



The effect of pre-clearing on forest birds in Swedish forestry

Lina Näsström

Independent project • 15 credits

Swedish University of Agricultural Sciences, SLU

Faculty of Natural Resources and Agricultural Sciences (NJ) • Department of Ecology

Biology and Environmental Science • Bachelor's programme

Uppsala 2026



The effects of pre-clearing on forest birds in Swedish forestry

Underröjningens effekter på skogsfåglar i svenskt skogsbruk

Lina Näsström

Supervisor:	Ineta Kačergytė, Swedish University of Agricultural Sciences, Department of Ecology
Assistant supervisor:	Marcus Sydh Göransson, Mellanskog, Sustainability Unit
Examiner:	Göran Hartman, Swedish University of Agricultural Sciences, Department of Ecology
Credits:	15 hp
Level:	G2E
Course title:	Independent project in Biology
Course code:	EX0894
Programme/education:	Biology and Environmental Science
Course coordinating dept:	Department of Aquatic Sciences and Assessment
Place of publication:	Uppsala
Year of publication:	2026
Cover picture:	Klara Tellebo
Copyright:	All featured images are used with permission from the copyright owner.
Keywords:	Forestry, bird ecology, pre-clearing, pre-commercial thinning, understory, understory vegetation.

Swedish University of Agricultural Sciences

The faculty of Natural Resources and Agricultural Sciences (NJ)

Department of Ecology

Abstract

In today's forest landscape in Sweden, a large percentage of the forests are traditionally managed. It is clear that clear-cutting is affecting bird diversity negatively, but while many studies have been made on that connection, not so many have studied the effects of pre-clearing on species diversity of birds. In this study, I examined how pre-clearing in forest management may impact forest birds in the Swedish forestry landscape. With data of bird inventories from Swedish Bird Survey (SBS), along with management information of pre-clearing, thinning and clear-cutting from Mellanskog, a spatial and temporal investigation in QGIS was performed to identify suitable study locations. Different ecological groups of birds were selected based on their breeding needs that were predicted to respond to forest pre-clearings. Included bird species groups were shrub nesters, ground nesters and cavity nesters as control. Additionally, nesting generalists and specialists were also compared. The study was performed using a Before-After-Control-Impact design, where pre-clearing locations with a matching line transect from SBS were compared with another line transect from the same SBS route as control for Before and After studies. Some trends indicated that shrub nesters were affected negatively by pre-clearing and ground nesters positively, and one site showed significant results. But for the rest of the sites, there were no clear evidence that pre-clearing affect forest bird species composition or abundances. The lack of pre-clearing effect could be due to that this management does not have a strong enough impact to cause species to decline. The lack of detected pre-clearing effect could also be due to the limitations of the study, such as the study design and the relatively small sample size. Since Swedish forestry affect such a big part of Sweden's forests, it is important with further research on the subject to be able to detect trends so that a sustainable forestry can meet the needs of forest birds.

Keywords: Forestry, bird ecology, pre-clearing, pre-commercial thinning, understory, understory vegetation.

Table of contents

List of tables	5
List of figures	6
Abbreviations	9
Glossary	10
1. Introduction	11
1.1 Forestry management.....	11
1.1.1 Pre-clearing.....	12
1.2 Forest birds' ecology	13
1.2.1 Understory as habitat.....	13
1.3 Aim and objective.....	16
2. Method	18
2.1 Study design.....	18
2.2 Swedish Bird Survey and Mellanskog's data	18
2.3 Ecological groups	21
2.4 Statistical analyses	22
3. Result	24
3.1 Species diversity	24
3.2 Number of individuals	26
3.3 Species lost and gained.....	30
3.4 Nesting habitat variety	34
3.4.1 Specialists	34
3.4.2 Generalists	36
4. Discussion	38
4.1 Ecology	38
4.2 Species diversity	39
4.3 Number of individuals	39
4.4 Species lost and gained.....	40
4.5 Nesting habitat variety	40
4.6 Study limitations	41
4.7 Management suggestions and Future research	42
4.7.1 Suggestions.....	42
4.7.2 Future research	42
5. Reference list	44

List of tables

Table 1. Three groups categorized according to ecological niches. Ecological data from
Bird Database (<https://birds.imsezer.com/>). 22

List of figures

- Figure 1. The rotation cycle of even-aged forest management, often used in Swedish forestry. Illustration: M. Holmer. Image: <https://www.ksla.se/wp-content/uploads/2024/06/Forests-and-Forestry-in-Sweden-2024.pdf> 12
- Figure 2. A capercaillie's nest on the ground (scrape), partly covered by vegetation. CC BY-NC 4.0. Image: H. Mickelsson. Image: <https://digitaltmuseum.se/021017673075/tjaderbo-med-agg-maj-juni-1983> ... 15
- Figure 3. A wood warbler's dome shaped nest with its well camouflaged eggs (A) and nestlings (B). CC BY 4.0. Image: G. Hebda and M. Maziarz https://www.researchgate.net/deref/https%3A%2F%2Fcreativecommons.org%2Flicenses%2Fby%2F4.0%2F?_tp=eyJjb250ZXh0Ijp7ImZpcn..... 15
- Figure 4. A willow warbler's cup-shaped nest hidden in a juniper tree. The picture is taken from above. CC BY 4.0. Image: K.W. Larson <https://journals.lub.lu.se/os/article/view/22583/20086> 16
- Figure 5. The standardized routes from Swedish Bird Survey, displaying the route layout along with its numbering. Each square is 1x1 km. <https://www.fageltaxering.lu.se/sites/fageltaxering.lu.se/files/2024-01/Standardrutt.pdf> 19
- Figure 6. A satellite image of the Swedish Bird Survey standard route visible as an orange square. The green and yellow polygons are performed managements from Mellanskog. Green is for pre-clearing and yellow is for thinning or clear-cutting. The red polygon is the selected pre-clearing for the study and the Impact and Control line transects are marked in red. 20
- Figure 7. Box plots illustrating the mean number of shrub nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Before' period (dark green) and the 'After' period (bright green). 24
- Figure 8. Box plots illustrating the mean number of ground nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Before' period (dark green) and the 'After' period (bright green). 25
- Figure 9. Box plots illustrating the mean number of cavity nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Before' period (dark green) and the 'After' period (bright green). 26

Figure 10. Box plots illustrating the mean number of individuals of all groups of bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Before' period (dark purple) and the 'After' period (bright purple).....	27
Figure 11. Box plots illustrating the mean number of individuals of shrub nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Before' period (dark purple) and the 'After' period (bright purple).....	28
Figure 12. Box plots illustrating the mean number of individuals of ground nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Before' period (dark purple) and the 'After' period (bright purple).....	29
Figure 13. Box plots illustrating the mean number of individuals of cavity nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Before' period (dark purple) and the 'After' period (bright purple).....	30
Figure 14. Box plots illustrating the mean number of lost and gained bird species across all groups (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Lost' section (dark blue) and the 'Gained' section (bright blue).....	31
Figure 15. Box plots illustrating the mean number of lost and gained shrub nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Lost' section (dark blue) and the 'Gained' section (bright blue).	32
Figure 16. Box plots illustrating the mean number of lost and gained ground nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Lost' section (dark blue) and the 'Gained' section (bright blue).	33
Figure 17. Box plots illustrating the mean number of lost and gained cavity nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Lost' section (dark blue) and the 'Gained' section (bright blue).	34
Figure 18. Box plots illustrating the mean change in individuals of shrub nesting specialist species (marked with an X) after pre-clearing, with control sites on the left (dark orange) and impact site (bright orange) on the right.	35
Figure 19. Box plots illustrating the mean change in individuals of ground nesting specialist species (marked with an X) after pre-clearing, with control sites on the left (dark orange) and impact site (bright orange) on the right.	36

Figure 20. Box plots illustrating the mean change in individuals of shrub nesting generalist species (marked with an X) after pre-clearing, with control sites on the left (dark orange) and impact site (bright orange) on the right. 36

Figure 21. Box plots illustrating the mean change in individuals of ground nesting generalist species (marked with an X) after pre-clearing, with control sites on the left (dark orange) and impact site (bright orange) on the right. 37

Abbreviations

Abbreviation	Description
SLU	Swedish University of Agricultural Sciences
BACI	Before-After-Control-Impact design
SBS	Swedish Bird Survey

Glossary

Rotation period – In forestry, the time from the soil scarification to harvesting

Pre-commercial thinning – The clearing of smaller trees a couple of years after planting, to regulate the number of stems per hectare

Pre-clearing – The clearing of smaller shrubs and trees before harvest of bigger trees, to increase visibility and maneuverability for the machine operators

Thinning – The harvesting of bigger trees used as pulp wood

Clear-cutting – The harvesting of the biggest trees in an area, usually used as timber

Pulp wood - Thinner trees that are felled and used in paper and fiber products

Energy wood - Branches and roots that are used for biomass energy

Nestling – A young chick, still in its parents' nest

Fledgling – A young bird that has recently left the nest but is still dependent on its parents to feed them

Clutch size – The number of eggs laid in a single brood by a nesting pair of birds

Understory/understory vegetation/undergrowth – Lower vegetation in a forest

Landscape of fear – When the mere presence of predators changes the prey's behaviour

Dictionary Swedish – English

Markberedning - Soil scarification. At the beginning of the rotation period, the soil is turned over mechanically so that new plants can grow more easily.

Underröjning/förröjning/siktröjning - Pre-clearing, undergrowth clearing

Ungskogsröjning - Pre-commercial thinning

1. Introduction

Sweden is covered to a large extent of forest. The forest is many things – a place for recreation, a carbon sink, an economic investment, a place for ecosystems to thrive, a place for traditional land use, and a source for biofuel (Nolander, 2021; Berg, 2010). With the current climate change, the forests act as a natural barrier against erosion and extreme weather and binds heavy metals (Giesler et al., 2017) as well as stores enormous amounts of sequestered carbon (Jackson et al., 2026). At the same time, wood products and biofuel can help us mitigate climate change by phasing out fossil fuels and non-sustainable building materials (Simonsen et al., 2023). How we manage our forests is very important, and not entirely easy considering all of these competing interests.

Today in Sweden, the forests spark a lot of interest and there is an intense debate about how the forests should be managed. A clear majority of Sweden's forests are in some way managed through forestry, often by traditional fellings by clear cutting where a part of the forest is cut down and re-planted. As this is a large change in the forest landscape, it directly and indirectly affects the species that live there (Asplund et al., 2022). While many studies have been made of how big changes in the forest structure, like clear-cuttings, affect bird diversity, not a lot of studies have investigated the effects of pre-clearing on bird diversity.

1.1 Forestry management

Swedish forest management in the traditional sense has a rotation period (Figure 1) of around 60-120 years depending on the tree species, which is usually Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*) (Normark, 2024).



Figure 1. The rotation cycle of even-aged forest management, often used in Swedish forestry. Illustration: M. Holmer. Image: <https://www.ksla.se/wp-content/uploads/2024/06/Forests-and-Forestry-in-Sweden-2024.pdf>

It starts with soil scarification where the top layer of soil is turned over so that the conditions to support new plants are more favourable. Then new young trees can grow either by being planted or by retaining a few trees to disperse seeds.

After around five to ten years of being planted, the young forest is undergoing pre-commercial thinning by the removal of smaller trees and shrubs to favour the desired tree species, to favour the trees with a broader diameter and to regulate the number of stems per hectare. The cut trees are left in the forest where they bring nutrients back to the soil when decomposing. Usually, a pre-commercial thinning when the forest is young is an economic investment, as it helps reduce costs later on (Normark, 2024; Skogsstyrelsen 2025).

Up to two years before a thinning or clear-cutting, (but usually a couple of weeks or months) the undergrowth, also called understory, is pre-cleared. This is done to allow the machine operator to get a better visual view of the trees that are going to be taken out, as well as better manoeuvrability (Kärhä, 2006).

Next in the cycle is the thinning. Depending on the geographic location, the trees are thinned when they are between twenty-five to fifty years old (Mellanskog 2026). At the thinning, up to 40% of the trees are felled (Kanth, n.d.), transported and used in industry as energy wood or pulpwood. The thinning is done to allow more nutrition and sunlight go to the thicker trees of higher quality and to reduce the risk of damage to the remaining trees by making sure

they are of good quality and can withstand storms, droughts and snow better (Mellanskog, 2024).

In the final stage of the forest cycle, the trees are harvested through a clear-cutting where all the trees in the area are felled, transported and sold as timber (Normark 2024).

1.1.1 Pre-clearing

Mellanskog is a cooperative society owed by its 29 000 forest owners. They operate and help forest owners manage their forests between Härjedalen in the north of Sweden to Gotland in the south. Their work involves planning and conducting forestry management for their members. At the moment, there is a lack of information of the connection between pre-clearing and forest birds and the reason why it is the focus of this study.

During the pre-clearing, Mellanskog cuts all trees with a diameter of less than seven centimeters (Mellanskog, 2026) and these smaller trees are around a couple of decimetres to five metres high (Iwarsson, 2001).

Pre-clearing in forestry is therefore mainly done for practical reasons rather than direct economic gain from wood products. However, studies states that removal of understory might impacts forest birds negatively (Klein, 2020). Since the pre-clearing can be performed up to a couple of years before a bigger management (like thinning or clear-cutting), the understory can therefore no longer serve as an important and continuous habitat for many ground- and shrub nesting birds during that time.

1.2 Forest birds' ecology

With climate change, there will be more and longer heat waves across Sweden. This will affect our ecosystems profoundly, including our forests. With less precipitation, the trees will become more stressed, making them more susceptible for insect pests and diseases (Jönsson et al., 2009).

Birds have been proven to increase the overall health of forests, by dispersing seeds and eating insects that are causing tree damage (Stratford and Şekercioğlu, 2015; Niemi et al., 1998). Forests with an abundance of bird species and individuals show a higher resilience against certain pests and may because of this be used as natural pest control (Raz, 2021). There might therefore be an economic interest in having forests with many bird species and individuals, since they might help in reducing outbreaks of pests that affect the managed forests' economic value negatively (BirdLife International, 2023).

Boreal forests usually consist of three vegetation layers: the top canopy, understory vegetation often including woody bushes and small trees, and the ground layer consisting mainly of mosses and lichens (Nilsson & Wardle, 2005). The species in a forest ecosystem are adapted to these different vegetation layers

by their foraging habits, food type and breeding. A multi-layered forest structure can support more species in different ecological niches than a mono cultural stand can (Bollmann, 2018). However, forest management, including pre-clearing, changes the forest structural diversity and thus influence species.

Generalist and specialist species have a different breadth of ecological needs where the generalists have a broader diet and nesting habitat and can more easily adapt to changes in their environment. The specialist species on the other hand are more sensitive with a more narrow diet and nesting habitat and are thus not able to cope with environmental changes to the same extent (National Geographic Society, 2023).

1.2.1 Understory as habitat

Understory vegetation serves as an important habitat for many bird species in the form of protection against predators as well as nesting and foraging sites. If the vegetation changes, so does the conditions for the species tied to the vegetation. For ground nesters, which build their nest on or near the ground, the understory vegetation serves as important protection for their nest. Some species, like the hazel grouse (*Tetrastes bonasia*) and capercaillie (*Tetrao urogallus*), build their nest as a scrape, directly on the ground (Figure 2) (Storch, 1994; Åberg, 2000).



Figure 2. A capercaillie's nest on the ground (scrape), partly covered by vegetation. CC BY-NC 4.0. Image: H. Mickelsson. Image: <https://digitaltmuseum.se/021017673075/tjaderbo-med-agg-maj-juni-1983>

The wood warbler (*Phylloscopus sibilatrix*) also builds their nests on the ground (Figure 3) but dome shaped (Wesolowski, 1985).

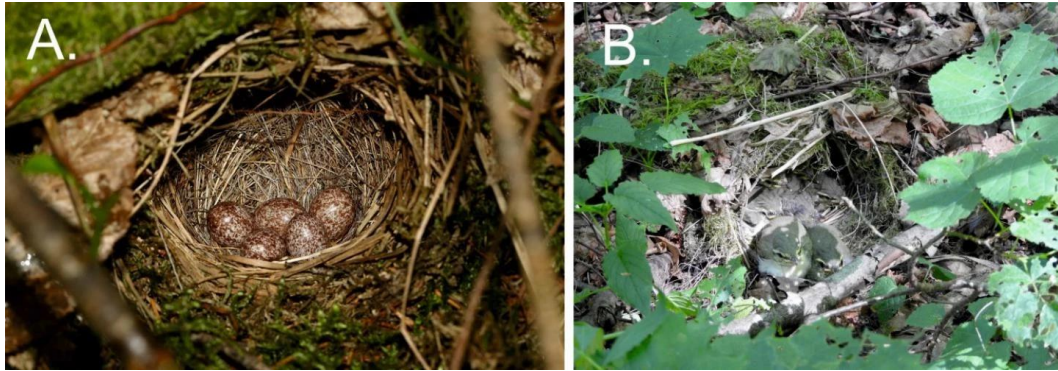


Figure 3. A wood warbler's dome shaped nest with its well camouflaged eggs (A) and nestlings (B). CC BY 4.0. Image: G. Hebda and M. Maziarz https://www.researchgate.net/deref/https%3A%2F%2Fcreativecommons.org%2Flicenses%2Fby%2F4.0%2F?_tp=eyJjb250ZXh0Ijp7ImZpcn

Even though these species sometimes lay their eggs without vegetation cover, more often than not their nests are found under understory (Wesolowski, 1985; Storch, 1994; Åberg, 2000). Eggs laid on the ground are often spotted and thus well camouflaged for the surrounding predators, like foxes who often use the understory as cover when hunting (Stevens, 2013; Tobajas et. al., 2025).

Shrub nesters, like the willow warbler (*Phylloscopus trochilus*) build cup shaped nests low in vegetation (Figure 4) where the understory plays a crucial role for their nesting success, acting as protection against egg predators (Mlodinow et al., 2025).



Figure 4. A willow warbler's cup-shaped nest hidden in a juniper tree. The picture is taken from above. CC BY 4.0. Image: K.W. Larson
<https://journals.lub.lu.se/os/article/view/22583/20086>

The song thrush (*Turdus philomelos*), also a shrub nester, build their nests higher up than the ground nesters (Collar, 2020), but still low enough to likely be affected by the removal of understory by pre-clearing.

There are several factors that can affect the species' survival. Foraging and the abundance of food, suitable habitats for nesting and protection against predators as well as the ability to adapt to changes in their environment (Newton, 1998).

In today's forest landscape, with less diversity in the forest structure because of many monocultural stands and habitat loss, the specialist species might find it harder to cope and end up getting outcompeted by the more generalist species (Clavel et al., 2010; Gamfeldt et. al., 2013). Therefore, comparing specialist versus generalist species, as well as comparing bird groups with different dependence on understory are suitable to investigate the effects of pre-clearing on forest birds.

1.3 Aim and objective

In this study, the aim is to get a deeper understanding of how pre-clearing in boreal forests affect forest birds. Focus was on birds closely tied to understory through their nesting sites. The research question asked was therefore:

“Does pre-clearing affect different ecological groups of forest birds in boreal forests negatively?”

2. Method

The study was conducted in Sweden using biodiversity data from the Swedish Bird Survey (SBS) and management data from Mellanskog's database in boreal forests. It was conducted in the central parts of the country since that is where Mellanskog mainly operates and have data from their management, including pre-clearing, thinning and clear-cutting events.

2.1 Study design

This study was conducted using a Before-After-Control-Impact (BACI) design. With this design, one impact site is selected as well as one control site (Smith, 2002). They are then sampled both before and after an impact, which in this case is the pre-clearing event before a thinning or clear-cutting. While the impact site is the one used for answering the research question asked, the control site is selected to make sure that the results from the impact site is likely to be because of the impact itself and not because of stochastic events. In other words, the control site helps to distinguish the effect of measured impact from random population fluctuations. If both the impact site and the control site show similar results, the results are most likely because of stochastic events, an example of that being the weather. This study design is using already collected data instead of designing the surveys for the specific purpose of pre-clearings' effect on forest birds.

2.2 Swedish Bird Survey and Mellanskog's data

SBS conducts standardized surveys every year around the same time and in the same location, providing reliable data on bird presence and abundance in that specific location (Svensk fågeltaxering 2026).

The SBS is performed following set squares where each side is 2 km long, 8 km in total. This square is divided into 8 line transects and 8 point counts (Figure 5).

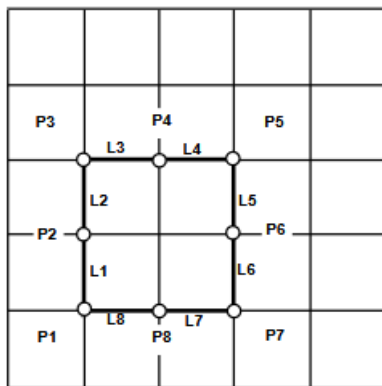


Figure 5. The standardized routes from Swedish Bird Survey, displaying the route layout along with its numbering. Each square is 1x1 km.
<https://www.fageltaxering.lu.se/sites/fageltaxering.lu.se/files/2024-01/Standarddrutt.pdf>

At every 1 km, after each line transect, the surveyor stopped for five minutes and counted all the birds they could see or hear. Along the line transect between the point count stops, the surveyor counted all the birds they could see or hear while walking at constant pace. Both species and the number of observed individuals of each species were counted and noted. Both point counts and line transects were used in this study.

Data on the timing and locations of the pre-clearings were implemented as shape files in QGIS along with the squares from SBS. The pre-clearings were visible as polygons in QGIS (Figure 6), while the SBSs were represented as squares.

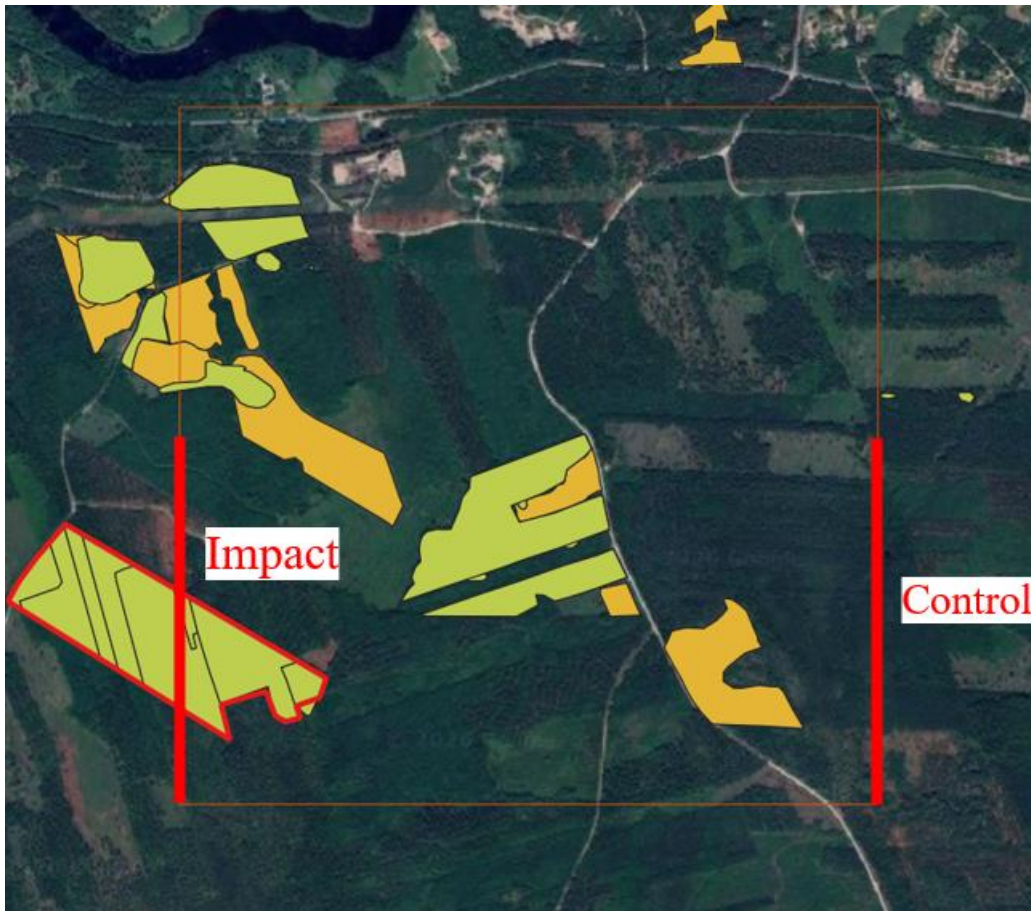


Figure 6. A satellite image of the Swedish Bird Survey standard route visible as an orange square. The green and yellow polygons are performed managements from Mellanskog. Green is for pre-clearing and yellow is for thinning or clear-cutting. The red polygon is the selected pre-clearing for the study and the Impact and Control line transects are marked in red.

A visual inspection was made to see where the two were overlapping. If they overlapped, these locations were used for further investigation. The timing of the survey and pre-clearing were examined to make sure that there were no interference from other forestry managements, like thinning or clear-cutting, between the SBS before and after the pre-clearing event, as this would likely influence the number of bird species and individuals present.

Five squares were deemed suitable and used after inspection for the analyses, whereas one of the squares had two polygons of pre-clearings on two separate line transects and the rest of the squares had one polygon each. The square with two polygons were treated as a single study site, resulting in five locations used for the analyses. Each of the sites had a line transect or a point count for each suitable pre-clearing polygon.

First, for each location that was suitable to examine the effects of pre-clearing, the line or point overlapping with the SBS was used for the analyses to represent

the impact site. A control site with similar environmental conditions (based on visual assessment from satellite images) of the impacted site was then selected from the same square and that did not have recent management from Mellanskog, which might have impacted the control location. If the impact site was a line transect, the control site was also a line transect. The same method was used for point counts where suitable pre-clearing polygons overlapped with the SBS square. If the impacted site was a line transect, the selected control site was at least one transect away to minimize the probability of the same bird individuals being observed and counted at both the control and impact sites. For the points, they were already a minimum of 1 km apart and therefore assumed to not be at as high risk of double counting.

Under ideal circumstances, there would be as little time between the surveys and the pre-clearing as possible to minimize other interferences. However, some years the SBS squares were not inventoried. At one of the squares, it was three years between the first bird inventory and the pre-clearing. At the rest of the four sites, the before inventory were the same year as the pre-clearing and the after inventory the following year. In the squares selected it was mainly the tree species pine and spruce.

Furthermore, most of the recorded pre-clearings were from recent years with the oldest one in 2020, and therefore it was not enough data to use several SBSs before and after pre-clearing.

2.3 Ecological groups

To test whether the pre-clearing has an impact on birds, I looked at the changes in species diversity, the number of individuals, the number of lost and gained species as well as nest generalists and nest specialists species (nesting habitat variety). Some species were observed at the first inventory (before the pre-clearing) but not at the second one (after).

The different bird species were classified by their primary diet, primary habitat, diet variety, habitat variety, nesting and nesting substrate. Bird Database was used to categorize these ecological traits for each species (Şekercioğlu et al., 2025).

The bird species were then grouped according to primary habitat, primary nesting site and nesting substrate. Three groups were created: Shrub/Bush/Vine nesters (Group 1), Ground nesters (Group 2) and a control category of Cavity (tree) nesters (Group 3). The first two groups were expected to be most affected by the pre-clearings since they nest on or near the ground in understory vegetation, while the cavity nesters build their nests higher up in the trees and were not expected to be influenced by the pre-clearings to the same extent and could therefore serve as a control group.

Primary habitats chosen were Forest, Woodland and Shrub while primary nesting sites were Cup/Bowl, Scrape, Dome and Sphere (Table 1). The substrates

chosen for nesting sites were Shrub/Bush/Vine and Ground. Furthermore, Tree, Pole and Stump were used for Group 3.

Table 1. Three groups categorized according to ecological niches. Ecological data from Bird Database (<https://birds.imsezer.com/>).

	Group 1	Group 2	Group 3 (control)
Primary habitat	Forest Woodland Shrub	Forest Woodland Shrub	Forest Woodland
Primary nesting type	Cup/Bowl Platform Dome	Scrape Cup/Bowl Sphere Dome	Cavity (tree)
Substrate nesting site	Shrub/Bush/Vine	Ground	Tree Pole Stump

At Bird Data, the different species' nest variety were categorized on a scale from 1-8, where species in group 1 had a very specialised nesting site and species in group 8 had a very generalised nesting site. For this study, the specialist and generalists were divided into two groups, where specialists were classified from 2-4 and generalists were classified from 5-8. As there were no birds with a nesting variety of 1 for this study, the scale started from 2.

An analysis of diet was excluded since it was estimated that nesting habitat and variety would have a bigger, or at least an equally important, effect on the bird species diversity and number of individuals. With limited time, the diet analysis was therefore not conducted.

2.4 Statistical analyses

Box plots showing the mean value and spread were made in Excel for the control and impact sites both before and after the pre-clearing. T-tests with a chosen significance level of 0,05 were conducted of the mean species diversity, number of individuals, species gains and losses and nesting habitat variety to see if there were any statistically significant effects. I subtracted the values of the 'after' inventory (species diversity, number of individuals, species lost and gained and habitat variety) from the 'before' inventory and compared these values between the control and impact site. A two-tailed two-sampled t-test with equal variance was used for all groups. The t-statistic value (t-value) and degrees of freedom (df)

were also noted for each group studied, as well as the p-value. If the p-value was lower than 0,05, a statistically significant effect was assumed.

3. Result

For species diversity, number of individuals, species lost and gained and nesting habitat variety, no clear effect of the pre-clearing could be detected, and only one t-test out of fourteen showed a statistically significant result. However, in some specific groups a trend could be seen. The results of the groups are presented below.

3.1 Species diversity

For shrub nesting species, the mean species diversity on the impacted site decreased from 6,6 to 5,8 species after the pre-clearing (Figure 7) whereas the control site showed no clear change over time. However, the t-test that compared the species richness differences before and after pre-clearing at the impacted and control sites (p -value=0,49, t -statistic value=0,73, df =8) indicated no statistically significant effect. The degrees of freedom (df) were the same for every test presented below.

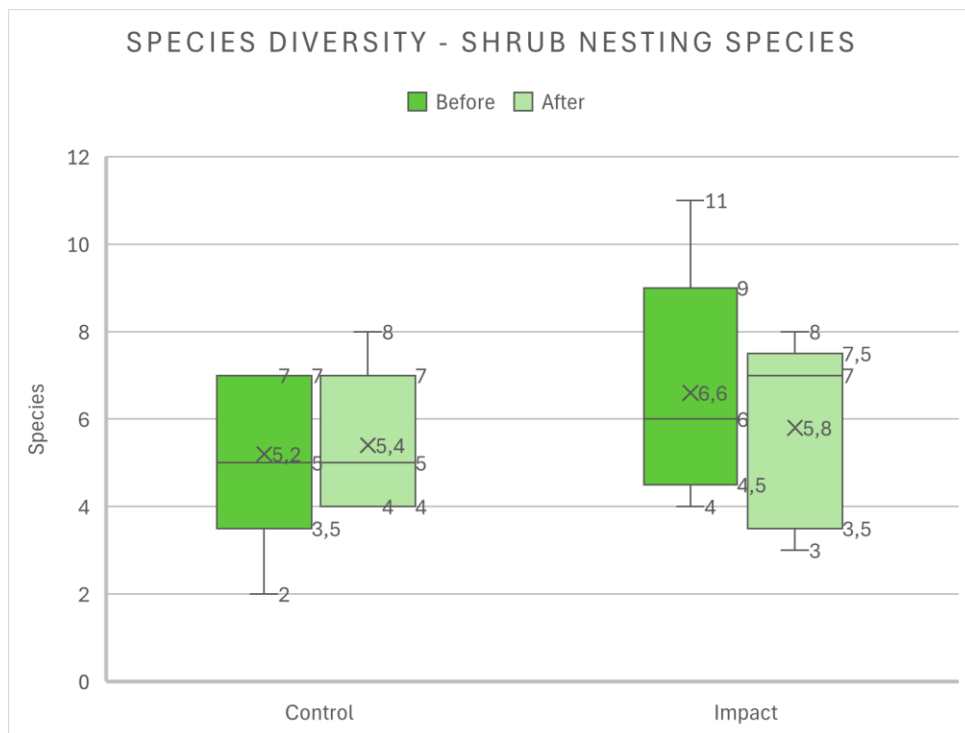


Figure 7. Box plots illustrating the mean number of shrub nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Before' period (dark green) and the 'After' period (bright green).

For ground nesting species, the mean species diversity at the impacted site increased from 2,2 to 3,4 species (Figure 8). At the control site, the same numbers went from 3,2 to 3. However, the slight increase in the mean was not statistically clear, ($p=0,10$, $t=-1,8$), indicating no statistically significant effect.

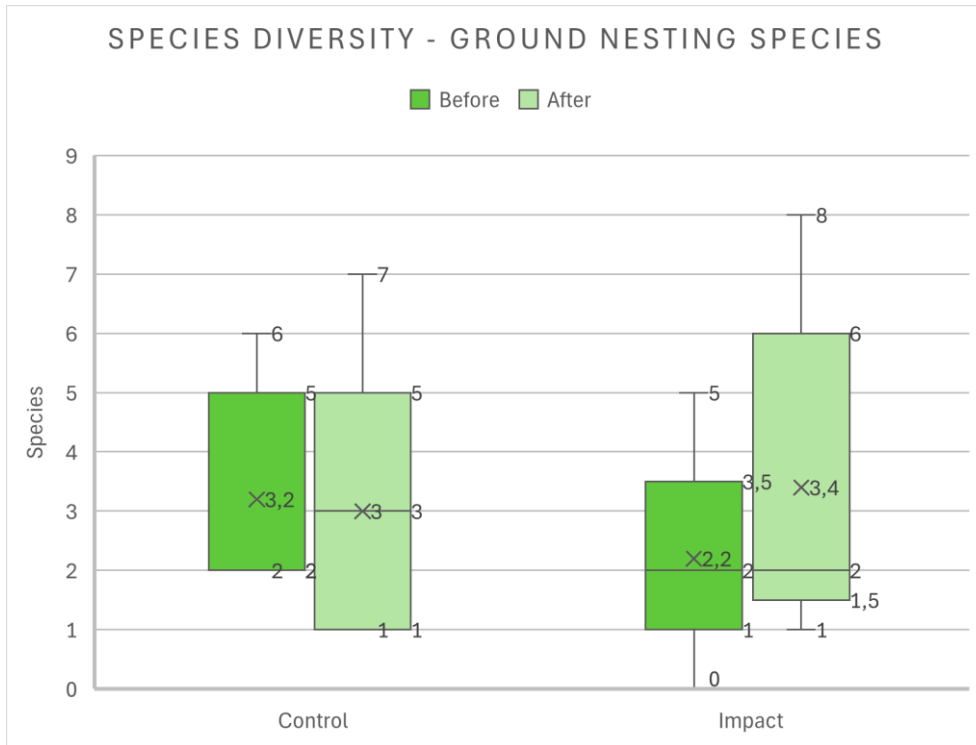


Figure 8. Box plots illustrating the mean number of ground nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Before' period (dark green) and the 'After' period (bright green).

Cavity nesting species were hypothesised to be affected by pre-clearings to a much lesser extent than shrub- and ground nesting species. Here, the mean species diversity at the impacted site decreased from 3,0 to 1,6 (Figure 9). At the control site, there was also a decrease from 2,8 to 1,6. The results were not statistically clear ($p=0,85$, $t=1,9$), indicating no pre-clearing effect.

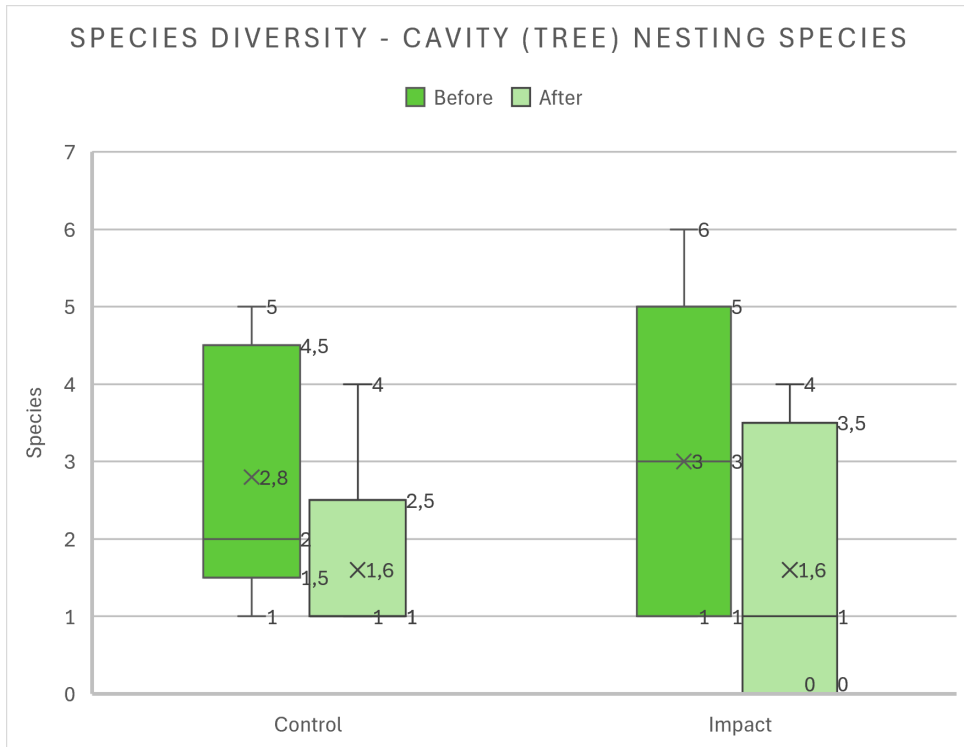


Figure 9. Box plots illustrating the mean number of cavity nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Before' period (dark green) and the 'After' period (bright green).

3.2 Number of individuals

Across all groups, the mean number of individuals at the control site changed from 26,6 before pre-clearing to 22,2 after (Figure 10). At the impact site the mean changed from 30 individuals to 25,6 individuals, indicating similar individual loss. The t-test ($p=1,0$, $t=0$) indicated no clear difference between the change in the number of individuals between control and impact sites.

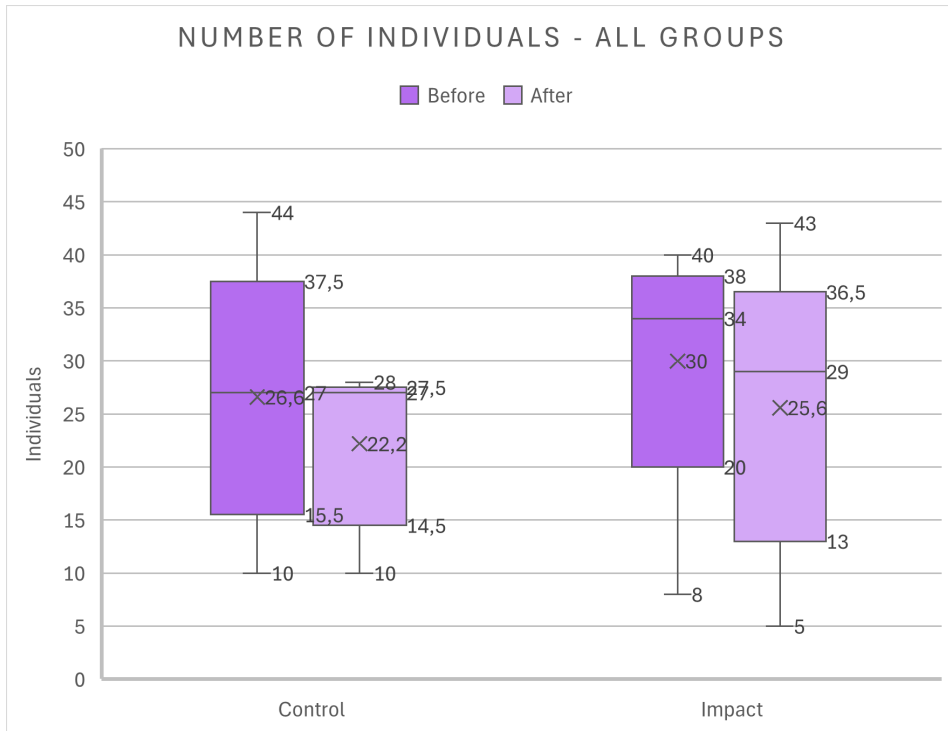


Figure 10. Box plots illustrating the mean number of individuals of all groups of bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Before' period (dark purple) and the 'After' period (bright purple).

The shrub nesting species' mean number of individuals decreased from 13,8 at the control site before pre-clearing to 11,6 after (Figure 11). At the impacted site, the same numbers decreased from 18,8 individuals before to 15,2 after. The t-test ($p=0,72$, $t=0,38$), indicated no statistically significant effect.

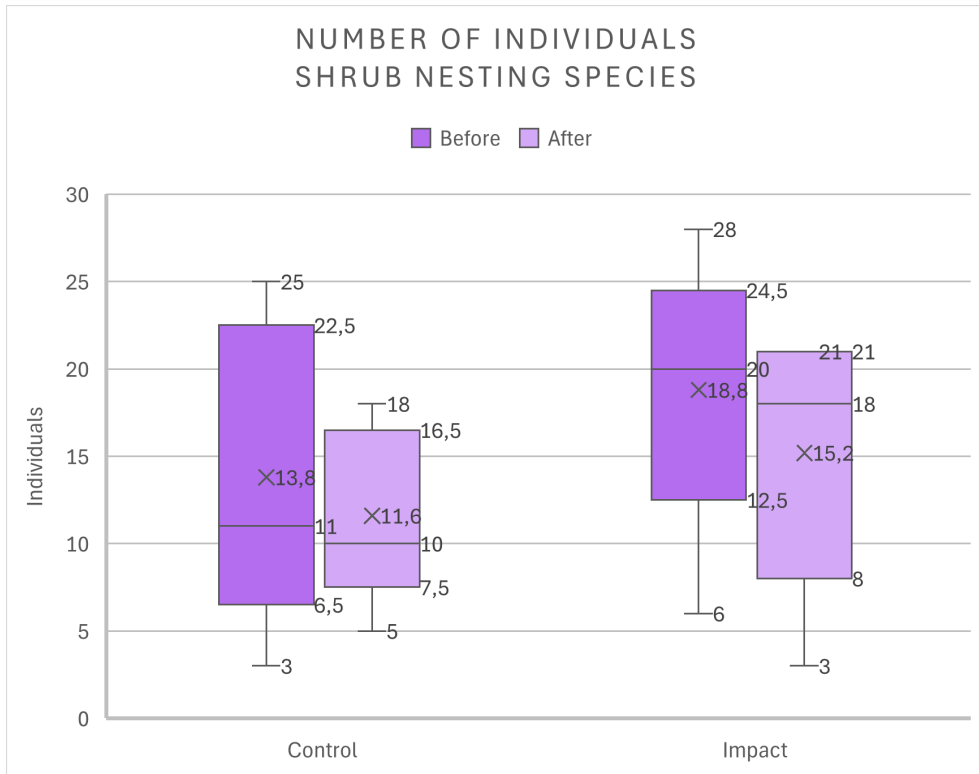


Figure 11. Box plots illustrating the mean number of individuals of shrub nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Before' period (dark purple) and the 'After' period (bright purple).

As comparison, the mean number of individuals of the ground nesting species remained the same at the pre-cleared site with 8,4 individuals before and after the impact and the control site increased slightly from 7,6 and 7,8, respectively (Figure 12). The t-test ($p=0,95$, $t=0,07$) indicated no statistically significant effect.

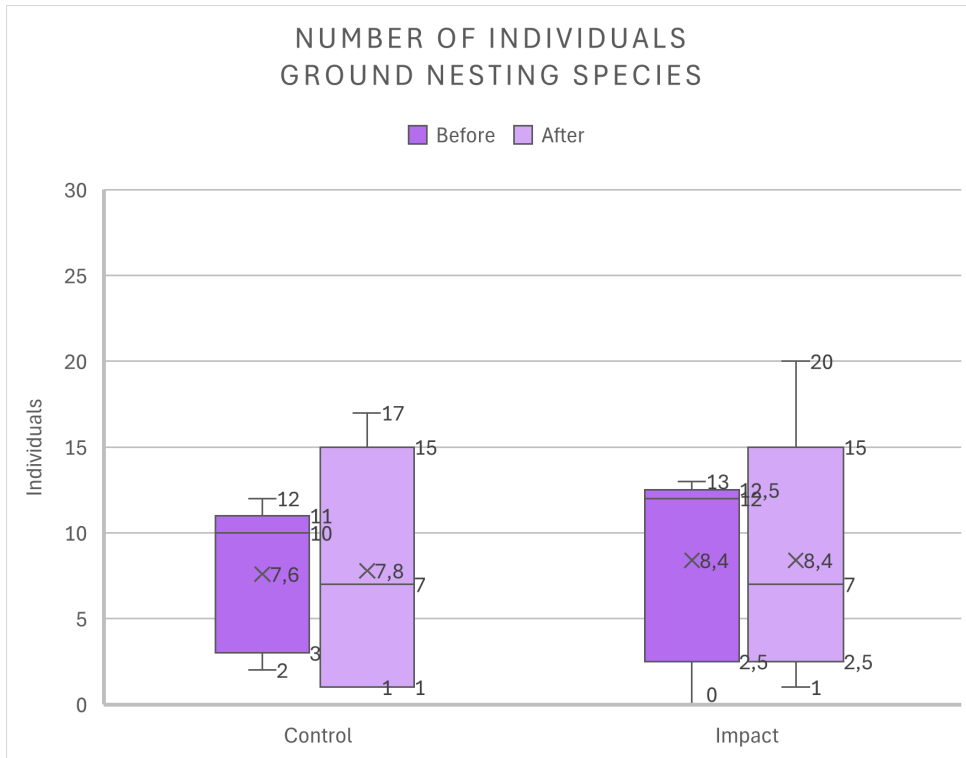


Figure 12. Box plots illustrating the mean number of individuals of ground nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Before' period (dark purple) and the 'After' period (bright purple).

As for the control group of cavity nesters, the mean number of individuals at the impact site decreased from 5,0 to 2,8 (Figure 13). However, the control site showed a similar trend, also with a decrease in mean individuals with 3,8 before the pre-clearing and 2,8 after. This suggested that the decrease was due to other reasons than the pre-clearing. The t-test ($p=0,54$, $t=0,65$), indicated no statistically significant effect.

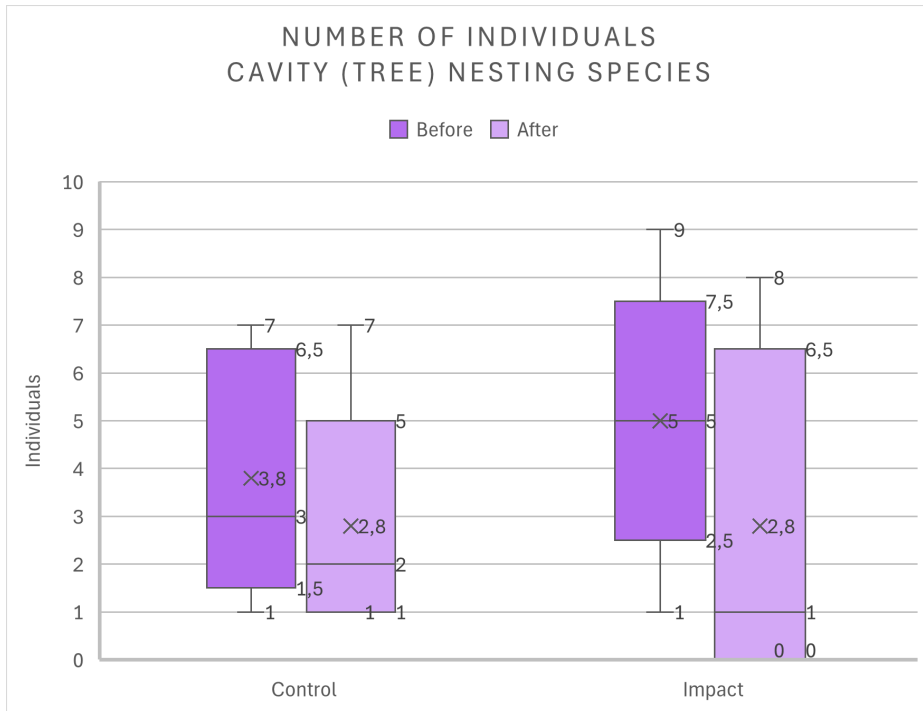


Figure 13. Box plots illustrating the mean number of individuals of cavity nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Before' period (dark purple) and the 'After' period (bright purple).

3.3 Species lost and gained

On average across all sites, the mean number of species lost were 9 for the control site and 9,8 for the impact site (Figure 14). As for gains, 6,2 species were gained on average at the impact site and 6,4 at the control site. No statistically significant difference between the control and impact sites was detected, as shown in the t-test for lost species ($p=0,85$, $t=0,19$) and for gained species ($p=0,94$, $t=0,080$). Even though there was no significant result, a difference in observed mean can be observed in Figure 14, where the average for species lost was higher than species gained for all groups. This was, however, applicable for both the control and impact sites.

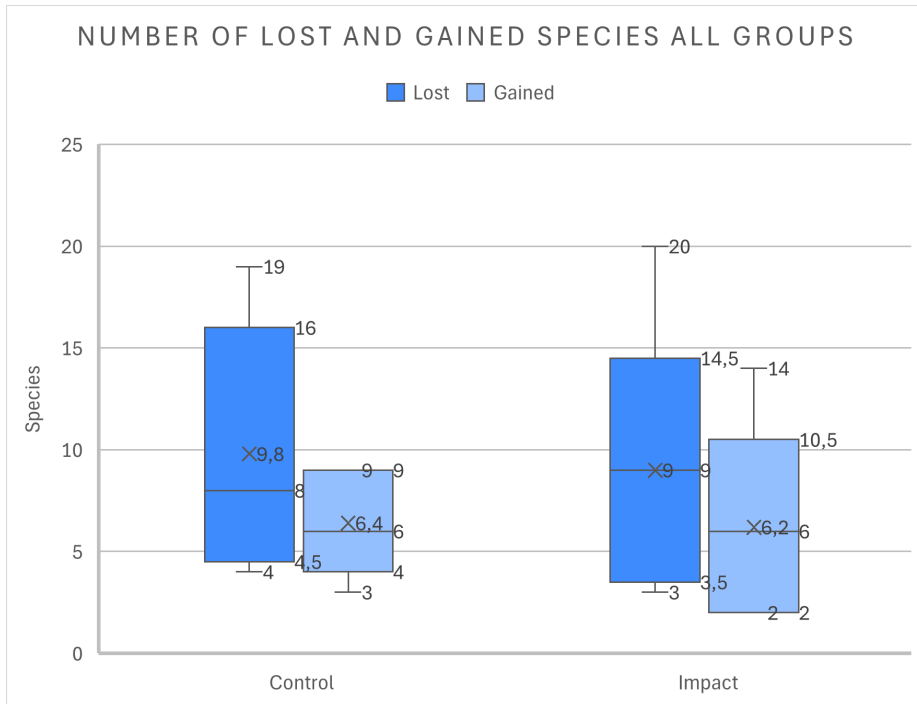


Figure 14. Box plots illustrating the mean number of lost and gained bird species across all groups (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Lost' section (dark blue) and the 'Gained' section (bright blue).

On average, shrub nesters at the impact site lost 2,8 species, compared to the control site, which lost 2,6 species (Figure 15). As for gains, the impact site gained 2,0 species on average and the control site 2,8. However, the t-test did not indicate a clear difference in species lost ($p=0,87$, $t=-0,17$), and species gained ($p=0,34$, $t=1,0$).

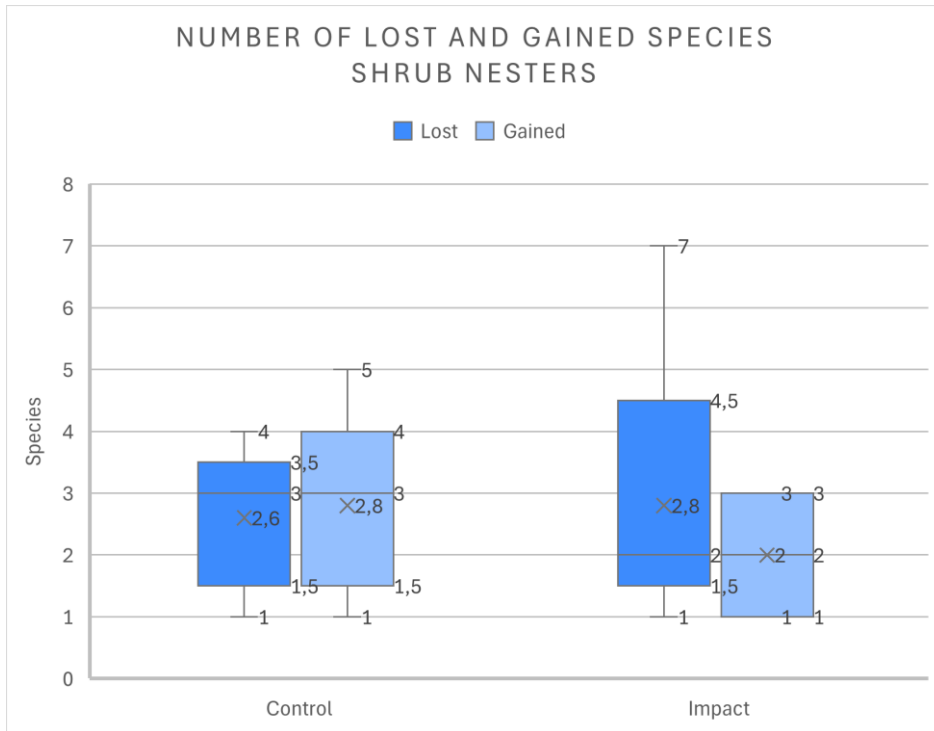


Figure 15. Box plots illustrating the mean number of lost and gained shrub nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Lost' section (dark blue) and the 'Gained' section (bright blue).

For the average gains and losses for the ground nesters, there were no species lost at the impact site, but on average 1,2 at the control site (Figure 16). As for gained species, there were on average 1,2 at the impact site and 1,0 at the control site.

The t-test for lost species ($p=0,040$, $t=2,4$) and gained ($p=0,84$, $t=-0,20$) indicated a statistically significant effect for lost species but not for gained.

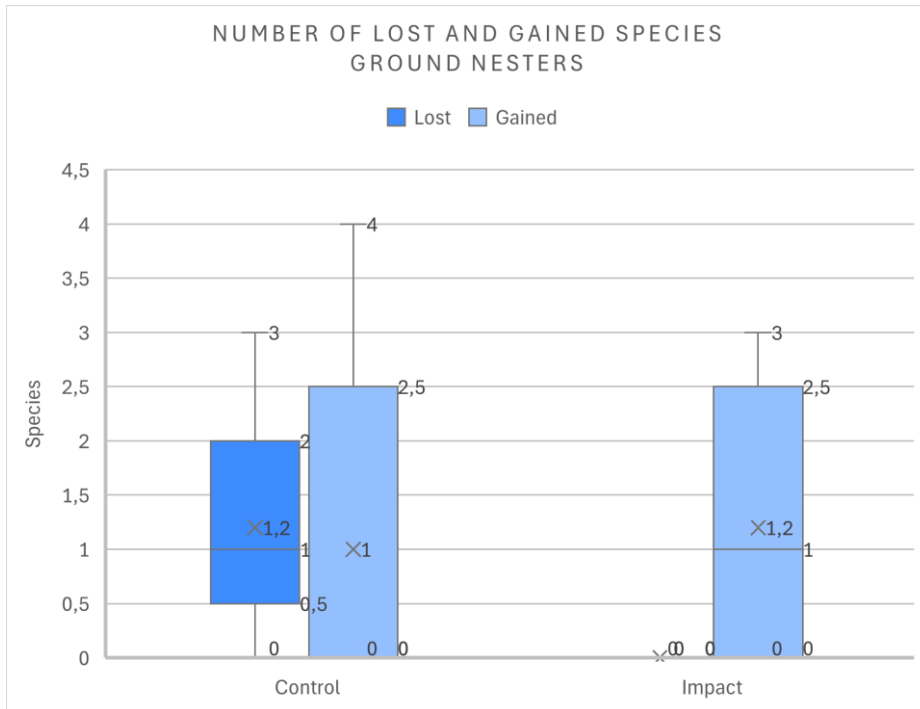


Figure 16. Box plots illustrating the mean number of lost and gained ground nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Lost' section (dark blue) and the 'Gained' section (bright blue).

For the cavity nesters, the number of species lost on average for the impact group was 2,2 and the same number for the control group was 1,8 (Figure 17). As comparison, the average of gained species at the impact site was 0,8 and at the control site 0,6 – a similar result.

The t-test for the lost species ($p=0,70$, $t=-0,40$) and the gained species ($p=0,72$, $t=-0,37$) indicated no clear effect.

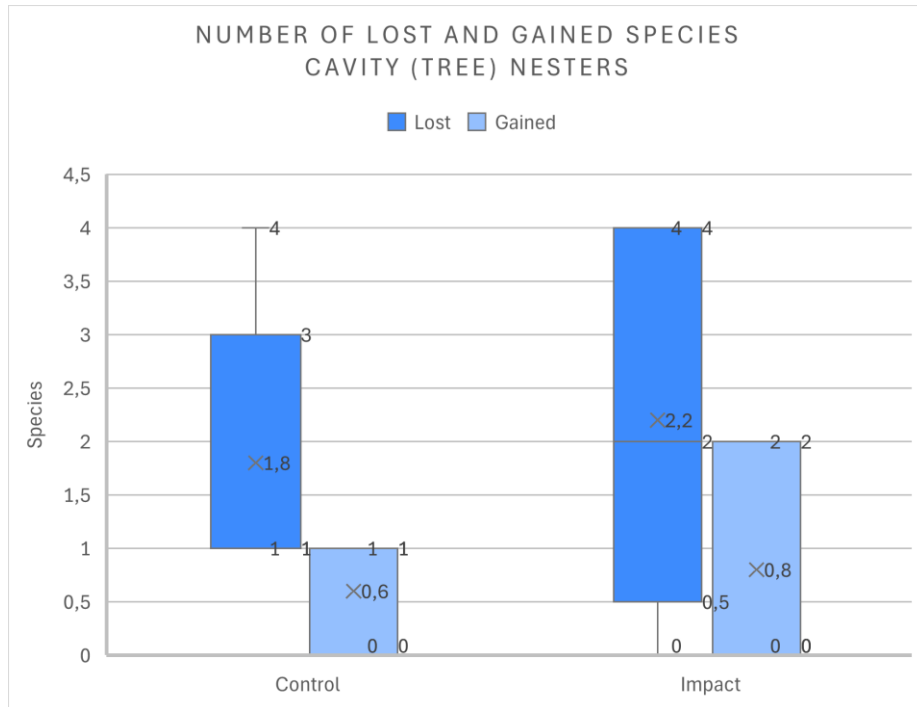


Figure 17. Box plots illustrating the mean number of lost and gained cavity nesting bird species (marked with an X) and their data distribution between the control sites (on the left) and the impacted sites (on the right), in the 'Lost' section (dark blue) and the 'Gained' section (bright blue).

3.4 Nesting habitat variety

3.4.1 Specialists

For the shrub nesting specialists, the change in individuals varied between the control and impact site before and after pre-clearing. The change between the number of species before and after pre-clearing is represented in the following graphs. For the impact site, there was on average 3,6 less individuals after pre-clearing whereas for the control site, there were 2,0 individuals less (Figure 18), indicating greater individual loss at the impacted site. However, t-test results for shrub nesting specialists ($p=0,68$, $t=0,43$), indicated no statistically significant effect.

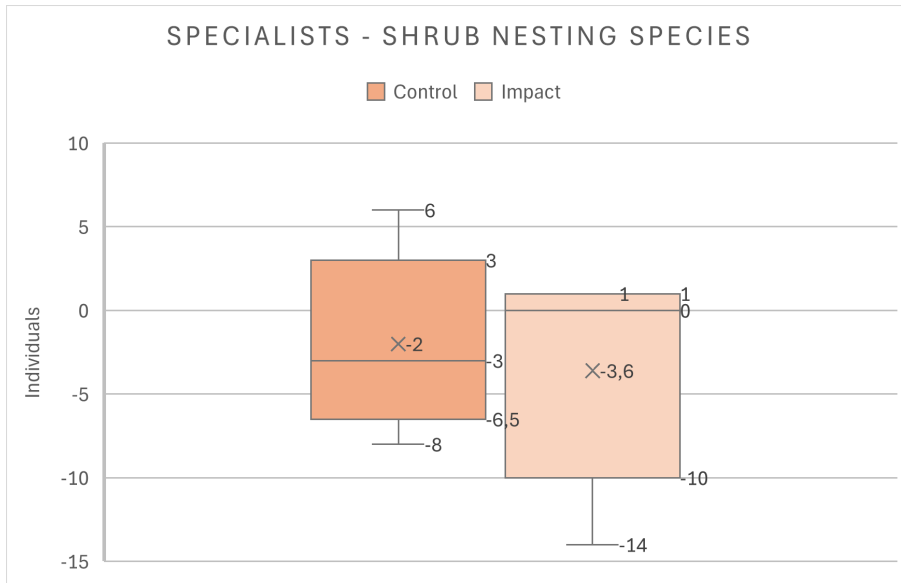


Figure 18. Box plots illustrating the mean change in individuals of shrub nesting specialist species (marked with an X) after pre-clearing, with control sites on the left (dark orange) and impact site (bright orange) on the right.

The average number of individuals of specialist ground nesting species was 0,8 for impact and 0,8 less for control (Figure 19), indicating individual gain at pre-cleared but not at control sites. The t-test ($p=0,089$, $p=-1,9$) indicated no statistically significant effect.



Figure 19. Box plots illustrating the mean change in individuals of ground nesting specialist species (marked with an X) after pre-clearing, with control sites on the left (dark orange) and impact site (bright orange) on the right.

3.4.2 Generalists

For the shrub nesting generalists, the average change was none for the impact site, but 0,2 individuals less at the control site (Figure 20). The t-test ($p=0,95$, $t=-0,063$), indicated no statistically significant effect.

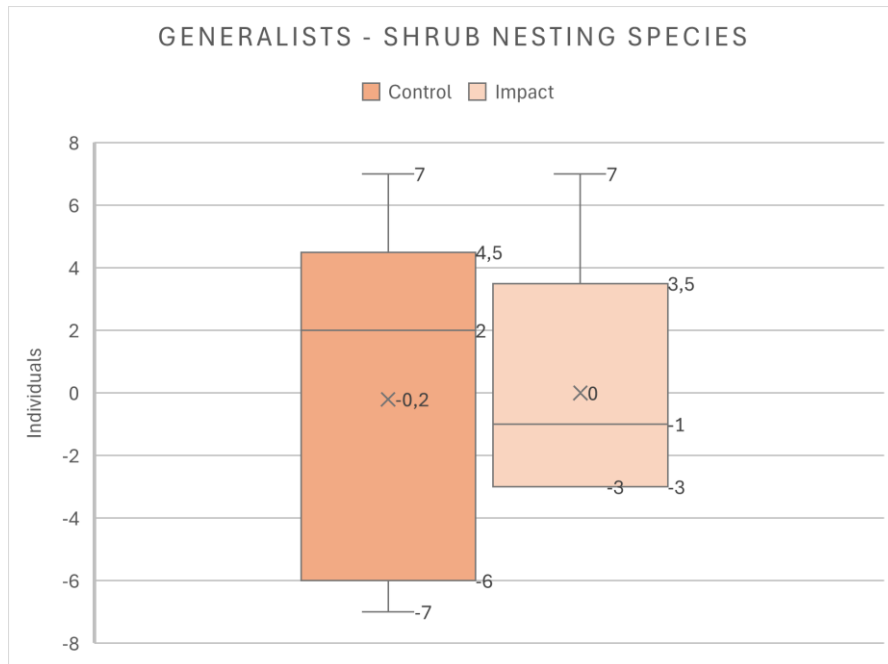


Figure 20. Box plots illustrating the mean change in individuals of shrub nesting generalist species (marked with an X) after pre-clearing, with control sites on the left (dark orange) and impact site (bright orange) on the right.

The ground nesting generalists had an average change of 0,8 individuals less at the impact site after pre-clearing (Figure 21), indicating a slight decrease because of the pre-clearing. However, the t-test ($p=0,58$, $t=0,58$), indicated no statistically significant effect. At the control site, the average number of individuals was 1,0.

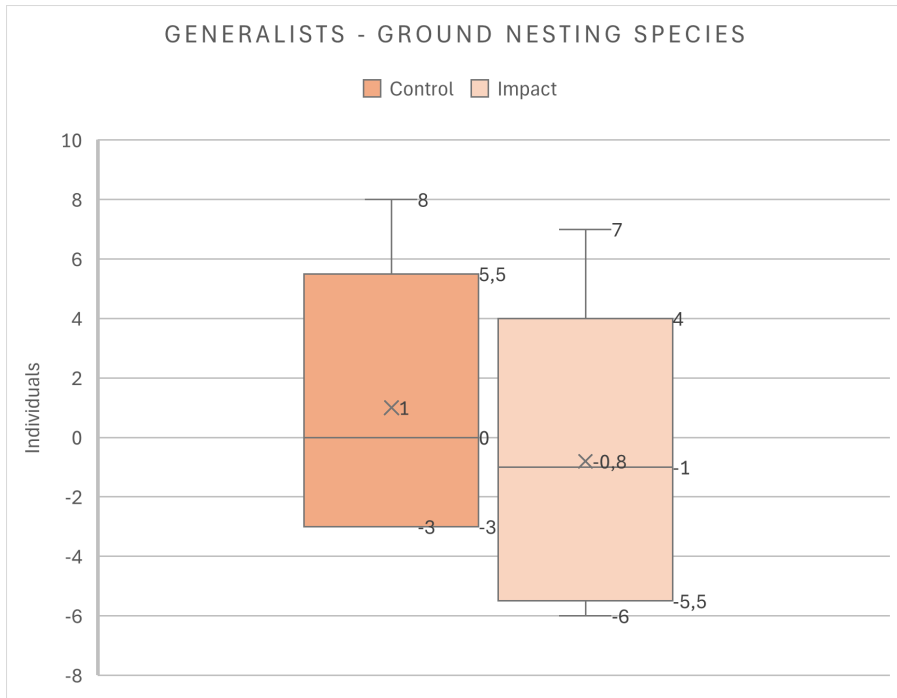


Figure 21. Box plots illustrating the mean change in individuals of ground nesting generalist species (marked with an X) after pre-clearing, with control sites on the left (dark orange) and impact site (bright orange) on the right.

4. Discussion

Forest birds are dependent on understory vegetation for several reasons, mainly for breeding and protection against predators (Klein, et.al., 2020). In this study, the effects of the removal of understory vegetation on forest birds was investigated using BACI design.

Some trends could be detected in this study based on observed species and abundance. One site showed a statistically significant effect from pre-clearing, with no lost species for ground nesters, a result which was not predicted. Other than this site, no clear negative effect of pre-clearing was detected of the three groups of nesters across the five study sites. While the lack of an observed effect could be because of the small sample size (i.e. not enough statistical power to detect an effect), there could also be many other reasons for this, as discussed below.

The sample size for the study was small, with only five squares from SBS meeting the requirements for this study. This was expected, considering the requirements to match the timing and location of the SBSs with the timing and location of Mellanskog's pre-clearing and other forestry managements. It is very possible that the small sample size was a factor for the inconclusive results, since previous studies with greater sample sizes showed that removal of understory vegetation has a negative effect on forest birds (Klein, 2020).

The classification of ecological groups was made to make sure that the birds not tied to forest or woodland were excluded from the study. Since the transect used for this analysis sometimes passed near a lake or an open field, the surveyor would also include birds of different habitats than forest. These were not relevant for this study since they have different ecological needs than forest tied species. Some analyses, however, included all bird species, to give some context to the study and function as comparison to the selected groups.

4.1 Ecology

Apart from the small sample size, there are many reasons why both the control site and impact site showed similar trends in this study. Since only one bird survey was used before the pre-clearing and one after, events such as the weather could have influenced the number of birds at both the control and impact sites. For instance, extreme weather could have caused lower nest success, with fewer reproductive individuals the following year (Jenouvrier, 2013). A higher number of voles could have led to more predators out hunting, which could create a 'landscape of fear' which, in turn, could lead to less activity in forest birds (Laundré et al. 2010). Less activity could lead to reduced foraging and breeding which could lead to a lower nest success and fewer individuals (Mizutani et al.,

2025). All of these examples might have caused the impact and control site to show similar trends, and even if the pre-clearing had an effect, it might not have been enough to be visible with these other changes in the ecosystem.

Additionally, some sites for control and impact were fragmented by different land use, with less connection to surrounding forest and might therefore have a different species composition and possibly less vital species tied to the selected birds (Lennartsson, 2005). None of these potential factors could be controlled or tested in this study, and is the reason why a control site was selected for each impact site. These limitations in the study design makes it hard to pinpoint the exact reasons for the lack of the effect from pre-clearing on forest birds.

4.2 Species diversity

Because of their tendency to nest on or near the ground in low vegetation, species diversity was expected to decline for the shrub and ground nesting species after the pre-clearing. At the impact site for shrub nesting species, a decrease in species diversity could be observed while the control site increased slightly in the opposite direction (Figure 7). This can be interpreted as a trend towards a decrease in diversity of shrub nesters, since the control site did not change in the same direction. It could therefore indicate that the change was not because of stochastic events, like the weather or predator-prey interactions on a larger scale, and more likely to be caused by pre-clearing. However, future research with a bigger sample size and more statistical power will have to verify this.

As for the ground nesters in the same category, they did not have the same trend as the shrub nesters, with no indication of possibly negative effects from pre-clearing. In fact, the opposite was observed, with a higher species richness at the impact site after pre-clearing. Apart from the small sample size, this might be because some birds prefer to nest in more open areas and were therefore not affected by pre-clearing. Ground nesters might actually have been benefitted by the removal of understory which would create more suitable nesting sites for them.

4.3 Number of individuals

The number of individuals decreased similarly at both the impact site and the control site for all groups as well as for shrub, ground and cavity nesters. It was expected that the number of individuals at the impact site would decline because of the pre-clearing, but since the control site showed similar trends, the decrease was most likely because of unrelated events. As previously mentioned, the ecological interactions, processes and stochasticity might have disguised the pre-clearing effects, considering the small sample size, the type of bird diversity

measures used in this study or the fact that the SBS surveys were not designed for this specific research question.

4.4 Species lost and gained

A clear way to measure the impact of managements are to measure the number of lost and gained species while comparing species composition before to after the impact. There was an expectation that more species would be lost than gained after the pre-clearing. While this was a visible trend for shrub nesters, it was not for ground nesters. The analysis for losses and gains of ground nesting species showed that there were more lost species at the control site than at the impact site. In fact, the impact site had no species lost at all. In addition to this, the statistical test showed significance and so the pre-clearing was therefore assumed not to affect the ground nesting species, in contrast to the initial theory. As mentioned in the species diversity section, some ground nesters prefer to nest in open areas, and that might be an explanation as to why ground nesters did not lose any species.

For the other sites, there were no clear difference in species gains and losses among the groups between impacted and control sites, but there was an indication of potential trend in means. The impacted site for shrub nesting species gained 0,8 species less on average than the control site, while there were slightly more losses (Figure 15). This indicates that for shrub nesters, there could be some negative impact from pre-clearing. This might be an indicator that the shrub nesters are more dependent on the low vegetation for nest success compared to the ground nesters. Since ground nesters can nest both on the ground in vegetation as well as without vegetation, while shrub nesters can only nest in the actual vegetation, the ground nesters might represent a broader category of nesting sites.

This highlights the importance of investigating different ecological niches. If only the mean of species richness, a quite similar metric to gains and losses, were analysed, I would not have discovered the specifics of species lost on average. With these two combined, it helps to paint a picture of the ecological pre-clearing impact for ground nesters, and which environments might benefit them in the forest landscape.

4.5 Nesting habitat variety

While generalist species can adapt more easily to a changing environment, specialist species are more vulnerable as they are more dependent on certain habitat features that might disappear after certain forest management, like pre-clearing. Therefore, both specialist ground- and shrub nesting species were expected to decline after a pre-clearing with less suitable substrates - shrubs, bushes, small trees and ground sites - for them to nest in.

However, we could see a trend that specialist ground nesters increased at the impacted site and decreased at the control site (Figure 19), which indicates that the pre-clearing might have benefitted specialised species which prefer a less dense vegetation. The understory left after pre-clearing might also create a new habitat for specialised species, with more substrates for them to nest in.

The generalists slightly decreased at the ground nesting impact site. Since they are more flexible in nesting substrate than the specialists, they might have simply chosen another nesting site outside of the pre-cleared area. However, there can be no way of knowing what happened outside of the SBS square without more targeted research, which is needed for these kinds of science projects.

4.6 Study limitations

As the survey was not designed for the specific purpose of this study, the expected effects might not have been visible. The only individuals noted by the surveyor doing the inventory were adult singing birds with no regard to breeding behaviour and attempts, hatching success, the number of eggs, predation of nests, the number of fledglings and nestlings and the survival rate of young, non-singing birds. While the surveyor also noted birds they saw, birds are often covered by vegetation and hard to see. Therefore, it is more common to hear them, but of course, only the adults are the ones singing. A wide range of potential data is therefore not covered by the SBSs, and is not included in this study.

The polygons from Mellanskog's pre-clearing did not overlap with the whole transect of the surveyor's route for inventory (Figure 6). At some sites the overlap was one fourth of the transect, with the rest of the transect having forest of different ages and structures, or other types of habitats. This would most likely impact the observed bird species used in this analysis and therefore the result as it was not possible to retrieve finer bird data to match exactly with the pre-cleared location. Thus, the data from the area with pre-clearing and adjacent forest were collected together and therefore could not be distinguished from one another. It would have been ideal if the whole line transect overlapped perfectly with the pre-clearing area. However, there could still have been birds heard from outside the area of pre-clearing so it might also have its limitations.

While the control sites were chosen to match the pre-clearing polygons as well as possible, they were outside of Mellanskog's area and there is therefore no way of knowing for sure what the forest structure looks like. There might have been different species of trees, where a damp spruce forest would have a different species composition of birds than a dry pine forest.

Also – the geographical differences might play a part in species composition, abundance and forest structure. Since the most northern location was in the south of county Härjedalen and the most southern location was in the county of Södermanland, some northern bound species might be present at one location but

not the other, and vice versa. Furthermore, the forest structure in these parts of the country differs, with more slow-growing trees in the north, which would likely also affect the bird species tied to those forest structures differently.

As for limitations connected to the sample size, it would have been interesting to study the specific species that Mellanskog often encounter in their daily work, to be able to present a decision basis for how they can adapt their forestry managements to support these species. However, since the available matching data was quite small, it was not possible to conduct singular species analyses.

4.7 Management suggestions and Future research

4.7.1 Suggestions

While forestry managements with a bigger impact on the forest structure, like thinning and clear-cutting, affect birds to a large extent, the environmental disturbances such as pre-clearing most likely have consequences to biodiversity. Although I did not find a clear indication of pre-clearing having negative effects on birds in this study, previous research shows that removal of understory does have a negative impact on bird species (Klein, 2020). Therefore, even if not visible in the presented analyses, pre-clearing could still play a role for bird diversity disturbance and added negative effects to the following thinning or clear-cutting events, especially for certain groups of species.

However, there are ways to limit these potentially negative effects. One suggestion would be to only cut the trees absolutely necessary for visual sight and leave the rest. A similar suggestion is to leave shrubs and small trees with a diameter of less than a few centimetres, since they likely would not impose on the machine operator's view as the bigger trees would. Since the time between the pre-clearing and the actual thinning or clear-cutting can be up to two years, the retained understory would benefit bird species during that period and serve as temporary important nesting, foraging and protective habitat in the managed forest landscape.

As Mellanskog always leave the small, cut trees in the forest, they might serve as protective habitat for birds compared to if they were taken out and used as biofuel. This potentially suitable new habitat might be a reason why no bigger effects were noted.

4.7.2 Future research

For the future, it would be better to have a bigger sample size and conduct a study with appropriate sample design to detect the potentially negative effects of pre-clearing activities. It would be interesting to look at the whole of Sweden, and partner up with other forest companies to get more detailed data regarding forest management events which could allow not only to expand the sample size but to

ensure that the controls are appropriate. As the SBS have collected data from 1990 onwards, it could be a time series spanning over 30 years, if the forestry data from the forest companies are available and recorded with dates. With a longer time series and thus a bigger sample size, clearer trends with a higher statistical power could be detected. Trends could also, in extension, be connected to how birds act as indicator species of how climate change and traditional forestry affects biodiversity in managed forests. This highlights the importance of keeping an archive of performed managements, so that they can support a long timeline of information to understand biodiversity and complex structures in the forests and how they interact with anthropogenic disturbances.

Furthermore, continuous education aimed towards forest owners, machine operators and forestry companies of the importance of biodiversity and how forest managements affect birds is important to get a better understanding of why it is crucial with a high number of bird species and individuals in the managed forest.

These kinds of science projects are crucial in understanding how forest managements affect the bird composition in the traditionally managed forests in Sweden. By giving us a broader picture of these interactions, they give us a decision basis and an important opportunity in adapting accordingly, so that birds can still call the Swedish forests their home for a long time to come.

5. Reference list

Åberg, J. (2000). *The Occurrence of Hazel Grouse in the Boreal Forest Effects of habitat composition at several spatial scales*. [PhD Thesis] *SLU Pub Epsilon*, p.5. Available at: https://pub.epsilon.slu.se/17686/1/aberg_j_201005.pdf [Accessed 15 May 2026].

Asplund, B., Karlberg, L., Petersson, L., Sahlin, M., Stighäll, K. and Widman, M. (2022). *Long live the forest - A sustainable use of Swedish forests*. [online] *Naturskyddsföreningen*, pp.4–5. Available at: https://cdn.naturskyddsforeningen.se/uploads/2022/06/27114507/31877_3acf52d110c5014.pdf [Accessed 22 May 2026].

Berg, A. (2010). Reindeer herding and modern forestry. *Acta Universitatis Agriculturae Sueciae*, [online] (2010:45), p.3. doi:https://pub.epsilon.slu.se/2290/1/Berg_A_100510.pdf.

BirdLife International (2023). *Birds control insect pests in farmlands and forests* | *BirdLife DataZone*. [online] DataZone by BirdLife. Available at: <https://datazone.birdlife.org/articles/birds-control-insect-pests-in-farmlands-and-forests?utm> [Accessed 22 May 2026].

Bollmann, K. (2018). *Can structural diversity and habitat heterogeneity explain species diversity in temperate forests?* [online] Swiss Federal Institute for Forest, Snow and Landscape Research WSL. Available at: <https://www.wsl.ch/en/projects/structural-diversity-and-forest-biodiversity/> [Accessed 15 May 2026].

Clavel, J., Julliard, R. and Devictor, V. (2010). Worldwide decline of specialist species: toward a global functional homogenization? *Frontiers in Ecology and the Environment*, [online] 9(4), p.222. doi:<https://doi.org/10.1890/1523-1739-2010-001>.

Collar, N. (2020). *Song Thrush (Turdus philomelos)*. [online] Birds of the World. doi:<https://doi.org/10.2173/bow.sonthr1.01>.

Gamfeldt, L., Snäll, T., Bagchi, R., Jonsson, M., Gustafsson, L., Kjellander, P., Ruiz-Jaen, M.C., Fröberg, M., Stendahl, J., Philipson, C.D., Mikusiński, G., Andersson, E., Westerlund, B., Andrén, H., Moberg, F., Moen, J. and Bengtsson, J. (2013). Higher levels

of multiple ecosystem services are found in forests with more tree species. *Nature Communications*, [online] 4, pp.1–2. doi:<https://doi.org/10.1038/ncomms2328>.

Giesler, R., Clemmensen, K.E., Wardle, D.A., Jonatan Klaminder and Bindler, R. (2017). Boreal Forests Sequester Large Amounts of Mercury over Millennial Time Scales in the Absence of Wildfire. *Environmental Science & Technology*, 51(5), p.1. doi:<https://doi.org/10.1021/acs.est.6b06369>.

Green, M., Lindström, Å. and Biologiska (n.d.). *STANDARDRUTTERNA - Resultatprotokoll från kombinerad punkt-och linjetaxering*. [online] *Fågeltaxering*, Fågeltaxering, pp.1–5. Available at: <https://www.fageltaxering.lu.se/sites/fageltaxering.lu.se/files/2024-01/Standardrutt.pdf> [Accessed 13 May 2026].

Iwarsson, M. (2001). *Motormanuell röjning*. [online] Skogforsk. Available at: <https://www.skogforsk.se/contentassets/f92f64311750474d9a186db5b9ce485c/motormanuell-rojning.pdf> [Accessed 15 May 2026].

Jackson, R., Ahlström, A., Pascual, D. and Garthwaite, J. (2026). *A ‘shocking’ carbon discovery in Sweden’s forests*. [online] Stanford Doerr School of Sustainability. Available at: <https://sustainability.stanford.edu/news/shocking-carbon-discovery-swedens-forests> [Accessed 22 May 2026].

Jenouvrier, S. (2013). Impacts of climate change on avian populations. *Global Change Biology*, [online] 19(7), pp.2–3. doi:<https://doi.org/10.1111/gcb.12195>.

JÖNSSON, A.M., APPELBERG, G., HARDING, S. and BÄRRING, L. (2009). Spatio-temporal impact of climate change on the activity and voltinism of the spruce bark beetle, *Ips typographus*. *Global Change Biology*, 15(2), pp.486–499. doi:<https://doi.org/10.1111/j.1365-2486.2008.01742.x>.

Kanth, R. (n.d.). *Bästa tipsen till dig som gallrar själv*. [online] *Billerud*. Available at: <https://www.billerud.se/skog/livet-med-skogen/tips-till-dig-som-gallrar-sjalv> [Accessed 16 May 2026].

Karhä, K. (2006a). Effect of undergrowth on the harvesting of first-thinning wood. *ResearchGate*, [online] 45, pp.101–117. Available at:

https://www.researchgate.net/publication/266491186_Effect_of_undergrowth_on_the_harvesting_of_first-thinning_wood#full-text [Accessed 2 Apr. 2026].

Karh , K. (2006b). *Profitability of pre-clearance in first-thinning Scots pine stands*. [online] *AgEcon Search*, Scandinavian Forest Economics: Proceedings of the Biennial Meeting of the Scandinavian Society of Forest Economics, pp.137–146. Available at: <https://ageconsearch.umn.edu/record/198548?v=pdf> [Accessed 2 Apr. 2026].

Klein, J. (2020). *The forgotten forest: on thinning, retention, and biodiversity in the boreal forest*. [PhD Thesis] *SLUpub*, pp.10, 13, 31. Available at: https://pub.epsilon.slu.se/17565/1/klein_j_200921.pdf [Accessed 14 May 2026].

Klein, J., Haverkamp, P.J., Lindberg, E., Griesser, M. and Eggers, S. (2020). Remotely sensed forest understory density and nest predator occurrence interact to predict suitable breeding habitat and the occurrence of a resident boreal bird species. *Ecology and Evolution*, [online] 10(4), pp.2238–2239. doi:<https://doi.org/10.1002/ece3.6062>.

Korpela, K., Helle, P., Henttonen, H., Korpim ki, E., Koskela, E., Ovaskainen, O., Pieti inen, H., Sundell, J., Valkama, J. and Huitu, O. (2014). Predator–vole interactions in northern Europe: the role of small mustelids revised. *Proceedings of the Royal Society*, [online] 281(1797), p.2. doi:<https://doi.org/10.1098/rspb.2014.2119>.

Kungliga Skogs- och Lantbruksakademin and Holmer, M. (2024). *Sketch Showing the Principle of even-aged Forest management*. [Online Image] *KSLA*. Available at: <https://www.ksla.se/wp-content/uploads/2024/06/Forests-and-Forestry-in-Sweden-2024.pdf> [Accessed 20 May 2026].

Larson, K.W. and Kundish, S. (2012). *Willow Warbler Phylloscopus trochilus nesting in a juniper during a peak lemming year*. [Journal] *Ornis Svecia*. Available at: <https://journals.lub.lu.se/os/article/view/22583/20086> [Accessed 24 May 2026]. CC BY 4.0.

Laundr , J., Hern andez, L. and Ripple, W. (2010). The Landscape of Fear: Ecological Implications of Being Afraid. *The Open Ecology Journal*, 3, pp.1–7.

Lennartsson, T. (2005). *Fragmenterat landskap - en kunskapssammanst llning om fragmentering som hot mot biologisk m ngfald*. [online] *Jordbruksverket*. Available at:

https://www2.jordbruksverket.se/webdav/files/SJV/trycksaker/Pdf_rapporter/ra05_9.pdf
[Accessed 13 May 2026].

Lindström, Å. (2026). *Inventera*. [online] Fageltaxering.lu.se. Available at:
<https://www.fageltaxering.lu.se/inventera>.

Maziarz, M. and Hebda, G. (2023). *Nests of wood warblers, Phylloscopus sibilatrix, on the forest floor, with (A) eggs and (B) nestlings in the Białowieża Forest, Poland*.

[Article] *Experimental and Applied Acarology*. Available at:

[https://doi.org/10.1007/s10493-023-00800-](https://doi.org/10.1007/s10493-023-00800-8?urlappend=%3Futm_source%3Dresearchgate.net%26utm_medium%3Darticle)

[8?urlappend=%3Futm_source%3Dresearchgate.net%26utm_medium%3Darticle](https://doi.org/10.1007/s10493-023-00800-8?urlappend=%3Futm_source%3Dresearchgate.net%26utm_medium%3Darticle)

[Accessed 20 May 2026]. CC BY 4.0. <https://creativecommons.org/licenses/by/4.0/> .

Mellanskog.se. (2024). *Gallring*. [online] Available at:

<https://www.mellanskog.se/vara-tjanster/salja->

[virke/gallring/?gad_source=1&gad_campaignid=20072681488&gclid=Cj0KCQjwp7jOBhDGARIsABe7C4c8k42QFijpRzEb3xjvtILGwO-](https://www.mellanskog.se/vara-tjanster/salja-virke/gallring/?gad_source=1&gad_campaignid=20072681488&gclid=Cj0KCQjwp7jOBhDGARIsABe7C4c8k42QFijpRzEb3xjvtILGwO-)

[V6i0yaWJ9yDpp0gGXZvfP4Fj7WPQaAqTDEALw_wcB](https://www.mellanskog.se/vara-tjanster/salja-virke/gallring/?gad_source=1&gad_campaignid=20072681488&gclid=Cj0KCQjwp7jOBhDGARIsABe7C4c8k42QFijpRzEb3xjvtILGwO-V6i0yaWJ9yDpp0gGXZvfP4Fj7WPQaAqTDEALw_wcB) [Accessed 2 Apr. 2026].

Mickelsson, H. (2018). *Tjäderbo med ägg maj-juni 1983*. [Online Image]

Hälsinglands Museum. Available at: <https://digitaltmuseum.se/021017673075/tjaderbo-med-agg-maj-juni-1983> [Accessed 20 May 2026]. CC BY-NC 4.0.

<https://creativecommons.org/licenses/by-nc/4.0/deed.en>.

Mizutani, Y., Goto, Y., Shoji, A. and Yoda, K. (2025). Effects of nest locations on foraging behavior and physiological responses in seabird colony. *Frontiers in Physiology*, [online] 16, p.1. doi:<https://doi.org/10.3389/fphys.2025.1519701>.

Mlodinow, S.G., Pyle, P. and Boesman, P.F.D. (2025). Common Chiffchaff (*Phylloscopus collybita*). *Birds of the World*. [online] doi:<https://doi.org/10.2173/bow.comchi1.02>.

National Geographic Society (2023). *Generalist and Specialist Species*. [online] Education National Geographic Society. Available at: <https://education.nationalgeographic.org/resource/generalist-and-specialist-species/> [Accessed 16 May 2026].

Newton, I. (1998). *Population Limitation in Birds*. [online] *Population Limitation in Birds*, Elsevier, pp.147, 191, 211. doi:<https://doi.org/10.1016/b978-012517365-0/50007-7>.

Niemi, G., Hanowski, J., Helle, P., Howe, R., Mönkkönen, M., Venier, L. and Welsh, D. (1998). Ecological Sustainability of Birds in Boreal Forests. *Conservation Ecology*, [online] 2(2). doi:<https://doi.org/10.5751/es-00079-020217>.

Nilsson, M.-C. and Wardle, D.A. (2005). *Understory vegetation as a forest ecosystem driver: evidence from the northern Swedish boreal forest*. [online] *ESA Journals*. Available at: [https://esajournals.onlinelibrary.wiley.com/doi/10.1890/1540-9295\(2005\)003%5B0421:UVAAFE%5D2.0.CO;2](https://esajournals.onlinelibrary.wiley.com/doi/10.1890/1540-9295(2005)003%5B0421:UVAAFE%5D2.0.CO;2).

Nolander, C. (2021). *Carbon Sink or Energy Source*. [PhD Thesis] p.2. Available at: <https://www.diva-portal.org/smash/get/diva2:1564070/FULLTEXT02.pdf> [Accessed 22 May 2026].

Normark, P. (2024). *Forests and Forestry in Sweden*. [online] *The Royal Swedish Academy of Agriculture and Forestry*. Available at: <https://www.ksla.se/wp-content/uploads/2024/06/Forests-and-Forestry-in-Sweden-2024.pdf> [Accessed 2 Apr. 2026].

Raz, M. (2021). *Biological pest control in the forest by birds*. [online] *Keren Kayemeth LeIsrael-Jewish National Fund*, Rehovot: Journal of forest and open lands management, pp.1–2. Available at: <https://marketingsections.kkl-jnf.org/forestry/wp-content/uploads/sites/11/2024/04/Biological-Pest-Control-in-the-Forest-by-Birds-accessible.pdf> [Accessed 25 May 2026].

Şekercioğlu, Ç.H., Kittelberger, K.D., Mota, F.M.M., Buxton, A.N., Orton, N., DeNiro, A., Buechley, E.R., Horns, J.J., Blount, J.D., Socci, J. and Neate-Clegg, M.H.C. (2025). BIRDBASE: A Global Dataset of Avian Biogeography, Conservation, Ecology and Life History Traits. *Scientific Data*, [online] 12(1). doi:<https://doi.org/10.1038/s41597-025-05615-3>.

Sezer, M. (2026). *Birds Database - Explore 10,000+ Species*. [online] *Imsezer.com*. Available at: <https://birds.imsezer.com/> [Accessed 6 May 2026].

Simonsen, M., Kjønaas, O.J. and Aall, C. (2023). *Substitution of fossil-energy intensive building materials by wood products – Does it matter? A case study from Western Norway*. [online] *ScienceDirect*, Journal of Cleaner Production, p.1. Available at:
<https://www.sciencedirect.com/science/article/abs/pii/S0959652622045140?via%3Dihub> [Accessed 16 May 2026].

Skogsstyrelsen.se. (2025). *Röjning*. [online] Available at:
<https://www.skogsstyrelsen.se/bruks-skog/rojning/> [Accessed 2 Apr. 2026].

Smith, E.P. (2002). *BACI Design*. [online] *Scribd*, Encyclopedia of Environmetrics, pp.1–9. Available at: <https://www.scribd.com/document/40226403/BACI> [Accessed 13 May 2026].

Stevens, M. (2013). Evolutionary Ecology: Knowing How to Hide Your Eggs. *Current Biology*, [online] 23(3), pp.1–2. doi:<https://doi.org/10.1016/j.cub.2012.12.009>.

Storch, I. (1994). Habitat and survival of capercaillie Tetrao urogallus nests and broods in the Bavarian alps. *Biological Conservation*, [online] 70(3), p.237. doi:[https://doi.org/10.1016/0006-3207\(94\)90168-6](https://doi.org/10.1016/0006-3207(94)90168-6).

Stratford, J. and Şekercioğlu, Ç. (2015). *Routledge Handbook of Forest Ecology*. [online] London: Routledge, pp.279, 294. Available at:
<https://www.taylorfrancis.com/chapters/edit/10.4324/9781315818290-23/birds-forest-ecosystems-jeffrey-stratford-%C3%A7a%C4%9Fan-%C5%9Fekercio%C4%9Flu> [Accessed 14 May 2026].

Tobajas, J., Afonso Jordana, I. and Roig, J. (2025). Coexistence conservation strategies: Testing conditioned food aversion to protect the endangered Western capercaillie. *Elsevier*, [online] 2026(89), p.1. doi:<https://doi.org/10.1016/j.jnc.2025.127140>.

Trust, W. and Juniors Bildarchiv Gmbh (n.d.). *Wood Warbler (Phylloscopus sibilatrix)*. *Woodland Trust*. Available at: <https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/animals/birds/wood-warbler/> [Accessed 15 May 2026].

Wesolowski, T. (1985). The Breeding Ecology of the Wood Warbler *Phylloscopus sibilatrix* in Primaeval Forest. *Ornis Scandinavica*, [online] 16(1), p.50.
doi:<https://doi.org/10.2307/3676575>.

www.skogsstyrelsen.se. (2025). *Gallring*. [online] Available at:
<https://www.skogsstyrelsen.se/bruka-skog/gallring/> [Accessed 13 Oct. 2025].

Publishing and archiving

YES, I, Lina Näsström, have read and agree to the agreement for publication and the personal data processing that takes place in connection with this

YES, I, Lina Näsström, have read and agree to the agreement for publication and the personal data processing that takes place in connection with this.

NO, I/we do not give my/our permission to publish the full text of this work. However, the work will be uploaded for archiving and the metadata and summary will be visible and searchable.