Chapter 6

The Scientific Basis for Conserving Forest Carnivores: Considerations for Management

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INTRODUCTION

The reviews presented in previous chapters reveal substantial gaps in our knowledge about marten, fisher, lynx, and wolverine. These gaps severely constrain our ability to design reliable conservation strategies. This problem will be explored in depth in Chapter 7. In this chapter, our objective is to discuss management considerations resulting from what we currently know (and don't know) about these four forest carnivores.

The authors of each species chapter have summarized the current state of knowledge about the biology and ecology of each species. Management considerations might lead to modifications or restrictions in the way these species or other resources are managed, given that the conservation of one or more forest carnivores is a management objective. As appropriate, we will compare and contrast management considerations for all four species and identify management considerations that apply to the population status or habitat quality for two or more species at the same time.

These discussions should not be interpreted as management recommendations. Rather, we intend to broadly address management activities likely to influence the persistence of forest carnivore populations. The information we have drawn upon is limited and often derived from studies conducted over brief time periods with insufficient replication and small sample sizes (see Chapter 1 for further discussion of these limitations).

All of the forest carnivores are trapped for their fur within some portion of their geographic range. Because of their status as furbearers, these species require population management involving the regulation of trapping seasons and harvest levels. We will not ignore the need for management of this significant source of mortality, but our primary focus in this chapter will be on the management of habitat. Clearly, habitat management cannot be expected to maintain or increase population levels where trapping pressure is not carefully regulated. It is our hope that an increased awareness among all managers about the conservation status and habitat needs of these carnivores will foster improved cooperation. Federal agencies are responsible for managing much of the habitat occupied by these furbearers. State and provincial agencies are responsible for regulating trapping. These responsibilities cannot be isolated by these agencies if successful conservation strategies are to be developed.

Spatial Relationships

The forest carnivores under consideration here range over extremely large geographic areas. They occupy home ranges that vary in size from under 16 km^2 for marten to over 900 km^2 for wolverine. Management and conservation of these species can only be understood over a range of spatial scales. In this chapter, we consider four spatial scales nested in a hierarchy of increasing size. These scales are ecologically linked and generically equivalent to scales used in Ecomap (Bailey et al. 1993) and ecoprovinces (Demarchi, Appendix A). Our primary interest is in habitat needs of each carnivore species considered at the stand, landscape, ecoprovince, and region levels defined as follows:

Stand is a homogeneous habitat patch such as a cutting unit or a relatively small-scale burn or blowdown in any stage of regrowth. Resting and denning requirements can usually be described as structural characteristics of individual stands or even unique structures within stands. Habitats selected for foraging may include certain stand structures but require several adjacent stands. Stands are always smaller than the average home range size for each species.

Landscape, in our hierarchy of geographic scales, is defined as an aggregation of stands. Landscapes are not precisely defined in terms of the geographic area they may encompass but, in order to be meaningful for animals, they must be defined in relation to the ecology and mobility of each species under consideration. Thus, landscapes may vary in the following discussion as a function of the species under discussion, but they will always be large enough to encompass one or more average home ranges (see Chapter 7 for further discussion).

Ecoprovince recognizes an even larger spatial scale encompassing an aggregation of landscapes as defined above. Ecoprovinces are areas where the climate and landforms provide a common influence on vegetation, on the behavior and dynamics of animal populations, and on some land-use activities. Management considerations at this scale involve population viability over areas so large they encompass more than one agency's jurisdiction. Management strategies may require at least multi-jurisdictional cooperation.

Region. At the greatest spatial scale considered here, ecoprovinces are aggregated into geographic regions, which include such areas as the Rocky Mountains or the Sierra Nevada. Species persistence must be considered at this scale. Management strategies may require international cooperation.

Categories of Management Considerations

We will consider three broad categories of management considerations for forest carnivores: habitat, populations, and species. The first section discusses considerations for management through the management of habitats beginning at the stand level and progressing through landscapes and ecoprovinces. The latter sections represent management considerations of a very broad nature, relating to either populations and metapopulations within an ecoprovince portion of the species' range or for the entire species in a geographic region or even the North American continent.

HABITAT MANAGEMENT CONSIDERATIONS

In the following synthesis of habitat management considerations, we first examine habitat components within stands to emphasize the hierarchical nature of these spatial scales and the fact that adequate habitat for any of these forest carnivores can only be maintained by providing suitable habitat components at all spatial scales.

Stands and Components Within Stands

Stand-level habitat for marten is described as late-seral mesic conifer stands with complex structure near the forest floor. Habitats occupied most commonly by fishers have an overhead canopy and complex physical structure, including dead and down material as well as low branches or shrubby vegetation near the forest floor. Lynx appear to be somewhat more tolerant of openings, but they also prefer forest habitats with overhead cover and vegetation near the ground. For these three species, physical structure of the forest appears to be more important than species composition of the vegetation, and while suitable habitat is not necessarily old growth, there is little question that some preferred components are representative of old-growth structures. While only suggestive, we interpret this as an indication that late-successional forest stands or their structural features are essential stand-level components of habitats for marten, fisher, lynx, and probably wolverine.

Wolverines, however, seem less sensitive to overhead canopy cover or vegetation near the ground, possibly because they are often detected in alpine or subalpine situations. When detected at lower elevations, they show a preference for mature to intermediate aged forests. The essential component of wolverine habitat may be isolation and the total absence of disturbance by humans. Where isolation happens to coincide with forests, as it often does in designated wilderness areas of the United States, wolverines will be found in forest habitats.

Specific within-stand structures for denning, resting, and foraging are somewhat different for each of these carnivores, but all include late-seral stand structures. Fisher and marten are more selective of habitat for resting than of habitat for foraging and appear more selective for natal den sites than for resting sites. Within stands, these considerations are thought to apply equally to all four species. Thus, the denning site is considered to be the most unique and possibly limiting of within-stand habitat structures.

Denning Sites

With the exception of the marten, the number of dens reported in the literature is too small to provide meaningful structural descriptions of den characteristics for any of these small forest carnivores. Only two natal dens of fisher, and four of lynx, have been described in the western mountains, and wolverine den information, mostly from Europe, is biased toward tundra. This lack of specific description is compounded by the fact that natal den sites (i.e., parturition sites) of all four species are usually abandoned as soon as the young can be moved to a maternal or rearing den. Such movement of young may take place several times prior to their independence.

Stands in which dens of marten, fisher, lynx, and (to a lesser extent) wolverine have been found are characterized by downfall, snags, large trees, hollow trees, and stumps. Similar characteristics describe wolverine denning areas in forest habitats. These are very specific habitat settings that provide structural diversity and cover for the young. We do not know which components may limit reproductive success; although the marten literature indicates a preference for denning in logs, large trees, and snags. For marten, fisher, and lynx, at least until definitive habitat descriptions become available, managers can probably provide denning habitat by preserving and recruiting large snags, decadent broken-top trees, and downfall as potential components of structural diversity necessary for den sites in closed-canopy forest.

Unlike the three smaller carnivores, wolverines may not require snags and large trees for natal den sites. Wolverine natal dens have been found in snow tunnels, hollow trees, or even caves in the ground. In forested habitats, however, the structural diversity provided by large snags, fallen logs, and stumps will likely provide natal den sites for wolverines. Isolation from human disturbance also appears to be an important den-site requirement for wolverines. Once the young can be moved, maternal dens of marten, fisher, and lynx, and rendezvous sites of wolverine, are also located in habitats characterized by structural diversity.

Resting Sites

Marten and fisher rest primarily in large downed logs and snags, but live trees are also used. Downfall is essential for marten in winter since virtually all rest sites are subnivean and downed material that protrudes through the snow provides access. Fisher resting sites are selected for warmth in winter and to prevent overheating in summer. Fisher and wolverine dig snow tunnels; brushpiles, logs, stumps, and hollow trees have also been used. Marten also rest in rock piles, squirrel middens, large-diameter trees, and witches' brooms. Resting sites for all four species again demonstrate the need for structural diversity within stands.

Foraging Areas

Foraging areas are habitats where important prey species are available to each carnivore. The similarities and some major differences among the foraging habitats selected by forest carnivores are a reflection of the foraging behavior of the predator and the habitat requirements of the primary prey. Marten capture a wide variety of small mammals, but the primary food source appears to be ground-dwelling voles found in forests with complex structure near the ground. Downed dead material is particularly important in providing access to subnivean space during the winter. The lynx, on the other hand, is considered dependent on snowshoe hares over much of its range; and the early successional forests that provide cover and browse for hares are the habitats favored by lynx for hunting. Hares are also important components in the diets of fisher and wolverine, but the fisher appears far less tolerant of open, early successional habitats favored by the snowshoe hare. Fishers are a specialized predator of porcupines,

a prey species for which they have almost no competition, but fishers will eat any small- to medium-sized mammal or bird they can capture. They also readily eat carrion but are not nearly as dependent on this resource as the wolverine, for which the carrion of large ungulates is a primary food source.

In describing habitat structures required for hunting, a common behavioral thread for all of these carnivores is some degree of reluctance to forage in the open. Openings, either natural or created by human actions, are not well tolerated and a common behavior pattern for fisher and lynx in openings is a quick crossing unless the vegetation supports high numbers of a desired prey species. Wolverine have also exhibited this behavior in forested habitats, and marten tend to avoid use of openings. Fishers will hunt in open-forest situations, but they minimize travel in the open. In diverse landscapes, lynx will use habitats with overhead cover to move between foraging and denning areas. Clearcuts, specifically, are avoided until canopy closure is reached or understory herbaceous growth has become particularly attractive to snowshoe hares. Even under these conditions, lynx require cover for security and for stalking prey.

Wolverines will almost certainly hunt in the same kinds of habitats used by other forest carnivores, but there is no evidence hunting by wolverines is limited by habitat structure. Primarily a scavenger, rather than a hunter, the wolverine forages where carrion can be found.

Stand Management to Favor Prey

More than the other forest carnivores, reproductive success of lynx has been shown to be highly correlated with the density of snowshoe hare populations. In northern boreal forests, increases in hare numbers are followed by increases in lynx, and conversely, a decline in hare abundance will affect reproductive success and survivorship of lynx. This correlation has been presented as evidence that snowshoe hare populations can be used as a surrogate of habitat capability for lynx. It can further be implied that an increase in snowshoe hares is likely to benefit other carnivores as well. Similarly, habitat capability for large ungulates has been postulated as a surrogate of habitat quality for wolverines, and distribution of microtines as a measure of habitat quality for marten. These kinds of interpretations can be dangerously incorrect.

Implications derived from correlations between predator and prey populations seem worthy of consideration, but they are very simplistic, and it must be recognized that many other factors contribute to habitat quality. For example, lynx-snowshoe hare relationships observed in the north are not applicable to western mountain habitats within the United States. As discussed by Koehler and Aubry (Chapter 4), the more southerly hare populations are not cyclic but instead should be considered similar to hare population lows in the northern boreal forests. Even if hare habitat were improved, it might prove detrimental to the predator. It is possible, for example, that conversion of late-seral components required for resting and denning by lynx into early seral hare habitat could prevent lynx from occupying these habitats. The interspersion of foraging habitats with habitats that address other life needs appears to be a requirement for all forest carnivores.

The assumptions regarding forest carnivores other than lynx require even more care and consideration because the potential for habitat loss seems almost as great as the potential for habitat improvement. Even if we assume that success in managing habitat to produce high hare densities might benefit fishers, we must also consider that any benefit will be limited by the degree to which patches of high hare density are accessible to fishers from adjacent resting and denning cover. In addition, the manager must consider whether habitat manipulation might result in increased snow depths. Reductions in tree canopy to increase herbaceous vegetation for hares could favor lynx, but where snow depths are also increased, fishers could well be excluded. Disturbance, including logging, can increase the abundance of small mammals, especially cricetine mice. However, marten prefer the voles and pine squirrels associated with mesic, late-seral habitats. Similarly, management to create early seral communities for ungulates might not provide adequate security for wolverines or sufficient den sites for marten or fisher.

Stand Management to Benefit Forest Carnivores

The potential for short-term direct action to manipulate hunting habitats to favor predation by marten, fisher, and lynx seems somewhat limited. Removal of canopy often affects these species adversely, depending on the scale of canopy removal. One possible exception was suggested in a dissertation where second-growth marten habitat appeared to be suitable because it included large-diameter coarse debris. Until this research has been confirmed in other

areas, we consider it doubtful that individual structural components, like residual material from late-successional stands, can meet marten habitat requirements. In the case of the wolverine, the creation or improvement of hunting habitat has not been attempted, and success seems highly unlikely considering the aversion shown by wolverines toward human activities.

Landscape Considerations

The preceding discussion has indicated stand-level requirements for denning, resting, and foraging by all four forest carnivores. Acceptable within-stand structural components for denning and resting appear to be somewhat comparable, but these features alone may not meet foraging requirements. Thus, while stand-level structures provide essential habitat components, stands must have suitable spatial distribution over a landscape if habitat needs are to be satisfied. Lynx usually select den sites connected by travel cover, or close to early successional forests where hares are abundant. This adjacency requirement seems more apparent for the lynx because there are obvious disparities between early-seral foraging habitat and late-seral denning requirements. However, the arrangements and linkages between stands are even more important for species like the marten and fisher that exhibit great reluctance to cross openings or venture very far from overhead cover. For these species, fragmentation of continuous forest cover may have negative consequences.

Home Range Habitats

Earlier in this discussion, we defined a landscape as an aggregate of stands large enough to encompass at least one average home range. We emphasize here that such a landscape, in a context applicable to forest carnivores, can be extremely large. Landscapes must provide all the stand attributes of habitat and, in addition, travel cover to connect the components. The home range is probably the minimum spatial unit capable of supporting a single individual. Home range size is not well described for any of the forest carnivores except marten, but all home range estimates are considered large in relation to the size of the animal. One important management consideration appears to be the relationship between home range size and tolerance for openings and fragmentation. The marten, with an average home range under 16 km^2, requires a very high level of habitat connectivity within that range. Fisher home ranges are at least twice as large, and while the fisher exhibits some tolerance for openings, forests fragmented with open areas are used infrequently by fishers. A lynx home range can be 6-8 times larger than the marten, but lynx habitat can be quite diverse and fragmented. The very large home ranges of wolverines (up to 900 kmz for males) seem to be less affected by fragmentation than by major dissection and human intrusion.

If a home range is viewed as the habitat unit required by a single animal, an initial management concern might be the size and spatial array of stands required for a suitable home range. Among the four forest carnivores, lynx appear to be the most tolerant of disturbed landscapes. Indeed, a basic requirement of lynx habitat may be an early successional component significantly greater than acceptable for the other species. Early successional forests resulting from fire or timber harvest provide conditions that favor snowshoe hares and which, in turn, benefit lynx. At the same time, lynx require cover for security, for stalking prey, and for denning. At the southern limits of their distributional range, the fragmented and discontinuous nature of available habitats are sometimes cited as the reason both hare and lynx populations are more stable (although less dense) than populations at more northern latitudes. Productive lynx habitat appears to consist of a mosaic of old and young stands, both dense and fairly open, with diversity in communities expressed on both spatial and temporal scales.

Landscapes with abundant early successional stands and small patches of mature forest are not likely to provide acceptable habitat for the other three forest carnivores. Fishers appear to require a high proportion of continuous and mostly mature forest. For marten, overhead cover is essential, and the habitat should probably be continuous. A diversity of communities and younger stands might conceivably be acceptable for wolverine, but the almost certain presence of human disturbances makes acceptance highly unlikely.

POPULATION MANAGEMENT CONSIDERATIONS

Landscapes and Metapopulations

Obviously, if a home range area is needed for a single animal, then multiple home ranges are required to support a population. For a species like the marten, several adjacent home ranges simply become a larger landscape; but for a wide-ranging species like the wolverine the population unit might be an

ecoprovince. In terms of habitat suitability, the size of the area is not as important as the concept that a population can only exist where landscapes adequate for individual home ranges are numerous and interlinked.

Habitat descriptions for landscapes adequate to support populations are virtually nonexistent. Buskirk and Ruggiero (Chapter 2) indicate that behavioral and population responses of marten to such landscape attributes as stand size, shape, interior, insularity, corridors, and connectivity are largely unknown. The same statement certainly applies to fisher and probably to lynx and wolverine, but at very different landscape scales.

The importance of scale cannot be ignored because our understanding of landscape configurations declines drastically for the species with larger home ranges. Habitat that provides for the life requisites of the marten and fisher and their prey may only provide for lynx and wolverine at the stand level, and while we have some appreciation of the landscape diversity required for lynx, our knowledge of wolverine habitat needs at the landscape scale is virtually nonexistent. Banci (Chapter 5) points out that if we do not know what wolverine need in habitats where their numbers are stable, it will be extremely difficult to provide for the needs of populations whose status is tenuous.

The implications of maintaining population-level habitats extends to maintenance of habitat linkages/ corridors between possible population centers. Populations of marten, fisher, and lynx can be characterized by fluctuations in excess of an order of magnitude, influenced by spatial and temporal variation in prey abundance. It may even be perfectly normal for these populations to exhibit episodes of local extinction and recolonization. Thus, the maintenance of linkages within a larger metapopulation becomes significant as insurance against random local extinctions. The wolverine, on the other hand, occupies such an extremely large landscape that recolonization of vacant habitats may not be of as much concern as for other species.

Fragmentation and Linkages

Throughout the species chapters we see reiterated statements indicating that forest fragmentation is the most important isolating mechanism working today. Only the wolverine appears to be immune, and that may simply be a perception related to tremendous home ranges occupied. In any case, all the chapter authors agree that maintaining habitat linkages between populations may be important to ensure the long-term viability of isolated populations. Activities that fragment, dissect, and isolate habitats have undesirable effects on all forest carnivores in two different ways. First, disturbance in forest habitats attracts habitat generalist predators like the great-horned owl, coyote, and bobcat. All can be successful competitors, and the smaller forest carnivores can also become prey. Equally important, maintenance of habitat quality requires maintenance of linkages, connectedness, and interspersion over geographic areas large enough to benefit individuals and join individuals into populations. Newly isolated populations will be generated unless efforts are made to eliminate and reverse forest fragmentation.

Fragmentation in forest habitats is most frequently caused by human activities including road construction and logging. The amount of habitat disruption that can be tolerated is not known, but the negative impact appears stronger for marten and fisher than wolverine and lynx. Powell and Zielinski (Chapter 3) indicate that riparian areas appear to be important elements in marten and fisher home ranges and may be dispersal avenues. This is probably true for the other species as well, suggesting that protection of riparian corridors is a valid management concern. It is, however, unknown whether fishers will use corridors of forest through otherwise open habitats. Despite some exceptions in rural environments, none of these carnivores are likely to persist where people or human influences dominate the landscape.

Detecting Carnivore Populations

The forest carnivores considered here occur at low densities, are primarily nocturnal, leave little sign, and shun human activity. Unless they are commercially harvested by trapping, their presence can easily go undetected. Given these problems, an overriding initial management concern is to determine whether any of these species are even present. Where commercial harvest is permitted, information on the location of trapped individuals can answer this question. Where commercial harvest does not occur, a variety of techniques are available for attempting to detect the presence of these species. New approaches, such as the use of baited cameras, sooted track boxes, and traditional methods such as snow-tracking are useful, but protocols for the consistent application of these techniques are currently lacking.

Caution should be exercised in the interpretation of survey results. Failure to detect a species has multiple implications. Until standardized methods for detection are developed, the confidence in declaring "absence" will be low. And, even if failure of detection conveys a high probability of absence, the unstable nature of some forest carnivore populations suggests that areas of suitable habitat could be occupied in the future. Finally, because management activities occur in small areas, relative to the home ranges of some of the species considered here, communication with the managers of adjacent lands is essential. The existence of a population nearby indicates the potential for recolonization of currently unoccupied, but suitable, habitat.

Population Abundance and Trends

Although methods currently under development should allow managers to determine whether forest carnivores are present or probably absent in a particular location, methods of indexing or estimating population size are costly and have not been rigorously tested. Indeed, the detection of population changes at any measurement scale, ranging from presence /absence to ratio estimation, has not been shown to be feasible. The use of any of the detection methods, over time, may eventually become a successful means of indexing population change. However, before managers can evaluate the effect of trapping or habitat manipulation on populations of these species, a successful population monitoring protocol must be developed.

Population Dynamics and Habitat Management

The abundance and fitness of any forest carnivore population will be affected by habitat quality and by community interactions that may be mediated by habitat. As already noted, some populations may never be stable in an area, due to factors independent of their specific habitat needs (e.g., variation in abundance of prey, competitive interactions with other carnivores, time lags in recolonization). While this may suggest that habitat management is superfluous, that is not the case. Although suitable habitat may be a necessary but not sufficient requirement for healthy populations, habitat manipulation is the primary method by which forest managers influence forest carnivore populations.

The Effects of Trapping

Commercial trapping can affect populations and habitat management in several ways. Our attempts to manage furbearer populations hinge on the assumption that there is a positive relationship between populations and habitat quality. Thus, human-induced mortality that exceeds natural levels, or that affects age or sex structure, can affect population persistence by influencing population response to habitat variation or by obscuring the relationship between habitat and populations. Efforts to enhance populations via habitat management will be less effective if trapping reduces the population or changes the relationship between population density and habitat quality. Trapping can also induce behavioral changes in individuals that can affect habitat choices. And, if trapping eliminates adults, which are usually considered to make habitat choices with the benefit of the greatest experience and with the fewest social constraints, it cannot be assumed that trapped populations will exhibit the same use of habitats and home ranges as unexploited populations.

A frequent objective of a trapping program is to reduce the variance in population size, yet this natural variance is what provides the impetus for dispersal and recolonization. Even moderate trapping levels can affect the dynamics of populations. For example, if dispersing individuals are essential to maintain metapopulation integrity and to recolonize locally extirpated areas, trapping may eliminate potential emigrants and slow recolonization. This can be especially critical where refugia have been established as a part of a management program for wolverine, lynx, or fisher. A failure of coordination between political jurisdictions can also result in overexploitation that decreases the number of emigrants.

Trapping programs can be compatible with the conservation of forest carnivores, especially in the northern extent of their range, if they are managed to be sustainable. Sustainability can be enhanced if adults are minimized in the harvest, seasons are timed so that females with dependent young are not killed, and trapping mortality occurs during a season when most natural mortality occurs. Banci (Chapter 5) has suggested that jurisdictions that do not have the resources to monitor populations at the level of intensity required, or do not have large refugia, cannot justify a harvest. Although the land manager has little authority to regulate commercial harvest, the issues summarized here highlight the interaction between fur trapping and habitat management.

Finally, it should be emphasized that where sustainable harvests can be defended, managers can reap important information benefits from responsibly managed commercial harvest programs. Caution must be applied when using fur harvest data to interpret population parameters, but careful documentation of trapping effort and trapping locations can provide a source of information on population distribution and possibly indices of abundance.

SPECIES MANAGEMENT CONSIDERATIONS

All four forest carnivores considered here have suffered range reductions in historic times. Trapping and habitat destruction have been individually and jointly implicated. However, development of a conservation strategy for these species will require a far more complex analysis of habitat loss and trapping influences than has so far been developed. With the possible exception of the marten, these forest carnivores occupy extremely large geographic areas to maintain populations of low absolute density. This situation has implications that must be recognized across adjacent ecoprovinces and geographic regions for both habitat management and population management.

Managers must begin to think about ecosystems in which forest carnivores coexist and interact with a common prey base (see Chapter 7 for further discussion). Ecosystem management will be essential for forest carnivore conservation, but the concept must be built upon knowledge of each species' ecology and upon broad landscape-level planning. Relevant scales for each species need to be integrated. The challenge is to determine how the scales overlap for all four species and how this information can be used to better manage the ecosystems in question.

Regional Management

Our knowledge of species ecology suggests that forest carnivore management should be developed at the regional level, rather than provincial or state administrative levels. Indeed, Banci (Chapter 5) suggests that evaluation of the population status for wolverine requires a multiregional scale. If habitats and populations are to be reasonably connected, it is necessary to plan landscapes at the species level, which means a great deal of cooperation among adjacent management jurisdictions. The U.S.-Canadian border, for example, includes 15-20 administrative and jurisdictional authorities that may influence management of transborder wolverine, lynx, and fisher populations. Clearly, if a conservation program is to benefit forest carnivores, it must transcend political boundaries. And, in the same way, if refugia and protected habitats are to function as population sources, coordinated management with common goals and objectives is a necessity.

Reintroduction

Where populations have been extirpated, reintroductions into areas of suitable habitat may be appropriate. Before such management strategies are implemented, however, it is essential that the causes of extirpation be evaluated to determine if reintroduction is likely to succeed. Local extirpations are usually due to the combined effects of overtrapping, loss or degradation of suitable habitat due to timber harvesting, and disturbance from human encroachment into wilderness areas. Unless these conditions have been remedied, there is no logical justification for considering reintroduction. Suitable habitat must be restored before reintroduction can succeed.

Ecotypic factors must also be considered. Genetic and behavioral differences may exist among metapopulations, and animals from one geographic region may not be suited for survival in a different region. If remnants of the population are still present in the target area, the introduction of genetic stock from other areas may swamp existing populations with maladaptive genes. This phenomenon, known as "outbreeding depression," has physiological effects and population implications similar to those described for inbreeding depression. Further, even if genetic differences among populations of forest carnivores are not significant, the acquired behaviors of individuals may influence the success of reintroductions. Individuals that have existed in one forest type with a particular structure and array of potential prey may have difficulty surviving in a substantially different forested environment, especially in the critical period immediately following release. Thus, animals selected for reintroduction should be from the same metapopulation or ecotypes as once occurred in the target area, or at least from forested habitats similar in structure and species composition.

Existing Populations

The primary objective in the conservation of forest carnivores is to prevent the decline and extirpation of extant populations. All four species have their

distributional centers in the boreal forests of northern North America. Populations in montane regions in the western United States, including the Rocky Mountains, Cascade Range, Olympic Mountains, Coast Ranges, and Sierra Nevada, represent southern extensions of these ranges. Those populations at the southernmost limits may occupy marginally suitable habitats. These are also the areas in which human encroachment into otherwise suitable habitat tends to be the most severe. Boreal habitats in montane regions are peninsular in nature, and populations in these regions are much more likely to become fragmented and isolated from each other than are populations in the north. Range reductions for all four species have occurred in the western mountains, and for marten and fisher in the northeast; all have been either at the southern margin of species' distributions or in peninsular extensions of continuous distributions in northern boreal regions. Management concerns will be greatest in these areas.

Fishers are not good colonizers of isolated patches of suitable habitat and marten have relatively small home ranges and low dispersal capabilities. Thus, small, isolated populations of these species may be particularly susceptible to extirpation resulting from stochastic demographic or environmental events, because recolonization of these areas may not be possible. Local extirpations from portions of a species' range results in the further isolation of remaining populations.

In California, two populations of fishers may be effectively isolated; one in the southern Sierra Nevada and another in the northwestern part of the state. Because fishers appear to be very rare in Oregon and Washington, especially in the Olympic Mountains, fisher populations in California may be completely isolated from those in Canada and the eastern United States.

Marten also occur in isolated populations in the southern Rockies and Pacific States. Marten are found in very low numbers in the Olympic Mountains in Washington and are apparently isolated from populations in the Cascade Range; marten are rare or extinct in the Coast Ranges in southern Washington and in Oregon. The status of the Humboldt marten (*Martes americana humboldtensis*) in northwestern California is also uncertain.

Wolverine have declined dramatically in the western United States in the last 100 years but are apparently beginning to recover in certain areas. The wolverine is a boreal forest and tundra species that occupies habitats near treeline in the western mountains. Thus, even in areas where wolverine occur in the western mountains, gene flow may be restricted by the disjunct distribution of preferred habitat. Thus, for wolverine, as for fisher and marten, the western montane regions are of particular conservation concern.

Lynx have been extirpated from Oregon and occupy only the northernmost portions of the Cascade Range in Washington; they also occupy a relatively narrow distribution in the Rockies. Montane habitats appear to provide less productive but more stable habitat for lynx, probably because snowshoe hare populations do not cycle to superabundance in montane forests as they do in the northern boreal forests.

The implications of these population declines for conservation are not clear because they have not been studied through time. At the same time, we do know that every one of these forest carnivores is considered sensitive, threatened, or extinct in one or more of the western states, on one or more of the national forests, or in some part of its range by the federal government. Nothing in our review of existing knowledge suggests that conservation status designations by these agencies are incorrect. The state of existing knowledge makes it clear that concern about the conservation of forest carnivores is justified.

CONCLUSIONS: THE MAJOR CONSIDERATIONS FOR MANAGEMENT

In this section, we bring together and emphasize those overarching considerations that appear to be important in any situation where one or more of these forest carnivores might occur.

- We found nothing in our assessment to suggest that existing designations of forest carnivores as species of concern are incorrect. We conclude that conservation strategies for forest carnivores in western mountains are needed to ensure their persistence.
- Complex, large physical structures commonly associated with mesic late-successional forest stands will be important in forest carnivore conservation. There is little information to suggest that forest carnivore habitat requirements can be met by these components outside of their natural ecological context.
- Research in forest carnivore ecology produces information that can be used to design silvicultural prescriptions. Monitoring species' response following management actions cannot adequately meet this information need.

- Habitat modification that favors generalist predators is potentially detrimental to forest carnivores.
- Further reduction or fragmentation of late-successional forests, especially through clearcutting of contiguous forest, may be detrimental to the conservation of forest carnivores. This may be most true for marten and fisher, and specific effects will depend on the context within which management actions occur.
- Forest carnivore conservation will require an ecosystem management approach at the landscape scale. Management at the scale of the stand will not suffice for conservation.
- Interregional, interagency, and international cooperation will be essential to conserving forest carnivores.
- Maintaining ecotypic variation in forest carnivore populations, including those on the periphery of a species' range, may be crucial to forest carnivore conservation.
- Special conservation challenges exist where isolated populations are identified.
- Major information gaps exist for these forest carnivores. A sustained commitment to research is needed for developing scientifically sound conservation strategies to ensure the persistence of forest carnivore populations.
- Although there is insufficient information available to develop highly reliable conservation strategies, this should not deter management from developing conservative interim guidelines that will maintain future options.

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