# Tree regeneration in protected forest areas

## - The potential influence of large ungulate populations on tree regeneration

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Johanna Olsson

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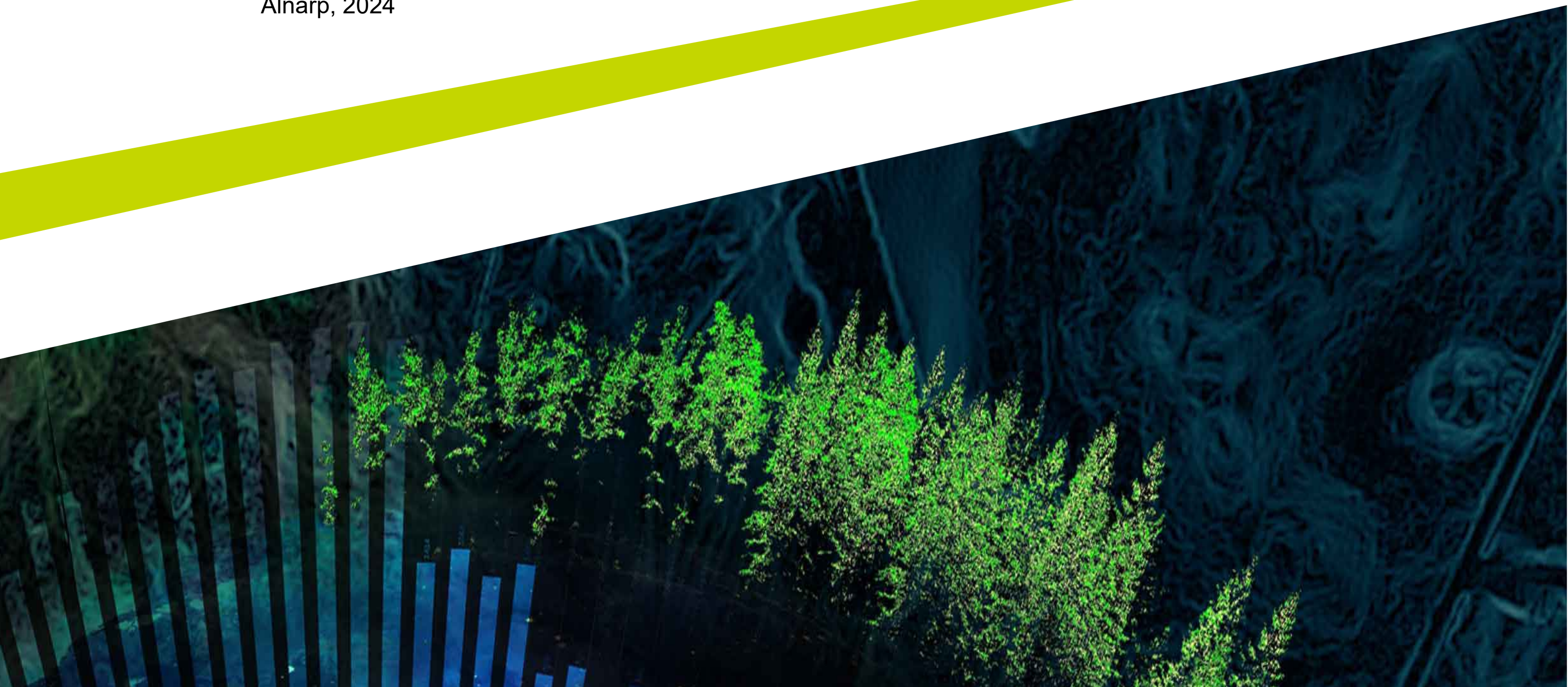

# Tree regeneration in protected forest areas. The potential influence of large ungulate populations on tree regeneration.

Johanna Olsson

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| **Supervisor:** | **Per-Ola Hedwall, Swedish University of Agricultural Sciences, Southern Swedish Forest Research Centre** |
| **Examiner:** | Jörg Brunet, Swedish University of Agricultural Sciences, Southern Swedish Forest Research Centre |

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**Swedish University of Agricultural Sciences**
Faculty of Forest Sciences
Southern Swedish Forest Research Centre

# Abstract

In a time marked by human-induced environmental changes and an alarming loss of biological diversity, understanding on how to safeguard natural values has become a pressing concern. Forest ecosystems, shaped by various factors including ungulate browsing, face challenges in sustaining tree regeneration, especially in areas with high ungulate populations. By comparing tree seedlings within fenced and unfenced areas, this study assesses browsing impact on tree regeneration and seek to answer the question, if fencing can be used as a tool in protecting tree regeneration suffering from browsing damages within protected forest areas?

Fenced plots, seven by seven metres, were established during 2017-2018 to exclude ungulates in nature reserves, in southern Sweden, with different intensities of browsing pressure. Alongside, control plots were additionally established. An inventory was conducted in two nature reserves where field studies focused on tree regeneration quantity, species identification, and browsing damage assessment. Statistical analyses compared data from 2018 and 2024 inventories.

Results provide insights on the persistent effect ungulate browsing puts on tree regeneration in areas with a high browsing pressure. The reserve with a high browsing pressure showcased a much higher number of seedlings, a lower proportion of browsed seedlings and a greater height growth where browsing had been excluded. Statistical analysis reveals browsing's influence on seedling height growth, even in areas with medium to low browsing pressure, notably impacting species like beech. Small fences were conclusively effective in mitigating damage where browsing pressure was high, and if placed strategically with enough light availability they could promote seedling growth.

Future research should monitor the long-term development of seedling growth to further explore the dynamics between browsing and tree regeneration.

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# 1. Introduction

## 1.1 Loss of Biological Diversity

In a time marked by anthropogenic exploitation and pollution influencing climate and environments pivotal in the support of human well-being (UNEP 2021), it is of high importance to acquire knowledge on safeguarding natural values. The rate of species extinction and the loss of biological diversity currently ongoing is an alarming consequence of human activities. More than half of earths land surface has substantially been altered by human induced influential factors (IPBES 2019). Species extinction rates have increased considerably during the last century (IPBES 2019) and several studies suggests that a sixth mass extinction event is undergoing (Ceballos et al. 2015, 2017; Régnier et al. 2015; European Parliament 2020; Cowie et al. 2022).

The loss of biodiversity can be traced to land use changes, direct exploitation, climate change, pollution and invasive alien species (European Parliament 2020). These five drivers of biodiversity loss are mainly induced by human activities (European Parliament 2020) and to ensure future human well-being different uses of earth's resources than those current, that decreases the potential of a continuous provision of human well-being, are required (UNEP 2021).

One way of halting biodiversity loss is through protecting hot-spots of natural values at multiple scales (Lindenmayer & Franklin 2002; Gustafsson & Perhans 2010). In addition, the protection of natural forests is one of several crucial activities in the work towards a sustainable management of land and in the mitigation of climate change (CBD 2023).

## 1.2 Browsing & Forest dynamics

Forest ecosystems are dynamic and complex systems that are shaped by numerous influencing factors (Polis & Strong 1996; Levin 2005), biotic or abiotic (Larsson et al. 2001). Community structure in an ecosystem can be seen being controlled "bottom-up", starting with primary production limiting the food availability for herbivores and therefore the herbivore population size, or "top-down" which contrarily from the top of the food chain through predation limits the herbivore populations (Smith 2015). Ungulates feeding on tree regeneration could potentially be a top-down control of the vegetation structure in a forest ecosystem.

Browsing on tree seedlings most commonly occurs on the top shoots, which encompass a lot of nitrogen and energy (Danell et al. 2006). As a seedling grows and woody tissue increases, less of the seedling is attractive to ungulates as it becomes less digestible (Danell et al. 2006). A seedling is therefore most vulnerable to being damaged by browsing when it is very young (Van Hees et al. 1996). Depending on how severely browsed, it can have an effect on seedling mortality, as in a study observing kermes oak (*Quercus coccifera*) where the simulated increased browsing intensity had a profound effect, and persistently repeated simulated browsing caused seedling death (Tsiouvaras 1988). Also in later stages of the seedling growth, browsing can affect survival. As browsing on new shoots slows down growth (Cooke & Lakhani 1996; Angst & Kupferschmid 2023), the capacity to compete for resources is limited (Danell et al. 2006). Consequently, slowing growth even more and possibly causing fatality.

A study made in the protected area of the Białowieża primeval forest showed that the presence of ungulates has an effect on species composition of tree seedlings and on the recruitment of seedlings into larger height classes, but that this top-down effect is not always the dominating factor influencing the forest structure (Kuijper et al. 2010). It was concluded that influencing factors, top-down or bottom-up, are significant in the course of different phases of tree regeneration (Kuijper et al. 2010). Within the context of preserving natural values in protected areas, it is of interest to gain knowledge upon how severe the top-down effect by browsing ungulates is in areas with large ungulate populations.

## 1.3 Browsing pressure and protecting natural values

The Scanian landscape in southern Sweden possesses a richness of biological diversity and natural values in the noble broadleaf forests (Skogskunskap 2017). Many noble broadleaf species grow here, at the northern border of the continental deciduous forests (Skogskunskap 2017). Several noble broadleaves growing here are shown to have had a long history in the landscape and that they have been dominating parts of the landscape (Länsstyrelsen Skåne 2003; Brunet 2004; Lindbladh et al. 2007).

Land use changes have however had a strong influence on the Scanian landscape where agriculture is now dominating large parts of the landscape and spruce (*Picea abies*) has been introduced by planting, resulting in a strong decline of the prehistoric broadleaf forests and a loss of continuity (Skogskunskap 2017; Länsstyrelsen Skåne n.d.b). The many species associated with these forests have consequently experienced a decline in available habitat areas, as is reflected in the increase of red listed species (Gärdenfors 2010; ArtDatabanken 2015; SLU Artdatabanken 2020, 2024d). As continuity to a relatively large extent already is lost due to the fragmentation of the broadleaf forests, natural values can be preserved by the establishment of a protected forest area (hereafter PFA) where high natural values already occur (Brunet 2004).

Officially protected areas are however not always sufficient in preserving natural values as PFAs are also subject to influences other than direct land use changes. Petersson et al. (2019) addressed the issue of the experienced decline in successful natural regeneration that many tree species are facing. With a combination of long term data from national forestry inventory in Sweden and hunting statistics on four deer species present in the Swedish forest, it was revealed that the decline in natural regeneration of oak (*Quercus spp*) was the result from a long ongoing land use change, adapting forests to optimize wood production, combined with increased deer populations (Petersson et al. 2019). With few natural predators in the landscape, hunting is the main regulator of ungulate populations. The increase of ungulate populations is additionally a consequence of hunting management aiming at large population densities (Petersson et al. 2019) at landscape level, while PFAs commonly only represent a small share of the landscape.

Conclusively, there exists a need to develop measures for conserving natural values, including biological diversity, within already protected areas and to further increase our knowledge on how browsing intensities affect tree regeneration within these areas.

## 1.4 Objectives & Hypothesis

The main purpose of this study is to increase our knowledge about the impact of browsing on tree regeneration in PFAs. Additionally, to learn how effective the implementation of fences can be towards the goal of protecting tree regeneration within a PFA. This was done by investigating the effects of fencing, as a tool to prevent browsing by ungulates, on tree regeneration in nature reserves with a high respectively lower browsing pressure. Tree seedlings were measured in height and checked for browsing damage both within fenced areas and in areas where ungulates had access to browse. Conclusively, this study looks to answer the question, if fencing can be used as a tool in protecting tree regeneration suffering from browsing damages within PFAs?

Fences are expected to show a positive effect on tree regeneration, given that the fence has been keeping ungulates out. It is common practice to fence when regenerating broadleaves due to the generally high risk of suffering browsing damages (Skogskunskap 2023) and fencing has been found to be effective on oak regeneration by reducing browsing and having a positive effect on height growth (Löf et al. 2010, 2021). Therefore, the control plots are hypothesised to have a higher proportion of browsed seedlings and a lower number of seedlings compared to the fenced plots. Seedlings in control plots are also hypothesised to have a reduced height growth than seedlings within fenced plots. These effects are additionally hypothesised to be more profound in areas where the higher browsing pressure persists.

# 2. Material and Methods

## 2.1 Main Project and Study Sites

A project called "To protect the protected? How is plant diversity and forest structure affected by herbivory in small forest reserves in landscapes with high ungulate density?" was initiated in a collaboration between the County Administrative Board in Skåne, The Swedish Forest Agency, scientists at the mammal research Institute in Białowieża, Poland and the Swedish University of Agricultural Sciences. The project aims at obtaining knowledge on the impact of browsing by ungulates on tree regeneration and forest structure. Additionally, the project looks to evaluate the use of fencing in restoration of vegetation that has been damaged by herbivory.

With inspiration from an ongoing project in the Białowieża National Park (Kweczlich & Miścicki 2004) a total of 30 fenced quadratic plots were put up during the winter 2017-2018, on three different locations (10 per location). To study the impact of browsing on tree regeneration, 30 control plots adjacent to the fenced plot were additionally marked out. Control plots were paired with a fenced plot and located such as to match the condition of the fenced plot, same surrounding tree species composition, similar canopy openness and soil conditions. Each plot is quadratic, seven by seven metres, covering an area of 49m$^2$. The intention of the fence is to keep all ungulates from browsing with a two-meter high fence. It could however be possible for smaller rodents to get inside the fenced plots as the net of the fence has quadratic holes with circa 5 centimetres large sides. Inventories of established plots were then conducted 2018, 2019, 2021, and 2024. Results investigating possible effects of fences are presented by Johansson (2020), Ramberg & Sjöqvist (2023), and in this report 2024.

### 2.1.1 Study sites

Each location is a forested nature reserve with different intensity of browsing pressure. This study will include two of the three established locations, Hästhagen and Maltesholm (Figure 1). These two reserves are also Natura 2000 areas (Naturvårdsverket 2012), as they hold natural values worth protecting.

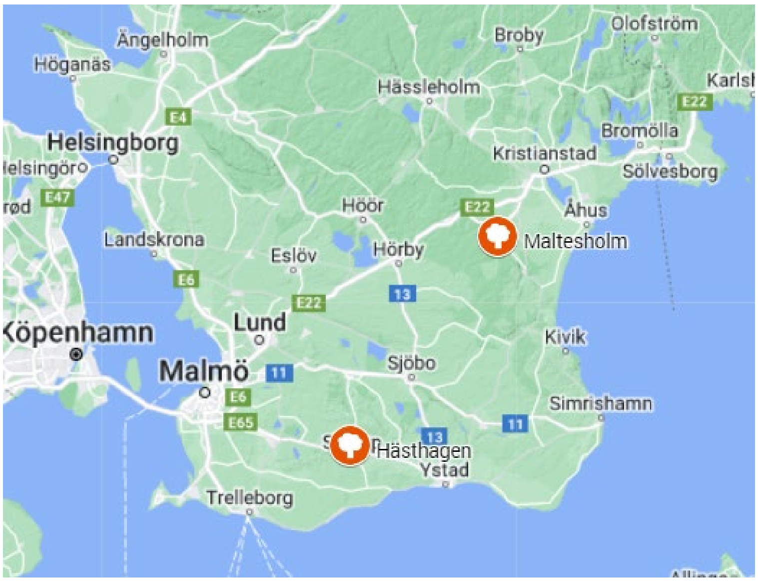

*Figure 1. Location for Hästhagen and Maltesholm nature reserves in Skåne, Sweden. Map:(Google maps 2024).*

Maltesholm Natura 2000 area was initiated to protect the beech (*Fagus sylvatica*) forest and red listed species bound to it, its large amount of deadwood and to preserve streams and watercourses that set the condition for the flora and fauna in the area (Naturvårdsverket 2012). For the Natura 2000 area in Hästhagen the protection plan strives to conserve the typical structure of the old beech forest, care for the natural values that the area holds with its long continuity of being a forest (Naturvårdsverket 2012).

### *Hästhagen*

Hästhagen is a nature reserve located in southern Skåne close to the castle of Svaneholm. The area, that is 56 hectares, is comprised of an old beech forest with some additions of elm (*Ulmus glabra*), hornbeam (*Carpinus betulus*), oak (*Quercus robus*) and ash (*Fraxinus excelsior*) (Länsstyrelsen Skåne 2024). Despite being located on an elevated spot in the flat surrounding agricultural landscape, the soil at the top is mostly composed of clay (glacial fine clay) (Naturskyddsföreningen Skåne n.d.; Sveriges geologiska undersökning n.d.). While the hillsides are composed of a coarser clayey moraine and lower parts more of a peat soil (Sveriges geologiska undersökning n.d.).

### *Maltesholm*

In northeastern Skåne the nature reserve called Maltesholm is located. Over 29 hectares this reserve holds an old beech forest with a rich diversity of beetles (Länsstyrelsen Skåne n.d.a) and an uncommonly high biological diversity (Brunet 2004). Majority of the area is composed of a sandy moraine with a few smaller parts containing more peat soil in the topsoil (Sveriges geologiska undersökning n.d.).

The geological location between the ridge Linderödsåsen and the plain of Kristianstad and the lime rich soil, sets favourable conditions for a rich flora and fauna, with many herbaceous forest species growing here (Länsstyrelsen Skåne n.d.a).

### 2.1.2 Ungulate population

Hunting statistics in Skåne give indications on ungulate species present, and population size, in the region. It is however not possible to distinguish differences in ungulate population sizes between the two reserves based on these statistics due to the low spatial resolution. Statistics covering the years from 2018 until 2022 include the ungulate species roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), fallow deer (*Dama dama*), wild boar (*Sus scrofa*) and moose (*Alces alces*) (Svenska Jägareförbundet 2019, 2020, 2021, 2022). Number of ungulates shot varied over the years. However, generally a higher number of wild boars were shot, followed by fallow deer and roe deer (Svenska Jägareförbundet n.d.)(Appendix 1).

Majority of the fallow deer diet contains grass, the fallow deer however also feeds on herbs and browse on trees and bushes (Bergquist et al. 2002; SLU Artdatabanken 2024a). The diet is complemented with berries, acorns and beech nuts in the autumn (SLU Artdatabanken 2024a). The diet of roe deer consists of leaves, shoots, grasses and herbs of various species in the summer, and mostly on shoots in the winter, including beech, ash and elm (Bergquist et al. 2002; SLU Artdatabanken 2024c). Roe deer additionally feeds on herbs, grasses, berries and heather (*Calluna vulgaris*). Wild boars are omnivores with a mainly plant-based diet that most commonly roots in deciduous forests (Bergquist et al. 2002). A large part of the energy intake comes from acorns and beech nuts (SLU Artdatabanken 2024b). In its search for food, vegetation and tree seedlings and saplings get uprooted (Bergquist et al. 2002).

## 2.2 Field study

Using a quantitative method for data collection, a field inventory was carried out in the end of March 2024, covering a total of forty sample plots, twenty fenced plots and twenty control plots. Tree species and seedling height was determined for all regeneration of woody species, higher than ten centimetres, within each sample plot.

### 2.2.1 Data Collection and processing

All woody plants above ten centimetres within sample plots was examined. Using a yardstick height of the seedling was noted down in centimetres. Dead seedlings were not included in the inventory. When measured, tree species were determined using the visual characteristics of the buds. Lastly the seedling was examined for browsing damages. When assessed, the seedling was logged as either being browsed or not, yes (y) or no (n) in the protocol.

Additional obvious deviations were documented on each plot. Holes in the fence and fallen trees that had caused some damage to the fence are deviations that were documented.

Inventories have previously been made within the main project in the year of establishment 2018 and later in 2019 and in 2021 according to the same protocol as applied here. Data from the inventory in 2024 were compared to 2018 to determine significant differences in average seedling count and, average heights for the most common tree species per site. The same comparisons were additionally made between fence and control plots within the 2024 inventory in addition to comparing percent browsed seedlings per plot.

Tests for statistically significant differences were made using paired t-tests to compare with the 2018 inventory. Paired t-tests were additionally used to compare average height and average seedling count between fenced and control plots. All tests were performed in Minitab after compilation and calculation of averages in Excel.

# 3. Results

A total of 3884 seedlings were found in the forty plots, twenty in Hästhagen and twenty in Maltesholm, distributed unevenly among ten different tree species. Specimen of ash, beech, elm, hazel (*Corylus avellana*), hornbeam, maple (*Acer spp*), oak, rowan (*Sorbus aucuparia*), elderberry (*Sambucus spp*), and european spindle (*Euonymus europaeus*) were found.

## 3.1 Hästhagen

The total number of seedlings found in Hästhagen was 1523. Number of seedlings decreased since the previous inventory in 2021 when looking at the total number of seedlings (Table 1). Comparing to the first year, 2018, the total number of seedlings decreased in control plots but increased in fenced plots (Table 1). It can be observed that number of beech seedlings has fluctuated since the inventory in 2018 with a peak in 2021 (Table 1). The number of seedlings 2024 was lower than the peak in 2021, for fenced plots the number of seedlings in 2024 was however greater than in 2018 (Table 1).

*Table 1. Number of seedlings per species and year in Hästhagen, separated into control and fenced plots.*

| | **Control** | | | | **Fence** | | | |
|---|---|---|---|---|---|---|---|---|
| **Tree species** | **2018** | **2019** | **2021** | **2024** | **2018** | **2019** | **2021** | **2024** |
| Ash | 801 | 696 | 799 | 702 | 340 | 571 | 537 | 444 |
| Aspen | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Beech | 88 | 165 | 552 | 145 | 141 | 68 | 509 | 139 |
| Elm | 40 | 0 | 7 | 18 | 29 | 0 | 16 | 20 |
| Hazel | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 11 |
| Common hornbeam | 1 | 0 | 14 | 2 | 0 | 0 | 16 | 5 |
| Maple | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| Oak | 3 | 0 | 9 | 1 | 0 | 0 | 0 | 0 |
| Rowan | 1 | 0 | 0 | 0 | 4 | 0 | 2 | 3 |
| Goat willow | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Elderberry | 11 | 0 | 5 | 8 | 10 | 0 | 5 | 7 |
| European spindle | 0 | 0 | 0 | 3 | 10 | 0 | 12 | 8 |
| Raspberry | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 |
| Guelder rose | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total:** | **949** | **861** | **1387** | **886** | **536** | **639** | **1099** | **637** |

Specimens of aspen (*Populus tremula*), rowan (*Sorbus aucuparia*), goat willow (*Salix spp.*), raspberry (*Rubus spp.*) and guelder rose (*Viburnum opulus*) were all previously observed but were not found in 2024 (Table 1). Hazel had not been observed previously but was found both in fenced plots, 11 seedlings, and control plots, 4 seedlings (Table 1).

Beech had a statistically significant greater average height in the fenced plots in 2024 compared to 2018 (Table 2). The average height of beech was additionally found to be significantly higher in fenced plots than control plots in 2024 (Table 2). Number of elm seedlings was close to statistically significantly lower in both control, P = 0.055, and fenced, P = 0.054, plots in 2024 than 2018 (Table 2). Average height for ash in fenced plots was close to significantly higher than in 2018, P = 0.055 (Table 2).

*Table 2. Average number of seedlings and average heights per species and year with standard errors, separated into control and fence plots, in Hästhagen. Significant differences in bold comparing 2018 to 2024, and comparing fenced plots to control plots 2024, based on paired t-tests where $P \leq 0.05$.*

| | **Control** | | **Fence** | | **P-Value: 2018 vs 2024** | | **P-Value: Control vs Fence** |
|---|---|---|---|---|---|---|---|
| **Year** | **2018** | **2024** | **2018** | **2024** | **Control** | **Fence** | **2024** |
| **Count** | | | | | | | |
| Ash | 80.1±34.6 | 73.0±26.9 | 34.0±10.4 | 44.4±15.5 | 0.661 | 0.289 | 0.439 |
| Beech | 8.8±2.4 | 14.5±5.2 | 14.1±3.9 | 13.9±3.7 | 0.321 | 0.909 | 0.922 |
| Elm | 4.0±2.1 | 1.8±1.5 | 2.9±1.6 | 2.0±1.7 | 0.055 | 0.054 | 0.930 |
| **Height** | | | | | | | |
| Ash | 22.7±1.4 | 23.5±1.6 | 22.1±1.3 | 39.3±8.4 | 0.436 | 0.055 | 0.109 |
| Beech | 19.0±0.9 | 20.2±2.6 | 19.1±1.5 | 36.4±6.1 | 0.660 | **0.014** | **0.013** |
| Elm | 28.1±0.9 | 22.4±1.2 | 29.2±5.8 | 72.4±20.0 | 0.067 | 0.206 | |

Control plots were found to have significantly more browsed seedlings and a significantly higher proportion of browsed seedlings than in the fenced plot (Table 3). Looking at the per species values, ash had significantly more browsed seedlings and a higher proportion of browsed seedlings in control plots than fenced plots (Table 3). A significantly higher proportion of browsed beech seedlings was also found in control plots, the number of browsed beech seedlings was however not significantly greater compared to fenced plots (Table 3).

*Table 3. Number of browsed seedlings per treatment and the proportion of browsed seedlings. Significant differences comparing fenced plots to control plots 2024 in bold, for both number of browsed seedlings and proportion of browsed seedlings, based on paired t-tests where P ≤ 0.05.*

| | **Browsed: Count & (%)** | | **P-value** | |
|---|---|---|---|---|
| | **Fence** | **Control** | **Count** | **%** |
| **Total** | 16 (2.5) | 508 (55.6) | **0.03** | **0.001** |
| **Per Species** | | | | |
| Ash | 4 (0.9) | 446 (61.1) | **0.044** | **0.000** |
| Beech | 10 (7.2) | 29 (20) | 0.152 | **0.011** |
| Elm | 1 (5) | 18 (100) | 0.286 | 0.089 |

## 3.2 Maltesholm

Total number of seedlings in Maltesholm was 2333. The total number of seedlings decreased from 7182 seedlings in 2021 to 2326 in 2024 in fenced plots, but comparing to 2018, 2326 was an increase by 2319 seedlings (Table 4). In control plots the total number increased from two seedlings in 2021 to seven in 2024 (Table 4). Four out of ten control plots had zero seedlings higher than ten centimetres. Majority of seedlings in both control and fenced plots were beech (Table 4). Number of beech seedlings in fenced plots peaked in 2021 with 7082 seedlings compared to seven in 2018, zero in 2019 and 2139 in 2024 (Table 4).

*Table 4. Number of seedlings per species and year in Maltesholm, separated into control and fenced plots.*

| | **Control** | | | | **Fence** | | | |
|---|---|---|---|---|---|---|---|---|
| **Tree species** | **2018** | **2019** | **2021** | **2024** | **2018** | **2019** | **2021** | **2024** |
| Ash | 0 | 0 | 1 | 2 | 0 | 0 | 96 | 180 |
| Beech | 1 | 0 | 1 | 5 | 7 | 0 | 7082 | 2139 |
| Hazel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Common hornbeam | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Maple | 0 | 0 | 0 | 0 | 0 | 18 | 4 | 5 |
| Oak | 0 | 3 | 0 | 0 | 0 | 30 | 0 | 0 |
| Elderberry | 3 | 5 | 0 | 0 | 0 | 25 | 0 | 0 |
| European spindle | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 |
| Raspberry | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Guelder rose | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| **Total:** | **4** | **8** | **2** | **7** | **7** | **89** | **7182** | **2326** |

Specimen of oak, elderberry, european spindle, raspberry and guelder rose were all previously observed but were not found 2024 (Table 4). Hazel and hornbeam had not been observed previously but were found in fenced plots 2024 (Table 4).

A significantly higher number of beech seedlings was observed in fenced plots compared to control plots 2024 and compared to fenced plots 2018 (Table 5). No significantly higher proportion of browsed seedlings were found in control plots than fenced plots (Table 6).

*Table 5. Average number of seedlings and average heights per species and year with standard errors, separated into control and fence plots, in Maltesholm. Significant differences in bold comparing 2018 to 2024, and comparing fenced plots to control plots 2024, based on paired t-tests where P ≤ 0.05.*

| | **Control** | | **Fence** | | **P-Value: 2018 vs 2024** | | **P-Value: Control vs Fence** |
|---|---|---|---|---|---|---|---|
| **Year** | **2018** | **2024** | **2018** | **2024** | **Control** | **Fence** | **2024** |
| **Count** | | | | | | | |
| Ash | 0±0 | 0.2±0.1 | 0±0 | 18.0±9.5 | 0.168 | 0.092 | 0.094 |
| Beech | 0.1±0.1 | 0.5±0.3 | 0.7±0.6 | 213.9±80.8 | 0.269 | **0.027** | **0.027** |
| **Height** | | | | | | | |
| Ash | - | 14.0±4.0 | 13.0±1.0 | 20.7±3.7 | - | 0.223 | 0.544 |
| Beech | - | 10.7±0.3 | - | 13.1±1.7 | - | - | 0.232 |

*Table 6. Number of browsed seedlings per treatment and the proportion of browsed seedlings. Significant differences comparing fenced plots to control plots 2024 in bold, for both number of browsed seedlings and proportion of browsed seedlings, based on paired t-tests where P ≤ 0.05.*

| | **Browsed: Count & (%)** | | **P-value** | |
|---|---|---|---|---|
| | **Fence** | **Control** | **Count** | **%** |
| **Total** | 63 (2.7) | 3 (42.9) | 0.083 | 0.740 |
| **Per Species** | | | | |
| Ash | 7 (3.9) | 2 (100) | 0.182 | 0.591 |
| Beech | 56 (2.6) | 1 (20) | 0.391 | 0.564 |

# 4. Discussion

The main purpose of this study was to gain knowledge of the impact by browsing on tree regeneration in PFAs. It was found that browsing by ungulates is likely to put limitations to tree regeneration where browsing pressure is high. Statistically significant differences showed that browsing influences seedling height growth in an area with a medium to low browsing pressure for some species. Results indicate that fences could offer aid in safeguarding tree regeneration in PFAs experiencing a high browsing pressure from large ungulate populations. However, where browsing pressure is not extremely high, fencing does not differentiate the success of tree seedling establishment.

It was hypothesised that control plots would encompass a higher proportion of browsed seedlings, lower number of seedlings and lower height growth than fenced plots. This was found to be true in Maltesholm. Statistical significance was however only found in the greater number of beech seedlings within fenced plots. The absence of seedlings in control plots showcases the impact by browsing, with almost no seedlings established in Maltesholm control plots. Not all hypotheses were confirmed in Hästhagen. Statistically significant difference in proportion of browsed seedlings was found, where control plots had a higher proportion. A statistically significant difference in height was further observed for beech seedlings in fenced plots compared to control plots 2024 and compared to fenced plots 2018. The number of seedlings was however higher in control plots. It was further hypothesised that these effects would be more profound where the higher browsing pressure persists. Data analyses cannot conclusively express that the absence of seedlings for control plots in Maltesholm are due to browsing as there were no seedlings to examine for browsing damages. However, the great gap in number of seedlings between control and fenced plot displayed in Maltesholm implies that the area is affected by a high browsing pressure. Additionally, the statistically significant difference in number of beech seedlings, where fenced plots contained more seedlings, validates the difference between treatments.

Similar results were found based on the inventory in 2019, with a visible difference in the success of tree regeneration in fenced plots compared to control plots in Maltesholm where browsing pressure is high (Johansson 2020). Results from the inventory in 2021 further contributed to this consensus. The influence on tree regeneration differed between the sites, where Maltesholm was affected by a large ungulate population (Ramberg & Sjöqvist 2023). It was concluded that fences were effective in protecting tree regeneration in Maltesholm, 2021, but where the browsing pressure was not as high, tree regeneration was as successful in fenced plots as control plots (Ramberg & Sjöqvist 2023). Furthermore, the study conducted in Poland with a similar experimental design also showed negative effects of browsing on tree regeneration (Kweczlich & Miścicki 2004), which aligns with what was found in the Scanian nature reserves.

This study includes the use of small fences, contrarily to where whole regeneration- and forested areas are fenced, which creates a big enclosure. Fencing is commonly done in production forestry when regenerating with broadleaves (Löf et al. 2015; Skogskunskap 2023). In the Scanian landscape predominantly comprised of agricultural fields, PFAs constitute a significant potential food source. Preventing ungulates from entering areas with a potential food source might displace the issue rather than resolve it entirely, which is why the use of small fences could be of interest. Results indicated that at a site experiencing substantial browsing pressure, excluding ungulates with the use of small fences facilitated a higher presence of number of seedlings which displays the effectiveness of these fences. Fences should however be consistently monitored and checked for damages. Among others, wild boars tend to create holes in the fence which further leaves open access to the area for other ungulates (Löf et al. 2015). With the use of small fences this risk is likely reduced as wild boar and other ungulates have access to most of the forested area. However, for these fences to be effective in the safeguarding of tree regeneration the placement is of importance. Light availability is essential to seedling growth (Pacala et al. 1994) hence the fence should be placed where the tree canopy is sufficiently open. It has been found that canopy openness promoted growth and survival rates in oak (Barrere et al. 2021). On top of that, results from Barrere et al. (2021) demonstrated the positive effect of small fences on seedling growth as the increased light availability also increased browsing damages. Conclusively, small fences could be effective in promoting tree regeneration to minimise the risk of wild boar forcement, if placed with a good amount of light available.

The total number of beech seedlings peaked substantially in 2021, in all treatments except from control plots in Maltesholm, followed by a high mortality. This study is designed to control for the factor of browsing however, it is not completely unaffected by other driving forces of seedling survival and growth. A likely contributor to the peak in number of beech seedlings in 2021 could be the mast year observed in 2019 (Skogsstyrelsen 2019; Carlen et al. 2022). The mortality and decrease in the number of beech seedlings that followed could partly be explained by the drought seen in 2023 (SMHI 2024; Lantbrukarnas Riksförbund n.d.) as the scarcity of water, and competition for resources among vegetation, may have limited seedling development (Grossnickle 2018). However, the great difference between control and fenced plots in Maltesholm highlights the negative effect on tree regeneration caused by browsing.

Amount of leaf litter and the ash dieback are additional components that could have had an impact on tree regeneration. Different amount of leaf litter was observed among sample plots where fenced plots tended to have a thicker accumulated layer of leaf litter, possibly influencing the development of tree regeneration, no measurements was however carried out on this. Furthermore, the ash dieback (*Hymenoscyphus fraxineus*) could potentially have been an influential factor on ash seedlings as the disease is established and largely spread in Sweden and northern Europe (SLU Artdatabanken n.d.). It is reasonable to believe that this fungal disease has decreased the treatment effect by mortality in ash seedlings as well as played a role in the growth development if new shoots have suffered fungal infestation (SLU Artdatabanken n.d.).

When conducting the inventory a few fences were found to be damaged. As the fence was completely damaged on one plot in Hästhagen as well as one in Maltesholm, where wind felled trees had wrecked the poles holding the fence, there is a risk that ungulates have had access to browse within. Additionally, three fences in Hästhagen and one in Maltesholm had smaller holes in the net where smaller herbivores such as hares could have entered the plot. These damages could have caused results not to represent a true exclusion of ungulate browsing. However, as damaged fences only account for a small proportion of all plots, the effect of non-damaged fences dominates the results.

During inventory, herbaceous ground vegetation was more or less present in different plots. The ground was covered by wild garlic (*Allium ursinum*) in several plots in Maltesholm, in contrast to the plots in Hästhagen where the ground was mostly covered in leaf litter. The contrasts complicated inventory to a certain extent, where plots covered in wild garlic required more thorough observation for small seedlings. Additionally, previous inventories in 2018, 2019, and 2021 have all been carried out by different persons and despite using the same inventorying method, the results could be affected by the subjectivity of each respective person and the different units of tools for height measurements.

Further investigation is required to ascertain whether the use of small fences promotes seedling recruitment into larger height classes. Using the same experimental design as this study and in the same Polish forest as Kweczlich and Miścicki (2004) conducted their study, Kuijper et al. (2010) seven-year monitoring of tree regeneration investigated dynamics between biotic and abiotic influential factors. It was found that herbivory more significantly impacted seedling recruitment into heights above 50 cm, while abiotic factors impacted earlier stages of tree regeneration. This highlights the need for further research and long-term monitoring of seedling growth in the Scanian nature reserves to investigate potential consistency and similarities. Data analyses for inventory of Hästhagen and

Maltesholm 2024 could include comparisons where height measurements are separated into different height intervals to differentiate recruitment into greater heights. This could contribute to the analysis of growth development over time and for comparison to prior inventories.

# 5. Conclusion

This study provides insights to the complex dynamics between browsing pressure and tree regeneration in PFAs. Findings recognise significant limitations browsing by ungulates imposes on tree regeneration in areas with a high browsing pressure. Statistical analysis further disclosed that browsing influenced height growth in seedlings also in areas with medium to low browsing pressure for certain species, including beech. Fencing conclusively was found to be effective in mitigating damage by browsing on tree regeneration where a high browsing pressure exists.

Consistent monitoring and maintenance of fences are essential, as wild boars can create openings that could leave access to browsers. The use of small fences may mitigate this risk, and if placed strategically with high light availability seedling growth can be promoted.

Future research should further investigate interactions between ungulates and tree regeneration through experiments that monitor the long-term development of tree regeneration and how effective sustained fences are in the conservation of natural values. Additionally, the broader landscape perspective needs to be considered as fencing of larger areas could displace browsing pressure elsewhere.

# References

Angst, J.K. & Kupferschmid, A.D. (2023). Assessing Browsing Impact in Beech Forests: The Importance of Tree Responses after Browsing. *Diversity*, 15 (2), 262. https://doi.org/10.3390/d15020262

ArtDatabanken (2015). *Rödlistade arter i Sverige 2015*. SLU. https://www.artdatabanken.se/publikationer/rodlistan2015/

Barrere, J., Petersson, L.K., Boulanger, V., Collet, C., Felton, A.M., Löf, M. & Saïd, S. (2021). Canopy openness and exclusion of wild ungulates act synergistically to improve oak natural regeneration. *Forest Ecology and Management*, 487, 118976. https://doi.org/10.1016/j.foreco.2021.118976

Bergquist, J., Björse, G., Johansson, U. & Langvall, O. (2002). *Vilt och Skog. Information om aktuell forskning vid SLU om vilt och dess påverkan på skogen och skogsbruket.*

Brunet, J. (2004). *Skånes skogar - historia, mångfald och skydd*. (2005:12). Länsstyrelsen i Skåne län. https://www.lansstyrelsen.se/skane/om-oss/vara-tjanster/publikationer/2004/skanes-skogar---historia-mangfald-och-skydd.html

Carlen, M., Rolander, M., Grammer, T. & Svensson, L. (2022). *Skogsskador i Sverige 2021*. (6). Skogsstyrelsen.

CBD (2023). *Climate Change and Biodiversity Introduction. Convention on Biological Diversity*. https://www.cbd.int/climate/intro.shtml [2024-05-03]

Ceballos, G., Ehrlich, P.R., Barnosky, A.D., García, A., Pringle, R.M. & Palmer, T.M. (2015). Accelerated modern human–induced species losses: Entering the sixth mass extinction. *Science Advances*, 1 (5), e1400253. https://doi.org/10.1126/sciadv.1400253

Ceballos, G., Ehrlich, P.R. & Dirzo, R. (2017). Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. *Proceedings of the National Academy of Sciences of the United States of America*, 114 (30), E6089–E6096. https://www.jstor.org/stable/26486175 [2024-05-11]

Cooke, A.S. & Lakhani, K.H. (1996). Damage to coppice regrowth by muntjac deer *Muntiacus reevesi* and protection with electric fencing. *Biological Conservation*, 75 (3), 231–238. https://doi.org/10.1016/0006-3207(95)00070-4

Cowie, R.H., Bouchet, P. & Fontaine, B. (2022). The Sixth Mass Extinction: fact, fiction or speculation? *Biological Reviews*, 97 (2), 640–663. https://doi.org/10.1111/brv.12816

Danell, K., Bergström, R., Duncan, P. & Pastor, J. (2006). *Large Herbivore Ecology, Ecosystem Dynamics and Conservation*. Cambridge University Press. http://ebookcentral.proquest.com/lib/slub-ebooks/detail.action?docID=261098 [2024-04-15]

European Parliament (2020). *Biodiversity loss: what is causing it and why is it a concern? Topics | European Parliament.* https://www.europarl.europa.eu/topics/en/article/20200109STO69929/biodiversity-loss-what-is-causing-it-and-why-is-it-a-concern [2024-04-25]

Gärdenfors, U. (ed.) (2010). *Rödlistade arter i Sverige 2010 - The Red List of Swedish Species*. ArtDatabanken, SLU. https://www.artdatabanken.se/publikationer/rodlista-2010/

Google maps (2024). Skåne län Map. https://www.google.se/maps/place/Sk%C3%A5ne+l%C3%A4n/@56.0232582,13.3083085,8.5z/data=!4m6!3m5!1s0x464d783fe43b503f:0xbd47a217e2b7f0e1!8m2!3d55.9902572!4d13.5957692!16zL20vMHN2bWg?entry=ttu [2024-05-10]

Grossnickle, S. (2018). Seedling Establishment on a Forest Restoration Site: An Ecophysiological Perspective. *REFORESTA*, (6), 110–139. https://doi.org/10.21750/REFOR.6.09.62

Gustafsson, L. & Perhans, K. (2010). Biodiversity Conservation in Swedish Forests: Ways Forward for a 30-Year-Old Multi-Scaled Approach. *Ambio*, 39 (8), 546–554. https://www.jstor.org/stable/40928411 [2024-05-02]

IPBES (2019). *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Zenodo. https://doi.org/10.5281/zenodo.6417333

Johansson, P.O. (2020). *Att skydda det skyddade*. [Avancerad nivå, A2E]. https://stud.epsilon.slu.se/16127/ [2024-04-05]

Kuijper, D.P.J., Cromsigt, J.P.G.M., Jędrzejewska, B., Miścicki, S., Jędrzejewski, W., Churski, M. & Kweczlich, I. (2010). Bottom-up versus top-down control of tree regeneration in the Białowieża Primeval Forest, Poland. *Journal of Ecology*, 98 (4), 888–899. https://www.jstor.org/stable/40732015 [2024-04-23]

Kweczlich, I. & Miścicki, S. (2004). The impact of herbivorous ungulates on forest regeneration in the Białowieża National Park. 148 (6), 18–29. https://www.cabidigitallibrary.org/doi/full/10.5555/20063023174#core-collateral-purchase-access

Länsstyrelsen Skåne (2003). *Kulturmiljöprogram: Skogens landskap. Länsstyrelsen Skåne*. [text]. https://www.lansstyrelsen.se/skane/besoksmal/kulturmiljoprogram/kulturmiljoprogram-skanes-historia-och-utveckling/kulturmiljoprogram-skogens-landskap.html [2024-04-27]

Länsstyrelsen Skåne (2024). *Svaneholm Hästhagen*. [text]. https://www.lansstyrelsen.se/skane/besoksmal/naturreservat/skurup/svaneholm-hasthagen.html [2024-04-17]

Länsstyrelsen Skåne (n.d.a). *Maltesholm*. [text]. https://www.lansstyrelsen.se/skane/besoksmal/naturreservat/kristianstad/maltesholm.html [2024-04-18]

Länsstyrelsen Skåne (n.d.b). *Skogen i jordbruket*. [text]. https://www.lansstyrelsen.se/skane/besoksmal/kulturmiljoprogram/kulturmiljoprogram-skanes-historia-och-utveckling/kulturmiljoprogram-skogens-landskap/skogen-i-jordbruket.html [2024-05-14]

Lantbrukarnas Riksförbund (n.d.). *Torka*. https://www.lrf.se/sakomraden/torka/ [2024-05-08]

Larsson, T.-B., Angelstam, P., Balent, G., Barbati, A., Bijlsma, R.-J., Boncina, A., Bradshaw, R., Bücking, W., Ciancio, O., Corona, P., Diaci, J., Dias, S., Ellenberg, H., Fernandes, F.M., Fernández-Gonzalez, F., Ferris, R., Frank, G., Møller, P.F., Giller, P.S., Gustafsson, L., Halbritter, K., Hall, S., Hansson, L., Innes, J., Jactel, H., Dobbertin, M.K., Klein, M., Marchetti, M., Mohren, F., Niemelä, P., O'Halloran, J., Rametsteiner, E., Rego, F., Scheidegger, C., Scotti, R., Sjöberg, K., Spanos, I., Spanos, K., Standovár, T., Svensson, L., Tømmerås, B.Å., Trakolis, D., Uuttera, J., VanDenMeersschaut, D., Vandekerkhove, K., Walsh, P.M. & Watt, A.D. (2001). Biodiversity Evaluation Tools for European Forests. *Ecological*

*Bulletins*, (50), 1–237. https://www.jstor.org/stable/20113288 [2024-04-15]

Levin, S.A. (2005). Self-organization and the Emergence of Complexity in Ecological Systems. *BioScience*, 55 (12), 1075–1079. https://doi.org/10.1641/0006-3568(2005)055[1075:SATEOC]2.0.CO;2

Lindbladh, M., Brunet, J., Hannon, G., Niklasson, M., Eliasson, P., Eriksson, G. & Ekstrand, A. (2007). Forest History as a Basis for Ecosystem Restoration—A Multidisciplinary Case Study in a South Swedish Temperate Landscape. *Restoration Ecology*, 15 (2), 284–295. https://doi.org/10.1111/j.1526-100X.2007.00211.x

Lindenmayer, D.B. & Franklin, J.F. (2002). *Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach*. Island Press. http://ebookcentral.proquest.com/lib/slub-ebooks/detail.action?docID=3317325 [2024-05-03]

Löf, M., Barrere, J., Engman, M., Petersson, L.K. & Villalobos, A. (2021). The influence of fencing on seedling establishment during reforestation of oak stands: a comparison of artificial and natural regeneration techniques including costs. *European Journal of Forest Research*, 140 (4), 807–817. https://doi.org/10.1007/s10342-021-01369-w

Löf, M., Bergquist, J., Brunet, J., Karlsson, M. & Welander, N.T. (2010). Conversion of Norway spruce stands to broadleaved woodland-regeneration systems, fencing and performance of planted seedlings. *Ecological Bulletins*, (53), 165–174. https://www.jstor.org/stable/41442028 [2024-04-15]

Löf, M., Møller-Madsen, E. & Rytter, L. (2015). *Skogsskötselserien – fördjupade kunskaper om skogsskötsel, Kapitel 10*. https://www.skogsstyrelsen.se/mer-om-skog/skogsskotselserien/ [2024-05-28]

Naturskyddsföreningen Skåne (n.d.). *Hästhagen – Naturskyddsföreningen i Skåne*. https://skane.naturskyddsforeningen.se/hittaut/sydvastra-skane/hasthagen/ [2024-04-18]

Naturvårdsverket (2012). *Skyddad natur*. https://skyddadnatur.naturvardsverket.se/ [2024-04-18]

Pacala, S.W., Canham, C.D., Silander Jr., J.A. & Kobe, R.K. (1994). Sapling growth as a function of resources in a north temperate forest. *Canadian Journal of Forest Research*, 24 (11), 2172–2183. https://doi.org/10.1139/x94-280

Petersson, L.K., Milberg, P., Bergstedt, J., Dahlgren, J., Felton, A.M., Götmark, F., Salk, C. & Löf, M. (2019). Changing land use and increasing abundance of deer cause natural regeneration failure of oaks: Six decades of landscape-scale evidence. *Forest Ecology and Management*, 444, 299–307. https://doi.org/10.1016/j.foreco.2019.04.037

Polis, G.A. & Strong, D.R. (1996). Food Web Complexity and Community Dynamics. *The American Naturalist*, 147 (5), 813–846. https://doi.org/10.1086/285880

Ramberg, H. & Sjöqvist, K. (2023). *Föryngring med hägn*. [Grundnivå, G2E]. https://stud.epsilon.slu.se/19477/ [2024-04-05]

Régnier, C., Achaz, G., Lambert, A., Cowie, R.H., Bouchet, P. & Fontaine, B. (2015). Mass extinction in poorly known taxa. *Proceedings of the National Academy of Sciences*, 112 (25), 7761–7766. https://doi.org/10.1073/pnas.1502350112

Skogskunskap (2017). *Södra lövskogsregionen*. https://www.skogskunskap.se:443/hansyn/naturhansyn/naturmiljoer-fran-norr-till-soder/sodra-lovskogsregionen/ [2024-04-19]

Skogskunskap (2023). *Viltskador på löv*. https://www.skogskunskap.se:443/skota-lovskog/foryngra/viltskador-pa-lov/ [2024-04-28]

Skogsstyrelsen (2019). *Efter värmen förra året: bokollon-år i sydsvenska skogar. Skogsstyrelsen*. https://www.skogsstyrelsen.se/pressmeddelanden/ [2024-05-28]

SLU Artdatabanken (2020). *Rödlistade arter i Sverige 2020*. SLU. https://www.artdatabanken.se/publikationer/bestall-rodlista-2020/

SLU Artdatabanken (2024a). *Dovhjort Dama dama - Artfakta från SLU Artdatabanken*. https://artfakta.se/ [2024-05-06]

SLU Artdatabanken (2024b). *Eurasiatiskt vildsvin Sus scrofa scrofa - Artfakta från SLU Artdatabanken*. https://artfakta.se/ [2024-05-06]

SLU Artdatabanken (2024c). *Rådjur Capreolus capreolus - Artfakta från SLU Artdatabanken*. https://artfakta.se/ [2024-05-06]

SLU Artdatabanken (2024d). *Sammanfattning Rödlista 2020 | SLU Artdatabanken. SLU.SE*. https://www.artdatabanken.se/det-har-gor-vi/rodlistning/Sammanfattning-rodlista-2020/ [2024-05-07]

SLU Artdatabanken (n.d.). *Ask Fraxinus excelsior - Artfakta från SLU Artdatabanken*. https://artfakta.se/ [2024-05-15]

SMHI (2024). *Juni 2023 - Mycket varm med långvarig torka. SMHI.* https://api.screen9.com/embed/jH4KUZ9TxVrEzA7TKECOdA [2024-05-08]

Smith, T.M. (2015). *Elements of ecology*. 9. ed., Global edition. Pearson.

Svenska Jägareförbundet (2019). *Avskjutningsrapportering Skåne Län - Jaktåret 2018-2019*. Svenska jägareförbundet.

Svenska Jägareförbundet (2020). *Avskjutningsrapportering Skåne - jaktåret 2019/2020*. Svenska Jägareförbundet.

Svenska Jägareförbundet (2021). *Avskjutningsrapportering Skåne Län - Jaktåret 2020/2021*. Svenska Jägareförbundet.

Svenska Jägareförbundet (2022). *Avskjutningsrapportering Skåne - Jaktåret 2021/2022*. Svenska Jägareförbundet.

Svenska Jägareförbundet (n.d.). Avskjutnings- rapporter. *Viltdata*. https://www.viltdata.se/avskjutningsrapporter/ [2024-05-06]

Sveriges geologiska undersökning (n.d.). SGUs Kartvisare . https://apps.sgu.se/kartvisare/kartvisare-jordarter-25-100.html [2024-04-18]

Tsiouvaras, C.N. (1988). Long-term effects of clipping on production and vigor of kermes oak (*Quercus coccifera*). *Forest Ecology and Management*, 24 (2), 159–166. https://doi.org/10.1016/0378-1127(88)90119-3

UNEP (2021). *Making Peace With Nature: A scientific blueprint to tackle the climate, biodiversity and pollution emergencies. .* https://www.unep.org/resources/making-peace-nature [2024-05-02]

Van Hees, A.F.M., Kuiters, A.T. & Slim, P.A. (1996). Growth and development of silver birch, pedunculate oak and beech as affected by deer browsing. *Forest Ecology and Management*, 88 (1), 55–63. https://doi.org/10.1016/S0378-1127(96)03809-1

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# Appendix 1

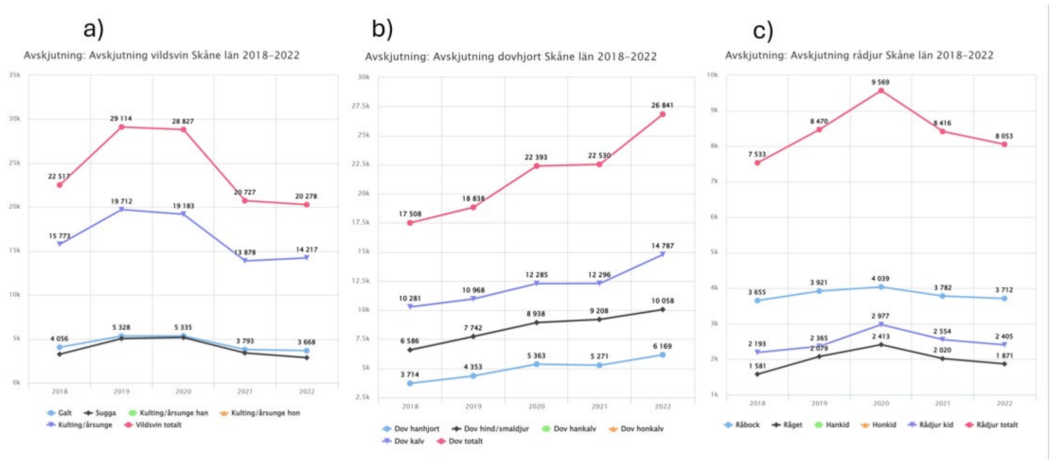

*Figure 2. Hunting statistics from 2018 – 2022 in Skåne, for a) wild boar, b) fallow deer, and c) roe deer.*

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