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Management and conservation of large mammals in the Bavarian Forest National Park

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Abstract
The Bavarian Forest National Park is a part of the Greater Bohemian Forest Ecosystem, which is the largest strictly protected contiguous forest expanse in Central Europe. Therefore, the region is of exceptional importance for the protection of large wildlife species. The preservation of large faunal elements in a landscape is not only decisive to assure the completeness of the respective biocenosis; it is necessary because of their function as vectors of important processes that significantly influence the development of forest ecosystems and ultimately contribute to increased biodiversity. In the article, the main goals for wildlife management in the National Park are described: (1) native species are to be preserved as wildlife and as agents of natural dynamic processes, (2) wild animal populations should not be affected by human activity, (3) wildlife visibility and experiences are to be promoted for the enjoyment of visitors to the National Park, (4) the natural species diversity of flora and fauna are to be preserved, (5) privately owned forests and private property that border the National Park must be protected from damages caused by wildlife. Also, wildlife management measures, such as population control, reduction of disturbances by guiding public access, reduction of winter feeding, damage prevention, coordination with the National Park's neighbours, and improvement of the acceptance for wildlife in areas surrounding the park are presented in general and specifically for the following species: red deer, roe deer, wild boar, lynx, and wolf. Finally, perspectives for the further development of wildlife management in the park are discussed.

Key words: red deer, *Cervus elaphus*, roe deer, *Capreolus capreolus*, wild boar, *Sus scrofa*, wolf, *Canis lupus*, Eurasian lynx, *Lynx lynx*, wildlife management, protected area management

Introduction

The Bavarian Forest National Park was established in 1970 as the first national park in Germany. With this accomplishment, the state of Bavaria provided protection for a unique forest and mountain landscape on the international frontier bordering the Czech Republic. Since its expansion in 1997, the protected area now covers an area of more than 240 km². Nearly the entire extent of the National Park is covered with vast forests that have been allowed to develop according to an unprecedented concept that excludes human interference. This ensures the expression of natural environmental forces and the undisturbed dynamics of the area's natural communities. Because of the emphasis on conservation goals, the Bavarian Forest National Park was also the first area in Germany to achieve international recognition. It is now adjoined directly on the Czech side of the international frontier by the Šumava National Park, with an area of 690 km². In addition, these protected entities are embedded within the Bavarian Forest Nature Park (3,070 km²) and the Šumava Protected Landscape Area (1,000 km²). The entire complex is referred to as the "Greater Bohemian Forest Ecosystem".

The Greater Bohemian Forest Ecosystem is the largest strictly protected contiguous forest expanse in Central Europe. Entire tracts of forest are the property of the Bavarian state or the Czech Republic. The density of human habitation is very low compared to elsewhere in Europe. In the core areas, it is less than 30 inhabitants per km²; at the margins it is approximately 70. Due to these factors, the region is of exceptional importance for the protection of large wildlife species. This is indicated by the occurrence of lynx (*Lynx lynx*), wolf (*Canis lupus*), red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), moose (*Alces alces*), river otter (*Lutra lutra*), ural owl (*Strix uralensis*), capercaillie (*Tetrao urogallus*), black grouse (*Lyrurus tetrix*), and hazel grouse (*Tetrastes bonasia*). Because of its size and its location between the Carpathians and the Alps, the Greater Bohemian Forest Ecosystem also fulfils an important function as a stepping stone within the European habitat complex system.

According to the definition of the International Union for the Conservation of Nature (IUCN), protection of the unaltered processes is – beside species protection – the most important purpose of national parks. This is confirmed in the action plan for protected areas in Europe (IUCN 1994). Consequently, the preservation of large animals in a natural setting is necessary, especially because of their function as vectors of important processes that significantly influence the development of forest ecosystems and ultimately contribute to increased biodiversity. Therefore, the presence of large faunal elements in a landscape is not only decisive to assure the completeness of the respective biocenosis; it also has an emergent effect on the ecosystem itself (Gill et al. 1995; Fuller & Gill 2001; Gill & Beardall 2001; Russell et al. 2001; Selva et al. 2003; Schütz et al. 2003; Gill 2006). Accordingly, through its wildlife management activity, the National Park administration has a profound – albeit sometimes indirect – influence on the natural processes that ultimately determine forest development. In order to avoid the potential negative effects of such policy, the designated goals of the National Park require that human manipulation of the populations of large herbivores should be reduced to a minimum. This will provide the natural dynamics of the system with more room to unfold.

While it is possible to protect the smaller animal species, with their smaller territorial demands, within the limits of the national parks, larger animals cannot be preserved in the national parks alone. This is especially true for animals that undertake seasonal migrations or that range over extremely large territories. An essential prerequisite for the preservation of large animals and the processes they promote, therefore, is an effective cooperation between park administrators and the various interest groups active in the vicinity of the protected areas (ecosystem approach).

In this article, we describe first the preconditions and goals for the management of large mammals in the Bavarian Forest National Park. Second, we discuss the management measures in general and in detail for the species, red deer, roe deer, wild boar, Eurasian lynx, and wolf. Finally, the perspectives for wildlife management are presented and discussed.

General conditions

Although the Bavarian Forest National Park, with an area of 24,250 ha, is one of the largest forest national parks in Central Europe, its configuration (with a length of 40 km and a width of only 6 km) and elevation (nearly one third of the area is over 1000 m above sea level) predetermine that it cannot function as a complete annual habitat for large indigenous mammal species. For the majority of these animals, most of the area of the National Park can only serve as a summer range. In winter, when snow at the crest accumulates to depths of up to 3 metres, the animals would normally migrate to the lower elevations and to the more cli-

matically favoured surroundings of the National Park to spend the season. Since the true natural winter ranges of red deer lie outside of what has been legally designated as red deer territory, the species cannot be allowed to migrate into the respective lowland areas (Heurich & Neufanger 2004).

In the course of recent centuries, human activity has had a decisive influence on the occurrences of the various wildlife species. Wild ungulates that originally inhabited the Bavarian Forest, such as red deer, moose and European bison (*Bison bonasus*), were extirpated, while others, such as roe deer, red deer, and wild boar (*Sus scrofa*) were promoted, either by management as wild game, or indirectly through improved foraging conditions, which resulted from changes in land management (Wotschikowsky 1984). In addition, a number of non-native wild ungulates, such as fallow deer (*Dama dama*), sika deer (*Cervus nippon*), and mouflon (*Ovis musimon*), that have been introduced as game or have occasionally escaped from enclosures now also occur in the vicinity of the National Park. Even greater than the changes that took place among the large herbivores were those in the species assemblage of large carnivores. Bear, wolf, and lynx had already been exterminated by the mid 19th century (Festetics 1980). It was not until the 1990s that the lynx returned from areas in the Czech Republic and has begun to contribute again to the natural regulation of the wild ungulate species (Červený & Bufka 1996). At long intervals, there have been repeated indications of individual wolves (Bufka et al. 2005). On the whole, however, the natural regulation of red deer and wild boar by predators remains insufficient.

Before establishment of the National Park, forest use led to extensive alterations in structure and tree species distribution. One of the most remarkable aspects was the reduction of silver fir (*Abies alba*) from 30% at the onset of regulated forest management in the mid nineteenth century to only 3% today (Heurich & Engelmeier 2010). This was accompanied by the simultaneous and gradual transformation of the ancient, nearly primeval, mixed montane forests, which had still covered approximately 14,000 ha in 1900, into stands of same-aged, economically managed forest (Plochmann 1961). Since the middle of the 1990s, forest development in the National Park has been affected by the results of a massive bark beetle (*Ips typographus*) infestation. In the mean time, older spruce stands have died off over an area of almost 6,000 ha (Heurich & Jehl 2000). This progression has been advantageous in regard to food availability for herbivores, since a major proportion of the nutrient production can now take place on the forest floor (Heurich & Neufanger 2005).

Another key to the understanding of the current wildlife management program in the National Park is its enlargement in 1997. The addition of the so-called Falkenstein-Rachel Region increased the size of the park by another 10,685 ha. While in the older section of the National Park (so called Rachel-Lusen-Region), 70% of the total area had already been designated as a "nature zone", this status applied to only 26% of the Falkenstein-Rachel Region. Accordingly, the larger proportion of the Falkenstein-Rachel Region is still categorized as a transitional zone, which is to be gradually developed into a nature zone over a 30 year period that will end in 2027. During this transition period, silvicultural practices, such as pest control for the spruce bark beetle and planting of mixed tree species within pure spruce stands will be allowed. For this reason, wildlife management will be handled differently in either area.

One of the supervisory functions of the National Park administration is that of a "lower hunting agency" (county-level government). The park is also a member of the "Hochwildhegegemeinschaft Bayerischer Wald" (Bavarian Forest Association for the Management of "Hochwild" = animals that, historically, were reserved for nobility), which is responsible for the coordination of red deer hunting in the Bavarian part of the Greater Bohemian Forest Ecosystem.

Wildlife management goals

The wildlife management goals for the National Park are manifested in the National Park Plan, especially in the appendices "Species Protection" and "Wild Ungulate Management", which are in accordance to the IUCN Management Guidelines for protected areas (IUCN 1994). These are summarised below.

(1) Native species are to be preserved as wildlife and as agents of natural dynamic processes.

The primary goal of wildlife management in the National Park is to preserve sustainable populations of the native species, red deer, roe deer, red deer, wild boar, and lynx as components of the natural species assemblage and to take preparatory measures to promote acceptance for the return of the wolf. An essential aspect of this species protection mandate is to maintain the character of the species as wild animals (evolution, migration, density fluctuations, effects of factors leading to natural mortality, and behaviour).

(2) Wild animal populations should not be affected by human activity.

The goal is to leave nature to its own means and to ensure that the influences of natural environmental factors and the uninhibited dynamics of the natural communities will be allowed to take their course. This includes acceptance of natural predator-prey relationships and of wildlife migrations, as well as acceptance of the effects that bark peeling and browsing have on trees. For this reason, absolutely no management measures should be undertaken in at least 75% of the area of the National Park. Even in the remainder of the area, wildlife management is to be kept to a minimum; e.g., in order to achieve the above stated goals, the method will be chosen that involves the least amount of intervention in natural processes. This approach will increase the natural character of the conditions for the existence of wildlife and of the entire ecosystem of the National Park.

(3) Wildlife visibility and experiences are to be promoted for the enjoyment of visitors to the National Park.

In contrast to the animals in many national parks in other continents, most wildlife in Central Europe is extremely timid and is only rarely experienced in their natural environment by humans. This behaviour is primarily a result of game hunting. The fear of humans, which is increased by the killing of members of the various species, has led to the avoidance not only of hunters, but of humans in general (Sauerwein et al. 2004; Benhaiem et al. 2008). Management is to be carried out so that visitors will be able to observe and experience wild animals exhibiting their natural behaviour.

(4) Preservation of the natural species diversity of flora and fauna.

The effects of wild ungulates in a national park are not regarded as "damage", as they would be in an economically managed forest, but are considered part of a process that enhances the natural character of the ecosystem. Besides assumed destructive habits, such as browsing and bark peeling, wildlife has unequivocal positive effects on biodiversity, such as, zoochory (Brathen 2007; Bruun & Poschlod 2006), nutrient translocation (Schütz et al. 2006; Steinauer 1997), trophic functions for necro- and coprophagous species (Sikes 1994; Selva 2004), and structural diversity (Hester et al. 2006; Gill & Fuller 2007). Similar to the important function of deadwood as habitat for xylobiotic species, numerous other species are also dependent on the presence of large animals. On the other hand, large wild ungulate populations can also have negative effects on individual animal and plant species. Anthro-

pogenically induced, high wildlife densities are especially responsible for the detrimental effects on the regeneration of trees that are highly susceptible to browsing, such as fir, valuable hardwoods, and yew (Ammer 1996; Motta 2003). If browsing is so intense as to threaten stands of these tree species, there may be some justification for imposing management or regulatory measures.

(5) Protection of privately owned forests and private property that border the National Park from damages caused by wildlife.

Since national parks do not pursue economic goals, the results of certain behaviour attributed to wild animals are generally not regarded as "damage" in the National Park. However, the forests and agricultural properties that adjoin the National Park are managed for economic gain. Therefore, the National Park administration is determined to institute appropriate measures to prevent negative impacts to conventional forestry and agricultural use (e.g., by browsing and bark stripping) in areas in the vicinity of the National Park. This is especially important in regard to browsing damage and damage to animal husbandry.

Wildlife management measures

The above-mentioned goals are co-ordinated in an integrative manner with each other as well as with the other protection goals and responsibilities of the National Park. Currently, the goals prescribe active forms of wildlife management, which are composed of the following modules.

(a) Control of wildlife populations

One of the first questions here is: according to which criteria should regulatory measures be determined? How can problems be solved in the face of the prevalent basic conditions (i.e., fractured habitat ranges, lack of predation), when it is not even possible to acquire a satisfactory census of the animals to be controlled? Furthermore, it is difficult to define the desired overall natural population density when the populations are normally subject to spatial as well as temporal fluctuations. The very low densities in heavily shaded old forest stands are just as natural as the high densities of the sun exposed, storm damaged areas. Determination of a numerically uniform natural wildlife density is, therefore, neither possible nor realistic. Until now, wildlife management in the National Park is based on the same criteria as those used in all other state owned forests: primarily on the amount of browsing damage caused to economically significant tree species. The problematic aspects of this approach are similar to those for natural wildlife densities since the effects of browsing are also subject to spatial and temporal fluctuations (Sato & Iwasa 1993; Yokozawa et al. 1999; Sage et al. 2003). Phases with low browsing intensity are just as natural as phases with greater browsing intensity. According to our current knowledge, it is just as impossible to determine a level of "natural browsing intensity" as it is to determine the natural wildlife population density (Scherzinger 1996). Since browsing intensity was very low in the past several years, control quotas have been based primarily on the goal to avoid damages on adjacent private property (Fig. 1).

According to §13 Section 2 of the National Park Ordinance (NP-VPO), required population control measures are carried out by personnel of the National Park Administration, primarily by the park's game wardens. Outside hunters are not permitted to hunt in the National Park. The primary methods of wild ungulate control are killing of individuals, control of red deer in the winter enclosures, and the use of traps for wild boar. The use of feeding material to lure animals for control measures (=Kirrjagd) is currently practised in the Falkenstein-Rachel-Region of the National Park.

In order to keep disturbances at a minimum, control measures are limited in time and space. The control of the native wild ungulate species is restricted to the legal hunting seasons and is generally limited to the period between September 1 and January 31 at the latest.
At the same time, these measures are meant to be:
- practised preferably outside of the limits of the National Park, or at least only in its buffer zone,
- absolutely limited to the lowest necessary scale,
- carried out with the least possible amount of disturbance, in a species-appropriate manner, using methods that are adapted to natural processes.

(b) Large-scale abandonment of wildlife control

Wildlife control measures are undertaken only in the buffer zone and in the development zone of the National Park. As a result, the animals in the core area, public access and recreation zones, and nature conservation zones of the National Park do not experience hunting pressure. The current extent of the zone that is released from control measures is shown in Fig. 1. It encompasses an area of 17,000 ha (71% of the present total area of the National Park).

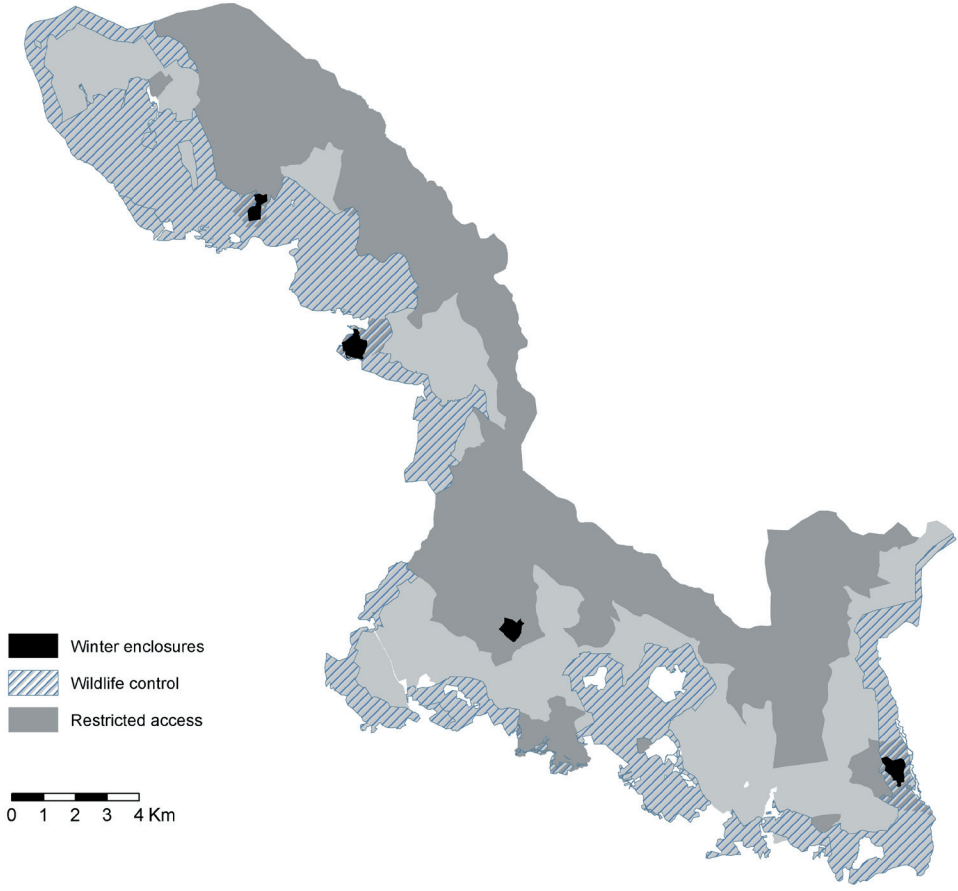

Fig. 1. Map of the wildlife management areas in the Bavarian Forest National Park.

(c) Reduction of disturbances by guiding public access

Disturbances caused by ecotourism, such as hiking, ski-touring, and snow shoeing during the winter season, have some of the most serious impacts on the behaviour and physical constitution of wildlife (Schultz & Bailey 1978; Knight & Gutzwiller 1995). For this reason, a number of legal regulations were implemented to protect the wildlife species and avoid unnecessary disturbances (National Park Ordinance, Public Access Ordinance, Wildlife Protection Ordinance). The provision that, especially within the core zone, during the time period between November 16 and July 14, only specifically marked paths are to be used and that they must be kept to even in the summer months, has contributed to a qualitative improvement of wildlife habitat. The regulations are enforced by the park rangers and the game wardens. The National Park administration exerts additional influence on visitor behaviour by using positive incentives (signage, educational plaques, and information on the needs of wildlife).

(d) Reduction of winter feeding

Between 1970 and 1985, the approximately 40 wildlife feeding stations in the Rachel-Lusen Region were closed and removed. In the Falkenstein-Rachel Region, there have been no feeding stations since the expansion of the National Park into that area. On the one hand, this allows winter mortality to exert its influence once again as an important evolutionary factor, and on the other hand – at least for roe deer and wild boar – it allows seasonal migrations to the lowland.

In order to compensate for the effects of the bylaw that restricts the range of red deer so that they are no longer able to migrate to their natural winter habitat, four so called winter enclosures, encompassing 50–60 ha, were installed in the 1970s and early 1990s. The majority of red deer spend the winter in these enclosures where they are fed and where their numbers are controlled. The purpose of this management measure is to simulate the winter absence of the species in the montane forest (Wotschikowsky 1984).

(e) Damage prevention and evaluation of predation

With the return of the lynx and the expected return of the wolf, conflicts have arisen, especially in regard to predation of domestic and wild animals. Through its participation in the "Large Predator Network", the National Park administration is involved in the examination of and compensation for incidents of predation in the environs of the National Park. Furthermore, trained members of the National Park administration are available to advise the owners of pastures and animal enclosures on appropriate damage prevention measures (Breitenmoser et al. 2005).

(f) Coordination with the National Park's neighbours and the Šumava National Park

The extensive ranges and seasonal migrations of wildlife species result in complex interactions between the National Park and its surroundings. In addition, the removal of the boundary fence between Bavaria and the Czech Republic in the spring of 1990 and the establishment of the Šumava National Park provided new opportunities for international cooperation. The very deep winter snows that usually accumulate in the montane forest ecosystems of the National Park stimulate the migration of the animals to lower elevations that are partly beyond the limits of the National Park. Because of this phenomenon, it has become necessary to coordinate the management of wild ungulates in general – and red deer in particular – with the National Park's neighbours, including the Šumava National Park. Within Bavaria, this is accomplished through the framework of the "Hochwildhegegemeinschaft Bayerischer

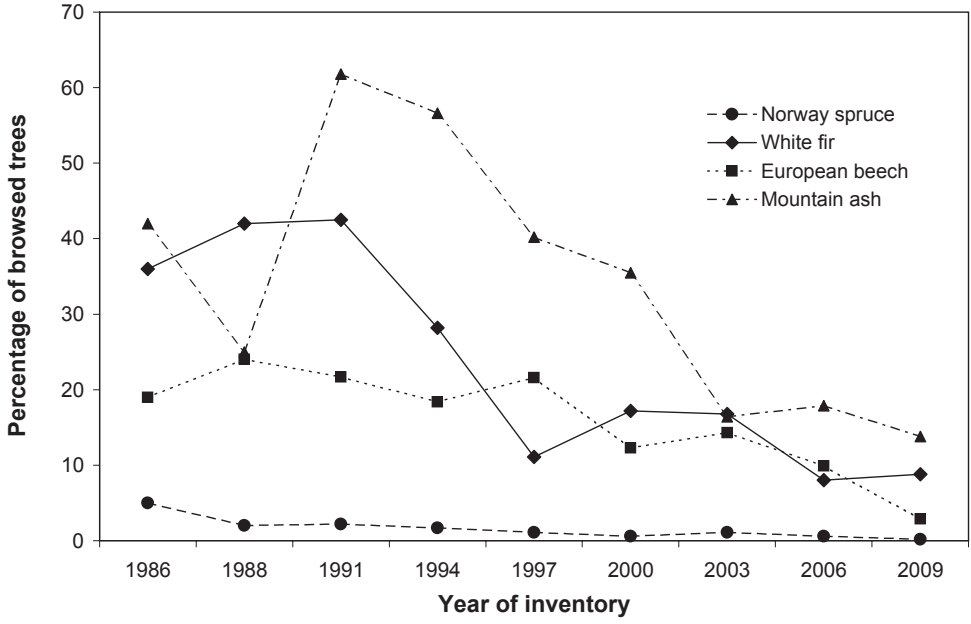

Fig. 2. Development of terminal shoot browsing intensity between 1986 and 2009 in the Rachel-Lusen Region (Source: Vegetation survey 1986 to 2009).

Wald". Coordination with the Šumava National Park is realised according to the so called memorandum process of 31 August 1999. The memorandum is a document signed by the ministers of each country and it regulates the cooperation between the two National Park Administrations.

An attempt to organise a "Round Table" for coordinating wildlife management in the National Park surroundings that would have involved various special interest groups (hunters, foresters, farmers, and nature conservationists) failed due to the resistance of fractions within the respective interest groups against a moderated discussion with the National Park Administration.

(g) Improving the acceptance for wildlife by the National Park's neighbours

A key element in the protection and management of large animals – as in national park management in general – is acceptance, especially by the land users surrounding the protected areas (Witter & Jahn 1998). For this reason, the educational and informational efforts of the National Park should promote discussion about wildlife and point out its value. The local population should be able to experience wildlife species as typical, native animals of high ecological and socio-cultural value that enrich the native landscape. In the past four years, public relations events have included 102 presentations and 78 group excursions. In addition, there have been red deer, wolf, and lynx days held as special events in the information centres and in co-operation with the local communities. With the support of T-mobile, a wildlife website on wildlife protection and research in the Greater Bohemian Forest Ecosystem has been made available in three languages (www.luchserleben.de). The site is maintained in co-operation with the Czech colleagues. An intensive presence in the media has also been pursued with 75 articles presented to the press and 17 features in television and radio.

(h) Complementing wildlife management with biological research

In recent years, the meaning of science as a foundation for making successful management decisions for natural resources has increased considerably (Wright 1992; White et al. 2009). The purpose of wildlife biological research is to document wild ungulate ecology and management and the effects on the flora and fauna of the National Park and the surrounding areas (Fig.2). The National Park administration's wildlife biological monitoring programme comprises several modules, including surveys on the development of the vegetation and of browsing intensity, population studies on lynx, wolf, roe deer, red deer, and moose (in the Czech Republic), and studies on the spatial and temporal relationships between red deer, roe deer, and lynx by means of satellite telemetry (Heurich et al. 2007). The outcome of this research will play a major role in the wildlife management decision-making process.

The individual wildlife species

Red deer

Before establishment of the park, a high red deer population was the goal of the forest service, in order to harvest trophy stags. Since the establishment of the park, numbers were reduced significantly and were kept at a low level through population control. Uncontrolled population growth among red deer would result in a large increase in numbers and in intensive damage in adjacent areas, for example, in private forests beyond the National Park boundaries. For this reason, and under prevalent conditions with the absence of the wolf as the main predator, it is not possible to disregard the need to control these animals. However, even though our current knowledge on the dynamics of red deer populations and their influence on forest development are incomplete, it is obvious that wildlife populations that are controlled to a constant level do not reflect natural conditions (e.g., Singer et al. 1989). Consequently, the former goal of maintaining a constant density of one animal per 100 ha is no longer pursued. This concept is no longer in accordance with the actual conditions. As a result of natural forest development, an enormous increase in the nutritional base in the extensive areas affected by the bark beetle infestation was to be expected. This, in turn, would lead to a heavy increase in the deer population. Under these conditions, even wolves would not have been able to prevent the population increase. On the other hand, under the formerly prescribed density, a combination of harsh winters and high predatory pressure would have resulted in a significant decrease in deer numbers and an increase in migratory behaviour. In view of the constantly changing habitat capacity in the aftermath of the extensive bark beetle infestation and the related large-scale processes of forest regeneration, larger population fluctuations that are in accordance with the habitat conditions in the National Pak should be accepted. However, adherence to this goal will have to depend on the other conservation goals for the National Park and on the ability to ensure avoidance of wildlife induced damage in adjacent private property. Furthermore, the capacity of the winter enclosures, which are a central element of the current management policy, limits the possible population growth.

In accordance with the changing habitat quality due to the bark beetle outbreak, the red deer population has increased markedly in the past ten years and now numbers about 400 animals (spring population) – that is approximately 1.7 individuals per 100 ha. The number of killed animals has been between 80 and 130, with an average of about 100 animals, annually (Fig. 3).

As compensation for the current situation that prohibits the migration of red deer to their natural winter habitat in the surroundings of the National Park, the four winter enclosures

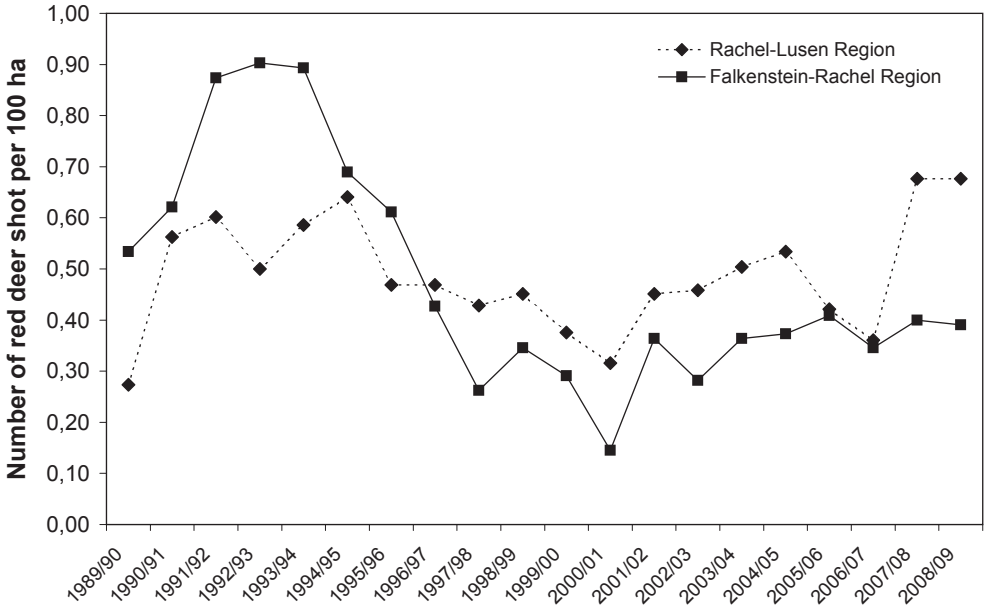

Fig. 3. Development of red deer control measures, including other causes of mortality (relative = per 100 ha) between 1989 and 2009.

will continue to be maintained. The enclosures not only serve as a surrogate for the wintering areas; they also help to simulate the absence of red deer in the montane forests during the snowy winter months. In contrast to the situation at the usual, freely accessible red deer feeding stations, the effects of heavy browsing and bark peeling on forest trees that commonly occur during the feeding periods, especially in late winter, are thereby limited to the areas within the enclosures.

Red deer are fed only in order to preserve their basic body functions; not to improve their body condition or antlers. Feeding is therefore limited qualitatively as well as quantitatively to the minimum requirements of the animals. In the winter enclosures, feed is provided in the period between the end of October and early May exclusively in the form of roughage and succulent feed. As a basic principle, the composition of the feed is designed to closely resemble the materials obtained under the natural foraging conditions of red deer in winter. In order to protect the red deer while they are feeding from undesired disturbances by visitors, access to the wildlife protection areas in the vicinity of the enclosures is restricted to designated paths.

Control of the red deer populations is carried out primarily in the winter enclosures by game wardens employed by the National Park. Here, the animals are culled selectively and quickly, with regard for animal welfare, and without disturbing the other animals. The percentage of animals killed in the winter enclosures is about 50%. In the management area of the park, red deer are also hunted from high seats to limit population growth. Only females, fawns, and young stags up to three years in age are removed in this manner.

Roe deer

Ecological conditions for roe deer are still determined largely by natural factors. Now, when winter feeding stations are no longer maintained in the National Park, roe deer have resumed their seasonal migrations. Depending on the date of the beginning of snowfall and the depth

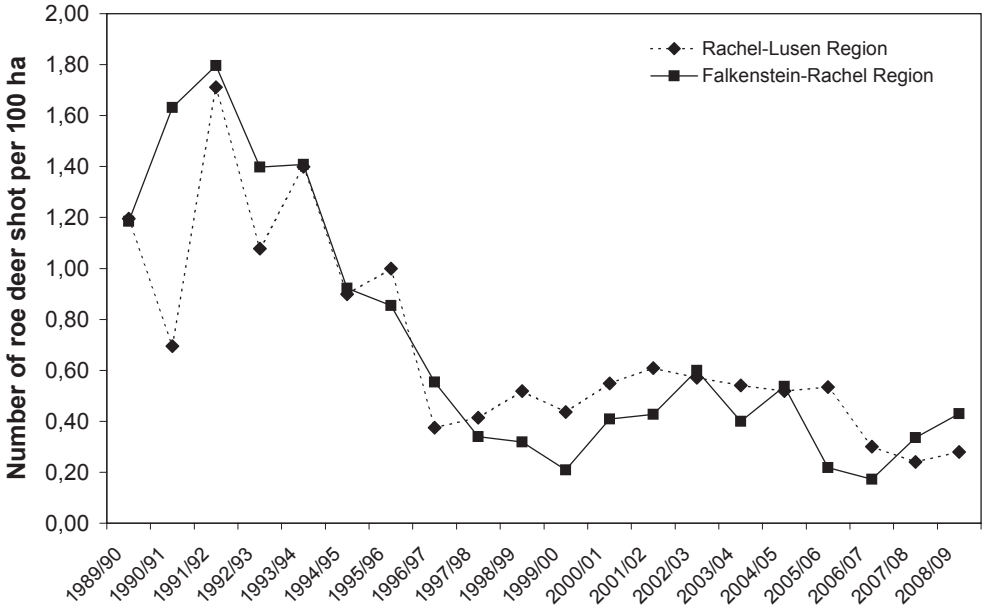

Fig. 4. Development of roe deer control measures, including other causes of mortality (relative = per 100 ha) between 1989 and 2009.

of the snow, a portion of the roe deer population leaves the territory of the National Park to spend the winter at the lower elevations in the surrounding areas where there is less snow. However, since numerous feeding stations are maintained in the private and communal hunting grounds outside of the National Park, the effects of winter starvation as a natural regulatory mechanism are limited (Wotschikowsky 1984).

Lynx, which over the past 20 years have again become an integral component of the montane forest community, is an important mortality factor for roe deer. Whether lynx are capable of limiting the roe deer population to a degree that would render regulatory measures no longer necessary is the subject of a current study. Therefore, roe deer control in the Rachel-Lusen Region was temporarily suspended for a four year period that started in 2007 (Fig. 4). In this area, only ten animals will be killed per year as required for the environmental sample bank monitoring programme (Umweltprobenbank).

At present, control of the roe deer population is practised only in approximately 4,000 ha of the Falkenstein-Rachel Region. Does, fawns, and yearling bucks are selected for culling. The reason for this control measure is to protect deciduous trees that were planted in pure Norway spruce stands. The average numbers killed within the entire area of the National Park in the past few years were approximately 100 animals annually (corresponding to about 0.4 per 100 ha for the whole park).

Taken together, control measures for roe deer have been suspended over an area of 20,000 ha now. This has been supplemented by additional approximately 60,000 ha in which roe deer are also no longer controlled in the Šumava National Park.

Wild boar

Until the early 1980s, wild boar was extremely rare in the inner reaches of the Bavarian Forest. Even the older hunting records indicate that boars were only harvested infrequently.

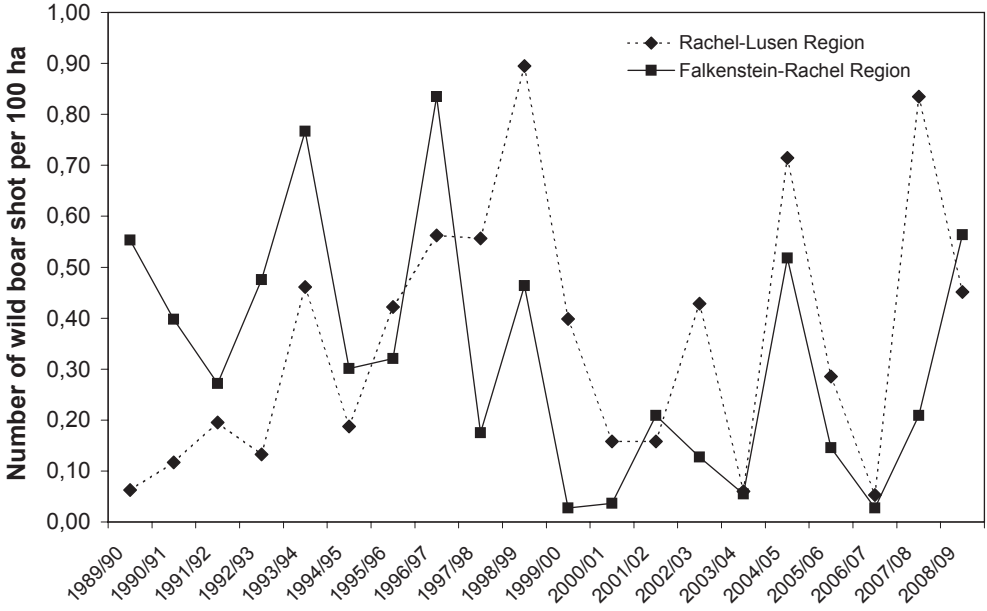

Fig. 5. Development of wild boar control measures (relative = per 100 ha) between 1989 and 2009.

The numbers of wild boar have also increased heavily over the past 20 years so that they are now an integral component of the National Park's fauna. The increase in maize production and the establishment of hunting practices that now include baiting animals with food have increased the reproductive potential of wild boar. Moreover, as a consequence of a series of relatively mild winters, the natural winter mortality has decreased. This has led to a situation in which wild boar now occur throughout the year over the entire territory of the National Park, especially in beechnut mast years in combination with mild winters, whereby the population densities can vary considerably.

In order to prevent unacceptable damages to agricultural property within and in the periphery of the National Park, the wild boar population is reduced locally whenever it enters phases of high density. Although wild boars are culled from raised seats in the course of red deer and roe deer control, the effects are limited. Because of this situation, boar traps are also used in specific cases (wildlife induced damage in the park's surroundings). In the past several years, depending on the respective endangerment of agricultural areas and enclaves, between 10 and 170 wild boar have been culled per year within the territory of the National Park (Fig. 5). Approximately 55% of them were captured in wild boar traps. As a further damage prevention measure, electric fences are temporarily set up along the borders of agricultural properties.

Eurasian lynx

Lynx returned to the Bavarian Forest National Park in the late 1980s. The animals originated from a reintroduction programme in an area that is now part of the Šumava National Park, where a total of 18 lynx from the Carpathian were released between 1982 and 1987 (Koubek & Červený 1996). The lynx population in eastern Bavaria has been stable since the mid 1990s, however at a very low level. Although lynx enjoy a high level of acceptance

among a broad spectrum of the general public, the return of this predator also poses a potential for conflict with those involved in ungulate hunting and animal husbandry. Evaluation of cadavers and faeces samples has revealed that roe deer comprise 83% and red deer 11% of lynx kills (Heurich & Wölfl 2002). With roe deer being the most important game animal in the hunting grounds outside of the red deer ranges, the lynx now competes with human hunters. The situation is intensified by the observation reported by many hunters that even the simple presence of lynx causes roe deer to become more secretive in their behaviour. This presumably influences the hunting success of the human hunters. For this reason, a central source of conflict revolves about the discussion on how to include the influence of lynx in determining the official hunting quotas for roe deer. Accordingly, information on the influence of lynx on the population of its prey has a practical application. This is of major importance for the acceptance of the species among the land users and, consequently, for the survival of the eastern Bavarian–Bohemian lynx population. A research project on the influence of lynx on its prey has been initiated for this purpose (Heurich et al. 2007). At the same time, intensive public relation activities are under way to increase the acceptance for lynx in the region. Further information on this international project can be found at www.luchserleben.de.

Wolf

There have been repeated reports of single wolves in the Greater Bohemian Forest Ecosystem. These are most likely based on dispersing individuals. But there have not yet been any reports of occurrences of multiple animals or of successful reproduction attempts (Bufka et al. 2005). Due to their high potential for dispersion, it is to be expected that individual animals from neighbouring populations will repeatedly migrate into the area. The populations in the eastern Czech Republic, Slovakia, and Saxony are especially relevant in this respect.

The wolf is a key species for forest wildlife-predator systems that are practically free of human intervention. They are a necessary component of intact ecosystems, in which natural predator–prey relationships are of major importance (Ripple et al. 2001; Fortin et al. 2005). Among a major portion of the general public, however, acceptance for the wolf is extremely low (Wechselberger & Leizinger 2005; Kaczenzky 2006). For this reason, and because of the current management plan for wolves in Bavaria, it is not possible to actively reintroduce the species. The goal of the National Park administration is to improve acceptance for the wolf in order to create more advantageous conditions for its return through natural migration. Simultaneously, trained professionals have been examining all reports on wolf sightings in the region, and a network of knowledgeable individuals is being organised, who can be contacted at the local level in case any conflict should arise.

Perspectives for the further development of wildlife management

Over the past 40 years, wildlife management in the Bavarian Forest National Park has been repeatedly adapted to the changing requirements as well as to the evolving wealth of knowledge. It was necessary to react, for example, to the extended range of wild boar and to the return of the lynx. The traditional methods of red deer management by hunters had to be revisited. In addition, the Falkenstein-Rachel Region, which was added to the National Park in 1997, had to be incorporated in the wildlife management program. The way in which the role of wildlife in the ecosystem is viewed has also changed dramatically. While in the 1970s, wildlife species still were perceived as evolutionary luxuries that were without impact on the course of natural processes (e.g. Stern et al. 1989), they are now seen as key elements of the ecosystem.

Since the establishment of the National Park, experience has shown that it is very difficult to define appropriate and acceptable wildlife management measures. This has been a major challenge for the National Park administration. Under current conditions, the primary goal of the National Park, which is to protect the natural dynamics of the ecosystem, can only be achieved to a limited degree. This is due mostly to the following factors:

1. Important elements of the natural fauna, such as wolf and European bison are no longer present.
2. The National Park is too small to accommodate the natural dynamics of predator–prey relationship systems.
3. Due to its natural setting, the National Park encompasses only one component of the wildlife's total annual range.
4. Damages caused by wildlife outside of the protected area are only tolerated to a limited degree.
5. Management of wildlife outside of the protected area (hunting, feeding, etc.) differs from that practiced within the park's borders.

Based on the above factors, especially item 3, it is apparent that the creation and preservation of a natural system with intact population dynamics for large wildlife species cannot be achieved within the current extent of the protected areas. From a professional standpoint, the conditions for an optimal wildlife management program are clear and simple. The first step would be to adjust the borders of the protected area to include the winter habitat of the animals. The second step would be to reintroduce locally extinct keystone species, such as wolf and European bison. After reestablishment of these populations, the third step would be to abandon the control and feeding of the species in the National Park. To raise the tolerance for population fluctuations outside of the National Park, these measures would have to be supplemented with a system that is designed to prevent and compensate for damages caused by wildlife. A wildlife management system of this nature, however, would be impossible to achieve under the prevailing conditions in the region. First of all, the National Park surroundings are densely settled. This precludes an extension of the protected area to include the winter habitat of the animals. Secondly, there is a very low level of acceptance towards the reintroduction of large animals. Therefore, the implementation of such measures would be out of the question. The management plan for wolves in Bavaria, for example, states explicitly that "there is no intention to reintroduce wolves in Bavaria" (STMUGV 2007). Furthermore, current hunting laws do not provide for a compensation program for damage to forest regeneration caused by browsing or bark peeling. Therefore, the owner of the hunting rights must compensate for economic damages. A system for the prevention of and compensation of damages caused by herbivores would have to be developed on the basis of private law. Therefore, it will not be possible to achieve optimal wildlife management under the present conditions. However, a realistic goal can be found in the specifications of the International Union for Conservation of Nature (IUCN 1994), according to which 75% of the protected area must be excluded from wildlife management practices. At the same time, the goal will be to relegate measures that are still necessary to areas outside of the National Park. This will require coordination with the various stakeholders in the region.

To reach this, the following measures are to be realised in the coming decade.

Increased promotion for the acceptance of wildlife

A key element for the success of any improvement in wildlife management beyond the boundaries of the protected areas themselves is a sufficient level of acceptance within the various interest groups. Much in the sense of an "ecosystem approach", it is also necessary to involve the local population in the various projects. Often, the evaluation of the presence

of wildlife is based primarily on the potential damages that the animals might cause to silvicultural and agricultural land or products. In addition to the usual educational and informational efforts that employ a rational approach ("No one is likely to protect what they are not familiar with"), it is also desirable to change our inner, emotional attitude. In order to replace the anthropocentric "useful vs. harmful" way of thinking with a more enduring attitude based on respect for the inherent values of nature, a new creed must become the basis for working towards a sensitive and lasting acceptance: "No one is likely to protect what they do not appreciate".

Reduce the size of the area in which wild ungulates are controlled in the Falkenstein-Rachel Region

In order to achieve the goal of not practising wild ungulate control on 75% of the territory of the National Park, control measures in the Falkenstein-Rachel Region have to be limited within the next few years to the peripheral areas. This will require an increase in the size of the non-intervention zone by approximately 2,000 ha. An accompanying measure will be the goal to relegate management activity to the neighbouring hunting territories.

Further reduction of roe deer control quotas

Provided that the lynx population in the National Park region becomes fully established and the level of browsing damage to forest regeneration can be tolerated, especially in the neighbouring areas, the extent to which roe deer are controlled and the size of the area in which control measures take place should be reduced further. Whether or not control of roe deer can be given up completely within the territory of the National Park is the subject of the current telemetry project to study the influence of lynx on its prey.

Discontinue killing of individual wild boar

The shooting of individual wild boar in combination with the control of roe deer and red deer not only disrupts the natural behaviour of this species and promotes its fear of humans; it is also not very effective. In consideration of the National Park goals, the shooting of individual wild boar should eventually be discontinued entirely.

Re-evaluate the red deer management programme

Although the National Park's winter enclosure concept has certain advantages (high level of acceptance with the National Park's neighbours, easy observability of the animals for ecological education programmes, availability of the animals for research purposes, including attachment and removal of transmitters), together with artificial feeding, it poses a serious interference with the natural behaviour patterns of red deer, their use of habitat, and their population development. Each of these aspects is contrary to the National Park goals and the IUCN Guidelines for National Parks (IUCN 1994). Furthermore, with the expected return of the wolf, the winter enclosures would become superfluous since they would either deny the wolf access to its main prey or deny the red deer the ability to flee if wolves should gain access to the enclosures. After the refusal of some interest groups in the Falkenstein-Rachel-Region to participate in a round table about red deer management a close down of the winter enclosures will not be a aim for the national park administration. But a first step for a more natural red deer management away from the winter enclosure solution would be to allow the part of the deer herd that overwinters outside of the enclosures to increase in size and to study the spatial aspect of their behaviour in regard to land use. Simultaneously, it will be necessary to designate suitable winter habitat ranges based on habitat analyses that consider such aspects as susceptibility to wildlife damages, property ownership, anthropogenic dis-

turbances, available food resources, and forest structure. Most important of all, property owners and hunters must be convinced of the practicability and advantages of the revised red deer management programme.

Development of a wildlife monitoring and management system across international boundaries

A challenge to be worked out over the next several years will be the attempt to achieve further unity between the administrations of the Bavarian Forest and Šumava National Parks. The goal is to create a wildlife monitoring system across the international boundary that will provide uniform information over the entire territory of the National Parks. Furthermore, it is recommended to attempt to closely co-ordinate wildlife management programmes that are based on the common status of information and based on a uniform treatment of wildlife on both sides of the international frontier.

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