LIFE Lynx

Preventing the extinction of the Dinaric-SE Alpine lynx population through reinforcement and long-term conservation

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CONSIDERATION OF LARGE CARNIVORES IN THE MANAGEMENT OF WILD UNGULATES

Action C.10

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Andrej Rot, Rok Černe, Matej Bartol, Matija Stergar

ZAVOD za GOZDOVE SLOVENIJE
Slovenia Forest Service

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INTRODUCTION

In areas where large carnivores are permanently present, predation can be an important cause of wild ungulate mortality. The impact on ungulate populations varies greatly in different environments, depending on populations' densities and a number of environmental factors. In some wild ungulate populations, predation is a key cause of mortality of prey species, but in others predation has a less pronounced effect, and predation may account for a major part of that mortality that would have been caused by other environmental factors in their absence (i.e. compensatory mortality) (Černe R. et al., 2012). In this document, we focus on the impact of wolf and lynx, which are the most important predators of wild ungulates in our country. At the same time, sufficient abundance of wild ungulate populations is an important factor for the existence of wolf and lynx in the environment.

To this end, as part of the preparation of long-term hunting management plans for the period 2021-2030, the Slovenian Forest Service, in cooperation with the LIFE Lynx project and hunting ground managers, has prepared new guidelines for the consideration of lynx and wolf in the management of wild ungulates. The main purpose of the guidelines is to contribute to the preservation of viable populations of ungulates through "adapted game management", to ensure a permanently available food source for lynx and wolf, which is a prerequisite for the long-term conservation of both species, and to maintain hunters' tolerance toward presence of large carnivores. However, as the availability of natural prey is also (negatively) correlated with the level of predation on farmed/domestic animals, adapted management of ungulates can also help to reduce predation on livestock.

In addition to the biological and ecological capacity of the environment, it is also extremely important to consider the attitudes of local people and key stakeholders, in particular hunters, toward large carnivores,. Slovenian hunters support the presence of large carnivores in the ecosystem (Bele et al., 2022), which is a crucial starting point for further conservation activities and an important asset for Slovenia. A survey of attitudes toward the wolf (Mavec and Majić Skrbinšek, 2020) shows that the attitudes of the local general public and stakeholders (farmers and hunters) are generally favourable to the conservation of the species. However, trust in decision-makers appears to be a key starting point for successful management of the species and maintaining people's tolerance (Mavec and Majić Skrbinšek, 2020). Most studies focusing on attitudes toward large carnivores highlight the importance of involving the public, and key stakeholders in particular, in the species management process itself. For this reason, the Slovenian Forest Service decided to adopt a participatory approach in the adoption of the guidelines, thus engaging with hunters from the very start of the process. In this way, different needs and perspectives of this key stakeholder group were coordinated and taken into account throughout the process.

These guidelines are a tool for planning the removal of wild ungulates and as such are integrated into long-term hunting management plans. The document addresses the main prey species of lynx and wolf (red deer, roe deer) and those that might be affected in a locally significant context (chamois, mouflon). The guidelines will serve as a guide for hunters and planners when adapting hunting management plans in areas where large carnivores are regularly present, ensuring an adequate prey base for the nutritional needs of lynx and wolf (by planning lower degree of culling). The guidelines will also help game reserve managers to meet the challenges posed by large carnivores in game management. An important added value of the guidelines will therefore be their contribution to maintaining the tolerance of game park managers toward the presence of large carnivores.

The guidelines were developed in the framework of the project "LIFE Lynx – Preventing the Extinction of the Dinaric-SE Alpine Lynx Population Through Reinforcement and Long.term Conservation", Action C.10. The guidelines were based on the guidelines developed in 2012 in the framework of the project "LIFE Slowolf - Conservation and surveillance of the conservation status of the wolf (*Canis lupus*) Population in Slovenia". The new guidelines were developed by incorporating and adapting the existing guidelines, taking into account both large carnivore species, the lynx and the wolf. They are adapted to the overall concept of wild ungulate management. At the same time, they additionally include the impact of lynx and wolf on chamois and mouflon. The new and improved guidelines replace the existing guidelines in wild ungulate management planning and are part of the document 'Guidelines for the management of wild game in Slovenia in the period 2021-2030'.

We wanted to involve as much as possible the managers of the hunting grounds in the development of the guidelines. Hunters can make an important contribution to optimizing the management of wild ungulates and to the long-term conservation of large carnivores in Slovenia through their field observations and experience. To this end, we have been collecting opinions and suggestions on the consideration of large carnivores in the management of wild ungulates through the regional associations of hunting ground managers (hereafter: OZULs). Their suggestions and opinions were collected and discussed by the expert group for consideration of large carnivores in the management of ungulates at the Slovenian Forest Service. This was followed by the presentation of the collected proposals and proposed improvements of draft guidelines during four sectoral meetings with representatives of OZUL of the Notranjska, Zahodnovisokokraško, Triglavsko, Gorenjska, Kočevsko-Belokranjsko and part of Novomeško

and Primorsko hunting management areas.[1] The hunters presented their views on the subject, made additional suggestions and highlighted the problems they face in their hunting grounds. After the workshops, a draft document was prepared on the basis of all suggestions collected. In the frame of preparation of strategic documents in hunting management area, this draft was further discussed by an expert group consisting of representatives of the Hunting Association of Slovenia, game management planners from the Slovenian Forest Service and researchers in the field of large carnivores.. This was followed by a meeting of the hunting managers of the Slovenian Forest Service, which considered all the comments collected. After the coordination of the collected proposals and previous versions, the guidelines were incorporated into one of the two overarching strategic documents of the Slovenian Forest Service for the management of wild game populations in Slovenia: *The Guidelines for game management in Slovenia in the period 2021-2030*. This document was also reviewed and approved by the expert council of the Slovenian Forest Service.

These guidelines will be taken into account in the 10-year (long-term) and 2-year (short-term) hunting management plans of those hunting management areas and hunting grounds' plans that cover the area of permanent presence of wolf and lynx. The 10-year (long-term) hunting management plans will be approved by the Government of the Republic of Slovenia.

[1] These are areas where lynx and wolf are currently present or are expected to expand into these areas in near future.

THE IMPACT OF LYNX AND WOLF PREDATION ON WILD UNGULATES

The impact of both carnivores on prey species is presented so as to facilitate understanding of this document and to guide managers in making decisions when preparing short- and long-term management plans.

The impact of wolf and lynx on wild ungulates is based on data from studies on large carnivore predation in Slovenia and from studies in other parts of Europe, especially those areas with conditions more similar to those in Slovenia. These surveys form the basis for this chapter, which summarizes the essential data on the impact of lynx and wolf predation. The impact of both predators on red deer and roe deer is presented here on basis of conclusions from research on real data from Slovenia. The impact on chamois and mouflon is presented on the basis of research from abroad, as we do not have concrete data and research on the impact of large carnivores on these two ungulate species in Slovenia.

The impact of predators on wild ungulates in the hunting ground (abundance, age-sex structure of prey) depends on several factors, namely:

- Predator species composition,
- Prey species composition,
- Population density of prey species,
- Age-sex structure of prey species,
- Population viability of prey species and
- Seasonal and circadian activity rhythms of prey species,

Through predation, wolf and lynx have both, a direct impact on their prey and an indirect impact on the whole ecosystem. Predation can have a direct effect on the game population abundance , as well as on the sex and age structure of the population, as wolf in particular preferentially prey on certain age and sex categories of prey species (Černe R. et al., 2012). Physically weaker and sick individuals are more vulnerable to predation. The permanent presence of wolf and lynx also directly influences the behaviour of wild ungulates and their distribution in space. The long-term impact of the continued presence of predators also has an impact on the genetic characteristics of individual species and thus on the evolution of both, wolf and lynx, and wild ungulates. Indirectly, wolf and lynx predation also has an effect of potentiating effects through different levels of the food web (the so-called trophic cascade), increasing biodiversity and

ecosystem services, and ensuring ecosystem stability (Mech and Boitani, 2003).

THE IMPACT OF LYNX PREDATION

Data on the impact of lynx predation are obtained from several studies in Slovenia (mainly in the Dinaric Mountains) and supported by findings from international research.

Unlike wolf, the lynx is solitary, but just as territorial. It is a specialised predator of small-sized ungulates, supplementing its diet by opportunistically preying on a wide range of other prey species (Kos I. et al., 2005). As an opportunistic predator, it usually chooses the smallest species among the available ungulates(Krofel M., 2011).

As a territorial species, males defend their territory from other males and females from other females (there is relatively little overlap between adjacent territories), while males and females tolerate each other and overlap their territories. The size of home ranges is quite variable, generally larger in males. In Europe, the range of home ranges for males is from 180 to 2780 km^2 and for females from 98 to 759 km^2 (Breitenmoser et al., 2000).

Based on telemetry monitoring of radio-collared individuals, the average size of a lynx territory in Slovenia is around 21,500 ha (Krofel M., 2012).

Frequency of lynx predation

The frequency of predation depends on the sex, age and reproductive status of the lynx, as well as prey density and abiotic factors (Krofel M., 2012). The highest predation frequency occurs in females with pups, followed by adult males and then adult females without pups (Andren H. et al., 2015). The lynx consumes smaller prey completely. Consumption of larger prey, however, takes place over a longer period of time. It returns to larger prey for 1 to 7 days, depending on the prey type, and consumes 3.2 to 4.9 kg of meat on each visit. The average daily food requirement, including days when it does not feed, is around 2 kg (Krofel M., 2012).

In a study in the Dinaric region (Slovenia), where the authors compared roe deer culling with lynx predation on roe deer, concrete data on lynx predation in Slovenia were presented. Based on telemetric monitoring of lynx in an area of 931 km^2 , the average frequency of lynx predation on roe deer was 47.8 roe deer per year. This means that the average predation frequency is 1 roe deer per 7.64 days or 0.22 roe deer/100 ha/year, which represents approximately 8% of the local roe deer population (Krofel M. et al., 2013). [2]

[2] In the same study it was estimated that if the lynx population in Slovenia were saturated, the average predation rate would be around 0.33-0.38 roe deer/100 ha/year, which represents around 12-14% of the local roe deer population. This average value would be valid, if the entire population were optimally distributed in the area of Slovenia, given the geographical characteristics and spatial distribution of lynx. It should be noted that these are average values at the level of the lynx territory (in smaller areas there may be variations in one direction or the other).

Species composition of lynx prey

Besides wolf, lynx is considered to be the most important predator of large herbivores in Europe, and the most important predator of European roe deer (Jedrzejewski W. et al., 2011).
In the Dinarics, roe deer represents about 80% of the total biomass consumed by lynx (Krofel M. et al., 2011). Specific to the Dinarides, the second most important species in lynx diet is a rodent, the European edible dormouse, which accounts for about 7% of the lynx dietary requirements. However, this proportion varies considerably from year to year, as there are considerably more dormice in the mast years, when fruit-bearing trees are masting, than in non-masting years.. Among other prey species of lynx red deer, chamois, rabbit, wild boar, fox, wolverines and birds can be found, but all these species together represent only a small part of the lynx diet (Krofel M. et al. 2011).

Sex and age structure of lynx prey

a) Red deer and roe deer

Data obtained from research on the predation of lynx from the northern Dinaric Mts. (Slovenia) show that in case of red deer predation occurs almost exclusively on fawns and females, while in case of roe deer, lynx also preys on adult males (Krofel M., 2012). The demographic structure of lynx prey is shown in the graph below:

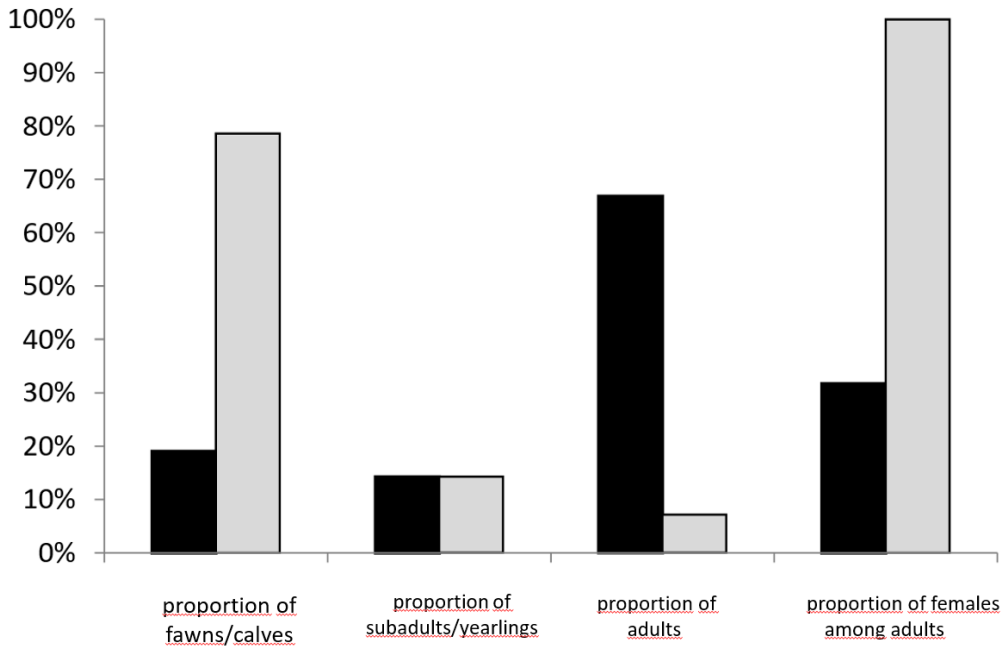

Image 1: Comparison of the demographic structure of lynx prey for roe deer (black) and red deer (grey) (Krofel M., 2012).

ROE DEER: A study was carried out in the Northern Dinarides (Slovenia), comparing roe deer hunting bag with the predation of Eurasian lynx. Based on the data from the cull and the analysis of lynx prey found, it is evident that compared to the cull, lynx predates less frequently on adult males than adult females. In terms of age, lynx are less likely to prey on adults than on fawns or subadults (Krofel M. et al., 2013). The data are shown in the table below:

Table 1: European roe deer hunting bag (for the period 2006-2011) compared to lynx predation (for the period 2005-2012) on roe deer, (Krofel M. et al., 2013).

	Fawns (M/F)		Subadults (M/F)		Adults (M/F) 2+	
	M	F	M	F	M	F
cull	0,181	0,198	0,127	0,103	0,251	0,139
lynx prey	0,127	0,063	0,079	0,063	0,349	0,317

Lynx preferentially prey on roe deer in poorer physical condition. Based on the findings of the study, the proportion of predated roe deer in poor condition was 69 %, while the proportion of completely starved animals (compensatory mortality) is 10 %. However, in the area of permanent bear presence, it should be noted that bears find on average 32 % of the lynx prey remains, to which lynx respond by increasing the frequency of predation by approximately 23 % (Krofel M., 2012).

RED DEER: Lynx very rarely prey on red deer, so the impact of predation is negligible. However, when predation does occur, lynx predates mainly calves, which are more vulnerable than adults due to their smaller size, inexperience and often poorer physical condition. . Among adults, predation is limited to adult females, as males are a stronger opponents due to their larger size and antlers (Krofel M., 2012).

b) Chamois and mouflon

We do not have specific data on the impact of lynx predation on chamois and mouflon. Based on data from foreign studies, it has been found that, in principle, in areas where roe deer and chamois coexist, roe deer are the preferred prey species, even in cases where the chamois population is more abundant than the roe deer population (Molinari-Jobin A. et al., 2007).[3] Findings showed that lynx kill a maximum of 11% of the spring chamois population per year (Molinari-Jobin A. et al., 2002). The habitat in which chamois live also has a major influence on

[3] The surveys were carried out in the Swiss Alps and the Swiss Jura Mountains. The terrain and habitat configuration is similar to that of the Slovenian Alps. In these areas, the chamois represents the main alternative prey species for lynx (Krofel M. et al., 2013).

their exposure to predation. In forested areas, chamois are significantly more exposed to lynx predation than chamois above the forest line.

The impact of lynx is expected to be significant in some smaller areas with concentrated populations of chamois and mouflon, where they might represent an important alternative component of the lynx diet.

THE IMPACT OF WOLF PREDATION

The impact of wolf on prey species populations varies greatly in different parts of the world, depending on latitude, the demographic characteristics of prey populations and their health, the presence of alternative prey species and their relative abundance, predator preference for a particular species, and other factors. Therefore, the assessment of the impact of wolf on ungulate populations and its consideration in the hunting bag planning should be based on realistic data from the area for which the hunting bag is planned (Černe et al. 2013). The prey preference of a wolf pack toward a particular prey species may be related to the size of individual wolf in the pack and the number of wolf in the pack. This is closely related to the size (body mass) and condition of the prey, so that energy expenditure during hunting is balanced between energy output and energy input (Zlatanova D. et al. 2014). It is a risk-return relationship between predation efficiency and profitability, which relates to the vulnerability of a particular prey species (Mech and Boitani 2003).

According to surveys, the average wolf territory size for Slovenia is around 350 km^2 (Štrbenac et al. 2010, Potočnik et al. 2011).Given that wolf are territorial animals, , we do not expect any significant changes in the future in terms of the impact of wolf on ungulates in the areas of long-term wolf presence (i.e. the Dinaric and Pre-Alpine regions), as the number of wolf in the already occupied territories is not significantly increasing or decreasing. However, changes are expected in those parts of Slovenia, where wolf numbers are currently increasing due to the wolf population expansion, i.e. areas where wolf have been previously absent or only occasionally present (e.g. the Alpine area).

Assessments of the impact of wolf on wild ungulate populations in Slovenia have been carried out based on different indices (Černe et al., 2013):

- records of animals killed by wolf, collected in special purpose hunting grounds (within Slovenia Forest Service) in the area of regular wolf presence;
- assessment of the dietary needs of wolf and the densities or biomass of wild ungulates;
- wolf prey found using telemetric wolf-tracking;
- analysis of wolf excrements.

Frequency of wolf predation

Several studies have also shown that predation rates can vary widely between packs, areas and seasons, and therefore it is only reasonable to generalise that wolf only kill enough to sustain themselves (Mech and Boitani, 2003).

According to studies from abroad (Poland), the number of wolf in a pack influences the consumption rate, i.e. the yield from each prey, more than the predation rate (Jedrzejewski et al. 1993, Okarma et al. 1997). Excess predation, where wolf prey on more than they can consume at any given time, occurs in rare situations where prey is simple to catch and vulnerable (Mech and Boitani, 2003).

Species composition of wolf prey

Due to considerable differences in species composition and the proportion of each prey species in the wolf diet between different areas explained above, it is not easy to generalize the impact of wolf predation to other areas of the world, but it is reasonable to limit ourselves to research carried out in Slovenia, which is supported by data from research in similar areas abroad.

Several studies[4] have been carried out in Slovenia on the impact of wolf on individual prey species. Analyses of wolf excrements have shown that in Slovenia the impact of wolf on prey species in the Kočevska, Notranjska and Primorska regions is as follows:

Table 2: Analysis of wolf faeces by individual regions (fort he period 2009-2012), (Potočnik H. et al., 2014).

KOČEVSKA		**NOTRANJSKA**		**PRIMORSKA**	
Roe deer + roe deer*	77%	Roe deer + roe deer*	63%	Red deer + roe deer*	39%
Wild boar	17%	Wild boar	31%	Wild boar	37%
Domestic animals	4%	Domestic animals	2%	Domestic animals	20%
Rabbit, birds, rodents, other	2%	Rabbit, birds, rodents, other	4%	Rabbit, birds, rodents, other	4%

**Data for red deer and roe deer are combined due to the difficulty of distinguishing the hairs of each species in the faeces. The approximate ratio of wolf predation to prey biomass between roe deer and red deer is 2:3 at the national level (no precise data are available for individual packs).*

In terms of the biomass of species killed by wolf from the above calculations from wolf excrements, the national average is 35% red deer, 30% wild boar, 22% roe deer, 10% domestic animals, 1% field rabbit, 1% rodents, <1% other.

[4] The purpose of presenting the data from these studies is to provide a general understanding of the impact of wolf on prey species. For a more specific and in-depth understanding, we recommend reviewing the studies cited (see Sources and Literature section).

Sex and age structure of wolf prey

a) Red deer

In Slovenia, extensive data on the age and sex structure of wolf prey were collected between 2001 and 2010 in four special purpose hunting grounds (Medved, Žitna gora, Jelen and Snežnik Kočevska Reka) operating within the Slovenian Forest Service. In the case of red deer, the data collected show that in the total prey of wolf , male calves and male yearlings represent 21.8% of all predated animals, 33.9% are female calves and female yearlings, in the class of two years and older (2+) however, 4.4% are adult males and 39.8% are adult females (Černe et al. 2012).[5] This is the most comprehensive analysis of wolf predation in Slovenia to date, and the data are therefore also presented here. The data are shown in the graph below:

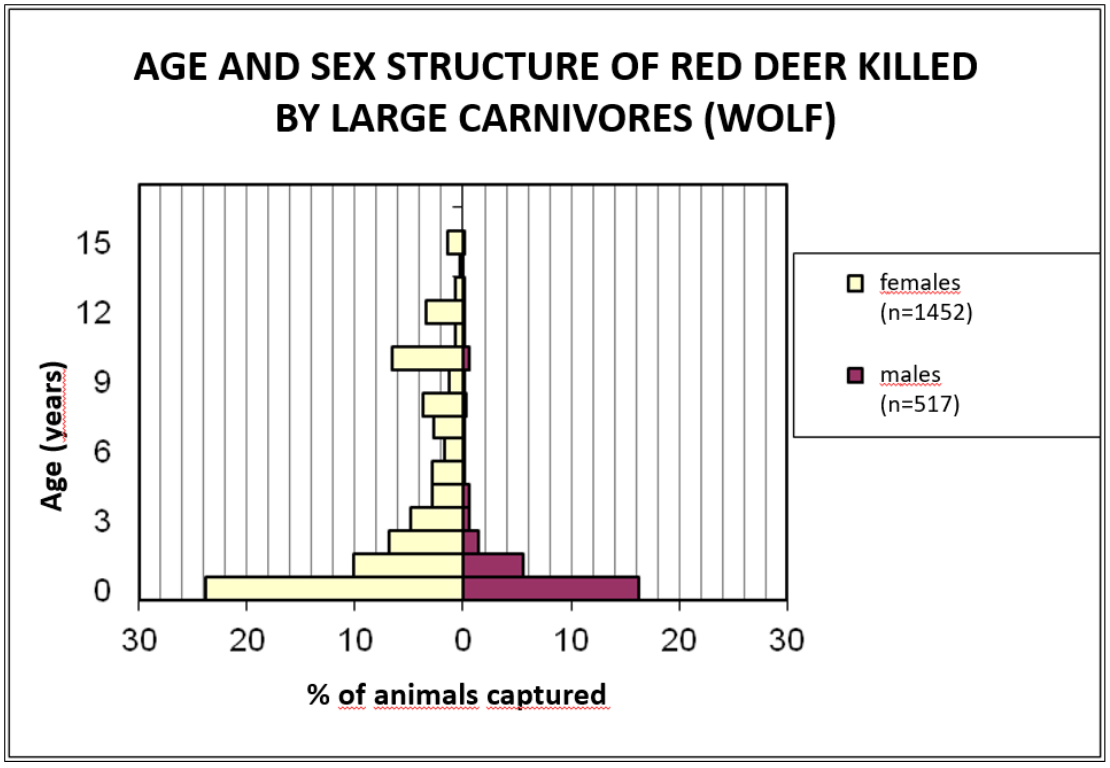

Image 2: Age and sex structure of red deer killed by large carnivores (wolf) for the 10-year period between 2001 and 2010 (Černe et al. 2013).

The most common prey of wolf were calves of both sexes, but in the class of yearlings predation

[5] A very similar relationship between the age and sex structure of red deer killed by wolf was confirmed in a study conducted within the LIFE08 NAT/SLO/000244 SloWolf project, Action C.1. More detailed data are presented in the project report Monitoring of Conservation Status of wolf in Slovenia (3), seasons 1, 2, 3 -2010/11, 2011/12 and 2012/13.

of females was predominant, followed by adult females (> 10+). With more frequent predation of adult females, wolf seem to impact the sex structure of the adults in the red deer population. This impact should be taken into account in red deer management.

The density of red deer population influences the most the proportion of red deer in the wolf diet. Therefore, the proportion of red deer in the wolf diet increases in line with increasing density in the environment (Potočnik H. et al., 2014).

b) Roe deer

Wolf predation has a relatively small impact on sex and age structure of roe deer, as there was no significant preference for predation on different sex or age classes of roe deer, although wolf predated slightly more frequently adult animals and males. Unlike in case of red deer, the proportion of roe deer in the wolf diet is independent of their density in the environment (Potočnik H. et al., 2014). Data on the sex and age structure of predated roe deer are shown in the table below:

	Males	**Females**	**Unkown gender**	**SUM**	**%**
0+	2	2	3	7	**39%**
Adults	6	3	2	11	**61%**
Unknown age	0	1	11	12	
SUM	**8**	**6**	**17**	**31**	
%	**57%**	**43%**			

Table 3: Sex and age structure of roe deer found killed by wolf (Potočnik H. et al., 2014).

c) Wild boar

Wild boar is present almost throughout Slovenia, but at different population densities. In areas of permanent wolf presence and high densities of wild boar, the wild boar occurs in the wolf's diet. In Slovenia, this is mainly the area of Primorska and Notranjska (Krofel M. and Kos I. 2010). Wolf preferentially prey on wild boar between 10 and 35 kg, as animals of this weight can not be well enoughdefended by their mothers, and besides, live in larger groups that are more easily spotted by predators, or separate from their mothers before the first year of age and are therefore more vulnerable. Piglets (under 10 kg) are well defended by their mothers, sowolf generally do not take such a risk for profiting with a small amount of food only (Zlatanova D. et

al., 2014). Predation of larger boars is generally avoided by wolf due to the potential of suffering an injury.

Red deer population densities and the proportion of wild boar in wolf diet are negatively correlated, meaning that high red deer densities result in a low proportion of wild boar in the wolf diet (Potočnik H. et al., 2014).

Given the wide distribution, high fertility and density of wild boar, the impact of wolf predation on the wild boar population is negligible and no special adjustments in hunting management are needed.

d) Chamois and mouflon

Data from abroad (France) show that in areas where both chamois and mouflon are permanently present, there are differences in the frequency of wolf predation between the two species, depending on the time of the year (Poulle M., Carles L, Lequette B, 1997). For instance, mouflon was twice as likely to be predated by wolf in spring, autumn and winter than chamois, despite the fact that mouflon was ten times less abundant than chamois in the study area. In summer, however, there was a markedly low level of mouflon predation compared to other seasons. On the contrary, in summer there was more than twice the predation of chamois compared to mouflon (Poulle M., Carles L, Lequette B, 1997).

Seasonal differences in mouflon predation were most likely related to the fact that mouflons have difficulties to escape predators when snow cover is thicker; in winter, they groupin predictable areas of favourablepatches; they generally stay at lower altitudes than chamois from spring to autumn; they have one of the earliest fawning seasons among wild ungulates(Poulle M., Carles L, Lequette B, 1997).

DESIGNATION OF LARGE CARNIVORES PRESENCE AREA

Adapted models for wild ungulates management (red deer, roe deer, chamois, mouflon) are only considered in those spatial units (i.e. hunting grounds and special purpose hunting grounds) where wolf and/or lynx are regularly present. The spatial units of regular presence, where the management adjustments take place, are updated each time the biannual hunting management plans are being prepared and apply for the entire (biannual) period of validity of the plans.

The condition of regular presence in a spatial unit is met, if there is evidence of a territorial pack present for at least two consecutive seasons or at least one confirmed reproduction during this period in case of wolf, and a territorial animal present for at least two consecutive seasons in case of lynx. Additionally, the regular presence of a single territorial wolf in areas of current wolf expansion, i.e. areas where prior there have been no territorial wolf for the last 20 years, shall also be considered as conditions met for adjusted ungulate management. Sporadic passages of wolf and lynx in the hunting ground are not a sufficient proof to comply with the adapted wild ungulate management model.

Basis for the designation of areas of permanent wolf presence are data collected in the frame of annual national wolf monitoring, funded by the Ministry of Environment and Spatial Planning of the Republic of Slovenia. Wolf monitoring comprises genetic analyses of non-invasive genetic samples (feces, urine, hair and saliva from livestock depredation events). Samples are collected in the field by staff of Slovenian Forest Service and Biotechnical Faculty , hunters and other volunteers. It is important to collect and analyze a sufficient number of samples in order to provide good quality data, so the help of everyone involved in sample collection is very much appreciated. In addition to genetic methods, data from wolf-howling surveys, data on livestock depredations and data on recorded predations on wild ungulates are used to determine the presence and impact of wolf.
Basis for the designation of areas of permanent lynx presence are data collected through lynx monitoring, which at this moment is being carried out in the framework of various international projects and regular duties of Slovenian Forest Service staff. Lynx monitoring in Slovenia is based on both, the systematic camera-trapping method, where individual lynx are identified based on coat patterns, the use of genetic methods and the collection of information on occasional sightings of lynx.

The use of the adapted model in red deer management is only applicable in areas where the territorial wolf pack is regularly present for two consecutive seasons. The presence of lynx alone is not a sufficient reason to apply an adapted red deer management model. Moreover,

in exceptional circumstances (e.g. the hunting management plan has set a strong red deer population reduction as an objective), the hunting planner is not obliged to apply an adapted model, even if the conditions to do so are met.

The use of the adapted model in the management of roe deer, chamois and mouflon is allowed in those spatial units, where a wolf pack has been regularly present for at least two consecutive years and/or a territorial lynx has been regularly present for at least two years.

There is no possibility of adjusting already adopted biannual hunting management plan during the period of its validity . If the impact of large carnivores increases within the two-year period, this will be taken into account in the subsequent plans.
The only exception to amending the biannual hunting management plans within the two-year period of validity is in the case of new re-introductions of lynx. In this case, the areas of lynx presence may be updated/ changed after the end of the first year of the plan's validity.

INSTRUCTIONS FOR RED DEER MANAGEMENT

Adapted red deer management is only applied in areas of permanent wolf presence. Wolf prefers to prey on calves and adult females. Lynx presence is not taken into account in modifications of red deer management due to its negligible predation on red deer.

In addition to taking into account the permanent presence of wolf, the planning of red deer removal must also take into account the actual situation of the red deer population.
Adapted management plans for removal of red deer in areas with permanent wolf presence should take into account the population status of red deer, as well.
On one hand, an adequate prey base for the wolf must be ensured, while at the same time red deer densities must be adequate and appropriate in regards to other activities in the area (influence on anthropogenic forest and agricultural activities). From a hunting point of view, an appropriate proportion of adult males cull and an appropriate proportion of adult females removals must be ensured to meet hunting management objectives.

The current red deer density in the Notranjsko and Kočevsko-Belokranjsko hunting management area, which are also the main areas of wolf presence in Slovenia, represents an adequate prey base for wolf. The spatial expansion of red deer population is also undergoing in the Zahodnovisokokraško, Triglavsko, Primorsko and Gorenjsko hunting management area. If wolf population expands into new areas, the prerequisite of a proven permanent presence of a territorial pack or at least one confirmed reproduction in a bi-seasonal period will be taken into account in the adjustments of the next biennial hunting management plan. It should be noted, that there is no possibility of adjusting the hunting regime during the validity of the biennial plan.

The adapted red deer management model in areas of permanent wolf pack presence includes:

- The planned removal of adult females must not amount to more than 25% of the total planned removal of red deer;
- A predation of an adult male aged 5+ years by wolf does not affect the possibility of culling an adult male by hunters. This means that the permissible deviation of the planned hunting bag for the 5+ adult males can be increased for a maximum of the number of recorded losses due to wolf predation in this age class.

In exceptional cases, where such adjustments could be in clear conflict with other game management objectives (e.g., in areas where the objective is a strong reduction of red deer), these hunting management adjustments are not to be taken into account.

INSTRUCTIONS FOR ROE DEER MANAGEMENT

Roe deer management adjustment in large carnivore areas takes into account the impact of both, wolf and lynx. Roe deer represent a crucial part of the nutritional needs for both large carnivore species, and is especially important for lynx. Both predators primarily affect its abundance. However, their impact on the sex and age structure of the roe deer population is relatively small. Unlike in case of red deer, upon which wolf predates selectively, roe deer is opportunistic prey, regardless of the sex or age of the individual. Nevertheless, there is a preferential predation of weaker individuals.[6] For these reasons, roe deer management should be adjusted by reducing or increasing cull. It is advisable to direct the culling in such a way as to maximize reproduction and progression into the higher age-class categories. At the same time, it is important to maintain a balanced sex and age structure of the population. In Slovenia, ungulate management pays particular attention to the proportion of females and males in the cull. This means that a certain percentage of females should be culled in connection to a certain percentage of males culled, or vice versa. This principle in roe deer hunting planning is known as binding by gender.
Moreover, the differences in roe deer densities between large agglomerated forest complexes, where roe deer densities are lower, and fragmented landscapes, where roe deer densities are higher, should also be taken into account.

Roe deer management should be adjusted in regards to the density of roe deer removal, which generally reflects the population density and intensity of roe deer management in an area. To this end, three categories of adaptive management measures for roe deer are established in areas of permanent wolf and/or lynx presence, in accordance to the population density of roe deer in that area:

1. Hunting grounds with very low roe deer removal (i.e., hunting grounds with planned annual hunting bag of up to 1 individual per 100 hectares of hunting ground);
2. Hunting grounds with moderately low roe deer removal (planned annual hunting bag between 1 and 2 individuals per 100 hectares of hunting ground);
3. Hunting grounds with high roe deer removal (planned annual hunting bag above 2 individuals per 100 hectares of hunting ground).

On one hand, large and mature forest complexes (especially in areas of permanent lynx presence) are not optimal habitats for roe deer, and on the other hand, roe deer is a key prey for the endangered lynx population in Slovenia. For this reason, roe deer management in these areas should be adjusted in a way to allow greater ingrowth of younger animals into the higher age-class categories. In such areas with very low roe deer removal densities, it is advisable to give hunting ground managers more discretion over the level of roe deer removal itself, and

[6] The study, which compared the culling of European roe deer with the prey of Eurasian lynx in the Dinaric Mountains in Slovenia, found that the proportion of roe deer with depleted fat reserves in the bone marrow is higher in animals captured by lynx than among culled ones (Krofel M. et al., 2012) .

to eliminate binding by gender rule, thus freeing up management options. However, despite the abandonment of these conditions, the hunting bag quotas within each category must not be exceeded. In areas with very low removal, in order to ensure the long-term persistence of roe deer, management must also be adjusted in such a way as to allow for absolute deviations (downwards) in the realization of the planned removal in cases, where the natural conditions (forest regrowth, weather conditions, disturbance in the area) deteriorate significantly.

In areas with moderately low annual roe deer removal densities (annual removal densities above 1 and below 2 individuals per 100 hectares of hunting ground), where lynx and wolf are permanently present, management adjustments should allow greater tolerances on the realization of the removal for all categories.

In areas with higher annual roe deer removal densities (annual roe deer removal densities above 2 individuals per 100 hectares of hunting ground), despite the permanent presence of wolf and lynx, no specific adjustments of deer management are required.

The adapted roe deer management model in areas of permanent wolf pack and/or territorial lynx presence includes:

1. In hunting grounds where planned annual roe deer removal is up **to 1 individual per 100 hectares of hunting ground:**
    - The tolerances for the realization of the removal for all categories and overall are -100 % and +20 %;
    - Binding by gender rule for the cull of adult females 2+ and subadult females with the adult males 2+ is not valid.

Table 4: Management adjustments in those hunting grounds where planned annual removal is below 1 individual per 100 hectares of hunting ground.

Age categories	**Tolerance intervals (in % of the planned number in a given category)**	
	M	**F**
Fawns	+ 20 % /- 100 %	
Subadults	+ 20 % /- 100 %	
Adult males 2+ / Adult females 2+	+ 20 % /- 100 %	+ 20 % /- 100 %
Total	+ 20 % /- 100 %	

2. In hunting grounds where planned annual roe deer removal is **above 1 and below 2 individuals per 100 hectares of hunting ground:**
    - The tolerances on the realization of the removal for all categories and overall - 40% and +20%;
    - Binding: the height of adult female 2+ and female subadults cull shell be at least 60% of the height of the adult male 2+ cull.

Table 5: Management adjustments in those hunting grounds where planned annual removal is between 1 and 2 individuals per 100 hectares of hunting ground.

Age categories	**Tolerances (in % of the planned number in a given category)**	
	M	**F**
Fawns	+ 20 % /- 40 %	
Subadults	+ 20 % /- 40 %	
Adult male 2+ / Adult female 2+	+ 20 % /- 40 %	+ 20 % /- 40 %
Total	+ 20 % /- 40 %	

3. In areas where planned annual roe deer removal **exceeds 2 individuals per 100 hectares of hunting ground**, and despite permanent presence of territorial wolf and/or a territorial lynx, the adapted management measures shall not be included in roe deer removal planning. Roe deer management is planned in the same way as in areas without regular wolf and lynx presence.

Such management plan adjustments with allowing wide and flexible tolerance intervals for deviations from annual removal quota is to ensure long-term preservation of roe deer. This is because the impact of large carnivores on prey species is not entirely predictable, and may be particularly high at lower prey population densities. Therefore, in such a situation, particularly flexible management with larger downward culling tolerances is adopted with the aim of ensuring the sustainable conservation of prey species. At the same time, such management approach better reflects the preferences of the hunting ground managers, and will by our knowledge contribute to increased tolerance for the presence of large carnivores.

INSTRUCTIONS FOR CHAMOIS MANAGEMENT

Adaptation of chamois management in areas where large carnivores are regularly present takes into account the impact of the territorial pack of wolf and/or lynx. The impact of wolf and lynx on chamois in Slovenia is relatively unknown. The potential impact of these two large carnivores is expected to affect mainly the chamois populations in the medium mountain region, where the chamois habitat is predominantly forested terrain. No impact is expected in the high mountains. Opportunistic predation of all sex and age categories is expected.

The adapted management model for chamois in areas of permanent wolf pack and/or lynx presence includes:

- The planning of the height of removal is adapted to estimates of chamois population trends;
- The tolerance on the realization of total removal is increased downwards to -30%.

Management adjustments regarding the presence and impact of large carnivores are made as part of the preparation of each biennial game management plans. Within the duration of the biennial management plan, adjustments are not possible, despite the possible occurrence of large carnivores.

INSTRUCTIONS FOR MUFLON MANAGEMENT

The impact of the territorial pack of wolf and/or lynx shall be taken into account when adapting the management of mouflon in areas of regular presence of large carnivores. Of the four wild ungulate species considered, the impact of wolf and lynx on mouflon is expected to be the greatest. For this reason, maximum flexibility of mouflon population management is foreseen in certain areas.

The adapted management model for mouflon in areas of permanent wolf pack and/or lynx presence includes:

- The removal tolerances for all categories and overall are -100% and +100%, provided that this does not conflict with other management objectives.

The purpose of the complete flexibility of mouflon management in the area of permanent presence of large carnivores is that the hunting ground managers decide on the height of the annual cull on the basis of observations in the hunting ground.
In some areas, the impact of carnivores is expected to be so great that individual mouflon colonies will be exterminated. In this case, it is possible that the hunting ground managers may decide to intensify the culling of the mouflon population and to exceed the realization of the removal by up to 100%.

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