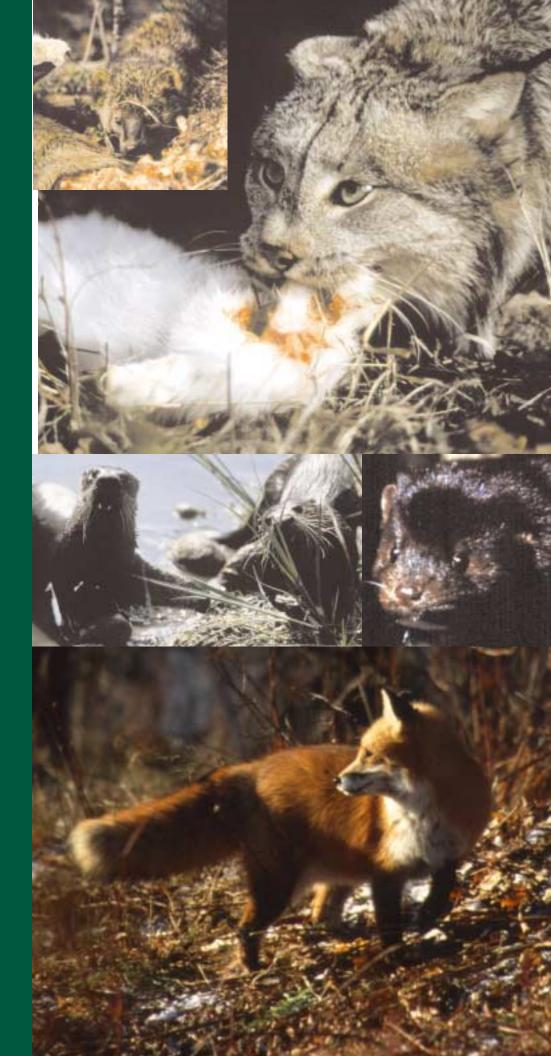WCS Working Paper No. 15
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Mesocarnivores of Northeastern North America: Status and Conservation Issues

Justina C. Ray

WCS

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Mesocarnivores of Northeastern North America   Justina C. Ray

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MAP PREPARED BY ERIC SANDERSON AND KAREN WILLETT, WCS

General Introduction

Members of the order Carnivora form a unique mammalian group from an historical perspective. They have been subject to centuries of persecution and exploitation—maligned and feared as predators, but valued for their fur coats. They also have exhibited remarkable resilience in the face of such pressures (Schaller 1996). The early 20th century marked a turning point, however, as destruction and degradation of natural habitats began to pose an additional threat. Through land clearing for agriculture, extensive logging, unregulated trapping activities, as well as anti-predator control efforts, several mesocarnivore inhabitants of northeastern North America faced local extirpation at one time or another—notably lynx *(Lynx canadensis),* marten *(Martes americana),* fisher *(Martes pennanti),* and river otter *(Lontra canadensis).* Thanks to management efforts and several successful reintroductions beginning in the 1950s, as well as natural range expansion as forest cover returned, most species have experienced population rebounds and have gradually re-occupied many parts of their former ranges—sometimes in a remarkably short timespan. By contrast, larger wolves *(Canis lupus)* and cougars *(Puma concolor),* which were extirpated from the Northeast by the beginning of the 20th century, have not fared as well and have not experienced similar recoveries. At the same time, some mesocarnivores have taken advantage of anthropogenic habitat change to expand their ranges. The result has been relatively rapid shifts in predator communities during this century, often occurring in landscapes very much altered from those of 150 years ago.

In recent years, attention has turned beyond the traditional issues of furbearer management. In a region that has undergone substantial transformation of the landscape, one of the greatest threats is the homogenization of wildlife communities, and carnivores are no exception. Agriculture, forestry, and suburban development are replacing the original diverse communities of specialist and generalist species with one dominated by just a few generalists. Shifts in habitat conditions can lead to the emergence of new competitive relationships between formerly allopatric species. In many cases, the status of local mesocarnivore populations is poorly known, because of their secretive habits, dwindling and diverted research and monitoring budgets, and a lack of obvious economic values. In addition, research and conservation agendas regarding the most threatened members of the group are driven by outside perspectives, with little recognition of the unique nature of the Northeast with respect to its ecology and conservation. Thus, while many carnivores are safe from the exploitative practices of the past, a new suite of threats has taken center stage. Although more subtle, they may prove equally detrimental to the long term viability of mesocarnivore populations and communities in northeastern North America.

The following Working Paper contains a discussion of the principal conservation issues facing mesocarnivores in northeastern North America, followed by detailed accounts for each of 14 species that summarize the status and distribution of each, and review what is known about their habitat associations and responses to human-induced distur-

bance. This paper takes an historical perspective, and focuses upon issues that are salient and unique to the region. Information for this paper was obtained from published and unpublished reports and detailed telephone interviews with scientists and managers from each jurisdiction. Large carnivores such as black bears *(Ursus americanus),* wolves, and cougars were intentionally excluded, as were wolverines *(Gulo gulo)* and arctic foxes *(Alopex lagopus)* — mesocarnivores that occur in only a very small part of the region. All taxonomic names are according to Wilson & Reeder (1993).

This paper represents a follow-up to a 1996 workshop co-sponsored by the University of Massachusetts, the U.S. Fish and Wildlife Service, and the Wildlife Conservation Society, entitled "Mesocarnivores in the Northeast: establishing research priorities" (Organ et al. 1997), the purpose of which was to identify and prioritize research needs. One of the top research priorities identified at that meeting was to collect essential information about the region's mesocarnivore species in a single report, which this document aspires to do.

Part I:
Conservation Issues

The Unique Nature of the Northeast

As the first area in North America to be colonized by European settlers, the Northeast has a long history of intensive human use (Cronon 1983), and contains large areas with the highest human population densities on the continent. Most of the region surrounding and extending south of the Canadian border has been altered so extensively through the processes of deforestation, farming, urbanization, and even reforestation that the structure and composition of today's forests bear little resemblance to those of three centuries ago (Foster 1993; Fuller et al. 1998). Despite reforestation over large areas, pollen data indicate that forests in New England are showing little sign of returning to pre-settlement species composition (Fuller et al. 1998).

Given these circumstances, it is tempting to dismiss the Northeast as a focal point for conservation of carnivores—animals that traditionally evoke images of large expanses of wilderness. Indeed, carnivore research and conservation in North America have a distinctly western bias, due in part to the common view that the West's shorter history of intensive human use offers more hopeful prospects for such animals. Research aimed at acquiring ecological information on mesocarnivores is generally conducted in "natural" or undisturbed habitats, which are most abundant in the West. Even species as ubiquitous as raccoons *(Procyon lotor),* foxes *(Vulpes vulpes* and *Urocyon cinereoargenteus),* and striped skunks *(Mephitis mephitis)* have been the subjects of surprisingly few studies in human-modified landscapes. As a result, not only is the knowledge base for many mesocarnivores generally lacking with regard to disturbance impacts, but aspects of their ecology, as gleaned from these studies, are often assumed to be equally applicable in the Northeast. A U.S. Forest Service science report on the lynx in the United States (Ruggiero et al. 1999a), for example, acknowledges the atypical ecological conditions in the Northeast, but has great difficulty in drawing pertinent conclusions about the status and conservation potential of this species in the region, because of a relative lack of research in comparable habitats. The fact that so much of the landbase in the Northeast is privately owned adds an extra dimension to the particular challenges facing regionally-based habitat conservation efforts for wide-ranging mesocarnivores (Harper et al., cited in USFWS 2000).

Recent observations of northeastern species highlight the important ecological differences between regions, and the dangers of generalization: The fisher, which is rare in the Northwest and closely associated with late-successional forests there (Powell & Zielinski 1994), has undergone rapid population and range expansions in New England where it is occupying highly disturbed areas with increasing frequency (Kilpatrick & Rego 1994; S. Langlois, P. Rego, pers. comm.). Although lynx were

thought to depend on old growth forests for denning, a female was found this spring nesting in a recently-logged (15-20 year old) stand in northern Maine (USFWS 1999).

The time to consider the opportunities for mesocarnivore conservation in northeastern North America is long overdue. As it turns out, there is some cause for optimism. Several mesocarnivore species (e.g., marten, fisher, river otter, and red fox) that have faced local extirpation in the region during this century have staged remarkable recoveries, as reviewed in this paper. In an analysis of potential lynx habitat in the northeastern U.S. (McKelvey et al. in press), maps identified an area more continuous in nature than in suitable habitats in the Northwest, and at least as large as existing blocks in the Rocky Mountain region. One western lynx expert notes that the Northeast may hold even more promise for lynx conservation by virtue of the fact that potential habitat is not fragmented by mountain ranges as it is in the West (G. Koehler, pers. comm.). Furthermore, in northern coniferous forests of the U.S., foresters are noting the increasing presence of softwoods in the understory following large-scale disturbance events such as the 1998 ice storm (S. Morse, in litt.), thereby enhancing habitat suitability for this endangered felid.

Several important questions arise in the context of the extensive changes that have occurred since human settlement in the Northeast: What is the baseline? What constitutes "natural"? What should be the targets for mesocarnivore conservation? Some argue that human impacts have been so pervasive in the region for such a long time that it would be impossible, and perhaps undesirable, to attempt a return to pre-settlement conditions. Others envision the restoration of pre-settlement carnivore communities, which includes formulating plans to reintroduce large carnivores to the region. In either case, it is clear that conservation of some mesocarnivore species in this ever-changing landscape will be a challenge, but the fact that several species have demonstrated unexpected resilience in the face of this change over the past century should be seen as encouraging.

Habitat Fragmentation

During the last century, increased human populations and development activities in northeastern North America (i.e., logging, agricultural development, urban sprawl, exurban development, road construction, and recreational snowmobile use) have led to broad-scale habitat change. The most obvious adverse impacts of such change is loss of habitat or the break-up of critical habitat into small patches that are isolated from one another. Both phenomena have negative implications for movements through the landscape and hence maintenance of viable populations (Beier 1993; Gaona et al. 1998).

Ecosystem change brought about by anthropogenic fragmentation of forests can result in decreases in the abundances of some carnivore species and increases in others (Goodrich & Buskirk 1995). Area loss and reduced habitat connectivity have negative implications for widely-ranging species and species that require interior forest conditions. On the other

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hand, human-dominated landscapes can often provide resource-rich habitats for generalist species (Goodrich & Buskirk 1995). Mesocarnivore species susceptible to the effects of forest fragmentation through loss of interior forest conditions and/or habitat area include the marten (Hargis et al. 1999) and lynx (Koehler & Aubry 1994). This has been a particularly salient issue for the lynx in the southern periphery of their range where their area requirements can be substantial due to relatively low snowshoe hare *(Lepus americanus)* densities (Koehler 1990; Koehler & Aubry 1994).

With human activities giving rise to new disturbance regimes and new habitats in the region, the relationship between vegetation and environmental variables (such as climate and soil) can become obscured. Instead of the pronounced regional variation in vegetation patterns that existed prior to 1700, forest structure and composition has since experienced broad-scale homogenization (Foster et al. 1998; Fuller et al. 1998). As a consequence, habitat for carnivores at the landscape level has become greatly simplified. Generalist predators—such as raccoons, coyotes *(Canis latrans)*, striped skunks, and red foxes—have become increasingly abundant in landscapes where the creation of edge habitats and the resultant juxtaposition of habitats offered increased foraging opportunities (Adkins & Stott 1998; Oehler & Litvaitis 1996; Parker 1995; Rosatte 1987). Hence, in some regions carnivore communities have become less diverse as species such as lynx, marten, and even bobcat *(Lynx rufus)* have disappeared. Prince Edward Island provides an excellent illustration, as one of the most highly urbanized regions in eastern Canada. Lynx, bobcat, marten, fisher, and otter populations were extirpated from the island by the 1890s, never to return. In their stead, striped skunks and raccoons became established on the island from fur farm escapees, and coyotes were also successful colonists. Today's carnivore community is represented by the suite of generalized predators that typify urban and suburban areas throughout the Northeast (R. Dibblee, pers. comm.). Southern New England (Massachusetts, Connecticut, and Rhode Island) have likewise become increasingly subjected to suburban sprawl, and carnivore communities are simpler than those of 100 years ago.

Superabundance of some native species, which occurs when anthropogenically altered environments promote population expansion of one set of species to the detriment of other sympatric species, is an emerging conservation problem. Of 21 species in a list of "North American species that have proven a problem in their native habitats due to overabundance," five (23%) are mesocarnivores. All five are found in the Northeast and fall in the category of mid-sized omnivores that do especially well in domesticated landscapes (Garrot et al. 1993). Overabundant species can "reduce natural diversity by monopolizing resources, introducing or spreading infectious diseases and parasites, and changing the species composition or relative abundance of sympatric species, and even causing local extinctions" (Garrot et al. 1993). An overabundance of small to mid-sized predators that can occur in response to the local extirpation of dominant carnivores ("mesopredator release;" Soulé et al. 1988) has been implicated in the decline or disappearance of small vertebrate prey in a variety of ecosystems.

Shifts in Mesocarnivore Distributions and Community Composition

During the past century in northeastern North America, the ranges and population densities of most of the species profiled in this paper have undergone substantial fluctuations. Several species, for example, have expanded their geographic ranges, a phenomenon that has been in large part facilitated by large-scale habitat transformations across the region. Shifts in community composition have taken place concomitant with these distributional dynamics, such that some species have been forced to share their ranges with a revised suite of potential competitors during relatively short time-frames. Those species that are more specialized in their resource requirements are the most vulnerable in the face of such change. To date, little research has addressed inter-relationships among northeastern carnivores, particularly in the face of continually changing ecological conditions.

The best example of a mesocarnivore that has taken advantage of changing habitat conditions in the Northeast is the coyote, an animal that may serve as an indicator of environmental change (Gipson & Brillhart 1995). The well-known intolerance of wolves towards coyotes (e.g., Fuller & Keith 1981) adds credibility to the reasoning behind the historic expansion of coyotes throughout much of North America following the extirpation of the wolf in the late 1800s (Parker 1995). The introduction of a smaller canid into the region posed a more direct competitive threat to existing mesocarnivores, such as bobcats, lynx, and foxes. Population declines of bobcats in southern Québec coincided with the arrival and establishment of coyote populations (Lariviere & Crete 1992). Bobcats in eastern Maine exhibited contraction of their niche after coyote colonization, and were thought to be most vulnerable during winters when competition for a limited prey base was heightened (Litvaitis & Harrison 1989). While the behavioral plasticity of coyotes enables them to switch easily to alternative prey sources when snowshoe hare populations are low, lynx are not as effective in this. Therefore, Buskirk et al. (1999a) speculate that greater dietary options open to coyotes in sub-boreal regions may provide a buffer to them when hares are scarce that is not available to lynx, and this in turn may make coyotes more effective competitors with lynx through time. The perception that red foxes have been forced into urban and suburban areas since coyotes became established is also common (e.g., PEI: R. Dibblee, pers. comm.; Rhode Island: L. Supprock, pers. comm.; Whitaker & Hamilton 1998).

Fisher and marten are potential competitors due to their large diet overlap, their dependence in some areas on snowshoe hares, and their use of similar den sites. Although their ranges demonstrate broad areas of overlap, several authors have pointed out the inverse relationship between population densities in areas where they are sympatric, corroborated by harvest records (Krohn et al. 1995; Strickland & Douglas 1987). Both climate and interspecific factors play roles in determining the distributions of both mustelids: fisher populations may be limited by snow accumulation, whereas martens may be limited by fisher populations, because the latter

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are more opportunistic feeders and are larger and thus able to handle a wider range of prey (Douglas & Strickland 1987; Krohn et al. 1995; 1997). Marten reintroduction efforts in southern Vermont may have been thwarted, for example, by high fisher populations. Of 47 camera traps placed in the areas two years after the effort, 87% of them yielded photographs of fisher, while not one marten was captured (K. Royar, pers. comm.). The future prospect of climate change adds a further layer of complexity: with milder winters characterizing some parts of the geographic range of marten, the more opportunistic fisher may be at a distinct advantage.

Snow depth is also thought to be a major factor limiting the bobcat's northward range (McCord 1974). A felid with generalized resource requirements, it shares a relationship with the lynx similar to that of the fisher with marten, and the two experience ecological and geographic separation as a result. Lynx are behaviorally and morphologically adapted to be superior competitors to bobcats in areas characterized by severe winters, but may become increasingly vulnerable when ecological conditions change to favor the more generalist bobcat. At this point, however, interspecific relations between mesocarnivores are mostly subject to speculation, and there has been little or no research that has convincingly demonstrated cause and effect. Due to the daunting nature of the task, the evidence thus far is largely qualitative in nature; it is unknown, for example, to what extent various densities of one species affect the abundance or behavior of another (Palomares & Caro 1999).

Polarized Public Perception

Wildlife managers are being forced to pay closer attention to the political and sociological aspects of wildlife management rather than the biological aspects.

The primary emphasis on management of furbearers has been towards the control of human use rather than specific habitat management (Allen 1987). Traditionally, this has been directed at the management of trapping activities. While this remains the case in the northern regions of the Northeast, there is a rising tendency for conservation and management of mesocarnivores—particularly in southern New England—to be driven by urban and/or economic issues. At the forefront of this agenda is the management of human/carnivore conflicts. Furbearer managers are receiving increasingly higher numbers of calls from residents with coyote, fox, raccoon and striped skunk concerns in suburban areas (W. Jakubas, S. Langlois, P. Rego, L. Supprock, M. Kautz, pers. comm.). During the summer of 1998, for example, the first recorded human attack by a coyote in Massachusetts took place on Cape Cod—an event that was highly publicized. Since that time, calls concerning coyotes have been on the rise, perhaps due to a growing public perception of conflict, rather than a reflection of increasing coyote populations (S. Langlois, pers. comm.).

In a recent survey, 81% of 545 agricultural producers in the northeastern United States reported wildlife damage to their farm or ranch during the previous year, with 53% declaring that the damage exceeded their levels of tolerance (Conover 1998). Several carnivores topped the list of perpetrators: raccoons (36%), coyotes (17%), foxes (16%), and skunks (8%). Again, although the relationship between perceived and actual levels of wildlife damage is never clear, such reports are significant as they influ-

ence public attitudes about wildlife, which in turn can set the agenda for resource management. One result is that financial and personnel resources of government departments charged with managing these furbearer populations (many of which have already faced severe cuts) are being increasingly used to counter these complaints. Wildlife managers are being forced to pay closer attention to the political and sociological aspects of wildlife management rather than the biological aspects (Andelt et al. 1999).

At the same time that some furbearers are coming into increasing conflict with humans, public outcry against trapping is on a steady uprise. Beginning in 1994, four U.S. states have passed referenda to ban or limit trapping, and state and national surveys indicate that most citizens do not support this activity (Andelt et al. 1999). In 1991, the European Council passed a regulation prohibiting the use of foothold traps in 12 countries, and signed separate agreements with the U.S. and Canada in which those two nations agreed to phase out conventional steel-jawed leghold restraining traps (Andelt et al. 1999). One outcome of this has been an aggressive movement by the United States and Canada towards the improvement of traps and trapping methods so as to maximize their humaneness, efficiency, and selectivity. On the other hand, restrictions on furbearer trapping can place limits on the extent to which this activity can be used for the purposes of management. Most jurisdictions in North America refer nuisance furbearer complaints to trappers (Williams & McKegg 1987). One effect of a 1996 Massachusetts referendum (in which the public voted to ban all trapping devices except for rat/mouse traps and cage [live] traps), has been an increase in annual beaver complaints from an average 310 (1991-1996) prior to the new law to an average 585 (1997-1998). The more common, efficient and practical methods of trapping beaver are no longer legal, which results in an ineffective harvest season to help control the growth of the population. This has relegated the beaver to a pest species, thereby using many of the department's limited financial and personnel resources (S. Langlois, pers. comm.).

Epizootics

Research on epizootics in mesocarnivore populations has focused more on the threat of human exposure, and less on transmission to, and impacts on, the carnivore populations themselves. The main conservation concerns posed by disease in mesocarnivore populations are two-fold: First, transmission of diseases among mesocarnivore species remains ill-understood, and evidence suggests that this phenomenon is occurring to an increasing extent as land use changes bring about more inter-specific contacts between species that previously did not share ranges. Second, the financial costs associated with protection of human populations can be quite substantial, and may take resources away from the conservation and management of the mesocarnivores themselves.

Carnivores are susceptible to a wide array of highly lethal or debilitating parasites (Appel 1987). Disease transmission from one carnivore to the other is a conservation issue that has been largely overlooked. Under greater range restriction and increased encroachment by humans, incidents of disease transmission from domestic to wild carnivores are becoming

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increasingly common (Murray et al. 1999). Research in New York, for example, revealed a high (21%) prevalence of feline panleokopenia antibodies in bobcats, suggesting that this virus was an important source of mortality brought about by contact with housecats (Fox 1983). Canine distemper morbillivirus is an additional serious concern: Readily able to cross over from one species to another, the range of hosts among the Carnivora for this often fatal disease is expanding (Harder & Osterhaus 1997). Morbillivirus infection (canine distemper) was diagnosed in two bobcats from New Brunswick in 1993 (Daoust & McBurney 1995). Between November 1996 and July 1997, four lynx from Cape Breton Island, Nova Scotia that were exhibiting abnormal behavior and neurological signs were confirmed to have the same virus (McBurney et al. 1997), and two additional cases have been confirmed since then (S. McBurney, pers. comm.). It is particularly alarming that these first records of canine distemper in North America of indigenous wild felids should come from such a relatively isolated area; the origin of this epizootic is unknown (S. McBurney, pers. comm.). Raccoons are known sources of infection for distemper (Mitchell et al. 1999), and are a tremendous concern for populations of less common mesocarnivores. They were, for example, implicated in a recent distemper outbreak in captive exotic felids in North America, underlining the susceptibility of immunologically naive populations (Appel et al. 1994). The increasing emergence of epizootics highlights the need for ongoing surveillance of wildlife populations, in the form of serologic surveys, including efforts such as the Canadian Cooperative Wildlife Heath Center.

The most well-known epizootic is rabies. While the fox strain has been indigenous to southern Canada for several decades (Rosatte et al. 1997), the raccoon strain of rabies has only recently made its way northward from the southeastern U.S. (Krebs et al. 1996; 1998). The financial impact has been staggering, with costs associated with the epidemic increasing in direct relation to the spread of the rabies itself. In Connecticut, for example, whereas post-exposure treatments were administered to only 41 individuals in 1990 (before the arrival of the epizootic), 887 received the treatment in 1994 once the rabies had arrived, at a median cost of $1,500 per person (CDC 1996). The ecology of the rabies virus and its impact on population dynamics of North American mesocarnivores remain ill understood.

Environmental Contaminants

Chemical contamination of waterways is widely recognized as a major environmental problem. As animals that are heavily dependent on fish as a food resource, evidence suggests that mink *(Mustela vison)* and otter are vulnerable to the toxic effects of substances such as polychlorinated biphenyls (PCBs) and mercury. This problem was first detected after ranch minks exhibited reproductive failure which was traced to high organochloride content in fish from the Great Lakes region (see Wren 1991). Reduced trapping returns in the Great Lakes region likewise suggested a decline in wild mink populations, and examination of carcasses revealed high PCB concentrations (Foley et al. 1988). Toxic chemicals have been

implicated in the decline of mink populations in the American South (Osowski et al. 1995), otter in Scandinavia (Sandegren et al. 1980, cited in Wren 1987) and Britain (Chanin & Jefferies, cited in Wren 1991), and both mink and otter in Columbia River, Oregon (Henny et al. 1981, cited in Wren 1987). In the region surrounding Lake Ontario, mink harvest has increased as water quality has improved over the past 15 years (Wren 1991). In some parts of the Northeast (i.e., Nova Scotia, New Brunswick, and Maine), mink and otter populations are experiencing unexplained reductions in trapping returns, and research is focusing on issues of water contamination. It is difficult, however, to separate other possible explanations, such as food quality and availability, and human-induced mortality (Haffner et al. 1998). Results from field studies generally report comparative data of tissue chemical levels between "exposed" and uncontaminated populations, but fail to demonstrate a clear cause-effect relationship between toxic exposure and declining mink and otter population levels (Wren 1991). More research on this issue is needed.

Overharvesting Potential

In southern New England, paramount mesocarnivore management concerns have shifted away from furbearer harvesting, whereas in the North, fur trapping remains an important source of mortality for many species. While regulation of legal trapping has contributed to the recovery of many species that were over-exploited in the early part of the century, history has shown that several species—notably lynx, marten, fisher, and otter—can be vulnerable to overexploitation. High pelt prices have the potential to exert heavy demands on populations and can precipitate declines (Cumberland 1994). Some furs were in vogue as recently as the 1980s, and demand for all species has certainly exhibited pronounced fluctuations over the past century (Obbard et al. 1987). Unfortunately, it is difficult to separate real problems of overharvesting from natural predator population dynamics responding to prey cycles (i.e., snowshoe hare). Moreover, demand is influenced not only by fur prices, but by public anti-trapping sentiment, which has escalated over the past years (Andelt et al. 1999).

Regulation of trapping by furbearer managers in many cases has not only aided the recovery of previously endangered mesocarnivores during this century, but currently helps to minimize legal overharvest by controlling such factors as season length, zone closures, and trap types. The registered trapline system in many Canadian Crown lands may add more confidence in setting spatially-defined harvest quotas in areas where trapping pressures on localized populations are more substantial (G. Forbes, pers. comm.). The highly regulated nature of this system gives furbearer managers valuable information on local offtake and encourages individual trappers to conserve harvests (Novak et al. 1987). Managing for optimum sustainable yields, however, necessitates keeping population levels below the carrying capacity. Hence, some species may be maintained at densities that are significantly lower (as much as 50%) than might otherwise be the case (Tapper & Reynolds 1996).

Several other factors that may contribute to overharvesting potential are difficult or impossible to control using traditional furbearer man-

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Carnivores that depend on the snowshoe hare and other cyclic prey for sustenance may be particularly susceptible to overexploitation during prey population crashes when they are already vulnerable to starvation.

agement techniques. Increased access by logging roads and snowmobile trails enhances mortality from both legal and illegal trapping (Hodgman et al. 1997; Strickland & Douglas 1987; Thompson 1988). For species that are vulnerable to the effects of forest fragmentation, mortality due to harvesting is expected to act in a more additive fashion with natural mortality factors as species' habitats become more fragmented (Clark & Fritzell 1992). Carnivores that depend on the snowshoe hare and other cyclic prey for sustenance may be particularly susceptible to overexploitation during prey population crashes when they are already vulnerable to starvation (e.g., bobcat, Knick 1990; lynx, Hatler 1988; Slough & Mowat 1996). Populations subjected to trapping may depend on dispersal from less heavily trapped or non-trapped areas (Hatler 1988; Hodgman et al. 1994). Again, it is difficult to tease apart the various factors contributing to population changes. In most cases, it is very challenging to separate the effects of habitat alteration and trapping on mortality, and to determine whether trapping mortality is compensatory or additive to natural causes (Hodgman et al. 1997). Non-target harvest of some species is an additional concern. Martens and fishers are easy to trap, including in traps set for other furbearers (Powell 1979; 1993; Strickland et al. 1982; Whitaker & Hamilton 1998). Incidental harvest of the endangered marten is an important issue in Newfoundland, where snowshoe hare is a major quarry for human hunters (Thompson 1991). A goal of ongoing trap testing (see above) is to minimize incidental captures of non-target furbearer species.

Tapper & Reynolds (1996) make a strong case for regulated harvesting of furbearers: 1) in non-wilderness areas it gives economic value to furbearers that are otherwise viewed as pests; 2) in more remote areas, less damage is incurred than by other resource extraction activities, such as logging and mining, and trapping can provide revenue without causing serious damage; 3) revenue can be used to conserve and manage species; 4) it is particularly suited to the way of life of native peoples. In many areas (particularly in Canada), furbearer trapping is a "mainstay of the culture and economy of aboriginal communities, which otherwise have little means of support," and furbearers are therefore "respected as a resource," an essential pre-requisite for conservation (Prescott-Allen & Prescott-Allen 1996).

Monitoring of Mesocarnivore Populations

Many of the mesocarnivore species that are the subject of this paper present particular challenges with respect to the monitoring of their populations. They are often nocturnal, occur at relatively low densities, live in closed forest habitats, and are difficult or impossible to census using traditional methods designed to target large game species (Zielinski & Kucera 1995). Since many of these species are managed as furbearers, North American managers have relied upon fur harvest records to monitor their populations and distribution patterns. Yet, because the size of the harvest is often so dependent on pelt prices and other economic factors, and because trapping location and effort cannot be controlled or even ascertained in some cases by the managers, it is questionable how well these

Table 1.
Techniques used by furbearer managers to monitor mesocarnivore populations in each of 13 jurisdictions in northeastern North America.

Jurisdiction	Harvest records/ Furbuyer reports/ Tagging/ Export permits/[1]	Trapper Questionnaires/ Logbooks	Carcass/jaw/ skull Collections (Trappers/Hunters)	Sighting Reports (Public)	Roadkill Collections/ Nuisance complaints	Snow tracking	Specialized studies (radio-tel., camera-trapping, etc)
Ontario	Harvest records (all furbearers) (non-mandatory)	Catch/unit effort; abundance trends[2]	Fisher	No	No	No	No
Quebec	Harvest records; furbuyer reports (all furbearers)	Catch/unit effort abundance trends[2] (non-mandatory)	Lynx, bobcat, marten, fisher	No	No	No	No
New Brunswick	Harvest records, Export permits, furbuyer reports (all furbearers)	Abundance trends[2] (non-mandatory)	Fisher, marten, otter, bobcat	No	Yes (nuisance)	All species	No
Nova Scotia	Harvest records, Export permits, furbuyer reports (all furbearers)	Report card; impression of abundance trends (mandatory)	Bobcat, otter, fisher (mandatory); lynx, marten (incidental)	Marten, lynx (roadkill); nuisance	Yes (nuisance and roadkill)	Lynx, marten	Marten, lynx, fisher
P.E.I.	Harvest records, Export permits, furbuyer reports (all furbearers)	No	Coyote	No	No	No	No
New-Foundland/ Labrador	Harvest records (all); Export permits (all furbearers)	Catch/unit effort (non-mandatory)	Lynx	No	No	Lynx	Marten
Maine	Harvest records, Tagging (bobcat, coyote, fisher, marten, fox, otter, mink)	Catch/unit effort (non-mandatory); deer hunter survey (coyotes)	No	Lynx	No	Bobcat, marten, fisher, lynx	Lynx
New Hampshire	Harvest records, Tagging (fisher, otter) lynx, marten sightings	Catch/unit effort (non-mandatory)	No	No	No	No	No
Vermont	Harvest records (all); Tagging (bobcat, fisher, otter)	Catch/unit effort (mandatory)	Fisher, otter, bobcat	No	No	No	Marten in reintroduction site
Massachusetts	Harvest records, Tagging (coyote, red & gray fox, mink, bobcat, fisher, otter), furbuyer reports	Catch/unit effort (non-mandatory)	Fisher, otter, bobcat	Otter, fisher, bobcat (roadkill); Nuisance	No	No	No
New York	Harvest records, Tagging (coyote, otter, bobcat, fisher, marten)	Bowhunter sighting log; Catch/unit effort (otter)	Otter	Bobcat	No	Otter (in restoration sites); bobcat	Otter (in restoration sites)
Rhode Island	Harvest records; Tagging (otter, fisher, bobcat)	No	No	Coyote (roadkill)	Coyote (roadkill)	Bobcat	No
Connecticut	Harvest records, Tagging (otter, mink, coyote, red fox, gray fox)	Abundance trends[2] (non-mandatory)	Otter, coyote	Bobcat, fisher	Bobcat, fisher (roadkill)	Bobcat, fisher	Raccoon

[1]Tagging: plastic seals attached to pelt/unskinned animals; Export permits: permit required for animals to be exported out of jurisdiction; Furbuyer reports: mandatory reports from fur buyers; Harvest records: harvest records returned by trappers.
[2]Trapper and hunter records of perceptions of population trends regarding furbearer species

statistics reflect the true population size of the furbearer in question (Strickland 1994). Nevertheless, these figures have been very useful for monitoring regional trends in mesocarnivore populations over time (Raphael 1994), particularly for species that are most noticeable from a nuisance perspective (M. O'Brien, in litt.).

The continued reliance on harvest data for population monitoring is decreasing in its utility in some areas, because some mesocarnivores are trapped in exceedingly low numbers or have no open harvest season established, and there has been a downward trend in the number of fur trappers across northeastern North America. Lynx, marten, fisher, and bobcat are protected from trapping in several jurisdictions (Appendix 2) and other species—such as weasels *(Mustela erminea, M. nivalis,* and *M. frenata)*—are trapped in such low numbers (no more than two individuals per year in some New England states), that harvest figures do not yield any useful monitoring information whatsoever. Mink, which also are not generally trapped in large numbers, have not been effectively monitored throughout the region, even though at least two states and provinces (Maine and New Brunswick) are currently concerned with the status of some local populations. In addition, the status and distribution of rare and cryptic carnivores, such as lynx, continue to be unknown in many states and provinces. The development of a clear and meaningful protocol to investigate the credibility of sporadic sightings and to evaluate the status of these species is a lofty, but important goal (S. Morse, pers. comm.).

The increasing public concern for the environment and animal rights has affected the status of trapping, particularly in the U.S. (Novak et al. 1987). Trapping participation has been on the decline for many reasons, including low pelt prices, posting of private land, and the increasing political influence of the animal rights movement (Daigle et al. 1998). Almost without exception, furbearer managers interviewed for this report remarked upon the demographics of the trapper population. Trappers are aging, and are not generally being replaced by the following generation. While there continues to be a greater tradition of trapping in Canada than the U.S., most managers noted a general downward trend in the number of fur licenses issued over the past decade. In Québec for example, nearly 20,000 trappers were licensed in 1984, and only 8,500 in 1997 (R. Lafond, pers. comm.). The trapper population in New Hampshire has decreased from about 900 individuals in the 1970s to 400 today (M. Ellingwood, pers. comm).

Although harvest records do not provide reliable monitoring information for many mesocarnivore species throughout the Northeast, few jurisdictions have replaced this method with others (Table 1). Not only are many of the departments hampered by a lack of funding for regular surveys, but reliable harvest-independent techniques of population estimation and evaluation for most of these species simply have not been developed and tested in the region. Considerable progress is being made with rare forest carnivore species in western North America (Zielinski & Kucera 1995; Weaver, pers. comm.), and community wildlife monitoring programs (S. Morse, pers. comm.). There is also a strong need to standardize such techniques for consistency in data collection among jurisdictions, in order to enhance opportunities to pool data to monitor species on a

regional level (Organ et al. 1997). In some areas, however, the need for the development of new survey methodology may not be as acute, and harvest trends (or sometimes nuisance trends) in conjunction with data on population condition (i.e. age structure and reproductive information), may provide the necessary information for conservation and management decisions pertaining to some species.

Gaps in Research Knowledge

Effective conservation planning must draw upon information from all aspects of a species' ecology (Ruggiero et al. 1994a). A recent report addressing the conservation and research priorities of western forest carnivores stressed the importance of knowledge of habitat requirements at various scales, community interactions, and responses of carnivores to human-altered landscapes for providing a scientific basis for conservation of these animals (Lyon et al. 1994; Ruggiero et al. 1994b). While an understanding of habitat requirements is relatively advanced in the case of a few northeastern mesocarnivore species (e.g., marten and coyote), several have received relatively little attention in the region (e.g., mink and lynx). Although it is tempting to apply existing ecological information gleaned from studies conducted elsewhere (i.e. western North America) to northeastern populations, such an exercise may be misleading or unreliable (Ruggiero et al. 1994a).

Very little research has examined the impact of changing land use patterns on the ecology of individual species, or on shifting patterns of species inter-relationships in the face of such change. Furthermore, it is becoming increasingly critical as natural habitat on a regional level is being converted to suburban and industrial habitats, to focus scientific inquiry of species habitat requirements at the landscape level. Indeed, habitat selection by many of the species in this report are likely dominated by factors operating at the home range and regional scales, rather than specific attributes at the stand-level (e.g., Carroll et al. 1999). Recent work on the marten, for example, has shown that there are thresholds of fragmentation beyond which populations will be unable to persist, even when habitat at the stand-level is suitable (e.g., Chapin et al. 1998; Hargis et al. 1999). Similar studies on other sympatric mesocarnivores for which habitat degradation may be a threat (lynx, bobcat, and fisher) are vital. It would be of equal interest to evaluate the extent of habitat modification that favors generalist predators, such as coyotes, foxes, raccoons, and striped skunks in the landscape. A key question is the degree to which increased connectivity among secondary habitats facilitates invasion by generalist species into the forest interior and hence contributes to declines in abundances of forest interior species.

Drawing up a list of research needs for northeastern mesocarnivores is beyond the scope of this paper; efforts to engage in this exercise commenced in the form of a workshop held in 1996 (Organ et al. 1997). Attendees (including biologists, managers, and academics) identified five top research priorities: 1) to develop standard survey/census techniques; 2) to develop reliable species/habitat models to predict the effects of habitat change; 3) to comprehensively review the current distribution and status

Mesocarnivores do not recognize the artificial boundaries that divide the states, provinces or the two countries. We must, therefore, limit the extent to which this situation places limits on our abilities to conserve, manage, and study these animals.

of the region's mesocarnivores; 4) to study the community ecology of mesocarnivores; and 5) to investigate the effects of habitat loss and pollution on mink and otter populations. A dilemma, best stated by Ruggiero et al. (1994a) is "how to be scientifically rigorous in prescribing needed research while also recognizing the practical limits of available resources and acknowledging real questions about the feasibility of collecting certain crucial information." Prioritizing research needs may lead to a piecemeal approach, with studies being conducted on an "opportunistic rather than a comprehensive and well-integrated basis."

Regional Coordination of Mesocarnivore Research and Conservation

One of the greatest challenges facing mesocarnivore conservation in the Northeast relates to the issue of regional coordination of activities. As discussed in this report, the differences between jurisdictions with respect to the suite of species in question, and the management priorities and conservation issues pertaining to them, can be quite dramatic. There can also be important differences in both funding levels and personnel. An additional layer of complication is presented by the fact that the region in question straddles two countries. If conservation of these animals is to be addressed at a regional level, it is critical that the information gathering be conducted on a more or less standardized basis, to allow for comparisons between jurisdictions as well as inferences of results to be made on the largest scales possible. It will be equally important to provide mechanisms that foster inter-jurisdictional information exchange, and coordinate research activities so as to minimize overlap. The Northeast Furbearer Resources Technical Committee (NEFRTC), whose members consist of regional public agency representatives charged with the management of furbearers, is the closest there is to a coordinated entity of this nature, and represents an important first step. Unfortunately however, non-governmental and academic carnivore biologists and conservationists are not included in its membership, and its mandate is, by necessity, limited in scope.

Mesocarnivores do not recognize the artificial boundaries that divide the states, provinces or the two countries. We must, therefore, limit the extent to which this situation places limits on our abilities to conserve, manage, and study these animals.

Part II
Species Profiles

Lynx
(Lynx canadensis)

Distribution/History

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Lynx are primarily restricted to boreal forests, which are widespread in Canada and extend southward only into cool and mesic high elevation areas (Koehler & Aubry 1994; McKelvey et al. 1999; Quinn & Parker 1987). They are particularly limited by the availability of snowshoe hare, the range of which is coincident (Koehler & Aubry 1994; Ruggiero et al. 1999). The historical range of the lynx in Canada remains largely intact, with the exception of Prince Edward Island and mainland Nova Scotia, from where it was extirpated this century (Quinn & Parker 1987). Northern boreal forests of central Canada are considered by scientists to be the core areas from which North American lynx populations emanate. They occur in southern transitional boreal forests at naturally low densities, due to the patchy nature of the habitat and lower snowshoe hare populations (Buskirk et al. 1999a; McKelvey et al. 1999). There have been instances of recovery in Canadian populations after major population declines during the early 1900s (Todd 1985a).

The lynx's range in the northeastern United States has shrunken during historic times (Quinn & Parker 1987). Although this felid once occurred as far south as Indiana and Pennsylvania (Whitaker & Hamilton 1998), it may never have been common in the region and these extreme occurrences most likely did not represent breeding populations. Instead, population persistence in the southern periphery of its range—where habitat conditions are highly variable in distribution and quality (Buskirk et al. 1999b; Koehler 1990), and hares do not experience the same population dynamics as in the northern taiga and occur at lower densities (Aubry et al. 1999)—likely has been, and continues to be aided by immigration of lynx from the North (Koehler & Aubry 1994; Litvaitis et al. 1991; Thiel 1987). Today, breeding populations of lynx probably do not occur anywhere in the eastern U.S. (Whitaker & Hamilton 1998), with the exception of Maine (USFWS 1999), although sightings continue to be reported (e.g., Morse 1997; Weaver 1999). Due to the contiguous nature of suitable habitat just south of the St. Lawrence Seaway, lynx populations from southeastern Québec, New Brunswick, Maine, and New Hampshire probably comprise one metapopulation. Little connectivity remains, however, with Canadian lynx populations north of the river, due to tremendous development activity along the river and icebreaking to allow year-round shipping (USFWS 2000). This species is unlikely to re-establish viable populations in areas such as southern New England due to irrevocable environmental and social changes that have taken place this century (Buskirk et al. 1999b; McCord & Cardoza 1982). Indeed, given the species'

reliance on snowshoe hare and associated early successional habitat, it is unlikely that viable populations of lynx could have persisted in these peripheral areas during recent historic times.

Habitat Associations

Habitat changes have been shown to more negatively affect lynx than bobcat.

Lynx are habitat specialists that are at home in boreal forests and not well adapted to other habitats (Quinn & Parker 1987). As such, they are most likely to be found in dense coniferous forests interspersed with bogs, swamps, and thickets (McCord & Cardoza 1982; Whitaker & Hamilton 1998). Their northerly distribution is reflected by their large spreading feet, an adaptation that allows them to support their weight in deep snow (Parker et al. 1983; Whitaker & Hamilton 1998). McKelvey et al.'s (1999) analysis of lynx records from the northeastern United States found that most were located within "mixed-forest-coniferous forest-tundra" cover type at elevations ranging from 250-750m.

Although deforestation can have negative impacts on lynx populations (see below), these felids are not old growth specialists. Their prime habitat is composed of an irregular mosaic of mature and young forests (Allen 1987; Parker 1981; Parker et al. 1983). Early successional forests (20-30 years old, but not less than 5) as well as gaps in old-growth stands (Ruggiero et al. 1999b) provide food and cover for their principal prey, snowshoe hares (Allen 1987; Koehler & Brittell 1990; Pietz & Tester 1983; Ruggiero et al. 1999b; Thompson et al. 1989), while mature cone-producing coniferous forests are vital for red squirrel *(Tamiasciurus hudsonicus)*, a chief alternative prey (Ruggiero et al. 1999b). Likewise, both late and early successional forests can exhibit the structural characteristics (i.e., an abundance of downed woody debris) required for denning (Koehler & Brittell 1990; Organ et al. in prep.; USFWS 1999).

Throughout their range, lynx only reach high population densities when snowshoe hares are at peak levels. Reproduction and recruitment rates decrease in the face of hare declines (Brand & Keith 1979; Hatter 1988; Parker et al. 1983; Ward & Krebs 1985). At southern limits of their distribution, where hares apparently do not cycle or reach high population levels, research has shown the demographics of lynx populations to be similar to those in northern boreal forests during the low point of hare cycles (Aubry et al. 1999; Koehler 1990).

Responses to Human-Induced Disturbances

Habitat changes have been shown to have more negative impacts on lynx than bobcat (see below). Neither lynx nor snowshoe hare respond positively to large-scale forest clearing—whether due to clearcut logging or agricultural development—and the attendant elimination of cover critical for both species (Koehler & Brittell 1990; McCord & Cardoza 1982). Koehler & Brittell (1990) point out, however, that the negative effects of forest clearing may be offset by the benefits incurred by increasing hare populations as succession progresses. In the northern core of its range, natural disturbances, such as fire and forest disease/pest epidemics characteristic of boreal forests, may stand the best chance of providing the mosaic of closely juxtapositioned successional habitats required by lynx. In the

sub-boreal southern periphery, however, where disturbance dynamics are mainly driven by humans (Buskirk et al. 1999b), persistence of lynx populations will depend on prudent land use management practices.

Agricultural clearing also has been implicated in the loss of lynx habitat in Europe through the 1940s (McCord & Cardoza 1982). Lynx have been known to inhabit farming country only if it is interrupted by extensive woodlands (Todd 1985a). They tend to avoid large open areas and typically do not cross openings wider than 300 ft (Koehler & Brittell 1990). Citing evidence of movement across landscapes fragmented by industrial forestry and road crossings, Ruggiero et al. (1999b) argue that roads do not constitute a major mortality factor for lynx. Radio-collared lynx in Wyoming and Montana successfully crossed a variety of paved and unpaved roads (Squires and Laurion 1999). Highways with high traffic volumes and associated housing developments, however, are far more likely to negatively influence lynx movements (Apps 1999). Most deaths following a reintroduction effort in the Adirondacks, New York in 1989-90 were due to automobiles (Brocke & Gustavson 1992). It should be noted, however, that upon release these animals moved unusually great distances, which was likely an artifact of their non-resident status (Aubry et al. 1999). At the same time, the island-like nature of the park probably limited severely the ranging ability of lynx that occurs in the face of low hare densities characteristic of the region (Weaver 1999). Recreational snowmobile use, which has expanded dramatically in the United States during the past 25 years (see Buskirk et al. 1999a) further fragments the habitat, and provides access to humans and generalist predators (see below). This factor has been attributed to lynx decline in the western United States, but has not been demonstrated in the East, where crusting of snow is common and snowmobile trails may not enhance access for generalist predators to the same degree (J. Organ, pers. comm.).

An indirect effect of habitat change has been increased opportunities for invasion of bobcat in areas that were formerly strongholds of lynx. More generalized and opportunistic than lynx, the bobcat has penetrated into many sections of the range that have recently been vacated by lynx (Rolley 1987). Mixed populations are confined to the southern fringe of lynx range in Ontario and Québec (de Vos & Matel 1952). One possible example is provided by Cape Breton Island. When bobcats were able to colonize the island for the first time after completion of a causeway in 1955 that connected the island to Nova Scotia, lynx populations declined everywhere except in highland areas, the one area where bobcats have not yet established (perhaps because of deep winter snow cover; Parker et al. 1983). It is important to note, however, that the authors of this study did not establish clear cause and effect between the two events. Likewise, Buskirk et al. (1999a) and Ruggiero et al. (1999b) speculate as to the superior competitive capabilities of coyotes over lynx populations in southern latitudes where low population levels of snowshoe hare necessitate prey switching. Newly emerging diseases may constitute a new threat to lynx populations: Since 1996, six lynx from Cape Breton Island, Nova Scotia have tested positive for Morbillivirus (canine distemper) infection (McBurney et al. 1997; S. McBurney, pers. comm.).

Lynx are also vulnerable to over-trapping, particularly during lows of snowshoe hare population fluctuations (Hatler 1988; Slough & Mowat 1996). During such periods, lynx tend to concentrate in pockets where snowshoe hares are locally abundant. Therefore, hunting pressure applied at these times could wipe out local populations which act as sources for recovery once conditions improve (Hatler 1988). British Columbia, for example, proposed a "tracking strategy" for managing harvests of cyclic lynx, whereby harvest pressure would cease during the period of low hare populations, and hare/lynx "refugia" would then be protected (Hatler 1988).

Additive trapping mortality at or near the cyclic low in the 1970s may have taken the lynx population lower than it would have gone other-wise (Todd 1985a). Recovery from over-exploitation in Canada earlier this century took at least 15-20 years, and was aided by relatively intensive management and extremely low pelt prices (Todd 1985a). Although lynx had been harvested for fur for two centuries, the value of the pelt increased only in the past 30 years. When importation of spotted cat furs was banned in the 1970s, both lynx and bobcat were suddenly in demand (Tumlison 1987). By the mid 1980s, lynx had "superceded beaver and muskrat as the economic staple for Canadian trappers" (Todd 1985a). Today they are worth far less (Whitaker & Hamilton 1998). In general, the future of the lynx looks a great deal more promising than for most of the world's felids (Nowell & Jackson 1996). Lynx can demonstrate some degree of tolerance of human disturbance, particularly when not subjected to trapping (Todd 1985a).

Bobcat

(Lynx rufus)

Distribution/History

The original range of the bobcat extended from southern Canada through the lower 48 states to Mexico. With the exception of the Great Lakes region and a large coastal swath from Massachusetts to Virginia, this generalist felid still occurs throughout much of this range (Larivière & Walton 1997; Rolley 1987; Whitaker & Hamilton 1998). Northward expansion of the bobcat's range has taken place over the last century, along with land clearing for agriculture and a corresponding northward retreat of the southern limit of lynx's range (Larivière & Walton 1997; Nowell & Jackson 1996; Whitaker & Hamilton 1998). In Ontario for example, bobcats were unknown in the western half of the province until early this century. Since the 1920s and 30s they spread North and East, and were trapped with increasing frequency in the 1940s (Peterson & Downing 1952).

Habitat Associations

The broad geographic range of the bobcat is reflective of its adaptable and generalist habits (Rolley 1987). This felid is known to use a wide variety of natural habitats, such as swamps, wooded areas, and mountainous

regions. Unlike the lynx, the bobcat does not depend on deep forest and can exploit areas close to agricultural lands as long as rocky ledges, swamps or forested tracts are present (Whitaker & Hamilton 1998). Only large, intensively cultivated areas are unsuitable (Rolley 1987). Early to mid-successional stages of forest growth are generally the centers of bob-cat activity; preferred habitat is comprised of a mosaic of ecotones and cover types (Allen 1987). Ledges, cliffs, and outcrops have been noted by many authors to be critical refugia for resting, denning, and escape (Allen 1987; McCord & Cordoza 1982; Morse 1996; Whitaker & Hamilton 1998). Bobcats are not well-adapted for travel in deep snow (when sinking depths exceed 15 cm), and their winter habitat use appears to be governed by avoidance of such conditions (McCord 1974). Snow depth also plays a likely role in limiting the northern range of this felid species (Whitaker & Hamilton 1998).

Bobcats demonstrate marked preferences for habitats with heavy undergrowth and avoid areas of sparse understory cover (Knowles 1985; Litvaitis et al. 1986a; Rolley & Warde 1985). In northern parts of their range, they are known to frequent conifer and mixed hardwood stands, which support high densities of snowshoe hare and comprise the winter habitat of white-tailed deer (*Odocoileus virginianus*)—both important food resources of northern bobcat populations (Knowles 1985; Litvaitis et al. 1986b; McCord & Cordoza 1982; Parker & Smith 1983; Rolley 1987). Deer become less important in the diet where winters are milder (Litvaitis et al. 1986b). Generally speaking, bobcats specialize on mam-malian prey in the 150-1000 g range, and demonstrate a considerably higher degree of opportunism than lynx, as demonstrated by high dietary diversity (Rolley 1987). Bobcats are still vulnerable to fluctuations of prey populations, however, with one population exhibiting a 9-fold decrease in response to population crashes of two lagomorph species (Knick 1990).

Responses to Human-Induced Disturbances

The influence of humans on bobcat habitat has been described as "not excessively great" (McCord & Cardoza 1982). For example, this felid has been able to maintain its historic range in Massachusetts, one of the four most densely populated states in the nation, and has proven adaptable enough to utilize remaining natural habitats throughout its range (McCord & Cordoza 1982). In western parts of its range, bobcats have been known to use residential areas, including areas with urban-level housing densities as long as they are adjacent to large undeveloped areas (Harrison 1998). Nevertheless, conversion of forest, wetlands, and prairies can be detrimental to bobcats. A careful look at historical records, for example, suggested that the disappearance of bobcats in Illinois coincided with human settlement, with habitat loss the paramount factor (Woolf & Hubert 1998). Development of lower elevation habitats in Vermont threatens to fragment the rocky terrain that is so vital for resident bobcats (Morse 1996). Within established home ranges in northwestern Wisconsin, bobcats crossed secondary highways, unpaved roads, and trails in propor-tion to their occurrence, but crossed paved roads less than expected (Lovallo & Anderson 1996). In general, areas located fewer than 100 m from roads contained less preferred habitat for bobcats than roadless

Although bobcats have largely escaped persecution as pest/nuisance species, the species has become one of the most heavily harvested and traded of the world's cat species during the past 20 years.

areas. Roads contributed to higher mortality due to hunting, especially during fresh snowfalls, by facilitating access (Lovallo & Anderson 1996).

Although bobcats have largely escaped persecution as pest/nuisance species, the species has become one of the most heavily harvested and traded of the world's cat species during the past 20 years. Today, it is the only spotted cat in the world that can be legally trapped, although at present the trade in bobcat pelts is declining (Nowell & Jackson 1996). Historically, as the value of bobcat pelts has increased, so has the harvest. During the 1970s, demand for bobcat pelts sharply increased about the time that large spotted cats were afforded protection by CITES Appendix I and the U.S. Endangered Species Act (Rolley 1987). Bobcat populations in the U.S. and Canada were apparently abundant enough to withstand increased levels of exploitation from the mid 70s to the mid 80s.

Recent decreases in commercial trapping, coupled with changes in land-use practices, have created conditions of population growth in many areas (although it is difficult to separate these causes from natural population dynamics that occur in response to cyclic snowshoe hare populations). Most mortality is due to harvesting, vehicle collisions, other bobcats, and disease (see Fuller et al. 1995). In some areas, poaching has reduced annual survival of bobcats (Fuller et al. 1985; 1995). There is some evidence that bobcats are vulnerable to feline panleokopenia virus carried by housecats (Fox 1983), and in 1993 two bobcats from New Brunswick were confirmed to have canine distemper (Daoust & McBurney 1995).

Interspecific relations in some cases may have detrimental effects on bobcat populations. It has been proposed, for example, that competition with coyotes may have contributed to the protected status conferred on bobcat in Québec in 1991 (Larivière & Crête 1992). There is a general feeling that coyotes can potentially out-compete bobcats and will cause decreases in bobcat populations (McCord & Cordoza 1982). For example, bobcats apparently increased over much of the West in areas where coyotes were eradicated through predator control (Robinson & Grand 1958). Under harsh winter conditions, bobcats are susceptible to starvation and the possibility of exploitation competition between coyotes and bobcats becomes very real (Koehler & Hornocker 1991; Major & Sherburne 1987). Resource partitioning between bobcats and coyotes was studied during a period of rapid coyote population expansion in Maine in the 1970s (Litvaitis & Harrison 1989). The authors documented niche contraction by bobcats compared to 20 years previously, although no active spatial displacement was observed. Through exploitation competition for a more limited prey base in winter and spring, coyotes were hypothesized to diminish the bobcat carrying capacity in eastern Maine by causing a decrease in prey availability.

American Marten

(Martes americana)

The ecology of the American marten is relatively well-studied throughout its range. This is illustrated by the appearance of two volumes entirely devoted to the genus *Martes* (shared with fisher and other species occurring outside of North America).

Distribution/History

In colonial times, the American marten was distributed throughout the coniferous forests of eastern North America (Gibilisco 1994; Whitaker & Hamilton 1998). With trapping virtually unregulated before the 1920s, together with highly valued fur pelts and habitat reduction from agricultural clearing and logging, populations were extirpated from most of the Northeast by the early 1900s (Strickland 1994). Subsequent protective laws adopted and enforced by wildlife agencies, regrowth and maturation of forests, and a number of successful reintroductions, allowed many populations to recover (Obbard et al. 1987; Strickland 1994). At least 27 marten populations considered self-sustaining have reportedly been established through reintroduction programs since the 1950s, with factors such as habitat quality and number of martens released most clearly associated with success (Slough 1994). The current distribution of the American marten remains smaller than its historical distribution in the Great Lakes and New England regions, but is otherwise largely intact (Gibilisco 1994).

Habitat Associations

Although marten are known as old-growth-dependent species (Thompson 1991), they are not restricted to "wilderness climax forests" (Soutiere 1979). The key to their preferred habitat is not late successional forest *per se,* but rather the complex physical structure with which it is associated (Sturtevant et al. 1996; Thompson & Curran 1995; Whitaker & Hamilton 1998). Likewise, physical structure of a stand is more important than species composition (Whitaker & Hamilton 1998). Micro-habitat features such as downed woody debris (DWD), cavities in large diameter trees, and vertical stem structure are critical for denning, thermoregulation, foraging, resting, and escaping predators (Bowman & Robitaille 1997; Brainerd 1990; Snyder & Bissonette 1987). An abundance of such features are characteristic of northern spruce and balsam fir forests or mixed deciduous/coniferous forests (Whitaker & Hamilton 1998).

Habitat structure required for healthy marten populations generally takes decades to develop (Sturtevant et al. 1996). Numerous analyses have indicated that older uncut forests contained more structure at ground level than younger forests because of more woody debris, more young balsam fir, less litter, more mosses and more low shrubs (Sherburne & Bissonette 1994; Thompson & Curran 1995). Mid- and early-successional forests and forest openings are usually avoided (Whitaker & Hamilton 1998). In some parts of their range, however, martens are found in second growth boreal forest, where they respond to similar structure characteris-

Although marten are known as old-growth-dependent species, they are not restricted to "wilderness climax forests."

tics as in mature/overmature forests (Bowman & Robitaille 1997). Research in Newfoundland has also shown that marten use of spruce-budworm defoliated stands is relatively common (Drew 1995; Sturtevant et al. 1996), a finding that contradicts HSI models and other stand prescription models (Allen 1982; Watt et al. 1996) which view the extent of overhead cover as critical. From a marten's perspective, such habitats contain complex physical structure on the forest floor, in addition to vertical structure. With clearcut logging, this structural legacy is generally removed.

Marten exhibit marked discrimination and fidelity in their use of rest sites, which are critical to their survival (Buskirk et al. 1989). The importance of resting where DWD is available to provide thermal cover and access to subnivean spaces may explain the apparent dependence of marten on old-growth forests, especially in winter (Buskirk et al. 1989; Corn & Raphael 1992; Thompson & Harestad 1994). During periods of less than 100% snow cover, live trees and snags are used most frequently as rest sites, whereas resting sites are beneath snow when the ground is completely covered with snow (Spencer 1987). Female marten are highly selective of natal dens, again choosing habitat attributes most associated with late successional forests (Ruggiero et al. 1998).

Marten are the only mesocarnivore for which habitat relationships at the landscape level have been investigated. Several recent studies have uncovered valuable information on the spatial distribution of stands over a landscape and have added significantly to knowledge of stand-level habitat requirements. For example, habitat use by marten in forests fragmented by clearcutting is influenced by the distribution of residual forest in the landscape, with area and isolation of residual patches the most important characteristics (Chapin et al. 1998; Snyder & Bissonette 1987). In Maine, home ranges of resident adult marten were associated with the large contiguous residual patches in an extensively clearcut landscape. Residual patches occupied by marten were much larger than those that were unoccupied (Chapin et al. 1998). Martens appear to tolerate 20-25% openings over the landscape, with abundance declining to zero when this threshold is exceeded (Hargis & Bissonette 1997). Landscapes lacking forest interior may not sustain reproducing individuals (Hargis et al. 1999). Interestingly, the amount of edge was not known to influence marten distributions across a wide range of spatial scales, and may in fact be beneficial with respect to availability of prey (Brainerd 1990). The use of edge may depend on the habitat composition on the two edge sides (Chapin et al. 1998; Hargis et al. 1999).

It is important to note that most of these studies have been conducted in areas where marten trapping is taking place. As a major source of mortality, hunting may reduce marten population densities below the level at which habitat is limiting; therefore these results may reflect martens at their most selective. At higher densities, they may occupy a wider array of habitats (Chapin et al. 1998).

Responses to Human-Induced Disturbances

The generally adverse response of marten to clearcutting of boreal forests is well known (Steventon & Major 1982; Thompson 1991). In Maine, densities of marten were found to be substantially lower in commercially

clear-cut forest than in undisturbed or partially harvested forests (Soutiere 1979). Balsam fir/black spruce stands often regenerate to balsam fir and are often thinned mechanically and herbicided if white birch and alder are present, thereby promoting the emergence of a monoculture that is even-aged, even-sized, and with no DWD or snags (Thompson 1991). Movements of radio-collared marten show strong avoidance of clearcuts (Bissonette et al. 1991), where marten survival is lowest. This is not, however, a universal phenomenon, suggesting that under certain circumstances martens can be more tolerant of fragmentation than previously reported (Potvin & Breton 1997). For example, individuals frequenting clearcuts in a site in western Québec had larger home ranges and longer movements (Potvin & Breton 1997). Some studies have reported travel along edges of open areas or crossings of narrow open areas, although with general avoidance of open areas (Buskirk & Powell 1994).

The key appears to be extent of fragmentation, with marten nearly absent from landscapes with more than 25% non-forest cover, even when forest patches are well-connected (Hargis et al. 1999). When average nearest neighbor distances between non-forested patches are less than 100 meters, forest interior conditions that contain habitat attributes required by martens tend to become eliminated, even though prey densities in regenerating clearcuts abound (Hargis et al. 1999). Marten home ranges are known in some cases to contain relatively high densities of roads. They tend to respond more strongly to forest fragmentation associated with clearcut logging than to proximity to forest roads (Chapin et al. 1998). Effects of trapping appear confounded with forest harvesting because trappers use logging roads to access residual marten habitat.

Marten are easily trapped. Moreover, their reproductive rates are low and the age at sexual maturation high—by mammalian standards—suggesting that for an animal of its size (1 kg), marten are slow to recover from population-level impacts (Buskirk & Ruggiero 1994). In Maine, marten were nearly eliminated by the 1930s due to overtrapping (Aldous & Mendall 1941 cited in Hodgman et al. 1994). Fears of overtrapping in Maine continue today (Hodgman et al. 1994).

There is some evidence to suggest that fisher population densities play a role in limiting marten distributions (Strickland & Douglas 1987; Krohn et al. 1995; 1997). When protected from trapping this century, fishers re-colonized mid-successional second growth forested areas in the Northeast that had continuous canopy of broad-leaved and conifer species, whereas marten did not re-colonize these forest types and did not establish viable populations (Buskirk & Powell 1994).

The key appears to be extent of fragmentation, with marten nearly absent from landscapes with more than 25% non-forest cover, even when forest patches are well-connected.

Fisher

(Martes pennanti)

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Distribution/History

Fishers represent one of the most remarkable cases of population recovery of a mesocarnivore during the 20th century. Originally occurring throughout the northern forests of North America, this species disappeared from much of its range beginning in the late 1800s (Brander & Books 1973; Coulter 1960; Dodds & Martell 1971; Gibilisco 1994; Hagmeier 1956; Powell 1993; Strickland 1994). By the 1930s, isolated northeastern populations remained in Maine and the White and Adirondack Mountains (Brander & Books 1973). Protective legislation, habitat improvement through reforestation, and reintroductions since the 1940s have resulted in restoration of viable fisher populations throughout most of their original northeastern range (Douglas & Strickland 1987; Gibilisco 1994; Whitaker & Hamilton 1998). During the 1950s, interest in re-establishing fisher populations through reintroductions was heightened in response to rising porcupine populations, which were blamed for timber damage (Brander & Books 1973; Earle & Kramm 1982; Powell 1993; Powell & Zielinski 1994). Many such attempts were successful, but populations also re-established themselves naturally after abandoned farmland reverted to forest (Coulter 1960; Kilpatrick & Rego 1994; Powell 1993; Powell & Zielinski 1994; Whitaker & Hamilton 1998).

Habitat Associations

The rapid re-colonization of hardwood dominated forests in southern New England by fishers may have been facilitated by the superabundance of grey squirrels.

Fishers are often lumped together with marten as "old growth specialists" (see Krohn et al. 1995). Patterns of re-colonization in the 20th century, however, have called this designation to question. Fishers exhibit more diverse patterns of habitat use than predicted by habitat suitability index models (Allen 1983). In general, habitats used by fisher are forest- or woodland-dominated landscape mosaics, with a high diversity and interspersion of forest types, tree species, and age classes (Arthur et al. 1989; Buskirk & Powell 1994; de Vos 1951; Krohn et al. 1995). Individuals along the southern limit of their range are flourishing in hardwood-dominated forests. Perhaps because these areas are subject to relatively moderate winter conditions and a maximum snow depth that never exceeds 25 cm, resident fishers are less dependent on conifer forest types that may act to ameliorate harsh winter conditions, such as deep snow accumulation (Kilpatrick & Rego 1994; Raine 1983). Indeed, Krohn et al. (1995) pointed out that reports of fishers using secondary deciduous habitats were from relatively low snowfall regions of the northeastern U.S. whereas those using old growth coniferous forest were from deep snow environments.

Of key importance is a relatively closed canopy (Buskirk & Powell 1994; Carroll et al. 1999; Whitaker & Hamilton 1998). Physical structure of a given stand is more important than species composition (Buskirk & Powell 1994). Structurally complex forest stands are preferred, although access to subnivean spaces is not as critical for the fisher as for the marten

(Buskirk & Powell 1994). For denning sites, fishers tend to select large tree diameter classes as well as dead and/or cavity trees (Carroll et al. 1999; Paragi et al. 1996; Powell et al. 1997a). The opportunistic feeding habits of fishers throughout their range facilitate their catholic habitat requirements. In general, fisher prey is larger and more diverse than that of martens, and fishers have the flexibility to profit from local and seasonal availability of food resources (Martin 1994; Powell et al. 1997b). In the North, fishers feed upon snowshoe hares and small mammals and are specially adapted to prey upon porcupines where they co-occur (Earle & Kramm 1982; Powell 1993; Whitaker & Hamilton 1998). The rapid re-colonization of hardwood dominated forests in southern New England by fishers may have been facilitated by the superabundance of grey squirrels (*Sciurus carolinensis;* Kilpatrick & Rego 1994; P. Rego pers. comm.; L. Supprock pers. comm).

Research examining fisher habitat selection at the landscape level is largely lacking. Recent research in the fragmented forests of the Pacific Northwest (Carroll et al. 1999) suggested that habitat selection by fishers was governed more by factors operating at the scale of the home range or above, such as regional forest cover, than by those at the stand level. While fishers tend to avoid open areas, they have been known to travel along edges (see Buskirk & Powell 1994). Patches of preferred habitat that are separated by open areas of sufficient size are unlikely to be used at all (Buskirk & Powell 1994). Snow depth plays an additional role in limiting the distribution of fishers, although it is not yet well understood (Krohn et al. 1997). Fishers are less abundant in areas where snow accumulation is deepest (Arthur et al. 1989).

Responses to Human-Induced Disturbances

The avoidance of open areas by fisher has been described as "near universal" (Buskirk & Powell 1994). Many authors agree that fishers avoid open spaces with no overhead cover, run when crossing open spaces, and minimize the number of open spaces to be crossed (Strickland et al. 1982; Buskirk & Powell 1994). Unforested lands may serve as barriers, but not as clearly as for marten (Gibilisco 1994). Nevertheless, the remarkable population recoveries exhibited by fishers in southern areas not considered "classic" fisher habitat (i.e., rural agricultural and even industrial areas; Kilpatrick & Rego 1994; P. Rego pers. comm.; L. Supprock pers. comm.) suggest more disturbance tolerance than has hitherto been understood (see also Johnson & Todd 1985). Fishers tolerate fairly high degrees of human activity, including low density housing, farms, roads, small clearings, and gravel pits (Arthur et al. 1989).

Fishers are vulnerable to destruction of habitat, namely forest cover. This is best illustrated by the distributional dynamics of this mustelid in northeastern North America in the 20th century. In New Hampshire, for example, forest cover was reduced to 50% from 95% in 200 years and the fisher nearly disappeared (Powell 1993). In the western United States, fisher have continued to decline due to extensive forest fragmentation (Carroll et al. 1999; Powell & Zielinski 1994).

One of the easiest furbearers to trap, fishers demonstrate a susceptibility to overtrapping, and are easily trapped in sets for other furbearers

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(Whitaker & Hamilton 1998). The importance of pelt prices in driving fisher trapping returns has been well documented, especially in Canada (see Powell 1993). Krohn et al. (1994) speculate that in areas without trapping, natural mortality would presumably replace much of the trapping mortality, since properly regulated trapping probably targets juveniles that would otherwise have died of natural causes.

Interspecific relations with marten remain understudied, particularly in the face of shifting ecological conditions and disturbance regimes. There is much evidence of an inverse relationship between population sizes of sympatric marten and fisher (see Krohn et al. 1997). In most cases, fishers may have a competitive advantage due to an ability to exploit a wider variety of prey size classes and their more flexible habitat requirements (Douglas & Strickland 1987; de Vos 1951; Whitaker & Hamilton 1998). Depending on the specific area, fishers may potentially compete with coyotes, foxes, bobcats, lynx, martens, wolverines, or weasels. However, fishers have been successfully reestablished in areas inhabited by foxes, coyotes, bobcats, and lynx, suggesting that competition with these predators is not limiting. Where fishers and porcupines are sympatric, fishers have little competition for food with other predators which generally kill porcupines only occasionally (Powell & Zielinski 1994).

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River Otter

(Lontra canadensis)

Distribution/History

Along with beaver and gray wolf, the river otter once occupied one of the largest geographical areas of any North American mammal. This species was found in all major waterways of the US and Canada until at least the 18th century, but was subsequently extirpated throughout much of its range (Melquist & Dronkert 1987; Polechla 1990; Toweill & Tabor 1982). The river otter has been making a comeback in much of its former range, aided by reintroduction efforts in some jurisdictions. Presently, in northeastern North America the river otter occurs in most of New England, New York, and eastern Canada (Whitaker & Hamilton 1998). Its current distribution is reportedly more widespread than it was in the 1970s (Polechla 1990). Conservation measures implemented at the beginning of the 20th century, in addition to the reintroduction and stocking of beavers throughout the region during the 1920s to the 1950s (with whom otters have a facultative commensal relationship) have had a positive influence on otter populations (Polechla 1990).

The river otter has been making a comeback in much of its former range, aided by reintroduction efforts in some jurisdictions.

Habitat Associations

The habitat requirements of river otters include areas with abundant water and aquatic vegetation characteristic of permanent waterbodies (Larivière & Walton 1998; Melquist et al. 1981; Whitaker & Hamilton 1998). Able to adapt to a diverse array of aquatic habitats, northern otters are generally most abundant along food-rich coastal areas (excluding large metropolitan areas) such as along lower portions of streams and rivers, in estuaries, and in areas having extensive non-polluted waterways minimally impacted by humans (Polechla 1990; Toweill & Tabor 1982). Severe winter conditions probably limit otter populations in the North (Melquist & Dronkert 1987), with ice cover and low temperatures limiting foraging and shelter opportunities (Reid et al. 1994). Otters are widely recognized to have a commensal relationship with beaver, the presence of which is correlated with abundant summer food sources and den and resting sites, stable water levels, areal increases in wetland habitat, and abundant herbaceous cover (Dubuc et al. 1990; Polechla 1990; Reid et al. 1994).

Watershed use by otters is negatively associated with the proportion of mixedwood stands in forested areas adjacent to waterways, which generally occur in headwater systems characterized by steep gradients and low productivity. It is positively related to the number of beaver flowages, watershed length, and average shoreline diversity (Dubuc et al. 1990). Habitat features found more often at frequented sites include large conifers, points of land, beaver bank dens and lodges, isthmuses, and mouths of permanent streams. (Newman & Griffin 1994). Primarily foragers in shallow waters, fish comprise the bulk of the river otter diet, but crustaceans, shellfish, amphibians, and other non-aquatic foods are also fed upon opportunistically (Larivière & Walton 1998; Whitaker & Hamilton 1998).

Responses to Human-Induced Disturbances

Otters may be able to tolerate a large variety of threats as long as food availability remains high.

In the late 1800s and early 1900s, wetland destruction, pollution and overexploitation for furs was devastating to North American river otter populations. Populations were reduced to the greatest extent where human populations were dense, agricultural and/or industrial practices were particularly intense, wetlands were naturally sparse, or oligotrophic waters could not support a healthy prey base (Polechla 1990). Otters are scarce in heavily settled areas, particularly if waters are polluted (Toweill & Tabor 1982). Nevertheless, they are highly catholic with respect to their choice of streams and banks, and are unlikely to be affected by removal of trees, straightening of banks, or agricultural activities, and can actually demonstrate a remarkable tolerance of human disturbance (Kruuk 1995). Otters may be able to tolerate a large variety of threats as long as food availability remains high.

Although management practices aimed at increasing beaver populations over several decades before 1990 improved otter habitat in the northeastern U.S., habitat change continues to be the major cause of concern. Otters are made vulnerable due to: 1) linear home ranges requiring large areas; 2) reliance on water, also badly needed by humans; and 3) importance of bank vegetation, also sought after by humans (Kruuk

1995). By virtue of their aquatic existence and position at the top of the foodchain, otters are particularly vulnerable to pollution in aquatic ecosystems (Melquist & Dronkert 1987; Foley et al. 1988). They readily accumulate high levels of mercury, organochloride compounds, and other chemicals to levels significantly above environmental concentrations (see references in Larivière & Walton 1998). The decline of otter in Europe has been attributed in large part to the introduction of organochlorine insecticides for use in sheep dip and as seed dressings (Dunstone 1993). In one study of sympatric otters and mink, otter contained greater PCB concentrations than did mink, suggesting that the exposure to this compound was greater for otters than mink, that otters were more tolerant of PCBs than mink, or that otters were less efficient than mink in eliminating PCBs (Foley et al. 1988). Recent work in Nova Scotia showed much higher mercury concentrations in otters captured in inland vs. coastal waters, and scientists are investigating whether declines reported by trappers working in inland areas are related to this condition (N. Burgess et al. in prep.).

The recent history of otter populations points to the fact that this species is vulnerable to overexploitation. It has one of the most valuable pelts, consisting of short dense soft underfur protected by long glossy guard hairs, and demands high prices because of its durability. Steady increases in harvests were reported from the 1920s to 1980s (Obbard et al. 1987). Otter harvests are positively correlated with beaver harvest and average beaver pelt price in most northeastern states, indicating that management practices targeted at the two are not independent (Chilelli et al. 1996). Linear, long distance travel on waterways can make members of the species vulnerable to heavy and efficient harvest by otter "specialist" trappers, which pose more of a potential threat than incidental take by beaver trappers in some areas, e.g., Nova Scotia (M. O'Brien in litt.).

American Mink

(Mustela vison)

Most research that has been conducted on the ecology of American mink has taken place with non-native European populations (Dunstone 1993). (The native European mink, *Mustela lutreola,* disappeared from most of western Europe by the early part of the 20th century, after which time American *Mustela vison* were introduced). The impetus behind this work often has been related to worries about potential competition with the native otter species *(Lutra lutra),* which has exhibited declines at about the same time. Although low otter population levels may have facilitated the spread of mink in these areas, otters are presently recovering in Europe through captive breeding and reintroduction programs in areas where mink have become well established (Dunstone 1993).

Distribution/History

Mink are widely distributed throughout Canada and the United States except for the extreme North of Canada and arid areas of the southwest-

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Mink are generally considered to be abundant throughout their range, and their population status has remained essentially unchanged over the past hundred years.

ern United States (Eagle & Whitman 1987). They occur throughout the eastern United States wherever watercourses provide sufficient food and shelter (Whitaker & Hamilton 1998). Mink are generally considered to be abundant throughout their range, and their population status has remained essentially unchanged over the past hundred years. Unlike many other northeastern mesocarnivores, the number of pelts harvested since 1920 has not declined over time (Eagle & Whitman 1987). This is partly due to the success of mink ranching, whereby the world production of mink pelts has gradually exceeded the wild harvest (Obbard et al. 1987). The tremendous adaptability of the mink is well illustrated by the ease and speed by which populations become established outside of their geographic range, often as a result of fur farm escapees. In Newfoundland, for example, mink were first imported from Nova Scotia in 1934 for farming, and as many as 70 farms had been established by the 1950s. Thirty-five years after the first escapes, mink occupied most if not all suitable habitats on the island with a dispersal rate of about 1-6 miles/year (Northcott et al. 1974). Non-native *Mustela vison* populations have also become well-established in Europe (Dunstone 1993) and South America (Medina 1997).

Habitat Associations

Mink occupy a wide variety of wetland habitats, including coastal areas, streams, rivers, lakes, and freshwater/saltwater marshes (Whitaker & Hamilton 1998). Permanence of water, shoreline, and emergent vegetation are considered to be the most important variables governing habitat suitability (Allen 1983). Mink movements are generally restricted to waterways, where feeding activities are concentrated in shoreline and intertidal zones, and not in open water (Eagle & Whitman 1987). It is, however, not uncommon for mink to be found up to 500 m from the nearest body of water (Thompson 1988). Mink activity is greatest on coniferous and

mixed shorelines with little or no human development. Deciduous shorelines are not used much regardless of development levels (Racey & Euler 1983). Mink feed upon a variety of aquatic and terrestrial foods (Whitaker & Hamilton 1998). Although fish can form a significant part of their diet, mink are less dependent on this prey type than otters (with whom they are sympatric throughout much of their range) and exhibit a generally more diverse diet (Melquist et al. 1981; Melquist & Dronkert 1987).

Responses to Human-Induced Disturbances

The principal threats to mink populations in eastern North America are habitat destruction or degradation and water pollution as a result of land-use practices and chemical pollutants. Their high reproductive potential and generalist food habits may serve as a buffer against deleterious habitat changes (Eagle & Whitman 1987). By virtue of their dependence on aquatic habitats, mink are highly susceptible to mercury, PCB, and pesticide contamination. Shoreline cottage development in central Ontario has a direct detrimental effect on habitat of mink, through alteration of vegetation structure and distribution, species composition of vegetation, and prey availability (Racey & Euler 1983). In one study, 52 of 59 dens were found on undeveloped shorelines, where both coniferous composition and shrub coverage was higher. Sand beaches and docks on the aquatic portion of the shorelines simplify mink foraging grounds by removal of submerged snags, large boulders or stones, and submergent, emergent and floating vegetation, resulting in a highly negative regression between mink density and index of cottage development (Racey & Euler 1983). Conversely, local mink activity increased following habitat improvement in a Québec trout stream, one effect of which was to increase crayfish biomass (Burgess & Bider 1980).

Mink populations are not usually monitored throughout their range, because they are widely thought not to be in danger (Eagle & Whitman 1987), and they are difficult to census. Nevertheless, in some jurisdictions, managers have noted decreases in local populations, for example New Brunswick and Maine (Anon. 1998; W. Jakubas, pers. comm). Mink are also caught incidentally in muskrat traps (Wren 1991). Seeking an explanation for the decline of mink populations since the 1960s in Atlantic coastal plain areas, Osowski et al. (1995) found mercury concentrations in mink kidneys to be elevated in comparison to those from inland areas, where population levels have been consistently higher. Mink are extremely sensitive to PCBs, with even low dietary levels resulting in reduced reproduction (Haffner et al. 1998; Wren 1987). Both wild and ranch mink are susceptible to diseases such as distemper, which is not often noted due to their low profile with most management agencies (M. O'Brien in litt.).

Like otter, by virtue of their dependence on aquatic habitats, mink are highly susceptible to mercury, PCB, and pesticide contamination.

Coyote

(Canis latrans)

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The coyote is the most successful colonizing mammal in recent history, particularly in northeastern North America.

Distribution/History

The coyote is the most successful colonizing mammal in recent history, particularly in northeastern North America (Litvaitis 1992; Parker 1995). At the time of European settlement in the western U.S. (c. 1830), coyotes were limited in their distribution to the prairies and grasslands of the midwest. Beginning in the early 1900s, they expanded rapidly eastward through both natural means and casual transplantations (Parker 1995; Voigt & Berg 1987; Whitaker & Hamilton 1998). The speed of colonization in the East was remarkable: in Maine, it proceeded at a rate of 1,867 km^2/year and in New York, at 2,240 km^2/year (Richens & Hugie 1974). Coyotes were first reported in Ontario in 1919, and after expanding southward then eastward, arrived in Newfoundland in the 1990s (Larivière & Crête 1992; Parker 1995). Boreal forest currently represents the northern limit of coyote distributions in northeastern North America (Tremblay et al. 1998).

Prior to the 20th century, coyotes did not venture far from grassland habitats (Gipson & Brillhart 1995). Their eastward expansion coincided with the commencement of intensive forestry in the Great Lakes region, large-scale agricultural development, and the local extermination of a chief competitor in forested habitats, the gray wolf (Larivière & Crête 1992; Parker 1995; Whitaker & Hamilton 1998). At the same time, improved habitat conditions for white-tailed deer, together with a more favorable climate and the disappearance of wolf, facilitated their range expansion northward (Parker 1995). The coyote expanded its range along with deer to the limit where deep and prolonged snow cover and limited food resources were problematic. Bounties were immediately set up upon first discovery of coyotes in Maine in the early 1930s "to concentrate efforts towards their extermination" (Aldous 1939). However, efforts to control coyotes throughout their range have been largely ineffective (Bekoff 1977; 1982).

Habitat Associations

Coyotes occupy a great range of habitats, but are not as abundant in dense forest as in more open habitats. Ideal coyote habitat consists of scrub country, open ranch lands, and areas containing a diversity of habitats, such as brushy country, ravines, thickets and small woodlots (Whitaker & Hamilton 1998). Although coyotes were originally confined to open country and grasslands, they have occupied many diverse habitats, expanding their range within historic time along with the opening of forested areas, such as along forest access routes (Bekoff 1977; Parker 1995; Young & Jackson 1951, cited in Richens & Hugie 1974). In Maine for example, coyotes inhabit wilderness and forest land as well as areas characterized by an interspersion of cultivated fields, orchards and woods. There appeared to be no barrier to coyote spread as long as adequate food was available (Richens & Hugie 1974). Rural coyotes tend to be heavier

and taller than forest coyotes, and the variation in foraging efficiency between the two lends support to the hypothesis that forest landscapes are sub-optimal (sink) habitats for coyotes due to lower overall food quality (Tremblay et al. 1998). This result, however, is contradicted by the fact that in Nova Scotia, colonizing coyotes remained for some time in forested habitats before moving into more open agriculturally developed areas (M. O'Brien in litt.).

Coyotes eat mammals, fruit, insects, and birds, and in general adapt to whatever food is most readily available (Parker 1995; Whitaker & Hamilton 1998). In the Northeast, because the prey base is less diverse than in more western environs, two prey species (white-tailed deer and the snowshoe hare) have become the staple prey of the eastern coyote (Patterson et al. 1998). Under more severe winter conditions, coyotes are capable of killing both juvenile and adult deer. This is facilitated by the increased vulnerability of deer in deep snow, as well as the larger average body size and tendency for increased sociality and hence group hunting of coyotes (Messier & Barrette 1982; Parker 1995). Data gathered in a Nova Scotia study (Patterson et al. 1998) demonstrated that coyotes prefer to feed upon deer rather than hare where available, presumably because of high profitability. Consumption of deer fawns during summer months exceeded that of hare in all areas, even where there were high hare densities. During mild winters, however, coyote were forced to use prey sources other than deer, regardless of their density, due to the lowered vulnerability of deer. Predation on deer by coyotes is generally opportunistic in nature and is often compensatory to other forms of mortality (Parker 1995). Research in Québec and Maine, however, has shown that coyotes are clearly responsible for "substantial" deer mortality and may be retarding the recovery of deer populations since the 1970s in the northern extreme of their range (Crête & Lemieux 1996; Hilton 1992; Messier et al. 1986). The impact of coyote predation on deer is likely to be most significant in forested wilderness areas with severe winter weather and few alternate sources of prey (Parker 1995; Parker and Maxwell 1989). Forest-dwelling coyotes in the North are more vulnerable to the vagaries of prey abundance than farmland coyotes, because little alternative prey is generally available (Todd 1985b).

Eastern coyotes are 27% larger in average body size than their western counterparts (Parker 1995). There is considerable debate as to whether this larger body size is due to interbreeding with wolves, better nutrition, or simply natural selection in response to new habitat and prey conditions (see Larivière & Crête 1992; Parker 1995). Morphological and genetic examinations suggest interspecific hybridization in some zones of contact (Schmitz & Kolenosky 1985; Wayne et al. 1995). A condition of successful hybridization between coyotes and wolves seems to be increasing coyote densities in areas where frequent interspecific contacts are made (Lehman et al. 1991). Other explanations have pointed to a phenotypic response to food supply, including low prey diversity and/or abundant deer populations in the Northeast (Samson & Crête 1997; Thurber & Peterson 1991).

A condition of successful hybridization between coyotes and wolves seems to be increasing coyote densities in areas where frequent interspecific contacts are made.

Responses to Human-Induced Disturbances

Concomitant with its range expansion, coyotes may be affecting the population status of other mesocarnivores in the Northeast.

Coyotes are well adapted to agricultural areas or other altered environments containing high human densities (Bounds & Shaw 1994; Person & Hirth 1991). Suburban and periurban development provides abundant anthropogenic food sources. Even so, in urban environments of Washington state, coyotes prefer to travel through, and remain close to relatively undisturbed habitats (Quinn 1997). The well-established populations in the Los Angeles area represent remnant populations that predated the expansion of suburbs (Harris 1977).

The expansion of coyote populations has led to increasing conflicts with humans. Coyote predation continues to be a serious problem for livestock producers in the western U.S. (Wagner & Conover 1999) and sheep farming may have facilitated the range expansion of this species in Québec (Georges 1976). Nuisance reports have been on the increase in New England and eastern Canada in recent years (R. Dibblee pers. comm.; W. Jakubas pers. comm.; S. Langlois pers. comm.; M. O'Brien in litt.; P. Rego pers. comm.). In 1988 in Cape Breton Highlands National Park, a young coyote which campers had been feeding bit a young girl (M. O'Brien in litt.), and the first "attack" on a human in Massachusetts was reported in 1998 on Cape Cod (S. Langlois pers. comm.). The increase in nuisance reports, however, may be more a matter of public perception of a growing problem rather than reflective of increasing coyote populations (W. Jakubis, pers. comm.; S. Langlois, pers. comm.).

It has been proposed, for example, that competition with coyote has contributed to the protected status conferred on bobcat in Québec in 1991 (Larivière & Crête 1992). Trappers in the Northeast have noted declines in red fox populations following colonization by eastern coyotes (Parker 1995). In northern areas where predator populations rely on a limited prey base (especially snowshoe hare), more specialized felids (lynx and bobcat) may become increasingly vulnerable to starvation if coyotes diminish prey availability (Litvaitis & Harrison 1989). There is concern on Cape Breton Island for the lynx, as winter observations indicate that coyotes regularly frequent highland lynx refugia, and do not appear to be limited by deep snow as are bobcats (M. O'Brien in litt.).

In Gaspésie National Park, Québec, the last population of caribou south of the St. Lawrence was apparently seriously impacted by coyote predation. Coyotes were held primarily responsible for the high rate of calf mortality since 1987, putting survival of the population in serious jeopardy (Larivière & Crête 1992; Messier et al. 1986; Crête & Lemieux 1996). Once these predators were reduced in the park, caribou survival was enhanced (Crête & Desrosiers 1995). Coyotes carry a variety of diseases, including distemper and sarcoptic mange (Gese et al. 1997; Pence & Windberg 1994). Despite their widespread distribution and abundance (even in suburban neighborhoods), rabid coyotes have been reported rarely and sporadically (Rupprecht et al. 1995).

Red Fox
(Vulpes vulpes)

Distribution/History

The red fox is the most widely distributed carnivore in the world, occurring throughout North America and Eurasia, and having been introduced to the Australian continent (Larivière & Pasitschniak-Arts 1996). During aboriginal times, this species was scarce or absent in the mid United States in hardwood forests where gray fox was common (Gilmore 1946). Dissatisfied with the gray fox (which treed itself rather than ran), colonial hunters introduced red foxes from England to North America for fox hunting purposes (Gilmore 1946). Several authors claim that the southern limit of red fox at the time of settlement (c. 1600) included Québec and the Great Lakes region in Ontario, but not New England (north of 40-45° N. lat.) (Churcher 1959; Peterson et al. 1953; Voigt 1987). It is of considerable debate however, whether or not this species actually was present in New England prior to the European introduction. Concomitant with clearing of forests in the Northeast, and possibly facilitated by climate change and the extirpation of the wolf, red foxes have increased in abundance and have expanded their range over the past two hundred years (Voigt 1987; Whitaker & Hamilton 1998).

Red fox populations in northeastern North America declined in the late 1800s as a result of anti-predator poisoning efforts, after which the fur value increased. By the late 1920s population levels had reached a new low due to over-trapping. The demand for long-haired fur decreased through the 1930s, but rose thereafter to reach a harvest rate in the 1980s that was six times greater than the maximum attained prior to the turn of the century (Obbard et al. 1987). Local fluctuations of fox populations during the past 50 years have been related to sarcoptic mange and rabies outbreaks (Halpin 1984). In Nova Scotia, fox (red and gray) ranching was popular in the early 1900s, and price declines in the 1930s resulted in releases into the wild of ranch stock, such that even today silver and cross fox color morphs are still relatively common in wild populations in areas where ranching once occurred (M. O'Brien in litt.).

The red fox is the most widely distributed carnivore in the world, occurring throughout North America and Eurasia, and having been introduced to the Australian continent.

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Habitat Associations

Red foxes occupy a diverse range of habitats. They are most common in rolling farmland, mixed with sparsely wooded areas, marshes and streams. They frequent forest edges, open areas in heavily forested regions, and live within the limits of greater metropolitan and suburban areas, e.g., parks, ravines, golf courses, cemeteries, and large gardens. The red fox does well in settled areas, particularly in "broken country," but not in dense forest, and is associated with agricultural areas where woodlots are interspersed with cropland and pasture grassland (Allen 1987; Samuel & Nelson 1982; Voigt 1987; Whitaker & Hamilton 1998). Habitat use can be influenced by snow depth: red foxes use and travel in conifer forest more than expected by chance and tend to avoid hardwood forests during winters with heavy snow (Halpin & Bissonette 1988).

North American red foxes may not be as habituated to urban life as populations described from Great Britain and mainland Europe, where this species has colonized urban areas from surrounding rural areas.

North American red foxes may not be as habituated to urban life as populations described from Great Britain and mainland Europe, where this species has colonized urban areas from surrounding rural areas (e.g., Harris 1977; Harris & Rayner 1986). The urban colonization is perhaps facilitated by the absence of the raccoon. In North America, urban red foxes are primarily located in bushy ravines containing golf courses and parkland, and use areas of low-density housing characterized by large, well-vegetated lots with little pedestrian or road traffic at night while avoiding medium and high density housing areas (Adkins & Stott 1998). The presence of red fox in urban greenways is strongly associated with greenway width, connectivity with natural forest, and adjacent land use types (Schiller & Horn 1997).

Red fox are generalists with respect to food habits, consuming plant and animal material alike, and readily change their diet according to season (Voigt 1987; Whitaker & Hamilton 1998). They are not as prone to scavenging human refuse as in England, and instead consume birds and voles, frequenting habitats that support such prey types, even in urban environments (Adkins & Stott 1998). In the northern parts of their range, they, like many sympatric predators, include snowshoe hare and carrion at higher frequencies in the diet (Halpin & Bissonette 1988; Voigt 1987).

Responses to Human-Induced Disturbances

Red foxes are generally more abundant in agricultural regions than in northern forested areas and have responded positively to forest clearing in the Northeast over the past hundred years.

Red foxes are generally more abundant in agricultural regions than in northern forested areas (Halpin 1984) and have responded positively to forest clearing in the Northeast over the past hundred years (Whitaker & Hamilton 1998). Heterogeneous and fragmented landscapes constitute better habitat for this species than homogenous ones (Catling & Burt 1995). Habitat quality can limit red fox numbers, but seldom their distribution (Voigt 1987). Red foxes are known to make extensive use of roads, particularly in winter time to facilitate travel in high snowfall areas (Halpin & Bissonette 1988; Thompson 1988). They display largely positive responses to urbanization, although access to natural habitat within areas settled by humans is critical (Adkins & Stott 1998; Schiller & Horn 1997). Even while traveling at night in residential areas, red foxes will use corridors of vegetation whenever possible, and will limit their foraging to patches of vegetation with dense cover (Adkins & Stott 1998).

Foxes are the most widespread reservoir of rabies in the wild, with one of the geographic foci for fox rabies located in southeastern Canada and the northeastern United States (Chomel 1993). For example, 44% of reported cases of rabies in Ontario between 1954 and 1993 were red foxes (Rosatte et al. 1997). Oral rabies vaccination of the red fox with vaccine-laden baits is an integral aspect of rabies control throughout southeastern Canada (Rupprecht et al. 1995).

While red foxes have profited from human disturbance with respect to range and population increases, there is much debate as to how the abundance and distribution of this species have been impacted by the increasing presence of the coyote. For nearly 50 years there was no major canid predator in New England except the red fox (Hilton 1992). Certainly, there is "substantial" (Johnson et al. 1996) evidence of an

inverse relationship between red fox and coyote population densities, by means of active aggression by the latter, or avoidance by the former. Trappers in the Northeast have noted declines in red fox populations following colonization by eastern coyotes, especially in regions with no deer, where coyotes and foxes depend on the same prey (snowshoe hare) (Parker 1995; Voigt 1987). Finely (1996) describes an "explosion" of red fox populations in Saskatchewan in the 1960s after the decimation of coyotes due to snowmobile-enhanced poison and slaughter.

Gray Fox
(Urocyon cinereoargenteus)

Distribution/History

More southerly in distribution than the red fox, the current range of the gray fox includes all of the eastern United States except for extreme northern Maine. In Canada, it occurs in southern Ontario and Québec but is absent from the Maritime provinces (Fritzell & Haroldson 1982; Whitaker & Hamilton 1998). Prior to the arrival of Europeans, this species occurred in much of eastern North America as far north as Ontario. Since their arrival, however, this species was only known to occur in southern New England. Reentry into New England within the past century may have been related to a general warming trend in the region since about 1850 (Waters 1964), and/or reforestation. Exterminated by either European settlers or some unknown agency before their coming, the gray fox was absent from Ontario for over 300 years and has been re-invading the province since the 1930s (Downing 1946).

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Habitat Associations

Much less is known about the ecology of the gray fox than the red fox (Whitaker & Hamilton 1998). It is associated with deciduous forest and does not take as readily to farmlands as does the red fox (Fritzell & Haroldson 1982; Fritzell 1987; Whitaker & Hamilton 1998). The species prefers a diversity of woods and fields rather than homogeneous habitats such as agricultural lands, although the latter are also utilized to some extent (Allen 1987; Haroldson & Fritzell 1984, cited in Fritzell 1987; Samuel & Nelson 1982). Forested areas are generally preferred, especially when widely available, but much variation is in evidence (Fritzell 1987). One study found "best" habitat to include areas comprised of 30% forest and 40% farmed land with much interspersion maximizing the amount of edge present (Peterson et al. 1977, cited in Samuel & Nelson 1982). Dense cover is preferred for daytime resting sites (Fritzell 1987). Considered more omnivorous than the red fox (Hockman & Chapman 1983), the diet of the gray fox includes considerable quantities of fruits and grains, which may have facilitated range extension along with agricultural expansion in the Northeast (Fritzell 1987). The presence of gray fox in urban greenways is strongly associated with greenway width, connectivity with natural forest, and adjacent land use (Schiller & Horn 1997).

This species apparently does not flourish in farmlands to the extent that the red fox does.

Responses to Human-Induced Disturbances

Gray foxes have expanded their geographic range in the Northeast during the past century, facilitated by extensive reforestation in the region (Whitaker & Hamilton 1998). For example, the proportion of gray foxes in the total fox population in central New York experienced a marked increase from the 1950s to the 1980s, from 1:10 to 1:1.4 (gray fox: red fox) (Tullar & Berchielli 1982). This species apparently does not flourish in farmlands to the extent that the red fox does (Whitaker & Hamilton 1998). Few studies have examined the impacts of urbanization on gray foxes. There are some indications, at least in New Mexico, that gray foxes decline as residential development increases. Even though the overall food resource availability was greater in residential than undeveloped areas, gray foxes avoided high-density residential subdivisions (>128 residences/km2) and exhibited a threshold of tolerance at between 50-125 residences/km2 (Harrison 1997). In a survey of anthropogenic factors potentially affecting ecology of gray foxes in the same rural residential area, the extent of original habitat was found to be a significant factor (Harrison 1993).

Raccoon

(Procyon lotor)

Distribution/History

Today, it is conservatively estimated that there are 15 to 20 times as many raccoons as in the 1930s, with some recent range extensions having taken place northward into Canada.

Raccoons are widely distributed across northeastern North America (Lotte & Anderson 1979; Whitaker & Hamilton 1998). Populations all over the continent experienced a sharp decline by the 1930s, after which a continent-wide increase began in the 1940s. Today, it is conservatively estimated that there are 15 to 20 times as many raccoons as in the 1930s, with some recent range extensions having taken place northward into Canada (Lotte & Anderson 1979; Sanderson 1987; Simkin 1966). Population and range increases of the raccoon came about without any management interventions other than regulation of timing and length of trapping seasons (Sanderson 1987). Habitat modifications resulting from agricultural development, as well as the availability of overwinter sites in brushpiles and active or abandoned farmstead buildings, and the accessibility of stored grain as food, also presented favorable conditions for rebounding populations (Allen 1987).

Habitat Associations

Raccoons are found wherever suitable combinations of woods and wetlands provide acceptable food and den sites, including swamps and marshes, mesic woods, cultivated areas and urban areas (Whitaker & Hamilton 1998). During range expansion occurring this century, raccoons also expanded habitat use into plains, prairies, deserts and farmland (Sanderson 1987). Throughout their range they occur almost anywhere that water is available. Relatively scarce in dry upland woodlands, they

tend to avoid large open fields and conifer stands, which offer few food resources (Kaufmann 1982; Pedlar et al. 1997). In one study in rural Ontario, raccoons attained the highest abundances in mid- and high-intensity agricultural areas along an agricultural gradient ranging from nearly entirely wooded to heavily cultivated (Pedlar et al. 1997). They preferred woody vegetation fencerow features, den trees, deciduous stands, macrohabitats with extensive agricultural edge, and wooded remnants with extensive corn cover. In New Hampshire, the relative abundance of raccoons was found to be greatest in landscapes that contained the least amount of forest and largest proportions of agricultural and developed habitats, and the least in continuous forest (Oehler & Litvaitis 1996).

Densities of raccoons in urban areas of North America are generally significantly higher than in rural areas (Rosatte et al. 1997; Riley et al. 1998). Within urban areas, however, densities are greatest within forested parks and residential areas, although other habitats such as groomed grass and industrial areas are used when population densities are high (Rosatte et al. 1992). Population densities of raccoons in Toronto are inversely related to those of striped skunks (Rosatte et al. 1992).

Responses to Human-Induced Disturbances

As one of the most familiar creatures in urban environments, raccoons are well-adapted to survive near humans (Whitaker & Hamilton 1998). Urban environments likely provide resources (such as food and den sites) and conditions (such as greater protection from exploitation) that directly benefit and support dense raccoon populations (Anthony et al. 1990; Rosatte et al. 1992). In urban areas, raccoons may benefit from stable food and denning resources that mitigate severe winter effects, with garbage acting as a supplemental resource (Hoffman & Gottschang 1977; Riley et al. 1998). Raccoons are among the most common agents of damage to agricultural producers in the Northeast (Conover 1998). As urban pests, potential transmitters of diseases such as rabies, and predators of waterfowl and other birds, raccoons are frequently reported as nuisances (Whitaker & Hamilton 1998). Raccoons have been heavily harvested over the past hundred years, particularly in the U.S., a reflection of increases in population sizes throughout its range (Obbard et al. 1987). This species appears to be able to withstand high harvesting pressure, as demonstrated by largely unaffected population levels in states where harvesting levels have been high and sustained (Sanderson 1987).

There has been a continuing spread of an epizootic of raccoon rabies affecting mid-Atlantic and northeastern United States. Rabies was introduced to the region in the 1970s, probably as a result of the translocation of animals from the southeastern United States. The rapidity of spread throughout the region may reflect the high density of raccoon populations associated with abundant food supplies and denning sites in urban and suburban areas (Anthony et al. 1990). During 1995, states in the mid-Atlantic and Northeast regions accounted for 89% of the reported cases of raccoon rabies in the U.S. (Krebs et al. 1996). In 1997, 93% of all reported cases in the U.S. were wild animals, with raccoons having the highest relative contribution (over 50%) (Krebs et al. 1998). In a Connecticut study documenting the emergence of rabies from 1991 to

Raccoons are among the most common agents of damage to agricultural producers in the Northeast.

1994 (Wilson et al. 1997), 47% of all raccoons tested were infected, representing 88% of all animals found positive. There have been many local and state-wide population decreases (some drastic) in New England during recent years as a result of this disease, which has not affected other carnivore populations to nearly the same extent (Sanderson 1987; S. Langlois pers. comm.; P. Rego pers. comm.; W. Jakubas pers.comm.). The costs associated with rabies control and prevention in the northeastern U.S. have increased in direct relation to the spread of the raccoon rabies epizootic, due in large part to the rapidly increasing numbers of post-exposure treatments in humans (see Rosatte et al. 1997). The public health burden has therefore been described as "considerable" (Rupprecht et al. 1995; Wilson et al. 1997). The first three cases of raccoon rabies in Ontario, where the dominant strain has affected red foxes and skunks (Rosatte et al. 1997), were found near the New York border between July and September 1999. In response, the Ministry of Natural Resources has initiated a campaign to air-drop vaccinated baits, and depopulate areas around the confirmed cases of skunks and raccoons (OMNR 1999). Although raccoon rabies has yet to be reported in Québec, managers are currently engaged in active bait distribution as a result of a recent case near the border in Maine (M. O'Brien in litt.).

Striped Skunk

(Mephitis mephitis)

Distribution/History

Striped skunks formed the major animal reservoir for rabies from 1961 to 1989 until they were unexpectedly supplanted by the raccoon during the rabies outbreak in the mid-Atlantic and northeastern states.

Striped skunks are widespread throughout the United States and southern Canada (Wade-Smith & Verts 1982; Whitaker & Hamilton 1998). Considered valuable for the fur trade during the first half of the 20th century, their value declined dramatically in the 1950s and 60s as fashions shifted away from long-haired furs. Even when these returned to vogue, striped skunk were not harvested in substantial numbers, especially once labeling legislation was passed prohibiting the use of names that obscured the true identity of furs used in garments (Obbard et al. 1987; Wade-Smith & Verts 1982; Whitaker & Hamilton 1998).

Habitat Associations

Striped skunks inhabit a variety of habitat types (Godin 1982), but are most abundant in agricultural areas, grassy fields, brushy areas, ravines, drainage ditches, hedgerows, and mixed-crop lands (Whitaker & Hamilton 1998). Their preferred habitat includes a mixture of woodlands, brushy corners, open field broken by wooded ravines and rocky outcrops, as is typical of intensively cultivated areas (Wade-Smith & Verts 1982). They are usually absent in areas where the water table is high, making ground dens impossible, or in unbroken forested areas, where their food supply is too low (Verts 1967, cited in Rosatte 1987). They are also known to use buildings extensively in winter (Roasatte 1987).

In a study of urban skunk populations in Toronto (Rosatte et al. 1992), capture success was greatest in field habitats, followed by industrial, commercial, then residential areas (the latter three were utilized more during population increases). Groomed park and forested parks were characterized by the lowest skunk densities. As corroborated by other studies in North American cities, densities of skunks in urban areas are significantly higher than in rural areas. In the Toronto study, population densities were inversely related to those of raccoons.

Responses to Human-Induced Disturbances

Striped skunks have a promising future in the face of human disturbance because of their large litter sizes and high percentage of yearlings that breed (Rosatte 1987). Along with raccoons, they are one of the most familiar species of urban wildlife, and populations have responded favorably to both the urbanization and agricultural clearing over the past hundred years. As a result, this species has been managed much more as a nuisance animal than as a furbearer (Rosatte 1987). Striped skunks formed the major animal reservoir for rabies from 1961 to 1989 until they were unexpectedly supplanted by the raccoon during the rabies outbreak in the mid-Atlantic and northeastern states (Parkham 1983, cited in Rosatte 1987; Rupprecht et al. 1995). Between 1954 and 1993, for example, striped skunks comprised 19% of the 55,166 reported cases of rabies in Ontario (Rosatte et al. 1997). The cost of rabies control can be substantial (Rupprecht et al. 1995). Research has been unsuccessful at distinguishing whether or not rabies is limiting to striped skunk populations (Schubert et al. 1998).

Short-tailed, Least, and Long-tailed Weasels

(Mustela erminea, M. nivalis, M. frenata)

Most ecological studies of weasels have been undertaken in Europe. Unfortunately, results from these studies in many cases are not readily transferable to the weasels of northeastern North America. Prey species differ between the two continents (Ralls & Harvey 1985) and there is significant variation in body size within species (for example, *Mustela erminea* of North America are appreciably smaller than elsewhere). *M. frenata* does not occur outside of the North American continent.

Distribution/History

The long-tailed weasel *(Mustela frenata)* has the largest range of any mustelid in the western hemisphere (Whitaker & Hamilton 1998, Sheffield & Thomas 1997) and in general occurs to the south of the other two species. It is known from all 48 contiguous states (Sheffield & Thomas 1997). The study region of the northeastern United States and southeast-

ern Canada is one of two relatively narrow belts where the species is sympatric with *M. erminea* (Hall 1981). Harvesting of *M. frenata* (which were probably lumped with *M. erminea* records) as recorded by the Hudson's Bay Company show a steady decline over the last 40 years, probably as a result of habitat loss (Fagerstone 1987). The species is considered rare in Canada (Fagerstone 1987). The short-tailed weasel, or ermine, *(M. erminea)* is a boreal species and is most numerous in the coniferous forests of Canada and northern U.S. It occurs throughout the northeastern U.S., but is uncommon in coastal regions (Whitaker & Hamilton 1998). The least weasel *(Mustela nivalis)* is widely distributed, however, it is considered rare in North America. In the northeastern U.S., it is known only from extreme western New York (two records from Chautauqua County in 1948 and 1981). Although suitable habitat appears to be available, *M. nivalis* does not occur in New England, which is probably related to the fact that the subspecies of *M. erminea* in the region is unusually small (Hall 1981). The high dispersal and colonization abilities of weasels allow for rapid re-colonization of vacated areas when small rodents increase in numbers. Populations fluctuate considerably and females breed or forego breeding in accordance with the state of the prey base (Sheffield & King 1994).

Many more weasels are trapped in Canada than in the U.S. Economically, these taxa are relatively unimportant as furbearers (Fagerstone 1987) and pelt prices are the lowest next to red squirrels. Harvest levels were an order of magnitude higher in the 1920s and 1930s than in the 1980s, partly due to changes in distribution and population size due to habitat loss during the 20th century. In addition, changes in trapping practices in Canada especially have resulted in lower incidental catch in sets for other furbearers.

Habitat Associations

M. frenata is found in a variety of habitats, from dense hammocks and swamp fringes, to thickets of low-growing shrubs along watercourses, to sparsely wooded second growth forest (Whitaker & Hamilton 1998). With the exception of deserts, it inhabits all life zones in its range, from alpine-arctic to tropical. In general, it favors early successional habitats and avoids forested habitats (Simms 1979). Preferred habitats include brushland and open timber, brushy field borders, grasslands along creeks and lakes, and swamps (Svendsen 1982). In agricultural areas, this species is usually restricted to waterways not suitable for cultivation, especially in the vicinity of free-standing water. Its northern distributional boundary in Ontario and Québec occurs at the transition zone between the deciduous Great Lakes/St. Lawrence forest and more coniferous boreal forest. Where the species occurs together with *M. erminea,* it is thought that *M. frenata* occurs in more open areas and *M. erminea* occurs in forested land. This is the largest and least specialized member of the small carnivore guild that preys on small to medium-sized mammals (Rosenzweig 1966). Compared to the other weasels, it is a generalist predator given to prey switching. There is some degree of dietary overlap with other species, especially with *M. erminea.* Its larger size allows it to take a wider variety of prey. The species appears to occur naturally at low densities and is less abundant than *M. erminea* in areas of sympatry. Although populations experience fluctuations, and can become locally extinct if rodent numbers are too low, they are more stable than populations of *M. erminea* or *M. nivalis* (Sheffield & Thomas 1997). Presumably, this is related to the more generalist food habits of this species.

 M. erminea is mostly found in forested habitats, and compared to *M. frenata,* favors late successional environs (Simms 1979). In the southern part of its range, it often occupies habitats similar to *M. frenata,* namely brushy fields bordering cultivated areas (Robitaille & Raymond 1995; Samson & Raymond 1998; Whitaker & Hamilton 1998). In the Holarctic region, ermine tend to avoid dense forest and deserts and occupy forest and forest-edge habitats, scrub, alpine meadows, marshes, riparian woodlands, hedgerows and riverbanks (Fagerstone 1987). Structural habitat components, such as a high abundance of hardwood understory, and not relative prey abundance, influenced short-tailed weasel distribution in New Brunswick. (Edwards 1998). The species appears well-adapted to snowy environments and ranges above the treeline into alpine areas. Snow apparently presents no obstacle to its distribution and provides vital insulation against low temperature extremes (King 1983). In the boreal zone, *M. erminea* is often abundant in coniferous forests and ecotonal areas (Allen 1987). The species feeds chiefly on small mammals, but will also eat other vertebrates and some insects (Whitaker & Hamilton 1998). Population fluctuations parallel those of their prey, but are not as drastic as fluctuations of *M. nivalis* (Fagerstone 1987). Although populations are not declining, this species is now regarded as less common than earlier in the 20th century (Fagerstone 1987).

 M. nivalis is the smallest of the three weasel species and the smallest living carnivore. Habitats include open forests, farmlands, cultivated fields, grassy fields, meadows, riparian woodlands, hedgerows, alpine

M. nivalis *is the smallest of the three weasel species and the smallest living carnivore.*

Because of their small size and secretive habits, very little is known about the conservation status of the weasels.

meadows/forests, scrub, steppe, semi-deserts, prairies and coastal dunes. In agricultural lands, its primary habitat consists of mixed grasslands, hedgerows, and pond edges, where the species makes extensive use of cover (hedgerows, fencelines, and piles of cutover brush; Sheffield & King 1994). Habitat selection appears to be determined by the local distribution of small rodents. Deep dense forests and sandy deserts are avoided. The species occurs in tundra and sometimes in coniferous forest/woodland. To the south, the species tends to occur in more open areas than the other two weasels. *M. nivalis* pursues its major prey in their burrows. With respect to food habits, it is the most specialized of the three weasels, preying primarily on small mammals, especially rodents (Fagerstone 1987). Humans are seldom aware of its presence (Whitaker & Hamilton 1998).

Responses to Human-Induced Disturbances

Because of their small size and secretive habits, very little is known about the conservation status of the weasels. Most studies of weasel habitat selection have been conducted in agricultural regions, hence knowledge of weasel habitat requirements in forested landscapes is limited (Edwards 1998). They are seldom the target of trappers, and populations are therefore not generally monitored. Ecological studies have not examined responses of any of the three species to changing ecological conditions brought about by disturbance. At least two of the three species (*M. frenata* and *M. nivalis*) appear to thrive in relatively open areas, and do well in agricultural regions, as long as habitat diversity is maintained (Sheffield & King 1994; Sheffield & Thomas 1997; Svendsen 1982). The dependence of *M. erminea* on forested habitats may indicate a vulnerability to forest clearing. The decline in fur returns of *M. frenata* is of concern, and may reflect habitat loss as natural woodlands have been transformed to industrial, agricultural and urban landscapes.

Acknowledgements

Appendix One:
Present Distribution of Northeastern Mesocarnivores and Historical Notes

	LYNX *Lynx canadensis*	BOBCAT *Lynx rufus*	MARTEN *Martes americana*	FISHER *Martes pennanti*
ON	present; reintroduction attempt in 1950s cut short due to public outcry	present along the southern border	present; successful reintroductions in 1950s/60s and early 80s	present; 3 successful reintroductions 1950s-70s
QU	present		present	natural population recovery
NB	viable population uncertain; spotty distribution (possibly transients)	present	present; reintroductions in 1950s/60s	present; successful reintroductions 1950s/60s
NS/CB[1]	probably no viable population on NS (a few recent incidental captures); present on CB	present on NS; colonized CB after causeway built in 1955	present on NS/CB; successful reintroduction on NS in 1980s	present; successful reintroduction in NS; never present on CB
NF/LAB[2]	present	never present	present, but rare NF/ present LAB; successful reintroductions in 1980s	never present on NF; unconfirmed reports near QU border in LAB
PEI	extirpated	extirpated; illegal, unsuccessful reintroduction attempts	extirpated	extirpated
ME	present in the north	present	present	present
NH	probably no viable population other than transients from QU		present in the north but rare; reintroduction attempt in 1975, success uncertain	present; natural population recovery
VT	probably no viable population, but 1-2 credible recent sightings		present in the north but rare; viable population uncertain; reintroduction attempt 1989-91, success poor.	present; successful reintroductions in 1950s
NY	probably no viable population; reintroduction attempt in 1989-92; probably unsuccessful.		present; natural population recovery	present; in-state translocations 1976-79; natural population recovery
MA	never common; now extirpated		extirpated	present; natural population recovery
RI		present, but rare		present; natural population recovery
CT			never present	present; natural population recovery; successful reintroduction 1989-90

	OTTER *Lontra canadensis*	MINK *Mustela vison*	RED FOX *Vulpes vulpes*	GRAY FOX *Urocyon cinereoargenteus*	COYOTE *Canis latrans*
ON	present	present	present	marginally present along southern border	present; colonizing since 1930s
QU				marginally present along southern border	
NB				never present	present; colonizing since 1973
NS/CB[1]					present; colonizing since 1977
NF/LAB[2]		Not historically present in NF; population established fur farm escapes 1930–1970; present in LAB	present; populations may have been augmented by introductions of European red fox in colonial times for hunting		present; NF: colonizing since mid 80s; LAB: unconfirmed reports near QU border
PEI	extirpated	present			
ME	present			present along southern border	present; colonizing since late 1970s
NH	present; natural population recovery				present; colonizing since 1930s
VT				present	present; colonizing since 1940s
NY	present; ongoing in-state translocations (since 1995)				
MA	present; natural population recovery				
RI					
CT					

	RACCOON *Procyon lotor*	STRIPED SKUNK *Mephitis mephitis*	SHORT TL. WEASEL *Mustela erminea*	LONG TL. WEASEL *Mustela frenata*	LEAST WEASEL *Mustela nivalis*
ON	present	present	present	present	present
QU					present, but rare
NB					
NS/CB[1]	never present	never present		never present	never present
NF/LAB[2]	historically not present; population established fur farm escapes	never present		never present (NF); present but rare (LAB)	never present (NF); present (LAB)
PEI		historically not present; population established fur farm escapes		never present	never present
ME	present	present		present	
NH					
VT					
NY					present but very rare (known from 2 records)
MA					never present
RI					
CT					

NOTES:
[1]Nova Scotia and Cape Breton Island: unless otherwise noted, notes refer to both
[2]Newfoundland and Labrador: unless otherwise noted, notes refer to both.

Appendix Two: Conservation and Management Status of Northeastern Mesocarnivores

BOBCAT (*Lynx rufus*)

The bobcat has been listed under Appendix II of CITES since 1977. This protection status stipulates that the export of hides will only be allowed if harvest levels are not detrimental to the survival of the species or any of its populations.

	STATUS	SEASON LENGTH (days)	BAG LIMIT	REQ'D COLLECT.
Ontario	furbearer	Trapping: 128	no limit	
Québec	protected[1]	no open season (closed in 1995)		
New Brunswick	furbearer	Trapping & Hunting: 56[2]	2/zone (draw system)	carcass
Nova Scotia	furbearer	T & H: 121	5	carcass
Maine	furbearer	T: 62; H: 77	no limit	tag
Vermont	furbearer	T: 16; H: 29		carcass
New Hampshire	protected	no open season		
New York	furbearer	T: 37-107[2]; H: 44-149[2]	no limit	tag
Massachusetts	furbearer	T: 30[2]; H: 80[2]	no limit	tag & carcass
Rhode Island	protected	no open season		
Connecticut	protected	no open season		

[1]likely to be listed as endangered in Québec
[2]closed seasons in some parts of jurisdiction

LYNX (*Lynx canadensis*)

The lynx has been listed under Appendix II of CITES since 1977. This protection status stipulates that the export of hides will only be allowed if harvest levels are not detrimental to the survival of the species or any of its populations. On March 24, 2000, the U.S. Fish and Wildlife Service made the decision to list the "contiguous United States Distinct Population Segment" of lynx as "threatened by the inadequacy of existing regulatory mechanisms." The distinct population segment covers 13 states in four separate regions, including the Northeast (Maine, New Hampshire, Vermont, and New York).

	STATUS	SEASON LENGTH (days)	BAG LIMIT	REQ'D COLLECT.
Ontario	furbearer	Trapping: 128	no limit	
Québec	furbearer[1]	T: 30-31[2] (closed 1995-1998)	2	carcass
New Brunswick	endangered	no open season		
Nova Scotia	protected[1]	no open season		
Newfoundland	furbearer	T: 32 (NF); 148-158 (LAB)	no limit	carcass
Maine	"special concern"	no open season		
Vermont	endangered	no open season		
New Hampshire	endangered	no open season		
New York	small game	no open season		

[1]likely to be listed as endangered in jurisdiction
[2]closed seasons in some parts of the jurisdiction

FISHER (*Martes pennanti*)

	STATUS	SEASON LENGTH (days)	BAG LIMIT	REQ'D COLLECT.
Ontario	furbearer	Trapping: 68-128	no limit	
Québec	furbearer	T: 61-171[1]	no limit	carcass
New Brunswick	furbearer	T: 15-22[1]	no limit	carcass
Nova Scotia	furbearer	no open season; in 3 counties, incidental harvest only	1	carcass
Newfoundland	protected	no open season (NF & LAB)		
Maine	furbearer	T: 62	no limit	tag
Vermont	furbearer	T: 16	no limit	carcass
New Hampshire	furbearer	Trapping & Hunting: 31	10	tag
New York	furbearer	T: 44[1]	no limit	tag
Massachusetts	furbearer	T: 22	no limit	tag; carcass
Rhode Island	protected	no open season		
Connecticut	protected	no open season		

[1] closed seasons in some parts of the jurisdiction

AMERICAN MARTEN (*Martes americana*)

	STATUS	SEASON LENGTH (days)	BAG LIMIT	REQ'D COLLECT.
Ontario	furbearer; "provincially featured species"	Trapping: 68-128	no limit	
Québec	furbearer	T: 17-142[2]	no limit	carcass
New Brunswick	furbearer	T: 15[2]	no limit	carcass
Nova Scotia	protected[1]	no open season		
Newfoundland	furbearer	T: no open season (NF); 148-158 (LAB)	no limit (LAB)	
Maine	furbearer	T: 62	25	tag
Vermont	endangered	no open season		
New Hampshire	threatened	no open season		
New York	furbearer[3]	T: 44[2]	6	tag

[1] likely to be listed endangered in jurisdiction
[2] closed seasons in some parts of the jurisdiction
[3] special permit required

AMERICAN MINK (*Mustela vison*)

	STATUS	SEASON LENGTH (days)	BAG LIMIT	REQ'D COLLECT.
Ontario	furbearer	Trapping: 68-109	no limit	
Québec	furbearer	T: 121-156[1]	no limit	
New Brunswick	furbearer	T: 66-78	no limit	
Nova Scotia	furbearer	T: 121	no limit	
Prince Edward Island	furbearer	T: 93	no limit	
Newfoundland	furbearer	T: 120 (NF); 141 (LAB)	no limit	
Maine	furbearer	T: 62	no limit	tag
Vermont	furbearer	T: 63	no limit	
New Hampshire	furbearer	T: 104-174	no limit	
New York	furbearer	T: 72-170	no limit	
Massachusetts	furbearer	T: 45	no limit	tag
Rhode Island	furbearer	T: 92	no limit	
Connecticut	furbearer	T: 130	no limit	tag

[1]closed seasons in some parts of the jurisdiction

RIVER OTTER (*Lontra canadensis*)

The river otter has been listed under Appendix II of CITES since 1977, not because of its own status, but because it looks like endangered otter species from other continents. This protection status stipulates that the export of hides will only be allowed if harvest levels are not detrimental to the survival of the species or any of its populations.

	STATUS	SEASON LENGTH (days)	BAG LIMIT	REQ'D COLLECT.
Ontario	furbearer	Trapping: 158-224	no limit	
Québec	furbearer	T: 121-156[1]	no limit	
New Brunswick	furbearer	T: 85-99	no limit	carcass
Nova Scotia	furbearer	T: 121	no limit	carcass
Newfoundland	furbearer	T: 148 (NF); 158 (LAB)	no limit	
Maine	furbearer	T: 62	no limit	tag
Vermont	furbearer	T: 107	no limit	carcass
New Hampshire	furbearer	T: 162	10	tag
New York	furbearer	T: 58-163[1]	no limit	tag; jaw
Massachusetts	furbearer	T: 45	no limit	tag; carcass
Rhode Island	protected	no open season		
Connecticut	furbearer	T: 130	8	tag; carcass

[1]closed seasons in some parts of the jurisdiction

RED FOX (*Vulpes vulpes*)

	STATUS	SEASON LENGTH (days)	BAG LIMIT	REQ'D COLLECT.
Ontario	furbearer	Hunting & Trapping: 168-365	no limit	
Québec	furbearer	T:15-142; H: 114-128	no limit	
New Brunswick	furbearer	T: 102-152; H: 152	no limit	
Nova Scotia	furbearer	T: 136	no limit	
Prince Edward Island	furbearer/game	T: 62; H: 92	no limit	
Newfoundland	furbearer	T: 105 (NF); 148-158 (LAB)	no limit	
Maine	furbearer	T: 77; H: 143	no limit	tag
Vermont	furbearer	T: 63; H: 108	no limit	
New Hampshire	furbearer	T: 76-78; H: 183	no limit	
New York	furbearer	T: 51-114; H: 114-149	no limit	
Massachusetts	furbearer	T: 30; H: 121	no limit	tag
Rhode Island	furbearer/game	T: 92; H: 30-137	no limit	
Connecticut	furbearer	T: 130; H: 135	T: no limit; H: 30	tag

COYOTE (*Canis latrans*)

	STATUS	SEASON LENGTH (days)	BAG LIMIT	REQ'D COLLECT.
Ontario	furbearer	Trapping: no closed season; Hunting: 258-365	no limit	
Québec	furbearer	T: 15-142; H: 144-187	no limit	
New Brunswick	furbearer	T: 102-152; H: 151	no limit	
Nova Scotia	"other harvestable wildlife"	T: 121; H: no closed season	no limit	
Prince Edward Island	furbearer/game	T: 62; H: 152	no limit	
Newfoundland	furbearer	T: 105 (NF); 148-158 (LAB)	no limit	
Maine	furbearer	T: 77; H: no closed season	no limit	tag
Vermont	furbearer	T: 63; H: no closed season	no limit	
New Hampshire	unprotect.	T & H: no closed season	no limit	
New York	furbearer	T: 51-114; H: 178	no limit	tag
Massachusetts	furbearer	T: 30; H: 121	no limit	tag
Rhode Island	furbearer	no closed season	no limit	tag
Connecticut	furbearer	T: 130; H: 331	no limit	tag; carcass

RACCOON (*Procyon lotor*)

	STATUS	SEASON LENGTH (days)	BAG LIMIT	REQ'D COLLECT.
Ontario	furbearer	Trapping & Hunting: 77-93	no limit	
Québec	furbearer	T: 15-142; H: 38-128	no limit	
New Brunswick	furbearer	T: 66-78; H: 92-106	no limit	
Nova Scotia	furbearer	T: 121; H: 136 (night)	no limit	
Prince Edward Island	furbearer/ game	T: 92; H: 108	no limit	
Maine	furbearer	T: 62; H: 92	no limit	
Vermont	furbearer	T: 63; H: 84	no limit	
New Hampshire	furbearer	T: 76-78; H: 213	no limit	
New York	furbearer	T: 51-114; H: 114-149	no limit	
Massachusetts	furbearer	T: 121; H: 123	no limit	
Rhode Island	furbearer	T: 92; H: 46-152	no limit	
Connecticut	furbearer	T: 130; H: 94	no limit	

GRAY FOX (*Urocyon cinereoargenteus*)

The gray fox is listed as vulnerable under COSEWIC (The Committee on the Status of Endangered Wildlife) in Canada, which has no legislative authority.

	STATUS	SEASON LENGTH (days)	BAG LIMIT	REQ'D COLLECT.
Ontario	furbearer; vulnerable	Trapping & Hunting: 128	no limit	
Québec	protected	no open season		
Maine	furbearer	T: 77; H: 143	no limit	tag
Vermont	furbearer	T: 63; H: 108	no limit	
New Hampshire	furbearer	T: 76-78; H: 183	no limit	
New York	furbearer	T: 51-114; H: 114-149	no limit	
Massachusetts	furbearer	T: 30; H: 121	no limit	tag
Rhode Island	furbearer/ game	T: 92; H: 30-137	no limit	
Connecticut	furbearer	T: 130; H: 135	T: no limit; H: 30	tag

SHORT-TAILED, LEAST, AND LONG-TAILED WEASELS (*Mustela erminea, M. nivalis, M. frenata*)

	STATUS	SEASON LENGTH (days)	BAG LIMIT	REQ'D COLLECT.
Ontario	furbearer	Trapping & Hunting: 126	no limit	
Québec	furbearer	T: 15-142	no limit	
New Brunswick	furbearer	T: 43	no limit	
Nova Scotia	furbearer	T: 121	no limit	
Prince Edward Island	furbearer	T: 77	no limit	
Newfoundland	furbearer	T: 132 (NF); 148-158 (LAB)	no limit	
Maine	furbearer	T: 62	no limit	
Vermont	not protected	T: no closed season	no limit	
New Hampshire	furbearer	T: no closed season	no limit	
New York	furbearer	T: 51-114; H: 114-149	no limit	
Massachusetts	furbearer	T: 30	no limit	
Rhode Island	furbearer	T: 92	no limit	
Connecticut	furbearer	T: 130	no limit	

STRIPED SKUNK (*Mephitis mephitis*)

	STATUS	SEASON LENGTH (days)	BAG LIMIT	REQ'D COLLECT.
Ontario	furbearer	Trapping & Hunting: no closed season	no limit	
Québec	furbearer	T: 15-142	no limit	
New Brunswick	furbearer	T: 14-22; H: 92-106	no limit	
Nova Scotia	"other harvestable wildlife"	T: 121; H: no closed season	no limit	
Prince Edward Island	furbearer	no closed season	no limit	
Maine	furbearer	T: 62; H; 84	no limit	
Vermont	furbearer	T: 63	no limit	
New Hampshire	furbearer	T & H: no closed season	no limit	
New York	furbearer	T: 51-114; H: 51-114	no limit	
Massachusetts	furbearer	T: 121	no limit	
Rhode Island	furbearer	T: 92	no limit	
Connecticut	furbearer	T: 130	no limit	

Appendix Three: Government Agencies Responsible for Furbearer Management

Ontario:	Ministry of Natural Resources; Fish & Wildlife Branch. URL: http://www.mnr.gov.on.ca/MNR/fwmenu.html
Quebec:	Ministère de l'Environnement et de la Faune; Service de la Faune Terrestre. URL: http://www.mef.gouv.qc.ca/fr/faune/faune.htm
New Brunswick:	Ministry of Natural Resources and Energy; Fish and Wildlife Branch. URL: http://www.gov.nb.ca/dnre/index.htm
Nova Scotia:	Department of Natural Resources; Wildlife Division. URL: http://www.gov.ns.ca/natr/
Prince Edward Island:	Department of Natural Resources; Fish and Wildlife Division. URL: http://www2.gov.pe.ca/te/faw-info/index.asp
Newfoundland:	Department of Forest Resources and Agrifoods; Inland Fish and Wildlife Division. URL: http://www.gov.nf.ca/forest/fra_p&s.htm#for
Maine:	Department of Inland Fisheries and Wildlife. URL: http://janus.state.me.us/ifw/
Vermont:	Agency of Natural Resources; Department of Fish and Wildlife. URL: http://www.anr.state.vt.us/fw/fwhome/index.htm
New Hampshire:	Fish and Game Department. URL: http://www.wildlife.state.nh.us

New York:	Department of Environmental Conservation, Division of Fish, Wildlife and Marine Resources. URL: http://www.dec.state.ny.us
Massachusetts:	Department of Fisheries, Wildlife, and Environmental Law Enforcement; Division of Fisheries and Wildlife. URL: http://www.state.ma.us/dfwele/dfw/
Rhode Island:	Department of Environmental Management; Division of Fish & Wildlife. URL: http://www.state.ri.us/dem
Connecticut:	Department of Environmental Protection; Wildlife Division. URL: http://dep.state.ct.us/

International Association of Fish and Wildlife Agencies:
URL: http://www.sso.org/iafwa/

Literature Cited

Adkins, C.A. & Stott, P. (1998). Home ranges, movements and habitat associations of red foxes *Vulpes vulpes* in suburban Toronto, Canada. *Journal of Zoology (London)* 244:335-346.

Aldous, C.M. (1939). Coyotes in Maine. *Journal of Mammalogy* 20:104-106.

Allen, A.W. (1982). Habitat suitability index models: marten. U.S. Fish & Wildlife Service. FWS/OBS-82/10.11.

Allen, A.W. (1983). Habitat suitability index models: fisher. U.S. Fish & Wildlife Service. FWS/OBS-82/10.45.

Allen, A.W. (1987). The relationship between habitat and furbearers. Pp. 164-179 in *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., eds.). Ontario Trappers Association, North Bay.

Andelt, W.F., Phillips, R.L., Schmidt, R.H., & Gill, R.B. (1999). Trapping furbearers: an overview of the biological and social issues surrounding a public policy controversy. *Wildlife Society Bulletin* 27:53-64.

Anon. (1998). New Brunswick Furbearer Harvest Report 1997-98. Dept. of Natural Resources & Energy, Fish and Wildlife Branch, Fredericton, New Brunswick.

Anthony, J.A., Childs, J.E., Glass, G.E., Korch, G.W., Ross, L., & Grigor, J.K. (1990). Land use associations and changes in population indices of urban raccoons during a rabies epizootic. *Journal of Wildlife Diseases* 26:170-179.

Appel, M.J.G., ed. (1987). *Virus Infections of Carnivores.* Elsevier Science Publication Company, New York.

Appel, M.J.G., & others. (1994). Canine distemper epizootic in lions, tigers, and leopards in North America. *Journal of Veterinary Diagnostic Investigation.* 6:277-288.

Apps, C.D. (1999). Space use, diet, demographics, and topographic associations of lynx in the southern Canadian Rocky Mountains: a study. In *Ecology and conservation of lynx in the United States* (Ruggieri, L.F., Aubry, K.B., Buskirk, S.W., Koehler, G.M., Krebs, C.J., McKelvey, K.S., & Squires, J.R., eds.). General Technical Report RMRS-GTR-30, U.S. Department of Agriculture, Forest Service, Fort Collins, Colorado.

Arthur, S.M., Krohn, W.B., & Gilbert, J.R. (1989). Habitat use and diet of fishers. *Journal of Wildlife Management* 53:680-688.

Aubry, K.B., Koehler, G.M., & Squires, J.R. (in 1999). Ecology of Canada lynx in southern boreal forests. In *Ecology and conservation of lynx in the United States* (Ruggieri, L.F., Aubry, K.B., Buskirk, S.W., Koehler, G.M., Krebs, C.J., McKelvey, K.S., & Squires, J.R., eds.). General Technical Report RMRS-GTR-30, U.S. Department of Agriculture, Forest Service, Fort Collins, Colorado.

Bailey, T.N. (1971). Biology of striped skunks on a southwestern Lake Eerie marsh. *American Midland Naturalist* 85:196-207.

Beier, P. (1993). Determining minimum habitat areas and habitat corri-

dors for cougars. *Conservation Biology* 7:94-108.

Bekoff, M. (1977). *Canis latrans. Mammalian Species* 79:1-9.

Bekoff, M. (1982). Coyote. Pp. 447-459 <u>in</u> *Wild Mammals of North America: Biology, Management, and Economics* (Chapman, J. A. & Feldhamer, G. A., eds.). Johns Hopkins University Press, Baltimore & London.

Bergerud, A.T. (1969). The status of pine marten in Newfoundland. *Canadian Field-Naturalist* 83:128-131.

Bissonette, J.A., Fredrickson, R.J., & Tucker, B.J. (1991). American marten: a case for landscape-level management. Pp. 116-133 <u>in</u> *Wildlife and Habitats in Managed Landscapes* (Rodiek, J. E. & Bolen, E. G., eds.). Island Press, Washington, D.C.

Bounds, D.L. & Shaw, W.W. (1994). Managing coyotes in U.S. national parks: human-coyote interactions. *Natural Areas Journal* 14:280-284.

Bowman, J.C. & Robitaille, J.-F. (1997). Winter habitat use of American martens *Martes americana* within second-growth forest in Ontario, Canada. *Wildlife Biology* 3:97-105.

Brainerd, S.M. (1990). The pine marten and forest fragmentation: a review and general hypotheses. *Transactions of the Congress of the International Union of Game Biologists* 19:421-434.

Brand, C.J. & Keith, L.B. (1979). Lynx demography during a snowshoe hare decline in Alberta. *Journal of Wildlife Management* 43:827-849.

Brander, R.B. & Books, D.J. (1973). Return of the fisher. *Natural History* 82:52-57.

Brocke, R.H. & Gustavson, K.A. (1992). Lynx *(Felis lynx)* in New York State. *Reintroduction News* 4:6-7.

Burgess, S.A. & Bider, J.R. (1980). Effects of stream habitat improvements on invertebrates, trout populations, and mink activity. *Journal of Wildlife Management* 44:871-880.

Buskirk, S.W. (1992). Conserving circumboreal forests for marten and fishers. *Conservation Biology* 6:318-320.

Buskirk, S.W. & Powell, R.A. (1994). Habitat ecology of fishers and American martens. Pp. 283-296 in *Martens, Sables, and Fishers: Biology and Conservation* (Buskirk, S. W., Harestad, A. S., Raphael, M. G., & Powell, R. A., eds.). Cornell University Press, Ithaca, New York.

Buskirk, S.W. & Ruggiero, L.F. (1994). American marten. Pp. 7-37 in *American Marten, Fisher, Lynx, and Wolverine: the Scientific Basis for Conserving Forest Carnivores in the Western United States* (Ruggiero, L. F., Aubry, K. B., Buskirk, S. W., Lyon, L. J., & Zielinski, W. J., eds.). General Technical Report RM-254, U.S. Department of Agriculture, Forest Service, Fort Collins, Colorado.

Buskirk, S.W., Forrest, S.C., Raphael, M.G., & Harlow, H.J. (1989). Winter resting site ecology of marten in the central rocky mountains. *Journal of Wildlife Management* 53:191-196.

Buskirk, S.W., Ruggiero, L.F., Aubry, K.B., Pearson, D.E., Squires, J.R., & McKelvey, K.S. (1999a). Comparative ecology of lynx in North America. <u>In</u> *Ecology and conservation of lynx in the United States*

(Ruggieri, L.F., Aubry, K.B., Buskirk, S.W., Koehler, G.M., Krebs, C.J., McKelvey, K.S., & Squires, J.R., eds.). General Technical Report RMRS-GTR- 30, U.S. Department of Agriculture, Forest Service, Fort Collins, Colorado.

Buskirk, S.W., Ruggiero, L.F., & Krebs, C.J. (1999b). Habitat fragmentation and interspecific competition: implications for lynx conservation. In *Ecology and conservation of lynx in the United States* (Ruggieri, L.F., Aubry, K.B., Buskirk, S.W., Koehler, G.M., Krebs, C.J., McKelvey, K.S., & Squires, J.R., eds.). General Technical Report RMRS-GTR-30, U.S. Department of Agriculture, Forest Service, Fort Collins, Colorado.

Carroll, C., Zielinski, W.J., & Noss, R.F. (1999). Using presence-absence data to build and test spatial habitat models for the fisher in Klamath Region, U.S.A. *Conservation Biology* 13:1344-1359.

Catling, P.C. & Burt, R.J. (1995). Why are red foxes absent from some eucalypt forests in eastern New South Wales? *Wildlife Research* 22:535-546.

CDC (Center for Disease Control) (1996). Rabies postexposure prophylaxis -- Connecticut, 1990-1994. *Morbidity and Mortality Weekly Report* 45:232-234.

Chamberlain, M.J., Leopold, B.D., Burger, Jr., L.W., Plowman, B.W., & Conner, L.M. (1999). Survival and cause-specific mortality of adult bobcats in central Mississippi. *Journal of Wildlife Management* 63:613-620.

Chapin, T.G., Harrison, D.J., & Katnik, D.D. (1998). Influence of landscape pattern on habitat use by American marten in an industrial forest. *Conservation Biology* 12:1327-1337.

Chapin, T.G., Phillips, D.M., Harrison, D.J., & York, E.C. (1997). Seasonal selection of habitats by resting martens in Maine. Pp. 166-181 in *Martes: Taxonomy, Ecology, Techniques, and Management* (Proulx, G., Bryant, H. N., & Woodard, P. M., eds.). Provincial Museum of Alberta, Edmonton.

Chilelli, M.E., Griffith, B., & Harrison, D.J. (1996). Interstate comparisons of river otter harvest data. *Wildlife Society Bulletin* 24:238-246.

Chomel, B.B. (1993). The modern epidemiological aspects of rabies in the world. *Comparative Immunology and Microbiology of Infectious Diseases* 16:11-20.

Churcher, C.S. (1959). The specific status of the New World red fox. *Journal of Mammalogy* 40:513-520.

Clark, W.R. & Fritzell, E.K. (1992). A review of population dynamics of furbearers. Pp. 899- 910 in *Wildlife 2000*: *Populations* (McCullough, D. R. & Barrett, R. H. eds.). Elsevier Science Publishers, Ltd., London.

Conover, M.R. (1998). Perceptions of American agricultural producers about wildlife on their farms and ranches. *Wildlife Society Bulletin* 26:597-604.

Corn, J.G. & Raphael, M.G. (1992). Habitat characteristics at marten subnivean access sites. *Journal of Wildlife Management* 56:442-448.

Coulter, M.W. (1960). The status and distribution of fisher in Maine. *Journal of Mammalogy* 41:1-9.

Crête, M. & Desrosiers, A. (1995). Range expansion of coyotes, *Canis latrans,* threatens a remnant herd of caribou, *Rangier tarandus,* in southeastern Quebec. *Canadian Field-Naturalist* 109:227-235.

Crête, M. & Lemieux, R. (1996). Population dynamics of coyotes colonizing the boreal forest of southeastern Québec. *Journal of Wildlife Research* 1:99-105.

Cronon, W. (1983). *Changes in the Land: Indians, Colonists, and the Ecology of New England.* Hill & Wang, New York.

Cumberland, R.E. (1994). *The History of Marten and Fisher in New Brunswick.* Furbearer Report # 9 Department of Natural Resources and Energy, Fish and Wildlife Branch, Fredericton, New Brunswick.

Daigle, J.J., Muth, R.M., Zwick, R.R., & Glass, R.J. (1998). Sociocultural dimensions of trapping: a factor analytic study of trappers in six northeastern states. *Wildlife Society Bulletin* 26:614-625.

Daoust, P.-Y. & McBurney, S. (1995). Morbillivirus infection (canine distemper) in a bobcat. *Canadian Cooperative Wildlife Health Centre Newsletter* 3(1):4.

de Vos, A. (1951). Recent findings in fisher and marten ecology and management. *Transactions of the 16th North American Wildlife Conference* 16: 498-505.

de Vos, A. & Matel, S.E. (1952). The status of the lynx in Canada, 1929-1952. *Journal of Forestry* 50:742-745.

Dibello, F.J., Arthur, S.M., & Krohn, W.B. (1990). Food habits of sympatric coyotes, *Canis latrans,* red foxes, *Vulpes vulpes,* and bobcats, *Lynx rufus,* in Maine. *Canadian Field- Naturalist* 104:403-408.

Dobbyn, J. (1994). *Atlas of the Mammals of Ontario.* Federation of Ontario Naturalists, Toronto, Ontario.

Dodds, D.G. & Martell, A.M. (1971). Recent status of the fisher, *Martes pennanti pennanti* (Erxleben) in Nova Scotia. *Canadian Field-Naturalist* 85:62-65.

Douglas, C.W. & Strickland, M.A. (1987). Fisher. Pp. 510-529 <u>in</u> *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., eds.). Ontario Trappers Association, North Bay.

Downing, S.C. (1946). The history of the gray fox in Ontario. *Canadian Field-Naturalist* 60:45-46.

Drew, G. (1995). *Winter Habitat Selection by American Marten in Newfoundland. Why Old Growth?* Ph.D. Dissertation, Utah State University, Logan, Utah.

Dubuc, L.J., Krohhn, W.B., & Owen, Jr.R.B. (1990). Predicting occurrence of river otters by habitat on Mount Desert Island, Maine. *Journal of Wildlife Management* 54:594-599.

Dunstone, N. (1993). *The Mink.* T & A D Poyser Ltd., London.

Eagle, T.C. & Whitman, J.S. (1987). Mink. Pp. 614-625 <u>in</u> *Wild Furbearer Management and Conservation in North America*

(Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., eds.). Ontario Trappers Association, North Bay.

Earle, R.D. & Kramm, K.R. (1982). Correlation between fisher and porcupine abundance in Upper Michigan. *American Midland Naturalist* 107:244-249.

Edwards, M.A.St.C. (1998). *Influence of habitat structure and prey abundance on weasels in a forested landscape.* M.Sc. Thesis, University of New Brunswick, Fredericton.

Evans, R.D., Addison, E.M., & Villeneuve, J.Y. (1998). An examination of spatial variation in mercury concentrations in otter *(Lutra canadensis)* in south-central Ontario. *Science of the Total Environment* 213:239-245.

Fagerstone, K.A. (1987). Black footed ferret, long-tailed weasel, short-tailed weasel, and least weasel. Pp. 548-573 <u>in</u> *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., eds.). Ontario Trappers Association, North Bay.

Finley, K. (1996). The red fox invasion and other changes in wildlife populations in west-central Saskatchewan since the 1960s. *Blue Jay* 54:206-210.

Foley, R.E., Jackling, S.J., Sloan, R.J., & Brown, M.K. (1988). Organochlorine and mercury residues in wild mink and otter: comparison with fish. *Environmental Toxicology and Chemistry* 7:363-374.

Foster, D.R. (1993). Land-use history and forest transformations in central New England. Pp. 91-110 <u>in</u> *Humans as Components of Ecosystems: the Ecology of Subtle Human Effects and Populated Areas* (McDonnell, M.J. & Pickett, S.T.A., eds.). Springer-Verlag, New York.

Foster, D.R., Motzkin, G. & Slater, B. (1998). Land-use history as long-term broad-scale disturbance: regional forest dynamics in central New England. *Ecosystems* 1:96-119.

Fox, J.S. (1983). *Relationships of diseases and parasites to the distribution and abundance of bobcats in New York.* Ph.D. Dissertation, State University of New York, Syracuse.

Fritzell, E.K. (1987). Gray fox and island gray fox. Pp. 408-421 <u>in</u> *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., eds.). Ontario Trappers Association, North Bay.

Fritzell, E.K. & Haroldson, K.J. (1982). *Urocyon cinereoargenteus. Mammalian Species* 189:1-8.

Fuller, T.K. & Keith, L.B. (1981). Non-overlapping ranges of coyotes and wolves in northeastern Alberta. *Journal of Mammalogy* 62:403-405.

Fuller, T.K., Berg, W.E., & Kuehn, D.W. (1985). Survival rates and mortality factors of adult bobcats in north-central Minnesota. *Journal of Wildlife Management* 49:292-296.

Fuller, T.K., Berendzen, S.L., Decker, D.A., & Cardoza, J.E. (1995). Survival and cause- specific mortality rates of adult bobcats *(Lynx rufus). American Midland Naturalist* 134:404-408.

Fuller, T.L., Foster, D.R., McLachlan, T.S., & Drake, N. (1998). Impact of human activity on regional forest composition and dynamics in central New England. *Ecosystems* 1:76-95.

Gaona, P. Ferreras, P., & Delibes, M. (1998). Dynamics and viability of a metapopulation of the endangered Iberian lynx *(Lynx pardinus). Ecological Monographs* 68:349-370.

Garrot, R.A., White, P.J. & Vanderbilt-White, C.A. (1993). Overabundance: an issue for conservation biologists? *Conservation Biology* 7: 946-949.

Georges, S. (1976). A range extension of the coyote in Quebec. *Canadian Field-Naturalist* 90:78-79.

Gese, E.M., Schultz R.D., Johnson, M.R., Williams, E.S., Crabtree, R.L., & Raff, R.L. (1997). Serological survey for diseases in free-ranging coyotes *(Canis latrans)* in Yellowstone National Park, Wyoming. *Journal of Wildlife Diseases* 33:47-56.

Gibilisco, C.J. (1994). Distributional dynamics of modern Martes in North America. Pp. 59-71 in *Martens, Sables, and Fishers: Biology and Conservation* (Buskirk, S. W., Harestad, A. S., Raphael, M. G., & Powell, R. A., eds.). Cornell University Press, Ithaca, New York.

Gilmore, R.M. (1946). Mammals in archaeological collections from southwestern Pennsylvania. *Journal of Mammalogy* 27:227-235.

Gipson, P.S. & Brillhart, D.E. (1995). The coyote: an indicator species of environmental change on the Great Plains. Pp. 305-307 in *Our Living Resources: A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems* (LaRoe, E. T., Farris, G. S., Puckett, C. E., Doran, P. D., & Mac, M. J., eds.). U.S. Department of the Interior, National Biological Service, Washington, D.C.

Godin, A.J. (1982). Striped and hooded skunks. Pp. 674-687 in *Wild Mammals of North America: Biology, Management, and Economics* (Chapman, J. A. & Feldhamer, G. A., eds.). Johns Hopkins University Press, Baltimore & London.

Goodrich, J.M. & Buskirk, S.W. (1995). Control of abundant native vertebrates for conservation of endangered species. *Conservation Biology* 9:1357-1364.

Haffner, G.D., Glooschenko, V., Straughan, C.A., Hebert, C.E., & Lazar, R. (1998). Concentrations and distributions of polychlorinated biphenyls, including non- orthocongeners, in mink populations from southern Ontario. *Journal of Great Lakes Research* 24:880-888.

Hagmeier, E.M. (1956). Distribution of marten and fisher in North America. *Canadian Field-Naturalist* 70:149-168.

Hagmeier, E.M. (1961). Variation and relationships in North American marten. *Canadian Field-Naturalist* 75:122-137.

Hall, E.R. (1981). *The Mammals of North America,* Second Edition. John Wiley & Sons, New York.

Halpin, M.A. (1984). Winter habitat use and ecology of red fox in eastern Maine and the history of red fox in Maine. University of Maine, Orono, Maine (abstract).

Halpin, M.A. & Bissonette, J.A. (1988). Influence of snow depth on prey availability and habitat use by red fox. *Canadian Journal of Zoology* 66:587-592.

Harder, T.C. & Osterhaus, A.D.M.E. (1997). Canine distemper virus: a morbillivirus in search of new hosts? *Trends in Microbiology* 5:120-124.

Hargis, C.D. & Bissonette, J.A. (1997). Effects of forest fragmentation on populations of American marten in the intermountain west. Pp. 437-451 in *Martes: Taxonomy, Ecology, Techniques, and Management* (Proulx, G., Bryant, H. N., & Woodard, P. M, eds.). Provincial Museum of Alberta, Edmonton.

Hargis, C.D., Bissonette, J.A., & Turner, D.L. (1999). The influence of forest fragmentation and landscape pattern on American martens. *Journal of Applied Ecology* 36:157-172.

Harris, S. (1977). Distribution, habitat utilization and age structure of a suburban fox *(Vulpes vulpes)* population. *Mammal Review* 7:25-39.

Harris, S. & Rayner, J.M.V. (1986). Urban fox *(Vulpes vulpes)* population estimates and habitat requirements in several British cities. *Journal of Animal Ecology* 55:575-591.

Harrison, D.J. (1992). Dispersal characteristics of juvenile coyotes in Maine. *Journal of Wildlife Management* 56:128-138.

Harrison, D.J., Bissonette, J.A., & Sherburne, J.A. (1989). Spatial relationships between coyotes and red foxes in eastern Maine. *Journal of Wildlife Management* 53:181-185.

Harrison, R.L. (1993). A survey of anthropogenic ecological factors potentially affecting gray foxes *(Urocyon cinereoargenteus)* in a rural residential areas. *Southwestern Naturalist* 38:352-356.

Harrison, R.L. (1997). A comparison of gray fox ecology between residential and undeveloped rural landscapes. *Journal of Wildlife Management* 61:112-122.

Harrison, R.L. (1998). Bobcats in residential areas: distribution and homeowner attitudes. *Southwestern Naturalist* 43:469-475.

Hatler, D.F. (1988). *A Lynx Management Strategy for British Columbia.* Wildlife Bulletin No. B-61, British Columbia Ministry of Environment, Wildlife Branch, Victoria.

Hilton, H. (1992). Coyotes in Maine: a case study. Pp. 183-194 in *Ecology and Management of the Eastern Coyote* (Boer, A. H, ed.). Wildlife Research Unit, University of New Brunswick, Fredericton.

Hockman, J.G. & Chapman, J.A. (1983). Comparative feeding habits of red foxes *(Vulpes vulpes)* and gray foxes *(Urocyon cineroargenteus)* in Maryland. *American Midland Naturalist* 110:276-285.

Hodgman, T.P., Harrison, D.J., Katnik, D.D., & Elowe, K.D. (1994). Survival in an intensively trapped marten population in Maine. *Journal of Wildlife Management* 58:593-600.

Hodgman, T.P., Harrison, D.J., Phillips, D.M., & Elowe, K.D. (1997). Survival of American marten in an untrapped forest preserve in Maine. Pp. 86-99 in *Martes: Taxonomy, Ecology, Techniques, and Management* (Proulx, G., Bryant, H. N., & Woodard, P. M, eds..). Provincial Museum of Alberta, Edmonton.

Hoffman, C.O. & Gottschang, J.L. (1977). Numbers, distribution, and movements of a raccoon population in a suburban residential community. *Journal of Mammalogy* 58:623-636.

Johnson, W.A. & Todd, A.W. (1985). Fishers, *Martes pennanti,* behavior in proximity to human activity. *Canadian Field-Naturalist* 99:367-369.

Johnson, W.E., Fuller, T.K., & Franklin, W.L. (1996). Sympatry in canids: a review and assessment. Pp. 189-218 in *Carnivore Behavior, Ecology, and Evolution,* Volume 2 (Gittleman, J. L., ed.). Cornell University Press, Ithaca, New York.

Johnston, D.H. & Beauregard, M. (1969). Rabies epidemiology in Ontario. *Bulletin of Wildlife Diseases Association* 5:357-370.

Katnik, D.D., Harrison, D.J., & Hodgman, T.P. (1994). Spatial relations in a harvested population of marten in Maine. *Journal of Wildlife Management* 58:600-607.

Kaufmann, J.H. (1982). Raccoon and allies. Pp. 567-585 in *Wild Mammals of North America: Biology, Management, and Economics* (Chapman, J. A. & Feldhamer, G. A., eds.). Johns Hopkins University Press, Baltimore & London.

Kilpatrick, H.J. & Rego, P.W. (1994). Influence of season, sex, and site availability on fisher *(Martes pennanti)* rest site selection in the central hardwood forest. *Canadian Journal of Zoology* 72:1416-1419.

King, C.M. (1983). *Mustela erminea. Mammalian Species* 195:1-8.

Knick, S.T. (1990). Ecology of bobcats relative to exploitation and a prey decline in southeastern Idaho. *Wildlife Monographs* 108:1-42.

Knowles, P.R. (1985). Home range size and habitat selection of bobcats, *Lynx rufus* in north-central Montana. *Canadian Field-Naturalist* 99:6-12.

Koehler, G.M. (1990). Population and habitat characteristics of lynx and snowshoe hares in north central Washington. *Canadian Journal of Zoology* 68:845-851.

Koehler, G.M. & Aubry, K.B. (1994). Lynx. Pp. 74-98 in *American Marten, Fisher, Lynx, and Wolverine: the Scientific Basis for Conserving Forest Carnivores in the Western United States* (Ruggiero, L. F., Aubry, K. B., Buskirk, S. W., Lyon, L. J., & Zielinski, W. J., eds.). General Technical Report RM-254, U.S. Department of Agriculture, Forest Service, Fort Collins, Colorado.

Koehler, G.M. & Brittell, J.D. (1990). Managing spruce-fir habitat for lynx and snowshoe hares. *Journal of Forestry* 88:10-14.

Koehler, G.M. & Hornocker, M.G. (1991). Seasonal resource use among mountain lions, bobcats and coyotes. *Journal of Mammalogy* 72:391-396.

Krebs, J.W., Strine, T.W., Smith, J.S., Noah, D.L., Rupprecht, C.R., & Childs, J.E. (1996). Rabies surveillance in the United States during 1995. *Journal of the American Veterinary Medical Association* 204:2031-2034.

Krebs, J.W., Smith, J.S., Ruprecht, C.E., & Childs, J.E. (1998). Rabies surveillance in the United States during 1997. *Journal of the American Veterinary Medical Association* 213:1713-1728.

Krohn, W.B., Arthur, S.M., & Paragi, T.F. (1994). Mortality and vulnerability of a heavily trapped fisher population. Pp. 137-145 in *Martens, Sables, and Fishers: Biology and Conservation* (Buskirk, S. W., Harestad, A. S., Raphael, M. G., & Powell, R. A., eds.). Cornell University Press, Ithaca, New York.

Krohn, W.B., Elowe, K.D., & Boone, R.B. (1995). Relations among fishers, snow, and martens: development and evaluation of two hypotheses. *Forestry Chronicle* 71:97-105.

Krohn, W.B., Zielinski, W.J., & Boone, R.B. (1997). Relations among fishers, snow, and martens in California: results from small-scale spatial comparisons. Pp. 211-232 in *Martes: Taxonomy, Ecology, Techniques, and Management* (Proulx, G., Bryant, H. N., & Woodard, P. M., eds.). Provincial Museum of Alberta, Edmonton.

Kruuk, H. (1995). *Wild Otters: Predation and Populations.* Oxford University Press, Oxford, United Kingdom.

Larivière, S. & Crête, M. (1992). *Causes Et Conséquences De La Colonisation Du Québec Par Le Coyote (Canis latrans).* Ministère du Loisir, Chasse et Pêche SP 1935-07-92, Québec.

Larivière, S. & Pasitschniak-Arts, M. (1996). *Vulpes vulpes. Mammalian Species* 537:1-11.

Larivière, S. & Walton, L.R. (1997). *Lynx rufus. Mammalian Species* 563:1-8.

Larivière, S. & Walton, L.R. (1998). *Lontra canadensis. Mammalian Species* 587:1-8.

Lehman, N., Eisenhawer, A., Hansen, K., Mech, L.D., Peterson, R.O., Gogan, P.J.P., & Wayne, R.K. (1991). Introgression of coyote mitochondrial DNA into sympatric North American gray wolf populations. *Evolution* 45:104-119.

Litvaitis, J.A. (1992). Niche relations between coyotes and sympatric Carnivora. Pp. 73-85 in *Ecology and Management of the Eastern Coyote* (Boer, A. H., ed.). Wildlife Research Unit, University of New Brunswick, Fredericton.

Litvaitis, J.A. & Harrison, D.J. (1989). Bobcat-coyote niche relationships during a period of coyote population increase. *Canadian Journal of Zoology* 67:1180-1188.

Litvaitis, J.A., Kingman, Jr.D., Lanier, J., & Orff, E. (1991). Status of lynx in New Hampshire. *Transactions of the Northeast Section of the Wildlife Society* 48:70-75.

Litvaitis, J.A., Major, J.T., & Sherburne, J.A. (1987). Influence of season and human-induced mortality on spatial organization of bobcats *(Felis rufus)* in Maine. *Journal of Mammalogy* 68:100-106.

Litvaitis, J.A., Sherburne, J.A., & Bissonette, J.A. (1986a). Bobcat habitat use and home range size in relation to prey density. *Journal of Wildlife Management* 50:110-117.

Litvaitis, J.A., Clark, A.G., & Hunt, J.H. (1986b). Prey selection and fat deposits of bobcats *(Felis rufus)* during autumn and winter in Maine. *Journal of Mammalogy* 67:389-392.

Lotze, J.-H. & Anderson, S. (1979). *Procyon lotor. Mammalian Species* 119:1-8.

Lovallo, M.J. & Anderson, E.M. (1996). Bobcat movements and home

ranges relative to roads in Wisconsin. *Wildlife Society Bulletin* 24:71-76.

Lyon, L.J., Aubry, K.B., Zielinski, W.J., Buskirk, S.W., & Ruggiero, L.F. (1994). The scientific basis for conservation forest carnivores: considerations for management. Pp. 128-137 in *American Marten, Fisher, Lynx, and Wolverine: the Scientific Basis for Conserving Forest Carnivores in the Western United States* (Ruggiero, L. F., Aubry, K. B., Buskirk, S. W., Lyon, L. J., & Zielinski, W. J., eds.). General Technical Report RM-254, U.S. Department of Agriculture, Forest Service, Fort Collins, Colorado.

Major, J.T. & Sherburne, J.A. (1987). Interspecific relationships of coyotes, bobcats, and red foxes in western Maine. *Journal of Wildlife Management* 51:606-616.

Martin, S. K. (1994). Feeding ecology of American martens and fishers. Pp. 297-315 in *Martens, Sables, and Fishers: Biology and Conservation* (Buskirk, S. W., Harestad, A. S., Raphael, M. G., & Powell, R. A., eds.). Cornell University Press, Ithaca, New York.

McBurney, S., Banks, D., & Anderson, D. (1997). Morbillivirus infection in four lynx. *Canadian Cooperative Wildlife Health Centre Newsletter* 5(1):5.

McCord, C.M. (1974). Selection of winter habitat by bobcats *(Lynx rufus)* on the Quabbin Reservation, Massachusetts. *Journal of Mammalogy* 55:428-437.

McCord, C.M. & Cardoza, J.E. (1982). Bobcat and lynx. Pp. 728-766 in *Wild Mammals of North America: Biology, Management, and Economics* (Chapman, J. A. & Feldhamer, G. A., eds.). Johns Hopkins University Press, Baltimore & London.

McKelvey, K.S., Aubry, K.B., & Ortega, Y.K. (1999). History and distribution of lynx in the contiguous United States. In *Ecology and conservation of lynx in the United States* (Ruggieri, L.F., Aubry, K.B., Buskirk, S.W., Koehler, G.M., Krebs, C.J., McKelvey, K.S., & Squires, J.R., eds.). General Technical Report RMRS-GTR-30, U.S. Department of Agriculture, Forest Service, Fort Collins, Colorado.

Medina, G. (1997). A comparison of the diet and distribution of southern river otter *(Lutra provocax)* and mink *(Mustela vison)* in southern Chile. *Journal of Zoology* (London) 242:291-297.

Melquist, W.E., Whitman, J.S., & Hornocker, M.G. (1981). Resource partitioning and coexistence of sympatric mink and river otter populations. Pp. 187-220 in W*orldwide Furbearer Conference Proceedings* (Chapman, J. A. & Pursley, D., eds.). Worldwide Furbearer Conference, Inc., Frostburg, Maryland.

Melquist, W.E. & Dronkert, A.E. (1987). River otter. Pp. 626-641 in *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., eds.). Ontario Trappers Association, North Bay.

Messier, F. & Barrette, C. (1982). The social system of the coyote *(Canis latrans)* in a forested habitat. *Canadian Journal of Zoology* 60:1743-1753.

Messier, F., Barrette, C., & Huot, J. (1986). Coyote predation on a white-tailed deer population in southern Quebec. *Canadian*

Journal of Zoology 64:1134-1136.

Mills, J.K. (1984). Food habits of bobcats, *Lynx rufus*, in Nova Scotia. *Canadian Field-Naturalist* 98:50-51.

Mitchell, M.A., Hungerford, L.L., Nixon, C., Esker, T., Sullivan, J., Koerkenmmeier, R., & Dubey, J.P. (1999). Serologic survey for selected infectious disease agents in raccoons from Illinois. *Journal of Wildlife Diseases.* 35:347-355.

Moore, G.C. & Millar, J.S. (1984). A comparative study of colonizing and long established eastern coyote populations. *Journal of Wildlife Management* 48:691-699.

Morse, S. (1996). Keeping a place for Vermont's bobcats. *Vermont Woodlands.* Spring:12-16.

Morse, S. (1997). The missing lynx. *Vermont Woodlands.* Winter:24-27.

Murray, D.L., Kapke, C.A., Evermann, J.F., & Fuller, T.K. (1999). Infectious disease and the conservation of free-ranging large carnivores. *Animal Conservation* 2:241-254.

Newman, D.G. & Griffin, C.R. (1994). Wetland use by river otters in Massachusetts. *Journal of Wildlife Management* 58:18-23.

Northcott, T.H., Payne, N.F., & Mercer, E. (1974). Dispersal of mink in insular Newfoundland. *Journal of Mammalogy* 55:243-248.

Nowell, K. & Jackson, P. (1996). *Wild Cats: Status Survey and Action Plan.* IUCN/SSC Cat Specialist Group, IUCN, Gland, Switzerland.

Novak, M., Baker, J.A., Obbard, M.E., & Malloch, B. (1987). The future of trapping. Pp. 89-100 in *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., ed.). Ontario Trappers Association, North Bay.

OMNR (1999). MNR broadens protection measures for third case of rabies. Press Release, September 28, Ontario Ministry of Natural Resources, Peterborough.

Obbard, M.E., Jones, J.G., Newman, R., Booth, A., Satterthwaite, A.J., & Linscombe, G. (1987). Furbearer harvests in North America. Pp. 1007-1038 in *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., eds.). Ontario Trappers Association, North Bay.

Oehler, J.D. & Litvaitis, J.A. (1996). The role of spatial scale in understanding responses of medium sized carnivores to forest fragmentation. *Canadian Journal of Zoology* 74:2070-2079.

Organ, J.F., Fuller, T.K., Jonker, S.A., & Weber, W. (1997). *Mesocarnivores in the Northeast: Establishing Research Priorities.* Departmental Report Series No. 2, Dept. Forestry & Wildlife Management, University of Massachusetts, Amherst, Massachusetts.

Osowski, S.L., Brewer, L.W., Baker, O.E., & Cobb, G.P. (1995). The decline of mink in Georgia, North Carolina, and South Carolina: the role of contaminants. *Archives of Environmental Contamination and Toxicology* 29:418-423.

Palomares, F. & Caro, T.M. (1999). Interspecific killing among mammalian carnivores. *American Naturalist* 153:492-508.

Paragi, T.F., Arthur, S.M., & Krohn, W.B. (1996). Importance of tree

cavities as natal dens for fishers. *Northern Journal of Applied Forestry* 13:79-83.

Parker, G.R. (1981). Winter habitat use and hunting activities of lynx *(Lynx canadensis)* on Cape Breton Island. Pp. 221-248 in *Worldwide Furbearer Conference Proceedings* (Chapman, J. A. & Pursley, D., eds.). Worldwide Furbearer Conference, Inc., Frostburg, Maryland.

Parker, G. (1995). *Eastern Coyote: the Story of Its Success.* Nimbus Publishing, Halifax, Nova Scotia.

Parker, G.R. & Maxwell, J.W. (1989). Seasonal movements and winter ecology of the coyote, *Canis latrans,* in northern New Brunswick. *Canadian Field-Naturalist* 103:1-11.

Parker, G.R. & Smith, G.E.J. (1983). Sex- and age-specific reproductive and physical parameters of the bobcat *(Lynx rufus)* on Cape Breton Island, Nova Scotia. *Canadian Journal of Zoology* 61:1771-1782.

Parker, G.R., Maxwell, J.W., Morton, L.D., & Smith, G.E.J. (1983). The ecology of the lynx *(Lynx canadensis)* on Cape Breton Island. *Canadian Journal of Zoology* 61:770-786.

Patterson, B.R., Benjamin, L.K., & Messier, F. (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.

Pedlar, J.H., Fahrig, L., & Merriam, H.G. (1997). Raccoon habitat use at 2 spatial scales. *Journal of Wildlife Management* 61:102-112.

Pence, D.B. & Windberg, L.A. (1994). Impact of a sarcoptic mange epizootic on a coyote population. *Journal of Wildlife Management* 58:624-633.

Person, D.K. & Hirth, D.H. (1991). Home range and habitat use of coyotes in a farm region of Vermont. *Journal of Wildlife Management* 55:433-441.

Peterson, R.L. & Downing, S.C. (1952). Notes on the bobcat *(Lynx rufus)* of eastern North America with the description of a new race. *Contributions of the Royal Ontario Museum* 33:1-23.

Peterson, R.L., Standfield, R.O., McEwen, E.ZH., & Brooks, A.C. (1953). Early records of the red and gray fox in Ontario. *Journal of Mammalogy* 34:126-127.

Pietz, P.J. & Tester, J.R. (1983). Habitat selection by snowshoe hares in north central Minnesota. *Journal of Wildlife Management* 47:686-696.

Pilgrim, W. (1980). Reports of significant range extensions. Fisher, *Martes pennanti* (Carnivora:Mustelidae) in Labrador. *Canadian Field-Naturalist* 94:468.

Polechla, P. (1990). Action plan for North American otters. Pp. 74-79 in *Otters: an Action Plan for Their Conservation* (Foster-Turley, P., Macdonald, S., & Mason, C. eds.). IUCN/SSC Otter Specialist Group, IUCN, Gland, Switzerland.

Potvin, F. & Breton, L. (1997). Short-term effects of clear-cutting on martens and their prey in the boreal forest of western Quebec. Pp. 452-474 in *Martes: Taxonomy, Ecology, Techniques, and*

Management (Proulx, G., Bryant, H. N., & Woodard, P. M., eds.). Provincial Museum of Alberta, Edmonton.

Poulle, M.-L., Crete, M., & Huot, J. (1995). Seasonal variation in body mass and composition of eastern coyotes. *Canadian Journal of Zoology* 73:1625-1633.

Powell, R.A. (1979). Fishers, population models and trapping. *Wildlife Society Bulletin* 7:149-154.

Powell, R.A. (1993). *The Fisher: Life History, Ecology and Behavior*, Second Edition. University of Minnesota Press, Minneapolis.

Powell, R.A. & Zielinski, W.J. (1983). Competition and coexistence in mustelid communities. *Acta Zoologica Fennica* 174:223-227.

Powell, R.A. & Zielinski, W.J. (1994). Fisher. Pp. 38-73 in *The Scientific Basis for Conserving Forest Carnivores: American Marten, Fisher, Lynx and Wolverine in the Western United States* (Ruggiero, L. F., Aubry, K. B., Buskirk, S. W., Lyon, L. J., & Zielinsky, W. J., eds.). General Technical Report RM-254, U.S. Department of Agriculture, Forest Service, Ft. Collins, Colorado.

Powell, S.M., York, E.C., Scanlon, J.J., & Fuller, T.K. (1997a). Fisher maternal den sites in central New England. Pp. 265-278 in *Martes: Taxonomy, Ecology, Techniques, and Management* (Proulx, G., Bryant, H. N., & Woodard, P. M., eds.). Provincial Museum of Alberta, Edmonton.

Powell, S.M., York, E.C., & Fuller, T.K. (1997b). Seasonal food habits of fishers in central New England. Pp. 279-305 in *Martes: Taxonomy, Ecology, Techniques, and Management* (Proulx, G., Bryant, H. N., & Woodard, P. M., eds.). Provincial Museum of Alberta, Edmonton.

Prescott-Allen, R. & Prescott-Allen, C. (1996). Assessing the impacts of uses of mammals: the good, the bad and the neutral. Pp. 45-61 in *The Exploitation of Mammal Populations* (Taylor, V. J. & Dunstone, N., eds.). Chapman & Hall, London.

Quinn, N.W.S. & Parker, G. (1987). Lynx. Pp. 682-694 in *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., eds.). Ontario Trappers Association, North Bay.

Quinn, T. (1997). Coyote *(Canis latrans)* habitat selection in urban areas of western Washington via analysis of routine movements. *Northwest Science* 71:289-297.

Racey, G.D. & Euler, D.L. (1983). Changes in mink habitat and food selection as influenced by cottage development in central Ontario. *Journal of Applied Ecology* 20:387-402.

Raine, R.M. (1983). Winter habitat use and responses to snow cover of fisher *(Martes pennanti)* and marten *(Martes americana)* in south-eastern Manitoba. *Canadian Journal of Zoology* 61:25-34.

Ralls, K. & Harvey, P.H. (1985). Geographic variation in size and sexual dimorphism of North American weasels. *Biological Journal of the Linnean Society* 25:119-167.

Raphael, M. G. (1994). Techniques for monitoring populations of fishers and American martens. Pp. 224-240 in *Martens, Sables, and Fishers: Biology and Conservation* (Buskirk, S. W., Harestad, A. S.,

Raphael, M. G., & Powell, R. A. eds.). Cornell University Press, Ithaca, New York.

Reading, R.P. & Clark, T.W. (1996). Carnivore reintroductions: an inter-disciplinary examination. Pp. 296-336 in *Carnivore Behavior, Ecology, and Evolution,* Volume 2 (Gittleman, J. L., ed.). Cornell University Press, Ithaca, New York.

Reid, D.G., Code, T.E., Reid, A.C.H., & Herrero, S.M. (1994). Spacing, movements, and habitat selection of the river otter in boreal Alberta. *Canadian Journal of Zoolog*y 72:1314-1324.

Richens, V.B. & Hugie, R.D. (1974). Distribution, taxonomic status and characteristics of coyotes in Maine. *Journal of Wildlife Management* 38:447-454.

Riley, S.P.D., Hadidian, J., & Manski, D.A. (1998). Population density, survival, and rabies in raccoons in an urban national park. *Canadian Journal of Zoology* 76:1153-1164.

Robinson, W.B. & Grand, E.F. (1958). Comparative movements of bob-cats and coyotes as disclosed by tagging. *Journal of Wildlife Management* 22:117-122.

Robitaille, J.-F. & Raymond, M. (1995). Spacing patterns of ermine, *Mustela erminea*, in a Quebec agrosystem. *Canadian Journal of Zoology* 73:1827-1834.

Rolley, R.E. (1987). Bobcat. Pp. 670-681 in *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., eds.). Ontario Trappers Association, North Bay.

Rolley, R.E. & Warde, W.D. (1985). Bobcat habitat use in southeastern Oklahoma. *Journal of Wildlife Management* 49:913-920.

Rosatte, R.C. (1987). Striped, spotted, hooded, and hog-nosed skunk. Pp. 598-613 in *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., eds.). Ontario Trappers Association, North Bay.

Rosatte, R.C., Power, M.J., & MacInnes, C.D. (1992). Density, disper-sion, movements and habitat of skunks *(Mephitis mephitis)* and raccoons *(Procyon lotor)* in metropolitan Toronto. Pp. 932-944 in *Wildlife 2000: Populations* (McCullough, D. R. & Barrett, R. H. eds.). Elsevier Science Publishers, Ltd., London, UK.

Rosatte, R.C., MacInnes, C.D., Williams, R.T., & Williams, O. (1997). A proactive prevention strategy for raccoon rabies in Ontario, Canada. *Wildlife Society Bulletin* 25:110-116.

Rosenzweig, M.L. (1966). Community structure in sympatric Carnivora. *Journal of Mammalogy* 47:602-612.

Ruggiero, L.F., Pearson, D.E., & Henry, S.E. (1998). Characteristics of American marten den sites in Wyoming. *Journal of Wildlife Management* 62:663-673.

Ruggiero, L.F., Zielinski, W.J., Aubry, K.B., Buskirk, S.W., & Lyon, L.J. (1994a). A conservation assessment framework for forest carni-vores. Pp. 1-6 in *The Scientific Basis for Conserving Forest Carnivores: American Marten, Fisher, Lynx, and Wolverine in the Western United States* (Ruggiero, L.F., Aubry, K.B., Buskirk, S.W., Lyon, L.J., & Zielinski, W.J., eds.). U.S. Dept. of Agriculture,

Forest Service, Rocky Mountain Forest and Range Experiment Station, Gen. Tech. Rep. RM-254, Ft. Collins, Colorado.

Ruggiero, L.F., Buskirk, S.W., Aubry, K.B., Lyon, L.J., & Zielinski, W.J. (1994b). Information needs and a research strategy for conserving forest carnivores. Pp. 138-152 in *The Scientific Basis for Conserving Forest Carnivores: American Marten, Fisher, Lynx, and Wolverine in the Western United States* (Ruggiero, L. F., Aubry, K. B., Buskirk, S. W., Lyon, L. J., & Zielinski, W. J., eds.). U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Gen. Tech. Rep. RM-254, Ft. Collins, Colorado.

Ruggiero, L.F., Aubry, K.B., Buskirk, S.W., Koehler, G.M., Krebs, C.J., McKelvey, K.S., & Squires, J.R., eds. (1999a). *Ecology and conservation of lynx in the United States.* General Technical Report RMRS-GTR-30, U.S. Department of Agriculture, Forest Service, Fort Collins, Colorado.

Ruggiero, L.F., Aubry, K.B., Buskirk, S.W., Koehler, G.M., Krebs, C.J., McKelvey, K.S., & Squires, J.R. (in 1999b). The scientific basis for lynx conservation: qualified insights. In *Ecology and conservation of lynx in the United States* (Ruggieri, L.F., Aubry, K.B., Buskirk, S.W., Koehler, G.M., Krebs, C.J., McKelvey, K.S., & Squires, J.R., eds.). General Technical Report RMRS-GTR-30, U.S. Department of Agriculture, Forest Service, Fort Collins, Colorado.

Rupprecht, C.E., Smith, J.S., Fekadu, M., & Childs, J.E. (1995). The ascension of wildlife rabies: a cause for public health concern or intervention? *Emerging Infectious Diseases* 1:107-114.

Samson, C. & Crête, M. (1997). Summer food habits and population density of coyotes, *Canis latrans,* in boreal forests of southeastern Quebec. *Canadian Field-Naturalist* 111:227-233.

Samson, C. & Raymond, M. (1998). Movement and habitat preference of radio-tracked stoats, *Mustela erminea,* during summer in southern Quebec. *Mammalia* 62:165-174.

Samuel, D.E. & Nelson, B.B. (1982). Foxes. Pp. 475-490 in *Wild Mammals of North America: Biology, Management, and Economics* (Chapman, J. A. & Feldhamer, G. A., eds.). Johns Hopkins University Press, Baltimore & London.

Sanderson, G.C. (1987). Raccoon. Pp. 486-499 in *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., eds.). Ontario Trappers Association, North Bay.

Schaller, G.B. (1996). Introduction: carnivores and conservation biology. Pp. 1-10 in *Carnivore Behavior, Ecology, and Evolution* (Gittleman, J. L., ed.). Cornell University Press, Ithaca, New York.

Schiller, A. & Horn, S.P. (1997). Wildlife conservation in urban greenways of the mid- southeastern United States. *Urban Ecosystems* 1:103-116.

Schmitz, O.J. & Kolenosky, G.B. (1985). Wolves and coyotes in Ontario: morphological relationships and origins. *Canadian Journal of Zoology* 63:1130-1137.

Schubert, C.A., Rosatte, R.C., MacInnes, C.D., & Nudds, T.D. (1998).

Rabies control: an adaptive management approach. *Journal of Wildlife Management* 62:622-629.

Sheffield, S.R. & King, C.M. (1994). *Mustela nivalis. Mammalian Species* 454:1-10.

Sheffield, S.R. & Thomas, H.H. (1997). *Mustela frenata. Mammalian Species* 570:1-9.

Sherburne, S.S. & Bissonette, J.A. (1994). Marten subnivean access point use: response to subnivean prey levels. *Journal of Wildlife Management* 58:400-405.

Simkin, D.W. (1966). Extralimital occurrences of raccoons in Ontario. *Canadian Field-Naturalist* 80:144-146.

Simms, D.A. (1979). North American weasels: resource utilization and distribution. *Canadian Journal of Zoology* 57:504-520.

Slough, B.G. (1994). Translocations of American martens: an evaluation of factors in success. Pp. 165-178 in *Martens, Sables, and Fishers: Biology and Conservation* (Buskirk, S. W., Harestad, A. S., Raphael, M. G., & Powell, R. A., eds.). Cornell University Press, Ithaca, New York.

Slough, B.G. & Mowat, G. (1996). Lynx population dynamics in an untrapped refugium. *Journal of Wildlife Management* 60:946-961.

Snyder, J.E. & Bissonette, J.A. (1987). Marten use of clear-cuttings and residual forest stands in western Newfoundland. *Canadian Journal of Zoology* 65:169-174.

Soulé, M.E., Bolger, E.T., Alberts, A.C., Wright, J., Sorice, M., & Hill, S. (1988). Reconstructed dynamics of rapid extinctions of chaparral-requiring birds in urban habitat islands. *Conservation Biology* 2:75-92.

Soutiere, E.C. (1979). Effects of timber harvesting on marten in Maine. *Journal of Wildlife Management* 43:850-860.

Spencer, W.D. (1987). Seasonal rest-site preferences of pine martens in the northern Sierra Nevada. *Journal of Wildlife Management* 51:616-621.

Squires, J.R. & laurion, T. (1999). Lynx home range and movements in Montana and Wyoming: preliminary results. In *Ecology and conservation of lynx in the United States* (Ruggieri, L.F., Aubry, K.B., Buskirk, S.W., Koehler, G.M., Krebs, C.J., McKelvey, K.S., & Squires, J.R., eds.). General Technical Report RMRS-GTR-30, U.S. Department of Agriculture, Forest Service, Fort Collins, Colorado.

Steventon, J.D. & Major, J.T. (1982). Marten use of habitat in a commercially clear-cut forest. *Journal of Wildlife Management* 46:175-182.

Storm, G.L. (1972). Daytime retreats and movements of skunks on farmlands in Illinois. *Journal of Wildlife Management* 36:31-45.

Strickland, M.A. (1994). Harvest management of fishers and American martens. Pp. 149-164 in *Martens, Sables, and Fishers: Biology and Conservation* (Buskirk, S. W., Harestad, A. S., Raphael, M. G., & Powell, R. A., eds.). Cornell University Press, Ithaca, New York.

Strickland, M.A. & Douglas, C.W. (1987). Marten. Pp. 530-547 in *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., eds.).

Ontario Trappers Association, North Bay.

Strickland, M.A., Douglas, C.W., Novak, M., & Hunziger, N.P. (1982). Fisher. Pp. 586-598 in *Wild Mammals of North America: Biology, Management, and Economics* (Chapman, J. A. & Feldhamer, G. A., eds.). Johns Hopkins University Press, Baltimore & London.

Sturtevant, B.R. & Bissonette, J.A. (1997). Stand structure and microtine abundance in Newfoundland: implications for marten. Pp. 182-198 in *Martes: Taxonomy, Ecology, Techniques, and Management* (Proulx, G., Bryant, H. N., & Woodard, P. M., eds.). Provincial Museum of Alberta, Edmonton.

Sturtevant, B.R., Bissonette, J.A., & Long, J.N. (1996). Temporal and spatial dynamics of boreal forest structure in western Newfoundland: silvicultural implications for marten habitat management. *Forest Ecology and Management* 87:13-25.

Svendsen, G.E. (1982). Weasels. Pp. 613-628 in *Wild Mammals of North America: Biology, Management, and Economic*s (Chapman, J. A. & Feldhamer, G. A., eds.). Johns Hopkins University Press, Baltimore & London.

Tapper, S. & Reynolds, J. (1996). The wild fur trade: historical and ecological perspectives. Pp. 28-44 in *The Exploitation of Mammal Populations* (Taylor, V. J. & Dunstone, N., eds.). Chapman & Hall, London.

Theberge, J.B. & Wedeles, C.H.R. (1989). Prey selection and habitat partitioning in sympatric coyote and red fox populations, southwest Yukon. *Canadian Journal of Zoology* 67:1285-1290.

Thiel, R.P. (1987). The status of Canada lynx in Wisconsin, 1865-1980. *Wisconsin Academy of Sciences, Arts and Letters* 75:90-96.

Thompson, I.D. (1988). Habitat needs of furbearers in relation to logging in boreal Ontario. *The Forestry Chronicle* 64:251-261.

Thompson, I.D. (1991). Could marten become the spotted owl of eastern Canada? *Forestry Chronicle* 67:136-140.

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

Thompson, I.D. & Curran, W.J. (1995). Habitat suitability for marten of second-growth balsam fir forests in Newfoundland. *Canadian Journal of Zoology* 73:2059-2064.

Thompson, I. D. & Harestad, A. S. (1994). Effects of logging on American martens, and models for habitat management. Pp. 355-367 in *Martens, Sables, and Fishers: Biology and Conservation* (Buskirik, S. W., Harestad, S., Raphael, M. G., & Powell, R. A. eds.). Cornell University Press, Ithaca, New York.

Thompson, I.D., Davidson, I.J., O'Donnell, S., & Brazeau, F. (1989). Use of track transects to measure the relative occurrence of some boreal mammals in uncut forest and regeneration stands. *Canadian Journal of Zoology* 67:1816-1823.

Thurber, J.M. & Peterson, R.O. (1991). Changes in body size association with range expansion in the coyote *(Canis latrans). Journal of Mammalogy* 72:750-755.

Todd, A.W. (1985a). The Canada lynx: ecology and management. *Canadian Trapper* 13:15-20.

Todd, A.W. (1985b). Demographic and dietary comparisons of forest and farmland coyote, *Canis latrans,* populations in Alberta. *Canadian Field-Naturalist* 99:163-171.

Toweill, D.E. & Tabor, J.E. (1982). River otter. Pp. 688-703 <u>in</u> *Wild Mammals of North America: Biology, Management, and Economics* (Chapman, J. A. & Feldhamer, G. A., eds.). Johns Hopkins University Press, Baltimore & London.

Tremblay, J.-P., Crête, M., & Huot, J. (1998). Summer foraging behaviour of eastern coyotes in rural versus forest landscape: a possible mechanism of source-sink dynamics. *Ecoscience* 5:172-182.

Tullar, B.F., Jr. & Berchielli, L.T., Jr. (1982). Comparison of red foxes and gray foxes in central New York with respect to certain features of behavior, movement and mortality. *New York Fish and Game Journal* 29:127-133.

Tumlison, R. (1987). *Felis lynx. Mammalian Species* 269:1-8.

U.S.F.W.S. (1999). Discovery of Canada lynx kittens proves that the wild cats reproduce in Maine. U.S. Fish & Wildlife Service Press Release, June 28.

U.S.F.W.S. (2000) Endangered and threatened wildlife and plants; Determination of threatened status for the contiguous U.S. Distinct Population Segment of the Canada lynx and related rule. *p* 65: 16052-16086.

Voigt, D.R. (1987). Red fox. Pp. 378-393 <u>in</u> *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., eds.). Ontario Trappers Association, North Bay.

Voigt, D.R. & Berg, W.E. (1987). Coyote. Pp. 344-357 <u>in</u> *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., eds.). Ontario Trappers Association, North Bay.

Wade-Smith, J. & Verts, B.J. (1982). *Mephitis mephitis. Mammalian Species* 173:1-7.

Wagner, K.K. & Conover, M.R. (1999). Effect of preventative coyote hunting on sheep losses to coyote predation. *Journal of Wildlife Management* 63:606-612.

Ward, R.M.P. & Krebs, C.J. (1985). Behavioural responses of lynx to declining snowshoe hare abundance. *Canadian Journal of Zoology* 63:2817-2824.

Waters, J.H. (1964). Red fox and gray fox from New England archaeological sites. *Journal of Mammalogy* 45:307-308.

Watt, W.R., Baker, J.A., Hogg, D.M., McNicol, J.G., & Naylor, B.J. (1996). *Forest Management Guidelines for the Provision of Marten Habitat.* Ontario Ministry of Natural Resources, Sault Ste. Marie, Ontario.

Wayne, R.K., Lehman, N., & Fuller, T.K. (1995). Conservation genetics of the gray wolf. Pp. 399-407 <u>in</u> *Ecology and Conservation of Wolves in a Changing World* (Carbyn, L. N., Fritts, S. H., & Seip, D. R., eds.). Canadian Circumpolar Institute, Occasional Publication No. 35, Alberta, Edmonton.

Weaver, J.L. (1999). *Lynx survey in the Adirondack Park.* Unpublished

Report. Wildlife Conservation Society, Bronx, New York.

Whitaker, J.O. & Hamilton, W.J. (1998). *Mammals of the Eastern United States.* Cornell University Press, Ithaca, New York.

Williams, O. & McKegg, J. (1987). Nuisance furbearer management programs for urban areas. Pp. 156-166 in *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., & Malloch, B., eds.). Ontario Trappers Association, North Bay.

Wilson, D.E. & Reeder, D.M., eds. (1993). *Mammalian Species of the World.* Smithsonian Institution Press, Washington, D.C.

Wilson, M.L., Bretsky, P.M., Cooper, G.H., Egbertson, S.H.Van Kruiningen, H.J., & Cartter, M.L. (1997). Emergence of raccoon rabies in Connecticut, 1991-1994: spatial and temporal characteristics of animal, infection and human contact. *American Journal of Tropical Medicine and Hygiene* 57:457-463.

Witmer, G.W. & DeCalesta, D.S. (1986). Resource use by unexploited sympatric bobcats and coyotes in Oregon. *Canadian Journal of Zoology* 64:2333-2338.

Wren, C.D. (1987). Toxic substances in furbearers. Pp. 930-940 in *Wild Furbearer Management and Conservation in North America* (Novak, M., Baker, J. A., Obbard, M. E., and Malloch, B., eds.). Ontario Trappers Association, North Bay.

Wren, C.D. (1991). Cause-effect linkages between chemicals and populations of mink *(Mustela vison)* and otter *(Lutra canadensis)* in the Great Lakes Basin. *Journal of Toxicology and Environmental Health* 33:549-585.

Woolf, A. & Hubert, Jr. G.F. (1998). Status and management of bobcats in the United States over three decades: 1970s-1990s. *Wildlife Society Bulletin* 26:287-293.

Zielinksi, W.J. & Kucera, T.E. (1995). American Marten, Fisher, Lynx, and Wolverine: Survey Methods for Their Detection. General Technical Report PSW-GTR-157. Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture, Albany, California.

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