



Conservation of biodiversity in Scandinavian boreal forests: large carnivores as flagships, umbrellas, indicators, or keystones?

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Abstract. Large carnivores are often used as focal species (indicators, umbrellas, flagships or keystones) in conservation strategies either aimed at conserving carnivores, the rest of the biodiversity that occupies their habitats, or both. We evaluate their suitability for these roles in the context of boreal forest biodiversity conservation in the multi-use landscapes of Scandinavia. The enormous conflicts, especially with livestock, that carnivores cause in these areas makes them very controversial flagships to the extent that it may affect rural people's attitudes to conservation in general. Because of the broad habitat tolerance of large carnivores and their prey, and the difficulties in surveying carnivore numbers, they are very insensitive and impractical indicators of forest biodiversity. This ability of large carnivores to thrive in industrial forests means that the many species that are sensitive to modern forestry will not fall under the umbrella of areas managed for large carnivores. If large carnivores have a keystone function with respect to affecting the density of their ungulate prey it is likely to lead to even further conflicts with hunters who gain economic benefit from harvesting wild ungulates. In other words, none of the classic 'ecological' arguments are likely to help justify large carnivore conservation, and large carnivore conservation is unlikely to help conserve the rest of the boreal forest's biodiversity. Based on these arguments we recommend that (1) justification for large carnivore conservation focus on the real philosophical and value orientated reasons rather than ecological justifications, (2) that this conservation should be brought about in practice by dedicated management programs that specifically address the conflicts caused by large carnivores, and (3) that boreal forest biodiversity is best conserved by specific actions designed to establish reserves or change forestry practices.

Key words: biodiversity, boreal forest, carnivore, conservation

Introduction

The application of the discipline of conservation biology to real world situations has as much to do with public relations and politics as science (Warren et al. 1990). In order to communicate often complex information to lay-people, conservationists have recognised that there is a need to develop clear 'sales strategies' that capture the public's imagination. Two strategies are commonly used. The first strategy focuses on a single charismatic focal-species with which the public can become

emotionally engaged, epitomised by the ‘Save the tiger’, ‘Save the panda’, or other large carnivore-orientated campaigns (Seidensticker 1997). The second strategy focuses on biodiversity and the staggering diversity and complexity of life, for example that found in the tropical rain forests. In response to a change in emphasis from single species to ecosystem research (Estes 1996), there have been many attempts to connect, and scientifically justify the connection of, the two strategies. Various claims are made that charismatic species (such as large carnivores) can act as important flagships, umbrellas or indicators (sensu Simberloff 1998; Caro and O’Doherty 1999; Table 1) for the conservation of the rest of the biodiversity, or even that some are vital keystone species for ecosystem function (Estes 1996; Noss et al. 1996; Simberloff 1998). As a result various arguments are made that either (1) if large carnivores are conserved, the rest of the biodiversity within their habitat will automatically be conserved, or (2) it is necessary to conserve large carnivores because they are useful indicators or because they are vital for ecosystem function.

Major conservation debates are currently underway in Scandinavia concerning both large carnivores (Swenson et al. 1998; Andersen and Swenson 1999) and boreal forest biodiversity in general (Essen et al. 1992). Scandinavia’s boreal forests (300 000 km² in Norway and Sweden) are among the most intensively exploited forests in the world, with less than 5% virgin forest left standing. Naturally reseeded or replanted stands are clear-cut on a 70–80 year cycle using a highly mechanised system and a dense network of forest roads. Hunting for wild ungulates is a very widespread, but carefully regulated, activity (Cederlund and Bergström 1996). Other recreational and commercial uses include small game hunting, mushroom, berry and lichen picking, and grazing of domestic sheep and semi-domestic reindeer (*Rangifer tarandus*). The affect of such use on biodiversity has been the subject of a large amount of research in the last decade (Essen et al. 1992; Hörnberg et al. 1998). Following protection and better regulation of harvest, populations of wolf (*Canis lupus*), brown bear (*Ursus arctos*) and Eurasian lynx (*Lynx lynx*) have increased during the

Table 1. Explanations of the terms indicator species, umbrella species, flagship species and keystone species.

Concept	Explanation	Reference
Indicator	“An organism whose characteristics (presence or absence, population density, dispersion, reproductive success) are used as an index of attributes too difficult, inconvenient, or expensive to measure for other species or environmental conditions of interest.” Sub-divided into health, population and biodiversity indicators.	Landres et al. (1998) Caro and O’Doherty (1999)
Umbrella	“...a species that needs such large tracts of habitat that saving it will automatically save many other species.”	Simberloff (1998)
Flagship	“...normally a charismatic large vertebrate, is one that can be used to anchor a conservation campaign because it arouses public interest and sympathy...”	Simberloff (1998)
Keystone	“...certain species have impacts on others, often far beyond what might be expected from a consideration of their biomass or abundance.”	Simberloff (1998)

1990s, and all species are presently the subject of intensive field work in order to increase the knowledge base for their management (Andersen and Swenson 1999). The objective of this essay is to use available knowledge to critically evaluate the possible utility of large carnivores as a means to focus public attention on boreal forest conservation through their potential roles as flagships, umbrellas, indicators or keystones.

When flagships risk sinking in a sea of conflict

Charismatic species like brown bears or tigers (*Panthera tigris*) are often used as flagship species to justify the creation of protected areas, free from human disturbance of habitat, and large enough to maintain populations of the carnivore in question. By definition hundreds, or thousands, of square kilometres of habitat are protected along with their cargo of biodiversity. In this context large carnivores are without equal in their ability to focus public attention and to generate the pressure required for the conservation of biodiversity at the landscape level (Fritts et al. 1994). However, we argue that this is not the case for conservation of boreal forest biodiversity in Scandinavia. In the boreal habitats typical of Scandinavia large carnivore densities tend to be low (range from 0.2–2 per 100 km²) and individual home ranges are large (100–1000 km²) (Linnell et al. 1996). When this scale is considered, there are few, if any, wildernesses or protected areas in Scandinavia or Europe which are large enough to maintain populations of wolves, brown bears, or lynx (Table 2). The few large protected areas that exist tend to include mainly alpine habitats (above the tree line) and are therefore not suitable for large forest carnivores. Therefore the entire large carnivore conservation strategy for Scandinavia (and much of Europe) is based around their integration into human dominated multi-use landscapes.

It is in such landscapes that carnivores come into greatest conflict with humans (Kaczensky 1996). As hunters perceive large carnivores as competitors for ungulates, and sheep farmers and semi-domestic reindeer herders suffer high losses due to depredation events, attitudes among rural people towards large carnivores are often very negative (Bjerke and Reitan 1994; Boitani 1995; Sagør and Aasetre 1996;

Table 2. The sizes of protected areas in Scandinavia and continental Europe. The table includes all IUCN category 1, 2 and 4 areas (strict nature reserves, national parks, and managed nature reserves). Data from the 1993 United Nations list of national parks and protected areas (IUCN 1994). Much of the area of the largest protected areas consists of alpine habitats and is therefore not often suitable habitat for forest carnivores. In addition, at least within Norway, there are many sheep grazing within protected areas so that even these areas are not conflict free.

Region	Number of protected areas within each size range (km ²)			
	100–499	500–999	1000–4999	>5000
Scandinavia	39	13	19	1
Continental Europe	136	38	2	1

Breitenmoser 1998). In Norway, in 1994 alone, compensation was paid for 15 180 sheep and 4200 semi-domestic reindeer that were killed by large carnivores. Even though depredation on sheep can be reduced through improved husbandry methods (Linnell et al. 1996), these require changes in subsidy practices and breaking with recently established 'traditions' (Breitenmoser 1998; Savelli et al. 1998). Under such conditions it does not seem logical to choose a flagship that attracts such polarised and emotional viewpoints. Rejection of large carnivore conservation by rural people may also lead to rejection of all conservation programs. In addition there are many areas where large carnivore recovery will never be practicable but where much other biodiversity can be conserved (Franklin 1993; Stokland 1997). Too great a focus on large carnivores could draw attention away from the value of such sites, or exhaust limited conservation funding.

How wide is a bear's umbrella?

In multi-use environments, each element of ecosystem exploitation requires individual regulation. The decision as to whether large carnivores should be conserved in a given landscape is largely independent from those regarding the regulation of hunting, construction codes, permitted pollution levels, or forestry and agricultural practices. Conservation of carnivores generally only requires a prey base and protection, or at least a careful regulation of their harvest (Fritts et al. 1994). This requires large areas of at least semi-natural, but not pristine, habitat as the wild ungulates on which large carnivores depend have shown great adaptability with respect to human modified landscapes (Cederlund and Bergström 1996). If such areas are available for carnivores, it is not automatic that other threatened components of biodiversity like birds, amphibians, lichens, arthropods, insects, fungi or bryophytes fall under the carnivore's umbrella (Berg et al. 1994, 1995; Sjöberg 1996; Niemelä 1997; Rydin et al. 1997; Thor 1998). Many of these species have very subtle habitat requirements as regards micro-climate, fire/disturbance regime, and the availability of dead wood and other substrates, which will not be met by semi-natural habitats (Hörnberg et al. 1998; Jonsell et al. 1998). There are only a few patches of old-growth forest larger than a few square kilometres remaining in Scandinavia as a result of modern forestry (Essen et al. 1992; Stokland 1997). The main threats to boreal forest diversity are suppression of natural fire cycles, drainage, and forest-cutting practices (Esseen et al. 1992; Hörnberg et al. 1998). None of these issues needs to be considered when specifically planning for large carnivore conservation.

Insensitive and impractical indicators

Despite the intuitive attraction of the indicator species concept, cases studies have highlighted the many conceptual and practical problems with their application (Niemi et al. 1997; Caro and O'Doherty 1999; Lindenmayer 1999). Large carnivores are

Table 3. The main prey species of Eurasian lynx, brown bear and wolf in Scandinavia, and the effect of modern forestry practices on these prey groups. '+' indicates a positive effect, '0' indicates a neutral effect, and '-' a negative effect.

Species	Main diet components and the effect of forestry	References
Lynx	Roe deer (+), hares (+/0), forest tetranoids (-/0)	1, 2, 3, 4
Brown bear	Berries (0), moose (+), <i>Camponotus</i> ants (+)	5, 6, 7, 8, 10
Wolf	Moose (+), roe deer (+)	9, 2, 7

1. Linnell et al. (1996), 2. Jedrzejewska et al. (1994), 3. Sjögren (1996), 4. Swenson and Angelstam (1993), 5. Dahle et al. (1998), 6. Kardell and Eriksson (1990), 7. Cederlund and Bergström (1996), 8. Rolstad et al. (1998), 9. Olsson et al. (1997), 10. Swenson et al. (1999).

not an exception. The three species of large carnivore most commonly found in Scandinavian forests, lynx, wolf, and brown bear, are all habitat generalists, with wide geographic distributions and broad niches (Fuller and Kittredge 1996). Their main prey species are generally not greatly affected by, or may even benefit from, modern forestry (Table 3). For example, in western Sweden where some of the world's most intensive forestry is practiced (Essen et al. 1992), brown bears have a higher population growth rate than elsewhere (Sæther et al. 1998), at least in part because two of their important prey species, moose (*Alces alces*) and ants, (Dahle et al. 1998; Swenson et al. 1999), benefit from modern forestry practices. In a recent government white paper on carnivore management in Norway (Anon 1997) no mention is made of any habitat related issues – all attention is directed to conflict reduction. As such, these large carnivores do not make good indicators, as most sensitive species of conservation importance could go extinct following land management practices that would actually favour large carnivores and their prey. Similar results have also been found for raptors in Mexico (Rodríguez-Estrella et al. 1998), where many raptor species actually showed positive association with human modified landscapes. Finally, large carnivores occur at such low densities that monitoring their numbers with any degree of accuracy is likely to be much more time consuming and costly (Linnell et al. 1998) than monitoring some of the more sensitive species of conservation interest, like birds, lichens or insects (Jansson 1998; Landres et al. 1988; Thor 1998).

Unwelcome keystones

Simberloff (1998) has proposed that the concept of keystone species could be used more in conservation contexts when looking for a focal species. There is no doubt that large carnivores may influence numbers of both other carnivores and of prey species and therefore have some keystone functions, although the extent and nature of the relationship is still unclear despite decades of research (Skogland 1991; Wright et al. 1994; Linnell et al. 1995; Mech 1996; Palomares and Caro 1999). Among the many arguments advanced by conservation advocates is that large carnivore recovery will result in ungulate populations being 'more in balance with their environment'.

This point of view may be valid for wilderness conservation programs, where ecosystem integrity is often a stated goal. However, in Scandinavia the harvest of wild ungulates like moose and roe deer (*Capreolus capreolus*) is regarded as being both an important recreational activity and a substantial source of income for forest owners (Cederlund and Bergström 1996; Andersen and Swenson 1999). Most rural people in Scandinavia are therefore very happy with their presently 'unbalanced' environment where ungulate densities are artificially high (Cederlund and Bergström 1996), and will definitely not welcome any potential reduction in their density. Therefore the concept of large carnivores as possible keystones will not make them any easier to 'sell' to the rural public of Scandinavia.

Large carnivores and the rest of the forest's biodiversity

Whereas the image of a bear, wolf or lynx silently roaming the moonlit boreal forest may be a good image to sell a conservation program for a large forest reserve to politicians and the urban public, these large-carnivores would probably not be greatly affected, and may even benefit, if the whole forest was turned into a mosaic of even aged stands, plantations and clear cuts. A vast number of less charismatic smaller species of vertebrates, invertebrates, plants and lichen would be affected, possibly to the point of extinction. Although we do not dispute the importance of large carnivores to natural ecosystem function, their value as symbols of changing public attitudes, and their intrinsic value (Terborgh 1988; Estes 1996), we feel it is necessary to remove some the complacency that often results in 'protect the big species and the rest follow' statements. We also believe that any remaining romantic illusions about large carnivore conservation needs to be removed in the face of the conflicts that arise in our far from natural multi-use landscapes (Mech 1995; Kaczensky 1996; Breitenmoser 1998), and that we need to honestly focus on the true reasons for conservation (often philosophical), rather than expounding pseudo-ecological arguments (Warren et al. 1990). Conservation of the vast majority of the species that make up boreal forest diversity is likely to obtain little benefit from coupling to large carnivore issues – the scales are simply too different.

The true reasons to conserve large carnivores

So, when large carnivores are conflict-full flagships, leaky umbrellas and insensitive indicators, and their keystone role is uncertain or at best a source of further conflict, why should we single them out for such attention, or indeed conserve them at all in areas where conflict can arise? Proximately, the long term survival of virtually all carnivore populations is dependent on areas outside protected reserves to ensure contact between protected populations, and to increase the area of available habitat to support as large populations as possible. Especially in the Scandinavian context where there are no alternative wilderness areas there is therefore little choice but to

conserve carnivores in suitable multi-use landscapes. The ultimate reasons why we should conserve carnivores at all in such landscapes are clearly subjective, based on personal or social ethics, and our perception of what is right and wrong with respect to human interactions with the natural world (Hunter and Hutchinson 1994; Boitani 1995; Breitenmoser 1998). It is our personal view that large carnivores are best regarded, and marketed, as symbols of human indulgence, a 'luxury item' that we want to, and can, afford to conserve in the boreal forest for a host of moral, ethical and emotional reasons (Schaller 1996).

Interestingly it is similar reasoning that has led Scandinavia and Europe into a situation whereby vast amounts of money are spent on subsidy to unprofitable agriculture and regional development – which are also the main barriers to carnivore conservation (Savelli et al. 1998). As a result large carnivore populations are far higher, and public attitudes more positive, in Sweden (where agricultural subsidy, and therefore low intensity farming, is much less) than in Norway (Swenson et al. 1995; Andersen and Swenson 1999). In the same way that the closing of the last mountain farmers barn door would be perceived by many as a sad moment, so would the day that the last wolf howled, or the last bear dug its winter den. The irony of two partners in conflict being dependent on subjective judgement of values is extreme. While Kay (1997) is rightly sceptical about the value of ethics in driving environmental protection, there can be no doubt as to how far public opinion has changed in favour of carnivore conservation during recent decades (Mech 1995, 1996). Although this change has been slower in rural areas where conservation must occur, the process must be planned for over long time periods, possibly generations (Breitenmoser 1998). In truth we may never be able to convince all of the present generation of rural people that conserving large carnivores is philosophically 'right'. However, there are some success stories which give ground for hope, when, and only when, conflicts can be prevented (Marker-Kraus et al. 1996).

The way forward

In the previous sections we have argued against both the use of some familiar justifications and methods used for motivating carnivore conservation. What approaches can take their place? Once the philosophical decision to conserve large carnivores within a given landscape has been made, the emphasis for conservation biologists needs to be on the practical and economical measures required to ensure protection, reduce conflicts, and make human–carnivore coexistence as peaceful as possible (Boman 1995; Fuller and Kittridge 1996; Linnell et al. 1996; Sagør et al. 1997). In other words, carnivore conservation in Scandinavia is so especially filled with specific problems (scale of movements, high conflicts etc.) that it requires special conservation planning, and cannot ride on the back of, or carry, other conservation initiatives. To fulfil these special requirements network groups like the WWF backed Large Carnivore Initiative for Europe (Schröder 1998) have been formed to facilitate the exchange

of the necessary knowledge from country to country and from scientist to manager to conservationist. Destroying the myth that large carnivores require/are indicators of pristine wilderness may at first glance seem to harm the cause of large carnivore conservation. However, we believe that it is actually good news for large carnivore conservation as there is virtually no pristine forest left in Scandinavia or continental Europe today (Angelstam et al. 1997; Schröder 1998). This recognition allows effort to be focused on non-wilderness settings where carnivores can actually be conserved, and on the conflict-reduction which is needed to achieve some form of co-existence.

And what about the rest of the boreal forest's biodiversity? Removing the false security of a leaky umbrella exposes the real problems facing boreal forest biodiversity – that of forestry and other land use practices. Only by concentrating directly on the real threats can any solutions ever be achieved. If indicators are desired it is likely that practical candidates can be found from among the smaller carnivore species or from other vertebrate, invertebrate, plant or lichen life forms. Many of these species are likely to be easier to survey and display greater sensitivity to environmental change. If a large vertebrate is needed to serve as an umbrella or flagship, or to be regarded as a keystone, we suggest that a boreal forest ungulate (Hanley 1993) such as the moose should be considered (Crichton 1998). They have large area requirements, have effects on other forest biodiversity (Crichton 1998; Suominen et al. 1999), have a high cultural profile, and because of their high economic value to hunters, are not associated with such extreme conflicts.

Do these results from Scandinavia apply elsewhere?

Although we have specifically addressed the situation in Scandinavia, an area with which we have experience, it would appear that our results apply to the rest of continental Europe. As in Scandinavia, large carnivore conservation in Europe will mainly occur in human-modified multi-use landscapes (Schröder 1998) where conflicts can occur, and specific land use controls will be needed to achieve specific conservation objectives. The prey base required for large carnivores will be just as able to survive in human-modified landscapes in continental Europe as in Scandinavia (Jedrzejska et al. 1994; Mech 1995). Although conflicts are not so severe in Europe as in Scandinavia in terms of the numbers of livestock killed (Kaczensky 1996), large carnivores are still able to generate polarised debate, and many people in rural areas have strong negative attitudes (Breitenmoser 1998). Against this background we feel that the reservations we have expressed concerning the conservation of large carnivores and other forest biodiversity can be extended from Scandinavia to other regions with two exceptions. One possible exception exists in terms of using large carnivores as a flagship species to maintain connectivity between forest patches. Fragmentation of forest patches in a matrix of non-forest habitat is a far greater problem in continental Europe than in Scandinavia, as is the construction of linear barriers such as highways. This fragmentation causes problems for large carnivores (e.g. Kaczensky et al. 1996).

so that they make suitable flagships for maintaining connectivity, or at least mitigating some of the effects of infrastructure development. Secondly, home range sizes of all three large carnivore species are far smaller in central and southern Europe than in Scandinavia (Linnell et al. 1996). This means that protected areas may be able to play a greater role in large carnivore conservation in southern regions. Therefore there may be a potential to use large carnivores as flagships for specific protected areas. However given the relatively small size of European protected areas (the chances of individuals leaving the protected areas are high) and the fact that livestock grazing (and therefore conflict potential) is widespread in many European protected areas, there is every chance that this focus on carnivores will still lead to damaging conflicts.

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