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Forest management and hunting in areas adjacent to national parks: the example of the Magura National Park

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Abstract. The aim of the study was to evaluate arguments for hunting and its impact on forest management and conservation in national parks as well as areas directly adjacent to them. The issue was examined using the example of the Magura National Park (MNP) for which data on the number of deer and predatory mammals included in the statistical yearbooks for 2013–2014 were available. The quality and size of the food sources provided by this type of forest habitat were evaluated using data obtained from the literature. We also included data on the dietary habits of wolves and lynxes as well as their impact on the number of large ungulates in our analysis.

The maximum carrying capacity of forest stands in the Magura National Park was determined to be 789 deer units (dear unit = 1 red deer or 0.3 elk or 5 roe deer), whereas in fact in 2014, the abundance of ungulates reached a total of 1230 deer units. Our analysis evaluating the impact of wolf and lynx populations on ungulates in the area showed that these predators can kill up to 212 deer per year (140 individuals by wolves and 72 by lynxes). The growth in deer population, however, varies from 25.8% to 27.7%, which in the MNP amounts to 258–277 new born individuals per year, meaning that the wolf and lynx populations in the MNP are not able to prevent the number of deer from growing.

The current population of ungulates (1230 deer units) having reached a density of 6.6 deer units/km^2 exceeds the capacity of the MNP and thus poses a real threat to maintaining both, the nature of the park and the adjacent stands.

This article shows that the natural maintenance of balance in the predator-prey relationship is unlikely under these conditions and failure to allow for anthropogenic interference to regulate the number of ungulates in protected areas may result in an increase in the density of their population. Potential destruction of other valuable assets such as forest habitats may consequently follow.

The current population of ungulates (1,230 deer units) having reached a density of 6.6 deer units/km^2 exceeds the capacity of the MNP and thus poses a real threat to maintaining the nature of both the park and the adjacent stands.

This article shows that the natural maintenance of balance in the predator–prey relationship is unlikely under these conditions and failure to allow for anthropogenic interference to regulate the number of ungulates in protected areas may result in an increase in the density of their population. Potential destruction of other valuable assets such as forest habitats may consequently follow.

Keywords: red deer, wolf, lynx, number, the Magura National Park, hunting management, nature conservation

1. Introduction

Over the past several decades, the number of deer in Poland has been steadily increasing (Budny et al. 2010, GUS 2011, 2012, 2013, 2014), resulting in a great challenge to forest management and nature conservation. The overly high numbers of ungulates carry a real threat to the stability and sustainability of forest ecosystems, as was already seen in the 1970s with the damage done by red deer in the Bieszczady Mountains (Shukiel 1982). At present, this is a problem

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in all of Poland, as evidenced by the increase in the number of red deer from 41,500 individuals in 1975 (Shukiel 1979) to 213,500 in 2015 (GUS 2015).

At present, the extent of the damage in many tree stands caused by ungulates transforms forest communities and even threatens their existence. The transformation involves the elimination of important forest-forming species preferred by deer, primarily fir, sycamore, ash and oak and also linden, pine, spruce and other species (Shukiel 1979; Jamrozy, Tomek 1997; Szukiel 2001; Mikoś, Merta 2009).

For years, there has been discussion on reaching a compromise between the objectives of the hunting industry, which governs the populations of common ungulates in Poland, and the objectives of forestry and the protection of forest ecosystems. Developing solutions that are acceptable to all stakeholders is extremely complex when managing natural resources within and adjacent to national parks. Previous attempts to alleviate the conflicts that have arisen at the interface between nature conservation and the hunting, forestry or agricultural industries have failed to produce lasting, scientifically sound solutions to this problem. In the ongoing discussion, some adversaries are convinced that the proportion of deer in the diets of wolves and lynxes is so significant that, in the case of national parks, these predators are the natural and optimal regulator of dense populations of ungulates. This opinion, however, is not confirmed by the inventory of the level of damage to tree stands and regeneration stands caused by deer in national parks when compared with the number of predators and ungulates there. For example, in the Bieszczady Mountains, despite having the world's largest population density of wolves (Śmietana 2000), the level of damage caused by deer in sapling and regeneration stands has reached a level that threatens the sustainability and biodiversity of that region's forests.

The purpose of the study was to assess the validity of the hunting economy and its impact on forest management and nature conservation in national parks and their neighbouring areas. The issue was analysed using the example of Magura National Park (MNP). The basis for these considerations was the problem of protecting and managing deer populations, with particular reference to the red deer.

2. Study area

The study area, MNP, is located in the middle of the Low Beskid Mountains, in the upper part of the Wisłoka River valley. Its characteristic feature is very dense forest cover, reaching over 95.5%, with a total area of 19,437.9 ha (GUS 2014). The MNP area is the backbone of a special habitat protection area called the Magura Refuge [Ostoja Magurska] with an area of 20,084 ha. This refuge was established because of its special natural value, which is related to the occurrence of natural habitats such as those listed in Annex I of Council Directive 92/43/EEC (HD): acidic (9110) and fertile (9130) beech and sycamore forests and maple-lime forests on slopes and inclines (9180). This area is dominated by beech or predominantly beech forests (about 55% of forest area), followed by pine (19%), spruce (12%) and alder (9.7%). The large share of more than 50-year-old pine is the result of post-war afforestation on former agricultural land, which now requires urgent redevelopment to achieve optimal species composition (Jamrozy 2014). As much as 96.43% of the forested area within the boundaries of MNP is occupied by mountain forest habitat (LG), but there are also habitats of mixed mountain forest (LMG), 0.52%; upland forest (Lwyż), 1.57%; riverine mountain forest (LLG), 0.95%; alder (Ol), 0.42%; and mountain alder (OlG) forests, 0.11% (Przybylska 2009).

MNP is an important refuge of wild fauna, represented by 54 species of mammals, 120 species of breeding birds, 9 species of amphibians and 5 species of reptiles. Almost all possible predators are present, including the bear, wolf, lynx and wildcat. Ungulates are represented by numerous red deer, roe deer, wild boar (*Sus scrofa*) and elk, whose numbers are estimated at several individuals (Jamrozy 2014).

3. Materials and methods

Data on the numbers of cervids and predatory mammals included in the 2013–2014 statistical yearbook (GUS 2014, 2015) were used. On the basis of available data and Fruziński's (1989) study, the feeding capacity of MNP forest habitats was calculated using the criteria of the aforementioned author of dividing the tree stands into mountain forecrop forests and lower mountain zone forests. Using Fruziński's (1998) proposed deer unit formula, based on the trophic requirements and energy budget of ungulates, one deer unit was assumed to be one red deer or 0.3 elk or five roe deer. On this basis, the acceptable cervid density for the study area was determined. In the next step, the possible impact of predatory mammals, that is, the wolf and lynx, on the red deer population of MNP was calculated. These calculations were based on the results of studies on the diet of the wolf and lynx as well as on the impact of these predators on the numbers of large ungulates (Głowaciński 1997, Śmietana 1998, Jędrzejewski, Jędrzejewska 2001, Jędrzejewski et al. 2002, Schmidt et al. 2009, Okarma, Schmidt 2013; Okarma 2015).

4. Results

The feeding capacity of MNP tree stands was estimated at a maximum of 789 deer units (Table 1). The calculations assumed that 4,707 ha was forecrop stands and the rest (13,865 ha) was classified as lower mountain zone stands. In fact, in the

Table 1. Capacity of stands in the Magura National Park calculated in deer units per 1 thousand hectares of forest area (deer units/1000 ha)

Group of forests with uniform capacity of forest environment for deer	Estimated capacity of food of cervids* [deer units/1000 ha]	Forest area [ha]	Estimated capacity of forest [deer units]
Mountain forests forecrops	25–35	4 707	118–165
Forests of lower mountain zone	36–45	13 865	499–624
Total		18 572	617–789

*by Fruziński (1989)

area of MNP, which constitutes 96.7% of the Magura Refuge, the number of ungulates reached a value of 1,230 deer units (9 elk = 30 deer units; 1,000 red deer = 1,000 deer units; 1,000 roe deer = 200 deer units) in 2014. Assuming that the forest surface of MNP is 18,572 ha, it was calculated that the deer density of 1,000 ha of this area is 66 deer units, including 54 red deer.

In 2013, there were eight wolves, four lynxes and one bear (GUS 2014) in MNP. In subsequent calculations, it was assumed that only the wolf and lynx affected the abundance of the red deer population in the Park.

Based on the results of the study conducted by Śmietana (1998) in the Bieszczady Mountains, it was assumed that four to six individuals in a wolf pack annually kill 35–65 red deer, 14–16 roe deer and 9–11 wild boar. There were eight wolves in the Park, and in the subsequent analyses, it was assumed that they lived in two packs. As a consequence, the wolves in MNP reduce prey populations living there by 70–35 red deer, 28–32 roe deer and 18–22 wild boars (Table 2).

However, based on the research results from Białowieża Forest (Jędrzejewski et al., 2002), it was assumed that one wolf eats, on an average, 5.6 kg of biomass per day, so that the eight Magura wolves are able to consume 16,352 kg of meat per year. Assuming that 68% of wolf kills are red deer (Okarma 2015a), then this species represents 11,119 kg. Amongst the red deer killed by the Bieszczady wolves (Cream 2005), males predominated (49.1%), with females and calves accounting for 29.6% and 21.3%, respectively. If the mean body weight of a male is 147 kg, with a female and calf at 106 and 67 kg, respectively, as noted by Tomek (2002) in the Krynica forests, wolves in MNP reduce the deer population annually by 95 individuals, which includes 47 males, 28 females and 20 calves (Table 2), for a total weight of 11,217 kg.

The impact of wolves on the wild ungulate population in Białowieża Forest was also determined for an area of 100 km^2 by Jędrzejewski et al. (2002), who reported that wolves kill, on an average, 72 red deer, 31 wild boars and 16 roe deer. Given these numbers, we can assume that in MNP (an area of almost 20,000 ha), wolves reduce the red deer population by 140 individuals and wild boars and roe deer by 60 and 31 individuals, respectively (Table 2).

The second large predator, which can significantly impact the size of the deer population, is the lynx, whose abundance in MNP is determined to be four individuals (GUS 2014). According to Schmidt et al. (2009), on an average, lynx kills 48 roe deer and 18 red deer annually, so the 4 lynxes in MNP consume 192 roe deer and 72 red deer per year. The impact of this predator on the number of its victims can also be calculated based on its meat requirements. According to Okarma et al. (1997), the lynx consumes, on an average, 1.7–3.6 kg of meat per day, so four lynxes require 2,482–5,256 kg per year. Amongst the victims of this predator, 69% of its prey is roe deer , 28% red deer and 3% wild boars (Jędrzejewski et al. 1993). It follows that the requirements of the Magura lynxes for red deer ranges from 695 to 1,472 kg per year. Amongst the red deer killed, calves predominate (61%), with females following at 39% (Jędrzejewski et al., 1993; Okarma et al., 1997). Given that the mean body mass of a female is 106 kg and a calf is 67 kg (Tomek 2002), it was calculated that lynxes in the MNP area could kill 9 (3 females and 6 calves at a total weight of 720 kg) to 18 (7 females and 11 calves at a total weight of 1,479 kg) red deer per year. With an average use rate of 75% of deer carcasses killed by the lynx (Okarma et al. 1997), the demand in MNP for this prey ranges from 12 (4 females, 8 calves) to 25 (10 females, 15 calves) red deer per year (Table 2).

The calculations show that within MNP, wolves and lynxes can kill a maximum of 212 red deer per year, of which 140 individuals are the victims of wolves and 72 of lynxes (Table 2). If the population growth rate of red deer varies from 25.8% to 27.7% of all individuals (Tomek 2002), the red deer population of the MNP area is increasing by 258−277 individuals annually. The balance indicates that the wolf and lynx are unable to stop the growth of red deer in MNP.

5. Discussion

The current abundance of the ungulate population (1,230 deer units) in MNP exceeds the volume of food available from its tree stands, and the density of 6.6 deer units/km^2 is a genuine threat to maintaining the character of both the park

Table 2. The hypothetical impact of the wolf and lynx on ungulates in the Magura National Park (MNP) on the basis of calculations according to the published results of studies on diet wolf and lynx as well as the impact of these predators on the number of large hoofed mammals

Predator	Research area	Results	Number of victims killed by predators in the Magura National Park during the year
Wolf	(Śmietana 1998)	pack of wolves kills 35–65 red deer, 14–16 roe deer, 9–11 wild boar	70–135 red deer 28–32 roe deer 18–22 wild boar
	Białowieża Forest (Jędrzejewski et al. 2002)	daily requirement of wolf ranges from 4 to 9 kg feed, on average 5.6 kg	95 red deer (47 ♂; 28♀; 20 juv.)
		wolves killed an average of 72 red deer, 31 wild boar and 16 roe deer per 100 km^2	140 red deer 60 wild boar 31 roe deer
Lynx	Białowieża Forest (Schmidt et al. 2009)	the average lynx killed 48 deer and 18 deer in the year	192 roe der 72 red deer
	Białowieża Forest (Okarma et al. 1997)	lynx eats an average of day from 1.7 to 3.6 kg of meat	from 12 (4♀; 8 juv.) do 25 red deer (10♀; 15 juv.)

*in the Magura National Park live 8 wolves and 4 lynxes (GUS 2014)

and its neighbouring stands. This is also confirmed by Głowaciński (1997), who stated that a deer density higher than that recorded in the mid-1990s, which reached 5−7 individuals/km^2, causes about 60% more losses in the tree stands.

It is assumed that the level of damage caused by ungulates in commercial forests is acceptable if it does not endanger the achievement of the planned silviculture objectives (Miścicki 1998). On the other hand, in relation to Natura 2000 sites (MNP is practically the Magura Refuge), the level of damage must not jeopardise the preservation of natural habitats in their proper state of conservation, as required by Council Directive 92/43/EEC. In this perspective, the situation of MNP is unacceptable. The maintenance of the process of fir renewal in many Carpathian forests was already threatened in the 1980s, amongst other reasons, by exceeding the allowable damage threshold (Jamrozy et al. 1981; Szukiel 1982; Bernadzki 1983; Głaz 1991).

From the point of view of forest regeneration, ungulates are a factor hindering and limiting natural and artificial stand renewal, especially during the process of reconstructing and transforming the tree stands. It should be noted that in the Magura Refuge, the area only within the boundaries of MNP requires more than 4,707.11 ha of reconstruction, including 3,932.95 ha of urgent need (Romańczyk 2009). Reconstruction in such a state of ungulate abundance requires that these areas be fenced, even for a period of 60 years, to protect the fir. The effort and costs of such activities are great, and the results are uncertain (Szukiel 1982; Poznań, Jaworski 2000). Despite such threats, the MNP is nevertheless undertaking the reconstruction of its tree stands as the beneficiary of the Operational Programme Infrastructure and Environment, Action 5.1 (Project POIS.05.01.00-00-191/09 and Project POIS.05.01.00-00-375/12). Within the framework of the first of these projects, for example, fences with a total length of 14,340 m were built and 150,600 fir trees were planted in an area of 25.10 ha. It should be emphasised that given the current status of ungulates in MNP, each planted fir seedling not enclosed by fencing in reality becomes food for the ungulates. Taking down fences around fir sapling and pole wood stands can also be called the delayed feeding of cervids, as confirmed by Jamrozy and Brewczynski's (1998) study, which found a much greater pressure of ungulates on the forests of MNP compared to Babiogorski National Park.

Kuijper et al. (2010a) indicated that changes in the densities of large herbivores played an important role in the species composition of trees in Białowieża National Park (BNP) over the past 70 years. The number of younger generation of trees, referred to as ingrowth, calculated for all species was negatively correlated with ungulate concentrations, including red deer. On the other hand, periodic decreases in the number of ungulates, caused by humans or natural factors, can create conditions for the renewal of various tree species and promote more diversified and dynamic forest development. Research conducted at the BNP also showed that abiotic factors determine the early stages of the forest regeneration process, whereas the impact of ungulates has the greatest impact on subsequent stages (Kuijper et al. 2010b).

In turn, a different view on the impact of ungulates on forest regeneration is presented by Chwistek (2010). In discussing the results of research carried out in Gorczański

National Park (GNP), this author states that climatic factors are the dominant influence in the process of shaping the species composition of forest stands. In interpreting the results obtained for the transition from sapling to stratification, he presents the opinion on the lack of the impact of cervids on this process. However, this view is not supported by the results of the study because it did not include the extent of damage caused by ungulates to the young generation of trees nor did it refer to the population density of these animals in GNP during the study period.

The need to regulate the number of ungulates by humans in order to reconcile various ecosystem management objectives has recently been raised in the context of protecting Białowieża Forest (Jędrzejewska et al. 2011). This was pointed out earlier in relation to MNP (Jamrozy, Tomek 1997). The aforementioned authors proposed that the number of individual deer in the MNP area should not exceed 900 red deer and 1,500 roe deer (total of 1,200 deer units or almost 68 deer units per 1,000 ha). The result obtained of 66 deer units/1,000 ha compared to the recommendations cited by the authors may be considered satisfactory, but doubts are raised by the surprisingly low numbers of ungulates recorded between 2013 and 2014, compared to 2011, amounting to 1,221 red deer, 1,682 roe deer and 8 elk (85 deer units per 100 ha) (GUS 2012, 2013, 2014, 2015). It is difficult to determine why the estimated numbers decreased so significantly, and given this, accept the values proposed by the authors (Jamrozy, Tomek 1997). Bearing in mind the principles of managing ungulate populations, it cannot be ruled out that this was deliberate and only an indication of the scale of the problem of managing red deer and roe deer populations in protected areas. Red deer numbers determined for MNP are surprisingly low compared to the remote sensing results of March 2015 (Okarma 2015b). This inventory was conducted, amongst others, in the Low Beskids, where the Magurski National Park is located. This inventory, conducted along a 520-km long transect, determined an average density of red deer at 108.44 individuals per 1,000 ha of forest area. Accepting such a density in MNP means that there are twice as many deer in its area as the official statistics (GUS 2014, 2015). In the initial period of the Park's operation (in 1996−2005 and 2007), animals were counted annually in sample plots (using the sample round-up method, also called an extended line count) and tracked on permanent tracking trails (Jamrozy, Górecki 2009). These inventories showed that initially there were even more than 2,000 deer in the Park (500 according to the opinion of local foresters and hunters) and after several years, as a result of intensive reductions (not only in the Park but also in neighbouring hunting districts), this number decreased to about 1,200−1,500 individuals (Jamrozy, Tomek 2003). In 2013, an attempt was made to count the number of red deer by counting the faecal standing crop. On this basis, it was found that there are 630 red deer (Pirga 2014) in the Park. However, this result should be considered as indicative and subject to significant error, as the reliability of this method depends on the precise determination of the rate of deer defecation and the rate at which their faeces decompose (Chećko 2011), which was not determined; the calculations were based on the study results of animals kept in enclosures. In 2013−2014, animals were also counted on permanent sample plots and it was shown that there were between 1,994 and 2,306 red deer in the Park, which corresponds to the results obtained by Okarma (2015b). On this basis, it is highly probable that there are twice as many red deer in the Park than is presented in the official statistics (GUS 2014, 2015).

Acknowledging wolves and lynxes as the sole regulators of ungulates in MNP (Magura Refuge) is, from the perspective of the sustainability and stability of the tree stands in this area, detrimental to the forest ecosystems. The calculations clearly show that the large predators (eight wolves and four lynxes) living in MNP are unable to stop the growth of the red deer population (258−277 individuals). Within the scope of active protection, the number of deer was reduced through hunting. In 2010−2014, 51–82 deer (GUS 2011, 2012, 2013, 2014) were taken each year. MNP is not an island, so ungulates move to neighbouring areas and vice versa in search of food, shelter and so on. Owing to the distribution of ecological corridors in the Małopolska region (Jędrzejewski et al. 2005; Perzanowska et al. 2005), one can assume that deer will migrate from MNP to the west through the tree stands of Gorlice and Łosie Forest Districts. The radius of impact associated with this movement, represented by a significant increase in the damage in these stands, can reach as high as 100 km (Górny, Jędrzejewski 2011). This indicates that in the commercial forests bordering MNP, including those in Natura 2000 sites, the movements of ungulates may prevent the achievement of renewal objectives. Therefore, the concern is justified, especially because the sustainability of the commercial forests included in the Natura 2000 refuge is a prerequisite for maintaining habitats and species in good condition, whose presence was the basis for determining the borders of the Magura Refuge.

6. Conclusions

1. Maintaining balance in the 'predator–prey' relationship ('wolf, lynx–deer') under the conditions prevailing in Poland, even in consideration of the spatial scale of the problem, is unrealistic.

2. Quantifying the 'predator–prey' dependency requires improvements in inventory methods of both the game animals and predators.

3. Failure to regulate the number of ungulates in national parks may adversely affect the biodiversity in both these parks (e.g. the reduction and even the elimination of preferred tree species, the degradation and disappearance of natural habitats) and adjoining areas.

Conflicts of interest

The authors declare no potential conflicts of interest.

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M.W., K.Sz. – writing the text, literature review; Z.K., P.B. – concept of the paper, literature review.

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