SUSTAINING FELID POPULATIONS IN HUMAN-DOMINATED LANDSCAPES

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Abstract: Worldwide, populations of wild cats have been reduced and fragmented by exploitation and contemporary land uses. Although many of these populations are now protected from legal exploitation, they continue to decline as human-related factors (e.g., habitat degradation, poaching, and vehicle collisions) and stochastic events limit survival and reproduction. Local efforts to protect endangered populations of felids will likely fail because of the area requirements of these wide-ranging carnivores. Previous research has demonstrated the importance of maintaining demographic connections (via habitat corridors) to ensure long-term viability of these populations. However, such management efforts may require decades to implement and small populations may perish before such efforts are completed. Therefore, we suggest that conservationists consider a multi-scaled approach in space (local, landscape, regional, and international) and time (immediate action, interim steps, and long-term goals) to expanding and maintaining these populations. The advantages and limitations of such an approach are examined with information on bobcats (L. rufus) in the northeastern United States and Iberian lynx (Lynx pardina) in southern Spain. Persistence of disjunct populations of felids in human-dominated habitats will likely be dependent on management efforts at several spatial and temporal scales.

Key words: corridors, felids, fragmentation, prey enhancement, scale, wild cats.

INTRODUCTION

Populations of wild cats have been substantially reduced throughout the world, and many are currently threatened with extinction (reviews in Miller and Everett 1986). Habitat degradation and excessive hunting or trapping have been identified as the principal factors responsible for reductions in the abundance of these carnivores (e.g., Reza Khan 1986). Although many populations of felids are now protected from legal exploitation, they continue to decline as other human-related factors (deforestation, poaching, and vehicle collisions) and stochastic events (e.g., disease outbreaks) limit survival and reproduction (Seidensticker 1986, Ferreras et al. 1992). In response to this situation, conservationists are hurriedly developing management programs to reverse these trends (e.g., Belden 1986, ICONA 1992, Beier 1993). Local efforts to protect wild cats and their habitat are not sufficient because of the large areas requirements of these carnivores. Previous research has demonstrated the importance of maintaining demographic connections among disjunct populations of felids to ensure long-term viability (Litvaitis et al. 1991, Beier 1993). However, such efforts may require decades to implement because of the obstacles created by current land-ownership patterns (Maehr 1990) or political borders (Litvaitis et al. 1991). Small populations of felids may perish before such efforts are completed (e.g., Berger 1990). Therefore, it is likely that future management efforts will need to be multi-scaled in space (local, landscape, regional, and international) and time (immediate action, interim steps, and long-term goals) if they are to succeed. In this paper, we examine the benefits and limitations associated with such an approach to sustain felids in human-dominated habitats.

DECLINE OF FELIDS IN HUMAN-ALTERED HABITATS

Although the forces that threaten populations or felids are varied, these forces may be placed into several categories that operate at different, but not mutually exclusive scales (Fig. 1). Initial declines of many species of wild cats were from overexploitation. High market values of pelts or body parts of some cats (e.g., ocelots (Leopardus pardalis), and jaguars (Panthera onca), and tigers (P. tigris)), or a perceived competition for game and livestock between humans and felids (e.g., cougars (F. concolor)) led to extensive harvests. The effects of overexploitation on local densities were rapid, often occurring in less than a decade. Over a longer period (several decades), deforestation, intensive agriculture and urban expansion produced incremental reductions in habitat quality and quantity. This
process created a matrix of low quality (sink) habitat that surrounds patches of suitable habitat that support small groups of breeding individuals (source habitats). The regional expansion of such habitat degradation and fragmentation (over many decades) has isolated remnant subpopulations from one another. As demographic exchanges between these subpopulations continue to decline, surviving individuals may become inbred and vulnerable to stochastic extinctions (Fig. 1). Below, we will summarize two examples of how these forces have affected felid populations.

**Bobcats in the northeastern United States**

At the time of settlement of North America by Europeans, bobcats ranged throughout the contiguous United States (Young 1958). In New England (the northeast portion of the United States), bobcats were common except in the extreme northern areas where Canada lynx (*Lynx canadensis*) occurred (Silver 1974). During the early 1800s, widespread agriculture and bounty programs reduced the abundance of bobcats (Litvaitis 1994). However, by the middle of the last century, large-scale abandonment of agricultural lands and their subsequent reforestation resulted in expansion of bobcat populations throughout this region (Litvaitis 1993). As the second-growth forests matured and became less productive for small and medium-size prey, bobcat populations began to decline rapidly. By this time, urbanization also had eliminated large tracts of habitat and began to fragment populations of many terrestrial vertebrates, including bobcats. Yet bobcats remained common in suitable habitat. However, several unexpected events changed this situation.

During the 1970s, the commercial value of bobcat pelts increased dramatically, and trappers and hunters concentrated their efforts on this species (Litvaitis 1987). A series of severe winters in the 1980s reduced annual recruitment and survival (Litvaitis et al. 1987), and shifted trapping/hunting mortality of bobcats from partially additive to largely additive (K. Morse, Maine Dept. Inland Fisheries and Wildlife, personal communication). Also during this period, colonizing populations of coyotes (*Canis latrans*) increased rapidly and may have reduced the availability of prey consumed by bobcats. Competition with coyotes may have had a substantial influence on bobcats in northern New England where predator-prey systems are relatively simple (Litvaitis and Harrison 1989).

Populations of bobcats in New England have apparently stabilized at reduced levels of abundance as harvest pressures have diminished. Currently, populations in this region are disjunct and are threatened by increased fragmentation of remnant habitats (e.g., Vogelmann 1994), and other human-related mortality factors. Even in rural New England, the second most frequent mortality factor among a group of transmitter-equipped bobcats (20% of all mortalities) was collisions with motor vehicles (Litvaitis et al. 1987).

**Iberian lynx**

The Iberian lynx is considered taxonomically unique (Werdelin 1981, Honacki et al. 1982), and once ranged over a large portion of the Iberian peninsula (Graells 1897, as cited in ICONA 1992). Historically, this species was hunted intensively as a game species, or pursued as a potential predator of

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**Table 1.** Summary of computer simulations used to examine the relative importance of initial population size, prey abundance, and immigrants on the persistence of an isolated population of Canada lynx (source: Litvaitis et al. 1991).

<table>
<thead>
<tr>
<th>Initial population</th>
<th>Prey abundance</th>
<th>Average immigrants/year</th>
<th>Probability of surviving 50 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>Moderate</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>80</td>
<td>Moderate</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>40</td>
<td>High</td>
<td>0.00</td>
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</tr>
<tr>
<td>20</td>
<td>Moderate</td>
<td>1.00</td>
<td>0.97</td>
</tr>
</tbody>
</table>

*aInitial population restricted to yearlings and adults. bPrey abundance: moderate < hare/ha, high = 2-5 hare/ha. Annual survival with moderate prey: juvenile - 0.05, yearling - 0.62, adult - 0.62 with high prey: juvenile - 0.35, yearling - 0.80, adult - 0.80. Young/female with moderate prey: adult - 1.1 with high prey - 1.8. See Litvaitis et al. (1991) for coefficients of variation of these parameters.*

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**Spatial / Temporal Scale**

- Overexploitation
- Deforestation, Intensive Agriculture, and Urbanization
- Population Fragmentation
- Reduced density
- Sink / Source Habitats
- Inbreeding

Fig. 1. Human-related forces and their effects on felid populations. These forces are expressed at different, but not mutually exclusive spatial and temporal scales.
livestock and game. By the early 1900s, lynx were restricted to the southern half of Spain and a small portion of Portugal. Intensive agriculture, disruption of natural-disturbance regimes (especially fire), and forest conversions to monocultures continued to reduce the habitat of lynx in Spain (Ales et al. 1991, Moreno and Villafuerte 1994). Although recognition of the downfall of this species resulted in legal protection in 1973, this designation did not stop the decline of lynx.

Rodríguez and Delibes (1992) reported that the breeding range of lynx in Spain is now restricted to about 11,000 km² and fragmented among 48 sites. Of these, 75% are <200 km² and many support fewer than 50 breeding individuals. The total population in Spain is approximately 1,100. Ferreras et al. (1992) found that human-related factors (incidental captures in traps set for other species, collisions with motor vehicles, and accidental drownings in wells) are still the main causes of mortality among lynx, even in protected reserves. Myxomatosis and a recent outbreak of viral hemorrhagic disease in Spain (Villafuerte et al. 1994) have reduced the major prey of lynx, European rabbits (Oryctolagus cuniculus). Additionally, generalist carnivores (e.g., red foxes (Vulpes vulpes)) have increased as habitats have become more heterogenous (Rau et al. 1985). These factors may have reduced prey abundance and further reduced lynx fertility and survival. Finally, the lack of demographic exchanges among disjunct populations of lynx may have already resulted in a reduction in heterozygosity in these populations (Beltrán and Delibes 1993).

REVERSING THE DECLINES
As these two examples illustrate, the forces affecting felid populations operate at several spatial and temporal scales. We suggest that efforts to sustain or restore populations of wild cats should also occur at several scales that are not mutually exclusive (Fig. 2).

Legislation/education
Legislation to eliminate trapping and hunting of declining populations of felids can be enacted quickly. Such legislation should be flexible to local concerns (e.g., livestock protection). When legislation is combined with an active campaign to educate the public about the plight of wild cats (e.g., Project Tiger), cat populations can respond rapidly. However, if commercial demands remain high, even international agreements to eliminate trade of endangered or threatened species (i.e., CITES) may not succeed. Education efforts, therefore, may need to be global and active for many years if attitudes toward felids are to change.

Habitat manipulation and rehabilitation
The abundance of prey consumed by felids has obvious effects on several demographic parameters (Fig. 3). Spatial and temporal variation in prey density of bobcats (Litvaitis et al. 1986) and Canada lynx (analysis of Table 2 of Ward and Krebs 1985) explained 22–30% of the variation in home range size. Survival and fertility of felids are sensitive to changes in prey abundance (e.g., Brand and Keith 1979). Therefore, this parameter has obvious implications to increasing carrying capacity of felids that are restricted to limited habitats. Prey populations of felids may be very responsive to habitat manipulations. For example, Litvaitis et al. (1985) reported a close relationship between understory density and the abundance of snowshoe hare (Lepus americanus) that represented approximately 60% of the diet of bobcats in northern New England (Litvaitis et al. 1986). Habitat of snowshoe hares can be increased and sustained with even-aged forest management. Likewise, Moreno and Villafuerte (1994) have demonstrated that the abundance of European rabbits consumed by Iberian lynx can be increased locally by planting forage crops consumed by rabbits. Large-scale increases of this rabbit may be achieved by restoring natural disturbance regimes, especially periodic fires (Moreno and Villafuerte 1994).

The distribution of habitat management efforts to enhance
prey abundance should also be considered. These efforts may be most influential when placed in remote areas where felids are less likely to encounter humans. Ferreras et al. (1992) observed that Iberian lynx that resided at the edge of Doñana National Park had a higher mortality rate than individuals that resided in the core of this reserve. Therefore, concentrating felids in cores of reserves or in roadless areas will likely increase the security of a population (Fig. 4), and have a greater effect on population restoration than simply distributing habitat management efforts throughout a landscape.

Habitat corridors

Although the value of habitat corridors that link disjunct habitats has been a controversial issue among conservation biologists (Simberloff and Cox 1987), recent research has demonstrated that such features may be essential for assuring periodic emigration/immigration among small, scattered populations (Beier 1993). The "rescue effect" that immigrants have on small populations (Brown and Kodric-Brown 1977, Forney and Gilpin 1989) may be of greater significance to survival of these populations than maintaining heterozygosity (Lande 1988).

We acknowledge that developing an effective system of habitat corridors is the most difficult portion of a management program to restore and sustain felid populations in human-altered landscapes. Can a restoration effort be effective without these linkages? We do not believe so. Litvaitis et al. (1991) and Beier (1993) demonstrated how influential even an occasional immigrant (e.g., 1 every other year) can be to a small population of wild cats. Table 1 summarizes the relative effect of immigration on an isolated Canada lynx population in comparison to elevating carrying capacity, fertility, and survival (with enhanced prey populations). Even a very small population (20 yearlings and adults) had a high probability of surviving if it was supplemented by immigrants on a regular basis.

Although we have stressed the importance of corridors to long-term survival of felids, we must also emphasize that other efforts (legal protection and enhanced prey populations) are important to maintaining population viability (Fig. 5). These efforts may be especially important during the period that corridors are not yet functional. In conclusion, we recommend that conservationists involved in restoring endangered or threatened populations of wild cats work at several spatial and temporal scales. Such an approach may be appropriate for a wide variety of organisms (especially other carnivores) that are threatened with local or global extinction.

LITERATURE CITED


