Resiliency of furbearers to trapping in Canada

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CHAPTER 13

RESILIENCY OF FURBEARERS TO TRAPPING IN CANADA

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Abstract: From the early 1600s to the early 1800s, the European fur trade became established in North America. Not guided by today's principles of conservation, increasing pressure was applied on many furbearer species, causing local population extirpations as well as wide-spread reductions. The near-extinction of beaver (*Castor canadensis*) and sea otter (*Enhydra lutris*) are examples of the short-sightedness of the early fur-trade days. Since the 1900s, regulation of the fur industry has improved and fur management programs have been implemented. We review how trapping affects a natural population's structure and growth, and may affect behavior and genetic diversity. We suggest that furbearers should be classed and managed according to their degree of resiliency, defined as the capability of species to recover from a reduction in numbers. Resiliency depends on population distribution, density, reproduction, mortality and dispersal. We classify furbearer species in Canada into four groups. Species with low resiliency have limited range and distribution, low reproductive rates or large home ranges. Examples include the swift fox (*Vulpes velox*), the sea otter and the wolverine (*Gulo gulo*). Sustainable harvests range from 0 to 10% of the pre-harvest populations. Species with high resiliency can withstand high trapping pressure because of their widespread distribution, and high reproductive and dispersal rates. Muskrat (*Ondatra zibethicus*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), arctic fox (*Alopex lagopus*), and the short-tailed weasel (*Mustela erminea*) are highly resilient to harvest rates up to 75%. Most furbearers have an intermediate resiliency. Depending on environmental conditions and population characteristics, wolves (*Canis lupus*), fisher (*Martes pennanti*), marten (*Martes americana*), long-tailed weasel (*Mustela frenata*), river otters (*Lutra canadensis*), striped skunk (*Mephitis mephitis*), mink (*Mustela vison*), raccoon (*Procyon lotor*), beaver, red squirrel (*Tamiasciurus hudsonicus*), and gray squirrel (*Sciurus carolinensis*) can tolerate harvest rates from 10 to 50%. Bobcat (*Lynx rufus*) and lynx (*Lynx canadensis*) are two species with low-intermediate resiliency depending on their population characteristics, which are influenced by prey abundance. The North American badger (*Taxidea taxidus*) is a low-intermediate resilient species because it is at the northern limit of distribution in Canada and at least one population has been severely reduced. Using long-term harvest records, carcass analyses, and evaluations of habitat characteristics and prey abundance, fur managers may determine the degree of resiliency of populations and develop comprehensive management programs appropriate for a variety of spatial scales.

INTRODUCTION

The trapping industry is often touted by its supporters as an environmentally sound, sustainable use of a renewable resource (Fur Institute of Canada 1989). Alternatively, claims have been made that reliable data on furbearer populations and the impacts of trapping are lacking, and fur trapping is not properly managed (Defenders of Wildlife 1984, O'Sullivan 1989). As a means of addressing these conflicting views, we reviewed the impacts of trapping on furbearers in Canada. We discuss the effects of market demand and trapper effort on furbearer populations from the early fur trade to current times. We compare trapped and natural populations, and discuss how trapping may affect genetic and behavioral diversity. On the basis of our review, we suggest that furbearers in Canada be classed and managed according to their degree of resiliency, which we define as the capability of species to recover from a reduction in numbers. Recommendations for monitoring the effects of trapping on populations and measures to ensure sustainable harvests are proposed.

THE EARLY FUR TRADE

Prehistoric people hunted furbearers in North America for more than 11,000 years (Wright 1987). However, most furbearers were of limited importance at this time because the primary concern of Aboriginal people was to acquire the meat and hides of large animals such as ungulates (Wright 1987). When the European fur trade came to North America, hunting and trapping were for commercial reasons rather than subsistence, and market demand replaced individual need in controlling the size of the harvest (Obbard et al. 1987). The early fur trade, not guided by today's principles of conservation, caused local extirpations as well as widespread reductions of some furbearer species.

The beaver (*Castor canadensis*) was the first species to experience the negative effects of excessive trapping pressure. The underwool of beaver pelts was a principal raw material in the felt-making process for hats. Early in the fur trade, transportation costs were significant and merchants had to secure high volumes of fur to be profitable. The numbers of pelts required exceeded the capacity of the land to provide (Ray 1987), and by 1821, many beaver populations had been seriously overtrapped (Innis 1956, Williams 1983).

Other furbearer species were also affected, especially those with high-value longhaired pelts (Innis 1956). Early fur-trade practices were particularly detrimental to species of limited distribution, such as sea otters (*Enhydra lutris*). The magnitude of the west coast trade was large compared to the land-based trade, and sea otter populations were rapidly depleted (Ray 1987). By 1800, only 22 years after the arrival of Captain Cook, declines were evident. By 1820, the unchecked maritime fur trade terminated due to the lack of sea otters.

George Simpson, a manager with the Hudson Bay's Company, implemented the first conservation measures in Canada in 1821 (Ray 1987). He reduced the number of trading posts and labor force, established beaver trading quotas within each district, banned the trade of cubs and summer beavers, and implemented trapping seasons. Trading posts were relocated in response to local resource conditions, and to draw Aboriginal trappers to areas of relative abundance and away from depleted zones. Simpson was responsible for Canada's first registered traplines by assigning Indian bands to specific tracts of land and refusing furs from trappers operating outside their assigned territories (Ray 1987). These conservation measures were successful, however the beaver market disappeared when silk hats replaced felt as a key fashion article in the 1830s (Ray 1987).

In the 1900s, the fur industry became more regulated. Fur trapping was incorporated into wildlife management programs aimed at ensuring future viable populations and habitats, and human multi-use activities (Proulx and Barrett 1991). Wildlife managers monitored population trends, annual harvests, trapping seasons and quotas, and conducted research to better understand the population dynamics and behavior of furbearers. Unfortunately, many jurisdictions did not provide sufficient resources to monitor populations and to apply corrective measures where necessary (Fritzell and Johnson 1982, Slough et al. 1987). Given the lack of necessary data, wildlife managers acknowledged that trapping had the potential to negatively affect furbearer populations (Proulx and Barrett 1991).

HOW TRAPPING AFFECTS FURBEARER POPULATIONS

An assessment of the impact of trapping on furbearer populations is not an easy task. Harvest data are routinely collected by wildlife agencies in Canada, however, there are many limitations associated with these data. In general, harvests are poor short-term indicators of abundance and distribution. Changes in annual harvests may result from changes in abundance, but they also are a function of pelt price, weather, trapping regulations, prey cycles, economics, trappers' experience or interest, and other factors (Erickson 1982, Hamilton and Fox 1987). We acknowledge that harvest data collected over decades may depict trends in relative abundance and general distribution, and may be useful to assess the effect of trapping (Obbard et al. 1987, Golden 1999). However, interpretation requires related information on the mortality and productivity of populations (Erickson 1982, Proulx and Barrett 1991).

Effects Of Market Demand And Trapper Effort

Wildlife agencies encourage trappers to manage traplines in a sustainable fashion but trappers are business people and an increase in market prices is a motivation to trap more animals. Positive correlations have been noted between high market values and the number of fur-traders, the number of trappers, and the harvest of high-demand species (Erickson and Sampson 1978, Bailey 1981, Todd and Boggess 1987). It would be erroneous to interpret the increase in harvest that follows an increase in price as an increase in abundance. In an examination of Canadian annual fur harvest data since 1970, Reid (1988) concluded that the numbers of animals trapped generally coincided with pelt price or followed price changes with a lag of one or two years. Harvests of species in demand such as lynx (*Lynx canadensis*), bobcat (*Lynxs rufus*), red fox (*Vulpes vulpes*), coyote (*Canis latrans*), wolf (*Canis lupus*), and raccoon (*Procyon lotor*) have been directly correlated to market price, and some of these have been subjected to more intense harvest pressure (Bailey 1981, Hamilton and Fox 1987). The harvests of species with low commercial value may be more representative of relative abundance because their harvests are subject to less direct influence by the fur market and less regulatory manipulations by management agencies (Erickson 1982).

Trapper effort is influenced by several interacting variables including the number of trappers, their skill, the size of traplines, weather conditions, accessibility, and economics. When the economic climate is poor, employment opportunities other than trapping may be limited. Stabler et al. (1990) identified two distinct sub-groups of trappers in the Northwest Territories. One group, accounting for about 15% of those who trapped, had a substantial commitment to the activity, and was motivated by the income-earning potential of fur sales. The second group, which included approximately 85% of the study participants, consisted of those whose involvement was best explained by the lack of alternative employment opportunities. In British Columbia, 52% of questionnaire respondents indicated that livelihood was their main reason for trapping (Reid 1988). Poor economic conditions may create a greater need for trapping income as well as allowing more time for an unemployed trapper to spend on the trapline, both of which result in increased effort.

Subsistence trapping is important in many rural areas of Canada, as is the lifestyle that trapping provides. Trapping can provide meaningful employment, regardless of the income earned from selling furs. Some trappers prefer the benefits of self-sufficiency, physical labor, and being outdoors to typical wage paying employment. In addition, where fresh meat is expensive or not available, snowshoe hare (*Lepus americanus*), muskrat, beaver and lynx can be important sources of food (Winterhaulder 1980, Reid 1988, Berkes et al. 1994).

Trappers motivated by income or the need for wild meat expend more effort (Meredith and Todd 1979). In general, the greater the number of traps and the greater the area covered, the greater the trapping success (Todd and Boggess, 1987). However, trapper skill and experience are also important, as the most experienced trappers are the most efficient and successful (Todd and Boggess 1987). The relative importance of effort and skill can vary depending on the species. Harvests of furbearers which are easy to trap, such as marten, reflect the skill of the trapper less than species which are difficult to trap, such as wolf (Todd and Boggess 1987).

Environmental constraints influence trapper effort, especially in areas where access is limited. For example, if little snowfall occurs, effort may be curtailed because it may be more difficult for trappers to access their trapline by snowmobile. In much of northern Canada, it is the lack of access that hampers or discourages trapping activities, and maintains unharvested populations without the need for legislation. Habitat modification from resource uses such as logging, mining, agriculture and settlement influence trapper effort by increasing access. Road construction not only makes the trapline more accessible, but weather becomes less of a factor in reducing effort. Trappers who use trucks instead of snowmobiles spend less time traveling and are able to check traps more often and in more severe weather. This increased effort may result in larger harvests (Bailey 1981). Conversely, these trappers may limit their activities to a few winter-maintained roads. Also, in areas with increased access, the degree of habitat loss and fragmentation can be so significant that furbearer populations are reduced, compromising the trapper's ability to harvest animals for some period of time.

Effects Of Trapping On Furbearer Population Dynamics

Juveniles are vulnerable to trapping due to their inexperience and dispersal behavior, and as a result, are over-represented in the harvest compared to their actual occurrence in the population (Krohn et al. 1994). Similarly, males are over-represented due to typically larger home ranges and greater movements. The increased vulnerability of adult males is especially evident during the breeding season due to their increased movements. Females tend to exhibit greater site fidelity and have less opportunity to encounter traps. For example, higher survival of adult female marten results from their lower vulnerability to trapping compared to other age-sex classes (Buskirk and Ruggiero 1994).

Harvest ratios begin to reflect actual population characteristics once a large proportion of the population has been removed. Of course, this indicates that over-harvesting is likely occurring. Fisher (*Martes pennanti*) is a furbearer species that is susceptible to being over-trapped throughout its range (Banci 1989, Powell and Zielinski 1994, Garant and Crête 1997). Contrary to other mustelids, a female bias, specifically in adults, appears to be characteristic of fisher harvests (Douglas and Strickland 1987, Banci 1989). Why this occurs merits some discussion. As adult males suffer greater total mortality than adult females, the adult segment has a preponderance of adult females (Krohn et al. 1994). In a situation of heavy harvesting, trappers begin to remove adult females and the harvest becomes biased to females. If the skew in sex ratios becomes extreme at either end, females cannot mate because of too few males, or there are too few females to maintain productivity, hampering the ability of the population to replace harvested individuals (Strickland and Douglas 1981).

The majority of furbearer populations in North America have been harvested and the characteristics of unexploited furbearer populations are largely unknown (Powell 1994). However, a few studies of untrapped populations provide insight. In general, natural mortality of juveniles is high, due to the same reasons that juveniles are vulnerable to trapping. Thus much of juvenile trapping mortality may be compensatory. In an untrapped population, adults essentially occupy all habitats and turnover is low, leaving few areas for juvenile dispersal (Krohn et al. 1994). In the first year of trapping in an area which had been protected for over a century harvests of marten were not biased to juveniles, presumably because the population was composed mostly of adults (Fortin and Cantin 1994). The proportion of juveniles increased annually once trapping began. Similarly, in an untrapped fisher population, juveniles accounted for only 21% of the live-trapped animals and the age structure differed significantly from the age structure in the region surrounding the park, where juveniles comprised 75% of the harvest (Garant and Crête 1997).

Effects Of Trapping On Behavioral And Genetic Diversity

Harvesting not only affects population size but also population dynamics, age structure, sex ratio, spacing, and likely mating patterns and foraging costs (Powell 1994). Because of the difficulties in obtaining large enough samples, few radio-collaring studies have assessed how trapping alters behavior, especially of territorial species with well-developed social systems and low adult turnover rates, such as the mustelids. Impacts can be significant. Hornocker and Hash (1981) suggested that intensive trapping of a recent re-established wolverine population contributed to behavioral instability, and was responsible for the extensive home range overlap observed among adult residents.

Animals in different regions or ecotypes are adapted for living in those areas. As a result, individuals and populations cannot be assumed to be equivalent. Attempts at re-colonization of species such as fisher apparently have failed because the re-introduced animals originated from areas that were too different, in habitat, prey base or predators (Banci 1989). It is possible that these ecotypic differences in behavior have a genetic basis, and that trapping can and has had an impact on genetic diversity (Banci 1989). Recent advances in genetics may help explain the significance of the historical reductions in populations such as beaver and sea otters. In recent years, habitat losses and alienation due to increasing access, human settlement and resource extraction activities, especially in southern and agricultural areas of all of Canada, have decreased the distribution and abundance of some furbearers. Although there have been notable successes in the recovery of species and populations, we cannot discount importance of the behavioral and genetic diversity that may have been lost.

NUMERICAL RESPONSES OF FURBEARER POPULATIONS TO TRAPPING: THE CONCEPT OF RESILIENCY

The responses of individuals and populations to changes in abundance, habitat, and weather conditions vary both in space and time. Two populations of a same species may not have equivalent responses to an environmental change because the characteristics of their populations differ. To better understand the responses of furbearer populations to trapping, we classed species according to their degree of resiliency, defined as the capability to recover from a reduction in numbers.

Species With Low Resiliency

Species with low resiliency are sensitive to trapping because their populations have one or more of the following characteristics: 1) limited range or distribution, 2) low reproductive rate, or 3) large home range. Because their populations are not widespread, over-exploitation may lead to local extirpation. Due to their low abundance and productivity, the replacement of trapped animals may be slow and incomplete. In Canada, the swift fox (*Vulpes velox*), the sea otter and the wolverine (Fig. 1) are low resilient species with limited distributions and relatively low productivity (Table 1).

While the decline of swift fox may be attributed to wolf poisoning programs and habitat loss (Scott-Brown et al. 1987), trapping certainly was an additive mortality factor that contributed to its decline (Banfield 1974). Originally found only in the western prairies, the arrival of settlers led to a sharp decrease of swift fox numbers and by 1900 the species was rare (Hillman and Sharps 1978). Current efforts to recover and restore this species are hampered by the extensive habitat losses that occurred when natural grasslands were converted to pasture and farmland. The recently re-introduced population is considered endangered by the Committee of Endangered Wildlife in Canada (COSEWIC) and is not trapped.

Figure 1. The wolverine: a low-resilient species (Photo: V. Banci).

The British Columbia sea otter population, estimated at a minimum of 1552 animals in 1995, originated from 89 animals reintroduced to Vancouver Island from 1969 to 1972 (Watson et al. 1997). While the species is no longer in danger of imminent extirpation from Canadian waters, it is still restricted in distribution and vulnerable to environmental catastrophes such as oil spills (Watson et al. 1987), and remains protected from trapping. In Alaska, considerable discussion has occurred on whether the sea otter population, estimated at more than 150,000 animals, is sufficiently resilient to withstand some trapping pressure (Samuel and Foin 1983, Garshelis 1987).

Wolverines occur at low densities and, even in optimal habitat, are less abundant than other carnivores (Quick 1953, van Zyll de Jong 1975, Banci 1994). Home ranges are typically large relative to carnivores of similar size and vary from 100 to over 1000 km^2 (Banci 1994). Wolverines are susceptible to trapping because they travel widely and are readily attracted to bait (Hornocker and Hash 1981). Little is known about the effects of trapping on western wolverine populations and, on the basis of limited information, annual sustainable harvest rates have been estimated at a maximum of 10% of fall densities (Dauphiné 1989, Gardner et al. 1993).

In Canada, at least two wolverine populations have shifted to very low resiliency, in Eastern Canada and Vancouver Island (*Gulo gulo vancouverensis*). Although incompletely understood, the decline of the eastern population can be attributed to a natural low density population, the increased scarcity of caribou (*Rangifer tarandus*) during the early 1900s, trapping and extensive wolf poisoning programs (RENEW 1996). The historical distribution of the Vancouver Island wolverine was altered due to human settlement, access and extensive forestry activities, as well as over-trapping (Banci 1982). The Vancouver Island wolverine is red-listed (a species at risk) by the British Columbia government. Both eastern and Vancouver Island populations are protected from trapping, although at the present time Aboriginal people in eastern Canada could harvest wolverine for traditional and personal uses.

Species With High Resiliency

High resilient species can withstand high trapping pressure with little if any negative impacts. Populations have one or more of the following characteristics: 1) widespread distribution, 2) high reproductive rate, and 3) high dispersal rate. In Canada, muskrat, coyote, red fox, arctic fox (*Alopex lagopus*), and short-tailed weasel (*Mustela erminea*) are highly resilient species with widespread distributions and high productivity (Table 1, Fig. 2). Compensatory mortality and natality enable all to withstand high trapping mortality (Errington et al. 1963, Macpherson 1969, Knowlton 1972, Connolly 1978, Hiruki and Sterling 1989). A high dispersal capability and rapid recolonization of depleted areas have been described for muskrat (Errington 1963), coyote (Davison 1980, Carbyn and Paquet 1986), red fox (Storm et al. 1976), arctic fox (Wrigley and Hatch 1976, Eberhardt and Hanson 1978, Fay and Rausch 1992), and short-tailed weasel (Simms 1979a, King 1989, Raymond and Bergeron 1989).

Sustainable harvest rates for highly resilient species can be as much as 75% of the pre-trapping population (Table 1). However, a species that is highly resilient under normal conditions may become less resilient if affected by a lack of prey or loss of critical habitat. For example, arctic fox and short-tailed weasel populations fluctuate from year to year, largely because of variations in prey numbers (Chesemore 1968, Macpherson 1969, Speller 1972, Raymond and Bergeron 1989). During years of low prey abundance, fox and weasel populations may take longer to recover from a reduction in numbers. Harvest rates greater than 60% may also be inappropriate for muskrat populations where resiliency has been compromised by unfavorable environmental conditions. For example, when water levels are low and negatively affect movements, feeding activities, and reproductive and survival rates of muskrats (Proulx and Gilbert 1983), 50% is a more appropriate harvest rate (Alexander 1955, Smith and Jordan 1976).

Species with Intermediate Resiliency

In Canada, most furbearers fall somewhere between low and high resiliency levels. Some species with intermediate resiliency may have a limited distribution; others may be widespread. Most species reach sexual maturity during the first year, however, sexual maturity may be delayed for mustelids and those living in family groups (Table 1). The reproductive rate of intermediate-resiliency species is moderate. Most of them have high dispersal capability. We include 11 species in this group: wolf, fisher, marten, river otter (*Lutra canadensis*), long-tailed weasel (*Mustela frenata*), striped skunk (*Mephitis mephitis*), mink (*Mustela vison*), raccoon, beaver, red squirrel (*Tamiasciurus hudsonicus*), and gray squirrel (*Sciurus carolinensis*).

Table 1. Population characteristics and range of sustainable harvest rates for furbearers in Canada according to their degree of resiliency.

Species	National status	Distribution	Age at sexual maturity	Average number of young	Range of sustainable yearly harvest rates
LOW RESILIENCE					
Swift fox	Endangered[1]	Western prairies[1]	1[2]	2[2]	0
Sea otter	Threatened[1]	West coast of British Columbia[3]	3-4[4]	1[5]	0
Wolverine	Vulnerable (western population)[1]	Boreal forest, tundra, mountains; associated with wilderness[1]	≥1[6]	2-3[7]	≤10[8]
	Endangered (eastern population)[1]	Central-northern Québec and Labrador[1]	-	-	0
HIGH RESILIENCE					
Muskrat	Furbearer	Wetlands, lakes, rivers[9]	≤1[9]	12[12]	≤75[11]
Coyotes/foxes	Furbearer	Open areas, ecotones, forests[12]	≤1[12]	3-9[13]	≤75[13]
Short-tailed weasel	Furbearer	Grasslands, wetlands, forests[14]	≤1[16]	6[16]	≤80[17]
INTERMEDIATE RESILIENCE					
Wolf	Furbearer	Boreal and sub-boreal forests, tundra, montane[18]	2[19]	6[19]	≤40[20]
Fisher	Furbearer	Boreal forest[21]	1[22]	2-3[23]	≤25[24]
Marten	Furbearer	Boreal and sub-boreal forests, tundra, montane[25]	1[26]	2-3[26]	≤25[27]
Mink	Furbearer	Wetlands, lakes, rivers[28]	≤1[29]	4[30]	30-50[31]
River otter	Furbearer	Wetlands, lakes, rivers[32]	≥2[33]	2-3[32]	≤25
Long-tailed weasel	Furbearer	Grasslands and forests of southern Canada[14]	≥1[15]	4-5[34]	≤25
Striped skunk	Furbearer	Forest ecotones and grasslands[35]	1[36]	5-9[37]	30-50
Raccoon	Furbearer	Southern areas of Canada[28]	1[40]	2-5[41]	41-59[42]
Beaver	Furbearer	Lakes and rivers	1.8[43]	3-4[44]	20-43[45]
Red squirrel	Furbearer	Forests across Canada	≤1[46]	3-5[47]	20-25[48]
Gray squirrel	Furbearer	Southeast Canada[28]	≤1[49]	6[50]	30-40[51]
LOW-INTERMEDIATE RESILIENCE					
Badger	Furbearer Endangered (BC)	Southern areas of western and central Canada[38]	≤1[39]	2[38]	≤25
Bobcat	Furbearer	Southern Canada[28]	≥1[52]	2-3[52]	0-20[53]
Lynx	Furbearer	Boreal and sub-boreal forests[54]	≥1[55]	0-16[56]	0-≤40[57]

[1]Twolan and Nadeau 1998;[2]Scott-Brown et al. 1987 (in the Wildlife Reserve of Western Canada); [3]Watson et al. 1997; [4]Wendell et al. 1984;); [5]Schneider 1972; [6]Banci 1994; [7]Rausch and Pearson 1972, Liskop et al. 1981; [8]Dauphiné 1989, Gardner et al. 1993; [9]Perry 1982, Parker and Maxwell 1984, Proulx and Buckland 1985; [10]Proulx and Gilbert 1983, Proulx and Buckland 1986; [11]Smith et al.1981, Parker and Maxwell 1984, Clark 1987; [12]Voigt 1987, Voigt and Berg 1987, Garrott and Eberhardt 1987; [13]Connolly and Longhurst 1975, Sterling et al. 1983, Garrott and Eberhardt 1987; [14]Fagerstone 1987; [15]Deanesley 1943; [16]Stubbe 1973; [17]King 1989; [18]Carbyn 1987; [19]Mech 1974; [20]Keith 1983, Ballard et al. 1987; [21]Douglas and Strickland 1987; [22]Wright and Coulter 1967; [23]Coulter 1966, Douglas and Strickland 1987; [24]Strickland and Douglas 1987; [25]Strickland and Douglas 1987; [26]Strickland and Douglas 1987, Aune and Schladweiler 1997; [27]Fortin and Cantin 1994; [28]Banfield 1974; [29]Enders 1952; [30]Hanson 1947; [31]Eagle and Whitman 1987; [32]Melquist and Dronkert 1987; [33]Hamilton and Eadie 1964, Tabor and Wight 1977; [34]Wright 1948; [35]Rosatte 1987; [36]Verts 1967; [37]Schowalter and Gunson 1982, Rosatte 1987; [38]Todd 1980, Lindzey 1981, Messick and Hornocker 1981; [39]Wright 1966; [40]Sanderson 1960, Cowan 1973; [41]Asdell 1964; [42]Sanderson 1987, Clark et al. 1989; [43]Gunson 1970, Wigley et al. 1983; [44]Novak 1987; [45]Henry and Bookhout 1969, Novak 1977, Payne 1984; [46]Millar 1970, Lair 1985; [47]Ferron and Prescott 1977, Rusch and Reeder 1978; [48]Obbard 1987; [49]Flyger and Gates 1982; [50]Brown and Yeager 1945, Barkalow and Shorten 1973; [51]Mosby 1969, Mosby et al. 1977; [52]Parker and Smith 1983; [53]Knick 1990; [54]Koehler and Aubry 1994; [55]Brand et al. 1976, O'Connor 1986; [56]O'Connor 1986, Mowat et al. 1996; [57]Bailey et al. 1986, Quinn and Thompson 1987.

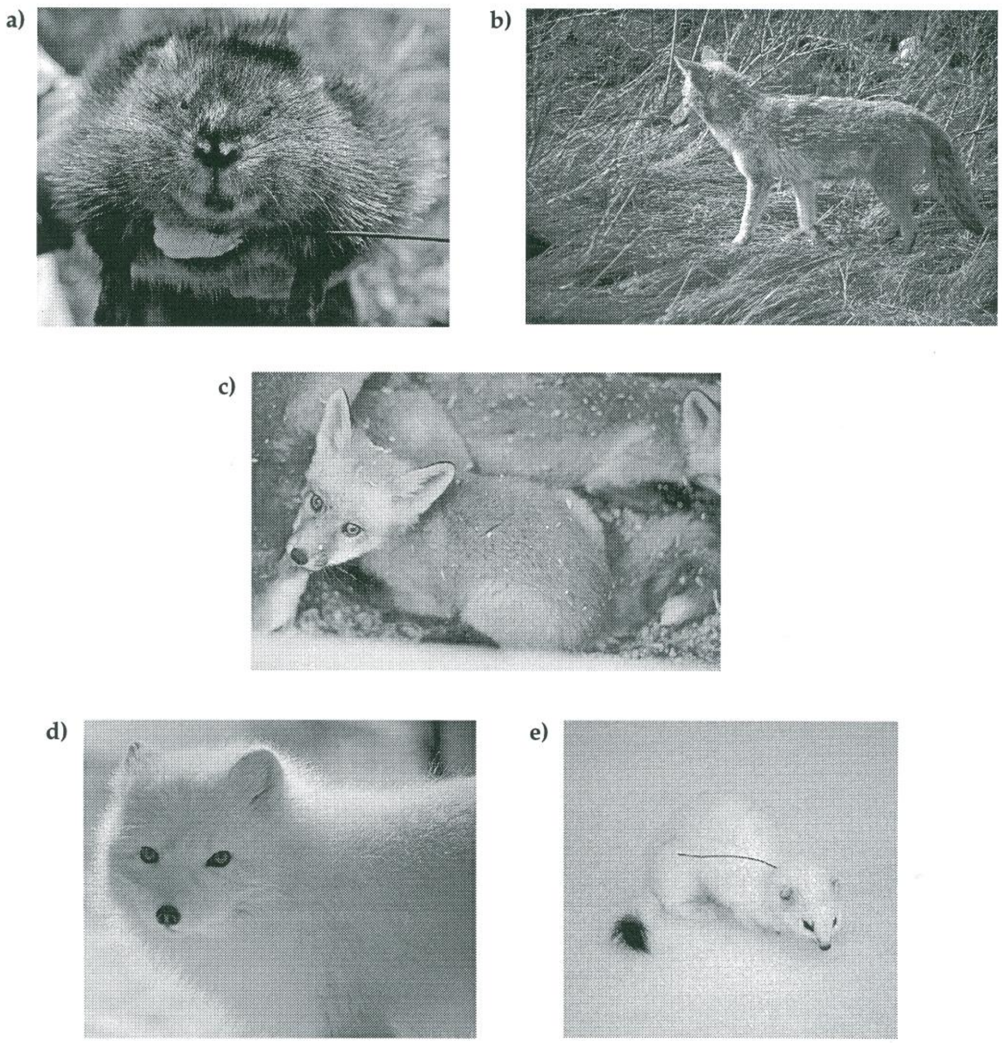

Figure 2. Species highly resilient to trapping: a) muskrat, b) coyote, c) red fox, d) arctic fox, and e) short-tailed weasel (Photos: G. Proulx).

Wolves have a high reproductive potential and yet are sensitive to over-harvesting because of their large home ranges, low densities, and complex social behavior (Carbyn 1987). Over-harvests may occur during high price cycles (Gunson 1992), or when wolf populations are already in decline because of a lack of prey (Gasaway et al. 1983). Although wolf reproductive and dispersal rates are high and populations can quickly increase following reduced harvest efforts (Mech 1970, 1995), estimated maximum annual harvest rates are markedly lower than those of highly resilient species. In north central Minnesota, harvests exceeding 28% of the winter population often resulted in declines (Fuller 1989). Keith (1983) concluded that wolves could sustain harvests of 23-38% and that stationary populations, whether exploited or not, would be composed of 40% pups by autumn or winter. In Alberta, Ballard et al. (1987) noted that harvests greater than 40% of autumn wolf numbers resulted in a population decline. They suggested that acceptable levels of trapping varied depending on the sex and age composition of each pack, and the timing of the harvest. Heavily exploited packs are composed of only a few adults and several pups; therefore, any additional mortality could greatly affect reproductive success (Ballard et al. 1987). In the light of these studies, we suggest that the upper limit of sustainable harvest rates for wolves be conservatively established at 40%.

Both fisher and marten (Fig. 3) are easily trapped (Coulter 1966, Archibald and Jessup 1984) and are susceptible to over-harvest because of their relatively low natality and large home ranges (Douglas and Strickland 1987, Strickland and Douglas 1987, Buskirk and McDonald 1989, Aune and Schladweiler 1997). Because fishers are easily caught in traps set for other furbearers (Hamilton and Cook 1955, Coulter 1960, 1966, Douglas and Strickland 1987, Powell 1993), the frequency of incidental captures may negatively affect existing populations or prevent the recovery or establishment of others (Lewis and Zielinski 1996). Douglas and Strickland (1987) modeled a trapped Ontario fisher population using an extensive data set on sex and age distribution, reproduction, and harvest, for a period extending from 1973 to 1984. A harvest rate above 25% of the pre-trapping population caused a decrease in population size while a harvest rate of 20-25% resulted in a stable population. Similar conclusions were reached in Maine (Coulter 1966) and Minnesota (Douglas and Strickland 1987).

In a marten population protected since 1895 but recently subjected to fur harvest, Fortin and Cantin (1994) estimated that the natural and trapping mortality corresponded to 35 and 25% of the fall-winter population, respectively. They concluded that part of the trapping mortality was additive and recommended a harvest rate of less than 25% of the pre-trapping population to ensure a sustainable yield. In Ontario, trapping mortality was additive when food was scarce, reproduction was low, and adult martens were forced to disperse in search of food (Thompson and Colgan 1994). When subjected to both habitat degradation and intense trapping pressure, the resiliency of fisher and marten may decrease and populations may be compromised (Buskirk and Ruggiero 1994, Powell and Zielinski 1994). This is particularly true in managed forests where expanding road networks associated with timber harvesting increase trapper access (Soukkala 1983, Thompson 1988, 1994, Hodgman et al. 1994).

The Newfoundland marten, *Martes americana atrata*, is an example of a population where resiliency has fallen below the intermediate level because of habitat loss and intensive widespread mortality. Despite complete protection since 1934, habitat loss and natural mortality (Bergerud 1969, Thompson 1991), accidental captures in traps set for other furbearers, and incidental mortality in snares set for snowshoe hares, have reduced the Newfoundland marten population to approximately 300 animals (Forsey et al. 1995). The Newfoundland marten is now considered to be endangered (Twolan and Nadeau 1998) and has a low resiliency to trapping.

a) 

b) 

Figure 3. American marten (a) and fisher (b) are both sensitive to over-trapping (Photos: G. Proulx).

Both mink and raccoon exhibit high ecological adaptability, occur in a variety of ecosystems, have a moderate reproductive rate and extensive dispersal abilities that allow them to rapidly colonize new or depleted areas (Asdell 1964, Northcott et al. 1974, Fritzell 1978). There have been no attempts to evaluate adequate harvests for wild mink. Limited information from studies on mink biology (Eagle and Whitman 1987) suggests populations can withstand harvests of 30 to 50%. Clark et al. (1989) projected raccoon population growth rates based on data collected during two trapping seasons in Iowa, and calculated a maximum sustainable harvest of 41%. In Illinois, Sanderson (1987) suggested sustainable harvest rates ranging from 49% for a population with low fecundity to 59% for one with high fecundity.

As history has shown, beavers can be vulnerable to over-harvesting, despite their own tendency to overpopulate beyond habitat capability. Beavers are easy to trap because they are confined to watercourses, and their lodges and dams are easy to find (Fig. 4). Harvest rates ranging from 20 to 43% have been recommended (Henry and Bookout 1969, Novak 1977, Payne 1984). In Ontario, Novak (1987) recommended that 30% of a beaver population be harvested regardless of the habitat type, corresponding to 1 to 2.5 beavers per colony. In northern New York, however, Parsons and Brown (1981) noted that the number of active beaver colonies declined significantly when the harvest per colony approached or exceeded 2. When the harvest per colony remained at or below 1.5, the number of active colonies remained relatively stable.

Compensatory mortality and natality, relatively high reproductive and dispersal rates, and ecological adaptability (Mosby 1969, Barkalow et al. 1970, Flyger and Gates 1982) enable squirrels to withstand harvest rates ranging from 20 to 40% (Obbard 1997, Mosby 1969, Mosby et al. 1977). With the exception of some traplines in western Canada, red squirrels are not subjected to intense harvests. As noted by Obbard (1987), harvest densities in boreal forests are typically less than 1 squirrel/km^2, much lower than estimated population densities.

There are no data on the numerical responses of river otter, long-tailed weasel and striped skunk to trapping. However, because of similarities between their reproductive, dispersal and survival rates and those of other species that have an intermediate resiliency level, we included them in this category.

River otter populations exhibit low fecundity levels, increased survival, and low generation times; therefore, they cannot readily compensate for heavy losses (Melquist and Dronkert 1987). Considering that sexual maturity in river otter is generally not reached until 2 years of age (Hamilton and Eadie 1964, Tabor and Wight 1977), the harvest of adult females may affect population growth in the short-term. Frequent use of beaver ponds, bank dens and lodges increases the likelihood of otters being accidentally caught in traps set for beavers (Reid et al. 1994, Chilelli et al. 1996). River otters are also sensitive to riparian habitat destruction (Toweill and Tabor 1982, Bowyer et al. 1995). In adequate habitats, because of incidental captures in beaver sets and the low productivity of otter populations, conservative policies are essential to maintain viable populations. We suggest that this species be classed at a resiliency level similar to that of fisher (Table 1).

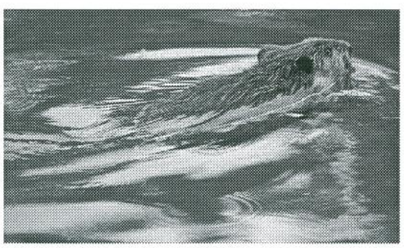

Figure 4. Beavers are easy to find and trap (Photos: G. Proulx).

Although the fur trade does not distinguish between short-tailed and long-tailed weasel pelts, the latter are markedly less numerous. This may be due to a lack of favorable habitat conditions and competition with other mustelids, particularly when snow cover is prolonged and extensive. Simms (1979b) suggested that in central and eastern North America, the distribution of the long-tailed weasel was limited to the north by the presence of marten, a more effective surface predator, and to the south by the short-tailed weasel, a more effective subnivean predator. In the Canadian prairies, although the species' distribution did not change significantly over the last decades (Johnson et al. 1992, Proulx and Drescher 1993), the long-tailed weasel has been affected by habitat loss and alteration and increased use of agricultural pesticides (Gamble 1982; Proulx, unpublished data). Research from western North America suggests the long-tailed weasel may be associated with high structural diversity, particularly in the understory (Carey et al. 1992, Carey 1995). Because of its limited distribution, this species may be less resilient than other intermediate furbearers and we suggest a harvest rate of less than 25% (Table 1).

The striped skunk is viewed as a pest in most areas and may be harvested year-round

(Rosatte 1987). Skunks have increased their geographic range in North America with clearing of first-growth forests (Rosatte 1987). Considering their high reproductive (Schowalter and Gunson 1982) and dispersal (Sargeant et al. 1982) rates, we suggest this species is at least as resilient as mink, and can withstand harvests of 30 to 50% (Table 1).

Species With Low-Intermediate Resiliency

North American badgers (*Taxidea taxus*) are found in southern areas of the Canadian western provinces and occasionally in southern Ontario (Messick 1987). However, only Alberta considers the badger common and abundant (Rahme and Harestad 1991). Badgers are difficult to census, thus it is not surprising that sustainable harvest rates have not been estimated for this species (Messick 1987). North American badgers have a relatively low reproductive rate, extensive dispersal movements, and high human-caused mortality other than trapping (Messick 1987). Some badger populations may be able to sustain harvest rates recommended for mustelids with lower resiliency, a maximum of 25% (Table 1). Others, such as the red-listed British Columbia badger, are too rare to be trapped.

Bobcat and lynx (Fig. 5) are two species whose resiliency may range from low to intermediate according to their survival and reproductive rates, which vary significantly according to prey abundance. In the case of bobcat, population densities and distribution vary considerably from one jurisdiction to another. For example, bobcat is one of the most important trapped species in Nova Scotia (Parker and Smith 1983). In contrast, populations have declined in Quebec since 1970, and have been protected from trapping since 1991 (C. Fortin, 1999, Ministère de l'Environnement et de la Faune du Québec, personal communication).

Figure 5. Lynx: a low-intermediate resilient species (Photo: G. Proulx).

Many factors affect bobcat populations, but anthropogenic influences, especially rate of exploitation and land use, have the greatest impacts (Woolf and Hubert 1998). Natural mortality rates of bobcat populations are apparently low (Rolley 1987). Crowe (1975) estimated mortality at 3% in a protected population. However, in a harvested population, mortality rates may be as high as 40% (Parker and Smith 1983, Fuller et al. 1985). Sources of mortality other than legal trapping and hunting can also be substantial, exceeding 20% of all deaths (Litvaitis et al. 1987, Fuller et al. 1985, 1995). Females with kits appear to be highly susceptible to trapping during winter (Parker and Smith 1983, Knick et al. 1985). In Montana, bobcats were more vulnerable to trapping when snow depths exceeded 20 cm and affected their ability to hunt (Koehler and Hornocker 1989). In Idaho, Knick (1990) used computer simulations based on social organization and population dynamics of female bobcats to determine yield at different harvest intensities. He recommended a maximum harvest rate of 20% of the fall population.

The resiliency of lynx populations is a function of the snowshoe hare cycle, which they lag by 2-3 years. In years of hare abundance, large litters and high kitten survival suggest a large potential for growth. In Ontario, during a period of high productivity, a lynx population increased despite a high estimated annual trapping mortality of 40% (Quinn and Thompson 1987). However, in years of low hare abundance, lynx populations are characterized by an absence of kitten recruitment, increased home-range sizes, intensified dispersal, and increased mortality (Poole 1994). Mowat et al. (1996) found that although adult lynx continued to produce young for one year after hares had declined, most yearlings discontinued reproduction. There was an abrupt cessation of reproduction by both adults and yearlings two years after the hare decline. During periods of hare scarcity, kittens are not produced (Poole 1994) or their survival declines (Brand and Keith 1979, Koehler 1990, Mowat et al. 1996).

Natural mortality may increase from 5 to 10% during years of increasing or high hare abundance to 60-70% during years of low hare abundance (Brad and Keith 1979, Ward and Krebs 1985, Koehler 1990, Poole 1994, Slough and Mowat 1996). Thus, lynx trapping during the 2-3 winters after a snowshoe hare decline may be at least partially compensatory (Poole 1994, Slough and Mowat 1996). Implementation of cautious trapping seasons or quotas during this period may target lynx most likely to starve, which would have little effect on subsequent lynx population recovery (Poole 1997). Some authors have concluded that, since most natural mortality occurs during summer months prior to the winter trapping season, trapping mortality could be additive (Brand and Keith 1979, Koehler and Aubry 1994).

The proportion of lynx that survives years of hare scarcity determines the speed and magnitude of population recovery once hare numbers rebound and kitten recruitment increases. Intense trapping during the lynx population low may jeopardize future recovery despite abundant hares (Poole 1994). Brand and Keith (1979) recommended at least a 3-year curtailment of trapping during lynx population declines to ensure survival of adequate breeding populations for the next cycle. Depending on kitten recruitment and population recovery, a maximum of 40% of fall populations could be harvested during the increasing phase of the lynx cycle (Bailey et al. 1986, Quinn and Thompson 1987).

MANAGING FURBEARERS ACCORDING TO THEIR DEGREE OF RESILIENCY

Our classification of species according to degree of resiliency suggests that, depending on environmental conditions and population characteristics, harvest rates may range from 0 to 10% for species with low resiliency, 10 to 50% for intermediate species, and 50 to 75% for highly resilient furbearers (Fig. 6). Density-, age-, sex-, time- and area- specific differences in population characteristics must be considered when estimating resiliency levels and determining harvest rates. By using long-term harvest records, carcass analyses (sex and age ratios, reproductive and survival rates), and evaluations of habitat characteristics and prey abundance, fur managers may be able to estimate the status of populations and their degree of resiliency to trapping. Resiliency levels may be used to manage furbearer harvests at different geographic scales, and determine appropriate regulations.

In Canada, it is commonplace for trappers on Crown land to be licensed within a system of registered traplines. The designation of registered traplines means that furbearer harvests can be monitored over a long time period for a particular tract of land. When this information is used in conjunction with habitat information (forestry and agricultural cover, changes in watercourses, urban developments, etc.), the degree of resiliency of species can be estimated. For example, if harvest records and carcass analyses suggest that the distribution, numbers, and productivity of marten within an extensively logged area have decreased significantly over the years, this population is likely at the lower end of resiliency and should be subjected to a lower harvest rate, 10-15%. In contrast, nearby populations with a stable or growing densities may sustain higher harvest rates (up to 25%, Fig. 1).

At the national and international levels, the classification of populations according to "standardized" resiliency levels is particularly useful for the management of species that are wide-ranging and are monitored by agencies from different jurisdictions. It is not sufficient to ensure that a recovering population is protected from intensive trapping as these populations may depend on influx from other regions. Thus, managing an intermediate resilient population as having a low resiliency may assist in population recovery elsewhere. This likely is the case for lynx and fisher in southern British Columbia and Alberta, to assist recovery of depleted populations in the Pacific Northwest of the United States (Ruggiero et al. 1994), which are dependent on dispersal from neighboring Canadian populations.

Medium and low resilient species require a more intensive management approach than do high resilient species. Trapping seasons for the latter can be based on pelt primeness while management of the former requires a suite of options. Trapping seasons can be manipulated to account for the behavior and trapping susceptibility of age- and sex-classes. For example, juvenile and adult male martens predominate in harvests from early fall trapping. Short seasons with early openings protect breeding females (Ruggiero et al. 1994). Conversely, for lynx during the medium-low resiliency phase of their population cycle, a late season opening is best to protect adult females and young. This is due to the hunting behavior of this species. When a lynx family approaches a trap, the adult female is caught first. Kittens that are orphaned early in winter may have lower survival than later in the season (Mowat et al. 1996). Setting harvest limits and promoting the utilization of more selective trapping devices may also be used to capture juveniles, manipulate sex ratios in the harvest, and preserve breeding females (Novak 1987).

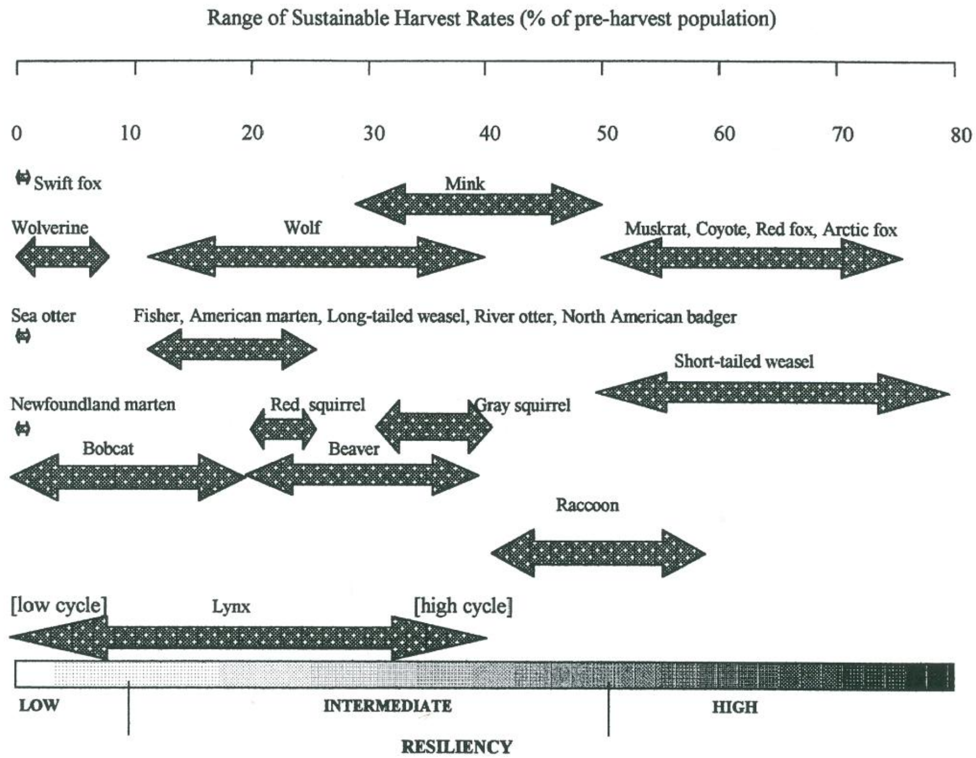

Figure 6. Resiliency of furbearers to trapping pressure.

RECOMMENDATIONS

In Canada, 23 species are legally designated as furbearers, covering every potential niche and trophic level. It is because of the diversity and abundance of furbearers that the fur industry has been, and continues to be, an important part of our history and culture. Furthermore, trapping is an important tool in the management of furbearer populations, and provides a source of information on these species that often is the only biological data available to the fur manager. To maintain the viability of furbearer populations and the fur industry, we recommend that:

- Long-term comparative studies be conducted between non-harvested and harvested furbearer populations to better understand the effects of trapping on population dynamics, structure, genetics and behavior.
- Field studies be conducted to assess sustainable harvest rates for all furbearer species under diverse environmental conditions and prey abundance. Particular attention should be given to species for which we have little information, such as wolverine, long-tailed weasel, river otter, striped skunk, North American badger, red squirrel and bobcat.
- For intermediate to low resilience species, biological data from carcasses be collected and be used to monitor harvest age and sex structure, natality, food habits, and physical condition.
- In conjunction with research, fur harvest and biological data be used to estimate the resiliency of furbearer populations, and to develop sustainable harvest programs, at the regional, provincial, and national levels.

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