THE LIVING LODGE: ACCOMMODATING LIFE

An assessment of integration and monitoring of biodiversity

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Representation of the Biesbosch ecosystem and recreation.

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EXECUTIVE SUMMARY

The Living Lodge concept revolves around sustainability and the integration of nature into its structural design, thereby improving the quality of the habitat it occupies. This report assesses this concept by giving ecological advice regarding species integration and setting up a sound ecological monitoring system. Expert consultation and literature study form the basis for the knowledge underlying the report.

Five main components are at the core of this advice. Firstly, the species composition of the Brabantse Biesbosch is analysed using three criteria: 1) Conservation concern, 2) Ecological value and 3) Attractiveness. The species groups that are addressed in this section are vegetation, birds, dragonflies, butterflies and mammals. Secondly, an overview of the currently available resources regarding green infrastructure and building. The third component is a synthesis, resulting in a tool to select target species for the pilot location. This tool is synthesized using the first two main components. The fourth component is a monitoring system. The protocols for this monitoring system is split up into two parts; one to be conducted by an ecological expert and another designed as a citizen science study. The monitoring system for experts is designed to assess the impact of the lodge on biodiversity, whereas the citizen science study mainly has an educational purpose. To reduce future efforts, the ecological process for establishing the Living Lodge is standardized in the fifth component. This component contains a flowchart which concerns five steps: an ecosystem assessment, restoration advice, species selection, species integration, and ecosystem monitoring.

Furthermore, an activity list for guests is provided which contains suggestions for connecting guests with nature. Finally, the report concludes with limitations and future research recommendations.

PREFACE

This report was commissioned by the Science Shop Wageningen UR, on behalf of their client organisation, the 'Nature Nomads' in conjunction with Vogelbescherming. It is the end product of an eight-week Academic Consultancy Training course at Wageningen University and is developed by a team of MSc. students with an ecological background. The purpose of our project is to offer our commissioners advice on enhancing and monitoring biodiversity in the Brabantse Biesbosch and to summarize this methodology to facilitate replication in other areas.

Many individuals provided our team with knowledge, expert advice and feedback that went a long way in shaping our final outputs. We are thankful for their valuable guidance. We would like to thank Stefan Nortier for his coaching during this consultancy training, his guidance and support was an invaluable component throughout the process. Jeroen Sluijsmans for his feedback on the quality of the product, his professional input is greatly appreciated. Keete Voerman for assessing the project proposal and providing us with instruction for improvement. We thank Hugo Hoofwijk and Herbert Smeenk for their arrangements during our field visit, the time spent with them in the field was a great motivation to the team. We thank them along with Emile Smeenk for giving us the opportunity to work on this project and for encouraging us during the process. Thanks to Marijke Smeenk-Brinkert for sharing her expertise as a field guide in the Biesbosch, her enthusiasm and insights had a large influence on our work. The expert knowledge of Rene Henkens (Alterra), Henk Siepel (RUG), Gerdien Bos (vlinderstichting), Jurriën van Deijk (Vlinderstichting), Michiel Wallis de Vries (Vlinderstichting), Ronald Zollinger (RAVON), Han Sluiter (Staatsbosbeheer), Robbert Snep (Alterra), Charlotte Lelieveld (WUR), Wim Ruis (IVN) is thoroughly appreciated. Finally, we thank the ACT coordination team for their support and for their timely responses to our office and meeting room requirements.

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1. Introduction

This study focusses on integrating the species composition in the Biesbosch with available greening components and provides a monitoring plan for tracking the change in species richness over a period of 10 years. These methods are standardized to guide the establishment of Living Lodges in other areas. This study also touches upon guest involvement in enhancing biodiversity. The following research questions were formulated:

1. What is the current species composition of the Biesbosch?
2. How can biodiversity be enhanced through the Living Lodge itself?
3. What are target species for the Living Lodge area?
4. What are monitoring criteria and how to monitor the area after establishing the Living Lodge?
5. How can biodiversity be enhanced through tourist involvement?
6. How can the methods be used to implement the Living Lodge in new areas?

To answer these questions, a literature study was carried out and interviews with experts were performed. To provide a theoretical framework, background information is given in chapter 2. Chapter 3 provides an overview of the habitat types and characteristic species in the Biesbosch. Habitat requirements of these species are given in the appendix. Chapter 4 provides an overview of green façade elements and other structures for integrating biodiversity that are currently available. It also briefly discusses their possible applications in the Biesbosch. These two outputs are combined in chapter 5, where the Species selection tool that was produced, is discussed. Chapter 6 provides a monitoring system that can be used to track the effect of the Living Lodge on the area. Accompanying field forms can be found in Appendix 9 – Field forms. Chapter 7 briefly touches upon nature education and activities guests could perform to contribute to nature development. To conclude, chapter 8 describes a flowchart in which methods and considerations are given to guide the establishment of Living Lodges in other areas and chapters 9, 10 and 11 contain limitations and recommendations.

Theoretical framework

2.1 CONNECTEDNESS TO NATURE

Mental and psychological health have been decreasing in the last few decades, largely due to the effects of urbanization. An enormous increase in depression treatments in the last decades has been observed from 1987 onwards, which is a reliable indication of the state of global mental health (Marcus & Olfson, 2010; Olfson et al., 2002). Additionally, a vast increase in the use of antidepressant treatments in younger people are cause for great concern, especially regarding the mental safety of younger people. This is only one example concerning the mental wellbeing of our current population. Many studies have connected mental health to the degrading environment (Bragg, 1996; Feral, 1998; Kahn Jr, 1997). Especially "[...] *fragmented human-nature relationships negatively affects psychological health"* (Nisbet et al., 2010, p303). 'Connectedness' to nature is suggested to be a source of human well-being. This is supported by several studies. It has been shown that among others, clean coastal regions (Wyles et al., 2015), walking (Johansson et al., 2011), running (Bodin & Hartig, 2003) and exercising in general (Plante et al., 2007) are beneficial to the psychological well-being of people and therefore contribute to enhancing human well-being. The local environment also contributes to human attitudes and behavior (Bragg, 1996). In the light of climate change the environment will be undergoing vast degradation. The connectedness to nature will enhance the chance of mitigation to environmental degradation (Feral, 1998).

These examples all tend to go into the same direction. This general goal of oneness with nature has been recognized by Feral (1998) as she states that "*when people consciously understand that they are part of, and intricately connected to, the natural world, they will be able to expand their boundaries of empathy to include all of creation."* (Feral, 1998, p244). This disconnection, she argues, can result in several imbalances in lifestyles like aggression, toxic environments, fear, isolation and even illness. That the awareness of this issue is being increased, can be illustrated by the development of hypotheses regarding this topic, of which the 'biophilia hypothesis' is an example. This hypothesis is stating that there is a tendency for humans to seek connections with nature (Rogers, 2015). Since people have started living in cities relatively recently, in evolutionary terms, it may be one of the causes for this feeling of disconnection with nature (Nisbet et al., 2009). This in turn could be contributing to the degradation of the earth (Schultz et al., 2004) and causing mental degradation as well (Feral, 1998).

2.2 NATURE-BASED TOURISM

Wildlife watching tourism and ecotourism are two forms of tourism aiming at the connection of humans with nature. Wildlife watching tourism is tourism organised to watch flora and/or fauna (Tapper, 2006). Ecotourism is based on several principles including the contribution to the conservation of natural and cultural heritage and a form of tourism managed in an ecologically sustainable way (Quebec Declaration on Ecotourism, 2002; Lindberg et al., 1997). A subgroup of ecotourism is volunteer tourism, which goes much further than the observational activities of wildlife watching tourism. Volunteer tourists can provide a direct contribution to nature conservation. They pay to actively participate in research, monitoring, and conservation activities (Tapper, 2006). Several environmental benefits of ecotourism and volunteer tourism have been recognized. Firstly, ecotourism supplies funds for maintenance, management and enhancement of protected nature areas (Weaver, 2002). Secondly, tourists can be directly involved in nature conservation and improving biodiversity by volunteering in habitat maintenance and enhancement activities (Weaver, 2002). Conservation scientists acknowledged the considerable contribution volunteer tourism may provide by means of providing funding and labour and became more interested in volunteer tourism the past decade (Brightsmith et al., 2008).

However, environmental costs and potential drawbacks of nature-based tourism have been

identified as well. Firstly, the construction of a lodge inevitably involves permanent environmental restructuring and establishes ongoing waste generation in the area (Weaver, 2002). Building a lodge in a nature area becomes more acceptable by taking measures to limit environmental restructuring and waste generation. Finally, a potential drawback of volunteer tourism is the reliability of volunteer-collected data. The value of volunteers participating in data collection for monitoring is greatly reduced when the collected data are inaccurate. However, many studies have shown that volunteers can collect usable data of high quality when they were given sufficient training and assigned to appropriate tasks (Darwall & Dulvy, 1996; Schmitt & Sullivan, 1996; Newman et al., 2003; Pattengill-Semmens & Semmens, 2003). The knowledge and skills of volunteers are important selection criteria for assigning volunteers to appropriate tasks.

Analysis of the Biesbosch

3.1 INTRODUCTION

3.1.1 GENERAL INFORMATION

On May 10, 1992, the Biesbosch area became a National Park. This National Park covers 9,720 ha and is intersected by the river De Nieuwe Merwede and is bordered by the rivers Amer and Beneden Merwede (Figure 1). The area consists of three parts: The Sliedrechtse and Dordtse Biesbosch, located in the province of Zuid-Holland, and the Brabantse Biesbosch located in the province of Noord-Brabant (Ministry of Economic Affairs, 2016; Nationaal Park De Biesbosch, 2013). The Biesbosch is located in the downstream river area of rivers originating from the rivers Rhine and Meuse and is a freshwater tidal zone. Currently, the dynamics of the river level are determined by the tide (however, this is strongly muted), impoundment by wind, water level of the major rivers and the drainage regime of the Haringvliet Sluices (KIWA & EEG, 2007).

Figure 1. Map of the Biesbosch area. Green lines represent the border of the national park. Adapted from: http://np-debiesbosch.nl/voorlichting-educatie/publicaties/

Origination of the Biesbosch ecosystem

The Biesbosch owes its existence to a severe flood in the fifteenth century (Janssen, 2009; Nationaal Park De Biesbosch, 2013). In the night of November 18, 1421, this flood, known as the Elizabethsflood, turned the agricultural polder 'De Groote en Zuid-Hollandse Waard' into an inland sea. Around 1550 land reclamation began and by 1850 two third of this inland sea was reclaimed and in use for agricultural purposes. Shortly after, from 1850-1870, the river the 'Nieuwe Merwede' was dug, securing the land north of it from flooding in the future and splitting the Biesbosch in two (Janssen, 2009; Nationaal Park De Biesbosch, 2013).

History and key events

Silt and sand from the rivers deposited and on these emerging sandbanks the first vegetation began to grow. Rushes appeared first, followed by reed (Nationaal Park De Biesbosch, 2013). The Biesbosch is named after this first vegetation type, as "Bies-bosch" means "rush-woods"

More and more sandy deposition from the rivers caused the sandbanks to become higher and dryer, causing the reed to make space for willows. As willow branches and twigs could be used for many purposes, willow plantations were established to ensure sufficient harvest (Bijlsma, Weeda, Neut, & Sluiter, 2011; Nationaal Park De Biesbosch, 2013). For these so-called withy-beds, around 40 different willow varieties were used. However, increases in labour costs and the availability of alternative resources caused the willow cultivation business to shut down. Other traditional land use forms were hunting (e.g. duck decoys), farming and fishing.

In the previous century, new agricultural areas were created and after World War II, construction of houses and industries in the western part of the Sliedrechtse Biesbosch began. However, after the flood in 1953 the Biesbosch changed permanently (Nationaal Park De Biesbosch, 2013). To protect the inland from flooding again, it was decided to close off most of the sea arms (Delta Works project). This included closing the Haringvliet in 1970 through the Haringvliet Sluices. This caused the tidal movements in the Biesbosch area to decrease from on average 1.8 meters to an average of only 0.3 meters and an increase in water level of around 0.4 meters (KIWA & EEG, 2007). Depending on the location in the area, the tidal movements range from 0.2-0.8 meters (Nationaal Park De Biesbosch, 2013).

These changes in the tides caused major changes in the undergrowth of the floodplain forests. Before closing off the Haringvliet, most withy-beds were under the influence of the tides which prevented domination by brushwood herbs like the stinging nettle and kept the soil 'young' by constant silt and sand depositions (Bijlsma et al., 2011). The stinging nettle has taken over the undergrowth area after closing off the Haringvliet (Bijlsma et al., 2011).

Chemical pollution of the river water coming from abroad and of the silt that was deposited has been a big issue (Nationaal Park De Biesbosch, 2013). International agreements that tackle this problem at its source have resulted in an improvement of the water quality in the last few years. However, chemicals that are stored in the sediment can be released back into the water due to, for example, the river works that are going on now (pers. com. with Henk Siepel, 14-4-2016).

Flora and fauna

In Europe, conservation of rare, threatened or endemic animal and plant species is recorded in The Habitats Directive, adopted in 1992 (European Commission, 2016b), and conservation of Europe's endemic bird species is recorded in The Birds Directive, adopted in 1979 (European Commission, 2016a). The Biesbosch in specific is designated for preservation, expansion or improvement of 6 habitat types (including floodplain forests and brushwood and seams), 13 habitat species (mostly fishes, but also the beaver, root vole, pond bat and the moss Orthotrichum rogeri), 12 breeding birds (including the great bittern and kingfisher) and 17 migratory birds (Bijlsma et al., 2011; Programmadirectie Natura 2000, 2013).

In 1988 five beaver couples were released into the area, as an experiment. Later on, more beavers were released. Nowadays, the beaver thrives in the area with numbers exceeding 200 individuals (Nationaal Park De Biesbosch, 2013).

The former richness in fish species has disappeared, as the Haringvliet Sluices form a barrier for typical river migratory fish like salmon and seatrout (Nationaal Park De Biesbosch, 2013). However, due to the decrease in tidal effects, the number of mammals in the Biesbosch increased, like deer, fox and the rare root vole. The increase in small mammals in turn resulted in an increase in birds of prey. For example, sea eagles are breeding in the area (Nationaal Park De Biesbosch, 2013).

Current willow forests in the Biesbosch are the result of the former willow cultivation industry (Bijlsma et al., 2011; Nationaal Park De Biesbosch, 2013). The majority of the withy-beds have not been chopped and have therefore grown to lush willow forests with crooked and fallen trees. This provides an excellent habitat for rare moss species and forest birds. There are still a few places where the former willow cultivation practises are still in place. Here the rare marsh marigold still occurs (Nationaal Park De Biesbosch, 2013).

In a major part of the area there is still a lot of sand and silt deposition, resulting in nutrient rich soils (KIWA & EEG, 2007).

Recreation and Management

National Park De Biesbosch fulfils an important recreational function. To protect vulnerable nature from a too high tourist pressure, the park introduced recreational zoning (Nationaal Park De Biesbosch, 2013). This means that some parts of the park are inaccessible to visitors.

Tourism within the Biesbosch is meant to be sustainable tourism. This means that electric boats are promoted, hiking and cycling tracks are improved and tourist enterprises are supported in their efforts to become sustainable (Nationaal Park De Biesbosch, 2013).

Staatsbosbeheer is responsible for the management of the Biesbosch. Their management strategy is increasingly focussing on natural processes and nature developing itself in the most natural way possible (Nationaal Park De Biesbosch, 2013). This means limited human influence on the area, although sometimes a little help of adjustment is needed. In principle, however, nature is left to develop in its own way. For the management of polders and other open terrains, Staatsbosbeheer uses cattle (Nationaal Park De Biesbosch, 2013). These animals keep the vegetation short and thus the area open.

The grasslands in the Biesbosch are property of Staatsbosbeheer and are leased to local farmers under certain restrictions (Nationaal Park De Biesbosch, 2013). Fertilizers and pesticides cannot be used in this area.

From 1873, three large drinking-water reservoirs in the Brabantse Biesbosch have been supplying well-purified water from the Meuse to water companies (KIWA & EEG, 2007; Nationaal Park De Biesbosch, 2013).

The Biesbosch has not yet reached its final goals. Various plans exist to add new nature and a lot of new nature has been added already (Nationaal Park De Biesbosch, 2013). Eventually, the Biesbosch area will cover some 12,000 ha. From 2009 onwards, the project 'Ruimte voor de River' has been working to reclaim ('ontpolderen') the Noordwaard, a polder north of the Biesbosch (Figure 2) (Ruimte voor de Rivier, n.d.). By doing this, the Noordwaard can increase the capacity of the Nieuwe Merwede. With high water levels the water flow to the sea is increased (Ruimte voor de Rivier, n.d.). These developments also give room for nature development. Part for the Noordwaard can be transformed into nature and can play an important role as feeding and breeding ground of birds (Janssen, 2009; Ruimte voor de Rivier, n.d.). Another planned management measure is to partly open the Haringvliet Sluices (Janssen, 2009; Rijksoverheid, 2013). Depending on how far the sluices will be opened, some effects of the tides will reach the Biesbosch again. Probably, only migratory fish will initially benefit from this measure (Janssen, 2009).

3.1.2 METHODS

In this chapter we will discuss 5 species groups: vegetation, birds, dragonflies, butterflies and mammals. As vegetation is the backbone of every ecosystem, this group will be discussed first. Secondly, the Natura 2000 target bird species will be discussed, as the Biesbosch is internationally a very important area for birds (Programmadirectie Natura 2000, 2013). Dragonflies will be discused next, as this species group is widely present in this wetland system. The Biesbosch is not a very special area for butterflies (pers. com. with Michiel WallisdeVries, 5-4-2016), but as they are very attractive for people, they will also be discussed. This chapter will conclude with some mammals that are present in the Biesbosch. Most of these analyses will be focussed on the Brabantse Biesbosch.

When selecting the species that should be discussed in these chapters, we have used 3 criteria:

1. Conservation concern
2. Ecological value
3. Attractiveness

Species of conservation concern are for example species that are targetted by Natura 2000 or that are on the IUCN or the Dutch red list. Species with a high ecological value are for example characteristic Biesbosch species and/or species that improve the quality of the habitat by being present. Species that are very attractive will please the guests, therefore this is also an important criterium.

Not all relevant species groups are dicussed in detail in this chapter. Spiders and beetles, for example, can be greatly affected by the lodge, but these groups are so diverse and so much expert knowledge is needed that we decided to not go into this during this project. Reptiles are not present in the area and are therefore not dicussed. Amphibians are present, but not very diverse and they are not of real conservation concern in the Biesbosch. Bees are also present, but are also not of conservation concern in this area. There are a few special fish species in the Biesbosch that are also targetted by Natura 2000, but as the Living Lodge will mainly affect the terrestrial ecosystem first, we decided to place our focus on land. For bees, beetles, spiders and amphibians the general ecology is discussed briefly.

3.2 VEGETATION – NATURA 2000 HABITAT TYPES

The Biesbosch is appointed as special protection zone for 6 different Natura 2000 habitat types, namely (Programmadirectie Natura 2000, 2013):

- H3260: Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation ('Beken en rivieren met waterplanten'),
- H3270: Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention p.p.* vegetation ('Slikkige rivieroevers'),
- H6120: Xeric sand calcareous grasslands ('Stroomdalgraslanden'),
- H6430: Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels ('Ruigten en zomen'),
- H6510: Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*) ('Glanshaver- en vossenstaarthooilanden'),
- H91E0: Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) ('Vochtige alluviale bossen').

3.2.1 METHODS

The first step was to identify the dominant habitat types in the Biesbosch. For this purpose the government document by Programmadirectie Natura 2000 (2013) was used. For each habitat type, several things were considered: the status in the Biesbosch, typical flora and fauna and, if applicable, measures to improve or restore this habitat type.

For this analysis, two main sources were used. The first one is the vegetation database SynBioSys (Hennekens, Smits, & Schaminée, 2016). Next to this, for each habitat type a profile produced by the Dutch government and the Natura 2000 direction was used (Programmadirectie Natura 2000, 2008a, 2008b, 2008c, 2008d, 2008e, 2008f, 2013). The information in these profiles concerns the habitat type on a nationwide scale and is not always applicable to specific Natura 2000 sites (Programmadirectie Natura 2000, 2014). Information specific to the Biesbosch was retrieved from Programmadirectie Natura 2000 (2013). Therefore, only the subheading "situation in the Biesbosch" is specific to the Biesbosch, the rest can slightly differ. More information about how to interpret the profiles can be found in the reading guide (Programmadirectie Natura 2000, 2014).

As some habitat types occur in great diversity, the Dutch government has decided to split some habitat types into subtypes. In Europe in general, however, this distinction is not made (Programmadirectie Natura 2000, 2014).

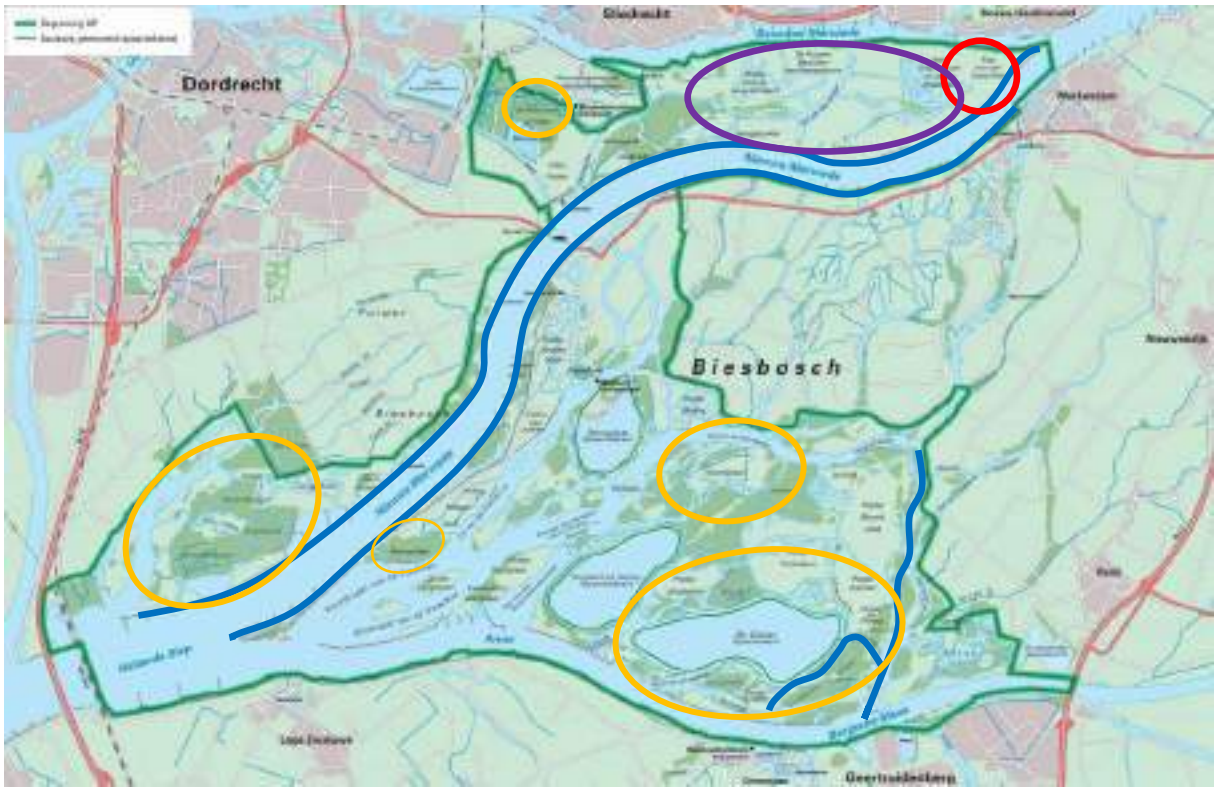

Figure 2. Map of the Biesbosch area with occurrence of habitat types. Green lines represent the border of the national park, blue lines indicate the approximate range of the habitat type H3260, red indicates H6120, purple indicates H6510 and yellow indicates H91E0. Adapted from: http://np-debiesbosch.nl/voorlichting-educatie/publicaties/

3.2.2 H3260: WATER COURSES OF PLAIN TO MONTANE LEVELS WITH THE *RANUNCULION FLUITANTIS* AND *CALLITRICHO-BATRACHION* VEGETATION

General description

This habitat type (Figure 3) includes the parts of rivers and streams that contain submerged or floating water plant vegetation (Deltares, n.d.; Programmadirectie Natura 2000, 2008e). Because of its great diversity, the Dutch government has split this habitat type into two subtypes: Subtype A with mainly the alliance *Ranunculion peltati* (Verbond van Grote waterranonkel) and subtype B with mainly the association *Ranunculo fluitantis-Potametum perfoliati* (Associatie van Doorgroeid fonteinkruid) (Programmadirectie Natura 2000, 2008e).

Figure 3. Picture of 'De Geul' near Cottessen. © J.A.M. Janssen. Source: Hennekens et al. (2016).

Situation in the Biesbosch

In the Biesbosch, pondweed vegetation belonging to subtype B is present. It is mainly found in bays and between groynes in the 'Nieuwe Merwerde' from the 'Kievitswaard' to the 'Dordtse Biesbosch, in the 'Steurgat van Bovenhennip' to the 'Spijkerboor' and in the 'Zijkgat', 'Middelgat van de Plomp' and 'Sloot van St. Jan' (blue lines, Figure 2) but it has also been seen in other bigger creeks in the 'Brabantse Biesbosch' (Programmadirectie Natura 2000, 2013).

The Natura 2000 goal in the Biesbosch is to maintain the surface area and quality of subtype B (Programmadirectie Natura 2000, 2013). Therefore, the rest of this paragraph will only discuss this type.

Vegetation

Characteristic plant species for the *Ranunculo fluitantis-Potametum perfoliati* association are *Potamogeton perfoliatus* (doorgroeid fonteinkruid), *Potamogeton nodosus* (rivierfonteinkruid) and *Potamogeton pectinatus* (schedefonteinkruid) (Hennekens et al., 2016). This association occurs in nutrient-rich, buffered and preferably flowing water and is able to withstand very eutrophic conditions, given that the water is still clear and the salinity not too high (Hennekens et al., 2016).

Subtype B also includes the association *Callitricho hamulatae-Ranunculetum fluitantis* (Associatie van Vlottende waterranonkel) (Programmadirectie Natura 2000, 2008e). Characteristic plant species for this association are *Ranunculus fluitans* (Vlottende waterranonkel) and *Ranunculus penicillatus* (Penseelbladige waterranonkel) (Hennekens et al., 2016). A common species is *Elodea Canadensis* (Brede waterpest). This association occurs in fast-flowing streams with moderate nutrient-rich and clear water. The association is characterized by a mosaic structure; the plants form more or less independent groups in the water (Hennekens et al., 2016).

Typical species

Characteristic fauna species for subtype B are the dragonfly *Gomphus flavipes ssp. Flavipes* (Rivierrombout) and the fish species *Gobio gobio* (Riviergrondel) (Programmadirectie Natura 2000, 2008e).

Threats, management and restoration

Important for subtype B is the creation of sheltered sites in the rivers (Programmadirectie Natura 2000, 2008e). Other measures to improve the growth of water plants in rivers are for example the reduction of shore disturbances and the creation of gravel bars (shallow riffles) and side channels (Deltares, n.d.).

3.2.3 H3270: RIVERS WITH MUDDY BANKS WITH *CHENOPODION RUBRI P.P.* AND *BIDENTION P.P.* VEGETATION

Figure 4. Picture of the Ossenwaard, near Deventer. © J.H.J. Schaminée. Source: Hennekens et al. (2016).

General description

This habitat type (Figure 4) includes muddy, sandy or gravelly tidal banks of rivers or side channels, where high river dynamics create erosion and sedimentation (Programmadirectie Natura 2000, 2008d).

Situation in the Biesbosch

Rivers with muddy banks are widespread in the Biesbosch, but after the decrease in tidal movement due to the closure of the Haringvliet, its surface area declined sharply (Programmadirectie Natura 2000, 2008d).

The Natura 2000 goal in the Biesbosch is to increase the surface area and improve the quality of this habitat type (Programmadirectie Natura 2000, 2013).

Vegetation

Characteristic for this habitat type is the pioneer vegetation *Bidention tripartitae* (het tandzaadverbond) (Hennekens et al., 2016). This vegetation develops on bare soil, relatively late in

the year. As the soil is only periodically dry, the vegetation develops within a short period of time (Deltares, n.d.).

Other vegetation communities that occur in this habitat type, are:

- *Polygono-Veronicetum anagallidis-aquaticae* (Associatie van Blauwe watereereprijs en Waterpeper),
- *Gnaphalium uliginosum-[Isoeto-Nanojuncetea/Bidentet ea tripartitae]* (Rompgemeenschap met Moerasdroogbloem van de Dwergbiezenklasse/de Tandzaadklasse)
- *Polygono-Bidentetum* (Associatie van Waterpeper en Tandzaad)
- *Rumicetum maritimi* (Associatie van Goudzuring en Moerasandijvie)
- *Chenopodietum rubri inops* (Associatie van Ganzevoeten en Beklierde duizendknoop)
- *Chenopodietum rubri rorippetosum* (Associatie van Ganzevoeten en Beklierde duizendknoop (subassociatie met Akkerkers))
- Eleocharito acicularis-Limoselletum (Slijkgroen-associatie)
- *Ranunculus sceleratus-[Bidentetea tripartitae/Phragmitetea]* (Rompgemeenschap met Blaartrekkende boterbloem van de Tandzaad-klasse/de Rietklasse)

Typical species

Characteristic plant species for this habitat type are *Chenopodium rubrum* (Rode ganzenvoet), *Rumex palustris* (Moeraszuring), *Rumex maritimus* (Goudzuring), *Persicaria lapathifolia* (Beklierde duizendknoop), *Potentilla supina* (Liggende ganzerik), *Veronica anagallis-aquatica* (Blauwe watereereprijs), *Cyperus fuscus* (Bruin cypergras), *Pulicaria vulgaris* (Klein vlooienkruid), *Lythrum hyssopifolia* (Kleine kattenstaart), *Artemisia biennis* (Rechte alsem), *Limosella aquatica* (Slijkgroen), *Nasturtium officinale* (Witte waterkers) and several *Bidens* species (Tandzaden) (Hennekens et al., 2016; Programmadirectie Natura 2000, 2008d).

Threats, management and restoration

For a sustainable conservation of this habitat type, river dynamics are essential, as erosion and sedimentation will provide a good habitat for pioneer communities (Hennekens et al., 2016; Programmadirectie Natura 2000, 2008d). Therefore, sluices and other structures that cause a decrease in river dynamics are a big threat. In the Biesbosch, slightly reopening the Haringvliet Sluices may be favourable for this habitat type (Programmadirectie Natura 2000, 2008d). This habitat type can also benefit from land reclamations ('ontpoldering') and the excavation or levelling of banks (Programmadirectie Natura 2000, 2013).

3.2.4 H6120: XERIC SAND CALCAREOUS GRASSLANDS

General description

Xeric sand calcareous grasslands (Stroomdalgraslanden, Figure 5) occur on relatively nutrient-poor, sandy and calcareous soils along rivers and are species and flower rich (Programmadirectie Natura 2000, 2008d). It depends on flooding by rivers in winter to restore the buffer capacity of the soil and thereby prevent acidification (Hennekens et al., 2016).

Figure 5. Top: Picture of the Millingerwaard. Due to sedimentation in winter, this habitat type can grow. © J.A.M Janssen. Source: Hennekens et al. (2016). Bottom: Picture of typical species: Eryngium campestre and Euphorbia cyparissias. © J.H.J. Schaminée.

Situation in the Biesbosch

In the Biesbosch, this habitat type occurs in the 'Kop van de Oude Wiel', at the intersection of the 'Beneden Merwede' and the 'Nieuwe Merwede' (red line, Figure 2), and is of good quality. (Programmadirectie Natura 2000, 2013). The Natura 2000 goal for this habitat type is to increase in surface area and to maintain the quality (Programmadirectie Natura 2000, 2013).

Vegetation

The most important plant communities in this habitat type belong to the alliance *Sedo-Cerastion*, in which two associations can be distinguished: *Medicagini-Avenetum pubescentis* (Associatie van Sikkelklaver en Zachte haver) and *Sedo-Thymetum pulegoidis* (Associatie van Vetkruid en Tijm) (Hennekens et al., 2016). As these communities depend on flooding during the winter, they mostly occur in the floodplains.

Other vegetation communities within this habitat type are (Programmadirectie Natura 2000, 2008b):

- *Festuco-Thymetum serpylli jasionetosum* (Associatie van Schapegras en Tijm, subassociatie met Zandblauwtje)
- *Festuco-Thymetum Serpylli anthoxanthetosum* (Associatie van Schapegras en Tijm, subassociatie met Gewoon reukgras)
- *Euphorbia cyparissias-[Koelerio-Corynephoretea]* (Rompgemeenschap met Cipreswolfsmelk van de Klasse der droge graslanden op zandgrond)
- *Festuca ovina subsp. cinerea-[Trifolio-Festucetalia ovinae]* (Rompgemeenschap met Hard zwenkgras van de Struisgras-orde)
- *Lolio-Cynosuretum plantaginetosum mediae* (Kamgrasweide, subassociatie met Ruige weegbree)
- *Galio-Trifolietum* (Associatie van Ruige weegbree en Aarddistel)
- Bromo inermis-Eryngietum campestris (Kweekdravik-associatie)
- *Galium verum-Festuca filiformis-[Plantagini-Festucion]* (Rompgemeenschap Geel walstro-Fijn schapegras-[Verbond van Gewoon struisgras])

Typical species

Characteristic plant species for this habitat type are, among others: *Medicago falcata* (Sikkelklaver), *Euphorbia cyparissias* (Cipreswolfsmelk), *Eryngium campestre* (Kruisdistel), *Ranunculus bulbosus* (Knolboterbloem), *Plantago media* (Ruige weegbree), *Helictotrichon pubescens* (Zachte haver), *Thalictrum minus* (Kleine ruit), *Carex caryophyllea* (Voorjaarszegge), *Potentilla verna* (Voorjaarsganzerik), *Salvia pratensis* (Veldsalie), *Sedum sexangulare* (Zacht vetkruid), *Sedum reflexum* (Tripmadam), *Cynodon dactylon* (Handjesgras), *Herniaria glabra* (Kaal breukkruid), *Dianthus deltoids* (Steenanjer), and *Euphorbia seguieriana* (Zandwolfsmelk) (Hennekens et al., 2016; Programmadirectie Natura 2000, 2008b).

Exclusive species for this habitat type are: *Veronica austriaca subsp. teucrium* (Brede ereprijs), *Veronica prostrata* (Liggende ereprijs), *Carex ligerica* (Rivierduinzegge), *Orobanche lutea* (Rode bremraap) and *Artemisia campestris ssp. Campestris* (Wilde averuit) (Programmadirectie Natura 2000, 2008b).

Common grassland species that can occur in high numbers are, among others: *Festuca rubra* (Rood zwenkgras), *Poa pratensis* (Veldbeemdgras), *Plantago lanceolata* (Smalle weegbree), *Achillea millefolium* (Gewoon duizendblad), *Agrostis capillaris* (Gewoon struisgras) and *Anthoxanthum odoratum* (Gewoon reukgras).

Characteristic fauna species are the butterfly *Thymelicus sylvestris* (Geelsprietdikkopje) and the bird *Anthus pratensis ssp. pratensis* (Graspieper).

Threats, management and restoration

When there is no haying or grazing management with sufficient intensity, this habitat type will roughen, causing tall herbs and shrubs to increase and diversity of flowering plants to decrease (Programmadirectie Natura 2000, 2008b). River and wind dynamics are also important processes for the origination and maintenance of this habitat type, especially flooding in winter and deposition of

base-rich sand (Programmadirectie Natura 2000, 2008b). Appropriate management and space for river dynamics are therefore important restoration measures.

3.2.5 H6430: HYDROPHILOUS TALL HERB FRINGE COMMUNITIES OF PLAINS AND OF THE MONTANE TO ALPINE LEVELS

Figure 6. Picture of a species rich reed roughage along the old Meuse. © J.A.M Janssen. Source: Hennekens et al. (2016).

General description

This habitat type (Figure 6) includes wet, productive roughages and is divided in three subtypes, according to the vegetation alliance they include (Programmadirectie Natura 2000, 2008f). Subtype A is the *Filipendulion* alliance (Moerasspirea-verbond), subtype B is the *Epilobion hirsuti* alliance (Verbond van Harig wilgeroosje) and subtype C is the *Galio-Alliarion* alliance (Verbond van Look-zonder-look).

Situation in the Biesbosch

Subtype A is mainly present in the Dordtse Biesbosch and the Brabantse Biesbosch and subtype B occurs in the whole Biesbosch on banks of river branches and creeks (Programmadirectie Natura 2000, 2013). Both subtype A and subtype B cover a large area.

In the Biesbosch, subtype B mainly includes the association *Valeriano-Senecionetum fluviatilis* (Rivierkruiskruidassociatie). The freshwater tidal area in the Biesbosch is very important for this rare form (Programmadirectie Natura 2000, 2013). The Natura 2000 target for subtype A is the maintenance of surface area and quality and for subtype B the increase of surface area and maintenance of quality. Because subtype C is not of concern in the Biesbosch, the rest of this paragraph will only focus on subtype A and B.

Vegetation

Subtype A, the alliance *Filipendulion*, occurs on sandy and loamy soils covered with organic material, on riverbanks, along streams and on moist grasslands (Hennekens et al., 2016). Common species are *Filipendula ulmaria* (Moerasspirea) and *Valeriana officinalis* (Grote valeriaan). More important, however, are communities with rare species like *Veronica longifolia* (Lange ereprijs) and *Euphorbia palustris* (Moeraswolfsmelk) or the unusual *Thalictrum flavum* (Poelruit) (Programmadirectie Natura 2000, 2008f). Another characteristic plant species for subtype A is *Mentha longifolia* (Hertsmunt).

Subtype B, the alliance *Epilobion hirsute*, occurs mainly on peat and clay soils in fens and freshwater tidal areas and occurs on the boundaries between brackish to fresh waters (Deltares, n.d.; Hennekens et al., 2016). Well-developed forms contain communities such as *Senecio fluviatilis* (Rivierkruiskruid), *Caltha palustris subsp. araneosa* (Spindotterbloem) and *Leucojum aestivum* (Zomerklokje). In weakly brackish environments, the species *Althaea officinalis* (Heemst), *Cochlearia officinalis subsp. officinalis* (Echt lepelblad), *Oenanthe crocata* (Dodemansvingers), *Oenanthe lachenalii* (Zilt torkruid) and *Apium graveolens* (Selderij) can occur (Programmadirectie Natura 2000, 2008f). In Europe, the associations *Valeriano-Senecionetum* and *Oenantho-Althaeetum* are almost unique to the Netherlands (Programmadirectie Natura 2000, 2008f). Another characteristic plant species for subtype B is *Sonchus palustris* (moerasmelkdistel).

Typical species

Characteristic fauna for subtype A are the butterfly *Brenthis ino* (Purperstreepparelmoervlinder), the bird *Acrocephalus palustris* (Bosrietzanger) and the mammals *Micromys minutus* (Dwergmuis) and *Neomys fodiens ssp. fodiens* (Waterspitsmuis) (Programmadirectie Natura 2000, 2008f).

Characteristic fauna for subtype B are the bird *Acrocephalus palustris* (Bosrietzanger) and the mammal *Micromys minutus* (Dwergmuis) (Programmadirectie Natura 2000, 2008f).

Threats, management and restoration

This habitat type does not need a lot of management measures; doing nothing or mowing incidentally are sufficient (Deltares, n.d.).

3.2.6 H6510: LOWLAND HAY MEADOWS (ALOPECURUS PRATENSIS, SANGUISORBA OFFICINALIS)

General description

The two subtypes within this habitat type are also divided according to the vegetation communities they contain and consist of species and flower rich hay meadows (Figure 7). Type A is the alliance *Arrhenatherion elatioris* (Glanshaverhooiland) and type B the alliance *Alopecurion pratensis* (Vossenstaartgrasland) (Programmadirectie Natura 2000, 2008c). The main difference between the two subtypes is there sensitivity for inundation, where *Alopecurion pratensis* can be inundated in winter and *Arrhenatherion elatioris* cannot stand inundation (Hennekens et al., 2016). Both types belong to the same class, *Molinio-Arrhenatheretea*, and therefore have a large number of general species in common (Hennekens et al., 2016).

Figure 7. Picture of Fritillario-Alopecuretum pratensis. © R. Knol. Source: Hennekens et al. (2016).

Situation in the Biesbosch

This habitat type occurs in the Sliedrechtse Biesbosch (purple lines, Figure 2), where the Hengstpolder is the last remaining site in the Netherlands of significant size and quality for the rare association *Sanguisorbo-Silaetum* (Associatie van Grote pimpernel en Weidekervel, part of subtype B) (Programmadirectie Natura 2000, 2013). The Natura 2000 goal for subtype A is to maintain surface area and to improve the quality. The goal for subtype B is to increase the surface area and maintain the quality.

Vegetation

Subtype A occurs on the higher lying parts of the floodplains and comprises of the association *Arrhenatheretum elatioris* and the alliance *Primula veris-[Arrhenatherion]* (Rompgemeenschap Rulden sleutelbloem-[Glanshaver-verbond]) (Programmadirectie Natura 2000, 2008c). Characteristic species indicating a well-developed subtype A are *Pimpinella major* (Grote bevernel), *Peucedanum carvifolia* (Karwijvarkenskervel), *Pastinaca sativa* (Pastinaak), *Tragopogon pratensis* subsp. *orientalis* (Oosterse morgenster) and *Geranium pratense* (Beemdooievaarsbek) (Programmadirectie Natura 2000, 2008c). Other typical plant species for subtype A are *Geranium pyrenaicum* (Bermooievaarsbek), *Tragopogon pratensis ssp. pratensis* (Gele morgenster), *Trisetum flavescens* (Goudhaver), *Lathyrus nissolia* (Graslathyrus), *Crepis biennis* (Groot streepzaad), *Carum carvi* (Karwij), *Campanula glomerata* (Kluwenklokje) and *Campanula rapunculus* (Rapunzelklokje).

Subtype B includes the rare associations *Fritillario-Alopecuretum pratensis* (Kievitsbloem-associatie) and *Sanguisorbo-Silaetum* (Associatie van Grote pimpernel en Weidekervel) and the alliance Bromus racemosus subsp. racemosus- [Alopecurion pratensis] (Rompgemeenschap Velddravik-[Verbond van Grote vossestaart]) (Hennekens et al., 2016; Programmadirectie Natura 2000, 2008c). It occurs on the lower lying parts of the floodplains (Programmadirectie Natura 2000, 2008c) and important are high water levels in winter (Hennekens et al., 2016). A characteristic species for the *Fritillario-Alopecuretum pratensis* association is the *Fritillaria meleagris* (Wilde Kievitsbloem) and characteristic species for the *Sanguisorbo-Silaetum* association are *Sanguisorba*

offcinalis (Grote pimpernel) and *Silaum silaus* (Weidekervel) (Hennekens et al., 2016). The species *Alopecurus pratensis* (Grote vossenstaart) occurs in both associations. Other typical plant species for subtype B, are *Galium boreale* (Noords walstro) and *Bromus racemosus* (Trosdravik).

Typical species

Characteristic fauna for subtype A are the butterfly *Thymelicus sylvestris* (Geelsprietdikkopje) and the bird *Coturnix coturnix ssp. coturnix* (Kwartel) (Programmadirectie Natura 2000, 2008c).

Characteristic fauna for subtype B is the butterfly *Thymelicus sylvestris* (Geelsprietdikkopje) (Programmadirectie Natura 2000, 2008c).

Threats, management and restoration

Intensive agriculture (e.g. use of fertilizers and pesticides) and changes in water management (e.g. building dikes and lowering groundwater level) are major threats for this habitat type (Deltares, n.d.; Hennekens et al., 2016). Mowing yearly once or twice a year is essential for the preservation of characteristic plant communities (Programmadirectie Natura 2000, 2008c). Also, with the right mowing or grazing management, arable land within the floodplains has the potential to become a subtype A habitat.

3.2.7 H91E0: Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)

Figure 8. Willow forests along the Waal. © R. Knol. Source: Hennekens et al. (2016).

General description

This habitat type includes riparian forests (Figure 8), forests that are under direct or indirect influence of river water, and is split into three types: *Alno-Padion* (hardwood riparian forest subtype B), *Alnion glutinosae* (subtype C) and *Salicion albae* (softwood riparian forest, subtype A) (Programmadirectie Natura 2000, 2008a).

Situation in the Biesbosch

Subtype A is covering substantial surfaces widespread at different locations in the Biesbosch (yellow lines, Figure 2), for example the Dordtse Biesbosch, the Kikvorsch of Otterpolder, Deeneplaat, banks of the Nieuwe Merwede, around the Noorderplaat, and around the drinking-water reservoir De Gijster (Programmadirectie Natura 2000, 2013). Subtype B is not very common in the Biesbosch and only occurs sporadically in the eastern part of the Brabantse Biesbosch (Programmadirectie Natura 2000, 2013). The Biesbosch contains the largest surface area of subtype A, but these softwood riparian forests are not of high quality due to the decrease in tidal movements after the Haringvliet was closed (Programmadirectie Natura 2000, 2013). Therefore, the Natura 2000 for this subtype is to maintain the surface area and to improve the quality (Programmadirectie Natura 2000, 2013). Subtype B may arise from subtype A through natural succession, therefore a slight loss in surface area of subtype A for the benefit of subtype B is accepted (Programmadirectie Natura 2000, 2013). The Natura 2000 goal for subtype B is to increase the surface area and improve the quality (Programmadirectie Natura 2000, 2013). Subtype C is not present in the Biesbosch and is therefore not discussed in this paragraph.

Vegetation

Subtype A is found along rivers and in freshwater tidal areas, where they may be under the influence of the tides (Programmadirectie Natura 2000, 2008a). It is dominated by willows, mostly *Salix alba* (Schietwilg) or *Salix viminalis* (Katwilg). The understory mostly consists of common marsh plants and brushwood, like *Urtica dioica* (Grote brandnetel), *Symphytum officinale* (Gewone smeerwortel), *Phalaris arundinacea* (Rietgras), *Galium aparine* (Kleefkruid), *Lythrum salicaria* (Grote

kattenstaart) and *Iris pseudacorus* (Gele lis) (Hennekens et al., 2016). Other typical plant species for subtype A are *Cardamine amara* (Bittere veldkers) and *Populus nigra* (Zwarte populier).

Subtype B is found on the higher parts of the floodplains and is mostly only influenced indirectly by the river, due to rising of the groundwater level during high river water levels (Programmadirectie Natura 2000, 2008a). The main alliance for this subtype is *Alno-Padion*, with characteristic species like *Prunus padus* (Vogelkers), *Festuca gigantean* (Reuzenzwenkgras), *Rumex sanguineus* (Bloedzuring) and the rare species *Equisetum hyemale* (Schaafstro), *Elymus caninus* (Hondstarwegras) and *Gagea lutea* (Bosgeelster) (Hennekens et al., 2016). The community that characterizes this subtype is *Fraxino-Ulmetum* (Essen-Iepenbos), in which two rare species can occur, namely *Elymus caninus* (Hondstarwegras) and *Geranium phaeum* (Donkere ooievaarsbek) (Hennekens et al., 2016). Another typical plant species for subtype B is *Rumex sanguineus* (Bloedzuring).

Vegetation communities that can be found within these two subtypes are (Programmadirectie Natura 2000, 2008a):

Subtype A

- Artemisio-Salicetum albae (Bijvoet-ooibos)
- Irido-Salicetum albae (Lissen-ooibos)
- *Cardamino amarae-Salicetum albae anthriscetosum* (Veldkers-ooibos, subassociatie met Fluitekruid)
- *Cardamino amarae-Salicetum albae alismatetosum* (Veldkers-ooibos, subassociatie met Grote waterweegbree)
- *Cardamino amarae-Salicetum albae urticetosum* (Veldkers-ooibos, subassociatie met Grote brandnetel)
- Cardamino amarae-Salicetum albae inops (Veldkers-ooibos, arme
- subassociatie)
- *Impatiens glandulifera-[Salicion albae/Alno-Padion]* (Derivaatgemeenschap met Reuzenbalsemien van het Verbond der wilgenvloedbossen en –struwelen/het Verbond van Els en Vogelkers)
- *Urtica dioica-[Salicion albae]* (Rompgemeenschap met Grote brandnetel van het Verbond der wilgenvloedbossen en –struwelen)

Subtype B

- Fraxino-Ulmetum (Essen-Iepenbos)
- *Anthriscus sylvestris-[Ulmenion carpinifoliae]* (Rompgemeenschap met Fluitekruid van het Onderverbond der Iepenrijke Eiken-Essenbossen)

Typical species

Characteristic mosses for subtype A are *Anomodon viticulosus* (Groot touwtjesmos), *Homalia trichomanoides* (Spatelmos), *Orthotrichum rogeri* (Tonghaarmuts), *Timmia megapolitana* (Vloedschedemos) and *Fissidens gymnandrus* (Vloedvedermos). Characteristic fauna for subtype A are the butterfly *Limenitis populi* (Grote ijsvogelvlinder, disappeared in the Netherlands), the birds *Dendrocopos major ssp. pinetorum* (Grote bonte specht) and *Nycticorax nycticorax ssp. nycticorax* (Kwak, disapperad in the Netherlands) and the mammal *Castor fiber ssp. albicus* (Bever) (Programmadirectie Natura 2000, 2008a).

Characteristic mosses for subtype B are *Anomodon viticulosus* (Groot touwtjesmos) and *Homalia trichomanoides* (Spatelmos). Characteristic fauna for subtype B are the butterfly *Limenitis populi* (Grote ijsvogelvlinder, disappeared in the Netherlands) and the birds *Dendrocopos major ssp. pinetorum* (Grote bonte specht), *Parus montanus ssp. Rhenanus* (Matkop) and *Luscinia megarhynchos ssp. Megarhynchos* (Nachtegaal) (Programmadirectie Natura 2000, 2008a).

Threats, management and restoration

When subtype B is targeted for the conservation of mosses (in particular epiphytes), it is important to maintain the coppice management, as this creates an important microclimate for theses moss species (Hennekens et al., 2016).

In general, development of forests with willows and poplars only happens when there is no (extensive) grazing (Deltares, n.d.).

3.3 VEGETATION – PLANT SPECIES

3.3.1 METHODS

To identify important plant species, the results of the previous analysis were used. For this purpose, we focussed our research on the Brabantse Biesbosch, which means that only the habitat types H3260, H3270, H6430 and H91E0 were used. Our first step was to put the characteristic plant species of high ecological value mentioned in the previous chapter in a list. Using the citizen science website Waarneming.nl (2016) and the Alterra program SynBioSys (Hennekens, Smits, & Schaminée, 2016), all species were checked for whether they had been observed in the Brabantse Biesbosch in the last 5 years. The next step was to identify whether species were on the IUCN red list and/or the Dutch red lists (Siebel, Bijlsma, & Sparrius, 2013; Sparrius, Odé, & Beringen, 2014). This information was used to narrow down the list of species to a list of species of extra concern. Criteria for this were:

- Species that are at least rare (Criteria: conservation interest)
- Species that do not occur or in very low numbers (Criteria: conservation interest)
- Species that are typical for the freshwater tidal system. (All criteria: attractive, high ecological value and conservation interest)

This resulted in two lists of species, namely a list of species that can be targeted because they are characteristic for a certain habitat type (analysis previous chapter), and a list of species that may need extra attention because they meet one or more of the extra criteria. This last list is given below. In the rest of this chapter, habitat requirements for species from this list are given. General characteristic and habitat requirements for the selected moss species are given in Appendix 1 – Moss species requirements), and for plants are given in Appendix 2 – Plant species requirements.

3.3.2 SPECIES LIST

Plant species name	Criteria
• *Ranunculus fluitans* (Vlottende waterranonkel)	Rare and endangered , not observed
• *Ranunculus penicillatus* (Penseelbladige waterranonkel)	Not observed
• *Potentilla supina* (Liggende ganzerik)	Rare, observed in low numbers
• *Cyperus fuscus* (Bruin cypergras)	Rare, typical
• *Pulicaria vulgaris* (Klein vlooienkruid)	Rare
• *Lythrum hyssopifolia* (Kleine kattenstaart)	Rare, nearly threatened, observed in low numbers
• *Artemisia biennis* (Rechte alsem)	Observed in low numbers
• *Limosella aquatica* (Slijkgroen)	Rare
• *Bidens radiate* (Riviertandzaad)	Rare
• *Veronica longifolia* (Lange ereprijs)	Rare, not observed
• *Euphorbia palustris* (Moeraswolfsmelk)	Rare, vulnerable, observed in low numbers
• *Senecio fluviatilis* (Rivierkruiskruid)	Rare, typical
• *Caltha palustris subsp. araneosa* (Spindotterbloem)	Rare, typical
• *Leucojum aestivum* (Zomerklokje)	Rare, vulnerable, not observed
• *Mentha longifolia* (Hertsmunt)	Rare, typical
• *Cardamine amara* (Bittere veldkers)	Rare, typical
• *Gagea lutea* (Bosgeelster)	Rare, not observed
• *Geranium phaeum* (Donkere ooievaarsbek)	Rare, observed in low numbers
• *Schoenoplectus triqueter* (Driekantige bies)	Iconic Biesbosch species (pers. com. with Han Sluiter, 21-4-2016)

Moss species name	Criteria
• *Anomodon viticulosus* (Groot touwtjesmos)	Rare, observed in low numbers
• *Homalia trichomanoides* (Spatelmos)	Rare

- *Orthotrichum rogeri* (Tonghaarmuts) Rare, Natura 2000, not observed
- *Timmia megapolitana* (Vloedschedemos) Rare, not observed
- *Fissidens gymnandrus* (Vloedvedermos) Rare, observed in low numbers

Note with regard to Waarneming.nl (2016): as this website is based on citizen science, it can only tell us something about species that are present, not about species that are not present. When a certain species is not observed, it does not necessarily mean that it is not present. It may be that this species is hard to find or identify or that it is present in low numbers.

3.3.3 CONCLUSION

Appendix 2 – Plant species requirements, shows that most of the low abundant species are pioneer species. This may be expected, as the Biesbosch is getting older and thus less young riparian forests and open river banks are present in the area (pers. com. with Han Sluiter, 21-4-2016). Therefore, a decrease in suitable habitat and/or a dominance by late successional species may have caused this decline in pioneer species. As these species are mostly typical for the freshwater tidal area, they would preferably stay present within the Biesbosch. An example of such a species is the *Schoenoplectus triqueter*. The Biesbosch owes its name to rushes like this species. It does not occur in the list of characteristic habitat type species from the previous chapter, but according to Han Sluiter (pers. com. 21-4-2016) it is a characteristic Biesbosch species.

However, according to the information in Appendix 2 – Plant species requirements, and personal communication with Han Sluiter (21-4-2016), some species do not seem to be appropriate to target. These species need conditions that are not present in the Biesbosch and are not likely to be created by the Living Lodge. *Ranunculus fluitans* and *Ranunculus penicillatus* are species that occur more in streams with a sandy soil. As this type of bottom is not or hardly present in the Biesbosch, it is not wise to target these species. *Leucojum aestivum* is a species that needs great tidal movement. This is also something that is not likely to change in the near future and the Lodge cannot influence this. Therefore, targeting this species is not wise. The species *Gagea lutea* is more appropriate for a brook accompanying forest (pers. com. with Han Sluiter, 21-4-2016). Therefore, targeting this species is also not advised.

3.4 BIRDS

3.4.1 METHODS

According to the Natura 2000 guidelines, the Biesbosch has been set as an important area for birds (Programmadirectie Natura 2000, 2013). This chapter will assess these birds and to what extent they will be of concern for the lodge. First an overview of Natura 2000 target bird species will be given. Later this species list will be further elaborated with regards to Natura 2000 goals, history in the Netherlands and Ecology and conservation status. Regarding the Red-list species and the Natura 2000 breeding birds, a number of management recommendations will be mentioned when applicable.

The list of birds has been taken from the Natura 2000 report on the Biesbosch (Programmadirectie Natura 2000, 2013). The ecology, conservation status and national trend of the birds has been retrieved from Vogelbescherming Nederland (2016) and can be found in Appendix 3 – Bird ecology.

3.4.2 SPECIES LIST

List of targeted birds breeding in the Netherlands (Programmadirectie Natura 2000, 2013) (names are given in English, Dutch and Latin respectively (Vogelbescherming Nederland, 2016)):

- Great cormorant (D: Aalscholver, L: *Phalacrocorax carbo*)
- Eurasian bittern (D: Roerdomp, L: *Botaurus stellaris*)
- Marsh harrier (D: Bruine kiekendief, L: *Circus aeruginosus*)
- Spotted crake (D: Porseleinhoen, L: *Porzana porzana*)

- Common kingfisher (D: IJsvogel, L: *Alcedo atthis*)
- Bluethroat (D: Blauwborst, L: *Luscinia svecica*)
- Savi's warbler (D: Snor, L: *Locustella luscinioides*)
- Sedge warbler (D: Rietzanger, L: *Acrocephalus schoenobaenus*)
- Great crested grebe (D: Fuut, L: *Podiceps cristatus*)
- Great egret (D: Grote zilverreiger, L: *Casmerodius albus)*
- Eurasian spoonbill (D: Lepelaar, L: *Platalea leucorodia*)
- Bewick's swan (D: Kleine zwaan, L: *Cygnus columbianus bewickii*)
- Greater white-fronted goose (D: Kolgans, L: *Anser albifrons*)
- Greylag goose (D: Grauwe gans, L: *Anser Anser*)
- Barnacle goose (D: Brandgans, L: *Branta leucopsis*)
- Eurasian wigeon (D: Smient, L: *Anas Penelope*)
- Gadwall (D: Krakeend, L: *Anas strepera*)
- Eurasian teal (D: Wintertaling, L: *Anas crecca*)
- Mallard (D: Wilde eend L: *Anas platyrhynchos*)
- Northern pintail (D: Pijlstaart, L: *Anas acuta*)
- Northern shoveler (D: Slobeend, L: *Anas clypeata*)
- Common pochard (D: Tafeleend, L: *Aythya ferina*)
- Tufted duck (D: Kuifeend, L: *Aythya fuligula*)
- Smew (D: Nonnetje, L: *Mergellus albellus*)
- Common merganser (D: Grote zaagbek, L: *Mergus merganser*)
- White-tailed eagle (D: Zeearend, L: *Haliaeetus albicilla*)
- Osprey (D: Visarend, L: *Pandion haliaetus*)
- Eurasian coot (D: Meerkoet, L: *Fulica atra*)
- Black-tailed godwit (D: Grutto, L: *Limosa limosa*)

The species ecology is addressed in Appendix 3 – Bird ecology.

3.4.3 CONCLUSION

The species to target by the Living Lodge can be divided into three groups: 1) Species that are not feasible to target, 2) species that can be targeted by the lodge and 3) species that can be integrated in the lodge. Firstly, the species that are not feasible to target by the lodge are the Osprey, White-tailed Eagle, Eurasian Bittern and the Spotted Crake. These species require areas that are undisturbed by humans, which makes them unsuitable for the lodge. The species that can be targeted by the lodge are all waterfowl, including ducks and geese, Warblers, the Cormorant, the Great Egret, Eurasian Spoonbill and the Marsh Harrier. These species require some rest, but can handle a little disturbance. These are therefore not species that can be integrated in the lodge but can benefit from the living grid to some extent. Finally, the species that can be integrated in the lodge are the Black-tailed Godwit and the Kingfisher. The Black-tailed Godwit is a grassland species and can possibly use the roof of the lodge, when planted with grasses, as an breeding area. The Kingfisher can be integrated when one of the walls of the lodge is right next to flowing water and this wall is representative of a natural bank. This can be achieved by building this wall out of mud or sand and by building a thick enough wall to reduce disturbance by the guests inside the building.

For all birds the following general measures will help to reach the Natura 2000 targets (Stowa, 2016):

- Avoid changes in water level during breeding season.
- Avoid trampling and working in potential breeding areas.
- Avoid working activities at night.

3.5 DRAGONFLIES

3.5.1 METHODS

A large number of dragonfly species has been observed in the Biesbosch. According to the NDFF database (NDFF, 2016) 33 species of dragonflies have been observed in the last 5 years. A number of these species are unlikely to have a population in the Biesbosch, such as the Broad Scarlet (D: Vuurlibel; L: *Crocothemis erythraea*), Lesser Emperor (D: Zuidelijke Keizerlibel; L: *Anax Parthenope*) and Red-veined Darter (D: Zwervende Heidelibel; L: *Sympetrum fonscolombii*). Based on ecology (Dijkstra, 2014; Nederlandse Vereniging voor Libellenstudie, 2002) and number of observations (NDFF, 2016) (these three only have one observation in the last 5 years) this statement is made. Some noteworthy dragonfly species that have been observed in the Biesbosch are in the list below. (NDFF, 2016; Nederlandse Vereniging voor Libellenstudie, 2002; Termaat & Kalkman, 2012).

This list of dragonflies has been taken from the NDFF database (NDFF, 2016) and has been crosschecked with Gerdien Bos of the Vlinderstichting, Wageningen (pers. com., 08-04-2016). Using the three selection criteria 1) Conservation status, 2) Ecological value, 3) Attractive for guests, we narrowed the list down to 8 species. The ecology of the species has been checked using the Nederlandse Vereniging voor Libellenstudie (2002), which is known as a standard. The ecology has been crosschecked with the identification guide by Dijkstra (2014). The conservation status has been retrieved from the Dutch Red-list (Termaat & Kalkman, 2012).

3.5.2 SPECIES LIST

These dragonflies have sustainable populations in the Biesbosch (NDFF, 2016) and could therefore potentially be enhanced by the lodge, depending on their requirements and habitat preferences.

- Brown Hawker (D: Bruine glazenmaker; L: *Aeshna grandis*)
- Blue Chaser (D: Bruine korenbout; L: *Libellula fulva*)
- Hairy Hawker (D: Glassnijder; L: *Brachytron pratense*)
- Western Willow Spreadwing (D: Houtpantserjuffer; L: *Lestes viridis*)
- Brilliant Emerald (D: Metaalglanslibel; L: *Somatochlora metallica*)
- Scarce Blue-tailed Damselfly (D: Tengere grasjuffer; L: *Ischnura pumillo*)
- River Clubtail (D: Rivierrombout; L: *Gomphus flavipus*)
- Green-eyed Hawker (D: Vroege glazenmaker; L: *Aeshna isoceles*)

All these species are very special for the Netherlands, either due to their conservation status or due to their distribution or habitat requirements. This chapter will contain a general introduction to dragonfly ecology. Appendix 4 – Dragonfly ecology, will elaborate on the species in the list regarding their ecology, habitat requirements, conservation status and likelihood of occurrence in the Biesbosch.

3.5.3 DRAGONFLY ECOLOGY

Dragonflies are an ancient predatory insect group comprising the order of Odonata, which means 'the toothed ones' (Corbet & Brooks, 2008). These very agile predators are one of the most effective predators in the animal kingdom (Corbet & Brooks, 2008; Gonzalez-Bellido, Penga, Yanga, Georgopoulosc, & Olberga, 2013) with a success rate of 95% (Gonzalez-Bellido et al., 2013). The larvae of this order are nearly all aquatic and adults are all aerial. The larvae catch their prey using a telescope like lower lip, while adults predate on flying insects (Corbet & Brooks, 2008). These species are characterized by their large compound eyes used for scanning the environment for prey and a potential mating partner. The order of Odonata is divided into two major groups; the Anisoptera and the Zygoptera, which are different in size and morphology. Adult Zygoptera, known as damselflies, can fold their wings together, whereas the Anisoptera cannot fold their wings together in rest (Nederlandse Vereniging voor Libellenstudie, 2002). Both groups have in principle the same

ecology. Aquatic environments are very important for the larval stage, which is the reason that dragonflies are most often found in the vicinity of water (Corbet & Brooks, 2008; Nederlandse Vereniging voor Libellenstudie, 2002). All dragonfly species have their own preferences regarding vegetation and abiotic factors. This habitat selection is so specific that the presence of certain species can tell the state and characteristics of the environment (Corbet & Brooks, 2008). These differences in habitat selection are based on the larval behaviour, resting behaviour and reproduction substrate as well as pH and water temperature. Odonata deposit their eggs directly into the water (exophitically), inside a substrate (endophitically) or on plants (epiphytically). Deposition substrate is ranging from mud to living wood, again species specific (Corbet & Brooks, 2008; Nederlandse Vereniging voor Libellenstudie, 2002). After the eggs are deposited and have hatched, the larvae go through a number of successional stages. These stages can last from two months up till 4 years (Dijkstra, 2014). During the last stage the larvae come out of the water and undergo a metamorphosis resulting in the adult dragonfly, also called an imago. This process is called 'emergence' (Corbet & Brooks, 2008; Dijkstra, 2014; Nederlandse Vereniging voor Libellenstudie, 2002). After hardening the adult dragonfly takes its maiden flight and starts looking for a potential mate. Mating takes place in a so called 'wheel', in which the male and the female form a closed loop (Corbet & Brooks, 2008; Dijkstra, 2014; Nederlandse Vereniging voor Libellenstudie, 2002).

3.5.4 CONCLUSION

Dragonflies are a relatively easy species group to attract providing the habitat quality is high. This is due to their high dispersal capability. To attract dragonfly species, the habitat requirements should be met. However, there are very large differences in habitat requirements between these eight species of dragonflies. This means that not all these dragonflies will be attracted by the Living Lodge, but rather a few species. As mentioned, these eight species are not the only dragonfly species in the Biesbosch, but are a selection, meaning that more species can be attracted by the water bodies around the lodge. From this list the Scarce Blue-tailed Damselfly is very hard to identify compared to other species and therefore is not the ideal species to target by the lodge. The Brown Hawker and the Green-eyed Hawker are two species that have some striking similarities and some care during identification is therefore required. The differences, however, are very clear once compared in a field guide. The other species from this list are relatively easy to identify even by guests, when a clear identification guide is provided.

3.6 BUTTERFLIES

3.6.1 METHODS

Butterflies are arguably the most attractive insect group in nature due to their size and colours. This species group, however, is not that interesting in the Biesbosch, since the diversity is not high and all species occurring in the Biesbosch are relatively common in the Netherlands (pers. com. with Michiel WallisdeVries, 5-4-2016). These species can quite easily be attracted by the Living Lodge, depending on the local vegetation. This chapter will provide a list of the butterflies observed in the Biesbosch and their habitat requirements. Further, a list of plant communities of the southern part of the Brabantse Biesbosch will be linked to these butterflies to get an indication of plant communities to target and what butterfly species will be attracted. Unlike other chapters, specific ecology of the species will not be addressed but the overall ecology of butterflies will be given.

The list of butterflies has been taken from the NDFF database (NDFF, 2016) and has been crosschecked with 'de Vlinderstichting, Wageningen'. This organization provided us with the four most special butterflies of the list. The food and host plants of all butterfly species were determined by using the database of host plants of Dutch butterflies (Ferguson, 2012) and crosschecked using the book 'De Dagvlinders van Nederland', which is known as a standard in the field of butterflies (Bos, Bosveld, Groenendijk, Van Swaay, & Wynhoff, 2006). Of all the food and host plants, only the food and host plants occurring in the Brabantse Biesbosch have been selected using Waarneming.nl (accessed at 19-04-2016) and the search was narrowed down to the years 2010-2016. This resulted in Appendix 5 - Relation butterfly and vegetation 1. Thereafter, the communities that occur in the

southern part of the Brabantse Biesbosch have been extracted from *SynBioSys* (Hennekens et al., 2016). Of the vegetation communities list, the host plants of Appendix 5 - Relation butterfly and vegetation 1, have been crosschecked to provide Appendix 6– Relation butterfly and vegetation 2.

3.6.2 SPECIES LIST

The species on this list have been observed in the Brabantse Biesbosch during the last five years (NDFF, 2016). The butterfly species indicated with * are pointed out as most interesting or special species by Gerdien Bos of the Vlinderstichting (pers. com., 08-04-2016). It should be kept in mind that none of the species on this list are special species in the Netherlands and not unique to the Biesbosch.

- Wall Brown* (D: Argusvlinder L: *Lasiommata megera*)
- Red Admiral (D: Atalanta L: *Vanessa atalanta*)
- Speckled Wood (D: Bont zandoogje L: *Pararge aegeria*)
- Holly Blue (D: Boomblauwtje L: *Celastrina argiolus*)
- Brown Argus* (D: Bruin blauwtje L: *Aricia agestis*)
- Meadow Brown (D: Bruin zandoogje L: *Maniola jurtina*)
- Brimstone (D: Citroenvlinder L: *Gonepteryx rhamni*)
- Peacock (D: Dagpauwoog L: *Aglais io*)
- Painted Lady (D: Distelvlinder L: *Vanessa cardui*)
- Comma (D: Gehakkelde aurelia L: *Polygonia c-album*)
- Large Skipper* (D: Groot dikkopje L: *Ochlodes sylvanus*)
- Large White (D: Groot koolwitje L: *Pieris brassicae*)
- Large Tortoiseshell (D: Grote vos L: *Nymphalis polychloros*)
- Small Heath* (D: Hooibeestje L: *Coenonympha pamphilus*)
- Common Blue (D: Icarusblauwtje L: *Polyommatus icarus*)
- Green-veined White (D: Klein geaderd witje L: *Pieris napi*)
- Small White (D: Klein koolwitje L: *Pieris rapae*)
- Small Tortoiseshell (D: Kleine vos L: *Aglais urticae*)
- Small Copper (D: Kleine vuurvlinder L: *Lycaena phlaes*)
- Old World Swallowtail (D: Koninginnenpage L: *Papilio machaon*)
- Map (D: Landkaartje L: *Araschnia levana*)
- Clouded Yellow (D: Oranje luzernevlinder L: *Colias croceus*)
- Gatekeeper (D: Oranje zandoogje L: *Pyronia tithonus*)
- Orange-tip (D: Oranjetipje L: *Anthocharis cardamines*)
- Essex Skipper (D: Zwartsprietdikkopje L: *Thymelicus lineola*)

Appendix 5 - Relation butterfly and vegetation 1, is providing a list of food and host plants for each butterfly species and provides an indication to the identification difficulty according to Van Nieukerken et al. (2013). Appendix 6– Relation butterfly and vegetation 2, is providing the butterfly species for each suitable vegetation community in the Biesbosch.

Note with regard to Waarneming.nl (2016): as this website is based on citizen science, it can only tell us something about species that are present, not about species that are not present. When a certain species is not observed, it does not necessarily mean that it is not present. It may be that this species is hard to find or identify or that it is present in low numbers.

3.6.3 GENERAL ECOLOGY

Butterflies are classified in the order of Lepidoptera, which refers to the flattened hairs that cover both the wings and the body of the insect (Bos et al., 2006; Van Nieukerken et al., 2013). Lepidoptera are divided into butterflies and moths, where the butterflies are mainly day active and moths mainly night active. The lifecycle of a butterfly consists of 4 main phases. Firstly, there is the egg stage. The eggs are deposited on a host plant (Bos et al., 2006; Van Nieukerken et al., 2013). This host plant differs between the butterfly species. Eggs are deposited in large numbers on the plants. There are some species that just throw their eggs in the vegetation after which the caterpillars have to look for a suitable host plant themselves. The next stage in the lifecycle is the caterpillar.

After hatching, the caterpillars start eating the host plant and after several moults the caterpillar goes to the third stage (Bos et al., 2006; Van Nieukerken et al., 2013). The last moult is different from the previous ones, because the outer skin of the caterpillar is hard and within the shell a metamorphosis takes place. This last moult, which is called the pupal stage, is different for every species with regard to the time and host plant. After several weeks the butterfly emerges from the pupa and starts inflating its wings after which it takes its maiden flight. At this time the butterfly starts looking for a mate and the cycle starts all over again (Bos et al., 2006; Van Nieukerken et al., 2013). While the caterpillars are mainly herbivores, the butterflies are foraging on natural sugars, like tree saps, rotting fruit or nectar. The butterflies suck these substances by rolling their tongue. Females attract males by producing pheromones. The males use these pheromones to detect where the female is. In this adult stage the butterflies are very capable to migrate and to colonize new territory (Bos et al., 2006; Van Nieukerken et al., 2013).

3.6.4 USING THIS ANALYSIS

Since the vegetation analysis *in situ* has not been performed in this project, we suggest selecting the target butterfly species after performing the initial ecological assessment (Chapter 8). We provide this advice because of the specific needs of the butterfly species with regard to food and host plants. Another approach to attract butterflies is by selecting several species and providing host and food plants for those species. Natural dispersal will ensure the colonisation of the area by the target butterflies.

3.7 MAMMALS

3.7.1 METHODS

This chapter will assess a few mammals that are interesting to the Biesbosch. The selection of mammals was based on Natura 2000 targets (Programmadirectie Natura 2000, 2013) and expert knowledge, both from Marijke Smeenk-Brinkert (pers. com., 12-04-2016) and from Han Sluiter (pers. com., 21-04-2016).

The large list of mammals in the Biesbosch has first been reduced to a few species using one or more of the following selection criteria; 1) Conservation status, 2) Ecological value, 3) Attractive for guests. Natura 2000 was mainly used for the 'conservation status' criterion, whereas ecological value was based on expert knowledge and characteristic species of habitat types.

3.7.2 SPECIES LIST

The species selected are:

- Tundra Vole (D: Noordse Woelmuis L: *Microtus oeconomus*)
- Pond Bat (D: Meervleermuis L: *Myotis dasycneme*)
- Beaver (D: Bever L: *Castor fiber*)
- Otter (D: Otter L: *Lutra lutra*)
- Eurasian Harvest Mouse (D: Dwergmuis L: *Micromys minutus*)
- Eurasian Water Shrew (D: Waterspitsmuis L: *Neomys fodiens*)

The first three species are Natura 2000 target species (Programmadirectie Natura 2000, 2013) in the Biesbosch and the Otter is mentioned by Marijke Smeenk-Brinkert as a species likely to be reintroduced in the area in the near future (pers. com., 12-04-2016) and the final two species are of high ecological value of habitat type H6430 (Programmadirectie Natura 2000, 2008). These species will be addressed in Appendix 7 – Mammal ecology.

3.7.3 CONCLUSION

At first sight mammals seem to be an interesting species group to integrate in the lodge. This turns out to be partly true. Habitat can easily be created for the three small rodents. For the Beaver and the Otter, however, this is not feasible. The otter needs a quiet place to have its nest

and can therefore not be included in the lodge. Besides this, it is very unlikely that the Otter will be reintroduced in the Biesbosch in the near future according to Han Sluiter (pers. com., 21-04-2016). The Beaver may be an interesting species to create habitat for, but it is quite shy and therefore may not be the perfect species to integrate in a place where humans walk around. Considering this knowledge, we end up with three species (Tundra Vole, European Harvest Mouse and the Eurasian Water Shrew) that can benefit from the habitat around the lodge and perhaps make use of the possibility of refuge underneath the building. The Pond Bat, as well as all other bats in the Biesbosch, can benefit from the building itself when enough roosting spaces are available. Population dynamics will determine whether the lodge will be added to the current array of roosting places around the Biesbosch.

3.8 GENERAL ECOLOGY OF OTHER SPECIES GROUPS

Bees

Bees are insects that belong to the order Hymenoptera, specifically to the Aculeata (Chinery, 2009). Even though bees are mostly known for producing honey, there is only one species that does this, the honeybee (Peeters et al., 2012). In the Netherlands, there is a great diversity of bees, with around 358 different species (Peeters et al., 2012). Bees serve an important function in agriculture, as they are the most important pollinators of plants. Every bee species is adapted to a certain plant or flower, ranging from fruit trees to vegetables (Peeters et al., 2012). Most bees are solitary and are vegetarian, they collect pollen and nectar (Chinery, 2009). For their nesting places, bees prefer warm and dry places and they can either choose a location aboveground or belowground. Most species in the Netherlands nest below the ground (Peeters et al., 2012). Above grounds, they can use cavities in for example walls.

Beetles

Beetles are insects that belong to the order Coleoptera. This is the biggest insect order, with more than 300,000 described species worldwide and around 4,000 in the Netherlands and Belgium (Chinery, 2009). Most species are terrestrial, some are aquatic and for a few species it depends on the stage of their lifecycle (Noordijk, Kleukers, Van Nieukerken, & Van Loon, 2010). Characteristic for beetle species are elytra which are hardened forewings. They act as a hardened shield to protect the fragile hindwings. Due to their robust body structure, adult beetles are adapted to living in a wide range of substrates, including water (Noordijk et al., 2010). Therefore, a lot of species live a rather invisible life. The largest numbers of adult beetles can be found in spring and in autumn (Noordijk et al., 2010). Food sources are diverse and can range from insects to plants. A lot of species are adapted to a specific food source or environmental condition and are therefore limited to a certain microhabitat (Noordijk et al., 2010). These microhabitats range from dynamic banks to bare sand or dead wood. As these microhabitats differ greatly, beetles can be found almost everywhere in the Netherlands (Noordijk et al., 2010).

Spiders

Spiders belong to the order Araneae (Chinery, 2009). Virtually all species are terrestrial and can be found in nearly all terrestrial ecosystems. Only one species lives in fresh water and a few species hunt on or below the water surface (Noordijk et al., 2010). All species are predators, even eating other spider species or cannibalism occurs in some species. Hunting strategies can vary from actively searching for a prey to building a web and waiting (Noordijk et al., 2010). Spiders use venom to kill their prey. However, in the Netherlands spiders are not harmful to humans. Spiders have an important function, as their variety in hunting techniques and their large numbers can greatly affect the population size of several invertebrate species (Noordijk et al., 2010). Spiders use wind as their dispersal mean, as they use silk threads to catch the wind (Noordijk et al., 2010).

Amphibians

These cold-blooded animals can be divided into two main groups: the newts and the frogs and toads (Van Delft, 2009). Almost all amphibians rely on water for at least one aspect of their reproductive cycle. Adults spend most of their life on land and therefore may need to migrate to water to lay eggs (Van Delft, 2009). Adults are carnivorous and mainly hunt invertebrates. Many amphibians can be seen as opportunistic feeders, because they may target any invertebrate that fits in their mouth. However, there are differences in preferences and strategies between species (Van Delft, 2009).

Greening structures

4.1 INTRODUCTION

The primary objectives of the Living Lodge are two-fold. One aspect deals with the improvement of ecosystems while the other with bridging the divide in the relationship between the urban populace and the natural environment. The vision for the lodge is to create a space that can be shared by its human occupants as well as the flora and fauna of the area. This leaves us with one question: how do we integrate nature into the structure of the lodge? This is a question that is becoming increasingly relevant in the current scenario of rampant urbanization. The disconnect between people and the natural environment is finally being recognized as an issue that needs addressing, especially due to its effect on the mental and physical well-being of the population.

This school of thought has gained popularity and is increasingly being incorporated into the fields of urban planning, building and landscape architecture. Apart from the associated health benefits of green living, interaction with nature also has a significant effect on a person's willingness to conserve it (Chen & Jim, 2010). The Living Lodge will use an ecotourism platform to provide the opportunity for people not just to interact with nature, but to also reside in a home that embraces it. The hope is that the guests of the lodge will enjoy the experience enough to want to recreate it in their own homes.

There are several options available in the market currently, some old and some new. They range from simple indoor planting systems to more complicated green facades that cover entire structures. Other innovations include spider bricks, green roofs and vertical gardens to name a few. The functionality and application of these products depend on a variety of factors such as maintenance regimes, budgetary and environmental constraints as well as product development. For the purposes of this report, the available options have been categorized into biotic and abiotic components. This is in order to distinguish between living components that might require regular maintenance and non-living structural components that provide supporting services.

While our research on the subject has been quite extensive, information on products and innovations that are new to the market or are still in the research and development stage have been hard to investigate in detail. We have primarily focused on components that have been available on the market long enough to have had field trials, so as to avoid issues with reliability. Another important factor taken into consideration is its applicability to the Biesbosch and to the design of the lodge itself. However, we have tried to touch upon those components that might become available in the future as well as those that could be used in other habitat types and would make useful additions.

4.2 BIOTIC COMPONENTS

Vertical greening systems (VGSs)

While the concept of vegetated façades is not necessarily new, there has been a resurgence in their popularity and have subsequently taken many different forms. This has largely been driven by current environmental issues and in response to the need for greening urban built areas (Kohler, 2008). While it is beneficial to the building itself by protecting it from environmental factors such as sun, dust and acid rain, it also helps in thermal regulation and insulation. Additionally, it has the added benefit of providing refuge to wildlife such as birds, beetles and spiders (Kohler, 2008). It has also been suggested as a way to integrate biodiversity conservation and sustainable development (Baldwin et al., 2010). 'Biophilic design' aims to integrate the social and environmental sciences to produce a habitat for people that sustains and promotes a human-nature connection (Kellert, 2005). VGSs, as the name suggests, come in several designs, depending on the requirement and feasibility of application. They are typically characterized by structural components such as vertical gardens,

living walls, hanging gardens, green roofs and green facades (Wong et al, 2010). These structures are generally incorporated externally, on to the superstructure of the building thereby allowing structural integrity and integration of biodiversity.

Vertical gardens

Vertical gardens are designed in a way that allows plants to be rooted in the ground or to be hung from supports on top of the wall (Wong et al., 2010). Support structures may or may not have to be incorporated on the superstructure of the building depending on whether the target plant species are climbers, creepers or hanging plants. Hanging gardens allow the inclusion of epiphytic species that have an aerial adaptation. In addition to providing insulation and habitat for fauna, vertical gardens can be designed in such a way as to facilitate roof water drainage and even grey water filtration (Oberndorfer at al., 2007). Vertical gardens are more flexible in the number of species that they can accommodate, as structural components can be fabricated in accordance with species requirements. One of the key contributions of vertical gardens is to provide habitat connectivity between the ground and green roof habitats, something that would be essential in an area such as the Biesbosch. They also work well with roof top gardens and can be used in a complementary fashion. Like living walls, these systems can be indoor or outdoor, but in the case of the Biesbosch, an outdoor system with local vegetation could be pragmatic as it reduces the need for maintenance. To choose suitable species for this system, please refer to the Species selection tool in Appendix 8 – Species selection tool.

Living walls

Living walls go a step further than vertical gardens in the sense that they accommodate the root system of plants within its structure (Oberndorfer at al., 2007). Water and nutrition are derived from an irrigation system integrated with the wall itself. There are three main systems for constructing living walls as described by (Feng et al, 2014): the felt layer system, the planter box system and trellis system Figure 9. Having a nutrient rich substrate and being prone to desiccation means that these walls are generally ideal for acid tolerant plants species (Feng et al., 2014). However, the Biesbosch is a well buffered system and irrigating these walls with calcium rich water is a potential solution to this problem. Other limitations include the cost of construction and high level of maintenance. However, there are several new innovations in the design and implementation of these systems and customization to a specific habitat type might become a possibility in the near future (Wong et al., 2010).

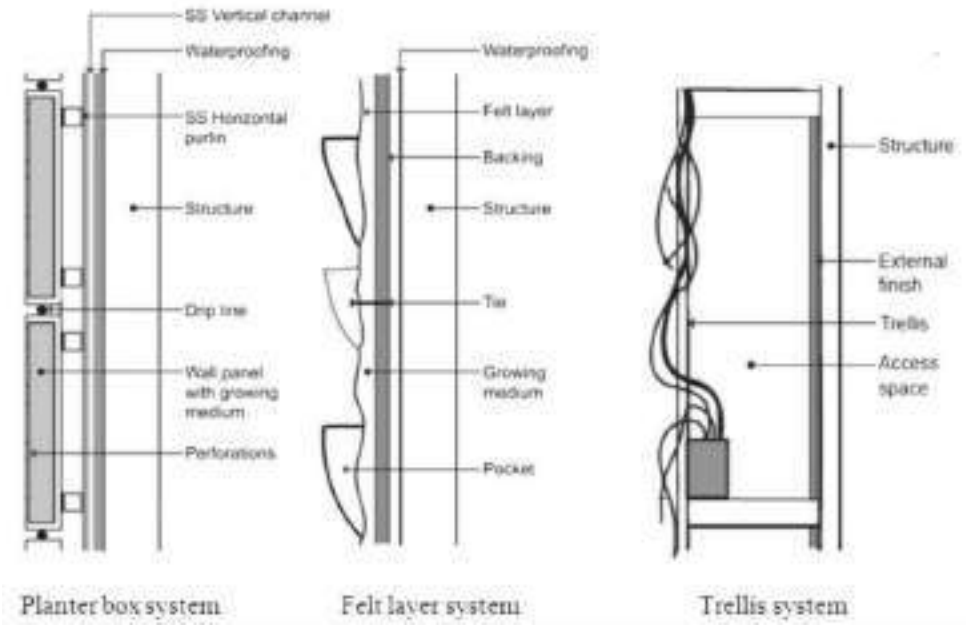

Figure 9. Living walls. Source: Feng et al. (2014)

Green roofs

Extensive green roofs are a modern version of roof gardens that date back to ancient times. Current green roofing systems use a vegetated surface in combination with a substrate. These systems are multifunctional in the services they can provide, which can range from sound-proofing to cooling. They can also act as refuges for wildlife in crowded urban areas. These roof systems can broadly be classified into two types; intensive green roofs and extensive green roofs (Figure 10), each having its own purpose and functionality. While green roofs themselves can act as a distinct ecosystem, they have been treated largely as an engineering and horticultural challenge, rather than as ecological systems (Oberndorfer, 2007).

The type of vegetation used could depend on a variety of factors, including the type of roof (extensive or intensive) or other environmental variables such as wind, rain and precipitation (Kohler, 2008). Extensive systems would require hardy species in general as they would need to withstand moisture stress, severe drought, high wind speed and change in light intensities. These factors can increase the chances of desiccation and physical damage (Dunnett & Kingsbury, 2004). The plants that are generally selected for these systems should have stress tolerant characteristics such as low, mat-forming growth or compact growth. Other favourable characteristics include evergreen foliage or tough, twiggy growth (Grime, 2001). For selection of species specific to the Biesbosch please refer to Species selection tool in Appendix 8 – Species selection tool.

Characteristic	Extensive roof	Intensive roof
Purpose	Functional; storm-water management, thermal insulation, fireproofing	Functional and aesthetic; increased living space
Structural requirements	Typically within standard roof weight-bearing parameters; additional 70 to 170 kg per m^2 (Dunnett and Kingsbury 2004)	Planning required in design phase or structural improvements necessary; additional 290 to 970 kg per m^2
Substrate type	Lightweight; high porosity, low organic matter	Lightweight to heavy; high porosity, low organic matter
Average substrate depth	2 to 20 cm	20 or more cm
Plant communities	Low-growing communities of plants and mosses selected for stress-tolerance qualities (e.g., *Sedum* spp., *Sempervivum* spp.)	No restrictions other than those imposed by substrate depth, climate, building height and exposure, and irrigation facilities
Irrigation	Most require little or no irrigation	Often require irrigation
Maintenance	Little or no maintenance required; some weeding or mowing as necessary	Same maintenance requirements as similar garden at ground level
Cost (above waterproofing membrane)	\$10 to \$30 per ft^2 (\$100 to \$300 per m^2)	\$20 or more per ft^2 (\$200 per m^2)
Accessibility	Generally functional rather than accessible; will need basic accessibility for maintenance	Typically accessible; bylaw considerations

Figure 10. Extensive & intensive green roofs. Source: Oberndorfer et al. (2007)

Wildflower patches

Urbanization and agriculture are some of the biggest drivers of biodiversity loss due to habitat fragmentation and loss of open spaces (Connor et al., 2002; Hedblom, 2007). Butterflies are highly dependent on host plants for laying eggs and development during caterpillar phases. In addition, there are a range of herbs, shrubs and fruiting trees that butterflies are dependent on for foraging. The Southern Biesbosch is estimated to have a total of 26 distinct species of butterflies, that can potentially colonize the Living Lodge. This can be achieved by creating diverse wildflower beds in the vicinity of the lodge. The "Gita Prasada" butterfly garden in Indonesia is an example of a butterfly garden that successfully brought back the butterfly to Mount Betung (Soekardi, 2002). Butterfly gardens are a simple addition to the Living Lodge that would comprise of selecting the most common host and food plants and establishing these communities in either the structures or in the perimeter.

Increased fragmentation of habitats has a detrimental effect on insect pollinators. This is largely due to the landscape connectivity issues that can disrupt the availability of foraging areas and nesting sites (Blaauw & Isaacs, 2014). Sown wild flowers strips are increasingly being used in Europe to mitigate the effects of intensified agriculture (Haaland, 2010). These strips have a positive

effect on biodiversity (Haaland, 2010). Restoring plant diversity by establishing native flowering plants can improve the quality of resource poor areas by providing nectar, pollen and shelter to pollinators (Blaauw & Isaacs, 2014).

With respect to the living lodge, the use of wildflowers patches or strips to attract pollinators such as butterflies and bees would have to be site specific. The use of sown strips or patches would be determined by the type of habitat (agricultural field, forest etcetera). Larger and more diverse patches increase pollinator activity and are essential to improving the quality of fragmented habitats. For the Biesbosch, determining species of wild flowers while keeping in mind its relation to the target pollinators is advised.

4.3 ABIOTIC COMPONENTS

Sand wall

Artificial walls (Figure 11) can play a significant role in providing optional habitat for certain birds such as the Kingfisher and the Sand martin. In line with the goals of the lodge, this structure would not just attract target species within the perimeter of the lodge but also enhance the quality of the habitat for the Kingfisher, which is one of the iconic birds of the Biesbosch. Studies have shown that species with similar nesting behaviours preferred to use structures that were close to water bodies (Extezarreta & Arizaga, 2014). This would mean that a suitable location for this type of structure would have to be either close to the water bank or around a pond (natural or artificial). This would have to be determined in situ once the exact location is determined. This structure would require some maintenance to ensure that it is free of vegetation, which is an important factor for species such as the Kingfisher (Extezarreta & Arizaga, 2014).

Figure 11. Sand wall construction – RSPB, UK

Wildlife ponds

Wildlife ponds are a proven method to attract biodiversity (Oertli, 2002). They can act as micro habitats within a larger landscape and can provide resources to a variety of taxa ranging from aquatic insects to migratory birds. This would not only enrich the habitat around the lodge but can also serve as an activity for guests to participate in.

Ecological theory suggests that larger areas attract more biodiversity. An interesting study by Oertli (2002), that sampled 80 lakes in Switzerland, showed that many small lakes had more diversity than a single large lake. As one of the primary goals of the lodge is to increase biodiversity in the area, a few small ponds could be dug within the wall and grid areas around the lodge. This would also benefit species that tend to avoid areas with human activities as they could frequent ponds that are some distance away from the lodge itself. There are several designs for wildlife ponds;

some more natural than others. It would be prudent to consult with a landscape architect in designing these elements for the lodge.

Rock gardens

Rock gardens are generally features that are valued for its aesthetic value. However, research has shown that they can serve as important refuges for biodiversity, ranging from mosses to amphibians and plants (Comisky et al., 2005). In an area with grazing pressure from herbivory such as the Biesbosch, rock gardens can be used within the perimeter to protect and nurture plant species that might otherwise be consumed in open areas (Comisky et al., 2005). Additionally, its microhabitat features can offer smaller taxa such as beetles and ants. Characteristics such as size and structure could should be site specific and determined during the assessment of the location. The same applies to the selection of species for this feature, using the Species selection tool provided in Appendix 8 – Species selection tool.

Litter and deadwood piles

Litter and deadwood piles offer the same benefits as rocks in that it offers refuge to biodiversity. Small mammals, amphibians as well as insects and arachnids use these structures for sheltering, foraging and other life history strategies. These refugia can also be used as points of focus for biodiversity surveys of local fauna. Owing to the monitoring aspect of the Living Lodge, these structures can be a useful aid in surveying for wildlife as well.

Hibernacula

Hibernacula are important to animals living in temperate climates as they offer shelter and security during the wintering months when animals are vulnerable not just to environmental factors but to predation as well. Artificial hibernacula can make an important addition to the lodge as they offer amphibians, small mammals and insects a safe refuge during overwintering. The size and scale of these hibernacula are site dependent and can be designed accordingly. It would also make an interesting and educative activity for guests to participate in.

The Clemson Beaver pond leveller

The Clemson Beaver pond leveller was developed by Clemson university in the United states as a tool to allow land managers to manipulate the flow of water through beaver dams. This device was largely used to mitigate the effects of beaver dams on private land without actually removing the dam. Since the Biesbosch is a National park, there should not be any need to mitigate the effects of the dams. One scenario where this could be applicable is if the dam was close enough to the site of the lodge to influence water flow on to the property itself. In the interest of not disturbing the activities of the animal and in assuring it of safety around the premises, the leveller could be deployed as a non-invasive strategy. It has a simple but robust design and can be assembled with detailed instructions available online.

Figure 12. Insect hotels

Insect hotels

Insect hotels (Figure 12) are becoming increasingly popular with urban wildlife gardeners. These would make useful additions to the lodge as they are easy to make and can make an interesting activity for guests. They are also easy to install and can be placed by the lodge itself and on various places around the perimeter. The size and structure can be manipulated and designed as per the requirements on site. For a list of structures and species that can be accommodated, please refer to the Species selection tool in the Appendix 8 – Species selection tool

Bat boxes and nest boxes

Bat boxes (Figure 13) and nest boxes have been successful in wildlife gardening as well as scientific research. They are easy to install and provide a useful service as sheltering and nesting sites for bats and birds. These boxes are simple in design and can be installed on or around the lodge. The nest brick is another variant that can be placed directly in the wall (Figure 14). Like the insect hotels, the guests could make these boxes as an activity during their stay. They also make wildlife easier to observe during otherwise secretive behaviours such as nesting. Additionally, video recording equipment can be placed within the box to allow for easy observation by guests of the lodge.

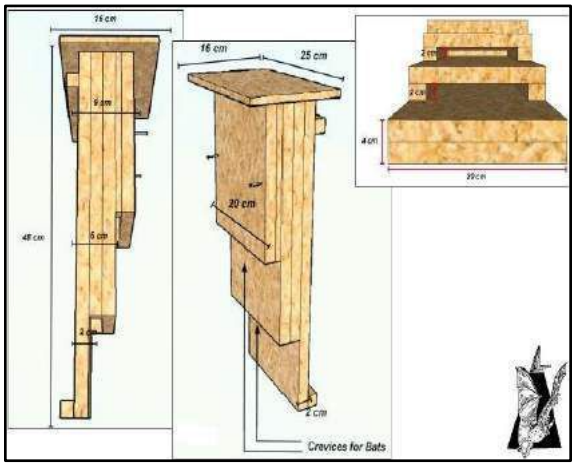

Figure 13. – Bat box design Source: Kent bat trust

Figure 14. Nest brick. Source: Google images

Integration

Once the assessment of an area is complete (chapter 3), data on the condition of the ecosystem including the habitat mosaic, species composition and ecosystem health are analysed. The next step involves choosing the appropriate greening structures (chapter 4) to best accommodate and integrate the selected species in the given habitat within the perimeter of the lodge itself. In this case we have used the Biesbosch as an example to illustrate the selection process.

The procedure of selecting species and appropriate greening structures depends on several variables including the type of habitat, interactions between species, their specific habitat requirements and condition of the ecosystem. This is a complicated process that requires relevant data and the expertise to analyse them. We have developed a Species selection tool in a bid to try and simplify this process as much as we possibly could. We provide an example of choosing habitat types in the Brabantse Biesbosch to illustrate the application of this selection tool. The Brabantse Biesbosch was chosen because this was the preferred site for the pilot location.

Choosing a species and the appropriate supportive structure is a relatively simple six step process which is summarized in the **'instructions'** sheet of the excel file of the tool. The six step process is broken down into two distinct protocols. For plant species selection follow steps one, two and three in a consecutive order. For animal species selection follow steps one, four, five and six in this very order. We have provided an explanation below to further clarify the required steps.

Step 1 Depending on the specific location, habitat types occurring in the region are analysed and selected. For the Biesbosch we have used the 'Natura 2000' classification system as it is the most comprehensive database available for the region.

Step 2 This step involves the selection of appropriate plant species according to the chosen habitat. In this step, it would be wise to keep in mind other factors involved in choosing plant species such as the specific ecological requirements associated with it.

Step 3 This step involves choosing the right greening structure for the plant species selected. The tool aids this process by clearly displaying the appropriate structure and species combination through the matrix table.

Step 4 This step is specifically for animal species. The different habitat structures (for example, roughages, water bodies and forests) in a habitat type need to be identified. As species also have specific structural requirements within a habitat, this step helps to narrow down the physical habitat requirements of the selected species. This is an important step in setting up a thriving ecosystem.

Step 5 Once the plant species and the supporting structures have been identified, suitable animal species that can benefit from the native environmental conditions are selected for each of the active components (= plant + greening structure + habitat requirements). In this step the 'plant' and 'habitat requirements' of the active component are brought together into the habitat structure. Therefore, this step aims at building a connection between the species and the different habitat structures.

Step 6 The final step is choosing the appropriate greening structure based on the habitat structural requirements for the animal species selected. In this step the habitat structure is complemented with the greening structure to finalize the connection between animal species and the active components. The combined aim of step 5 and 6 is to examine which species can be complementary to the active component. When implementing the greening structures that benefit animal species, one should reckon with the spatial layout. It is very important to consider the trophic flows in the system. For example, you would want to avoid setting up a nest box next to a flowering plant that attracts a target species of butterfly, as the latter would become prey.

These steps have been designed to replicate the process of building an ecosystem from the ground up. The greening structures act as a supporting base along with the appropriate vegetation that can then support animal life. When this examination is done properly it becomes a closed cycle as seen in nature and has the potential to be self-sustaining. However, this is easier said than done and requires careful assessment and planning which largely depends on background knowledge in the field of ecology and architecture, relevant sources of data followed by a detailed assessment and execution.

Monitoring system

6.1 INTRODUCTION

Monitoring is the process of collecting information about a system state variable at different time points. The ultimate goal of monitoring is to assess the state of the system and draw inferences about changes in the state over time (Yoccoz et al., 2001). Jones et al. (2011) has classified five reasons for setting up a biodiversity monitoring programme along a spectrum ranging from knowledge focused to action focused. The five reasons for monitoring biodiversity are: to learn about the system, detect unexpected change in the system, raise awareness among public and policy makers about conservation issues, audit management actions, and inform policy and management decisions (Jones et al., 2011; Jones et al., 2013).

We adapted the framework from Franklin et al. (2011) to design a monitoring plan for the Living Lodge. Our framework consists of several interconnected steps: 1) formulation of monitoring goals; 2) prioritization of taxonomic groups for monitoring; 3) formulation of monitoring objectives; 4) design of a monitoring plan; 5) execution of the monitoring plan by collecting and analysing data; 6) drawing inferences. The next paragraphs provide a more detailed overview of these six steps.

Clear monitoring goals are essential precursors to designing a successful monitoring program (Franklin et al., 2011). Monitoring can help Nature Nomads to accomplish two of their goals: (1) improving biodiversity; (2) re-uniting man with nature. The main reason for monitoring is to assess whether the Living Lodge can improve biodiversity because monitoring outcomes can inform management decisions. Here we focus on management decisions involved in the Biesbosch Pilot study. These decisions concern several stakeholders. Firstly, Nature Nomads can use the monitoring outcomes to assess whether the lodge at the Biesbosch pilot location should stay after the length of the pilot study, whether the Living Lodge concept needs revision, to build new lodges at other locations, or a combination of the previously mentioned decisions. Secondly, the land owners, Staatsbosheer at the Biesbosch, can decide whether they extend the permit, suspend the permit, offer permits to build lodges at other locations, or a combination of the previously mentioned decisions. Thirdly, monitoring outcomes can attract current investors and new investors to invest money in building new lodges at other locations.

Additionally, monitoring activities could help in re-uniting man with nature by involving guests in monitoring protocols. However, this is not the main reason for monitoring because other activities can also achieve this goal. For example, connections between guests and nature can be achieved with staying in the lodge and doing other nature-based activities (Chapter 7). Moreover, it is not feasible to perform all monitoring protocols with only citizen science. Some protocols are only successful and reliable if they are performed by experts and other protocols are only appropriate for citizens when an elaborate validation process is performed by experts. Also, the volunteers should collect a lot of monitoring data to keep track of species trends and this is not possible for the Living Lodge regarding the number of guests. Therefore, we suggest distinct monitoring protocols for guests and experts. Monitoring protocols for guests have mainly educational purposes, but could provide valuable input for the monitoring performed by experts. Monitoring performed by guests could highlight striking changes in certain taxa that were missed by less frequently performed expert protocols. For example, a drop in reed warbler numbers noticed by guests could mean that experts should monitor the reed bed plant communities more frequently. Monitoring protocols for experts aim to test the impact of the Living Lodge on biodiversity.

In conclusion, the main monitoring goal of Nature Nomads is to assess whether the Living Lodge can improve biodiversity.

The next step is to implement the expert-specific monitoring goal into specific monitoring objectives. These objectives describe how to reach the goals by mentioning what is measured during monitoring and the associated timeline of monitoring (Franklin et al., 2011). It would be very costly and time-consuming to comprehensively assess the state of all biodiversity at a specific location (Jones et al., 2013). Therefore, we selected two metrics of biodiversity and we prioritized specific

taxa in the Biesbosch. We focus biodiversity monitoring on measuring species richness and abundance. We define species richness as the number of species and abundance as the number of individuals. The prioritization of taxonomic groups was based on a selection process consisting of literature study and interviews with experts (Chapter 3). Regarding the timeline of monitoring, the Biesbosch pilot study lasts for ten years. Altogether, the monitoring objective is to assess the impact of the Living Lodge on the species richness and abundance of a selected group of animal taxa and plants belonging to Biesbosch-specific habitat types over a timeline of ten years.

The monitoring objective is further elaborated in the monitoring plan. The monitoring plan provides detailed answers to where, when, and how to monitor species richness and abundance of the selected taxa. Monitoring protocols for specific taxa will be described in separate subchapters in this report. This report contains monitoring protocols for birds, mammals, dragonflies, butterflies, ground arthropods and vegetation. All subchapters about taxa-specific monitoring protocols follow a similar structure. Firstly, the subchapters start with a short introduction about the importance of monitoring the taxonomic group concerned. Subsequently, the monitoring protocol for experts will be described. This protocol for experts addresses guidelines for designing and positioning monitoring sampling units in the Living Lodge area (e.g. transects, plots, traps), a description of the monitoring method and materials, recommendations for the best timing in the year to perform the protocols, and an example of a field form in the appendix. Additionally, a subchapter considers the monitoring protocol for citizens including monitoring methods and materials, recommendations for the timing in the year, and a field form in the appendix. The monitoring field form for citizens includes a list of species to ease identification and counting of species. Not all species present in the Biesbosch are included in these lists. The list contains a selection of species including iconic Biesbosch species (species listed in Natura 2000), species attractive to guests, and common and easily identifiable species. Finally, we conclude the monitoring part of this report with one year calendar for experts (Table 2) and one year calendar for citizen science (Table 3). These year calendars show the most appropriate months to perform the taxa-specific monitoring protocols.

The data collected from the expert monitoring plans need to be analysed to draw inferences about the impact of the Living Lodge on biodiversity. We will not discuss appropriate statistical analyses in this report. We recommend the "Centraal Bureau voor de Statistiek" (CBS) for the execution of statistical analyses. The CBS already has experience in statistical design and analyses for multiple monitoring projects such as "Landelijk Meetnet Vlinders" and "Landelijk Meetnet Libellen" (van Swaay et al., 2011) and "Meetnet Amfibieën" (Goverse et al., 2015).

6.2 BIRD MONITORING

6.2.1 SUMMARY

Criteria	By whom	Instruction
Species	Citizen science	Use selected list of species
	Expert	All species found within the grid.
Time		Before 10 AM under acceptable weather condition
Frequency	Citizen Science	1 sample every month in two points
	Expert	12 samples from two point counts, totaling 24 counts in a year
Fixing Sampling locations	Lodge Authority	Two points in Lodge Area. One is East Side and other one West side.
Number of sample locations	Citizen Science	2 points around the Lodge.
	Expert	2 points around the Lodge

6.2.2 INTRODUCTION

Birds are an important indicator of environmental change due to their worldwide distribution, they are also a well studied taxonomic group and they are easy to monitor (Şekercioğlu, 2012). Birds play an important ecological role through pollination and dispersal of seeds. The basic form of bird monitoring is to make a list of birds in a specific area. Many birds are habitat specialists and the disappearance or reduction in their numbers can bring changes in the ecosystem to light. From the perspective of the Living Lodge, an observed increase in the number of bird species is an indicator of enhanced habitat heterogeneity and food availability. Monitoring typical or iconic bird species through the Living Lodge citizen science study can provide valuable information regarding these species.

6.2.3 GUIDELINES

Points counts are the most popular bird surveying technique. However, walking transects, mist-netting and ad lib observation may also be used (Parker et al. 1993, Killeen and Sculenberg 1998). This subchapter describes a protocol to monitor birds within the Living Lodge grid. We suggest two, point count locations as the best means of monitoring birds using direct visual and auditory evidences.

Point count design

We selected two point count stations, one to the East and the other to the West of the lodge (Figure 15). Each counting station is placed at a 100m distance from the lodge. For the purpose of clarifying the sampling area and to avoid double counting birds, observation will be documented only if birds are detected within a 100m radius from the counting stations (Figure 16).

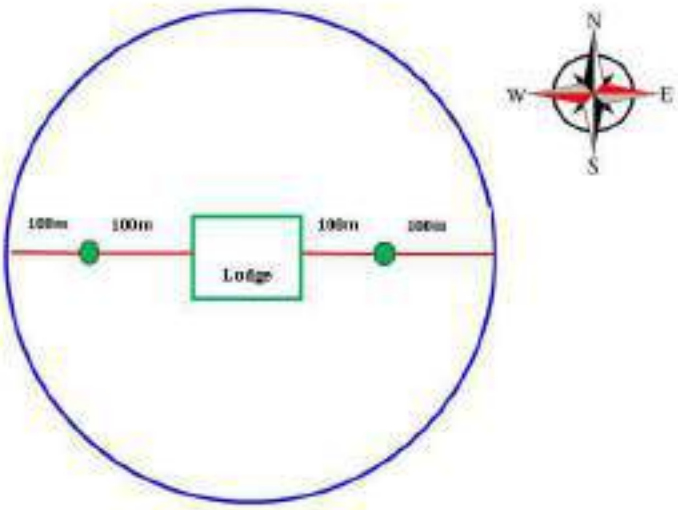

Figure 15. Overview of selected points for bird counts in the lodge area.

Timing for monitoring

The most favorable time for bird monitoring is just after dawn during favorable weather conditions. According to Verner (1985) "no surveys are conducted with winds greater than 11 km/hr, during precipitation, and under foggy conditions". The time for counting is before 10.00 a.m. under acceptable weather conditions. The count is conducted for duration of 10 minutes. Observers note down weather conditions, time of the day, and the date into the appendixed field form prior to every point count. The main observations to be recorded are, the bird species, the identification method (visual or auditory), number of birds as well as behaviour and activity. For example, on the ground, foraging, on a tree, flying over etc. This information is crucial as it allows for a distinction to be made between birds that are actively using the Lodge and those that might be simply passing by.

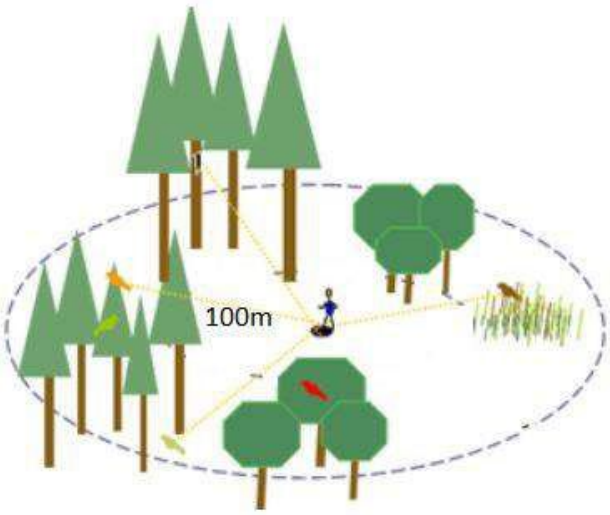

Figure 16. Point counting for birds monitoring. Adapted from: http://www.pwrc.usgs.gov/point/index.cfm?fa=pointcount.whatIsAPointCount

Monitoring by experts

The expert is expected to sample all bird species at least 12 times a year during the scheduled months for bird monitoring (see time schedule). During each of these 12 samples, both point counts will be sampled once, resulting in a total of 24 point counts per year. The chosen time periods take into consideration the nesting, migratory and high activity periods for most birds in the Biesbosch, allowing the entire bird community to be sampled. A species accumulation curve, can serve as a prediction for the number of birds in the area.

Monitoring by citizen science

Bird species are seen all around the year, allowing bird monitoring to be an activity for guests throughout the year. We suggest a minimum of one sample every month for both point counts, resulting in a total of 24 point counts a year. This bird database is valuable for designing environment education material for outreach purposes. The appendixed field form (see Appendix 9 – Field forms) contains all the guidelines and relevant fields to be considered while making observations. Since the focal species list for citizen science is comprised of 29 bird species selected according to the Natura 2000 targets. Observations by guests can be used to keep track of relative abundances of these target species thereby contributing to long term monitoring of these species.

6.2.4 CHECKLIST OF MATERIALS

- Field form
- Clipboard
- Binoculars
- Pencil
- Bird identification hand book

6.3 MONITORING MAMMALS

6.3.1 SUMMARY

Criteria	By whom	Instruction
Species	Citizen Science	All species observed
	Expert	All species that are found in the whole area of the lodge.
Time	Citizen Science	Whole year
	Expert	Camera Trapping April to September and Live trapping July to September
Frequency	Citizen Science	Opportunistic sightings, when people observe any mammals during the year, they mark it with a location.

	Expert	Camera trap 24 times in a year and Live trapping 6 times in a year.
Fixing Sampling locations	Citizen Science	Whole area of Living Lodge
	Expert	Whole area of Living Lodge and Selected point for camera trap and live trap
Number of sample locations	Citizen Science	Recording opportunistic sightings.
	Expert	10 trapping stations

6.3.2 INTRODUCTION

Mammal monitoring can be conducted in a wide variety of ways, visual encounter surveys and camera trapping can be conducted for large mammals while live trapping and DNA techniques for smaller mammals proves effective in identifying more cryptic species such as mice and shrews. Over the last two decades, advances in non-invasive sampling techniques have allowed ecologists to sample or monitor mammals populations without having to trap or handle them. One of the most popular non-invasive sampling techniques, particularly for elusive nocturnal species makes use of remote photography using camera traps (Kays and Slauson 2008). Camera traps not only allow 'round the clock' sampling opportunities but also provide video and photographic outputs that can contribute to the Living Lodge education materials. Unfortunately, there are some issues surrounding the effectiveness of using camera traps to sample small mammals as Identified by (Kelly 2008), therefore we suggest the use of live trapping in addition to camera trapping in this chapter.

For the purpose of sampling small and large mammals for the Living Lodge, we suggest the use of three sampling techniques that may be appropriately employed during different periods of the year as indicated in the time schedule. 1) Opportunistic surveys can be used to record individual sightings of mammals, this technique can be conducted all year round and can be made interactive wherein guests 'pin the location' of mammal sightings on a replica of the Living Lodge grid. 2) Sherman traps (H.B. Sherman Inc., Tallahassee, Flor.) or Longworth traps (Penlon Ltd., Oxford, U.K.) can be used to sample smaller rodent species that are relatively harder to identify through visual encounters. 3) camera traps can be appropriately baited or placed strategically along animals trails in order to capture photographic evidence of mammals that use the Living Lodge area.

6.3.3 GUIDELINES

This subchapter focuses on defining the monitoring protocols for guests and for experts. We suggest that live trapping and camera trapping be conducted by the expert as these techniques require prior training to be carried out effectively and ethically. The opportunistic documentation of mammal sightings can be conducted by guests.

Recording opportunistic sightings

A poster with pictures of the mammals in the Biesbosch can be made available inside the lodge to aid in identification of mammals. A 'mammal sighting book' can be maintained where numbers of animals and other information such as date and time of the day can also be recorded. To make the process more interactive and appealing to guests we suggest that a map of the Living Lodge grid be placed on a bulletin board, thereby allowing guests to use colour coded pins to mark the location of their sightings. This spatial distribution of mammal sightings will provide valuable input for the expert while selecting locations of interest for live trapping and camera trapping. In addition to these direct observation of animals, field notes of indirect evidences such as dung, tracks, beaver damage and other signs may be recorded under 'notes' in the mammal field form in Appendix 9 – Field forms. These indirect evidences can be used as an indication of presence of mammals within the living lodge grid.

Live trapping

Sherman traps or Longworth traps (Figure 18) that are available in a variety of sizes may be deployed in the Living Lodge grid during the months of July and September (Roverro and Marshall, 2009). This is the period of highest small mammal activity. Our protocol suggests the use of 20 individual traps deployed in pairs at 10 trapping stations to avoid saturation by 'trap happy species", this increases the chances of trapping animals less prone to being trapped (Drickamer, 1987). We recommend that traps are deployed for a 48-hour sampling period. Ideally, traps should be left un-deployed and un-baited in the field at least for 48 hours prior to sampling to reduce trap shyness. This trapping sampled at least 6 times in a year during the schedule month of monitoring (see schedule). In colder climates such as the Netherlands, it is advised that these traps include insulating material such as tufts of cotton or wool and an envelope of cardboard to reduce mortality of sensitive species. All traps must be checked every 12 hours to reduce stress and predation by ants. All animals must be released at their respective trapping stations immediately after identification.

Selection of trapping stations and fixing sampling time is the first step to live trapping. Since our sampling goals do not focus on determining species densities, the selection of the 10 trapping stations can be strategically selected by the expert. Traps are ideally set facing rodent trails, along logs or building edges that act as drift fences or near a hole/hiding place. Trap stations should be clearly marked with flagpoles to facilitate easy identification, quick re-baiting and reduce disturbance to the site. During inspection the expert may carry restraining tubes of varying sizes to aid in identification of key morphological characteristics. Photo documentation of unidentified specimens is recommended for identification by consulting a small mammal expert.

Figure 18. Sherman trapping for small mammals monitoring. Source: http://entogroup1.weebly.com/uploads/3/9/0/6/39066599/3403035_orig.jpg

Figure 17. Camera trapping for large and medium size mammals monitoring. Source: http://www.pestsmart.org.au/act/act-step-4/camera-trapping/

Camera trapping

Camera traps (Figure 17) are cheap and easy to use; they comprise of a digital camera integrated with an infra-red trigger, allowing the device to record animal presences without disturbance to the area. Camera trapping sampled at least 24 times in a year during scheduled month of monitoring (see schedule). A memory card can be used to store video and still photographs, this forms the raw data for analysis. Camera traps typically have a battery life of 30 days, depending on capture rate. The selection of camera trap locations for the purpose of documenting mammals and large birds in the living lodge area can be done in two ways. They can be strategically deployed in areas showing characteristics of frequent animal activity or they can be baited to attract animals towards it. To avoid attracting animals from outside the Living Lodge grid we suggest the first method for selecting camera trap locations. If baits have to be used, appropriate measures need to be taken to ensure captures do not represent animals attracted from large distances.

6.3.4 CHECKLIST OF MATERIALS

- Map with colour coded pins
- Sightings book
- Sherman or Longworth traps
- Restraining tubes of varying sizes
- Camera
- Camera traps, with batteries and memory card.

6.4 DRAGONFLY MONITORING PROTOCOLS

6.4.1 SUMMARY

Criteria	By whom	Instruction
Species	Citizen Science	Use list of selected species.
	Expert	All species that are found in the Lodge area.
Time	Citizen Science & Expert	Dragonfly monitoring is only performed on days with weather conditions corresponding to the weather guidelines and during the dragonfly flying season. Dragonflies are counted between the 1st of May and the 30th of September and between 11:00 AM – 16:00 PM.
Frequency	Citizen Science	Any day with appropriate weather conditions during the flying season.
	Expert	Twice a month in the dragonfly flying season
Fixing Sampling locations	Expert	Transects along water bodies such a linear transect along a river and a circular transect around an execavated pond.
Number of Sampling locations	Citizen Science	2 transects
	Expert	2 transects

6.4.2 INTRODUCTION

Dragonflies have been described as a valuable tool for environmental assessment and biodiversity monitoring in freshwater habitats (Simaika & Samways, 2011). They have been used as bio-indicators of biodiversity, water quality, environmental change (including climate change), and habitat recovery (Oertli, 2008; Simaika & Samways, 2011). Simaika and Samways (2011) provide several reasons for the success of dragonflies as bio-indicators: (1) well-characterized taxonomy; (2) easily identifiable in the field; (3) live in a wide range of habitats; (4) their sensitivity to changes in water quality and other ecological conditions of their habitat; (5) large enough species assemblages for assessments.

Regarding the Living Lodge pilot project, dragonfly monitoring is interesting for two main reasons. Firstly, it provides data to assess whether the Living Lodge improves biodiversity by attracting dragonflies and more specifically whether species noteworthy for the Biesbosch are attracted. Secondly, dragonflies can serve as a bio-indicator for the biodiversity of other taxonomic groups such as benthic macroinvertebrates (which would otherwise require labour-intensive monitoring) (Simaika & Samways, 2011).

The next subchapters focus on monitoring protocols for experts and volunteers. Although these protocols differ in the target group of observers, they overlap in general guidelines for dragonfly monitoring such as the design of the transects, the general counting method while walking a transect, the appropriate timing (flying season in year, time of day), and appropriate weather conditions. First, the general guidelines will be discussed and afterwards the monitoring protocols specific for experts

and volunteers will be addressed in separate subchapters. The design of the monitoring protocols is based on the monitoring methods used in the "Landelijk Meetnet Libellen" (van Swaay et al., 2011).

6.4.3 GUIDELINES

Dragonfly monitoring is mainly performed by walking transects. Nevertheless, dragonfly monitoring concerns more than simply counting along a transect. Several aspects need to be considered during the preparation and execution of monitoring to acquire reliable monitoring data. We will discuss the general guidelines for designing a transect, the timing in the year, weather conditions, and counting methods in this subchapter.

Designing transects

The location and length of transects are essential aspects for designing dragonfly transects.

The location of monitoring is mainly dependent on the habitat of dragonflies and the accessibility for the observer. Dragonfly monitoring is only possible when the Living L odge is nearby water such as a river, ditch, or pond. The ideal dragonfly transect should be located along an accessible and uncluttered waterside, along one biotope, and at a sunny location in both autumn and spring. Examples of unsuitable locations are watersides with a broad reed bed or inaccessible marshy watersides. It is possible to set up a transect with some inaccessible parts, but counting should be focussed on the accessible parts and no dragonflies will be counted at the cluttered or inaccessible parts.

A general transect is 100 metres long and divided in two sections (called sections 1A and 1B) of 50 metres (van Swaay et al., 2011). A transect may be shorter or longer than 100 metres. The minimum length of a transect is 25 metres and the maximum is 500 metres. A shorter transect is appropriate when not enough biotope is available for counting along 100 metres. A transect could be longer to increase the reliability of counting big dragonflies. Additional sections of 100 metres may be added to transects along canals, big ponds, brooks, and other big water bodies. This is allowed to a maximum length of 500 metres and only big dragonflies should be counted along the additional sections.

Figure 19. Schematic overview of potential dragonfly transects for the Living Lodge at the Biesbosch location. The two orange landmarks indicate the start and endpoint of a linear transect along a river and the grey landmark distinguishes section 1A (50 m) and 1B (50 m) along this transect. The red landmark indicates the circular transect around an excavated pond.

We envision two potential transects for the Living Lodge in the Biesbosch. One transect along a river bank at the edge of the Living Lodge grid and one circular transect around a newly excavated pond in the grid (Figure 19).

After designing the transects, the transects should be plotted on a map and in the field. The transects are fixed on a map by recording the Amersfoort coordinates (XY-coordinates) of start and endpoint of the transects. Furthermore, landmarks in the field are clearly indicated on the map. Natural and artificial landmarks (e.g. little pole) in the field should mark the beginning and end of all the sections on the transect. Sections can be measured in the field by taking 50 big steps or using a rope of 25 metres twice (van Swaay et al., 2011). It is not allowed to change and/or add sections during the 10-year monitoring plan after fixing the transects on a map and in the field.

Weather conditions

Good weather conditions are very important when counting dragonflies. The activity of dragonflies strongly depends on weather conditions. Counting during inappropriate weather conditions would result in less active dragonflies and consequently a wrong estimation of the dragonflies that are truly present in the area. Therefore, dragonfly counting should only be performed during weather conditions optimal for dragonflies. Guidelines for good dragonfly weather include recommendations on temperature, cloud cover, wind force, and precipitation. We will briefly describe

how these guidelines help in deciding whether it is appropriate to count dragonflies under certain weather conditions.

Firstly, the temperature helps in deciding whether a survey should be performed and at what time it should be performed. No surveys should be performed if the temperature is below 13 °C. Surveys are only appropriate between 11:00 – 16:00 if the temperature is between 13 and 17 °C. On warm days (> 22 °C) surveys could be performed between 10:30 – 16:30, but on extremely hot days (> 30 °C) the survey should preferably not be performed around mid-day.

Secondly, cloud cover expressed in eights (unit: Oktas) is an indicator for good dragonfly weather. A survey should only be performed when the cloud cover is 4/8 (50%) or less and the temperature is between 13 and 17°C. It is appropriate to count dragonflies if the cloud cover is above 4/8 (50%) if the temperature is 17 °C or more. Cloud cover should be estimated directly above the observer and not at another distance, because cloud cover seems to be higher when observed in an angle.

Thirdly, no surveys should be performed if the wind force is above 5 Beaufort. Finally, dragonflies should not be counted with precipitation.

In conclusion, dragonflies should only be counted with good dragonfly weather to acquire reliable data. The weather guidelines are strict and consequently it will not be possible to collect data during all weeks of the dragonfly flying season in the Dutch climate (van Swaay et al., 2011).

Timing of surveys

The dragonfly monitoring protocols focus on counting adult dragonflies. Hence, the recommended months to count adults is based on the flying season. The flying season is between the 1st of May and the 30th of September. van Swaay et al. (2011) recommend monitoring twice a month to obtain reliable data about dragonfly population trends. The required time to perform one survey, ranging between 15 (one section) and 45 minutes (multiple sections), depends on the number of sections on a transect.

Counting dragonflies

Experts and citizens use a field form before, during, and after the survey. Although they will use different field forms, some fields in the form are the same on both data sheets. Both experts and citizens should start a survey by writing down the name of the route, date, weather conditions (temperature, wind force, cloud cover), and start time. Subsequently, they will write down the observed dragonflies while walking a section. Finally, they finish the survey by filling in the end time.

The experts and citizens follow general counting rules while walking the transects (van Swaay et al., 2011). The rules concern the walking speed, counting on sections, a distinction in counting between small and large dragonflies, the stage of dragonflies, and preferred method of identification.

Firstly, they walk in a constant and relaxed pace along the fixed route. They are allowed to stop to write something down, but they should try to keep the time of each count similar among the transect. Secondly, dragonflies will be counted separately on sections 1A and 1B. In other words, a person counts while walking section 1A and starts from zero when starting section 1B.

Furthermore, it is recommended to walk sections 1A and 1B twice. The small dragonflies will be counted during the first walk and the large dragonflies during the second walk (). It is often challenging to count dragonflies simultaneously and the previously described method prevents overlooking animals. However, it is allowed to count all dragonflies simultaneously for people experienced in counting dragonflies. Thirdly, a different counting distance applies to small and large dragonflies (Figure 20. Counting distances used while monitoring dragonflies on a transect. The counting distance for small dragonflies is 2 metres water bank + 3 metres water and for large dragonflies 2 metres water bank + 5 metres water (van Swaay et al., 2011).). The counting distance for small dragonflies is 2 metres water bank and 3 metres water. The counting distance for large dragonflies is 2 metres water bank and 5 metres water. Fourthly, only adult dragonflies should be counted. Freshly hatched dragonflies or individuals with weak and soft wings will be ignored. A mating wheel will be counted as two individuals. Additionally, dragonflies observed outside the transect may be written down as 'casual record'. Finally, dragonflies will be identified by sight and binoculars are helpful for identification at larger distances.

Besides dragonfly monitoring, experts and citizens may perform opportunistic surveys for amphibians while counting dragonflies. Although the Biesbosch accommodates no unique amphibian species, it may be interesting to assess whether the Living Lodge attracts amphibians.

Table 1. Classification of 'small dragonflies' and 'large dragonflies' (van Swaay et al., 2011)

Small Dragonflies	Large Dragonflies
Spread-winged damselflies (D: pantserjuffers)	Broad-winged damselflies (D: beekjuffers)
Winter damselflies (D: winterjuffers)	Hawkers (UK)/Darners (USA) (D: glazenmakers)
Pond damselflies (D: waterjuffers)	Clubtail dragonflies (D: rombouten)
White-legged damselfly (D: blauwe breedscheenjuffer)	Emerald dragonflies (D: glanslibellen)
Darters (UK)/ meadowhawks (USA) (D: heidelibellen)	Golden-ringed dragonfly (D: gewone bronlibel)
	Skimmers/Perchers excluding Darters (D: korenbouten, behalve heidelibellen)

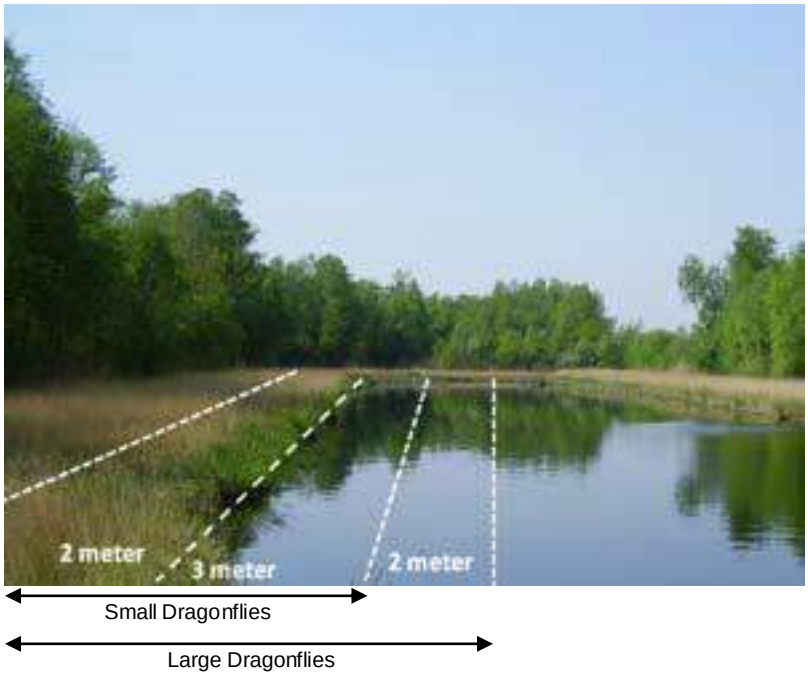

Figure 20. Counting distances used while monitoring dragonflies on a transect. The counting distance for small dragonflies is 2 metres water bank + 3 metres water and for large dragonflies 2 metres water bank + 5 metres water (van Swaay et al., 2011).

Dragonfly monitoring by experts

Data collected by the dragonfly expert will be used to test the impact of the Living Lodge on the species richness and density of dragonflies. Experts should count twice a month during the dragonfly flying season (Table 2) to get a reliable overview of dragonfly trends. The field form for experts (Appendix 9 – Field forms) differs in two aspects from the citizen science form.

Firstly, experts assess before the first survey of each year changes in management (e.g. vegetation mown, water body cleaned/dredged), environmental conditions (e.g. slower water movements due to new sluice), and plant cover/biotope (e.g. water surface covered by algae) along the transects. These factors could have a big effect on dragonfly abundance and are therefore important to record.

Secondly, the expert field form contains blank fields to record their dragonfly observations while the citizen science form contains a species list. The expert records all the dragonfly species and all the individuals observed during the transect.

Dragonfly monitoring by Citizen Science

Dragonfly monitoring by citizen science focusses on educational purposes. Citizens will learn guidelines for scientific dragonfly monitoring and are invited to count themselves during the dragonfly flying season (Table 3). A booklet with monitoring guidelines, a field form (Appendix 9 – Field forms) and a field guide will help citizens in identifying and counting dragonflies. The citizen science field form provides a list of species. This list includes iconic and common species of the Biesbosch which are easily identifiable for citizens. The citizens count the number of individuals on the species lists. After counting, citizens upload their observations on a Living Lodge database. Guests of the lodge and experts can read the dragonfly observations in the database.

6.4.4 CHECKLIST OF MATERIALS

Fixing transects in the field:

- Little wooden poles (or other landmarks)
- Map
- Pencil
- GPS
- Optionally rope of 25 metres

Counting dragonflies:

- Dragonfly monitoring guidelines
- Dragonfly field guide
- Field form expert/citizen science
- Map illustrating transects, sections, and landmarks
- Pencil
- Binoculars

6.5 BUTTERFLY MONITORING

6.5.1 SUMMARY

Criteria	By whom	Instruction
Species	Citizen Science	Use list of selected species.
	Expert	All species that are found in the Lodge area.
Time		Monitoring of butterfly is done during April to September and counting time is 10.45 AM to 15.45 PM but avoid hot weather (>30°C).
Frequency	Citizen Science	4 times in a month when the weather condition fulfills the requirements for butterfly monitoring.
	Expert	Weekly or more than that.
Fixing Sampling locations	Lodge Authority	Four directions from Lodge.
Number of Sample locations	Citizen Science	4 transect around the Lodge.
	Expert	4 transect around the Lodge

6.5.2 INTRODUCTION

Insects are the most diverse group of animals in the word that represent 50% of global terrestrial biodiversity (Thomas, 2005). Lepidoptera is an order of insects that the butterfly belongs to, this order is the most popular among society as they are relatively easy to identify and often display vibrant colours. Fortunately, the butterflies have been the focus of scientific documentation long into history and are well known and well documented. Butterflies are very sensitive to change in environmental conditions such as climate change, habitat fragmentation etc (Glibert 1984; Brown 1991; Eberhardt and Thomas 1991; Sutton and Collins 1991; Debinsky and Brussard 1992; Kremen 1992). Butterflies therefore serve as an important bioindicator to ecosystem degradation. From the literature study, we found that lot of butterfly are present in the pilot location of lodge. So, butterfly can be an interesting tool to get information about changing environment, in addition to serve as a focal species for inculcating interest in biodiversity appreciation.

6.5.3 GUIDELINES

Butterfly monitoring are mostly conducted by walking transects (Swaay et al. 2015) although other effective methods such as baited butterfly traps and butterfly nets have also been used in the past. The observer walks along the transect and counts the number of butterflies he/she sees. This counting depends on factors like weather, time of day and time of the year. A description of these conditions are given below in this chapter.

Designing the transect

The grid area of the Living Lodge is 200m in radius and forms the sampling area for butterflies. We planed 4 transects oriented North, South, East and West of the Lodge (Figure 22). The length of the transect for the "Living Lodge" is 200m divided into smaller sections of 50 meters. Each transect will then consist of 4 parts labelled 1A, 1B, 1C and 1D, as indicated in the figure. The reason for subdividing each transect is to ensure a more homogeneous sampling in each subdivision, and to provide a short break after every 50m to ensure that data is entered correctly. The observer

counts butterflies from 2.5m on his left side and 2.5m on his right side and 5m above (Figure 22) (Van Swaay et al. 2002). In such a case where a butterfly garden is planned within the grid, at least one transect must be relocated to include this patch. Alternatively, butterfly gardens can be positioned along one of the 4 transects.

After finalizing the transect locations using a GPS, all transects should be clearly marked in the field by using poles or ropes along the ground. Observers are required to walk along these fixed transects so that the same area is repeatedly sampled.

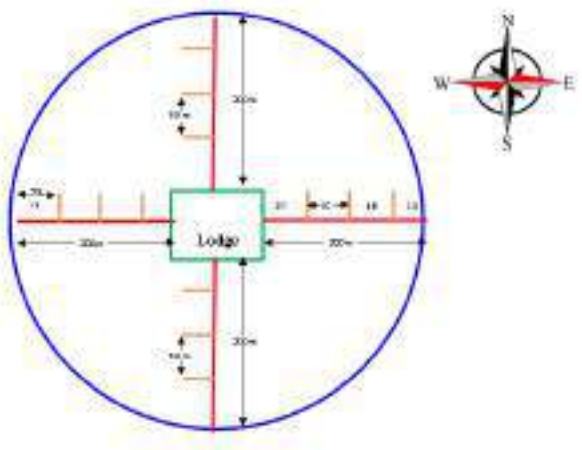

Figure 22. Overview of butterfly transect for monitoring butterfly in the Lodge area.

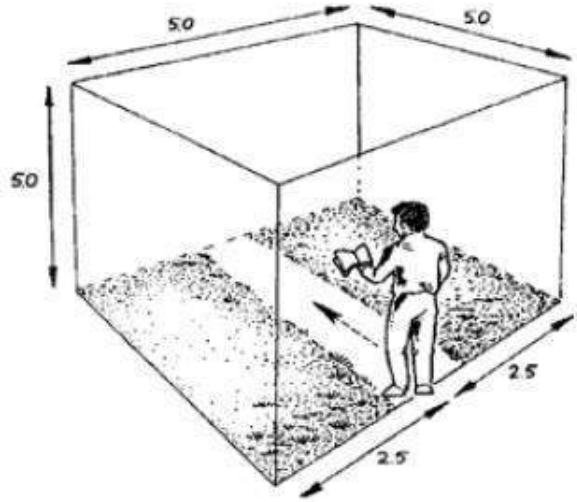

Figure 22. Counting area of butterfly during monitoring along transect (Swaay et al. 2015)

Weather conditions

Weather is a very important requirement for butterfly counting. We should conduct surveys during the day as a majority of the butterflies of interest are day active. Three weather components mainly determine butterfly activity namely temperature, wind and precipitation. The most suitable conditions for monitoring butterflies is on sunny days and temperatures between 13°C and 33-35°C with a wind velocity less than 6 on the scale of Beaufort (Swaay et al. 2015) during their flying season. Below 13°C temperature butterfly typically stop their activities and with temperatures above 30°C some species of are not seen. Due to this sensitivity to conditions, butterflies have to be monitored under optimum conditions for the best results, and for this reason it is useful to include recording weather conditions in the field form.

Sampling period

The flying season of butterfly are starting at 1 April and end on September (Hall, 1981 and Swaay et al. 2011). So the recommended month for butterfly monitoring is April to September. Swaay et al. (2015) recommended for weekly 1 times count. So, in a month 4 times counts conducted by citizen science and expert but the counting day should be decided by using the weather conditions. The time of survey should be from 10.45 AM to 15.45 PM but avoid hot weather (>30°C).

Counting Butterflies

Butterfly monitoring is conducted separately by guests and the experts. Two field forms will be provided, for the guests a field form comprises of selected species of interest whereas the expert will sample all butterfly species (Appendix 9 – Field forms). They walk along permanent transects with a field form and record sightings from each 50m transect. Each transect subdivision is sampled for a period of 10 minutes, resulting in a total sampling period of 20 minutes per transect. The observer may stop to write or consult a field guide but he/she should abide by the sampling time in order to homogenize sampling effort.

Butterfly Monitoring by Expert

The data of monitoring butterfly by expert will be used to record species composition in the Living Lodge grid and to understand changes in butterfly assemblages. The field form for the experts do not include any predetermined species as sampling will include a record of all butterfly species and their numbers.

Monitoring by Citizen Science

The citizen science methodology has two main goals. Firstly to facilitate interest in butterflies and in basic ecological monitoring. Secondly, the information collected by guests will provide a presence list of the selected butterfly species and may reveal a trend in their abundances over time. The field form for citizen science includes only charismatic butterfly species that have been selected according to criteria mentioned in chapter 3.1. The citizen science program is expected to have an output of 4 samples per transect per month over a period of 6 months, amounting to a total of 96 samples a year.

6.5.4 CHECKLIST OF MATERIALS

For transect establishment

- Little Pole
- Measuring tape
- Map of Lodge Area

For Counting

- Field form
- Booklet
- Pencil
- Map of the transect
- Hand held weather station

6.6 MONITORING FOR TERRESTRIAL ARTHROPODS

6.6.1 SUMMARY

Criteria	By whom	Instruction
Species	Citizen Science	Not Applicable
	Expert	All species that are found of the Lodge area.
Time	Citizen Science	Not Applicable
	Expert	April to August
Frequency	Citizen Science	Not Applicable
	Expert	10 times during scheduled time
Fixing Sampling units	Citizen Science	Not Applicable
	Expert	Selected Area
Number of sample units	Citizen Science	Not Applicable
	Expert	4 location

6.6.2 GUIDELINES

This chapter focuses on define monitoring protocols for terrestrial arthropods. This protocol is restricted to use by experts. We suggest pitfall traps with drift fences to aid in sampling terrestrial arthropods.

Designing of pitfall traps

We suggest the use for 4 simple pitfall trap arrays around the lodge area. 'Drift fences' or 'barriers' are used to direct specimens towards the pitfalls. A pitfall trap is a container that is sunk into the ground so that its rim is flush with the soil surface, a sloping roof must be included above the pitfall to ensure flooding does not occur. Insect and other arthropods are collected when they fall into the traps. Many pitfall trap studies suggest the use of detergents and alcohols to reduce the escape rate, for the purpose of the living lodge we suggest that this is not done. Alternatively, an inverted cone can be employed to reduce escapes. While checking pitfall traps, observers may empty the content of the pitfalls into a net or a bag and proceed to document the species present and their numbers. Photo documentation of unidentifiable species must be carried out for later identification.

Figure 23. Pitfall traps for ground arthropods monitoring (Source: Laub et al. 2009)

Install the pit fall trap

The barrier traps consist of pit fall at each end of the barrier. The barriers are created by using aluminum-flashing (Laub, 2009). We suggest the use of two different types of cups for the construction of each pitfall. Two holes need to be appropriately dug to accommodate one permanent cup each. The standard size of the barrier is with a length of 6 meters and the traps are of a diameter of 11.1cm (Brennan et al. 2005) (see Figure 23. Pitfall traps for ground arthropods monitoring (Source: Laub et al. 2009) for construction of pitfall traps), within which temporary cups can be used for sampling purposes (Larsen and Forsyth, 2005). To avoid flooding by rainwater, use a (20 × 20 cm) plywood square with the support of four nails (Laub, 2009) to create a roof for the pitfall traps. During non-sampling periods, ensure that the cups are sealed to avoid unnecessarily trapping animals. The traps need to be deployed for a period of 24 hours per sampling event and checked every 12 hours within that period.

Sampling period

The time of pitfall trap monitoring in between April to August. These monitoring works are conducted only by experts. The monitoring traps are conducted 10 times in a year (see Table 2). During each sample 4 pairs of pitfalls are sampled once resulting in a total of 80 samples in a year.

6.6.3 CHECKLIST OF MATERIALS

- Field form
- Aluminum-flashing
- Plywood
- Plastic Cup
- Soil digger
- Nails

6.7 VEGETATION MONITORING

6.7.1 SUMMARY

Criteria	By whom	Instruction
Species	Expert	All species that are found in the Lodge area.
Time	Expert	During the flowering seasons of plant species in the Biesbosch. The flowering season is between June and August.
Frequency	Expert	Once a year during the flowering season.
Fixing Sampling units	Expert	Quadrats in each habitat type observed in the lodge area.
Number of Sampling units	Expert	Strongly dependant on site-specific information.

6.7.2 INTRODUCTION

Vegetation monitoring provides valuable information about changes in an ecosystem. Plants are applicable as indicators of biotic and abiotic components. Vegetation is attractive to animals as food source, shelter, or for reproduction. For example, the presence or absence of specific nectar plants are predictive for the occurrence of butterfly species (Curtis et al., 2015). On the other hand, plant species are indicators of abiotic characteristics. Ellenberg's indicator values scale plant species along gradients of light availability, temperature, climate continentality, soil humidity, soil acidity, soil fertility, and soil salinity (Ellenberg et al., 1992). In other words, the occurrence of specific plant species predicts values of the previously mentioned soil characteristics. More recently, Wamelink et al. (2011) designed a system analogous to the Ellenberg system. They based their indicator values on soil measurements in the Netherlands. Their system includes indicator values for 1000 species and 18 abiotic variables. Examples of abiotic variables are soil pH, calcium concentration, phosphate concentration, and groundwater level.

The next subchapter addresses a monitoring protocol only for experts. The detailed determination methods to correctly identify plant species would be challenging for citizen science. We will discuss methods for vegetation monitoring including the design of quadrats, the timing of surveys, counting method, and a checklist of materials.

6.7.3 GUIDELINES

Sampling design

The main aim of vegetation monitoring is to assess whether vegetation composition, structure, and condition are changing over time (Rose, 2011). Monitoring methods are primarily based on the measurement of sampling locations at successive time points and at selected sites. Examples of sampling units are points, quadrats, and transects (Elzinga et al., 1998). It is usually impractical to count all individual plants at a selected site. Hence, sample units are chosen on selected sites to gain information about the population and draw inferences about the total population (Elzinga et al., 1998). The desirable sampling unit for a vegetation monitoring plan depends on the measured vegetation attribute. The most commonly measured vegetation attributes are density, cover, frequency, and biomass (Elzinga et al., 1998). Elzinga et al. (1998) discusses six basic decisions which need to be made for the sampling design in a monitoring plan: (1) what is the population of interest?; (2) what is an appropriate sampling unit?; (3) What is an appropriate sampling unit size and shape?; (4) How should sampling units be positioned?; (5) Should sampling units be permanent or temporary?; (6) How many sampling units should be sampled? Site-specific information and monitoring objectives should be considered to make these decisions. The exact location of the Living Lodge in the Biesbosch was not known yet during the preparation of this report. Therefore, we give general recommendations about a sampling design and we identify information required for creating

a more tailor-made sampling design. Detailled answers to these questions can only be made through on-site assessment by pilot sampling (Elzinga et al., 1998).

We followed the six basic decisions to formulate the sampling design for the Living Lodge in the Biesbosch. To start with, Elzinga et al. (1998) distinguishes a target population and a sampling population of interest. The target population is the population you would like to make inferences about, while the sampling population is the population you actually sample. We target all the plants on the lodge, living walls, and in the grid. The border for monitoring would be at the border of the living grid. Therefore, the target population and sample population are the same.

Next, we determined an appropriate type of sampling unit for our monitoring objective. The vegetation monitoring objective for the Living Lodge is to assess whether the Living Lodge components (lodge, living wall, grid) improve biodiversity in a period of 10 years. We envision biodiversity in vegetation as the number of species (i.e. species richness) and the density of individual plants (i.e. the relative abundance of species). Density is defined as the number of counting units per unit area (Elzinga et al., 1998). Quadrats are usually used as sampling unit when measuring density, frequency, or biomass (Elzinga et al., 1998).

Figure 24. Schematic overview of potential sampling design for vegetation monitoring. The strata 1-4 and the orange quadrats are located before the construction of the lodge. Stratum 5 and the red quadrat on the roof is located after the construction of the lodge.

Subsequently, the appropriate quadrat size and shape should be tailored to the spatial distribution of the sample population observed in the field (Elzinga et al., 1998). Most plant populations have an aggregated or clumped distribution in their growth area. Rectangular quadrats are most the most efficient quadrat shape compared to square or circular quadrats of similar size because rectangular quadrats are more likely to include clumps of plants (Elzinga et al., 1998). Elzinga et al. (1998) described a procedure to select quadrate size and shape by comparing the effiency of different quadrat sizes and shapes through pilot sampling. A larger quadrat is subsdivided into separate sections and subsequently plants will be counted in the separate sections during pilot sampling. This counting is performed for sections of several large quadrats and the means and standard deviations are calculated for the different size and shapes of quadrats. The different sizes are compared by calculating the coefficient of variation from the mean and standard deviation of each quadrat size. The quadrat size with the smallest coefficient of variation are from a statistical viewpoint the best. Besides the coefficient of variation, other factors such as ease in sampling and disturbance effects should be considered (Elzinga et al., 1998). Ease in sampling considers the challenges to count the entire quadrat area and to keep track of portions of the quadrat that were already counted. Long and narrow rectangular quadrats are easier to monitor than large and squared quadrats because the observer can start at one end of the rectangular quadrat and thereby keep track of counts along the length of the quadrat. Moreover, the quadrat size size should be confined to a size in which it is not necessary to stand in the quadrat to search for plants. A too large quadrat requires the observer to stand inside the quadrat and thereby rises the risk to disturb the population during counting.

Alternatively, Krebs (1999) gives mathematical equations for determining the optimal quadrat size. These equations include the following components: variation among quadrats, the cost to measure one quadrat, and the cost to locate another quadrat.

Preferably, the quadrats used during pilot sampling are randomly located according to the planned sampling design for the remainder of the monitoring study period. Two aspects should be considered for positioning the quadrats in the field: random sampling and interspersion. Firstly, the quadrats should be randomly located in the field to collect data for valid statistical tests. Preferential sampling should be avoided at all costs because it gives a distorted view of the target population.

Secondly, quadrats should have a good interspersion throughout the area of the target population (Elzinga et al., 1998). Elzinga et al. (1998) discusses nine methods of random sampling addressing these two requirements. The desirable method of random sampling mainly depends on the the measured vegetation attribute and the heterogeneity of the habitat. Systematic sampling, restricted random sampling, simple random sampling, or stratified random sampling could be appropriate types of random sampling for monitoring plant density. The first two methods assume a heterogeneous habitat and the latter a homogeneous habitat. It is essential to have a good interspersion of quadrats in a heterogeneous habitat because otherwise clumps of plants will be overlooked. Both systematic sampling and restricted random sampling incorporate a good interspersion in their design by incorporating predefined distances between quadrats. A disadvantage of systematic sampling is the highly logistical demands of this sampling design. A high number of quadrats is required to perform this type of random sampling. Alternatively, restricted systematic sampling is applicable when less than 25 quadrats are desirable. The interspersion is less critical in a homogeneous habitat. Simple random sampling and stratified random sampling do not include predefined distances between quadrats. The optimal sampling design for the Living Lodge is strongly dependant on the plant population at the exact location of the lodge.

For this report we specify one sampling design based on the assumption of a homogeneous habitat in each Biesbosch-specific habitat type. Four different habitat types are present in the Brabantse Biesbosch (Chapter 3.2). In theory, four different habitat types could be present in the Living Lodge area. Quadrats should be present in all the habitat types inside the Living Lodge area to prevent overlooking of plant species characteristic to specific habitat types. Stratified random sampling is a sampling method which ensures that quadrats are present in all habitat types. This type of sampling divides the Living Lodge area into subareas (strata). Besides the habitat types in the Living Lodge grid, the living walls and plants on the roof could be recognized as additional strata. We envision the stratified random sampling design for the Living Lodge as a two-step process (Figure 24). Firstly, the ecosystem assessment before the construction of the Living Lodge investigates the presence of different habitat types. Quadrats are randomly located in all the observed habitat types and subsequently the quadrats will be monitored for 10 years. Secondly, quadrats will be randomly positioned in newly created strata after the construction of the lodge and monitored during the remainder of the Biesbosch pilot study. New structures on the lodge and near the lodge could be recognized as new strata such as a green roof, a green wall, the borders of an exacavated pond, and newly created muddy banks. Randomly locating quadrats could be achieved by first determining the GPS coordinates of the strata and subsequently randomly selecting a X and Y coordinate within these GPS coordinates.

Additionally, the lifetime of quadrats should be chosen. Quadrats could be temporary or permanent. Temporary sampling requires randomly selecting new quadrat locations before each sampling period, while permanent sampling involves fixed locations of quadrats between different sampling events. We recommend permanent quadrats for the Living Lodge because the statistical tests for detecting change between one time point and next time points are more powerful and a lower number of sampling units are required compared to temporary quadrats. Landmarks on a map and in the field ensure the tracibility of the quadrats. Landmarks at the four corners of rectangular quadrats ensure that the quadrats are traceable and replicable during the whole monitoring period.

Finally, the required number of quadrats need to be determined. Elzinga et al. (1998) describes four possibilities: equal numbers for each stratum, in proportion to the size of each stratum, in proportion to the number of target plant per stratum, or in proportion to the variability per stratum. Regarding the variability, we would recommend more quadrats to strata in the grid compared to the roof and the living walls of the lodge. Furthermore, we recommend an equal number of quadrats in the strata of the grid. Mathematical formulas specific for a stratified random sampling design (Elzinga et al., 1998) help in identifying the optimal number of quadrats. The following information needs to be specified to calculate the optimal number of quadrats: the false-changer error rate, the power of the test, the minimum detectable change, and an estimate of the standard deviation. The first three variables are based on the desirable monitoring objectives and the latter should be estimated. Sequantial sampling is the best way to obtain an estimate of the standard deviation. Ideally, an estimate of the standard deviation is obtained by sampling the population for two years. Although sequential sampling is most reliable, two other options can also be considered. Firstly, the standard

deviation from a similar study with the same study design, vegetation attribute measurements, and vegetation type could be used. Secondly, an expert might help by determing the expected maximum and minimum value of the vegetation attribute and subsequently use this to estimate the standard deviation. However, the decision about the number of quadrats also depends on logistics (i.e. time and money). For example, the time required to count one quadrat depends on the density of plants and the difficult to identify the plant species in a quadrat. We would advise to locate per habitat type two or more quadrats.

Timing of surveys

The optimal monitoring period has been determined according to the flowering seasons of plant species in the Biesbosch-specific habitat types. The optimal timing of vegetation monitoring in the Brabantse Biesbosch is one survey between June and August each year (Table 2, pers. com. with Henk Siepel, 21-4-2016)

Counting the number and density of plant species

Experts fill in a field form before and during the survey (Appendix 9 – Field forms). They write down the date, the quadrat ID including number and habitat type, their contact details, and if applicable comments about changes in management and environmental conditions compared to monitoring in previous years. Subsequently, they will count for each quadrat the number and the density of plant species. The density is the number of individual plants per quadrat area. A transportable plastic framework, which fits on the four wooden poles at the corners of a quadrat, could help the expert in recognizing the borders of the quadrats. The expert counts all plant species within the borders. Two counting rules improve the monitoring the quality. Firstly, one rule should address whether plants near edge of the quadrat are included or excluded to improve the consistency of counting between different observers. Elzinga et al. (1998) describes two possibilities: (1) count every other plant on the edge and every other as out or (2) specify that any plant on the edge of specific sides of the quadrat are counted as in while any plant on the other sides is out. Secondly, setting a minimum search time per quadrat prevents rushed counting and consequently overlooking plants in the quadrats.

6.7.4 CHECKLIST OF MATERIALS

Fixing quadrats in the field:

- Little wooden poles
- Map
- Pencil
- GPS
- Measuring tape

Counting vegetation:

- Plastic quadrat framework
- Vegetation monitoring guidelines
- Field form
- Map illustrating quadrats and landmarks
- Pencil

6.8 MONITORING CALENDARS

The previous taxa-specific subchapters included recommendations about the timing of the protocols. This subchapter summarizes these recommendations in a year calendar for experts and citizens. Both year calendars illustrate the most suitable months to perform the monitoring protocols. The year calendar for experts specifies the desirable frequency of monitoring, while this is not specified for citizens. The monitoring for citizens has educational purposes and therefore we invite citizens to perform the monitoring protocols on any day they like during the recommended months.

Table 2. Year calendar for monitoring programs performed by experts. The cells highlighted in green indicate the suitable monitoring months for the taxonomic groups. The numbers inside the cells show the advised frequency of monitoring reported in literature.

Monitoring Group	January	February	March	April	May	June	July	August	September	October	November	December
Birds				2	2	2				2	2	2
Mammals: live trapping							2	2	2			
Mammals: camera trapping				4	4	4	4	4	4			
Dragonflies					2	2	2	2	2			
Butterflies				4	4	4	4	4	4			
Terrestrial arthropods: pitfall trapping				2	2	2	2	2				
Vegetation						1						

Table 3. Year calendar for monitoring programs performed by citizens. The cells highlighted in green indicate the suitable monitoring months for the taxonomic groups.

Monitoring Group	January	February	March	April	May	June	July	August	September	October	November	December
Birds												
Mammals												
Dragonflies												
Butterflies												

Nature education and activities for guests

7.1 NATURE EDUCATION

Current activities in de Biesbosch

A big part of the educational activities in the Biesbosch are coordinated and executed by the Dutch Institute for Nature Education and Sustainability (IVN) (Parkschap NP De Biesbosch, n.d.-a). Wim Ruis from IVN Brabant mentioned letting visitors experience nature from close by as one of the major goals (personal communication, 22-4-2016). IVN tries to reach this goal through organizing activities for children, adults and families and through the 2 visitor centers (one in Drimmelen and one close to Dordrecht) and a museum. Around 150 Biesbosch field guides are trained by IVN to accompany visitors in the field and educate them during their stay in the Biesbosch. To provide an ultimate experience, IVN tries to work together with so-called hosts, ranging from catering establishments to boat rentals.

Activities that are currently organized in the Biesbosch are diverse and for all age groups. To get a feel for the former willow cultivation culture, volunteer workers can stay in the withy-beds that are still in use to work and live there like in the old days (pers. com. with Wim Ruis, 22-4-2016). People sleep in the former workers houses and get instructed to their diet. Working in the withy-beds, however, is demanding and requires guidance by experts.

For children, IVN aims at letting them experience the Biesbosch to the fullest, as opposed to focussing on transferring knowledge. The "Ruige Biesboschtocht", for example, is a program for school classes. This program lets children explore the Biesbosch in a playful and adventurous way (Parkschap NP De Biesbosch, n.d.-b). Another example is the concept "Scharrelkids", were children get a set of basic materials to get familiar with nature, for example determination charts and materials to collect for example insects (IVN, n.d.). Activities for adults are generally more relaxed, ranging from hikes to boat trips. For the family activities, it is more than contact with nature alone, as contact with each other also plays an important role in this digital age.

According to Wim Ruis, guests of the Living Lodge are always welcome to join their current activities (pers. com., 22-4-2016). He personally feels that our group of approximately 6 people is not big enough for 1 guide, but we are welcome to make use of their guides to accompany our guests into the field and/or doing certain activities. A basic IVN activity takes approximately 2.5 hours and costs €30,- for one guide (this money is then used for the training of these and new guides). However, they cannot guarantee that during the peak season a guide can be available every day.

At the moment, the online community "de Biesbosch in mij" is used by IVN to promote an exchange of experiences in the Biesbosch among guests (De Biesbosch in Mij, n.d.).

Concluding, IVN is open to working with the Living Lodge and will be able to help out with materials for the Living Lodge guests, for example by providing determination charts.

7.2 ACTIVITIES FOR GUESTS

For all activities, experts' knowledge, instructions and/or guidance is preferred.

- Introduction workshop. This can for example be given when guests receive the key of the Lodge. It can contain an explanation of the different materials that could be used during their stay at the Living Lodge, for example the equipment to collect insects.
- Creating muddy banks. To provide a habitat for certain pioneer species, guests can work on creating muddy banks in the Living Grid.
- Planting flowering plants. This can help to attract bees and butterflies.
- Collecting dead wood. These can be gathered in the deadwood pile in the Living Grid.

- Dig a small pond. This can be done in the Living Grid to promote amphibians, dragonflies and aquatic life.
- Maintenance activities in willow forests. For example, cutting branches to make space for new branches. These new branches are not colonized by *Hypnales* mosses yet and can therefore be colonized by pioneer species like the Natura 2000 species *Orthotrichum rogeri*.
- Monitoring. Guests can be involved in the monitoring system. They will be introduced to the working of the system and the identification guides. In addition, there could be a bulletin board, which guests can use colour coded pins to specify their sightings. Besides being interactive, this will also give information about the spatial distribution of mammal sightings. This will be valuable for (setting up) the opportunistic surveys performed by experts.
- Library with field guides and background literature. A little library in the lodge offers guests the possibility to learn more about the iconic taxonomic groups and the history of the Biesbosch. Field guides provide guests the opportunity to identify animals and plants in the surroundings of the lodge by themselves.
- Videos/pictures of camera-trapping. Guests can see the results of the mammal monitoring protocols performed by experts.

Summary of methodology

This chapter focuses on providing an overview of the ecological considerations involved in setting up the Living Lodge. The methodology for covering these considerations can be summarized in five distinct steps (Figure 25). Steps 1 and 2 are outside the scope of this report while steps 3, 4 and 5 have been discussed in detail. The flow diagram can be used to ensure that all steps are systematically covered during the initial planning phases of a new lodge. The five steps described below follow a chronological order that takes root in our literature study on the Biesbosch ecosystem, ecosystem restoration methodology, ecosystem monitoring techniques and available greening structures that have been successfully used in various parts of the world.

Step 1 - The first step consists of a thorough ecosystem assessment to gain an overview of the biotic and abiotic conditions in the selected site. Key ecosystem attributes to be considered for restoration are: species composition and structure, habitat heterogeneity, basic functioning of ecological processes, natural dynamics and resilience to change (Hobbs et al., 1996). This step is essential as it determines what restoration measures are to be taken prior to physically establishing the Living Lodge.

Step 2 – At this stage, a restoration advice is required that determines whether restoration is required or not. In a healthy and well buffered ecosystem such as the Biesbosch, restoration interventions such as topsoil removal may do more harm than good by facilitating long periods of inundation and water logging. Considering that the established plant communities are quite representative of the natural species assemblage, the best way forward is to contribute to enriching the existing species composition rather than changing it. On the other hand, it could be helpful to promote seasonal flooding of the site to re-establish flood dynamics in order to maintain certain habitat types. These restoration considerations must be assessed before species selection can take place.

Referring to the flow diagram, step 2A involves the process of ecosystem restoration. Having identified and implemented restoration measures according to expert advice, it is essential to choose a reference site to guide the establishment of target habitat types. In practice, restoration goals have often targeted what conditions might have occurred on site in the past. However, multiple criteria for success and ambiguous targets only handicaps the definition of restoration goals (Cairns, 1989, 1991; Aronson et al., 1993). To formulate clear restoration targets, we strongly advise to choose a reference site that closely represents what the Living Lodge will eventually leave behind in the landscape.

Step 2B emphasises the need to select target habitat types when restoration interventions are not required. Although it may not be essential to choose a reference site in this context, it is essential to gain clarity on the end result by choosing habitat types that the lodge will strive to enrich.

Step 3 – This step includes the process of arriving at outputs one and two of this report as described above (see chapter 3 and 4). Choosing selection criteria for plants and animals ensures that species of ecological value are considered for the chosen location. In addition, it allows species to be selected based on other areas of interest such as their attractiveness to guests and their conservation significance, rarity, endemism etc. This report provides a comprehensive compilation of biotic and abiotic structures that can be used to attract biodiversity. Be it through enhancing foraging opportunities, breeding sites, roosting sites or simply by increasing habitat heterogeneity. A selection from this list can be made depending on the target species and selected habitat types as described in the next step 4.

Step 4 – The chosen greening structures and their associated species are intrinsically linked to one another. It is almost impossible to consider all the possible permutations and combinations to describe these linkages accurately at an ecosystem level. Therefore, we recommend the use of the Integration Tool described in chapter 5 to assist in species and greening structure selection. This tool takes into account the species habitat requirements, the micro-habitat conditions created by greening structures as well as habitat types.

Step 5 – Once the physical structures of the Living Lodge have been built, it is important to monitor the Living Lodge components (lodge, wall, grid) to quantify the impact the program has on the ecosystem. With this goal, we have provided advice on monitoring several taxa as described in chapter 6. While ecosystem monitoring protocols can be extremely complicated, we have considered cost limitations and the educational value of the monitoring system to arrive at effective and interactive means to collect relevant information. The monitoring system comprises of two main protocols, one designed around the principles of citizen science and one that origins from scientifically sound data collection techniques. Since long term monitoring systems can provide dynamic information and might have to be adapted along the way, we have not discussed data analysis techniques in this report. The information collected is expected to reveal trends in species composition and relative abundances of key species.

The five above mentioned steps are summarized in the flowchart on the next page.

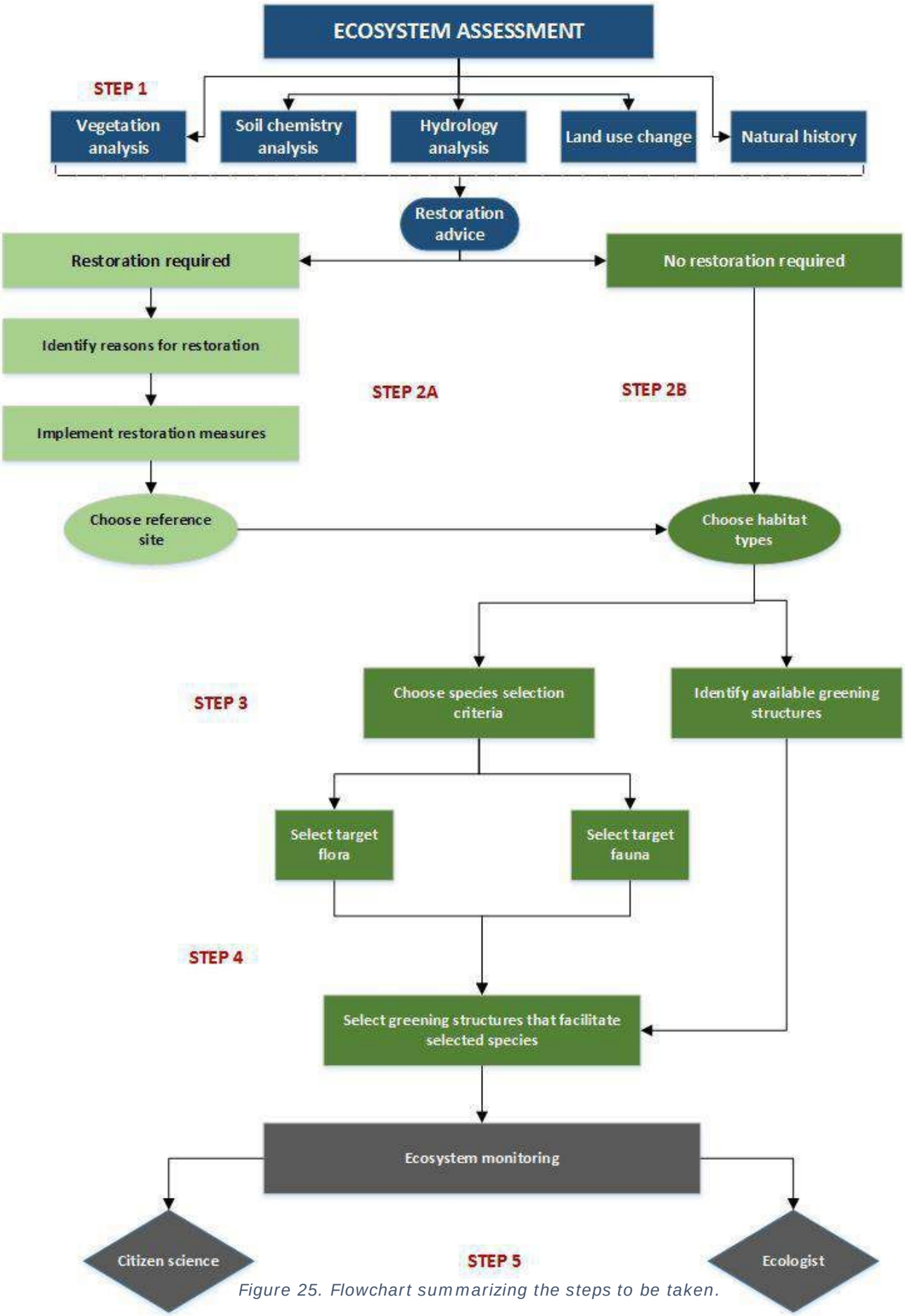

Figure 25. Flowchart summarizing the steps to be taken.

Discussion

The Biesbosch, being one of the key deltaic wetland systems in Europe with notable biodiversity, has been the focus of conservation and tourism for decades. The landscape offers activities, sights and sounds for visitors while creating a window of opportunity to raise funds to contribute to protecting the environment. Although this ecosystem is highly managed at a landscape level, the Biesbosch ecosystem is very rich. However, there are 'degraded' areas within the Brabantse Biesbosch that have been under recent management. These sites are ideal targets for implementing the lodge, since at these locations the lodge will have the greatest impact. For example, in the polders, increasing seasonal flooding by manipulating the height of dykes brings back natural flood dynamics and recreates conditions for suitable vegetation to establish. Similarly, the Living Lodge concept can be employed in smaller areas to specifically enrich on-site conditions and contribute to its surroundings by creating habitat connectivity, providing refuges for wildlife and by monitoring the environment in search of indications of change. Biodiversity in a landscape can be increased either by introducing new species or by manipulating the abiotic conditions in the area. A botanical garden or a zoological garden are examples of manipulated landscapes that can often have a higher biodiversity than most natural areas. However, with the interest of enhancing the condition of an ecosystem there are various considerations that must be made. Introducing or favouring pioneer plant species groups often serves the purpose of attracting a wide variety of animals faster, but under right conditions these plant groups can become invasive and have the capability of restricting establishment of all other vegetation communities.

Given the time constraints and the scale of the project, we discuss a few limitations that should be kept in mind in the context of this report. We have provided a Species selection tool that is based on species specific requirements. However, it is essential that this tool is used with the guidance of an ecologist to ensure the correct input is given for the specific location. The first step in species selection is to select relevant habitat types. However, there is a risk that some characteristic or typical species might be missed out. In order to translate a habitat selection list into a species selection list we made use of certain criteria which further contribute to the possibility of missing out important species. The species selection list can be made more robust by consulting experts about typical or important species of the target location. As an example, the triangular club-rush, a highly characteristic species from which the Biesbosch derives its name was found to be missing from our initial selection list. This was brought to light during consultation with Han Sluiter, an expert on the Biesbosch ecosystem. We also point out that it is extremely difficult to make a selection of all taxa belonging to an area and hence the focal species list had to be narrowed down, again, by making use of three selection criteria. It must be mentioned here that these selection criteria were chosen by us within the constraints of this project. Thereby running the risk of focussing only on species of charismatic or conservation concern. Therefore, a more detailed consideration of criteria such as the importance of the more common species and the effect of human disturbance on species must be taken into account. Since the main outputs of this study focus on increasing biodiversity, other ecosystem functions and processes are outside the scope of this report. Ideally, while working on restoring an ecosystem, the entire system must be considered.

The ~12.5-hectare reach of the grid is limited in its contribution to restoration at an ecosystem level and poses challenges for monitoring. To add to this, the small study site must be treated separately from the rest of the ecosystem. For example, while recording birds, it is difficult to determine whether individuals are actively using the structures within the grid or whether they are simply passing through it. In addition, the limited sampling area only records presences, whereas absence data might be an indicator of animals that might be negatively impacted by the lodge. These biases, must be considered while interpreting the results of the monitoring system. The reasons for selecting certain taxa for the monitoring system are expected to vary across different sites. We have standardized the monitoring system in a way that it is replicable in any ecosystem. Although the backbone of the monitoring system can be replicated in any ecosystem, it will have to be modified according to a specific site. For instance, recording dragonflies in the Biesbosch is important as the order Odonata are good bio indicators for wetland ecosystems. However, there may be no use in

monitoring dragonflies in a forest or heathland ecosystem. It may not be feasible to install pitfall traps in a wetland system that has a high water table and is prone to flooding. Moths, a highly diverse taxon in the Biesbosch cannot be sampled in the most effective ways of sampling them, because projecting a fluorescent light on a white sheet will attract insects from outside the Living Lodge grid. Spiders, aquatic macro fauna and other cryptic species could not be considered due to limitations with regard to invasive sampling techniques, processing of DNA samples etc. Because of all these limitations, the results of the monitoring system are limited to comparing biodiversity from one year to the next, over a ten-year period. In addition, we cannot provide statistical advice as monitoring systems are dynamic by nature and will have to be adapted to suit each scenario within a site. Due to varying seasonality in activity within the selected taxa the monitoring system we have designed is logistically challenging. The suggested taxa, methodology and sampling time are extensive and can be flexed according to available resources. Lastly, the monitoring system is biased towards increasing species richness as it does not take into account the initial disturbance to wildlife while the lodge is under construction. Ideally, the initial animal diversity of the site should be quantified before the area is disturbed by construction activities. We considered the use of a reference site but chose to leave it out of the design due to logistic limitations with regard to acquiring and monitoring an additional site of 12.5 hectares to serve as the control site. Alternatively, animal diversity can be included in the initial ecosystem assessment, however this will have to be done over all seasons, and ideally over many years. For this reason, we are limited to rely on existing databases (NDFF database) fed by ecological surveys and citizen science to gain clarity on the initial faunal assemblage.

Conclusion

Since its inception, the course of this project has been driven by the six research questions. As requested by our commissioner, we have used the Biesbosch as the pilot site for the Living Lodge. However, the need for replication of methods and concepts was kept in mind while formulating the outputs of this report. In the course of our research, we found that some of the questions regarding integration of biodiversity and greening infrastructure could have been answered in depth, had we worked in collaboration with experts working on other aspects of the project, in a trans-disciplinary team. As ecologists, we have striven to work within the limits of our own expertise and primarily cover the ecological aspects of the project. Additionally, we have included a recommendation section that includes the way forward for the project and some of the suggestions and ideas passed on to us by the experts we have been in contact with. The research questions, our approach to answering them, along with their respective outputs are briefly summarized below.

1. What is the current species composition of the Biesbosch?
2. How can biodiversity be enhanced through the Living Lodge itself?
3. What are target species for the Living Lodge area?
4. What are monitoring criteria and how to monitor the area after establishing the Living Lodge?
5. How can biodiversity be enhanced through tourist involvement?
6. How can the methods be used to implement the Living Lodge in new areas?

The first question was by far the most important in terms of data collection and analysis. It is also an integral part of the project as the other questions depend on the information gathered at this stage. This is a process that has to be repeated each time the lodge is placed in a new location. While this aspect of the project did not involve field work, it relied heavily on detailed literature research. This comprised of several volumes of books, journal articles and databases, supplemented with data from citizen science databases. As the Biesbosch is home to more than 2,500 species belonging to various taxa, we narrowed it down using certain criterion such as conservation concern, ecological value and attractiveness.

The 'Greening chapter' (chapter 4) offers an overview of available technologies that would aid in answering the second research question. As stated above, this question requires collaboration with experts from other fields such as biomimicry, landscape architecture and structural engineering to name a few. However, in accordance with the request of our commissioner, we briefly touched upon options that we as ecologists believe would enhance biodiversity. The general scheme we had in mind while researching this chapter was to think about microhabitats that could be created in and around the lodge. A clear description of the lodge and a specific design of the physical structure of the shell and kernel (when it is available) can be used to fine tune the possibilities for integration of biodiversity.

We hoped to produce a specific location based output concerning target species to answer our third research question. Due to the lack of information on a specific pilot location within the Biesbosch, we formulated species of interest for the entire Brabantse Biesbosch area. However, the Species selection tool (Appendix 8 – Species selection tool) can be adapted when a specific location is available in the future, to assist in narrowing down species based on the specific habitat information based on that location.

Our fourth research question is another integral part of the project as it not only tracks changes in the ecosystem but also allows for opportunities to the guests of the lodge to experience nature and to be involved in its management. The output for this question was developed to primarily detect changes in species richness and abundance. The monitoring system has two aspects involving ecologists and guests. The latter would be involved in a citizen science initiative that aims at collecting data as well as at disseminating knowledge and awareness. Additionally, it would help in quantifying the effect of the lodge on biodiversity over the time it is present in a given area. The backbone of this methodology is standardized and can be replicated in other locations with the required adaptation.

Our next research question aims at improving the relationship between people and nature by involving them in the monitoring aspects of the program. Other activities that can help in doing the same have been listed in Chapter 7. This plan would help to increase awareness and educate people on the importance of ecosystem health and the need for scientific management. In doing so,

we hope that they experience nature at a deeper level and that this would help in building a strong bond with natural landscapes.

The final research question deals with standardizing protocols and methodologies to enable the Living Lodge to be placed at different locations. Our main outputs for answering this question are a flowchart and a Species selection tool. This flowchart depicts the five main steps that need to be considered while setting up a Living Lodge. Additional outputs include the backbone of the monitoring protocols and the entire framework of our methodology for the project. It is important to keep in mind that these outputs can be used in other areas only after they have been adapted to the specific site.

In answering these questions, we found that there was still room for improvement in certain aspects of the project but were beyond the scope of our role as ecologists. We have listed these aspects as well as recommendations and ideas passed on to us by experts in the following section.

Recommendations

As the Living Lodge is still in its conceptual stage, there is still room for input in order to improve the design and implementation of the concept. This section has recommendations and suggestions based on our views as well as the views of experts that we have met during the course of our project.

The way forward

- As highlighted earlier in the report, trans-disciplinary knowledge on a common working platform is essential to the design and execution of the Living Lodge.

- When conducting the initial ecosystem assessment, narrowing down the exact location (~12.5 hectares) for the lodge will greatly increase the accuracy and effectiveness of the ecological investigation we have stated.

- We hypothesize that the best option for locating the lodge would be to target degraded sites in close proximity to healthy ecosystems. This would help in increasing species richness and abundance at the site as well as in creating a buffer zone.

- We emphasize that working with local flora and fauna is normally the safest option for improving ecosystem functioning. Pioneer plant species have a tendency to become invasive immediately after a restoration measure such as topsoil removal has been implemented. In this regard, it is wise to seek expert advice before and species introductions are made.

- The species selection criteria; ecological value, conservation concern and attractiveness may not always be the best filters for selecting species. This would have to be altered based on specific habitats and local conditions.

- Although the monitoring system should be consistent in design, it has to be adapted over time depending on changes to the ecosystem. In addition, the implementation of the monitoring protocols must be sensitive to different ecosystems and species assemblages.

- Focus must be given to the ecosystem as a whole. Localized functional processes (eg. effect of vegetation cover on topsoil erosion) and species interactions must be considered in addition to enhancing biodiversity.

This report is written in a format that makes it readable to scientists and non-scientists alike. However, there are parts in this report such as the monitoring system and the Species selection tool that require technical knowledge and expertise. We suggest to use this report as an overview of the ecological aspects for the Living Lodge. It should be used by the developers (architects and designers) of the lodge in conjunction with ecologists. Once the lodge is established, ecologists can use this report in its current format or build upon it depending on the site specific requirements.

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Appendices

APPENDIX 1 – MOSS SPECIES REQUIREMENTS

More information about specific requirements can be found in (Siebel, 2005).

*Characteristic mosses with a summary of their status and ecology. Sources: * Siebel et al. (2013), ** NDFF and BLWG (2016); Programmadirectie Natura 2000 (2013); Siebel et al. (2013), for the Tonghaarmuts, also: (Programmadirectie Natura 2000, 2008) and (Janssen & Schaminée, 2008).*

Scientific name	Common name	Status*	Substrate**	Ecology**
Anomodon viticulosus	Rambling Tail-moss (Groot touwtjesmos)	Rare and vulnerable	Stone and bark	In the riparian forests it grows on the base of stems of (old) trees like willow, ash and poplar but it has also been seen in the withy-beds. Another substrate is calcareous walls. Due to acid rain, numbers have decreased significantly. It prefers a neutral to base-rich substrate and traditionally only occurred in places where flooding with base-rich water occurred. Therefore, being within the flood range increases survival chances, as the river water can act as a buffer. This moss often grows on more or less vertical places and it sometimes covers big surfaces.
Homalia trichomanoides	Blunt Feather-moss (Spatelmos)	Rather rare and of least concern	Stone and bark	This epiphytic moss mostly grows on ash stumps in coppice forests. It also shows a preference for riparian forests and withy-beds, as it prefers bases of trees that are covered with a layer of silt after floods in winter. Sometimes it even grows on wooden or limestone walls. Possible accompanying species: *Neckera complanata, Isothecium alopecuroides.*
Timmia megapolitana	(Vloedschedemos)	Very rare and near threatened	Wood	In the Biesbosch, this moss is found on muddy stems of *Salix dasyclados* and *Salix alba* trees that are flooded twice a day. It is also found on branches and dead wood on the ground in overgrown old withy-beds. In 2010, there were still two big, vital subpopulations present in the Biesbosch, specifically in the "Ottergriend" and "Sterlinggriend". It is possible that the moss spreads to downstream areas through water. Possible accompanying species: *Calliergonella cuspidata, Plagiomnium ellipticum, Fissidens taxifolius, F. gymnandrus, Brachythecium mildeanum, Amblystegium varium, Leptodyctium riparium, Marchantia polymorpha, Lunularia cruciate.*
Fissidens gymnandrus	(Vloedvedermos)	Very rare and of least concern	Bark and wood	This moss mainly grows on root balls of fallen trees, the base of stems and now and then on calcareous stone (for example brick fragments) in areas that are flooded frequently.
Orthotrichum rogeri	(Tonghaarmuts)	Very rare and near threatened	bark	This pioneer species grows in moist and young willow forests oak (*Quercus robur*), but has also been found on poplar and elder. It mostly grows alone or in small groups and is therefore mostly outcompeted by Hypnales species after a few years. It is a nomadic species: it lives on a certain location for a short time, but produces a lot of spores, that can establish elsewhere. It prefers indirect sunlight to prevent dehydration. Succession and acidification of barks are this moss' biggest threats. For the persistence of this species the occurrence of young forests near current habitats is therefore of great importance. The Biesbosch is one of the most important areas for this species.

APPENDIX 2 – PLANT SPECIES REQUIREMENTS

*Characteristic plants with a summary of their status and ecology. Sources: * Sparrius et al. (2014), **Hennekens et al. (2016); Waarneming.nl (2016) *** NDFF and FLORON (2016); Van der Meijden (2005); personal communication with Han Sluiter (21-4-2016).*

Scientific name (habitattype)	Common name	Status*	Present in the Biesbosch?**	Ecology***
Ranunculus fluitans (H3260)	River Water-crowfoot (Vlottende waterranonkel)	Rare and endangered	Not observed	This originally native, big plant has long leaves under the water. It depends on flowing water and therefore needs to be able to attach to the bottom firmly. Sandy soils can be used for this. Due to pollution, it decreased in numbers and is now limited to affluents of the Meuse. This species is eponymous/determining for the association *Callitricho hamulatae-Ranunculetum fluitantis* and the association *Ranunculo fluitantis – Potametum perfoliati.* However, it rarely occurs in the latter. The former association occurs mostly in the hilly landscape of Limburg. This perennial plant prefers nutrient-rich waters and flowers from June till August.
Ranunculus penicillatus or *Ranunculus peltatus var. heterophyllus* (H3260)	Stream Water Crowfoot (Penseelbladige waterranonkel)	Not evaluated	Not observed	This originally native species occurs in sunny places. It prefers shallow till rather deep, stagnant till rather fast flowing, weakly acid till neutral, soft, rather nutrient-poor till nutrient-rich and sometimes even a bit polluted, water. Its leaves are submerged and it can grow in a wide variety of water bodies. It is a perennial species and flowers from May till August.
Potentilla supina (H3270)	Prostrate Cinquefoil (Liggende ganzerik)	Rather rare and of least concern	Yes, but low number of observations	This originally native pioneer species thrives on open, wet, clayey and nutrient-rich soils on riverbanks that are inundated in winter and dry out in summer. It is an annual species and flowers from June till September.
Cyperus fuscus (H3270)	Brown Galingale (Bruin cypergras)	Rare and of least concern	Yes	This originally native species occurs on places that are inundated in winter and dry out in summer, for example riverbanks, ditches and excavations. It prefers open, sunny till moderately shaded, warm, moist till wet, moderately nutrient-rich, low till high calcareous, often humus containing sand-, loam-, or clay soils. This annual plants flowers from July till October.
Pulicaria vulgaris (H3270)	Small Fleabane (Klein vlooienkruid)	Rather rare species and of least concern	Yes	This originally native species is a pioneer on moderately nutrient-poor and moist soils. It is an annual species and flowers from July till September.
Lythrum hyssopifolia (H3270)	Grass Poly (Kleine kattenstaart)	Very rare and near threatened	Yes, but low number of observations	The origin of this species lies in South-Europe. It established in the Netherlands between 1975 and 1999. This pioneer occurs on open, moist, acid and moderate nutrient-rich soils. It grows on river banks that fall dry, fallow arable land, nature development areas, periodically inundated locations, ploughed ground and industrial areas. Seeds are dispersed by water or water birds and retain their germination capacity for a long time. This annual species flowers from July till September. It is poisonous for cattle and sheep.

Artemisia biennis (H3270)	Biennial Wormwood (Rechte alsem)	exotic	Yes, but low number of observations	This exotic species originates from Northern Asia and established in The Netherlands between 1950 and 1974. It is a pioneer that grows on nitrogen-rich and wet soils. It mostly occurs on muddy banks along the river Meuse. This annual species flowers from August till fall.
Limosella aquatic (H3270)	Mudwort (Slijkgroen)	Rather rare and of least concern	Yes	This originally native species is a pioneer on moderately nutrient-poor, moist soil. It is a short-lived pioneer and grows on banks that fall dry. The most suitable sites occur in warm and dry summers. It prefers open, sunny, moist till wet, nitrogen-poor, moderately nutrient-poor till nutrient-rich, peaty till calcareous soils of silt, clay, sand and gravel. This annual species flowers from June till October. The seed-bank can survive for a long time.
Bidens radiate (H3270)	Radiating Bur-marigold (Riviertandzaad)	Rare and of least concern	Yes, but low number of observations	This species originates from Central Europe. It occurs on muddy banks, mostly together with other *Bidens* species. It is a pioneer on nitrogen-rich and wet soils and flowers from July till October.
Veronica longifolia (H6430)	Long-leaved Speedwell (Lange ereprijs)	Rather rare and of least concern. Protected	Not observed	This originally native species grows on wet, (moderate) nutrient-rich soils on river banks and along railways. This perennial plant flowers from July till August.
Euphorbia palustris (H6430)	Marsh Spurge (Moeraswolfsmelk)	Rare and vulnerable	Yes, but low number of observations	This originally native pioneer species grows in reed-lands and along watersides. It is a perennial species and flowers from May till June.
Senecio fluviatilis (H6430)	Broad-leaved Ragwort (Rivierkruiskruid)	Rare and of least concern	Yes	This originally native species prefers wet roughage and is adapted to inundation. It is a perennial plant that flowers from August till September.
Caltha palustris subsp. Araneosa (H6430)	(Spindotterbloem)	Rare and of least concern. Protected	Yes	This originally native species occurs in wet roughage in estuaries where the river water is subject to the tides. It depends on these tidal movement, as it has to be submerged to disperse its seeds. It prefers sunny till moderately shaded, peaty, wet and nutrient-rich soils. This perennial plant flowers from April till May.
Leucojum aestivum (H6430)	Summer Snowflake (Zomerklokje)	Rare and vulnerable. Protected	Not observed	This originally native species occurs on nutrient-rich banks, marshy meadows, wet forests and reed-lands outside the dike. Tidal movements are important for this species. It is a perennial species and flowers from April till June.
Mentha longifolia (H6430)	Horsemint (Hertsmunt)	Rather rare and of least concern	Yes	This originally native species occurs in roughage and on river banks. It prefers wet and nutrient-rich soils and grows mostly between stone revetments. This perennial plant flowers form July till September.
Cardamine amara (H91E0)	Large Bitter-cress (Bittere veldkers)	Rather rare and of least concern	Yes	This originally native species prefers wet spots with a high water quality and is therefore and indicator for clean water and good environmental conditions. It has a lot of beautiful flowers. This perennial species flowers from May till June.

Gagea lutea (H91E0)	Yellow Star-of-Bethlehem (Bosgeelster)	Rare and of least concern	Not observed	This originally native bulbous plant occurs on moist and nutrient-rich soils in deciduous forests and grasslands. It prefers shaded sites and sandy soils that dry out in summer. Vegetative reproduction is through bolls, but also produces seeds.
Geranium phaeum (H91E0)	Dusky Crane's-bill (Donkere ooievaarsbek)	Rather rare and of least concern	Yes, but low number of observations	The origin of this plant lies in South-Europe. It established in The Netherlands in the 18th century. This species grows on weakly acid till weakly alkaline sand, clay or loam soils. It prefers sunny till moderately shaded spots on (moderately) nutrient-rich, moist soils. It often occurs in different types of forests but also in rough grasslands and along the waterside. It is a perennial species and flowers from May till September.
Schoenoplectus triqueter	Triangular Club-rush (Driekantige bies)	Rare and endangered	Yes	This originally native species occurs on silty levees and tidal mud and sand plates. It prefers sunny, open shallow and nutrient-rich water with a bottom of sand, silt or a stones with silt. Especially areas that are exposed to a strong current and tidal differences are preferred. Decreasing tides has caused this species to decline in the Biesbosch. This perennial species flowers from June till September.

APPENDIX 3 – BIRD ECOLOGY

Great Cormorant

The Great Cormorant (Figure 26) is a large waterfowl species which lives in social communities or colonies. Their diet mainly consists of fish of shallow waters. Especially *Abramis brama* and *Gymnocephalus cernuus* contribute greatly to the diet of the Great Cormorant and these fish species are of no commercial concern. The European realm of this species is widespread and one of the greatest populations is based in the Netherlands, with more than 21,000 breeding couples (Programmadirectie Natura 2000, 2008a; Stowa, 2016; Vogelbescherming Nederland, 2016).

Figure 26: Great Cormorant. Source: www.vogel-pagina.nl

The habitat for this species is any aquatic system, even waters in urban areas. For breeding, however, they prefer trees in wetlands and saltmarshes. When breeding they have a great impact on the vegetation as the acids in the faeces result in a certain death of trees and surrounding vegetation (Stowa, 2016; Vogelbescherming Nederland, 2016). The Great Cormorant is susceptible to disturbances during the breeding season (Programmadirectie Natura 2000, 2008a).

With regard to the conservation status this species is a target species for Natura 2000. It, however, is not considered to be a red-list species (Vogelbescherming Nederland, 2016). The numbers of this species have never been of concern in the past (Programmadirectie Natura 2000, 2008a).

Eurasian Bittern

This relative of the herons (Figure 27) is famous for its motionless pose and its characteristic 'hummp'-like sound. This species needs vegetation that consists of *Phragmites australis* and *Typha* sp. for a fair part (at least a 0.5-1 km of reed-strips obligatory). Especially the old and robust reed patches form its main habitat. Their diet consists mainly of fish and amphibians, but small mammals are consumed when the opportunity is around. The ecosystems this species lives in are moors, reed lands and roughages. Foraging is mainly done in shallow waters near the edges of reed-zones (Programmadirectie Natura 2000, 2008q; Stowa, 2016; Vogelbescherming Nederland, 2016).

Figure 27: Eurasian Bittern. Source: http://www.ivnvechtplassen.org/ivn_vogels_plas_moeras/Roerdomp_Botaurus-stellaris.html

Some of the offspring migrates to southern Europe or northern Africa. The major part, however, stays in the area it was born in. Cold winters are of great concern for this species, since those result in a reduction of the population (Vogelbescherming Nederland, 2016).

In the beginning of the twentieth century the population of Eurasian Bittern began to reduce. Especially in the 70s the population was reduced significantly, since only 500-700 breeding couples were left. These numbers were reduced further in the 90s to only 150-180 couples. Due to conservation efforts the Dutch population was around 250-300 couples in 2008 (Vogelbescherming Nederland, 2016). In the Biesbosch this trend could be observed too, where the population even

had completely been diminished during the 80s and early nineties. In 2013 the Biesbosch population consisted of almost 10 couples (Boele et al., 2015).

This species is on the national red-list for birds and is a Natura 2000 target species. After cold winters, in which their population significantly reduces, the species has troubles to restore its population (Vogelbescherming Nederland, 2016). Vogelbescherming Nederland (2016) gives a summary of actions to be taken when enhancing habitat for the Eurasian Bittern. Firstly, they state, succession to forest in reed-lands needs to be prevented. Further, presence of pools or ponds, reed ditches and extensive farmlands in the vicinity are beneficial for foraging. To assist this, habitat for amphibians and fish should be enhanced, which could be done by rising the water table. During cold winters this species needs areas without human access. Current marshes or wetlands should be expanded to create new habitats (Programmadirectie Natura 2000, 2008q; Vogelbescherming Nederland, 2016). Den Boer (2000) in Vogelbescherming Nederland (2016) sums up some additional measures, namely:

- ☐Locally rising the water level in reed-lands
- ☐ Inundating grasslands
- ☐ Let succession proceed in peat ditches
- ☐ Digging ponds and ditches
- ☐ Mowing less frequently
- ☐ Increase mice density
- ☐ Enhancing groundwater seepage in reed-lands

Marsh Harrier

From a historic perspective, the Netherlands has always been a typical habitat for the Marsh Harrier (Figure 28), since in past times a major part of the Netherlands was marshes and wetlands (Stowa, 2016; Vogelbescherming Nederland, 2016). The habitat this species prefers is a marshe with a lot of reed. A dryer habitat, however, can also be occupied, but only when the density of mice is relatively high. Its main food source are mice and small birds. For breeding it needs some shrubs which stay dry, even during high water (Programmadirectie Natura 2000, 2008c; Stowa, 2016; Vogelbescherming Nederland, 2016). During winter this species migrates to Africa. The number of Dutch breeding couples is estimated at around 1200 (Boele et al., 2015; Vogelbescherming Nederland, 2016), of which only 30 live in the Biesbosch (Programmadirectie Natura 2000, 2013). Despite a negative trend since the 90s, the conservation status for this Natura 2000 target species is not that critical. Due to this, maintaining the current population can be the target (Programmadirectie Natura 2000, 2013). The negative trend is likely caused by forestation of marshes and desiccation and eutrophication of agricultural land (Programmadirectie Natura 2000, 2008c).

Figure 28: Marsh Harrier. Source: www.vogel-pagina.nl

Spotted Crake

The Spotted Crake is a mysterious bird (Figure 29). Its diet consists of plants, mainly seeds and roots, and small animals, like molluscs, insects and small fish (Programmadirectie Natura 2000, 2008o; Vogelbescherming Nederland, 2016). Its habitat mainly consists of floodplains, reed-lands, marshlands and inundated grasslands. Water depth of less than 15cm is essential for foraging. This widespread European bird uses very dense vegetation in shallow water. For breeding this bird prefers inundated grasslands. It builds its nest just above the water level (Programmadirectie Natura 2000, 2008o; Vogelbescherming Nederland, 2016). This migratory species overwinters in Africa (Stowa, 2016; Vogelbescherming Nederland, 2016).

Figure 29: Spotted Crake. Source: http://www.ivnvechtplassen.org/ivn_vogels_plas_moeras/Porseleinhoen_Porzana-porzana.html

The last century its numbers have reduced significantly due to widespread exploitation of peat-lands and marshes. Especially forestation and desiccation of marshes have negative effects on the abundance. The Dutch population consists of an estimated 300 individuals (Vogelbescherming Nederland, 2016). It is unknown how many individuals live in the Biesbosch (Programmadirectie Natura 2000, 2013). The target in the Biesbosch, however, is set at 9 breeding couples, since the area is not providing enough resources for a self-sustaining key population (Programmadirectie Natura 2000, 2013).

With regard to the conservation status, this species is incorporated in the red-list for birds. Its status is considered as "vulnerable", which results in some regulations regarding this species. Part of the yearly fluctuations of the Dutch population is due to population fluctuations abroad. In the long run this species will suffer from eutrophication of the surface water. The main measures to be taken to ensure the numbers of this species, is prevention of desiccation of suitable habitat. This species needs a significant buffer zone between reed-strips and the open waters. Den Boer (2000) in Vogelbescherming Nederland (2016) provides some extra measures

- Expanding area of wet roughages in peat-lands and mowing to prevent succession
- Expand marshes behind the dikes
- Create roughages on areas where extensive grazing is taking place
- Inundation of grasslands during summer

Common Kingfisher

The Common Kingfisher (Figure 30) is a typical bird at creeks, brooklets and rivers, since it prefers flowing water to catch its fish. Standing waters, however, can also be occupied by this species, but only when the fish stock is significant (Programmadirectie Natura 2000, 2008h; Vogelbescherming Nederland, 2016). To these habitats there is one very important restriction: this species breeds in rootballs of fallen trees (Programmadirectie Natura 2000, 2008h) or in steep sandy or loamy banks with tall vegetation (Programmadirectie Natura 2000, 2008h; Vogelbescherming Nederland, 2016). During winter this bird forages in many different waters. Its diet consists of small fishes and aquatic invertebrates, like dragonfly larvae (Programmadirectie Natura 2000, 2008h; Stowa, 2016; Vogelbescherming Nederland, 2016).

Figure 30: Common Kingfisher. Source: www.vogel-pagina.nl

Over time the Dutch population has been fluctuating a lot. These fluctuations are strongly correlated with the winter temperature, where in cold winters a strong reduction in the population is likely to occur (Boele et al., 2015; Vogelbescherming Nederland, 2016). In 2013, approximately 350 breeding couples were estimated in the Netherlands (Vogelbescherming Nederland, 2016). In the Biesbosch 6 couples were observed, which indicates that this is a good habitat for this species. The Natura 2000 target for the Biesbosch is 20 breeding couples (Programmadirectie Natura 2000, 2013).

The conservation status for this species is that it is a Natura 2000 target species. It, however, has not been incorporated on the red-list of birds. This species could locally be enhanced by digging a pond and in winter cutting holes in the ice sheet and keeping this open. Further, they can be helped by building riverbanks adjacent to brooklets, ponds and lakes (Stowa, 2016; Vogelbescherming Nederland, 2016).

Bluethroat

The Bluethroat (Figure 31) is a colourful bird species that uses wetlands and marshes as its primary habitat, but also can be found in similar habitats. This migratory bird stays in southern Europe and northern Africa during winter. It has a preference for vegetation near brooklets, rivers and lakes with a rich bushy vegetation and deciduous trees (Programmadirectie Natura 2000, 2008b; Vogelbescherming Nederland, 2016). Therefore, the gradient between reed-lands and the wet forest (Vogelbescherming Nederland, 2016), or gradient between bare agricultural land and a bushy vegetation is a perfect habitat (Programmadirectie Natura 2000, 2008b). Since its diet mainly consists of insects and berries, the insect richness of the vegetation is very important. The Bluethroat breeds near the ground in dense shrubs, preferably on a slight slope (Programmadirectie Natura 2000, 2008b; Stowa, 2016; Vogelbescherming Nederland, 2016).

Figure 31: Bluethroat. Source: www.vogel-pagina.nl

After only 1000 breeding couples were recorded in the Netherlands in 1970, this species increased with a tremendous amount (Den Boer, 2000; Vogelbescherming Nederland, 2016). In 2000 no less than 9000 breeding couples were recorded. This resulted in the exclusion of this species from the red-list of Birds. The reason for this increase can be found in the expansion of marsh area in the Netherlands (Vogelbescherming Nederland, 2016). In the Biesbosch, the population has been estimated at 1300 couples (Programmadirectie Natura 2000, 2013). The national target for this bird is the conservation of the realm to ensure a stable population. The Biesbosch population is big enough to be considered as a key population in the Netherlands (Vogelbescherming Nederland, 2016). There are no indications for negative influences of human use of wetlands on this species (Den Boer, 2000). To ensure that the vegetation will not become unsuitable due to succession, this natural process needs to be prevented (Den Boer, 2000).

Savi's Warbler

Savi's Warbler (Figure 32) is a typical species in dense vegetation at the edge of water (Vogelbescherming Nederland, 2016). Its preferred habitats are marshes, reed-lands and wetlands, with a large amount of reed beds (Den Boer, 2000; Programmadirectie Natura 2000, 2008s; Stowa, 2016). It builds its nest on a reed bed on inundated reed-lands (Den Boer, 2000; Vogelbescherming Nederland, 2016), with the restriction that this vegetation is at least 10 metres wide (Den Boer, 2000). The same vegetation is used for foraging, since it mainly eats small invertebrates in aquatic environments, like butterflies, dragonflies and molluscs (Den Boer, 2000; Stowa, 2016; Vogelbescherming Nederland, 2016). During fall, this bird migrates to Africa and returns in spring (Programmadirectie Natura 2000, 2008s; Vogelbescherming Nederland, 2016).

Figure 32: Savi's Warbler. Source: http://www.ivnvechtplassen.org/ivn_vogels_plas_moeras/Snor_Locustella-luscinioides.html

Since ages this bird lives in the Netherlands. The first population estimation was made in 1975, with an estimated 1,750-3,000 couples. Since then this species showed a gradual decline with an estimated 1,700-2,100 couples in 2000 (Vogelbescherming Nederland, 2016). The current population in the Biesbosch, which is one of the four main populations in the Netherlands (Vogelbescherming Nederland, 2016), is estimated at 130 couples (Programmadirectie Natura 2000, 2013). This species is placed at the red-list of Birds with the indication "vulnerable" (Vogelbescherming Nederland, 2016). This is due to the amount of suitable breeding area (Den Boer, 2000). The main reasons for this is toxification, eutrophication and acidification of its habitat, as well as unnatural water management and desiccation (Den Boer, 2000). Also intensive reed mowing and grazing reduces the breeding area. Recreational activities do not seem to have a negative effect, a part from accessing the marsh vegetation by foot (Den Boer, 2000).

The realm of this species could be expanded by (Den Boer, 2000):

- Locally inundating reed-lands and peat-lands and letting reed-lands develop into peat-lands
- Digging shallow ditches and pools and letting succession do its work in those areas
- Mowing less frequently in reed-lands
- Enhancing groundwater seepage

Sedge Warbler

Sedge Warbler (Figure 33) is a typical species of reed-lands near water, just as Savi's Warbler. The ideal vegetation is made up of a combination of young and old reed and a relatively high roughage vegetation. Its diet consists only of insects, which it will catch in dense reed-lands. They build their nests in this same habitat. This bird is a migratory bird (Programmadirectie Natura 2000, 2008p; Stowa, 2016; Vogelbescherming Nederland, 2016).

Figure 33: Sedge Warbler. Source: www.vogel-pagina.nl

In the 70s the Dutch population was an estimated 17,500-30,000 couples. This, however, reduced to 12,000-18,000 in the 90s (Programmadirectie Natura 2000, 2008p; Vogelbescherming Nederland, 2016). In 2000 the population had increased to 20,000-25,000, despite a reduction in breeding territory (Programmadirectie Natura 2000, 2008p; Vogelbescherming Nederland, 2016). This reduction of realm is mainly due to succession to the later hydrosere stages (Den Boer, 2000). After the reduction of the tides in the 70s, only 40-60 couples remained in the Biesbosch in the 80s, after which the numbers did increase (Programmadirectie Natura 2000, 2013). The main reasons for the reduction is toxification, eutrophication, desiccation and acidification of its habitat, as well as unnatural water management. Also intensive reed mowing and grazing reduces the breeding area, like the Sevi's Warbler (Den Boer, 2000). Recreational activities do not seem to have a negative effect, a part from accessing the marsh vegetation by foot (Den Boer, 2000). The current population in the Biesbosch is at least 260 couples (Programmadirectie Natura 2000, 2013). The Natura 2000 target is to conserve the current area in the Biesbosch, since it is a healthy population (Programmadirectie Natura 2000, 2013).

The realm of this species could be expanded by (Den Boer, 2000):

- Locally inundating reed-lands and peat-lands and letting reed-lands develop in peat-lands
- Digging shallow ditches and pools and letting succession do its work in those areas
- Mowing less frequently in reed-lands
- Enhancing groundwater seepage

Great Crested Grebe

The Great Crested Grebe (Figure 34) is a bird species that can live in all fresh surface water bodies where aquatic plants are abundant. It even has colonized the urban waters, whereas this was unthinkable a few decades ago (Vogelbescherming Nederland, 2016). This common European bird prefers to forage near the edges of water bodies where floating plants are abundant. It uses these floating plants to build its nest, which is floating itself (Stowa, 2016; Vogelbescherming Nederland, 2016). It mainly forages on fish, but also on aquatic insects (Programmadirectie Natura 2000, 2008d; Stowa, 2016; Vogelbescherming Nederland, 2016).

Figure 34: Great Crested Grebe. Source: www.vogel-pagina.nl

In the Netherlands the Great Crested Grebe trend shows an increase. This is no good sign, because it means that the eutrophic level of surface waters is increasing. The reasons for this eutrophication are artificial fertilizers used by farmers. The Dutch population is estimated at 13,000-16,000 individuals at the turn of the century. This is also the reason that this species is not on the red-list of Birds (Programmadirectie Natura 2000, 2008d;

Vogelbescherming Nederland, 2016). In the Biesbosch the population is 450 individuals on average. Since the Biesbosch is a very suitable foraging area, the Natura 2000 goal is to maintain the current population (Programmadirectie Natura 2000, 2013). The main threat to this species is disturbance during moulting season. At this time the aerial capabilities of the Great Crested Grebe are reduced significantly (Programmadirectie Natura 2000, 2008d).

Great Egret

The Great Egret (Figure 35) is a migratory species which originates from the Mediterranean. It lives in marshes, lakes, reed-lands and large grasslands. In these areas it prefers reed-zones, embankments of lakes and forests adjacent to rivers. To build its nest this species needs old reed, but can also use *Salix sp.* to nest in. It mainly forages on fish, amphibians and small mammals, like voles and moles (Programmadirectie Natura 2000, 2008f; Stowa, 2016; Vogelbescherming Nederland, 2016).

Figure 35: Great Egret. Source: www.vogel-pagina.nl

The Great Egret colonized the Netherlands for the first time in 1978 and after 1991 an increase took place, which resulted in 174-184 breeding couples in the whole of the Netherlands (Programmadirectie Natura 2000, 2008f; Vogelbescherming Nederland, 2016). In the Biesbosch, the Natura 2000 target is to maintain the current average population of 10 individuals and a maximum of 60 individuals to spend the night in the area. The Biesbosch is the second most important area in the Netherlands for Egrets staying overnight. Since its numbers are quite small in the Netherlands, this species has been given the status "Near Threatened" on the red-list of Birds (Vogelbescherming Nederland, 2016). The Great Egret is very susceptible to disturbance during the breeding season. This disturbance needs to be avoided (Programmadirectie Natura 2000, 2008f).

Eurasian Spoonbill

The Eurasian Spoonbill (Figure 27) is a migratory bird that is not widespread in Europe. The Netherlands is, together with Denmark, the most northern refuge for this species and these refuges are relatively remote to the other populations of this species (Vogelbescherming Nederland, 2016). Its habitat preference goes to reed-zones in tidal zones, marshes and roughages. In this habitat they forage on fish, shrimps and other small aquatic animals (Den Boer, 2000; Programmadirectie Natura 2000, 2008l; Vogelbescherming Nederland, 2016). Further they nest in these areas in dense reed-zones (Den Boer, 2000; Programmadirectie Natura 2000, 2008l; Vogelbescherming Nederland, 2016) or remote trees (Programmadirectie Natura 2000, 2008l; Stowa, 2016; Vogelbescherming Nederland, 2016).

Figure 36: Eurasian Spoonbill. Source: www.vogel-pagina.nl

From historic perspective the Eurasian Spoonbill has been living in the Netherlands for a long time. Its numbers, however, decreased dramatically when men started to desiccate the Netherlands by creating polders. Even before 1900 colonies of more than 1,000 individuals did not exist anymore. The numbers were decimated to 150 couples in 1969 after which the recovery started again. In 2013 the total number of couples was estimated at 2,530-2,570 (Vogelbescherming Nederland, 2016; Werkgroep Lepelaar, 2013), which indicates that a red-list status is not necessary (Vogelbescherming Nederland, 2016). In the Biesbosch, their trend shows a peak in the 90s, after which a gradual decline can be observed. The target set by Natura 2000 is to maintain the carrying capacity of 10 individuals.

The main factors that impact the Eurasian Spoonbill are eutrophication, toxification and acidification as well as unnatural water balance, reduction in prey (Den Boer, 2000) and disturbance (Programmadirectie Natura 2000, 2008l). Hunting and fisheries, predation by foxes, as well as

recreation do have a negative impact in the population (Den Boer, 2000). Several measures can be taken to ensure the population of Eurasian Spoonbills (Den Boer, 2000):

- Inundating reed lands and grasslands
- Creating recreation free zones
- Ensuring high quality habitat for prey
- Creating possibilities for fish migration

Bewick's Swan

Bewick's Swan (Figure 37) is a species that only stays in the Netherlands during winter, when they forage on peat meadows, agricultural land, floodplains and shallow waters. During summer this bird stays in the arctic tundra's (Programmadirectie Natura 2000, 2008i; Vogelbescherming Nederland, 2016). This species is a true herbivore and forages on grass in the Netherlands. During relatively warm winters almost 60% of the world population of this species stays in the Netherlands, and even in cold winters 35% of the world population is in the Netherlands (Vogelbescherming Nederland, 2016). They prefer open grasslands (Programmadirectie Natura 2000, 2008i; Vogelbescherming Nederland, 2016) to ensure safety from predators (Vogelbescherming Nederland, 2016).

Figure 37: Bewick's Swan. Soruce: www.vogel-pagina.nl

Their numbers in the Netherlands depend strongly on the winter temperature. Until 1995 their numbers were increasing, after which a gradual decline could be observed (Vogelbescherming Nederland, 2016). The Biesbosch has a carrying capacity of on average 10 birds and the target has been set at maintaining this carrying capacity (Programmadirectie Natura 2000, 2013).

Greater White-Fronted Goose

The Greater White-Fronted Goose (Figure 38) is an overwintering species in the Netherlands, like the Bewick's Swan is. This species too is eating grass, but sometimes they forage on the arable fields. They forage on grasslands in agricultural areas, tidal zones, marshes and river floodplains (Vogelbescherming Nederland, 2016).

Figure 38: Greater White-Fronted Goose. Source: www.vogel-pagina.nl

Since the 80s the number of breeding couples increased to the level of 540-2,350 in 2012. During winter, estimates are that 500,000-650,000 individuals visit the Netherlands (Vogelbescherming Nederland, 2016). The Biesbosch is mainly a foraging area and sleeping refuge for this species. On average the carrying capacity is 1,800 individuals with regard to foraging and 34,200 individuals overnight (Programmadirectie Natura 2000, 2013). This level should be maintained, according to Natura 2000 targets, as it is not incorporated in the red-list of Birds (Vogelbescherming Nederland, 2016).

Greylag Goose

The Greylag Goose (Figure 39) is a migratory bird which has colonized the Netherlands, resulting in a number of birds that stay year round. Agricultural land, brooklets, lakes, marshes and grasslands are the main living areas of this species, but it can also be found in urban areas. Especially the marshes and swamp forests are an ideal habitat, since this bird tends to build its nest on small islands (Vogelbescherming Nederland, 2016). This herbivore prefers grass to eat, but can also consume other plants if necessary

Figure 39: Greylag Goose. Source: www.vogel-pagina.nl

(RSPB, 2016; Vogelbescherming Nederland, 2016) and sometimes even goes into cereal plantations and consumes the leaves (RSPB, 2016).

The Greylag Goose nowadays is a common waterfowl species. This, however, was unthinkable a few decades ago, when even it was reintroduced in some places. 40 years ago the population in the Netherlands was approximately 150 couples, which this increased to 25,000 couples in 2005. The reason for this vast increase is thought to be the quality of the grass due to artificial fertilizers (Vogelbescherming Nederland, 2016). These large numbers result in no red-list status (Vogelbescherming Nederland, 2016), but the bird is included in the Natura 2000 goals (Programmadirectie Natura 2000, 2013; Vogelbescherming Nederland, 2016). In the Biesbosch the target for this species is 2,300 individuals, where this area mainly is meant for foraging and resting (Programmadirectie Natura 2000, 2013).

Barnacle Goose

This migratory bird, like the Greylag Goose, has colonized the Netherlands. Before 1984 this species was not breeding in the Netherlands. It mainly lives on agricultural lands, grasslands, tidal zones, marshes and river floodplains. In almost all vegetation a nest can be built, but the species prefers to build it on small islands for optimal protection against terrestrial predators. The diet of the Barnacle Goose (Figure 40) is the same as for the Greylag Goose (Vogelbescherming Nederland, 2016). This species, however, can also eat leaves, stems and roots (RSPB, 2016).

Figure 40: Barnacle Goose. Source: www.vogel-pagina.nl

Before 1984, this species only occurred in the Netherlands as migratory bird. Since 1984 the number of breeding couples have increased to 6,000 in 2005 and 8,900-25,500 in 2012 (Vogelbescherming Nederland, 2016). The Biesbosch has a population of 870 individuals year round and a seasons maximum of 4,900 birds. The latter birds mainly use the area for resting (Programmadirectie Natura 2000, 2013). This species has no red-list status. Creating rest areas for these birds will help them prepare for the migration.

Eurasian Wigeon

This mainly herbivorous bird lives in natural aquatic environments like rivers, marshes and lakes. The environment needs to consist of clean freshwater bodies with a rich vegetation both, in and around the water. The Eurasian Wigeon (Figure 41) is migratory and is overwintering in the Netherlands, where it mainly consumes grass and aquatic plants (Programmadirectie Natura 2000, 2008r; RSPB, 2016; Vogelbescherming Nederland, 2016). The females in particular complement their diet with midgets to gain extra proteins (Vogelbescherming Nederland, 2016).

Figure 41: Eurasian Wigeon. Source: www.vogel-pagina.nl

During the 70s and 80s the number of overwintering birds increased and stabilized during the 90s. After the turn of the century these numbers decreased again. The number of breeding couples in the Netherlands was between 10 and 20 in 2011 (Vogelbescherming Nederland, 2016). The cause behind this decrease has not been found yet. The Biesbosch is only used as foraging and sleeping area by this bird, with a maximum of 3,300 individuals during the winter (Programmadirectie Natura 2000, 2013). Extensive management, drainage of grasslands and recreation negatively affect this species (Programmadirectie Natura 2000, 2008r).

Gadwall

The Gadwall (Figure 42) is a waterfowl species of large lakes with a large amount of vegetation, including lakes with artificial embankments, like dikes and dams. They also tend to live in river and marsh areas (RSPB, 2016; Vogelbescherming Nederland, 2016) and eutrophic fresh water (Programmadirectie Natura 2000, 2008j). These birds are herbivorous, eating stems, leaves and seeds (Programmadirectie Natura 2000, 2008j; RSPB, 2016), but also like to eat the filamentous algae on rocks (Programmadirectie Natura 2000, 2008j; Vogelbescherming Nederland, 2016).

Figure 42: Gadwall. Source: http://www.ivnvechtplassen.org/ivn_vogels_winter/Krakeend_Anas-strepera.jpg

In the Netherlands this species occurs year round in some numbers, but the majority is migratory. Since the 70s the population exploded in the Netherlands, increasing from 550-800 couples to 6,000-7,000 couples in 2000. The number of non-breeding individuals increased to 25,000 in 2013 (Vogelbescherming Nederland, 2016). In the Biesbosch an average of 1,300 individuals can be found during winter. This area has been assigned to maintain the current population (Programmadirectie Natura 2000, 2013).

Eurasian Teal

The Eurasian Teal (Figure 43) is a small duck living in open, marsh like areas, but also near rivers, lakes and peat-lands (Programmadirectie Natura 2000, 2008v; Vogelbescherming Nederland, 2016) and in salt water (Programmadirectie Natura 2000, 2008v). A dense vegetation is needed to forage in, since plants and small aquatic animals are its main diet (Vogelbescherming Nederland, 2016). During winter they congregate in wetland areas in western Europe (RSPB, 2016).

Figure 43: Eurasian Teal. Source: http://www.ivnvechtplassen.org/ivn_vogels_veen_weide/Wintertaling_Anas-crecca.jpg

Although the overwintering numbers are very high (30,000 in 2012) this species is not doing well in the Netherlands. The number of breeding couples (2,000-2,500 in 2000) has gradually been decreasing with an overall decline of 20% in 2012 compared to the 80s. Based on this information, this species is "vulnerable" according to the Red-list of Birds (Vogelbescherming Nederland, 2016). This species is prone to disturbance, which will have an immediate negative effect. The Biesbosch is one of the most important areas for this species, with a carrying capacity of 1,100 individuals on average. In this area the numbers have been increasing lately, despite the national decline (Programmadirectie Natura 2000, 2013). To preserve this species, all recreation near the populations should be banned (Programmadirectie Natura 2000, 2008v; Vogelbescherming Nederland, 2016).

Mallard

The Mallard (Figure 44) is a very common duck, living in almost all nutrient rich freshwater systems, including marshes. This species breeds in the Netherlands in large numbers and its diet consists of aquatic plants and insects. Building the nest does not necessarily require water, as it is often built in gardens. The Mallard is the most common waterfowl species in the Netherlands, but a slight decrease in numbers is observed due to an increase in agriculture (Vogelbescherming Nederland, 2016). In the Biesbosch the population is 4,000 individuals on average. It is used as foraging habitat and therefore the realm of this species in the Biesbosch should be conserved.

Figure 44: Mallard. Source: www.vogel-pagina.nl

Northern Pintail

The Northern Pintail (Figure 45) is a typical species of mild winters in the Netherlands. This migratory bird prefers marshes, lakes and rivers in the coastal regions as its habitat, where it forages on aquatic plants and invertebrates (Programmadirectie Natura 2000, 2008n; Vogelbescherming Nederland, 2016).

Figure 45: Northern Pintail. Source: http://www.ivnvechtplassen.org/ivn_vogels_winter/Pijlstaart_Anas-acuta.jpg

Since the 70s, the number of breeding Northern Pintails in the Netherlands decreased from 45-75 to 5-15 in 2011 (Vogelbescherming Nederland, 2016). The Biesbosch is used as foraging territory and can sustain 70 individuals during winters. Since no national recovery program is established yet, maintaining the current population is sufficient (Programmadirectie Natura 2000, 2013). This species is "Threatened" according to the red-list of Birds and therefore conservation is needed (Vogelbescherming Nederland, 2016). In marshes this species is not declining and the expectation is that conservation efforts for other birds will help this species along the way (Den Boer, 2000).

Northern Shoveler

The Northern Shoveler (Figure 46) prefers rivers, marshes and large grasslands as its habitat (Vogelbescherming Nederland, 2016). Its diet consists of plants on the water surface and small insects (RSPB, 2016). This species can be found in marshes year round, but during winter also in grasslands. It is breeding in reed lands in the vicinity of open water (Stowa, 2016).

Figure 46: Northern Shoveler. Source: www.vogel-pagina.nl

In the Netherlands this species has decreased from 9,000-12,000 couples in the 70s to 8,000-9,000 couples in 2000. In the Biesbosch, the average number is 270 individuals, which use the area for foraging. The red-list status for this bird is "vulnerable" in the Netherlands and is under strong regulation regarding conservation by the Dutch law (Stowa, 2016). To conserve the population, differences in water level during breeding season need to be avoided, as well as disturbances by working activities (Stowa, 2016).

Common Pochard

This migratory bird lives near eutrophic lakes and marshes and slow flowing rivers, where it eats aquatic plants and small fauna. It needs dense reed vegetation in the vicinity of water (less than 10 metres) and the water depth should be at least 1 metre (Programmadirectie Natura 2000, 2008t; Stowa, 2016; Vogelbescherming Nederland, 2016).

Figure 47: Common Pochard. Source: www.vogel-pagina.nl

Since the 80s the population has been a quite stable 1,600-2,300 couples in the Netherlands (Vogelbescherming Nederland, 2016). In the Biesbosch, the population of Common Pochards (Figure 47) has been decreasing since the 80s and stagnated around 130 individuals on seasons average (Programmadirectie Natura 2000, 2013). Since this species has no red-list status, conservation is not of real concern, but it is under strong regulation regarding conservation by the Dutch law (Stowa, 2016). The population in the Biesbosch (Stowa, 2016; Vogelbescherming Nederland, 2016), however, should be kept at the current level (Programmadirectie Natura 2000, 2013).

Tufted Duck

Tufted Duck (Figure 48) can be found in the Netherlands year round and lives near lakes and slow flowing rivers. Its diet consists of molluscs, small aquatic animals and aquatic plants (Programmadirectie Natura 2000, 2008k; RSPB, 2016; Stowa, 2016; Vogelbescherming Nederland, 2016). In the Netherlands, the numbers are quite stable, with 14,000-18,000 breeding couples in 2000 (Vogelbescherming Nederland, 2016). On average, 3,800 individuals live in the Biesbosch, which acts as foraging territory (Programmadirectie Natura 2000, 2013). This species has no red-list status, but it is under strong regulation regarding conservation by the Dutch law (Stowa, 2016).

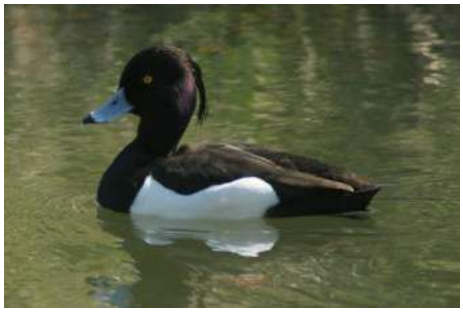

Figure 48: Tufted Duck. Source: www.vogel-pagina.nl

Smew

The Smew (Figure 49) is an overwintering bird in the Netherlands. It prefers marshes, lakes, rivers and coastal areas as its main habitat (Programmadirectie Natura 2000, 2008m; Vogelbescherming Nederland, 2016). It forages on small fish, crustaceans, molluscs and aquatic insects (Programmadirectie Natura 2000, 2008m; Vogelbescherming Nederland, 2016). The numbers visiting the Netherlands fluctuate a lot (Vogelbescherming Nederland, 2016). In the Biesbosch the target is to have a population of 20 birds during winter and the focus is on maintaining the current population (Programmadirectie Natura 2000, 2013). This species has no red-list status.

Figure 49: Male Smew. Source: http://www.ivnvechtplassen.org/ivn_vogels_winter/Nonnetje_Mergus-albellus.html

Common Merganser

The Common Merganser (Figure 50) is a typical bird for large, slow flowing rivers and lakes with a large area of forest around it (Programmadirectie Natura 2000, 2008e; Vogelbescherming Nederland, 2016). In the Netherlands, this habitat is very rare, resulting in no breeding birds in the Netherlands (Vogelbescherming Nederland, 2016). During winter this bird clusters in the Netherlands in large numbers (Vogelbescherming Nederland, 2016). The Common Merganser eats fish and aquatic insects (Programmadirectie Natura 2000, 2008e; Vogelbescherming Nederland, 2016). An estimated 24% of the North-west European population stays in the Netherlands during winter. The National trend is very difficult to determine due to large fluctuations (Vogelbescherming Nederland, 2016). The Biesbosch is targeted to maintain a population of 30 birds on average (Programmadirectie Natura 2000, 2013).

Figure 50: Common Merganser. Source: http://www.ivnvechtplassen.org/ivn_vogels_winter/Grote_Zaagbek_Mergus-merganser.html

Figure 51: White-tailed Eagle. Source: http://www.ivnvechtplassen.org/ivn_vogels_niet_vechtstreek/Zeearend_Haliaeetus-albicilla.html

White-Tailed Eagle

The White-Tailed Eagle (Figure 51) is breeding in the Netherlands only after 2006. This species prefers lakes and rivers to forage. Its diet consists of fish, waterfowl and mammals, but it can also be found scavenging (Programmadirectie Natura 2000, 2008w; Vogelbescherming Nederland, 2016). Its foraging territory can be up

to 10,000ha (Programmadirectie Natura 2000, 2008w). In the Netherlands there were five breeding couples in 2013, of which one couple lives in the Biesbosch (Programmadirectie Natura 2000, 2013; Vogelbescherming Nederland, 2016). Trend analysis cannot be done due to the small numbers. This bird is vulnerable to disturbances. The number of this species in the Biesbosch should be maintained and preferably increased (Programmadirectie Natura 2000, 2013).

Figure 52: Osprey. Source: http://www.ivnvechtplassen.org/ivn_vogels_winter/Visarend_Pandion-haliaetus.jpg

Osprey

This fish eating bird (Figure 52) is foraging in marshes, lakes, fens and rivers. In the Netherlands this species is only visiting during spring and autumn. They need a large area of water which is rich of fish and some large vegetation near the water (Programmadirectie Natura 2000, 2008u; Vogelbescherming Nederland, 2016). In the Netherlands there are no confirmed breeding couples (Vogelbescherming Nederland, 2016) and the numbers are too low and are fluctuating too much to get insight in their trend. In the Biesbosch the area is suited for up to 6 individuals, which is the target according to Natura 2000 (Programmadirectie Natura 2000, 2013).

Eurasian Coot

The Eurasian Coot (Figure 53) is a typical species of freshwater ecosystems with a lot of vegetation. It needs the vegetation to forage in and build its nest in. They can be found in almost all fresh surface waters, including urban areas. They forage on insects, molluscs, fish, aquatic plants and seeds (Stowa, 2016; Vogelbescherming Nederland, 2016). This bird breeds in large numbers (130,000-180,000 couples) in the Netherlands and is therefore of no conservation concern (Vogelbescherming Nederland, 2016). This species, however, is vulnerable to disturbances, which implies that the during breeding season recreationists should be made aware of this species (Stowa, 2016).

Figure 53: Eurasian Coot. Source: www.vogel-pagina.nl

Black-Tailed Godwit

The Black-Tailed Godwit (Figure 54) prefers open grasslands with short vegetation as it habitat. Here they forage on small invertebrates (Programmadirectie Natura 2000, 2008g; RSPB, 2016; Stowa, 2016; Vogelbescherming Nederland, 2016). This migratory bird breeds in the Netherlands and leaves in winter for Africa. 90% of the west European population lives in the Netherlands, which gave them the status "sensitive" on the red-list of Birds (Vogelbescherming Nederland, 2016). The Dutch population is an estimated 49,000-75,000 in 2004, which is a significant lower number than the 85,000-100,000 in the 80s (Programmadirectie Natura 2000, 2008g; Vogelbescherming Nederland, 2016). The reason for this decline is thought to be the desiccation of the agricultural grasslands, resulting in less food for this bird. Since small scale conservation efforts do not seem to have an effect, conservation organizations are focusing on creating reserves. Mowing can only be done after the first of June to protect nestlings (Vogelbescherming Nederland, 2016).

Figure 54: Black-Tailed Godwit. Source: www.vogel-pagina.nl

APPENDIX 4 – DRAGONFLY ECOLOGY

Brown Hawker

In the Netherlands, the Brown Hawker can be found near a wide variety of standing waters (Dijkstra, 2014; Dijkstra & Hoeffnagel, 2002), ranging from woodland habitat to polders. Its preference is, however, standing waters which are richly vegetated, like ditches with a bog like vegetation, fens, lakes and closed off river arms (Dijkstra & Hoeffnagel, 2002). These aquatic environments can have a wide range of abiotic characteristics. Reproduction has been observed even in waters with a pH of 3.9 and in brackish water. There is, however, a very important habitat requirement, the species only occurs in waters which are more than ten years old, meaning that it prefers waters in later succession stages (Dijkstra & Hoeffnagel, 2002).

This species has a one or two-year cycle of which the (first) winter is spent as an egg. Emergence occurs between June and September, with the largest numbers in July and August (Dijkstra & Hoeffnagel, 2002). For reproduction this species needs rather rotten floating plants or living Sphagnum species. Muddy banks can also be used for egg deposition. Larvae need a large amount of submersed plants to hide in. Imago's hunt on small insects, butterflies and even damselflies. There are observations of individuals catching small frogs. This species is very mobile and therefore one individual needs at least 50m bank as its territory (Dijkstra & Hoeffnagel, 2002).

There are strong distribution correlations between this species and two others on the list, namely the Western Willow Spreadwing and the Hairy Hawker, since these species use the same habitat. The Brown Hawker can fly great distances and there are even some indications of group migration (Nederlandse Vereniging voor Libellenstudie, 2002). With regard to monitoring, this species is rather big, meaning that it is hard to miss during transect counting. Numbers are quite high in the Biesbosch (Dijkstra & Hoeffnagel, 2002; NDFF, 2016).

Blue Chaser

The Blue Chaser is a species that prefers lakes, ditches and canals with some to a large amount of vegetation. These waters can be meso- to eutrophic and can have a pH between five and eight (Ketelaar, 2002). This tolerance to eutrophic waters is typical, but too eutrophic waters are being avoided. The straight waters, like ditches and canals, need to be at least four metres across and lakes need to have a diameter of ten metres (Ketelaar, 2002). The occurrence of fish does not affect the abundancy of this species. In the Netherlands, it is found on sandy soils near canals with a large amount of *Phragmites* species, in bogs and marshes with upward groundwater seepage (Dijkstra, 2014; Ketelaar, 2002), and in former sand mines in urban areas (Ketelaar, 2002). Egg deposition takes place on the border between bank vegetation and the open waters, where eggs are deposited in the water (Ketelaar, 2002). Larvae live in the mud and emerge on bank vegetation like *Phragmites, Phalaris arundinacea* and *Sparganium erectum* (Ketelaar, 2002).

The Blue Chaser has a lifecycle of two years, in which the larvae stay submersed for at least two winters (Ketelaar, 2002). Emergence occurs from the end of May till the end of June and imago's can be found till the end of July. This species has a relative low mobility and migrating has not been observed in the Netherlands. There are strong distribution correlations between this species and two others on the list, namely the Hairy Hawker and the Brilliant Emerald. These two species use the same habitat (Ketelaar, 2002). In the Netherlands this species is quite rare but a gradual increase has been observed from 1997 onwards (Termaat & Kalkman, 2012). This resulted in the change from "vulnerable" to "currently not threatened" on the red-list (Termaat & Kalkman, 2012).

The Blue Chaser has not been observed very much in the Biesbosch, therefore it is not certain that a population is in this area. The area does have patches of vegetation suitable for this species. To improve the distribution of this species, several measures can be taken (British Dragonfly Society, 2003):

- Inhabited, but suitable sites should be maintained
- Managing surrounding landscape
- Improving water quality
- Controlling and limiting boating activity

Hairy Hawker

The Hairy Hawker is a species that prefers open waters in bogs (De Groot, 2002b). These waters should be no more than 10 metres across and have high and rich vegetation on or near the banks, with some trees. The water richness can vary a lot, since this species has been found near nutrient poor till eutrophic waters. The water, however, should be clean with submersed vegetation (De Groot, 2002b). Plant species that are typical for the banks this species prefers, are *Sparganium sp.*, *Typha sp.*, *Scirpus sp.*, *Thelypteris palustris* and *Phragmites sp.*. The aquatic plants are *Potamogeton sp.* and *Utricularia sp.*. In ordinary reed-zones this species can be found too, however, in small numbers (De Groot, 2002b). In low densities the Hairy Hawker can be found at lakes, ditches and mesotrophic fens (De Groot, 2002b; Dijkstra, 2014), but all acidic waters are avoided. On sandy soils, a thick layer of organic material is needed at the bottom (De Groot, 2002b). Eggs are deposited in decaying plant debris floating in the water. The larvae forage in all layers of the water and emergence occurs at bank vegetation, like and *Carex sp.* and *Iris pseudacorus*. For reproduction, this species requires waters which are not in the later hydrosere stage of succession (De Groot, 2002b).

Three weeks after deposition, the eggs hatch. The larvae are likely to wait three winters before emergence. Shorter lifecycles of up to one year are observed, but in those circumstances the environmental conditions were extremely good (i.e. no fish, relative small aquatic environment and nutrient rich) (De Groot, 2002b). The last fresh imago's were seen in the mid of June (De Groot, 2002b) and reproduction takes place from early May until early July (De Groot, 2002b; Dijkstra, 2014). There are strong distribution correlations between this species and the Blue Chaser and the Brown Hawker. The Hairy Hawker is very mobile and can easily colonize new territory (De Groot, 2002b). In the Netherlands, this species became less rare, to a level of common on the red list (Termaat & Kalkman, 2012). This species has the conservation status "currently not threatened" (Termaat & Kalkman, 2012). The number of observations in the Biesbosch point in the direction of a healthy population (NDFF, 2016).

Western Willow Spreadwing

The Western Willow Spreadwing can be found in a wide range of aquatic environments, including urban, with respect to size and chemical characteristics (Dijkstra, 2014; van Berkel, Hoeffnagel, & Veling, 2002). Even pollution with heavy metals is not a big deal for this species. It prefers standing waters, but slow flowing water can also be occupied. This metallic green dragonfly's only requirement is living woody plants very close to the water. This has to do with its reproductive cycle (van Berkel et al., 2002). This species is the only one in Europe which uses living wood for egg deposition (Dijkstra, 2014; van Berkel et al., 2002). Eggs are deposited in the bark of relative young branches of woody plants. Almost all deciduous trees, among which at least 6 willow species, can be used when they are in the close proximity of water, but also shrubs and pine trees can be used. When eggs are deposited the plant reacts with thickening the bark, resulting in a row of small bumps in the bark (van Berkel et al., 2002). In the bark the eggs survive the winter (van Berkel et al., 2002), after which they hatch and the prolarvae fall in the water. Therefore, the branches need to hang over the water or need to be close to water. The larvae stay between the submersed plants and forage on small crustaceans and larvae of midgets. Emergence occurs at the parts of aquatic plants which are above the waterline. Plants that are used include *Stratiotes aloides* and *Nuphar lutea*. These larvae can also emerge at bridge piers (van Berkel et al., 2002).

The lifecycle of the Western Willow Spreadwing takes only one year. The larval period takes up to three months and imago's can be found from the end of June until the end of October (Dijkstra, 2014; van Berkel et al., 2002). This common species has "currently not threatened" as its red-list status (Termaat & Kalkman, 2012). In the Biesbosch this species is very common (NDFF, 2016) due to the large number of trees on the banks. The plantation of trees near water will further help this species with regard to its distribution (van Berkel et al., 2002).

Brilliant Emerald

The Brilliant Emerald in the Netherlands lives at large lakes, slow flowing canals and can sometimes be found in marshes and bogs (Dijkstra, 2014; Kalkman, 2002). The places where this species occurs are common in the way that they all are in the vicinity of a forest, whereas water

quality does not play that great of a role (Kalkman, 2002). The preference is to lakes without floating vegetation with an area of at least 150m^2 and a depth of at least one metre. Trees and reed is preferred. With regard to canals, the preference is to canals that are at least a couple of metres across and at least 1 metre in depth. The bank of the canal does not necessarily have to be vegetated. Eggs are deposited in peat, moist soil and decaying leaves. The prolarvae fall in the water right away to prevent dehydration (Kalkman, 2002). The larvae live in the soil and overwinter there too. Emergence occurs on vegetation at the bank or at an artificial revetment. The imago's normally stay close to the reproduction water. Territories are very large, resulting in low numbers being observed. In forested areas it is difficult for the individuals to keep their own territory. Open water is needed during the egg deposition period, but whether that is to treat the eggs or clean the abdomen is unclear (Kalkman, 2002).

After four to fourteen weeks the eggs hatch. The eggs that are deposited late in the season will hatch after winter. The lifecycle takes two to three years and the flying time is from the end of May until halfway July (Kalkman, 2002). This species is rare in the Netherlands, according to the red list (Termaat & Kalkman, 2012). Since this species does not migrate a lot it has difficulties in colonizing new territories. This knowledge might validate the statement that a population can be present in the Biesbosch, despite the low number of observations (NDFF, 2016). There are strong distribution correlations between this species and among others the Brown Hawker (Kalkman, 2002). Management of this species can be done by maintaining the water table and by sensitive cutting of emergent vegetation (British Dragonfly Society, 2004).

Scarce Blue-tailed Damselfly

The Scarce Blue-tailed Damselfly a typical pioneering species living in shallow waters with an open vegetation structure. Vertical vegetation, like *Carex sp.* and *Scirpus sp.*, is required for this species. It prefers a vegetation cover between 10 and 40% and further requires warm waters. Shallow lakes warm up easily, ensuring warm waters (Hermans, 2002). The Scarce Blue-tailed Damselfly can be found near sand mines and shallow heathland pools, shallow ditches and inundated grasslands and slow flowing brooklets. Water bodies deeper than 1.2 metres are not suitable. Eggs are deposited in the tissue of a wide range of plants, like *Juncus sp.* and *Eleocharis palustris* (Hermans, 2002). The eggs can withstand at least 2.5 weeks of drought, as Cham (1992) showed. Larvae forage on the bottom of the water body. Emergence occurs at the vertical plant structures. Imago's fly and forage close to the water surface in the vegetation and are therefore difficult to spot. Eggs are deposited just below the water surface (Hermans, 2002).

Eggs hatch between two and four weeks after deposition and the complete lifecycle is finished within one year. Even two generations in one year is not uncommon when conditions are favourable. Imago's can be found between half of May till half of September with the largest number in June and the beginning of August. There are strong distribution correlations between this species and *Libellula depressa,* which is another typical, but very common pioneering species (Hermans, 2002). This species is rare in the Netherlands, but has no red-list status (Termaat & Kalkman, 2012). Although the number of observations of this species is very low (9) (NDFF, 2016), a population of this species is quite possible in the Biesbosch. This species is, however, very mobile (Hermans, 2002), reducing the chances of a key population. The common threats to this species are alterations to the hydrology and succession (British Dragonfly Society, n.d.). It is therefore important to maintain the sites in an early successional stage and water levels and flows need to be maintained. Disturbance can be a good measure to keep the sites in a low successional stage. For this, small-scale habitat requirements should be kept in mind (British Dragonfly Society, n.d.).

River Clubtail

The River Clubtail can mainly be found in the lower areas and deltas of rivers (Crombaghs & Habraken, 2002; Janssen & Schaminée, 2008; Vlinderstichting, 2015). Its habitat is river areas with a slow flow of water. In fast flowing rivers this species prefers shallow parts of the river with sandy banks between the groynes. The groynes cause a lower flow speed in this situation. Eggs are deposited in the open waters, sometimes even in the middle of the river. Emergence takes place at sandy banks up to 5 metres from the water line. Imago's leave the water for some time and return for reproduction. The mating wheel can take up to 25 minutes (Crombaghs & Habraken, 2002).

The eggs develop only when the temperature is above 16 degrees Celsius. The larval stage normally takes three years (Crombaghs & Habraken, 2002; Janssen & Schaminée, 2008; Vlinderstichting, 2015), but two and four years are also registered. In the Netherlands this species can be seen from halfway June till the beginning of August (Crombaghs & Habraken, 2002). According to the red-list of 1997, this species was extinct in the Netherlands (Termaat & Kalkman, 2012). Currently, it is very rare and can only be found along the big rivers in low densities and only at specific sites. The River Clubtail is not threatened and therefore has no red-list status (Termaat & Kalkman, 2012). In the rivers near and in the Biesbosch populations are found and since this species is very mobile (Crombaghs & Habraken, 2002), it will most likely colonize new areas. Much is still unknown about this secretive species (Vlinderstichting, 2015). The recolonization of the Netherlands is strongly correlated with the quality of the Dutch rivers. Natural river dynamics will further enhance this species (Janssen & Schaminée, 2008).

Green-eyed Hawker

The Green-eyed Hawker is a typical species of the emergent and fringing hydroseres in relative nutrient rich waters in bogs. These waters need to have (quite) good water quality (De Groot, 2002a). A combination between large plants in the water and submerged plants are necessary for this species occurring. Reproduction takes place in shallow pools in bogs with areas of *Stratiotes aloides* and rich reed beds (De Groot, 2002a; Dijkstra, 2014). There is a strong correlation between the abundance of *Stratiotes aloides* and the density of the Green-eyed Hawker. This species can also reproduce in reed beds with *Utricularia vulgaris* and *Ceratophyllum demersum*. Outside bogs this species reproduces in loamy areas and in closed river arms. Eggs are deposited in the leaves of *Stratiotes aloides* or dead floating plants (De Groot, 2002a). Larvae live near the bank between the submerged vegetation. A wide variety of plants are used for emergence. Imago's almost only forage in sunny areas and when temperatures reach 22 degrees Celsius or higher. A typical territory consists of a strip of 30 metres vegetation on the bank (de Groot, 2002a).

Eggs hatch in the same summer as they were deposited in, whereas the total lifecycle takes up to three years. In warm conditions this lifecycle can be shortened to one year. Imago's can be seen from the beginning of May till the beginning of August (De Groot, 2002a). There are strong distribution correlations between this species and the Brown Hawker and with the Hairy Hawker. This species is very mobile and is often observed far away from reproduction territory (De Groot, 2002a). The number of observations in the Biesbosch indicate that a stable population is present in the area (NDFF, 2016). In 1997, this species was very rare and threatened in the Netherlands. Currently, this species is common in the Netherlands and has lost its red-list status (Termaat & Kalkman, 2012). The creation of beds with *Stratiotes aloides* will further enhance this species, as well as healthy aquatic environments. Mowing of *Stratiotes aloides* should be done in phases (De Groot, 2002a).

APPENDIX 5 - RELATION BUTTERFLY AND VEGETATION 1

Characteristics for butterfly species. Source: Bos et al. (2006); Ferguson (2012); Van Nieuwkerken et al. (2013) Hennekens et al. (2016); Waarneming.nl, (2016).

Species	Food plants	Host plants	Identification difficulty
Lasiommata megera	*Rubus, Trifolium, Cirsium, Buddleja* and others	*Agrostis capillaris (syn. Agrostis tenuis), Agrostis gigantea, Deschampsia flexuosa, Deschampsia cespitosa, Elytrigia repens, Holcus lanatus, Festuca rubra, Poa sp.*	easy
Vanessa atalanta	Shrubs, herbs and ripe fruit	*Humulus lupulus, Urtica dioica, Urtica urens*	easy
Pararge aegeria	Fruiting trees (nectar, sap and fruits), aphids	*Agrostis gigantea, Calamagrostis epigejos, Cynodon dactylon, Dactylis glomerata, Elytrigia repens, Festuca gigantea, Holcus lanatus, Poa annua*	easy
Celastrina argiolus	*Aphids, herbs,* tree sap	*Alnus glutinosa, Clematis vitalba, Cornus sanguinea, Euonymus europaeus, Filipendula ulmaria, Humulus lupulus, Hedera helix, Ilex aquifolium, Ligustrum vulgare, Lythrum salicaria, Medicago sativa, Melilotus officinalis, Rhamnus cathartica, Robinia pseudoacacia, Rubus fruticosus, Rubus idaeus, Syringa vulgaris, Buddleja davidii*	easy
Aricia agestis	*Tanacetum vulgare, Achillea millefolium, Jacobaea vulgaris* and others	*Erodium cicutarium, Geranium pusillum, Geranium molle*	medium
Maniola jurtina	Herbs	*Agrostis canina, Agrostis stolonifera, Alopecurus pratensis, Anthoxanthum odoratum, Helictotrichon pubescens (syn. Avenula pubescens), Dactylis glomerata, Deschampsia cespitosa, Elytrigia repens, Festuca rubra, Holcus lanatus, Lolium perenne, Poa pratensis*	easy
Gonepteryx rhamni	*Salix, Lythrum, Eupatorium* and others	*Rhamnus cathartica, Eupatorium cannabinum, Buddleja davidii, Lythrum salicaria, Salix sp.*	easy
Aglais io	Shrubs and herbs	*Urtica dioica*	easy
Vanessa cardui	Herbs and shrubs	*Arctium minus, Cirsium arvense, Cirsium oleraceum, Cirsium vulgare, Malva moschata, Malva sylvestris, Urtica dioica*	easy

Polygonia c-album	Shrubs and herbs, fruits and tree sap	*Corylus avellana, Humulus lupulus, Ribes nigrum, Ribes rubrum, Salix alba, Salix caprea, Ulmus glabra, Ulmus laevis, Ulmus minor, Urtica dioica*	easy
Ochlodes sylvanus	*Cirsium sp., Rubus sp.,* other herbs	*Agrostis capillaris, Calamagrostis epigejos, Dactylis glomerata, Elytrigia repens, Festuca arundinacea, Holcus lanatus, Juncus effusus, Molinia caerulea, Phleum pratense, Poa spp.*	easy
Pieris brassicae	Herbs, *Taraxacum sp.,*	*Alliaria petiolata, Arabidopsis thaliana, Brassica napus, Hesperis matronalis, Raphanus raphanistrum, Reseda lutea, Reseda Luteola*	easy
Nymphalis polychorus	Tree sap, aphids, fruits, nectar from *Salix.* and other tree species	*Crataegus monogyna, Malus sylvestris, Populus alba, Populus nigra, Populus tremula, Prunus avium, Prunus padus, Salix alba, Salix caprea, Salix viminalis, Ulmus glabra*	hard
Coenonympha pamphilus	Herbs	*Anthoxanthum odoratum, Cynosurus cristatus, Dactylis glomerata, Festuca rubra, Poa annua, Poa pratensis*	easy
Polyommatus icarus	*Fabaceae* and *Lotus corniculatus*	*Securigera varia, Medicago lupulina, Medicago sativa, Melilotus spp., Lotus corniculatus, Ononis repens subs. Fabaceae, Papillionaceae, Trifolium dubium, Trifolium repens, Trifolium pratense, Trifolium spp.*	easy
Pieris napi	Herbs and shrubs	*Alliaria petiolata, Cardamine amara, Cardamine pratensis, Cardamine pratensis subsp. palustris, Hesperis matronalis, Lunaria annua, Nasturtium officinale (syn. Rorippa nasturtium-aquaticum), Raphanus raphanistrum, Sinapis arvensis, Sisymbrium officinale,* (cultivated) *Brassicaceae*	easy
Pieris rapae	Herbs, *Teraxacum sp.* and *Trifolium sp.*	*Alliaria petiolata, Brassicaceae, Brassica oleracea, Brassica napus, Reseda lutea, Raphanus raphanistrum, Sinapis arvensis*	Easy
Aglais urticae	Herbs	*Urtica dioica*	easy
Lycaena phlaeas	*Ranunculus, Thymus pulegioides, Tanacetum parthenium, Tanacetum vulgare, Eupatorium cannabinum, Achillea millefolium, achillea ptarmica* and others	*Persicaria bistorta, Rumex acetosa, Rumex acetosella, Rumex hydrolapathum, Rumex obtusifolius*	easy
Papilio machaon	Nectar from flowering herbs and shrubs *Cirsium sp., Carduus sp., Trifolium sp., Buddleja davidii.*	*Aegopodium podagraria, Angelica archangelica, Angelica sylvestris, Apiaceae, Berula erecta (syn. Sium erectum), Daucus carota, Heracleum sphondylium, Pastinaca sativa, Peucedanum palustre, Pimpinella saxifraga, Sium latifolium*	easy
Araschnia Levana	Herbs, *Apiaceae sp.*	*Urtica dioica, Urtica urens*	easy

Colias croceus	Herbs, *Medicago sp. Trifolium sp.*, *Cirsium sp.*, *Buddleja Davidii.* and others	*Lotus corniculatus var. corniculatus, Lotus spp., Medicago lupulina, Medicago sativa, Medicago spp., Melilotus officinalis, Melilotus spp., Trifolium pratense, Trifolium spp., Vicia spp.*	easy
Pyronia tithonus	Herbs and shrubs	*Agrostis canina, Agrostis capillaris, Alopecurus pratensis, Calamagrostis, Dactylis glomerata, Elytrigia repens, Festuca pratensis, Festuca rubra, Lolium perenne, Phleum pratense subsp. pratense, Poa annua, Poa nemoralis, Poa pratensis, Poa trivialis*	easy
Anthocharis cardamines	*Cardamine pratensis,* other herbs like *Alliaria petiolata, Hesperis matronalis, Lunaria annua, Taraxacum sp.*	*Alliaria petiolata, Brassicaceae, Cardamine amara, Cardamine pratensis, Hesperis matronalis, Lunaria annua, Nasturtium officinale (syn. Rorripa nasturium-aquaticum), Thlaspi arvense, Sinapis arvensis, Sisymbrium officinale*	easy
Thymelicus lineola	Herbs, *Cirsium arvense, Lotus pedunculatus, Lotus corniculatus.*	*Agrostis capillaris, Anthoxanthum odoratum, Arrhenatherum elatius, Alopecurus pratensis, Calamagrostis epigejos, Carex acutiformis, Dactylis glomerata, Elytrigia repens, Holcus lanatus, Holcus mollis, Lolium perenne, Molinia caerulea, Phalaris arundinacea, Phleum pratense subsp. pretense*	medium

APPENDIX 6– RELATION BUTTERFLY AND VEGETATION 2

Relation between butterflies and plant communities. Source: Ferguson (2012); Hennekens et al. (2016).

Code	Name	Butterflies with specific hostplants in vegetation community	Butterfly species with specific foodplants in vegetation community
04BB01	Charetum vulgaris	*Maniola jurtina*	
04CA01	Charetum canescentis		*Lycaena phlaeas*
05BA02	Potametum lucentis		*Lycaena phlaeas*
05CA04	Callitricho hamulatae-Ranunculetum fluitantis	*Thymelicus lineola; Maniola jurtina*	*Lycaena phlaeas (ranunculus)*
05RG04	RG Ceratophyllum demersum-[Nupharo-Potametalia]		*Lycaena phlaeas (ranunculus)*
05RG05	RG Potamogeton pusillus en Elodea nuttallii-[Parvopotamion]	*Maniola jurtina*	*Lycaena phlaeas (ranunculus)*
08AB02	Sagittario-Sparganietum	*Thymelicus lineola; Maniola jurtina; Papilio Machaon*	
14CA03B	Tortello-Bryoerythrophylletum encalyptetosum	*Thymelicus lineola; Pararge aegeria; Ochlodes sylvanus; Coenonympha pamphilus; Pyronia tithonus; Maniola jurtina; Pyronia tithonus; Lasiommata megera; Gonepteryx rhamni*	*Anthocharis cardamines; Pieris brassicae; Lycaena phlaeas; Gonepteryx rhamni; Nymphalis polychorus*
21AB01	Asplenietum ruto-murario-trichomanis	*Celastrina argiolus*	
21AB02	Filici-Saginetum	*Pararge aegeria; Coenonympha pamphilus; Pyronia tithonus; Maniola jurtina; Celastrina argiolus; Gonepteryx rhamni*	*Papilio machaon; Colias croceus*
33RG03	RG Petasites hybridus-[Galio-Urticetea]	*Araschnia Levana; Aglais urticae; Polygonia c-album; Vanessa cardui; Aglais io; Vanessa atalanta; Pyronia tithonus; Papilio machaon; Thymelicus lineola; Pararge aegeria; Maniola jurtina; Ochlodes sylvanus; Lasiommata megera; Lycaena phlaeas; Gonepteryx rhamni; Coenonympha pamphilus; Nymphalis polychorus; Celastrina argiolus*	*Thymelicus lineola; Lycaena phlaeas; Gonepteryx rhamni; Nymphalis polychorus*

38AA01B	Artemisio-Salicetum agrostietosum stoloniferae	*Araschnia Levana; Aglais urticae; Polygonia c-album; Vanessa cardui; Aglais io; Vanessa atalanta; Pyronia tithonus; Maniola jurtina; Gonepteryx rhamni; Nymphalis polychorus; Thymelicus lineola; Pararge aegeria; Ochlodes sylvanus; Coenonympha pamphilus; Lasiommata megera; Lycaena phlaeas; Celastrina argiolus; Anthocharis cardamines; Pieris rapae; Pieris napi; Pieris brassicae; Polyommatus Icarus*	*Gonepteryx rhamni; Nymphalis polychorus; Ochlodes sylvanus; Papilio machaon; Colias croceus; Thymelicus lineola; Lycaena phlaeas; Anthocharis cardamines; Pieris brassicae; Anthocharis cardamines*
38AA03A	Cardamino amarae-Salicetum anthriscetosum	*Pyronia tithonus; Pieris napi; Gonepteryx rhamni; Polygonium c-album; Nymphalis polychorus; Araschnia levana; Aglais urticae; Vanessa cardui; Aglais io; Vanessa atalanta; Lycaena phlaes; Thymelicus lineola; Papilio machaon; Celastrina argiolus; Maniola jurtina; Polyommatus icarus; Colias croceus*	*Nymphalis polychorus; Gonepteryx rhamni; Lycaena phlaes; Ochlodes sylvanus; Lasiommata megera; Pieris rapae; Papilio machaon; Colias croceus*
38DG01	DG Impatiens glandulifera-[Salicion albae/Alno-Padion]	*Araschnia Levana; Aglais urticae; Polygonia c-album; Vanessa cardui; Aglais io; Vanessa atalanta; Lasiommata megera; Ochlodes sylvanus; Pyronia tithonus; Gonepteryx rhamni; Nymphalis polychorus; Celastrina agriolus; Pieris brassicae; Pieris napi; Pieris rapae; Anthocharis cardamines; Thymelicus lineola; Papilio machaon; Pararge aegeria; Maniola jurtina; Colias croceus*	*Gonepteryx rhamni; Nymphalis polychorus; Anthocharis cardamines; Lycaena phlaes*

APPENDIX 7 – MAMMAL ECOLOGY

Tundra Vole

The subspecies of the Tundra Vole (ssp. *arenicola*) is endemic to the Netherlands (Janssen & Schaminée, 2008; Koelman, 2007). This is the only mammal in the Netherlands that is endemic and is therefore of real conservation interest. The Tundra Vole (Figure 55), however, is classified as vulnerable on the red list of Mammals in the Netherlands (Koelman, 2007; Zoogdiervereniging, n.d.-d). This conservation status requires that this species gets special conservation attention. Therefore, specific areas are maintained for the conservation this species (Koelman, 2007). The Tundra Vole is active during the day as well as during night (Koelman, 2007; Zoogdiervereniging, n.d.-d). They are avid diggers and create molehills in their home ranges. A female can produce up to seven young in a nest following a gestation period of three weeks. This herbivore eats a wide variety of plants and stores food supplies in small chambers below the soil surface during winter (Koelman, 2007; Zoogdiervereniging, n.d.-d).

Figure 55. Tundra Vole.
Source:http://www.ecomare.nl/ecomare-encyclopedie/organismen/dieren/zoogdieren/knaagdieren/woelmuizen/noordse-woelmuis/

The Tundra Vole can live in a wide range of habitats, including reed-beds and wet grasslands, but it is susceptible to competition with other vole species (Janssen & Schaminée, 2008; Koelman, 2007). Fluctuating water levels, like winter inundation are necessary to ensure the success of this species as they are more adaptable to these conditions than other vole species (Janssen & Schaminée, 2008; Koelman, 2007). Over the last couple of years, the Tundra vole has been under pressure in the Netherlands due to intensive agriculture and recreation. For this reason the species is very dependent on wet to temporary inundated areas with *Phragmites* and *Carex* vegetation. Extensive mowing has disastrous results on the population. Therefore, periodic mowing is suggested (Koelman, 2007). Land bridges between islands should be avoided in order to reduce predation pressures (Janssen & Schaminée, 2008).

Pond Bat

Of the 18 bat species in the Netherlands (Haarsma, 2008) the Pond Bat (Figure 56) is the most important one for the Biesbosch. It has been assigned as a Natura 2000 target species (Janssen & Schaminée, 2008; Programmadirectie Natura 2000, 2013). This species is under strict regulation of the law of Flora and Fauna due to their migratory needs (Haarsma, 2008). This bat species is of an average size and mainly lives inside or in the wall of houses (Haarsma, 2008; Janssen & Schaminée, 2008). It forages on water bodies catching all kinds of flying and floating insects. It is a common species in low lying, water rich areas in the Netherlands (Haarsma, 2008). During summer months, the Pond Bat can only be found near waterways and wetlands in the Netherlands. In the vicinity of the Biesbosch there are two sites where an overnight population of this species can be found. Both these sites are places where mainly females live. Locations where males live can be found a little farther away from the Biesbosch (Haarsma, 2008). During winter, the male and female populations migrate to merge at other sites. Migration takes place along the same routes every year, mainly following commuter routes along water bodies (Haarsma, 2008; Haarsma & Siepel, 2013; Janssen & Schaminée, 2008). Mating in this species occurs during the winter. The bat is very mobile and can easily fly long distances looking for food (Haarsma, 2008; Janssen & Schaminée, 2008).

Figure 56. Pond Bat.
Source:http://www.ecopedia.be/38/dieren/Meervleermuis

Beaver

The Beaver (Figure 57) is the largest rodent in Europe and only has been reintroduced in the Netherlands in 1988 after having gone extinct in 1826 (Janssen & Schaminée, 2008; Sluiter, 2003; Zoogdiervereniging, n.d.-c). Beavers can be found in the buffer zone between terrestrial and aquatic ecosystems, like swamps and along brooklets and rivers (Zoogdiervereniging, n.d.-c). It prefers quiet places near rivers and lakes and riparian forest consisting of *Salix* sp. or *Fraxinus* sp.. Forest on the banks of flowing water is a key habitat requirement for the Beaver (Zoogdiervereniging, n.d.-c). Beavers are great ecosystem engineers, and they influence their environment by building dams (Janssen & Schaminée, 2008; Zoogdiervereniging, n.d.-c). Water depth need to be at least 50cm, but water bodies with a depth less than the threshold can be occupied (Janssen & Schaminée, 2008; Zoogdiervereniging, n.d.-c). In the latter situation the presence of beavers results in a rise in the water table due to their damming activities (Zoogdiervereniging, n.d.-c). These nocturnal animals do not hibernate, but during winter they can are restricted to their dens by the formation of ice sheets. During these situations they entirely depend on their food supplies of branches and tree bark stored in their dens. In summer, the Beaver's diet consists of soft tree species, like *Populus* and *Salix* species (Janssen & Schaminée, 2008; Zoogdiervereniging, n.d.-c). To this diet herbs and leaves of trees can be added (Zoogdiervereniging, n.d.-c) (Janssen & Schaminée, 2008). Young are born after a pregnancy of three and a half months and after 2-3 years they are fully grown. The Beaver is incorporated in the red-list of Mammals (Zoogdiervereniging, n.d.-c) and therefore some Natura 2000 areas are assigned as living area for the species. The Biesbosch is one of those area's (Programmadirectie Natura 2000, 2013; Zoogdiervereniging, n.d.-c). The population in the Biesbosch is growing vastly, but due to its current size the population is susceptible to diseases (Zoogdiervereniging, n.d.-c). Besides this, the reproduction capabilities of the beaver can be negatively affected by heavy metal pollution (Janssen & Schaminée, 2008).

Figure 57. Beaver. Source: http://www.freppi.com/Patronenbever.aspx

Otter

The Otter (Figure 58) was extinct in the Netherlands but has been reintroduced in 2002 (Dijkstra, Niewold, & Jansman, 2012; Zoogdiervereniging, n.d.-e). Its distribution is limited to the eastern part of the Netherlands, and no population has been established in the Biesbosch yet (Telmee.nl, n.d.). The Otter can be found in a wide array of surface waters with a healthy fish population. There is, however, a preference to dense bank vegetation and marshes (Dijkstra et al., 2012) and to areas with less disturbance (Zoogdiervereniging, n.d.-e). The Otter is a very good swimmer and is mainly fish-eating, but amphibians, grass snakes, birds and mammals can be added to the diet (Dijkstra et al., 2012; Zoogdiervereniging, n.d.-e). It can eat up to 1,5 kilograms every day (Zoogdiervereniging, n.d.-e). This solitary animal all have their own large territories (Dijkstra et al., 2012). These relatively nocturnal animals can give birth to up to 4 young every year. They need a nest in a quiet, remote area. This nest mostly is positioned in a burrow or under a tree or shrub (Dijkstra et al., 2012). One of the greatest threats to the otter is the amount of toxic substances, among which are heavy metals, in the Dutch rivers. These substances can lead to reduces reproductive capacity (CBS, PBL, & Wageningen UR, 2015; Lammertsma & van den Brink, 2012).

Figure 58. Otter. Source: http://archies.info/animals/river-otter/

Eurasian Harvest Mouse

The Eurasian Harvest Mouse (Figure 59) is quite common in the Netherlands and is noted to be a typical species of habitat type H6430 found in the Biesbosch (Programmadirectie Natura 2000, 2008). Between spring and fall it prefers tall grasses, *Carex sp.*, roughages, wooded banks and dunes as its living habitat (Zoogdiervereniging, n.d.-b). It seems to avoid intensively grazed or mowed grasslands. During winter it stays in farmhouses, barns or haystacks (Zoogdiervereniging, n.d.-b). This mainly nocturnal animal lives on solitary basis. Its diet consists of plants, insects and caterpillars and is adapted according the seasons (WAZA, n.d.; Zoogdiervereniging, n.d.-b).

Figure 59. Eurasian Harvest Mouse.
Source: http://www.visualnews.com/2012/06/14/the-tiny-world-of-the-eurasian-harvest-mouse/

The nest is built hanging in the vegetation and is made of woven grasses. A different nest is built for resting and for reproduction. The generation time for this species is 3 months (Zoogdiervereniging, n.d.-b). Densities of this species can go up to 250 individuals per hectare (Zoogdiervereniging, n.d.-b).

Eurasian Water Shrew

The Eurasian Water Shrew (Figure 60) is noted to be a typical species of habitat type H6430 found in the Biesbosch (Programmadirectie Natura 2000, 2008). It can be found near clean, moderately nutrient and richly vegetated water bodies. Preferred locations are near brooklets, drainage ditches, rivers, lakes and places with ground water seepage (The Mammal Society, n.d.; Zoogdiervereniging, n.d.-a). This species is very abundant at beds of water-cress (The Mammal Society, n.d.). In the Netherlands the habitat for this species is rather fragmented (Zoogdiervereniging, n.d.-a). The Eurasian Water Shrew predates, on insects and other invertebrates as well as small fish and amphibians (The Mammal Society, n.d.; Zoogdiervereniging, n.d.-a) using its venomous saliva (The Mammal Society, n.d.). They eat at least their own weight every day. The nest is built in small pits or burrows of other animals at the bank (Zoogdiervereniging, n.d.-a). The generation time of this shrew is at least 8 months (ADW, n.d.). The Eurasian Water Shrew is indicated as 'vulnerable' on the red list as a consequence to habitat fragmentation and pollution (Zoogdiervereniging, n.d.-a).

Figure 60. Eurasian Water Shrew.
Source: https://www.ivn.nl/afdeling/mierlo/activiteiten/lezing-ron-vodegel-hoe-vang-je-een-waterspitsmuis

APPENDIX 8 – SPECIES SELECTION TOOL

Important note

This tool is to be used only as a rough guide to species selection only after a complete assessment.
This should include a detailed investigation of the selected habitat *in-situ* for the specific ecological requirements of the species' present.

Steps for selection		**Source**
Note: For vegetation selection go through steps 1 -> 2 -> 3. **For the selection of animals** go through steps 1 -> 4 -> 5 -> 6		
1	Choose habitat type	External source
2	Select plant species according to habitat type	Example: sheet "Eg. Veg. Integration"
3	Decide on which greening structures to use	Greening Chapter in combination with sheet "Eg. Veg. Integration"
4	Identify habitat structure in habitat type	External source (SynBioSys)
5	Identify target animal species according to habitat structures	Sheet: "Eg. Hab. Structure"
6	Decide on which greening structure to use	Greening chapter and Methods of species selection chapter in combination with sheet "Eg. Hab. St. Integration"

Index-sheets	**Content of sheet**	**Note**
Example Vegetation Integration	Table with greening components suitable for each plant species addressed in (Ch. 3)	Before integrating the plant species, the specific ecological requirements of each species must be addressed with an *in-situ* assessment
Example Habitat Structure	Table with animal species (groups) and their habitat structure requirements as addressed in (Ch. 3)	Before selecting animal species, the habitat structures of the selected habitat type should be extracted from vegetation databases like SynBioSys or by using ecological experts.
Example Habitat Structure Integration	Table with greening components suitable for each habitat structure in a habitat type	

Index-codes		
Trees	Tr	Plants with an elongated stem or trunk supporting branches and leaves
Ferns	Fe	Sporulating plants bigger than mosses , so no flowering!
Grasses	Gr	Vegetation consisting of typically short plants with long narrow leaves.
Mosses	Mo	Small flowerless plants, green plants that lack true roots. Usualy grow as a carpet layer or rounded cushings in damp habitats
Flowering plants	Fp	Plant without woody stems, producing flowers. All plants that do not fit in the other categories
Butterflies	Bu	
Dragonflies	Dr	
Birds	Br	
Mammals	Ma	
Spiders	Sp	
Beetles	Bt	
Bees	Be	
Amphibians	Am	

Production	Action	contact details (22-04-2016)
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Version		Contact details
1.0	Beta version: including all species based on literature study from 18-03-2016 till 22-04-2016	gregory.vandentop@wur.nl
1.1	Beta version: minor tweaks to version 1.0	gregory.vandentop@wur.nl
1.2	Beta version: unfeasable species to target according to environmental requirements are removed	gregory.vandentop@wur.nl

Sheet Vegetation Integration

			living grid									shell									Lodge		
Species name	**Habitat type**	**Code**	**Rock garden**	**Deadwood pile**	**Bat-boxes**	**Muddy bank**	**Insect hotel**	**Hibernacula**	**Pond**	**Spider bricks**	**Flower patch**	**Living wall**	**Vertical garden**	**Sandy wall**	**Bat-boxes**	**Spider bricks**	**Insect hotel**	**Nest boxes**	**Pond**	**Flower patch**	**Insect hotel**	**Stilts**	**Green roof**
Potamogeton perfoliatus	*H3260*	Fp				y			y										y				
Potamogeton nodosus	*H3260*	Fp				y			y										y				
Potamogeton pectinatus	*H3260*	Fp				y			y										y				
Elodea Canadensis	*H3260*	Fp				y			y										y				
Chenopodium rubrum	H3270	Fp		y		y			y		y								y	y			
Rumex palustris	H3270	Fp				y			y										y				
Rumex maritimus	H3270	Fp				y			y										y				
Persicaria lapathifolia	H3270	Fp		y		y			y			y	y						y				y
Potentilla supina	H3270	Fp				y			y		y	y	y						y	y			y
Veronica anagallis-aquatica	H3270	Fp				y			y		y								y	y			
Cyperus fuscus	H3270	Gr				y			y										y				
Pulicaria vulgaris	H3270	Fp				y			y		y								y	y			
Lythrum hyssopifolia	H3270	Fp				y			y										y				
Artemisia biennis	H3270	Fp									y	y	y							y			y
Limosella aquatica	H3270	Fp				y			y										y				
Nasturtium officinale	H3270	Fp							y										y				
several Bidens species	H3270	Fp		y							y	y	y							y			
Filipendula ulmaria	*H6430*	Fp				y			y		y	y	y						y	y			
Valeriana officinali	*H6430*	Fp									y									y			y
Veronica longifolia	*H6430*	Fp									y									y			y
Euphorbia palustris	*H6430*	Fp									y									y			y
Thalictrum flavum	*H6430*	Fp				y			y		y								y	y			y
Senecio fluviatilis	*H6430*	Fp						y			y	y		y	y						y		
Caltha palustris subsp. Araneosa	*H6430*	Fp				y																	
Mentha longifolia	*H6430*	Fp				y			y		y								y	y			
Sonchus palustris	*H6430*	Fp				y			y		y								y	y			
Salix alba	*H91E0*	Tr			y	y			y									y					
Salix viminalis	*H91E0*	Tr			y	y			y									y					
Urtica dioica	*H91E0*	Fp				y			y		y								y	y			y
Symphytum officinale	*H91E0*	Fp				y			y		y	y	y						y	y			
Phalaris arundinacea	*H91E0*	Gr				y			y		y								y	y			y
Galium aparine	*H91E0*	Fp									y	y	y							y			y
Lythrum salicaria	*H91E0*	Fp				y			y										y				
Iris pseudacorus	*H91E0*	Fp				y			y		y								y	y			
Cardamine amara	*H91E0*	Fp				y			y		y								y	y			
Populus nigra	*H91E0*	Tr			y	y			y									y					
Anomodon viticulosus	*H91E0*	Mo	y	y		y		y	y			y	y	y					y			y	y
Homalia trichomanoides	*H91E0*	Mo	y	y		y		y	y			y	y						y				y
Orthotrichum rogeri	*H91E0*	Mo	y	y		y		y	y			y	y						y				y
Timmia megapolitana	*H91E0*	Mo	y	y		y		y	y			y	y						y				y
Fissidens gymnandrus	*H91E0*	Mo	y	y		y		y	y			y	y						y				y
Prunus padus	*H91E0*	Tr				y			y														
Festuca gigantea	*H91E0*	Gr	y								y									y			y
Rumex sanguineus	*H91E0*	Fp							y			y	y						y				y
Equisetum hyemale	*H91E0*	Fe		y		y			y										y				y
Elymus caninus	*H91E0*	Gr				y			y		y	y	y						y	y			y
Geranium phaeum	*H91E0*	Fp		y							y	y	y						y	y			y

Sheet Habitat Structure

Species name	Code	Reed-bed	Drainage ditch	Pond/Lake	River	Wetland Forest	Roughage	Meadow	Grassland	Bank	Manmade structures	Refuge
Lasiommata megera	Bu						y	y	y			
Vanessa atalanta	Bu						y				y	
Pararge aegeria	Bu					y		y	y			
Celastrina argiolus	Bu					y	y	y				
Aricia agestis	Bu							y				
Maniola jurtina	Bu							y	y			
Gonepteryx rhamni	Bu					y		y				
Aglais io	Bu						y	y				
Vanessa cardui	Bu						y	y				
Polygonia c-album	Bu					y	y	y			y	
Ochlodes sylvanus	Bu						y	y	y			
Pieris brassicae	Bu						y	y				
Nymphalis polychloros	Bu					y	y					
Coenonympha pamphilus	Bu							y	y			
Polyommatus icarus	Bu							y				
Pieris napi	Bu							y				
Pieris rapae	Bu							y				
Aglais urticae	Bu						y					
Lycaena phlaes	Bu						y	y				
Papilio machaon	Bu						y	y				
Araschnia levana	Bu						y					
Colias croceus	Bu							y				
Pyronia tithonus	Bu							y	y			
Anthocharis cardamines	Bu							y				
Thymelicus lineola	Bu							y	y			
Phalacrocorax carbo	Br			y	y	y						
Circus aeruginosus	Br	y					y	y	y			
Alcedo atthis	Br		y	y	y	y				y		
Luscinia svecica	Br	y				y						
Locustella luscinioides	Br	y										
Acrocephalus schoenobaen	Br	y										
Podiceps cristatus	Br		y	y	y							
Casmerodius albus	Br	y		y	y		y			y		
Platalea leucorodia	Br	y		y	y							
Cygnus columbianus bewic	Br							y	y			
Anser albifrons	Br							y	y			
Anser Anser	Br							y	y			
Branta leucopsis	Br							y	y			
Anas Penelope	Br	y	y	y	y		y			y		
Anas strepera	Br	y	y	y	y					y		
Anas crecca	Br	y		y	y		y			y		
Anas platyrhynchos	Br	y	y	y	y				y	y		
Anas acuta	Br		y	y	y		y		y	y		
Anas clypeata	Br	y		y	y				y	y		
Aythya ferina	Br	y		y	y							
Aythya fuligula	Br		y	y	y							
Mergellus albellus	Br		y	y	y					y		
Mergus merganser	Br			y	y	y						
Fulica atra	Br	y	y	y	y					y		
Limosa limosa	Br							y	y		y	
Aeshna grandis	Dr		y	y		y				y		
Libellula fulva	Dr		y	y			y			y		
Brachytron pratense	Dr		y	y		y	y	y		y		
Lestes viridis	Dr			y		y						
Somatochlora metallica	Dr	y		y		y				y		
Gomphus flavipus	Dr				y					y		
Aeshna isoceles	Dr		y	y								
Microtus oeconomys	Ma						y	y	y	y		y
Myotis dasycneme	Ma			y	y						y	
Micromys minutus	Ma	y				y	y	y	y			y
Neomys fodiens	Ma	y	y	y		y	y			y		
Spiders	Sp	y				y	y	y	y		y	y
Beetles	Bt					y	y	y	y	y	y	y
Bees	Be					y		y	y		y	y
Amphibians	Am	y	y	y	y	y	y			y		y

Sheet Habitat Structure Integration

Habitat structure	living grid									shell									Lodge		
	Rock garden	Deadwood pile	Bat-boxes	Muddy bank	Insect hotel	Hibernacula	Pond	Spider bricks	Flower patch	Living wall	Vertical garden	Sandy wall	Bat-boxes	Spider bricks	Insect hotel	Nest boxes	Pond	Flower patch	Insect hotel	Stilts	Green roof
Reed-bed				y		y	y			y										y	
Drainage ditch				y		y						y									
Pond/Lake				y			y					y					y			y	
River				y			y					y					y			y	
Wetland Forest	y	y	y		y	y		y				y	y			y			y		
Roughage	y	y			y	y	y	y	y	y	y			y	y		y	y	y		y
Meadow	y	y			y	y	y	y	y	y	y			y	y		y	y	y		y
Grassland	y	y					y	y	y					y	y		y	y	y		y
Manmade structures	y	y	y		y	y		y		y	y	y	y	y	y	y			y	y	y
Refuge	y	y	y		y		y	y	y	y	y	y	y	y	y	y	y	y	y	y	y

Please note that this appendix has been retrieved from the Species selection tool Excel file. We suggest to use the Excel file for any analysis.

APPENDIX 9 – FIELD FORMS

Field forms for experts and guests are given below.

BIRD MONITORING FIELDFORM EXPERTS

Name of Recorder: Date:
Address:
Start Time: End Time: Wind Speed: Sample Station:

Species Name	Number of Sightings	Behaviour				
		F	SG	G	S	N

F – Flying over head
SG – Foraging
TG – Roosting (Resting)
S – Singing
N – Nesting

BIRD MONITORING FIELD FORM GUESTS

Name of Recorder: Date:
Address:
Start Time: End Time: Wind Speed: Sample Station:

Species Name	Number of Sightings	Behaviour				
		F	SG	TG	S	N
Aalscholver						
Roerdomp						
Bruine kiekendief						
Porseleinhoen						
IJsvogel						
Blauwborst						
Snor						
Rietzanger						
Fuut						
Aalscholver						
Grote zilverreiger						
Lepelaar						
Kleine zwaan						
Kolgans						
Grauwe gans						
Brandgans						
Smient						
Krakeend						
Wintertaling						
Wilde eend						
Pijlstaart						
Slobeend						
Tafeleend						
Kuifeend						
Nonnetje						
Grote zaagbek						
Zeearend						
Visarend						
Meerkoet						
Grutto						

F – Flying over head
SG – Foraging
TG – Roosting (Resting)
S – Singing
N – Nesting

MAMMALS CAMERA TRAPPING

Name of the person who checks the camera:

Address of the person:

Camera No	Location of Camera		Active time			Result	Comments
	Latitude	Longitude	Camera Installation date and time	Camera Removal date and time	Trap effort (hours)	Species	

MAMMALS LIVE TRAPPING

Name of the person who check the Trap:

Address of the person:

Trap No	Location of Trap		Active time			Result	Comments
	Latitude	Longitude	Trap Installation date and time	Trap Removal date and time	Trap effort (hours)	Species	

MAMMAL MONITORING FIELD FORM GUESTS

Recorder Name:

Address of Recorder:

Name of the Species	Location (direction from Lodge)	Habitat (e.g muddy bank, garden etc)	Time

DRAGONFLY MONITORING FIELD FORM EXPERTS

Name of Recorder: Date:
Address:
Start Time: End Time: Wind Speed: Temperature:

Cloud Cover: Transect No: Transect Section:

Changes in management/biotope compared with last year: ☐ Yes ☐ No

Comments if any change:

Species Name	Number of Sightings	Total

DRAGONLFY MONITORING FIELD FORM GUESTS

Name of Recorder: Date:
Address:
Start Time: End Time: Wind Speed: Temperature:

Cloud Cover: Transect No: Transect Section:

Species Name	Number of Sightings	Total
Small dragonflies		
Houtpantserjuffer		
Large dragonflies		
Bruine glazenmaker		
Vroege glazenmaker		
Bruine korenbout		
Glassnijder		
Metaalglanslibel		
Keizerlibel		
Platbuik		
Weidebeekjuffer		

BUTTERFLY MONITORING FIELD FORM EXPERTS

Name of Recorder: Date:
Address:
Start Time: End Time: Wind Speed: Temperature:

Cloud Cover: Transect No: Transect Section:

Changes in management/biotope compared with last year: ☐ Yes ☐ No

Comments if any change:

Species Name	Number of Sightings	Total

BUTTERFLY MONITORING FIELD FORM GUESTS

Name of Recorder: Date:
Address:
Start Time: End Time: Wind Speed: Temperature:

Cloud Cover: Transect No: Transect Section:

Species Name	Number of Sightings	Total
Argusvlinder		
Atalanta		
Bont zandoogje		
Boomblauwtje		
Bruin blauwtje		
Bruin zandoogje		
Citroenvlinder		
Dagpauwoog		
Distelvlinder		
Gehakkelde aurelia		
Groot dikkopje		
Groot koolwitje		
Grote vos		
Hooibeestje		
Icarusblauwtje		
Klein geaderd witje		
Klein koolwitje		
Kleine vos		
Kleine vuurvlinder		
Koninginnenpage		
Landkaartje		
Oranje luzernevlinder		
Oranje zandoogje		
Oranjetipje		
Zwartsprietdikkopje		

TERRESTRIAL ARTHROPODS MONITORING FIELD FORM EXPERTS

Name of the person who check the Trap:

Address of the person:

Pit fall trap No	Location of pit fall trap		Active time			Result	Comments
	Latitude	Longitude	Pit fall trap Installation date and time	Pit fall trap Removal date and time	Trap effort (hours)	Species	

VEGETATION MONITORING FIELD FORM EXPERTS

Vegetation monitoring - Experts

Habitat type name + nr:	
Start time - End time:	Date:
Contact details observer Name: Street + nr.: Zip code: City: Telephone: E-mail:	

Changes compared to last year:

	Yes	No
In management		
In environmental conditions		

If yes, please fill in quadrat code(s) + explanation of change:

Quadrat code:	Explanation:

Comments:

Observed Vegetation

Quadrat nr.:	Quadrat size: ….. x ….. m
Species name	# Individuals

Quadrat nr.:	Quadrat size: ….. x ….. m
Species name	# Individuals