Transforming De Lieskamp estate into a biodiverse paradise

Project name: Enhancing biodiversity at estate De Lieskamp Wageningen

Consultancy team: QRAUXO eco consultancy

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Commissioner: Lian Grabijn (project leader), Martine & Rogier van der Mast (owners estate De Lieskamp)

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Executive Summary

Since the loss of biodiversity is a huge concern in the Netherlands, we researched how biodiversity could be enhanced on De Lieskamp, a six hectare estate in Wageningen, Gelderland. The two main objectives of this report are (1) to assess its current state of biodiversity through describing the different land use types associated to their current management practices, and monitoring the diversity of mammals, trees, and soil features within the estate, and (2) to formulate additional management recommendations to further promote biodiversity. To achieve this, we collected soil samples for laboratory analysis (nutrients, pH, moisture, and organic matter). We also evaluated the tree cover, structure, amount of deadwood, and tree-related microhabitats in the two coppice systems. We set mice and camera traps to assess the mammalian diversity. There were some pitfalls during soil analysis that led to unexpected results, probably due to wetness or leaching. In the coppice, European ash and black alder were the most abundant species in the coppice systems. Late blooming trees and shrubs were almost absent. We observed a high structural heterogeneity, but a small amount of deadwood. Although there was almost no grass in the understory, we observed a lot of (oak) regeneration indicating possible good light conditions for grasses and herbs to grow in spring. On the estate in general, the mice were not abundant, and most of them were spotted in areas with sheltered places. The occurrence of mice predators, like cats, or other disturbances, like sheep, could affect the abundant of mice. The camera traps indicated the presence of 15 species of bigger animals, such as roe deer, common pheasant and red fox. This indicates conducive conditions on the estate for these species. The current management practices already promote biodiversity on the estate. Still, there is potential for improvement. Examples of suggestions for enhancement of biodiversity are sowing seed mixtures to increase the plant diversity, creating a loosely stacked wall to provide hiding places and nesting sites, or planting hedges and shrub islands in the meadow to supply shelter and dispersal corridors. It is also important to manage the mowing and grazing pressure on the estate carefully. Finally, having a diversity of herbs, shrubs and trees with both early and late blooming species is essential for increasing biodiversity, as this provides resources to birds and other animals throughout the whole year. Overall, the estate is already moving in a good direction in terms of biodiversity, however, further improvement is possible and advisable.

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List of abbreviations

IUCN = International Union for the Conservation of Nature

NJN = Nederlandse Jeugdbond voor Natuurstudie

OM = Organic matter

TreM = Tree-related microhabitat

WENR = Wageningen Environmental Research

WUR = Wageningen University & Research

Glossary

List of Dutch words

Table 1. *List of Dutch words used in this report with their translation to English and an explanation.*

English name	Dutch name	Explanation
Hiking path	Klompenpad	Locally marked walking paths along the Netherlands
-	Avondvierdaagse	Yearly hiking event over four following days in the Netherlands
Science shop	Wetenschapswinkel	Organisation which organises projects on scientific basis
Wet grassland	Vochtig hooiland	Nature type
Flower rich grassland	Bloemrijk grasland	Nature type
Herb and fauna rich grassland	Kruiden en faunarijk grasland	Nature type
Hornbeam and ash forest	Haagbeuken- en essenbos	Nature type
Fresh water pool	Zoete plas	Nature type
High stem orchards	Hoogstamboomgaard	Nature type
Composted farmyard manure	Ruwe stalmest	Type of manure
Dry stone wall	Stapelmuur	Wall built with stones without the use of cement or clay
Gelderse hedge	Gelderse haag	Different type of plants that fit the Gelderse environment
Hay pile	Hooiruiter	A pile of hay that provides shelter for all kinds of animals
False seedbed	Vals zaaibed	A method used to remove fast growing species from the seed bank

List of species

Table 2. *List of all species mentioned in this report.*

English common name	Dutch common name	Scientific name
Alder buckthorn	Vuilboom	*Frangula alnus*
Bank vole	Rosse woelmuis	*Myodes glareolus*
Barred grass snake	Ringslang	*Natrix Helvetica*
Birch	Berk	*Betulus spec.*
Bird cherry	Gewone vogelkers	*Prunus padus*
Bird's-foot trefoil	Gewone rolklaver	*Lotus corniculatus*
Black alder	Zwarte els	*Alnus glutinosa*
Black-tailed godwit	Grutto	*Limosa limosa*
Blackthorn	Sleedoorn	*Prunus spinosa*
Brown hairstreak	Sleedoornpage	*Thecla betulae*
Cat	Huiskat	*Felis catus*
Common / Millet's shrew	Gewone / tweekleurige bosspitsmuis	*Sorex spec.*
Common blackbird	Merel	*Turdus merula*

Common chicory	Wilde cichorei	*Cichorium intybus*
Common dogwood	Rode kornoelje	*Cornus sanguinea*
Common hawthorn	Eenstijlige meidoorn	*Crataegus monogyna*
Common hazel	Hazelaar	*Corylus avellana*
Common nettle	Grote brandnetel	*Urtica dioica*
Common pheasant	Fazant	*Phasianus colchicus*
Common ragwort	Jacobskruiskruid	*Jacobaea vulgaris*
Common sedge	Zwarte zegge	*Carex nigra*
Common spindle	Wilde kardinaalsmuts	*Euonymus europaeus*
Cow parsley	Fluitekruid	*Anthriscus sylvestris*
Creeping thistle	Akkerdistel	*Cirsium arvense*
Daisy	Madeliefje	*Bellis perennis*
Dandelion	Paardenbloem	*Taraxacum officinale*
Dog rose	Hondsroos	*Rosa canina*
Elder	Gewone vlier	*Sambucus nigra*
English ryegrass	Engels raaigras	*Lolium perenne*
Eurasian magpie	Ekster	*Pica pica*
Eurasian water shrew	Waterspitsmuis	*Neomys fodiens*
European ash	Es	*Fraxinus excelsior*
European dewberry	Dauwbraam	*Rubus caesius*
European hare	Europese haas	*Lepus europaeus*
European hedgehog	Egel	*Erinaceus europaeus*
European robin	Roodborst	*Erithacus rubecula*
Field maple	Veldesdoorn	*Acer campestre*
Goat willow	Boswilg	*Salix caprea*
Great tit	Koolmees	*Parus major*
Greater white-toothed shrew	Huisspitsmuis	*Crocidura russula*
Greater yellow-rattle	Grote ratelaar	*Rhinanthus angustifolius*
Grey partridge	Patrijs	*Perdix perdix*
Guelder rose	Gelderse roos	*Viburnum opulus*
Harvest mouse	Dwergmuis	*Micromys minutus*
Himalayan blackberry bramble	Dijkviltbraam	*Rubus armeniacus*
Ivy	Klimop	*Hedera helix*
Japanese knotweed	Japanse duizendknoop	*Fallopia japonica*
Jay	Gaai	*Garrulus glandarius*
Juneberry	Amerikaans krentenboompje	*Amelanchier x lamarckii*
Large scabious mining bee	Knautiabij	*Andrena hattorfiana*
Lesser spearwort	Egelboterbloem	*Ranunculus flammula*
Little grebe	Dodaars	*Tachybaptus ruficollis*
Little owl	Steenuil	*Athene vidalli*
Marsh-marigolds	Gewone dotterbloem	*Caltha palustris*
Mouse	Muis	*Mus spec.*
Pedunculate oak	Zomereik	*Quercus robur*
Pigeon	Duif	*Columba spec.*

Pilewort	Gewoon speenkruid	*Ficaria verna subsp. verna*
Portugal laurel	Portugese laurier	*Prunus lusitanica angustifolia*
Purple mashlocks	Wateraardbei	*Comarum palustre*
Pygmy shrew	Dwergspitsmuis	*Sorex minutus*
Ragged-robin	Echte koekoeksbloem	*Silene flos-cuculi*
Rat	Rat	*Rattus spec.*
Red fox	Rode vos	*Vulpus vulpus*
Redwing	Koperwiek	*Turdus iliacus*
Ribwort plantain	Smalle weegbree	*Plantago lanceolata*
Roe deer	Ree	*Capreolus capreolus*
Rose of Sharon	Altheastruik	*Hibiscus syriacus*
Soft rush	Pitrus	*Juncus effusus*
Southern marsh orchid	Rietorchis	*Dactylorhiza praetermissa*
Sweet brier	Egelantier	*Rosa rubiginosa*
Sycamore maple	Gewone esdoorn	*Acer pseudoplatanus*
Velvety bentgrass	Moerasstruisgras	*Agrostis canina*
Weatherfish	Grote modderkruiper	*Misgurnus fossilis*
White clover	Witte klaver	*Trifolium repens*
Wild privet	Wilde liguster	*Ligustrum vulgare*
Willow	Wilg	*Salix spec.*
Wood mouse	Bosmuis	Apodemus sylvaticus

Introduction

Context and multi-perspective problem analysis

Over the last decades, the loss of biodiversity has become a main concern in the Netherlands, due to climate change, presence of invasive species, increase of urbanization, and the conversion of land into agricultural practices (e.g. Kalkman et al., 2010; Sanders et al., 2019; Borges et al., 2020). Fortunately, due to the interest of the Dutch government and the different agreements for increasing biodiversity, the biodiversity decline is currently decelerating slightly (Van Strien et al., 2016). However, the national biodiversity is currently only at a level of approximately 15% of the species abundance that is possible in a near natural state, so this is very low (PBL, 2008). To compare, in 1900 the Netherlands had a percentage of 40% of the possible species abundance. So in the last 100+ years, the biodiversity has still decreased drastically.

This national loss of biodiversity can be seen in a historical context. Following the second world war and the famine in the winter of 1944, the sentiment within the Netherlands was focussed on “no more hunger”. The national Dutch agricultural policy has since shifted the food production system towards more intensive forms of farming. Land consolidation, educational development programmes, industrialisation and specialisation drastically changed the rural Dutch landscape (Karel, 2010).

This intensification of agriculture has major impacts on the biodiversity. For example, it negatively affects a wide range of different organisms, including birds, plants, and invertebrates due to changes in food webs, habitat modification, and the loss of biological pest controls (Emmerson et al., 2016). From an ecological point of view, the declining of biodiversity greatly affects ecosystems due to these increasing anthropogenic pressures. Ecosystems become less resilient to changes, which leads to a decline in the capacity of that the system to tolerate disturbances and adapt to them (Rocha, 2022).

For this project we focused on increasing the biodiversity of the Lieskamp, an estate in the Binnenveld Wageningen, situated close to the campus of Wageningen University. It is managed by Martine and Rogier van der Mast, who took over the estate from a farmer in 2015. This former farm consists of six hectares including orchards, grass-dominated meadows, ponds, and two coppice systems (figure 3). There are several animals, such as sheep, chickens, and cats, which have different functions on the estate. A walking path (Klompenpad) crosses the property, making the estate accessible to the public. Furthermore, several events are organised throughout the year, such as the Avondvierdaagse and volunteer days to invite different groups to visit and help on the estate. One of the most important values of the owners, is to work with nature, and create a healthy environment to leave the world a better place for future generations. An important objective, therefore, is to improve biodiversity of the landscape.

This ACT project is the initial stage of a larger research on the biodiversity on the estate coordinated by the Wetenschapswinkel (“Science shop”). Since we are the first to study the biodiversity on the estate, as of now, there is (almost) no data about the current state of the biodiversity and current management practices. There have only been some measurements on the water quality in the ponds on the estate. Within our project, we aimed to start on a baseline, both for biodiversity data as well as a description of the current management. The data generated by this project will be available to the landowners and can be used for further research by other (ACT) groups.

Stakeholders

First, it is necessary to get an overview of all the involved stakeholders. The owners have called in many different parties to help them on their biodiverse mission with advice and intel. They contacted the Wetenschapswinkel, and they selected a project leader: Lian Grabijn. The project leader subsequently put together a research team and supervisory committee. They assisted the ACT team with questions and gave advice when requested. The project leader is the main contact person of the ACT team and also updates the research team and supervisory committee on progress of the ACT group. People working on the estate help the owners with the management. The owners want the visitors to be able to enjoy nature and learn about biodiversity conservation. The species organisations can provide additional advice. Lastly, there are people who have collaborations with the owners, like the neighbours. All the involved parties are visualised in figure 1.

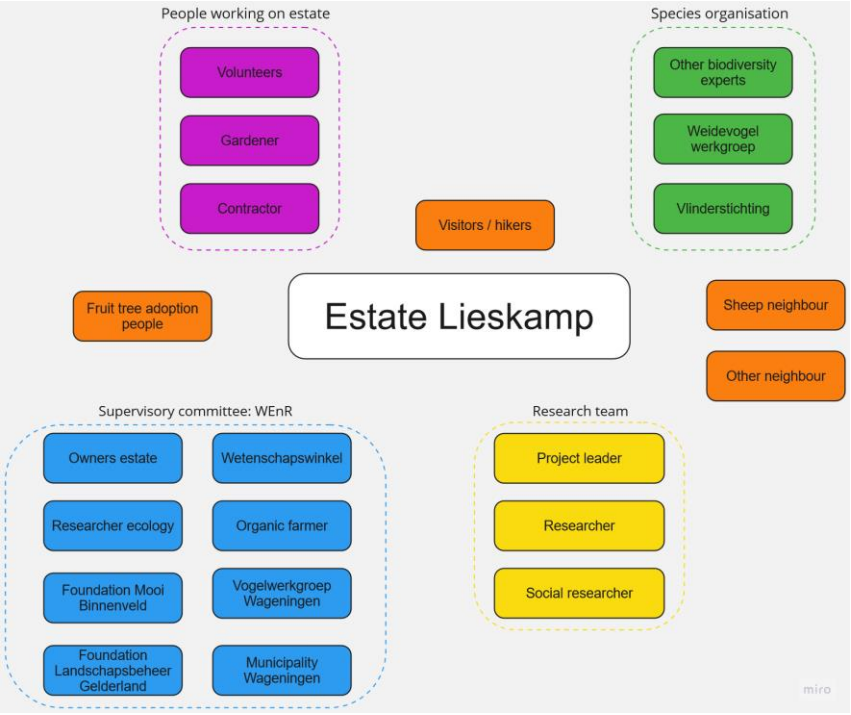


***Figure 1**. A representation of all involved parties at the Lieskamp.*

Description of power and interest stakeholders

Every stakeholder has both an interest and a power. Interest means how much they depend on the outcome of the project, so in this case the increase of biodiversity. Power reflects how much influence they have on the outcome of the project. To create an overview of the interests and power of every stakeholder, all stakeholders are put in a matrix on a position that visualises their relative interest and power (figure 2). The position in the matrix determines if a stakeholder is a latent (a lot of power, but a little indifferent about the outcome of the project), promotor (a lot of influence and very invested in the outcome), apathetic (low score in both departments, but they still need to be updated about the project) or defender (not much power, but very interested in the goal of the project). For every group of stakeholders (figure 1), we describe their precise power and interest in appendix A.

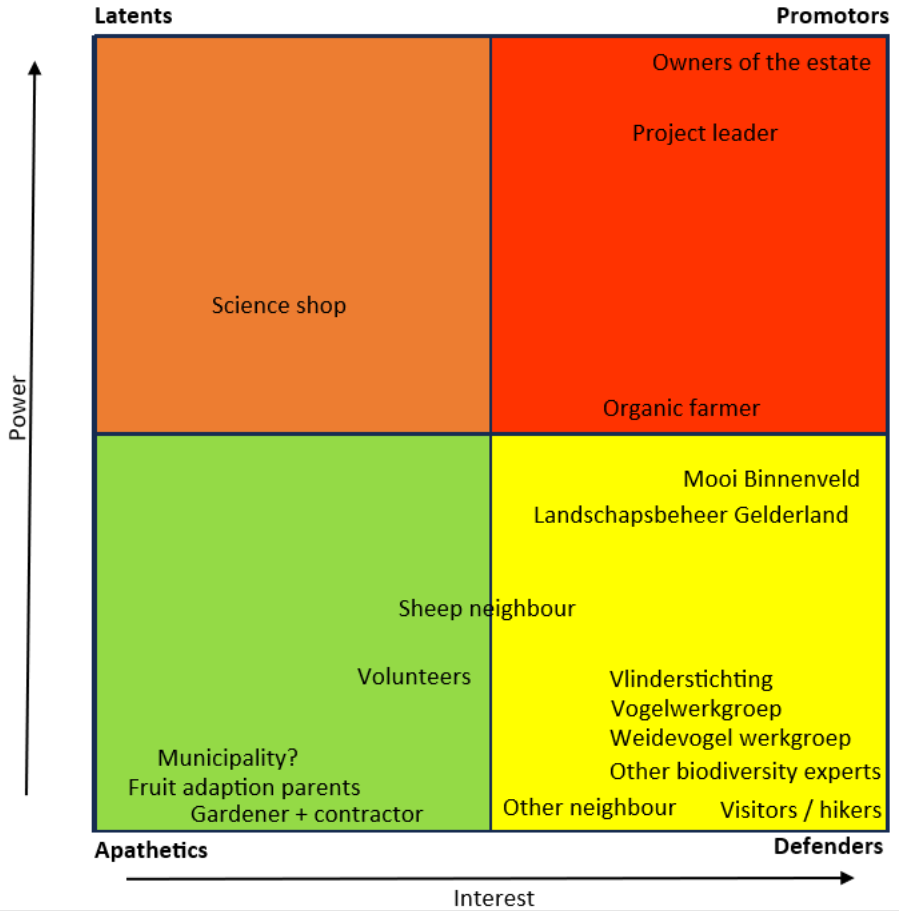


Figure 2. *Overview of all stakeholders with their interest and power.*

Specific problem and research questions

The owners of the Lieskamp aim to create a "nice biodiversity-rich property where people like to come, enjoy nature, and learn from it." They love to contribute to a more circular and green, biodiverse world and they are very passionate about leaving the estate as a nice place for their children to take over. They are not profit motivated, but it is important to them to maintain a certain budget to keep the project feasible. However, there is a knowledge gap for the owners concerning the current state of biodiversity on the property, and how this could be enhanced. This is where we come in.

Our main research goals are (1) to acquire a comprehensive assessment of the current state of the biodiversity regarding to biodiversity, mammals, trees and soil features within the estate, and (2) to formulate different management plans aiming at enhancing biodiversity across its different components.

We achieved this aim using literature study, interviews with experts and our own knowledge on ecology, farming, animal keeping and forestry.

We wanted to start making a baseline assessment by mapping the current state of the biodiversity on the estate. This baseline can be used in the future to assess whether the implemented additional management practices had any positive effect on the biodiversity. When providing recommendations, it was important to be aware of the time and budget limitations set by the owners.

Biodiversity is a broad topic, and a complex phenomenon. Its various components are interconnected and influence each other to a greater or lesser extent. We needed to narrow down the aspects of biodiversity that we would study, keeping in mind that we were the first step of a bigger project. We chose to focus on elements having a broad impact on biodiversity, such as soil quality. Winter was a major constraint in the choice of which aspects of biodiversity were studied in this report. For example, getting an overall knowledge of the current plant species on the estate was not possible, except for tree species. Finally, we chose to focus on the expertise we already had thanks to the diverse backgrounds of our group members. In the baseline assessment of the biodiversity, we thus focussed on the land use types, diversity of mammals and trees, and soil quality.

Through the project we elaborated on the below research questions:

- What is the current state of the biodiversity on the estate? Of:
    - Different land use types
    - Mammalian species diversity
    - Tree diversity
    - Soil quality
- What can be done to increase the biodiversity on the estate?
    - Which management options are currently implemented on the estate? How do these affect the biodiversity?
    - What additional management options could be implemented for improving the diversity?

Team composition

Our consultancy team consisted of six people: Josje Schuttinga (Manager), Zeta Zepou (Secretary), Marianne Héritier (Controller), Isa Priem, Maja Raemakers, and Tessel de Vries.

We all have a relevant background to undertake this consultancy project on how to enhance biodiversity on a historically agricultural estate. Some of us have experience with system management (especially on farms) and most of us have insights on biodiversity conservation, chiefly on plants and insects. Finally, we all have good knowledge of scientific research methods, both in ecology and social sciences. There is a small description of each member's background and contribution in appendix B.

Biodiversity baseline assessment

Study area description and current management

In the following section we will describe the different land use types (figure 3), subsidy types (figure 4), and the way the owners currently manage these. The interviews done to gather this information can be found in appendix H. Furthermore, we will discuss the impact this current management has on the state of biodiversity. By doing this, we will give an answer to the sub questions: "What management options are currently implemented on the estate and how do these affect biodiversity?"

To get a better understanding of the different systems on the estate, we divided the Lieskamp in several land use types (figure 3). Throughout the year, these land use types are managed in different ways.

As a source of income, the owners have applied for management subsidies. The estate is classified into subsidy types to which different amounts of subsidy apply. These are less detailed than the land use type division we have made. The main subsidy types on the estate are: vochtig hooiland, kruidenrijk grasland, haagbeuken- en essenbos and zoete plas (figure 4). With each of these types comes its own management, challenges and opportunities.

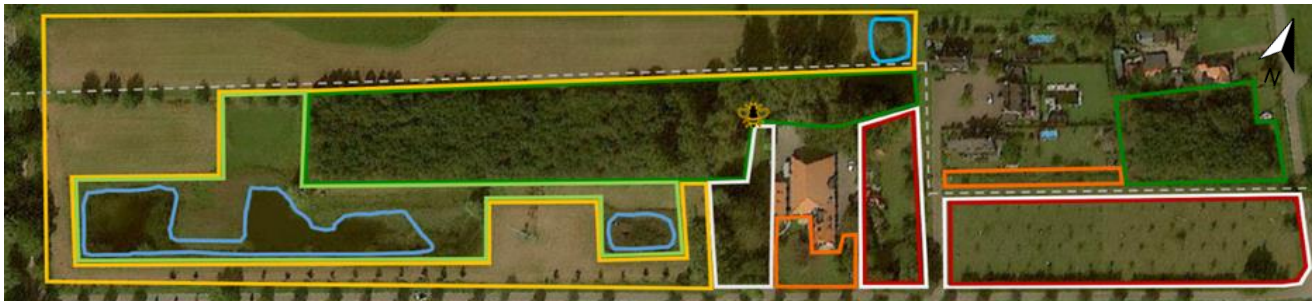


***Figure 3**. Map of the Lieskamp estate with different colours for the different land use types: dark yellow = grass-dominated meadow, light green = biodiverse meadow, dark green = coppice, orange = garden, red = orchard, white = sheep grazed area, light yellow = chicken coop, blue = water body, dotted grey = Klompenpad, bee symbol = honeybee hives. Source base map: Netherlands Space Office, 2023.*

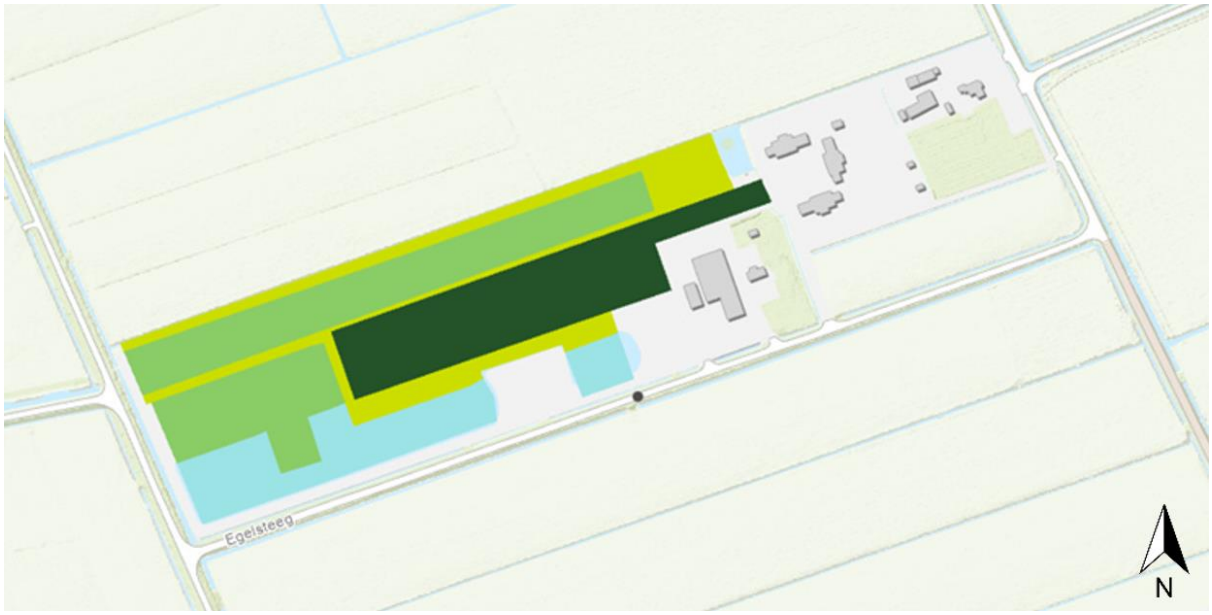


***Figure 4.** Map of the Lieskamp estate based on the subsidy types: dark green = haagbeuken- en essenbos (hornbeam and ash forest), green = vochtig hooiland ("wet grassland"), light green = kruidenrijk grasland ("herb-rich grassland"), blue = zoete plas ("fresh water pond"). Source: Geoportaal Gelderland, n.d.*

Meadows

The subsidy document identifies two types of meadows on the estate (figure 4). Vochtig hooiland ("wet grassland") is a type of grassland that has historically been used for hay production, which serves as a winter food for cattle. These meadows were created in wet areas, such as bogs or forests, but were then used for hay production. They consist of different (rare) grass and flower species and can host different insects and meadow birds, for which the right moisture content is crucial. Due to the intensification of agriculture, these types of meadows have become less common (Bij12, 2023a). The other part of the meadows, the kruidenrijk grasland ("herb-rich grassland") is a more common and less specific type of meadow and therefore can entail a large variety of species. When managed properly, it can provide a habitat for different insects, birds, and small mammals. For managing different types of meadows, the organisation overseeing the subsidies has created type-specific advice (Bij12, 2023b).

On the estate, the owners implement several of these management strategies. The grass-dominated meadows are mown twice a year. The first mow is done at least after the 15th of June, which is seen as the end of meadow bird season, but usually later in the beginning of July. The second mow is done at the end of September or the beginning of October. The mowing is done mechanically and is organised by a neighbouring organic farmer. Phased mowing is applied: leaving a strip of vegetation, which has a location that spatially alters throughout the years. The exact details about the amount of vegetation that is left are unknown. Furthermore, the produced hay is always removed from the meadow as this will prevent nutrients from returning into the soil. Removing the mowing clippings will benefit the impoverishment process, which has a positive effect on the flower diversity. The cuttings are used as hay and brought to a sheep farmer.

One of the goals of the owners for the meadows is to create a more nutrient-depleted soil (less nitrogen and phosphorus), similar to the schraallanden of the Hooilanden; a nature reserve in the area. This nature area was restored after the intensification of agriculture had turned the meadows into monocultural plots of English ryegrass (*Lolium perenne*; Engels raaigras). In 2019, the restoration started by excavating the top layer of nutrient-rich soil, up until 50 cm deep, and adding hay of other local natural reserves on top. This was conducted to decrease the high level of nutrients and to enhance a more diverse herbaceous vegetation. This has been very successful. Currently, there are a multitude of rare meadow birds, plants, mammals, and insects (Enting, Meijer zu Schlochtern & van der Sanden, 2023).

The previous owner of the Lieskamp also excavated one of the grass-dominated meadows (figure 3; figure 5c), although the details of this process are unknown to us. The current vegetation in winter mostly consists of species such as cow parsley (*Anthriscus sylvestris*; fluitekruid), dandelion (*Taraxacum officinale*; paardenbloem), daisy (*Bellis perennis*; madeliefje), and plant species from the genus *Ranunculus*, *Juncus*, *Plantago*, and *Rumex*. It should be taken into account that this research is conducted during the autumn/winter period, which results in a less accurate overview of the current vegetation. However, most of these aforementioned plant species are already indicators of a disturbed system.

The biodiverse meadow between the coppice and the ponds (figure 3), is managed by a biodiversity group. They have recently planted several bushes to increase structural variety. The grass is mown every eight weeks in summer using scythes, and they implement sinus mowing. With this method,

mowing happens more often, and every time a different 40% of the total vegetation is left. A section of the vegetation is left year round, which functions as a breeding ground for different types of butterflies (Vlinderstichting, n.d.).

In the biodiverse meadow you can already see that there is more diversity in the vegetation (figure 5b). This preliminary biodiversity assessment was also conducted during the autumn/winter period, which limited us to provide an exact overview of the characteristic plant species in this part of the estate. However, it has been observed by the ecologist we interviewed (appendix H), that the number of flowering plant species has been increasing over the years. Interestingly, during the last flowering season, approximately thirty individual orchids (probably species *Dactylorhiza praetermissa*; rietorchis) have been seen in this part of the estate. Orchids are vulnerable plant species due to their complex life history traits and sensitivity to changing environmental conditions, and are dependent on several specific (a)biotic interactions. The occurrence of orchids usually indicates a habitat of high ecological value without disturbances and fertilization. Furthermore, the shrubs that have been planted on the edge of this meadow reduce the sharp boundary between the meadow and the coppice area, which enhances diversity in the microclimate, resulting in benefits for insects. Lastly, two hooiruiters ("hay piles") have been put on the meadow to provide more shelter and nesting opportunities for all kinds of animals (figure 5a).

In general, the owners want to let nature run its own course in both meadows, and not intervene too much in the systems. However, as the hay from the meadows is used for agricultural purposes, there are certain species which they want to prevent or remove. Common ragwort (*Jacobaea vulgaris*; jacobskruiskruid), which is poisonous to cattle, and creeping thistle (*Cirsium arvense*; akkerdistel), which is not very preferable in feed due to its structure, are species which are monitored and explicitly targeted by removing them from the meadows as much as possible. Furthermore, at some point the invasive exotic species Japanese knotweed (*Fallopia japonica*; Japanse duizendknoop) was growing at the border of the estate, which was removed immediately.

Impact

The management practice that has the most influence on the biodiversity in the meadows, is the mowing. To protect flora and fauna, it is favourable to mow in an extensive way. As mentioned before, mowing after the 15th of June (but preferably a bit later) helps to protect meadow birds and the food supply for insects. By taking away the hay after mowing, nutrients are removed, and the soil will become more depleted. This can result in a greater variation of vegetation. Phased mowing, which is implemented in both meadows, as well as in the sinus management in the biodiverse meadow, are beneficial ways to preserve shelter for different species. Sinus mowing is also increasing biodiversity and has led to an enrichment of biodiversity in many cases (SLG, 2021).

Figure 5. *Pictures of what the meadows looks like now. A: hooiruiter. B: biodiverse meadow. C: grass-dominated meadow.*

Coppice

On the estate there are two parts with a coppice system (figure 3). A coppice is an anthropogenic system created for optimized wood production, characterized by even-aged stands for which the main regeneration method is vegetative sprouting of either suckers (from the existing root systems of cut trees) or shoots (from cut stumps) (Fabbio, 2016). Coppices are amongst the earliest known forms of woodland management. Distinctive assemblages of plants and animals are associated with such systems. Richness of such assemblages is linked to the alternation of relatively short light and dark phases, and to the assemblage of stands at different stages in the coppice cycle. Historically, coppice systems were developed to meet the local community needs, being for example a source of firewood and litter for animal bedding. As economic and social conditions are changing, these systems are gradually being replaced by higher forests and are declining. Hence, today they are highly valued for nature conservation. Compared to high forest stands, short cutting cycles allow for a high degree of spatial heterogeneity. This favours species that need more open areas or relate on forest understory. Moreover, they are also a form of cultural landscape (Kirby et al., 2017).

The trees in the coppice on the estate (figure 6) need to be cut every 5 years. The owners manage this by cutting a few trees each year. They are cut at knee height, and trees that have been cut before are pruned. Some of the wood is shredded and is taken by a neighbouring farmer who uses it to heat his company. If larger trees are cut, the wood is taken by different people.

Impact

The coppice is classified for the subsidies as a haagbeuken- en essenbos. When correctly managed, these types of forests can host a lot of different flora and fauna, containing shrubs, spring flowers and different trees. An overview of the exact species, based on our analysis, and their impact on biodiversity of this estate can be found in the tree diversity section of this report.

Figure 6. *Picture of the current small coppice.*

Garden

There are different parts that have been classified as garden (figure 3). There is a small vegetable garden, a flower garden, a garden in front of the house, and a strip with rhododendrons between the Klompenpad and the neighbour's house (figure 7). All of these are managed in such a way that their appearance is "traditional and neat", which means that the grass is cut short, and the owners want to keep this part like it is now and do not want to mix different species. However, the flower garden has

been designed with keeping the benefits for biodiversity in mind and here there are different types of flowers and plants. The garden in front of the house consists mainly of grass and a few hedges. The grass is mowed by a robot. The owners mentioned that they have had some issues with moles in this area, which they wish to combat using mole traps. In the past, the paths in the gardens have been treated with glyphosate, but it is not used any more after learning about the harmful effects on the environment and human health. Furthermore, the rhododendrons are seen as a lot of work. There is a fungus in the soil which kills them, and the owners spend a lot of time fighting this and replacing the plants. Therefore, they are looking for an alternative.

Impact

The rhododendron is a plant species that is part of the heather family. During the entire year, green, thick and waxy leaves are present. It can grow in the full sunlight as well as in the shade. The whole plant is poisonous. Flowering is started when the plant is around the age of 10 to 12 years. When the conditions are sufficient, flowering will occur every following year for a period of two weeks. The flowering will occur in the months May or June. The rhododendrons are very attractive for multiple insects due to the large amount of pollen and nectar (Higgins, 2008). So they are good for biodiversity, but it is not an indigenous species and it is a monoculture, so here there is still room for improvement.

Figure 7. *Rhododendrons on the estate.*

Orchards

On the estate there are two orchards (figure 3; figure 8). One orchard was planted by the previous owner and is located on the east side of the farm and is referred to as the old orchard. This orchard contains diverse variety of fruit trees. In the late 1940s, a few apple trees were planted. Later, pear and plum trees were added. In the old orchard there is a chickencoop and the undergrowth is grazed by sheep of the owners. The new orchard was planted in 2019 and consists of approximately 60 different ‘forgotten' local varieties of apple, plum and pear (appendix I). These trees have partly been adopted by people. The spacing between the trees was based on the width of the agricultural machines used. The fruit trees can be adopted on the website. The English ryegrass underneath the trees is managed by a neighbouring conventional farmer by letting his sheep graze there. For both of the orchards there is no economic interest and the harvest obtained is mainly used for personal consumption and gifts to the volunteers.

The management of the old orchard consists mainly of pruning the trees in winter. This is done by a fruit tree specialist from Wageningen. The trees have not been managed properly in the past, so the specialist now mainly tries to prune them into a useful shape and prolong their life as they are very old. The pruned branches are shredded and used in the vegetable garden or put around the picnic benches along the Klompenpad. In the old orchard there are a few hawthorn bushes, some of which have been affected by blight. These are immediately shredded. The Dutch health inspection (NVWA) recommends using glyphosate against this pest, but the owners try to avoid these chemicals when possible.

In the new orchard, the neighbouring farmer fertilizes the grass by injecting slurry, this is done once a year when needed. The fruit trees are pruned in winter by the specialist, who removes branches when needed. Currently mainly the branches containing blossom are removed, to promote tree growth. The trees are fertilized in spring when needed using decomposed farmyard manure from the neighbouring organic dairy farmer. This is not done every year, but only when advised by the specialist. The fruit is harvested when ripe by the owners and people who adopted the fruit trees. The owners currently struggle with the exact timing of the harvest.

Impact

Orchards have the potential to enhance biodiversity in many ways. The trees can provide food and shelter for a lot of different species. The blossom provides nectar for several insects, and the trees can benefit different birds, arthropods, and small mammals by providing nesting and feeding opportunities. Furthermore, orchards have cultural significance in the local landscape. This significance is even more enhanced by the use of traditional local species (*Aanplant hoogstamfruit beheer hoogstamboom fruitboom boomgaard*, 2023). Grazing livestock in an orchard is also a traditional use of land in this particular area. However, when looking at biodiversity, the diversity in vegetation in the undergrowth is quite low. The grassland is dominated by English ryegrass. Furthermore, it is currently managed in a conventional way. The origin of the slurry used for fertilisation of the sward is unknown to us, but using manure from industrial farming systems can potentially be harmful to the soil biodiversity. In conventional farming, the use of pesticides and antibiotics is common. These can have a negative effect on the soil biota (Köninger et al., 2021).

Figure 8. *Overview of the new (left) and old (right) orchards.*

Sheep grazed area

The sheep grazed area is a fenced area next to the house of the owners and is mostly functioning as grazing area for the owner's sheep (figure 9). It is indicated in white on the map of the estate (figure 3). The sheep graze alternately in the old orchard and in this area to reduce grazing pressure on the vegetation. Furthermore, there are a few large poplar trees on this grazed area, one of which contains an inhabited little owl box. These trees are pruned in winter. Any smaller side branches are removed from the trunk using a saw. This is done to keep the trunk tidy and to let light onto the meadow. Twice a year, chalk and organic fertilizer are added to the meadow to promote grass growth.

In both grazing areas the sheep and chickens forage together. The owners mentioned that they want the animals on the farm to have a function. The sheep are seen as grass mowers that keep the grass short and tidy. The chickens are the cleaners and eat any waste products. They also help to prevent pests and parasites in the sheep by eating insects and larvae in the manure. The sheep are vaccinated and sheared every year.

Impact

Grazing of livestock can have an impact on the biodiversity of grassland. Grazing will impact the vegetation diversity, composition and the structure (Huaranca et al,. 2022). The stocking density can determine the potentially positive or negative consequence for the biodiversity. When the stocking intensity is too high, the composition and biodiversity will be negatively affected. Low stocking density positively affects the biodiversity (Scimone et al., 2007). Species richness only increases with low stocking density, which was between 0.5-1.5 sheep per hectare (Tóth et al., 2016). For small mammals medium grazing pressure has a positive effect on small mammal density while high grazing pressure has a detrimental effect (Schmidt et al., 2005).

Figure 9. *Sheep grazed meadow with the sheep of the owners. On the right tree with the inhabited little owl box.*

Water

There are three ponds and several ditches on the estate (figure 3; figure 10). The ponds were dug by the previous owner in 2008. The bottom of the ponds consists of the top layer of clay taken out in the process. They are rainwater fed (De Ruiter, 2022). The reeds in the pond are cut in the winter, each time 2/3rd of them is cut, the rest is left. This needs to be done before the 1st of March, and the soil needs to either be dry enough or frozen for the machine to be able to drive on it. The management is done by a contract worker. Currently, the machine cannot reach the middle of the large pond, so a small island is formed. The owners mentioned they might have to do something about this in the

future. The ditches on the side of the road are managed by the municipality, on their own terrain they are managed by a contract worker. There are several water birds living in the pond, an interesting one that has been identified is the little grebe (*Tachybaptus ruficollis;* dodaars).

Impact

As it is not our expertise, we will not go into the specific impact on biodiversity and species of this land use type. However, in general, ponds like these have a positive impact on biodiversity. They can help to provide a habitat for different types of (fish eating) waterbirds, fish, insects, and bats (Bij12, 2023c).

Figure 10. *Small pond on the estate.*

Beehives

In the coppice there are six honeybee hives (± 10 000 honeybees per hive) owned by a beekeeper (figure 11). They are mainly used for pollination, but the honey is sold at the estate. It is bought by local visitors, the owners mentioned that they mainly sell to people with pollen allergies and people from North-Africa who use for cooking.

Impact

Worldwide, there has been a dramatically decrease in insect populations (Wagnet et al., 2021). As reported by Hallmann et al. (2017), the biomass of flying insects has declined by over 75% in just under three decades. Negative effects on insect populations have also been observed in the Netherlands. Bees appear to be among the most drastically affected groups, with 55% of all considered bee species in the Netherlands listed on the Rest List (Reemer, 2018). The decline in bee populations is frequently connected to habitat loss resulting from agricultural expansion and intensification, eutrophication, pollution, and the use of insecticides. However, pollinators play a crucial role in the ecosystem due to maintaining genetic diversity in flowering plant populations, and the benefits in the production of fruits and seeds (Gill et al., 2016). On a local level, the presence of high densities of honeybees can affect wild pollinators, such as hoverflies and wild bee species (Cane & Tepedino, 2016; Mallinger et al., 2017). A honeybee hive houses a single colony with one queen. A healthy colony consists usually between 20,000 and 50,000 individuals during the summer season (Van der Steen, 2015; Andriessen, 2011). Honeybees, being generalists, visits a wide range of flowering plants. To collect pollen, they usually fly about five to six kilometres to collect pollen, but, if necessary, they can extend their reach to a distance of thirteen kilometres from the hive (Van der Steen, 2015). This is in great contrast to

wild bees, as these species specialize in only one or a few types of flowers and generally stay within a travel distance of a few hundred meters from their nest (Gathmann & Tscharntke, 2002). Both wild bees and honeybees rely on flowers not only for nectar for their own energy, but also for pollen as a crucial food source for their larvae. Limited availability of pollen and nectar creates natural food competition among various pollinating insects. However, there are concerns about the extent to which honeybees compete with wild pollinators, such as wild bees and hoverflies. The honeybee is kept in large colonies and cared for by beekeepers, which results in benefits compared to wild pollinators. This can put pressure on the local wild bee populations. One colony of honeybees collects approximately ten kilograms of pollen per summer season. An average wild bee individual requires 90 mg pollen per offspring. This means that the amount of pollen collected by one honeybee colony is equivalent to the amount of food that is needed for 110.000 wild bee larvae (Cane & Tepedino, 2016).

Figure 11. *Honeybee hives in the coppice system.*

Klompenpad

The Klompenpad is a public walking path that partly runs over the estate (figure 12). The grass on this path is mown every two weeks from approximately April to October. Furthermore, the owners keep an eye on the safety of the visitors. An example of this is the fact that they removed a European hornet nest that was in a tree next to the path. They do the same with wasp nests, if they are close to where people walk or picnic. If they aren't, the nests are left alone.

Figure 12. *Bridge over small ditch with the sign of the Klompenpad.*

Surroundings

The Lieskamp is only a small part of nature in the larger area of the Binnenveld. The biodiversity of the estate is influenced by the surrounding plots of land. The estate is directly surrounded by different farmers, both conventional and organic. Some farm in a nature inclusive, agroecological way, using practices that work with nature and try to prevent harm. Others farm in a more industrial way, which can be harmful to biodiversity. Examples of practices that could be destructive are using pesticides, focussing on creating monocultures, and intensive specialised livestock farming. The Lieskamp is also to a lesser degree surrounded by and connected to different natural reserves. One of the closest, and most similar is that of the Hooilanden. As mentioned before, this area is restored farmland, which now hosts a multitude of different species. The Lieskamp can be seen as a natural stepping stone between the different nature reserves. This is a very important aspect and function of the estate, as natural bridges are an essential part to increase biodiversity on a larger scale.

Discussion and conclusion

Throughout the year, there are several management practices that are implemented on the estate. Many of these practices and the way the estate is designed already (potentially) promote biodiversity in a variety of ways. However, there are also points which could be improved. We have researched options and provide suggestions for additional management at the end of this report.

As can be seen in this section, in making different management choices, the owners have to deal with several viewpoints, interests and limitations. For each choice that is made, they have to keep legislation, stakeholders and their own values in mind. Managing the estate is a balancing act.

Soil measurement

Introduction

Soil is an important part of biodiversity, as one of the richest habitats (Nielsen, 2015). However, soil degradation is a serious issue currently. So, it is essential to use sustainable soil management practices and protect it from further degradation. Diverse plants species can grow on an area with increasing soil fertility (Dybzinski, 2008) and vice versa. Different plant species have different niches and they have a different capacity of liberate, capture, or retain nutrients (Furey, 2021). This is why assessing the estate soil quality is essential to have a comprehensive understanding of the current state of the biodiversity.

For this, soil analyses of moisture, pH, nutrients, and organic matter took place. Measuring the moisture is essential as the amount of water influences the soil ecological and biological reactions. For instance, through water the nutrients are transported to the plants and contribute to the plant growth (Lekshmi, 2014). Moreover, the leaching of nutrients dissolved into the water can modify the soil structure. The pH and nutrient availability influence the plant diversity. Plants have different needs, and they can grow and thrive in specific levels of pH and nutrients. Nowadays, soil acidification is an important challenge. On acidifying soil, only particular plant species can thrive, which leads to a decline in plant species richness and biodiversity. Soil with higher availability of nutrients, such as nitrogen deposition, could be a limiting factor in the growth of specific plant species (Bobbink, 2010). Organic matter maintains the soil structure by preserving soil from erosion and providing the plants

with nutrients by keeping them in an available form (Bot; Benites, 2005). Knowing the percentage of organic matter in the soil is beneficial to increase the biodiversity. The analysis explained below will give an overview of the current soil quality.

Methods

To have a better understanding of the current situation on the estate, we conducted a soil analysis (figure 13b; figure 13c). This involved examining 23 soil samples from the Lieskamp, collected from three distinct areas: grass-dominated meadow, biodiverse meadow and new orchard. In the biodiverse meadow (B) and new orchard (O) we collected 5 soil samples from each area, covering approximately 100 meters per area. The grass-dominated meadow (T) which was around 200-meter long was divided into 13 soil samples. Every 20 meters (20 steps from the same person), we collected soil samples along a straight line. The samples were taken using a gouge auger (figure 13a). For each drill, 20 cm of topsoil was extracted. At each sample location, we drilled twice to have sufficient soil for our analysis. In the lab, we measured the pH levels (figure 14a) and the concentrations of nutrients (figure 14c), specifically NO_3, NH^{4+} and PO_4^{3-}, in the soil by using an extract of $CaCl_2$. Additionally, we estimated the soil moisture content (figure 13d), and the percentage of organic matter in each sample (figure 14b). More detailed information regarding the protocol we used for soil analysis can be found in appendix C.1, as well as a more detailed overview of the results.

***Figure 13**. A: Soil sampling with gouge auger on the estate. B: Measuring soil sample to centrifuge tubes. C: Put soil samples to mechanical shaker to equilibrate the samples. D: Weighing samples before drying in the oven.*

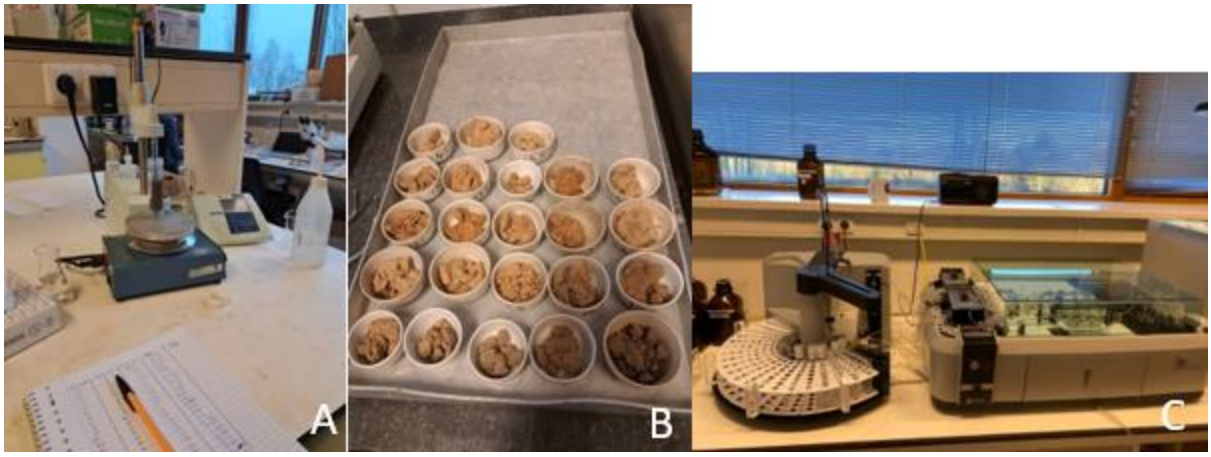


Figure 14. *A: Measuring level of pH with an electrode. B: Dry soil after heating the soil samples in the stove to 550 °C. C: Flow injection analysis to measure the nutrients.*

Results

The results from our soil analysis can be found in table 3, more elaborate results can be found in appendix C.2.

Table 3*. Results soil analysis.*

Soil sample	Nitrate (mg/kg N-NO3)	Ammonia (mg/kg N-NH4)	Phosphate (mg/kg P-PO4)	pH (CaCl2. 25 C)	DM %	Moisture %	OM %
O1	2,360655738	0,245901639	1,524590164	5,4	79,06	20,94	4,56
O2	3,431372549	1,225490196	1,12745098	5,44	72,59	27,41	7,06
O3	2,271293375	0,615141956	0,899053628	5,13	73,55	26,45	6,6
O4	2,980769231	1,490384615	0,817307692	4,93	71,69	28,31	7,54
O5	3,398058252	0,825242718	2,378640777	4,99	74,99	25,01	7,22
B1	0,802675585	1,555183946	0,25083612	5,5	76,53	23,47	4,18
B2	0	3,566775244	0,342019544	4,73	77,79	22,21	2,49
B3	0	1,937086093	0,248344371	4,56	77,79	22,21	3,43
B4	1,006711409	1,459731544	0,151006711	5,26	76,46	23,54	5,42
B5	0,59602649	1,738410596	0,149006623	5,3	73,96	26,04	5,32
T1	0,967741935	1,790322581	0,725806452	5,47	76,52	23,48	4,09
T2	0,290322581	1,403225806	0,048387097	5,29	71,89	28,11	6,1
T3	1,390728477	1,341059603	0,049668874	5	72,1	27,9	6,65
T4	0,098684211	1,529605263	0,049342105	4,74	64,84	35,16	7,98
T5	0	1,05	0,05	4,68	68,99	31,01	4,66
T6	0,376175549	0,611285266	-0,04702194	5,77	73,86	26,14	4,06
T7	0,670926518	1,389776358	0,047923323	5,15	72,83	27,17	5,62
T8	0,402684564	0,855704698	0,05033557	6,1	69,01	30,99	6,61
T9	0	0,962837838	-0,05067568	6,57	71,88	28,12	3,41
T10	0,304054054	0,962837838	-0,05067568	5,98	68,04	31,96	5,15
T11	-0,09646302	1,591639871	-0,04823151	4,63	72,01	27,99	4,54
T12	0	1,412337662	0,048701299	4,65	76,51	23,49	3,52
T13	-0,09803922	0,245098039	-0,04901961	4,41	72,42	27,58	3,74

pH

In the orchard, the pH ranged between 4.93 and 5.44, and was on average 5.18. The pH of the biodiverse meadow was between 4.56 and 5.5, with an average of 5.07. Lastly, the pH of the grass-dominated meadow varied the most and ranged between 4.41 and 6.57, with an average of 5.2. The averages of the different meadows were very similar. It is important to keep in mind that these pH values were based on a solution with calcium chloride. This method always results in lower pH values than when measured in distilled water (van Lierop, 1981). For these types of meadows, the pH is on the low side. (Bij12, 2023a; Department of Jobs, Precincts and Regions, 2023). This can affect the growth and type of species of the vegetation. Especially certain key species wanted in the vochtig hooiland nature type such as orchids and marsh-marigolds (*Caltha palustris*; gewone dotterbloem), are not able to thrive in more acidic soil. Acidification of soil is a natural process, but it can be intensified by disturbances in the water supply (Natuurkennis, n.d.). Furthermore, acidification can be caused by deposition of ammonia from manure. Because of the number of intensive conventional farms in the Netherlands, this deposition is higher than in other countries (Natuurmonumenten, n.d.). A high percentage of soft rush (*Juncus effusus*; pitrus) can be an indicator of acidification. In the grass-dominated meadow this type of vegetation has been identified, which would be in line with our measurements. Other species that indicate the acidification of soil are common sedge (*Carex nigra*; zwarte zegge), velvety bentgrass (*Agrostis canina*; moerasstruisgras), lesser spearwort (*Ranunculus flammula*; egelboterbloem) and purple marshlocks (*Comarum palustre*; wateraardbei) (Bij12, 2023a).

Organic matter

For the orchard, the average OM content was 6.6 %. In the grass-dominated and biodiverse meadow they were 5.1% and 4.1% respectively. An explanation of the differences between the meadows could be the management. In both the grass-dominated and biodiverse meadow, hay is removed after mowing. In the orchard, however, the sheep graze and manure is injected into the soil.

Nutrients

For the orchard, the average nutrient amount was 3.77 mg/kg nitrogen and 1.35 mg/kg phosphorus. This is higher than both of the meadows. The grass-dominated meadow had 1.5 and 0.06 mg/kg N and P respectively, and the biodiverse meadow had 2.53 mg/kg N and 0.23 mg/kg P. It makes sense that the nutrients in the orchard are higher than in the meadows, as this is fertilized. In the meadows on the other hand, nutrients are actively removed by mowing and removing the hay.

Discussion

Our results for the organic matter and nutrients are much lower than would be expected from the land use types we measured. We compared the data to an analysis done in the Hooilanden in 2019, which is a similar area (M. Heijmans, personal communication, November 16, 2023). Furthermore, we discussed the results with an expert (M. van Hoef, personal communication, December 8, 2023). There are possible reasons why our results were so low compared to this. First of all, there could be a problem with the sampling or analysis in the lab. After sampling, the soil was not dried before the nutrient analysis. The soil was very wet, as can be seen in the results of the moisture percentage. This could potentially mean that the measured 3g was in reality closer to 2g of soil and the nutrient content of the soil was therefore higher than measured. Secondly, it could mean that the depletion of the soil in the meadows has worked very well, and that the orchard is fertilized very effectively. This means

that there is no surplus added and all the plant available nutrients are taken up. However, seeing as the vegetation in the meadows does not indicate a depleted soil (over-abundance of English ryegrass and soft rush), we feel this is unlikely. Next to the vegetation indication, the estate is situated in an agricultural area. In the Netherlands the nitrogen deposition is a national problem.

Furthermore, the organic matter was relatively low. This also meant that less nutrients were retained in the soil. There was a difference in the first 10 cm and the lower 10 cm of the soil sample. The first part consisted of organic material and the second part consisted of minerals. Therefore, the results could have been affected for the different layers of soil when they were mixed. Lastly, and probably most relevant, it had been a very wet year. There had been quite a lot of rain at the end of summer and in autumn. This could mean that a lot of nitrogen had been leached before our sampling, and there was not a lot of soluble nitrogen left. It could also have influenced the pH of our soil. The rainwater could affect the levels of pH in the soil and be more acidic, as the pH of rainwater was slightly acidic around 5.0 . The level of pH could also decrease with the use of fertilizers, as already happens in the orchards. In the end, this measurement were only a snapshot of reality. We recommend that the soil analysis is repeated in a different season, to get a better understanding of the situation.

Conclusion

Due to the fact that the results of the soil analysis were not clearly evident, it's challenging to draw conclusions. Because of that we recommend the following ACT group to repeat the soil analysis. During the winter season the soil measurements could be affected from numerous factors, hence on spring hopefully the results would be more reasonable. Afterwards, a comparison of the results to observe the differences between winter and spring. We suggest to the next group for the soil analysis to sample only the first 10 cm of the soil, so the layer differentiation won't affect the results.

Tree diversity

Introduction

The diversity of trees provides ecosystem services and can be beneficial for wildlife, species richness and forest resilience (Ampoorter et al., 2020; Tedersoo et al., 2016). A variety of tree species can facilitate the support of different insects and birds, provide them with food, shelter, nesting and breeding sites. Therefore, in order to provide advice for future research and additional management, it is important to get a complete knowledge of the current tree species present on the estate and their significance within the biodiversity.

Assessing the tree coverage into forest areas can be effective to monitor tree composition (Lwin et al., 2019). It becomes easier to recommend different management approaches (Lwin et al., 2019). Tree cover directly impacts the availability of the understory resources, such as light, nutrients and water, thereby influencing the growth of understory plant cover and composition (Ren et al., 2022).

Dead wood can promote biodiversity through various ways. Primarily, it enhances the diversity of saproxylic, wood-dependent, species that rely on dead or decaying wood (Sandström et al., 2019). This creates microhabitats suitable for different species, including birds that use them as breeding sites (Doerfler et al., 2018). Moreover, dead wood acts as a host for a wide variety of fungi, further

promoting biodiversity (Tláskal et al., 2021). The dead wood initiates change in the canopy by opening gaps and affects the light availability to the understory (Doerfler et al., 2018).

The presence of multiple canopy layers is linked to greater biodiversity within the vertical structure (Toivonen et al., 2023; Hinckley, 2012), and is usually assessed by counting the layers of foliage (Franklin & Van Pelt, 2004). Estimating the understory cover is essential as it is a good indicator of increased biodiversity, facilitating the prediction of potential animal diversity (Crespo-Peremarch et al., 2018; Botequim, 2021).

Finally, conducting a survey to evaluate the occurrence of tree-related microhabitats (TreM) is valuable to complete the assessment of biodiversity value of the coppice system. They are defined as well-delineated morphological singularities occurring on living or standing dead trees which constitute crucial substrates for various species, as they provide specific conditions, notably microclimatic conditions, where specialized taxa shelter, forage or breed (Larrieu et al., 2021).

Methods

Tree cover

For the assessment of the tree diversity in the coppice systems, we estimated the tree cover per species, evaluate the presence of lying dead wood and examine the various microhabitats. Two coppice areas are found on the estate, one big and one small. Their locations are shown on the map below in the result section (figure 17).

In the beginning, we walked around in the stand to identify the species growing in each coppice system. We attempted to cover the entire area by walking around it to have a clear view of the current variation present in the stand. We only considered the tree species and the shrubs with a height of more than 2 meters. To estimate the cover of each species we used the crown projection of individual trees on the ground. After the crown projections of individual trees were summed up, we classified the species into 7 categories of tree cover. The categories are divided as follows: 1-4%, 5-10%, 11-20%, 21- 40%, 41-60%, 61-80% and 81-100%. We identified the rare species that have a low coverage, in order to have an overview of the current state of the stand. When the stand was very dense the total number of the tree cover could be more than 100%. Then, we researched in the literature information on the value for biodiversity of the encountered species.

Amount of lying dead wood

We estimated the volume of the lying dead wood, by using the line intersect sampling method. Following Huber's method, we only measured the dead stems that crossed the intersect and that had a diameter (in the middle) of 10 cm or more (Huber, 1828). We chose a random point by having one person walk around the area while the other called out "stop" randomly. Then we laid down a line in that direction and placed a second rod at 40-meter distance on the line. Creating the intersect, we measured the diameter of each intercepted log. To estimate the diameter, we measured the perimeter at the midpoint of the log's length using a tape measure and then estimated the diameter using the formula: $d = \frac{C}{\pi}$, (where d represents diameter, C represents circumference). Identification of the tree species was conducted whenever possible, considering the winter season and most of the trees are without leaves or exhibited a higher decomposition rate. The dead wood's decomposition class was classified into 5 classes, as mentioned and shown in table 4 and figure 15 below.

Table 4. *Decomposition class for lying deadwood regarding to decomposition phase, present percentage bark and presence of branches and branchlets.*

Decomposition class	Decomposition phase	Present percentage bark	Branches and branchlets
1	Fresh dead wood	>50% present	Present
2	Superficially decomposed	<50% present	Only branches >3cm
3	Moderately decomposed	Not present	Not present
4	Mostly decomposed	Not present	Not present
5	Remains in the litter layer	Not present	Not present

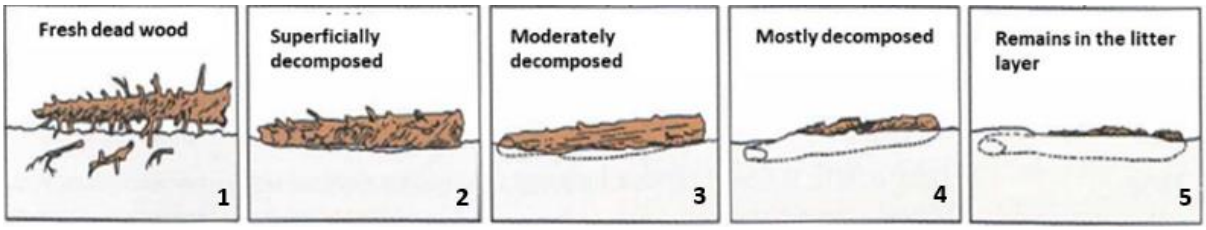


Figure 15. *Illustration of the decomposition phase for each class 1-5 for lying deadwood. Source: Peña Claros, 2023.*

Vertical structure

To define the vertical structure, we conducted a walk around the coppice systems and evaluating the distinct foliage layers present. This involved assessing the number of layers among shrubs, the levels in the tree stems and the composition of the understory layer.

Tree-related microhabitats

We used the current typology of Larrieu et al. (2018), that defines 47 TreM types, and selected the ones that are thought as encompassing the most variety in utility for biodiversity of TreM in broadleaved species: the cracks, the burrs and cankers, and the amount of crown deadwood (Larrieu et al., 2021). Table 5 displays the definitions of the surveyed TreM along with their size thresholds to be included in the survey, and their utility for biodiversity. Figure 16 provides illustrations of TreM types. In order to evaluate the present conditions of the microhabitats within the coppice systems, we conducted a walk throughout the forest. During the walk we identified the TreM types and other factors associated with enhanced biodiversity, such as fungi, within the coppice.

***Table 5**. Surveyed TreM: definition, size threshold for inclusion in the survey, and utility for biodiversity according to Larrieu et al., (2018).*

TreM type	Definition	Size threshold for inclusion in survey	Associated biodiversity
Crack	Crack through the bark and the wood, exposing the sapwood and the heartwood	Length > 30cm Width > 1cm Depth > 10cm	Insects (Coleoptera, Diptera); Arachnids; Gastropods; Birds; Bats; Fungi; Lichens
Burr	Proliferation of cell growth with rough bark	Largest diameter > 20cm	Insects (Lepidoptera); Bryophytes; Fungi
Canker	Dead sections of bark on branches or main trunks of trees	Largest diameter > 20cm or large part of the trunk covered	Insects (Lepidoptera); Bryophytes; Fungi
Crown deadwood	Dead branches *and/or* Dead top *and/or* Remaining broken limb	1 branch diameter > 10cm, or > 10% of the crown is dead and branches diameters > 3cm Diameter > 10cm at the base of the piece of deadwood Broken end diameter > 20cm, length of the remaining piece > 0.5m	Insects (Coleoptera, Diptera, Hemiptera); Arachnids; Birds; Fungi; Lichens

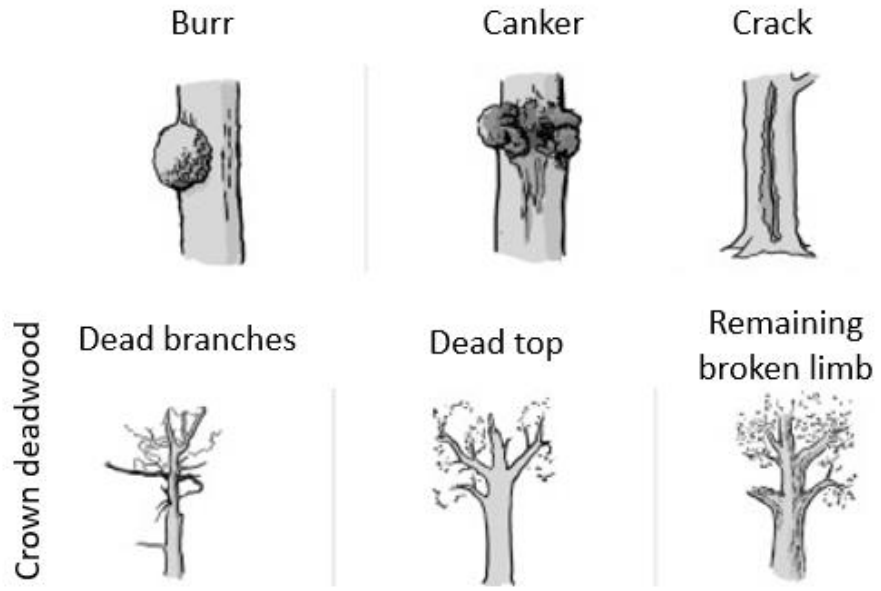
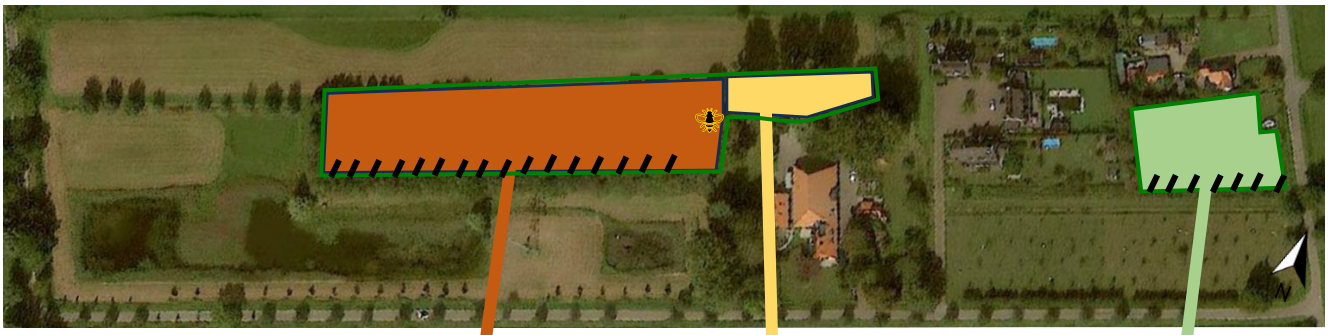


***Figure 16**. Illustration of surveyed TreM with their associated size thresholds for inclusion in the survey. Source: Larrieu et al., 2018.*

Results

Based on the results on the tree monitoring in the two coppices of the system, we identified 3 main different areas (the big coppice was divided into two parts, A and B). They are shown on figure 17 with an overview of the main species and characteristics.



Recently planted, more biodiverse border

Big coppice _ A:

Heterogenous, young and old trees

European ash	Common hawthorn	Black alder	Sycamore maple
Fraxinus excelsior	*Crataegus monogyna*	*Alnus glutinosa*	*Acer pseudoplatanus*

Big coppice _ B:

Homogenous, young shouts (1-5 years)

European ash	Black alder
Fraxinus excelsior	*Alnus glutinosa*

Small coppice:

Homogenous, young shouts (1-5 years)

European ash	Black alder
Fraxinus excelsior	*Alnus glutinosa*

Figure 17. *Overview of the main characteristics and dominant species of the three distinctive coppice stands on the estate. Sources: Netherlands Space Office, 2023.; Flanagan, 2013; East West School of planetary herbology, n.d.; European forest genetic resources programme, 2003; Olaf Op den Kamp, 2021.*

Table 6. *Observed species in the three main distinctive areas in the coppices of the estate. The cover class typology indicates the proportion of the canopy which is occupied by a species and is as follow: 1 = 1-5% ; 2 = 5-10% ; 3 = 11-20% ; 4 = 21-40% ; 5 = 41-60% ; 6 = 61-80% ; 7 = 81-100%. The " * " following a species name indicates that this species was present only in the south border of the corresponding area (with the biodiverse meadow in the part B of the big coppice, and with the Klompenpad in the small coppice), which was more biodiverse because recently planted.*

Stand	Vertical structure	Species scientific name	Species English name	Species Dutch name	Cover class
Big coppice A	5 levels, all entangled together	*Crataegus monogyna*	Common hawthorn	Eenstijlige meidoorn	4
		Salix sp.	Willow	Wilg	1
		Cornus sanguinea	Common dogwood	Rode kornoelje	1
		Corylus avellana	Common hazel	Hazelaar	1
		Alnus glutinosa	Black alder	Zwarte els	3
		Ligustrum vulgare	Wild privet	Wilde liguster	2
		Acer pseudoplatanus	Sycamore maple	Gewone esdoorn	3
		Fraxinus excelsior	European ash	Es	5
		Viburnum opulus	Guelder rose	Gelderse roos	1
		Sambucus nigra	Elder	Gewone vlier	1
		Betula sp.	Birch	Berk	2
Big coppice B	3 levels but including one by the planted tree and bushes on the south border. Inside the coppice, only 2 layers (brambles / saplings; and trees). Different sub-stands corresponding to different tree height and age.	*Crataegus monogyna*	Common hawthorn	Eenstijlige meidoorn	1
		Acer pseudoplatanus	Sycamore maple	Gewone esdoorn	1
		Alnus glutinosa	Black alder	Zwart els	5
		Fraxinus excelsior	European ash	Es	5
		Betula sp.	Birch	Berk	1
		Salix caprea *	Goat willow *	Boswilg	2
		Viburnum opulus	Guelder rose	Gelderse roos	1
		Corylus avellana	Common hazel	Hazelaar	1
		Sambucus nigra *	Elder *	Gewone vlier	1
		Ligustrum vulgare	Wild privet	Wilde liguster	1
Small coppice	3 levels but including one by the planted tree and bushes on the south border. Inside the coppice, only 2 layers (brambles / saplings; and trees)	*Alnus glutinosa*	Black alder	Zwarte els	4
		Fraxinus excelsior	European ash	Es	4
		Viburnum opulus	Guelder rose	Gelderse roos	1
		Salix sp.	Willow	Wilg	2
		Corylus avellana	Common hazel	Hazelaar	1
		Ligustrum vulgare	Wild privet	Wilde liguster	1
		Prunus padus	Bird cherry	Gewone vogelkers	2
		Quercus robur	Pedunculate oak	Zomereik	1
		Ligustrum ovalifolium *	Garden privet *	Haagliguster	1
		Malus sp. *	Apple tree *	Appel	1
		Cornus sanquinea *	Common dogwood *	Rode kornoelje	1
		Sorbus aucuparia *	Rowan *	Wilde lijsterbes	1

Big coppice A, heterogenous

The A part of the big coppice was the forested area with the highest species diversity and structural heterogeneity. In terms of cover, the main species were the European ash, the common hawthorn, the black alder, and the sycamore maple. If some trees seemed to be managed like in a traditional coppice (with old stumps but young shouts and branches), the stand presented many older and higher trees. We identified 5 foliage layers, entangled together. Many bushes (like wild and garden privet) were present in the understory, and the grass layer covered 10% of the ground (the rest being tree leaf litter, and small branches). Many young saplings were present, most of them belonging to the sycamore maple, the pedunculate oak and the European ash species. We also observed common nettles (*Urtica dioica*; grote brandnetel).

Big coppice B and small coppice, similar and more homogenous

The small coppice and the B part of the big coppice both presented a similar more homogenous structure. Both stands were largely dominated by the black alder and the European ash but presented a higher tree biodiversity on their south border (with the biodiverse meadow for the part B of the big coppice and with the Klompenpad for the small coppice) where different species were recently planted.

In the understory, we observed a lot of tree regeneration, mostly of pedunculate oak and elder in the part B of the big coppice, and pedunculate oak and sycamore maple in the small coppice. Himalayan blackberry brambles (*Rubus armeniacus*; dijkviltbraam) were present in both stands. It covered only up to 5% in the big coppice part B whereas in the small coppice it represented 50% of the understory, which made some places inaccessible. Apart from the brambles and the tree saplings, common nettles were observed in the big coppice part B, but not in the small coppice. In both stands, few grasses and herbs were observed, and bare soil covered with litter represented a large part of the understory.

Overall, both stands displayed 3 different foliage layers, but they were not as entangled as in the part A of the big coppice. At a given location, the inner part of both stands presented two foliage layers, one for of the brambles/ bushes/ tree saplings), and one for the canopy. The third layer was provided by the recently planted south borders. In the big coppice part B, even though trees close to each other had the same height, several sub-stands corresponding to different tree age and height could be observed.

Deadwood and microhabitats: similar observations on all stands

No dead logs above 10 cm of diameter were found on the intersects, which indicates a low amount of lying deadwood in the big coppice, in both A and B parts. The same observation was made in the small coppice, except for the large logs that were recently cut and will be removed. However, a wall made of branches was built at the south border of the big coppice B, to provide a habitat for insects and small animals. We also found two standing dead stumps, as displayed in figure 18.

Figure 18. *Picture of a standing dead stump in the big coppice part B (23/11/2023).*

In the three stands, none of the TreM suggested by Larrieu et al. (2021) (cracks, crown deadwood, cankers and burrs) was found. However, we noticed other TreM types described in Larrieu et al. typology (2018): fungal fruiting bodies (figure 19a), small chimney trunk/branches rot-holes (figure 19b), and bark loss associated to insect galleries (figure 19c). Small chimney trunk/branches rot-hole were quite common as they appeared on the scars of the logged branches.

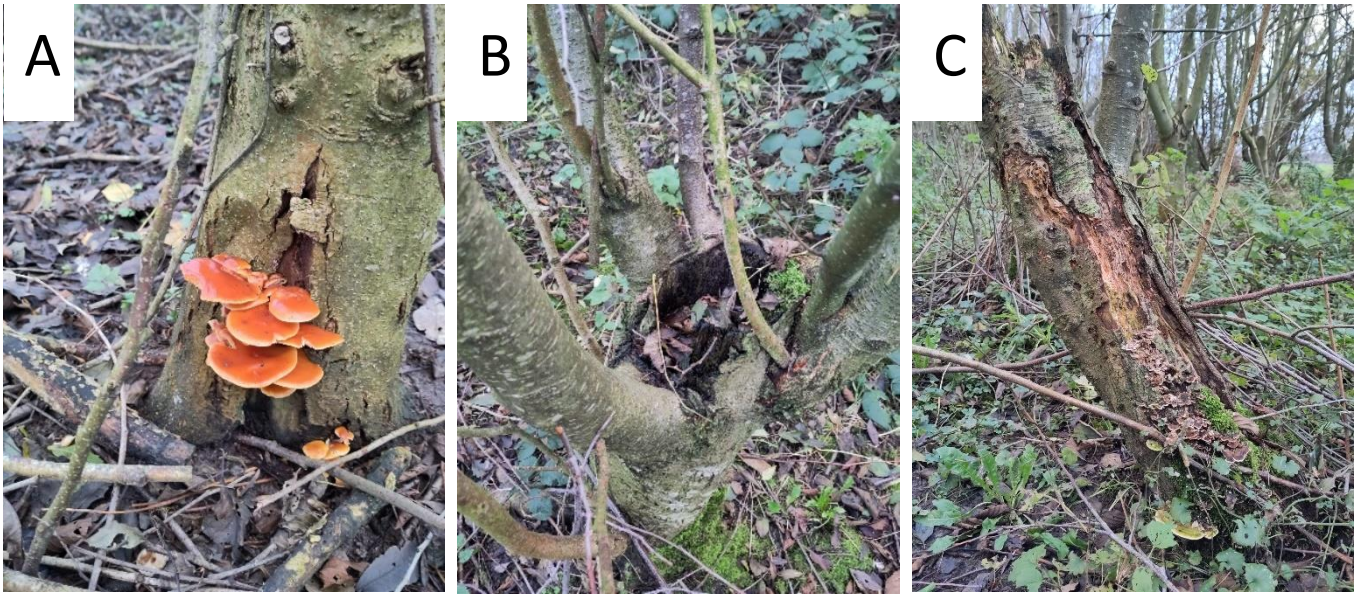


Figure 19. A: fungal fruiting bodies. B: small chimney trunk rot-hole. C: bark loss associated to insect galleries found on the estate (23/11/2023).

Discussion

Intrinsic value of tree species for nature conservation

Almost all tree species present on the estate are common in the Netherlands and their conservation status is described as of least concern by the International Union for the Conservation of Nature (IUCN) in their Global Red List classification (IUCN, 2023). The European ash and the goat willow are two small exceptions. The European ash is classified as near threatened on the world level by the IUCN, which means that its conservation status is not threatening yet but that it is getting closer to being classified as endangered. However, the population at the local level is not worrying as it is described as a common indigenous species in the Netherlands in the WUR tree database (Goudzwaard, 2012). The goat willow conservation status is classified of least concern in the global Global Red List (IUCN, 2023) but the species is described in the WUR tree database as an infrequent indigenous species in the Netherlands (Goudzwaard, 2012). For these reasons, the two species have a special value for biodiversity conservation.

Value for wildlife

Utility of tree species for biodiversity

The largest part of the coppice systems consists of black alder and European ash. Black alder is known for its characteristic to fix nitrogen (Hugues et al., 2010). In the Netherlands following specific alder plantation in order to minimizing the water banks of erosion and keep in balance water temperature and nutrient availability (Hugues et al., 2010). European ash is a good indicator of high biodiversity due to its bark's richness in nutrients and a higher level of pH (Lévesque et al., 2023). Fungi, mosses and insects derive benefits from these qualities and thrive easily within the bark of the European ash (Lévesque et al., 2023). Additionally, the litter it produces is rich and easily decomposable. This prevents the soil acidification, allowing for the efficient nutrient cycles restoration due to high quality litter it produces (Desie et al., 2020).

Common hawthorn can be found only in the big coppice, the most diverse part, providing food, shelter to insects and birds. During the blooming season, different species of insects can source their food from the nectar and pollen given by the common hawthorn (Fichtner et al., 2021). Birds utilize the common hawthorn to create nesting shelters and feed on the red berries produced by the bush around August (Fichtner et al., 2021).

The presence of sycamore maple growing only within the big coppice, along with a numerous regeneration in the understory, contributes to the increase of biodiversity. Numerous epiphytes, herbivores and ground flora are growing because of the presence of maple (Hein et al., 2009). Sycamore maple contributing through litter by improving humus formation and nutrients cycling (Collet et al., 2008). After canopy opening, sycamore maple can grow rapidly and is really common to find a lot of maple regeneration in the understory.

Wild privet, while presents in all the areas of coppice systems on the estate, provide food for animals with the production of ample of seeds (Enescu et al., 2015). Important contribution of wild privet in the soil improvement, in both physical and chemical soil features.

Beside their own value for nature conservation, trees are valuable to wildlife as they provide food, shelter, and sites for reproduction.

Food

When blooming, trees produce nectar that bees and other insects feed on. Their fruit seeds are usually eaten by small mammals and birds. A large diversity of tree species blooming and ripening time at a given location ensures food is available throughout the whole year. On the estate, the tree species bloom from January to July, and there are ripening fruit and seeds from June to January (see appendix D for the phenological tables). On one hand, this means that from August to December, less food is available to insects. It would be interesting to promote species blooming later to ensure a continuity in nectar supply. Moreover, in January and February, only the Hazel is flowering, which makes this species even more valuable. Even if it represents a small part of the canopy cover, it is present in all 3 stands, and can provide early food for insects over a large part of the estate. On the other hand, the ripening period of tree species is largely spread through the year on the estate. The gap between February to May is hardly avoidable, but some species produce seeds that can last a few months, like hazelnuts or maple winged seeds, which can be used by birds and mammals during the winter. Oak acorns would also be a valuable source of food, but despite the presence of many saplings, only one adult individual was found, in the small coppice.

Substrate and shelter

Overall, the forested areas of the estate display a high structural heterogeneity, which can provide various kinds of habitats for wildlife. The structure could be improved in the traditionally managed coppices (small coppice and big coppice part B stands), which are more homogenous in their inner part, at a given location. However, on a slightly larger scale they still provide a high degree of spatial heterogeneity as they display various foliage layers due to the juxtaposition of stands with different tree ages. This promotes wildlife biodiversity (Kirby et al., 2017).

We did not observe the main TreM recommended by Larrieu et al. (2021) (cracks, crown deadwood, burrs, and cankers). This is probably due to the difference between coppice and high-forest development. Indeed, the recommended thresholds are probably too high when applied to a coppice system. The other microhabitat types that we observed are also very valuable for biodiversity. In particular, even though no trunk was actually forming a chimney, we observed rotting remaining parts of cut branches on almost every tree, which can sustain various organisms like fungi.

Although many branches were present on the ground, no big deadwood was found on the intersects in all coppices. It would be interesting to increase the amount of lying deadwood. Standing dead wood is even more valuable than lying dead wood. The presence of snags into forest stands creating different kind of microhabitats and enhance the biodiversity in the area (Paillet et al., 2017). Microhabitats could be beneficial for different kinds of species, such as birds for foraging or as breeding sites (Doerfler et al., 2018), beetles and fungi.

Understory

Our observations support the hypothesis that the coppices on the estate provide good conditions for the development of a grass layer in the understory. Indeed, the various oak saplings indicate high light conditions on the ground of the coppice. This suggests that the apparent lack of grass layer may be due to the winter. Further research should be conducted in the spring to evaluate the grass and herbs cover and biodiversity, and to check whether interesting understory species are present, which is seen as a common by-product of coppice systems. However, compared to traditional coppices where the

soil conditions are in general poor due to a high export of nutrients (consumption of wood and litter) (Kirby et al., 2017), it is suspected that the nitrogen level of the soil is high, as indicated by the presence of nettles, and nitrogen-fixing black alder. This could prevent the establishment of some species that would thrive in poorer soils. Furthermore, the expanding brambles could be a threat to the understory vegetation if they become too invasive. Himalayan blackberry bramble is moreover an exotic species which can outcompete other brambles species (N. Groendijk, 20-11-2023).

Scope and limitations

The research was conducted in November. Almost all trees had lost their leaves. It made the identification more difficult. Although the survey was done carefully, it is possible that some trees were misidentified, or that some species were not noticed. Moreover, it was difficult to draw conclusions on some elements. For example, to properly assess the understory, information on which species are present in the spring are needed. Finally, we did not look at all trees on the estate. Only the coppice areas were taken into account.

Conclusion

Species

We identified 16 tree species in the coppices of the Lieskamp. The most abundant species were the European ash and the black alder. All tree and shrub species in the coppices of the Lieskamp are common in the Netherlands. Although also common in the Netherlands, the European ash, one of the most abundant tree species on the estate, has a special value for tree biodiversity as it is considered as near threatened in the world in the IUCN Red List.

Blooming and ripening periods

There is a lack of tree and shrub species that bloom late in the year, which means few resources for pollinators from August onwards. Common hazel is very valuable for early insects as it is the only early blooming species. There is no ripening fruit on trees and shrubs between February and May, which means less resources for small mammals and birds in the winter. This is compensated by the trees and shrubs which produce seeds that can be conserved for several months, like the European oak that produces acorns, and the hazel and its nuts.

Structure

The distinctive coppice stands on the estate display diverse structural features, which brings an overall high structural heterogeneity. This can provide different habitats and sheltering places, which can support a wide range of wildlife. The traditionally managed coppices (the small coppice, and the part B of the big coppice) are more homogenous inside, with trees close together having the same age and height.

Deadwood

Little big deadwood was found, both regarding lying and standing deadwood. Increasing the amount of big lying logs and standing dead trunks would provide habitat for many fungi and insects.

Microhabitats

Most trees were too small and young to host the main microhabitats described in the literature. However, other TreM were observed, with starts of rot-holes in the trunk or in branches being the most abundant. This can provide a habitat and a substrate for fungi and insects.

Understory

Coppices are often associated with a specific understory flora, which takes more and more importance for nature conservation as coppices are declining. Almost no grass was observed in the coppices. However, abundant tree regeneration, especially of oak, indicates good light conditions which could be favourable to the establishment of grass and herbs species in other seasons. This should be monitored by the future spring research groups. Himalayan blackberry bramble, an exotic species of brambles, could be a threat to the establishment of understory plants, if too invasive. However, brambles provide food and shelter for many animals, so having some on the estate is also a good resource for part of the biodiversity.

Small mammal diversity

Introduction

Small mammals, especially mice, are often perceived as intrusions that ruin harvests, plunder kitchen cupboards, and bring diseases. They are, however, also a very important part of a healthy ecosystem, which is why we wanted to research them. Small mammals play a few important roles in the ecosystem. Firstly, they fulfil the role of an ecosystem engineer (Dickman, 1999): the ability to alter their environment thus creating more niches and therefore more possibilities for increased biodiversity. They engineer their environment by for example building nests, digging tunnels, and foraging on plants. This could improve biodiversity by suppressing the density of dominant plant species (Huntly & Reichmann, 1994; Andersen, 1987). Secondly, small mammals disperse seeds, improving plant distribution. Thirdly, they function as food source for all kinds of predators (Sunyer et al., 2016), so their biodiverse presence could also potentially increase the diversity of predators. This means that a high diversity of small mammals could help increase biodiversity of other taxonomic groups as well. Lastly, small mammals can also be used as indicators of ecosystem integrity (Avenant, 2011). This means that small rodent diversity and richness decline with the degradation of habitat and the number of specialist species serves as indicator of successional process. So, we wanted to find out which small mammalian species occur on the estate, because then we can infer something about the ecosystem integrity of the estate. These were all reasons as to why we want to improve small mammal diversity on the estate and to do so we first need a baseline measurement to map the current state.

Methods

In order to get a good estimation of biodiversity of small mammals on the estate, we used walk-in traps that we borrowed from the NJN (Nederlandse Jeugdbond voor Natuurstudie). The traps contained hay, fruit (apple and carrot) and mealworms, so that both the herbivorous mice and the insectivorous shrews had enough food. We were aiming to catch small mammals like mice, shrews and possibly martens. The traps were left on the estate for two weeks (for an example of a trap set-up, see figure 20) and data was collected about what different species occur on the estate. Tessel had knowledge on mice diversity through previous experience with the NJN and also conducted small interviews with experts from the NJN to gather more detailed information about setting up a small mammal research. Setting up 20 traps per land use type and sampling for four days is a proved method to get a trustworthy estimation of the small mammal populations on the estate. We chose not to do a capture-mark-recapture method, since mice are known to re-enter traps on purpose, thus causing noise in the data. A permit for the research was provided by the Zoogdiervereniging, and in return the collected data was send to them.

Figure 20. *Two examples of the walk-in traps we were using in the gathering of the small mammals (approximately 25 cm long and 10 wide).*

We set up a total of 80 traps, divided over four different land use types: grass-dominated meadow, biodiverse meadow, sheep grazed meadow and coppice (for locations of the traps, see figure 21). A more elaborate map can be found in appendix E.1. The traps were placed in pairs, so that there were 10 points with two traps each in every land use type. We based our choices for the locations of the traps on an equal distribution over the land use type, and on getting as many niches in there as possible. This meant, for example, placing one trap in the grass-dominated meadow close to the ditch and one close to the edge of the coppice or close to a small bush of nettles. After a tip of the owner of estate about mice sightings in the chicken coop, we placed one extra pair of traps there as well.

Figure 21. *Map of the Lieskamp estate with circles that indicate the locations of the pairs of small mammal traps. The different colours indicate the different land use types where the traps were placed: dark yellow = grass-dominated meadow, light green = biodiverse meadow, dark green = coppice, orange = garden, red = orchard, white = sheep grazed area, light yellow = chicken coop, blue = water body, dotted grey = klompenpad, bee symbol = honeybee hives. Source: Netherlands Space Office, 2023.*

To increase our chances for proper results, we did pre-baiting for 8 days before activating the traps. This entailed filling the traps with food and putting them in the field without activating them. This way the mice got used to the traps and to finding food inside of them, but only got caught once we started the activation. When placing the traps, we made sure the corridor was lower than the chamber to prevent flooding. While putting out the traps we entered their coordinates on a map with a corresponding number to make sure we could find them all back, especially during the night.

On the morning of the 27th of November, we restocked the food in the traps and activated them. From this point onwards the gathering of the data started (figure 19), by emptying the traps two times a day and writing down the species and the location where it was found. We emptied the traps by shaking the content of the trap into a plastic bag and carefully looking at defining characteristics to identify the species. This way the mice mostly didn't have to be handled manually and this reduced a lot of stress for them. After emptying we put back the contents of the trap, refilled food (with special care for putting enough mealworms), and checked that the trap was activated. We made sure we stayed put for 20 seconds after the release of the mouse so that it got away safely.

Figure 22. *Catching mice and restocking traps.*

After 4 days of sampling, we removed the traps and cleaned them thoroughly to prevent a potential spreading of pathogens. An overview of all our activities regarding the small mammals is summarised in appendix E.2.

Results and discussion

Over the course of the four days, we caught a total of 44 small mammals: 10 shrews, 14 true mice and 19 voles. We caught small mammals of five different species: greater white-toothed shrew (*Crocidura russula*; huisspitsmuis), common shrew/ Millet's shrew (*Sorex spec.*; gewone/ tweekleurige bosspitsmuis), wood mouse (*Apodemus sylvaticus*; bosmuis*),* house mouse (*Mus musculus*; huismuis), and bank vole (*Myodes glareolus*; rosse woelmuis) (figure 23).

Catching 44 mice in four days is less than we expected, but it can be explained by the following reasons. Firstly, it is winter and mouse populations fluctuate a lot during the year, depending on available food stocks and seasons (Andreassen et al., 2021). Maybe we were just unlucky and in spring there will be more mice. Secondly, we did our field work when temperatures were around the freezing point, with even some snow on a few days (figure 20). This may have caused the mice to be less active and therefore end up less in our traps. Lastly, the estate is possibly just not very rich in mice, since a big part consists of open vegetation and mice generally need more shelter to thrive. It is also important to consider the fact that at least three cats roam the estate and they are extremely detrimental to small mammal populations. House cats in the Netherlands are responsible for killing approximately 64.000.000 of mammals every year, mainly mice and among which also endangered species (Knol, 2015). So, the presence of these cats probably has an enormous adverse effect on the small mammal abundance on the estate.

Figure 23. *Pictures of the five mammal species we found in the mouse traps, left to right: greater white-toothed shrew (Crocidura russula), common shrew / Millet's shrew (Sorex spec.), wood mouse (Apodemus sylvaticus), house mouse (Mus musculus), and bank vole (Myodes glareolus).*

Species abundance

An overview of what species we found in which land use type and in how many different traps, can be found in table 7. More elaborate data in appendix E.3. We found the bank vole the most often (19 times), followed by the wood mouse (11 times), and the greater white-toothed shrew (7 times). We found one shrew that cannot be identified in the field, because you can only tell the common shrew and Millet's shrew apart by looking at DNA and skull characteristics and this was obviously impossible in this project. So we noted it down as common shrew/ Millet's shrew. Lastly, we found the house mouse only three times, but this data is skewed since we only placed the traps in the chicken coop when Martine (owner of the estate) gave us the tip, after two days of measuring. So, it could be possible that there are actually more house mice present.

Table 73. *An overview of all the mice we caught and over how many different traps they were distributed during the week.*

Land use type	Common shrew / Millet's shrew	# different traps	Greater white-toothed shrew	# different traps	Wood mouse	# different traps	House mouse	# different traps	Bank vole	# different traps
Traditional meadow	1	1	3	2	-	-	-	-	-	-
Biodiverse meadow	-	-	2	1	-	-	-	-	19	3
Coppice	-	-	2	1	9	4	-	-	-	-
Sheep grazed	-	-	-	-	2	1	-	-	-	-
Chicken coop	-	-	-	-	-	-	3	2	-	-

Some species we came across a lot in our traps, like the 19 bank voles we found in the biodiverse meadow. This seems to indicate a great abundance of this species. However, it is important to note that these bank voles were only caught in three different traps (table 7). It can be that they were all different individuals, but it is more likely that the same mice kept returning to the traps. We saw this phenomenon with the wood mice as well and also with the greater white-toothed shrew, although to a lesser degree. This can be explained by the fact that some mice are known to be relatively trap happy. They know they can find food and shelter in the traps, so keep getting caught on purpose. We expected this to happen, which is why we will not try to infer a population size of the mice species based on our data. This means we can only conclude that there are populations of at least five small mammal species present on the estate, but nothing can be said about their abundance.

Small mammals in different land use types

The distribution of the species we found over the different land use types makes sense, since they correspond to the normal habitats of the species (table 8). All the species we found are common species and none are very critical of their habitat. They mostly only need a certain amount of shelter to be able to build their nests, find food, and hide from predators (Twisk et al., 2010). Especially for bank voles it has been proved that structural elements have a positive correlation with their occurrence (Ecke et al., 2001).

Table 84. *The habitats of the five small mammal species we found on the estate (Twisk et al., 2010).*

	Greater white-toothed shrew	**Common shrew / Millet's shrew**	**Wood mouse**	**House mouse**	**Bank vole**
Habitat	Everywhere, but not in very dense forests.	All types of grasslands and forests, as long as there is ground covering vegetation.	Mostly forests, but everywhere with shelter. Doesn't occur in very wet areas or open meadows.	Everywhere humans are. Also outdoors if there are no other mouse species present.	Very common, in deciduous and mixed forests. It needs shelter and good shrubs and herb layer.

There were a few things that stood out about the places where we found certain species. One would not expect the common/ Millet's shrew in the grass-dominated meadow since it is a very open environment. However, the trap we found it in was next to the water side with lots of reed, so there is considerately more shelter here than in other parts of the grass-dominated meadow. This is the same trap where we found the greater white-toothed shrew, so this also makes sense. The rest of the grass-dominated meadow seemed to be depleted of small mammals. It is however important to keep the seasonal fluctuations of mice populations into mind. It could be that in spring and summer, when the vegetation provides more cover, there are small mammals populations that take their refuge here.

The sheep grazed meadows (including the orchards) were also very open and this is reflected in the small number of mice we found here. Only in one trap, next to the fence that was close to the ditch we found some wood mice. This indicates very little mammalian activity in these parts and we don't expect it to increase much in other seasons, since vegetation will still be very open due to the sheep grazing. Furthermore, it is known that intense grazing negatively effects small mammal densities, while a medium amount of grazing positively effects it (Schmidt et al., 2005). So the absence of mice on the sheep grazed meadow can be an indication that the grazing pressure might be too high on the grazed meadows for optimal mammalian biodiversity.

We expected the biodiverse meadow to be more diverse, but it was also a very small area, so more than two species would maybe not be realistic due to territory restraints. If the biodiverse meadow would be expended, we expect that more species would settle there.

In the coppice we also found two species, with the bank vole missing while it would be expected there because of the habitat. It also struck us that all the small mammals in the coppice were only found in the big coppice and not in the small one. The camera traps (see next chapter) showed the presence of a hedgehog in the small coppice, which could explain that we did not catch mice there, as hedgehogs can feed on mice. It can also be explained by the fact that the small coppice is simply too small to sustain a healthy population, especially because there is no other structurally diverse land use type nearby like the big coppice that borders with the biodiverse meadow. If the two pieces of coppice were connected by a green corridor, we believe that the small coppice could also be inhabited by small mammal species.

Small mammal diversity on the estate

Since we only found five generalist species on the estate we can conclude that the estate is not approaching its maximum potential and there is still room for improvement. Furthermore, the absence of certain species also says a lot about the state of the biodiversity on the estate. For example the absence of the Eurasian water shrew (*Neomys fodiens*; waterspitsmuis), which is a target species for the municipality of Wageningen (Werkgroep 't Pasje & De Nieuwe Nu, 2022). The Eurasian water shrew needs clean, nutrient poor water in its habitat (Twisk et al., 2010) and at nature reserve 't Pasje new adjustments have been done to facilitate this species. The water quality of the estate was assessed in the research of De Ruiter (2022) and this showed that the ponds on the estate are of reasonable water quality, but the phosphate concentrations exceed the national target level. This could explain the absence of the Eurasian water shrew. Other explanations include: the connection between the estate and its current habitat is inadequate so the species could not reach the estate up to now. Another possibilities is that the species is present but we just didn't catch it since water shrews are relatively hard to catch with walk-in traps (Lange et al., 2003). It would be interesting to dive

deeper into this, by for instance looking for the presence of the Eurasian water shrew in the Binnenveld with walk-in traps and looking through owl pellets of mainly the barn owl and long-eared owl (Lange et al., 2003).

Other species that could be expected on the estate are the pygmy shrew (*Sorex minutus*; dwergspitsmuis) and the harvest mouse (*Micromys* minutus; dwergmuis). The pygmy shrew is very territorial so maybe the estate is too crowded, meaning that the amount of small mammal species already present on the estate is very high, making it too crowded for another species to settle (*Dwergspitsmuis*, n.d.). On top of that they are also so small that they can sometimes enter the walk-in traps without triggering them, so maybe they are present but we just didn't catch them (Twisk et al., 2010). Further research with pitfalls is a possibility, but this is more disturbing for the mice so it is not recommended unless absolutely necessary. Harvest mice live in reed lands, so they are also expected on the estate. Their absence can also be explained by the same reasons. Lastly, all field work has its limitations, so it could also be that these species are indeed present but we just didn't catch them in our traps during our research.

Conclusion

We caught small mammals of five different species: greater white-toothed shrew, common shrew/ Millet's shrew, wood mouse, house mouse, and bank vole. They are all common, generalist species, so they don't say something specific about the state of the biodiversity on the estate. Conditions can still be improved to attract other species, like the Eurasian water shrew, since this is a good indicator of good water quality.

We caught 44 small mammals in total and this is not a lot since we put out 80 traps and emptied them eight times. We have a strong inclination that some individuals kept returning to the trap, so the real amount of unique small mammals we caught is even lower. This is probably due to the presence of cats, not enough shelter and seasonal population fluctuations.

We found most small mammals in the biodiverse meadow and big coppice. This makes sense since there is more shelter. The grass-dominated meadow and sheep grazed meadow has remarkably low densities and it is worth it to improve this.

Camera traps

Introduction

To give an answer to the research question "What is the current state of the biodiversity on the estate" focussing on mammalian species diversity, we used camera traps. This gave an overview of which animal species were located or crossing the estate over time. Management options for the estate could then take into account hiding or feeding places for the different present animals. It would also be possible to create optimal living conditions for a species of interest.

Camera traps do not invade or influence the daily life pattern of animals, and provide information about the presence of different animal species (Silveira et al., 2003; Grotta-Neto et al., 2020). Detection rates of an animal species is not only determined by the abundance of the species itself, but other factors such as body size, movement speed, vegetation, survey duration and others will

influence the detection (Burton et al., 2015). The focus will be on identifying the different species present, not on the abundance.

Methods

In total ten cameras were available to use on the estate. The cameras used were Reconyx Hyperfire 2. Five traps were already attached to a pole, which were placed next to a tree to be able to secure them with a lock. The other five traps were attached to a tree with the help of straps to avoid damaging the tree itself (figure 24). The cameras were active for 7 days in a row, day and night.

Figure 24. *The two different types of camera traps. The left one attached to a tree with the help of straps. The right one on a pole in the ground.*

The cameras were placed in the small and big coppice, to prevent them from being seen from the Klompenpad. It was not possible to place cameras on other parts of the estate because of the visibility. Two cameras were placed in the small coppice, because of the smaller size. The other eight cameras were divided over the big coppice (figure 25). More detailed information about the meaning of the exact locations can be seen in appendix F.1. When the cameras were placed, they were often hidden with the use of trees, brambles or with log piles. This was done to make them invisible from the Klompenpad.

Figure 25. *Overview of locations of cameras in the big and small coppice. Source: Netherlands Space Office, 2023.*

The cameras were set using deliberately biased allocation (Meek et al., 2014; Rovero et al., 2013) to meet the restrictions, both in terms of visibility from the Klompenpad, and accessibility. The irregularity of the trees and coppice itself did not allow to set cameras everywhere, like in the small

coppice where brambles prevented the access to some parts. We did not consider preferred locations for certain animal species. This was not a problem as we achieved a high density of cameras, covering a large part of the available area. In the big coppice we placed one camera per 750 m^2, and in the small coppice it was 1500 m^2 per camera. Finally, there was no specific species of interest, therefore the distance the placement of the camera fluctuated between more and less dense parts of the coppice (Meek et al., 2015).

With the placement of the traps, it was important that nothing obstructed the camera lens. When leaves or grasses were in the detection zone, they were removed. When it was not allowed to remove items, the camera was placed somewhere else. The height of all cameras was between 30 and 50 centimetres, depending on the pole and tree. Poles were placed in the ground until they were steady enough. The camera heights on the trees were not specifically measured, but the focus was on the angle of the camera.

The specific settings of the cameras were determined with the help of experts from the department of WENR. 10 pictures were taken per trigger. The interval of the pictures was set on RapidFire. In order to get also fast or small animals on the pictures, the sensitivity was high or very high depending on the amount of disturbance in the surroundings such as leaves. When it was expected that leaves or trees would trigger the camera fast, the sensitivity was placed high instead of very high. In total 7 cameras were on the setting high and 3 on very high. Every camera also took a lapse picture every 24 hours at 00:00 in order to check if it was still on. We did not activate the video function as the focus of the project was only to get a baseline of the available species, except on three cameras to get illustrative materials.

Results

In total 15 different animal species were captured over 10 cameras. These cameras were all in a different angle, without any overlapping detection zones. In figure 26, multiple results are shown from different cameras on the estate. Multiple species were detected in multiple locations over all days. The species seen in most locations was the common pheasant, which was seen in 7 of the 10 locations (table 9). The species that were seen in only one location were the great tit, red fox, European robin and one species of pigeon (table 9).

***Figure 26**. Selection of pictures of the results from the camera traps. A: Roe deer (Capreolus capreolus), B: European hare (Lepus europaeus), C: Red fox (Vulpus vulpus), and D: European hedgehog (Erinaceus europaeus).*

There was a small difference between the species found in the small and big coppices. In the small coppice 9 different species were found. In the large coppice 13 different species were found. The species that were present in the small coppice but not in the big coppice were the great tit and the pigeon (table 9). The species present in the big coppice but not in the small coppice were the European robin, hare, mouse, rat, red fox and roe deer (table 9). More precise data can be found in appendix F.2.

***Table 9**.5 Overview of species found in the big and small coppices. The number of locations (#) where the species are found.*

Species	**Scientific names**	**Found in # locations**	**Big coppice**	**Small coppice**
Cat	*Felis catus*	3	**x**	**x**
Common blackbird	*Turdus merula*	6	**x**	**x**
Common pheasant	*Phasianus colchicus*	7	**x**	**x**
Eurasian magpie	*Pica pica*	3	**x**	**x**
European hare	*Lepus europaeus*	4	**x**	
European hedgehog	*Erinaceus europaeus*	5	**x**	**x**
European robin	*Erithacus rubecula*	1	**x**	
Great tit	*Parus major*	1		**x**
Jay	*Garrulus glandarius*	2	**x**	**x**
Mouse	*Mus spec.*	2	**x**	
Pigeon	*Columba spec.*	1		**x**
Rat	*Rattus spec.*	3	**x**	
Red fox	*Vulpus vulpus*	1	**x**	
Redwing	*Turdus iliacus*	5	**x**	**x**
Roe deer	*Capreolus capreolus*	4	**x**	

Discussion

The use of camera traps goes hand in hand with multiple potential pitfalls. There is a possibility that the animal passes the camera but is not in the detection zone and the camera is not triggered (Meek et al., 2015). It is possible that the sensitivity of the camera is not high enough, or that the animals are too far away to be in the detection zone (Meek et al., 2015). The study period was relatively short, which could cause a bias and would not give a full overview of all the species present (Rovero et al., 2013). Moreover, this study itself could not give an idea of the density of animal populations on the estate itself. Conclusions could only be made about the number of different species present in this time period.

In the analysis of the pictures, multiple false triggers were available. False triggers are pictures without an animal present or blurry pictures. There are multiple reasons why false triggers are present. First, the placement of the camera itself is important. When there is direct sunlight or shadows in the lens, the picture becomes blurry or unclear. Secondly, it is important that there is no vegetation in front of the camera taking all the light for the night vision (Glover-Kapfer et al., 2019). Next, vegetation such as leaves and trees moving in front in the camera can trigger the camera.

Beside the camera traps other practical measurements were done in the same week. This potentially biased the results from the camera traps. In the usual situation the coppice is not disturbed by humans. During the week of the camera traps, multiple persons walked daily around the locations of the camera traps, especially for looking at the mice traps. Therefore, a lot of pictures contained persons and were not useful at all.

The direction of movement of the animals depends on their behaviour, habitat and density and is hard to determine without marking of specific animals (Burton et al., 2015). No conclusions about the activity pattern of the animals could be taken from the data.

In the following paragraphs, we describe some of the species we found and their ecology. The focus is on mammalian species because the presence of different bird species is seasonally different, and the observed bird species in this research are common all year round in the Netherlands, except for the redwing (Vogelbescherming Nederland, n.d.).

The hedgehog is an omnivorous species, with mostly an insectivorous diet (Robinson & Routh, 1999). The actual diet depends on food availability of the moment in the year (Twisk et al., 2010). The home range differentiate depending on the amount of food available. In forest areas the home range is smaller, whereas the home range in an open landscape can be up to 30 hectares (Twisk et al., 2010). Taken this information into account, it is a possibility that the hedgehog has a home range on the estate itself of nearby. This indicates that food and hiding places availability are sufficient.

The home range of the hare has an average of 26-38 hectares (Lange et al., 2003), preferably in agricultural areas with small parts of forests (Twisk et al., 2010). The estate and its surrounding agricultural areas are thus likely to provide sufficient living conditions.

The habitat of the roe deer consists of a woody area with agricultural land or grassland. The home range differentiate from 12 until 60 hectares (Lange et al., 2003). The estate itself consists only of a few hectares, which means that it can only be a part of the home range of the roe deer. Despite its presence on the estate, there are a lot of lively tree saplings in the coppices, which indicates that the pressure is not too high for tree species.

The red fox is an omnivorous species and feeds on what is available in its home range, for example mice, rabbits, and birds, but also insects, eggs, and fruit (Twisk et al., 2010). Goszczyński (2002) mentioned that the home range of a red fox can vary between a few hectares up to 3000 hectares. It is a very territorial species, which indicates that the estate is probably part of a home range.

Redwings are present in the Netherlands from September until May and they forage on berries, seeds, and worms during the winter period (Vogelbescherming Nederland, n.d.). On the estate, multiple berry trees are present, which can attract redwings in the fall and winter.

Conclusion

In conclusion, 15 different animal species were present on the estate itself. Different small animals were seen on multiple locations. No information could be drawn about the density of the recorded animals. Our results indicated that the living conditions for multiple animals were sufficient to be present in fall/winter on the estate. To increase the living conditions of several animals, additional management options could be given (see section additional management).

Overall baseline summary

To provide an overview of the results and conclusions found in the previous chapter about the baseline assessment of biodiversity on the estate, a summary of the different sections is shown below.

Soil 

- The indicators we looked at (pH, nutrients, OM, moisture) were all low, except for the moisture. The results are ambiguous and not in line with what we expected.
- There are several interpretations that could explain these results. During winter there are many factors which can influence the measurements.
- We recommend that the next group repeats the soil analysis, and only takes the top 10 cm of soil to provide a clearer overview.

Trees 

- 6 tree species were identified on the estate. European ash is considered “Near threatened” in the world by the IUCN Red List.
- There is a lack of late blooming species, which means a low level of resources for insects from August.
- The overall structure of the forested areas of de Lieskamp is heterogenous and can provide various habitats and shelters for wildlife. However, the traditionally managed coppice and more homogenous in their inner parts.
- Little lying and standing deadwood was found.
- There seem to be good light conditions for the development of a grass and herb layer in the understory in the spring. However, brambles could be a threat if becoming too dominant.

Mice 

- Five different mice species were seen on the estate. In the future, we aim to attract the Eurasian water shrew, since this is an indicator of good water quality.
- There were remarkably low densities of mice. This is probably due to the cats presence and the lack of shelter in land use types like the grass-dominated meadow and the sheep grazed meadow.

Camera traps 

- 15 different animal species were seen on the estate, which indicates that the living conditions for these species are sufficient during this time of the year. These sufficient living conditions include the food availability as well as hiding places. These results can help to recommend additional management aiming at increasing the living conditions for the species present at this moment.

Additional management

Beside the measurements we performed for the baseline measurements, we also critically looked at the management of the estate and we came up with a selection of alterations that will improve the biodiversity. We identified target species and proposed additional management practices for the different land use types. We end with some overall remarks.

Target species

Biodiversity is declining globally and the Netherlands is no exception. Attention followed up by action is necessary for the conservation and restoration of biodiversity. It is crucial to focus on active protection of native species. Several indigenous species are under pressure and threatened with extinction. We are obligated to comply with the general duty of care for biodiversity, which indicates that everyone has to pay sufficient care to all wild plant and animal species and their corresponding habitat. Species require abundant and suitable habitats for nesting, foraging, and reproduction, and they must be able to move safely between these functional areas. The connection between these areas is also important for the genetic exchange between populations. Certain organisms are often used as focus species in plans to emphasize on maintaining or improving biodiversity in particular regions. By examining the development of the target species, it can be determined how effective the current management practices are and what additional measures may be necessary. The purpose is to increase the population sizes and enhance the distribution of these target species. Generally, these species are selected based on their level of threat, rareness, and international importance (Doelsoortenlijst: Soort van doelsoortenlijst | Beschermde natuur in Nederland, n.d.).

In the biodiversity plan of the municipality of Wageningen, species such as the black-tailed godwit (*Limosa limosa*; grutto), little owl (*Athene vidalli*; steenuil), grey partridge (*Perdix perdix*; patrijs), European hare (*Lepus europaeus*; haas), weatherfish (*Misgurnus fossilis*; grote modderkruiper), and ragged-robin (*Silene flos-cuculi*; echte koekoeksbloem) have been indicated as focus species for the region the Binnenveld and surroundings (Ter Harmsel, 2023). We suggest to use these target species indicated by the municipality until a more elaborated baseline assessment is conducted. However, for future research we think it may be interesting to focus on, for example, the following species:

- Brown hairstreak (*Thecla betulae*; sleedoornpage)
- Specific wild bee species, such as the large scabious mining bee (*Andrena hattorfiana*; knautiabij)
- Eurasian water shrew
- Barred grass snake (*Natrix Helvetica*; ringslang)
- Bats & swallows

No assessment of current vegetation has been carried out due to seasonal conditions. However, it is suggested for the next research groups to follow the plant community classification that could potentially occur in vochtige hooilanden with their corresponding target species (appendix G). Furthermore, the monitoring assessment on the vegetation within the Groene Grens project can be used as a reference for the target species (Verbeek, 2021).

Management alterations for different land use types

Grass-dominated meadow

To improve the biodiversity on the grass-dominated meadow, there are a few things that deserve extra attention and we believe that changing them for the better could really improve the biodiversity on the whole estate. We will discuss them below.

Soil

One of the bottlenecks in the nature type vochtig hooiland is that the soil can become too acidic for the type-specific species to grow there. According to the subsidy management advise, the pH should ideally be higher than 5.5, but is acceptable between 5 and 5.5 as well. However, if lower than this, the quality is low and there is a chance that the rarer species that can be found in these types of meadows, such as orchids and marsh marigolds, cannot thrive anymore (Bij12,2023a). In our soil analysis we found quite low pH. Even though our soil results are ambiguous, soil acidification is a problem in the Netherlands. Therefore, it is good to keep monitoring the acidity.

An indicator for the acidification of the soil is an increase in species, such as common sedge, velvety bentgrass, lesser spearwort, and purple marshlocks. It is good to keep an eye out for these species, we recommend that these species are kept in mind in further research (Bij12, 2023a).

If these species become too prominent in the meadow landscape, and the soil becomes too acidic it is advised to take measures in management. There are two measures that Bij12 advise. The first one is the application of composted farmyard manure (ruwe stalmest). It is important that the manure has been decomposed properly, which ensures proper mineralisation. It is advised to only apply manure once every three years, to avoid adding too much nutrients. Furthermore, it is possible to lime the soil. For both of these measures it is important to apply after the first mow, and before the wet period. This will help to ensure proper uptake and prevents leaching (Bij12, 2023a).

An alternative to the liming is the use of rock dust. This helps to counteract soil acidification in a more gradual way than usual liming, which limits negative effects of too sudden changes in pH on the soil flora and fauna. For this reason, it is increasingly used in nature areas. For example, this has been used in the Hoge Veluwe in the Netherlands. It is very important to choose the right type of dust, i.e. one that closely matches the mineralogical and chemical composition of the site's parent material (Vries et al., 2019).

Greater yellow-rattle

Furthermore, to enhance the flowering herbaceous vegetation in the grassland, greater yellow-rattle (*Rhinanthus angustifolius*; grote ratelaar) can be introduced. This is an annual plant species with yellow flowers that are mostly visited by bumblebees during their flowering season from May until July. It grows on moderately moist to wet soils with a moderate nutrient level. The greater yellow-rattle is a root hemiparasite of which the host species consist of grasses and legumes (Ameloot et al., 2006). This plant property can be beneficial to suppress dominant grass species, which results in more opportunities for the development of other herbaceous species. However, the greater yellow-rattle can be outcompeted for light when the vegetation becomes too dense. Besides the valuable characteristic to potentially suppress dominant grass species, the presence of the greater yellow-rattle is also beneficial to the nectar supply for wild pollinators, such as bumblebees (Kwak, 2002). With

regard to the management, this is an annual plant lacks forming a persistent seed bank in the soil, so it should be taken into account that a regularly input of fresh seeds are needed (Ameloot et al., 2006).

Sowing seed mixtures

To increase the biodiversity, the plant diversity must be increased. This can be done by sowing local, indigenous seed mixtures with species that occur in the vegetation type of the area. It is important to take local seeds, because that way you preserve local genetic variation and also because of the century long co-evolution of local plants and insects, that causes the native insects to have flying times and pollination techniques in sync with the local plants. There are a few companies that sell seeds of wild, local plants, so we advise to buy seeds for sowing from these stores: De Bolderik, Biodivers or Cruydthoeck. On the estate there are different land use types, and therefore every piece needs a different seed mixture. We give a seed mixture suggestion for the land use types. Since we have little to no information about the plant species that already occur on the estate, because our project took place in the fall, we recommend first monitoring which species occur, and then choosing an appropriate seed mixture. All seed mixtures we suggest are perennial, meaning that they only need to be sowed once. The sowing is best done in the fall, around September or October. We think it would be wise to start with ordering and sowing seeds for about 4 m^2 to test out if they work. It is normal that the first spring the newly sown plants are still not very present, the real results can be expected after. After sowing, the grasslands need to be mowed twice a year and it is important to leave the hay laying on the grounds for five days, so all the seeds can fall out and the plants can regenerate. Before the sowing of the seed mixtures, the soil has to be prepared in order to get rid of the species that now dominate the grassland, like English ryegrass. This can be done by ploughing, milling (fresen in Dutch) or creating a vals zaaibed (false seedbed) (Biodivers, 2021; De Bolderik, 2023). What is necessary to do exactly, depends on the plants present and the soil conditions. If the owners chose to take the advice of sowing seed mixtures to heart, it would be wise to contact the company where they buy the seeds for additional advice. We cannot provide more information now, since we have too little knowledge of the plants species present due to the fall/winter season.

Northern grass-dominated meadow

For the northern part of the grass-dominated meadow, which is vochtig hooiland, we advise to use a seed mixture for wet, flower-rich soils. Also because a lot of the species in the seed mixture are corresponding to the target species of vochtig hooiland, so this mixture helps reach our goal for enhancing biodiversity.

Name seed mixture	GR3; moist to wet, flower rich grassland
Sowing period	March to October
Sowing density	1 gram/m^2
Information	https://www.debolderik.nl/product/gr3-graslandmengsel-vochtig-tot-natte-grond/

Below transmission tower

Since there are restrictions on the height of vegetation below the transmission tower (figure 27) due to safety reasons, we advise to use a seed mixture for low growing vegetation that grows up to a maximum of 40 cm.

Name seed mixture	L2; low growing, flower rich vegetation
Sowing period	March to October
Sowing density	1 gram/m^2
Information	https://www.debolderik.nl/product/laagblijvend-mengsel-tot-40cm-l2/

Figure 27*. Transmission tower on the south side of the estate.*

Southern part of the grass-dominated meadow

On the southernmost part of the grass-dominated meadow, i.e. the strip of land south of the electricity tower, there is a different vegetation present according to BIJ12, namely: bloemrijk grasland. So, here we need to sow a different flower mixture. Since the soil here consists of an upper layer of clay, we recommend using a mixture for heavier soil.

Name seed mixture	GR2; flower rich grassland for heavier soils
Sowing period	March to October
Sowing density	1 gram/m^2
Information	https://www.debolderik.nl/product/gr2-graslandmengsel-zwaardere-grond/

Alongside ponds and ditches

To stimulate the typical vegetation for ditch banks and reed lands, we recommend sowing the following seed mixture:

Name seed mixture	RO1; reed land and banks
Sowing period	March to October
Sowing density	1 gram/m^2
Information	https://www.debolderik.nl/product/ro1-rietland-en-oevermengsel/

Fauna friendly mowing

Mowing is already done quite well on the grass-dominated meadow, with the extra care for the late mowing with a frequency of twice a year to benefit the meadow birds and insects. We, however, also advice to always mow from the centre outwards, working to the edges. This reduces animal mortality by giving them the chance to escape (Green, 1998). Furthermore, to make or to keep the estate suitable for bees and other insects, mowing of grass and reed lands is an important aspect in the management practices. Regardless of the timing of mowing during the year, it is suggested that the estate should always be mowed in phases. At the moment, the owners of the estate are already partly mowing in phases and it is strongly recommended that they continue with this. Mowing of grasslands causes always direct mortality of (in)vertebrates, especially a high mortality of often 50% or more has been observed among invertebrates (Humbert et al., 2009; Wallis de Vries & Knotters, 2000). However, mowing is often the only possibility to prevent the succession process of grasslands, particularly in areas where no grazing takes place. By mowing in phases, sufficient resources, such as food and nesting and hiding places, are available for insects. This aforementioned aspect about mowing in phases is not only important for grassland but also for reed lands. Reed lands are specific habitats, in which the development of certain organisms, such as some specific wild bee species, occur in perennial reed stems. During the winters, it is suggested that the remaining reed part is the same to enhance the opportunities for organisms, but changing it every three years to prevent reed vegetation encroachment. It is recommended that the unmown part consists of 15-30% of the surface (Van Rooij et al., 2020; *Bijvriendelijk maaien*, n.d.). This unmown part does not have to be a contiguous surface, it can also be distributed over several patches. This applies for all year round. Always having an unmown part on the estate is crucial for food resources and hiding places for different kinds of organisms, even during the winter period. Furthermore, it is recommended to mow at least once with a maximum of two times a year. A too high mowing frequency results into many interruptions in the food supply for insects and other animals. However, it is possible to deviate of the aforementioned management practices if first the main goal consist of achieving impoverishment the landscape. This may be necessary in very nutrient-rich situations, where dominant plant species outcompete the biodiverse herbaceous vegetation. If this is the case, it can be an option to mow the certain area completely three times a year, remove the clippings and continue this management for three years. Furthermore, it is important to take the timing of mowing into account. It is crucial to take the time period in which vegetation deposit their seeds into consideration. Especially, certain target plant species for the ecosystem. This time period can differ from year to year, depending on the weather conditions. In general, it is recommended to mow in autumn to promote a more biodiverse ecosystem, because most of the insect populations will not be active during that time of the year. In addition, it is preferred to use light and small materials to mow on the estate. The use of heavy machinery will compress the soil, which negatively affects the soil biota. For example, using heavy machinery can lead to the loss of soil nest of insects (Van Rooij et al., 2020). However, as a disadvantage, mowing with smaller machinery will be more time consuming and less efficient for a farmer.

Stapelmuur

Another aspect to take into account in the management plan, is the importance of the available nesting sites for wild bees and other pollinating insects. In general, the nesting sites of wild bees are characterized by warm and dry conditions. The majority of wild bees in the Netherlands dig their own nests in in the soil, which are preferably open sunny areas with sand or loam, such as steep edges,

sandy paths, and the slopes of dikes and ditches. However, some species nest above ground, and are mainly found in old tree trunks, fence posts, and hollow stems of, for example, reed, blackberry, elder or thistles. There are also the cuckoo bees, which is a parasitic group that benefit from the efforts of other bees (Peeters et al., 2001). An option to enhance the suitable nesting availability on the Lieskamp estate, is to create a stapelmuur: a loosely stacked wall (figure 28).

Figure 28. *Example of a stapelmuur: a loosely stacked wall that provides a lot of opportunities for biodiversity. Source: ff25 shutterstock, n.d.*

This wall can easily be made from old leftover stones, brick, sidewalk and roof tiles, or pieces of wood. The pile is messily stacked on each other and filled up with loam. The many cracks and crevices resulting in diverse shelter places. Species, such as hedgehogs, spiders, beetles, centipedes, and amphibians, like frogs and salamanders, can hide in the wall. Furthermore, walls located on sunny spots are used by insects and other small organisms to benefit from the thermal properties. Even some wild bee and solitary wasp species can use the loam and the little holes in the wall to make their nests. Sometimes, small birds nest in these types of landscape elements. In addition, the wall can potentially functioning as a hiding place or thermal gradient for snakes. A potential location of this wall can be on the northwest side of the estate, parallel to the row of trees and the Klompenpad (figure 29). Overall, creating a stapelmuur as additional landscape element results in a high ecological value for the biodiversity on the estate.

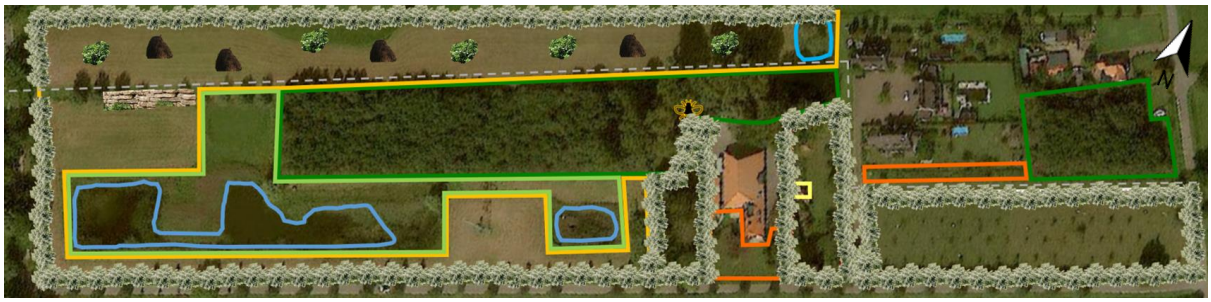


Figure 29. *Map of the estate showing the suggested locations for the biodiversity islands, hedges and the stapelmuur. Different coloured lines indicate different land use types: dark yellow = grass-dominated meadow, light green = biodiverse meadow, dark green = coppice, orange = garden, red = orchard, white = sheep grazed area, light yellow = chicken coop, blue = water body, dotted grey = klompenpad, bee symbol = honeybee hives. Source: Netherlands Space Office, 2023.*

Biodiversity islands and hedges

One of the main problems with the grass-dominated meadow is that it provides no shelter for animals in the winter, because there is little to no structural variation in the landscape. Since the grass-dominated meadow is a large proportion of the whole estate, improving the biodiversity here would contribute a lot to the overall goal. It would be ideal to create so called biodiversity islands, consisting of islands of various shrubs and herbs that provide structural diversity, nesting opportunities, and hiding places for animals when the mowing takes place. It would be ideal to have a combination of shrub islands and on other places put more hooiruiters (see figure 29 for potential locations). However, we recognize that implementing these biodiversity islands in the grass-dominated meadow, would mean more effort for the mowing and since this is done by Lodewijk (the neighbouring farmer) as a favour, it is important to not let the workload get out of hand. So, implementing this recommendation would have to be discussed with Lodewijk. We do think that it would be very beneficial for the biodiversity on the estate.

To still create more structural diversity nearby, we therefore suggest the planting of hedges on the borders of the grass-dominated meadow (figure 29). Hedges contribute a lot to biodiversity: they provide shelter, nesting opportunities, act as dispersal corridors, and food resources for many animals (De la Peña et al., 2003, Le Viol et al., 2008, Batary et al., 2010). In the province of Gelderland, the Gelderse haag ("Gelderland hedge") like can be seen in figure 30 is typical for the region, providing cultural value to this hedge (Ten hoven bomen, n.d.). It consists of a mixture of nine different species, making it also a very diverse hedge: beech (both red and green) and hornbeam are used as a basis. This is supplemented with species, such as the Guelder rose, common hawthorn, blackthorn (*Prunus spinosa*; sleedoorn), dog rose (*Rosa canina*; hondsroos), field maple (*Acer campestre*; veldesdoorn), common spindle (*Euonymus europaeus*; wilde kardinaalsmuts), and juneberry (*Amelanchier x lamarckii*; Amerikaans krentenboompje). This is why we recommend planting the Gelderse haag alongside the borders of the grass-dominated meadow. When planting these hedges, it is however important to keep in mind that the base of the hedge has enough complexes of stones, logs and roots, since this is crucial for creating unique microhabitats that provide essential refuges for many different animal species (Lecq et al., 2017).

Figure 30. *An example of a Gelderse haag, a biodiverse hedge that increases local biodiversity and is typical for the province of Gelderland.* Source: *Tenhoven-bomen, n.d.*

Biodiverse meadow

For the biodiverse meadow, it is recommended that the general fauna-friendly mowing practices can be applied in this area as well. These mowing practices are previously mentioned in the grass-dominated meadow section. Furthermore, it is suggested to let nature take its own course as much as possible in this area.

Coppice

Overall, the coppices on the estate presented a good structural and tree species diversity, especially thanks to the newly planted edges. The following measures could further enhance biodiversity in these areas.

Trees and shrubs species

The traditionally managed coppices (the small coppice and the part B of the big coppice) could develop into coppice-with-standards systems. That would consist of leaving saplings growing into older and higher trees in the middle of the coppice (without logging them when cutting the other trees as is normally done). These trees are called standards. European oak and Sycamore maple would be interesting species for this. Since a lot of saplings are already in the understory, which shows that they are likely to establish easily. Moreover, they are interesting for promoting biodiversity. Maple trees support a wide range of epiphytes, herbivores, and ground flora (Hein et al., 2009). Adult oak individuals would provide food for birds and small mammals during the winter, as acorns can be conserved and consumed in winter when no tree is ripening. However, many other species could be interesting; the presented ones are just examples. To promote the establishment of the standards, a tree should be cut to create a gap and give them the opportunity to grow. If a sapling of the desired species is not already present, another sapling in the coppice should be transplanted on the desired location. The ideal period for this is fall.

Promoting species with early, but especially late blooming time, will expand the period when nectar is available to insects. For now, early nectar is provided only by common hazels. So, we recommend giving them a special attention and ensure they grow and regenerate properly. From August onwards, no tree is flowering on the estate, so new late-flowering species should be introduced. The Alder buckthorn (*Frangula alnus*; vuilboom) would be suitable, as it can bloom until late September. It would also probably establish well on the estate, as it thrives in wet conditions. Moreover, ivy (*Hedera helix*; klimop) would be a very valuable asset for biodiversity. We understood that this was a species that the owners of De Lieskamp did not want to be present on some parts of the estate, especially close to the house, however, we still want to mention it here because its contribution to biodiversity is largely recognized as very valuable and difficult to be provided by other plant species. It is the last species to bloom in autumn (from September to November) and would provide food for insects in a time when the resources are scarce on the estate. Moreover, it produces berries in the winter (between December and February), which would provide very valuable resources for overwintering birds (Hall, 2019). Except when the whole canopy is invaded, ivy climbs on trees without damaging or hindering their growth, as it uses them only for support and does not take up nutrients from them. It is a shade-tolerant species and is easy to propagate from cuttings of climbing shoots in late summer. However, ivy produces flowers and berries only after 10 years, when the maturity stage is reached (Royal Horticulture Society, 2023). To be valuable for biodiversity on the estate, ivy should grow on old trees rather than coppice trees whose shouts are cut every 5 years.

Understory

In the understory, according to Nynke (appendix H.2), efforts should be made on preventing the brambles from expanding too much in the area. Even though they can provide berries for wildlife, there are also very competitive and could prevent other understory vegetation to establish. To control them from expanding too much, stems should be cut, and roots dug out. This will create more space for the understory plants to flourish and in doing so, boosting the biodiversity in the system. If it is desired to get rid of the exotic Himalayan blackberry, then all stems must be removed, and it can be replaced by the European dewberry (*Rubus caesius*; dauwbraam), an indigenous species. Since we have no knowledge of the current undergrowth in spring, we recommend the next group to pay special attention to which species are present in the understory of the coppice. It would be good if they also look for the presence of spring flowering plants like pilewort (*Ficaria verna subsp. verna*; gewoon speenkruid), since they provide an important food resource for insects in early spring. If it turns out that there is not a healthy understory community, we recommend sowing a flower mix for undergrowth, which one depends on how wet the soil is. We noticed that the soil is particularly wet in the winter, but since we have no knowledge of the conditions in summer, we recommend the next group to also look into moisture levels in the warmer parts of the year, and then make a decision on which seed mixture to use. Here, we provide two options from De Bolderik (a website that provides seed mixtures of local, wild plants):

Name seed mixture	BO1; forest edges and undergrowth mix for (relatively) wet soils
Sowing period	March to October
Sowing density	1 gram/m^2
Information	https://www.debolderik.nl/product/bo1-bosranden-en-onderbegroeiingsmengsel/

Name seed mixture	BO2; forest edges and undergrowth mix for (relatively) dry soils
Sowing period	March to October
Sowing density	1 gram/m^2
Information	https://www.debolderik.nl/product/bo2-bosranden-en-onderbegroeiingsmengsel-fijn/

Deadwood

The amount of big deadwood should be increased. This can be done by, leaving a few big, isolated logs left on the ground after logging. Furthermore, a few trees should be slowly killed while left standing. For this, the method of girdling could be used. In this method, two cuts are made with a chainsaw to form rings around the trunk. The cuts should be a few centimetres deep to cut both the bark and the cambium (which is the thin conductive tissue just before the wood). The bottom and upper cuts should be respectively around 30 and 40 centimetres above the ground. The bark between them should be removed (Game & Wildlife Conservation Trust, 2023).

Honeybees

Several studies have found that the competition on resources have a negative effect on wild bee populations (e.g. Cane & Tepedino, 2016; Van der Spek, 2012; *Samenvatting concurrentie*, n.d.). For

example, high presences of honeybees results in changes in flower visiting behaviour, reduced presence on the flowers, reduced foraging success, and reduced reproduction success of wild bees. Eventually, this can lead to decline in population sizes or even total absence of wild bees, which results in a biodiversity loss of the ecosystem. In West-Europe, a general guideline of maximum number of 3 honey bee colonies per km^2 is suggested for nature areas. Several studies on competition between honey bees and wild bees is often difficult to translate into concrete guidelines, however, Steffan-Dewenter & Tscharntke (2000) found no effect on wild bee populations with an abundance of three honeybee hives per km^2. In the Netherlands, several biodiversity consultancy's state that it seems sensible to use this density as a maximum in areas without massive flowering vegetation (*Adviezen concurrentie*, n.d.). The Lieskamp estate consists of an area of approximately 0.06 km^2. To reach the full potential of wild pollinating insect biodiversity, it is recommended to have one single honeybee hive on the estate instead of the six that are now present. Or at least, it is strongly recommended to reduce the amount of honeybee hives to a total of three.

Orchard and sheep-grazed meadow

As mentioned before, the biodiversity in the swards of both orchards and the sheep grazed garden could improve. This can be done by adding clover to the nutrient rich English ryegrass that is now present, improving the soil quality, and reducing the grazing pressure of the sheep.

Clover

The biodiversity of the vegetation in the sheep grazed meadows is low and consists mainly of English ryegrass. One of the ways in which diversity could be enhanced is through the addition of white clover (*Trifolium repens*; witte klaver), and potentially other herbs or legumes.

White clover is a herbaceous perennial and is part of the Fabaceae family. These legumes are able to fix atmospheric nitrogen through rhizobia bacteria in their root nodules. This is then converted into a form suitable for plant uptake. Because of this fixation, it has the potential to reduce the amount of added nitrogen from fertiliser needed (Carlin et al., 2010).

Furthermore, the flowers of the white clover are an attractive source of nectar for (bumble)bees (Carlin et al., 2010). The past years, bumblebees have a hard time in the Netherlands. Previous research has found that 72% of the bumblebee species in the Netherlands, i.e. 21 out of 29 species, have drastically declined (Reemer et al., 2012). Besides the importance of nesting sites, food availability is a critical aspect for the survival of bumblebees. By implementing white clover in the orchard on the estate, the occurrence of bumblebee species can be enhanced.

Because of their ability to fix nitrogen white clover contains high levels of protein. This can be beneficial for ewe and lamb performance. Including clover into a sward has been shown to increase average gains and overall weight and body condition of sheep. These effects are especially significant when other herbaceous species are added. Examples of these species are common chicory (*Cichorium intybus*; wilde cichorei), ribwort plantain (*Plantago lanceolata*; smalle weegbree) and bird's-foot trefoil (*Lotus corniculatus*; gewone rolklaver). Adding these other herbaceous species, can also help reduce the parasitic burden in sheep (Carlin et al., 2010). In conclusion, multispecies swards have the potential to lower the need for nitrogen inputs, while increasing sheep performance (Grace et al., 2019).

Agroecological manure management

Currently, the orchard is managed by a conventional farmer. Some conventional farming practices can have a harmful impact on biodiversity. The use of conventional manure can negatively influence soil biota due to the possible presence of antibiotics and pesticides. We would advise to have a look at the origin of the manure, and change it to organic if possible.

Hedges

To further increase biodiversity it is also advised to plant Gelderse hedges at the edges of both the old and new orchard (figure 29), like around the edges of the grass-dominated meadow. Besides their value for biodiversity, they also add to the cultural value of the orchard. Stichting Landschapsbeheer Gelderland reports that in the hooilanden landscape, hoogstamboomgaarden ("high stem orchards") are a traditional landscape element, and these hoogstamboomgaarden have hedges at the edges (*Hooilandenlandschap*, 2023). Therefore, we advise to plant hedges all around the orchards (figure 29).

Grazing pressure

Grazing of livestock can have an impact on the biodiversity of grasslands (Huaranca et al., 2022). Therefore, it is important to keep in mind the density of the grazers in the new orchard. Besides the number of animals in the orchard, also the method of grazing is important. Year-round grazing can lead to reduction in the vegetation, when the conditions are too wet and insufficient food availability. It is advisable to keep the number of sheep and the amount of time on the grassland in the new orchard low. We suggest that experiments are done in the orchard with lowering the amount of sheep to see if this will lead to more species diversity, since here the farmer can be asked to put less sheep in the orchard, instead of reducing the amount of sheep of the owners. If the experiments with the orchard show that less sheep is better for the biodiversity, the owners can consider selling some of their sheep.

Rhododendron strip

At this moment, rhododendrons are located in the small garden. Because of the fungus present, removal of all individuals of this species is advised. Removal of the rhododendrons is quite hard because of the fast regrowth. Therefore, the removal includes multiple management procedures. Only cutting the branches and stems will not control them in the long-term. In order to get rid of the whole species on the long term, the use of herbicides is needed. Therefore, cutting until ground height is essential followed by herbicide treatment. Herbicide treatment must be applied to every single stem, because a single stem is in own contact with the root system (Higgins, 2008). However, the use of herbicides is not ecologically preferred. Herbicides can potentially harm the aquatic life in the surrounding area, therefore the pros and cons of herbicides has to be considered (Higgins, 2008). Therefore, information about the requirements to use a herbicide needs to be considered, such as a dry period after spraying in order to allow the stems to take up the herbicide and no washing to the ground is possible. Another option which is more ecologically friendly to get rid of the rhododendrons is to use big machines in order to pull out the roots. The adult roots form shallow root balls up to 60 cm3, depending on how wet or dry the ground is. The soil layer will be disturbed for a period of time. But when taken this into account, replanting other plant species will help to restore the soil. (Higgins, 2008; Edwards, 2006). To ensure replacing the ecological functionality of the rhododendrons part,

another plant species can be planted. Otherwise, there can be an impact for the living conditions of insects, mammalian and bird species.

New species

After the removal of the rhododendrons in the small garden, an alternative must be found. The owners of the estate expressed a wish for a plant species that both provides additional value for the biodiversity and has an aesthetic look, since it is next to the house of the neighbours and they want to maintain a good relationship with them.

The owner had as a first suggestion the Portugal laurel (*Prunus lusitanica angustifolia*; Portuguese laurier). It is a shrub that is used in hedges a lot (figure 31). It can grow to a maximum between three and five meters. It does not have a lot of requirements about its conditions, can survive in winter and does not lose its leaves. This has the advantage to provide more privacy. In summer, it might need some extra water in order to stay healthy. It blooms in May and June, attracting insects. However, when looking into the flowering times of the current trees and shrubs on the estate, you can see that the latest one to bloom is in July (appendix D.1). This shrub does not help to bridge this gap as it does not provide either flowers for the insects in the fall / late summer. Another disadvantage is that it is an exotic species, so it might not be as beneficial for local biodiversity as local plant species.

Figure 31. *Prunus lusitanica angustifolia (portugese laurier). Portugal laurel.Prunus lusitanica angustifolia (portugese laurier). Portugal laurel. Sources: Mostert W., n.d.; Haagplanten, 2019.*

That is why we searched for a shrub that was both beautiful and a late bloomer and found rose of Sharon (*Hibiscus syriacus*; altheastruik) (figure 32; Oude Essink, 2010). It is a perennial shrub that blooms from July up to October, can grow up to three meters high and favours a sunny standing place. It can form a nice, dense hedge, can grow on many different soils and survives winter temperatures. It is not an indigenous species but attracts a lot of insects, so still benefits the biodiversity. It does lose its leaves in winter, so it may provide a little less privacy compared to the Portugal laurel.

Figure 32. *Rose of Sharon.Rose of Sharon.Rose of Sharon. Sources: matunka istockphoto, 2022; Pepiniera Sascut Garden Center, n.d.*

However, it is not an indigenous species and therefore we present a third option: a mix of indigenous shrub species in combination with the rose of Sharon to still have the late flowering time. This will create a diverse, mostly indigenous hedge. Local species to include can be: sweet brier (*Rosa rubiginosa*; egelantier), blackthorn, wild privet and elder.

Overall remarks

Cats

On the estate a lot of effort is done to improve the state of biodiversity, but the presence of cats might annihilate a lot of the progress (figure 33). On the estate, cats are useful to keep the mice and rat population around the house low. However, cats are responsible for enormous losses in populations of small mammals, birds, amphibians and reptiles (Knol, 2015). The losses of other species are probably higher compared to catching mice and rats, which directly influences the biodiversity. Keeping cats as a pet indoors is therefore more advisable than having a function of reducing the number of vermin. Having cats indoors is not detrimental for their mental health if they are used to being indoors their whole lives and if enough variation is provided inside the house (Scherk, 2016). It is not a realistic possibility to now get rid of the cats, but it is something that should be kept in mind when the current cats die, and the decision about taking new ones is made.

Figure 33. *Time lapse of a happy pheasant walking in the woods, until a cat comes along to chase it (ending of this encounter unknown).*

General discussion

Multiple additional management options can be seen from different perspectives, which is a consideration to be made. The recommendations therefore included both viewpoints on the management options.

There are different viewpoints to be taken into consideration:

- Owners' values: "creating a biodiverse paradise"
- Farmers
- Other stakeholders
- Practicality
    - Time constraints
    - Financial constraints

Even though the owners have a clear goal they want to achieve, together with the values that fit with these goals, there are always trade-offs that need to be made. There are a lot of different people and groups involved in the farm, and these various perspectives need to be taken into account. Furthermore, there are financial and time constraints as limiting factors in creating the biodiverse paradise the owners would love the Lieskamp to be. In our additional management recommendations, we have tried to keep the different viewpoints of the involved stakeholders into consideration. There will never be a perfect solution or one way to achieve biodiversity. However, based on the context and the baseline we tried to make a start with working towards the overarching goal and the values of the owners.

Biodiversity is a complex phenomenon that includes a wide variety of components. Different ecosystems, species, and their genetic variability are all interconnected with each other. This also applies to the potential management practices. For instance, if the goal is to enhance the occurrence of a specific insect target species, vegetation should be taken into account, which is also associated with soil properties of the area. However, it should be considered that this is a preliminary assessment on the biodiversity of the estate and providing advice on the additional management faced some limitations. First, this study was carried out during the winter, resulting in less accurate findings on the current biodiversity. During this time of the year, it is more difficult to identify the vegetation and most fauna species are less active. So, it was challenging to recognize certain relations within the ecosystem. Moreover, time was a constraint as well. Assessing the biodiversity and providing some management advice is a broad project with involving a wide variety of components and their connections. The entire project performed in just eight weeks, in which we had to conduct the literature research, fieldwork, and interviews, and to come up with a management plan to increase biodiversity.

To elaborate further on our findings on the current biodiversity baseline and the additional management options, we suggest the following additional research aspects:

- Profound measurements on the soil. Soil is an importance aspect of the ecosystem and is the basis for biodiversity. As previous mentioned in the discussion section about the soil measurements, the obtained soil results are less accurate, so further research is needed.

- Monitoring the vegetation during spring. This will provide a more completely overview of the occurrences of plant species. The vegetation composition will be connected to the soil characteristics.
- Monitoring insects' populations during spring. Insects play a crucial role in the ecosystems and providing a wide variety of ecosystem services. Pollinating can be seen as one of the most important aspects in biodiversity. The viability of insect populations depends on the vegetation.
- Monitoring bats. This can be used as an indicator to map out the state of nature quality on the estate.

Based on the more extensive biodiversity assessment on the estate, the additional management options can be more detailed and shaped into the desired outcomes. Therefore, additional management options need to be considered during spring and summer in order to come with the complete picture of the estate.

Conclusion and final recommendations

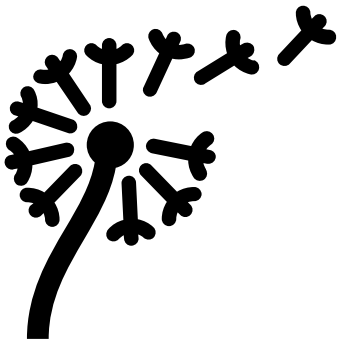
The goal of this report was to give an insight in the current state of the estate regarding biodiversity and to come with additional management options for improvement. Overall, the estate is currently quite biodiverse looking at the baseline made in this report. Multiple important management options are already implemented that helped increasing and keeping the biodiversity on the estate.

All possible implications for the estate are summarised in table 10 below. For all measurements the advantages and disadvantages are mentioned in the table. The recommended measurements are based on the baseline information from the fieldwork and information that is gathered from multiple parties.

Table 10. *Overview of all recommendations made in this report.*

Measurements	Advantage	Disadvantage
Use of composted farmyard manure	Reduce acidification of the soil	Can cause oversupply of nutrients to the soil
Addition of chalk to lime the soil	Reduce acidification of the soil	Can cause too sudden changes in pH on the soil and will affect flora and fauna
Use of rock dust	Will counteract soil acidification in a gradual way	
Introduction of greater yellow-rattle	Supress dominant grass species. Nectar supply for wild pollinators	Can be outcompeted when vegetation is too dense. Plant can lack forming a persistent seed bank
Sowing of local, indigenous seed mixtures	Increase the plant diversity	Can be expensive
Creating stapelmuur	Provide shelter and nesting places for small animals and insects	
Creating vegetation islands	More shelter and nesting possibilities for fauna	More difficulties with mowing
Mowing from inside to the outside	Give invertebrates time to move out of the grassland	
Mowing in phases	Provide enough resources for animals and insects and lower the mortality of (in)vertebrates	
Remove cutting when mowed	Prevent nutrients from returning into the soil	
Only mow ones or twice a year in autumn	Mowing too often resulting in too many distributions in the food supply for invertebrates.	
Use only light and small mowing machinery	Prevent compressing of the soil	Will be more time consuming

Apply coppice-with-standards system	Promoting biodiversity by providing food	
Implement species with early or late blooming	Increase the period of availability of nectar for insects	
Prevent expanding of brambles	Give understory vegetation the possibility to establish	Less berries are provided which is a food source
Increase amount of dead wood	Provide resources for insects, fungi, arthropods and small mammals	
Reduce the number of honeybee hives	More resources are available for wild bees	Less honey will be produced from honeybees
Addition of white clover in orchard	To reduce the amount of added nitrogen from fertiliser. Will attract (bumble)bees	
Adding hedges to the border	Provide shelter, nesting opportunities and food resources for diverse animals. Also adds to the cultural value of the orchard.	
Reduce the number of sheep and amount of time in new orchard	Higher species richness in the vegetation	
Replace rhododendrons with other species	Longer blooming period which is beneficial for insects	Disturbed soil biota when taking out the rhododendrons



References

Aanplant hoogstamfruit beheer hoogstamboom fruitboom boomgaard. (2023, 16 augustus). SLG. https://slgelderland.nl/kennisbank/hoogstamfruit-fruitbomen

Adviezen concurrentie. (n.d.). https://www.bestuivers.nl/bedreiging/concurrentie-honingbij/adviezen-concurrentie

Ameloot, E., Verheyen, K., Bakker, J. P., De Vries, Y., & Hermy, M. (2006). Long-term dynamics of the hemiparasite Rhinanthus angustifolius and its relationship with vegetation structure. Journal of Vegetation Science, 17(5), 637–646. https://doi.org/10.1111/j.1654-1103.2006.tb02487.x

Ampoorter, E., Barbaro, L., Jactel, H., Baeten, L., Boberg, J., Carnol, M., Castagneyrol, B., Charbonnier, Y., Dawud, S. M., Deconchat, M., Smedt, P. D., Wandeler, H. D., Guyot, V., Hättenschwiler, S., Joly, F., Koricheva, J., Milligan, H., Muys, B., Nguyen, D., Ratcliffe, S., Raulund-Rasmussen, K., Scherer-Lorenzen, M., van der Plas, F., Van Keer, J., Verheyen, K., Vesterdal, L., Allan, E. (2020). Tree diversity is key for promoting the diversity and abundance of forest-associated taxa in Europe. Oikos, 129(2), 133–146. https://doi.org/10.1111/oik.06290

Andersen, D. C. (1987). Below-ground herbivory in natural communities: a review emphasizing fossorial animals. *The Quarterly Review of Biology, 62(3), 261-286.*

Andreassen, H. P., Sundell, J., Ecke, F., Halle, S., Haapakoski, M., Henttonen, H., ... & Ylönen, H. (2021). Population cycles and outbreaks of small rodents: ten essential questions we still need to solve. Oecologia, 195, 601-622.

Andriessen, L. 2011. Hoe groot wordt een bijenvolk? – De Vlaamse Imker 15(9): 7-29

Avenant, N. (2011). The potential utility of rodents and other small mammals as indicators of ecosystem 'integrity' of South African grasslands. Wildlife Research, 38(7), 626–639. https://doi.org/10.1071/WR10223

Batáry, P., Matthiesen, T., & Tscharntke, T. (2010). Landscape-moderated importance of hedges in conserving farmland bird diversity of organic vs. conventional croplands and grasslands. Biological Conservation, 143(9), 2020-2027.

Bestuivers. (n.d.). Bijvriendelijk maaien. https://www.bestuivers.nl/bescherming/bijvriendelijk-maaien

BIJ12. (2023a, December 9). N10.02 Vochtig hooiland - BIJ12. https://www.bij12.nl/onderwerp/natuursubsidies/index-natuur-en-landschap/natuurtypen/n10-vochtige-schraalgraslanden/n10-02-vochtig-hooiland/

BIJ12. (2023b, December 9). N12.02 Kruiden- en faunarijk grasland - BIJ12. https://www.bij12.nl/onderwerp/natuursubsidies/index-natuur-en-landschap/natuurtypen/n12-rijke-graslanden-en-akkers/n12-02-kruiden-en-faunarijk-grasland/

BIJ12. (2023c, December 1). N04.02 Zoete plas - BIJ12. https://www.bij12.nl/onderwerp/natuursubsidies/index-natuur-en-landschap/natuurtypen/n04-stilstaande-wateren/n04-02-zoete-plas/

Biodivers. (2021b, maart 9). Zaai- maaiadviezen. https://biodivers.nl/zaai-maaiadviezen/

Bobbink, R., Hicks, K., Galloway, J., Spranger, T., Alkemade, R., Ashmore, M., Bustamante, M., Cinderby, S., Davidson, E., Dentener, F., Emmett, B., Erisman, J.-W., Fenn, M., Gilliam, F., Nordin, A., Pardo, L., & De Vries, W. (2010). Global assessment of nitrogen deposition effects on terrestrial plant diversity: A synthesis. Ecological Applications, 20(1), 30–59. https://doi.org/10.1890/08-1140.1

Borges, P. A. V., Gabriel, R., & Fattorini, S. (2020). Biodiversity erosion: causes and consequences. In Springer eBooks (pp. 81–90). https://doi.org/10.1007/978-3-319-95981-8_78

Bot, A., Benites, J. (2005). The importance of soil organic matter: Key to drought-resistant soil and sustained food production

Botequim, B., Bugalho, M. N., Rodrigues, A. R., Marques, S., Marto, M., & Borges, J. G. (2021). Combining tree species composition and understory coverage indicators with optimization techniques to address concerns with landscape-level biodiversity. Land, 10(2), 126. https://doi.org/10.3390/land10020126

Burton, A. C., Neilson, E., Moreira, D., Ladle, A., Steenweg, R., Fisher, J. T., Bayne, E. M., & Boutin, S. (2015). REVIEW: Wildlife camera trapping: a review and recommendations for linking surveys to ecological processes. Journal of Applied Ecology, 52(3), 675–685. https://doi.org/10.1111/1365-2664.12432

Cane, J. H., & Tepedino, V. J. (2016). Gauging the effect of honey bee pollen collection on native bee communities. Conservation Letters, 10(2), 205–210. https://doi.org/10.1111/conl.12263

Carlin, C., Finn, J. A., Ó hUallacháin, D., & Gormally, M. (2010). Overview of methods to create and enhance farmland habitats in Ireland.

Collet, C., Piboule, A., Leroy, O., & Frochot, H. (2008). Advance Fagus sylvatica and Acer pseudoplatanus seedlings dominate tree regeneration in a mixed broadleaved former coppice-with-standards forest. Forestry, 81(2), 135-150. 3.

Crespo-Peremarch, P., Tompalski, P., Coops, N., & Ruiz, L. A. (2018). Characterizing understory vegetation in Mediterranean forests using full-waveform airborne laser scanning data. Remote Sensing of Environment, 217, 400–413. https://doi.org/10.1016/j.rse.2018.08.033

De Bolderik. (2023, 3 november). Zaai Instructies van de Bolderik | Lees meer. https://www.debolderik.nl/zaaiinstructies/

de la Peña, N. M., Butet, A., Delettre, Y., Morant, P., & Burel, F. (2003). Landscape context and carabid beetles (Coleoptera: Carabidae) communities of hedgerows in western France. Agriculture, Ecosystems & Environment, 94(1), 59-72.

De Ruiter, Y. (2022). Water quality assessment ponds Egelsteeg [Bachelor thesis]. Wageningen University and Research.

Department of Jobs, Precincts and Regions. (2023, November 17). Soil acidity. Agriculture Victoria. https://agriculture.vic.gov.au/farm-management/soil/soil-acidity#h2-3\

Desie, E., Vancampenhout, K., Nyssen, B., van den Berg, L., Weijters, M., van Duinen, G.-J., den Ouden, J., Van Meerbeek, K., & Muys, B. (2020). Litter quality and the law of the most limiting: Opportunities for restoring nutrient cycles in acidified forest soils. Science of The Total Environment, 699, 134383. https://doi.org/10.1016/j.scitotenv.2019.134383

Dickman, C. R. (1999). Rodent-ecosystem relationships: a review. Ecologically-based management of rodent pests. ACIAR Monograph, 59, 113-133.

Doelsoortenlijst: Soort van doelsoortenlijst | Beschermde natuur in Nederland. (n.d.). https://minlnv.nederlandsesoorten.nl/content/doelsoortenlijst-soort-van-doelsoortenlijst

Doerfler, I., Gossner, M. M., Müller, J., Seibold, S., & Weisser, W. W. (2018). Deadwood enrichment combining integrative and segregative conservation elements enhances biodiversity of multiple taxa in managed forests. Biological Conservation, 228, 70–78. https://doi.org/10.1016/j.biocon.2018.10.013

Dwergspitsmuis. (n.d.). De Zoogdiervereniging. https://www.zoogdiervereniging.nl/zoogdiersoorten/dwergspitsmuis

Dybzinski, R., Fargione, J. E., Zak, D. R., Fornara, D., & Tilman, D. (2008). Soil fertility increases with plant species diversity in a long-term biodiversity experiment. Oecologia, 158(1), 85–93. https://doi.org/10.1007/s00442-008-1123-x

Ecke, F., Löfgren, O., Hörnfeldt, B., Eklund, U., Ericsson, P., & Sörlin, D. (2001). Abundance and diversity of small mammals in relation to structural habitat factors. *Ecological Bulletins*, 165-171.

Edwards, C. (2006). Managing and controlling invasive rhododendron. Forestry Commission.

Emmerson, M., Morales, M. B., Oñate, J. J., Batáry, P., Berendse, F., Liira, J., Aavik, T., Guerrero, I., Bommarco, R., Eggers, S., Pärt, T., Tscharntke, T., Weisser, W. W., Clement, L. W., & Bengtsson, J. (2016). How agricultural intensification affects biodiversity and ecosystem services. In Advances in Ecological Research (pp. 43–97). https://doi.org/10.1016/bs.aecr.2016.08.005

Enescu, C. M., Loghin, C., & Stefan, V. (2015). Wild privet (Ligustrum vulgare L.): a multipurpose species with an important role in forest land reclamation. J Hortic For Biotechnol, 19, 70-3.

Fichtner, A., & Wissemann, V. (2021). Biological flora of the british isles: Crataegus monogyna. Journal of Ecology, 109(1), 541–571. https://doi.org/10.1111/1365-2745.13554

Franklin, J. F., & Van Pelt, R. (2004). Spatial aspects of structural complexity in old-growth forests. Journal of Forestry, 102(3), 22–29. Scopus.

Furey, G. N., & Tilman, D. (2021). Plant biodiversity and the regeneration of soil fertility. Proceedings of the National Academy of Sciences, 118(49), e2111321118. https://doi.org/10.1073/pnas.2111321118

Game & Wildlife Conservation Trust. (2023). How to create dead wood. Game and Wildlife Conservation Trust. https://www.gwct.org.uk/wildlife/advice/woodland/how-to-create-dead-wood/

Gathmann, A., & Tscharntke, T. (2002). Foraging ranges of solitary bees. Journal of Animal Ecology, 71(5), 757–764. https://doi.org/10.1046/j.1365-2656.2002.00641.x

Gill, R. J., Baldock, K. C. R., Brown, M. J. F., Cresswell, J., Dicks, L. V., Fountain, M. T., Garratt, M. P. D., Gough, L. A., Heard, M. S., Holland, J. M., Ollerton, J., Stone, G. N., Tang, C. Q., Vanbergen, A. J., Vogler, A. P., Woodward, G., Arce, A. N., Boatman, N. D., Brand-Hardy, R., . . . Potts, S. G. (2016). Protecting an ecosystem service. In Advances in Ecological Research (pp. 135–206). https://doi.org/10.1016/bs.aecr.2015.10.007

Glover-Kapfer, P., Soto-Navarro, C., & Wearn, O. R. (2019). Camera-trapping version 3.0: current constraints and future priorities for development. Remote Sensing in Ecology and Conservation, 5(3), 209–223. https://doi.org/10.1002/rse2.106

Goszczyński, J. (2002). Home ranges in red fox: territoriality diminishes with increasing area. Acta Theriologica, 47(S1), 103–114. https://doi.org/10.1007/bf03192482

Goudzwaard, L. (2012). Temperate Species—Tree Database. WUR. https://www.wur.nl/en/research-results/chair-groups/environmental-sciences/forest-ecology-and-forest-management-group/education/tree-database/temperate-species.htm

Grace, C., Lynch, M., Sheridan, H., Lott, S., Fritch, R., & Boland, T. M. (2019). Grazing multispecies swards improves ewe and lamb performance. Animal, 13(8), 1721–1729. https://doi.org/10.1017/s1751731118003245

Green, C. (1998). Reducing mortality of grassland wildlife during haying and wheat harvesting operations. Oklahoma State University Forestry Publications, 1–4.

Grotta-Neto, F., De Faria Peres, P. H., Piovezan, U., Passos, F. C., & Duarte, J. M. B. (2020). Camera trap feasibility for ecological studies of elusive forest deer. Wildlife Society Bulletin, 44(3), 640–647. https://doi.org/10.1002/wsb.1121

Hall, A. (2019). The Importance of Ivy. Jersey Biodiversity Centre. https://jerseybiodiversitycentre.org.je/article/importance-ivy

Hallmann, C. A., Sorg, M., Jongejans, E., Siepel, H., Hofland, N., Schwan, H., Stenmans, W., Müller, A., Sumser, H., Hörren, T., Goulson, D., & De Kroon, H. (2017). More than 75 percent decline over 27 years in total Flying insect biomass in protected areas. PLOS ONE, 12(10), e0185809. https://doi.org/10.1371/journal.pone.0185809

Hein, S., Collet, C., Ammer, C., Goff, N. L., Skovsgaard, J. P., & Savill, P. (2009). A review of growth and stand dynamics of Acer pseudoplatanus L. in Europe: implications for silviculture. Forestry, 82(4), 361-385. 2.

Higgins, G. T. (2008). Rhododendron ponticum : a guide to management on nature conservation sites. National Parks and Wildlife Service. http://edepositireland.ie/handle/2262/69413

Hinckley, Tom. (2012). Diversifying Forest Structure to Promote Wildlife Biodiversity in Western Washington Forests. Washington State University Extension. EM044. 1 - 17.

Hooilandenlandschap. (2023, 21 juli). SLG. https://slgelderland.nl/kennisbank/hooilandenlandschap

Huaranca, J. C., Novaro, A. J., & Valdivia, C. E. (2022). Effects of livestock grazing on biodiversity: A meta-analysis on three trophic levels. Journal for Nature Conservation, 66, 126126. https://doi.org/10.1016/j.jnc.2021.126126

Huber, F.-X. (1828). Hilfs-Tafeln für Bedienstete des Forst- und Baufaches: Zunächst zur leichten und schnellen Berechnung des Massengehaltes roher Holzstämme und der Theile derselben, und auch zu anderm Gebrauche für jedes landesübliche Maaß anwendbar. Fleischmann.

Hugues Claessens, Anne Oosterbaan, Peter Savill, Jacques Rondeux, A review of the characteristics of black alder (Alnus glutinosa (L.) Gaertn.) and their implications for silvicultural practices, Forestry: An International Journal of Forest Research, Volume 83, Issue 2, April 2010, Pages 163–175, https://doi.org/10.1093/forestry/cpp038

Humbert, J., Ghazoul, J., & Walter, T. (2009). Meadow harvesting techniques and their impacts on field fauna. Agriculture, Ecosystems & Environment, 130(1–2), 1–8. https://doi.org/10.1016/j.agee.2008.11.014

Huntly, N., & Reichman, O. J. (1994). Effects of subterranean mammalian herbivores on vegetation. *Journal of Mammalogy, 75(4), 852-859.*

IUCN. (2023). The IUCN Red List of Threatened Species. Version 2022-2. IUCN Red List of Threatened Species. https://www.iucnredlist.org/en

Kalkman, V.J., van Duuren, L., Gmeling Meyling, A.W., & Odé, B. (2010). De Nederlandse Biodiversiteit: Veranderingen in de Nederlandse biodiversiteit. Natuur van Nederland, 10(1), 339–354.

Karel, E. (2010). Modernization of the Dutch agriculture system 1950-2010. In Paper for the International Rural History Conference 2010, University of Sussex, Brighton (UK) 13-16 September 2010.

Kirby, K. J., Buckley, G. P., & Mills, J. (2017). Biodiversity implications of coppice decline, transformations to high forest and coppice restoration in British woodland. Folia Geobotanica, 52(1), 5–13. https://doi.org/10.1007/s12224-016-9252-1

Knol, W. (2015). Verwilderde huiskatten: Effecten op de natuur in Nederland. Koninklijke Nederlandse Jagersvereniging, Amersfoort. Intern rapport nummer, 15-01.

Köninger, J., Lugato, E., Panagos, P., Kochupillai, M., Orgiazzi, A., & Briones, M. J. I. (2021). Manure management and soil biodiversity: Towards more sustainable food systems in the EU. Agricultural Systems, 194, 103251. https://doi.org/10.1016/j.agsy.2021.103251

Kwak, M. M. (2002). Hommels als bloembezoekers: bestuivers en profiteurs. Entomologische Berichten, 62(3-4), 73-81.

Lange, R., Twisk, P., Van Winden, A., & Van Diepenbeek, A. (2003). Zoogdieren van West-Europa (2nd edition). Stichting Uitgeverij van de Koninklijke Nederlandse Natuurhistorische Vereniging.

Larrieu, L., Cabanettes, A., Courbaud, B., Goulard, M., Heintz, W., Kozák, D., Kraus, D., Lachat, T., Ladet, S., Müller, J., Paillet, Y., Schuck, A., Stillhard, J., & Svoboda, M. (2021). Co-occurrence patterns of tree-related microhabitats: A method to simplify routine monitoring. Ecological Indicators, 127, 107757. https://doi.org/10.1016/j.ecolind.2021.107757

Larrieu, L., Paillet, Y., Winter, S., Bütler, R., Kraus, D., Krumm, F., Lachat, T., Michel, A. K., Regnery, B., & Vandekerkhove, K. (2018). Tree related microhabitats in temperate and Mediterranean European forests: A hierarchical typology for inventory standardization. Ecological Indicators, 84, 194–207. Scopus. https://doi.org/10.1016/j.ecolind.2017.08.051

Le Viol, I., Julliard, R., Kerbiriou, C., De Redon, L., Carnino, N., Machon, N., & Porcher, E. (2008). Plant and spider communities benefit differently from the presence of planted hedgerows in highway verges. Biological conservation, 141(6), 1581-1590.

Lecq, S., Loisel, A., Brischoux, F., Mullin, S. J., & Bonnet, X. (2017). Importance of ground refuges for the biodiversity in agricultural hedgerows. *Ecological Indicators*, *72*, 615-626.

Lekshmi S.U., S., Singh, D. N., & Shojaei Baghini, M. (2014). A critical review of soil moisture measurement. Measurement, 54, 92–105. https://doi.org/10.1016/j.measurement.2014.04.007

Lévesque, M., Bustamante Eduardo, J. I., & Queloz, V. (2023). Potential alternative tree species to Fraxinus excelsior in European forests. Frontiers in Forests and Global Change, 6. https://www.frontiersin.org/articles/10.3389/ffgc.2023.1048971

Lwin, K. K., Ota, T., Shimizu, K., & Mizoue, N. (2019). Assessing the importance of tree cover threshold for forest cover mapping derived from global forest cover in myanmar. Forests, 10(12), 1062. https://doi.org/10.3390/f10121062

Mallinger, R. E., Gaines-Day, H. R., & Gratton, C. (2017). Do managed bees have negative effects on wild bees?: A Systematic Review of the literature. PLOS ONE, 12(12), e0189268. https://doi.org/10.1371/journal.pone.0189268

Meek, P. D., Ballard, G., & Fleming, P. J. S. (2015). The pitfalls of wildlife camera trapping as a survey tool in Australia. Australian Mammalogy, 37(1), 13. https://doi.org/10.1071/am14023

Meek, P. D., Ballard, G., Claridge, A. W., Kays, R., Moseby, K. E., O'Brien, T., O'Connell, A. F., Sanderson, J. G., Swann, D. E., Tobler, M. W., & Townsend, S. E. (2014). Recommended guiding principles for reporting on camera Trapping research. Biodiversity and Conservation, 23(9), 2321–2343. https://doi.org/10.1007/s10531-014-0712-8

Natuurkennis. (n.d.). Bedreigingen en kansen - Het Kennisnetwerk Ontwikkeling en Beheer Natuurkwaliteit (OBN). https://www.natuurkennis.nl/natuurtypen/n10-vochtige-schraalgraslanden/n10-02-vochtig-hooiland/Bedreigingen-en-kansen-N1002/

Natuurmonumenten (n.d.) Wat is stikstof? https://www.natuurmonumenten.nl/stikstof/wat-is-stikstof

Nielsen, U. N., Wall, D. H., & Six, J. (2015). Soil biodiversity and the environment. Annual review of environment and resources, 40, 63-90.

Oude Essink, H. (2010, april). Bijenplant belicht: Kaasjeskruid (Malva L.). Bijenhouden, 8, https://edepot.wur.nl/156507.

Paillet, Y., Archaux, F., Boulanger, V., Debaive, N., Fuhr, M., Gilg, O., Gosselin, F., & Guilbert, E. (2017). Snags and large trees drive higher tree microhabitat densities in strict forest reserves. Forest Ecology and Management, 389, 176–186. https://doi.org/10.1016/j.foreco.2016.12.014

PBL. (2008, May 20). Halting biodiversity loss in the Netherlands: Evaluation of progress [Text]. PBL Netherlands Environmental Assessment Agency. https://www.pbl.nl/en/publications/Halting-biodiversity-loss-in-the-Netherlands

Reemer, M. 2018. Basisrapport voor de Rode Lijst Bijen. – EIS Kenniscentrum Insecten, Leiden. [PDF available via www.bestuivers.nl/rodelijst]

Reemer, M., Kleijn, D., & Raemakers, I. (2012). Veranderingen in de Nederlandse bijenfauna.

Ren, Y., Guo, M., Yin, F., Zhang, M.-J., & Wei, J. (2022). Tree cover improved the species diversity of understory spontaneous herbs in a small city. Forests, 13(8), 1310. https://doi.org/10.3390/f13081310

Robinson, I., & Routh, A. (1999). Veterinary care of the hedgehog. In Practice, 21(3), 128–137. https://doi.org/10.1136/inpract.21.3.128

Rocha, J. (2022). Ecosystems are showing symptoms of resilience loss. Environmental Research Letters, 17(6), 065013. https://doi.org/10.1088/1748-9326/ac73a8

Rovero, F., Zimmermann, F., Berzi, D., & Meek, P. D. (2013). "Which camera trap type and how many do I need?" A review of camera features and study designs for a range of wildlife research applications. Hystrix-italian Journal of Mammalogy, 24(2), 148–156. https://doi.org/10.4404/hystrix-24.2-6316

Royal Horticulture Society. (2023). Hedera (ivy). RHS Gardening. https://www.rhs.org.uk/plants/ivy/growing-guide

Samenvatting concurrentie. (n.d.). https://www.bestuivers.nl/concurrentie

Sanders, M. E., Henkens, R. J. H. G., & Slijkerman, D. M. E. (2019). Convention on biological diversity: Sixth national report of the Kingdom of the Netherlands. https://doi.org/10.18174/499170

Sandström, J., Bernes, C., Junninen, K., Lõhmus, A., Macdonald, E., Müller, J., & Jonsson, B. G. (2019). Impacts of dead wood manipulation on the biodiversity of temperate and boreal forests. A systematic review. Journal of Applied Ecology, 56(7), 1770–1781. https://doi.org/10.1111/1365-2664.13395

Scherk, M. (2016). Optimizing an indoor lifestyle for cats. Veterinary Focus, 26(2), 2-9.

Schmidt, N. M., Olsen, H., Bildsøe, M., Sluydts, V., & Leirs, H. (2005). Effects of grazing intensity on small mammal population ecology in wet meadows. Basic and Applied Ecology, 6(1), 57-66.

Silveira, L., Jácomo, A. T. A., & Diniz-Filho, J. a. F. (2003). Camera trap, line transect census and track surveys: a comparative evaluation. Biological Conservation, 114(3), 351–355. https://doi.org/10.1016/s0006-3207(03)00063-6

SLG. (2023, July 21). Sinusbeheer, hoe werkt het in de praktijk https://slgelderland.nl/kennisbank/sinusbeheer-hoe-werkt-het-in-de-praktijk

Steen, J. van der 2015. Factoren die het foerageergedrag van honingbijen bepalen (deel I). – Plant Research International, Wageningen University, rapport 606: 1-37.

Steffan-Dewenter, I., & Tscharntke, T. (2000). Resource overlap and possible competition between honey bees and wild bees in central Europe. Oecologia, 122(2), 288–296. https://doi.org/10.1007/s004420050034

Sunyer, P., Muñoz, A., Mazerolle, M. J., Bonal, R., & Espelta, J. M. (2016). Wood mouse population dynamics: Interplay among seed abundance seasonality, shrub cover and wild boar interference. *Mammalian Biology*, 81, 372-379.

Tedersoo, L., Bahram, M., Cajthaml, T., Põlme, S., Hiiesalu, I., Anslan, S., Harend, H., Buegger, F., Pritsch, K., Koricheva, J., & Abarenkov, K. (2016). Tree diversity and species identity effects on

soil fungi, protists and animals are context dependent. The ISME Journal, 10(2), 346–362. https://doi.org/10.1038/ismej.2015.116

Ten hoven bomen. (n.d.). Landschappelijke hagen. cultureel en ecologisch van hoge waarde. https://www.tenhoven-bomen.nl/thema/landschappelijke-hagen

Ter Harmsel, R., 2023. Biodiversiteitsplan gemeente Wageningen. Wageningen, Wageningen Environmental Research, Rapport, [Unpublished manuscript].

Tláskal, V., Brabcová, V., Větrovský, T., Jomura, M., López-Mondéjar, R., Oliveira Monteiro, L. M., Saraiva, J. P., Human, Z. R., Cajthaml, T., Nunes Da Rocha, U., & Baldrian, P. (2021). Complementary roles of wood-inhabiting fungi and bacteria facilitate deadwood decomposition. mSystems, 6(1), e01078-20. https://doi.org/10.1128/mSystems.01078-20

Toivonen, J., Kangas, A., Maltamo, M., Kukkonen, M., & Packalen, P. (2023). Assessing biodiversity using forest structure indicators based on airborne laser scanning data. Forest Ecology and Management, 546, 121376. https://doi.org/10.1016/j.foreco.2023.121376

Tóth, E., Deák, B., Valkó, O., Kelemen, A., Miglécz, T., Tóthmérész, B., & Török, P. (2016). Livestock Type is More Crucial Than Grazing Intensity: Traditional Cattle and Sheep Grazing in Short-Grass Steppes. Land Degradation & Development, 29(2), 231–239. https://doi.org/10.1002/ldr.2514

Twisk, P., Diepenbeek, A. van, & Bekker, J. P. (2010). Europese zoogdieren (Ser. Veldgids, nr. 23). KNNV Uitgeverij.

Van Baren, S., Schulte, W., & Hogeschool Van Hall- Larenstein Velp. (2017). Realisatieplan SNL beheertypen gronden Siemons [Graduation project].

Van der Spek, E. (2012). Effecten van honingbijen, Apis mellifera, op insecten in natuurterreinen. Entomologische Berichten, 72(1-2), 103–111

Van Lierop, W. (1981). CONVERSION OF ORGANIC SOIL pH VALUES MEASURED IN WATER, 0.01M CACl2 or 1N KCl. Canadian Journal of Soil Science, 61(4), 577–579. https://doi.org/10.4141/cjss81-067

Van Rooij, S., Cormont, A., Geertsema, W., De Groot, G., Haag, M., Opdam, P., Reemer, M., Snep, R., Spijker, J., Steingröver, E., Stip, A., & Ozinga, W. A. (2020). Een bij-zonder kleurrijk landschap in land van wijk en wouden : Handreiking 3.0 voor inrichting en beheer voor bestuivende insecten. https://doi.org/10.18174/519243

Van Strien, A., Meyling, A. G., Herder, J., Hollander, H. D., Kalkman, V. J., Poot, M., Turnhout, S., Van Der Hoorn, B., Van Strien-Van Liempt, W. T., Van Swaay, C., Van Turnhout, C., Verweij, R. J. T., & Oerlemans, N. (2016). Modest recovery of biodiversity in a Western European country: The Living Planet Index for the Netherlands. Biological Conservation, 200, 44–50. https://doi.org/10.1016/j.biocon.2016.05.031

Verbeek, P.J.M. (2021). Monitoring Groene grens, Flora, fauna en beheer 2020. Natuurbalans - Limes Divergens BV, Nijmegen

Vlinderstichting . (n.d.). Sinusbeheer. https://www.vlinderstichting.nl/sinusbeheer/

Vogelbescherming Nederland. (n.d.). Koperwiek. Vogelbescherming. https://www.vogelbescherming.nl/ontdek-vogels/kennis-over-vogels/vogelgids/vogel/koperwiek#Leefwijze

Vries, W., Weijters, M., De Jong, A., Van Delft, B., Bloem, J., Van der Burg, A., Duinen, G.-J., Verbaarschot, E., & Bobbink, R. (2019). Verzuring van loofbossen op droge zandgronden en herstelmogelijkheden door steenmeeltoediening. https://research.wur.nl/en/publications/verzuring-van-loofbossen-op-droge-zandgronden-en-herstelmogelijkh

Wagner, D. L., Grames, E. M., Forister, M. L., Berenbaum, M. R., & Stopak, D. (2021). Insect decline in the anthropocene: Death by a thousand cuts. Proceedings of the National Academy of Sciences of the United States of America, 118(2). https://doi.org/10.1073/pnas.2023989118

Wallis de Vries, M.F. & J.C. Knotters 2000. Effecten van gefaseerd maaibeheer op de ongewervelde fauna van graslanden. – De Levende Natuur 101: 37-41.

Werkgroep ’t Pasje & De Nieuwe Nu. (2022). Biodiversiteitsplan voor de Nude in Wageningen. In *De Nieuwe Nu*. https://www.denieuwenu.nl/wp-content/uploads/2022/09/220303-Biodiversiteitsplan-voor-de-Nude-DEF-LR.pdf

Reference images list

East West School of planetary herbology (n.d.). Figure 14 [photograph]. Retrieved from https://planetherbs.com/blogs/lesleys-blog/hawthorn-teaching-an-old-herb-new-tricks/

European forest genetic resources programme (2003). Figure 14 [photograph]. Retrieved from https://www.euforgen.org/species/alnus-glutinosa/

European forest genetic resources programme (2003). Figure 14. Retrieved from https://www.euforgen.org/species/alnus-glutinosa/

Ff25 shutterstock (n.d.). Figure 23 [photograph]. Retrieved from https://www.shutterstock.com/es/image-photo/old-stone-wall-park-city-small-1706330635

Flanagan, J., Meyer, M., Pasamar, M. A., Ibarra, A., Roller, M., i Genoher, N. A., Leiva, S., Gomez-Garcia, F., Alcaraz, M., Martinez-Carrasco, A., Vicente, V. (2013). Safety evaluation and nutritional composition of a Fraxinus excelsior seed extract, FraxiPure™. Food and Chemical Toxicology, 53, 10-17. Figure 14 [photograph]. Retrieved from https://www.researchgate.net/figure/Fraxinus-excelsior-seeds-from-which-FraxiPure-was-obtained_fig1_267630115

Geoportaal Gelderland (n.d.). Figure 4 [photograph]. Retrieved November 1, 2023 from https://geoportaal.gelderland.nl/portaal/apps/webappviewer/index.html?id=d8fc942b0c7646ff8900c26f05effef9

Haagplanten (2019). Figure 27 [photograph]. Retrieved from https://www.haagplanten.net/haagplanten-blog/deze-haagplanten-kunt-u-ook-solitair-planten.html

Larrieu, L., Paillet, Y., Winter, S., Bütler, R., Kraus, D., Krumm, F., Lachat, T., Michel, A. K., Regnery, B., & Vandekerkhove, K. (2018). Tree related microhabitats in temperate and Mediterranean European forests: A hierarchical typology for inventory standardization. Ecological Indicators, 84, 194–207. Figure 13 [photograph]. Retrieved from https://doi.org/10.1016/j.ecolind.2017.08.051

matunka istockphoto (2022). Figure 28 [photograph]. Retrieved from https://www.istockphoto.com/nl/foto/beautifully-blooming-hibiscus-syriacus-blue-bird-with-attractive-flowers-gm1371941514-441178828

Netherlands Space Office (2023). Figure 14 [photograph]. Retrieved November 1, 2023, from https://www.satellietdataportaal.nl/?base=brtachtergrondkaart&res=0.3%2C0.5&datemin=14-12-2022&q=Egelsteeg+2+Wageningen&loc=51.98741%2C5.637263%2C17z&overlay=mos-0

Netherlands Space Office (2023). Figure 18 [photograph]. Retrieved November 1, 2023, from https://www.satellietdataportaal.nl/?base=brtachtergrondkaart&res=0.3%2C0.5&datemin=14-12-2022&q=Egelsteeg+2+Wageningen&loc=51.98741%2C5.637263%2C17z&overlay=mos-0

Netherlands Space Office (2023). Figure 22 [photograph]. Retrieved November 1, 2023, from https://www.satellietdataportaal.nl/?base=brtachtergrondkaart&res=0.3%2C0.5&datemin=14-12-2022&q=Egelsteeg+2+Wageningen&loc=51.98741%2C5.637263%2C17z&overlay=mos-0

Netherlands Space Office (2023). Figure 24 [photograph]. Retrieved November 1, 2023, from https://www.satellietdataportaal.nl/?base=brtachtergrondkaart&res=0.3%2C0.5&datemin=14-12-2022&q=Egelsteeg+2+Wageningen&loc=51.98741%2C5.637263%2C17z&overlay=mos-0

Netherlands Space Office (2023). Figure 3 [photograph]. Retrieved November 1, 2023, from https://www.satellietdataportaal.nl/?base=brtachtergrondkaart&res=0.3%2C0.5&datemin=14-12-2022&q=Egelsteeg+2+Wageningen&loc=51.98741%2C5.637263%2C17z&overlay=mos-0

Olaf Op den Kamp (2021). Figure 14 [photograph]. Retrieved from https://observation.org/photos/40571371/

Peña Claros, M. (2023) *Forest inventory-Fieldwork: FEM-30306 Forest ecology and forest management* [Course Notes]. Wageningen University and Research. Figure 12 [photograph].

Pepiniera Sascut Garden Center (n.d.). Figure 28 [photograph]. Retrieved from https://pepinierasascut.ro/en

Tenhoven-bomen (n.d.) Figure 25 [photograph]. Retrieved from https://www.tenhoven-bomen.nl/thema/landschappelijke-hagen

Willemien Mostert (n.d.). Figure 27 [photograph]. Retrieved from https://plantnu.nl/portugese-laurierkers/

Appendices

Appendix A: Power and interest of stakeholders

Research team: the people in this committee have high power in the process. They have the ability to form the way the project is executed. They are coordinated by the project leader.

Supervisory committee: these stakeholders have high interest but varying power. The researcher ecology, science shop and owners of the estate for example have the ability to shape the different stages and outputs of the project. The organic farmer helps the estate with management so has quite a lot of power and is also interested in an enhanced biodiversity. Nature organisations like the "Vogelwerkgroep", the "Stichting Landschapsbeheer Gelderland" and "Stichting Mooi Binnenveld" give advice but do not have a lot of power. Other stakeholders in this group, such as the municipality have less power.

People working on the estate: there are several people working on the estate. The owners do not have the ability to do all of the management themselves due to time constraints. Therefore, they partly rely on volunteers and hired workers like the gardener and contractor. We estimate that the volunteers are more motivated if they work on something with high biodiversity, so they have interest in the project and some power since their help is essential to the owners. The hired workers have some interest in the project, as the results may change the way in which these stakeholders work. Their power, however, is low.

Species organisations: there are different organisations affiliated to the project, and therefore have a good amount of interest. These stakeholders have similar objectives as the project goal. Their power however is not that great since they mostly have an advisory role.

Other stakeholders: other groups that have an interest in the project, but have varying power to shape the content. Visitors of the estate and the adoption people of the fruit trees want the estate to look nice and the owners want them to be satisfied with the estate, but they don't have a lot of power. The neighbour that provides sheep to graze the new orchard wants the grass to be nutritious for the sheep so they have an interest in the project since increasing the biodiversity might change the nutritional value of the grass. They also have some power, since the owners depend on the free grazing, so they don't have to mow. The other neighbour doesn't have a collaboration with the owners but a piece of land in front of their house is part of the estate, so they have an interest in the aesthetics of this part. They don't have real power, but the owners want them to remain content.

Appendix B: Team members

Josje Schuttinga (Manager): Josje is a master student in "Organic Agriculture" with a specialisation in sustainable food systems. She has a broad background combining both social and natural science, and therefore has a hybrid view focussing on agroecological food production and sustainable farm systems. She has a collaborative attitude and is good at communicating and having a larger overview of a project. For this project, she mainly focused on the current and additional management and the soil analysis.

Zeta Zepou (Secretary): Zeta is doing her masters in "Forest & Nature Conservation" with specialisation on ecology. She attended a lot of courses during her academic career on ecology, dynamics of ecosystems and conservation, and is passionate about biodiversity conservation. Some of her quality's characteristics are cooperation, thrives on pressure, practical and good listener. For this project, she focused on tree diversity and soil analysis.

Marianne Héritier (Controller): Marianne is a master student in "Forest & Nature Conservation". Her specialisation track "Management" provides her with insights in both ecological and social aspects of nature conservation, with a stronger focus on plant and tree biodiversity. Before that she also studied agroecology and is passionate about promoting society's collaboration with nature. She likes working in a team and coordinating projects. Marianne focused on mice measurements, camera traps and tree diversity.

Isa Priem (Member): Isa is doing her masters in "Animal Science" with specialisation Genetics and biodiversity. She started the master with a broad focus on animal ecology, nutrition and genetics. Nowadays, her focus is on animal ecology and genetics only. She can keep the overview of the work that has to be done and can handle pressure. Her main expertise is in the biodiversity related to animal species. For this project, she focused on current and additional management options and camera traps.

Maja Raemakers (Member): Maja is a master student "Biology" with a specialisation in Ecology. Her fascination in nature has developed into a more in-depth interest in ecosystem biodiversity, especially focussing on the relationships between vegetation and insects. She is solution-oriented, conscientious and has a great perseverance. Maja focused on the area description (especially insects), camera traps, current and future management options.

Tessel de Vries (Member): Tessel is a master student "Biology", also with a specialisation in Ecology. She is very passionate about preserving and increasing biodiversity. Doing fieldwork makes her enthusiastic, especially if it involves plants and she has a good knowledge about wild plant species. She is good at keeping structure in a project, likes to spark everyone to come up with wild ideas and is driven to make a good end product. Tessel focused on area description, mice and management options to increase biodiversity.

Appendix C: Additional soil analysis information

C.1: Protocol soil analysis

$CaCl_2$ extracts for measuring pH:

1. Add approximately 3.0 gram of soil sample to centrifuge tubes, ensuring the balance is zeroed before each weighing.
2. Include one control sample containing clay soil.
3. Add 30 mL 0.01 M $CaCl_2$ solution with a dispenser.
4. Place the tubes in the mechanical shaker for 3 hours to equilibrate the samples.
5. Use a pH meter to measure the pH.
6. Clean the pH-electrode with demi water between measurements, removing any salt crystals.
7. Calibrate the pH meter.
8. Measure the pH in the supernatant (i.e., watery part) of the extracts.

$CaCl_2$ extracts for measuring soluble N and phosphorus concentrations:

1. After measuring the pH, use the mechanical shaker to filter the supernatant from the tubes.
2. Handle the tubes carefully to prevent mixing the liquid with the soil settled at the bottom.
3. Collect approximately 10 mL of each sample in a glass test tube for analysis.
4. Apply flow injection analysis to the samples to quantify nitrate, ammonia, and total phosphate.

Soil respiration and organic matter

1. Ensure the balance is zeroed before weighing.
2. Weigh the empty porcelain cups directly from the oven when warm, as the weight changes when cooling.
3. Let the cups cool down.
4. Fill each cup halfway with soil.
5. Weigh the mass of the soil by zeroing the scale with the cup on it.
6. Place the cup on the designated stove plate and dry the samples at 105℃ overnight.
7. Weigh the cups with the dried soil samples directly from the oven.
8. Place the cups back to the stove, heating them to 550℃ for 3 hours to burn the organic matter in the samples.
9. Weigh the cups with the dried soil samples directly from the oven when warm.

C.2: Results soil analysis

Table 1. *Overview of results soil analysis.*

Soil Sample	Weight tube (g)	Nitrate (mg/l N-NO3)	Nitrate mg/kg N-NO3)	Ammonia (mg/l N-NH4)	Ammonia (mg/kg)	Total N	Phosphate (mg/l P-PO4)	Phosphate (mg/kg)	pH (CaCl2. 25 C)
O1	3,05	0,3	2,360655738	0,23	0,245901639	2,606557377	0,15	1,524590164	5,4
O2	3,06	0,41	3,431372549	0,33	1,225490196	4,656862745	0,11	1,12745098	5,44
O3	3,17	0,3	2,271293375	0,27	0,615141956	2,886435331	0,09	0,899053628	5,13
O4	3,12	0,37	2,980769231	0,36	1,490384615	4,471153846	0,08	0,817307692	4,93
O5	3,09	0,41	3,398058252	0,29	0,825242718	4,223300971	0,24	2,378640777	4,99
B1	2,99	0,14	0,802675585	0,36	1,555183946	2,357859532	0,02	0,25083612	5,5
B2	3,07	0,06	0	0,57	3,566775244	3,566775244	0,03	0,342019544	4,73
B3	3,02	0,06	0	0,4	1,937086093	1,937086093	0,02	0,248344371	4,56
B4	2,98	0,16	1,006711409	0,35	1,459731544	2,466442953	0,01	0,151006711	5,26
B5	3,02	0,12	0,59602649	0,38	1,738410596	2,334437086	0,01	0,149006623	5,3
M1	3,1	0,16	0,967741935	0,39	1,790322581	2,758064516	0,07	0,725806452	5,47
M2	3,1	0,09	0,290322581	0,35	1,403225806	1,693548387	0	0,048387097	5,29
M3	3,02	0,2	1,390728477	0,34	1,341059603	2,731788079	0	0,049668874	5
M4	3,04	0,07	0,098684211	0,36	1,529605263	1,628289474	0	0,049342105	4,74
M5	3	0,06	0	0,31	1,05	1,05	0	0,05	4,68
M6	3,19	0,1	0,376175549	0,27	0,611285266	0,987460815	-0,01	-0,047021944	5,77
M7	3,13	0,13	0,670926518	0,35	1,389776358	2,060702875	0	0,047923323	5,15
M8	2,98	0,1	0,402684564	0,29	0,855704698	1,258389262	0	0,05033557	6,1
M9	2,96	0,06	0	0,3	0,962837838	0,962837838	-0,01	-0,050675676	6,57
M10	2,96	0,09	0,304054054	0,3	0,962837838	1,266891892	-0,01	-0,050675676	5,98
M11	3,11	0,05	-0,096463023	0,37	1,591639871	1,495176849	-0,01	-0,048231511	4,63
M12	3,08	0,06	0	0,35	1,412337662	1,412337662	0	0,048701299	4,65
M13	3,06	0,05	-0,098039216	0,23	0,245098039	0,147058824	-0,01	-0,049019608	4,41

# oven	Empty (g)	Weight sample (g)	After 105'C (g)	After 550'C (g)	DM %	Moisture %	OM %
121	14,1736	10,6334	22,5801	22,1971	79,06	20,94	4,56
122	14,8592	9,8881	22,0369	21,5305	72,59	27,41	7,06
123	13,8182	7,6698	19,4596	19,0875	73,55	26,45	6,6
124	12,7926	10,5363	20,3456	19,776	71,69	28,31	7,54
125	20,9327	15,0044	32,1843	31,372	74,99	25,01	7,22
126	20,4248	19,677	35,4837	34,8536	76,53	23,47	4,18
127	25,8452	20,1054	41,4857	41,0961	77,79	22,21	2,49
128	12,4074	12,3838	22,0408	21,7102	77,79	22,21	3,43
129	15,8327	12,7946	25,6153	25,0846	76,46	23,54	5,42
130	17,3261	12,4211	26,5122	26,0235	73,96	26,04	5,32
131	12,8825	14,4688	23,9542	23,5015	76,52	23,48	4,09
132	15,1125	13,6243	24,9067	24,3089	71,89	28,11	6,1
133	16,843	15,6074	28,0965	27,3484	72,1	27,9	6,65
134	22,9462	18,8177	35,1481	34,1742	64,84	35,16	7,98
135	25,8596	23,0393	41,7543	41,0144	68,99	31,01	4,66
136	12,143	15,2769	23,4261	22,968	73,86	26,14	4,06
137	16,8082	16,0701	28,5128	27,8553	72,83	27,17	5,62
138	14,1767	9,1244	20,4731	20,057	69,01	30,99	6,61
139	26,7167	18,3727	39,9224	39,4725	71,88	28,12	3,41
140	17,0918	13,3763	26,1924	25,7239	68,04	31,96	5,15
141	15,7909	12,9118	25,089	24,667	72,01	27,99	4,54
142	18,8188	22,5779	36,0922	35,4837	76,51	23,49	3,52
143	17,31	18,8123	30,9333	30,4237	72,42	27,58	3,74

Appendix D. Tree measurements

D.1: Blooming period of tree species

***Table 2**. Blooming period of tree species found the estate.*

Species _ Scientific name	Species _ Common name	January	February	March	April	May	June	July	August	September	October	November	December
Acer pseudoplatanus	Sycamore maple												
Alnus glutinosa	Black alder												
Betula sp.	Birch												
Cornus sanguinea	Common dogwood												
Corylus avellana	Common hazel												
Crataegus monogyna	Common hawthorn												
Fraxinus excelsior	European ash												
Ligustrum ovalifolium	Garden privet												
Ligustrum vulgare	Wild privet												
Malus sp.	Apple sp.												
Prunus padus	Bird cherry												
Quercus robur	Pedunculate oak												
Salix caprea	Goat willow												
Sambucus nigra	Elder												
Sorbus aucuparia	Rowan												
Viburnum opulus	Guelder rose												

D.2: Fruiting period of tree species

***Table 3**. Fruiting period of tree species found the estate.*

Species _ Scientific name	Species _ Common name	January	February	March	April	May	June	July	August	September	October	November	December
Acer pseudoplatanus	Sycamore maple												
Alnus glutinosa	Black alder												
Betula sp.	Birch												
Cornus sanguinea	Common dogwood												
Corylus avellana	Common hazel												
Crataegus monogyna	Common hawthorn												
Fraxinus excelsior	European ash												
Ligustrum ovalifolium	Garden privet												
Ligustrum vulgare	Wild privet												
Malus sp.	Apple sp.												
Prunus padus	Bird cherry												
Quercus robur	Pedunculate oak												
Salix caprea	Goat willow												
Sambucus nigra	Elder												
Sorbus aucuparia	Rowan												
Viburnum opulus	Guelder rose												

Appendix E. Mice measurements

E.1: Map of locations of mouse traps

Figure 13. *Map of all the locations of the mouse trap pairs.*

E.2: All activities related to mouse traps

Table 4. *Overview of all the activities related to the small mammal fieldwork.*

Date	Time	Activity
20-11-2023	09.00	Setting up all traps for pre-baiting
27-11-2023	09.00	Refilling all the traps and activating them
27-11-2023	21.00	Emptying traps and writing down results
28-11-2023	09.00	Emptying traps and writing down results
28-11-2023	21.00	Emptying traps and writing down results
29-11-2023	Same two moments	Emptying traps and writing down results
30-11-2023	Same two moments	Emptying traps and writing down results
01-12-2023	09.00	Emptying traps, writing down results removing them
01-12-2023	10.30	Cleaning all the traps

E.3: All data of results mouse traps

Table 56. *All data of all the traps where we found mice and where.*

Habitat	Trap number	27 - Evening	28 - Morning	28 - Evening	29 - Morning	29 - Evening	30 - Morning	30 - Evening	1 - Morning
Grass-dominated meadow	T1 (left when facing the entrance)	house shrew	-	house shrew	false trigger	-	-	-	-
Grass-dominated meadow	T2 (right when facing the entrance)	-	forest shrew (dead)	-	-	-	-	-	-
Grass-dominated meadow	T3	-	-	-	-	-	-	-	-
Grass-dominated meadow	T4	-	-	-	-	-	-	house shrew	-
Grass-dominated meadow	T5	-	-	-	-	-	-	-	-

Grass-dominated meadow	T6	-	-	-	-	-	-	-	-
Grass-dominated meadow	T7	-	-	-	-	-	-	-	-
Grass-dominated meadow	T8	-	-	-	-	-	-	-	-
Grass-dominated meadow	T9	-	-	-	-	-	-	-	-
Grass-dominated meadow	T10	-	-	-	-	-	-	-	-
Grass-dominated meadow	T11	-	-	-	-	-	-	-	-
Grass-dominated meadow	T12	-	-	-	-	-	-	-	-
Grass-dominated meadow	T13	-	-	-	-	-	-	-	-
Grass-dominated meadow	T14	-	-	-	-	-	-	-	-
Grass-dominated meadow	T15	-	-	-	-	-	-	-	-
Grass-dominated meadow	T16	-	-	-	-	-	-	-	-
Grass-dominated meadow	T17	-	-	-	-	-	-	-	-
Grass-dominated meadow	T18	-	-	-	-	-	-	-	-
Grass-dominated meadow	T19	-	-	-	-	-	-	-	-
Grass-dominated meadow	T20	-	-	-	-	-	-	-	-
Biodiverse	B1	-	-	-	-	-	-	-	-
Biodiverse	B2	-	-	-	-	-	-	-	-
Biodiverse	B3	bank vole	false trigger	false trigger	bank vole	bank vole	house shrew	house shrew	bank vole
Biodiverse	B4	-	false trigger	-	-	-	-	-	-
Biodiverse	B5	-	-	-	-	-	-	-	-
Biodiverse	B6	-	-	-	-	-	-	-	-
Biodiverse	B7	-	-	-	-	-	-	-	-
Biodiverse	B8	-	-	-	-	-	-	-	-
Biodiverse	B9	-	-	-	-	-	-	-	-

Biodiverse	B10	-	-	-	-	-	-	-	-
Biodiverse	B11	-	false trigger	-	-	false trigger	-	-	false trigger
Biodiverse	B12	-	-	-	-	-	-	-	-
Biodiverse	B13	-	bank vole	bank vole	bank vole	bank vole	bank vole	bank vole	bank vole
Biodiverse	B14	bank vole	bank vole	bank vole	bank vole	bank vole	bank vole	bank vole	bank vole
Biodiverse	B15	false trigger	-	-	-	-	-	-	-
Biodiverse	B16	false trigger	-	-	-	-	-	-	-
Biodiverse	B17	-	-	-	-	-	-	-	-
Biodiverse	B18	-	-	-	-	-	-	-	-
Biodiverse	B19	-	-	-	-	-	-	-	-
Biodiverse	B20	-	-	-	-	-	-	-	-
Grazed	G1	-	-	-	-	-	-	-	-
Grazed	G2	-	-	-	-	-	-	-	-
Grazed	G3	-	-	-	-	-	-	-	-
Grazed	G4	-	-	-	-	-	-	-	-
Grazed	G5	-	-	-	false trigger	-	-	-	-
Grazed	G6	-	-	-	-	-	-	-	-
Grazed	G7	-	-	-	-	-	-	-	-
Grazed	G8	-	-	-	-	-	-	-	-
Grazed	G9	-	-	-	-	-	-	-	-
Grazed	G10	-	-	-	-	-	-	-	-
Grazed	G11	-	-	-	-	-	-	-	-
Grazed	G12	-	-	-	-	-	-	-	-
Grazed	G13	-	-	-	-	-	-	-	-
Grazed	G14	-	-	-	-	-	-	-	-
Grazed	G15	-	-	-	-	-	-	-	-
Grazed	G16	-	-	-	-	-	-	-	-
Grazed	G17	-	-	-	-	-	-	-	-
Grazed	G18	-	-	-	-	-	-	-	-
Grazed	G19	wood mouse	wood mouse	-	-	-	-	-	-
Grazed	G20	-	-	-	-	-	-	-	-
Coppice	C1								
Coppice	C2							wood mouse	
Coppice	C3								
Coppice	C4								
Coppice	C5	wood mouse	wood mouse	-		wood mouse	wood mouse	wood mouse	false trigger
Coppice	C6	-	-	-		wood mouse	wood mouse	-	-
Coppice	C7	-	-	-		-	-	house shrew	house shrew (dead)
Coppice	C8	-	-	-		-	-	-	-
Coppice	C9	-	-	-		-	-	-	-
Coppice	C10	-	-	-		-	-	-	-
Coppice	C11	-	-	-		-	-	-	-

Coppice	C12	-	-	-		-	-	wood mouse	-
Coppice	C13	-	-	-		-	-	-	-
Coppice	C14	-	-	-	false trigger	-	-	-	-
Coppice	C15	-	-	-		-	-	-	-
Coppice	C16	-	-	-		-	-	-	-
Coppice	C17	-	-	-		-	-	-	-
Coppice	C18	-	-	-		-	-	-	-
Coppice	C19	-	-	-		-	-	-	-
Coppice	C20	-	-	-		-	-	-	-
Chicken coop	E1				-	-	house mouse (dead)	-	-
Chicken coop	E2				house mouse	-	house mouse (dead)	-	-

Appendix F: Additional camera trap information

F.1: Location of all camera traps

Table 6. *Location of the camera traps places on the estate.*

Location number	Location
1	Westside big coppice
2	Eastside big coppice
3	Edge big coppice 1
4	Woodpile northside big coppice
5	Edge big coppice 2
6	Inside coppice
7	Woodpile eastside big coppice
8	Beehives
9	Small coppice 1
10	Small coppice 2

F.2: Results of camera trap

Table 7. *All results of camera traps on the estate.*

Location	Species	Date	Day/Night	Time
Beehives	Common Pheasant (Phasianus colchicus)	25-11-2023	Day	
Beehives	Common Pheasant (Phasianus colchicus)	26-11-2023	Day	15:14
Beehives	Common Pheasant (Phasianus colchicus)	26-11-2023	Day	15:14
Beehives	Common Pheasant (Phasianus colchicus)	29-11-2023	Day	15:27
Beehives	Common Pheasant (Phasianus colchicus)	29-11-2023	Day	17:13
Beehives	Common Pheasant (Phasianus colchicus)	30-11-2023	Day	17:04
Beehives	hare (Lepus europaeus)	25-11-2023	Night	01:17
Beehives	hare (Lepus europaeus)	25-11-2023	Night	20:51
Beehives	hare (Lepus europaeus)	1-12-2023	Night	08:12
Beehives	hare (Lepus europaeus)	1-12-2023	Night	08:13
eastside big coppice	cat	26-nov	night	00:17
eastside big coppice	common blackbird (Turdus merula)	29-nov	Day	15:43
eastside big coppice	Common Pheasant (Phasianus colchicus)	24-nov	day	14:05
eastside big coppice	Common Pheasant (Phasianus colchicus)	24-nov	night	17:57
eastside big coppice	Common Pheasant (Phasianus colchicus)	29-nov	day	13:22
eastside big coppice	Common Pheasant (Phasianus colchicus)	29-nov	day	17:34
eastside big coppice	European hedgehog (Erinaceus europaeus)	25-nov	night	21:06
eastside big coppice	hare (Lepus europaeus)	23-nov	Night	19:18
eastside big coppice	hare (Lepus europaeus)	25-nov	night	19:16
eastside big coppice	hare (Lepus europaeus)	25-nov	night	19:33
eastside big coppice	hare (Lepus europaeus)	26-nov	night	08:43
eastside big coppice	hare (Lepus europaeus)	28-nov	day	17:08
eastside big coppice	redwing (Turdus iliacus)	26-nov	day	13:01

eastside big coppice	roe deer (Capreolus capreolus)	24-nov	night	01:28
eastside big coppice	roe deer (Capreolus capreolus)	24-nov	night	01:28
eastside big coppice	roe deer (Capreolus capreolus)	24-nov	night	06:58
eastside big coppice	roe deer (Capreolus capreolus)	25-nov	night	19:39
eastside big coppice	roe deer (Capreolus capreolus)	25-nov	night	23:07
eastside big coppice	roe deer (Capreolus capreolus)	26-nov	night	03:04
eastside big coppice	roe deer (Capreolus capreolus)	29-nov	day	09:26
edge big coppice 1	Common Pheasant (Phasianus colchicus)	24-11-2023	Day	13:53
edge big coppice 1	Common Pheasant (Phasianus colchicus)	29-11-2023	Day	17:34
edge big coppice 1	Eurasian magpie (Pica pica)	28-11-2023	Day	14:14
edge big coppice 1	Eurasian magpie (Pica pica)	28-11-2023	Day	14:14
edge big coppice 1	Jay (Garrulus glandarius)	29-11-2023	Day	15:36
edge big coppice 1	redwing (Turdus iliacus)	30-11-2023	Day	13:33
edge big coppice 1	redwing (Turdus iliacus)	30-11-2023	Day	16:27
edge big coppice 1	roe deer (Capreolus capreolus)	25-11-2023	Night	02:20
edge big coppice 1	roe deer (Capreolus capreolus)	25-11-2023	Night	23:20
edge big coppice 1	roe deer (Capreolus capreolus)	26-11-2023	Night	03:00
edge big coppice 1	roe deer (Capreolus capreolus)	26-11-2023	Night	03:00
edge big coppice 2	Common Pheasant (Phasianus colchicus)	29-11-2023	Day	13:03
edge big coppice 2	roe deer (Capreolus capreolus)	25-11-2023	Night	02:20
edge big coppice 2	roe deer (Capreolus capreolus)	25-11-2023	Night	23:00
edge big coppice 2	roe deer (Capreolus capreolus)	26-11-2023	Night	03:00
edge big coppice 2	roe deer (Capreolus capreolus)	29-11-2023	Day	09:18
small coppice 1	cat	30-nov	Night	07:59
small coppice 1	cat	30-nov	day	16:08
small coppice 1	common blackbird (Turdus merula)	25-11-2023	Day	14:09
small coppice 1	common blackbird (Turdus merula)	28-11-2023	Day	12:44
small coppice 1	Common Pheasant (Phasianus colchicus)	25-11-2023	Day	11:25
small coppice 1	Common Pheasant (Phasianus colchicus)	28-11-2023	Day	14:36
small coppice 1	Common Pheasant (Phasianus colchicus)	28-nov	day	16:13
small coppice 1	Common Pheasant (Phasianus colchicus)	28-nov	day	16:20
small coppice 1	Common Pheasant (Phasianus colchicus)	28-nov	day	16:37
small coppice 1	Common Pheasant (Phasianus colchicus)	28-nov	day	16:37
small coppice 1	Common Pheasant (Phasianus colchicus)	28-nov	day	16:40
small coppice 1	Common Pheasant (Phasianus colchicus)	28-nov	day	16:40
small coppice 1	Common Pheasant (Phasianus colchicus)	28-nov	day	16:50
small coppice 1	Common Pheasant (Phasianus colchicus)	28-nov	day	16:58
small coppice 1	Common Pheasant (Phasianus colchicus)	28-nov	day	17:08
small coppice 1	Common Pheasant (Phasianus colchicus)	28-nov	day	17:08
small coppice 1	Common Pheasant (Phasianus colchicus)	29-nov	day	15:45
small coppice 1	Common Pheasant (Phasianus colchicus)	30-nov	day	14:33
small coppice 1	Common Pheasant (Phasianus colchicus)	30-nov	day	15:47
small coppice 1	Common Pheasant (Phasianus colchicus)	30-nov	Day	16:08
small coppice 1	Common Pheasant (Phasianus colchicus)	30-nov	day	17:01
small coppice 1	European hedgehog (Erinaceus europaeus)	23-11-2023	Night	19:36
small coppice 1	European hedgehog (Erinaceus europaeus)	27-11-2023	Night	01:53
small coppice 1	European hedgehog (Erinaceus europaeus)	30-nov	Night	17:43

small coppice 1	Pigeon	24-11-2023	Day	13:21
small coppice 2	cat	26-nov	night	01:49
small coppice 2	cat	27-nov	night	12:00
small coppice 2	cat	28-nov	night	05:25
small coppice 2	cat	28-nov	day	02:41
small coppice 2	cat	29-nov	night	05:31
small coppice 2	cat	29-nov	night	03:46
small coppice 2	common blackbird (Turdus merula)	30-nov	day	01:34
small coppice 2	common blackbird (Turdus merula)	30-nov	day	03:45
small coppice 2	Common Pheasant (Phasianus colchicus)	26-nov	day	04:21
small coppice 2	Common Pheasant (Phasianus colchicus)	28-nov	day	03:43
small coppice 2	Common Pheasant (Phasianus colchicus)	28-nov	day	03:59
small coppice 2	Common Pheasant (Phasianus colchicus)	28-nov	day	04:25
small coppice 2	Common Pheasant (Phasianus colchicus)	30-nov	day	10:39
small coppice 2	Common Pheasant (Phasianus colchicus)	30-nov	day	01:02
small coppice 2	Common Pheasant (Phasianus colchicus)	30-nov	day	01:07
small coppice 2	Common Pheasant (Phasianus colchicus)	30-nov	day	01:33
small coppice 2	Common Pheasant (Phasianus colchicus)	30-nov	day	01:36
small coppice 2	Common Pheasant (Phasianus colchicus)	30-nov	day	01:36
small coppice 2	Eurasian magpie (Pica pica)	25-nov	day	13:56
small coppice 2	Eurasian magpie (Pica pica)	28-nov	day	02:14
small coppice 2	Eurasian magpie (Pica pica)	30-nov	day	03:08
small coppice 2	European hedgehog (Erinaceus europaeus)	23-nov	Night	10:32
small coppice 2	European hedgehog (Erinaceus europaeus)	26-nov	Night	12:12
small coppice 2	European hedgehog (Erinaceus europaeus)	27-nov	Night	07:22
small coppice 2	Great tit (Parus major)	28-nov	day	12:26
small coppice 2	Jay (Garrulus glandarius)	30-nov	day	09:04
small coppice 2	Jay (Garrulus glandarius)	30-nov	day	02:54
small coppice 2	redwing (Turdus iliacus)	24-nov	day	10:24
westside big coppice	common blackbird (Turdus merula)	28-11-2023	Day	
westside big coppice	common blackbird (Turdus merula)	29-11-2023	Day	10,4
westside big coppice	common blackbird (Turdus merula)	29-11-2023	Day	11:50
westside big coppice	common blackbird (Turdus merula)	29-11-2023	Day	13:13
westside big coppice	common blackbird (Turdus merula)	29-11-2023	Day	13:37
westside big coppice	common blackbird (Turdus merula)	29-11-2023	Day	15:50
westside big coppice	common blackbird (Turdus merula)	29-11-2023	Day	16:05
westside big coppice	common blackbird (Turdus merula)	29-11-2023	Day	16:23
westside big coppice	common blackbird (Turdus merula)	29-11-2023	Day	17:38
westside big coppice	common blackbird (Turdus merula)	29-11-2023	Day	17:38
westside big coppice	common blackbird (Turdus merula)	30-11-2023	Day	13:07
westside big coppice	common blackbird (Turdus merula)	30-11-2023	Day	14:07
westside big coppice	Eurasian magpie (Pica pica)	29-11-2023	Day	13:49
westside big coppice	European hedgehog (Erinaceus europaeus)	27-11-2023	Night	
westside big coppice	hare (Lepus europaeus)	28-11-2023	Day	
westside big coppice	Jay (Garrulus glandarius)	29-11-2023	Day	13:48
westside big coppice	Jay (Garrulus glandarius)	29-11-2023	Day	15:50
westside big coppice	Mouse	26-11-2023	Night	

westside big coppice	Rat	30-11-2023	Night	00:15
westside big coppice	Rat	30-11-2023	NIght	00:47
westside big coppice	Rat	30-11-2023	Night	20:53
westside big coppice	Rat	30-11-2023	Night	04:00
westside big coppice	redwing (Turdus iliacus)	29-11-2023	Day	9,45
westside big coppice	redwing (Turdus iliacus)	29-11-2023	Day	10,04
westside big coppice	redwing (Turdus iliacus)	29-11-2023	Day	12:40
westside big coppice	redwing (Turdus iliacus)	29-11-2023	Day	13:14
westside big coppice	redwing (Turdus iliacus)	29-11-2023	Day	13:29
westside big coppice	redwing (Turdus iliacus)	29-11-2023	Day	13:33
westside big coppice	redwing (Turdus iliacus)	29-11-2023	Day	13:43
westside big coppice	redwing (Turdus iliacus)	29-11-2023	Day	14:23
westside big coppice	redwing (Turdus iliacus)	29-11-2023	Day	16:46
westside big coppice	redwing (Turdus iliacus)	29-11-2023	Day	17:29
westside big coppice	redwing (Turdus iliacus)	30-11-2023	Day	12:52
westside big coppice	redwing (Turdus iliacus)	29-11-2023	Day	11:43
westside big coppice	roe deer (Capreolus capreolus)	23-11-2023	Night	
woodpile eastside big coppice	common blackbird (Turdus merula)	25-nov	day	12:14
woodpile eastside big coppice	common blackbird (Turdus merula)	25-nov	day	12:36
woodpile eastside big coppice	Common Pheasant (Phasianus colchicus)	23-nov	night	17:43
woodpile eastside big coppice	European Robin (Erithacus rubecula)	29-nov	day	13:29
woodpile eastside big coppice	mouse	28-nov	night	01:52
woodpile eastside big coppice	rat	26-nov	night	04:33
woodpile eastside big coppice	rat	28-nov	night	23:26
woodpile eastside big coppice	rat	1-dec	night	08:09
woodpile northside big coppice	common blackbird (Turdus merula)	28-nov	day	16:38
woodpile northside big coppice	common blackbird (Turdus merula)	29-nov	day	14:02
woodpile northside big coppice	common blackbird (Turdus merula)	30-nov	day	14:37
woodpile northside big coppice	Common Pheasant (Phasianus colchicus)	28-nov	day	11:35
woodpile northside big coppice	European hedgehog (Erinaceus europaeus)	25-nov	night	21:31
woodpile northside big coppice	hare (Lepus europaeus)	25-nov	night	17:35
woodpile northside big coppice	hare (Lepus europaeus)	28-nov	Night	17:08
woodpile northside big coppice	rat	23-nov	Night	22:36
woodpile northside big coppice	rat	30-nov	night	19:33
woodpile northside big coppice	rat	1-dec	night	00:56
woodpile northside big coppice	rat	1-dec	night	03:29
woodpile northside big coppice	rat	1-dec	night	04:39
woodpile northside big coppice	rat	1-dec	night	06:19
woodpile northside big coppice	rat	1-dec	night	06:43
woodpile northside big coppice	redwing (Turdus iliacus)	28-nov	day	12:17
woodpile northside big coppice	redwing (Turdus iliacus)	29-nov	day	14:02
inside coppice	roe deer (Capreolus capreolus)	24-nov	night	06:59
inside coppice	roe deer (Capreolus capreolus)	25-nov	night	19:52
inside coppice	fox (Vulpes vulpes)	27-nov	night	19:40
inside coppice	roe deer (Capreolus capreolus)	28-nov	night	23:01
inside coppice	hare (Lepus europaeus)	30-nov	day	10:34
inside coppice	hare (Lepus europaeus)	30-nov	night	18:37

Appendix G: Potential plant communities of vochtig hooiland

***Table 8**. Plant communities and corresponding target species of vochtig hooiland (Van Baren & Schulte, 2017).*

Code VN	**Code SBB**	**Name plant community**	**Target species**
8RG5	08C-b	Rompgemeenschap moeraszegge: *Carex acutiformis*	*Caltha palustris* subsp. *Palustris*
16Ab1	16A2a	Veldrus-associatie: *Crepido-Juncetum acutiflori*	*Dactylorhiza majalis*, *Caltha palustris* subsp. *palustris*, *Valeriana dioica*
16Ab4	16B1a	Associatie van Boterbloemen en Waterkruiskruid: *Ranunculo-Senecionetum aquatici*	*Jacobaea aquatica*, *Caltha palustris* subsp. *palustris*, *Dactylorhiza majalis*, *Valeriana dioica*
16Ab6	16B2	Dotterbloemgrasland: *Angelico-Cirsietum oleracei*	*Crepis paludosa*, *Cirsium oleraceum*, *Persicaria bistorta*, *Caltha palustris* subsp. *palustris*, *Dactylorhiza majalis*, *Valeriana dioica*

Appendix H : Interviews

H.1: Interview Martine and Rogier van de Mast (owners estate)

- **Trees**
- **Meadows**
- **Klompenpad**
- **Orchards**
- **Ponds**
- **Animals**
- **Other**
- **Possible management/species**

Trees

Winter (coppice)	Natuurwerkdag (November) depens on what is needed • Cut some trees knee high • Prune what has been cut
	Winter (Nov, Dec, Jan): checking safety all trees, do they need to be cut, pruning
	Shredded wood is taken by neighbouring farmer who uses it for heating in his company
	People come to take would if it is a lot
Winter (other trees)	Every 2 or 3 years, zoo will come and prune willow branches. --> alternating trees. Take branches for elephants
	Every 5 years black alder pruned. Cut side branches along trunk.
	Branches along trunk silver lime trees are cut. Mowing grass around trunks
	Poplar trees: keep trunk tidy, twigs are removed from stem with saw. Also important to get light on the sheep meadow.

Meadow

Summer (big meadow)	Mow twice a year. After meadow bird season (15 June) but usually after 1 July. Second mow end of September, beginning of October. Done by care farm: maaien, schudden, dijken, balen persen. They always leave a strip, alternating, butterfly highway. Part behind coppice, but also around electricity pole.
	Removing akkerdistel (creeping thistle, *cirsium arvense*) cut before flowering. Dilemma because good for insects and soil.

	Removing jacobskruiskruid (common ragwort, *Jacobaea vulgaris*) by hand after flowering. Not so much on own land, but on side of the road. Removed so the seeds don't blow onto the meadow. Advised by Lodewijk.
Summer (biodiverse meadow)	Maintenance is done by biodiversity group.
	Mown every 8 weeks with a scythe
Separate incidents	Topsoil big meadow removed in 2008 for depletion. Don't know how much was removed
	Has been 'geklepeld' once, but it was very expensive

Klompenpad

Summer	Mown every week (Apr-Okt)
All year	When needed (rot, broken) benches are maintained
	When needed bridges are maintained. Now talking to the municipality of Ede to replace one of the bridges for a more natural one. Just two planks (so strollers can still cross) and a small tree trunk.
	Rhododendrons are a lot of work. There is a fungus in the soil which kills them. They are looking for an alternative
Separate incidents	European hornet nest next to the walking path removed
	Chicken wire at one point to stop people from slipping
	Presumably yellow sand used to make the path

Orchards

Winter (new orchard)	(Jan, Feb) Trees pruned by fruit tree expert in Wageningen. Removes branches when needed, now mostly branches with blossom to help with growth
Spring (new orchard)	Fertilizing trees with cow manure if needed (advised by fruit tree specialist). Cow manure from Lodewijk. (Verteerde stalmest) • Because of limited extra nutrients in soil. • Not done every year
Summer (new orchard)	Fruit is harvested when ripe. Planning still tricky. Harvested by owners and fruit tree adopters. Eaten by hikers or made into jam by Martine.
Separate incidents (New orchard)	Sheep farmer injects liquid manure into the soil when needed. Not every year
	Trees were planted so the machines can still drive through
Winter (old orchard)	Pruned by fruit tree expert in Wageningen. Tries to prune them into a useful shape. They are very old.

	Pruned branches are shredded and put around benches or in the vegetable garden.
All year (old orchard)	Few hawthorn bushes with blight (bacterievuur). Need to be shredded immediately. NVWA comes to check which need to be removed, they used to recommend using glyphosphate, but Rogier and Martine do not do this.

Ponds

Winter	Mowing 2/3rd of the reed, leave 1/3, underneath the water level. • Before the 1st of March • Needs to be dry (enough) or light frost • Done by contract worker
	Ditches on the side of the road are maintained by the municipality
	Ditches on their own terrain are done by contract worker
All year	A lot of work, but are not very profitable for subsidies
Separate incidents	Dug in 2008, removed clay put back in for the bottom

Animals

All year (sheep)	Vet, vaccinations
	Function: keeping the grass short
	Sheep are sheared
Chicken	Function: cleaning. Eat eggs insects, also larvae sheep poop
Meadow (own sheep)	2x year chalk, and organic 'gazonmest' (fertilizer)
Insects	5 beehives (+- 10 000 per hive), mainly for pollination
	People that buy honey (local) • Good for allergies • North-African people, use it in their food
	Nice to have a mx between wild and honey bees
	Keep an eye on wasp nests, and check whether it is dangerous for humans. If it is not, they leave it, if it is (eg close to the picnick tables) they remove it using poison
Moles	Mole traps are used in the front garden

Other

All year	Maintenance of fences, checking for rot, reuse by rotating poles
	Mowing underneath fences

Autumn	Using leaf blower to remove leaves from yard. Blow them into the bushes, are not taken away.
	Berry shoots from the vegetable garden are put in the coppice (maybe it will do something but they don't know for sure)

Possible management/species

Rhododendrons	Portugese laurier (Portuguese laurel, *Prunus lusitanica Angustifolia)*
Subsidies	Check kadaster map to see the different management types. Focus on profitable type (probably schraalgrasland)
English ryegrass	Have been advised to use ratelaar (Rhinanthus). It is a possibility, but they do not necessarily want to intervene in nature
Brambles	Have been advised to use lupin. • Lot of varieties, which one?? • Don't only want lupin, keep diversity • Good for cattle and some varieties can also be used for human consumption
Preferences Martine and Rogier	Like poppy's, camomile and cornflower (however don't know whether it will grow there/is useful for biodiversity)
	NO hedera (ivy)

H.2: Interview Nynke Groendijk

- **Current management**
- **Possible management**
- **Current species**
- **Possible species**

Current management

Coppice (small)	For insects it is good to have variation in vegetation height (next to trees, also shrubs and other small plants)
Flower strip	They tried but failed. It was too dry. Difficult. Soil is too rich (nettle as indicator species)
Meadow	Water pond (right corner): removing reed in different sections, but not everything at once.
Vochtig hooiland	Around the ponds: mowing reeds in phases
	Mow gradually and use small machines and scythe à more precisely, don't leave any tracks and less pressure on soil (less compact soil) They 'rent' (for free) the small machine but it is a lot of organise effort. Using the scythe is easier
	They let the vegetation develop in a natural way (without sowing any seeds)

Possible management

Coppice (small)	Additional management measurements: less brambles and more indigenous plants & mantel zoomvegetatie (Dutch term to get more structure/ height variation within the forest edges).
	Mantel zoomvegetatie is beneficial for microclimate --> more insects --> more birds
	Clear 0.5 from path --> sow with other plants to get more structure (variation in height)
Orchard + sheep	Possibility: divide parts, sow with diverse plant species to get more flowers. Sheep rotating to different parts to have low disturbance pressure
Rhodondendron	Tree layer system --> more biodiversity
	Water ditch: make less steep edges so water can get out. This results in variation in plant species Nutrient rich water. Making it poor through mowing and removing
Flower strip	Can try it again. But first mowing and keeping it open and afterwards sowing Cruydt-Hoeck: seed mixture
Old orchard	Possibility: hedges along the sides of the fences + making it more flowerful
	Prune trees so food goes towards the branches
Coppice (big)	Don't need to do much. Is east & north side, so not much sun but it is possible to look into mixtures for shadow plant species
	But maybe cutting off some trees to open op some space and light for other plant species (undergrowth)
Vochtig hooiland	Possibility: creating an insect/arthropod/reptile wall Making a wall of old stones, wood and loam for bees, (hagedissen??), snakes, and other very little organisms. Placing in sun
	Action in pruning brambles, otherwise they will overgrow other plants
Electricity field	Making it more diverse through sinus mowing (gefaseerd maaien)
Sheep meadow	Not much to do for biodiversity
Other	Soil most important for biodiversity. What happens below ground is basis for biodiversity

Current species/habitat

Coppice (small)	A lot of nettles (brandnetel) and brambles (bramen --> Dijkviltbraam (Rubus armeniacus) is an invasive exoot). Quick growers, this is a problem for other plants --> outcompete. These plants like N (nitrogen)
	Current tree species: es (Fraxinus excelsior), zwarte els (Alnus glutinosa), Gelderse roos (Viburnum opulus, is the tree with the berries), wilg (willow spec.), meidoorn eenstijlig (Crataegus monogyna, planted), zomer eik (Quercus robus) or hybirds.
Old orchard	Only chicken
Coppice (big)	Current species: witte dovenetel (Lamium album) good for insects
	Dead wood
	At the moment there are no voorjaarsgroeiers (spring growers). Probably due to soil quality
Meadow	Current species: boterbloem (Ranunculus), fluitenkruid (Anthriscus sylvestris), paardenbloem (Taraxacum officinale), madeliefje (Bellis perennis), weegbree (Plantago), zuring (Rumex, less attractive for cattle), akkerdistel (Sphaeroderma testaceum, less attractive for cattle but good for insects)
Vochtig hooiland	Past bench and at the edge of coppice: they have planted shrubs to create more layers Not in a straight line but more flowy to enhance diversity in the microclimate
	Number of flowers this year higher than year before (same applies for the number of orchids) Probably Rietorchis (Dactylorhiza praetermissa). This year they counted around 30 individuals, the year before around 10.
Sheep meadow	Steenuil (little owl)
	Next to it they planted Populus trees
Other	Enough willow. But they are good for insects (produce a lot of nectar)

Possible species

Orchard + sheep	Clover (White clover)
Rhodondendron	Vuilboom (Rhamnus) good species for butterflies
Coppice (big)	Possibility: planting bio bulbs --> good spring flowers. This is food for bees after hibernation
Meadow	More flowers also for meadow birds
	Possibility: shrubs/ higher vegetation islands/ patches. Especially, keeping higher vegetation between path and meadow.

Vochtig hooiland	Wild bees need more connection between different patches of vegetation. Very open and boring surroundings. Steppingstones
	Wanted/ increasing plant species: echte koekoeksbloem (Silene flos-cuculi), rolklaver (Lotus corniculatus var. corniculatus).
Other	Make sure to have a wide range of flowering plants, from start till end of season
	Klimop (ivy): important for insects in autumn since they are the last flowering plants. But make sure that to do not grow over and outcompete other plants
	Hazelnut, not so good for insects
	Tilia good for soil but not sure if they grow here
	Liguster (Ligustrum) is a good plant species for insects. Attracts a lot of insects
	Garden front house: butterfly plants

H.3: Interview Fons Koomen

- **Position of the Lieskamp in the area**
- **Hooilanden**
- **Species (current and possible)**
- **Possible management and questions to look at**

Position of the Lieskamp in the area

Neighbouring farmers	It is good to involve the area. There are a lot of different stakeholders involved
	Some of the neighbouring farmers between the Hooilanden and the Lieskamp are conventional, some of them mow up to 7 times a year
	I'm not sure which land belongs to who, it's difficult to find out. Lodewijks land is more to the North.
	Weidevogelbeheer is a contract. There are zones in which this is worked on. There are collectives of farmers who ask for subsidies and work on it together.
Ecological corridor	Now it is like an island, it would be good to connect it to the nature area
	There is some connection through the Klompenpad, but there is an asphalt road in the way
	The estate is not super useful for bigger birds, but there is a big potential and value for smaller birds
	Create the right conditions and the species will come

	If you attract more smaller birds to the estate, they will also go into the Hooilanden to find food.
Value & vision	It has additional value at this point, I really like the initiative
	In the future I would like the state to have a similar function, I like the different habitats it has now (meadow, water and coppice). However, in the area I would like it if there was more nature
	It is not necessary to turn the Lieskamp into extreme nature. You can think in zones, extreme nature in the middle (hooilanden) and nature inclusive agriculture surrounding it. Less (big) machines and less English ryegrass.
	Making the connection with other nature area's (eg. Utrechtse Heuvelrug)
	There is a lot of value in the current bird diversity already

Hooilanden

Past management	We put clippings from other nature areas on the bare soil. It is nice to see the diversity, you can see from which nature area it came.
Visions	There are different visions on the nature area, farmers think it is too wet, they cannot use it for mowing anymore. They think it is important to mow and be able to earn some money off of this.
	Some people want to use subsidies to finance the project, others say it is important to create monetary value in another way (eg mowing)
Current management	Mowing: when it is too wet, they use a machine with 'rupsbanden'

Species (current and possible)

Birds	Waterral
	Bosrietzanger
	Steenuil (seen at estate)
	Dodaar (seen at estate)
	Kievit
	Ringmussen
	Zwaluwen (Swallow)
	Mezen
	Gekraagde roodstaart
	Zettenzanger
	Kemphaan

	Roodpootvalk
	Bruine Kiekendief
	Zeearend
Mammals	Das (Badger)
	Boommarter
	Vos (Fox)
Plants	Berry bushes serve as food for a lot of birds

Possible management/questions to look at

Questions	How much topsoil has been taken off? In the Hooilanden this was up to 40cm, good to check this and how much it has influenced the meadow.
	How are the nutrients in the grassland? Did removing the topsoil work?
	Look at the impact of the metal fence, can animals cross it?
	Could be nice if it is possible to monitor birds more. You could ask volunteers to visit every 2 weeks and write down what they see. Cluster method, to look at territory.
Possible species	It would be nice if you could get blauwgrasland, but I do not have enough knowledge whether it is possible.
	What kind of species do you want to attract? Create the right conditions and the species will come
Possible management	It is useful to put on clippings to stimulate new species in grassland, however it is only possible on bare soil otherwise it does not get the chance to compete
	For soil depletion and getting rid of English ryegrass, mowing is not always enough. There was a lot of density and soft rush. I am not sure if there are other ways to achieve it apart from removing topsoil, you might need to contact someone else. Maybe ploughing could be something you can look at?
	Making the edges of the ditches less steep
	Making a connection between different nature areas--> who is in charge of the Klompenpad, maybe it is possible to work together
	After removing topsoil it is possible to mow quickly, can be in the first or second year.
	More nesting for smaller birds

Appendix I. Species list new orchard

Plattegrond hoogstamboomgaard de Lieskamp

Rij 1	Rij 2	Rij 3	Rij 4
Eldense Blauwe		Opal	
	Anna Späth		Reine Victoria
Reine Claude Verte		Reine Claude d'Althan	
	Betuwse kwets		Wijnpruim
Zigeunerin		Yellow	
	Yellow		Honingzoet
Zigeunerin		Sterappel	
	Clapps Favourite		Peterselie appel
Glorie van Holland		Suikerpeer	
	Zoete Bloemee		Ent: Jan Steen (not. Appel onderstam)
Glorie van Holland		Gravensteiner	
	Notarisappel		Ent: Giesser Wildeman (St Remy onderstam)
Triumph de Vienne		Notarisappel	
	Notarisappel		Ent: Giesser Wildeman (St Remy onderstam)
Lunterse Pippeling		vergeten ras (schone)	
	Groninger Kroon		Ent: GrootHertog Friedrich von baden (schone van boskoop onderstam)
Groninger Kroon		vergeten ras (St Remy)	
	St-Remy		vergeten ras (St Remy)
Dijkmanszoet		Bramley Seedling	
	Brabantse Bellefleur		vergeten ras (not. appel)
Legipont		Zoete Campagner	
	Lemoenappel		Binder Zoet
Present van Engeland		Schone van Boskoop	
	Rode van Boskoop		Engelse bellefleur
Ingrid Marie		Dubbele Bellefleur	
	Schone van Boskoop		Bramley Seedling
Winterjan		vergeten ras (schone)	
	Jasappel		vergeten ras (schone)
Gieser Wildeman		Zoete Brederode	
	Winter Calville		Anijs appel
Zwijndrechtse Wijnpeer			
Op de plekken van 'vergeten ras' staan jonge peren- en appelbomen die in de komende jaren met oude (vergeten) rassen worden omgeent, bij voorkeur met rassen uit de Gelderse Vallei.			
De bomen zijn in driehoeksverband aangeplant met een plantafstand van 9m.			
De bomen zijn aangeplant op pluktijdstip: pruimen zijn het eerst en onderin staan de late rassen.			

***Figure 2**. A list of species present in the new orchard.*

Appendix J. Flyer of recommendations for overall management

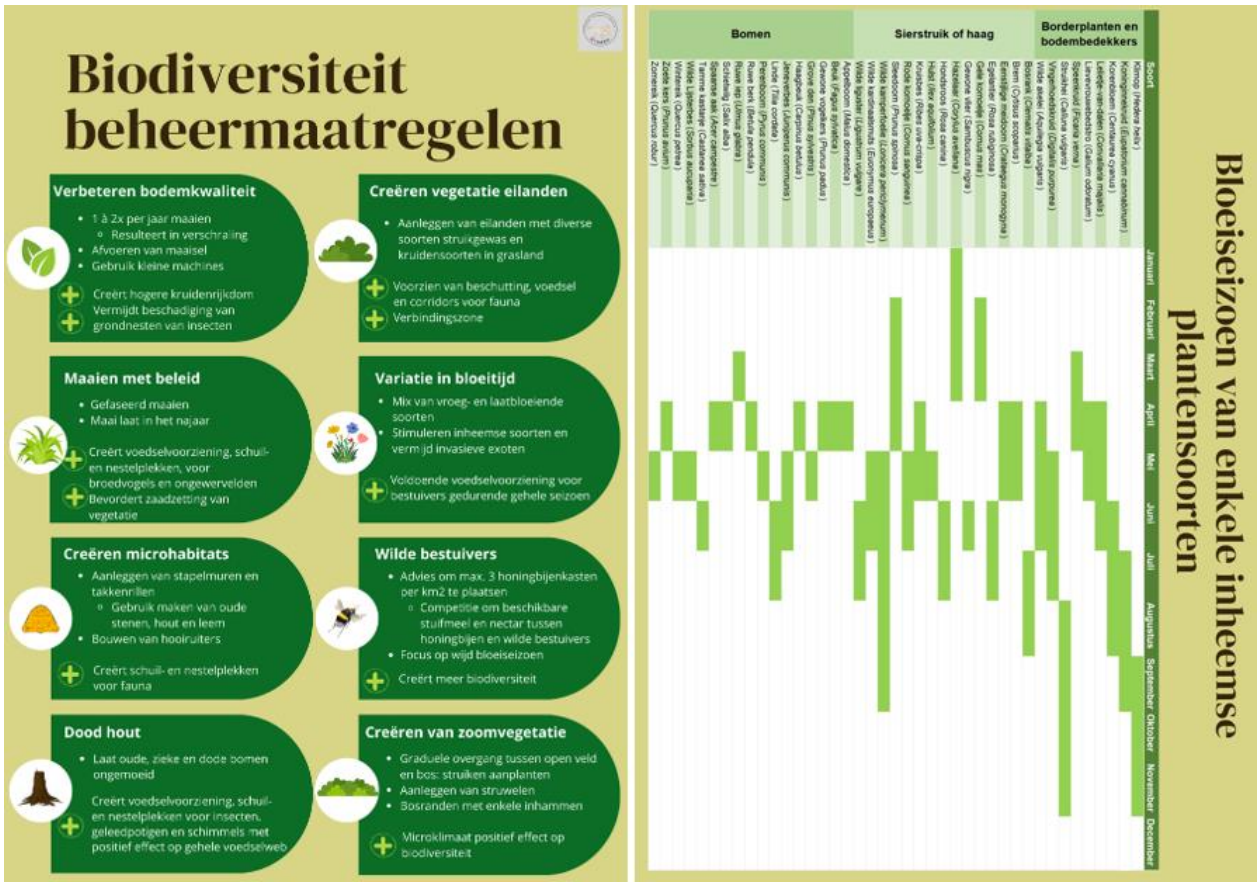


Figure 3. *Flyer for the take-home package made for overall management.*