Photo: Dave Watts

Wolverine

(Gulo gulo) in Ontario

Ontario Recovery Strategy Series

Draft

Natural. Valued. Protected.

Ministry of Natural Resources

Ontario

About the Ontario Recovery Strategy Series

This series presents the collection of recovery strategies that are prepared or adopted as advice to the Province of Ontario on the recommended approach to recover species at risk. The Province ensures the preparation of recovery strategies to meet its commitments to recover species at risk under the Endangered Species Act (ESA) and the Accord for the Protection of Species at Risk in Canada.

What is recovery?

Recovery of species at risk is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of a species' persistence in the wild.

What is a recovery strategy?

Under the ESA, a recovery strategy provides the best available scientific knowledge on what is required to achieve recovery of a species. A recovery strategy outlines the habitat needs and the threats to the survival and recovery of the species. It also makes recommendations on the objectives for protection and recovery, the approaches to achieve those objectives, and the area that should be considered in the development of a habitat regulation. Sections 11 to 15 of the ESA outline the required content and timelines for developing recovery strategies published in this series.

Recovery strategies are required to be prepared for endangered and threatened species within one or two years respectively of the species being added to the Species at Risk in Ontario list. There is a transition period of five years (until June 30, 2013) to develop recovery strategies for those species listed as endangered or threatened in the schedules of the ESA. Recovery strategies are required to be prepared for extirpated species only if reintroduction is considered feasible.

What's next?

Nine months after the completion of a recovery strategy a government response statement will be published which summarizes the actions that the Government of Ontario intends to take in response to the strategy. The implementation of recovery strategies depends on the continued cooperation and actions of government agencies, individuals, communities, land users, and conservationists.

For more information

To learn more about species at risk recovery in Ontario, please visit the Ministry of Natural Resources Species at Risk webpage at: **www.ontario.ca/speciesatrisk**

RECOMMENDED CITATION

Ontario Wolverine Recovery Team. 2011. DRAFT Recovery Strategy for the Wolverine (*Gulo gulo*) in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources, Peterborough, Ontario. vi + 62 pp.

Cover illustration: Dave Watts

© Queen's Printer for Ontario, 2011
ISBN [*SAR Branch will insert prior to final publication.*]

Content (excluding the cover illustration) may be used without permission, with appropriate credit to the source.

Cette publication hautement spécialisée Recovery strategies prepared under the *Endangered Species Act, 2007*, *n'est disponible qu'en anglais en vertu du Règlement 411/97 qui en exempte l'application de la* *Loi sur les services en français*. *Pour obtenir de l'aide en français, veuillez communiquer avec Cathy Darevic au ministère des Richesses naturelles au 705-755-5580.*

AUTHORS

Neil Dawson – Ontario Ministry of Natural Resources
Hilary Gignac – Ontario Ministry of Natural Resources
Justina Ray – Wildlife Conservation Society Canada

ACKNOWLEDGMENTS

The Ontario Wolverine Recovery Team would like to thank the members of the Wolverine Recovery Advisory Team for their constructive input and advice during the initial preparation of this strategy (February 2007). We also acknowledge the thoughtful review and editing of Erin Koen (Trent University) of an earlier draft.

DECLARATION

The recovery strategy for the Wolverine has been developed in accordance with the requirements of the *Endangered Species Act,* 2007 (ESA). This recovery strategy has been prepared as advice to the Government of Ontario, other responsible jurisdictions and the many different constituencies that may be involved in recovering the species.

The recovery strategy does not necessarily represent the views of all of the individuals who provided advice or contributed to its preparation or the official positions of the organizations with which the individuals are associated.

The goals, objectives and recovery approaches identified in the strategy are based on the best available knowledge and are subject to revision as new information becomes available. Implementation of this strategy is subject to appropriations, priorities and budgetary constraints of the participating jurisdictions and organizations.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy.

RESPONSIBLE JURISDICTIONS

Ontario Ministry of Natural Resources

EXECUTIVE SUMMARY

Wolverine (*Gulo gulo*) have disappeared from much of their historical range in Ontario and other parts of Canada and the United States. It has been estimated that the range of Wolverine in Ontario has decreased over 50% since the mid-1800s. The decline in Wolverine range and numbers of individuals has been attributed to a number of inter-related factors that include human settlement and land-clearing, forest harvesting, reductions in prey species, Wolverine harvest, and landscape fragmentation.

The Wolverine is listed as threatened on the Species at Risk in Ontario (SARO) List under the *Endangered Species Act, 2007* (ESA). Nationally, Ontario Wolverine are part of the Western Population, which was designated as special concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), but has no status under the *Species at Risk Act* (SARA). The national Eastern Population (Quebec and Labrador) is designated as endangered by both COSEWIC and under SARA. This provincial recovery strategy has been prepared to improve the status of Wolverine in Ontario by providing guidance and advice on the approaches required for recovery of the species.

The recovery goal is to achieve self-sustaining Wolverine populations within Ontario's recovery range[1]. The following recovery objectives have been identified as necessary to attain the recovery goal.

1. Protect and manage Wolverine populations and their associated habitat.
2. Reduce or eliminate known threats to Wolverine populations and their habitat.
3. Increase understanding of Wolverine ecology, threats to their habitat and survival through inventory, monitoring and research.
4. Integrate Ontario Wolverine conservation efforts with those of other jurisdications (provincial, territorial, and federal), ministries and First Nations, and ensure consideration of Wolverine conservation objectives in landuse and resource management planning processes.
5. Generate support and partnerships for Wolverine conservation by promoting education, awareness and stewardship of Wolverine and boreal forest ecosystems.

A number of recovery approaches have been identified that focus on minimizing the threats to Wolverine and their habitat and enhancing our knowledge of Wolverine ecology in Ontario.

Three recovery zones are proposed based on differences in Wolverine distribution, ecological conditions and threats that should be considered in implementation of recovery approaches. The success of the recovery strategy should be evaluated by tracking the values of a number of indicators, with provincial range occupancy acting as

[1] The region encompassed by the combined area of the three proposed recovery zones: Northern, Western, and Eastern.

the overall measure of Wolverine recovery.

Drawing from knowledge acquired through recent provincial research efforts, extrapolation of relevant literature from alternate jurisdictions and application of a precautionary approach, the recovery team recommends that the entire area captured by the three recovery zones be prescribed as Wolverine habitat under the ESA. This recommendation recognizes that functional habitat for Wolverine is provided at the larger landscape scale and that an ecosystem approach will be required to achieve habitat conservation for this broad-ranging species.

TABLE OF CONTENTS

RECOMMENDED CITATION i
AUTHORS ii
ACKNOWLEDGMENTS ii
DECLARATION iii
RESPONSIBLE JURISDICTIONS iii
EXECUTIVE SUMMARY iv
1.0 BACKGROUND INFORMATION 1
1.1 Species Assessment and Classification 1
1.2 Species Description and Biology 1
1.3 Distribution, Abundance and Population Trends 5
1.4 Habitat Needs 10
1.5 Limiting Factors 16
1.6 Threats to Survival and Recovery 16
1.7 Knowledge Gaps 22
1.8 Recovery Actions Completed or Underway 27
2.0 RECOVERY 32
2.1 Recovery Goal 32
2.2 Protection and Recovery Objectives 32
2.3 Approaches to Recovery 36
2.4 Performance Measures 44
2.5 Area for Consideration in Developing a Habitat Regulation 46
REFERENCES 49
RECOVERY STRATEGY DEVELOPMENT TEAM MEMBERS 62

LIST OF FIGURES

Figure 1. North American and world distribution. 7
Figure 2. Core and peripheral Wolverine range in Ontario. 10
Figure 3. Proposed Ontario Wolverine recovery zones. Note: Only large protected areas are depicted 35

LIST OF TABLES

Table 1. Protection and recovery objectives 32
Table 2. Approaches to recovery of the Wolverine in Ontario 36

1.0 BACKGROUND INFORMATION

1.1 Species Assessment and Classification

COMMON NAME: Wolverine

SCIENTIFIC NAME: *Gulo gulo*

SARO List Classification: Threatened

SARO List History: Threatened (2004)

COSEWIC Assessment History:
Wolverine (Canada) – Rare (1981)
Western Population (includes Ontario) – Special Concern (2003, 1989)
Eastern Population – Endangered (2003, 1989)

SARA Schedule 1:
Western Population (includes Ontario) – No Schedule, No Status
Eastern Population – Endangered (January 12, 2005)

CONSERVATION STATUS RANKINGS:
GRANK: G4 NRANK: N4 SRANK: S2

The glossary provides definitions for the abbreviations above.

1.2 Species Description and Biology

Species Description

Wolverine (*Gulo gulo*) are the largest terrestrial member of the weasel family (Order *Carnivora*, Family *Mustelidae*) and have a compact and strongly built body resembling a small bear. Adult males weigh 14 to 27.5 kg and females 7 to 14 kg. The head-body length of adults range from 65 to 105 cm and tail length varies from 17 to 26 cm (Hash 1987). Wolverine are well-adapted to life in boreal and tundra habitats as they have long, thick fur and large feet, which allow them to move more easily in deep snow, with a relatively low weight load for their size (Teplov 1955). A keen sense of smell allows a Wolverine to detect carrion over long distances and also beneath one to two metres of snow (Hornocker and Hash 1981). A robust and muscular skull enables the Wolverine to easily consume frozen meat and bones.

Current taxonomy regards both Old and New World animals as conspecifics of *Gulo gulo* (Kurten and Rausch 1959). Banfield (1974) noted two sub-species in Canada, *G. g. luscus* and *G. g. vancouverensis*, the latter occurring only on Vancouver Island. Banci (1982) did not find evidence to support the sub-specific classification of *G.g. vancouverensis*, however this subspecies is still recognized (Nagorsen 1990 cited in

Slough 2007). Wolverine in Ontario belong to the *G. g. luscus* sub-species. Kyle and Strobeck (2002) found high levels of gene flow among all sampled northern North American Wolverine populations. However, they observed increasing genetic structure in populations at the southern and eastern edge of the distribution, suggesting that these populations may have been partially fragmented from a formerly panmictic population. Ontario and Manitoba populations were found to be quite similar to one another but relatively distinct from other sampled regions although the national Eastern Population (Quebec and Labrador) was not sampled (Kyle and Strobeck 2002). A recent analysis of nuclear and mitochondrial genetic diversity suggests that there may be two contemporary genetic populations within the national Western Population: the core population in the Canadian territories, western provinces and Alaska; and a peripheral cluster in Manitoba and Ontario (Zigouris et al. in Prep.).

Wolverine have inspired near mythic tales of their strength, ferocity and destruction of cabins and food caches (Thompson 1929, Hash 1987, Banci 1994). Such a reputation while dramatic and deeply rooted in legends and folklore, is largely undeserved. By virtue of their scavenging habits, however, Wolverine can and do have conflicts with humans under certain conditions. Wolverine have long been valued for the frost-resistant properties of their pelts making them valuable as fur trim on parkas. In the past, pelts were also in demand for use as rugs or mounts to sell to tourists (Hash 1987).

Wolverine play an important role in the cultural beliefs of many First Nations as symbols of strength and determination and also appear in First Nations mythology and legends in the role of the trickster. Wolverine play an important role in the creation story of the Nishnawbe-Aski Nation (Appendix in Loutitt 2009).

By virtue of their tendency to inhabit large areas essentially free of human disturbance, Wolverine are true symbols of wilderness regions. As one of the first species to disappear with the onset of human disturbance, Wolverine can be excellent indicators of ecosystem integrity. They should also be good indicators of changing climates in light of their tie to areas that maintain cold temperatures and deep snow cover through spring. The ecological role of the Wolverine is as both top predator and scavenger relying on adequate large ungulate densities to maintain viable populations.

<u>Species Biology</u>

Wolverine have developed life history strategies that result in their living at low densities over the landscape (Banci 1994). Their scavenging lifestyle requires them to cover home ranges much larger than similar-sized carnivores. They are opportunistic feeders and tend to cache surplus food items (Hash 1987). Wolverine are strong for their size and can drag food items several times their weight over a considerable distance.

Food Habits - The Wolverine has been called a ‘scavenging predator’ (Hash 1987) relying primarily on scavenging during the winter months, but becoming an opportunistic omnivore in the summer (Banci 1994). Large mammals primarily in the form of carrion, are important year-round, although availability generally varies seasonally. Moose (*Alces alces*) and Woodland Caribou (*Rangifer tarandus caribou*) are the primary

ungulate species in the Wolverine diet in North America (Rausch 1959, Rausch and Pearson 1972, Hornocker and Hash 1981, Gardner 1985, Magoun 1985, Banci 1987, Banci 1994, Lofroth et al. 2007). In Ontario, Wiwchar (2004) found two of three Wolverine stomachs collected in the Red Lake area contained Moose, while the third was empty. Watson (2009) examined the stomach and intestinal contents of 12 Wolverine collected mainly in the Red Lake area and found Moose (3), White-tailed Deer (*Odocoileus virginianus*) (2), Woodland Caribou (1), Striped Skunk (*Mephitis mephitis*) (1) and Ruffed Grouse (*Bonasa umbellus*) (1), while four were empty or contained only Wolverine hair. Collared Wolverine were observed feeding on Woodland Caribou and Moose carcasses during telemetry flights in Ontario (Ontario Boreal Wolverine Project unpubl. data).

Under the right conditions Wolverine are able to kill ungulates although this is generally believed to be a rare circumstance. Limited Wolverine predation on Moose of all sex and age classes has been documented in Russia, Scandinavia (Haglund 1974, Guiliazov 1998, Kozhechkin et al. 2005) and North America (Magoun et al. 2005b). Lofroth et al. (2007) recorded nine predation events by Wolverine on Woodland Caribou. All Woodland Caribou involved appeared to be in poor condition based on bone marrow fat. Gustine et al. (2006) found that Wolverine accounted for 29% (5 of 17) of known predation events on Woodland Caribou calves in northern British Columbia, with four of five mortalities occurring at nine to fifteen days of age.

Banci (1994) suspected that the large number of empty Wolverine stomachs in food habits studies was an indication of the uncertainty in availability of food supplies. When carrion is scarce, small mammals and birds become primary prey for Wolverine. Trappers in Ontario have noted Wolverine actively hunting Beaver lodges and lakeshores. This activity was confirmed for one radio-collared adult male Wolverine in Ontario during 2004. As well, Wolverine tracks were commonly associated with Beaver lodges with evidence of Beaver kills on several occasions during aerial surveys. Further verification of the importance of Beaver to Ontairo Wolverine was acquired through interviews with elders and trappers from northern First Nations communities (Ontario Boreal Wolverine Project unpubl. data). The availability of small mammals may be particularly important to females during the denning/rearing periods when energy demands are high and movements are restricted (Landa et al. 1997). Lofroth et al. (2007) found that reproductive females had different diets in the winter season relative to other age and sex classes. Persson (2005) showed that the ability to obtain adequate winter food resources was critical to successful female reproduction in Wolverine.

Reproduction - Wolverine have relatively low reproductive potential (Magoun 1985, Copeland 1996, Weaver et al. 1996, Persson 2003). Wolverine breed from May to August with male Wolverine generally mating with more than one female (Rausch and Pearson 1972). Births generally coincide with periods of greater ungulate carrion availability and snow cover which provides enhanced security cover for kits (Banci 1994). Average litter size is two to three kits (Hash 1987).

Males are not sexually mature until over two years, while females reach sexual maturity at about 15 months (Banci 1987, Banci and Harestad 1988). Females however, do not produce litters successfully until they are an average of 3.4 years old (Persson 2003). Adult females appear to breed each year but do not necessarily give birth annually (Magoun 1985). The reported proportion of pregnant females varies and appears to be influenced by age with younger Wolverine age classes (two to three year olds) more likely to be pregnant than older age classes (e.g. six years plus) (Rausch and Pearson 1972, Liskop et al. 1981, Banci and Harestad 1988, Persson 2003). While older females are capable of producing larger litters, fewer older females appear to produce litters (Banci 1994).

Food availability appears to play a critical role in the ability of females to produce young. Rapid growth of kits and the relative availability of winter food appear to place high energetic demands on females and can affect female reproduction in a subsequent year (Banci 1987, Persson 2003). Female body condition may be the most critical factor in determining successful births (Banci 1994, Persson 2003). As a result, the interval between litters for the average adult female Wolverine is likely two years or more (Weaver et al. 1996).

In North America, Magoun (1985) reported a birth rate of 0.6 to 0.7 offspring per adult female per year. Weaver et al. (1996) estimated that the average female Wolverine would have a lifetime production of only two female offspring and that Wolverine may have lower lifetime productivity than even Grizzly Bears (*Ursus arctos horribilus*).

Mortality - Wild Wolverine generally have a life expectancy of eight to ten years (Hash 1987). Krebs et al. (2004) summarized causes of mortality and survival rates for radio-collared Wolverine in North America. Of 62 mortalities in 239 radiomarked Wolverine, causes of death included: trapping or hunting (22); road or rail kill (3); predation (11); starvation (18) and unknown causes (8) (Krebs et al. 2004). Human-influenced mortality accounted for 46% of deaths in trapped populations and was not detected in untrapped populations[2] (Krebs et al. 2004). Subadult males made up 11 of the 25 human-caused mortalities. Within trapped populations the most common cause of natural mortality was starvation, followed by predation and unknown causes (Krebs et al. 2004). Deaths due to predation were caused by Gray Wolf (*Canis lupus*), Cougar (*Puma concolor*) and Wolverine. In untrapped populations the number of Wolverine dying from starvation (2), predation (2) and unknown causes (4) were similar (Krebs et al. 2004). In northern Scandinavia, intraspecific predation was the most common cause of juvenile mortality (Persson et al. 2003).

North American Wolverine survival rates were markedly lower in trapped (less than 0.75 for all age-sex classes) than in untrapped populations (greater than 0.84 for all age-sex classes) (Krebs et al. 2004). Human-caused mortality was determined to be primarily additive to natural mortality for Wolverine. Logistic growth rate estimates suggested

[2] Trapped populations include those where targeted and incidental trapping pressure exists.

that trapped populations would decline (λ ≈ 0.88) in the absence of immigration from untrapped populations (λ ≈ 1.06).

Squires et al. (2007) reported on sources of mortality for 36 Wolverine in two study areas in western Montana. Of the 14 documented mortalities, nine (64.3%) were the result of licensed trapper harvest. The five remaining mortalities were outside the trapping season and included one death from an unknown predator, one death from an avalanche, and three from unknown causes. Annual survival was estimated at 0.80 when harvest was not considered but declined to 0.57 when mortality of harvest was added (Squires et al. 2007). The Glacier National Park area provided some refuge with an annual survival rate of 0.77 and a stable to slightly increasing population (λ = 1.1), relative to the Pioneer Mountain study area where annual survival was 0.51 and λ = 0.7, indicating a 30% annual decrease during their study. Golden et al. (2007) also outlined the importance of having trapping refugia (areas where no harvest is permitted) and Magoun and Copeland (1998) suggested a system of spatial harvest control to minimize harvest in Wolverine denning areas.

In Ontario, three of seven radio-collared individuals died during the 13 months that radiocollars were active: two were trapped and one succumbed to an unknown predator (Dawson et al. 2010). A fourth radio-collared individual was killed in a vehicle collision in 2009, five years after capture (Dawson et al. 2010). Other documented causes of mortality are biased toward trapper harvest primarily in the area between Fort Severn and the Manitoba border in extreme northwestern Ontario between 1985 and 2004 and shifting eastward between Fort Severn and Peawanuck in recent years. Although zero quota on non- Aboriginal traplines has been in place since the 2001/2002 trapping season, there were 21 confirmed incidental Wolverine captures as of the end of the 2008/2009 season in the southern part of the range (OMNR unpubl. data). First Nations harvest reported during the 2001/2002 to 2007/2008 periods was 50 Wolverine. As of March 2009, 11 known Wolverine deaths in Ontario resulted from vehicle collisions and one death from a train collision. Eleven of the 12 road/rail mortalities have occurred since 1990.

1.3 Distribution, Abundance and Population Trends

The Wolverine is circumpolar in distribution, occupying the boreal and tundra zones of the Northern Hemisphere in Europe, Asia and North America as illustrated in Figure 1.

United States

Historically Wolverine occurred throughout Alaska with the exception of the extreme northeastern coastline. There has been no significant change in distribution with populations in the state generally considered robust. Wolverine range experienced substantive retraction by the mid 1900s in the lower 48 states (Aubry et al. 2007). The species formerly occurred along the western mountain ranges as far south as Arizona and New Mexico, and eastward through the northern states from Washington to Maine (Figure 1). While Figure 1 indicates the presence of Wolverine in portions of California,

Colorado, Oregon and Utah, the most current review of Wolverine status in the lower 48 states indicates that small populations continue to persist only in high elevation forest and alpine habitats in Washington, Montana, Idaho and Wyoming (Aubry et al. 2007). However, lone male Wolverine have recently shown up in California (Moriarty et al. 2009) and Colorado (Inman et al. 2009). Wolverine were believed extirpated from the northeastern and central states by 1900 (de Vos 1964), although verifiable historical records are primarily from the western mountains and Great Lakes region (Aubry et al. 2007). An apparent wild Wolverine was found in Michigan in 2004 and was recorded by trail cameras annually until its death by apparent natural causes in 2010 (MI DNRE 2010). The addition of the Wolverine population in the lower 48 states to the List of Endangered and Threatened Wildlife and Plants was recently determined to be warranted (Federal Register 2010 75 FR 78030).

Canada

Historically Wolverine were distributed across Canada although there are no records of Wolverine occurrence in Prince Edward Island, Nova Scotia, eastern New Brunswick, Newfoundland and Anticosti Island (Hall and Kelson 1959, Banfield 1974) (Figure 2). Nationally, Wolverine has been separated into a Western and Eastern population which primarily reflects patterns in range recession. Wolverine in Ontario comprise the eastern-most portion of the national Western Population. Based on harvest records, COSEWIC (2003) provided an estimate of 15,000 to 19,000 Wolverine in late winter for the national Western Population under the assumption that current harvest levels were sustainable (2.5 to 8%). The Wolverine population stronghold is in the north and western part of Canada (British Columbia, Yukon, Northwest Territories), with populations from Alberta eastward having experienced range recessions over the past century (Slough 2007).

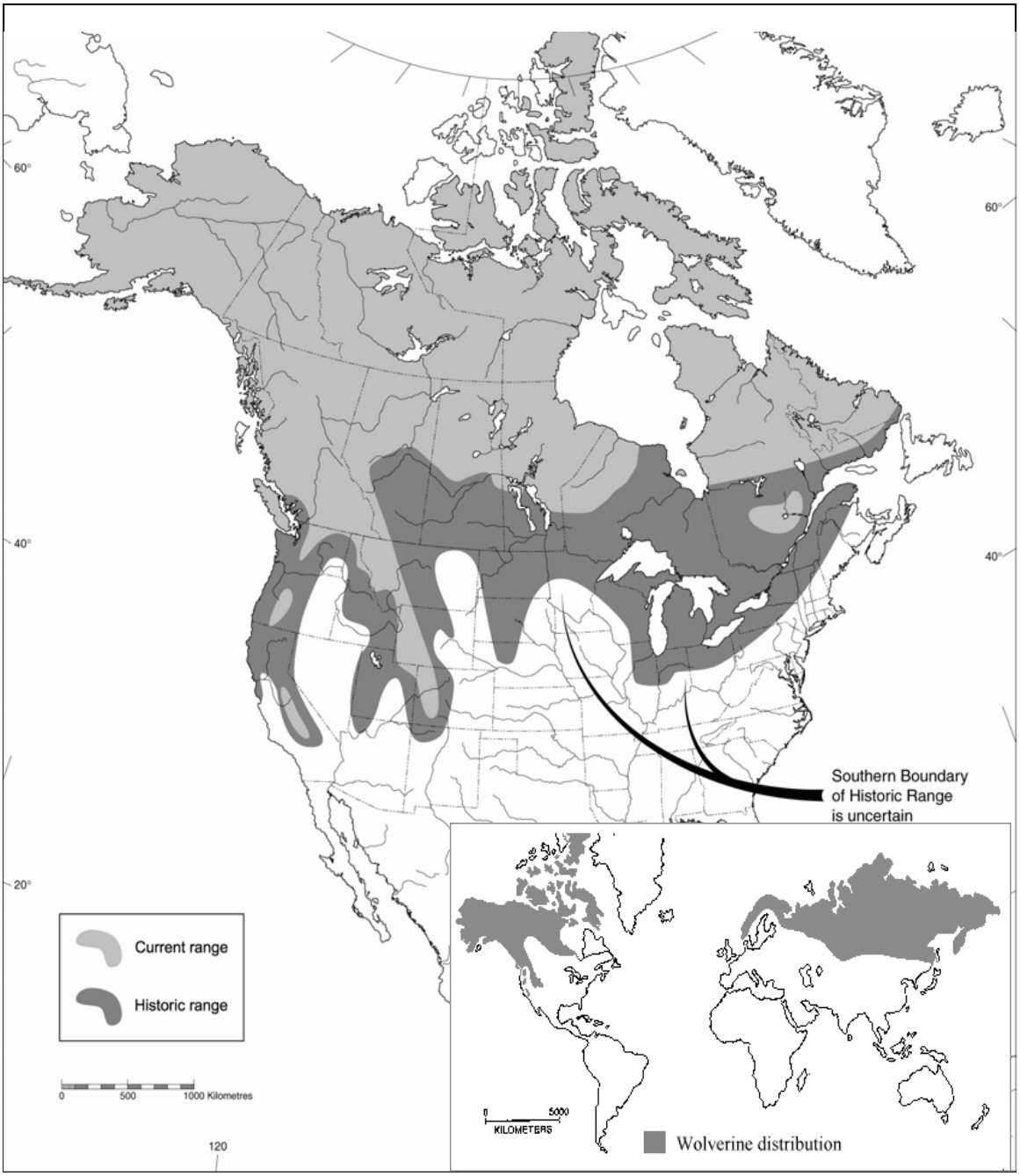

Figure 1. North American (COSEWIC 2003) and world distribution [inset, Pasitchniak-Arts and Larivière (1995)] of the Wolverine. [Note that there have been no confirmed records in Quebec and Labrador since 1979/1980 and 1965, respectively and that Wolverine are either extirpated or extremely rare in these areas (see text; Slough 2007)].

A component of the national Western population of special concern, Manitoba Wolverine numbers were reported to have seriously declined during the early to mid-1900s (van Zyll de Jong 1972) but noted to have re-occupied some of their former range in the central portions of Manitoba by the 1980s (Johnson (1990). This range expansion was attributed to the cessation of predator poisoning programs, an increase in Wolf populations that would provide carcasses for scavenging and shortened trapping seasons. Johnson (1990) estimated Wolverine in Manitoba to number between 500 and 800 animals. Harvest continued to increase up to the early to mid-1980s, although since that time they have declined, most likely due to reduced trapping effort. The population is generally believed to be stable to increasing and is currently estimated at 1200 to 1600 (Berezanski, 2004) However little information exists to support this population estimate.

Forming part of the national endangered Eastern Population, the last confirmed wild specimen in Québec was trapped during the 1979/1980 season (Moisan 1996). A wolverine was captured in a wolf snare in 2004 near Saint-Côme (Lanaudière region) but had a microchip revealing it to be an escaped captive animal from southeastern Ontario (Isabelle Thibeault, pers. comm. June 28, 2011). By the year 1996, 18 sightings were reported between 1979/1980 and 1995 and occurred mainly in the Lac St Jean region (10 observations). Small numbers of observations occurred in the northeast along the border with Labrador (4 sightings) and in the Abitibi region of northwestern Quebec (3 sightings) near the Ontario border (Moisan 1986). Since that time a number of additional wolverine observations have been reported and are currently being consolidated to develop an updated map for Quebec (Isabelle Thibeaullt, pers. comm..June 29, 2011). Consequently, Wolverine are considered to be extremely rare or extirpated in Quebec. Similarly, the last verified Wolverine specimens in Labrador were two animals harvested in 1965. Since then there have been more than 40 reports of animals or their tracks at locations throughout Labrador although none has been verified (Schmelzer 2005). An extensive aerial track survey to clarify the distribution and status of Wolverine in Labrador was conducted in March 2005. No Wolverine tracks or animals were observed on 6630 km of transects within the 195 to 1000 km^2 hexagons surveyed (Schmelzer 2005). Results suggest that the national Eastern Population is very rare at best if present and that recovery by natural means seems unlikely. The trapping of Wolverine is not permitted in Québec or Labrador at this time. A National Recovery Plan for the Wolverine (*Gulo gulo*) [Eastern Population] has been prepared (Fortin et al. 2005).

<u>Ontario</u>

Historically, the Wolverine was found throughout all of Ontario (Hall and Kelson 1959) (Figure 1), although Banfield (1974) did not indicate the occurrence of Wolverine in the southwestern part of the province. Banfield (1974) identified the southern extent of their historical range as north of a line running due west from the southwestern tip of Lake Ontario to the southern tip of Lake Huron. The disappearance of Wolverine from southern Ontario appears to have occurred fairly rapidly during the 1800s. What was perhaps the last southern Ontario specimen was an adult of unknown sex killed in Keppel Township, Grey County in 1889 (J. Eger, Royal Ontario Museum pers. comm.).

Trappers in the Quetico Park area of northwestern Ontario estimated that the Wolverine disappeared from that area around 1900 (Cahn 1936), while Peterson and Crichton (1949) felt that Wolverine had disappeared from the Chapleau area in northeastern Ontario between 1885 and 1900. DeVos (1964) reported that while the Wolverine apparently had a wide distribution in the Great Lakes region, they occurred only in low numbers and were apparently extirpated by the early 1900s. By 1950, most of the province's Wolverine were found north of the Canadian National Railway line. From that point until the 1970s, Wolverine distribution continued to retract westward, with most declines reported in the Hudson Bay and James Bay Lowlands area.

Similar to elsewhere in North America (Aubry et al. 2007), the recession of Wolverine from the southern portion of their historic range in Ontario appears to be related to the combination of habitat conversion resulting from large increases in human settlement, logging, railroad construction, and overharvest of Moose, White-tailed Deer, Eastern Elk (*Cervus elaphus canadensis*), Woodland Caribou and American Beaver during the mid to late 1800s (Dawson 2000). While there is some question whether changes in the persistence of snow cover due to climate change may be a contributing factor to historical range recession of Wolverine (Aubry et al. 2007), the rate of change appears to be more consistent with human activity, in a pattern similar to Woodland Caribou population change (Racey and Armstrong 2000, Vors et al. 2007).

At present Wolverine are found primarily in the northwestern portion of the province (Figure 2). The modeled core occupied range for Wolverine (based on comprehensive Wolverine aerial surveys undertaken across northern Ontario in 2003 and 2004) roughly corresponds to Wolverine range from 1980 to 2005 based on harvest records. The modeled range (and aerial survey observations) extended northeast to Cape Henrietta Maria where there were no harvest records. Furthermore, detection probabilities did not indicate a higher relative abundance of Wolverine in the northern half of the core range as expected from the distribution of Wolverine harvests from 1980 to 2005. This is likely reflective of the higher rate of opportunistic encounters with Wolverine in this sparsely forested region (Ontario Boreal Wolverine Project unpubl. data). The current distribution of Wolverine in Ontario, based on the modeled occupied range results from 2003-4 and occurrences gathered from 2008 to 2010 aerial track surveys, is shown in Figure 2. Both recent aerial surveys and scattered reports by Aboriginal trappers provide evidence that Wolverine in northern Ontario show increasing presence east of the identified peripheral range, which is suggestive of some range reclamation. Observations of Wolverine in the Fort Severn and Peawanuck areas may be linked to reported increases in the Pen Islands Woodland Caribou herd in the 1980s and 1990s (Abraham and Thompson 1998) and recent changes in Woodland Caribou distribution in the Hudson Bay Lowland (Magoun et al. 2005a). Additionally, an increased concentration of occurrences in the central portion of Wolverine peripheral range has been recently documented suggesting that there has been an increase in numbers to provide a source for this immigration. Due to our incomplete knowledge of how distribution or relative abundance patterns of Wolverine in Ontario translate into abundance estimates, no reliable population estimate is available. Slough (2007:80)

has published a “rough population estimate” of equal to or less than 300 individual Wolverine in Ontario, although no rationale is provided.

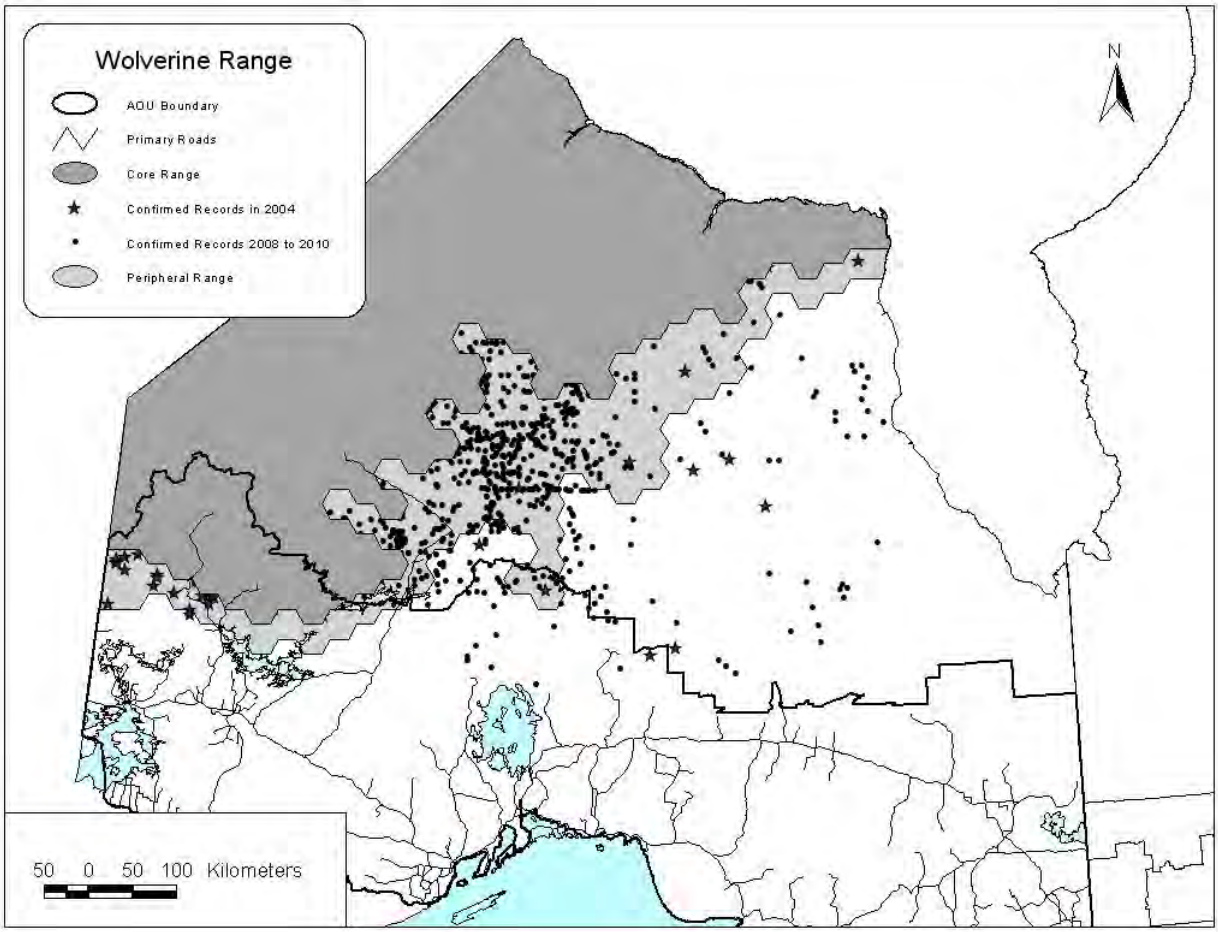

Figure 2. Core and peripheral Wolverine range in Ontario (based on aerial track survey detection probabilities, Magoun et al. 2007) and results of 2008 to 2010 Far North and Species at Risk stewardship funded surveys. Note – confirmed records in 2004 and 2008-2010 are not displayed within the Core Range. Source: Ontario Boreal Wolverine Project, Wildlife Conservation Society Canada, and OMNR.

1.4 Habitat Needs

<u>Population Density and Home Range</u>

Wolverine population densities are naturally low relative to other similar-sized carnivores, even under the best conditions. Wolverine densities in North America range from 2.2 (Squires et al. 2006) to 20.8/1000 km^2 (Magoun 1985) and average around 4 to 6/1000 km^2 (Quick 1953, Banci 1987, Whitman and Ballard 1992, Copeland 1996, Lofroth and Krebs 2007, Fisher et al. 2010). Food availability appears to be a primary factor influencing changes in the distribution of Wolverine (Hornocker and Hash 1981).

Regions with higher Wolverine densities tend to be those with the greatest variety and abundance of both prey and habitat types (Banci 1994).

Wolverine home range size varies widely, influenced by both study location and home range estimation techniques. Typically, male home ranges are larger than those of females and single females have larger home ranges than females with young. Average home range sizes vary from 73 to 3,513 km^2 depending on age and sex (Hornocker and Hash 1981, Gardner 1985, Magoun 1985, Whitman et al. 1986, Banci 1987, Copeland 1996, Mulders 2000, Copeland and Yates 2006, Squires et al. 2006, Inman et al. 2007, Krebs et al. 2007). Winter home range sizes from Ontario are at the high end of reported ranges for North America, with those of males averaging 2,563 km^2 and females 428 km^2 (Dawson et al. 2010).

Overlap of adult male and female Wolverine home ranges can be extensive and one male's home range may cover portions of one to six females' (Magoun 1985, Banci 1987, Copeland 1996, Krebs and Lewis 2000). There is, however, variation between studies regarding the degree of home range overlap reported within individuals of the same gender. No, or very little overlap of home ranges between adults of the same sex was reported by Squires et al. (2006), Wedholm (2006) and Inman et al. (2007). Overlap of home ranges between individuals of the same sex was reported by Hornocker and Hash (1981), Lofroth (2001) and Whitman et al. (1996). Copeland and Yates (2006) reported that resident female home ranges overlapped by seven percent on average, while male home ranges overlapped by an average of 30 percent. Overlap of adult males with their male offspring was reported on three occasions by Squires et al. (2006). Magoun (1985) reported overlap of adult female home ranges only in winter. Banci and Harestad (1990) also reported spatial overlap of adult females during the winter but noted that the overlap areas were not used at the same time by individual females. Magoun (1985) suggested that adjacent adult females are likely related and therefore more tolerant of spatial overlap between individuals. Aronsson (2009) found high home range fidelity between years for female Wolverine and that when female territories became vacant, replacing females were generally daughters (54%) or granddaughters (15%).

<u>Habitat Use</u>

Throughout their North American range, Wolverine occupy a variety of habitat types. Our knowledge about North American Wolverine habitat associations is biased towards mountainous regions, where the majority of studies have occurred. Kelsall (1982) stated that "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". Copeland et al. (2010) has recently shown a strong correlation between global Wolverine distribution and persistent spring snow cover (April 24 – May 15), and less strongly to an upper limit of thermoneutrality (average maximum August temperatures equal to or less than 22º C). Spring snow cover correlated strongly with Wolverine denning locations and year-round movements from studies in Scandinavia and western North America. Schwartz et al. (2009) also

found that spring snow cover was correlated with gene flow between Wolverine in the northwest United States.

In Montana, 70% of all locations of radio-collared Wolverine occurred within large areas of medium or scattered timber, while areas of young dense timber were used least, and Wolverine were rarely located in recent burn or wet meadow areas (Hornocker and Hash 1981). In south-central Alaska, Whitman et al. (1986) found no specific habitat preference in either summer or winter, but did note avoidance of forest (predominantly spruce *Picea* spp.) in summer (April – October) and tundra in winter (November – March). Copeland (1996) found that Wolverine in Idaho avoided lowland grass/shrub and Ponderosa Pine (*Pinus ponderosa*) cover types. In the Yukon, female Wolverine tended to use habitat in proportion to its availability while males used subalpine coniferous habitats more frequently than other habitat types during the winter (Banci and Harestad 1990). In north-central British Columbia, Lofroth (2001) found few significant patterns of habitat use in home ranges relative to that available within the study area at the landscape scale. He also reported that more than 50% of radio-tagged Wolverine locations were in late successional stands and Wolverine used mid-successional stands considerably less often. In the northern Columbia Mountains of British Columbia, Wolverine used late-successional stands most frequently when not using alpine habitats (Krebs and Lewis 2000). Snow-tracking in the boreal forest of northwestern Alberta and northeastern British Columbia indicated that Wolverine were selecting for the densest, older conifer stands for travel and food caching (Wright and Ernst 2004a, 2004b).

There are few published data on the relationship between Wolverine and disturbed landscapes and the factors that influence this relationship. Hornocker and Hash (1981) noted that no Wolverine were relocated in clearcuts (age 0 to 15 years) of any size, although tracks were occasionally observed crossing clearcuts. Males tended to be found further from active roads, clearcuts and burns than females (Hornocker and Hash 1981). Krebs et al. (2007) found that in British Columbia males were associated with food-related habitat variables in both summer and winter, such as areas where ungulate carrion and small mammal prey are available. Male winter habitat use was positively associated with Moose winter ranges, valley bottom forests and avalanche terrain. In the Columbia Mountains, male winter habitat use was negatively associated with helicopter skiing areas. Female Wolverine in the same study area showed complex associations with variables related to food, predation risk and human disturbance during both summer and winter (Krebs et al. 2007). Summer locations of female Wolverine were negatively associated with roads and recently logged areas. Females had positive associations with Moose winter ranges within rugged landscapes in winter, while in the Columbia Mountains, where winter recreation was widespread, females were negatively associated with helicopter and backcountry skiing (Krebs et al. 2007). Krebs et al. (2007) stated that their work “suggests Wolverine were negatively responding to human disturbance within occupied habitat”.

Initial habitat analyses from collared Wolverine in northwestern Ontario within a managed forest area indicate that although Wolverine frequently used areas in close

proximity to clear cuts, track observations within clear cuts were rare. Only one of 99 Wolverine locations obtained during telemetry flights was in a clear cut and in that instance the animal was within an uncut patch of timber within the cut area (Ontario Boreal Wolverine Project unpubl. data).

Krebs and Lewis (2000) found that geographic (e.g., watercourses) and manmade features (e.g., reservoirs and highways) defined Wolverine home range boundaries. Male Wolverine in British Columbia were able to cross large reservoirs and at times crossed major highways during dispersal movements, while females appear not to have crossed reservoirs; only one female crossed the Trans-Canada Highway. Austin (1998) noted that Wolverine avoided areas within 100 m of the Trans-Canada Highway and preferred areas greater than 1,100 m from the highway. Wolverine that did approach the highway made repeated approaches and retreats and crossed only three of six times. Mean right-of-way width at crossings (68 m) was significantly shorter than approaches where no crossings occurred (165 m) (Austin 1998). Squires et al. (2006) reported that Wolverine crossings of major roads in their Montana study occurred in areas with the narrowest distance between forest cover on each side of the road, suggesting that width between habitats in road right-of-ways should be important in highway planning. Hornocker and Hash (1981) noted that rivers, reservoirs, highways, valleys or major mountain ranges apparently did not affect movements. Landscape models developed by Rowland et al. (2003) indicated that amount of habitat, road density and human population density were important components in predicting Wolverine occurrence, with areas of high suitable habitat and low road and human population densities having greater Wolverine occurrence. In a north-central British Columbia study, capture frequencies were greater along timbered corridors adjacent to active haul roads and in timbered corridors in general, than at other trap locations (Lofroth 2001). Lofroth (2001) hypothesized that the matrix of cut and uncut stands which resulted from timber harvesting may “funnel” Wolverine into uncut forest areas and as a result, Wolverine may be more sensitive to the need for forest habitat as human activity in an area increases.

In Ontario, road densities were lower in core home range (50% use area, 0.33 km/km^2) than overall home range area (95% use area, 0.43 km/km^2) (Dawson et al. 2010). Of seven study animals, the two (both females) whose home ranges contained the highest road densities (0.55 and 1.15 km/km^2) were both victims of incidental harvest. May et al. (2006) examined the impact of human infrastructure (houses, cabins, settlements, public and private roads) on habitat selection by Wolverine in two areas of Norway and found that Wolverine selected undeveloped areas for home range locations and that human development was a more important factor in home range selection than habitat. They hypothesized that Wolverine distribution may be influenced by direct disturbance or increased risk of human-caused mortality associated with infrastructure. Bowman et al. (2010) found that both Wolverine and Woodland Caribou were negatively associated with the footprint of human activities in northwestern Ontario. The pattern of Wolverine track distribution in the study suggested that although Wolverine 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. This also

provides preliminary support for the premise that Wolverine populations require refugia free from human disturbance to ensure their persistence in the broader landscape. Wolverine tend to be concentrated in bog areas and mature conifer stands outside of the main cutover area and avoid deciduous forests (Ontario Boreal Wolverine Project unpubl. data; Bowman et al. 2010) They are more broad in their habitat use patterns in far northern Ontario where the dominant disturbance agent is fire and there are no permanent roads (J. Ray unpubl. data).

Denning is critical for survival and Wolverine select den sites in part, to avoid humans and predators during the denning and kit-rearing period. Magoun and Copeland (1998) described two types of dens. Natal dens are used during parturition, generally mid-February to mid-March while maternal dens are used subsequent to natal dens and before weaning, generally from mid-March to end of April. Den sites have a number of structural features in common that afford protection from extreme weather and predators. Dens were complex, extensive snow tunnel systems averaging over 30 m in length and snow depth from the snow surface to the deepest point in the tunnel system was greater than one metre. Females used one to three maternal dens per year. The single Wolverine denning area described in Ontario consisted of three dens within a 300 m radius. The main den consisted of a boulder pile covered with snow, (with the largest boulder being four metres in diameter) and the other two dens consisted of fallen/blown-down trees covered with snow (Dawson et al. 2010). The importance of snow-covered fallen trees and boulder piles as denning sites has been documented by other North American Wolverine studies (Magoun and Copeland 1998, Krebs and Lewis 2000, Lofroth 2001, Copeland and Yates 2006). Some den sites may be used repeatedly in subsequent years, increasing the importance of these habitat features (Lee and Niptanatiak 1996, Magoun and Copeland 1998).

Magoun and Copeland (1998) suggested that a critical feature of Wolverine denning habitat was the dependability of snow cover throughout the denning period. This was defined by at least one metre of snow, either evenly distributed or drifted and present by February and persisting until May. Verified Wolverine reproductive dens were almost always covered by one to five metres of snow. Denning habitat selection by female Wolverine may also be influenced by the suitability of the area as rearing habitat for kits after weaning (Magoun and Copeland 1998); foraging on small mammals and birds is believed to be an important component in the rearing of kits (Magoun 1987, Copeland 1996, Landa et al. 1997).

Wolverine appear to be sensitive to disturbance during the denning period and select denning areas in remote undeveloped areas (Copeland 1996, Krebs and Lewis 2000, Copeland et al. 2007, Krebs et al. 2007, May 2007). Den abandonment due to human disturbance has been reported (Myrberet 1968, Copeland 1996). May (2007) noted that for 50 natal dens in southern Norway, the mean distance to the nearest public road was 7.46 km and from the nearest private road (presumably with less traffic) was 3.06 km. Krebs et al. (2007) noted that female Wolverine habitat associations in summer were negatively associated with roads and recently logged areas. Of 21 dens documented in two British Columbia studies, the closest road access was a minimum of four kilometres

away, despite the fact that most of the Wolverine were live-trapped adjacent to logging roads (J.A. Krebs, Columbia Basin Fish and Wildlife Compensation Program, 2006). Similarly, the Ontario denning site was seven kilometres from the closest active logging road and five kilometres from the nearest human access, a mining trail (Dawson et al. 2010).

Movement and Dispersal

Snow-tracking has revealed that Wolverine can travel long distances during daily hunting; with distances of 30 to 40 km considered “normal” (Krott 1960, Haglund 1966, Pullianen 1968) and covering distances up to 65 km without rest if pursued (Wilson 1982). Adult males tend to move greater distances and make longer and more direct movements than adult females (Banci 1994). Females with young move less than solitary females and hunting mothers leave their young at rendezvous sites that are visited daily (Magoun 1985). Kits were moved to new rendezvous sites every one to nine days and more frequently (every one to two days) as they grew older (Magoun 1985).

Male Wolverine are capable of large dispersal movements, 378 km over eight months (Gardner et al. 1986) and 874 km in 42 days (Inman et al. 2004). Similar large movements of 185 to 326 km for males have been reported (Copeland 1996, Krebs and Lewis 2000, Mulders 2000). A dispersal distance of 100 km for a juvenile male was documented in the Ontario study (Ontario Boreal Wolverine Project unpubl. data). Adult males may influence the dispersal and settlement of juvenile males (Gardner 1985, Banci 1987).

Dispersal distances of juvenile female Wolverine are generally shorter than males, with female residency being established adjacent to or within their natal home range (Magoun 1985, Aronsson 2009). Magoun (1985) reported a dispersal of 300 km by a yearling female, while Mulders (2000) reported female movements of 69 to 225 km. Vangen et al. (2001) found similar dispersal distances for males (51 km) and females (60 km), although they cautioned that these were likely underestimates because radio contact was lost to a greater extent with long distance dispersers compared to those that remained in the study area. Flagstad et al. (2004) suggested that males may disperse up to 500 km and females more than 100 km based on indirect estimates of dispersal distance inferred from mother-offspring relationships. Genetic evidence collected from a male Wolverine at a camera trap site in northern California revealed a western Rocky Mountain origin, opening the possibility of a lengthy dispersal event across hostile habitats (Moriarty et al. 2009). Support for such movements is provided by the recorded dispersal of a collared male Wolverine from northwestern Wyoming to Colorado, a straight line distance of 541 km, and minimum distance traveled of 942 km (Inman et al. 2009).

Various studies have found that male Wolverine may disperse as either young-of-the-year or subadults (Gardner 1985, Magoun 1985, Banci 1987). Wolverine are known to cross significant natural and artificial landscape barriers while undergoing long-distance movements (Inman et al. 2004, 2009). These increased movements by juvenile males,

either for exploratory or dispersal purposes, may make them more susceptible than females to trapping and roadkill (Banci 1987, Banci and Proulx 1999).

1.5 Limiting Factors

Low Population Resiliency

As noted previously, Wolverine have relatively low reproductive potential (Magoun 1985, Copeland 1996, Weaver et al. 1996, Persson 2003). Factors such as relatively late age of sexual maturity, high interbirth interval and low recruitment rate contribute to the low life-time productivity of Wolverine compared to other large carnivores (Weaver et al. 1996). Food availability appears to play a critical role in the ability of females to produce young and kit survival. This translates into a relative lack of resilience whereby Wolverine populations are slow to recover in the face of higher-than-average mortalities. Since the interval between litters is generally two or more years due to female body condition, food supply and adequate habitat conditions, recruitment of juveniles into the population may be intermittent. In situations where births are unable to keep pace with deaths, the long-term viability of a population will be sensitive to small declines in adult survivorship (Weaver et al. 1996). Banci (1994) hypothesized that due to their lower overall population numbers and relatively lower habitat diversity and prey abundance in eastern North America, these Wolverine have historically had the lowest level of population resilience among North American populations and have subsequently seen the greatest decline in both numbers and range.

Habitat Specificity

The importance of spring snow cover to successful Wolverine natal denning has been widely reported in the literature (Pulliainen 1968, Banci 1994, Magoun and Copeland 1998, Persson et al. 2003, Aubry et al. 2007, Inman et al. 2007a). Copeland et al. (2010) suggested that Wolverine in fact have an “obligate association” with spring snow cover. Snow cover acts as insulation from extreme weather as well as protection from predators; winters with high snow accumulation and abundant snowpack provide suitable denning habitat and potentially more winter-killed ungulates. Snow cover is not consistent from year to year in any given place and can demonstrate variability across a landscape, particularly at the southern extent of Wolverine distribution.

1.6 Threats to Survival and Recovery

The Wolverine is among the least understood of North America’s medium to large-sized carnivores (Ruggerio et al. 1994, Weaver et al. 1996). Although this species has experienced range loss and fragmentation across North America over the past 150 years, particularly at the southern margins (Banci 1994, COSEWIC 2003, Aubry et al. 2007), there is little definitive empirical evidence linking specific factors to Wolverine decline anywhere. Only in the last few decades have we begun to learn more about this species and how human activities may influence Wolverine.

In Ontario, Wolverine range recession since 1880 has been documented by Dawson (2000) based on sightings and fur harvest returns. The pattern for Wolverine has been similar to that of Woodland Caribou. Both species disappeared from southern Ontario fairly rapidly during the nineteenth century during a period characterized by a large increase in human settlement, logging and railroad construction and during the early twentieth century, a period of intensive exploitation of wildlife (Dawson 2000, Racey and Armstrong 2000, Schaefer 2003). In addition to this documented correspondence between Wolverine decline and the spread and intensity of the human footprint in Ontario is the fact that Wolverine populations have a low intrinsic ability to recover and repopulate areas from which they have been extirpated (Weaver et al. 1996, COSEWIC 2003).

A discussion of factors that pose the principal threats to Wolverine recovery in Ontario follows. Although an attempt has been made to discuss threats individually, it is recognized that many of these do not act in isolation and that various combinations of factors likely work together, resulting in cumulative effects and compounded threats. For the same reason, prioritization of threats is not possible. Moreover, each threat varies in its intensity across Wolverine range in Ontario and may be important in some areas while inconsequential elsewhere. In a similar fashion some threats that are of relatively minor concern today are anticipated to rise in severity in the future.

<u>Climate Change</u>

Reduction of spring snow cover and natal denning habitat – Climate and weather conditions have the potential to affect the suitability of Wolverine habitat. A spatial correlation between spring snow cover and Wolverine occurrences in North America (Aubry et al. 2007) and world-wide (Copeland et al. 2010) has been documented. Brodie and Post (2009) have suggested a link between decreasing snowpack and Wolverine declines, which has generated much debate (DeVink et al. 2010, McKelvey et al. 2010, Brodie and Post 2010).

Climate change is expected to alter the availability of spring snow cover. Recent projections of changes in Wolverine habitat as a result of climate change indicate potentially dramatic declines in Wolverine habitat in the contiguous United States (Peacock 2011, McKelvey et al. in review). Climate change has the potential to influence future distribution and abundance of Wolverine due to increased variability in snowfall patterns and accumulation, and changes in precipitation falling as rain versus snow. Similar modeling exercises have not been conducted to assess potential impacts on Wolverine in low-elevation boreal habitats in Ontario.

Alteration of habitat from temperature extremes – Copeland et al. (2010) suggest that in addition to spring snow cover, Wolverine are also restricted by an upper thermal limit. They modeled Wolverine distribution with a mean August maximum temperature of 22°C and while this was a less effective predictor of Wolverine presence than spring snow cover, Wolverine did prefer summer temperatures lower than those available (Copeland et al. 2010).

Reduction and alteration of Wolverine and prey habitat – A changing climate will alter the species composition of forested ecosystems and may result in loss of conifer cover and snow conditions which are important to prey species such as Woodland Caribou. A transition to an increased deciduous component may negatively affect Wolverine. Bowman et al. (2010) found a significant negative correlation between Wolverine and deciduous habitat.

Habitat Loss, Degradation, and Fragmentation

Habitat loss, degradation and fragmentation constitute important threats to Wolverine in Ontario and Canada although the nature and mechanisms of their impact remain poorly understood (COSEWIC 2003). Habitat loss follows permanent changes that result in areas with no current or potential value to Wolverine. Habitat degradation implies a reduced but not total loss of habitat value for Wolverine. Fragmentation of habitat refers to the breaking up of continuous habitat that can serve to isolate populations from one another due to the impermeability of the intervening landscape.

Habitat loss has been most evident in the Wolverine's historic range and along the southern margins of current range[3] (van Zyll de Jong 1975, Dawson 2000). This loss is attributed to the permanent conversion of once suitable habitat to areas now heavily interspersed with human infrastructure (urban centers, settlement and associated linear corridors). Remaining potential habitat at the southern edge of Wolverine range exists in small patches surrounded by areas characterized by high Wolverine mortality that may not sustain populations. Habitat loss is a potentially increasing threat in current Wolverine range if resource development activities that move northward permanently alter the environment.

Activities such as forestry, mineral development and exploration, and development of linear corridors influence Wolverine ecology through the degradation, fragmentation and effective loss of Wolverine habitat (Banci 1994, Krebs et al. 2004, Aubry et al. 2007, Slough 2007). Degraded habitats can theoretically increase in quality and become suitable in the future if given the opportunity to recover naturally. While the exact impacts of forest management on Wolverine are not completely understood, evidence suggests that there is a threshold of human access (road density) and habitat removal or degradation at which Wolverine will cease to use or occupy an area which overcomes any benefits brought about by logging-induced increases in prey levels. Losses or displacements can have a significant impact on local populations and impede the natural recovery of populations at the periphery of current range (Aubry et al. 2007, Krebs et al. 2007).

It is anticipated that mining will supplant forestry as the principal resource development activity in Ontario's Far North in the coming decades. This is already apparent in the significant interest in the "Ring of Fire" mineral exploration area where plans are

[3] Wolverine distribution as determined by detection probabilities calculated from the Ontario Boreal Wolverine Project aerial track surveys conducted in 2003 and 2004 and aerial efforts completed in 2009 and 2010 (see Figure 2).

currently underway to develop mining operations for the extraction of chromite and other minerals. The impacts of mineral development of this scale on Wolverine are largely unknown. Future impacts may range from displacement of individuals from areas subjected to sustained disturbance from helicopters during exploration activity, to permanent conversion of habitat due to infrastructure and accompanying road networks, and the accumulation of these impacts. It is unknown at this time whether the regulatory environment for mineral exploration and mining activities, which does not currently emphasize biodiversity protection, will be able to mitigate this threat for Wolverine. In addition, the enhanced potential for conflicts may arise if Wolverine are attracted to the human domestic waste sources at these developments.

Wolverine populations in Ontario and Manitoba currently show signs of genetic isolation from Wolverine in alternate jurisdictions (Kyle and Strobeck 2002, Zigouris et al. in prep.), perhaps underlining the enhanced vulnerability of their status as peripheral populations. While the factors causing this genetic isolation are not known, major transportation and transmission corridors may impede Wolverine movements ultimately affecting gene flow and population persistence (COSEWIC 2003). Increasing road development within Wolverine range may result in higher incidences of Wolverine-vehicle collisions, particularly for young dispersing males (Krebs et al. 2004). As noted in the Species Biology section, a number of Wolverine have been killed in vehicle collisions in Ontario.

Anthropogenic activities, such as recreation, tourism, research activities and vehicle or air traffic have been correlated with the displacement of Wolverine from areas of suitable habitat (Krebs et al. 2007). At present some of these activities are not as prevalent in the Ontario Wolverine range as they are in mountainous areas of western North America. For example, there are fewer snowmobile trails in the Red Lake and Ear Fall areas of Ontario compared to trail density throughout the rest of Ontario and western North America.

Declines in prey species due to natural or anthropogenic causes can result in reduced Wolverine fitness, reproduction and recruitment (Persson 2005, Lofroth and Krebs 2007). Woodland Caribou, Moose and American Beaver are important food sources for Wolverine (Ontario Boreal Wolverine Project unpubl. data). Woodland Caribou populations tend to decrease in areas of young deciduous forest that follow forest harvesting or fire, whereas Moose and White-tailed Deer populations tend to increase in these areas (Fisher and Wilkinson 2005, Courtois et al. 2007, Vors et al. 2007, Wittmer et al. 2007, Bowman et al. 2010). While areas recently disturbed by natural or human-induced means may have increased ungulate biomass relative to undisturbed mature forest, the relative availability of ungulate prey to Wolverine is unclear due a number of confounding effects such as access, trapping and increased predator (Wolf and Black Bear) populations. Thus it is not simply prey numbers that should be looked at but rather the landscape context in which that prey biomass exists. Wolverine utilizing these areas may be susceptible to increased mortality due to greater trapping effort or vehicle collisions as a result of enhanced access.

Increased Predator/Competitor Encounter Rates - Interspecific interactions are among the least understood aspects of Wolverine biology. As Moose and White-tailed Deer populations increase in logged areas, so do wolf populations (Bergerud 1974, Schwartz and Franzmann 1989, Ontario Boreal Wolverine Project unpubl. data). Wolverine may benefit from low to moderate increases in wolf densities in some areas due to increased access to carrion from wolf kills however predation risk is also increased. Wolves (Boles 1977, Krebs et al. 2004) and Black Bears (Inman et al. 2007b) have been identified as predators of Wolverine on a few occasions. Recent studies in Norway (van Dijk et al. 2008) suggest spatial separation between Wolverine and wolves. While Wolverine appear to depend on wolves for carrion in the winter they do not use wolf trails to find carcasses suggesting they reduce predation risk from wolves by avoiding direct confrontation with them. It is possible although speculative, that activities that result in increased predator populations may have a negative impact on Wolverine.

Targetted and Incidental Trapping

By virtue of their low reproductive rates, limited range and distribution and large home ranges, Wolverine has a low resilience to trapping pressure. As such, overexploitation can lead to local extirpation with replacement of removed animals a slow process, if it occurs at all (Banci and Proulx 1999). In populations outside Ontario, the consequences of overexploitation have been clearly demonstrated: In Scandinavia, Wolverine was nearly extirpated as a result of uncontrolled harvest prior to their legal protection (Landa et al. 1997). In a recent synthesis of survival and mortality data from 12 North American radio-telemetry studies, Krebs et al. (2004) found that survival was much lower in trapped than untrapped Wolverine populations and that immigration from untrapped areas is often required to sustain Wolverine in trapped areas. Because Wolverine can travel great distances and are attracted to bait by virtue of their scavenging habits they are more susceptible to trapping than many other furbearing species (Hornocker and Hash 1981). Lofroth and Ott (2007) assessed the sustainability of Wolverine harvest (trapping and hunting) in British Columbia over the 1985 to 2004 period and concluded that harvests were likely to have been unsustainable in 15 of the 71 population units occupied by Wolverine. An additional five of the remaining 56 population units were deemed to be marginally sustainable and of potential management concern.

In Ontario through 2009, between five and 15 Wolverine were harvested annually in the province primarily by First Nations trappers in the Fort Severn area but also in the vicinity of other northern communities (OMNR unpubl. data). This number was stable since at least the 1980s (Dawson 2000). Most traplines where Wolverine have been harvested have had very low total numbers (one to two) removed over the past 28 years. The vast majority of traplines have had either no reported harvest or long periods of time between harvest. Five traplines accounted for 40% of the Wolverine harvest; all are among the largest traplines (by area) and are concentrated in northwestern Ontario. For Ontario at large there is nothing to suggest that current reported Wolverine harvest levels pose a threat to the overall survival or recovery of the species in the province. The spatial pattern and intensity of harvest is indicative of a very light overall harvest level spanning a vast geographic area. Indications of an

expanding range and possibly increasing population numbers suggest that current mortality rates from harvest or any other means are not occurring at rates that would negatively influence Wolverine recovery in the province with the exception of areas along the southern and eastern edges of Wolverine range.

Particular conditions within localized areas do however, make Wolverine more susceptible to overharvest. For example, Wolverine appear to be more commonly harvested where trappers have road access and forests have been harvested. Likewise, removal of any individuals through trapping may be harmful to populations that are at low levels (e.g., northeastern Ontario where Wolverine have been absent until recently).

A zero quota for trapping Wolverine was placed on non-Aboriginal trapping licenses during the 2001/2002 trapping season in Ontario. Since that time an average of 2.6 Wolverine per year have been incidentally harvested in Gray Wolf, Canada Lynx (*Lynx canadensis*), American Marten (*Martes americana*) or River Otter (*Lontra canadensis*) trap sets (OMNR unpubl. data). This harvest is primariliy concentrated at the southern extent of current Wolverine range and may serve as an impediment to the establishment of sustainable Wolverine populations in this area and a barrier to further expansion into previously occupied range. Forest harvesting and mineral exploration have altered the age, structure and composition of the forest and increased human access into the southern portions of current Wolverine range. This may predispose Wolverine to increased trapping mortality through ease of trapper access and a reduction in mature forest habitat which may be funneling remaining animals into more concentrated areas of remaining habitat, as hypothesized by Lofroth (2001). Of more immediate concern to the recovery of Wolverine however, is the threat posed by lack of information about Wolverine mortality in Ontario as a result of incidental trapping. While sub-section 14(d) of Ontario Regulation 242/08 mandates reporting of incidentally caught Wolverine within seven days of knowledge of the event, it is difficult to establish whether this requirement is being adhered to. Similarly with the elimination of a Wolverine harvest season in 2009, because Wolverine cannot be sold under existing legislation and regulations, tracking of current Wolverine harvest by First Nations under Treaty rights is difficult to nearly impossible.

While sale may be restricted provincially, it is speculated that Wolverine acquired in Ontario have been sold in alternate jurisdictions. Fur market prices may also influence harvest of Wolverine as the effort expended on trapping generally mimics the market environment (i.e., as pelt prices increase, so does effort, which increases the probability of Wolverine harvest and vice versa). However, from more than 125 interviews with trappers in northwestern Ontario, Ray et al. (2005) found that the majority of Wolverine harvests have been motivated by opportunistic encounters, accidents (incidental harvest), or retaliation for real or perceived threats to trapper success, rather than the fur itself. All are likely to increase as human development moves northward, thereby providing enhanced access into the core of current Wolverine range in Ontario.

<u>Wolverine – Human Interactions and Human Attitudes</u>

A great deal of folklore surrounds the Wolverine, which has led to a negative reputation influencing people's attitudes towards recovery. Its reputation as a thief or pest to the trapline and food caches has been passed down through generations and does a great deal to shape current attitudes, regardless of personal experience. Members of the general public likewise perceive this animal to be a ferocious and blood-thirsty creature, even though there has never been to our knowledge, a documented attack on a human by a Wolverine. Conservation measures and recovery efforts may be hindered by these attitudes.

As well, increased human access and activity in previously undeveloped areas of the north increase the opportunity of Wolverine-human interactions. This is most likely to occur through attraction of Wolverine to camp kitchens or waste disposal sites, potentially resulting in harm, harassment or targeted killing of Wolverine linked back to misconceptions of this animal.

Cumulative Effects of Multiple Threats

Threats to Wolverine rarely act in isolation and cumulative effects of many activities (direct and indirect) can have a large influence on the ability of an area to support a viable population. Cumulative effects of multiple resource management activities are seldom adequately addressed in planning or in development and implementation of mitigation strategies. This is in addition to direct and indirect threats posed by specific resource management activities. The lack of integrated land use and resource development planning at appropriate scales and examination of cumulative effects within Wolverine range likely serve to exacerbate the above described threats for Wolverine.

Caution must be exercised due to uncertainties associated with the direct and indirect effects of forestry and other resource extraction activities on Wolverine. Wolverine are already in a state where limited flexibility exists to allow activities to occur when the consequences of those activities are not clearly understood. This becomes apparent when considering the subsequent changes in habitat conditions and access that influence the resulting use of the landscape by wildlife species. As with other mustelids for which the cumulative effects of trapping and forest harvesting have been demonstrated (Thompson and Colgan 1987, Thompson 1994), as well as northern carnivores at the southern periphery of their range (Carroll 2007), high mortality rates of animals from already-compromised habitats are likely to be of greater detriment to Wolverine than trapping alone (Banci and Proulx 1999, Krebs et al. 2004).

1.7 Knowledge Gaps

Additional research on Wolverine in Ontario is necessary in order to make effective management decisions to ensure the Wolverine recovery goal and objectives are achieved in the face of increasing development activities within Wolverine range (see sections 2.1 and 2.2).

Our knowledge of Wolverine ecology in Ontario is profoundly limited owing to the fact that most current Wolverine range in Ontario has been generally coincident with those regions of little historical interest for resource development although this situation is changing rapidly. It is only in the last five years that we have begun to gain an initial understanding of Wolverine ecology in Ontario. Some initial effort has been made to gather traditional knowledge from several hundred trappers and elders (e.g., Whitefeather Forest Initiative, Ontario Boreal Wolverine Project unpubl. data). Our limited knowledge base for Wolverine in Ontario and the mechanisms that drive population decline serves as an impediment for formulating actions to ensure Wolverine conservation in the face of projected land use changes.

The following list of knowledge gaps focuses on those topics for which there is a practical application that will benefit Wolverine recovery efforts. The recovery team has elected not to prioritize them, leaving that instead for a future exercise to be done in the context of recovery implementation and formalization of an adaptive management process.

<u>Wolverine Distribution and Abundance</u>

Surveying and monitoring techniques - We possess basic yet general knowledge of broad distribution patterns of Wolverine in the province. But we do not have information with the resolution required (e.g., den surveys, baseline population health estimates such as recruitment rates, or provincial population size estimates with known confidence intervals) to effectively support land use or resource management planning. Traditionally fur-trapping records and incidental observations have been the sole means of monitoring Wolverine distribution and relative abundance in the province. An effective and efficient Wolverine survey and monitoring protocol using aerial surveys of tracks in snow has recently been developed for the purposes of evaluating the extent of distribution and area of occupancy via hierarchical spatial modeling (Magoun et al. 2007). Further testing of this monitoring protocol and its ability to detect changes in Wolverine occupancy and relative abundance at the southern extent of current range and range-wide is warranted. There are currently no reliable population-level estimates for Wolverine in Ontario. While important advances have been made recently on deriving population estimates of Wolverine at smaller scales (< 10,000 km^2; Magoun et al. 2010; Royle et al. 2010), the low densities, large home range sizes, long-distance movements and logistical constraints mean that it is not presently considered feasible to generate such a population estimate across the entire Wolverine range in northern Ontario.

Genetic diversity within Wolverine populations - The genetic profile of Wolverine is not understood well enough to assess, predict or manage the genetic connectivity of this species across Ontario, neither between recovery zones (see section 2.2) nor neighbouring jurisdictions. Studies based on nuclear DNA loci have demonstrated little structuring among Wolverine sampled across northern Canada suggesting a single, panmictic population (Wilson et al. 2000, Kyle and Strobeck 2001, 2002). However, studies examining mitochondrial DNA (mtDNA) have shown considerable genetic structuring among Wolverine samples from these same regions as well as other areas

of North America (Wilson et al. 2000, Chappell et al. 2004, Tomasik and Cook 2005, Cegelski et al. 2006). These findings are consistent with male-biased dispersal but emphasize the importance of female philopatry and successful dispersal of females between populations to maintain genetic diversity (Chappell et al. 2004, Tomasik and Cook 2005, Cegelski et al. 2006). At present, samples from approximately 40 Ontario Wolverine have been collected, most from a relatively small area near Red Lake and Ear Falls. It will be necessary to acquire as many Wolverine hairs and tissue samples from as wide an area in the province as possible for both nuclear and mtDNA genetic analyses to determine levels of genetic structuring within Ontario Wolverine populations.

<u>Habitat and Habitat Management</u>

Habitat selection

1. It is presumed that Wolverine habitat needs are met at a variety of spatial scales, yet the specific contribution (mechanism, relative importance) of physical and biological factors to habitat suitability at each scale is not known. It is therefore difficult to translate these needs into specific habitat or population management prescriptions. Moreover, Wolverine habitat information collected in North America has been traditionally biased towards western mountainous regions. While data gathered thus far by the Ontario Wolverine Project has contributed valuable information on the distribution patterns and general habitat associations of Wolverine in the province, further research is needed at the following forest management planning scales:

    Landscape– It is important to resolve the uncertainty about the extent to which different landscape-scale habitat attributes, resulting from both natural and anthropogenic disturbances (e.g., number, size, shape and placement of timber harvest blocks, other anthropogenic disturbances, fires or blowdown; percentage composition of various habitat seral stages; linear corridor density and placement) may be important for predicting Wolverine use. This information will contribute to an evaluation of the ability of forest management guidelines (currently existing and in development) to maintain Wolverine habitat at the landscape scale under landscape change by any agent. It will also help to understand Wolverine response to cumulative effects and provide information relevant to land use planning. Specific information is needed to develop recommendations for road density and human footprint thresholds, spatial and temporal scales for harvesting and habitat required for stable viable Wolverine populations.

    Stand– Studies of the habitat needs and human activity disturbance thresholds of Wolverine at the stand/site scale (specifically, conservation of natal and maternal denning features) are necessary to support the development and refinement of habitat management prescriptions. While these scales are management constructs specific to forestry, insight derived from these research activities are expected to be helpful for managing other resource management activities that affect Wolverine habitat at multiple scales.

2. It is unknown to what extent the distribution and abundance of boreal forest landscape features in relation to human developments and activities accounts for the overall distribution of Wolverine across the landscape. An analysis of current Wolverine distribution in Ontario in relation to current and projected land-use activities at several spatial scales will assist in identifying potential locations and sizes of refugia, travel corridors for Wolverine and the point at which habitats and populations become fragmented or isolated.

Movement patterns - Wolverine have large home ranges and move widely across the boreal forest landscape. However it is unknown which factors or interactions between factors encourage or impede this movement, expand or contract home ranges, or support successful dispersal of juveniles across the landscape. It is also unknown to what extent these factors contribute to population status such that they could be managed to support achievement of the recovery goal.

1. More details on Wolverine movement patterns in and around disturbed (both natural e.g., fire and anthropogenic e.g., timber harvest) and road areas is needed to understand how Wolverine react to changes in land use patterns and adjust their movements and home ranges to accommodate various types of disturbance (e.g., forestry, mining, power development, fire).

2. Resident adult Wolverine occasionally make long-distance movements beyond the boundaries of their home range (Banci 1994). Future research efforts should therefore attempt to document these movements, noting their frequency of occurrence, sex of animals involved and what factors (e.g., habitat, food availability, or other Wolverine) may be influencing these patterns.

3. Dispersal of young female Wolverine has been suggested as the primary factor limiting the re-colonization of habitats (Banci 1994). Detailed information on the movements and habitat use of dispersing females is needed to determine and identify the appropriate composition and location of potential dispersal or travel corridors within and between recovery zones.

4. Monitoring of Wolverine in the Eastern Recovery Zone in collaboration with Québec to evaluate dispersal of individuals towards the Québec border and the likelihood of colonizing the Québec territory.

Home range size and movements of reproductive females - The minimum size and composition of a landscape capable of supporting a minimum viable population of Wolverine in Ontario is not known. Although we know the general distribution of Wolverine across the province, we do not know how many populations occur in the province. We also do not know whether they are viable (and reliant on rescue from Manitoba) or how confident we would be in predicting the relative change in viability resulting from specific changes in human activities or habitat quality. The location and size of home ranges for reproductive females are probably determined by a combination of food, predation risk and human disturbance factors. Home ranges of adult males are

influenced by the location and number of reproductive females and food-related habitat variables (Sandell 1989, Krebs et al. 2007). Information on home range sizes for reproductive females will help determine the minimal amount of suitable habitat needed (i.e., thresholds) to support viable Wolverine populations, which is useful information for land use planning. Additionally, information on the movements of reproductive females and their centres of activity will aid in the identification and availability of important food items.

Den site characteristics and availability

Presently, there is no method for predicting den site locations or denning/maternal areas for Wolverine in lowland boreal forests.

1. Limited information currently exists on Wolverine den site characteristics in Ontario. It is presumed that den site selection is a significant factor in survival and recruitment of kits. 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 habitat features necessary for Wolverine recovery in Ontario and understand the extent to which they may be limiting. Of particular interest are not only the structures themselves, 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, food availability (Section 4.2) etc.] and the relative importance of these factors. Such knowledge will aid in the evaluation of the “denning potential” of areas planned for resource development.

2. The role of den selection in predator avoidance remains uncertain. Knowledge of how the distribution and abundance of predators such as Wolves and Black Bears may affect the location and types of natal and maternal dens and rendezvous sites used by Wolverine is needed.

3. The impact of climate change on Wolverine denning habitat is uncertain but potentially significant. Factors such as a potential decrease in snow cover and persistence during the denning period, the potential impact of more frequent thick snow crusts on access to denning habitat and survival of small mammals in the sub-nivean layer is required.

Population dynamics - Reliable predictive models of Wolverine population dynamics are absent for Ontario as are the values to calibrate significant parameters of such a model. These models are very important for addressing uncertainties as they relate to population-level responses to human and natural disturbance including harvest levels. They are required to make predictions on the outcomes of management actions and allow for the explicit testing of any predictions that derive from them.

1. Population modeling would assist in understanding the dynamics of Wolverine populations and allow the evaluation of the sustainability of populations and potential for future sustainable fur harvests as well as the design of conservation measures such as trapping refugia. Field studies are needed to build a database of Wolverine population attributes (see 2 - 4 below) and to parameterize the models.

2. We require field investigations to determine female pregnancy rates, sex ratios at birth and sex-specific recruitment rates to derive a better understanding of how reproductive success and female condition vary with environmental factors such as the availability of food and natal dens.

3. Information on the causes and extent of adult and juvenile Wolverine mortality in managed and natural landscapes will assist in developing parameters for models and developing strategies for managing mortality.

4. The ultimate application of population and habitat modeling will be for researchers to put forward robust recommendations on the size of area or number of animals required for a sustainable population and the identification of potential refugia.

Relative importance of ungulates and small prey as direct or secondary food sources - Based on Wolverine research from other regions and anecdotal evidence from Ontario, we assume that carcasses of caribou and moose are important foods for Wolverine in lowland boreal forest in Ontario particularly in winter. Information from the Ontario Boreal Wolverine Project also indicates that American 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, how the availability of various food items affects Wolverine distribution and abundance on the landscape and how these may be affected by changes in landscape pattern or composition as a result of resource development.

Cumulative effects of anthropogenic disturbance on the distribution of Wolverine - As described in section 1.4, preliminary results from the Ontario Boreal Wolverine Project have indicated that as logging and other human disturbances (particularly road networks) expand on the landscape, Wolverine probability of occupancy tends to decrease. However, more information is needed to understand the mechanism of distributional shifts (e.g., direct responses to habitat changes produced by forest management activities) and to cumulative effects of human disturbance on the landscape (e.g., enhanced opportunities for additive mortality through encounters with traps or roads).

1.8 Recovery Actions Completed or Underway

<u>Status Assessments</u>

In the first provincial status report, Novak (1975) concluded that “because of the precarious status of Wolverine in Ontario, the population levels and harvests should be

watched closely". A provincial status designation did not result from this report. More recently, Dawson (2000) prepared an updated status report for Wolverine in Ontario. Dawson (2000) did not provide a population estimate owing to the general lack of information on the species. However he concluded that Wolverine range had receded in the province by over 50% in the last 150 years and attributed this to "human activities including trapping and resource extraction operations such as logging." This status report resulted in Wolverine being recommended as Threatened in Ontario by COSSARO and listed as such in 2004.

Ontario's Wolverine belong to the national Western Population which was designated as Special Concern by the federal COSEWIC in 1988. Slough (COSEWIC 2003) updated the national status report, reconfirming the status as a species of Special Concern. This recommendation was not adopted by Environment Canada and therefore Western Wolverine is not listed in Schedule 1 of the federal SARA.

Legislation and Policy

The Wolverine was provincially designated as a threatened species on the Species at Risk in Ontario List (OMNR 2004) in April 2004. On June 30, 2008 the new provincial ESA came into effect providing protection to individual Wolverine (e.g., killing, harm, harassment). The Wolverine is listed in Schedule 4[4] of the ESA. As such, the transition clauses regarding the habitat protection provisions apply. Specifically, automatic habitat protection will apply to Wolverine as of June 30, 2013, unless a habitat regulation for the species comes into force before then.

The Wolverine is classified as a furbearer by Ontario Regulation 669/98 under the *Fish and Wildlife Conservation Act*. In recognition of declining numbers, all non-Aboriginal trapping licenses have been assigned a zero quota for Wolverine since the 2001/2002 trapping season. Additionally, in 2009 the season for Wolverine was closed.

Research

A general lack of knowledge and attention to Wolverine in Ontario has been attributed to the Wolverine's occupancy of areas north of current forest management activities and historically low populations and harvest rates (Dawson 2000). Recently, interest levels in Wolverine have increased due to increasing development pressures (forestry, mining, power development) within its current range. Recent and ongoing provincial Wolverine research efforts are summarized below:

- *2001 and 2002 - Initial camera "trapping" surveys* were conducted by the OMNR in the Red Lake area to document Wolverine presence at the southern limit of their current range.

- *2003 - 2005 – The Ontario Boreal Wolverine Project,* a partnership between the OMNR, the Wolverine Foundation and Wildlife Conservation Society (WCS) Canada began in 2003. The principle goals of this project were: to gain a better understanding of the ecology of Wolverines in Ontario; refine our knowledge of

[4] Schedule 4 refers to transition species listed as threatened in Ontario Regulation 230/08 under the ESA.

Wolverine distribution; develop and test tools for inventory and monitoring of Wolverine populations; and gather initial knowledge on the effects of forest management and increased development on Wolverine habitats and populations.

The study area was divided into two units: 1) the intensive study area (27,900 km^2) was located in the Red Lake/Ear Falls area where several survey techniques (live-trapping, satellite radio-tracking, aerial surveys, hair snaring, and camera trapping) were tested in both logged and unlogged habitats; and 2) the extensive study area (599,000 km^2) extended from latitude 50º north to the Hudson Bay coast and from the border of Manitoba east to James Bay. In this study area interviews to obtain ecological knowledge from First Nations and broad-scale aerial surveys were conducted to obtain information on the distribution and status of Wolverine throughout the rest of the province. During the third season of fieldwork, the intensive study area was extended around Red Lake to the north (unlogged), south (intensively logged) and east (minimally logged). As well track surveys were carried out to investigate the relationship between patterns of Wolverine track distribution and the distribution and disturbance levels of forest habitat produced by logging activities and roads. Data analyses have been completed, and papers are currently in review or in the process of being submitted to peer-reviewed journals. The survey methodology developed for Wolverine in remote inaccessible regions has been published (Magoun et al. 2007). This paper formed the basis for a surveying and monitoring techniques manual for Wolverine, recently published jointly by WCS Canada and OMNR (Koen et al. 2008).

- *2006-2007 - Trapper Survey at the Southern Limit of Wolverine Distribution in Ontario* - This project was a joint effort of WCS Canada, Ontario Fur Managers Federation, and OMNR, which aimed to collect objective information from trappers relating to individual attitudes towards Wolverine, incidental harvest circumstances, and quantification of trap damage from Wolverine. Insights from this study were incorporated into the development of the Wolverine chapter of the Fur Harvest, Fur Management and Conservation Course manual (see below).

- *2006-2009– Red Lake District Non-invasive Survey* – These camera surveys, conducted by OMNR in partnership with local trappers, built on non-invasive survey work in 2003 and 2004 of the Ontario Boreal Wolverine Project in the Red Lake/Ear Falls area. Trappers were involved with the location and checking of the camera and hair traps on a regular basis.

- *2008-2010 – Aerial Surveys* - This project has been led by WCS Canada in collaboration with several First Nations and OMNR. Deploying the methodology of Magoun et al. (2007), its principal goals have been to conduct intensive aerial surveys for Wolverine (and other large mammals) within several traditional areas of northern Ontario First Nations and in caribou collaring study areas in and around Pickle Lake, Hearst and Nakina. This study has provided new information on Wolverine habitat use in undeveloped areas and relative abundance of this species at the edge of its core range and in relation to other large mammal species.

- *2009 – 2011 – Far North Aerial Wildlife Surveys* – Funded by the Far North Branch (OMNR) as part of the Information Knowledge Management Strategy, aerial track surveys have been conducted across the far North planning area from 2009 – 2011. These surveys documented continued range re-colonization to the east by Wolverine.

- *2009 – Wolverine Food Habits Study* - The stomach and intestinal contents of 12 incidentally harvested Wolverine primarily from the Red Lake area, were examined as part of a four year honours thesis project at Lakehead University (Watson 2009).

- *2009-2011 – Wolverine Genetics Project* – Genetic analysis of historical and recent Wolverine samples from Ontario was conducted with funding from the Far North Branch by the Trent University Natural resources DNA Profiling Lab. Over 60 samples have been analyzed and a final report is pending.

<u>Habitat Management</u>

Habitat classification schemes and habitat models do not currently exist for Wolverine. The Boreal Landscape Guide, currently in development, is intended to address the general habitat requirements for area-demanding species such as Wolverine by applying the coarse filter in forest management. Landscape level Woodland Caribou direction is expected to be included in the Boreal Landscape Guide and it is hoped that Wolverine conservation will therefore be addressed indirectly if cumulative effects can be adequately managed at appropriate scales. Wolverine and Woodland Caribou exhibit clear similarities that make it advantageous to consider both species together in management decisions.

Standards and guidelines for addressing specific habitat concerns such as Wolverine denning sites, are contained in the Forest management guide for the conservation of biodiversity at the stand and site scales (OMNR 2010). A standard four kilometre radius Area Of Concern centred on the den site and development of a den site management plan are requirements under this guide. Guidelines include, to the extent possible, incorporation of these local site features into larger blocks of unharvested forest without roads on the landscape.

<u>Communications and Outreach Initiatives</u>

An awareness poster and reporting postcards seeking information on Wolverine sightings were prepared and distributed by the OMNR in 2001 in an effort to increase OMNR staff and public awareness of Wolverine and improve our understanding of this species' provincial distribution. While relatively few Wolverine observations are received annually (one to two per year on average), overall levels of media coverage and positive reaction from the public to news articles and public presentations give some collective indication that the program has helped to increase public awareness of Wolverine in Ontario.

Several informative articles about the Ontario Boreal Wolverine Project appeared during the duration of the project in local newspapers and publications. A mailing list of interested individuals and organizations was created for distribution of project updates. Additionally, preliminary results have been shared with other jurisdictions and Wolverine experts through presentations at conferences and workshops.

An article entitled ‘Why is the Wolverine a threatened species in Ontario?’ (Ray and Dawson 2006) was published in the Ontario Fur Managers Federation publication to enhance awareness of the status of Wolverine in Ontario. Recent activities to enhance awareness being undertaken in the province include several presentations and workshops held since 2004 in Red Lake/Ear Falls and in selected First Nations communities on the subject of Wolverine ecology, conservation and management.

The Ontario Fur Managers Federation, in partnership with WCS Canada and OMNR prepared a special section of the Fur Harvest, Fur Management and Conservation Course manual devoted to Wolverine. This included general information on Wolverine identification (e.g. tracks), practices for avoidance of incidental capture and trap damage, as well as a review of provincial legislation, regulation and policy and associated trapper responsibilities (i.e. reporting). This project was followed up with the preparation of a brochure devoted to best management practices for avoiding incidental harvest of this species and Wolverine damage to traps.

Data Management

The development of a provincial Wolverine database to house all Wolverine observations and research data is underway by OMNR. When populated, the database will aid in land use planning for proposed resource management activities and recovery planning initiatives. The database will track observations, aerial survey efforts, collaring projects, remote camera and hair-snare surveys, DNA projects and reported mortality events resulting from harvest and vehicle or train collisions.

2.0 RECOVERY

2.1 Recovery Goal

The recovery goal is to ensure self-sustaining[5] Wolverine populations within Ontario's recovery range.

Ontario currently has the most easterly Wolverine populations in North America, given the questionable status of Wolverine in Québec and Labrador. Thus, Ontario Wolverine are strategically important for both the maintenance of the national Western Population and the recovery of the national Eastern Population. This recovery strategy focuses on the attainment of Wolverine range occupancy across the province and enhancement of connectivity to adjacent populations. Its goals and objectives aspire to achieve self-sustaining populations at levels that would allow genetic exchange with the national Western Population and support emigration to the Eastern Population. If successful, Ontario Wolverine would attain levels able to withstand future commercial harvest.

2.2 Protection and Recovery Objectives

Table 1. Protection and recovery objectives

No.	Protection or Recovery Objective
1	Protect and manage Wolverine populations and their associated habitat.
2	Reduce or eliminate known threats to Wolverine populations and their habitat within Ontario's recovery range.
3	Increase understanding of Wolverine ecology, threats to their habitat and Wolverine survival through inventory, monitoring and research.
4	Integrate Ontario Wolverine conservation efforts with those of other jurisdications (provincial, territorial, and federal), ministries and First Nations; and ensure consideration of Wolverine conservation objectives in landuse and resource management planning processes.
5	Generate support and partnerships for Wolverine conservation by promoting education, awareness and stewardship of Wolverine and boreal forest ecosystems.

<u>Recovery Zone Delineation</u>

Historically Wolverine were distributed throughout the province (Figure 1). However recovery efforts should be focused within the three defined recovery zones in the northern half of Ontario (Figure 3). This recovery range includes both areas currently occupied by Wolverine as well as those where the species is known to be re-occupying at present and that are key to the objective of promoting connectivity between the

[5] Self-sustaining – a population that has a high (90%) probability of persistence and is capable of sustaining itself while under the influence of stressors and in the absence of mitigative intervention.

nationally defined Western and Eastern Wolverine populations. All recovery zones contribute together to facilitate this future connection: both the Northern and Western recovery zones form a core area for gene flow and dispersal in a north-south direction and eastward to re-populate the Eastern recovery zone. This will provide an essential long-term link to Québec and the nationally endangered Eastern Population of Wolverine. It is important to note that although this defined recovery range encompasses the current thrust of recovery activities, Wolverine occurring outside this area (e.g., southward) should not be ignored and form the basis of activities that may occur on an ad hoc basis.

Individual recovery zones were delineated on the basis of a number of criteria (described below) that inform the geographic context for Wolverine recovery efforts, which is variable throughout the recovery range. As such, some recovery approaches are not relevant to all zones (Table 2). For those approaches that are, this zoning will inform their implementation, whereby activities can be tailored to the geographic context of Wolverine recovery in Ontario.

The following criteria were considered during the delineation of proposed recovery zones for Wolverine in Ontario: current Wolverine distribution (based on 2003 and 2004 aerial surveys supplemented with 2008 – 2011 survey results); historic Wolverine range (specifically, estimated 1955 range from Dawson, 2000); Ontario Ecoregion boundaries (Crins 2002); and the southern boundary of the zone of continuous Woodland Caribou distribution identified in the Caribou Conservation Plan (OMNR 2009b). Recovery zones for Wolverine (Figure 3) have been delineated to capture variation in: (1) Wolverine status, (2) degree and type of threat, and/or (3) appropriateness of management tools that are expected across and within Wolverine recovery range in Ontario. For example, all-weather road access and resource extraction activities are not expected to occur with the same intensity across the north due to varying habitat and terrain conditions. Management tools to achieve recovery objectives would be expected to vary as a function of both the threat and relative abundance of Wolverine. A description of each recovery zone follows.

Northern Recovery Zone - This area (Figure 3) is approximately 226,600 km^2 in size and comprises portions of the Hudson Bay Lowland ecozone (Ecoregions 0E, 1E; 54% of the area) and the Boreal Shield ecozone (Ecoregion 2W; 46% of the area). It is bounded on the south by the Aguta moraine system, in the west by the approximate northern boundary of the Far North Planning area and in the east by the northern boundary of Ecoregion 2E. There is currently no all-weather road access in this recovery zone and relatively little resource extraction (forestry, mining) compared to the other two recovery zones. The Ring of Fire mineral exploration zone straddles the boundary between the Northern and Eastern recovery zones. Wolverine are currently distributed throughout this zone and based on aerial survey results are believed to be stable or increasing in numbers.

Western Recovery Zone - This recovery zone is roughly 195,500 km^2 in size and extends north from the southern boundary of continuous Woodland Caribou distribution

(OMNR 2009b) to the northern edge of the major moraine system at the south end of Opasquia Provincial Park (Figure 3). This is generally thought to be the northern extent to which all-weather road access and widespread resource extraction (e.g., forest harvesting) would occur. This recovery zone lies entirely within the Boreal Shield ecozone (Ecoregions 2W, 3S, 3W, 4S). The zone includes areas within the currently managed forest as well as the Far North planning area and has high development potential and both all-weather and winter road access that will likely be expanded. Wolverine are primarily concentrated in the northern and western portion of this zone with increasing evidence of colonization of the east side of the zone based on recent aerial surveys.

Eastern Recovery Zone - This recovery zone is approximately 177,400 km^2 in size and is bounded by the northern boundary of Ecoregion 2E in the north, and in the south by the boundary of continuous Woodland Caribou distribution (OMNR 2009b). This zone is primarily within the Hudson Bay Lowland ecozone (Ecoregion 2E; 68% of the area) with the southern portion in the Boreal Shield ecozone (Ecoregion 3E; 32% of the area). This zone includes a small area within the currently managed forest as well as the Far North planning area. There is high development potential from mining (e.g., diamonds and Ring of Fire), power development, forestry and a combination of all-weather and winter road access. Current occupied Wolverine range based on aerial track surveys is low and at present occurs only in the northern portion of the recovery zone. Unverified reports of wolverines have been reported by trappers and other members of the public in the southern portion of the zone and occasionally in areas south of this proposed zone. A report of tracks by very experienced observers occurred near Chapleau during an aerial wolf survey in 2006. This zone is considered essential for providing a long-term link to Québec and the nationally endangered Eastern Population of Wolverine.

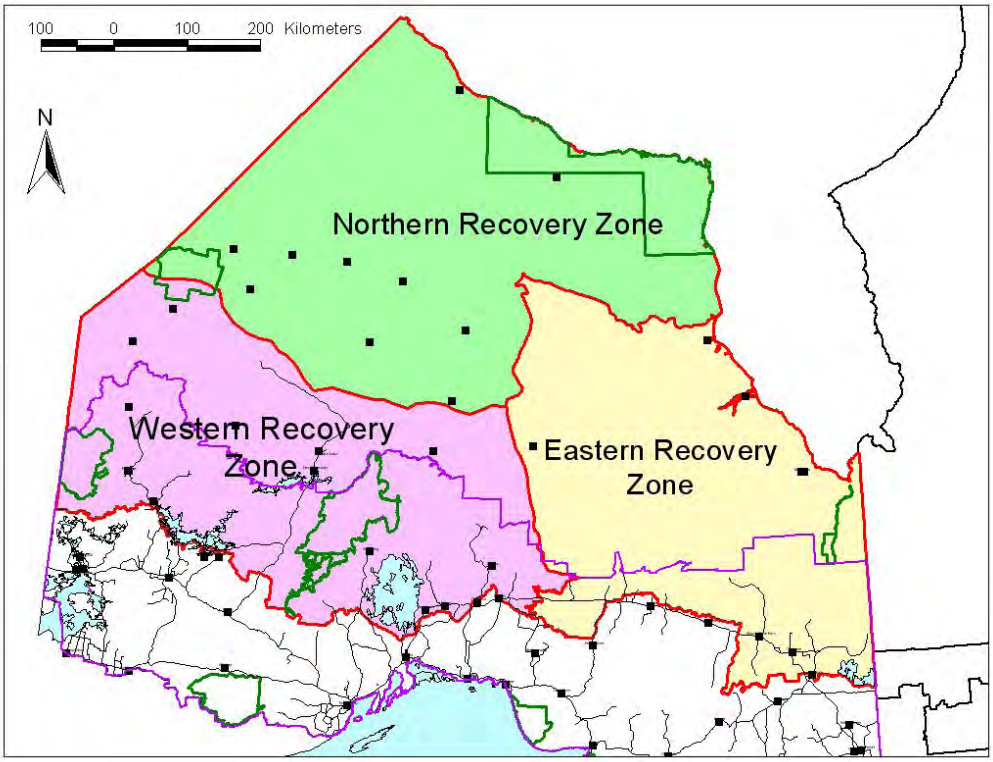

Figure 3. Proposed Ontario Wolverine recovery zones. Note: Only large protected areas are depicted.

2.3 Approaches to Recovery

Table 2. Approaches to recovery of the Wolverine in Ontario

Relative Priority (zone)[6]	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
1. Protect and manage Wolverine populations and associated habitat.				
Critical (WRZ) Necessary (NandERZ)	Short-term	Protection, Management, Stewardship	**1.1** Finalize policy and procedures to inform implementation of section 14 (incidental catch) of Ontario Regulation 242/08. – Establish best management practices to reduce incidental catch. – Guidance on the disposition of incidentally caught Wolverine. – Develop a tracking mechanism for issued letters of authorization (possession).	• Trapping[7]
Critical (WRZ) Necessary (NandERZ)	Ongoing	Protection	**1.2** Incorporate compliance monitoring for section 14 (incidental catch) of Ontario Regulation 242/08 into annual Ministry enforcement workplans.	• Trapping
Necessary (all zones)	Short-term	Protection, Management	**1.3** Develop guidance on the disposition of Wolverine acquired through means other than trapping (e.g. roadkill).	• Roadkill, Perceptions
Critical (all zones)	Short-term	Protection	**1.4** Undertake a conservation assessment and legal treaty analysis of First Nations harvest of Wolverine.	• Trapping

[6] WRZ = Western Recovery Zone; ERZ = Eastern Recovery Zone; NRZ = North Recovery Zone (see section 2.2 – Recovery Zone Delineation)

[7] Trapping includes both targeted efforts and incidental catch.

Relative Priority (zone)[6]	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Necessary (all zones)	Short-term	Protection	**1.5** Develop a species specific habitat regulation and associated guidance defining "damage and destroy" to inform implementation of the regulation.	• Habitat Fragmentation, Degradation and Loss
Beneficial	Short-term	Management	**1.6** Integrate Wolverine recovery objectives into Ministry of Natural Resource policy that focuses on management of Wolverine predator/prey species (i.e. Ecological Framework for Cervids, Wolf Management Framework, Black Bear Management Framework).	• Predator Competition, Prey Availability
2. Reduce or eliminate known threats to Wolverine populations and their habitat within Ontario's recovery range.				
Critical (W RZ)	Short-term	Protection, Management, Research, Stewardship	**2.1** Refine, test and implement Wolverine specific beneficial management practices for trapping to minimize both incidental catch and trapline damage.	• Trapping • Habitat and Habitat Management
Necessary (EandW RZ)	Short-term	Protection, Management, Research, Stewardship	**2.2** Evaluate the effectiveness of current and forthcoming forest management guidance (Area of Concern perscription and Boreal Landscape Guide) in supporting attainment of the Wolverine recovery goal.	• Habitat Loss, Trapping • Habitat and Habitat Management
Necessary (all zones)	Short-term	Protection, Management, Research, Stewardship	**2.3** Develop, test and implement Wolverine specific best practices for mining, mineral exploration and additional resource management activities (e.g., peat extraction, hydro corridors, etc.).	• Habitat Loss, Trapping • Habitat and Habitat Management
3. Increase understanding of Wolverine ecology, threats to their habitat and Wolverine survival through inventory, monitoring and research.				
Critical (all zones)	Short-term and Ongoing	Management	**3.1** Finalize and maitain a standardized central data repository for Wolverine population and habitat data.	• Distribution and Abundance, Habitat and Habitat Management

Relative Priority (zone)[6]	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Critical (all zones)	Short-term and Ongoing	Research	**3.2** Initiate research into the ecology of Wolverine in lowland and boreal forest habitats, with emphasis on den site selection, productivity and survival rates in both undisturbed and modified habitats	• Habitat Loss, Trapping, Cumulative Effects • Habitat and Habitat Management, Human Perceptions
Critical (all zones)	Ongoing	Research	**3.3** Initiate experimental treatments (management) in designated areas of proposed mitigating measures (e.g., trapping practices, habitat manipulation and translocations) to address key uncertainties (see section - Knowledge Gaps) that can be compared against control areas.	• Habitat Loss,Trapping, Cumulative Effects • Habitat and Habitat Management, Human Perceptions
Critical (all zones)	Ongoing	Research	**3.4** Develop models to examine the potential impact of climate change on availability of spring snow cover and mean August maximum temperatures for Wolverine in Ontario, scenario modeling that incorporates interactions between these predictions and anthropogenic land use change (cumulative effects).	• Habitat Loss, Trapping Cumulative Effects
Critical (all zones)	Ongoing	Research	**3.5** Develop and test population models associated with proposed experimental treatments.	• Habitat Loss • Habitat and Habitat Management, Human Perceptions
Critical (all zones)	Long-term	Inventory, Monitoring and Assessment	**3.6** Establish, implement and maintain a monitoring program that tracks landscape level habitat quality.	• Habitat and Habitat Management
Critical (all zones)	Long-term	Inventory, Monitoring and Assessment	**3.7** Establish, implement and maintain a monitoring program that tracks Wolverine distribution, abundance and population trends.	• Distribution and Abundance
Necessary (all zones)	Long-term	Inventory, Monitoring and Assessment	**3.8** Establish, implement and maintain a monitoring program that tracks societal engagement.	• Human Perceptions

Relative Priority (zone)[6]	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Necessary (all zones)	Ongoing	Research, Management	**3.9** Develop habitat suitability models associated with proposed experimental treatments	• Habitat Loss, Cumulative Effects • Habitat and Habitat Management
Necessary (all zones)	Short-term	Research	**3.10** Conduct a jurisdictional scan of management practices being employed relevant to Wolverine conservation to support recovery approaches 2.1, 2.2 and 2.3.	• All threats • Habitat and Habitat Perceptions
Necessary (all zones)	Short-term	Inventory, Monitoring and Assessment	**3.11** Explore opportunities to incorporate collection of Wolverine values (i.e., sightings, tracks, etc.) into established broad-scale terrestrial monitoring programs (e.g., Moose Aerial Inventory)	• Distribution and Abundance • Habitat and Habitat Management
Necessary (all zones)	Short-term	Inventory, Monitoring and Assessment	**3.12** Monitor sources of Wolverine mortality (e.g., roadkill, incidental catch, harvest); document in central data repository.	• Distribution and Abundance, Human Perceptions
Beneficial (all zones)	Short-term	Research	**3.13** Build a picture of Wolverine historical occupancy in Ontario through review of traditional knowledge and Hudson Bay harvest records.	• Distribution and Abundance, Human Perceptions
4. Integrate Ontario Wolverine conservation efforts with those of other jurisdications (provincial, territorial and federal), ministries and First Nations; and ensure consideration of Wolverine conservation objectives in landuse and resource management planning processes.				
Critical (all zones)	Ongoing	Management	**4.1** At the landscape scale, integrate Wolverine conservation efforts with other provincial boreal species at risk initiatives, specifically Woodland Caribou.	• Habitat Loss

Relative Priority (zone)[6]	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Critical (all zones)	Short-term, Ongoing	Management	**4.2** Develop an integrated and proactive land use planning process that addresses cumulative effects (including climate change) and ensures consistency with the protection of Wolverine and its habitat (forestry, access, power developments, tourism, mineral exploration and development, etc.)	• Cumulative Effects
Critical (all zones)	Ongoing	Management	**4.3** Establish standard Wolverine information requirements for incorporation in environmental assessments and resource development proposals.	• Habitat Loss
Critical (all zones)	Ongoing	Management	**4.4** Incorporate habitat and population-level recommendations or criteria into land use and resource management planning initiatives.	• Habitat Loss
Critical (all zones)	Ongoing	Protection, Management, Stewardship	**4.5** Develop a process that fosters engagement of First Nations communities in Wolverine recovery efforts.	• Trapping • Human Perceptions
Necessary (WandN RZ)	Ongoing	Management	**4.6** Work with the province of Manitoba to ensure consideration of Ontario's recovery goal in the preparation of a provincial (Manitoba) Wolverine management plan and encourage cross-border management of this shared population.	• Cumulative Effects
Beneficial (E RZ)	Ongoing	Management	**4.7** Work with the National Wolverine [Eastern population] Recovery Team and responsible jurisdictions (Quebec and Labrador) to facilitate recovery of Wolverine to these formerly occupied areas.	• Cumulative Effects
Beneficial (W and E RZ)	Long-term	Management	**4.8** Establish criteria to inform when translocation of Wolverine may be undertaken to support recovery efforts.	• Distribution and Abundance

Relative Priority (zone)[6]	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
5. Generate support and partnerships for Wolverine conservation by promoting education, awareness and stewardship of Wolverine and boreal forest ecosystems.				
Critical (all zones)	Ongoing	Stewardship	**5.1** Encourage trappers' (including First Nations) leadership in achieving Wolverine recovery.	• Human Perceptions
Critical (all zones)	Ongoing	Stewardship	**5.2** Encourage First Nations leadership in achieving Wolverine recovery.	• Human Perceptions
Necessary (all zones)	Ongoing	Education and Outreach	**5.3** Establish a formal mechanism for information exchange between the Ministry of Natural Resources, northern trappers and First Nations regarding Wolverine conservation efforts.	• Human Perceptions
Necessary (all zones)	Short-term	Education and Outreach	**5.4** Develop and implement a communications plan to enhance awareness of Wolverine conservation and create a positive atmosphere to support recovery efforts.	• Human Perceptions

Narrative to Support Approaches to Recovery

The listing of Wolverine as a species at risk in Ontario has created a number of significant management challenges, particularly in the areas of trapping and resource management. The lack of clear policy and management direction for incidental Wolverine harvest by non-Aboriginal trappers is a major issue that is already influencing management and recovery efforts for the species. Establishing policies and procedures associated with implementation of section 14 (incidental catch) of Ontario Regulation 242/08 (Approach 1.1) under the ESA should include an analysis of the opportunity to sell incidentally caught Wolverine under specified conditions, so as to reduce the likelihood of waste, potential non-reporting and legal challenges. The final policy and procedure should reduce uncertainty and provide security to trappers and aim to foster their cooperation and involvement in Wolverine data collection and population assessment. Opportunities to entrench best management practices into regulation should be examined and acted on where feasible.

A conservation assessment and legal analysis of Treaty rights pertaining to harvest of Wolverine by First Nations (Approach 1.4) should be completed to inform potential future regulatory amendments under the ESA. While established Aboriginal and Treaty rights are recognized under the ESA (e.g., harvest and sale of species at risk), the fact that non-Aboriginal individuals, fur dealers and auction houses are presently unable to purchase, possess or sell Wolverine has resulted in an inability to track mortality of this species in much of its range. This potentially affects recovery efforts.

Under current resource management, land use planning processes and associated policies, consideration of Wolverine (given its threatened status) is a requirement (e.g., *Wildlife Policy 6.04.01* (OMNR 1990)*: Management of Timber for Featured Wildlife Species*); however no species-specific habitat guidance exists aside from the protection of den sites in the *Forest Management Guide for the conservation of biodiversity at the stand and site scales* (OMNR 2010).

Wolverine are considered a transition species under the ESA, meaning that they presently do not receive habitat protection. However by June 30, 2013 they will receive general habitat protection unless a habitat regulation for this species is made in advance of this date. Ontario's Wolverine population is considered part of the national Western Population designated as special concern; as such, designation of Critical Habitat is not legally required under the federal SARA (Statutes of Canada 2003). The recovery team feels strongly that articulating measures for habitat protection is an essential aspect of Wolverine recovery in Ontario and recommends development of a species specific habitat regulation (Approach 1.5) and technical guidance to support implementation of the regulation. A habitat regulation is recommended to ensure clear articulation of what constitutes comprehensive Wolverine habitat under the ESA. The technical guidance should address land use planning and resource extraction activities at various spatial and temporal scales and define in general terms the activities that may result in damage or destruction of protected habitat.

There are several direct and indirect threats to Wolverine resulting from anthropogenic activities that compound the already limited resilience of this species. Because many of these lack conclusive empirical evidence of their real or potential role in Wolverine decline, continued research will be necessary to link direct and indirect threats and the mechanisms that drive them (Approach 3.2). Moreover, interactions between a species, its habitat and other species in the environment are complex and dynamic. Knowledge of the role played by individual factors and how they act in a cumulative fashion will allow us to improve upon the actions put forward in this recovery strategy and help prevent further reduction of Wolverine range.

Concurrent with the development of this recovery strategy, several policy and planning initiatives with the potential to influence and support Wolverine conservation efforts are underway. Integration of Wolverine recovery efforts should be considered in the development of the Boreal Landscape Guide for forest management planning; the development of the Far North Land Use Planning Strategy and the establishment and implementation of the community-based land use strategies across the Far North of Ontario; the implementation of the Caribou Conservation Plan; active mining and mineral exploration and development (especially the Ring of Fire); renewable energy developments (e.g., wind and waterpower); and the proposed establishment of all weather roads to service development and enhance access to remote First Nation communities. As such, Approaches 4.1 to 5 are identified as critical to ensure that Wolverine recovery is adequately considered within the context of the numerous planning and environmental assessment processes now and in the future. It is important that recovery actions be aligned with other boreal species at risk, particularly woodland caribou, given that these species share the same landscape, similar threats, and have similar large landscape requirements that should be addressed taking an ecosystem approach (Approach 4.1).

To address high levels of uncertainty regarding Ontario Wolverine status and ecology, research on the population ecology of Wolverine in lowland boreal forests, with emphasis on den site selection, productivity and survival rates in both undisturbed and modified habitats is urgently needed to inform future policy and management decisions. Implementation of recovery actions should follow an adaptive management approach. This approach dictates that actions be implemented in an experimental manner designed with adequate controls and with appropriate documentation, monitoring and evaluation to maximize learning potential and adjust management actions accordingly.

Encouraging and securing trapper and First Nation leadership (Approaches 5.1 and 5.2) is essential to achieve recovery. The Recovery Team recognizes the knowledge and expertise these individuals, communities and organizations can provide to support recovery implementation. Immediate action should be taken to engage these groups and secure support for Wolverine recovery.

As well, approaches to alter negative social perceptions of Wolverine will be critical to the success of recovery efforts (Approach 5.4).

2.4 Performance Measures

Evaluation of the achievement of the recovery goal and objectives will require long-term monitoring of ecological and social indicators over large areas (Approaches 3.6-3.8). Although we know what indicators should be utilized, the measurable standards have yet to be determined and should be established through research and where necessary tailored to Ontario. Ecological indicators associated with Wolverine population status (e.g., area of occupancy, probability of persistence, intrinsic rate of increase) reflect the response of Wolverine to recovery actions and the suitability of the landscape to support populations. Social indicators reflect the extent to which recovery actions have been implemented and supported. The spatial and temporal scale and acceptable values of indicators may vary among recovery zones. Regular monitoring and reporting on these indicators will allow comparison against desired outcomes and may suggest adaptation or adjustment of recovery approaches. Baseline values (against which future indicators will be measured to evaluate success), monitoring approaches and spatial and temporal scale of indicators must be established as a first step to developing a program for measuring progress on Wolverine recovery in Ontario.

With respect to the development of habitat suitability models (Approach 3.9), landscape level habitat quality should be assessed according to broad indicators of forest composition and structure. Indicators include:

- level of landscape pattern indices (specific indices should be harmonized with the draft Boreal Landscape Guide) indicating size of contiguous tracts of older conifer-dominated forest; and
- proportion of each recovery zone occupied by infrastructure. May vary by infrastructure class (roads, communities, mines, transmission lines).

Wolverine population status is difficult to assess so indices are used as indirect indicators (Approach 3.7). Indicators should assess relative abundance, range occupancy and population genetics. Abundance and distribution of Wolverine are linked and retraction or expansion of range can usually be interpreted as a change in population size. Occupied range is a concept applied across large spatial extents where habitat varies in suitability over space and time. Criteria for occupied range may vary by recovery zone. Changes within this range will reflect the relative success of recovery actions. Indicators include:

- index of relative abundance of Wolverine and their prey/competitors (caribou, moose, wolves) based on occurrence measures from direct surveys (tracks);

- index of relative abundance based on occurrence measures from indirect surveys (trap line reports);
- size of area in each recovery zone with specified levels of occurrence (highest level in range delineation and is reported by range size). A specific case is the size of the core range area in the Western and Northern recovery zones;
- gene flow across provincial populations (evidence that peripheral populations are readily exchanging dispersers with core populations and demonstrating minimal genetic differentiation);
- high genetic variability within recovery zones (evidence of high numbers of alleles and high levels of heterozygosity);
- level and geographic distribution of Wolverine harvest;
- level and geographic distribution of Wolverine vehicle collisions; and
- biometric data from sampled Wolverine;

Long-term involvement and demonstrated commitment of society in Wolverine conservation and recovery is essential to its success (Approach 3.8). This includes Provincial and First Nations governments, resource development industries, fur trappers and fur managers, environmental agencies, the academic community and the non-affiliated general public. Societal indicators may include:

- level of public awareness of Wolverine recovery and opinions on Wolverine recovery issues;
- reporting rates of Wolverine observations by land users [sign (such as tracks) or provision of biological samples];
- level of utilization of best management practices (i.e., trapping technologies) intended to reduce incidental catch (i.e., number of training sessions provided to trappers and trapper attendance);
- level of harvest of Wolverine and other human caused mortality such as road kills;
- number of, and land area covered by, land use and resource development plans that have specific objectives and management direction to address Wolverine recovery efforts;
- number of plans that adjust their management actions for Wolverine based upon other existing or proposed planning processes;
- level of participation by First Nations governments and neighbouring provincial governments in Wolverine recovery planning, knowledge exchange, research and resource development planning (e.g. Community-based Land Use Plans) designed to address Wolverine recovery;
- quantity and extent of relevant research sponsored and conducted by government, academic and non-government organizations for the purpose of: (a) addressing threats, and (b) improving the scientific basis for understanding Wolverine ecology and management in Ontario;

- compliance with voluntary measures regarding resource and land use activities affecting Wolverine; and
- number of development and resource extraction initiatives that integrate objectives and actions for both caribou and Wolverine conservation.

Regular monitoring and reporting on the above indicators will allow comparison against desired outcomes yet to be determined. A timeframe for the evaluation cycle will need to be developed based upon the level of risk faced by each population (i.e., populations at greater risk will receive greater monitoring frequency or intensity) or through the application of one level of monitoring and evaluation across all geographically defined populations. This will allow for evaluation of the progress of the recovery strategy and provide opportunities to identify additional approaches that may be necessary for Wolverine recovery.

2.5 Area for Consideration in Developing a Habitat Regulation

Under the ESA, a recovery strategy must include a recommendation to the Minister of Natural Resources on the area that should be considered in developing a habitat regulation. A habitat regulation is a legal instrument that prescribes an area that will be protected as the habitat of the species. The recommendation provided below by the author will be one of many sources considered by the Minister when developing the habitat regulation for this species.

The following recommendation for consideration in the development of a habitat regulation for Wolverine in Ontario has been derived to support the attainment of the recovery goal of this strategy (see section 2.1).

In light of the relative infancy of our knowledge of Wolverine ecology in Ontario, provision of a recommendation for an area to be prescribed in a habitat regulation is extremely challenging. However, drawing from knowledge acquired through recent provincial research efforts, extrapolation of relevant literature from alternate jurisdictions and application of a precautionary approach, the recovery team recommends that the entire area captured by the three recovery zones be prescribed as regulated Wolverine habitat under the ESA. This recommendation recognizes that functional habitat for Wolverine is provided at the larger landscape scale and that an ecosystem approach will be required to achieve habitat conservation for this broad-ranging species.

To meet their life history requirements, Wolverine select habitat at multiple spatial scales. For example, functional elements of habitat are provided from the large landscape scale (hundreds of thousands of km^2) to the den site, all of which are necessary to ensure the population sustainability of Wolverine. This means that site-level mitigation of habitat impacts is unlikely to support achievement of the population-level recovery goal. Therefore, in addition to population sustainability a fundamental

objective of Wolverine recovery is to provide for connectivity across Wolverine recovery range in Ontario and to neighbouring jurisdictions. Effective protection of habitat at this scale is necessary to address direct and indirect factors that influence mortality, natality, movement and distribution of Wolverine across the landscape. It is also necessary to facilitate continuous metapopulation connectivity between Ontario and the national Western Wolverine population and between Ontario and the nationally endangered Eastern Population. Delineation at this scale is therefore consistent with recovery objectives (1 and 2) and ultimately the recovery goal. Future boundary refinement of the three recovery zones should encompass historical, current and anticipated future range of Wolverine, accommodating movement across the boreal landscape between Ontario and Manitoba and through to Quebec.

Like most large-bodied carnivores, Wolverine are a highly mobile species, which do not appear to demonstrate a strong or consistent affinity to any particular habitat type. Their scavenging lifestyle requires Wolverine to cover extensive areas in search of food sources. One habitat feature which is of note is the apparent requirement for persistent spring snow cover to support successful denning. Refinement of the area delineated for habitat protection must consider this requirement in addition to the necessity to be located a substantive distance from human disturbance during the denning period. Research results from alternate jurisdictions suggest a requirement for areas with at least one metre of persistent snow depth from February through to May. It is important to note that the entire area does not have to be snow-covered but rather there must be smaller areas in which these conditions persist (due to topography for example) to provide denning opportunities.

Although there are uncertainties regarding the impacts of land use change, other anthropogenic disturbances and the underlying mechanisms, Wolverine nonetheless exhibit a demonstrated vulnerability to such perturbations (discussed extensively in this document). This merits a precautionary approach under the assumption that our knowledge will become more robust with time and will be applied where appropriate towards adjusting recovery actions within the context of adaptive management. This also means that a reductionist approach to habitat protection in which only key features are recognized and regulated as habitat will fall short of the ecosystem-based approach that is recommended for Wolverine and necessary if the recovery goal as proposed is to be realized.

Areas considered unsuitable such as built-up areas, including communities and a reasonable ‘disturbance’ buffer should be excluded from regulation. However areas which may be presently unsuitable but have the potential to be suitable if managed properly (through restorative or rehabilitative action) should be included in the habitat regulation.

GLOSSARY

Committee on the Status of Endangered Wildlife in Canada (COSEWIC): The committee responsible for assessing and classifying species at risk in Canada.

Committee on the Status of Species at Risk in Ontario (COSSARO): The committee established under section 3 of the *Endangered Species Act, 2007* that is responsible for assessing and classifying species at risk in Ontario.

Conservation status rank: A rank assigned to a species or ecological community that primarily conveys the degree of rarity of the species or community at the global (G), national (N) or subnational (S) level. These ranks, termed G-rank, N-rank and S-rank, are not legal designations. The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by the letter G, N or S reflecting the appropriate geographic scale of the assessment. The numbers mean the following:

1 = critically imperilled
2 = imperilled
3 = vulnerable
4 = apparently secure
5 = secure

Endangered Species Act, 2007 (ESA): The provincial legislation that provides protection to species at risk in Ontario.

Species at Risk Act (SARA): The federal legislation that provides protection to species at risk in Canada. This act establishes Schedule 1 as the legal list of wildlife species at risk to which the SARA provisions apply. Schedules 2 and 3 contain lists of species that at the time the act came into force needed to be reassessed. After species on Schedule 2 and 3 are reassessed and found to be at risk, they undergo the SARA listing process to be included in Schedule 1.

Species at Risk in Ontario (SARO) List: The regulation made under section 7 of the *Endangered Species Act, 2007* that provides the official status classification of species at risk in Ontario. This list was first published in 2004 as a policy and became a regulation in 2008.
http://www.mnr.gov.on.ca/en/Business/Species/2ColumnSubPage/276722.html

REFERENCES

Abraham, K.F. and J.E. Thompson. 1998. Defining the Pen Islands caribou herd of southern Hudson Bay. Rangifer Special Issue 10:33–40.

Aronsson, M. 2009. Territorial dynamics of female Wolverine.M.Sc. Thesis. Swedish University of Agricultural Sciences, Uppsala, Sweden.

Aubry, K.B., K.S. McKelvey and J.P. Copeland. 2007. Distribution and broadscale habitat relations of the Wolverine in the contiguous United States. Journal of Wildlife Management 71:2147-2158.

Austin, M. 1998. Wolverine winter travel routes and response to transportation corridors in Kicking Horse Pass between Yoho and Banff National Parks. MSc. Thesis, University of Calgary, Calgary AB. 40 pp.

Banci, V. A. 1982. The Wolverine in British Columbia: distribution, methods of determining age and status of Gulo gulo vancouverensis. Research, Ministries of Environment and Forests. IWIFR-15. Victoria, B.C. 90 p.

Banci, V. 1987. Ecology and behaviour of Wolverine in Yukon. MSc Thesis, Simon Fraser University, Burnaby BC. 178 pp.

Banci, V. 1994. Wolverine. Pages 99-127 *in*: Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, L.J. Lyon and W.J. Zielinski, eds. The scientific basis for conserving forest carnivores: American marten, fisher, lynx and Wolverine in the western United States. Gen.Tech. Rept. RM-254, U.S. Dept. of Agric., For. Serv, Rocky Mountain Forest and Range Experiment Station. Ft. Collins, CO.

Banci, V. and A.S. Harestad. 1988. Reproduction and natality of Wolverine (*Gulo gulo*) in Yukon. Annals Zoologica Fennici 25:265-270.

Banci, V. and A.S. Harestad. 1990. Home range and habitat use of Wolverine *Gulo gulo* in Yukon, Canada. Holarctic Ecology 13:195-200.

Banci, V. and G. Proulx. 1999. Impacts of trapping on furbearer populations in Canada. Alpha Wildlife, Edmonton, AB.

Banfield, A.W.F. 1974. The Mammals of Canada. University of Toronto Press, Toronto, ON. 438 pp.

Berezanski, D. J. 2004. Wolverine. Manitoba Endangered Species Advisory Committee Species Status Report. Unpublished manuscript. Manitoba Conservation, Winnipeg. 13pp.

Bergerud, A.T. 1974. Decline of caribou in North America following settlement. Journal of Wildlife Management 38:757-770.

Boles, B.K. 1977. Predation by wolves on Wolverine. Canadian Field-Naturalist 91:68-69.

Bowman, J., J.C. Ray, A.J. Magoun, D.S. Johnson and F.N. Dawson. 2010. Roads, logging, and the large-mammal community of an eastern Canadian boreal forest. Canadian Journal of Zoology. 88:454-467.

Brodie, J.F. and E. Post. 2009. Nonlinear responses of Wolverine populations to declining winter snowpack. Population Ecology published online 25 December 2009.

Brodie, J.F. and E. Post. 2010. Wolverine and declining snowpack: response to comments. Population Ecology published online 29 September 2010.

Cahn, A.R. 1936. The mammals of Quetico Provincial Park of Ontario. Journal of Mammalogy 18:19-30.

Carroll, C. 2007. Interacting effects of climate change, landscape conversion, and harvest on carnivore populations at the range margin: Marten and Lynx in the northern Appalachians. Conservation Biology 21:1092-1104

Cegelski, C.C., L.P. Waits, N.J. Anderson, O. Flagstad, C. Strobeck and C.J. Kyle. 2006. Genetic diversity and population structure of Wolverine (*Gulo gulo*) populations at the southern edge of their current distribution in North America with implications for genetic viability. Conservation Genetics 7:197-211.

Chappell, D.E., R.A. Van Den Bussche, J. Krizan and B. Patterson. 2004. Contrasting levels of genetic differentiation among populations of Wolverine (*Gulo gulo*) from northern Canada revealed by nuclear and mitochondrial loci. Conservation Genetics 5:759-767.

Copeland, J. 1996. Biology of the Wolverine in Central Idaho. MSc. Thesis, University of Idaho, Moscow, ID. 138 pp.

Copeland, J.P. and R.E. Yates 2006. Wolverine population assessment in Glacier National Park: Progress Report 2004-2005. USDA Forest Service, Rocky Mountain Research Station, Missoula, MT. 42 pp.

Copeland, J. P., K. Aubry, K. McKelvey and S. W. Running. 2006. The implications of global warming on a snow dependent species – a case for the Wolverine. Abstract. Carnivores 2006: Habitats, Challenges and Opportunities. Defenders of Wildlife. St. Petersburg, Florida. November 12-15, 2006.

Copeland, J.P., J.M. Peek, C.R. Groves, W.E. Melquist, K.S. McKelvey, G.W. McDaniel, C.D. Long and C.E. Harris. 2007. Seasonal habitat associations of the Wolverine in central Idaho. Journal of Wildlife Management 71:2201-2212.

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.

COSEWIC 2003. COSEWIC assessment and update status report on the Wolverine *Gulo gulo* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 41 pp.

Courtois, R., J-P. Ouellet, L. Breton, A. Gingras and C. Dussault. 2007. Effects of forest disturbance on density, space use, and mortality of woodland caribou. Ecoscience 14:491-498.

Crins, W.J. 2002. Ecozones, ecoregions and ecodistricts of Ontario (updated). Ontario Ministry of Natural Resources, Ontario Parks, Peterborough. Prepared for the Ecological Land Classification Working Group.

Dauphiné, T.C. 1989. Updated status report on the Wolverine *Gulo gulo*. Committee on the Status of Endangered Wildlife in Canada. 28 pp + i.

Dawson, F. N. 2000. Report on the status of the Wolverine (*Gulo gulo*) in Ontario. Species status report for the Committee on the Status of Species at Risk in Ontario (COSSARO), Ontario Ministry of Natural Resources, Thunder Bay, Ontario, Canada. 39 pp.

Dawson, F. N., A. J. Magoun, J. Bowman and J.C. Ray. 2010. Wolverine, *Gulo gulo*, home range size and denning habitat in lowland boreal forest in Ontario, Canada Canadian Field-Naturalist 124:139-144.

deVink, J-M., D. Berezanski and D. Imrie. 2010. Comments on Brodie and Post: harvest effort: the missing covariate in analyses of furbearer harvest data. Population Ecology published online 29 September 2010.

de Vos, A. 1964. Range changes of mammals in the Great Lakes region. American Midland Naturalist 71:210-231.

Flagstad, O., E. Hedmark, A. Landa, H. Brøseth, J. Perrson, R. Andersen, P. Segerström and H. Ellegren. 2004. Colonization history and noninvasive monitoring of a reestablished Wolverine population. Conservation Biology 18:676-688.

Fisher, J.T. and L. Wilkinson. 2005. The response of mammals to forest fire and timber harvest in the North American boreal forest. Mammal Review 35:51-81.

Fisher, J.T., S.M. Bradbury, A.C. Fisher and L. Nolan.2009. Wolverine on the edge of Alberta's Rockies. Alberta Research Council, Edmonton, Alberta, Canada.

Fortin, C., V. Banci, J. Brazil, M. Crête, J. Huot, M. Huot, R. Lafond, P. Paré, J. Shaefer and D. Vandal. 2005. National recovery plan for the Wolverine (*Gulo gulo*) [Eastern Population]. National Recovery Plan No. 26. Recovery of Nationally Endangered Wildlife (RENEW). Ottawa, Ontario. 33 pp.

Gardner, C.L. 1985. The ecology of Wolverine in southcentral Alaska. MSc. Thesis, University of Alaska, Fairbanks, AK. 82 pp.

Gardner, C. L., W. B. Ballard and R.H. Jessup. 1986. Long distance movement by an adult Wolverine. Journal of Mammalogy 67:603.

Golden, H.N., A.M. Christ and E.K. Solomon. 2007. Spatiotemporal analysis of Wolverine *Gulo gulo* harvest in Alaska. Wildlife Biology 13(Suppl. 2):68-75.

Guiliazov, A.S. 1998. Causes of reindeer (*Rangifer tarandus*) and moose (*Alces alces*) mortality in the Lapland Reserve and its surroundings. Alces 34:319-327.

Gustine, D.D., K.L. Parker, R.J. Lay, M.P. Gillingham and D.C. Heard. 2006. Calf survival of woodland caribou in a multi-predator ecosystem. Wildlife Monographs 165:1-32.

Hagen, A.N. and K.E. Hodges. 2006. Resolving critical habitat designation failures: reconciling law, policy, and biology. Conservation Biology 20:399-407.

Haglund, B. 1966. Winter habits of the lynx (*Lynx lynx* L.) and Wolverine (*Gulo gulo* L.) as revealed by tracking in the snow. Viltrevy 4:81-309.

Haglund, B. 1974. Moose relations with predators in Sweden, with special reference to bear and Wolverine. Le Naturaliste Canadien 101:457-466.

Hall, E.R. and K.R. Kelson. 1959. The Mammals of North America. Ronald Press Co., NY.

Hash, H.S. 1987. Wolverine. Pages 575-585 *in*: M. Novak, J.A. Baker, M.E. Obbard, and B. Malloch, eds. Wild Furbearer Management and Conservation in North America. Ontario Trappers Assoc., North Bay, ON.

Hornocker, M.G. and H.S. Hash. 1981. Ecology of the Wolverine in northwestern Montana. Canadian Journal Zoology 59:1286-1301.

Inman, R.M., R.R. Wigglesworth, K.H. Inman, M.K. Schwartz, B.L. Brock and J.D. Rieck. 2004. Wolverine makes extensive movements in the Greater Yellowstone Area. Northwest Science 78:261-266.

Inman, R. M., K. H. Inman, A. J. McCue, M. L. Packila, G. C. White, and B. C. Aber. 2007a. Wolverine space use in Greater Yellowstone. Chapter 1 *In:* Greater Yellowstone Wolverine Program Cummulative Report May 2007. Wildlife Conservation Society, North America Program.

Inman, R. M., K. H. Inman, A. J. McCue and M. L. Packila. 2007b. Wolverine harvest in Montana: Survival rates and spatial considerations for harvest management. Chapter 5 *In:* Greater Yellowstone Wolverine Program Cumulative Report May 2007. Wildlife Conservation Society, North America Program.

Inman, R.M., M.L. Packila, K.H. Inman, B. Aber, R. Spence and D. McCauley. 2009. Greater Yellowstone Wolverine Program, Progress Report – December 2009. Wildlife Conservation society, North American Program, general report, Bozeman, Montana, U.S.A.

Johnson, C.S. 1990. Re-evaluation of the status of the Wolverine in Manitoba. Manitoba Natural Resources, Tech. Rept. No. 90-01. Winnipeg, MB. 25 pp.

Kelsall, J.P. 1982. Status report on the Wolverine, *Gulo gulo*, in Canada in 1981. COSEWIC, Ottawa, ON. 47 pp.

Koen, E.L., J.C. Ray, J. Bowman, F.N. Dawson and A.J. Magoun. 2008. Surveying and monitoring Wolverine in Ontario and other lowland, boreal forest habitats: Recommendations and protocols. Ont. Min. Natur. Resour.,Northwest Sci. and Info. Thunder Bay, Ont. NWSI Field Guide FG-06. 94 pp. + append.

Kozhechkin, V., A. Shishikin and I. Tumanov. 2005. Moose (*Alces alces*) mortality caused by Wolverine in the forest zone of Krasnoyarsk Territory, Russia. Oral presentation abstract, 1st International Symposium on Wolverine Research and Management. June 13-15, Jokkmokk, Sweden.

Krebs, J. and D. Lewis. 2000. Wolverine ecology and habitat use in the North Columbia Mountains: Progress Report. Pages 695-703 *in:* L.M. Darling, (ed.). Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamploops, B.C., 15-19 Feb., 1999. Volume Two. B.C. Ministry of Environment, Lands and Parks, Victoria, BC and University College of the Cariboo, Kamloops, BC.

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 Wolverine. J ournal of Wildlife Management 68:493-502.

Krebs, J., E.C. Lofroth and I. Parfitt. 2007. Multiscale habitat use by Wolverine in British Columbia, Canada. Journal of Wildlife Management 71:2180-2192.

Krott, P. 1960. Ways of the Wolverine. Natural History 69:16-29.

Kurten, B. and R. Rausch. 1959. A comparison between Alaskan and Fennoscandian Wolverine (*Gulo gulo* Linnaeus). Acta Arctica 11:5-20.

Kyle, C.J. and C. Strobeck. 2001. Genetic structure of North American Wolverine *(Gulo gulo)* populations. Molecular Ecology 10:337-347.

Kyle, C.J. and C. Strobeck. 2002. Connectivity of peripheral and core populations of North American Wolverine. Journal of Mammalogy 83:1141-1150.

Landa, A., O. Strand, J.E. Swenson and T. Skogland. 1997. Wolverine and their prey in southern Norway. Canadian Journal of Zoology 75:1292-1299.

Landa, A., S. Krogstad, B.A. Tommeras and J. Tufto. 1998. Do volatile repellents reduce Wolverine *Gulo gulo* predation on sheep? Results of a large-scale experiment. Wildlife Biology 4:111-118.

Lee, J. and A. Niptanatiak. 1996. Observation of repeated use of a Wolverine, *Gulo gulo*, den on the tundra of the Northwest Territories. Canadian Field-Nataturalist 110:349-350.

Liskop, K.S., R. Sadleir and B. Saunders. 1981. Reproduction and harvest of Wolverine (*Gulo gulo* L.) in British Columbia. Pages 469-477 *in*: Chapman, J.A. and D. Pursley, eds. Proceedings of the Worldwide Furbearer Conference. Frostburg, MD.

Lofroth, E.C. 2001. Wolverine ecology in plateau and foothill landscapes 1996 - 2001. 2000/01 Year End report, Northern Wolverine Project. Forest Renewal Activity No. 712260. Ministry of Environment, Lands and Parks, Victoria, BC. 98 pp.

Lofroth, E.C. and J. Krebs. 2007. The abundance and distribution of Wolverine in British Columbia, Canada. Journal of Wildlife Management 71:2159-2169.

Lofroth, E.C. and P.K. Ott. 2007. Assessment of the sustainability of Wolverine harvest in British Columbia, Canada. Journal of Wildlife Management 71:2193-2200.

Lofroth, E.C., J.A. Krebs, W.L. Harrower and D. Lewis. 2007. Food habits of Wolverine *Gulo gulo* in montane ecosystems of British Columbia, Canada. Wildlife Biology 13 (Suppl. 2):31-37.

Loutitt, S. 2009. Ishi ka na wa pah ta mahk kit aski nanu: Our view of the land. Moose Cree First Nation Resource Protection. March 2009.12 pp.

Magoun, A.J. 1985. Population characteristics, ecology and management of Wolverine in northwestern Alaska. PhD. Thesis. University of Alaska, Fairbanks, AK. 197 pp.

Magoun, A.J. 1987. Summer and winter diets of Wolverine, *Gulo gulo*, in Arctic Alaska. Canadian Field-Naturalist 101:392-397.

Magoun, A.J. and J. Copeland. 1998. Characteristics of Wolverine reproductive den sites. Journal of Wildlife Management 62:1313-1320.

Magoun, A. J., K. F. Abraham, J. E. Thompson, J. C. Ray, M. E. Gauthier, G. E. Brown, G. Woolmer, C. J. Chenier and F. N. Dawson. 2005a. Distribution and relative abundance of caribou in the Hudson Plains Ecozone of Ontario. Rangifer special issue 16:105-121.

Magoun, A., G. Carroll, J. Krebs, E. Lofroth and P. Valkenburg. 2005b. Wolverine predation on moose in North America. Poster presentation abstract, 1st International Symposium on Wolverine Research and Management. June 13-15, Jokkmokk, Sweden.

Magoun, A., J. C. Ray, D. S. Johnson, P. Valkenburg, F. N. Dawson and J. Bowman. 2007. Modeling Wolverine occurrence using aerial surveys of tracks in snow. Journal of Wildlife Management 71:2221-2229.

May, R., A. Landa, J. van Dijk, J.D.C. Linnell and R. Andersen. 2006. Impact of infrastructure on habitat selection of Wolverine *Gulo gulo*. Wildlife Biology 12:285-295.

May, R. 2007. Spatial ecology of Wolverine in Scandinavia. Ph.D. Thesis. Norweigian University of Science and Technology, Trondheim, Norway. 209 pp.

McKelvey, K.S., J.P. Copeland, M.K. Schwartz, J.S. Littell, K.B. Aubry, J.R. Squires, S.A. Parks, M. McGuire Elsner and G.S. Mauger. In Review. Predicted effects of climate change on Wolverine distribution and movement in western North America.

MI DNRE. 2010. DNRE Confirms Death of Michigan's Only Known Wild Wolverine. News Release posted on Michigan Department of Natural Resources and Environment March 15, 2010. http://www.michigan.gov/dnr/0,1607,7-153-10371_10402-233468--,00.html

Miller, F.L. 1972. Wolverine in Gatineau Park, Quebec. Canadian Field-Naturalist 86:390.

Moisan, M. 1996. Status report on the Wolverine (*Gulo gulo*) in Quebec and Labrador. Unpublished report, Ministere de l'Environnemont et de la Faune, Quebec, PQ. 70 pp.

Moriarty, K.M., W.J. Zielinski, A.G. Gonzales, T.E. Dawson, K.M. Boatner, C.A. Wilson, F.V. Schlexer, K.L. Pilgrim, J.P. Copeland and M.K. Schwartz. 2009. Wolverine confirmation in California after nearly a century : native or long-distance migrant? Northwest Science 83 :154-162.

Mulders, R. 2000. Wolverine ecology, distribution and productivity in the Slave Geological Province. Final report to the West Kitikmeot/Slave Study Society. Dept. of Resources, Wildlife and Economic Development, Government of the Northwest Territories, Yellowknife, Northwest Territories. Vi + 30 pp + tables, figs, and append.

Myrberet, S. 1968. Jervens ynglehi [The breeding den of the Wolverine, *Gulo gulo*]. Fauna (Oslo) 21:108-115.

Novak, M. 1975. Recent status of the Wolverine in Ontario. Ontario Ministry of Natural Resources, Toronto, ON. 16 pp.

OMNR 1990. Management of Timber for Featured Wildlife Species. Ont. Min. Natur. Resour. Wildlife Policy 6.04.01.

OMNR. 2000. Forest Operations and Silviculture Manual First Edition February 20, 1995, Amended April 1, 2000, Ont Reg 283/00. Queen's Printer for Ontario, Toronto. 34 pp + append.

OMNR. 2004a. Species at risk in Ontario list. Ont. Min. Natur. Resour. Report, Peterborough, Ontario. 8 pp.

OMNR. 2010. Forest Management Guide for Conserving Biodiversity at the Stand and Site Scales. Toronto: Queen's Printer for Ontario. 211 pp.

OMNR. 2008b. SAR policy 4.1 – Habitat protection for endangered, threatened and extirpated species under the Endangered Species Act, 2007 (July 2008) (available at http://www.mnr.gov.on.ca/en/Business/Species/2ColumnSubPage/241604.html). 14pp.

OMNR. 2009a. Forest Management Planning Manual for Ontario's Crown Forests. Toronto: Queen's Printer for Ontario. 447 pp.

OMNR. 2009b. Ontario's Caribou Conservation Plan. Ont. Min. Natur. Resour., Toronto, Ontario. 24pp.

Ontario Woodland Caribou Recovery Team. 2007. Recovery Strategy for Woodland Caribou (*Rangifer tarandus caribou*) (Forest-dwelling, Boreal Population) in Ontario. Species at Risk Section, Ontario Parks, Ministry of Natural Resources, Peterborough, Ontario. 83 pp. + append.

Pasitchniak-Arts, M. and S. Lariviere. 1995. *Gulo gulo*, Mammalian Species. American Society of Mammalogists 499:1-10.

Peacock, S. 2011. Projected 21st century climate change for Wolverine habitats within the contiguous United States. Environmental Research Letters 6 (2011) 014007 (9pp)

Persson, J. 2003. Population ecology of Scandinavian Wolverine. Doctorol thesis, Swedish University of Agricultural Sciences. Silvestria 262. Umeå, Sweden.

Persson, J., T. Willebrand, A. Landa, R. Andersen and P. Segerström. 2003. The role of intraspecific predation in the survival of juvenile Wolverine *Gulo gulo*. Wildlife Biology 9:21-28.

Persson, J. 2005. Female Wolverine (*Gulo gulo*) reproduction: reproductive costs and winter food availability. Canadian Journal of Zoology 83:1453-1459.

Peterson, R.L. and V. Crichton. 1949. The fur resources of Chapleau District, Ontario. Canadian J. Res. D. 27:68-84.

Powell, R.A. 1979. Mustelid spacing patterns: variations on a theme by *Mustela*. Zhurnal Tierpsychologie 50:153-165.

Pulliainen, E. 1968. Breeding biology of the Wolverine (*Gulo gulo* L.) in Finland. Annales Zoologica Fennici 5:338-344.

Quick, H.F. 1953. Wolverine, fisher and marten studies in a wilderness region. Transactions of the North American Widlife Conference 18:513-532.

Racey, G.D. and T. Armstrong. 2000. Woodland caribou range occupancy in northwestern Ontario:past and present. Rangifer, Special Issue 12:173-184.

Rausch, R.L. 1959. Studies of the helminth fauna of Alaska. XXXVI. Parasites of the Wolverine, *Gulo gulo* L., with observations on the biology of *Taenia twirchelli* Scwartz 1924. Journal of Parisitology 45:465-484.

Rausch, R.L. and A.M. Pearson. 1972. Notes on the Wolverine in Alaska and the Yukon Territory. Journal of Wildlife Management 36:249-268.

Ray, J. 2004. Collecting ATK on Wolverine in northern Ontario. Appendix 6 (pp. 94-98) in Cardinal, N. Aboriginal Traditional Knowledge and the COSEWIC Species Assessment Process: A Case Study of Northern Canada Wolverine. Report for the Committee on the Status of Endangered Wildlife In Canada (COSEWIC), Ottawa, ON.

Ray, J., N. Dawson, A. Magoun and J. Bowman. 2005. Cultural relationships of northern trappers with Wolverine: a case study from Ontario. Oral presentation abstract, 1st International Symposium on Wolverine Research and Management. June 13-15, Jokkmokk, Sweden.

Ray, J. and N. Dawson. 2006. Why is the Wolverine a threatened species in Ontario? Ontario Fur Managers Federation: Summer 2006 Vol. 11, No. 2.

Rowland, M.M., M.J. Wisdom, D.H. Johnson, B.C. Wales, J.P. Copeland and F.D. Edelmann. 2003. Evaluation of landscape models for Wolverine in the interior northwest, United States of America. Journal of Mammalogy 84:92-105.

Ruggiero, L. F., S. W. Buskirk, K. B. Aubry, L. J. Lyon and W. J. Zielinski. 1994. Information needs and a research strategy for conserving forest carnivores. Pages 138 – 152 *in*: L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon and W. J. Zielinski, eds. The Scientific basis for conserving forest carnivores: American marten, fisher, lynx and Wolverine in the western United States. Gen. Tech. Rept. RM-254, U.S. Dept. of Agric., For. Serv., Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO.

Sandell, M. 1989. The mating tactics and spacing patterns of solitary carnivores. Pages 164-182 *in*: Gittleman, J.L. ed. Carnivore Behaviour, Ecology and Evolution. Cornell University Press, New York.

Sæther, B-E., S. Engen, J. Persson, H. Brøseth, A. Landa and T. Wildebrand. 2005. Management strategies for the Wolverine in Scandinavia. Journal of Wildlife Management 69:1001-1014.

Schaefer, J.A. 2003. Long-term range recession and the persistence of caribou in the taiga. Conservation Biology 17:1435-1439.

Schmelzer, I. 2005. Occurrence and distribution of Wolverine in northern Labrador: and aerial survey to clarify status and focus recovery. Wildlife Division, Government of Newfoundland and Labrador. St. John's: NL. Unpublished Report. 32 pp. + app.

Schwartz, C.C. and A.W. Franzmann. 1989. Bears, wolves, moose, and forest succession, some management considerations on the Kenai Peninsula, Alaska. Alces 25:1-10.

Schwartz, M.K., J.P. Copeland, N.J. Anderson, J.R. Squires, R.M. Inman, K.S. McKlevey, K.L. Pilgrim, L.P. Waits and S.A. Cushman. 2009. Wolverine gene flow across a narrow climatic niche. Ecology 90:3222-3232.

Slough, B.G. 2007. Status of the Wolverine *Gulo gulo* in Canada. Wildlife Biology 13(Suppl. 2):76-82.

Statutes of Canada. 2003. S pecies at Risk Act. Canada Gazette Part III. Queen's Printer for Canada. 25(3).

Statutes of Ontario. 2007. An Act to protect species at risk and to make related changes to other Acts (*Endangered Species Act, 2007*). Printed by the Legislative Assembly of Ontario.

Squires, J.R., D.H. Pletscher, T.J. Ulizio and L.F. Ruggiero. 2006. The association between landscape features and transportation corridors on movements and habitat-use patterns of Wolverine. FHWA/MT-06-005/8171 Final Report prepared for the Montana Department of Transportation. 53 pp.

Squires, J.R., J.P. Copeland, T.J. Ulizio, M.K. Schwartz and L.F. Ruggiero. 2007. Sources and patterns of Wolverine mortality in western Montana. Journal of Wildlife Management 71:2213-2220.

Teplov, V.P. 1955. On the winter ecology of the glutton in the Pechora Natura Preserve. Byull. Mosk. Obsch. Ispyt. Prir., Otd. Biol. 60:1 [cited by Haglund 1974].

Thompson, I.D. 1994. Marten populations in uncut and logged boreal forests in Ontario. Journal of Wildlife Management 58:272-280.

Thompson, I.D. and P.W. Colgan. 1987. Numerical responses of martens to a food shortage in northcentral Ontario. Journal of Wildlife Management 51:824-835.

Thompson, R. 1929. The Wolverine. Forest and Stream 12:934.

Tomasik, E. and J.A. Cook. 2005. Mitochondrial phylogeography and conservation genetics of Wolverine (*Gulo gulo*) of northwestern North America. Journal of Mammalogy 86:386-396.

Van Dijk, J., T. Andersen, R. May, Re. Andersen, Ro. Andersen and A. Landa. 2008. Foraging strategies of Wolverine within a predator guild. Canadian Journal of Zoology 86:966-975.

Vangen, K.M., J. Perrson, A. Landa, R. Anderson and P. Segerström. 2001. Characteristics of dispersal in Wolverine. Canadian Journal of Zoology 79:1641-1649.

van Zyll de Jong, C.G. 1972. The status of the Wolverine in Manitoba. Manitoba Dept. of Mines, Resources and Environmental Mgt., Research Branch, M.S. Rep. No. 72-2. 17 pp.

van Zyll de Jong, C.G. 1975. The distribution and abundance of the Wolverine (*Gulo gulo*) in Canada. Canadian Field-Naturalist 89:431-437.

Venter, O., N.N. Brodeur, L. Nemiroff, B. Belland, I.J. Dolinsek and J.W.A. Grant. 2006. Threats to endangered species in Canada. Bioscience 56:1-8.

Vors, L.S., J.A. Schaefer, B.A. Pond, A.R. Rodgers and B.R. Patterson. 2007. Woodland caribou extirpation and anthropogenic landscape disturbance in Ontario. Journal of Wildlife Management 71:1249-1256.

Watson, H. 2009. Food habit study of the Wolverine (Gulo gulo) in northwestern Ontario: and analysis of the stomach and intestinal tract using negative hair impressions. Undergradute Thesis, Faculty of Forestry and the Forest Environment, Lakehead University. 33 pp.

Weaver, J.L., P.C. Paquet and L.F. Ruggiero. 1996. Resilience and conservation of large carnivores in the Rocky Mountains. Conservation Biology 10:964-976.

Wedholm, P. 2006. Territoriality and social organization in Scandinavian Wolverine *Gulo gulo*. Dept. of Animal Ecology, Swedish University of Agricultural Sciences, Umeå, Sweden. 28 pp.

Whitman, J.S. and W.B Ballard. 1983. Big game studies. [Unpubl. Rep.]. Vol. VII, Wolverine. Alaska Dept. of Fish and Game. Susitna Hydroelectric Project; Phase II Progress Report. 25 pp.

Whitman, J.S., Ballard, W.B. and C.L. Gardner. 1986. Home range and habitat use by Wolverine in southcentral Alaska. Journal of Wildlife Management 50:460-462.

Wilson, D.E. 1982. Wolverine *Gulo gulo*. Pp. 644-652 *in* Chapman, J.A. and G.A. Feldhamer, eds. Wild Mammals of North America: biology, management and economics. Johns Hopkins University Press, Baltimore and London.

Wilson, G.M., R.A. Van Den Bussch, P.K. Kennedy, A. Gunn and K. Poole. 2000. Genetic variability of Wolverine (*Gulo gulo*) from the Northwest Territories, Canada: conservation implications. Journal of Mammalogy 81:186-196.

Wittmer, H.U., B.N. McLellan, R. Serrouya and C.D. Apps. 2007. Changes in landscape composition influence the decline of a threatened woodland caribou population Journal of Animal Ecology 76:568-579.

Wiwchar, D.M.A. 2004. Prey specialization, morphological conformation and sexual dimorphism in wolves and diets of black bears, lynx and Wolverine associated with woodland caribou in the boreal forest of northwestern Ontario. MSc.Thesis. Laurentian University, Sudbury, Ontario. 58 pp.

Wright, J.D. and J. Ernst. 2004a. Effects of mid-winter snow depth on stand selection by Wolverine, *Gulo gulo luscus*, in the boreal forest. Canadian Field-Naturalist 118:56-60.

Wright, J.D. and J. Ernst. 2004b. Wolverine, *Gulo gulo luscus*, resting sites and caching behavior in the boreal forest. Canadian Field-Naturalist 118:61-64.

Zigouris, J., N. Dawson, R.M. Gillet, J. Bowman, J.A. Schaefer and C.J. Kyle. In Prep. Genetic isolation of Wolverine (Gulo gulo) populations at the eastern periphery of their North American distribution.

RECOVERY STRATEGY DEVELOPMENT TEAM MEMBERS

NAME	AFFILIATION and OFFICE
Recovery Strategy Development Team	
Hilary Gignac (Co-chair)	OMNR, Northwest Region Planning Unit
Neil Dawson (Co-chair)	OMNR, Northwest Science and Information
Kim Austen	OMNR, Red Lake District
Danielle Berube**	OMNR, Sioux Lookout District
Chris Chenier	OMNR, Cochrane District
Howard Noseworthy*	Ontario Fur Managers Federation
Paul Parsons (alternate for Howard Noseworthy)	Ontario Fur Managers Federation
David Peerla*	Nishnawbe Aski Nation
Gerry Racey	OMNR, Northwest Science and Information
Justina Ray	Wildlife Conservation Society Canada
Lori Skitt**	OMNR, Red Lake District
Advisors* **	
Anna Baggio	Wildlands League
Jeff Bowman	OMNR, Applied Research and Development
Karen Hartley	OMNR, Species at Risk Unit
Chris Heydon	OMNR, Wildlife Section
Peter Kapashesit	OMNR, Moosonee Area
Steve Kingston	OMNR, Northwest Park Zone
Dana Kinsman	OMNR, Forest Management Branch
Audrey Magoun	WRAM, Alaska
Brian McLaren	Lakehead University
Tommy Miles	Fort Severn First Nation
Tom Nudds	University of Guelph

* Individuals were members of initial recovery team, initiated in 2006. Howard Noseworthy left the Recovery Team in October, 2008 and David Peerla left in December 2006.
** Individuals joined Recovery Team in 2009.
*** The Advisory Committee was utilized during the preliminary phases of drafting the recovery strategy 2006 – 2007.