Forest Management Considerations for Wolverine Populations in Areas of Timber Harvest in Ontario

Preliminary Recommendations

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NOTE: These preliminary recommendations have been prepared in fulfillment of reporting obligations to the Living Legacy Trust Fund for Project 08-024 titled *Boreal Wolverine: a Focal Species for Land Use Planning in Ontario's Northern Boreal Forest*. A final report on the initial project was submitted to the Trust in May 2004 and the report is archived at the Living Legacy Trust Document Repository at Lakehead University. An electronic copy of the final report is available at the following website: http://www.wolverinefoundation.org/research/Ontario%20Wolverine%20Project%20Report_July_04.pdf.

Complete analysis of data collected as part of the Boreal Wolverine Project is ongoing, and future projects to investigate habitat use in Ontario are in preparation. The following recommendations are preliminary in nature, realizing our incomplete knowledge concerning wolverines in Ontario and using the best available information from Ontario and other jurisdictions. These recommendations will be forwarded to the Ontario Ministry of Natural Resources (OMNR) Forest Management Planning Section for consideration in planning activities and current/future development of Landscape, Stand, and Site Guides We will submit an update to this set of guidelines upon completion of fieldwork scheduled for winter 2005.

Background

Wolverines are considered a Threatened species in Ontario. Nationally, the western population (which includes Ontario) is classified as Special Concern because wolverines have relatively large home ranges, low reproductive rates, intrinsically low population resilience, and are vulnerable to human disturbance (Weaver *et al*. 1996, Banci & Proulx 1999, Persson 2003).

Despite recent increases in research effort, our knowledge of wolverine habitat requirements remains incomplete and variable across the animal's range but particularly where wolverines occupy lowland boreal forest. Wolverines occur in tundra, alpine, subalpine, and boreal forest ecosystems. Even within Ontario, wolverines occupy different habitat types including tundra and boreal forest. The range in habitat types utilized by wolverines suggests that the species is adaptable to a broad range of ecological conditions within northern ecosystems. However, the one characteristic that

spans the range of ecotypes occupied by wolverines is the remoteness of habitats occupied by viable populations. Perhaps the best general description of wolverine habitat was provided by Kelsall (1982): “Habitat is probably best defined in terms of adequate year-round food supplies in large, sparsely inhabited wilderness areas, rather than in terms of particular types of topography or plant assemblages.” This apparent requirement for remote, sparsely inhabited ecosystems is thought to explain the disappearance of wolverines from a number of formerly occupied habitats (Banci 1994), including the Great Lakes region of Ontario and Minnesota, where wolverines once regularly occurred but were extirpated by 1900 (De Vos 1964). The conversion of suitable habitat to agricultural land and expanding road networks and human settlements that fragment remaining forested areas have undoubtedly contributed to the disappearance of wolverines from the region. However, despite general agreement that wolverines are susceptible to human encroachment into wilderness areas, there has been little research on determining the threshold at which human activities begin to impact wolverine population viability, and there is almost no published research on the effects of logging on wolverine habitat suitability (although comprehensive studies have recently been completed in British Columbia). The Ontario Boreal Wolverine Project -- the first field study of wolverine ecology in lowland boreal forest -- was designed, in part, to address the lack of knowledge concerning wolverine habitat requirements in Ontario and related management concerns regarding resource development, particularly forestry-related activities.

This report begins with a summary of ecological characteristics of wolverines that are the most relevant for consideration in the formulation of forest management guidelines, as gleaned from the direct results of the Ontario Boreal Wolverine Project, and supplemented by the published literature. This section is followed by a set of preliminary recommendations for the maintenance of wolverine populations in managed forest habitats in northern Ontario.

Home Range Size

Using ARGOS satellite and VHF collars on seven wolverines, we determined that wolverines are resident in the study area near Red Lake, Ontario and that denning occurs there. Home range size for radio-tagged wolverines in the study area were within the range of, or somewhat larger than, the sizes reported in the literature for wolverines in other habitat types. Winter home range size averaged 1,450 km^2 for males (n=3) and 525 km^2 for females (n=4). As in other studies, the winter home range of the denning female was the smallest (353.1 km^2), while that of a subadult male was the largest (3,815.1 km^2). Daily movements of the wolverines were also similar to that reported in the literature from other studies. Males moved an average of 13.8 km per day, with a maximum daily movement of 53 km, while females moved an average of 7.3 km per day with a maximum of 28 km. Wolverines sometimes make exploratory movements outside their normal home ranges; this is particularly the case for subadult animals prior to dispersal from the areas where they were born (Vangen *et al*. 2001) and resident animals when food resources are scarce (Magoun 1985). Dispersing wolverines can move over very

large areas and may remain essentially nomadic for a number of years (Inman *et al*. 2004).

Use of Logged and Burned Habitats

Home range polygons of the wolverines in the Ontario study area encompassed both logged and unlogged areas. Nearly all (~ 95%) of the VHF locations were in mature stands of trees or other unlogged habitat types, including about 15% that were in regenerating burns (although most of the latter belonged to one yearling female, 62% of whose home range was situated within a very large 1986 burn). Only one VHF tracking observation occurred inside a cutblock and in that case the wolverine was located in a residual patch of trees the day after it was captured, collared, and released. The percentage of total winter home range harvested for timber between 1990 and 2003 for radio-tagged wolverines averaged 8.0% (range 3.4 – 16.0%, n=6). Road density, as expressed by km of road per square kilometer of total home range area, averaged 0.399 km/ km^2 (range 0.057 – 0.968, n=6). The road density within the home range of female F02 (0.968 km/ km^2) was twice that of any other wolverine. F02 was killed in a trapper's otter set one month after she was radio-tagged. Excluding F02, the road density averaged 0.284 km/ km^2 within total winter home ranges. A further analysis of habitat use by wolverines in the Boreal Wolverine Project is ongoing and will be supplemented with data collected in winter 2005.

There are very little published data on the relationship between wolverines and logged landscapes and the factors that influence this relationship. Hornocker and Hash (1981) reported that no radiocollared wolverines were relocated in clearcuts (age 0 to 15 years) of any size in Montana, however, tracks were occasionally observed crossing clearcuts. In their study, 70% of all relocations of collared wolverines occurred within large areas of medium density or scattered timber, while areas of young, dense timber were used least, and wolverines were rarely located in burned over or wet meadow areas (Hornocker & Hash 1981). In the northern Columbia Mountains of British Columbia, wolverines often avoided cutblocks less than 25 years old (J. A. Krebs, personal communication *in* Weir 2004).

Wolverines do not, however, avoid open areas in all instances. For example, Idaho wolverines commonly crossed natural openings and areas with sparse overstory such as burned areas, meadows, or open mountaintops (Copeland 1996). In northwestern Alaska, wolverines maintained home ranges in tundra habitat where trees do not occur (Magoun 1985). In the Ontario study area, although wolverine tracks were not commonly found in recent cutblocks, wolverine tracks were frequently seen on frozen lakes in winter, but the tracks were almost always near cover at lake edges. Differences in the use of open areas by wolverines may be linked to the density of predators in the area; wolves did not occur in the Idaho study area or in winter in the northwestern Alaska study area. Wolves are known to kill wolverines, and females with young kits are particularly vulnerable to predators (White *et al*. 2002; Magoun and Copeland 1998; Magoun, unpublished data). Wolves may have been responsible for the death of one of the radiocollared female wolverines and her offspring in the Ontario study area (Magoun, personal observation).

In the boreal forest, avoidance of open areas could also be related to unfavorable snow conditions for traveling or the distribution of food resources.

We are currently unable to evaluate the extent to which failure to locate wolverines in cutblocks using telemetry technology is attributable to the temporal characteristics of data collection using both ARGOS satellite and VHF transmitters. Satellite data is only available when satellites pass over the region of interest, and in the case of the Ontario study, this meant that data collection was limited to daylight hours. Also, radiotracking of VHF signals could only be done when it was light enough to use tracking aircraft. We are currently exploring GPS technology, which could provide locations throughout the day, and has been used successfully on at least one wolverine (Inman *et al*. 2004), and is currently being tested in at least two other studies (in Alaska – H. Golden, personal communication, and in Montana – J. Copeland, personal communication).

We carried out preliminary aerial track surveys to determine the feasibility of using track surveys to examine the distribution and relative abundance of wolverines in relation to logging in northwestern Ontario. This technique documents wolverine tracks regardless of the time of day in which the animal was active and can be used to study habitat use at the landscape scale. During winter 2004, wolverine tracks were most commonly encountered in Woodland Caribou Provincial Park in the northwest quadrant of the study area and in the northeast quadrant of the study area where there is currently no logging activity. While tracks also occurred within active forest management units that were adjacent to unlogged habitat, no tracks were detected in the southern portion of the study area where logging is more extensive and road density is highest.

The pattern of wolverine track distribution in these preliminary surveys suggests that although wolverines use logged landscapes, there may be a threshold of logging intensity and/or road density at which suitability of boreal forest as wolverine habitat declines precipitously. It also provides preliminary support for the premise that wolverine populations require refugia free from human disturbance to ensure their persistence. Lofroth (2001) noted that in highly modified habitats in northcentral British Columbia, human activity (e.g., log hauling, logging, mining) may alter movement paths of wolverines. Austin *et al*. (2000) noted that transportation corridors can alter or interrupt daily movements, and Krebs & Lewis (2000) documented mortalities by vehicles in these corridors. In preparation for the new field season beginning in January 2005, we have expanded our study area to the north (unlogged), south (intensively logged), and east (minimally logged). We will carry out more intensive aerial track surveys for a broader area that encompasses a wide gradient of human disturbance to investigate whether the pattern of wolverine track distribution is related to the density of roads and the distribution and disturbance levels of forest habitat produced by logging activities.

Wolverine Den Sites

Wolverine dens are of two types: *natal dens* are used during parturition (mid-February to mid-March) and *maternal dens* are used subsequent to natal dens and before weaning (mid-March to end of April) (Magoun & Copeland 1998). Wolverines also use sheltered

areas as rendezvous sites after the kits are weaned but while the kits are too young to travel with their mothers. Magoun and Copeland (1998) summarized available information on wolverine dens (all den types) from around the world and noted the following types of den sites:

- ravines or drainages where snow accumulates
- snow-covered rocky scree or boulder talus
- snow-covered fallen trees, usually near timberline
- taiga peat bogs with rocky areas or fallen trees, and
- birch (*Betula spp.*) woodland areas near fells or alpine areas

The first wolverine natal den in lowland boreal forest was located in the Trout Lake Forest near Red Lake, Ontario in March 2004. The female was captured and collared on March 23, 2004 and used the den site until mid-May, 2004 before shifting activity southwest and then returning to the vicinity of the denning area in mid-June when she was killed by a predator. Three different structures were used at this den site, all located within approximately 300 m of each other on a hill in second growth timber (spruce, jack pine, and aspen) of medium age. One structure consisted of a mass of large boulders in a formation approximately 60 meters long and 30 m deep. The largest boulder was about 4 m in diameter; there were many cavities under the jumble of boulders. Another structure consisted of fallen trees covered with snow, near the top of the hill at the edge of a small opening in the forest. The third site was in a dense stand of trees and was probably under fallen trees, but, unlike the other two structures, this one was not visible from the air; only the boulder area was visited on the ground. The den site was 7 km from the closest forestry road and recently harvested cutovers and approximately 10 km from active logging. This female's core home range (50% MCP) was 21 km^2 in size and had a zero road density within that core area.

Refugia from active logging and mining, trapping, and human recreational activities may be necessary to provide denning and kit rearing opportunities for wolverines in Ontario's forested regions. Magoun and Copeland (1998) suggested that wolverines select den sites, in part, to avoid humans and predators during the denning and kit-rearing period. Protection of natal denning habitat from human disturbance just prior to and during denning is likely to be critical for the persistence of wolverine in disturbed landscapes. Idaho wolverines selected specific natal and kit rearing habitat and responded negatively to human disturbance near these sites, particularly at maternal den sites (Copeland 1996; Magoun and Copeland 1998). Maternal den sites and rendezvous sites where kits are left while their mothers are foraging have been identified in boulders, under masses of trees blown down by wind or toppled by avalanches, or in other sheltered areas that provide protection from predators. Kits may be left at these sites from the time they leave their natal or maternal dens in early May until they begin to regularly travel with their mothers in late June (Magoun 1985).

Food Habits

In most areas where they have been studied, wolverines are obligate scavengers of ungulate carcasses in winter (Magoun 1985, 1987, Banci 1994), although they

occasionally prey on ungulates themselves and have been known to kill Dall sheep (Gill 1978), caribou (Lofroth *et al*. 2000), and even moose (Haglund 1974). Ungulates available in our study area included moose, woodland caribou, and a small number of white-tailed deer. In summer, the wolverine diet is more varied and predation on small mammals provides an important food resource for rearing young (Magoun 1987, Landa *et al*. 1997). In the boreal forest of Ontario, beaver may be more important in the wolverine's diet than has been previously reported in other wolverine studies (Banci 1994). In winter we radiotracked both male and female wolverines to beaver flowages where tracks and blood in the snow indicated that they had captured and fed on beavers, apparently after the beaver were taken from beaver houses. It appeared the wolverines were able to dig or chew a hole in the side of the beaver house to gain entrance into the house (alternatively, beavers may have chewed out of the houses because of unfavorable ice conditions that blocked the underwater entrance). Trappers in the Red Lake/Ear Falls area (Dawson 2000) and trappers and elders from northern Ontario First Nations communities routinely report similar observations (Ray *et al*. in prep). It is likely that beaver also provide food in summer for wolverines when the beaver leave the safety of the water to access food resources, sometimes at some distance from water. More information is needed on the importance of beaver in the diet of wolverines in Ontario and the method by which wolverines prey on beavers.

Predators that might provide carcasses of both large and small prey for wolverines in the Ontario's boreal forest include wolves, black bears, lynx, coyotes, and red fox, all of which also compete with wolverines for prey and carrion. Wolves probably provide the highest amount of carrion for scavengers, but they also scavenge on ungulate carcasses and are known to prey on wolverines, possibly outweighing the benefit they provide, being the major large ungulate predator in the region. Where logging increases habitat availability for moose and deer, wolf numbers tend to increase. It is not clear whether the increase in the number of wolves in an area benefits wolverine populations. Wolverine populations may be more successful in habitat that supports woodland caribou and relatively low wolf numbers. Logging may increase total biomass of large ungulates and early successional species such as snowshoe hare and beaver that can provide food for wolverines, but at the same time, other scavengers and predators may also increase, compromising the net benefit to wolverines. The extent to which wolverines are able to take advantage of increased prey in logged habitats may be dictated by the availability of neighboring forest blocks that are both relatively undeveloped and contain lower wolf densities. Further information on wolverine food habits and distribution and movements relative to wolf packs in logged and unlogged landscapes would help to determine how logging affects food resources for wolverines in this habitat type.

Wolverine Population Viability

It appears that wolverine numbers may have increased in northern Ontario in recent years, particularly in the northwestern portion of the province. During the Boreal Wolverine Project, we interviewed trappers in northern communities and most trappers reported that wolverine numbers are higher now than they have been in recent decades. Our aerial surveys detected wolverine tracks in most areas in the western portion of

northern Ontario, and we also found tracks further east than we expected based on old distribution maps and trapping records. An increase in reports of trapline damage by wolverine in our study area and incidental captures in sets made for other species also support the general consensus that wolverine numbers have increased in forested areas of Ontario in recent years. Reasons for the apparent increase in wolverines are not known, but could include increases in food resources and/or decreases in trapping pressure. It will take time to determine whether the increase is a natural, short-term spike in population numbers due to a temporary abundance of food resources or a long-term increase in population size caused by ecological factors that will persist into the future. Increases in logging over large areas of boreal forest can affect wolverine population dynamics whether population changes are caused by changes in food abundance or changes in trapping pressure, because logging has the potential to significantly change abundance, distribution, and types of food resources and to increase access for trappers into previously untrapped areas. Until we understand more about the factors that affect wolverine population dynamics in Ontario, we are unable to determine if logging, as it occurs now in northern Ontario, has a net beneficial or detrimental effect on wolverine populations and at what scales or in what ways forest management can mitigate for negative effects of logging.

We do know that wolverines are currently present in logged landscapes in northern Ontario, but the intensity of logging, the density of roads, and extent of neighboring refugia, or undeveloped areas, may be the key factors that determine whether wolverines will persist in these landscapes. Wolverine populations have been shown to have relatively low reproductive potential (Magoun 1985, Copeland 1996, Persson 2003). Research indicates that females do not often produce litters successfully until they are an average of 3.4 years old, litter size is usually only 2 or 3 young, and surviving young are usually fewer by the time the kits are weaned; reproductive females often skip a year between litters if food resources are not abundant. Factors that both decrease food resources and increase mortality over extended periods will negatively affect wolverine population viability. Anthropogenic landscape-scale changes that negatively affect wolverine birth and survival rates may require protected areas or refugia from these human disturbances to ensure continued viability of wolverine populations in the region (Magoun and Copeland 1998). Persson (2003) concluded that in Scandinavia wolverine populations must have at least 46 sexually mature females to maintain the population without immigration from other areas. Refugia that contain a viable wolverine population can provide dispersers that help maintain populations in areas that would not otherwise be able to support wolverines over the long term.

Preliminary Forest Management Recommendations

The objective of planning for forest landscapes that ensure permanent range occupancy by wolverines is to supply suitable, year-round habitat, distributed both geographically and temporally across the landscape, where the density of roads is minimized as much as possible. Depending on the scale and intensity of logging activity, it may also be necessary to plan a system of large, interconnected refugia (unroaded forest blocks) to maintain wolverine populations within logged landscapes. Suitable, year-round habitat

must include winter and summer food resources and adequate protection from predators, including protection from overharvest by trappers. The following recommendations are based on the wolverine literature, Ontario study results, and recently published recommendations for wolverine management in British Columbia (Weir 2004).

Landscape-Scale Recommendations

A) ***Establishing refugia from resource development is probably the single most important landscape planning mechanism for the conservation of wolverine populations, particularly in regions where trapping of furbearers is permitted. Refugia should be designed using suitable portions of the landscape in conjunction with protected areas and "no-trapping" areas that are determined in consultations between government and stakeholders, and as part of a recovery planning process***.

Large blocks of inaccessible and undeveloped northern wilderness contribute to the continued existence of wolverine populations in North America. When habitat is fragmented by resource development, roads, and human settlements, wolverines disappear from the landscape; such is the case in Colorado, northern California, Minnesota, and the Great Lakes region of Ontario where historic records indicate that wolverines were once more common (K. Aubry, personal communication). In these regions, inaccessible wilderness areas were not large enough to maintain wolverine populations through the early 1900s when trapping and predator control were at their peak and habitat was being fragmented by human settlements. Today, the occasional dispersal of wolverines into these areas from distant refugia is not adequate to maintain viable populations, even when trapping of wolverines is curtailed. When resource development and road-building are planned for wilderness areas where wolverines occur, a combination of limiting human access and controlling wolverine harvest is essential for ensuring range occupancy by wolverines in the long-term.

Refugia must be large enough (i.e., at the scale appropriate to wolverine home range size and habitat requirements) to maintain viable populations or they must be planned in conjunction with protected areas and "no-trapping" zones, with effective dispersal corridors linking the reserve areas. Given the very limited information on wolverines in Ontario, we estimate that at least 20,000 km^2 of suitable habitat would be necessary to maintain wolverines in the area without immigration, assuming 1) the minimum number of reproductive-age females needed for a viable population is 46 (Persson 2003), 2) the average home range size for reproductive females in Ontario is 400 km^2, and 3) the home ranges of these females are contiguous. It should be noted that the assumption that home ranges of reproductive-age females are contiguous is probably unrealistic because required habitat components are probably not distributed evenly in wolverine habitat; therefore, refugia larger than 20,000 km^2 might be necessary for population viability in northern Ontario, if immigration from other regions is insufficient to maintain populations. Whether or not protected areas smaller than 20,000 km^2 could help maintain wolverine populations in a region depends upon the amount, proximity, and productivity of other wolverine habitat in the region and the ability of wolverines to disperse throughout the area without suffering high mortality. Our preliminary research suggests

that logged forest landscapes can contribute to the total amount of wolverine habitat available in a region depending on road density, the intensity of logging, the amount of adjacent undisturbed habitat, and limitations on wolverine trapping in roaded areas.

B) ***Plan forest development to occur in larger blocks as opposed to many small dispersed blocks. Limiting dispersal of cutblocks will concentrate the activity at any one time and allow wolverines to avoid operational areas as much as possible during their daily movements. This will reduce the mortality risk (e.g., road kill, trapping) and displacement associated with forest development and will help facilitate normal movement throughout the landscape***.

We recommend that cutblocks be concentrated within a designated zone within the management area, recognizing that wolverines will be absent from the area while logging is carried out. This must occur in a way that maintains undisturbed blocks of habitat that are large enough to support reproductive females and are connected to each other by effective dispersal corridors.

C) ***Minimize road access in terms of both length (number of km) and length of time active. The increase in access associated with forest development into previously inaccessible areas may expose resident wolverines to a higher mortality risk from trapping and road traffic. Careful road planning and deactivation should be considered***.

The decision to plan forest harvest units in large blocks or in smaller, scattered blocks must take into account how forest cutblock size and distribution will affect wolverine food and predators, and whether or not logging roads can be deactivated in a manner that effectively eliminates the use of the roads as travel corridors for humans and wolves after logging is completed.

Deactivation of logging roads is one of the most important management actions for maintaining wolverines in logged landscapes, especially where trappers are active. Access by snowmachine users into otherwise remote areas compromises the areas' suitability as reproductive habitat for wolverines. Once a road has been constructed and is regularly used by vehicles, especially by snowmachines in winter and off-road vehicles in summer, it can provide access for a long time with no road maintenance, even if it is no longer accessible by trucks. Over time, wolverines may be able to adjust to predictable (i.e., temporally and spatially consistent) noise and activity of snowmachines and other human activity (J. Persson, personal communication). However, trapping mortality is likely to be high in areas that are easily accessed by trappers (Krebs *et al*. 2004), even when wolverines are not targeted, because as scavengers wolverines are very vulnerable to trapping, including traps set for other species. Because of the size of wolverine home ranges and extent of their exploratory movements, access into the home ranges of a large percentage of resident wolverines in a region is possible even with a relatively low density of roads. If logging activity increases access for trappers, then to maintain long-term occupancy by wolverines, either the access must be eliminated after the area is

logged or, alternatively, traps that are effective in capturing wolverines must be restricted in the area.

Additional research on wolverines in Ontario is necessary before we can offer specific recommendations that will ensure permanent range occupancy of wolverines at the landscape scale in managed forests. In particular, more information is needed on home range size and movements of reproductive females, den site characteristics and availability, food habits of wolverines in logged and unlogged landscapes, and movement patterns and habitat use of wolverines in logged landscapes. Appendix A is an action plan for developing research projects that will address these information gaps. Completion of intensive aerial surveys of logged and unlogged landscapes in winter 2005 will help us to identify levels of logging intensity and road density that might have negative impacts on wolverine persistence at the landscape scale.

Stand-Scale Recommendations

a) Maintain patches of standing timber and downed woody material (DWM) within harvest blocks to provide security cover and future potential denning sites.

Although forest cover is not a prerequisite for wolverine habitat across its range, wolverine avoidance of open areas in our study area, at least during daylight hours, indicates that trees may provide important cover for wolverines in some predator-prey systems. Wolverines readily climb trees and use trees to escape from terrestrial predators; moreover, downed trees are used as den sites for the protection of kits (Magoun and Copeland 1998), which cannot climb trees until they are 3-4 months old (Magoun, personal observation). Management guidelines that retain trees or patches of trees throughout logged stands may offer enough security for wolverines to use logged stands for foraging and traveling. Managing for potential den sites includes retention of existing clumps of deadfall as well as patches of trees scattered in cutblocks that can provide future sources of deadfall in regenerating stands. Retention of deadfall improves habitat not only for wolverines but also for other furbearers such as lynx, fisher, and marten. Logging slash left scattered in cutblocks can create additional sources of shelter and improve habitat for voles that constitute prey for wolverines in summer, and will help to limit access by snowmachines in winter.

b) Maintain suitable habitat connectivity by providing suitable movement and dispersal corridors. Corridors may be along major waterways or "interior" habitat. Corridor width should be a minimum of 500 – 1000 meters. Cover should consist of mature conifer forest.

It is important that wolverines be able to move across the managed forest landscape between areas of suitable habitat. Wolverines readily travel along major watercourses and corridors in these areas would be appropriate. "Interior" forested corridors (not along watercourses) are also appropriate to maintain connectivity between habitat areas. Provision of mature conifer cover is preferred as this type of cover may provide greater

thermal and security cover as well as reduced snow depths for travel. Corridor width should be a minimum of 500 – 1000 meters (E. Lofroth, personal communication). Moreover, buffer strips of uncut trees should be left along flowages, especially along smaller streams where beavers are active, to provide cover for wolverines foraging in these areas. Some cutting could be considered along these smaller flowages to encourage regrowth of preferred beaver forage species. The buffer strips provide additional sources of deadfall that may be used as rendezvous sites for female wolverines with young kits.

Site-Specific Recommendations

a) Maintain suitable denning sites which provide security, protection from disturbance, and appropriate den structures.

b) Minimize disturbance at suitable den sites. Forestry operations should not occur during the January to June period when females are more sensitive to disturbance by humans.

Protection of potential denning sites should be a priority during land use planning for the wolverine habitat in logged landscapes. Suitable sites must offer security from predators and human disturbance immediately prior to (January) and during the denning period (February-April). Secure rendezvous sites are also required for kits that are weaned but are still too young to forage with their mothers (May-June). Information from our study area and other wolverine study areas indicate that sites that have large piles of boulders or downed trees forming extensive subnivean spaces in winter are most likely to be used by wolverines as denning and rendezvous sites. Den and rendezvous sites should also be relatively close to potential sources of food for rearing kits. Such sites in Ontario's boreal forest might include areas where beaver or snowshoe hares are relatively abundant or where caribou winter or within spring migration routes for caribou moving to traditional calving areas. Distance from roads or trails that are frequently traveled by wolves may be another requirement for wolverine denning habitat in logged landscapes or at least may be related to the successful production of kits. Because we know so little about how wolverines select den sites in boreal forest, it is difficult at this time to provide specific recommendations for maintaining wolverine den sites in logged landscapes. However, we recommend that attempts be made to locate large boulder areas in proposed cut areas and provide a large buffer of uncut trees around the boulders to provide cover and a source of deadfall near the boulders. Female wolverines will often move kits from boulder areas to sites under fallen trees when snow begins to melt in spring.

Appendix A: Research Considerations for Wolverines in Lowland Boreal Forest

Additional research on wolverines in Ontario is necessary for making effective management decisions that will ensure permanent range occupancy of wolverines at the landscape scale in logged landscapes. In particular, more information is needed on 1) home range size and movements of reproductive females in lowland boreal forest, 2) den site characteristics and availability, 3) food habits of wolverines in logged and unlogged landscapes, 4) movement patterns and habitat use of wolverines in logged landscapes, and 5) cumulative effects of logging and other anthropogenic disturbance on landscape scale distribution of wolverines. The following is an outline of research protocols that might be used to address each of these information needs.

Research Objective 1: home range size and movements of reproductive females

Planning for wolverines in boreal landscapes requires information on habitat requirements of reproductive female wolverines, which form the core of viable wolverine populations. Even though reproductive female wolverines have higher nutritional needs than adult males or subadult males and females, they have the smallest home ranges of the different sex and age classes of wolverines. The location and size of home ranges for reproductive females are probably determined by foraging requirements, while home ranges of adult males are influenced by the location and number of reproductive females. Subadult wolverines have the largest home ranges and they may, in large part, occupy suboptimal habitats. Information on home range size for reproductive females will help land use planners to determine the minimal amount of suitable habitat needed to support viable wolverine populations, and information on the movements of reproductive females and their centers of activity can help researchers identify important food items and foraging sites.

In the Boreal Wolverine Project, ARGOS satellite collars and VHF transmitters were used to determine approximate home range size and locations of wolverines. Our research showed that home range size calculated with ARGOS data was somewhat larger than that calculated from VHF data. A comparison of the two methods indicated that both methods were acceptable for acquiring home range data on wolverines for the purposes of defining habitat needs for wolverines. Both methods also provided information on daily movements, exploratory movements, and centers of activity, but for acquiring this type of data over the long term, the use of ARGOS transmitters would be more efficient and effective. The collars that were used in the Boreal Wolverine Project incorporated both technologies in the same collar, providing the efficiency of the ARGOS system while still allowing the accuracy of the VHF system for locating foraging sites. Until GPS technology is fully tested on wolverines, we recommend that ARGOS/VHF collars be used to collect information on the variability in home range size of reproductive females, their movements and centers of activity on the landscape, and the location of foraging areas.

Research Objective 2: den site characteristics and availability

The need for reproductive females to protect kits from predators requires that certain types of den structures be present in their home ranges. Information on den site characteristics and distribution of these structures on the landscape will help to define critical habitat for wolverines in lowland boreal forest. VHF transmitters may be required to pinpoint den sites, but ARGOS satellite locations can be used to define a center of activity that is indicative of a denning female, which would alert researchers of the possibility of an active den site and define a center of activity around the den site. The combination of ARGOS/VHF that was used in the Boreal Wolverine Project would be ideal for locating dens in this way. Once the den is pinpointed using VHF signals, the area can be visited on the ground after the female has moved her kits away, and the characteristics of the den site can be determined. We recommend that a VHF transmitter, well-protected in a sturdy container, be dropped from the air when the researchers fly over the den if the den will not be visited until after the snow has melted. This will help researchers on the ground to find the den in forested areas with dense canopy cover, where the exact structure used by the female could not be identified from the air. When dens are located under fallen trees and a number of sites with fallen trees are present near the den site, it may be difficult to determine which sites were used by the female and kits.

Descriptions of den sites should include not only the structures being used by reproductive females, but also other characteristics that might influence the selection of the site as a den (e.g., forest cover type, aspect and slope, distance to water, distance to active and inactive roads or trails, etc.). Once a number of den sites have been located and described, the number and location of *potential* den sites in areas planned for logging or for protected areas could be determined to help evaluate the areas' suitability as habitat for reproductive females. Forest managers could use information on den sites to make site specific and stand-scale management decisions and to plan for future den sites in logged areas.

Research Objective 3: food habits of wolverines in logged and unlogged landscapes

Based on wolverine research from other regions, we can assume that carcasses of caribou and moose are important foods for wolverines in lowland boreal forest in Ontario, particularly in winter. Information from the Boreal Wolverine Project also indicates that beaver may be an important source of food even in winter. However, we have no information on the relative importance of these items in the wolverine diet or how the importance of various food items affects wolverine distribution and abundance on the landscape. Knowing the relative importance of different foods in the wolverine diet in forested areas of Ontario, including both logged and unlogged areas, would help managers understand how resource development might affect wolverine populations. For example, if caribou prove to be more important in the diet of wolverines than moose or beaver, then management practices that negatively affect caribou are likely to have a negative effect on wolverines as well. However, if moose and beaver are important in the wolverine diet then management practices that support higher populations of moose and beaver could have a positive effect on wolverine populations. Much of the information

we have on wolverine food habits is derived from examination of gastrointestinal tracts from trapped wolverines in winter. Wolverine stomachs are often empty, so it usually takes a large sample of trapped wolverines to provide information on food habits using this technique. Where wolverines are scarce or trapping is prohibited, this method cannot be used. We recommend that a pilot study be conducted to determine if stable isotope analysis can be used to determine wolverine food habits in Ontario's lowland boreal forest. This method would require that samples be collected from wolverines and each species that might be a food item in the wolverine's diet. From the Boreal Wolverine Project, we determined that hair samples can be collected from wolverines using baited hair-snagging devices.

Research Objective 4: Movement patterns and habitat use of wolverines in logged landscape.

During the Boreal Wolverine Project, we tracked wolverines using ARGOS satellite and VHF transmitters but rarely located wolverines in active logging areas or in young cutover forest. Because we could not use these tracking methods to obtain locations of wolverines at night, we cannot be certain that wolverines avoided cutovers at night as well. However, preliminary aerial track surveys also indicated that wolverines were not using recent cutovers, even though their tracks were often quite close or even on the edge of cutovers and despite the fact that some wolverines had a considerable amount of recent cutovers in their home ranges. Determining wolverine movement patterns and habitat use in logged areas is needed to understand how wolverines react to logging activity and adjust their movements and home ranges to accommodate this type of disturbance. With the advent of GPS technology and its application to species the size of wolverines, it should soon be possible to apply this technology to studying wolverine movements and habitat use in logged forest landscapes and compare patterns in logged and unlogged areas. Forest managers can use this information to plan for forestry activities at the stand- and landscape-scales.

Research Objective 5: Cumulative effects of logging and other anthropogenic disturbance on landscape scale distribution of wolverines

In 2003 and 2004, the Boreal Wolverine Project team conducted aerial track surveys for wolverine in a 24,000-km^2 area near Red Lake, Ontario. Wolverine tracks were most commonly encountered in Woodland Caribou Provincial Park in the northwest quadrant of the study area and in northeast quadrant of the study area where there is no logging activity. Tracks also occurred within logged areas that were adjacent to the unlogged habitat, but no tracks were detected in the southern portion of the study area where logging is more extensive. These results indicated that as logging and other human disturbances expand on the landscape, wolverine distribution may be negatively affected. However, more information is needed to understand whether wolverines are responding directly to habitat changes produced by logging or to cumulative human disturbance on the landscape. In 2005 we have extended the study area to the north (unlogged), south (intensively logged), and east (minimally logged) and are in the process of carrying out a more intensive track survey to investigate whether the pattern of wolverine track

distribution is related to the distribution and disturbance levels of forest habitat produced by logging or to the density of roads in human-impacted landscapes. The study area has been divided into 100-km^2 hexagons, and transects that pass through the centers of the hexagons will determine the flight routes of the survey aircraft (PA-18 Supercub). From January-May, 2005, the study area will be surveyed multiple times (6-8 depending on snow-tracking conditions) and each hexagon will be examined for tracks at least once; most hexagons will be surveyed 2-4 times with some surveyed 6-8 times. When necessary (e.g., hexagons with closed forest canopies), the survey aircraft will deviate short distances from the transect line to investigate areas along the flight route where wolverine tracks can be detected (e.g., beaver ponds, creek drainages, forest openings). We will record the GPS location for each wolverine track as well as for tracks of wolves and caribou and sightings of moose; size of wolf packs will be estimated from the number of tracks. The habitat type in which the track occurred will also be recorded as well as signs of human activity.

The distribution of wolverine tracks will be analyzed (software program WINBUGS) in relation to a number of independent variables in both logged and unlogged habitats (e.g., density and types of roads, forest cover types and ages, active logging operations and other human activity, distribution of caribou, distribution of wolves and wolf pack size, etc.). Independent habitat variables will be defined using GIS layers and Forest Resource Inventory data available through the Ontario Ministry of Natural Resources and Wildlife Conservation Society Canada. Outputs will include a probability map for detecting wolverine tracks in areas with different intensity levels of habitat disturbance (relative to logging activity). A report on the survey results will include a discussion of factors that affect wolverine distribution and relative abundance in logged vs. unlogged habitats.

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