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Evaluation of wild boar *(Sus scrofa)* managemental practices on damages in agricultural land of hunting ground and proposal of solution

BACHELOR'S THESIS

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Declaration

I hereby declare that I have done this thesis entitled **Evaluation of wild boar *(Sus scrofa)* managemental practices on damages in agricultural land of hunting ground and proposal of solution**, independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague 17.04.2024

Sedlačík Jan

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Abstract

In the last years, concern over wild boar (*Sus scrofa*) populations has grown as a result of their effects on ecosystems and agriculture. In Central Europe, particularly in the Výprachtice region, managing wild boar populations has become critical for mitigating damage and ensuring sustainable coexistence between wildlife and humans. Despite the efforts made to monitor and regulate wild boar populations, a knowledge gap persists regarding the performance of adequate management strategies and the underlying population dynamics and lack of data-keeping methods. We address this gap by using a linear regression model to examine the data regarding wild boar hunting bag and identify trends in wild boar population increase. The study reflects the same trend as an increase in wild boar populations in the Czech Republic, aligning it with observations from the Výprachtice hunting grounds, highlighting the need for effective mitigating techniques. Furthermore, the study suggests that collaborative management measures involving both hunters and agricultural stakeholders are necessary to effectively manage wild boar populations and mitigate damages. The research shows that implementing a strip gaps technique in monocultures in Výprachtice hunting grounds leads to positive effects in wild boar damage mitigation, highlighting the importance of collaboration in addressing the challenges posed by wild boar populations. It emphasizes the major impact of human activities such as hunting and land use on wild boar dynamics, pointing out the importance of adaptive management measures considering both ecological and socioeconomic aspects. The proposed novel crop introduction to deterrent damages and sharing of mutual good practice examples from Brazil, where wild boars were introduced, might be inspirative and predictive to be incorporated to wild boar management decision process. Further data collection, introduction of a new methods of wild boar monitoring and control are necessary worldwide and in Výprachtice as well.

Key words: Agricultural losses, climate change, compensation, crop damage, overpopulation, soil deterioration, wildlife management

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VUMOP – The Research Institute of Melioration and Soil Conservation in Czech Republic

BPEJ – Soil ecological unit

1. Introduction

In the last decades, the wild boar (*Sus scrofa*) population has experienced a notable rise, posing significant challenges to woodland and agricultural land management practices in various regions throughout central Europe. (Langer 2008) Among these regions, the Výprachtice hunting ground has not been immune to the impacts of wild boar activity, with damages to agricultural crops and landscapes becoming increasingly prevalent. Consequently, there is a need for research to evaluate the effectiveness of current managemental practices and strategies and propose practical solutions to mitigate damages. This underscores the importance of assessing wild boar management practices, because their caused damages may be devastating in some cases, mainly in the cases of small farmers and in the case of larger organizations in the visible decrease of profits (Schmidt et al. 2015).

The Výprachtice hunting ground, situated in the Ustí nad Orlicí district in the Czech Republic, showcases a diverse ecosystem teeming with flora and fauna. However, the population increase of wild boars has resulted in a variety of adverse effects on the agricultural sector within the region. From crop destruction to soil erosion, the consequences of wild boar activity extend beyond mere economic losses, negatively affecting the livelihoods of local farmers and the sustainability of agricultural practices.

Understanding why wild boar populations are increasing and how they affect agricultural land is essential for creating effective management strategies. Factors like habitat, food availability, interactions between humans and wildlife, and the effectiveness of current management practices all influence the dynamics of wild boar populations and their interactions with agricultural landscapes (Schmidt et al. 2015).

This paper aims to address these issues by conducting an evaluation of wild boar management practices within the Výprachtice hunting ground. By examining existing data on wild boar population dynamics, annual reports on hunting grounds, game numbers and hunted game in Výprachtice throughout the last years, types of damages to agricultural land, and the efficiency of current management strategies, this research seeks to provide insights into the challenges faced by local stakeholders and propose evidence-

based solutions to mitigate damages and promote sustainable coexistence between wildlife and human.

The structure of this paper will comprise several key components. Firstly, a review of the literature will be conducted to provide background information on wild boar ecology, the impacts of their activities on agricultural landscapes and a description of the research area. This will be followed by an analysis of existing data on wild boar populations, agricultural land soil structure and agricultural damages. Subsequently, an evaluation of current management practices will be undertaken, with a focus on identifying strengths, weaknesses, and opportunities for improvement. Finally, based on the findings of this research, a proposal for implementing effective solutions to mitigate damages of such human-wildlife conflict caused by particular species of wild boar in agricultural land will be presented. Due to the fact, that wild boars were introduced to other parts of the planet like Latin America, there is more likely to expect increasing conflict between farmers and foresters, but also a negative effect on native species´ biodiversity and abundance. So, that may be areas of practical implementation of wild boar management or eradication, which might be challenging. Another negative effect can be also increased emission of carbon from the soil due to wild boar engraving its vertical profile and compactness during searching for food.

In summary, this study aims to add to the current understanding of wild boar management practices and their effects on agricultural landscapes. By addressing the unique challenges present in the Výprachtice hunting ground, this research aims to guide policy decisions and management approaches aimed at promoting a sustainable balance between wild boars and agricultural activities potentially to be implemented elsewhere.

2. Literature review

2.1. Wild boar (*Sus scrofa*)

2.1.1. Wild boar (*Sus scrofa*) distribution

Wild boars, scientifically known as *Sus scrofa*, are one of the most prevalent large mammals globally (Herrero et al. 2006). Their natural habitat spans from Western Europe and the Mediterranean region to Eastern Russia, Japan, and part of Southeast Asia (Sjarmidi & Gerard 1988). It's a native Eurasian species that currently thrive in the Central European landscape, experiencing minimal regulatory constraints due to global climate shifts and the lack of predation pressure from large predators with occurrence in many habitat types from alpine grasslands, forests, marshes to semi-arid ecosystems (Barrios-Garcia & Ballari 2012). The number of sightings of *wild boar* in urban and suburban areas is also higher as reported in Berlin, Barcelona, Vilnius, and Budapest showing that the wild boar population is spread around the world in either rural or urban areas (Jansen et al., 2007) & (Cahill et al. 2003).

2.1.2. Morphology and reproduction

Wild boar is a part of the Family Suidae, and they belong to the suborder Nonruminantia. The typical signs are the long, ever-growing, and sharpening canines and their simple stomach (Mottl & The Collective of Authors 1964). Wild boar has an elongated wedge-shaped head ending in a snout and a backward sloping back, ending in a tail. the weight fluctuates significantly based on the animal's build and the quantity of accessible sustenance. Upon reaching maturity, its weight ranges between 100 and 300 kilograms, while its body length typically measures 180 to 190 centimetres (Hanzal 2008).

Compared to domestic pigs, wild boar is seasonally polyoestrous breeder with two reproductive periods, where the primary phase is marked by oestrous cycles occurring between November and March, while the secondary phase involves mating activities during the springtime (Macchi et al. 2010). In the Czech Republic wild boars in particular are the most prolific game species, with each surviving wild sow able to give birth to approximately eight piglets in the spring before reaching a year of life. Despite persistent

advice and recommendations from experts, concerted efforts have been made for many years to protect them from the increasing numbers of wild boar (Drimaj & Kamler 2017). The time of the heat is inconsistent as a wild sow can be fertilised at any time in spring or summer. The wild sow is pregnant for 112 to 114 days (Rakušan 1979).

2.1.3. The wild boar diet

The wild boar diet consists of both animal and plant matter, where the plant matter consumed ranges from 86% up to 96% of the whole diet (Fournier-Chambrillon et al. 1995). The proportion of plant material by volume might be overestimated because animal material is digested more quickly, which is highly important for the digestive tract in order to help digest the plant material. Nevertheless, accounting for this factor, it's evident that wild boars primarily consume plant material across all regions where data is accessible (Schley & Roper 2003).

According to studies, the daily energy requirement is between 2500 and 5000 kcal, which requires about 4 kg of food to satisfy the wild boar needs (Malinová 2011).
They prefer to eat a diet rich in complete proteins, glycides, and fats, so wild boars compensate for the lack of glycides and the necessary food by visiting crop fields (Wolf & Rakušan 1977).

2.1.3.1. Plant part of wild boar diet

Main plant food categories for wild boars include fodder, roots, green plant matter, and mostly cereals. Additionally, they consume a variety of other plant foods, including bracken roots (*Pteridium aquilinum*), grasses, juniper berries (*Juniperus communis*), pine seeds (*Pinus* spp.), sedges (*Carex* spp.), common reed (*Phragmites communis*), olives (*Olea europaea*), and various fruits like berries and wild apples (*Malus* spp.) (Schley & Roper 2003). Plants from different biomes are listed as the plants consumed by wild boars differ by the availability in their location (Malinová 2011). A study conducted in 2004 determined the diet composition in the French Alps shows that the majority of the food consumed is comprised of plants, with only 1% being derived from animals. The most represented parts were underground plant parts, mainly roots and bulbs, which represented 39% of the diet. Other important components were animal remains 21 % and above-ground plant parts - green material 17 %, soil organic matter 6 %, berries 7 % and

maize 8 %. Mushrooms were the smallest proportion of dietary intake, at 1% (Baubet et al. 2003).

Another study conducted by Holý in 1983 found that 44% of the analysed food consisted of seeds from forest trees, primarily acorns accounting for 37.4% and buckeyes accounting for 5.4%. Cereal grains included maize 17.6%, wheat 6.7%, and oats 3.6%, accounting for 28.34%. Forest fruits and fruits contributed to 7.5% together. Green aerial parts of plants, arthropods, perennials, and vertebrates also contributed to the diet, while other items such as earthworms, grass seeds, tree parts, and molluscs were less significant (Malinová 2011).

2.1.3.2. Animal part of wild boar diet

Looking at the animal-based origin of wild boar food both vertebrates and invertebrates can be found in their diet, where invertebrates include larvae, slugs, snails, earthworms and other insects on the other hand vertebrates include birds, rodents, shrews and occasionally moles (Schley & Roper 2003).

The wild boar's diet reflects its habitat's environmental features and available resources, enabling it to impact its surroundings by causing damage to agricultural land, pastures, and forests, as well as engaging in predation and scavenging activities, including the consumption of carrion (Herrero et al. 2006).

2.1.4. Hunting in the Czech Republic

In the Czech Republic hunting is perceived in a very different way compared to other countries as there exists a specific word in Czech for hunting tied with wild game and ecosystem maintenance and management not just as a sport. Hunting in the Czech Republic has a long tradition, its own specific language, especially in falconry, which was listed in the year 2010 on intangible UNESCO monuments as a national cultural heritage (Unesco Czech Heritage n.d.). Falconry, a centuries-old bond between humans and predatory birds, has endured for over four millennia. It involves the age-old practice of utilizing trained birds of prey for hunting in their natural habitat. In order to understand more the situation and relations between different entities participating in forest and wildlife management, understanding the specific terms listed below is crucial:

Hunting - Hunting encompasses a range of outdoor pursuits involving wild game within natural ecosystems. It also includes community activities focused on preserving

and advancing hunting traditions and customs as integral components of the national cultural legacy (Polívka et al. 2022).

Hunting grounds/ Hunting estate - A hunting estate refers to a group of adjacent hunting grounds, owned by one or more individuals as determined by a decision, where hunting rights under this Act can be exercised (Polívka et al. 2022). In the Czech Republic, according to the provisions outlined in the Act on Hunting (449/2001 Coll.), which addresses the fundamental guidelines regarding the establishment of hunting areas, it is mandated that a fenced game (hunting) estate must cover at least 50 hectares, while other hunting grounds must have a minimum area of 500 hectares (Vodňanský 2009).

Hunting lands - all land that is not listed as non-hunting land.

Non-agricultural land/ Non-hunting land – Non-hunting land refers to areas within the current built-up zone of a municipality, such as squares, town squares, market squares, streets, roads, playgrounds, and parks. This classification excludes agricultural or forested land beyond this zone. Additionally, it encompasses built-up land, orchards, gardens, and nurseries with proper fencing, along with fenced land utilized for game farming. Non-hunting land also includes highways, roads, railway perimeters, paved areas of airports, cemeteries, and areas declared non-hunting by state hunting administrative authorities (Polívka et al. 2022).

Continuous hunting land - Contiguous hunting plots refer to areas of land where one can move between them without needing to cross someone else's property. Narrow strips of land don't break this connection, but if they run lengthwise, they don't count towards linking the land. Those can include motorways, roads resembling motorways, dams, and airports with paved surfaces, which can disrupt the continuity of the hunting plots.

Hunting law- refers to a collection of rights and responsibilities concerning the obligations to protect the game, purposefully breed, hunt, appropriately hunted or found dead game, its developmental stages and antler drops, and utilization of hunting land as required for these activities.

Holder of the hunting ground – the holder of the hunting ground is a person who has been granted recognition of the hunting ground by a decision of the state hunting administration authority and who, in recognition of is entitled to exercise hunting

rights in the recognised hunting ground. The holder of the hunting ground may use the hunting ground himself or may lease it. The leasing of the hunting area is permissible only under the following circumstances: (a) To a Czech citizen who holds a valid hunting license, (b) To a hunting association established in accordance with the regulations governing the formation of citizen associations for the purpose of leasing hunting areas, provided that at least three members of the said association meet the conditions outlined in point (a).

2.1.5. Wild boar regulations and population

Almost the sole effective means of regulating the boar population is hunting. However, despite numerous years of attempts to decrease their numbers using this method, it has not been successful. Consequently, the wild boar population across Central Europe persists in its expansion (Massei et al. 2015). Looking at the situation in the Czech Republic the trend in the population number growth is the same as in the rest of Central Europe. A study on the wild boar population in the Czech Republic was conducted and provides numbers of harvested wild boars in the Czech Republic as no other concrete data exists regarding the wild boar numbers; estimates of spring populations, remain speculative. Therefore, the population size can only be estimated based on recorded mortality, specifically the number of reported killed individuals. It's important to highlight the term "reported," as for accuracy, this figure would need to be augmented with data on natural deaths, road kills, and ultimately unreported individuals (Benda 2022). The European Commission called upon EFSA to evaluate the consistency of wild boar density estimations across the EU and to propose enhancements for data collection techniques. At present, the only data available on an EU-wide scale are related to hunting activities (More et al. 2018).

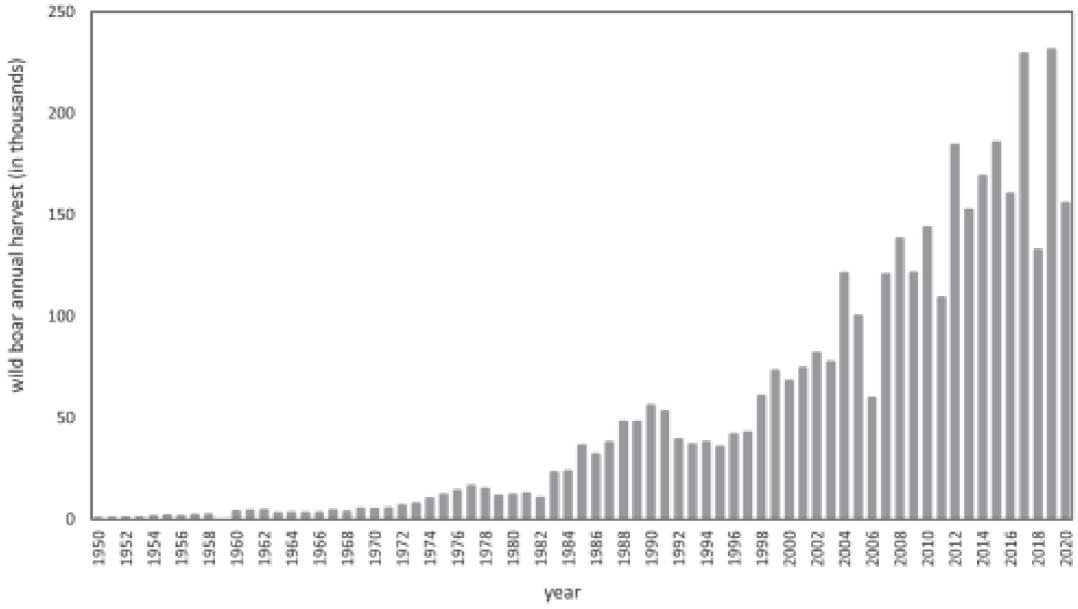

Figure 1 - Harvest of the wild boar (*Sus scrofa*) in the Czech Republic between 1950-2020

Source:https://publikace.nm.cz/en/file/4d9a88e22063bd1dfeb2891900ce10d9/31216/015_23_Andreska.pdf.

We can see in Figure 1 - **Harvest of the wild boar (*Sus scrofa*) in the Czech Republic between 1950-2020**, that even though fluctuations are present, the overall number of wild boar population is constantly growing. From the year 1950, where 198 wild boars were harvested in the current Czech Republic territory, by the year 1958 the numbers grew 10 times and in the year 1975 the population numbers grew approximately 60 times more in the referred period 1950-1975 based on the values of harvested wild boars (Benda 2022). The year 2004 brought a milestone as it was the first year with more than 100,000 harvested wild boars to be specific 121 002 (Benda 2022). The year 2017 brought the biggest changes for holders of the hunting grounds in the Czech Republic as the notable rise in the harvest in 2017 can be directly attributed to the introduction of incentives for each wild boar kill. This approach was a logical response by the state administration to the outbreak of African swine fever (ASF) in the Zlín Province. Additionally, during the same period, there was a thorough monitoring of Aujeszky's disease across the Czech Republic, also bolstered by the implementation of reward payments (Benda 2022). From the second half of the year 2023, those reward payments

account for 2000 CZK for each wild boar found dead or hunted within the hunting ground (ČTK (Czech News Agency) 2023).

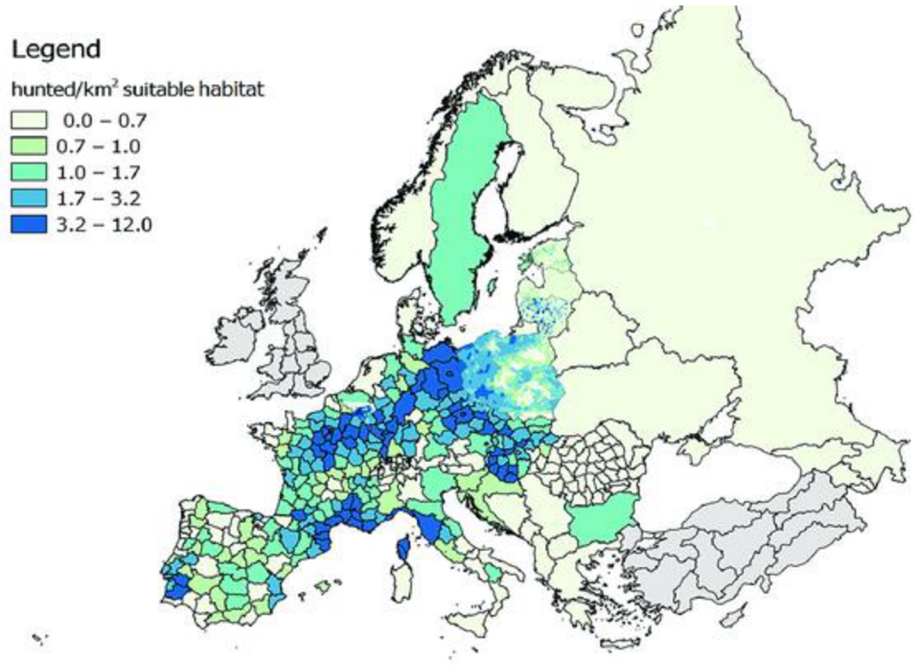

Figure 2 - Numbers of wild boar harvested in the hunting grounds in the EU Member States in 2017

Source: https://www.researchgate.net/figure/Numbers-of-wild-boar-harvested-in-the-hunting-grounds-in-the-EU-Member-States-in-2017_fig1_326332297

2.1.6. Wild boar caused farmland damage

Wild boar populations are already adapted to live in high human activity areas (Geisser & Bürgin 1998), where the clash between humans and wildlife is present resulting in conflicts mainly in agricultural economy, but also affecting the epidemiological situation as the spread of diseases to farm animals, domestic animals and humans poses a threat to local economy and health situation with this problem becoming more significant as the wild boar population is constantly growing in last decades (Jarolímek et al. 2014).

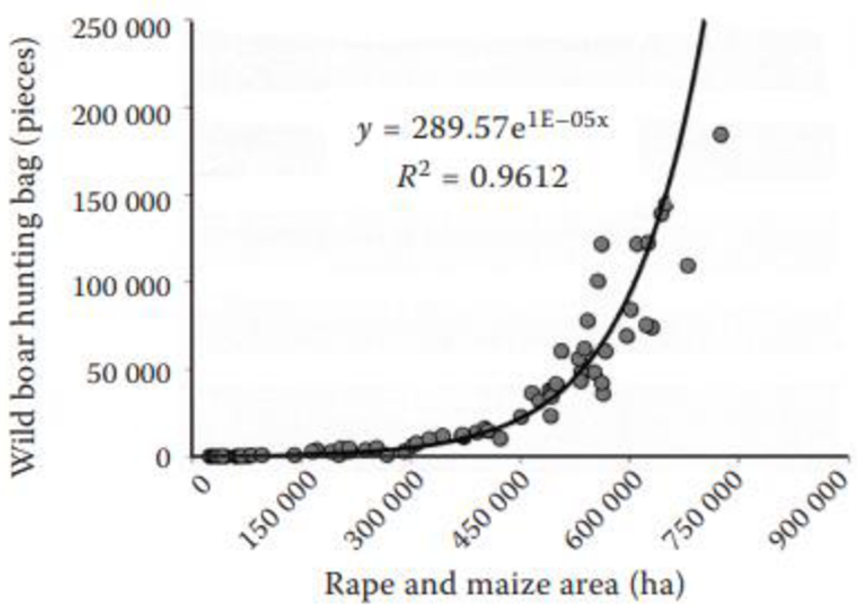

Figure 3 - Dependence of wild boar hunting bag on the area of rape and maize

Source: (Hruška 2013) https://lmda.silvarium.cz/view/uuid:c4ab5bb6-52cb-4514-bfc8-2ac632210061?page=uuid:674966f1-c67e-11e4-a51f-001b63bd97ba

As visible in the Figure 3 the registered harvest of wild boar in the Czech Republic in 2012 was 185 381 pieces. In this year the Czech Republic had the largest area sown with rape and maize accounting for 725 000 ha.

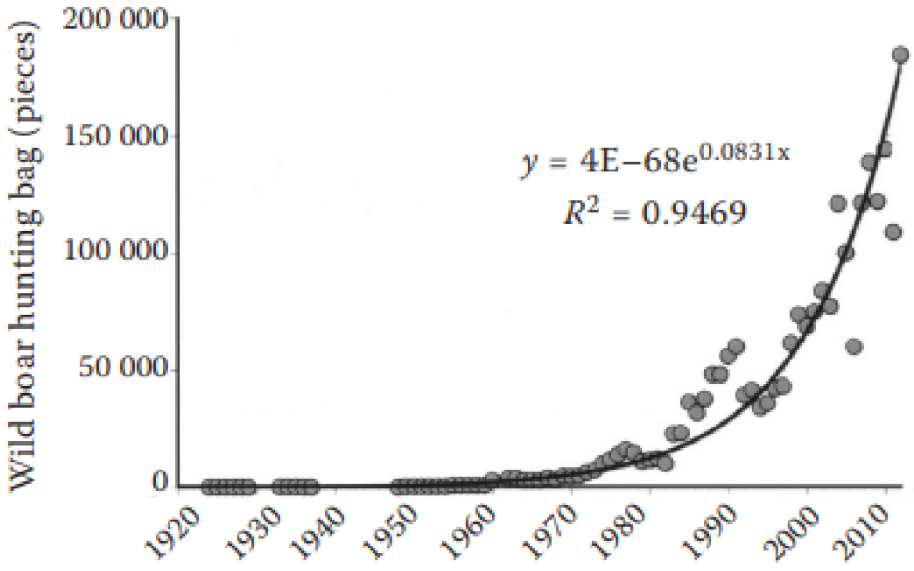

Figure 4 - Trends in wild boar hunting bag in the Czech Republic 1920-2012

Source: Hruška 2013 https://lmda.silvarium.cz/view/uuid:c4ab5bb6-52cb-4514-bfc8-2ac632210061?page=uuid:674966f1-c67e-11e4-a51f-001b63bd97ba

In Figure 4 the relationship between how rape and maize-sawn land is affecting the amount of harvested wild boar is shown and by combining both Figure 3 and Figure 4 we see that maize and rape are very important crops for the wild boar year cycle as a combination of these crops is providing perfect conditions for shelter and food (Jarolímek et al. 2014). When food becomes scarce in the spring, wild boar transition into the agricultural lands mainly rape fields, which with their rapid germination in spring make up a shelter by late April to May and by end of the May it becomes a sufficient food source until the harvest, which is generally in July (Jarolímek et al. 2014). From late July maize fields are already tall enough to serve as shelter and provide food minimally up to October, which brings the ripening of nuts and acorns resulting in the transition of the local wild boar community back to the forests (Jarolímek et al. 2014). The combination of maize and rape in relationship to the amount of harvested wild boar is showing how important agricultural lands are for wild boar life cycle as they spend around the same time or even more time in fields than in forests, which results in more damage on the crops and fields, combined with the trend of growing wild boar population throughout Europe, the expectations of wild boar damage on agricultural lands are getting higher and the demand for managemental practices and legislation change is growing.

Also forested areas, where production or tree rejuvenation takes place, are affected by wild boar damage. The damage caused to forest stands by wild boar in the Czech Republic in the year 2019 amounted to CZK 75 million. However, this amount does not include the value of the planting material. The actual damage, which encompasses the loss of timber production and other forest functions, as well as the unnecessarily high expenses associated with reforestation and seedling protection, is consequently even greater (Řezáč Jan n.d.). Wild boars can consume all attractive seeds during the winter, hindering natural regeneration. They also cause harm by nibbling on young plants and rubbing off trunks and root suckers, while indirect harm to forests, including harm to fences, plantations, and forest path surfaces, is noteworthy. Given the ongoing decline of spruce forests in Central Europe and the necessity to reforest extensive areas, the systematic destruction of planted seedlings by pigs is a growing concern, especially considering the vulnerability of young trees during the initial years post-planting (Řezáč Jan n.d.).

2.1.7. Factors affecting the occurrence of damage

For a long period of time, there has been a minimal focus on wildlife management within agricultural landscapes as a factor affecting the occurrence of damage and the focus of researchers in this field has shifted more to behaviour, abundance and wild boar biology (Amici et al. 2012). Typically, the level of agricultural losses varies based on factors such as the density and composition of the wild boar population, the availability of food within forested regions, the presence of buffer zones between forests and cultivated lands, the proximity to human habitation, and the maturity stage of the crops (Cappa et al. 2021). The cropping plan plays an important role as the wild boar population, transitions between crops for food or shelter and a properly thought out cropping plan can reduce the occurrence of wild boar in the fields.

Preventive measures also play a role in influencing the occurrence of agricultural damage, but these approaches typically require significant resources, leading to their adoption primarily on a limited number of larger fields (Cappa et al. 2021). These methods include the use of electric fencing, sound and scent deterrents, and dissuasive feeding techniques (Santilli & Stella 2006). The implementation of electrical fencing across expansive farmland areas has proven effective in reducing wild boar damage to agricultural crops. This aims to enhance crop protection and mitigate conflicts associated with the management of wild boar populations (Santilli & Stella 2006). However, due to the significant cost and labour involved in installation and maintenance, careful planning is necessary. Before taking any preventative measures, it is essential to prioritize mapping previous damage and identifying vulnerable crop fields. It's crucial to understand that electrical fencing, alongside dissuasive feeding, constitutes just one aspect of a comprehensive strategy for managing wildlife damage. Incorporating population control measures is equally vital to the overall plan's success (Santilli & Stella 2006).

Furthermore, many believe that reducing the number of wild boars will decrease damage to crops, there isn't much proof of this, but the lethal control is often perceived as effective management. Killing wild boars as a control method raises ethical concerns and sparks debate but has a long tradition and importance in the wildlife management (Cappa et al. 2021). It´s crucial to measure the success of reducing wild boar populations by looking at the actual decrease in damage and population size, but there is usually no data kept in hunting associations on wild boar caused damage (Cappa et al. 2021).

2.2. Výprachtice

2.2.1. Description of Výprachtice hunting grounds

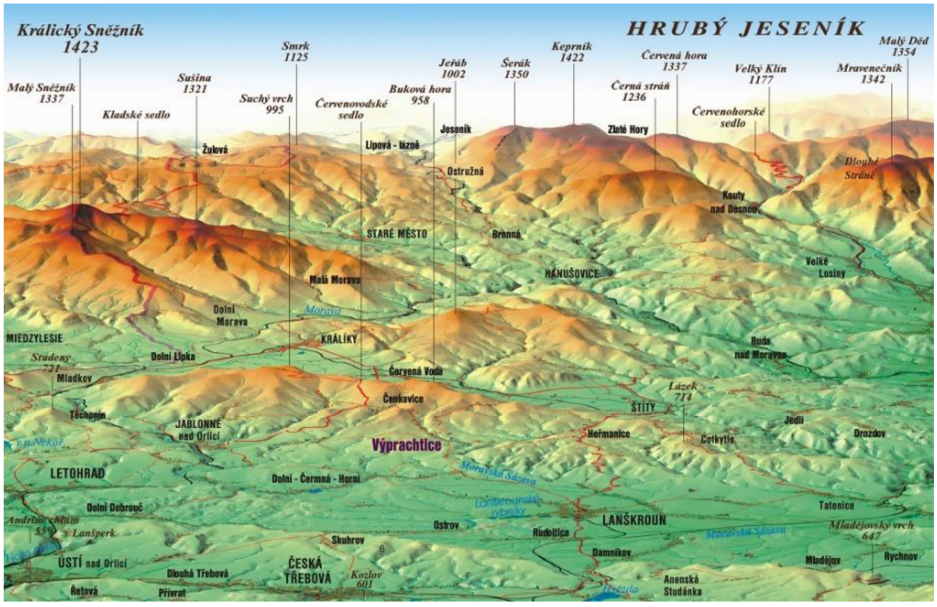

Figure 5 – Geomap of the village Výprachtice

Source: http://www.obec-vyprachtice.cz/clanky/geografie/

Výprachtice hunting grounds are part of Výprachtice a small village on the east side of Ústí nad Orlicí district under the Kralický Sněžník mountain and Hrubý Jeseník mountain range. Výprachtice lies at the altitude of 510–875 meters above sea level and consists of three parts called Výprachtice, Koburk and Valteřice with the cadastral area of the municipality accounting for 2172 ha (Obec Výprachtice 2005). In the year 2021 there were 948 residents (Regionální Informační Servis (Regional Information Service) 2021).

The total area of the hunting grounds accounts for 1370 ha, where agricultural lands are 858 ha, woodlands 488 ha and 24 ha are other grounds. Water bodies present are accounted for 0,0036 ha where river Moravská Sázava flows through (Hunting group Výprachtice 2010). The river Moravská Sázava springs near Výprachtice on the slope of Buková hora mountain, but not in the hunting grounds. In this area, it´s characteristics are mountain stream like, but later this river gets much larger and the average density of the river network is 1.55 km/km^2 with a flow length of 53.91 km. The presence of the water

body is very visible, making the Výprachtice hunting ground generally wetter and moister ecosystem (Elektronický digitální povodňový portál (Electronic digital flood portal) n.d.).

The holder of the hunting ground in this case is the Hunting Association Výprachtice and the user of the hunting ground is the Hunting group Výprachtice (Hunting group Výprachtice 2010). A Hunting Association is a legal entity established for the sole purpose of creating a hunting ground. The real number of gundogs registered to in the hunting ground in the year 2022 is 6, where two of them are for small game, other three gundogs are for the hoofed game, and one is for burrowing (Hunting group Výprachtice 2022). The number of game feeding installations is 30 and it is composed of 15 solonchaks and 15 feed racks, which are crucial in winter times as local wildlife starts using the feed rack after the first snow comes and they also provide minerals from salt in solonchaks and fibre from hay, but it said that smaller amounts of good quality hay mainly alfalfa or clover-grass hay should be put into the feed racks covered from snow and rain (Hunting group Výprachtice 2022).

2.2.2. Soil structure of agricultural lands in Výprachtice hunting grounds

The Research Institute of Melioration and Soil Conservation in the Czech Republic provides BPEJ code, which is used to access both the absolute and comparative productivity potential of agricultural soils and the factors influencing their optimal utilization (VUMOP n.d.).

Table 1 – BPEJ Code Breakdown

BPEJ Code designation	Order of the digits in the BPEJ Code		Range of values
X.xx.xx	1.	Climate region code	0-9
x.**XX**.xx	2. and 3.	Main land unit code	01-78
x.xx.**X**x	4.	Combined slope and exposure code	0-9
x.xx.x**X**	5.	Combined rock content and soil depth code	0-9

Source: https://bpej.vumop.cz

Climatic regions represent areas with similar conditions for agricultural crop growth. They are defined solely for assessing agricultural land. Criteria for defining these regions include temperature, rainfall, dry season probability, moisture security, and altitude. The Czech Hydrometeorological Institute compiled data from 1901 to 1950 to establish ten numerical-coded regions (0-9), categorized into very warm, warm, moderately cool, and cool, with subdivisions based on moisture levels (VUMOP n.d.).

The primary soil unit is a comprehensive agronomic entity formed by grouping genetic soil types, subtypes, soil-forming substrates, grain size, soil depth, hydro morphism, and area relief. The rating system comprises 78 Soil Productivity Units (HPUs), organized into 13 fundamental groups based on genetic and agronomic perspectives.

The fourth-to-last digit of the BPEJ code represents a combined slope and exposure code, as these factors are interconnected and impact the BPEJ quality. Slope influences land management practices and erosion risk, while exposure affects vegetation conditions due to temperature, light, and rainfall disparities.

Combined code of rock content and depth - These are two characteristics that are very close to each other and, as a result, significantly affect soil management and soil functions.

Looking specifically at Výprachtice agricultural lands the analysis of soil type groups for the Výprachtice Cadastral area with code: KU 787655 was done by VUMOP and the only values present in Climate region code are 8 and 9 (VUMOP n.d.). The climatic region with number 9 has specific characteristics and it is said that it is cool and moist. The average annual temperature in this climatic region is under 5 °C with average rainfall accounting for more than 800 mm. The fact that is area is very moist is proved by the probability of dry growing seasons, which is 0% probability (VUMOP n.d.). The climatic region with the number 8 is described by VUMOP to be slightly cool and moist. The average annual temperature accounts for 5-6 °C with average rainfall 700-800 mm. In this climatic region experiencing dry growing season is possible, but the probability of dry growing season is very low as it accounts for 0-5% (VUMOP n.d.). This data shows that the Výprachtice hunting grounds are almost permanently cool and wet, with a low chance of experiencing the dry season.

The main land unit code ranges from 34 to 68, resulting in three different hydrological groups present in Výprachtice hunting grounds and those are groups B, C, D characterized by VUMOP (VUMOP n.d.).

Table 2 - Different hydrological groups in Výprachtice agricultural land

	Group B – x.34.xx – x.41.xx	Group C – x.50.xx – x.58.xx	Group D – x.67.xx – x.68.xx
	soils with medium infiltration rates	soils with low infiltration rates	soils with very low infiltration rates
Permanently waterlogged land	NO	NO	YES
Periodically waterlogged soil	NO	YES	NO
Drying soil	NO	NO	NO
Infiltration and permeability	from 0.20 $mm.min^{-1}$	0.05 - 0.10 $mm.min^{-1}$	Up to 0.05 $mm.min^{-1}$
Water retention capacity	100 - 160 $l.m^{-2}$	160 - 220 $l.m^{-2}$	Up to 100 $l.m^{-2}$
Available water capacity	80 - 109 $l.m^{-2}$	from 200 $l.m^{-2}$	80 - 109 $l.m^{-2}$
Threat of acidification	high	high	High
Vulnerability to soil compaction	negligible	lower middle	High
Potential vulnerability to wind erosion	Not vulnerable	Not vulnerable	Not vulnerable

Source: https://bpej.vumop.cz/86841, https://bpej.vumop.cz/83441 https://bpej.vumop.cz/85800

Looking at the Combined slope and exposure code all the possible options are present with 9 having the steepest slope and 0 being a complete plain. Combined rock content and soil depth code have all values present except 9, which has the most combined rock content. The lowest value 0 with a total skeletal content not exceeding 10 % is present too, but the most represented ones are values 1 and 4 (VUMOP n.d.).

Soil type groups that are presented in the statistical database of VUMOP, where the rated area accounted for 1155 ha in Výprachtice hunting grounds.

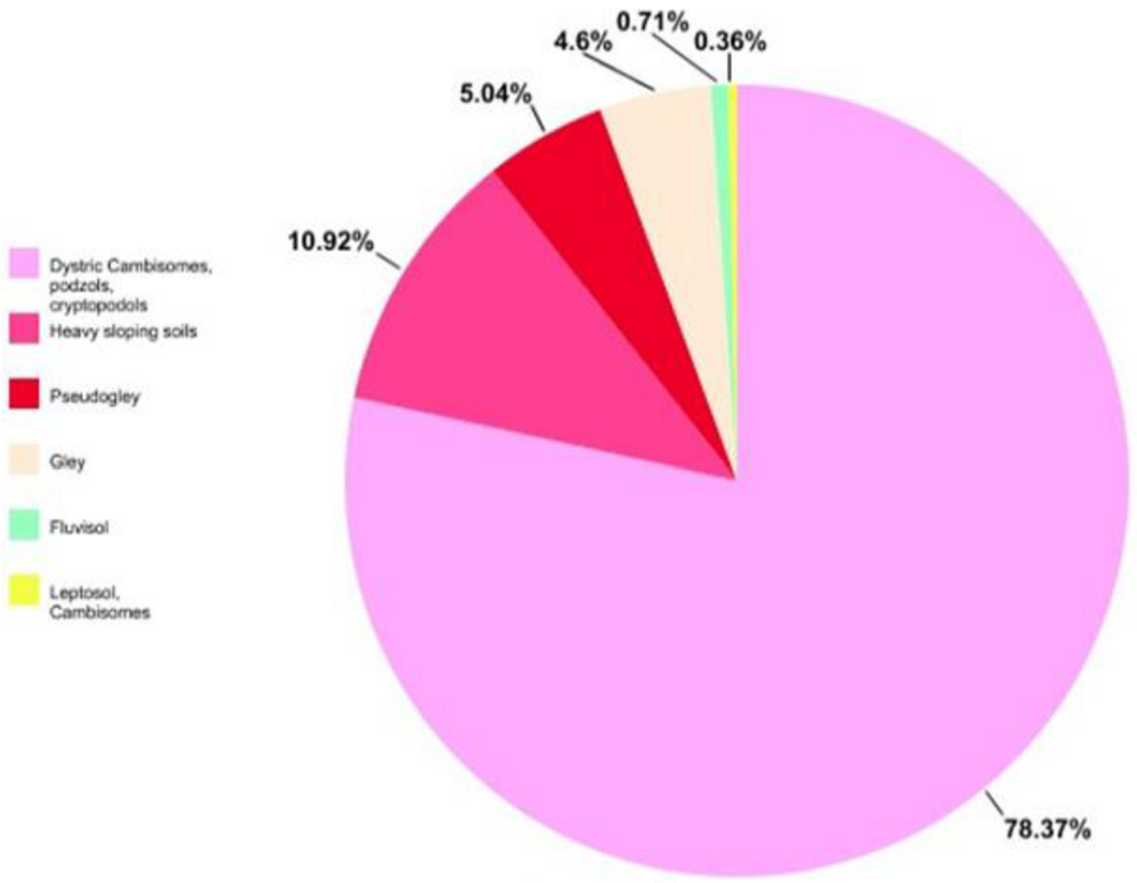

Figure 6 - Soil types present in Výpractice hunting grounds

Source: https://bpej.vumop.cz

3. Aims of the thesis

Main objective

The primary objective of this thesis was to evaluate the management practices concerning wild boars (*Sus scrofa*) and their impact on agricultural land within the Výprachtice hunting ground as the wild boar population constantly grows and the human-wildlife conflict is getting more serious due to the number of losses is getting higher.

Specific objectives

1. The assessment of current wild boar management practices in mitigating damages to agricultural land within the Výprachtice hunting ground.
2. Analysis of trends in wild boar (*Sus scrofa*) population in Výprachtice hunting ground.
3. Determination of the factors contributing to the occurrence of wild boar damage in agricultural lands of the Výprachtice hunting ground, including habitat structure, food availability, and interactions between wildlife and human activities.
4. The proposal of solutions and management strategies to minimize damages caused by wild boars (*Sus scrofa*) and promote sustainable coexistence between wildlife and agricultural practices in the Czech Republic hunting grounds or other areas specifically the example of Brazil. Discussion of implementation of proposed management strategies due to Brazil´s quickly rising numbers of wild boar and similarities in hierarchy and overpopulation regardless of the different geographical locations.

This study seeks to offer valuable insights into the difficulties encountered by local stakeholders and to assist in the creation of efficient management strategies for reducing the impact of wild boar damage on agricultural areas.

4. Methods

4.1. Research area

Výprachtice hunting ground was chosen because I am actively participating in the hunting association of Výprachtice in activities like collective hunts, building of feeding equipment, solonchaks, high seats and tree stands, but also feeding of wild animals. The hunting club Výprachtice provided me with documents like annual reports on hunting, condition, and game hunting bag from the year 2009 up to the current period and population statistics needed to understand the wild boar population numbers in the research area. Cooperation with the Hunting Association Výprachtice was crucial to retrieve data as the documentation is generally non-public. Due to the non-publicity of the data about harvested wildlife other areas were not in consideration.

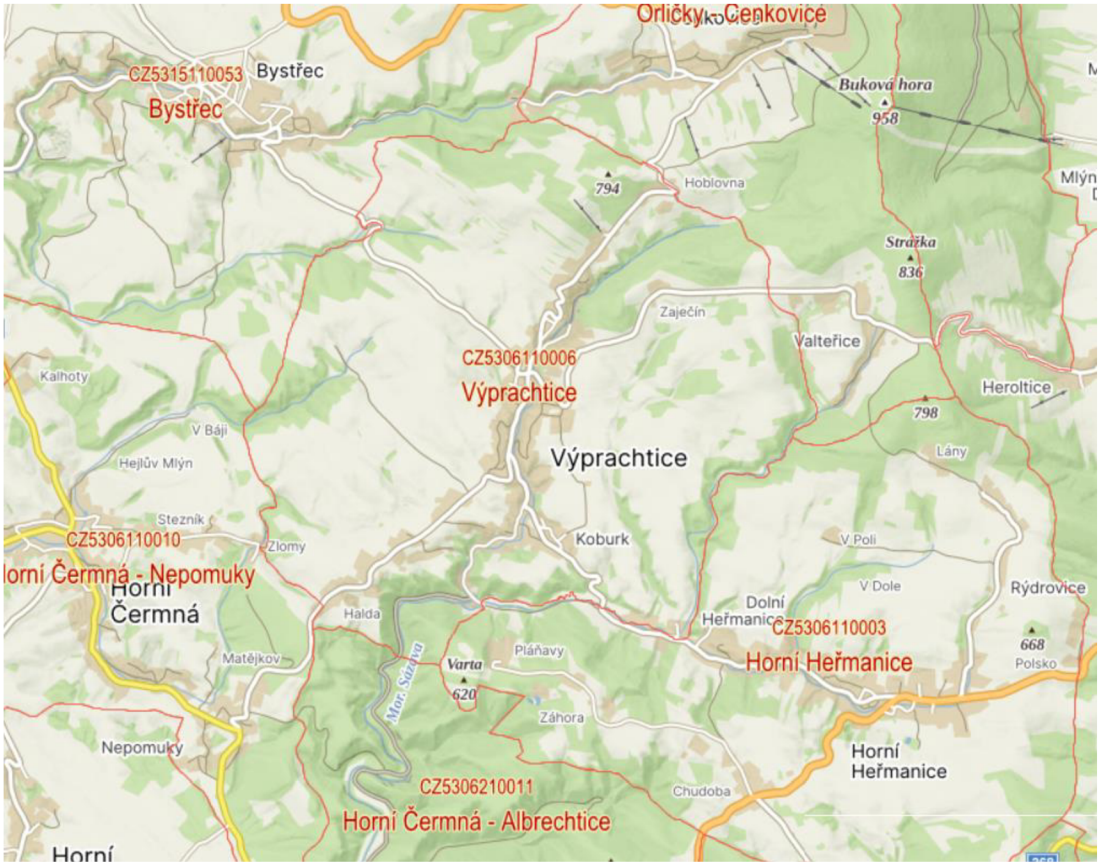

Figure 7 – Map of Výprachtice hunting grounds and other neighbouring hunting grounds

Source: https://geoportal.uhul.cz/mapy/mapyhon.html

The visible impact of wild boar caused damage on the landscapes and agricultural lands in the Výprachtice hunting grounds prompted the motivation for conducting this research.

Figure 8 – Pasture/permanent grassland after wild boar engraving in Výprachtice

Source: Sedlačík Jan (2024)

4.1.1. Research design

The purpose of this study is to understand and analyse various aspects related to the wild boar population, management practices, agricultural damage, and factors affecting the occurrence of damage. The research design is multidisciplinary with descriptive and analytical parts, as it must tackle all these factors together.

Mixed-Methods Approach was used to conduct qualitative interviews with stakeholders such as local farmers, hunters, hunting guards and corporate representative to gather qualitative data on their observations, experiences, and opinions regarding wild boar activity, damages, management practices, and potential solutions and quantitative

data analysis to provide a comprehensive understanding of the wild boar population dynamics and its impact on agricultural lands.

4.1.2. Qualitative interview

Interviews were conducted with six individuals, each of whom was selected to ensure that individuals holding diverse positions and job responsibilities on agricultural land within the hunting grounds of Výprachtice were represented in this group. Another significant factor in the selection of respondents was the size of the land area that the participant manages, as the majority of the farmland in the research area is being farmed by the respondents. Additionally, the age distribution was considered, with respondents younger or older than 50 years selected, with the exception of AGROSPOL Výprachtice s.r.o. representative and hunting guard, where a single participant is sufficient. Other farmers who manage agricultural land in Výprachtice hunting grounds have such small fields that, with those respondents, almost the entire area of 858 ha of agricultural land in Výprachtice hunting grounds is covered. Conversely, the respondents without agricultural land chosen for this research are critical as they provide views and opinions without any economic or emotional bias. All respondents are members of the Hunting group Výprachtice.

With regard to previously listed factors, the participants are shown in Table 3

Table 3 – Summary of respondents

Respondent	Entity	Sex / Age	Time spent farming/hunting in the research area	Commercially farmed area
Respondent 1	AGROSPOL Výprachtice s.r.o. representative		Since 1999	600 ha – arable land 360 ha – pastures and meadows
Respondent 2	Local farmer/hunter	Male / > 50 years old	Since 1989	120 ha – arable land and pastures
Respondent 3	Local farmer/hunter	Male / < 50 years old	Since 2017	40 ha - pastures
Respondent 4	Local hunter	Male / > 50 years	Since 1996	2 ha
Respondent 5	Local hunter	Male / < 50 years	Since 2000	0 ha
Respondent 6	Hunting guard/hunter	Male / < 50 years old	Since 2019	0 ha

Two voice recorded interviews were conducted with representatives of AGROSPOL Výprachtice s.r.o. and the local hunting guard. The other four respondents were not voice recorded, but the data was written. Interviews were conducted in March 2024.

The following questions were answered by respondents:

1. How long have you been farming or hunting in the Výprachtice hunting ground, and what changes have you observed in wild boar activity and damages over time?
2. Can you describe the damages caused by wild boars to agricultural crops and landscapes in this area?

3. Have you noticed any differences in wild boar damages related to any factors such as habitat structure, food availability, or human-wildlife interaction?
4. Have you been economically affected by the wild boar damages, if yes, can you tell how?
5. What preventative measures or managemental practices have you implemented to mitigate wild boar damages on your land, and how effective have they been?
6. How do you perceive the current wild boar management practices in the Výprachtice hunting ground, and do you have any suggestion for improvement or change?
7. Can you share your opinion or experiences regarding the effectiveness of hunting as a regulation method for the wild boar population and minimalization of damages?
8. Are there any specific limitations you face in the implementation of wild boar managemental practices or preventative measures on your agricultural land?
9. What do you think would make it easier for local farmers and hunters to efficiently control the wild boar population and mitigate the damages?
10. Are there any additional factors related to wild boar management and agricultural land damages that should be addressed in this research?

4.1.3. Data collection - number of harvested wild boar

Looking at the data collection regarding a number of harvested wild boar, the specific documentation was provided by the Hunting group Výprachtice, which is the only official documentation about the hunting bag and wild-life animals present in the area. Each year the Hunting group has a legal responsibility to provide an annual report on the hunting ground, game status and hunting bag for the period from 1.4. to 31.3 to the Ministry of Agriculture.

They provide a full account of the number of wild boars harvested each year with classification covering tuskers, wild sows, piglets, and yearling boars. There was no distinction made between yearling boars and piglets in the annual report on hunting

grounds, game status, and hunting bags from 1.4.2018 to 31.3.2019; therefore, both are listed under the piglet category in reports from subsequent years.

Categorization of Harvested Wild Boars:

a) Yearling Boar: Wild boars younger than one year old.
b) Piglet: wild boars with less than six months of age.
c) Wild Sow: Female wild boars.
d) Tusker: Male wild boars with noticeable tusks.

To find patterns in the wild boar population throughout the provided timeframe, the number of wild boars harvested each year was examined in analysis with the goal to identify whether the trend in population numbers is rising or decreasing. Linear Regression Model was applied to information obtained from the analysis on a number of hunting bag in the period from 2009 to 2024. The calculations in Figure 10 and Figure 11 were processed using IBM SPSS Statistics software. Linear regression was chosen as the major modelling technique for determining the association between the number of wild boars hunting bag and the overall population trend. This decision was based on its ability to quantify the direction and intensity of the links between variables, providing insights into population dynamics across time (Diskin 1970).

5. Results

5.1. Evaluation of current managemental and mitigation practices

5.1.1. Severity and frequency of damages

All respondents have acknowledged that wild boars have caused significant damage to agricultural crops and landscapes with a slight increase in their frequency during the last years in Výprachtice hunting grounds indicating possible growth in the future conflict between wild boars and local farmers. Specifically, the crops affected by wild boars were maize (*Zea mays*), sugar pea (*Pisum sativum*) and cereals, which include Triticale (*X Triticosecale Wittmack*) and winter wheat *(Triticum aestivum)*. Respondent 1 mentioned Výprachtice experienced a notable increase in area with maize sown as it is currently the main part of cattle feed in AGROSPOL. s.r.o. Výprachtice resulting in more suitable conditions for wild boar to transition fields thus more damage in the maize fields. Although the biggest damages were mentioned to be on meadows and pastures, which are susceptible to engraving by wild boars as stated by 5 of 6 respondents (see Figure 9). Farmers managing meadows and pastures within the Výprachtice hunting ground reported damage in Spring and Autumn being the most active, including uprooting of grass, roots, larvae of a cockchafer (*Melolontha melolontha*), worms, mice and trampling of vegetation. This led to a reduction in yield and excessive financial inputs. Respondent 2 experienced complete devastation of less than 5 ha in 2023, losing his investment in seed and incurring additional costs of 6300 Euros for grassing and soil restoration, putting the farmer in a desperate situation. Respondent 1 mentioned: *"The production of rapeseed in this region is present, where AGROSPOL. s.r.o. Výprachtice managed 70 ha in year 2023."* Looking into the rapeseed. The first difference compared to studies mentioned in this thesis as in Výprachtice hunting grounds the damages caused by wild boars are not in large numbers compared to other crops or pastures. The Respondent 1, AGROSPOL. s.r.o. Výprachtice representative mentioned: "*This may be caused by abundance and availability of more preferable feed and the damages caused as a result of wild boars using the rapeseed fields mainly as a hideout, thus more stress must be on how crucial planning of cropping plan is".*

Figure 9 – Effect of wild boar activity on permanent grasslands in Výprachtice

Source: Sedlačík Jan (2024)

5.1.2. Managemental and mitigation practices

All the respondents have at least once applied odour fences either on privately owned land or as a hunter´s responsibility in the Hunting club and found out that their effectiveness is rather negative as it was reported that the wild boar adaptation to these

odour fences is quick and usually already the next year after their installation wild boars are capable of undermining the fences. In the case of a wild sow with piglets, several cases have been reported of the mother breaking through the barrier and then crossing into the field with the piglets.

Not many scare tactics are present in the area, but there are small reflectors on the fencing contributing to the mitigation of damages as wild boars could get scared and discourage them from entering the field as mentioned by respondent 3. This practice proved itself helpful but can never be taken as a solution to this entangled problem rather mitigation strategy to apply simultaneously with other practices.

Together with the odour fences, AGROSPOL s.r.o. Výprachtice has applied, in cooperation with the hunting association, a strategy of gaps between larger areas of monocultures, specifically maize, rapeseed and previously cereals, which was proven to be effective for better handling during the wild boar capture in relation to the fact mentioned by several respondents that adaptation to human contact is changing and wild boars are being more cautious. For instance, as stated by respondents 2 and 6, the presence of wild boar tends to occur predominantly at night, making their capture during the day nearly impossible and the transition between forests and fields is more straightforward. Additionally, based on the local expert: *"Wild boar are prone to recalling their shooting locations and tend to avoid those locations, which results in more complicated monitoring and harvest of wild boars as this generally small hunting ground doesn't provide space for bigger wild boar population movement."* (Respondent 6, Hunting guard/Hunter)

Some of the mitigation strategies applied by farmers include adjusting grazing patterns, rotating pastures, and introduction of alternative sources of forage to minimize the impact of wild boar activity on the farmlands. As listed previously the hunting association has implemented feeding equipment and continues until now in order to shift and monitor the movement of wild boars for better population management. These basic mitigation strategies are quite essential as there is no single strategy going to solve this complicated problem. Due to the wild boar ability to quickly adapt to a changing environment and also the ability to move between many different hunting grounds per one day, causes the biggest problem in wild boar population management as ultimately agreed by all the respondents as being the major issue. Being able to monitor the wild boar population only in the area of 1370 ha, where 858 ha is agricultural land, the best

practice is harvesting of wild boar as agreed between all farmers and hunters. The biggest stress was put out on the cooperation between hunters and farmers as both AGROSPOL s.r.o. Výprachtice and reviewed local hunting association members pointed out that cooperation between farmers, corporates operating on the farmland and neighbouring hunting grounds is crucial to mitigate wild boar damages long-term. *"The occurrence of more damage on AGROSPOL s.r.o Výprachtice agricultural land was the most visible when there was no one from the Hunting association members or local farmers present during the development of the cropping plan."* (Respondent 1, AGROSPOL. s.r.o. Výprachtice representative)

It is in both hunters´ and farmers´ interest to mitigate the damages on farmland as farmers lose profit and the Hunting association is legally responsible for damages on the farmland, meaning it must pay for the farmer´s losses, which was stressed out by the Respondent 6. The current hunting law puts an obligation on the hunting ground user to compensate for damage caused by game not generally, but it refers only to the obligation already expressly limited in the basic provision of Section 52(1) of the Hunting Act to damage caused by game on hunting grounds, on field crops not yet harvested, on vines, on fruit crops and forest crops. This law causes many conflicts between the stakeholders and hunting associations as both of the identified sides want to do their job to the highest extent possible, meaning farmers want yields and profits and hunters properly managed wildlife animal populations. With the current overpopulation of wild boars due to favourable crops being grown in large monocultures and no natural predators it is almost impossible to completely mitigate wild boar caused damages resulting in repercussions of hunting associations even though its members fully committed and put in all of the time and work necessary to monitor and control the wild boar population majorly affecting the motivation of hunters coming back to point of cooperation between different stakeholders being crucial in long-term management and mitigation of damages as presented in the case of Výprachtice hunting grounds, where both AGROSPOL. s.r.o. Výprachtice and the Hunting group Výprachtice members said it is the main pillar of the local management and mitigation practices as local hunters are motivated to hunt as they are not scared of incoming repercussions thanks to the transparency between both entities managing the land. As a farmer, there is a high need for hunting activities in the farmed

location and without cooperation, it is much harder to manage the population as shown in this case, where stripe gaps in the fields and discussion on AGROSPOL s.r.o. Výprachtice cropping plan resulted in less damage caused by the wild boars. Being followed by a concern of all respondents regarding the long-term sustainable development of this conflict between wild boars and humans, where repercussions, investment and time spent is overcoming their motivation. One respondent pointed out: *"The fact. that the Czech government applied rewards for each wild boar harvest can help out the hunting association with their budget to be more self-sufficient and motivate members to hunt more as with bigger caution of wild boars comes higher investment into their hunt."* (Respondent 6, Hunting guard/Hunter) As stated by the Respondent 1: *"It is a start to an end if a farmer is against hunters and otherwise."*

5.2. Analysis of wild boar population trends

Figure 10 shows the evolution of the wild boar population (number of wild boar hunting bag in the Výprachtice hunting grounds) from 2009 to the present, separately in the categories hunting bag, yearling boar, piglet, wild sow and tusker. The anomaly in the yearling boar population is due to the fact that it has been monitored and recorded separately until 2017, afterwards, no difference between piglets and yearling boars is made.

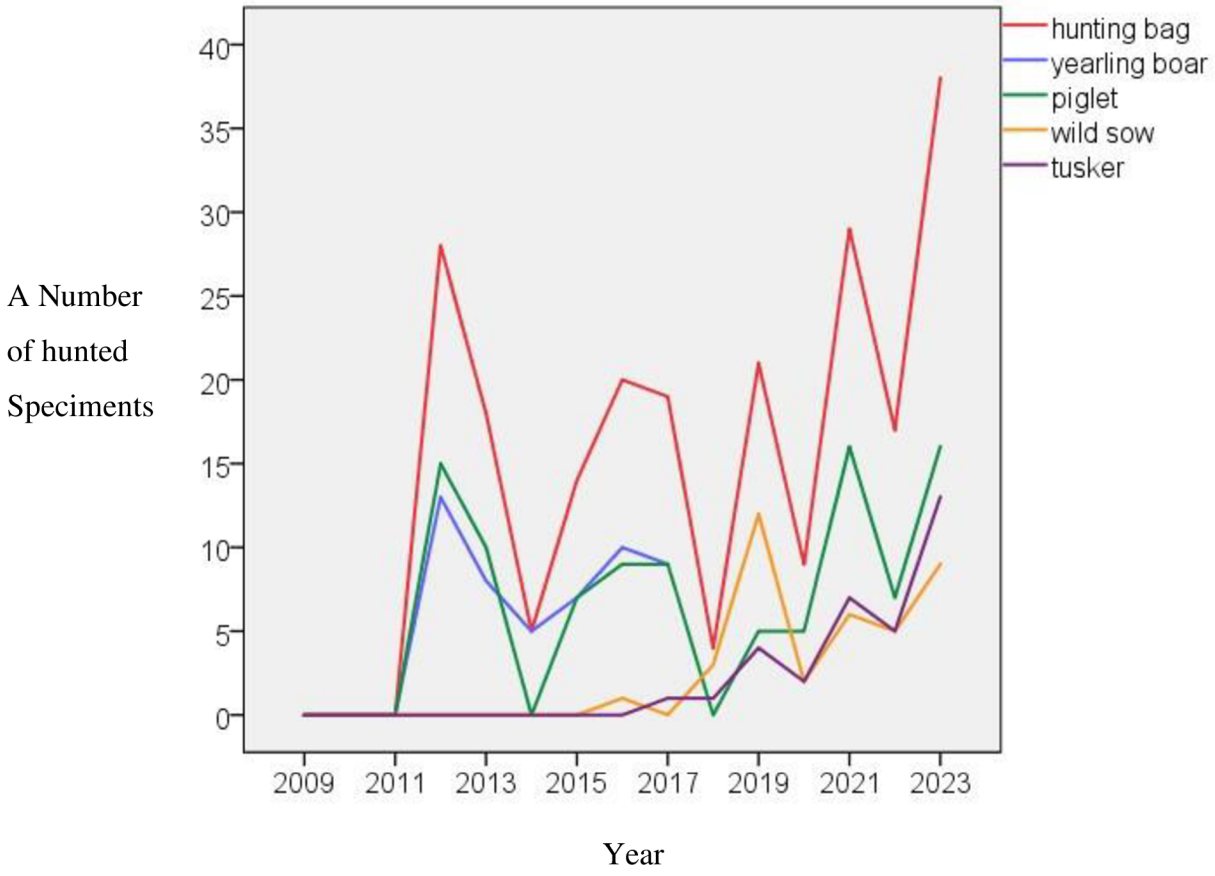

Figure 10 - Evolution of wild boar hunting bag in Výprachtice hunting grounds (2009-present)

Source: Hunting group Výprachtice

5.2.1. Linear regression model – number of hunting bag in the period from 2009 to 2024

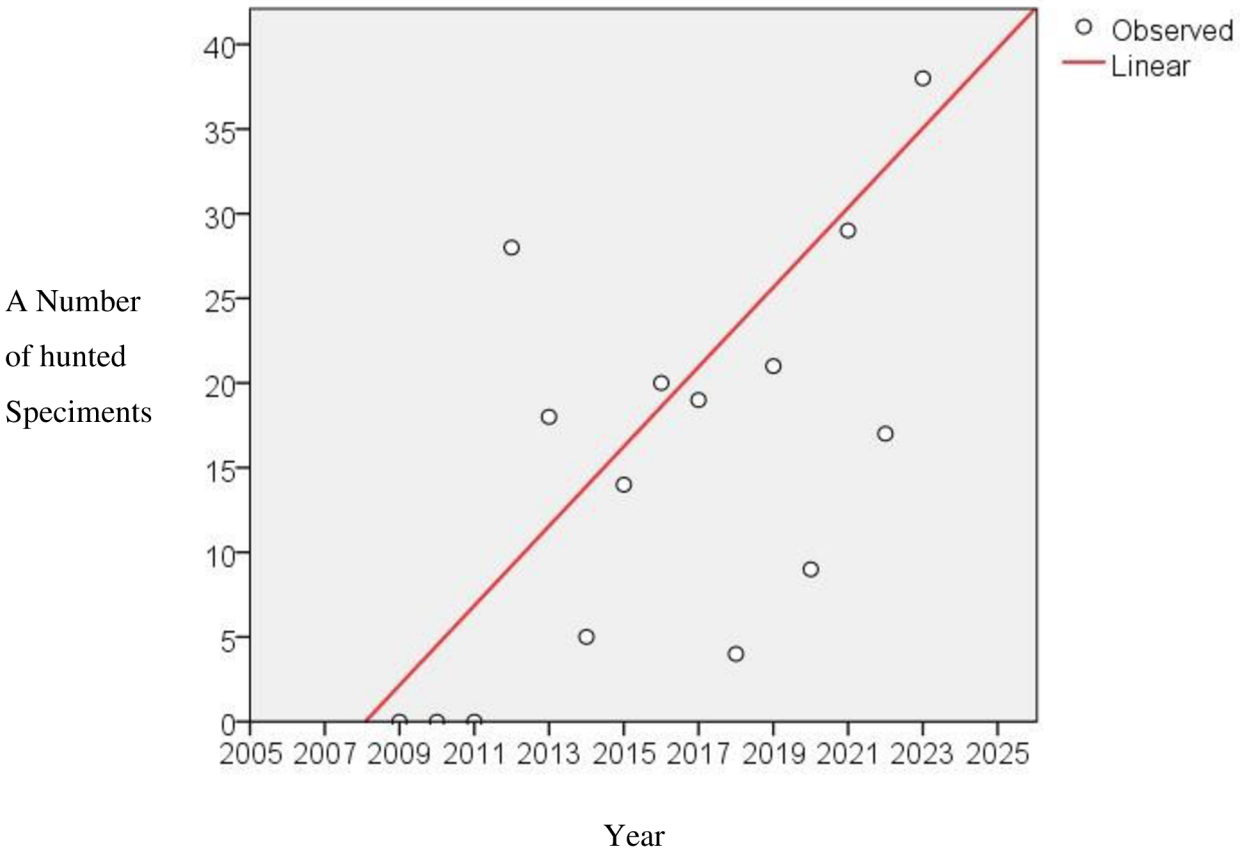

Figure 11 – Linear Regression Model – number of hunting bag in the period from 2009 to 2024

Source: Hunting group Výprachtice

The Figure 11 shows that the wild boar population is increasing derived from the amount of game hunted, as other more reliable method of tracking wild boar population trends is hardly available, which confirms the slope of the regression line. The standard linear regression technique was used for the calculation, see e.g. (Diskin 1970). For details, the results of the regression analysis are provided in Table 4. At the same time, recall that the intention was not to interleave the measured values as the best possible regression function, but only to demonstrate that the trend in the wild boar population numbers is increasing. The calculations and figures were processed using IBM SPSS Statistics.

5.2.1.1. Model summary

Dependent variable: hunting bag

Table 4 – Model summary

Equation	Model Summary			Parameter Estimates	
	R Square	F	p-value	Constant	b1
Linear	0.373	4.165	0.081	-4718.994	2.350

5.3. Factors contributing to wild boar caused damages

5.3.1. Tourism

Respondent 3, 4 and 5 pointed out tourism as one of the main affecting factors as forests are experiencing the highest visitation and permanent occurrence of human or domestic animals in the forest resulting in no rest hour for wild animals and their adaptation to the human contact. Modern technologies also contribute to this negatively affecting trend based on the local hunter: *"Loud four-wheelers, cars and heavy machinery contribute to no resting time for wildlife with generally higher occurrence of people in forests leaving wildlife with constant human contact."* (Respondent 5, local hunter) This ultimately results in wild boar transition to fields, where there is sufficient food and hideout constantly except in winter when they move back to forests.

5.3.2. Structure of the hunting ground

European spruce bark beetle *(Ips typographus),* which majorly affected forests in the Czech Republic in the 21st century, had a large impact on the forest cover making it harder for wild animals to find hideouts in the woodland resulting in the shift to fields for more suitable living conditions. (Respondent 3, local farmer/hunter) Sázavský les is in the lowest latitudes of the hunting ground close to borders with other hunting grounds. This forest is a dense place, where wild boars generally like to hideout as mentioned by respondents 1 and 6. This may be caused by the fact that not many shootings happened in this location and wild boars have a lot of cover. The harvest is complicated as wild boars usually transition between neighbouring hunting grounds also making it illegal for

the hunter to harvest the animal, which complicates the population management practices showing a need for change or discussion on making the mitigation strategies similar in neighbouring hunting grounds in order to tackle the ongoing problem of wild boar population growth and farmland damages.

Figure 12 – Permanent grassland after wild boar engraving in Výprachtice

Source: Sedlačík Jan (2024)

5.3.3. Cropping plan

One respondent (Respondent 2, local farmer/hunter) expressed: *"Výprachtice hunting grounds used to have mainly potato and common flax (Linum usitatissimum) fields before 30 years and higher diversification of crops were present opposed to the current situation, when the market pushes farmers to grow monocultures like maize, rapeseed and cereals including different variations of wheat, which provide more suitable conditions for wild boar´s survival in this location."* Maize monocultures were pointed out by all the other respondents as this location slowly experiences an increase in the maize-sawn land as proven by the Respondent 1. It provides both coverage and sufficient

food intake making them settle in the field, where the access is not possible or very limited making it impossible to hunt. Ultimately all the respondents agreed that a cropping plan is the most important management strategy as many aspects contributing to agricultural land damages can be controlled or mitigated. Respondents 1 and 5 pointed out: "*The crop selection is the start of the whole problem as all the crops grown it Výprachtice location are favourable for wild boar and choosing less attractive crops for wild boar consumption or shorter crops in order to not provide a perfect coverage".* (Respondent 5, local hunter) (Respondent 1, AGROSPOL. s.r.o. Výprachtice representative) Wild boars can get quickly accustomed to specific fields and the availability of food, thus applying crop rotation can disrupt these habits helping with damage mitigation as mentioned by respondents 2, 4 and 6. One respondent mentioned: *"Properly choosing the placement of the grow can affect wild boar transition between fields, adjacent fields of maize and rapeseed can result in wild boar transition just between the fields as they move from rapeseed fields to maize just when their ears start to get a little juicy, then we can expect to see them after the corn harvest or in special cases transitioning to a different place."* (Respondent 6, hunting guard/hunter) Overall, the cropping plan is the most crucial part of mitigation practices as it tackles all the factors mentioned above and in order to mitigate the damages to a higher extent, cooperation is encouraged by all the respondents as the cropping plan ultimately affects both hunters and farmers´ management practices for the whole year.

5.3.4. Climate change and hierarchy

Climate change is currently affecting the whole world and the wild boar population is no exception thus adaptation from wild boars themselves, but also an adaptation of humankind to their behaviour changes is crucial. Climate change can generally lead to shifts in temperature and precipitation patterns, which in turn affect the suitability of specific locations for the wild boar population, where the more suitable habitats are fields, where sufficient food income and cover is available almost through out the whole year with minimal number of transitions between fields and forests, which are the most vulnerable points for their populations. As stated by the respondent*: "The adaptation of wild boars and their causticness is higher making it harder to harvest and the longer wild boars stay in the field the larger the damages are."* (Respondent 6, hunting guard/hunter) As stated by the respondent 2 and 3 climate change very negatively

affects the changes in reproduction patterns contributing to the overpopulation of wild boars and their hierarchical structure. Warmer temperatures can alter the timing of reproductive cycles, leading to mismatches between peak food availability and breeding seasons. This can affect the timing of births and the survival of offspring, ultimately impacting population dynamics. One respondent mentioned: *"Wild sows weighing around 40 kilograms are already able to reproduce with a high number of piglets varying between 4-10, which together with different timings of breeding seasons throughout the year resulting in complete shifts in hierarchical positions just support the current overpopulation*." (Respondent 3, local farmer) Respondents 4 and 5 also mentioned that in Výprachtice hunting ground the hierarchy is missing older tuskers and wild sows causing shifts in transition behaviour as their migration is affected by the wild sow behaviour and followed by the piglets, who then inherit these habits.

5.4. The proposal of solutions and management strategies to minimize damages caused by wild boars (*Sus scrofa*)

The mitigation of damages caused by wild boars requires a multifaceted approach, encompassing various solutions and management strategies. This subchapter presents a comprehensive proposal aimed at minimizing the impact of wild boar activities on agricultural areas and landscapes. The proposed solutions are structured around four key pillars and must be seen as dependent on each other: hierarchical structure of the wild boar population, modern technologies, cropping plan, and cooperation between present stakeholders. The main aspect for successful mitigation of damages is the cooperation between farmers, the hunting group managing their land and neighbouring hunting associations otherwise the implementation of mitigation practices either from farmers´ or hunters´ perspective is going to be more difficult to introduce. As stated by respondents from both sides cooperation between AGROSPOL s.r.o. Výprachtice and Hunting Association was essential in hunting grounds, where the area of fields meadows and pastures accounts almost for two times more than the area of forests and the harvest of wild boars is the essential mitigation practice. On the other hand, as mentioned by 5 of 6 respondents the cooperation between neighbouring hunting associations is needed as wild boars do not respect hunting ground borders and their migration is high, which results in managemental conflicts and differences in the border areas. As a response to this newly

created need, I propose a plan that is based on the inclusion of distinct zones in the Hunting Management Act for hunting grounds in the border area with adjacent hunting grounds, which would impose an obligation on both hunting ground holders in that area to collaborate in the creation of a management plan for the wild game population control. Additionally, it would allow the harvest of wild boar in the distinct zone in the event of an overpopulation of wild boar, in order to enhance the management of the population and facilitate the harvest for both parties. As one respondent mentioned: *"The wild boar hunts are becoming harder and much more expensive for hunters, who usually have to pay for all equipment by themselves with the threat of hunting associations losing money due to the agricultural land damage resulting in financially challenging circumstances."* (Respondent 6, hunting guard/hunter) In terms of documentation, it is proposed that annual game harvest reports would be conducted separately by individual hunting groups, with the harvest recorded in the hunt by the origin of the member who harvested the wild game. Thus, there would be no requirement for modifying the current game harvest reporting system.

Secondly, there is a proposal for a change in the current legislation for the allowance of usage of drones equipped with thermal vision and night vision in specific cases, which would be only, when farmers themselves submit a permit for allowance of drone usage specifically only their agricultural land. There would be no other time possible to use drones for monitoring and hunting purposes other than on agricultural land and his administration's request in order to mitigate wild boar caused damages. Based on the local expert: It could result also in the enhancement of a wild boar population transition to forests needed to mitigate the damages long-term. (Respondent 5, local hunter)

Not only transition to forests and easier ways to harvest wild boars during its overpopulation period, are needed measures as from the sustainable point of view the need for correction of age distribution of male and female boars in the current wild boar population as the current situation is in poor state missing old tuskers and wild sows, with many yearling sows being able to reproduce and continuously rejuvenate the age of current wild Boar hierarchy and extend their numbers. This can be tackled by stopping the hunting of older wild boar for a certain period of time needed for the development of younger animals, but on the other hand, also hunting of younger animals in order to

balance the age structure of the population. One respondent mentioned: *"Wild boars are already capable of reproducing at an early age and regardless of the season due to the constant access to food and shelter*." (Respondent 2, local farmer/hunter) Hierarchy plays a huge role in wild boar migration as mentioned by respondents 3 and 4. Thus, I propose the introduction of resting zones in the hunting grounds in order to create quiet and natural conditions outside built-up areas and fields, promoting the natural self-regulation of the hierarchy. The area would be a shard of the whole hunting grounds area meaning tourism and access to forests is still available to the general public, but banning the public from entering the quiet zone would result in wild animals settling in the area without the human factor affecting their displacement. The prohibition of hunting and use of machinery would apply to this area with its hunting association being the administrator. This is a low cost possibility how to sustainably provide natural conditions and encourage the transition of wild boars from fields to forests while simultaneously tackling the current hierarchical problem, resulting in young piglets inheriting the correct foraging habits from their older hierarchical members mitigating the wild boar caused damage long-term.

Crop selection and rotation are the last proposed sustainable mitigation practices as when crop rotation is implemented farmers are able to make the local habitat less predictable for the wild boar population, which may reduce the interest in the area over time. In order to mitigate damages caused by wild boar finding a less attractive crop is crucial. In the case of Výprachtice hunting grounds quinoa (*Chenopodium quinoa*) pseudo-cereal, which is portraying itself as a suitable crop for this area. Many factors show that this crop might be the suitable as an additional cash crop or a complete alternative to traditionally harvested monocultures like maize and rapeseed. In those factors is the suitability of the research location as the soil structure of Výprachtice hunting grounds showed moist, high latitude and cold environments soil properties, which are perfect for quinoa cultivation. It is famous for its high adaptability to different growing conditions including poor soil nutrient properties and high latitudes, where Výprachtice with over 500 meters above sea level should be suitable for these conditions (Jacobsen 2003). Compared to traditionally grown grains in this location like maize and winter wheat, quinoa has a shorter growing period, quinoa is typically directly seeded or transplanted in the spring and matures in 90 to 120 days after planting, also promoting their transition to forests earlier (El Hazzam et al. 2020). The contribution to the

mitigation of wild boar caused damage is by quinoa's bitter saponin coating, which acts as a natural deterrent to pests and wildlife, including wild boars as it´s bitter taste and tough texture, which may discourage larger mammals from consuming them, reducing the risk of crop damage (El Hazzam et al. 2020). European Union and the USA are the main importers of quinoa, where for example one of the world's largest productions and exports is in Peru, where one third of its production is imported to the European Union (Lazíková et al. 2022). Many quinoa varieties have performed well in Central European conditions. The European market for quinoa is already set up and with suitable conditions for its production in Výprachtice and other similarly structured places, the implementation of quinoa in the cropping plan is encouraged (Dostalíková et al. 2023).

Respondent (Respondent 1, AGROSPOL. s.r.o. Výprachtice representative) stated: *"Leaving strips between around 15 ha in order to make the hunt of wild boars (Sus scrofa) easier for local hunters proven itself as success, thus applying this strategy in cooperation with local hunting association is encouraged on fields, where implementation and cooperation is possible."* Never forget that dealing with wild animals requires a balanced and humane approach. Furthermore, it is imperative to be aware of and comply with local regulations regarding wildlife management.

6. Discussion

The question of damage mitigation caused by wild boar is constantly circulating among farmers in the Czech Republic and Central Europe, but also on other continents the wild boar management caused wild boar populations to transition to fields and urban areas resulting in the need of adaptation and new mitigation practices.

6.1. Managemental and mitigation practices

In Výprachtice hunting grounds the effectiveness of applied mitigation practices varies, where odour fencing and small light reflectors attached around the field contribute partially to the mitigation, with similar results compared to previous studies, mentioning the long-term infectivity of odour fencing and deterrents (Schlageter 2015), but in my shared opinion with respondent 3 it also causes quicker adaptation to those specific practices and their return to the fields the following year.

Figure 13 – Wild boar caused damage on permanent grassland in Výprachtice

Source: Sedlačík Jan (2024)

With the hunting grounds being mainly located on agricultural land (crop fields and permanent grasslands), the essential mitigation practice is traditional hunting, which is being put the most trust into by the local stakeholders. Both AGROSPOL. s.r.o. and the local hunting group cooperated on the mitigation, which brought positive results for both sides. The implementation of the strip gaps strategy in the monocultures present in Výprachtice hunting grounds was possible only thanks to the cooperation of both stakeholders and the active participation of the hunters thus, in order to effectively implement the strategy the prior arrangement is needed as the farmer´s profit generation depends on the yield and it´s amount can be negatively affected if strips gaps are going to be made on the fields with no follow up from the hunting association. One respondent (Respondent 1, AGROSPOL. s.r.o. Výprachtice representative) mentioned*: "The current cooperation between AGROSPOL s.r.o. and Hunting group Výprachtice is perfect, with new active members participating in the harvest of wild boars and implementation of mitigation practices without necessary change needed in the participation of the association as the harvest of wild boar is constantly growing in the Výprachtice hunting grounds with same or slightly higher occurrence of damages."* As respondent 1 pointed out, the higher occurrence is thanks to the cropping plan structure and not enough local farmers and hunters participating in its development. Compared to researchers in the field of wild boar damage, who have focused more on behaviour, abundance, and wild boar biology as a reason for the occurrence of damage rather than humanmade factors affecting the change in wild boar behaviour promoting the occurrence of damage and growing population numbers (Barrios-Garcia & Ballari 2012).

6.2. Analysis of wild boar population trends

The trend in increasing numbers of wild boars in Výprachtice hunting ground is visible in Figure 11 as previously mentioned the annual reports on hunting ground, game status and hunting bag provide the only viable data on wild boar population numbers, on which the analysis of wild boar population was based and came out increasing in accordance with the analysis of the whole Czech Republic visible in Figure 1. In the future, emphasis should be put on the enhancement of monitoring practices and their documentation in order to have more viable data present on wild boar population

numbers. The documentation available is sufficient for the trend analysis conducted in this paper on the other hand keeping in mind that a higher harvest doesn't always mean higher wild boar population numbers is crucial as population numbers are affected mainly by human contact and followed by an adaptation of wild boars.

6.3. Factors contributing to wild boar caused damages

I would like to discuss the human factor affecting the wild boar (*Sus scrofa*) population occurrence and as mentioned by (Barrios-Garcia & Ballari 2012), the lack of natural predation results in humans being the main regulatory tool, which is visible as each hunting ground and farm has different management strategies and ways of hunting making the hierarchical structure of wild boar population in the Czech Republic very vulnerable. As mentioned in the results the climate change contributed to the change in reproduction patters and age distribution of tuskers and wild sows, but in my and respondent´s 3 opinion, the equal contribution to the hierarchical structure change has made a human management. Years without natural predation and decades of hunting and human management of wildlife influenced the wild boar population with the current overpopulation only contributing to a worsening of wild boar population age distribution (Johann et al. 2020). The 2017 legislation change of allowing the hunt of wild boar throughout the whole year at any age had a negative impact on the hierarchy making the complicated issue even more complex (Andreska & Andreska 2016). Younger wild sows being able to give birth to many piglets pass on their pre-learned habits to them (Bieber & Ruf 2005), where instead of foraging in the forests the agricultural lands and urban areas are their place of choice with increasingly higher occurrence. Thus, I want to put emphasis on the age distribution as a means of the transitional shift of wild boars to the fields and behavioural change, where the collective effort of hunters and hunting associations can contribute to the correction of this hierarchical issue and enhance the shift to forests and standard reproductive patterns (Scillitani et al. 2010). One of very few possible means of correction of the age distribution and reproductive patterns is hunting, where young piglets should not be left without older wild sow or hunted and leaving the older animals alive in order to give them space for the passing of habits on piglets such as forest foraging and less human contact. The other means is previously presented resting zones, which could help the animals with less human contact, which is ultimately, what

wild boar populations want, but humans don´t leave any space for the rest of the wild animals neither in forests or other ecosystems resulting in constant contact, overpopulation and urban areas foraging thus faster adaptation to humans, which the resting zone can mitigate and promote more natural conditions for wildlife.

6.4. Crop rotation and cropping plan

With the implementation of new non-traditional crops for a certain area into the cropping plan in this case the implementation of novel crop like quinoa, it is necessary to take into account the newly created challenges. Such a challenge is the development of an integrated pest management strategy to fight the pests affecting the quinoa as comprehensive knowledge on diseases transmitted by local pests is missing due to no previous information on quinoa farming in the Výprachtice region. A thorough analysis of economic viability in comparison to crops currently grown is critical to ensure the prosperity or levelling of previous earnings as the local and regional market acceptance can vary and variability must be expected with the introduction of quinoa. From the farmers´ point of view, their knowledge and specific expertise in quinoa farming is limited due to lack of practical experience in the Výprachtice location. Information and practical experience in relation to the local ecosystem including nutrient management, planting, and harvesting techniques must be acquired by the farmers themselves during the first years of quinoa implementation, which can cause issues with returns on initial investment. Transition to a non-traditional crop in a certain area can possibly bring constraints on farmers in the first years after transition on the other hand overcoming the first years can bring long-term assistance for mitigation of wild boar caused damage, diversification of cash crops and less dependency on traditionally grown monocultures.

6.5. Comparison and application of proposed mitigation practices in Brazil

Some tropical countries are facing of introduction of wild boar like Brazil (Etges et al. 2023). So mutual inspiration about the application of proposed management strategies in Brazil, as not only European countries have to face constraints regarding wild boar population and their damage mitigation, would be important. Commercial

livestock importation for the exotic meat industry was a major source of introduction in Brazil, followed by multiple escapes and releases into local natural environments, where wild boars have infiltrated natural and agricultural regions, and they are currently present in all six Brazilian biomes, with reports coming from 11 different states (Kmetiuk et al. 2023). Also, Southern Brazil protected areas experienced higher occurrence of wild boar sightings as 26 protected areas and 10 areas of sustainable use reported (Etges et al. 2023). Collected data in the year 2014 were processed into a comprehensive study about wild boar distribution, which presents that wild boars have been identified in 472 Brazilian municipalities, with the southeast leading with 253 municipalities, followed by the south with 133, the mid-west with 75, and the northeast with only 9 municipalities (Pedrosa et al. 2015). In the year 2007 just 91 municipalities accounted wild boar *(Sus scrofa)* presence, which is five times fewer locations compared to the data presented from year the 2014 (Pedrosa et al. 2015). The Brazilian Ministry of Environment claims that hunting has not been successful as a control measure mainly thanks to private hunting groups targeting males rather than females and piglets leaving them to reproduce in order to enhance wild boar reproduction. At the same time, public and animal welfare non-governmental organisations have brought attention to the abuse of hunting dogs and wild boars during the hunts, making the lethal management controversial as the current methods are focused more on occasional game hunts rather than effective governmental measures (Kmetiuk et al. 2023). The effect of wild boar population growth is visible as Brazil´s agricultural sector is facing similar wild boar damages as crop destruction is affecting the local stakeholders as one of the largest São Paulo´s agro-industry reported its losses accounting for 340 ha of maize crop in a year, equivalent to $430.000 dollars (Pedrosa et al. 2015). In response to rapidly growing wild boar populations the Brazilian Institute of Environment and Renewable Natural Resources allowed the persecution and slaughter of wild boars in the year 2013 with the aim of controlling their population numbers (Pedrosa et al. 2015). The geographical differences between Brazil´s unique biomes and Výprachtice hunting grounds do not pose any limitations in the implementation of management strategies as both regions face overpopulation of wild Boar with lethal control being the most used practice and age distribution issues. As this trend in Brazil started decades later with a much smaller hunting history than in the Czech Republic, thus introducing legislative changes can help mitigate damages and prevent the rapid expansion of wild boar populations. Both regions face the problem of age

distribution in the local wild boar hierarchy, significantly due to hunting methods, but also due to the rapid adaptability of wild boars to new environments and their ability to reproduce. The introduction of resting zones for wild animals should contribute the same way, as in the Výprachtice hunting ground, to the gradual self-regulation of the wild boar hierarchy in the area. It will also help with the movement of wild boar from fields and urban areas to the selected destination. I would like to recommend the closest possible collaboration between the government, local farmers, and hunters on a future strategy for mitigating damage and restraining increasing breeding. since the situation in Brazil is not as widespread as in central Europe, there is more room for manipulation of populations and the timely implementation of legislative and management changes can highly contribute to stopping or mitigating this trend of increasing populations in Brazil. Introducing temporary changes such as banning the hunting of older tuskers in order to correct the age distribution and therefore support the correction of breeding patterns. the proposal to allow drones with thermal imaging under the same rules mentioned in my proposal is only worth introducing if the cooperation between the stakeholders concerned works.

Quinoa is native to South America and cultivated for more than a thousand years in its regions with several characteristics suggesting that quinoa could thrive as an additional cash crop, or perhaps as a full replacement for traditionally cultivated monocultures such as maize and soybeans as Brazil's diverse climate and soil conditions provide prospects for quinoa cultivation, particularly in high-elevation and colder locations as quinoa is highly adaptable to a variety of growing situations, including low soil nitrogen levels and high elevations (Maughan et al. 2007). Implementation of quinoa into the cropping plan brings an advantage of functioning as a natural deterrent to pests and wildlife, including wild boars, potentially mitigating damage to agricultural crops and promoting earlier transition to forests thanks to quinoa´s shorter growing period. The potential for domestic production to meet local demand and even supply international markets is present thanks to the long cultivation history and cultural heritage. The implementation of the strip gap strategy on the cultivated fields is advised only with a high level of cooperation between farmers and hunters otherwise lower yield and high expenses for both sides will occur. Overall, the incorporation of quinoa into Brazil's cropping systems holds the potential for reducing the impact of wild boars and diversifying the range of agricultural production.

7. Conclusion

In recent years, wild boar (*Sus scrofa*) populations have experienced a remarkable expansion, with contributions to this trend with changes in hunting regulations, local legislation, human-induced habitat modifications, and the absence of natural predators as presented in this thesis. This expansion has resulted in an increase in human-wildlife conflict, crop damage, financial losses, and ecological imbalances. This multifaceted issue of wild boar population management and their damage mitigation demands a comprehensive approach that integrates various strategies and engages stakeholders at multiple levels. Mitigating these impacts requires a complex understanding of wild boar biology, behaviour, population trends, and in context of their management practices with the final goal to promote coexistence between agriculture and wildlife and ensure the long-term well-being of both human communities and natural ecosystems.

The analysis of the wild boar population in Výprachtice hunting ground reveals a complex interaction of ecological, socio-economic, and regulatory factors influencing population dynamics and human-wildlife interactions, but also proves their growing population numbers with statistical analysis of data on hunting bags from Výprachtice hunting grounds. More emphasis must be put on monitoring and data collection, which is essential to understanding population trends and informing management entities. Collaborative approaches that involve farmers, hunting associations, government and other stakeholders are critical for implementing effective mitigation measures and addressing the complex factors influencing wild boar populations. Based on findings from respondents' answers from different management bodies the most successful strategies are done with collaboration as strip gaps in the monocultural fields proved themselves as working mitigation strategies only thanks to the cooperation between the Hunting group and AGROSPOL s.r.o. Výprachtice.

Even though traditional hunting may be perceived as controversial, it is the most used mitigation practice with the wild boar populations growing around the world making lethal control a critical managemental practice. Without traditional hunting, hunting grounds with agricultural land accounting for most of its area could end up with a high occurrence of wild boars thus the possible larger scale of damage as lethal control is the most sufficient way if the local management does correctly choose the age of the hunted

animal, location of the hunt and monitor the wild boar population. Lethal control in collaboration with local farmers adjustments proved itself to be currently the most sufficient agricultural land damage mitigation. On the other hand, incorrectly performed lethal control can negatively affect wild boar behaviour in the local population resulting in poor age and sex distribution between the hierarchy. Quick adjustments to human contact are presenting a challenge as they are promoting the transition to fields and urban areas posing a threat to the local agricultural economy and landscapes leaving mostly performed mitigation practices including odour fences and fence reflectors insufficient in long-term use due to wild boar quick adaptation to those practices modifying their foraging habits.

Application of local legislative changes in the form of rest zones for wildlife and improvement of monitoring practices proposed can help local farmers and hunters better understand the local wild boar population and enhance the correction of their reproductive patterns and age and sex distribution. Promotion of transition to forests of wild boars and life closer to their natural habitat can serve simultaneously as a damage mitigation practice.

By utilizing non-traditional crops like quinoa, agricultural landscapes can achieve greater diversification, less dependence on monocultures, and ultimately mitigate the damages caused by wild boars. Its adoption requires careful consideration and proper planning. Due to the lack of experience in quinoa cultivation, adopting its farming in Výprachtice requires the development of pest management specific to the local ecosystem, evaluation of the economic feasibility of the market's adoption and adjustment to quinoa growing methods. Despite challenges, growing quinoa offers long-term benefits.

In conclusion, the agricultural landscape in Výprachtice faces multifaceted challenges, particularly regarding wild boar damage and overpopulation. However, by implementing innovative strategies and fostering collaboration between stakeholders, we can address these issues more effectively even in geographically different regions like Brazil, where the new trend of non-native introduced species of wild boar is steadily growing and causes losses and management constraints. Whether through the adoption of new crops like quinoa the enhancement of lethal control or better monitoring and data-keeping practices regarding wildlife. It's essential to promote knowledge sharing,

technological innovation, and coordinated efforts among farmers, hunting associations, and governmental bodies to achieve sustainable management of wild boar populations and promote ecological balance in the region.

8. Limitations of the data and available information

a) Sampling bias: Since the data only includes animals that have been harvested, it may not be an accurate representation of the total population of wild boars. Bias in the data may be created by factors like hunter preferences, hunting area accessibility, and hunting practices.
b) Record keeping: the true population size may be overestimated or underestimated because of inaccurate record keeping.
c) Change in regulation laws: The trend population study may be impacted by the quantity of wild boar harvested, as the year 2017 provided awards for hunting grounds for each harvested wild boar, with increasing rewards in subsequent years.
d) Missing data: There is no dataset that could provide insight into how human-wildlife conflict and climate change affect population shifts and their numbers.
e) Hunting ground borders: The research area's limited hunting ground size presents challenges since wild boar populations can move between borders, although hunting bags and management strategies may vary even though affecting the same wild boar hierarchy as hunters must respect the hunting grounds borders.
f) Research area: The Výprachtice hunting grounds are mostly composed of agricultural lands, thus this research does not apply to hunting grounds with most of its area being forested.

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Appendices

List of the Appendices:

Appendix 1: Yearly data on wild boar harvested from 2009 to 2024 in Výprachtice hunting grounds

year	hunting bag	yearling boar	piglet	wild sow	tusker
2009-2010	0	0	0	0	0
2010-2011	0	0	0	0	0
2011-2012	0	0	0	0	0
2012-2013	28	13	15	0	0
2013-2014	18	8	10	0	0
2014-2015	5	5	0	0	0
2015-2016	14	7	7	0	0
2016-2017	20	10	9	1	0
2017-2018	19	9	9	0	1
2018-2019	4	-	0	3	1
2019-2020	21	-	5	12	4
2020-2021	9	-	5	2	2
2021-2022	29	-	16	6	7
2022-2023	17	-	7	5	5
2023-2024	38	-	16	9	13

Contains data from 15 annual reports on hunting ground, game status and hunting bag for period from 1.4. to 31.3. each year.