) throughout the year including the denning period.



7. Would changes to the shape of the AOC affect protection of the den?

Recommendation #7: There should be no commercial harvest within an AOC and an AOC should include a minimum-forested area of ~50 km² (roughly the area of a 4 km radius circle). Whenever possible, the AOC should be maintained as a 4 km circle to buffer the den site from edge effects associated with human disturbance.

There have been proposals by government and industry to reshape the AOC from a 4 km radius circle to an irregular polygon. This approach would exclude certain blocks from the AOC that are slated for harvest in work plans and substitute them with areas outside the AOC that do not need to be harvested soon. Our

experience suggests that allowing forest harvest within the AOC would reduce wolverine survival and habitat suitability and therefore we recommend the AOC remain a 4 km radius circle. The circle also separates the core of the denning area (e.g., the den site) from potential edge effects associated with new roads and other disturbances.

There might be AOCs that include large water bodies or mines that are not wolverine habitat, with these features potentially making up a large percentage of an AOC. Therefore, we suggest it is biologically justified that an AOC include a minimum-forested area (e.g., ~50 km² or roughly the area of a 4 km radius circle) that replaces non-wolverine habitat with habitats that might be more usable for the wolverine. The habitats added to an AOC to create the minimum-forested area should be contiguous with other habitats in the AOC and, if possible, include post-successional forests, roadless areas or areas with rocky features such as moraines that we believe are good denning habitat for females and which will provide females with foraging opportunities.

However, even if the original AOC meets the minimum-forested area, the government should include any contiguous areas that are of high value for a denning female.

8. Does forest harvest help wolverines by creating habitat for their prey?

Recommendation #8: There should be enhanced efforts to track cumulative disturbances at landscape scales, including the implementation and study of effective road decommissioning.

Wolverines are adapted to a landscape shaped by disturbances including wind events, fires, and disease. The resulting landscape mosaic provides habitats of different age and composition for their primary prey including snowshoe hare, grouse, moose, caribou and beavers. Hypothetically, the addition of forestry and mining to landscapes could act as another source of disturbance that the prey of wolverines, and therefore wolverines, could benefit from. For example, there is some evidence that wolverines will use the edges of cutblocks and seismic lines for hunting small prey such as grouse and snowshoe hare (Scrafford et al. 2017; Kortello et al. 2019). Early-seral vegetation might increase moose populations that serve as an important food source for wolverines. Although forest management plans in Ontario have been designed with the premise that harvest patterns emulate natural disturbance patterns, forestry leaves roads that enhance human access thereby increasing mortality risk for wolverines long after the initial cutting (e.g., Golden et al. 2007; Kukka 2017). Moreover, wolves proliferate in managed forests where ungulate populations increase with abundant food via early-seral vegetation (Bowman et al. 2010). More wolves, and roads they can travel on, will increase wolf interactions with wolverines and increase mortality risk (e.g., White et al. 2002; Scrafford et al. 2017).

At present, there are no credible mechanisms available to forest managers in Ontario that mitigate the effects (e.g., off-road vehicle use, predator use) of roads on sensitive wildlife in the short or medium term; effectiveness of standard decommissioning practices have not been adequately studied (Hall et al. 2016), and the little monitoring that has taken place indicates that the positive ecological effects of decommissioning do not compensate for habitat loss and other post-harvest risk factors.

Finally, disturbances on the landscape accumulate to high levels when forestry and mining add to the impacts of other natural landscape disturbances. Habitat changes from climate change, for example with increased fire frequency or severity (Flannigan et al. 2013), are likely to further increase cumulative landscape disturbance in the future. Therefore, the addition of forest harvest is likely of little net benefit to wolverines under current circumstances.

9. Can slash piles provide wolverine den sites?

Recommendation #9: Slash piles should be left in cutblocks to provide habitat for wolverines and other species, and be placed and created in a way that wolverines might find suitable.

Wolverine den sites in natural habitats require an earth structure such as boulders, trees, or soil with snow providing additional structure (e.g., snow caves) and thermal cover. Generally, the wolverine accesses the earth structure through snow tunnels and there are often multiple access holes. Slash piles left after forestry activity provide excellent structure and it is not surprising that wolverines have used them as den sites both in Rainbow Lake and Red Lake. In particular, slash piles with some larger logs provide open pockets that the wolverine can use for denning



Wolverine den in a log deck/slash pile in Rainbow Lake, Alberta. Photo: Matt Scrafford

although they likely create their own space in these piles with digging and chewing as well. It is important to note that the evidence we have seen is that wolverines are generally using slash piles that are near regenerating roads and in regenerating cutblocks harvested decades ago, and that they are not using newer slash piles in fresh clear cuts along active or newer roads.

Forestry could create wolverine den sites by leaving slash piles in cutblocks during cutblock regeneration or when an area lacks large trees and blowdown for natural structures such as root balls and middens. We suggest leaving at least one slash pile per 500 ha of harvested area. For these slash piles to be suitable to the wolverine, we suggest the following guidelines for slash pile placement based on those we have observed in the field. Slash piles should:

- Be located at the edge of cutblocks in close proximity to mature forest that is not scheduled for harvest;
- Contain small and large unmerchantable logs and tree tops, which will provide both insulation and open space within the pile;
- Be located in a well-drained area (e.g., avoid pooling of water within and around slash pile); and
- Be located along roads that are scheduled for decommissioning.

It is important to stress that slash piles are only part of the answer and should not be considered a replacement for secure and natural denning areas. Forestry activities leave roads and degraded habitats that will remain on the landscape long after harvest is finished. Our observations indicate that slash piles left after logging cannot make up for negative effects of forestry activities, such as increased access into wolverine habitats and reduced wolverine habitat suitability.

10. Can timing restrictions lessen the negative effects of forestry on wolverines?

Recommendation #10: Harvest timing restrictions are a poor tool to mitigate impacts to wolverine dens as any human development within the AOC is likely to have long-term negative effects on wolverine habitat quality. In some situations, timing restrictions can be used to remove previously cut wood on established roads.

Timing restrictions are used to reduce human disturbance during periods when wildlife are most sensitive. Accordingly, it has been suggested that harvest can take place in a wolverine AOC during the summer when females are not at their den sites. Although this strategy might lessen the immediate effects of forestry during the winter and spring denning period, forestry activity in the AOC in the summer could negatively affect the ability of females to care for kits during the summer. We caution that there is currently poor information on the habitat needs of females when they are caring for mobile kits during the summer months and the relative importance of denning areas that are often in the core of the female's range.

We are also aware of proposals to allow harvest within the AOC the year after the female had kits because females often have kits every other year, suggesting the AOC will be unused by the female the following year. Although this reproductive pattern mostly conforms with available evidence, there are exceptions. During the prime years of a female's life she might have kits every single year - especially if surrounding habitat is of good quality (Rauset et al. 2015). Regardless, commercial forestry has negative effects that last long after cutting has concluded and which will affect her reuse of the AOC. Therefore, we advise against allowing harvest within AOCs.

The SSG does accommodate prohibited activities to occur within an AOC under "extraordinary circumstances". For example, we suggest it may be relatively low risk to allow hauling or chipping to occur in the AOC outside of the denning period so that wood cut prior to establishment of the AOC can be used. Hauling should only be allowed on roads that were established before the creation of the AOC.

Previously harvested wood can sometimes only be accessible by winter roads during winter and early spring. We suggest a winter road within an AOC could be used to extract previously harvested wood products if there are no other alternatives, but efforts should be made to extract the wood outside of the denning period (e.g., December). In these circumstances, there should be efforts to reduce driving speeds to 30 kmh within the AOC to lessen the risk of collisions with the female.

11. How can an AOC approach be implemented when multiple den sites are found in close proximity from a single female within a year or between years?

Recommendation #11: If there are multiple den sites discovered within a single denning period within 4 km of each other, form an AOC based on a point equidistant between the den sites but use discretion to expand the AOC to include important landscape features. Maintain the same AOC if new den sites are found in subsequent years within the AOC, but create a new AOC if dens are found outside of the AOC.

As stated previously, wolverines have multiple den sites they might use within a single denning period (Maggoun and Copeland 1998). Wolverines also might shift dens if they are disturbed by humans, disturbed by predators or if conditions within the den deteriorate.

There is no guidance within the SSG to deal with multiple den sites within an AOC during a denning period

or in subsequent denning periods. The enlargement of AOCs to accommodate new dens could make forest management planning difficult.

If multiple dens are found within an AOC within a denning period, and they are within close proximity (e.g., < 4 km), we suggest that a single AOC be established based on the centroid of known den sites. However, there should be efforts to expand this AOC beyond the minimum-forested area to include any contiguous habitats that are likely important to female denning (e.g., moraine, post-successional forest where structures are more available).

If a new den site is found outside of an AOC then a new AOC should be established.

12. Can wolverine dens be accurately identified outside of telemetry studies?

Recommendation #12: Because den sites are almost impossible to identify without radio-collared animals, female wolverine habitat management should simply focus on protecting habitats where females are confirmed to be present.

Telemetry, often with GPS and VHF, is the only method that allows researchers to track wolverine movements at a fine scale over a relatively long-time period. This method has produced the location of all the known wolverine dens in Ontario. When the wolverine's behaviour indicates it might be denning (e.g., missed GPS fixes and satellite uploads during the denning period because the wolverine is in a structure) researchers can use VHF to track the wolverine on the ground or in the air to identify a den site. A detailed look at the site is needed to discern between foraging and reproductive dens. Cameras can then be set up to monitor the movements of females and their kits. Although these procedures are invasive, there are no other ways to provide reliable information on the denning ecology of female wolverines.

Because telemetry studies are rare, the SSG relies on NDMNRF personnel to map or identify wolverine den sites for integration into a FMP. Finding den sites is difficult because of the scale over which searches need to take place and the low detection probability. For example, it is impossible to know whether tracks observed during an aerial survey are from a male or female wolverine, or whether a cluster of tracks is associated with a den site or foraging area. Moreover, ground surveys for wolverine den sites are unfeasible across large scales.

Likely the most practical survey option in Ontario is to simply look for evidence of female wolverines where a project is proposed through a grid of motion-sensor cameras and run poles set carefully to enable identification of individuals, including potentially lactating females (Magoun et al. 2011). If female ranges are identified through this work, there should be efforts to reduce habitat disturbance, namely road building, within these ranges. This would take the emphasis of monitoring away from the den sites and focus it instead on identifying female ranges and potential denning areas within. There should be field studies to better develop these methods.

13. Is the site scale the right scale for wolverine management?

Recommendation #13: Wolverine habitat is best managed at a landscape scale that matches wolverine space needs. The DCHS currently does a poor job in managing large roadless areas important to wolverines and caribou.

Although we understand that it simplifies management options for the SSG to focus on the protection of individual known den sites, this strategy provides limited benefit to the wolverine population. Similar to many wide-ranging species that are sensitive to disturbance, broader landscape conditions are likely more important factors affecting the persistence of wolverine populations than protection of individual features.

The SSG states that “The landscape-scale approach to the management of woodland caribou habitat is expected to maintain large blocks of unharvested and road less habitat suitable for wolverines”, but the Landscape Guide does not, in turn, explicitly address, or even mention, wolverines. We agree that large roadless blocks of habitat will benefit wolverines by reducing human-caused mortality risk and improving habitat suitability. Evidence suggests that availability of refugia is an important aspect of wolverine conservation in managed landscapes (COSEWIC 2014). Moreover, older or post-successional forests are most likely to provide forest conditions that provide suitable den sites such as root balls. However, there is no evidence that landscape-level planning for caribou, such as the Dynamic Caribou Habitat Schedule (DCHS), has retained large roadless areas in managed forests in Ontario. The lack of effective road decommissioning and rehabilitation and revegetation of roads following harvest in DCHS blocks (and local interest in maintaining primary road access) has likely compromised overall habitat quality for wolverines and caribou in the region. Although the DCHS does quantify landscape disturbance within blocks and is intended to support the maintenance of forest structure and composition within bounds of natural variation, it does not address risk and uncertainty associated with indicators managed near or exceeding their upper or lower limits. Therefore, there are some scenarios where large landscape patches supported in the LTMD and documented in the 10-year plan may be highly vulnerable to wildfire, other natural disturbances, and mining.

With climate change increasing fire severity and size, and with mining claims expanding throughout the boreal forest, there is increasing risk that failing to manage cumulative disturbance on the landscape will further compromise caribou and wolverine habitat quality.

14. Should other forms of human disturbance be mitigated for within AOCs?

Recommendation #14: Other forms of human disturbance, not just forestry, should be mitigated within AOCs. Trap line owners should be informed of the location of the AOC and develop guidelines to reduce the incidental harvest of wolverines.

The NDMNRF enacts the DSMP through FMPs and therefore only mitigates for the potential effects of commercial forestry activity on wolverines. But there are numerous other sources of disturbance on Crown Land that could affect AOCs. Mining activity, for example, involves both road building and maintenance activity which presents similar risks as forestry to wolverines. We suggest that all forms of human disturbance be managed with AOCs.

Fur harvest is another activity that will affect females within AOCs but is not accounted for within DSMPs. Although there is no commercial harvest of wolverines allowed in Ontario, trappers incidentally harvest

wolverines when targeting other species. Because wolverines travel across a large space, often across multiple registered trap lines, eliminating trapping within an AOC does not fully protect wolverines. But it would be worthwhile for local districts to reach out to local trappers to notify them of the location of the AOC and provide guidance on best practices to reduce the incidental harvest of wolverines (Ontario Fur Managers Federation 2016).

Conclusion

The habitat needs of wolverines in managed boreal landscapes could be regarded as relatively simple: they require large roadless areas with limited human-caused mortality and patches of mature forest for denning. Wolverines are unable to withstand high levels of mortality because of their low reproductive potential. This is especially true in Red Lake and likely throughout other areas of commercial forest harvest in Ontario where females comprise a very small proportion of the population. Altering AOC protections, the only habitat protections targeted specifically at wolverines in Ontario, to allow for harvest will only further reduce wolverine habitat quality with impacts to wolverine populations. Therefore, AOCs should be maintained and monitored in a way that confers at least some habitat protection to individual wolverines.

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