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Abstract: Although the role of top predators may vary, there can be little doubt that such animals have been instrumental in shaping the evolution, behavior, and ecology of many species, and the community structure of many natural ecosystems. However, there are very few systems left on Earth that can be called "natural" (in the sense that human influence is absent), given that the human footprint is detectable in virtually all ecosystems. The areas where ecosystems still function without major human influence are sadly very few. For a variety of economic, practical, ethical, scientific, and aesthetic reasons such areas should be conserved, and treated like the crown jewels of our planet's natural heritage. There is mounting evidence that for an ecosystem to be considered functionally intact, the full complement of top predators is required. Top predators may also be useful from a strategic point of view to promote the conservation of these systems (umbrellas and flagships). Anthropogenic changes to the planet's ecosystems span a wide gradient from seminatural habitats through various forestry and agricultural systems to suburban and urban habitats. Biodiversity, including top predators, can be found throughout this gradient of modification. It is in the context of these modified habitats that most conservation will have to take place in the future, and with this background that we aim to examine the potential linkage between conserving top predators and biodiversity. Our focus is on all of Europe with the exception of Russia, and we mainly consider wolves (*Canis lupus*), bears (*Ursus arctos*), and Eurasian lynx (*Lynx lynx*), which have the most widespread distributions on the continent. This is not an analytical work where we can justify all our conclusions with reference to statistical analyses of experimental data. Rather, it represents an attempt to combine the experience of the authors to identify elements of current European environmental philosophies ("visions" or "strategies" might be more modest words), and place the linkage between large carnivores and biodiversity into this context. At present we have no unifying philosophy to guide us in Europe. Given the diversity of social, cultural, and ecological conditions that categorize Europe, it is highly unlikely that any single philosophy could be accepted, and it may not even be desirable. In fact, this diversity, and especially mutual tolerance for this diversity, must lie at the heart of the European approach.

CHAPTER 19

The Linkage between Conservation Strategies for Large Carnivores and Biodiversity: The View From the "Half-Full" Forests of Europe.

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Although the role of top predators may vary (Strong 1992; Chase 2000), there can be little doubt that such animals have been instrumental in shaping the evolution, behavior, and ecology of many species (e.g., Byers 1997), and the community structure of many natural ecosystems (chapters in this volume). However, there are very few systems left on Earth that can be called "natural" (in the sense that human influence is absent), given that the human footprint is detectable in virtually all ecosystems (Nellemann et al. 2001; Western 2001; Matson et al. 2002; Sanderson et al. 2002a). The areas where ecosystems still function without major human influence are sadly very few. For a variety of economic, practical, ethical, scientific, and aesthetic reasons such areas should be conserved, and treated like the crown jewels of our planet's natural heritage. There is mounting evidence that for an ecosystem to be considered functionally intact, the full complement of top predators is required. Top predators may also be useful from a strategic point of view to promote the conservation of these systems (umbrellas and flagships) (Simberloff 1998; Leader-Williams and Dublin 2000; Ray, this volume).

Anthropogenic changes to the planet's ecosystems span a wide gradient from seminatural habitats through various forestry and agricultural systems to suburban and urban habitats (Sanderson et al. 2002c). Biodiversity, including top predators, can be found throughout this gradient of modification. It is in the context of these modified habitats that most conservation will have to take place in the future (Rosenzweig 2003), and with this background that we aim to examine the

potential linkage between conserving top predators and biodiversity (Linnell et al. 2000). Our focus is on all of Europe with the exception of Russia, and we mainly consider wolves (*Canis lupus*), bears (*Ursus arctos*), and Eurasian lynx (*Lynx lynx*), which have the most widespread distributions on the continent.

This is not an analytical work where we can justify all our conclusions with reference to statistical analyses of experimental data. Rather, it represents an attempt to combine the experience of the authors to identify elements of current European environmental philosophies ("visions" or "strategies" might be more modest words), and place the linkage between large carnivores and biodiversity into this context. At present we have no unifying philosophy to guide us in Europe. Given the diversity of social, cultural, and ecological conditions that categorize Europe, it is highly unlikely that any single philosophy could be accepted, and it may not even be desirable. In fact, this diversity, and especially mutual tolerance for this diversity, must lie at the heart of the European approach.

The Nature of Biodiversity

So much confusion exists around the term "biodiversity" that it may be useful to separate it out into its constituent elements, before going further. At its most simple, biodiversity is often perceived as a list of species, some of which may be endangered (species diversity). However, a far broader definition of biodiversity now exists such that all levels of *interactions* between species, ecological and behavioral *processes,* and *landscapes* can all be viewed as biodiversity (Redford and Richter 1999; Pyare and Berger 2003).

Europe: A Continent Shaped by Humans

Humans in their various forms have occurred in Europe during the many expansions and contractions of the Pleistocene ice age since at least 40,000 BP (Cunliffe 1994), and rapidly recolonized the land as the glaciers melted. These early humans were effective hunters and must be regarded as intrinsic members of the carnivore guild (Smith 1992; West 1997). Already from around 8000 BP humans

began farming in southeastern Europe and had begun modifying habitats throughout western and northern Europe by 3000 BP (Cunliffe 1994). Therefore, from the first moments that the European landmass was released from the ice age's embrace, humans have been influencing the structure and functioning of the ecosystem in various ways to a far greater extent than in other continents, such as North America (Kay 1994). Through their predation on prey species (Breitenmoser 1998), intraguild predation on other carnivores (Boitani 1995), and habitat modification (Berglund 1991), it is clear that from an ecological point of view humans have long asserted both top-down and bottom-up effects on the ecosystem and have clearly had a dominant influence over ecosystem processes on the continent.

This human influence has been complex, dynamic, and far from linear. Although habitats have been extensively modified, the ch, , canges in forest cover, the manner of forest exploitation, and patterns of human distribution and density have fluctuated widely under the influence of developing technology, climate change, disease (e.g., the black death), warfare, and social upheaval (e.g., Björse and Bradshaw 1998; Verheyen et al. 1999; Farrell et al. 2000). Despite these changes, most postglacial species have persisted through to modern times, albeit in greatly reduced numbers and in reduced ranges. This includes all four species of large carnivores: brown bear, wolf, Eurasian lynx, and wolverine (*Gulo gulo*) plus the smaller Iberian lynx (*Lynx pardinus*); four cervid prey: wild reindeer (*Rangifer tarandus*), moose (*Alces alces*), red deer (*Cervus elaphus*), and roe deer (*Capreolus capreolus*); bison (*Bison bonasus*); wild boar (*Sus scrofa*); and three mountain ungulates: chamois (*Rupicapra rupicapra*), isard (*Rupicapra pyrenaica*), and Alpine ibex (*Capra ibex*). Only two ungulate species, wild horses (*Equus ferus*) and auroch (*Bos primigenius*), have gone extinct. For all these species and most forested habitats, the 19th and early 20th centuries were the bottlenecks when a variety of factors coincided such that human pressure on land and resources was at its maximum.

At the start of the 21st century the situation has changed dramatically. Forest cover is generally higher than it has been for at least several centuries (average is 34% in continental Europe and 56% in Fennoscandia), and wild ungulates are now so widespread that they have not been so abundant for centuries (if ever), and in many areas are "overabundant" (*sensu* McShea et al. 1997; McShea, this volume). Despite high human population densities (121 km^{-2} in continental Europe and 16 km^{-2} in Fennoscandia), people are increasingly becoming concentrated in urban areas

(MacDonald et al. 2000). The fact remains, however, that Europe is home to ~580 million people, all trying to make a living, and these people are not going anywhere. Clearly, there are no wilderness areas left in Europe, although a few such fragments remain (Jędrzejewska and Jędrzejewski 1998). It is therefore important to set conservation goals that take into account the reality of the situation. Accordingly, European nature conservation is focused on integrating as much biodiversity into a human-dominated landscape as possible. Conservation efforts focus on all habitats, including urban, agricultural, and seminatural habitats, and the tiny fragments of relatively intact nature that remain (Redford et al. 2003).

Even in intensive agricultural areas, there have been attempts to integrate many species through subtle changes in land management, such as leaving slightly wider field margins and reducing the use of pesticides and herbicides (Sutherland 2002). Meanwhile, forestry is attempting to learn from the mistakes of the past and develop methods that better replicate natural disturbance processes (Bengtsson et al. 2000) and provide for "multiple uses," including biodiversity (Farrell et al. 2000). Because pure "naturalness" is not a goal, it is not an intrinsic problem for conservation if land is used, and thereby has had its original biodiversity and functionality changed (because it is inevitable that all use has an impact on biodiversity at some level; Redford and Richter 1999). Indeed many of the human-modified landscapes are preserved because of their visual or aesthetic appeal (e.g., Hunziker 1995). The integration of human structures into these landscapes is also regarded as positive in many contexts. Because of the very long period of human modification of Europe, the biotic landscape is as much a form of cultural heritage as any castle, cathedral, or monument. The landscapes that result from the combined effects of biotic and cultural processes are also associated with cultural identity (Sörlin 1999), and, interestingly, there appears to be a positive geographic relationship between species diversity and cultural diversity (Sutherland 2003), with areas of high biodiversity being linked to high human population density (Araújo 2003).

The interconnection of natural and cultural heritage is so extreme that in many cases some species and landscapes are totally dependent on constant human activity. This is most obvious for the biodiversity associated with grazing and hay production (Warren 1998). Since the Iron Age, pastoralists have been dependent

on using an infield–outfield system, where livestock were grazed and hay was collected on outfields, while manure from the livestock was used to fertilize the arable infields (Bruteig et al. 2003). Many species of plant, fungi, and insects, for example, depend on the grazing pressure to keep the landscape open and suppress tree and shrub growth, or on the hay meadows that have a net nutrient loss (Smallidge and Leopold 1997; Moen et al. 1999). For example, in Norway, up to 30% of red list species across all taxa are associated with agricultural landscapes (i.e., dependent on a certain type of land-use). A further extreme example lies with the importance attached to the conservation of livestock breeds (Hall and Bradley 1995) and local crop types (Wood and Lenne 1997). This appreciation of grazing-dependent species and landscapes goes to the extent that grazing is allowed, and even encouraged, in many national parks and nature reserves.

As a result, European conservation goals are complex in that nature and culture heritage are regarded as being closely linked in our landscapes. This recognition of the desirability of continued human activity, and the importance of aesthetics as well as biodiversity, is apparent in the European Landscape Convention (2000). In the preamble to the Convention it is noted that "landscape has an important public interest role in the cultural, ecological, environmental and social fields" and that "landscape contributes to the formation of local cultures and that it is a basic component of the European natural and cultural heritage, contributing to human well being and consolidation of the European identity." Finally, according to the Convention's definition, "Landscape means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors." The goals are therefore very focused on the conservation of landscapes aesthetics, species diversity, and rare species.

Thus far there has been relatively little in the way of movement toward conserving ecological processes. Recently, Europe has been focused on preventing the extinction of species and populations in the face of 19th- and 20th-century pollution, agricultural intensification, and urbanization. As success is achieved at this stage of conservation, there is little doubt that there will be an increased focus on conserving and restoring at least some processes, and moving toward an ecosystem approach, although human presence will be regarded as an integral part of the ecosystem. In focusing our attention on processes rather than species it is likely that the large carnivores may represent a powerful driving role.

Table 19.1
The current size of large carnivore populations in Europe[a]

	Eurasian Lynx	Wolf	Bear	Wolverine
Fennoscandia	2800	170	2000	700
Alps	300	Occasional	30	
Baltic/Poland	1000	1800	400	
Carpathians	2000	3000	6000	
Southeast Europe	300	2000	3500	
Iberia and Italy		3000	120	

[a]The numbers are very approximate because estimates are uncertain for many populations. Data are mainly taken from the LCIE action plans (Swenson et al. 2000; Landa et al. 2000; Boitani 2000; Breitenmoser et al. 2000) with more recent updates when available.

European Large Carnivore Populations

Direct persecution of large carnivores was once widespread throughout Europe. The earliest bounties stretch back over 2000 years, and enormous efforts were made to exterminate all predators. Direct persecution combined with widespread extermination of their ungulate prey and forest clearance ensured that many countries succeeded in driving their large carnivore populations to local extinction (Boitani 1995; Breitenmoser 1998; Linnell et al. 2001b). This was especially evident in the densely populated British Isles (even here wolves held on until the 18th century) and countries of western Europe. However, even in the sparsely populated Fennoscandian countries, large carnivore populations were severely reduced and even exterminated. In the south and east of Europe somewhat larger populations survived.

By the late 1960s the tide had turned, and today most populations are increasing or stable (Boitani 2000; Breitenmoser et al. 2000; Landa et al. 2000; Swenson et al. 2000; Table 19.1). This stems in part from the introduction of favorable legislation in most countries, and great improvements in habitat quality (forest cover and ungulate density). In addition, a number of reintroductions and population supplementations have been conducted, many of which have been successful (Table 19.2). Most notable has been the return of lynx to several west and central European mountain ranges, and the return of bears to Austria (Breiten-

Table 19.2
Large carnivore reintroductions/translocations in Europe

Species	Country	Area	Years	Number of animals	Result
Eurasian lynx	Russia	Rominter Heide	1941	5	Failure
	Germany	Bavaria	1970–75	5–7	Failure
	Switzerland	Jura	1871–80	10	Success
		Alps	1971–82	14–18	Success
		Jorat	1989	3	Uncertain
		E. Switzerland	2002–		Just started
	Italy	Gran Paradiso	1975	2	Failure
	Slovenia	Kocevje	1976	6	Success
	Austria	Alps	1977–79	9	Failure
	Czech Rep.	Sumava	1982–89	17	Success
	France	Vosges	1982–92	16–18	Uncertain
	Poland	Kampinoski	1993–95	5	Uncertain
Brown Bear	Poland	Białowieża	1938–44	10	Failure
	France	Pyrennes	1996	2	Running
	Italy	Trentino	1999–	7	Running
	Austria	Eastern Alps	1989–93	3	Success
Wolverine	Finland	Central Finland	?	?	Success?

From Breitenmoser et al. (2001).

moser et al. 2001). Natural expansion is also occurring (e.g., the return of wolves to the Alps, Germany, and Norway in recent years) (Wabakken et al. 2001; Lucchini et al. 2002). There are still some critically small and isolated populations (especially of bears, e.g., in northern Spain and the Pyrenees; Swenson et al. 2000), and some populations are suffering from overharvest and high rates of poaching, but in general the recovery picture is positive. The exceptions are the Iberian lynx which is suffering from the combined effects of habitat fragmentation and the loss of prey (Delibes et al. 2000), and some local wolverine populations (Landa et al. 2000).

The landscape within which large carnivores are recovering is heavily modified (albeit highly diverse), with relatively high human densities that have been associated with extinction under different management regimes (Woodroffe 2000; Linnell et al. 2001b). European wolves, lynx (Eurasian), and bears appear to be very

tolerant of human disturbance, and all three species have shown an ability to live close to people, even within suburban and urban environments (J. D. C. Linnell, pers. obs.).

The protected areas of Europe are generally too small to support more than a handful of individual large carnivores (Table 19.3), thus requiring them to live in the multiuse landscapes where conflicts are most likely to occur (Linnell et al. 2001a). These can be divided into material conflicts that have physical and/or economic components, and psycho-social conflicts that occur in the minds of individuals or between groups of people within society (Linnell et al. in press). The major material conflict is with domestic livestock. In areas where large carnivores have always been present, intensive husbandry using the traditional shepherd, guarding dog, or night-time enclosure system minimizes the conflicts (Linnell et al. 1996; Kaczensky 1996). However, in areas where large carnivores have returned following an absence, or where wild prey is otherwise scarce, depredation rates can be very high. Locally, depredation on horses, cattle, beehives, domestic dogs, and semidomestic reindeer, and competition with hunters for wild ungulates can be significant causes of material conflict.

Social conflicts associated with large carnivores include those between different knowledge systems (experience-based and hegemonic systems), economic and cultural modernization of rural communities, and urban–rural tensions (Skogen 2001; Ericsson and Heberlein 2003; Skogen et al. 2003). In most of these social conflicts, carnivores take on highly symbolic roles as the most important proximate factor that threatens rural lifestyles under perceived attack by national and international (e.g., globalization) forces. Fear of injury and death is also a factor in areas where wolves and bears have returned after an absence. There have been cases of both wolves and bears injuring and killing people in Europe (Swenson et al. 1996; Linnell et al. 2002), although most of the wolf cases belong to past centuries, and bears in Europe cause far fewer problems than elsewhere in Eurasia or North America.

The political landscape is also highly complex. In the last 14 years, Europe has seen the fall of the Iron Curtain and the increasing expansion of the European Union (EU). This is bringing enormous socioeconomic changes to the entire continent, which will greatly affect patterns of land use, human distribution, socioeconomics, and infrastructure. These in turn will influence large carnivores both

Table 19.3
The current number of protected areas (IUCN classes I to IV) of various sizes in selected regions of the world[a]

Region	100–999 km^2	1000–9999 km^2	> 10,000 km^2
Fennoscandia	63	17	0
Continental Europe	92	3	0
Canada and Alaska	137	118	37
South and East Africa	146	60	15
West Africa	33	34	5
Central Africa	11	30	4
Indian subcontinent	240	37	0
West USA	231	56	0
Northeast USA	35	2	0
East USA	34	5	0
Midwest USA	19	0	0

[a] Data taken from IUCN website, http://www.unep-wcmc.org/index.html?http://www.unep-wcmc.org/protected_areas/~main

positively and negatively. Large carnivore conservation is very active in Europe, with two major international pieces of legislation: the Directive on the Conservation of Natural Habitats and of Wild Flora and Fauna (1992) within the European Union (25 countries), and the Bern Convention (1979) within the Council of Europe (45 countries), both of which provide clear mandates for their conservation. Although the quality of research and management/conservation institutions varies widely, the overall trend is positive, and there is a high degree of transboundary cooperation. For example, the Large Carnivore Initiative for Europe (LCIE) is an expert group supporting both the EU and the Council of Europe and a wide spectrum of nongovernmental organizations (NGOs) that are involved in the process of carnivore conservation (LCIE 2004).

Goals for Large Carnivore Conservation in Europe

Given the historic bottlenecks that almost all European large carnivore populations have been through, conservation goals for the species have been fairly modest (see Box 19.1 for a conceptual overview). The short-term goals have been to

Box 19.1

Seven Levels of Conservation Ambition for Large Carnivores

In transferring the modern view of biodiversity into achievable conservation objectives (either for maintaining the status quo or for guiding restoration), there are at least seven possible levels of ambition and ecological complexity at which goals for large carnivore conservation can be set.

1. Species *presence*—e.g., lynx (*Lynx lynx*) persist in an area following recolonization or reintroduction.
2. Some ecosystem *processes* occur—e.g., the lynx begin to eat roe deer (*Capreolus capreolus*) (predation), kill red foxes (*Vulpes vulpes*) (intraguild predation), and leave carcasses for scavengers (secondary effects).
3. Species *demographic viability* is achieved—e.g., this lynx population increases to a level of demographic viability.
4. The *evolutionary potential* of the species to adapt to future conditions is maintained—e.g., the population increases to a level (of size or connectivity with other populations) where genetic viability (evolutionary potential) is ensured.
5. The full *community* of carnivores (and their prey) is restored—e.g., lynx, wolves (*Canis lupus*), and bears (*Ursus arctos*) occur in the same area, together with roe deer, red deer (*Cervus elaphus*), and moose (*Alces alces*).
6. The *limitation* and/or *regulation* of numbers of predators and prey are primarily determined by trophic interactions—e.g., prey density and intraguild interactions, rather than by human intervention, will limit the density of lynx and wolf populations.
7. The system is able to exist in a *dynamic* state, fluctuating under the influence of climate, disease, and other external factors.

The first three levels are relatively easy to define and document, and conservation can usually be achieved given the application of enough knowledge and resources. Level 4 concerns the issue of genetic viability and has received far less technical focus than the issue of demographic viability, and relatively little attention within the conservation movement (Myers and Knoll 2001). If we are to think long term, then far greater attention needs to be placed on this

level (Bowen 1999). Although it may be desirable to aim for level 6 or 7 conservation in wilderness areas, it may only be possible to achieve more modest goals in areas that have already been heavily modified by humans. In fact, even obtaining level 1 for some conflict-causing species (such as the large carnivores) has often proven to be problematic (Linnell et al. in press). Each step involves an increase in population size and the number of species considered. The choice of goal will clearly influence the extent to which conserving the large carnivores will also conserve biodiversity in its wider sense.

prevent the extinction of existing populations. We are now moving into a phase where attempts are being made to restore top predators to suitable areas and achieve population (demographic) viability. This requires their integration into human-dominated landscapes such that coexistence with human activities and increased acceptance for their presence are required. The mission statement of the LCIE reflects this approach: "To maintain and restore, in coexistence with people, viable populations of large carnivores as an integral part of the ecosystems and landscapes across Europe." Due to aspects of scale it is understood that this viability can be achieved only as a common effort through international cooperation. The focus at this early stage has been very much on the conservation of carnivores as species and much less on the ecological processes of which they are a part.

It is obvious that, when carnivores return to an area, some of the ecological processes also resume. Wolves and lynx (and bears to some extent) kill ungulates, the scavengers will probably benefit, and intraguild predation will resume (e.g., Linnell et al. 1998). We can also expect some changes in behavior and habitat selection of their ungulate prey and some resumption of selection effects on prey. We are just at the start of estimating the real effect restored populations of carnivores are having on ungulates, which is likely to vary dramatically between different areas. For example, the effect of returning carnivores will be greatest in areas with low prey densities, especially if hunting pressure on the ungulates is also heavy. However, in areas where ungulates occur at high densities (a common feature of highly modified landscapes where human land use enhances productivity), it will require very high densities of carnivores to have any significant effect on

prey demographics. In many situations human tolerance for carnivore presence may well be lower than the ecological carrying capacity. As a result legal harvest and/or poaching may limit their numerical response, and thereby their potential impact on prey numbers and their top-down influence on ecosystem processes (Andersen et al. in press). At present, even the return of these species and the resumption of these processes on a limited scale are controversial. Given the constraints on space, habitat, and human tolerance, it seems unlikely that Europe will ever get to a stage where carnivore and ungulates numbers are determined primarily by trophic interactions and nonhuman factors.

In terms of the seven levels of conservation (see Box 19.1) it is clear that in Europe we have come to stages 1 (presence) and 2 (process resumption) in many areas, and that stage 3 (demographic viability) has been achieved or maintained in at least some populations. Of these maybe a few have reached stage 4 (genetic viability or maintenance of evolutionary potential), although the lack of precise estimates of required numbers makes it difficult to assess. In some few areas (Sweden, the Baltic States, the Carpathians) we have intact guilds of both predators and their prey (stage 5). There are probably no areas where the numbers of predators and prey are determined by trophic interactions (stage 6) because of the extent to which humans directly influence predator and prey populations. Likewise, stage 7 (dynamic state) remains elusive and controversial. It seems unlikely that stages 6 and 7 will ever be achieved any place in Europe, and in many ways they may not even be desired because they exclude human influence from the system. As we have argued earlier, European nature conservation philosophy is somewhat uniquely built on the integration of people and nature.

A frequently asked question is, Why try and conserve carnivores at all in such a landscape? Although there are many motivations, it appears to us that aesthetic and ethical reasons dominate. In other words, the carnivores are being conserved largely for themselves. The same goes for the processes associated with the carnivores. The desire to see predation and scavenging is mainly for the abstract aesthetics of knowing they occur, rather than out of an expectation that they will dramatically affect the ecosystem services provided by the European landscape. If manipulation of wild ungulate density (the main potential link between large carnivores and habitat) is desired, it would be far more effective to act through hunter pressure than carnivore restoration. Certainly, Europeans are under few illusions that the presence of large carnivores will produce a net economic benefit, although

some of the costs may be mediated through ecotourism and trophy hunting. However, just because it is not possible to go all the way along the conservation ambition scale, it does not follow that it is futile to achieve as much presence, viability, and process as possible.

All this implies a clear focus on the intrinsic value of carnivores, which is a potentially legitimate and powerful conservation argument in and of itself (Lawton 1991; Redford and Richter 1999; Ghilarov 2000; Collar 2003; Jepson and Canney 2003) even if scientific or moral justifications remain elusive (Oksanen 1997; Rosenfeld 2002). Given the uncertainty of the relationship between biodiversity and ecosystem function (Ghilarov 2000; Schwartz et al. 2000; Hector et al. 2001; Loreau et al. 2001), it may well turn out that the preservation or restoration of fully functional "natural" ecosystems is also only built on similar aesthetic/ethical arguments. In a continent where the distinction between nature-dominated and human-dominated environments is often lost, we believe that large carnivores are present to remind people of the needs of nature, of the existence of some limits to the extent that humans can encroach on the environment if we wish to have an entity that we call "wild nature." Large carnivores embody an idea of nature that is otherwise lost to Europeans. The presence of large carnivores is what makes a difference between a "wild" area and an extended city park. Many view the return of carnivores as highly symbolic, almost as the ultimate test of human ability to coexist with biodiversity. In other words, although we cannot achieve wilderness as many conservationists hope for (e.g., in North America, Soulé and Terborgh 1999; Pyare and Berger 2003), we can at least restore some of the wildness to the landscape.

The danger of using carnivores as symbols is that they can symbolize very different things to different people. To the conservationist a wolf might represent beauty and wildness (in a positive sense), whereas to many others it may symbolize wastefulness, evil, and, in a more modern context, the intervention of powerful social forces in conservative rural lifestyles. In extreme cases, the return of the wolf, for example, may actually serve as the focus for an increased unity among rural people against central powers—a situation that will hardly benefit conservation of biodiversity (Ericsson and Heberlein 2003; Skogen et al. 2003).

Because of the dominant effect of humans in the European landscapes there are clear limits to how far we can restore species and processes. We probably can never approach the level of ambition that many conservation biologists hope for

in the Rocky Mountains of North America, for example (Soulé and Terborgh 1999; Pyare and Berger 2003). In effect, in much of Europe the large carnivores may be ecologically extinct (in the sense of Redford and Feinsinger 2001)—but they are very much alive. In terms of strict definition, large carnivore recovery in Europe is more of an exercise in reconciliation ecology (*sensu* Rosenzweig 2003) than in strict restoration ecology.

How Does Conserving Carnivores Conserve Biodiversity in Europe?

To best explore how the conservation of large carnivores and biodiversity interact we can begin by looking at some of the major threats to species diversity in Europe. The greatest long-term threats are in the field of large-scale processes and global change. These include climate change, pollution (acid rain, heavy metals, persistent toxins), and long distance transport of nitrogen (Matson et al. 2002). The second group of threats concern patterns of land use and habitat conversion, which not only remove habitat but fragment areas of unmodified habitat (Andrén 1994). Wetlands are very susceptible to drainage, forests to cutting and fire regimes, and grasslands to fertilization, grazing intensity, and potential reforestation. The European strategy to conserve biodiversity is therefore heavily focused on establishing a network of relatively small reserves under the Natura 2000 network in the EU, and on regulating patterns of land use and other human activity through incentives, subsidy, and legislation. Most of this conservation is occurring on private lands (typically even national parks are predominantly made up of private land in Europe), reflecting the greater extent to which landowner activities are regulated in Europe, compared to the United States.

Against this background, the threats that face large carnivores in Europe vary from country to country and species to species but include the following (Boitani 2000; Breitenmoser et al. 2000; Landa et al. 2000; Okarma et al. 2000; Swenson et al. 2000):

(1) lack of human tolerance due to depredation on livestock, competition for game, and fear; (2) inappropriate quotas for large carnivore hunting; (3) illegal killing; and (4) infrastructure development and human disturbance that can lead to both direct mortality and population fragmentation. Solutions therefore, need

to be focused on reducing livestock depredation and improving both the regulation of harvest and the enforcement of legislation. It is important to note that there is relatively little overlap between the first three of these threats and those facing species diversity at large.

So, does the conservation of large carnivores relate to the conservation of biodiversity in general? Large carnivore populations have three basic requirements for persistence: (1) careful regulation of human persecution, (2) large areas of connected habitat, and (3) adequate prey. Providing these things can assist other biodiversity up to a point. First, reducing persecution requires effective legislation and enforcement of legislation on the ground. Whether this takes the form of protection or regulated harvest is irrelevant; the process of setting up management structures that embrace carnivores will go a long way to serving the needs of other species.

Second, providing habitat for carnivores will provide habitat for at least many other species. Because of their large area requirements, large carnivores have been particularly useful for focusing attention on the importance of continuous habitat. For example, in Croatia reducing bear mortality in traffic was the main motivation behind costly investment in "green bridges" over new highways that benefit not only bears but many other species (Huber et al. 2002). In other cases the presence of carnivores; for example, bears in Austria (Norber Gerstl, pers. comm.) and Spain (Juan Carlos Blanco, pers. comm. 2003), have been used to justify the creation and expansion of relatively large protected areas. However, large carnivores are very tolerant of habitat quality, and patterns of land use (both inside and outside protected areas) that are compatible with large carnivores will not be compatible with the needs of many other threatened species. Conservation of species diversity in Europe will always require very detailed design and control of land use and the creation of reserves and protected areas, irrespective of the presence of large carnivores.

Thirdly, large carnivores need adequate prey populations. In an effort to reduce depredation on livestock by wolves in Portugal (Vos 2000) there is an active reintroduction program to reestablish roe deer in the area. Although such examples are few, they do indicate the ability of large carnivores to motivate the restoration of severely degraded habitats. Even though the predation process may not be restored to the level of allowing trophic regulation of carnivore and ungulate

densities, just the fact that some predation, scavenging, and avoidance processes resume is a form of conservation of processes. Finally, large carnivores are very successful at focusing the public's attention on conservation in general, although we have no quantitative data on the extent to which this benefits other species.

Overall, carnivores, together with their ungulate prey (Bruinderink et al. 2003), may be highly suitable umbrellas for a coarse-filter approach to conservation, but the fine-filter approach will also be necessary for many other species (*sensu* Noss 1996; Redford et al. 2003). This can be envisaged on a landscape scale where the needs of large carnivores and their prey are used to ensure the maintenance of large areas of connected habitat that is at least seminatural, but where a series of specially managed habitats and reserves are embedded in this favorable matrix to satisfy the needs of other species with more specific habitat requirements.

It is important to mention that the focus on large carnivores may also conflict with other conservation objectives. For example, the presence of large carnivores makes unsupervised extensive grazing of livestock almost impossible. In high-cost countries this may be the only way of farming livestock to maintain the grazing pressure needed to conserve grazing-dependent biodiversity. Furthermore, as discussed previously, large carnivores do create very real conflicts, and it seems that people with the most direct experience with carnivores (at least wolves) have the most negative views of them (Williams et al. 2002; Ericsson and Heberlien 2003). Although it is not clear if such negative views will result in a backlash in the form of decreasing the public's willingness to conserve biodiversity at large, there are reasons to believe that it may be more effective to increase the public's ecocentric values through a focus on less controversial species (Brainerd and Bjerke 2003).

Is Europe Unique?

Given the generally improving global attitudes toward conservation (at least in the industrialized world) there can be little doubt that there is sufficient incentive and motivation to preserve (or rewild) the last great wilderness areas and biodiversity hotspots on Earth in a manner that minimizes human influence on their systems (Soulé and Terborgh 1999; Myers et al. 2000). Clearly, in these situations the European approach has very little transfer value. However, those wilderness areas

that do remain worldwide are unfortunately few, relatively small, and surrounded by increasingly human-dominated landscapes. It is in heavily modified landscapes that the European approach of integrating biodiversity conservation and humans may work best, either alone in the absence of protected areas or to soften the contrast between large protected areas and the landscape matrices in which they occur. The role of these multiuse landscapes in biodiversity conservation has been receiving increased attention even in areas where protected areas have long been the main focus for conservation activity (North America, Rosenzweig 2003; Africa, Western 2001). Areas such as the eastern United States come to mind as discussions about the potential for wolf recovery (Elder 2000) occur in a landscape where conservation of the cultural landscape is also an issue (Foster 2002). What remains unclear is whether the European approach can work in areas of extremely high human densities, or in areas where socioeconomic conditions and poor institutional development render law enforcement ineffective, and where pressure on even seminatural habitat is intense (Woodroffe 2000; Linnell et al. 2001b). Obviously there is no single approach to conservation, and no single conservation goal that applies to all areas. Recognition of this technical and philosophical diversity is going to be vital in the unification of conservation effort to save biodiversity in all its facets and glory (Redford et al. 2003).

Conservation Recommendations

There is no doubt that large carnivores are highly suitable species for grabbing the public's attention, and that the umbrella and keystone concepts (Simberloff 1998) are generally easy to understand, elegant, intuitive, and sellable. Many aspects of conservation, however, are highly context-dependant. Although the role of large carnivores in conserving biodiversity may be highly relevant in wilderness areas, it becomes much less so in human-modified ecosystems. It is therefore necessary to tailor the message to the individual situation. In other words, there is no "one-size-fits-all" in conservation. Conservation is complex, and we must communicate this complexity to the public. The fact that in many areas the conservation of large charismatic carnivores may have very little impact on the rest of the biodiversity implies that we cannot use "scientific" arguments for their conservation. In fact,

there is a need for more honesty about the roles of science in conservation. Science is a provider of information and a tool for conservation, and scientists as individuals can be powerful and eloquent advocates for conservation. However, science cannot substitute for choices among values (Lackey 1998). This implies that the role of values in motivating the conservation of biodiversity in all its forms needs to be made much clearer (Collar 2003; Jepson and Canney 2003). A further consequence is that we need to tolerate a wide range of conservation philosophies, especially in how these place people with respect to nature.

Summary

Conserving large carnivores alone will not be enough to save the species diversity of Europe. Reciprocally, strategies aimed at conserving other endangered species through the creation of a system of reserves will not always be adequate for conserving large carnivores. However, an effective synergy could be produced by combining these two approaches into an overall concept where large carnivores are used as umbrellas to conserve a connected matrix of seminatural habitat within which a series of specially managed habitats and reserves can be embedded. Although large carnivore populations are recovering throughout Europe, and processes such as predation, predation avoidance, and scavenging have resumed, it is unlikely that they will ever recover to the stage where trophic interactions are the major determinant of abundance for either carnivores or their prey. The influence of humans is just too strong in Europe to allow a return to a "natural" system. However, this should not necessarily be viewed as a problem, because European visions of nature do not divorce humans from nature. Rather, the continentwide conservation ethic that is emerging is to integrate as much biodiversity into our lives as possible. Rather than creating high contrasts between reserves and intensive use, Europe is trying to minimize the gradients. The future path is not a return to the nostalgia of the Garden of Eden at noon on the sixth day of creation (after the creation of the fish, birds, and beasts, but before humans arrived on the scene), but a test of our ability to share a crowded continent with other species. It is clear that human activity is, and has been for millennia, the major selective force in all European ecosystems, and that this is unlikely to change. What

we can hope is that we can find ways to integrate humans into ongoing evolutionary processes (Barry and Oelschlaeger 1996). In this context, large carnivores have two main functions. First, they can put some of the wild back into our lives, and second they remind us that biodiversity consists of dynamic processes and interactions as well as species diversity.

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