

Status of Mammalian Carnivores and Evaluation of Monitoring Techniques in the Lake Superior Basin



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NRRI Technical Report No. NRRI/TR-2014/37 Release 1.1

Please contact authors before citing as manuscripts are in review and in preparation
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Summary

In this report we summarize current methods used by state, provincial, and federal agencies to monitor carnivores in the Lake Superior basin and discuss alternative techniques that could be used to monitor carnivores. Within the Lake Superior Watershed (LSW) there are now up to 20 carnivore species, ranging in size from the tiny least weasel (*Mustela nivalis*) to the black bear (*Ursus americanus*). Varied data sources help determine past and present distribution of carnivores in the LSW, such as museum records, DNR/MNR records, books, and the scientific literature. However, there is no single source for information on carnivores in the LSW. The Mustelidae has 9 species, the Canidae has 4 species, the Felidae have 3 species, the Mephitidae have 2 species, and there is 1 species in the Ursidae and 1 in the Procyonidae. We reviewed literature on the status of each species across its range, and also on status within the Lake Superior Watershed when possible. We searched for existing records of specific locations available in on-line research collections. We also summarized harvest records of each species when it was available within a jurisdiction. Finally, we summarized the methods currently used to monitor carnivore populations that are in the peer-reviewed literature. For each species we include some data on size, distribution, and harvest when possible. This report can be used as a baseline for distribution and numbers of carnivore species in the Lake Superior Watershed. It would be desirable at some point to search museum collections online again, or in person. Collections from some of the small museums are not likely to be digitized and accessible for internet searches. For the future, it would provide background data for developing monitoring techniques to serve as a basin-wide monitoring protocol that can be adopted (and modified as appropriate) by stakeholder agencies.

About the cover: These images of a Canada lynx (*Lynx canadensis*), a fisher (*Martes pennanti*), a red fox (*Vulpes vulpes*), and an ermine (*Mustela erminea*) were taken with trail cameras in northeastern Minnesota.

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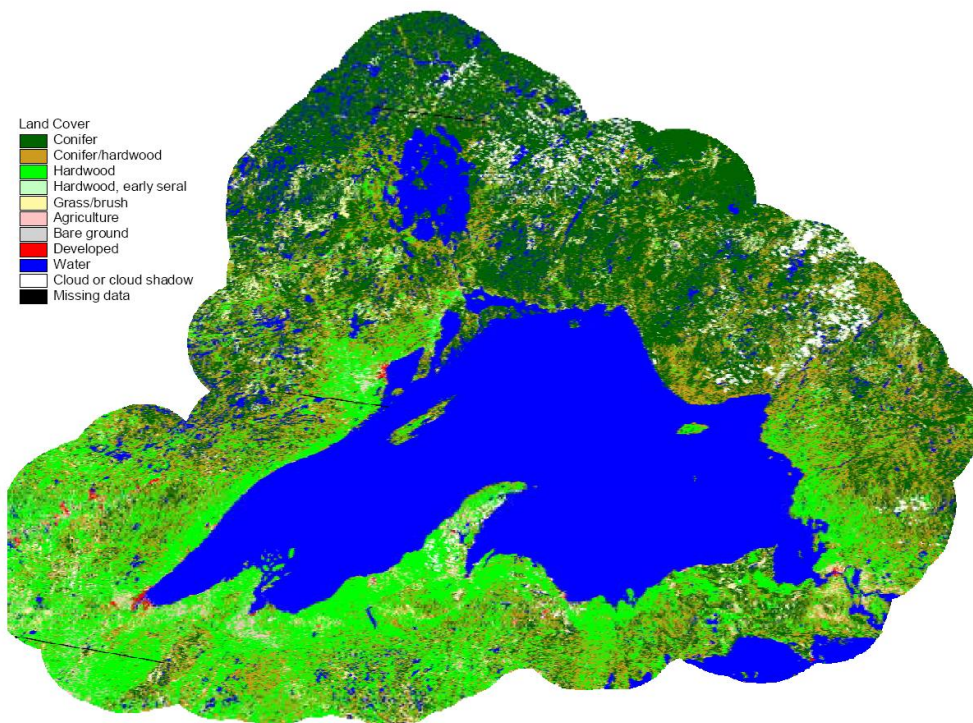
Introduction

The Lake Superior Binational Program (LSBP) is a partnership of Federal, State, Provincial, and Tribal/First Nations governments working together with citizens to ensure the protection of the Lake Superior watershed. The LSBP has completed a Lakewide Management Plan¹, which identified a need to expand current knowledge of distribution and monitoring effort on animal species in the Lake Superior watershed (LSW). A reptile and amphibian status report was completed in 2002 (Casper 2002). A report on the status of mesocarnivores was also recommended. This report covers all carnivore species in the LSW, including several small carnivore species, mesocarnivores, and three large carnivore species.

Carnivores are simultaneously loved and feared by many members of the public. Within the Lake Superior Watershed (LSW) there are now up to 20 carnivore species, ranging in size from the tiny least weasel (*Mustela nivalis*) to the black bear (*Ursus americanus*). There are several varied data sources to determine past and present distribution of carnivores in the LSW, such as museum records, DNR/MNR records, books, and the scientific literature. However, there is no single source for information on carnivores in the LSW, despite their management importance and their importance to ecosystem functioning. In fact, as top-level predators, carnivores may be an ideal taxonomic group to monitor as an indicator of ecosystem health.

One reason there are so many carnivore species is the geographic position of Lake Superior. The Lake Superior Watershed has forest communities associated with northern hardwood forests on the south, and forest communities associated with the boreal forest on the north (Fig. 1). Some animal and plant species are at the edges of their range in this transition between northern hardwood forests and boreal forests. For other species the Lake Superior Watershed is literally in the center of the species range in North America.

Figure 1. Major land cover categories in the Lake Superior Watershed (Lake Superior LaMP 2006 Fig. 23). Primarily hardwood forests in the south change to conifer forests on the north side of Lake Superior.



¹ <http://www.epa.gov/glnpo/lakesuperior/lamp2000/index.html>

Carnivore species at the southern edge of their distribution in the LSW include the wolverine (*Gulo gulo*) and the Canada lynx (*Lynx canadensis*). The eastern spotted skunk (*Spilogale putorius*), the gray fox (*Urocyon cinereoargenus*), and the bobcat (*Lynx rufus*) are at the northern edge of the species distribution. About half of the carnivore species in the LSW are present throughout the LSW, including the black bear (*Ursus americanus*), the gray wolf (*Canis lupus*), red fox (*Vulpes vulpes*), and the mink (*Mustela vison*). In addition there is a gradient from rare to common species among carnivores in the LSW. The wolverine and the mountain lion (*Felis concolor*) are very rare, while the black bear, raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*) are relatively common where they are present.

Given that many of these carnivores range throughout the LSW watershed, they could be an important set of species to monitor in a comprehensive measure of ecosystem health. Carnivores, as top-level predators, could be ideal proxy measures of overall ecosystem health. Presence of a complete carnivore community would indicate a healthy ecosystem. Conversely, a partial or declining carnivore community might be the result of low prey availability, human development, or cascading effects of ecosystem contamination or modifications at lower trophic levels.

Methods

Members of the order Carnivora found in the Lake Superior watershed are in 6 families (Table 1). Mustelidae, the weasel family, has 9 species, more than any other family. Mephitidae, the skunk family, historically has also been placed in the Mustelidae family. We summarize data for all species in the order Carnivora because there are so few species outside of the mesocarnivore classification and because it was relatively simple to expand our search effort to include all carnivores. Species larger than mesocarnivores are the wolf, the mountain lion and the black bear. Smaller species that would not be considered mesocarnivores include the least weasel and the ermine. Some smaller species are borderline, e.g., the mink and the long-tailed weasel. With these divisions, 13 of 20 members of Carnivora are within the mesocarnivore category, 4 of 20 may be too small to be considered mesocarnivores, and 3 of 20 are too big to be considered mesocarnivores (Table 1).

Table 1. Carnivore species included in this report. Relative size gives an indication of typical identification as a mesocarnivore. Under the LWMP column species identified as mesocarnivores in the LWMP are listed.

Family	Species	Common name	Relative size	LWMP
Canidae	<i>Canis latrans</i>	Coyote	Meso	
	<i>Canis lupus</i>	Gray wolf	Large	
	<i>Urocyon cinereoargenteus</i>	Gray fox	Meso	Yes
Felidae	<i>Vulpes vulpes</i>	Red fox	Meso	Yes
	<i>Lynx canadensis</i>	Canada lynx	Meso	Yes
	<i>Lynx rufus</i>	Bobcat	Meso	Yes
Mephitidae	<i>Felis concolor</i>	Mountain lion, cougar	Large	
	<i>Mephitis mephitis</i>	Striped skunk	Meso	
	<i>Spilogale putorius</i>	Eastern spotted skunk	Meso	
Mustelidae	<i>Lutra canadensis</i>	River otter	Meso	Yes
	<i>Gulo gulo</i>	Wolverine	Meso	
	<i>Martes americana</i>	Pine marten	Meso	Yes
	<i>Martes pennanti</i>	Fisher	Meso	Yes
	<i>Mustela erminea</i>	Ermine, short-tailed weasel	Small	
	<i>Mustela frenata</i>	Long-tailed weasel	Small	
	<i>Mustela nivalis</i>	Least weasel	Small	
	<i>Mustela vison</i>	Mink	Small	Yes
	<i>Taxidea taxus</i>	Badger	Meso	Yes
Procyonidae	<i>Procyon lotor</i>	Raccoon	Meso	
Ursidae	<i>Ursus americanus</i>	Black bear	Large	

We reviewed literature on the status of each species across its range, and also on status within the Lake Superior Watershed when possible. We also searched for existing records of specific locations available in on-line research collections. We queried the Global Biodiversity Information Facility (GBIF) database via the Royal Ontario Museum² and the Mammal Networked Information System (MaNIS) via the Museum of Vertebrate Zoology database at the University of California, Berkeley (MVZ³), to gather information on museum collection specimens for all mammalian carnivores, including furbearers, in the Lake Superior watershed region. We cross-referenced many of the records received through GBIF and MVZ with individual museum collections databases (e.g., Field Museum, American Museum of Natural History). The information obtained using these databases is not complete. Many museums containing large mammal collections provide data to GBIF or MVZ. Other museums and mammal collections may

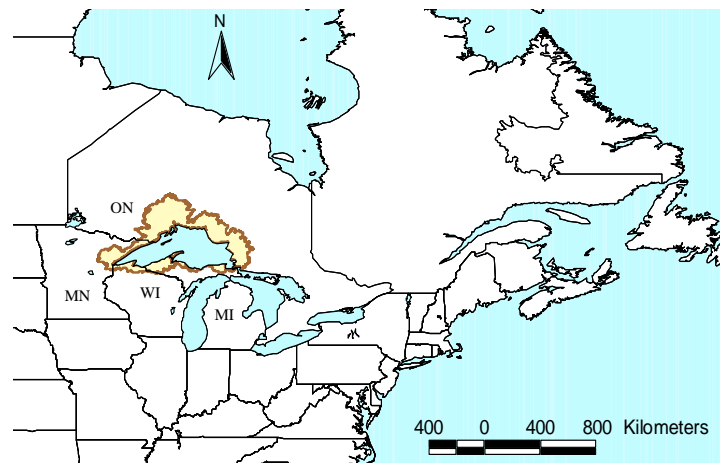
² www.gbif.org, <http://data.gbif.org/datasets/resource/657>

³ <http://manis.mvz.berkeley.edu/>

not be available via the computerized databases. A listing of all institutions providing collections data to GBIF and MVZ is available⁴. Only georeferenced specimens were included in query results.

We also considered harvest records of each species when it was available within a jurisdiction. For harvest records, it was rare for data to be available for the LSW because it is such a small part of Minnesota, Wisconsin, Michigan, or Ontario (Fig. 2). We searched the websites of the Minnesota, Wisconsin, and Michigan DNR and Parks Canada and contacted relevant personnel at these agencies to obtain information about survey reports and hunter/trapper questionnaire records. These publications were used to summarize current research methods and findings concerning mammalian carnivores in the Lake Superior basin. Finally, we summarize the methods currently used to monitor carnivore populations that are in the peer-reviewed literature.

Figure 2. The Lake Superior watershed (tan) includes parts of Ontario, Minnesota, Wisconsin, and the Upper Peninsula of Michigan.



Results

Species accounts

Species accounts are brief summaries of each carnivore species covered in this report, indicating body length, body mass, natural history, expected distribution based on literature reviews, and distribution of museum records plotted as a map. Many of these carnivores have an expected distribution that includes the entire LSW.

Members of Canidae, the dog family, include the gray wolf (*Canis lupus*) and several smaller mesocarnivores. The wolf is too large to be a mesocarnivore. Both the gray wolf and the red fox (*Vulpes vulpes*) have counterparts in Europe and Asia that are the same species.

The black bear (*Ursus americanus*) is the only ursid in the LSW, and it is too large to be a mesocarnivore. Black bears are harvested as big game species in Ontario, Minnesota, Michigan, and Wisconsin.

There are two skunk species potentially found within the LSW. The striped skunk is found in all parts of the LSW although it is less common in the Ontario portion. The eastern spotted skunk is nearing the

⁴ Institutions providing collection data: <http://data.gbif.org/datasets/> and at <http://manisnet.org/>

northern edge of its range and is not found in the eastern or northern portions of the LSW. It may not even be present in the western part of the LSW (Wires and Baker 1994).

Of the three felid species, Canada lynx (*Lynx canadensis*) has an ecological equivalent in the Eurasian lynx (*L. lynx*) in Scandinavia and northern Russia. The bobcat is a southern species, and the mountain lion at this time appears to be at most an occasional visitor to the LSW.

Almost half the species of Carnivora in the LSW are in the family Mustelidae. Many of the mustelids, or weasels, in the LSW are distributed from eastern Canada to Alaska, and have either the same species or a different but closely related species in Europe and Asia. Examples include the wolverine (*Gulo gulo*), the American marten (*Martes americana*) and the Eurasian pine marten (*M. martes*), the mink (*Mustela vison*) and the European mink (*Mustela lutreola*) and the stoat (*M. erminea*).

Table 2. Distribution of carnivore species in the Lake Superior watershed. Species are divided into those distributed throughout the LSW, those with a species range south of the LSW that reach northern edge of their distribution within the LSW, and those that reach the southern edge of their distribution in the LSW. Finally the four very rare species are listed.

Distribution	Common Name	Range in Watershed	Range and Habitat
All LSW	Coyote	Less common when wolves are present	Boreal to desert
	Gray wolf	Highest in MN and ON, lower in WI and MI	Boreal to prairie (historically)
	Red fox	Throughout	Temperate and boreal
	River otter	Throughout	Temperate and boreal
	Ermine, short-tailed weasel	Throughout	Temperate and boreal
	Mink	Throughout	Temperate and boreal
	Black bear	Throughout	Temperate and boreal
	Striped skunk	Throughout, less common in ON	Temperate and boreal
South	Gray fox	MI, WI, MN, southern edge of ON	Temperate
	Bobcat	Throughout, not common in ON	Prairie to temperate
	Long-tailed weasel	MN, MI, WI, southern ON	Temperate and boreal
	Badger	MN, MI, WI, southern ON	Temperate
	Fisher	Throughout, less common in ON	Temperate
North	Raccoon	MI, WI, MN, southern edge of ON	Temperate
	Canada lynx	ON, not common in northeast MN	Boreal
Very Rare	Pine marten	ON, MN, MI, rare in WI	Boreal
	Mountain lion	Not present, historical importance uncertain	Prairie to boreal (western states)
	Eastern spotted skunk	If present in SW corner of watershed in MN	Prairie, some temperate
	Least weasel	Should be Throughout but very few records	Temperate and boreal
	Wolverine	ON, may not reach watershed now	Boreal

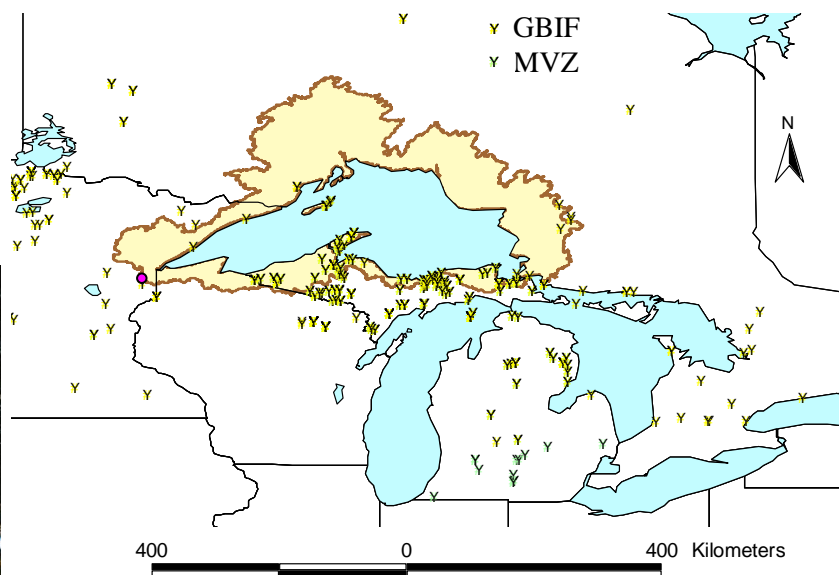
Coyote (*Canis latrans*). Coyotes are medium sized canids, 11-17 kg, about half the weight of wolves (Table 3). Body lengths are 1.2 to 1.3 m compared to about 1.5 to 1.6 m for wolves. Females have 5 to 7 young in April after a two-month gestation. Both parents care for the young. Coyotes eat mice, voles, rabbits, birds, invertebrates, and fruits when available. They will eat deer and livestock but primarily as carrion. Other work in the east has shown that coyotes will also prey on deer, particularly fawns (Patterson et al., 1998; Patterson & Power, 2002).

Coyotes are distributed from northern Canada into Mexico. The species range includes all of the Lake Superior watershed (Bekoff 1982, Whitaker and Hamilton 1998). Coyote density is generally lower when wolf densities are high. Most museum specimens are from the southern shore of Lake Superior, with fewer records from Minnesota and Ontario (Fig. 3).

Table 3. Measurements and body mass of coyotes.

Measurement	Sex	Mean	Min	Max	Location	Source
Total length (m)	U	1.3	1.2	1.3	MN	Hazard 1982
	U		1.1	1.2		Whitaker and Hamilton 1998
	U		1.1	1.3	WI	Jackson 1961
Tail (m)	U	328	0.3	0.4	MN	Hazard 1982
	U		0.3	0.4		Whitaker and Hamilton 1998
	U		0.3	0.4	WI	Jackson 1961
Body weight (kg)	MF		9.1	22.7	MN	Hazard 1982
	MF		14.5	15.9		Whitaker and Hamilton 1998
	MF		11.4	19.1	WI	Jackson 1961

Figure 3. Museum records for coyotes in the U.S. and Ontario. Isle Royale National Park locations of coyotes may be incorrect. Picture taken with trail camera within the LSW (magenta dot).



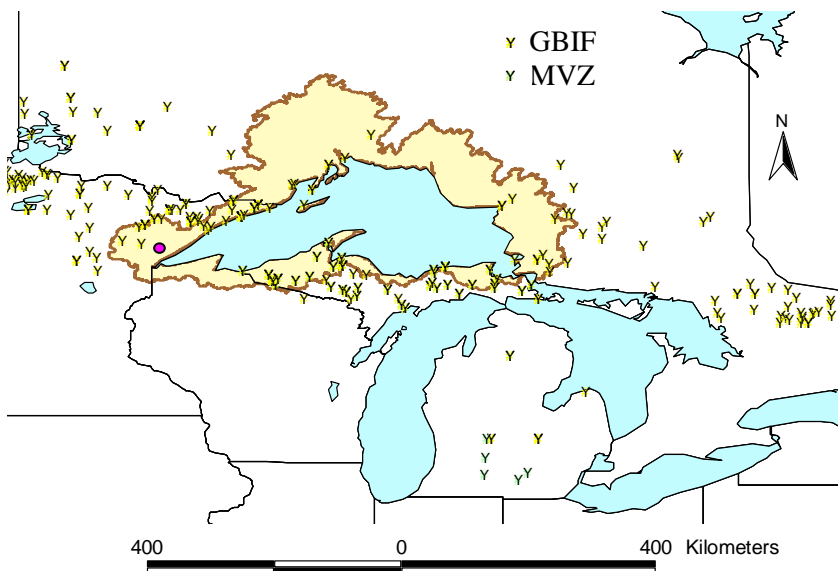
Gray wolf (*Canis lupus*): The gray wolf is a large canid with a bushy tail that is about 400 mm long. Total lengths of wolves are 1.5 to 1.6 m, compared to about 1.2 to 1.3 m for coyotes. Wolves in the Upper Midwest weigh from 25 to 45 kg. Fur is generally gray, although wolves can be black. Wolves have a broad muzzle and a large skull compared to coyotes. Wolves generally live in packs of a dominant adult pair with their offspring. Wolves mate in late February and have 4 to 7 young about two months later. Prey of wolves is primarily deer and moose in the Upper Midwest. Beaver are taken when available.

Wolves were originally present across the U.S. and Canada but were extirpated from much of the lower 48 states. Currently, wolves are in the process of being delisted in the U.S. There are wolves in all Lake Superior watershed states (Chapman and Feldhamer 1982, Mech 1974). Estimates are about 3,000 wolves in Minnesota, and more than 500 in both Wisconsin and Michigan⁵ (Erb 2009). Current estimate for Ontario province-wide are about 8,000 wolves, with an average harvest of about 500 per year since 1990⁶. Museum records of wolves are found throughout the LSW (Fig. 4).

Table 4. Measurements and body mass of gray wolves.

Measurement	Sex	Mean	Min	Max	Location	Source
Total length (m)		1.6	1.5	1.6	MN	Hazard 1982
			1.3	1.8	Unknown	Whitaker and Hamilton 1998
			1.5	1.7	WI	Jackson 1961
Tail (m)		0.4	0.3	0.5	MN	Hazard 1982
			0.4	0.5	WI	Whitaker and Hamilton 1998 Jackson 1961
Body weight						
Male and female (kg)			26	45	WI	Jackson 1961

Figure 4. Museum records for wolves in the U.S. and Ontario. Wolf pup picture taken about 25 miles north of Two Harbors, MN in August, 2009 (magenta dot).



⁵ http://www.fws.gov/midwest/wolf/aboutwolves/mi_wi_nos.htm

⁶ http://www.mnr.gov.on.ca/en/Business/SORR/2ColumnSubPage/STEL02_165923.html

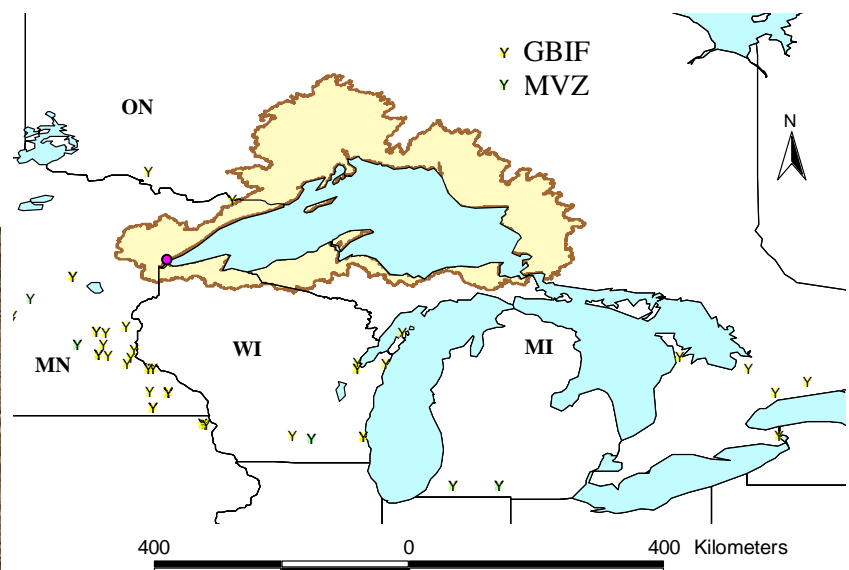
Gray fox (*Urocyon cinereoargenteus*): The gray fox is a small canid, 4 – 6 kg, similar in size to the red fox. Length is about 1,000 mm, and tail is about 350 mm. The gray color comes from guard hairs that have white bands and black tips. There is a black stripe down the middle of the back, which continues onto the tail which has a black tip. Gray fox feed on vertebrates or invertebrates depending on availability. Gray foxes can climb trees in search of food. Gestation is about two months, with one litter of about 4 pups each year.

The species range of the gray fox includes much of the eastern U.S. and southern U.S. into Mexico (Samuel and Nelson 1982). The gray fox is found in Minnesota, Wisconsin, and Michigan (Fritzell and Haroldson 1982). It was listed as a threatened species in Ontario in 2002 (Judge and Haviernick 2002), although according to some sources, the gray fox is not found in Ontario (Samuel and Nelson 1982). There are few museum records of gray fox within the LSW (Fig. 5), but there have been recent reports of gray foxes along the Minnesota portion of Lake Superior’s north shore (R. Moen, pers. obs.).

Table 5. Measurements and body mass of gray fox.

Measurement	Sex	Mean	Min	Max	Location	Source
Total length (mm)		933	905	1040	MN	Hazard 1982
			805	1065	IN	Whitaker and Hamilton 1998
			950	1040	WI	Jackson 1961
Tail (mm)		334	293	378	MN	Hazard 1982
			220	448	IN	Whitaker and Hamilton 1998
			310	390	WI	Jackson 1961
Body weight						
Male and female (kg)			3.8	5.2	MN	Hazard 1982
			3.2	5.9	IN	Whitaker and Hamilton 1998
			4.5	6.3	WI	Jackson 1961

Figure 5. Museum records for gray fox in the U.S. and Ontario. Gray fox road kill picked up about 10 miles north of Duluth, MN in winter 2009 within the LSW is indicated by the magenta dot.



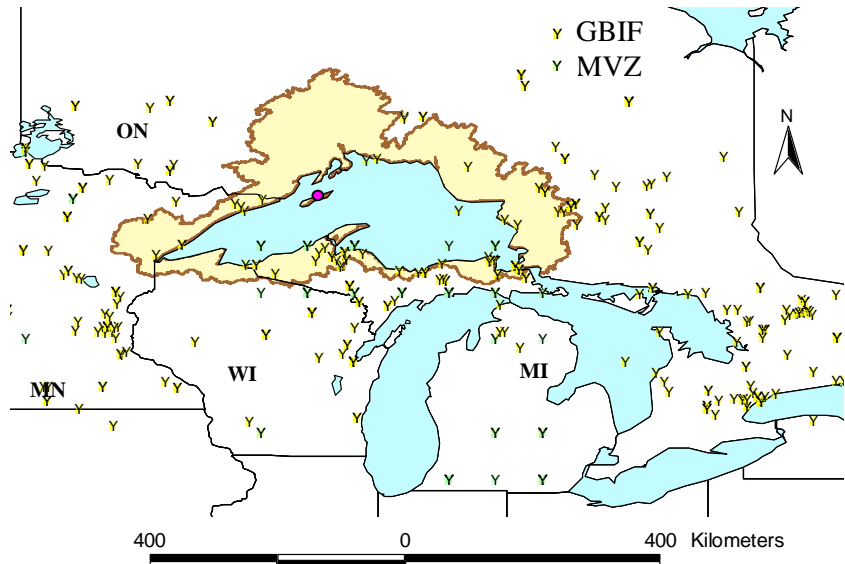
Red fox (*Vulpes vulpes*): The red fox is a small canid, with a total length of about 1,000 mm and tail length of about 350 mm. Body mass is about 4–6 kg. The fur is yellowish-red to red, and underside is white. The bushy tail often has black in it. Unlike wolves, red fox are solitary. Breeding is in February, with gestation lasting just over 50 days. Fox are carnivorous but also consume fruit and other items. Carrion is consumed when available. Small mammals consumed include mice, voles, muskrats, squirrels, rabbits, as well as birds, snakes, and frogs. Most prey eater are likely of mice and voles.

Red fox distribution is from northern Canada and Alaska south to Florida, including the throughout the Great Lakes region (Chapman and Feldhamer 1982, Samuel and Nelson 1982). Therefore, red fox should be present throughout the LSW which is supported by the distribution of museum records (Fig. 6).

Table 6. Measurements and body mass of red fox.

Measurement	Sex	Mean	Min	Max	Location	Source
Total length (cm)		1055	980	1115	MN	Hazard 1982
		946	842	1020		Whitaker and Hamilton 1998
		998	954	1045	WI	Whitaker and Hamilton 1998
			975	1050		Jackson 1961
Tail (cm)		346	356	420	MN	Hazard 1982
		337	294	368		Whitaker and Hamilton 1998
		359	320	340	WI	Whitaker and Hamilton 1998
			330	405		Jackson 1961
Body weight						
Male and female (kg)		5.14	4.3	6.1		Hazard 1982
			4.1	5.9	Whitaker and Hamilton 1998	
Females (kg)		3.9	3.0	4.6		Whitaker and Hamilton 1998
Males (kg)		4.5	4.1	5.7		Whitaker and Hamilton 1998

Figure 6. Museum records for red fox in the U.S. and Ontario. Picture of red fox taken on Isle Royale National Park in Lake Superior (Magenta dot).



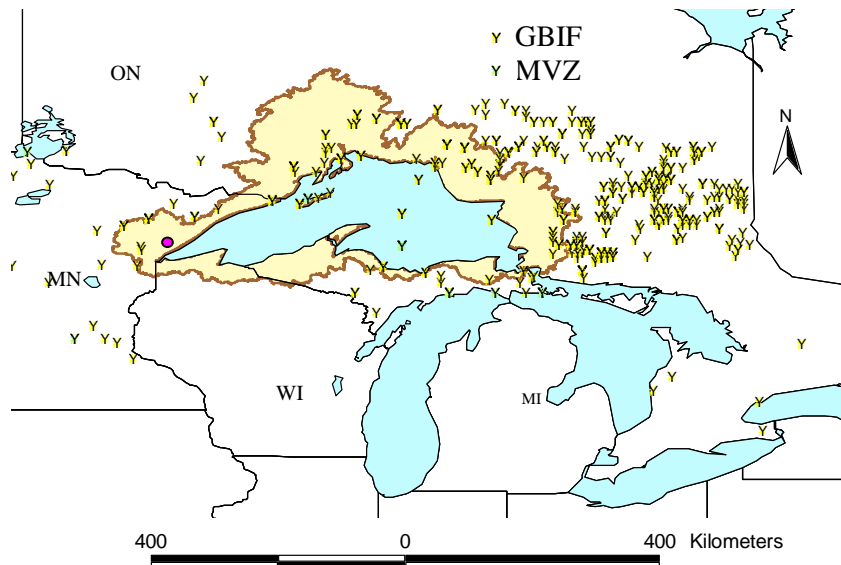
Canada lynx (*Lynx canadensis*): Canada lynx have a short, stubby tail and long legs with large paws and tufts on ears. Total length is about 1 m, and the tail is ≤ 10 cm. The tail is totally black at its tip. Lynx are found in forested areas in northern regions, particularly younger forests with snowshoe hare. Lynx primarily feed on snowshoe hare. It is possible with deep snow conditions for lynx to kill deer but this does not appear to happen often. Breeding season is in February, usually 5 or fewer young are born in early May. Young remain with the female for about one year.

Canada lynx are a furbearer in Ontario, and are rare and currently classified as threatened in the lower 48 under the Endangered Species Act (ESA). There has been historical harvest in MN large enough to indicate a resident population (Henderson 1979, McKelvey et al. 2000, Moen 2009). Historically the lynx population in MN was higher, and there may have been resident lynx in WI and MI (McKelvey et al. 2000). However, harvest records from the 1900s do not indicate that there were persistent lynx populations in MI and WI (Moen 2009). Most lynx records are from Ontario (Fig. 7).

Table 7. Measurements and body mass of Canada lynx.

Measurement	Sex	Mean	Min	Max	Location	Source
Total length (mm)			875	1000	MN	Hazard 1982
	F		765	965	Unknown	Whitaker and Hamilton 1998
	M		780	1065	Unknown	Whitaker and Hamilton 1998
Tail (mm)			100	120	MN	Hazard 1982
	F		76	122	Unknown	Whitaker and Hamilton 1998
	M		75	138	Unknown	Whitaker and Hamilton 1998
Body weight						
Male and female			7.3	15.9	MN	Hazard 1982
Males (kg)	M		6.7	17.2	Unknown	Whitaker and Hamilton 1998
Females (kg)	F		5.1	11.6	Unknown	Whitaker and Hamilton 1998

Figure 7. Museum records for Canada lynx in the U.S. and Ontario. Radiocollared Canada lynx L07 about 25 miles north of Two Harbors Minnesota in the LSW (Magenta dot).



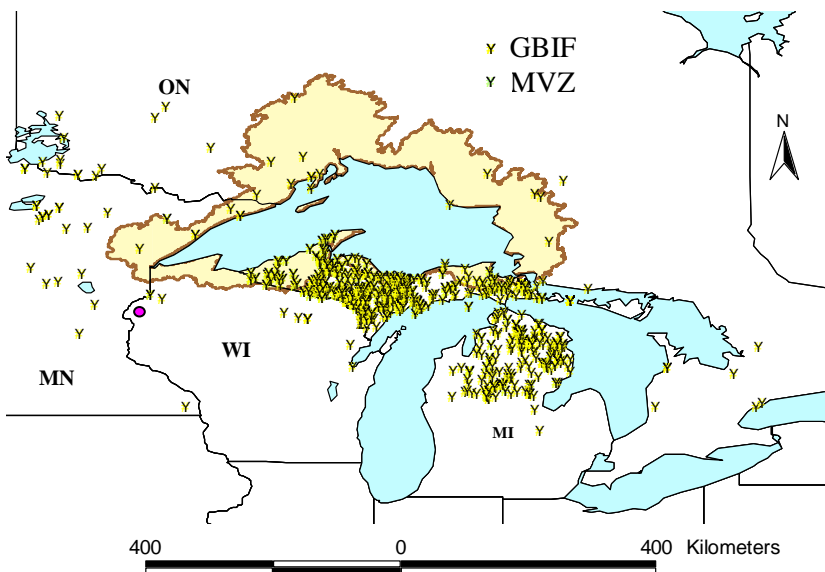
Bobcat (*Lynx rufus*): Bobcats have redder or browner fur than lynx, can be more spotted, and have smaller ear tufts and sideburns (ruff). The tail is generally longer than a lynx tail and not black tipped (top is black, bottom striped). Total length of bobcats is about same as lynx, but bobcats are usually heavier than lynx. Bobcats generally use forested and brushy habitats. Bobcats feed primarily on hares and rabbits, other species when available. Litters of 2 to 4 are born April to June after a gestation period lasting about two months.

Bobcats as a species are found throughout the U.S. and extend into Canada especially in the Rocky Mountains and along the Atlantic coast (McCord and Cardoza 1982). Bobcats are found throughout the LSW (McCord and Cardoza 1982). The northern extent of bobcat range has been within 100-200 km of the U.S.-Canada border. Bobcats are currently found in the northern part of Minnesota, Wisconsin, and Michigan. Bobcats do not range as far north as Canada lynx, typically there is a zone where the two species have some range overlap. Some authorities show bobcat range to be throughout the LSW (Chapman and Feldhamer 1982). There are many museum specimens from Michigan (Fig. 8).

Table 8. Measurements and body mass of bobcat.

Measurement	Sex	Mean	Min	Max	Location	Source and Comments
Total length (cm)			800	1015	MN	Hazard 1982
	M	865	691	972	NH	Whitaker and Hamilton 1998
	F	805	708	869	NH	Whitaker and Hamilton 1998
Tail (cm)			130	180	MN	Hazard 1982
	M	155	137	196	NH	Whitaker and Hamilton 1998
	F	145	133	178	NH	Whitaker and Hamilton 1998
Body weight						
Male and female			6.8	15.9	MN	Hazard 1982
Males (kg)	M			11	NH	Whitaker and Hamilton 1998
Females (kg)	F			7.3	NH	Whitaker and Hamilton 1998

Figure 8. Museum records for bobcat in the U.S. and Ontario. Picture courtesy of N. Kubacjwski taken within the LSW watershed summer 2008 near the St. Louis River (magenta dot).



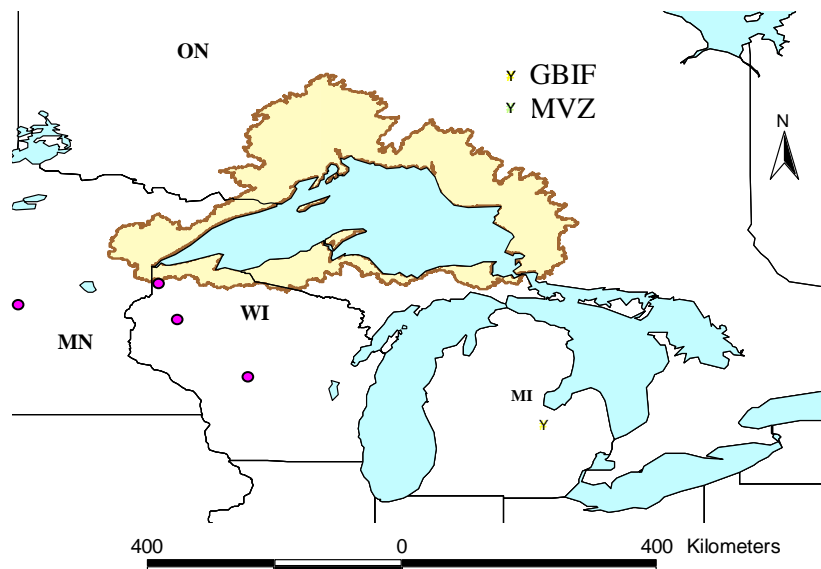
Mountain lion (*Felis concolor*): Mountain lions are usually uniformly brown without spotting. The tail is long, slender, and cylindrical. Body mass is typically 40 to 50 kg. Mountain lions are found in forested and brushy areas, often where humans are not present and feed primarily on deer. Two or three kittens remain with the female for almost two years.

Mountain lions were originally widespread throughout the lower 48 states. It is not certain they were present in Ontario (Dixon 1982). There have been recent sightings in many of the eastern states that mountain lions were extirpated from. Recent sightings and information about mountain lions are maintained on a website (www.easterncougarnet.org/). The source population for many recent mountain lion sightings is likely the Black Hills of South Dakota. Some of these reports may be of captive mountain lions that have been released. State game agencies consider mountain lions in the LSW to be an occasional visitor at this time.

Table 9. Measurements and body mass of mountain lion.

Measurement	Sex	Mean	Min	Max	Location	Source
Total length (mm)	M		2200	2300	FL	Whitaker and Hamilton 1998
	F		2000	2100	FL	Whitaker and Hamilton 1998
			1800	2590	WI	Jackson 1961
Tail (mm)			700	900	WI	Jackson 1961
Body weight						
Females (kg)			35	45	FL	Whitaker and Hamilton 1998
Females (kg)		61			WI	Jackson 1961
Males (kg)			55	66	FL	Whitaker and Hamilton 1998
Males (kg)		72			WI	Jackson 1961

Figure 9. Records for mountain lion in the upper Midwest states or Ontario in the BMVC or the GBIF databases. Locations of some recent sightings reports or trail camera pictures are shown as magenta dots (R. Moen, unpublished data).



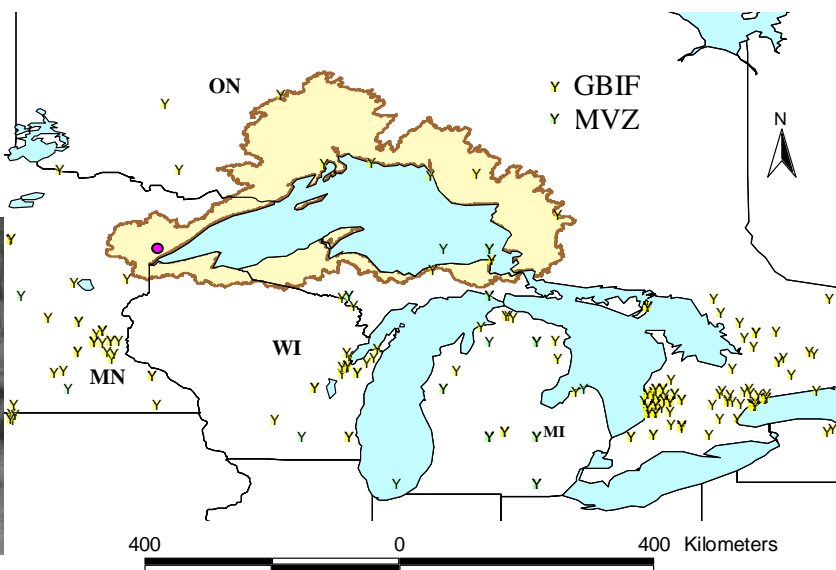
Raccoon (*Procyon lotor*): Raccoons have a black mask and a bushy, ringed tail. The weight of adult males is 5 to 12 kg, adult females weigh 5 to 10 kg. Raccoons use forested and urban areas. Raccoons are omnivorous, with their natural diet including both plant and animal matter. Diets may be modified by what is available from garbage, dumps, and other human sources. Raccoons are primarily nocturnal. Adults are solitary, and young stay with mother through the summer after being born in May. Raccoons den in the winter and are inactive, but they do not hibernate. Generally, raccoons are found in habitats where water is available.

Raccoons range from Mexico north into Canada, including all of the LSW (Chapman and Feldhamer 1982, Lotze 1979). There has been expansion of the range in Canada since the 1950's (Kaufmann 1982). There are few records from the Arrowhead region of NE Minnesota from the past, although the range of raccoons may be expanding northward. Most museum specimens of raccoons are from the southern portion of the LSW, or near the shoreline of Lake Superior (Fig. 10).

Table 10. Measurements and body mass of raccoons.

Measurement	Sex	Mean	Min	Max	Location	Source and Comments
Total length (mm)		833	753	940	MN	Hazard 1982
		757	550	853		Whitaker and Hamilton 1998
		812	751	852	WI	Whitaker and Hamilton 1998
			700	960		Jackson 1961
Tail (mm)		265	227	305	MN	Hazard 1982
		209	146	254		Whitaker and Hamilton 1998
		262	242	286	WI	Whitaker and Hamilton 1998
			225	275		Jackson 1961
Body weight		6.81	5.0	14.5		
Male and female			6	11	WI	Jackson 1961

Figure 10. Museum records for raccoons in the U.S. and Ontario. Picture taken within the LSW using trail camera in October 2009 (magenta dot).



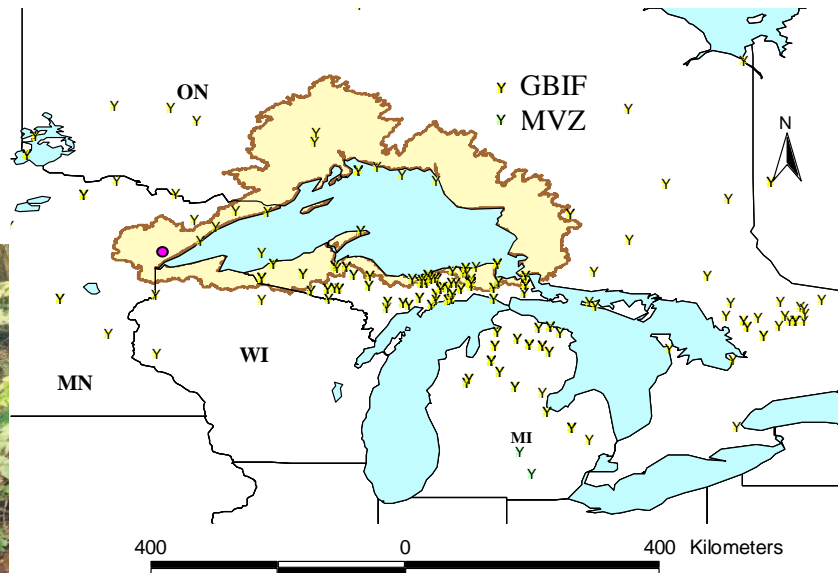
Black bear (*Ursus americanus*): Black bears are too big to be mesocarnivores, weighing 115 to 250 kg. Length can be 1 to 2 m, and the tail is short (< 40 cm.). Bears have large canines, but cheek teeth have low, flattened crowns typical of species with an omnivorous diet.

Black bears are found in forested areas across much of Canada and Alaska, including the northern parts of Minnesota, Michigan, and Wisconsin. Black bears are found throughout the LSW (LaRiviere 2001, Pelton 1982). Most museum records are from Michigan (Fig. 11) but bear populations are present throughout the LSW.

Table 11. Measurements and body mass of black bears.

Measurement	Sex	Mean	Min	Max	Location	Source and Comments
Total length (mm)			1370	1800	WI	Jackson 1961
Tail (cm)			90	125	WI	Jackson 1961
Body weight						
Male and female			113	136	MN	Hazard 1982
Females (kg)		50-204	102	204	WI	Jackson 1961
Males (kg)			113	227	WI	Jackson 1961

Figure 11. Museum records for black bears in the U.S. and Ontario. Picture taken with trail camera at location about 20 miles north of Two Harbors, Minnesota (magenta dot).



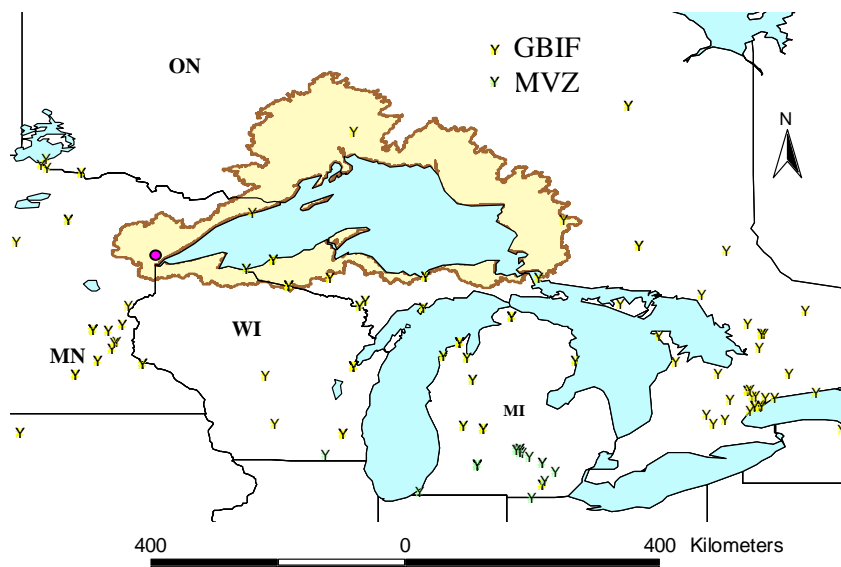
Striped skunk (*Mephitis mephitis*): The striped skunk is larger and more stout than the spotted skunk. The black fur with a thin white stripe on the forehead and two long stripes from the head to the rump is present in no other mammal in the LSW. Skunks are nocturnal and use dens during the day. They are omnivores, eating insects, fruits, invertebrates, as well as vertebrate prey. In areas where humans are present they also eat garbage. The scent of the defensive spray is one of its best known features.

The skunk ranges throughout the southern provinces of Canada, the United States, and into Mexico (Godin 1982). Skunks have been found throughout the LSW (Wade-Smith and Verts 1982, Chapman and Feldhamer 1982). However, there are relatively few museum records for such a common species (Fig. 13).

Table 12. Measurements and body mass of striped skunk.

Measurement	Sex	Mean	Min	Max	Location	Source and Comments
Total length (cm)		586	540	760	MN	Hazard 1982
			447	635	IN	Whitaker and Hamilton 1998
			540	750	WI	Jackson 1961
Tail (cm)		221	200	280	MN	Hazard 1982
			159	290	IN	Whitaker and Hamilton 1998
			200	280	WI	Jackson 1961
Body weight		1.8				
Male and female			0.9	2.8	MN	Hazard 1982
			1.8	4.0	WI	Jackson 1961
Females (kg)			1.8	4.1	IN	Whitaker and Hamilton 1998
Males (kg)			2.5	4.5	IN	Whitaker and Hamilton 1998

Figure 12. Museum records for striped skunk in the U.S. and Ontario. Striped skunk picture taken about 20 miles NW of Two Harbors, Minnesota (magenta dot).



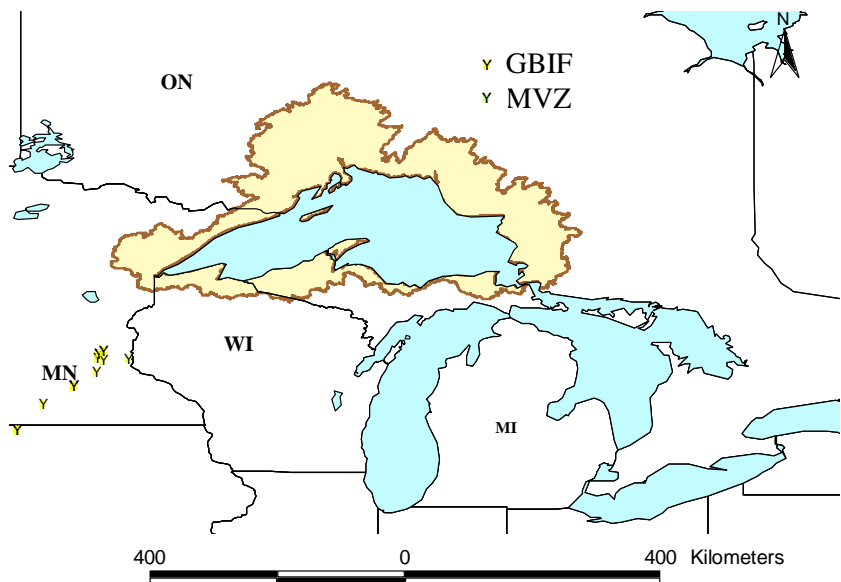
Eastern spotted skunk (*Spilogale putorius*): The eastern spotted skunk, like the striped skunk, has conspicuous black and white markings as a warning coloration. Instead of stripes there are white patches (spots) on this species. Eastern spotted skunks are smaller than the striped skunks, with body length of 470 to 550 mm, tail about 180 to 220 mm. Females are also smaller with total length of 450 to 480 mm, and tail length of 170 to 200 mm.

Records of the eastern spotted skunk are generally from outside the LSW, with a range that goes from NC Minnesota to Texas and into SE U.S. (Kinlaw 1995). There are no records for Ontario, Wisconsin, or Michigan within the LSW (Fig. 14). Minnesota is the northern most distribution of spotted skunks, with range records into the southwestern corner of the LSW (Howard and Marsh 1982). However, searches in the 1990's did not find the eastern spotted skunk in Minnesota (Wires & Baker, 1994), and the species is state-listed as threatened in Minnesota.

Table 13. Measurements and body mass of eastern spotted skunk.

Measurement	Sex	Mean	Min	Max	Location	Source and Comments
Total length (cm)			445	550		Whitaker and Hamilton 1998
			403	610		Whitaker and Hamilton 1998
			445	550	WI	Jackson 1961
Tail (cm)			165	220		Whitaker and Hamilton 1998
			165	280		Whitaker and Hamilton 1998
			168	330	WI	Jackson 1961
Body weight						
Male and female				0.7	MN	Hazard 1982
Females (kg)			0.3	0.6		Whitaker and Hamilton 1998
				0.7	WI	Jackson 1961
Males (kg)			0.4	1.3		Whitaker and Hamilton 1998

Figure 13. There are no museum records for eastern spotted skunk in the U.S. and Ontario within the LSW. The closest location of its current range would be on the southwestern end of the Lake Superior basin. Picture of skunk is an archived image of unknown geographic location⁷.



⁷ www.nps.gov/archive/tont/nature/skunk.htm

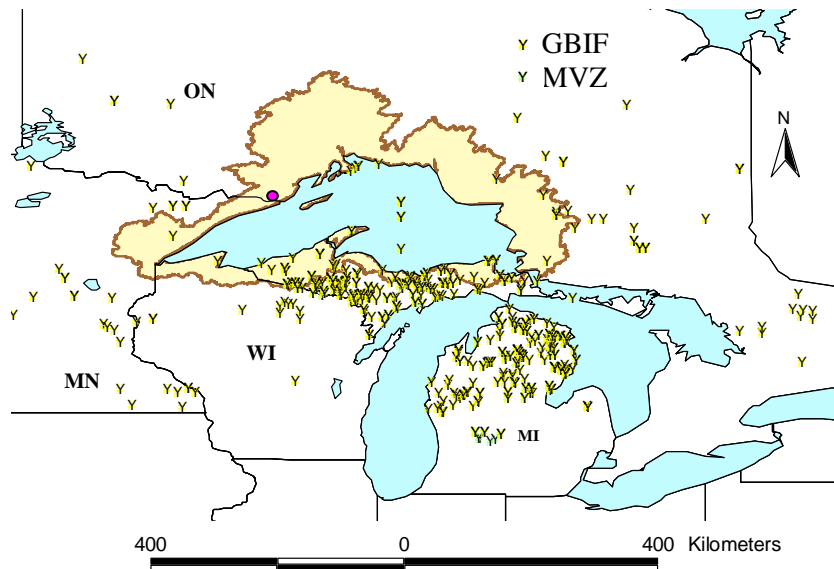
River otter (*Lutra canadensis*): The otter is a large, weasel-like aquatic mammal with short legs, and a long thick tail. Total length is 900 to 1,200 mm, tail is 300 to 475 mm. Weight is 7 to 11 kg. Eyes face forward rather than sideways. The fur is colored dark brown. The toes are fully webbed. Otters are found in or near rivers, streams and smaller lakes because they feed on fish and aquatic invertebrates. Otters swim with sinusoidal movements of the body and tail. On land they move with a lumbering lope, raising the back and then pushing it forward.

Otters are found in Alaska, throughout Canada except for in the prairie province region, and in all states bordering the Atlantic Ocean (Toweill and Tabor 1982). Otters are found throughout the LSW (Toweill and Tabor 1982, LaRiviere 1998). Most museum records are from Michigan (Fig. 12).

Table 14. Measurements and body mass of river otters.

Measurement	Sex	Mean	Min	Max	Location	Source and Comments
Total length (cm)			900	1300		Whitaker and Hamilton 1998
			900	1220	WI	Jackson 1961
Tail (cm)			340	510		Whitaker and Hamilton 1998
			300	475	WI	Jackson 1961
Body weight						
Male and female			6.8	11.3	WI	Jackson 1961
Males (kg)			5.4	9.0		Whitaker and Hamilton 1998

Figure 14. Museum records for river otters in the U.S. and Ontario. Otter picture taken in the LSW with trail camera (magenta dot).



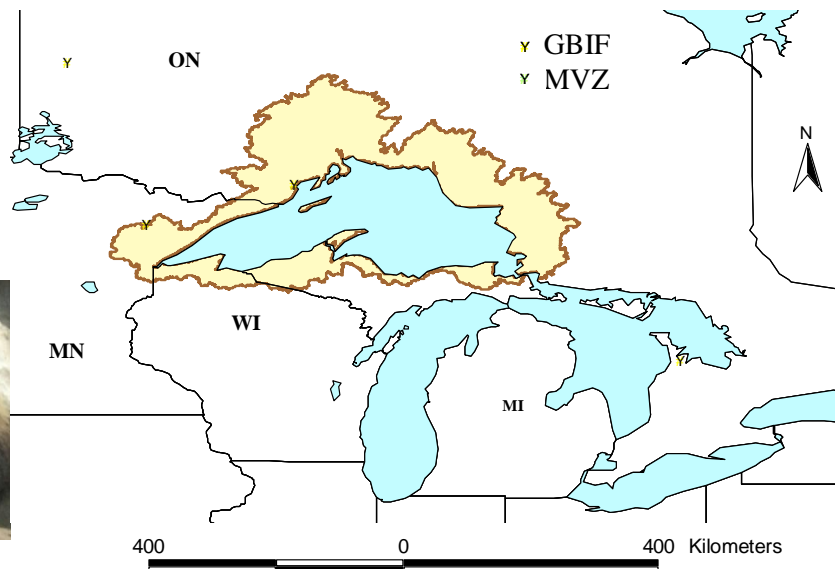
Wolverine (*Gulo gulo*): The wolverine, either extirpated or only an occasional visitor in Minnesota, Wisconsin, and Michigan, would be the largest mustelid in the region. Length of males is about 1 m, and length of females is over 800 mm. Tails are about 200 mm. Body mass is 14 to 20 kg in males, and 10 to 13 kg in females. The fur is typically dark brown with a light band extending back from the shoulders to the rump on each side. Wolverine are found in northern forested areas. Wolverines are solitary, wide-ranging, and mainly scavengers. They will consume food killed by other animals.⁸

Distribution of wolverines is circumpolar, although the North American wolverine was at one time classified as a separate species. Current species range in North America includes Alaska, northern Canada, and the Rocky Mountains in the U.S. Historical range may have included northeastern Minnesota, which would be in the LSW (Wilson 1982). There are other historical records for the LWS, but recent records and range maps indicate presence further north (Pasitschniak-Arts and LaRiviere 1995). There are few records of wolverines within the LSW (Fig. 15).

Table 15. Measurements and body mass of wolverine.

Measurement	Sex	Mean	Min	Max	Location	Source and Comments
Total length (cm)			650	1050		Wilson 1982
Tail (cm)			170	260		Wilson 1982
Body weight						
Male/Female (kg)			14	27.5		Wilson 1982

Figure 15. Museum records for wolverine in the U.S. and Ontario. There are few digitized museum records of wolverines in the Lake Superior Watershed. Image courtesy of Tom Ness, Minnesota Zoo.



⁸http://www.wolverinefoundation.org/research/ONWolverine_Habitat_Considerations_ActionPlan_Jan13_05_final.pdf

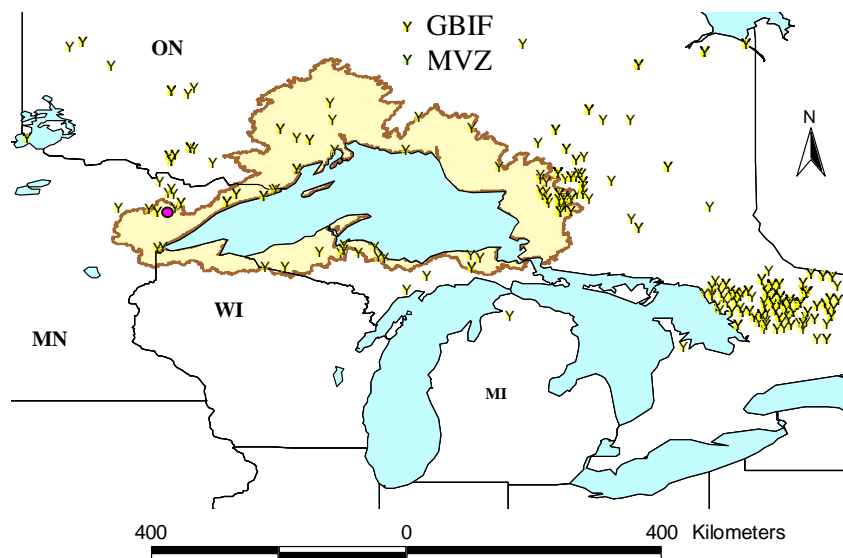
American marten (*Martes americana*): The American marten is an arboreal weasel, with reddish to yellowish brown fur that is darker on the back. There is a pale to orange-yellow bib on the throat. Marten are mostly nocturnal. They feed on mammals, birds, insects, fruits and berries. One of the common prey items are voles, such as in the genus *Clethrionomys*.

The species range is from Alaska across Canada in the boreal forest. The American marten is found in forested areas in northeast Minnesota, Ontario, and Michigan (Strickland et al. 1982, Clark et al. 1987). The American marten has been reintroduced into northern Wisconsin. Records of American Marten are distributed throughout the LSW (Fig. 16).

Table 16. Measurements and body mass of the American marten.

Measurement	Sex	Mean	Min	Max	Location	Source and Comments
Total length (cm)		615	551	650	MN	Hazard 1982
			600	675	WI	Whitaker and Hamilton 1998 Jackson 1961
Tail (cm)		195	150	205	MN	Hazard 1982
			190	220	WI	Whitaker and Hamilton 1998 Jackson 1961
Body weight		740				
Male and female					WI	Jackson 1961
Females (g)			0.6	0.8		Whitaker and Hamilton 1998
			0.7	1.0	WI	Jackson 1961
Males (g)			1.1	1.3		Whitaker and Hamilton 1998
			1.0	1.4	WI	Jackson 1961

Figure 16. Museum records for American marten in the U.S. and Ontario. The picture of a marten was taken by a trail camera on the northern edge of the Lake Superior watershed (magenta dot).



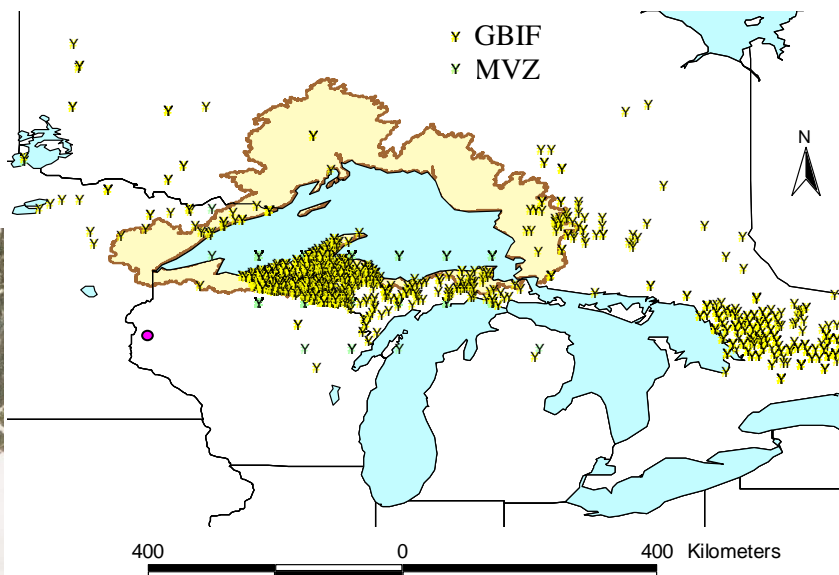
Fisher (*Martes pennanti*): The fisher is also an arboreal weasel that is larger than the pine marten. Body length is 900 to 1,000 mm in males, 880 to 920 mm in females. Fur is dark brown, and can be almost black, but there are white bands in the guard hairs, which give it a grizzled appearance. Spots may be on the ventral side, and there may be an orange bib. Fishers feed on animals and plants (fruit), but are more carnivorous than the marten.

The northern extent of the species range for Fisher is the provinces within the boreal forest zone across to the Atlantic Ocean (Strickland et al. 1982). The southern edge of fisher distribution is the forested areas of Wisconsin and Michigan (Fig. 17). Fisher, like marten, are found in all parts of the LSW (Powell 1981, Chapman and Feldhamer 1982).

Table 17. Measurements and body mass of the fisher.

Measurement	Sex	Mean	Min	Max	Location	Source and Comments
Total length (cm)		987	884	1055	MN	Hazard 1982
			800	1020	WI	Jackson 1961
Tail (cm)		372	355	397	MN	Hazard 1982
		360	910	1020	WI	Whitaker and Hamilton 1998 Jackson 1961
Body weight						
Male and female			3.6	5.5		Whitaker and Hamilton 1998
Females (kg)			2.1	2.2		Whitaker and Hamilton 1998
			1.8	2.9	WI	Jackson 1961
Males (kg)		3.94	2.9	5.7		Whitaker and Hamilton 1998
			3.2	5.9	WI	Jackson 1961

Figure 17. Museum records for fisher in the U.S. and Ontario. Trail camera picture taken with the LSW near magenta dot. Records in Lake Superior are a projection issue.



Genus *Mustela*. There are 4 species in the *Mustela* genus in Minnesota. *Mustela* is a circumboreal genus, present across North America and Eurasia. When harvested, the weasels (*M. erminea*, *M. frenata*, and *M. nivalis*) are often lumped together as a group, which means that it is not possible to obtain trends or distributions of individual species. The mink (*M. vison*) is usually tabulated separately in harvest data.

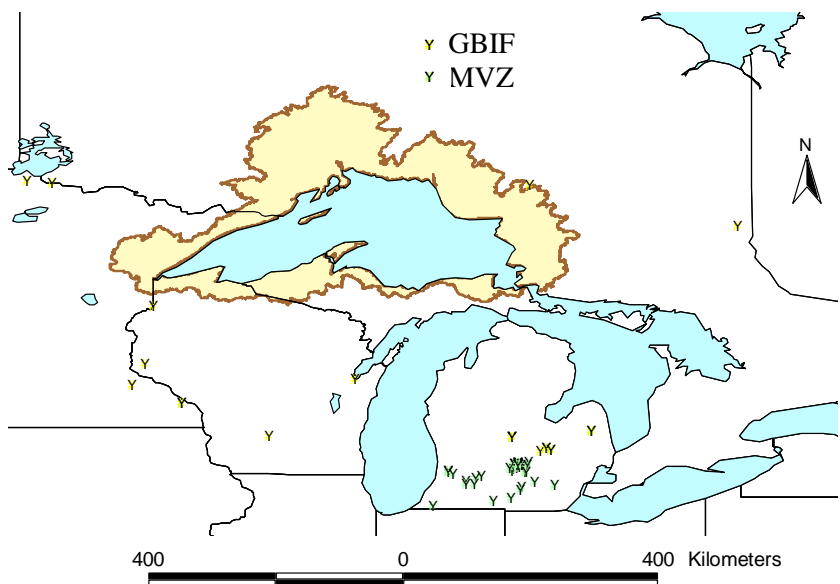
Least weasel (*Mustela nivalis*): The least weasel is the smallest member of Carnivora, and the smallest weasel in the LSW. Total length is about 180 mm, tail is about 30 mm. Body mass is 40-60 g. The least weasel is white in winter and brown in summer. The tail does not have a black tip in either season. The fur fluoresces under ultraviolet light, while the hair of other weasels does not. The least weasel probably feeds on mice and voles, as well as invertebrates.

The least weasel is a relatively unknown species in terms of its natural history. As a species the least weasel is circumpolar. Distribution is patchy and sporadic throughout the species range. Range maps indicate the least weasel is present throughout the entire LSW (Sheffield and King 1994, Chapman and Feldhamer 1982), but there are very few museum records (Fig. 18).

Table 18. Measurements and body mass of the least weasel.

Measurement	Sex	Mean	Min	Max	Location	Source and Comments
Total length (cm)		180	157	195	MN	Hazard 1982
			172	206	WI	Jackson 1961
Tail (cm)		33	27	37	MN	Hazard 1982
			24	38	WI	Jackson 1961
Body weight						
Male and female			37	50	MN	Hazard 1982
Females (g)		32	21	52	IN	Whitaker and Hamilton 1998
Males (g)		45	26	88	IN	Whitaker and Hamilton 1998
			41	50	WI	Jackson 1961

Figure 18. Museum records for least weasel in the U.S. and Ontario. There are additional records of the least weasel in Michigan and Wisconsin (Michael Joyce, pers. comm.). Picture is obtained from the internet site www.arkive.org.



Picture from Arkiv.org, Robin Redfern / gettyimages.com <<http://gettyimages.com>>

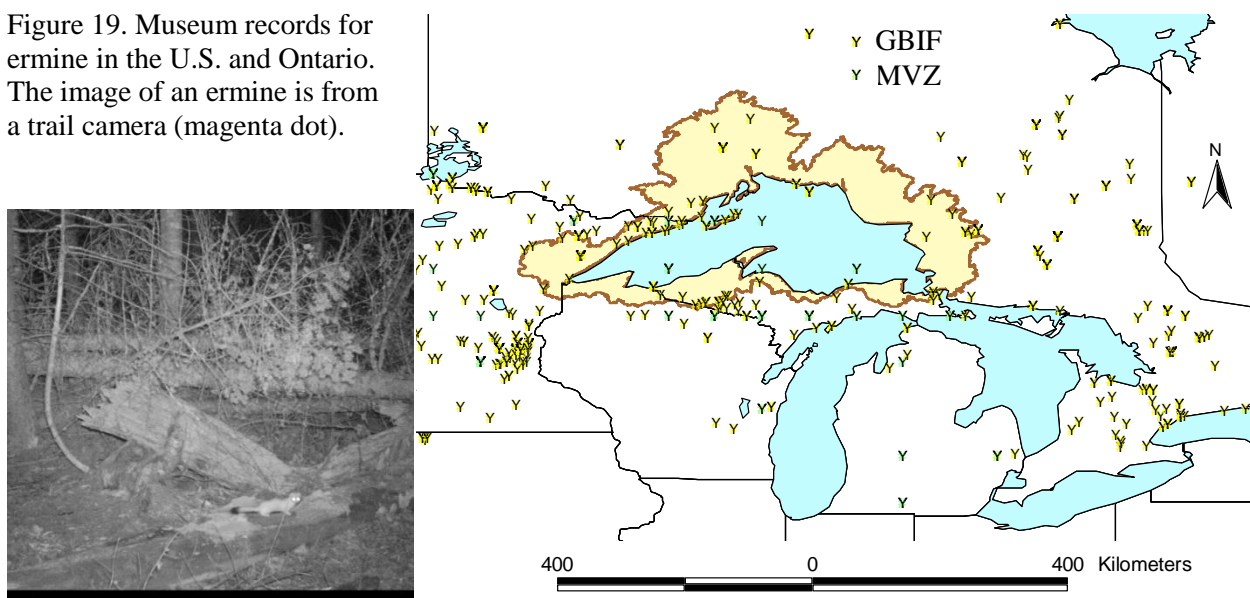
Ermine, Short-tailed weasel (*Mustela erminea*). Ermine are short-legged and long-bodied with small heads. Ermine are white in winter, and dark brown in summer dorsally, white ventrally, with white fur on the inner sides of the hind legs, too. The tip of the tail is black at all times. The tail is usually < 1/3 of total length (contrasting with the appropriately named long-tailed weasel). Ermine feed primarily on voles and mice, also consuming other small vertebrates, and invertebrates.

As a species, ermine have a holarctic distribution (King 1983). The North American range is from Alaska to the northern plains states, and east to western Pennsylvania and Quebec. Ermine are found throughout the LSW (King 1983. Chapman and Feldhamer 1982) and there are many museum records (Fig. 19).

Table 19. Measurements and body mass of the ermine.

Measurement	Sex	Mean	Min	Max	Location	Source and Comments
Total length (cm)	M	307	53	94	MN	Hazard 1982
	F	251				
	M	272	149	295	MI	Whitaker and Hamilton 1998
	F	236				
Tail (cm)	M	85	53	94	MN	Hazard 1982
	F	65				
	M	71	42	71	MI	Whitaker and Hamilton 1998
	F	55				
Body weight						
Male and female			42	170	WI	Jackson 1961
Females (g)		75.4	43	125	MI	Whitaker and Hamilton 1998
			42	71	WI	Jackson 1961
Males (g)		112.7	90	142	MI	Whitaker and Hamilton 1998
			90	170	WI	Jackson 1961

Figure 19. Museum records for ermine in the U.S. and Ontario. The image of an ermine is from a trail camera (magenta dot).



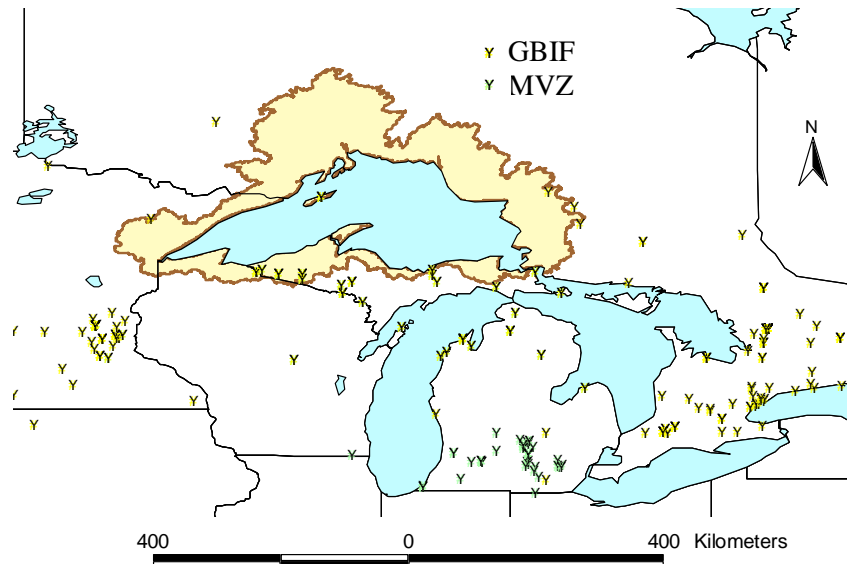
Long-tailed weasel (*Mustela frenata*): The long-tailed weasel is larger than the ermine, with a total length of over 400 mm in males, 350 mm in females. The black tipped tail is at least 1/3 of body length. Long-tailed weasels are brown in summer, white or brown in winter. Most of the long-tailed weasel diet is small mammals. Primarily mice and voles are consumed, but also rabbits by males.

The species range is from southern Canada into northern South America. The species range does not include Ontario except for the eastern part of the LSW (Sheffield and Thomas 1997, Chapman and Feldhamer 1992). The long-tailed weasel is reported from throughout Minnesota, although less commonly from the northeastern part of the state (Hazard 1982). It is also present throughout Wisconsin and Michigan, and in the southeastern part of Ontario (not part of the LSW). There are few museum records within the LSW (Fig. 20).

Table 20. Measurements and body mass of the long-tailed weasel.

Measurement	Sex	Mean	Min	Max	Location	Source and Comments
Total length (cm)		425	348	450	MN	Hazard 1982
			350	431	WI	Jackson 1961
	356	302	412	MN	Hazard 1982	
		285	340	WI	Jackson 1961	
Tail (cm)		152	131	165	MN	Hazard 1982
			115	150	WI	Jackson 1961
	107	96	139	MN	Hazard 1982	
		85	123	WI	Jackson 1961	
Body weight						
Male and female			85	245	WI	Jackson 1961
Females (g)		198.5	103	276	MN	Hazard 1982
			85	130	WI	Jackson 1961
Males (g)		316	243	414	MN	Hazard 1982
			170	245	WI	Jackson 1961

Figure 20. Museum records for long-tailed weasel in the U.S. and Ontario. Picture taken by D. Dahms.



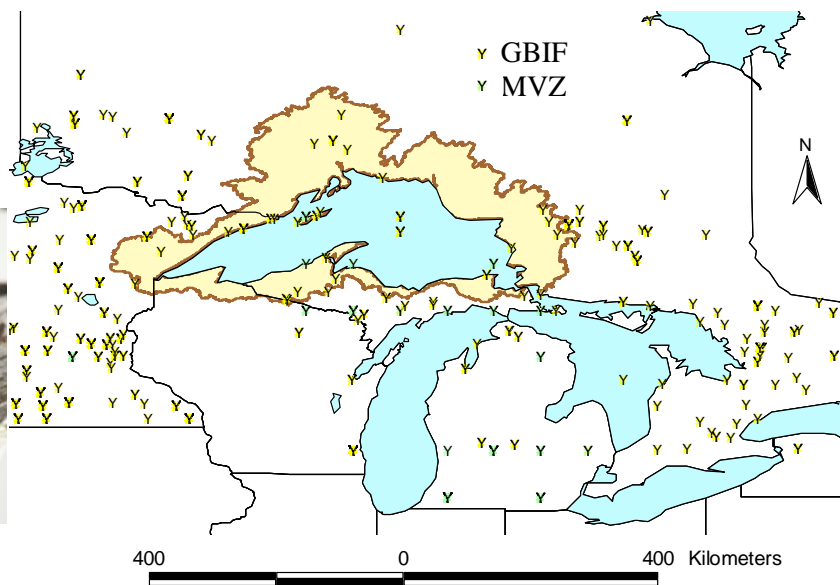
Mink (*Mustela vison*): Mink have elongate bodies and short legs just like most other mustelids. The mink is generally larger than the weasels. The tail is about 1/3 of body length, as in the long-tailed weasel. However, the mink has a tail that is bushier than that of the long-tailed weasel. The tail is also blackish towards the tip. The coat color is usually some shade of brown, and it is the same in winter and summer. Mink are mostly nocturnal. They hunt in aquatic and terrestrial environments, eating muskrats, rabbits, squirrels, birds, snakes, frogs, fish, and invertebrates.

Mink as a species is distributed from Alaska across Canada to the east coast, and south to Florida (Linscombe et al. 1982). Mink are absent from the southwestern states. Mink are found throughout the LSW (Chapman and Feldhamer 1982, LaRiviere 1999) and there is a broad distribution of museum records inside and adjacent to the LSW (Fig. 21).

Table 21. Measurements and body mass of the mink.

Measurement	Sex	Mean	Min	Max	Location	Source and Comments
Total length (cm)	M	618	460	705	MN	Hazard 1982
	F	513	158	149	NY	Whitaker and Hamilton 1998
		563	460	700	WI	Jackson 1961
Tail (cm)	M	146	160	187	MN	Hazard 1982
	F	176	491	590	NY	Whitaker and Hamilton 1998
		174.5	150	220	WI	Jackson 1961
Body weight						
Male and female						
Females (g)			598	794	NY	Whitaker and Hamilton 1998
			700	1100	WI	Jackson 1961
Males (g)		1607	964	1361	NY	Whitaker and Hamilton 1998
			900	1600	WI	Jackson 1961

Figure 21. Museum records for mink in the U.S. and Ontario. Picture taken by P. Myers.⁹



⁹ www.animaldiversity.unmz.umich.edu

Badger (*Taxidea taxus*): The badger is a digging animal, and the appearance of the body suggests that. They have powerful front legs with heavy claws. The banding pattern on the fur gives it a grizzled appearance. There is a white stripe on the head. Badgers prey on fossorial rodents (e.g., ground squirrels, pocket gophers) by digging out their holes or by ambushing them. They also eat other small vertebrates and invertebrates. Badger dig burrows for a den. Badgers are solitary as adults.

Badger as a species range from the prairie provinces south into Mexico (Lindzey 1982). There are records of badger in the SW corner, outside of the LSW. Most records of badger in Minnesota are from outside the Arrowhead region (Hazard 1982), but there is one record close to the LSW border in the UMD collection (Fig. 22). Other records are from Wisconsin and Michigan in the LSW (Long 1973). Badgers are in the northern edge of their eastern range in the LSW, and are not part of the eastern part of the LSW in Ontario (Long 1973).

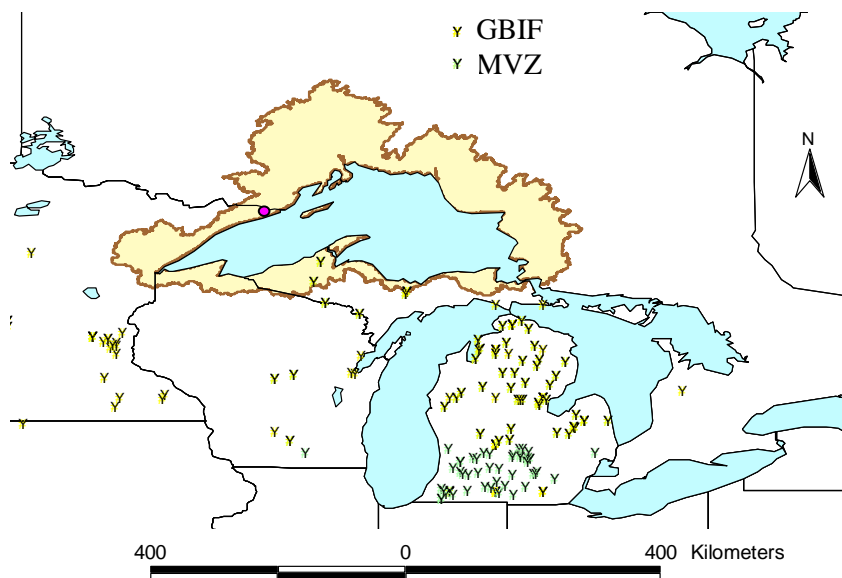
Table 22. Measurements and body mass of the badger.

Measurement	Sex	Mean	Min	Max	Location	Source and Comments
Total length (cm)		754	719	800	MN	Hazard 1982
			643	843	IN	Whitaker and Hamilton 1998
			770	800	WI	Jackson 1961
Tail (cm)		148	110	190	MN	Hazard 1982
			115	250	IN	Whitaker and Hamilton 1998
			120	150	WI	Jackson 1961
Body weight						
Male and female			6.3	11.8	WI	Jackson 1961
Females (kg)		6.4-7.1	5.3	9.1	IN	Whitaker and Hamilton 1998
Males (kg)		8.4-8.7	6.3	11.3	IN	Whitaker and Hamilton 1998

Figure 22. Museum records for badger in the U.S. and Ontario. Picture is obtained from the internet site www.arkive.org.



Picture from Arkiv.org, Shattil & Rozinski / naturepl.com
<<http://naturepl.com>>

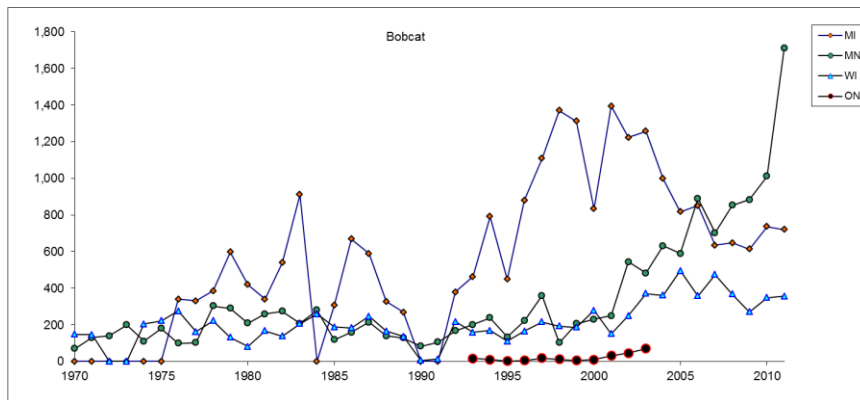


Harvest data for carnivores

Many carnivore species are legally harvested by trappers in Ontario, Michigan, Minnesota, and Wisconsin. Harvest data is not available specifically for the LSW, but we can use trends in statewide harvest to give a general indication of abundance of each species. Species with larger harvests may be the easiest to use in a monitoring program, and the simplest indirect monitoring program may be for state agencies to select out locations that are in or near the LSW. Some species, such as Canada lynx and the wolf, have not been harvested in the U.S. due to ESA listing⁹.

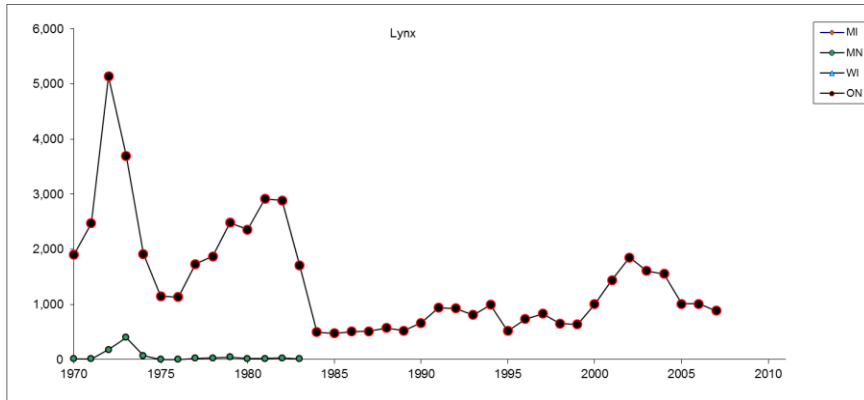
Some species will have low commercial value and low harvest in some years. Furbearer harvest each year varies because of changes in population size, and also because of changes in pelt prices. Lower harvests in the early 1990s are in part a reflection of low pelt prices. Bobcat harvests tended to increase during the 2000s in Michigan, Minnesota, and Wisconsin (Fig. 23). Lynx harvest also increased in Ontario in the 2000s.

Figure 23. Reported harvest of felid species in Michigan, Minnesota, and Wisconsin from 1970 to 2011. Bobcat is the only felid in the *Lynx* genus legally harvested in the lower 48 states. Harvest of lynx is also shown for the province of Ontario from 1993-2004 (data obtained from OMNR). Note different scale in years for lynx harvest in Ontario. Data obtained from AFWA National Furbearer Harvest Statistics Database¹⁰.



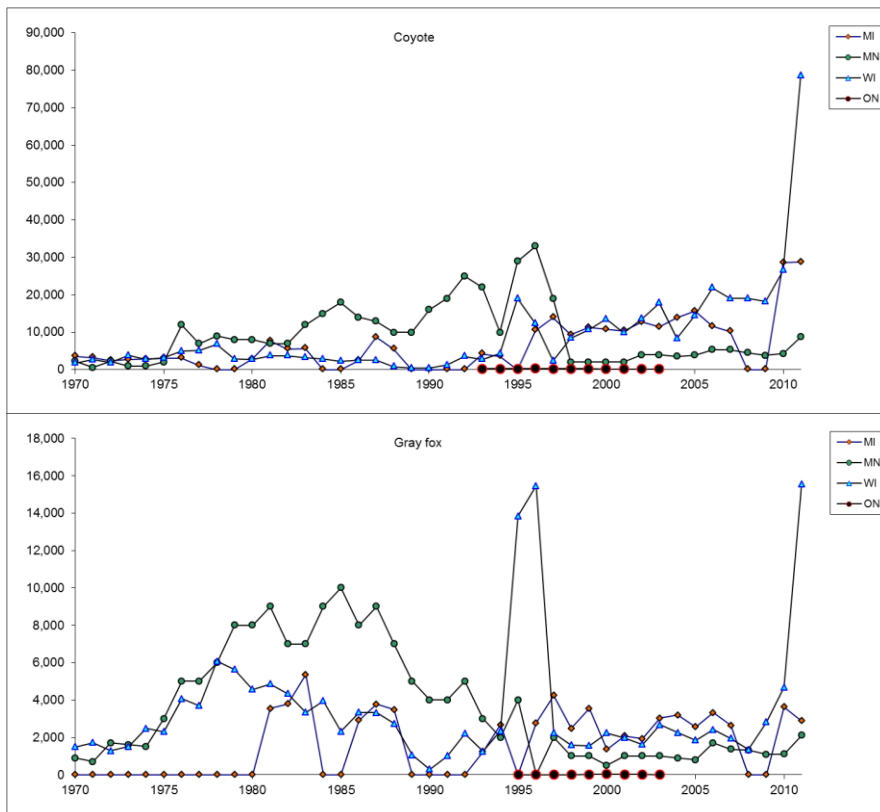
⁹ Wolves were federally delisted in 2012 and have been harvested in Minnesota and Wisconsin since 2012 and in Michigan since 2013

¹⁰ http://fishwildlife.org/?section=furbearer_management_resources



Canid harvest is 4 to 40 times higher than felid harvest, with the largest difference reported for Wisconsin (Fig. 24). Generally harvest has been stable since 1990, except for an increase in gray fox harvest in Wisconsin. With a consistent harvest of 5,000 to 15,000, there is likely not a population decline. Lower pelt prices are another reason for the harvest decline.

Figure 24. Reported harvest of canid species in Michigan, Minnesota, and Wisconsin from 1970 to 2011. Data obtained from AFWA National Furbearer Harvest Statistics Database¹¹. Ontario harvest obtained from Ontario MNR.

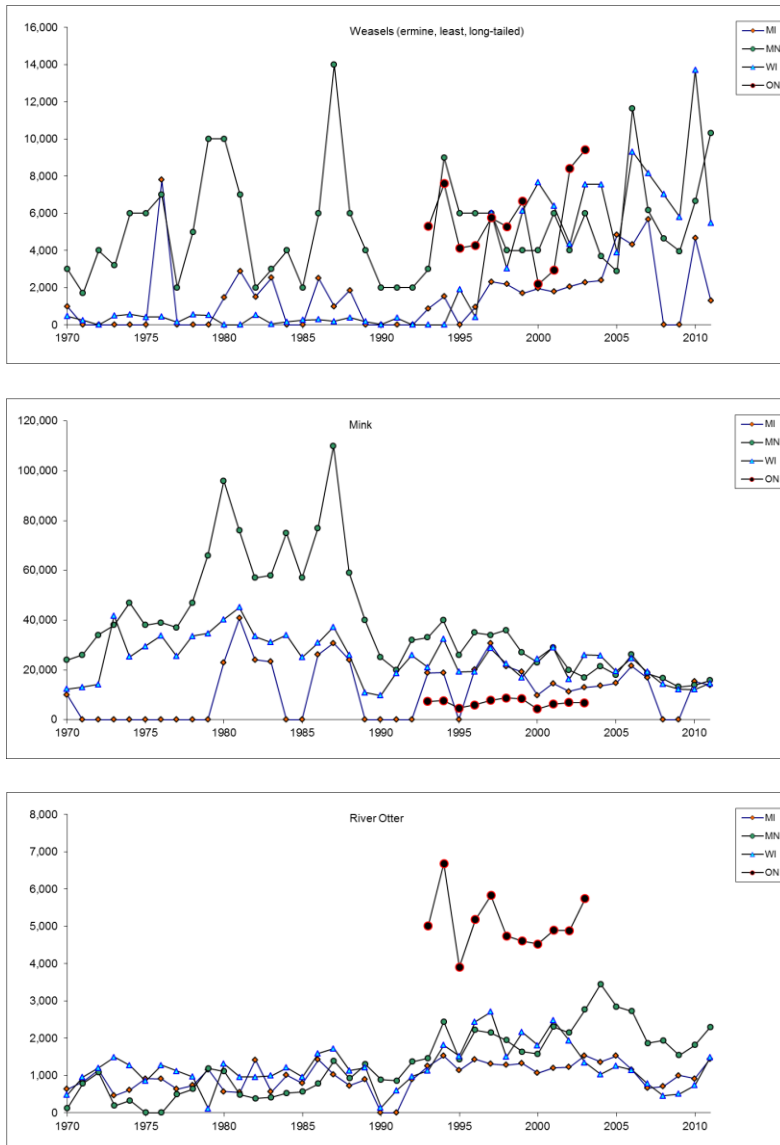


¹¹ http://fishwildlife.org/?section=furbearer_management_resources



The small weasels are lumped together, so individual species data is not available for the least weasel, the ermine, and the long-tailed weasel (Fig. 25). Harvest has been steady at about 2,000 in Michigan, and over 4,000 in Minnesota and Wisconsin. There were peaks in weasel harvest in Wisconsin in 1987, 1994, and 2003. Mink harvest has been stable in each state at about 20,000, and otter harvest increased from the 1980s to the 2000s. For all of these furbearers, harvest was stable or increasing in the late 1990's and early 2000's.

Figure 25. Reported harvest of weasels, mink, and otter in Michigan, Minnesota, and Wisconsin from 1970 to 2011. Data obtained from AFWA National Furbearer Harvest Statistics Database¹². Ontario harvest obtained from Ontario MNR.

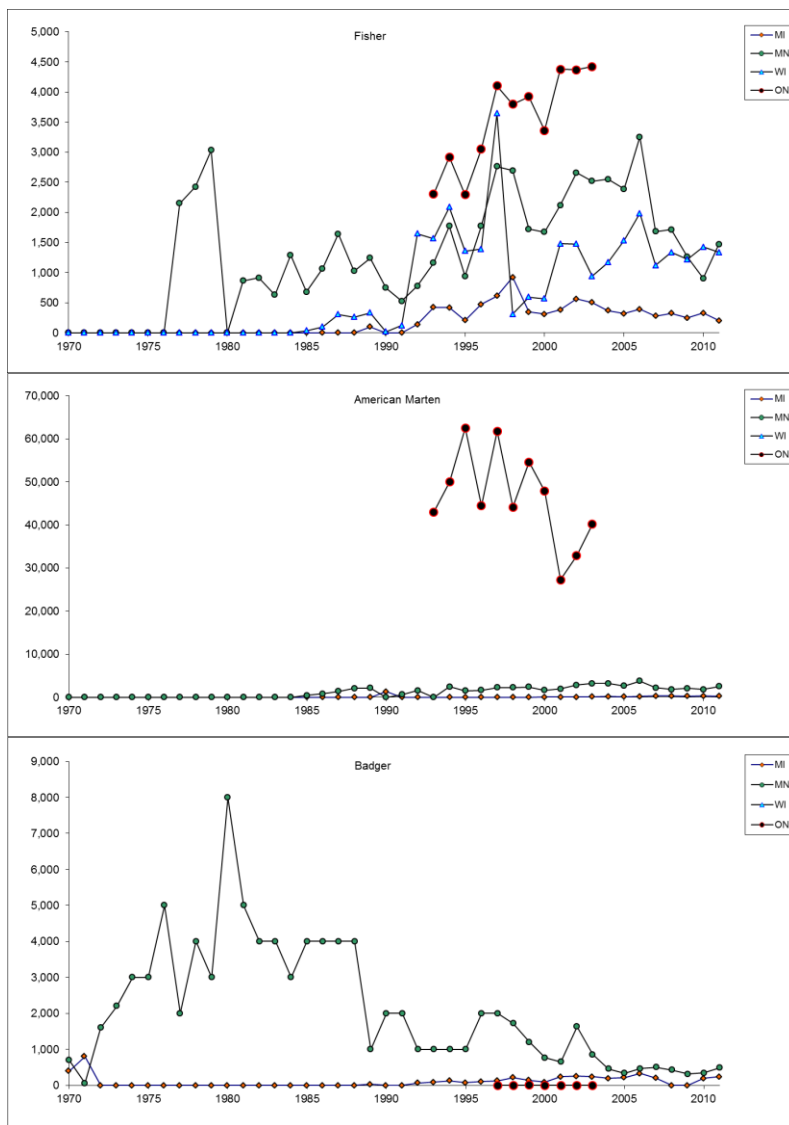


¹² http://fishwildlife.org/?section=furbearer_management_resources

Fisher harvest has generally increased slightly from 1986 to 2003 (Fig. 26). American marten is only harvested in Minnesota and Ontario, and harvest has increased from 1986 to 2003. Much of the harvest of American marten will occur near the LSW in the northeastern portion of Minnesota. Michigan had a 3-year period ending in 2003 during which American marten could be trapped.

Badger is a species which is either present in low numbers, has low vulnerability to trapping, or has a low pelt price. Badger harvest data from Minnesota between 1970 and 1997 seem to be an estimate as harvest numbers are rounded to the nearest 500. Badgers are protected from harvest in Wisconsin. Current annual badger harvest of less than 500 animals per jurisdiction is low compared to other furbearers. High levels of badger harvest in Minnesota prior to the late 1980's may have been from areas outside of the LSW.

Figure 26. Reported harvest of fisher, American marten, and badger in Michigan, Minnesota, and Wisconsin from 1970 to 2011. Data obtained from AFWA National Furbearer Harvest Statistics Database¹³. Ontario harvest obtained from Ontario MNR.

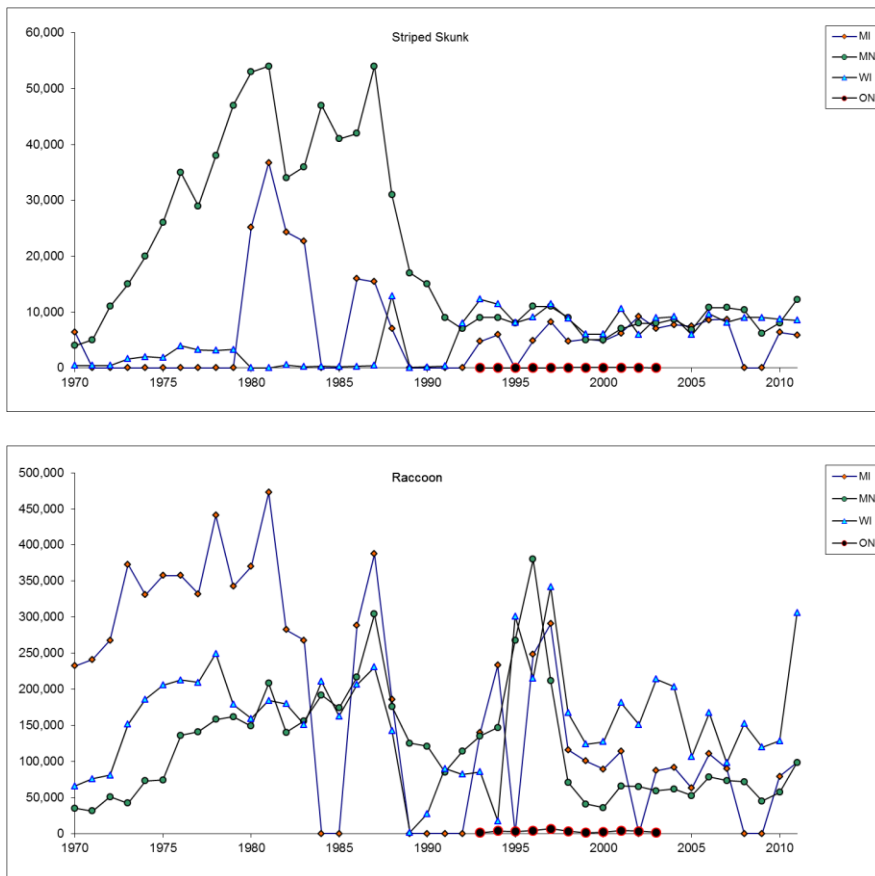


¹³ http://fishwildlife.org/?section=furbearer_management_resources

Skunk harvest peaked in Minnesota at over 50,000 in 1987 (Fig. 27). From 1991 to 2003 skunk harvest has been about 8,000 in each state, again probably an indication of constant trapping pressure and relatively constant population size. Skunk harvest is either very low or not recorded in Ontario.

Raccoons have the highest harvest of any carnivore in the states around the LSW, with over 250,000 taken in Wisconsin in 2003, and about 50,000 taken in Minnesota and Michigan (Fig. 27). Raccoon harvest is either very low or not recorded in Ontario.

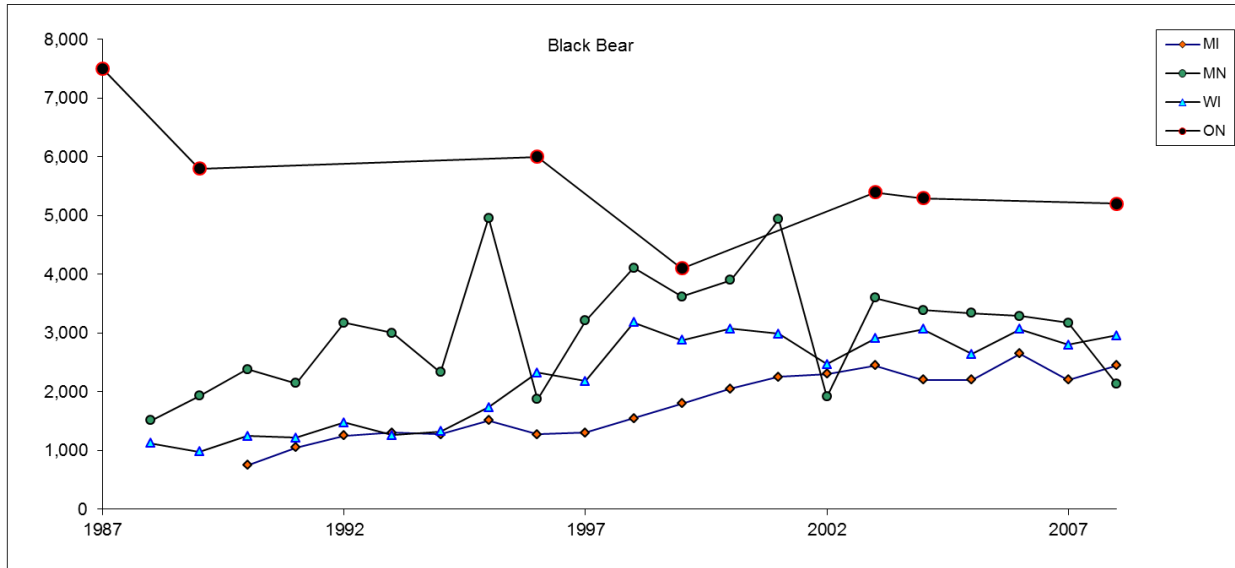
Figure 27. Reported harvest of striped skunk and raccoons in Michigan, Minnesota, and Wisconsin from 1970 to 2011. Data obtained from AFWA National Furbearer Harvest Statistics Database¹⁴. Ontario harvest obtained from Ontario MNR.



¹⁴ http://fishwildlife.org/?section=furbearer_management_resources

Black bear harvest has been increasing in Minnesota, Wisconsin, and Michigan, with a decline in Ontario (Fig. 28). With statewide harvests of about over 2,000 animals, and about 5,000 bears harvested consistently in Ontario, bear populations are likely in reasonable condition.

Figure 28. Reported harvest of black bears in Michigan, Minnesota, and Wisconsin. Harvest of black bears is also shown for the province of Ontario. Data obtained from harvest records from each agency (Environmental Commissioner of Ontario, 2010; Garshelis & Noyce, 2010; Frawley, 2009; Dhuey et al., 2009).



State/provincial/federal agency monitoring protocols and carnivore status

Minnesota

MN DNR conducts annual scent station surveys and winter track surveys to monitor furbearers and other mid-size and large carnivores (Erb, 2009c; Erb, 2009b). Scent station surveys monitor distributions and abundances of foxes, coyotes, skunks, and raccoons in farmland, forest, and farm/forest transition zones. There are annual fluctuations in the indices, and increases for some species with decreases for others. For the farmland, transitional, and forest zones populations of furbearers remain high enough to support an annual harvest. The MN DNR also conducts surveys of furbearer trappers to estimate annual harvests of all species¹⁵. The Forest Wildlife Division of the Minnesota DNR models the population trends of bobcat, fisher, marten, and otter based on harvest statistics and on scent station and track count indices. Results of the most recent report for these species is summarized below (Erb, 2009a):

Bobcat - The spring 2008 bobcat population was modeled as approximately 2,200 animals, representing a 14% decline from previous estimates. As estimated from examination of harvested bobcats, approximately 15% of females gave birth in 2007 (the 5-year average was 26%).

Fisher - Modeling of the fisher population projected a 2008 spring population of approximately 8,000, essentially remaining stable from the previous year. Reported harvest of fisher declined almost 50% from the previous year (approximately 17% of the population was harvested), likely related to a shortening of the trapping season by one week.

Marten - The marten trapping season was also reduced by one week, and reported harvest declined approximately 44% from the previous year (roughly 18% of the population was harvested). Despite a projected 2% population increase in 2008, several lines of evidence, including harvest data, long-term winter track index records, and an unusually low juvenile:adult female ratio in examined carcasses, suggest the marten population has been slowly declining over the past five years.

Otter - Despite an expansion of the northern Minnesota otter trapping zone, the estimated harvest of otter declined 32% from the previous year (estimated 16% of the population harvested). Population modeling suggests that, after years of apparent decline, the population in this zone may be currently increasing.

Gray wolf – Wolves have been harvested in Minnesota since delisting in 2012. The estimated population from the 2013 survey is 2,211 wolves in an estimated 438 packs. This estimate is lower than the 2008 population estimate of 2,921 wolves but still above the statewide minimum goal of 1,600 wolves. The reduced population estimate is associated with an increase in territory size and decrease in average pack size compared to the 2008 survey. Comprehensive wolf surveys are conducted every 4–6 years, while annual monitoring of wolves includes scent station surveys, winter track surveys, and depredation indices.

The Minnesota County Biological Survey¹⁶, administered through MN DNR, monitors several rare animal species, including small- and mid-size carnivores, using a variety of methods including cage traps, observations of dens and tracks, and auditory surveying. However, the CBS is limited to monitoring only a few counties each year.

¹⁵ <http://www.dnr.state.mn.us/publications/wildlife/index.html>

¹⁶ <http://www.dnr.state.mn.us/eco/mcbs/index.html>

Wisconsin

Since 1977, the WI DNR has monitored populations of furbearers and other carnivores using a combination of hunter/trapping surveys, winter track surveys, aerial monitoring, and, for black bears, bait station surveys. Live-trapping, radio-collaring, and howl surveys are used to monitor gray wolf populations. As an additional index of species distributions and abundances, local wildlife managers and other field personnel conduct annual terrestrial sighting surveys, and data are compiled by WI DNR and posted on the Internet¹⁷

The Annual Mammal Survey provides a general overview of the distribution and abundance of carnivores in Wisconsin. Survey forms are given to local field personnel, who are asked to report sightings of live and/or road-killed mammals. According to the 2008 survey, sightings of marten, black bears, bobcats, coyotes, and wolves were high relative to previous surveys, whereas sightings of badgers, fishers, gray foxes, red foxes, and otters were low.

In addition to the Annual Mammal Survey, independent systematic surveys are conducted on black bears, bobcats, fishers, otters, marten, and wolves (many of which are based largely on harvest data):

Black bear - Population modeling based on bait station visitations estimated a statewide bear population of approximately 13,050 individuals. Bear abundance is currently exceeding management goals in all Management Zones, and may be up to 30% above the goal in some zones.

Bobcat - Life history data were obtained from bobcats harvested between 1983 and 2006 and were combined with winter track survey indices to model the population dynamics of Wisconsin's bobcats. Fall populations apparently increased (perhaps doubled) during the 1990s and early 2000s, but the population may be currently declining.

Fisher - The fisher population is monitored largely via harvest statistics and winter track indices. The population grew rapidly during the 1980s, stabilized following increased harvesting in the 1990s, and increased again in the early 2000s following a reduction in harvest rates. The current population of approximately 14,000 individuals is well above the long-term goal of 9,200.

Otter - The river otter population, as indexed by track detection rates during aerial surveys, appears to be declining (by perhaps as much as 35% since 1994).

Marten - Winter track surveys of re-introduced marten in Chequamegon-Nicolet National Forest resulted in observations of 15 martens in both Chequamegon and Nicolet. The density appears higher in Nicolet, however – there were 21.3 detections per 100 miles surveyed there compared to 9.0 detections per 100 miles in Chequamegon.

Gray wolf – Wolves have been harvested in Wisconsin since delisting in 2012. The estimated population was 658-687 individuals in 2014, which is a 19% reduction from the 2013 estimate of 809-834 individuals. Despite the reduction, the estimated population size still exceeds the statewide management goal of 350 individuals. Mid-winter population estimates are generated annually, and wolves are also monitored yearly through winter track surveys, summer howl surveys for pups, radio-telemetry, and aerial surveys.

¹⁷ <http://www.dnr.state.wi.us/org/land/wildlife/harvest/harvest.htm> (Not available July 2014)

Michigan

Annual trapper surveys administered by MI DNR, which estimate the number of registered furbearer trappers and harvest intensity, serve as a primary means of monitoring populations of mid-size carnivores. Results of wildlife surveys and reports are posted on-line¹⁸, including independent reports for 1) marten and fisher, 2) beaver and otter, and 3) bobcat harvest estimates. MI DNR also recently (2007) implemented a statewide bear management plan, to be reviewed and updated at 10-year intervals. A PDF of the current bear management plan is available¹⁹. Under this management plan, several bear population indices are considered in monitoring efforts, including hunter harvest, success, and effort; bait-station surveys; and age/sex class distribution of harvested bears. Additional methods, including genetic mark-recapture techniques based on DNA obtained from hair and tissue samples, are used to monitor bear populations in the Lower Peninsula of Michigan.

Information on mammalian carnivores is available from MI DNR primarily through harvest survey reports. These surveys suggest that raccoon and opossum numbers may be increasing, while red fox numbers are declining. Additionally, estimated harvest and trapper effort statistics suggest that otter, beaver, and fisher may have declined from 2006-2007, while marten may have increased in number.

Ontario

Parks Canada utilizes a systematic protocol to monitor mid-size terrestrial carnivores, with reconnaissance, baseline, and monitoring stages. Reconnaissance surveys are conducted by searching for sign (tracks, scat, etc.) of target animals and/or of prey, and are focused primarily on confirming the presence of carnivores in an area. Baseline surveys, including snow-tracking and bait/scent stations with sooted track plates, hair snares, and/or camera traps, are then conducted to establish which species are present and to index gross habitat use attributes. Finally, monitoring of population trends and habitat use patterns is achieved through repeated censuses using the same methods established in the baseline stage.

¹⁸ http://www.michigan.gov/dnr/0,1607,7-153-10363_48664---,00.html

¹⁹ http://www.michigan.gov/dnr/0,1607,7-153-10363_51367---,00.html

Review of noninvasive methods used to monitor carnivore populations

Among the most common field methods used to monitor North American carnivores are camera traps, track plates, scent stations, snowtracking, hair snares, scat surveys, and genotyping analysis (Zielinski and Kucera 1995; Gese 2001, 2004; Wilson and Delahay 2001; Gompper et al. 2006, Long et al. 2008). These methods are often applied in combination, for example using hair snares to obtain samples for DNA analysis (e.g., Williams et al. 2009). Comprehensive reviews of current carnivore monitoring techniques can be found in Gese (2004) and Long et al. (2008). Although we review historical methods here, we believe that the best approach would be to use remote cameras (camera traps) with supporting evidence from furbearer harvest, snow-tracking, scent stations, and other methods already used by the management agency in a jurisdiction.

Track plates

Track plate surveys generally consist of a flat substrate covered with sand, carbon soot, chalk, or ink, and a lure (either olfactory or visual) to attract target animals to the apparatus. An animal that is attracted to the lure is then forced to step on the substrate surface to reach the attractant, thus producing tracks that are preserved on the substrate (see Zielinski and Kucera 1995 for details). A potential drawback of using track plates as a monitoring tool, and one that is a particular problem in regions with a diverse carnivore guild, is the difficulty in identifying, to the species level, tracks from closely related (and/or morphologically similar) taxa. This issue has been systematically addressed for *Martes* species (Zielinski and Truex 1995), but further study is necessary. Another major issue surrounding the use of track plates is common sand or carbon-soot construction methods are ineffective in capturing animal visitation in rainy conditions. Alternative methods, such as using an enclosed design (Loukmas et al. 2003) or a water-resistant phenolic foam substrate in place of sand or carbon-soot (Hooper and Rea 2009), may produce more reliable results. Although track plate surveys are useful for establishing the presence of a species in a given area, and thus for analyzing gross biogeographic distributions, their utility in determining relative animal abundance is limited (Gese 2004). However, the use of repeated surveys to estimate temporal variation in visitation rates may provide a means of estimating relative abundances over time (Gruber et al. 2008).

Snowtracking and track counts along transects

Snow-track surveys are frequently used to initially determine the presence of a species in a given area (e.g., Kortello et al. 2007), or to track fine-scale movements of individuals/groups (e.g., movement to den sites; Okarma et al. 1998). Similarly, during months lacking snowfall, movements of carnivores can be monitored via tracks embedded in moist soil (e.g., river beds, unpaved roads shortly after rainfall). Structuring observation routes along pre-defined transects or plots provides a standardized method for indexing relative animal abundance via track counts (Gese 2004). However, the power of such a monitoring protocol (i.e., its ability to detect population changes if such changes exist) may be limited for extremely low-density carnivore populations (Kendall et al. 1992). It is thus recommended that transect routes are made as long as possible given available manpower.

Scent stations

Scent station techniques are conceptually similar to track plate surveys, but have the added advantage of utilizing a substrate that is swept clear by a researcher each day. In this way, scent station surveys are likely better able to index relative animal abundance (as opposed to simply animal presence) than are track plate surveys. However, it is important to account for temporal variability in habitat use by resident carnivore populations in planning a scent station monitoring protocol (Smith et al. 1994).

Hair snares

Hair-snare traps can be used as an independent method of establishing the presence of a target species, and perhaps its abundance, in a given area (e.g., Lynch *et al.* 2006), but increasingly such traps are used as a means of noninvasively obtaining biological samples for DNA analysis (e.g., Foran *et al.* 1997, Boulanger *et al.* 2004, Weaver *et al.* 2005, Zielinski *et al.* 2006, Pauli *et al.* 2008, Williams *et al.* 2009). The design of hair snares is quite simple and cost-effective, generally involving the use of a rough surface, such as steel brush (Pauli *et al.* 2008), Velcro® (Castro-Arellano *et al.* 2008), barbed wire (Mowat and Paetkau 2002, Zielinski *et al.* 2006), or glue (Foran *et al.* 1997, Zielinski *et al.* 2006), from which hair is removed as a target animal attempts to manipulate and/or remove a piece of bait placed just beyond the surface (such that the animal is forced to make contact with the surface to reach the bait; Williams *et al.* 2009).

Scat surveys

Provided that scats can be appropriately assigned to species, systematic scat surveys (i.e., surveys conducted along pre-defined transect lines) can be used as an independent index of animal abundance and/or density (Andelt and Andelt 1984, Schauster *et al.* 2002, Bonesi and MacDonald 2004). To be most effective at detecting temporal changes in animal abundances, consecutive surveys should be conducted along the same routes at the same time of year to avoid biases relating to geographical and seasonal variation in prey availability (as differential prey digestibility can impact fecal deposition rates; Andelt and Andelt 1984, Gese 2004). Scat surveys may be the most efficient method of surveying species that tend to be particularly wary of the presence of camera traps, live traps, bait stations, or any other man-made apparatus (e.g., coyotes, Gompper *et al.* 2006). Also, scat surveying may be more appropriate for estimating relative animal abundances than it is for indexing absolute abundances (Harrison *et al.* 2002). A potential disadvantage of scat surveying is that it requires precise identification of scat to the species level. Recent advances in genotyping techniques (Foran *et al.* 1997, Davison *et al.* 2002, Pilot *et al.* 2007, Fernandes *et al.* 2008) and in the use of scat-detection dogs (Smith *et al.* 2005) have helped alleviate these difficulties.

Genetic techniques

A thorough review of genetic monitoring techniques for carnivores is given in Schwartz and Monfort (2008). Noninvasive genetic sampling entails the collection of hair and/or scat from which DNA can be extracted and amplified, which provides a wide variety of information ranging from species and/or sex identification (e.g., Fernandes *et al.* 2008, Taberlet *et al.* 1999) to population structure and abundance (e.g., Frantz *et al.* 2004, Robinson *et al.* 2007). Genetic techniques also provide a means of identifying individuals (in the absence of tags or other distinguishing features; Schwartz *et al.* 2007) and of detecting population trends that would otherwise be prohibitively difficult to monitor (e.g., the prevalence of lynx-bobcat hybrids in the Minnesota lynx population; Schwartz *et al.* 2004). Among the major drawbacks to the use of genetic techniques are: 1) sampling even a small number of individuals is far more expensive than most other monitoring techniques (with the possible exception of camera traps), and 2) contamination of sample material can easily occur from contact by the target animal with bait at a baiting station and/or from non-target animals contacting the same bait (Schwartz and Monfort 2008).

Camera traps

Camera traps have traditionally been used as a means of identifying the presence of a target species in a koepfligiven region (e.g., González-Esteban *et al.* 2004). Researchers have increasingly applied standard mark-recapture techniques on individually identifiable animals to index abundance and monitor

populations through camera trapping (Karanth 1995, Karanth and Nichols 1998, Carbone *et al.* 2001, Trolle and Kery 2003, Silver *et al.* 2004). Cameras can be placed along animal trails or at bait stations (Kucera *et al.* 1995) and most commonly are triggered by motion-sensing devices or by an animal breaking the plane of an infrared beam (Gese 2004). Over the course of the study period, individuals are “marked” (*i.e.*, initially photographed) and “recaptured” (*i.e.*, subsequently photographed again), and using software packages, such as CAPTURE (Rexstad and Burnham 1991), abundance estimates are generated based on the ratio of “recaptured” to “marked” individuals, on the frequency of recapture, and on several other variables (Karanth *et al.* 2006). This methodology assumes that animals can be individually identified (either by physical features or with individual tags), that the population was closed during the study period (no individuals were born, died, or migrated during the study period), and that all individuals in the population have a greater than zero percent probability of being detected by camera (Silver *et al.* 2004). Due to these assumptions, it is recommended that this method only be applied for relatively short study periods (*e.g.*, Karanth and Nichols [1998] conducted a three-month study of jaguars) to ensure “closure” of the population, and that a sufficient quantity of camera-trapping stations be deployed over a large area (relative to the home range of the species in question) to ensure that all individuals in the population have a chance of being detected.

Although camera-trapping holds great promise as a noninvasive method for monitoring carnivores using relatively straightforward analytic techniques (Karanth *et al.* 2006), its primary drawback is the high price of cameras (see Kucera *et al.* 1995).

Discussion and Recommendations

Based on historical museum records and range maps there are up to 20 carnivore species that could be monitored within the Lake Superior Watershed. Because of population status, 16 of these are candidate species for monitoring. The 4 rare species (Mountain lion, Eastern spotted skunk, Least weasel, Wolverine) would be of interest if presence was documented, but would not be part of a monitoring program.

Although mesocarnivores were the focus of the Terrestrial Wildlife Committee and Habitat Committee recommendations, with the methods and data that are currently available we recommend expanding the monitoring effort to include all carnivores. In part this is because there would be relatively little additional investment of resources, and in part because of the existing data collection protocols for some of the larger carnivore species that are already in place in management agencies.

We believe that the best approach for carnivore monitoring at the scale of the LSW would be to use remote cameras (camera traps). However, it is critical that management agencies be involved because they also collect data that can provide supporting evidence to remote camera methodology. The Ontario MNR, Wisconsin DNR, Minnesota DNR, and Michigan DNR all record data on furbearer harvest, snow-tracking, scent stations, and other methods. We reviewed statewide data to determine population status, but it is likely that with cooperation with the agencies it would be possible to obtain data with resolution that approximates the LSW.

Museum records provide background data on presence of the different species. There are smaller regional collections that could add to the existing data on fine-scale carnivore distribution. The species range map indicates that a species is present, but given differences in microhabitat requirements, vegetation, and other factors there are parts of any region that would not be used by some species. The otter is a good example. The range map shows distribution across much of North America, but in practice that distribution is limited by the presence of water bodies. Thus, it would be worthwhile to obtain any additional museum records that are easily available for carnivores and add them to the database we have

built as part of this report in Figures 3 to 22. The mammal collections at the University of Minnesota Duluth and at Lakehead University in Thunder Bay are good examples.

We also recommend that the hundreds (thousands?) of trail cameras being used by the public be considered as a possible data collection tool. It is difficult to estimate how many trail cameras are deployed in the LSW, but it is probably safe to say that there are 100 trail cameras deployed for every camera that could be deployed by a resource management agency. We believe the owners of many of these cameras would be willing to contribute their time and effort to a carnivore monitoring project.

This type of data collection approach fits under the category of “Citizen Science” that has been employed in many projects, ranging from the Christmas Bird Count to Monarch Butterflies (Cohn, 2008). On both the Canada lynx project (www.nrri.umn.edu/lynx) and a new project on moose one of the report authors (Moen) has been using public input to advantage. For the moose project, in about 6 months we received about 400 photographs of moose in Minnesota, and locations that were much more widespread than expected based on current knowledge of moose distribution (R. Moen, pers. obs.). Feedback is a critical aspect of Citizen Science, and we maintain a website on which the submitted pictures and other moose information is posted (www.nrri.umn.edu/moose).

Contributors would need to meet certain criteria to participate in the program. For example, it is critical to collect data on the deployment period of a trail camera to actually use the data. A picture of a red fox is not very useful or valuable without ancillary data indicating where a camera was deployed (township level), how long the camera was deployed, etc. We can accept single submitted pictures (if we can verify origin) to document presence across the LSW but to really use camera deployment data we need to know when a camera was active, have all pictures taken during a deployment submitted, know attractants used (if any), and location. We recommend developing a certification training process to make sure camera users collect this data, and to explain why these fields are critically important to the project. Location will be a sensitive issue for some contributors, and also for agencies in the case of threatened and endangered species. If maps and released data are at the township (6 x 6 mile) resolution, or perhaps somewhat higher in some cases, we could alleviate this problem.

Climate Change and Carnivore Monitoring

One of the reasons a monitoring program like this is important is to have baseline data for species distribution and relative abundance prior to effects of climate change on plant and animal communities. It is likely that the direct and indirect effects of climate change will largely shape the future community structure and population dynamics of Lake Superior carnivores. Boreal forests are among the plant communities most at risk from climate change in the Upper Midwest United States, from Minnesota to Michigan, and in southern Ontario. Previous work with downscaled general circulation model (GCM) output and an upper mid-range greenhouse gas emissions scenario indicated this region will experience climate equivalent to the current climate 50 – 400 km S-SW of the region by the year 2069 (Galatowitsch et al., 2009). Climate change will have the most striking impact at transitional zones between biomes. With a future warmer climate, boreal forests could change to temperate forest, savannas and grasslands, or to a mosaic of these biomes, depending on the magnitude of change, the future moisture regime, and its interaction with the physiography of the landscape. For example, northern Minnesota has a steep climatic gradient with transition among three biomes (prairie/oak savanna, northern hardwood forest and boreal forest) occurring within 100-200 km. It is very likely that the floral and faunal communities in transitional zones such as this will be dramatically altered under current climate change scenarios.

Boreal tree species whose ranges are expected to contract include black spruce (*Picea mariana*), white spruce (*P. glauca*), balsam fir (*Abies balsamea*), jack pine (*Pinus banksiana*), aspen (*Populus tremuloides*), and paper birch (*Betula papyrifera*). Temperate tree species that may expand their ranges northwards include northern red oak (*Quercus rubra*), bur oak (*Q. macrocarpa*), red maple (*Acer*

rubrum), sugar maple (*A. saccharum*), and American basswood (*Tilia americana*). Temperate forests may transition to savannas/grasslands, thus supporting a very different plant community.

Animal species will respond to these changes in vegetation, as well as directly to the warming climate. Some carnivores in the LSW, including Canada lynx (*Lynx canadensis*), may be directly affected by a changing climate and might not survive the transition to temperate forest and savanna. In some cases other species will compete with and ultimately replace current species. For example, bobcat (*L. rufus*) range has moved north and east since 1990, increasing interactions with lynx in Minnesota (Moen 2009). Future conditions will likely favor deer (*Odocoileus virginianus*) in northeast Minnesota, which may provide a resource base for large predators. Overall it is likely that changing community-level interactions (e.g., increasingly overlapping ranges of bobcat and lynx) will have important consequences for particular carnivore species.

Acknowledgements

We would like to thank the Great Lakes Indian Fish and Wildlife Commission for providing funds for this project. We would also like to thank the undergraduate students who assisted with collecting information and data for some of the carnivore species. Lastly, we would like to thank Michael Joyce, who provided some text and oversaw the updates for revision 1.1.

Literature Cited

- Abramov, A.V. 2000. A taxonomic review of the genus *Mustela* (Mammalia, Carnivora). *Zoosystematica Rossica*, 8: pp. 357-364.
- Andelt, W. F., and S. H. Andelt. 1984. Diet bias in scat deposition-rate surveys of coyote density. *Wildlife Society Bulletin*, 12: 74–77.
- Bekoff, M. 1982. Coyote (*Canis latrans*). In: Chapman, J. A. and Feldhamer, G. A. (eds). *Wild Mammals of North America*. Johns Hopkins University Press, Baltimore, Maryland, USA, pp. 447-459.
- Bonesi, L., and D. W. Macdonald. 1999. Evaluation of sign surveys as a way to estimate the relative abundance of American mink (*Mustela vison*). *Journal of Zoology*, 262(1): 65-72.
- Boulanger, J., S. Himmer, and C. Swan. 2004. Monitoring of grizzly bear population trends and demography using DNA mark–recapture methods in the Owikeno Lake area of British Columbia. *Canadian Journal of Zoology*, 82: 1267–1277.
- Carbone, C., S. Christie, K. Conforti, T. Coulson, N. Franklin, J. R. Ginsberg, M. Griffiths, J. Holden, K. Kawanishi, M. Kinnaird, R. Laidlaw, A. Lynam, D. W. Macdonald, D. Martyr, C. McDougal, L. Nath, T. O’Brien, J. Seidensticker, D. J. L. Smith, M. Sunquist, R. Tilson, and W. N. Wan Shahruddin. 2001. The use of photographic rates to estimate densities of tigers and other cryptic mammals. *Animal Conservation*, 4(01): 75-79.
- Casper, G. S. 2002. A Review of the Amphibians and Reptiles of the Lake Superior Watershed. Technical Report provided to the Terrestrial Wildlife Community Committee for the Lake Superior Lakewide Management Plan.
- Castro-Arellano, I., C. Madrid-Luna, T. E. Lacher, and L. León-Paniagua. 2008. Hair-Trap Efficacy for Detecting Mammalian Carnivores in the Tropics. *Journal of Wildlife Management*, 72(6): 1405-1412.
- Clark, T. W., E. Anderson, C. Douglas, and M. Strickland. 1987. *Martes americana*. *Mammalian species*, pp. 1-8.
- Cohn, J. P. 2008. Citizen Science: Can Volunteers Do Real Research? *BioScience* 58:192-197.
- Davison, A., J. D. Birks, R. C. Brookes, T. C. Braithwaite, and J. E. Messenger. 2002. On the origin of faeces: morphological versus molecular methods for surveying rare carnivores from their scats. *Journal of Zoology*, 257(2): 141-143.
- Dhuey, B., L. Oliver, and K. Warnke. 2009. Wisconsin Black Bear Harvest Report 2009. Unpublished Report, Wisconsin Dept. of Natural Resources.
- Dixon, K. R. 1982. Mountain lion (*Puma concolor*). In: Chapman, J. A. and Feldhamer, G. A. (eds). *Wild Mammals of North America*. Johns Hopkins University Press, Baltimore, Maryland, USA, pp. 711-727.
- Environmental Commissioner of Ontario. 2010. Editing Managing Black Bears: Thinking Beyond Harvest? Redefining Conservation, ECO Annual Report, 2009/10. Toronto: The Queen's Printer for Ontario. 65-9.
- Erb, J. 2009a. Registered Furbearer Population Modeling 2009 Report. Unpublished Report, Minnesota Dept. of Natural Resources.
- Erb, J. 2009b. Carnivore Scent Station Survey Summary, 2008. Minnesota Dept. of Natural Resources. Status of Wildlife Populations 2009. pp. 62-69.
- Erb, J. 2009c. Furbearer winter track survey summary, 2008. Minnesota Dept. of Natural Resources. Status of Wildlife Populations 2009. pp. 55-61.

- Fernandes, C. A., C. Ginja, I. Pereira, R. Tenreiro, M. W. Bruford, M. Santos-Reis, et al. 2008. Species-specific mitochondrial DNA markers for identification of non-invasive samples from sympatric carnivores in the Iberian Peninsula. *Conservation Genetics*, 9(3): 681-690.
- Foran, D. R., S. C. Minta, and K. S. Heinemeyer. 1997. DNA-based analysis of hair to identify species and individuals for population research and monitoring. *Wildlife Society Bulletin*, 25: 840-847.
- Frantz, A. C., M. Schaul, L. C. Pope, F. Fack, L. Schley, C. P. Muller, et al. 2004. Estimating population size by genotyping remotely plucked hair: the Eurasian badger. *Journal of Applied Ecology*, 41(5): 985-995.
- Frawley, B. J. 2009. 2008 Michigan black bear hunter survey. Michigan Department of Natural Resources Wildlife Division Report No. 3501.
- Fritzell, E. K., and K. J. Haroldson. 1982. *Urocyon cinereoargenteus*. *Mammalian species*, pp. 1-8.
- Galatowitsch, S., L. E. Frelich, and L. Phillips-Mao. 2009. Regional climate change adaptation strategies for biodiversity conservation in a midcontinental region of North America. *Biological Conservation* 142: 2012-2022.
- Garshelis, D. L., and K. V. Noyce. 2010. Status of Minnesota black bears, 2009. Unpublished Report, Minnesota Dept. of Natural Resources.
- Gese, E. 2001. Monitoring of terrestrial carnivore populations. In J. L. Gittleman, Funk, D. W. Macdonald, and R. K. Wayne, eds. *Carnivore conservation*. Cambridge University Press, London, UK, pp. 372-396.
- Gese, E. 2004. Survey and census techniques for canids. In C. Sillero-Zubiri, M. Hoffmann, and D. W. Macdonald, eds. *Canids: foxes, wolves, jackals, and dogs: Status survey and conservation action plan*. IUCN/SSC Canid Specialist Group, Gland, Switzerland, and Cambridge, UK, pp. 273-279.
- Godin, A. J. 1982. Striped skunk (*Mephitis mephitis*). In: Chapman, J. A. and Feldhamer, G. A. (eds). *Wild Mammals of North America*. Johns Hopkins University Press, Baltimore, Maryland, USA, pp. 674-687.
- Gompper, M., R. Kays, J. Ray, S. Lapoint, D. Bogan, J. Cryan, et al. 2006. A comparison of noninvasive techniques to survey carnivore communities in Northeastern North America. *Wildlife Society Bulletin*, 34: 1142-1151.
- González-Esteban, J., I. Villate, and I. Irizar. 2004. Assessing camera traps for surveying the European mink, *Mustela lutreola* (Linnaeus, 1761), distribution. *European Journal of Wildlife Research*, 50: 33-36.
- Gruber, B., B. Reineking, J. M. Calabrese, A. Kranz, A. Polednikova, L. Polednik, R. Klenke, A. Valentin, and K. Henle. 2008. A new method for estimating visitation rates of cryptic animals via repeated surveys of indirect signs. *Journal of Applied Ecology*, 45: 728-735.
- Harrison, R. L., D. J. Barr, and J. W. Dragoo. 2002. A comparison of population survey techniques for swift foxes (*Vulpes velox*) in New Mexico. *American Midland Naturalist*, 148: 320-337.
- Henderson, C. L. 1979. Bobcat (*Lynx rufus*) distribution management, and harvest analysis in Minnesota, 1977-79. In *Proceedings of the Bobcat Research Conference*, National Wildlife Federation Scientific and Technical Series. 6: 27-31.
- Hooper, J. And R. V. Rae. 2009. The use of an orthotic casting foam as a track-plate medium for wildlife research and monitoring. *Wildlife Biology*, 15: 106-112.

- Howard, W. E., and R. E. Marsh. 1982. Spotted and hog-nosed skunks. Wild mammals of North America: Biology, Management, and Economics, J. A. Chapman and G. A. Feldhamer, editors. Johns Hopkins University Press. Baltimore, Maryland, pp. 664-673.
- Jong, C. V. Z. D. 1987. A phylogenetic study of the Lutrinae (Carnivora; Mustelidae) using morphological data. Canadian Journal of Zoology, 65(10): 2536-2544.
- Judge, K. A., and M. Haviernick. 2002. Update COSEWIC status report on the grey fox *Urocyon cinereoargenteus* in Canada, in COSEWIC assessment and update status report on the grey fox *Urocyon cinereoargenteus* interior in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. pp. 1-32.
- Karanth, K. U. and J. D. Nichols. 1998 Estimation of tiger densities in India using photographic captures and recaptures. Ecology, 79: 2852–2862.
- Karanth, K. U. 1995 Estimating tiger (*Panthera tigris*) populations from camera-trap data using capture-recapture models. Biological Conservation, 71: 333–338.
- Karanth, K. U., J. D. Nichols, N. S. Kumar, and J. E. Hines. 2006. Assessing tiger population dynamics using photographic capture-recapture sampling. Ecology, 87: 2925-2937.
- Kaufmann, J. H. 1982. Raccoon (*Procyon lotor*). In: Chapman, J. A. and Feldhamer, G. A. (eds). Wild Mammals of North America. Johns Hopkins University Press, Baltimore, Maryland, USA, pp. 567-585.
- Kendall, K. C., L. H. Metzgar, D. A. Patterson, and B. M. Steele. 1992. Power of sign surveys to monitor population trends. Ecological Applications, 2: 422–430.
- King, C. M. 1983. *Mustela erminea*. Mammalian Species, pp. 1-8.
- Kinlaw, A. 1995. *Spilogale putorius*. Mammalian Species, pp. 1-7.
- Koepfli, K. P., K. A. Deere, G. J. Slater, C. Begg, K. Begg, L. Grassman, M. Lucherini, G. Veron, and R. K. Wayne. 2008. Multigene phylogeny of the Mustelidae: Resolving relationships, tempo and biogeographic history of a mammalian adaptive radiation. BMC Biology, 6: 1-22.
- Kortello, A. D., T. E. Hurd, and D. L. Murray. 2007. Interactions between cougars (*Puma concolor*) and gray wolves (*Canis lupus*) in Banff National Park, Alberta. Ecoscience, 14: 214-222.
- Kucera, T. E., A. M. Soukkala, and W. J. Zielinski. 1995. Photographic bait stations. In: W. J. Zielinski and T. E. Kucera (eds), American marten, fisher, lynx, and wolverine: survey methods for their detection. U.S. Forest Service General Technical Report PSW-GTR-157, Pacific Southwest Research Station, Albany, CA, USA, pp. 25–65.
- Kurose, N., A.V. Abramov, and R. Masuda. 2008. Molecular phylogeny and taxonomy of the genus *Mustela* (Mustelidae, Carnivora), inferred from mitochondrial DNA sequences: New perspectives on phylogenetic status of the back-striped weasel and American mink. Mammal Study, 33: 25-33.
- Larivière, S. 1998. *Lontra felina*. Mammalian Species, pp. 1-5.
- Larivière, S. 1999. *Mustela vison*. Mammalian species, pp. 1-9.
- Larivière, S. 2001. *Ursus americanus*. Mammalian Species, pp. 1-11.
- Lindzey, F. G. (1982). American badger (*Taxidea taxus*). In: Chapman, J.A. and Feldhamer, G.A. (eds). Wild Mammals of North America. Johns Hopkins University Press, Baltimore, Maryland, USA, pp. 653-663.

- Linscombe G., N. Kinler, and R. J. Aulerich. 1982. Mink (*Mustela vison*). In: Chapman, J. A. and Feldhamer, G. A. (eds). *Wild Mammals of North America*. Johns Hopkins University Press, Baltimore, Maryland, USA, pp. 629-643.
- Long, C. A. 1973. *Taxidea taxus*. *Mammalian Species*, 26: pp. 1-4.
- Long, R. A., P. MacKay, W. J. Zielinski, and J. C. Ray. 2008. *Noninvasive Survey Methods for Carnivores*. Island Press, Washington, D.C.
- Lotze, J. H., and Anderson, S. 1979. *Procyon lotor*. *Mammalian species*, pp. 1-8.
- Loukmas, J. J., D. T. Mayack, and M. E. Richmond. 2003. Track plate enclosures: box designs affecting attractiveness to riparian mammals. *American Midland Naturalist*, 149: 219-224.
- Lynch, Á. B., M. J. Brown, and J. M. Rochford. 2006. Fur snagging as a method of evaluating the presence and abundance of a small carnivore, the pine marten (*Martes martes*). *Journal of Zoology*, 270(2): 330-339.
- McCord, C.M. and J. E. Cardoza. 1982. Canada lynx (*Lynx canadensis*) and bobcat (*Lynx rufus*). In: Chapman, J. A. and Feldhamer, G. A. (eds). *Wild Mammals of North America*. Johns Hopkins University Press, Baltimore, Maryland, USA, pp. 728-766.
- McKelvey, K. S. 2000. History and distribution of lynx in the contiguous United States.
- Mech, L. D. 1974. *Canis lupus*. *Mammalian species*, 37: 1-6.
- Moen, R. 2009. Canada lynx in the Great Lakes region. 2008 Annual Report. NRRI Technical Report No. NRRI/TR-2009/06.
- Mowat, G., and D. Paetkau. 2002. Estimating marten (*Martes americana*) population size using hair capture and genetic tagging. *Wildlife Biology*, 8: 201-209.
- Myers, P., B. L. Lundrigan, S. M. G. Hoffman, A. P. Haraminac, and S. H. Seto. 2009. Climate-induced changes in the small mammal communities of the northern Great Lakes region. *Global Change Biology* 15: 1434-1454.
- Nowak, R. M. 1999. In: *Walker's Mammals of the World*, 6(2). Johns Hopkins University Press, Baltimore, Maryland, USA
- Okarma, H., W. Jędrzejewski, K. Schmidt, S. Śnieżko, A. N. Bunevich, and B. Jędrzejewska. 1998. Home ranges of wolves in Białowieża Primeval Forest, Poland, compared with other Eurasian populations. *Journal of Mammalogy*, pp. 842-852.
- Pasitschniak-Arts, M., and S. Larivière. 1995. *Gulo gulo*. *Mammalian species*, pp. 1-10.
- Patterson, B. R., L. K. Benjamin, and F. Messier. 1998. Prey switching and feeding habits of eastern coyotes in relation to snowshoe hare and white-tailed deer densities. *Canadian Journal of Zoology* 76:1885-1897.
- Patterson, B. R., and V. A. Power. 2002. Contributions of forage competition, harvest, and climate fluctuation to changes in population growth of northern white-tailed deer. *Oecologia* 130:62-71.
- Pauli, J., M. Hamilton, E. Crain, and S. Buskirk. 2008. A single-sampling hair trap for mesocarnivores. *Journal of Wildlife Management*, 72(7): 1650-1652.
- Pelton, M. R. 1982. Black bear (*Ursus americanus*). In: Chapman, J. A. and Feldhamer, G. A. (eds). *Wild Mammals of North America*. Johns Hopkins University Press, Baltimore, Maryland, USA, pp. 504-514.

- Pilot, M., B. Gralak, J. Goszczyński, and M. Posłuszny. 2007. A method of genetic identification of pine marten (*Martes martes*) and stone marten (*Martes foina*) and its application to faecal samples. *Journal of Zoology*, 271(2): 140-147.
- Powell, R. A. 1981. *Martes pennanti*. *Mammalian Species*, pp. 1-6.
- Rexstad, E. and K. P. Burnham. 1991. User's Guide for Interactive Program CAPTURE. Abundance Estimation of Closed Populations. Colorado State University, Fort Collins, Colorado, USA.
- Robinson, S. J., L. P. Waits, and I. D. Martin. 2007. Evaluating population structure of black bears on the Kenai Peninsula using mitochondrial and nuclear DNA analyses. *Journal of Mammalogy*, 88(5): 1288-1299.
- Samuel, D. E. and B. B. Nelson. 1982. Gray fox (*Urocyon cinereoargenteus*) and red fox (*Vulpes vulpes*). In: Chapman, J.A. and Feldhamer, G.A. (eds). *Wild Mammals of North America*. Johns Hopkins University Press, Baltimore, Maryland, USA, pp. 475-490.
- Schauster, E. R., E. M. Gese, and A. M. Kitchen. 2002. An evaluation of survey methods for monitoring swift fox abundance. *Wildlife Society Bulletin*, 30: 464-477.
- Schwartz, M. K., K. L. Pilgrim, K. S. McKelvey, E. L. Lindquist, J. J. Claar, S. Loch, and L. F. Ruggiero. 2004. Hybridization between Canada lynx and bobcats: genetic results and management implications. *Conservation Genetics*, 5: 349-355.
- Schwartz, M. K., K. L. Pilgrim, K. S. McKelvey, P. T. Rivera, and L. F. Ruggiero. 2007. DNA markers for identifying individual snowshoe hares using field-collected pellets. *Northwest Science*, 81: 316-322.
- Schwartz, M. K. and S. L. Monfort. 2008. Genetic and Endocrine Tools for Carnivore Surveys. In: Long, R. A., MacKay, P., Ray, J. C., and Zielinski, W. J. (eds) *Noninvasive survey methods for carnivores*. Island Press, Washington, D.C.
- Silver, S. C., L. E. Ostro, L. K. Marsh, L. Maffei, A. J. Noss, M. J. Kelly, et al. 2004. The use of camera traps for estimating jaguar *Panthera onca* abundance and density using capture/recapture analysis. *Oryx*, 38: 148-154.
- Smith, D. A., K. Ralls, B. L. Cypher, J. E. Maldonado. 2005. Assessment of scat-detection dog surveys to determine kit fox distribution. *Wildlife Society Bulletin*, 33: 897-904.
- Smith, W. P., D. L. Borden, and K. M. Endres. 1994. Scent station visits as an index to abundance of raccoons: an experimental manipulation. *Journal of Mammalogy*, 75: 637-647.
- Sheffield, S. R., and C. M. King. 1994. *Mustela nivalis*. *Mammalian Species*, pp. 1-10.
- Sheffield, S. R., and H. H. Thomas. 1997. *Mustela frenata*. *Mammalian Species*, pp. 1-9.
- Strickland, M. A., C. W. Douglas, M. Nowak, and N. P. Huntzinger. 1982. Fisher (*Martes pennanti*). In: Chapman, J.A. and Feldhamer, G. A. (eds). *Wild Mammals of North America*. Johns Hopkins University Press, Baltimore, Maryland, USA, pp.586-598.
- Strickland, M. A., C. W. Douglas, M. Nowak, and N. P. Huntzinger. 1982. Marten (*Martes americana*). In: Chapman, J. A. and Feldhamer, G. A. (eds). *Wild Mammals of North America*. Johns Hopkins University Press, Baltimore, Maryland, USA, pp. 599-612.
- Taberlet, P. and G. Luikart. 1999. Non-invasive genetic sampling and individual identification. *Biological Journal of the Linnean Society*, 68: 41-55.
- Toweill, D. E. and J. E. Tabor. 1982. River otter (*Lutra canadensis*). In: Chapman, J. A. and Feldhamer, G. A. (eds). *Wild Mammals of North America*. Johns Hopkins University Press, Baltimore, Maryland, USA, pp. 688-703.

- Trolle, M., and M. Kery. 2003. Estimation of ocelot density in the Pantanal using capture-recapture analysis of camera-trapping data. *Journal of mammalogy*, 84(2): 607-614.
- Wade-Smith, J., and B. J. Verts. 1982. *Mephitis mephitis*. *Mammalian Species*, pp. 1-7.
- Weaver, J. L., P. Wood, D. Paetkau, and L. L. Laack. 2005. Use of scented hair snares to detect ocelots. *Wildlife Society Bulletin*, 33(4): 1384-1391.
- Whitaker, J. O. and W. J. Hamilton. 1998. *Mammals of the Eastern United States*. Cornell University Press, Ithaca, New York, USA, pp. 393-497.
- Williams, B. W., D. R. Etter, D. W. Linden, K. F. Millenbah, S. R. Winterstein, and K. T. Scribner. 2009. Noninvasive hair sampling and genetic tagging of co-distributed fishers and American martens. *Journal of Wildlife Management*, 73(1): 26-34.
- Wilson, D. E. 1982. Wolverine (*Gulo gulo*). In: Chapman, J.A. and Feldhamer, G.A. (eds). *Wild Mammals of North America*. Johns Hopkins University Press, Baltimore, Maryland, USA, pp. 644-652.
- Wilson, G. J., and R. J. Delahay. 2001. A review of methods to estimate the abundance of terrestrial carnivores using field signs and observation. *Wildlife Research*, 28: 151–164.
- Wires, L. R., and R. J. Baker. 1994. Distribution of the Spotted Skunk (*Spilogale putorius*) in Minnesota. Final report submitted to the Minnesota Department of Natural Resources and the Zoological Society of Minnesota. pp. 1-14.
- Zielinski, W. J., and T. E. Kucera. 1995. American marten, fisher, lynx, and wolverine: survey methods for their detection. U.S. Forest Service General Technical Report PSWGTR-157, Pacific Southwest Research Station, Albany, CA, USA.
- Zielinski, W. J. and R. Truex. 1995. Distinguishing tracks of closely-related species. *Journal of Wildlife Management* 59: 571-579.
- Zielinski, W. J., F. V. Schlexer, K. L. Pilgrim, and M. K. Schwartz. 2006. The efficacy of wire and glue hair snares in identifying mesocarnivores. *Wildlife Society Bulletin*, 34: 1152-1161.

Appendix 1. Reference materials for carnivore species in the Lake Superior watershed

Regional guides

- Baker, R. H. 1983. Michigan Mammals. Michigan State University Press, East Lansing, MI.
- Chapman, J. A. and G. A. Feldhamer. 1982. Wild Mammals of North America. Johns Hopkins University Press, Baltimore, Maryland, USA.
- Eder, T. 2002. Mammals of Ontario. Lone Pine Publishing, Edmonton, Alberta, Canada.
- Gunderson, H. L. and J. R. Beer. 1953. The Mammals of Minnesota. The University of Minnesota Press, Minneapolis, MN.
- Hazard, E. B. 1982. The Mammals of Minnesota. The University of Minnesota Press, Minneapolis, MN.
- Jackson, H. H. T. 1961. Mammals of Wisconsin. The University of Wisconsin Press, Madison, WI.
- Long, C. A. 2008. The Wild Mammals of Wisconsin. Pensoft Publishers, Sofia, Bulgaria.
- Nowak, R. M. 1999. Walker's Mammals of the World, 6th edition. The Johns Hopkins University Press, Baltimore, Maryland, USA.
- Whitaker, J. O. and W. J. Hamilton. 1998. Mammals of the Eastern United States. Cornell University Press, Ithaca, New York, USA.

DNR and MNR website links

Other Links

[University of Wisconsin, Stevens Point - Mammals of Wisconsin database](#)

[Minnesota DNR](#)

[Wisconsin DNR](#)

[Michigan DNR](#)

[Ontario Ministry of Natural Resources](#)

Appendix 2. Changes in Release 1.1

1. We have added additional harvest data through 2012 for species in the U.S.

2. Species and higher level names change occasionally over time. Species which have changed recently include those in the table below. In the text we refer to the mountain lion as *Felis concolor*, the fisher as *Martes pennanti*, and the mink as *Mustela vison*.

Family	Common Name	Alternative Species	Reference
Felidae	Mountain lion, cougar	<i>Puma concolor</i>	Nowak 1999
Mustelidae	Fisher	<i>Pekania pennanti</i>	Koepfli et al. 2008
	American Mink	<i>Neovison vison</i>	Abramov 2000, Kurose et al. 2008
	American otter	<i>Lontra canadensis</i>	van Zyll de Jong 1987

3. It is also important to realize that more and more museums are digitizing their collections. At the time this publication was originally prepared, the collections listed here were the collections that were available online. Several other museum collections have now become searchable. Some of these are listed in the following table.

University of Wisconsin at Madison (UWZM)	atswindev.doit.wisc.edu/uwzm/collections.html
Field Museum of Natural History (Chicago, IL)	emuweb.fieldmuseum.org/mammals/Query.php
VertNet has records of over 13 million specimens from 62 research collections including large museums such as the American Museum of Natural History, Carnegie Museum of Natural History, Field Museum, and the Milwaukee Public Museum; large university collections such as University of Michigan, Kansas University, Michigan State University, and UC Berkeley; and smaller collections including Emporia State University and Illinois State University.	http://www.vertnet.org/

4. Updated state harvest sections to indicate that wolves are now being harvested after delisting.