

Bavarian Forest and Šumava National Parks: on the way to transboundary wildlife management and conservation?

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Abstract

The landscape of Central Europe has been shaped by humans for centuries. One of the less affected areas is the Bohemian Forest, located along the border of Germany (Bavaria), Austria, and Czechia. The Bohemian Forest ecosystem is protected as national parks in Bavaria and Czechia. Bavarian Forest and Šumava National Parks (NPs) together form one of the largest protected forested areas in Central Europe. However, both NPs differ in management, history and geography. Therefore, wildlife management measures (winter enclosures, feeding, hunting, law) were compared to reveal differences and similarities and red and roe deer densities were analysed as well. They represent abundant species with impact on vegetation. These measures are important for further harmonization of management. It is concluded that differences and obstacles for harmonization stem from a different legislation in both NPs, which causes that some measures cannot be applied in Šumava National Park in same way as in Bavarian Forest National Park, and it also stems from different development of management and nature protection in both NPs. On the other hand, there can be joint projects which can coordinate management. For example, the returning wolf (*Canis lupus*) is a good opportunity to enlarge transboundary non-intervention area.

Key words: wildlife management, National Parks, Šumava, Bavarian Forest, transboundary

INTRODUCTION

Protected areas have been here for a long time. The concept is not new. Conservation of iconic landscape and wildlife is a long-lasting topic for civilization (WATSON et al. 2014). Naturalness has been, especially in the past, the main measure for evaluating and establishing new protected areas (COLE et al. 2008).

Nowadays protected areas are struggling with a wider range of problems. Despite the growth of the number of protected areas since 1970 (NAUGHTON-TREVES et al. 2005, WATSON et al. 2014), we have been facing biodiversity loss (BROOKS et al. 2002) and social conflicts in addition (SOLIKU & SCHRAML 2018). To fulfil objectives and prevent conflicts, protected areas set the standards and frameworks for effective management (e.g. German National Parks; KEMKES et al. 2008).

Wildlife management is a part of the measures which are necessary for fulfilling the objectives of certain protected areas. Therefore, they can vary between the areas. Moreover, in Europe, we can see changes in densities and dispersion of large mammals. Despite the decreasing numbers of worldwide endangered herbivores (RIPPLE et al. 2015), common European ungulates are increasing their numbers (GEISSER & REYER 2004, CROMSIGT et al. 2013, BRAGINA et al. 2018).

Red deer (*Cervus elaphus* Linnaeus, 1758) and roe deer (*Capreolus capreolus* Linnaeus, 1758) live in Europe and increasing numbers bring conflicts in human-dominated landscape as well as in protected areas. Ungulate management is based on hunting, it was the most effective in selected case study (GEISSER & REYER 2004), but subsequent measures can influence whole ecosystem; for example, supplemental feeding affects the consumption and composition of vegetation (PUTMAN & STAINES 2004, MIRANDA et al. 2015), but it is not sufficient.

Similar to ungulates, large carnivores are resettling Europe and can coexist with people in the human-dominated landscape (CHAPRON et al. 2014), but their dispersal is slowed down by poaching (LIBERG et al. 2012, HEURICH et al. 2018). Generally, populations of large mammals are growing in Europe with the exception of less economically successful countries in Eastern Europe (e.g. Ukraine, Bulgaria, Latvia, Lithuania) (BRAGINA et al. 2018).

Despite the aim of naturalness of processes in national parks, European NPs are usually managed (GÜNTHER & HEURICH 2012). Wildlife management reacts to high numbers of ungulates and returning of the predators. NPs adopt a wide range of measures enabling the sustainable wildlife. Management considers many different aims: preserving the naturalness – wildlife and vegetation and social aspect (e. g. tourism and human activities).

Hunting, winter enclosures, feeding, restricted areas and tourism are activities influencing wildlife and are well-known from our study area. Presence of the measures can change behaviour of animals and subsequently the whole ecosystem. Avoiding areas of hunting (THEUERKAUF & ROUYS 2008) and neighbourhood of hiking trails can, for example, change browsing pressure of ungulates (MÖST et al. 2015). Furthermore, winter enclosure can have same effect (MÖST et al. 2015). But results differ for certain protected areas and species, those effects are not observed in each case, somewhere predators even select hiking trails (KAYS et al. 2017). Naturally it should be driven by predator-prey relationship. Then, predator's presence can influence browsing of ungulates which, for example, avoid a wolf pack's area (KUIJPER et al. 2013).

Therefore it is not easy fulfilling the goals for wildlife management in national parks, containing preservation of natural wildlife, non-intervention by human activities and, on the other hand, offering educational and visiting experience with nature for visitors (HEURICH et al. 2011).

Our aim is to compare two NPs – Šumava National Park (ŠNP) and Bavarian Forest National Park (BFNP) – creating a transboundary area which is the one of the largest forested protected areas in Central Europe (KŘENOVÁ & HRUŠKA 2012). Even though it is only one area, the two NPs differ in their wildlife management. This article wants to contribute to possible further harmonization in future and presents past and present management in both NPs. These questions were addressed: 1) How do the wildlife management differ? 2) What are the objectives and requirements for wildlife management? 3) Which measures do the NPs use and how do they differ? The study focused on key species of herbivores, zonation, hunting, feeding, wildlife management, and differences in law and their impacts on management. Based on management plans, NP administration documents, data, and scientific knowledge the study compared the NPs concerning management and proposed joint transboundary management.

MATERIAL AND METHODS

Study area

BFNP and ŠNP are situated in Central Europe, BFNP in eastern Bavaria, ŠNP in southwestern Czechia. Together they cover area of about 925 km². The mountains are part of one geomorphological unit (CGS 2012). The highest peak in the area is Mt. Rachel at 1453 m a.s.l. (KŘENOVÁ & KIENER 2012). The mean annual temperature varies from approximately 3°C to 6°C (TOLASZ et al. 2007) and precipitation from 800 to 1600 mm (DOHNAL et al. 2011).

The NPs are created by forested mountain ridges, with mountain plateau and a mosaic of peat bogs and meadows predominant in ŠNP and steep forested slopes predominant in BFNP (JANÍK & ROMPORTL 2016). The area is also important because of its size and location between the Alps and Carpathians and thus can serve as a stepping stone (HEURICH et al. 2011).

Management and history of the National Parks

Both NPs state that they belong to IUCN category II (BFNP 2018, ŠNP 2018a). According to IUCN, the primary objective of a category II NP is: “to protect natural biodiversity along with its underlying ecological structure and supporting environmental processes, and to promote education and recreation” (IUCN 2018). This goal should be fulfilled by management which protects processes, native species and the ecosystem as a whole – including natural forest processes and animal species (HEURICH et al. 2011).

Bavarian Forest NP

BFNP is the oldest German NP and was established in 1970 (HEURICH et al. 2011). The aim was to protect natural development of the area. In 1983 and 1984 the NP was affected by windstorms, but even so non-intervention management continued on a vast area (LAUSCH et al. 2011). The shift to a non-intervention NP continued even after the enlargement of the BFNP area in 1997 (BFNP 2018). Now, about 75% (ca. 185 km²) of BFNP is without hunting.

BFNP covers 242.5 km² and 68% of the area is in one core (“Naturzone”) under a non-intervention regime with natural processes and without human impacts. Every year, the area is enlarged with the aim of reaching 75% in 2027 (BFNP 2018). The Naturzone is located along the border with Czechia and it offers the creation of a wild transboundary area without human impacts (KŘENOVÁ & KIENER 2012). The second, development zone (“Entwicklungszone”) will become the part of the Naturzone in the next few years. On the boundary of BFNP there is the next “buffer” zone (“Randbereich”), which separates the NP from its surroundings and protects private forests outside the NP by active management measures. Finally there is the recreational zone (“Erholungszone”) (BFNP 2018).

Šumava NP

ŠNP is much younger than BFNP. ŠNP in Czechia was founded in 1991 after the fall of communism and removing of the Iron curtain on the border with Germany and Austria. It was established on an area of 683.4 km² as a part of a former larger Protected Landscape Area (PLA). Šumava PLA now surrounds ŠNP with 994.8 km². ŠNP is three times bigger than BFNP.

ŠNP management and zonation have gone through development. At the beginning ŠNP was divided into three nature conservation zones according to Czech law (Act No. 114/1992 Coll.). The most protected part (Zone I) covered 22% of the area initially and was divided into 54 patches; from 1995 it covered only 13% of the area and has been fragmented into 135 patches. Even in Zone I active management was applied during the recent bark beetle outbreak, but otherwise Zone I was strictly natural and non-intervention (KŘENOVÁ & HRUŠKA 2012). Zone II was the largest one (82%) and contains human-affected ecosystems which will be managed for future non-intervention. Zone III (5%) includes villages and their surroundings (ŠNP 2018c). Amendment of Act No. 114/1992 Coll. in 2017 enabled new zonation to be proposed, which since the 1st of March 2020 has come into force. This zonation delineates four zones – natural (28% of ŠNP), nature-related (25%), managed (46%) and zone of cultural landscape around villages (1%) (ŠNP 2019). This zonation combines conservation and management aims.

Moreover, another problem is that part of ŠNP is owned privately and by municipalities (Kašperské Hory and Volary municipalities are the biggest non-state owners) (KUČERA 2009). For example, Kašperské Hory municipality owns 4916 ha of forest and logged and removed trees from a significantly larger area than ŠNP (ZÝVAL et al. 2016). ŠNP is trying to rent and buy private forests and get them into state ownership (KUČERA 2009).

Methods

Both National Parks are presented in comparative perspective. At first, populations of the most abundant herbivores, which affect NPs the most were compared. Available data of shot and present red deer and roe deer from both NP's administrations were graphically and statistically (t-test in R (R CORE TEAM 2019)) analysed to reveal effect of wildlife management on populations and whether the effect is same or different in NPs. The numbers of shot animals were known for seasons (e.g. years 1993–1994 with the end on the last March), and density was counted as number of shot animals divided by area of NP (ŠNP or BFNP). Moreover, wildlife management and its path dependency were compared in both NPs in context of applied measures and law. We aimed at hunting and feeding measures including winter enclosures.

RESULTS

Wildlife species

Red deer

Density data were compared in both NPs. In BFNP, there are approximately 400 animals and 80–150 are shot per year (HEURICH et al. 2011); the estimated density is 1.56/km² (DUPKE et al. 2017) and it is increasing recently. In ŠNP, there are approximately 1000 individuals, with rather higher numbers in last years but with a slight decrease from 2018. Similarly, number of animals shot in ŠNP reached the top in 2017 and since the year 2017 has been falling. Now density of red deer is higher in BFNP than in ŠNP and numbers of shot animals in both NPs are getting closer with still higher number in ŠNP (Fig. 1 and Fig. 2).

Density data shows no significant difference in numbers of red deer per 1 km² between both NPs ($t = -1.397$, $\text{sig} = 0.170$, $\text{conf. level} = 0.95$, Fig. 1), but significantly different density in shot animals ($t = 9.206$, $\text{sig} = 0.000$, $\text{conf. level} = 0.95$, Fig. 2).

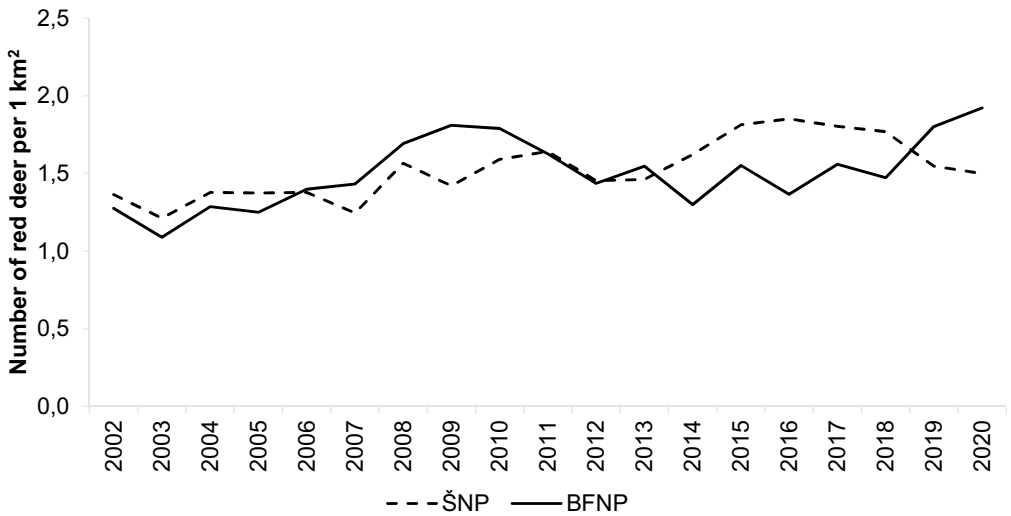


Fig. 1. Development of density of red deer in both National Parks based on spring censuses.

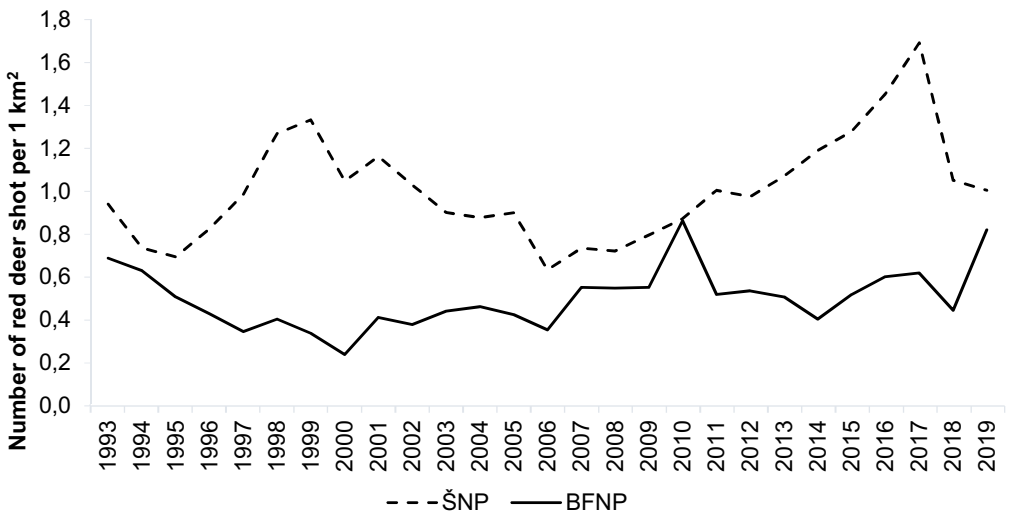


Fig. 2. Development of number of red deer shot in both NPs. Data are for seasons (beginning 93/94), not for years.

Roe deer

Density ranges from 1–3 animals per km² (DUPKE et al. 2017). Roe deer are more abundant in ŠNP (HEURICH et al. 2015). Approximately 100 animals were shot annually in BFNP (HEURICH et al. 2011), but now hunting of roe deer is banned (BELOTTI et al. 2015). Only about 30 individuals were killed for example in vehicle collisions on average per year in the last 3 years in BFNP. In ŠNP approx. 60–70 animals died per year and approx. 25–45 animals from them shot annually during the investigated period (Fig. 3). Density of shot animals in both NPs differs significantly ($t = -5.882$, $\text{sig} = 0.000$, $\text{conf. level} = 0.95$).

Comparison of the wildlife management measures

Winter enclosures and feeding

Winter enclosures are present in both NPs, they are primarily for red deer, but their purposes and management are different.

In Germany, winter enclosures compensate restriction of winter habitat, because natural winter ranges of red deer lie out of the BFNP and red deer cannot be allowed to migrate there (HEURICH et al. 2011). Moreover, winter enclosures simulate winter absence of red deer in higher elevation and enable to control population (HEURICH et al. 2015). After the foundation of the BFNP, about 40 feeding stations in Rachel-Lusen area had been maintained and until 1985 they were closed (HEURICH et al. 2011). The hunting was permitted in whole area with aim of reduction of the numbers. Then, instead of the feeding stations, four winter enclosures

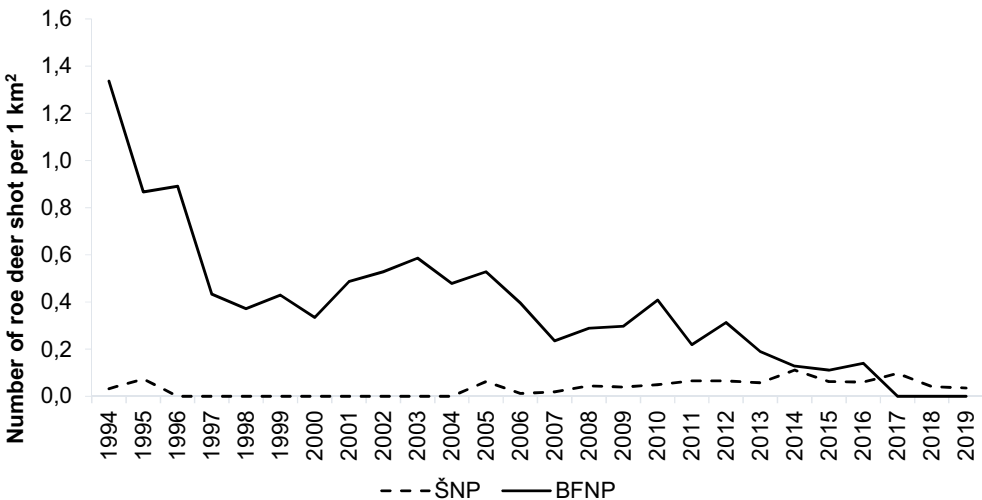


Fig. 3. Development of number of roe deer shot in both NPs. Data are for seasons (beginning 94/95), not for years.

were opened in 1970s (HEURICH et al. 2015) – enclosures were from 30 to 60 ha large fenced areas (overall 157.5 ha) with the central feeding place (MÖST et al. 2015), feeding is provided between October and May (HEURICH et al. 2011) and the hunting was prohibited in the core areas and since 1980s and early 1990s shooting has been allowed in the winter enclosures (HEURICH et al. 2011). Now, interventions are as low as possible, winter enclosures are key measures of the management prevents from the damage of surroundings of NP. More than 80% of animals stay in winter enclosures and majority is shot there (HEURICH et al. 2015). Only about 20% of red deer are hunted outside the enclosures (HEURICH et al. 2011).

History of the enclosures on the Czech side started between years 1998 and 2001. The first purpose was to protect forest after bark beetle outbreaks and monitoring of the population as well. Seventeen enclosures were built. Now, ten of them work and the total area is 215.5 ha (circa 22 ha per one enclosure on average). Seven were closed due to changes of ownership of forest and vicinity of agricultural land or due to increasing effectivity of rest of them. In ŠNP about 50% red deer spend winter in winter enclosures (JIRSA 2016). But no animals are shot (HEURICH et al. 2015) because the winter enclosures are smaller than in BFNP and not prepared for culling (JIRSA 2016); furthermore, Czech law does not allow it (Act No. 449/2001 Coll.). In ŠNP, intensive feeding is provided in winter enclosures. The feeding should attract animals to use the winter enclosures. It is concentrated in the winter enclosures, but it is not prohibited outside them (JIRSA 2016).

Hunting management

Hunting in BFNP is only a small part of wildlife management. Hunting is strictly regulated and evaluated from more points of view: return and numbers of predators, density of deer; in addition, trophy hunting was prohibited (LINNÉR & WANNIGER 2010). Generally, natural forest regeneration in Bavaria has priority over wildlife (HEURICH et al. 2015). The objective is to “let nature to nature”, but in a given condition (without enough predators, restricted winter ranges for red deer) BFNP must monitor and regulate numbers (LINNÉR & WANNIGER 2010). Despite that, hunting is almost excluded from BFNP. Red deer are shot in enclosures; it was around 50% (HEURICH et al. 2011) but this share has increased, with 80% mentioned by MÖST et al. (2015); shooting is also permitted in management zone on the edge of the NP (HEURICH et al. 2011). Red deer migration outside the park is restricted by law (HEURICH et al. 2015). Roe deer hunting is banned (BELOTTI et al. 2015).

On the other hand, in Czechia, hunting is more traditional and ŠNP management is more hunting-oriented (HEURICH et al. 2015). Non-hunting area covers just a small part of the ŠNP, but it was enlarged recently as a consequence of wolf occurrence (DVOŘÁK 2018). Trophy hunting is permitted but it is being limited (ŠNP 2017). Reduction of numbers in winter enclosures is not widely used. Winter enclosures in ŠNP are not suitable for culling and the law does not allow it to be done effectively (JIRSA 2016). Furthermore, hunting is only allowed in the hunting period, which is for red deer from the 1st of July to the 31st of January (male), from the 1st of August to the 31st of January (female), and for whole year (animals under two years old) (Act No. 323/2019 Coll.); thus, this period does not fully overlap the period of stay in winter enclosures. Outside the NPs, regular hunting and feeding occur (HEURICH et al. 2015).

Hunting law

In Bavaria, the law on winter enclosures only permits shooting of wounded and undesirable individuals, but with exception that hunting is allowed in the case of nature conservation (Act No. BayRS 792-1-L 1978). Therefore, the numbers of ungulates are kept at a level enabling natural regeneration of tree species (HEURICH et al. 2015). Furthermore, the range of red deer outside BFNP is restricted by law (HEURICH et al. 2015, MÖST et al. 2015) and compensation for ungulate damage (e.g. browsing) has to be paid to landowners (HEURICH et al. 2015).

Czech legislation (Act No. 449/2001 Coll.) only permits shooting of wounded and undesirable individuals in winter enclosures, but there is no exception for nature conservation purposes and hunting is only allowed with special permission. The animal must have obvious signs of injury or to be undesirable or weak (MŽP 2011). Reduction of numbers can also be a reason, but only in rare cases (spreading of illness, hugely increasing damage) (JIRSA 2016).

DISCUSSION

The article presented differences in zonation, management of the NPs, and selected wildlife management measures. As we can see from results and from summary Tab. 1, the management differs a lot.

Red and roe deer data comparison shows these differences between both NPs. Based on red deer density data, it is assumed, that due to forest regeneration after the bark beetle outbreak, an increasing nutritional base had been expected as well as a population increase (HEURICH et al. 2011), which was fulfilled circa from 2014 (Fig. 1) with larger recent area of forest regeneration (LAUSCH et al. 2011, JANÍK & ROMPORTL 2018). Development of number of red deer in both NPs is similar, now with higher number in BFNP.

Czech NP has also higher rate of shot red deer, which stems from different law (e.g. winter enclosures), management settings and their development and aims. However, recently numbers of shot red deer in both NPs are getting closer consequently with enlarging non-hunting area and wolf's presence in ŠNP. In BFNP the majority of red deer spend winter in enclosures. This management is applied because red deer presence would be harmful for private property outside the NP and it is also not allowed by law; furthermore, it simulates natural migration to lower elevations. In ŠNP, enclosures are not so widely used by red deer (HEURICH et al. 2015). Hunting in ŠNP is prohibited only on 10% of the area and winter enclosures and feeding are measures for hunting and forest protection, not for more natural development of the NP, which is the objective in BFNP. Czech legislation does not enable culling in the winter enclosures, which are smaller than in BFNP and therefore, number of shot red deer is higher and has been increasing recently (Fig. 2).

To sum up, according to data, densities of red deer are similar, but still for different purposes. In BFNP the objective is natural condition (LINNER & WANNIGER 2010, HEURICH et al. 2015). Furthermore, BFNP is older with longer non-intervention management, which is lacking in ŠNP and it means that protection of natural vegetation from herbivores is needed and thus this is next reason for more hunting-oriented wildlife management.

Roe deer shot data show that in BFNP numbers were reduced (Fig. 3). Recently, management controlled only a small area (40 km² in Falkenstein-Rachel area) (DUPKE et al. 2017).

Density data of red and roe deer could be influenced by migration outside of NPs, for e.g. shot red deer do not have to be included in spring census and reproduction, roe deer migrate

Table 1. Comparison of selected characteristics of both NPs.

Characteristics	Bavarian Forest NP	Šumava NP
Area	242.5 km ²	683.4 km ²
Founded	1970	1991
Management	Mostly non-intervention (68%), four zones, goal is 75% non-intervention in 2027	28% is in the most protected natural almost non-intervention zone
Non-hunting area	75%	10% (Zone A)
Winter enclosures	No: 4; mean size: 39 ha; ca. 80% of red deer use	No: 10; mean size: 22 ha; ca. 50% of red deer use
Law consequences	Enabling shooting in enclosures (80%); red deer restricted in certain range	Enabling shooting in enclosures only in rare cases; populations of roe and red deer migrate outside NP regularly

to surroundings of ŠNP (BELOTTI et al. 2015). Moreover, rules for hunting have been changing during the period.

However, BFNP management with winter enclosures and enabling shooting according to law (Act No. BayRS 792-1-L 1978, HEURICH et al. 2011, MÖST et al. 2015) is still considered as very artificial among German, Austrian, and Swiss NPs (GÜNTHER & HEURICH 2012) and cause artificial management-induced spatial inequalities in browsing pressure (MÖST et al. 2015).

Despite being one area, the NPs are different; they differ in history, area, and management (Tab. 1). On the other hand, there was an effort to create the “Wild heart of Europe” (KŘENOVA & KIENER 2012). But harmonization is not easy. ŠNP is significantly bigger and therefore its landscape is more diverse (ŠNP 2018b). Due to legislation and staff changes (including the head of the administration), ŠNP was without clear and long-lasting goals. Moreover, private owners within the NP influenced management goals and they remove trees from a significantly bigger area (ZÝVAL et al. 2016). Nowadays, new zonation for ŠNP since the 1st of March has come into force with only four management zones and about 28% of the NP is in the proposed natural almost non-intervention zone. The non-hunting area will be probably only be part of this zone. On the other hand, BFNP has a goal of creating a 75% non-intervention zone in 2027 (BFNP 2018).

CONCLUSION

This study shows how wildlife management in BFNP and ŠNP differs. There is still long way to transboundary wildlife management, because development and characteristics of both NPs are different. Different objectives – forest regeneration in BFNP and shorter and often unclear development in ŠNP are together with legislation, which does not allow to use winter enclosures for culling and to leave cadavers, and different forest structure, and development of protection, obstacles for harmonization.

There is also question for future development; return of the wolf will affect management in next period (requirements for management of the area: non-intervention and non-hunting; and wildlife management: winter enclosures and feeding) and can help to harmonize management of the NPs. In case of enlarging wolf's population dispersal, it is recommended to enlarge non-intervention and non-hunting areas as well as reducing the number of winter enclosures and consider their purpose (especially in ŠNP).

Continuous monitoring and evaluation of management measures and joint planning are factors which enable fulfilment of the aims of the NPs. Despite the differences described above, there is the opportunity to plan together at least in the core area; new zonation in ŠNP and the recent enlargement of the non-hunting area along the BFN boundary is an example. Moreover, change of legislation for ŠNP would be necessary for further harmonization.

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REFERENCES

- Act No. 114/1992 Coll.: Zákon č. 114/1992 Sb., o ochraně přírody a krajiny [Act No. 114/1992 Coll., on the Conservation of Nature and Landscape]. The Czech National Council: Collection of Laws of the Czech Republic. Online <https://www.zakonyprolidi.cz/cs/1992-114> (accessed on 16 May 2020) (in Czech).
- Act No. 323/2019 Coll.: Vyhláška č. 323/2019 Sb. Doba lovu jednotlivých druhů zvěře [Law announcement No. 323/2019. Hunting period for certain animal species]. Ministry of Agriculture of the Czech Republic, Collection of Laws of the Czech Republic. Online <https://www.zakonyprolidi.cz/cs/2019-323> (accessed on 16 May 2020) (in Czech).
- Act No. 449/200 Coll.: Zákon č. 449/2001 Sb., o myslivosti [Act No. 449/200 Coll., Game Management Act]. Parliament of the Czech Republic, Collection of Laws of the Czech Republic. Online <https://www.zakonyprolidi.cz/cs/2001-449> (accessed on 16 May 2020) (in Czech).
- Act No. BayRS 792-1-L: Bayerisches Jagdgesetz (BayJG) 1978 [Act No. BayRS 792-1-L, Bavarian Hunting Law]. Bavarian State Chancellery, Bavarian collection of laws. Online <https://www.gesetze-bayern.de/Content/Document/BayJG?AspxAutoDetectCookieSupport=1> (accessed on 16 May 2020) (in German).
- BFN, 2018: Aufgaben und Ziele [Aims and management of the National Park]. Online https://www.nationalpark-bayerischer-wald.bayern.de/ueber_uns/aufgaben/index.htm (accessed on 15 March 2018) (in German).
- BELOTTI E., WEDER N., BUFKA L., KALDHUSDAL A., KÜCHENHOFF H., SEIBOLD H., WOELFING B. & HEURICH M., 2015: Patterns of lynx predation at the interface between protected areas and multi-use landscapes in central Europe. *PLoS One*, 10: e0138139.
- BRAGINA E.V., IVES A.R., PIDGEON A.M., BALČIAUSKAS L., CSÁNYI S., KHOYETSKYY P., KYSUCKÁ K., LIESKOVSKY J., OZOLINS J., RANDVEER T., ŠTYCH P., VOLOKH A., ZHELEV CH., ZIOLKOWSKA E. & RADELOFF V.C., 2018: Wildlife population changes across Eastern Europe after the collapse of socialism. *Frontiers in Ecology and the Environment*, 16(2): 77–81.
- BROOKS T.M., MITTERMEIER R.A., MITTERMEIER C.G., DA FONSECA G.A.B., RYLANDS A.B., KONSTANT W.R., FLICK P., PILGRIM J., OLDFIELD S., MAGIN G. & HILTON-TAYLOR C., 2002: Habitat loss and extinction in the hotspots of biodiversity. *Conservation Biology*, 16(4): 909–923.
- CHAPRON G., KACZENSKY P., LINNELL J.D.C., VON ARX M., HUBER D., ANDRÉN H., ... & BOITANI L., 2014: Recovery of large carnivores in Europe's modern human-dominated landscapes. *Science*, 346(6215): 1517–1519.

- COLE D.N., YUNG L., ZAVALA E.S., APLET G.H., CHAPIN F.S.I., GRABER D.M., HIGGS E.S., HOBBS R.J., LANDRES P.B., MILLAR C.I., PARSONS D.J., RANDALL J.M., STEPHENSON N.L., TONNESSEN K.A., WHITE P.S. & WOODLE S., 2008: Naturalness and beyond: protected area stewardship in an era of global environmental change. *The George Wright Forum*, 25: 36–55.
- CROMSIGT J.P.G.M., KUIJPER D.P.J., ADAM M., BESCHTA R.L., CHURSKI M., EYCOTT A., KERLEY G.I.H., MYSTERUD A., SCHMIDT K. & WEST K., 2013: Hunting for fear: Innovating management of human-wildlife conflicts. *Journal of Applied Ecology*, 50: 544–549.
- CGS, 2012. Geological map. Czech Geological Survey, Prague. Online http://mapy.geology.cz/geocr_25/ (accessed on 15 March 2018) (in Czech).
- DOHNAL T., HUBENÝ P., JABLONSKÁ L., LÖW J., NOVÁK J. & ZIMOVÁ E., 2011. *Krajina Národního parku Šumava [Landscape of the Šumava National park]*. Správa Národního parku a Chráněné krajinné oblasti Šumava, Vimperk, 141 pp. (in Czech).
- DVOŘÁK J., 2018: Správa Národního parku Šumava stanovuje nové území bez lovu a pracuje na nové koncepci přezimovacích obůrek [The Šumava National Park Administration sets a new area without hunting and work on new conception of winter enclosures]. The Šumava National Park Administration, Vimperk, press release. Online <https://www.npsumava.cz/sprava-narodniho-parku-sumava-stanovuje-nove-uzemi-bez-lovu-a-pracuje-na-nove-koncepci-prezimovacich-oburek/> (accessed on 16 May 2020) (in Czech).
- DUPKE C., BONENFANT C., REINEKING B., HABLE R., ZEPPENFELD T., EWALD M. & HEURICH M., 2017: Habitat selection by a large herbivore at multiple spatial and temporal scales is primarily governed by food resources. *Ecography*, 40: 1014–1027.
- GEISSER H. & REYER H.-U., 2004: Efficacy of hunting, feeding, and fencing to reduce crop damage by wild boars. *Journal of Wildlife Management*, 68: 939–946.
- GÜNTHER S. & HEURICH M., 2012: Bewertung der Naturnähe des Rothirschmanagements in mitteleuropäischen Nationalparks [Assessment of naturalness of red deer management in Central European national parks]. *Allgemeine Forst- und Jagdzeitung*, 184: 1–16 (in German).
- HEURICH M., BAIERL F., GÜNTHER S. & SINNER K.F., 2011: Management and conservation of large mammals in the Bavarian Forest National Park. *Silva Gabreta*, 17: 1–18.
- HEURICH M., BRAND T.T.G., KAANDORP M.Y., ŠUSTR P. & MÜLLER J., 2015: Country, cover or protection: what shapes the distribution of red deer and roe deer in the Bohemian Forest Ecosystem? *PLoS One* 10: e0120960.
- HEURICH M., SCHULTZE-NAUMBURG J., PIACENZA N., MAGG N., ČERVENÝ J., ENGLER T., HERDTFELDER M., SLADOVA M. & KRAMER-SCHADT S., 2018: Illegal hunting as a major driver of the source-sink dynamics of a reintroduced lynx population in Central Europe. *Biological Conservation*, 224: 355–365.
- IUCN, 2018: Category II: National Park, IUCN document. International Union for Conservation of Nature. Online <https://www.iucn.org/theme/protected-areas/about/protected-areas-categories/category-ii-national-park> (accessed on 15 March 2018).
- JANÍK T. & ROMPORTL D., 2016: Comparative landscape typology of the Bohemian and Bavarian Forest National Parks. *European Journal of Environmental Sciences*, 6: 114–118.
- JANÍK T. & ROMPORTL D., 2018: Recent land cover change after the Kyrill windstorm in the Šumava NP. *Applied Geography*, 97: 196–211.
- JIRSA A., 2016: Audit přezimovacích obůrek v Národním parku Šumava [Audit of winter enclosures in Šumava National Park]. Ms., document of the Šumava NP Administration, Vimperk (in Czech).
- KAYS R., PARSONS A.W., BAKER M.C., KALIES E.L., FORRESTER T., COSTELLO R., ROTA C.T., MILLSPAUGH J.J. & MCSHEA W.J., 2017: Does hunting or hiking affect wildlife communities in protected areas? *Journal of Applied Ecology*, 54: 242–252.
- KEMKES W., WISCHOF L.M., TSCHERNIAK A., WESEMULLER H. & DIEPOLDER U., 2008: *Quality criteria and standards for German national parks*. EUROPARC Deutschland e.V., Berlin, 15 pp.

- KUČERA A., 2009: Stav a management lesních ekosystémů v NP Šumava [State and management of forest ecosystems in Šumava NP]. In: *Forest management of Czech national parks*, FANTA J. & KRÉNOVÁ Z. (eds). Šumava National Park Administration.
- KUIJPER D.P.J., DE KLEINE C., CHURSKI M., VAN HOOFT P., BUBNICKI J. & JEDRZEJEWSKA B., 2013: Landscape of fear in Europe: Wolves affect spatial patterns of ungulate browsing in Białowieża Primeval Forest, Poland. *Ecography*, 36: 1263–1275.
- KRÉNOVÁ Z. & HRUŠKA J., 2012: Proper zonation – an essential tool for the future conservation of the Šumava National Park. *European Journal of Environmental Sciences*, 2: 62–72.
- KRÉNOVÁ Z. & KIENER H., 2012: Europe's Wild Heart-still beating? Experiences from a new transboundary wilderness area in the middle of the Old Continent. *European Journal of Environmental Sciences*, 2: 115–124.
- LAUSCH A., FAHSE L. & HEURICH M., 2011: Factors affecting the spatio-temporal dispersion of *Ips typographus* (L.) in Bavarian Forest National Park: A long-term quantitative landscape-level analysis. *Forest Ecology and Management*, 261: 233–245.
- LIBERG O., CHAPRON G., WABAKKEN P., PEDERSEN H.C., HOBBS N.T. & SAND H., 2012: Shoot, shovel and shut up: Cryptic poaching slows restoration of a large carnivore in Europe. *Proceedings of the Royal Society B: Biological Sciences*, 279: 910–915.
- LINNER J. & WANNINGER J., 2010: Bavarian Forest National Park Plan. Concept and Objectives. Grafenau.
- MŽP, 2011: Věstník Ministerstva životního prostředí [Newsletter of the Ministry of Environment]. Ministry of Environment of the Czech Republic, 21(8–9): 10–20. Online [https://www.mzp.cz/web/edice.nsf/5874A6E4A6CA92F7C1257925004975C6/\\$file/OVV-Vestnik_8_9_2011-10102011.pdf](https://www.mzp.cz/web/edice.nsf/5874A6E4A6CA92F7C1257925004975C6/$file/OVV-Vestnik_8_9_2011-10102011.pdf) (accessed on 16 May 2020) (in Czech).
- MIRANDA M., CRISTÓBAL I., DÍAZ L., SICILIA M., MOLINA-ALCAIDE E., BARTOLOMÉ J., FIERRO Y. & CASSINELLO J., 2015: Ecological effects of game management: Does supplemental feeding affect herbivory pressure on native vegetation? *Wildlife Research*, 42: 353–361.
- MÖST L., HOTHORN T., MÜLLER J. & HEURICH M., 2015: Creating a landscape of management: Unintended effects on the variation of browsing pressure in a national park. *Forest Ecology and Management*, 338: 46–56.
- NAUGHTON-TREVES L., HOLLAND M.B. & BRANDON K., 2005: The role of protected areas in conserving biodiversity and sustaining local livelihoods. *Annual Review of Environment and Resources*, 30: 219–252.
- PUTMAN R.J. & STAINES B.W., 2004: Supplementary winter feeding of wild red deer *Cervus elaphus* in Europe and North America: Justifications, feeding practice and effectiveness. *Mammal Review*, 34(4): 285–306.
- R Core Team, 2019: R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>.
- RIPPLE W.J., NEWSOME T.M., WOLF C., DIRZO R., EVERATT K.T., GALETTI M., HAYWARD M.W., KERLEY G.I.H., LEVI T., LINDSEY P.A., MACDONALD D.W., MALHI Y., PAINTER L.E., SANDOM C.J., TERBORGH J. & VAN VALKENBURGH B., 2015: Collapse of the world's largest herbivores. *Science Advances*, 1: e1400103.
- SOLIKU O. & SCHRAML U., 2018: Making sense of protected area conflicts and management approaches: A review of causes, contexts and conflict management strategies. *Biological Conservation*, 222: 136–145.
- ŠNP, 2017: Příkaz ředitele 142 – podmínky lovu jelenů v režijních honitbách Správy NP Šumava [Director's order 142 – conditions of deer hunting in directing hunting grounds of the Šumava NP]. Ms., document of the Šumava NP Administration, Vimperk, 2 pp. (in Czech).
- ŠNP, 2018a: Územní ochrana – kategorizace IUCN [Spatial protection – IUCN categorization]. Šumava NP Administration, Vimperk. Online <https://www.npsumava.cz/priroda/veda-a-vyzkum/uzemni-ochrana/> (accessed on 14 May 2018) (in Czech).
- ŠNP, 2018b: Management území – dílčí plochy [Management of the National Park – Management of the areas]. Šumava NP Administration, Vimperk. Online <https://www.npsumava.cz/priroda/veda-a-vyzkum/management/> (accessed on 14 May 2018) (in Czech).
- ŠNP (ŠUMAVA NATIONAL PARK), 2018c: Nová zonace NPŠ [New zonation of Šumava National park], Šumava NP Administration, Vimperk. Online <https://www.npsumava.cz/sprava-np/nova-zonace-a-klidova-uzemi/> (accessed on 15 March 2018) (in Czech).
- ŠNP, 2019: Nová zonace [New zonation]. Šumava NP Administration, Vimperk. Online <https://www.npsumava.cz/sprava-np/nova-zonace-a-klidova-uzemi/nova-zonace-nps/> (accessed on 28 May 2019) (in Czech).
- THEUERKAUF J. & ROUYS S., 2008: Habitat selection by ungulates in relation to predation risk by wolves and humans in the Białowieża Forest, Poland. *Forest Ecology and Management*, 256: 1325–1332.

- TOLASZ R., MÍKOVÁ T., VALERIÁNOVÁ A. & VOŽENÍLEK V., 2007: Atlas podnebí Česka [Climate Atlas of Czechia]. Olomouc: Český hydrometeorologický ústav, Praha, Universita Palackého.
- WATSON J.E.M., DUDLEY N., SEGAN D.B. & HOCKINGS M., 2014. The performance and potential of protected areas. *Nature*, 515: 67–73.
- ZÝVAL V., KŘENOVÁ Z. & KINDLMANN P., 2016: Conservation implications of forest changes caused by bark beetle management in the Šumava National Park. *Biological Conservation*, 204: 394–402.

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