The Pioneering Forest

an explorative design research into large scale afforestation

Msc Thesis Landscape Architecture
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Colophon

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Foreword

Dear reader,

Before you lies my final written master thesis to fulfill the final phase of the Master Landscape Architecture at the Wageningen University. The majority of this thesis has been carried out during times of Covid restrictions. The isolation has been truely challenging, and I truly want to thank my friends and family for their support.

Special thanks go out to my partner and father. I want to thank Antje and Tjeerd for providing me with a much-needed workplace outside of my home. And finally, I want to thank Adriaan for guiding me, with a lot of patience, through this journey. I have learned many valuable things that I will take with me for the rest of my life.

Last but not least, I would like to thank everyone who has inspired me during this time. Thanks to Simon Klingen, Marjan van Elsland, and my accountability-buddies.

Abstract

To realize the goals of the Paris Climate Agreement, forest cover in the Netherlands should be expanded with 10% by 2030. However, forests have a vulnerable position in the context of economic competition for claiming space, and many other spatial claims are exerting pressure on the disappearance of the remaining cultural landscape inside the highly urbanized Dutch landscape. Strategies for the implementation of forest have been proposed, but a concrete translation into landscape design is often missing. This explorative design research aims to find insights on how to claim space for large scale afforestation, so that it contributes to enhancing spatial quality.

The diverse cultural landscape of the Region of Zwolle serves as a testing ground for systemic regional design that explores in which way large scale afforestation could be implemented and articulated. The research consisted of 4 steps. By conducting Research for design and a landscape analysis, a knowledge base was created on forest systems and factors that contribute to afforestation. This base was used as input for the second step, a model study. This model study aimed to find suitable configurations, locations and strategies in the region, that were evaluated using criteria. After evaluation, additional models helped combining the found strategies on location. Eventually a synthesis was designed and elaborated.

To articulate large scale afforestation while enhancing spatial quality, the multifunctional character of forest is used to integrate functions and programming inside the forest, while combining these functions with a broad range of landscape experiences. This interweaves the forest design with the fabric of the underlying landscape. The forest acts as an attraction factor to the region, and a structure of voids creates possibilities for flexibility, providing a varied recreational experience while maintaining ecological connectivity. Housing development and cycling routes are coupled to infrastructure to ensure accessibility.

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Chapter 1. Introduction

Part I. Introduction

Introduction.

Globally, we are in the middle of complex and urgent societal debates about climate change. These debates are intensified by the recent signing of the Paris Climate Agreement, and the urgency to reach the formulated goals before 2030. All 195 countries that signed, including The Netherlands, are now facing the task to massively reduce carbon dioxide (CO_2) emissions. The successive Dutch Climate Agreement has formulated the ambition that by 2030, 49% of carbon emissions should be reduced (compared to the emissions of 1990) (Rijksoverheid, 2019). Simultaneously, CO_2 should be reduced by increasing carbon sinks (Verkerk *et al.* 2020).

Forests prove to be good carbon storage sinks in the long term and the production of wood can substitute emission-intensive materials (Verkerk *et al.* 2020). To realize the goals of the Dutch Climate Agreement, different sectors contribute in various ways. For the sector of agriculture and land use, a National Forestry Strategy is created, in which the goal is formulated to expand forest cover in the Netherlands with 10% by 2030. This means 37.000 ha of new forests (Ministerie van LNV 2020).

However, next to the desired expansion of forest cover, other spatial claims are expected in the near future, like housing development, water safety measures and the energy transition (Ministerie van LNV 2020). On top of that, circular economy, infrastructure, recreational pressure and biodiversity are all demanding space (Rijksoverheid 2020). Even though the Netherlands has a remarkably long history of changing, adapting and redesigning the landscape, it is now more than ever facing a competition for space. The Netherlands is densely populated, and every square meter of space is utilized. Vacant land does not exist. All these claims are exerting pressure on the disappearance of the remaining cultural landscape inside the highly urbanized Dutch landscape.

Because the Netherlands is facing urgent and complex spatial challenges (Rijksoverheid 2020), changes in land use are needed. Recent policies urge to find and use win-win situations so that the new landscape can contribute to improved spatial quality (Rijksoverheid 2019). Luckily, forests have a multifunctional character, fulfill many societal functions and can be combined with many other functions inside the landscape. However, forests are also often seen as a primarily natural land use, and nature in general is often mistreated as a sector that can be weighed with the interest of other sectors (Staatsbosbeheer 2020). This makes the position of afforestation in the context of economic competition for claiming space vulnerable. It is therefore important to emphasize that forests can fulfill economic functions as well, both direct and indirect (Ministerie van LNV 2020).

However, looking at proposed strategies and visions for afforestation, the multifunctional character of forests is underexposed and some aspects of forests, such as aesthetics, accessibility and recreation are treated as secondary matters to the natural or economic value. Case- and pilot studies are being executed, but focus on small scaled interventions. This is valuable research, as it contributes for example to the 'Climate-Smart Toolbox for Forest- and Naturemanagement' (VBNE 2022) where bite-sized solutions and ideas stimulate to connect science to action while demonstrating all sorts of potentials. A concrete translation of these strategies into a landscape design is nevertheless often missing, especially on a regional landscape scale level. On top of that, the potential of truly large scale afforestation in the Dutch cultural landscape has not been researched.

As a student landscape architecture, I feel responsible for researching this potential, as it can stimulate to approach the complex spatial challenges of today from a large scaled design perspective, moving away from short term, procedural decision making, towards desirable and feasible proposals for the future. Large scaled landscape changes have been successful before in the Dutch cultural landscape, such as the land consolidation efforts or Delta works, and it's therefore not unimaginable that regional or even national design can shape the landscape again.

Knowledge gap

Even though the knowledge on forest management has greatly increased in the last 100 years, the knowledge on how to integrate such large amounts of forests inside the Dutch cultural landscape is in its infancy today. On top of that, the many expected spatial claims and the urgency behind these changes are exerting extra pressure on the valuable cultural landscape. How can space be claimed for large scale afforestation inside the Dutch cultural landscape?

Research Approach

Forests act as a natural tool to shape the landscape with a wide range of effects on different aspects of the environment. Therefore, finding locations for new forests requires systematically organizing functions and shaping these locations. An integral landscape architectural design research using the systems view can help finding insights on how to claim space for large scale afforestation, so that it contributes to enhancing spatial quality.

The aim of developing a regional design is to generate new insights into the placement and design of forests in the Dutch cultural landscape. This is done by taking a Research through Design approach in the constructivist claim, in the form of a regional qualitative case study in the Region of Zwolle.

Research through Design in the constructivist claim is predominantly about generating insights by exploring the 'new' and 'unknown' (Lenzholzer *et al.* 2013). The knowledge to be produced is qualitative and revolves around suggesting new constructs, in this case, for new physical constructs as forms of landscapes. The knowledge generated is not generalizable since it is embedded in the context of physical and social environments, but can be transferable to a certain extent. Constructivist research may help to find creative new solutions (Lenzholzer *et al.* 2013).

For this research the Region of Zwolle is chosen as a location (figure 2). The region consists of different valuable cultural landscapes that represent some of the dominant cultural landscapes present in the Dutch landscape. There are river landscapes, higher and dryer sandy soils, stream valleys, peat meadows and reclamations. This region therefore acts as a suitable demo landscape for the research into the implementation of forests in the Dutch cultural landscape.

Objectives

The pressure on the disappearance of the Dutch cultural landscape calls for a careful implementation of large scale afforestation, that can articulate and express the cultural landscape, instead of override it. The relatively weak economic position of forests compared to other land uses also underlines the need to find and create win-win situations and spatial quality. This thesis therefore aims to create a regional design that generates new insights on how large scale afforestation can be implemented in the Dutch cultural landscape of the Region of Zwolle.

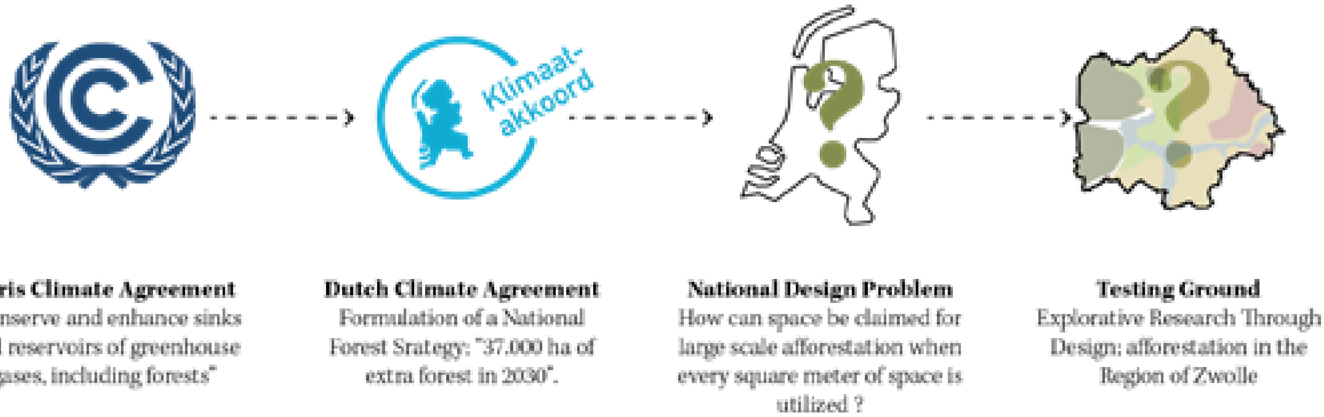


Figure 1: Sequence of the afforestation brief

Report Structure

After the introduction, a conceptual framework is used to briefly explain main concepts such as systemic design, spatial quality and multifunctionality. Then, a contextual backdrop is given that creates an overview of the role of afforestation in the climate debate, a clarification on the chosen testing ground, a framing of this thesis' brief in hectares and forest in a European context.

When thinking about meeting the afforestation ambition, two broad questions arise: Where and How? First, the different components and factors that contribute to the implementation are analyzed in the second and third chapter. This is taken into account when searching for a location within the Region of Zwolle using a model study in the fourth chapter. Conceptual models are designed to narrow down on locations and strategies, followed by models that weigh the found strategies on a more specific location. In the fifth chapter a regional masterplan will be designed more towards a detailed plan which acts as a design synthesis. Finally, the research is concluded and discussed in the sixth chapter.

Research Questions

Main Design Question
In which way could large scale afforestation be implemented and articulated in the diverse cultural landscape of the Region of Zwolle?

In order to answer the Main Design question (MDQ), different sub research questions need to be answered. These are questions that provide both Knowledge for Design and Knowledge through Design(ing), and therefore correspond with two different phases. The knowledge phase of this research consists of studying information that informs and supports the designing process. These questions are therefore called knowledge questions. The second phase is the design phase, where design questions guide the designing process.

Knowledge Questions

KQ1. What components does a forest system consist of and how can it be used in landscape design?

KQ2. What factors are contributing to the implementation of forests and what can be expected in the future?

The multifunctional character of a forest should be researched and understood in order to design forests that can contribute to enhancing spatial quality. The first knowledge question will therefore generate more general insights into the forest systems itself.

The second knowledge question will generate knowledge regarding general implementation factors as well as place-specific knowledge, as it analyses the landscape and systems of the Region of Zwolle specifically. It relates to diagnosing the past and current situation and near- and far-future developments, so that they can be addressed in the design phase.

Design Questions

DQ1. Can suitable locations and strategies be derived from model formulation in order to design a regional masterplan as a design synthesis?

DQ2. How can afforestation deliver collateral benefits to the landscape and/or society?

The first design question corresponds with a specific research part in which models are formulated. In this part, the previously found knowledge is used to formulate relevant criteria to evaluate these models, who research how and where forest can be implemented in the Region of Zwolle. The models help funnel the research towards a design synthesis.

In the last part of this research, a comprehensive masterplan design acts as a synthesis in which the previous knowledge as well as place specific information is applied and visually supported.

Methods

This research will use a mixed method approach. Every research question has its own methods in order to be able to produce an answer to the question. The main design question will be answered by answering the sub- knowledge and design questions.

In the Knowledge For Design phase, knowledge is gained through research, but does not entail the practice of designing yet. KQ1 acts as a theoretical base and will be researched through document analysis and literature study. General implementation factors are researched by literature and document study in KQ2. The landscape, characteristics and identity of the Region of Zwolle will be analyzed in by document, thematic- and geographical map analysis. This will be supported by site visits, where observations and photographs are gathered. The knowledge gathered will be used as input for designing and for the formulation of parameters.

From this point onwards, Research Through Design(ing) will be used as a method, meaning that the act of designing is used to find answers to the sub design questions (Lenzholzer *et al.* 2013). There is no pre-determined method for the act of designing, as it is a complex combination between multi-facetted and multi-levelled kinds of thinking (Cross 2006 p.16). Designers tend to take on a solution-focused strategy rather than a problem-focused strategy, to find solutions through synthesis; trying a series of solutions until an acceptabe one is found (Cross 2006 p.6). This is why DQ1 is embedded in a modelling phase, where the creation, design and evaluation of different models acts as a method for knowledge generation. The modelling strategy can roughly be described as Dynamic Simulation Modeling, which integrates knowledge and assumptions on how landscapes change and where this may lead (Deming and Swaffield 2011 p. 111). It integrates a representation of the way landscapes function and of how landscapes change over time, depending on combinations of conditions or decisions (Deming and Swaffield 2011 p.103). At last DQ2 will be answered through the design of not only a final regional masterplan design, but also by means of impressions, visualizations and sections. This thesis moves from more general ideas towards more specific design knowledge in an iterative manner.

Figure 3 provides an overview of the research process.

Materials

Materials for the research consist of peer reviewed scientific literature, grey literature, spatial data, observations and the designing process.

Research quality

Design problems are often defined as 'wicked' problems, in which all the necessary information is not, or will never be, available to the problem solver, meaning that there can never be a guarantee that the 'correct' solution is found (Cross 2006 p.7). On top of that, the act of designing is a complex personal process and cannot claim to be unbiased. The strength of this research therefore lies in authenticity and innovativeness of the research outcomes and the flexibility to respond to different contexts (Lenzholzer *et al.* 2013). However, these factors are not easily evaluated. The credibility of the research outcomes must therefore be guaranteed by transparency, which creates the possibility for discussion at all times (Lenzholzer *et al.* 2013).

Relevance

This research is an attempt to tackle the wicked problem of claiming space for afforestation and to look for answers that move towards a sustainable and habitable landscape. By researching the concretization and design of the national task of afforestation in a case study, new insights can help to expand a design focused knowledge base for future strategies and developments regarding afforestation in the Netherlands. The significance of the research thus lies in the potential of translating strategies and knowledge to into a regional systemic design that connects the multifunctional character of forest to current spatial pressures.

Figure 2 : The Region of Zwolle


Vledder
Dwingeloo
Ruinen
Hoogeveen
Meppel
Zuidwolde
Staphorst
Dedemsvaart
Hardenberg
Nieuw Leusen
Ommen
Dalfsen
Heino
Raalte
Source: Google Earth (2022)
5 km
10 km
20 km
40 km

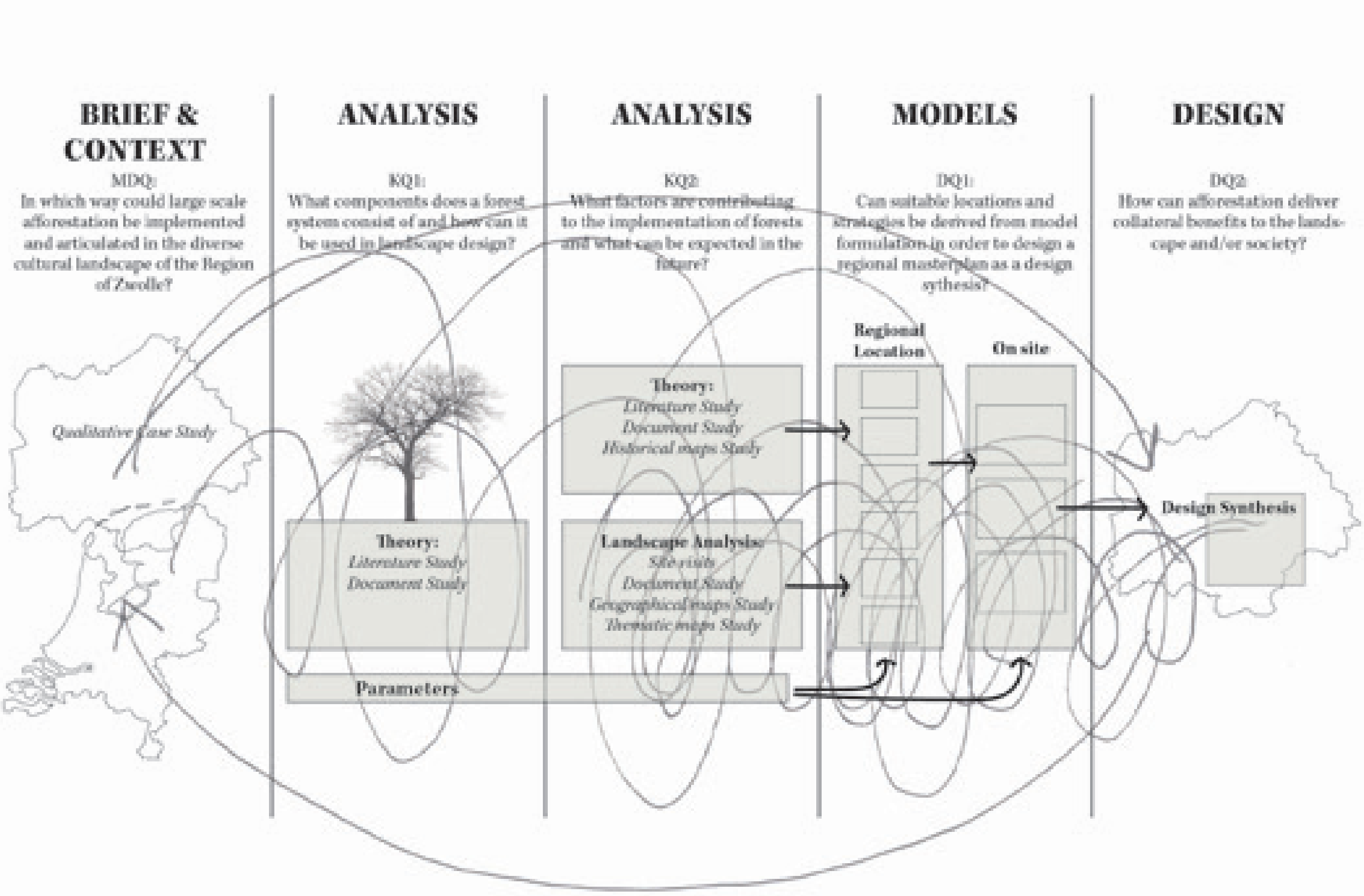


Figure 3 : The visualization of the complex research process.

Conceptual Framework.

Spatial Quality

The term 'Spatial Quality' has been used for the first time in 1982 by the Dutch National Planning Department, and soon it became clear that the term is never free of value, but depends on societal standards and preferences (Dauvellier 1991). Ever since then, discussions about the meaning and scope of the concept have been held. By setting a goal to 'improve Spatial Quality' by Dutch spatial planning departments, discussions about measuring, testing and improving the concept became relevant (Dauvellier 1991).

However, after many years, the term spatial quality has been criticized to be inconsistent and sometimes even a blank term. It has been reconstructed so often, in so many different ways, that in literature there seems to be no consensus on how to use and embed the concept.

Hooimeijer *et al.* (2001) also point out that spatial quality has so many different criteria or forms of assessments that differ per context, that it can hardly be seen as objective. At the same time, one of the most extensive and inclusive literature on spatial quality is the conceptualization and operalization of Spatial Quality by Hooimeijer *et al.* (2001). Their formulated matrix on Spatial Quality is elaborate and well supported.

However, the matrix does not indicate how these aspects should be evaluated. Examples of how the matrix can be used are given, but are still in essence subjective, as every person can formulate its content differently. This also works the other way around, when designing new landscapes, the matrix provides guidance, but does not indicate how the different aspects should be used. It is exactly as they stated, there are so many forms of assessments that differ per context, that it cannot be seen as objective. (Hooimeijer *et al.* 2001).

As Dauvellier (1991) states, the urge to define, conceptualize and operationalize spatial quality in order to use it as a template for designing and planning is of little use. The elusiveness of the concept can instead stimulate the imagination to search and find solutions to design a more habitable landscape.

Since measuring spatial quality is problematic in multiple ways, the matrix or any other theories of Spatial Quality will not be used to evaluate designs in this research. The evaluation of the models will be supported by literature, but are formulated specifically towards answering the design question at hand. In this way, the explorative nature of this research comes into its own.

The key takeaway in this conceptual frame is nevertheless the notion of Hooimeijer *et al.* (2001), that the definition of spatial quality is context-bound, and it is more than just avoiding spatial conflict. It includes mainly mutual reinforcement of shapes and functions by combining them in space and time. Usually, the added value that is created in this way, is defined as spatial quality. Every spatial plan must comply to the demands of the present, as well as being resilient to future developments, while respecting a past.

Multifunctional landscapes

Mander *et al.* (2007) describe the cultural landscape as multifunctional when it simultaneously supports various, sometimes contradictory functions, such as habitat, productivity, regulatory, social and economic functions. Elements inside the cultural landscape, such as forests, are classical examples of multifunctional landscapes as they control various energy and material fluxes in the landscape, protect biodiversity and provide recreational opportunities. Furthermore, on different scale levels, different levels of multifunctionality can be achieved. Larger areas have a broader range of functions that can be realized, where smaller areas, such as a single parcel, can harbor fewer functions.

Land use is the key function that determines the performance of landscapes with respect to the socio-economic aspect. However, the integration of socio-economic functions and environmental functions depend on the patterns and intensities of this land use. Landscapes and functions are therefore at interplay with each other, as landscape structure and its functionality are affected by human perception, cognition and values, but simultaneously also affect these apects (Mander *et al.* 2007). The implementation of multifunctionality in a landscape should therefore be done with care.

An encompassing definition of multifunctionality by Selman (2009), is that land is capable of serving more than one purpose and can fulfill several needs at the same time.

The Systems View

Systemic design stems from a systems view, or systems thinking, of which its emergence brought a revolution in the history of Western scientific thought. In the systems view, “the essential properties of an organism or living system are the properties of the whole, which none of the parts have” (Capra 1997 p.29). “Even though we can discern individual parts in a system, these parts are never isolated. The nature of the whole is more, and different, than the mere sum of its parts” (Capra 1997 p.29). Compare it to a forest; a healthy forest ecosystem is more than just a collection of individual trees.

In systems thinking, continuous shifting from parts to the whole and back is important, as the parts cannot be understood and analyzed on their own, but exist only in context of the whole. In is therefore also called, ‘contextual’ thinking (Capra 1997 p.37). However, what we call a ‘part’, is better understood as a pattern or a relationship.

At the Wageningen University, landscapes are considered to be such a living system, that can be studied and designed using the systems thinking approach.

According to Capra and Luisi (2014), the major problems of our time are systemic problems, as they are all interconnected and interdependent. These systemic problems also require systemic solutions. One of the advantages and qualities of a systemic solution is that it contains the ability to solve several problems simultaneously. The systems view is therefore not just relevant on an intellectual level, but also of practical relevance (Capra and Luisi 2014).

Systems thinking has contributed to the emergence of Landscape Urbanism in the field of landscape architecture. Some characteristics of Landscape Urbanism are described by Thompson (2012). In Landscape Urbanism, the boundaries between city and landscapes are lifted, non-binary and viewed as intertwined instead. It is always seeking connections with wider contexts, looking beyond the boundaries of the site or scale and ‘prepares stages for performances’. It seems to be less concerned with aesthetics and ornamentation, and more concerned with systems and what they do in terms of functions and services, creating connections and blurring the boundaries between different disciplines. Landscape Urbanism foregrounds otherwise frowned upon or invisible structures, whether green, mechanical or other forms of (infra)structures. Design and planning draw from ecological concepts and thinking, where natural systems are dynamic, fluid, unstable and complex, and require responsiveness. It thus encourages hybridity between natural and engineered systems and recognizes the remedial possibilities inherent in the landscape.

The Cultural landscape

The term cultural landscape has been defined many times. According to Konijnendijk (2018) a cultural landscape emerges where nature and culture meet. It is the integration of the human and cultural with the natural. Cultural landscapes are thus landscapes that have been cultivated and/or clearly reflect a history of cultivation (Dieterich and Straaten 2004 p.16).

Long term Perspectives

Long-term perspectives are used as devices to bring reality closer to ideals and visions. They can inspire policy making, strategizing and institutional changes, and these long-term perspectives play an important role in governance (Beunen and Barba Lata, 2021). The link between these long-term perspectives and their potentialities, roles, impact, policies, strategies and effects is complex and there is often a discrepancy between what is depicted in the long-term perspective and the effects that materialize on the way (Beunen and Barba Lata, 2021). An example of one of these long-term perspectives is the concept of the National

Ecological Network, who, to this day, still endures to promote a more coherent approach to nature conservation (Beunen and Barba Lata 2021). Long-term perspectives often articulate, imagine, speculate and visualize an uncertain yet desired future. Uncertainty mainly refers to the fact that there are always multiple perspectives, paths and outcomes of the future. They are based on certain understandings of the past, the present and the future (Beunen and Barba Lata 2021). A long-term perspective thus reflects a (desired)narrative for the future to inspire actions.

Contextualization.

Location Choice

When choosing a location for this research, a couple of aspects were important. The first aspect is a variety of landscape types, the second a rich and diverse palette of cultural landscapes. The focus on a broad spectrum of landscapes rather than one focused landscape type lies within the large scaled, explorative nature of this research.

If we look at the Netherlands as a whole (figure 4), it consists of some key landscape types; Coastal area, Peat meadows, reclamations, sea clay landscape, river landscape, sand landscape, peat colonies and the hilly landscape of Limburg (CLO 2013). The hilly landscape of Limburg can be excluded as it is significantly different in origin from the Dutch delta landscape and requires a separate approach. Around the coastal area, not enough different landscape types are present, in fact, the area of the West of the Netherlands lacks large areas of sandy soils. The only place where (almost) all landscape types intersect is in the Region of Zwolle. It even includes a small sea clay landscape, the 'Kampereiland'.

Some landscape actualities are represented in the Region of Zwolle. It is a delta landscape of the 'IJssel' river and 'Overijsselse Vecht', within a larger delta landscape of the Netherlands as a whole and is facing water issues with regards to climate change. Next to that, the region is expecting to grow in number of inhabitants and economic power (Engbers 2019), especially since the construction of the new 'Hanzelijn railway, who facilitates a better and faster connection with Amsterdam.

The task of afforestation in the Region of Zwolle

The Netherlands has a total land surface of 3.388.300 ha, of which about 370.000 ha is forested, almost 11% (CBS Statline 2018). On a national level, the target is to add 10% of forested surface, 37.000 ha. In order to calculate a reasonable amount as a target for afforestation in the region of Zwolle, two different approaches are possible.

The first is to calculate what the percentage of the total land surface of Zwolle is compared to the total land surface of the Netherlands. The Region of Zwolle is 345.426 ha in total (CBS Statline 2018), which is 10,1% of the total surface of the Netherlands. If we would divide the national task of 37.000 ha extra forest in the Netherlands completely evenly, based on surface amounts, Zwolle would get 10,6% of the total 37.000ha as a task, which comes down to 3.737 ha.

A second way is to take a more regional case study approach. The Region of Zwolle has a total land surface of 345.426 ha, of which 36.115 ha is forest (CBS Statline 2018). This is a percentage of 10,5%, which is close to the national 11%, proving the region of Zwolle to be a good representative for the National task. If the Region of Zwolle would add 10% extra new forest, on top of the already existing 10,5%, this would come down to 3612 ha.

This leaves a range of between 3612-3737 ha of new forest for the Region of Zwolle. However, some areas in the Netherlands are likely to contribute less or more to the National task, due to, for example, soil conditions or urbanization rates. Therefore, the target for this thesis is focused on aiming higher rather than lower. A minimum of 4000 ha of extra forest is defined as target, but if a higher amount of forest is possible, the research will not be restricted by an upper boundary.

The National Forest Strategy

In 2020 the National Forest Strategy was published. This document has been one of the main reasons for formulating this research. As a forest-enthusiast, I was obviously curious. However, the document lacked concreteness and desire. Its proposed strategies were lacking a systemic approach. Let me explain.

In the document, two main parts were defined. new afforestation within the Nature Network Netherlands (NNN), and outside of the NNN. For afforestation inside the NNN, no strategies or design have been provided. Even though the realization of the NNN is important, it is approached solely from a ecological perspective, enhancing biodiversity.

Figure 4: Landscape types of the Netherlands. Image adjusted from CLO (2013)

Figure 5: The national Forest strategy document. (Ministerie van LNV 2020)

For afforestation outside of the NNN, numerous strategies are given. There is acknowledgement on the fact that multifunctionality should be used and that win-win situations should be found and used, in light of the pressure on space, in order to enhance spatial quality. Strategies are given per location, such as for different landscape types, or close to natural areas or cities. These strategies relate to and explain different win-win situations.

However, the strategies are missing design or information regarding integration and implementation. They are lacking a scale in general, and there is a lack of alternation between different scale levels as well. Win-win situations are only explained without context. These different strategies are then separated and divided between different national-, public-, and private organizations, who will have to take action into their own hands. The document even mentions that 'afforestation is dependent on the choices of initiators'. This is worrisome, as the strategies are doomed to be grounded in budgets, planning. procedures and short-term plans. This could result in a decentralized muddle of small patches of forest here and there, missing opportunities of true multifunctionality. A central and desired vision is lacking.

Furthermore, strategies of 'trees outside of the forest' are given. These strategies focus on adding tree lanes or green structures in the landscape and city, as well as combinations with agriculture, such as agroforestry. Again, these strategies only enhance a landscape on a single part, instead of as a part of the whole, proving it to be little systemic, missing out on opportunities for multifunctionality. And they are simply not forest.

Lastly, the document mentions frequently that forest should be used for recreation purposes, but the statement is empty. This poses a large risk that recreation is secondary to finding a location, where for me, recreation is one of the key opportunities of afforestation.

To conclude, the strategies proposed in the National Forest Strategy are not necessarily 'wrong' and can be explained metaphorical, as the equivalent of a vegetable soup:

"At the end of the week, a household has some left-over ingredients lying around and decides to make a vegetable soup. The ingredients are added to a large pan of broth and that creates an ordinary soup, never in-edible yet never special. "

This vegetable soup will never be that special Christmas dinner:

"For Christmas dinner, the finest ingredients have been gathered over the past week, from different specialized stores. All courses are curated in such a way that each dish is unique, yet complements each other, so that as a whole, they form a well-balanced unity that will be remembered with pride."

Forests and CO2

The role of carbon sequestration as a way to reach climate related goals is used as a main argument for extra forest. A quick inside in how forests store carbon is presented below.

As long as trees grow, they take Carbon Dioxide (CO2) from the air and capture it in their wood as carbon, while giving oxygen back to the atmosphere. Only sunlight and water are required for this process. When wood is burned or degraded by organisms and bacteria, carbon will be returned into the atmosphere. Carbon will only be stored, without returning to the atmosphere, when wood is used for a long-lasting purpose, such as in furniture or in the construction of buildings (Klingen 2017; Klingen 2020).

Carbon is not just stored in the trunk of a tree, but also in its branches, roots, leaves or needles and even in flowers and seeds. Leaves and seeds fall, branches die, brake off and fall on the ground. This organic material is degraded by organisms in the forest soil. In that process, carbon is released again. A part of this organic material is washed out as humus into the soil, meaning that forest soils also store carbon. As a forest ages, more carbon is stored (Klingen 2020).

The forest soils of the Netherlands are relatively young, most of the forests just 100 years of age, and can store much more carbon, as the maximum is far from reached (Klingen 2020).

If a forest is completely unmanaged, meaning that all living trees will die at some point and new will trees grow in a natural succession, the total intake and release of carbon would be equal, a closed cycle. In young managed forests however, harvest is less than what is growing, and more carbon is stored than released.

When harvesting trees, only 1/3 of the tree is actually harvested. Its roots and canopy are left behind, to degrade and release carbon again (Klingen 2020). If the harvested wood is then used as biomass, carbon will be released back to the atmosphere without any profit. In fact, the transportation of that wood has released extra carbon. Biomass can only be justified as a climate friendly fuel if very low-quality residual wood is used, and when it is not imported (Klingen 2020).

Carbon compensation

As explained in the text above, forest can store carbon, so the question is then; how much forest is needed in order to compensate for our emissions?

If the Netherlands would decide to reduce 10% of carbon emissions from the atmosphere permanently, this will equal an annual carbon storage of 2,3 million ha of forest, 15 years after afforestation (Klingen 2020 p.26). That equals approximately half of the surface of the Netherlands.

The best strategy to significantly reduce CO2 from the atmosphere, would be to reduce carbon emissions, not to compensate for carbon emissions afterwards.

However, the current ambitions of afforestation are strongly focussed on carbon storage and reduction. Globally, it cannot be denied that it is a massive problem, as temperatures have already risen by 1 degrees Celsius (Attenborough 2020 p. 135). But the values of nature can become over-simplified to its carbon sequestration and storage capacities. We might start thinking that monocultures or biomass plantations are just as valuable as biodiverse forest (Attenborough 2020 p.170).

And it is no coincidence, that the planet falters, exactly when its biodiversity is decreasing, those two aspects are inseparable (Attenborough 2020, p.121). Only reducing and removing carbon is not going to save the planet from extinction. Biodiversity should be warranted in order to create a stable and healthy planet, the most important life support for humans (Attenborough 2020 p. 170-171).

Global biodiversity loss

The disappearance of biodiversity happens more than a hundred times faster than average, as the global rate of species extinction is already at least tens to hundreds of times higher than the average rate over the past 10 million years. The current loss of species is 114 times higher than average (Attenborough 2020 p.112, IPBES 2019).

The largest cause of biodiversity loss is the reclamation of wild habitats into agricultural land. More than half of the planets surface is reserved for humans, as we cultivate almost 5 billion ha of agricultural soils, an area the same size as North and South America and Australia altogether. This has caused the release of two thirds of the stored carbon inside the earths land surface (Attenborough 2020 p.154). The expansion of agricultural land mostly takes place in tropical countries, with the increasing demand for meat as the main cause (Attenborough 2020 p.163). The UN food- and agriculture organization expects that in 2040, a peak in land use will be reached (Attenborough 2020 p.166).

Reforesting and afforestation efforts help increase global biodiversity, and besides, when biodiversity increases, carbon sequestration and storage maximalizes. The more biodiversity in a habitat, the more carbon it stores (Attenborough 2020 p.171).

Other reasons

But there are more reasons for afforestation. Alongside carbon sequestration, biodiversity and recreational values a few are mentioned below.

The wood that can be harvested from forests can substitute for emission intensive materials such as concrete or steel (Verkerk *et al.* 2020), where fabrication and transportation of these materials emit large amounts of CO2. Wood is also the only natural resource that does not deplete (Klingen 2020 p.53). Large scale building with our 'national' wood harvest will however only possible in the very long term.

Forests and trees have an impact on the local climate and can increase livability. In cities, trees can reduce the urban heat island effect by reducing the temperature, they can capture fine dust from the air, increase the value of housing and can even act as a sound barrier (Pistorius and Vries 2013).

Inside a forest, the microclimate is milder and less extreme than in open spaces, which is important for the user experience, as well as for the battle against climate change (Klingen 2020 pp.84-85). In addition, healthy forest soils can store water, because a well-developed forest soil with a rich humus layer can hold on to water (LNV 2020 p.24).

The challenges of afforestation

In a societal context, afforestation is not easy, and there are multiple factors contributing to this. The challenge of afforestation is not IF it should be done, but WHERE. Many different interests complicate or even make it impossible to plant new forests. The protection of meadow birds or the conservation of cultural landscapes are examples of this (Boosten et al. 2020). The second challenge is high costs, not only for land purchase but also for the afforestation itself. On top of that, the value of the land will decrease and will generates little to no income. Revenue models are present to a small extent, but are much needed (Boosten et al. 2020). Another challenge relates to the creation of public appreciation, in order to make afforestation a defiance instead of a must (Boosten et al. 2020). The last challenge is the need to develop more knowledge about afforestation efforts. In the last decades there has barely been any afforestation, and with climate change, the knowledge that we do have is under pressure. To plant large scale new forests, in such a short period of time, experience and new knowledge is needed (Boosten et al. 2020).

Afforestation costs

In order to plant new forests, Teeuwen et al. (2020) explains that 3 different actions should be considered. The first is buying new land, usually this is land with a different function than forests, such as pastureland or agricultural land. Costs for this land can vary, depending on its ownership and if extra measures need to be taken, such as soil preparation. The second action relates to the costs that will be made during planting. There can be differences in the method of afforestation, such as mechanical or manually, the choice of species and the number of trees. It is estimated that the costs for buying land and planting trees ranges between 7.600eu per ha, without buying land, and 136.500eu per ha with land purchase costs and including write-off costs. The last action to consider is management costs after afforestation. These costs are estimated to be of an average of 270eu per ha per year. It includes replacing lost plantings and youth care. Sometimes extra measures need to be taken, such as placing fences when there is high game pressure or fertilizing the soil. The average costs of afforestation comes down to 13.750eu per ha, within a range of a minimal 7.600eu per ha towards 22.100eu per ha with maximal measures taken.

Wood market/sector

The National Forest strategy (LNV 2020) states that more of the produced wood should be of high-quality use. This relates to the long-term storage of carbon in wood, and preventing the use of carbon emission intensive materials. High-quality use of wood therefore means the most long-term application of the different qualities of wood, and the possibility to reuse this wood for the same or for different purposes, so that carbon is stored as long as possible (Reichgelt *et al.* 2020). This can be the application of wood as a building material or furniture, in the form of for example solid wood, CLT or sheet material (Reichgelt *et al.* 2020).

Currently, the wood of Dutch origin is used as 75% industrial roundwood and 25% firewood. However, 80% of the harvested hardwood is eventually sold as firewood for individuals, which is considered a low-quality use. With the increase of hardwood in forests in Europe, it is important that this wood is of more high-quality use in the future. Coniferous wood is often of more high-quality use. (Reichgelt *et al.* 2020)

The prices of the sold wood is currently dependent on two things. The roundwood industry is constantly searching for the highest prize per m3 of wood that the woodworking industry offers. The application of the wood is thus subordinate to the price. If markets can ask high prices to their customers, because they are willing to pay, wood will be sold to that woodworking market, because this delivers the highest price per m3. That explains why so much of the hardwood is sold to individuals as firewood, because these individuals are willing to pay, and do not have many alternatives (Reichgelt *et al.* 2020).

To achieve a shift towards more high-quality use of wood, it is therefore important that for example short chains, niche markets or even long-term agreements on a big scale should be made about the wood supply (Reichgelt *et al.* 2020).

Time aspect

A very important aspect, maybe even the most important aspect of afforestation, is time. A forest does not develop quickly, not visually, but also not ecologically. It can take decennia before there is a real forest climate and ecosystem (Klingen 2020). The development of an ecologically rich forest soil, especially on soils that have had a different land use before the afforestation, is crucial for a healthy forest, as it provides a suitable climate for tree seeds to germinate in. This makes rejuvenation possible, which is important for a forest (Klingen 2017). This soil develops over the course of decades, depending on the fertility and conditions of the (geological) soil on which the forest is planted. The conditions of this soil determine what organisms are present. These organisms play a crucial role in the degration of organic material. A healthy forest soil provides the forest with nutrients and a good moisture balance. On top of this all, the forest soil also determines what vegetation will grow. (Jong et al. 2015)

But that is not the only way in which time plays a role. If natural rejuvenation is desired, one needs to take into account that trees need to mature or become manable in order to produce fertile seeds, and this differs per species, some take 20 years, others 50 (Klingen 2017). For the harvest of valuable wood, 50 to 80 years is required (Klingen 2020).

Luckily, for the intake of Carbon, forests do not require to be old, after 10 to 15 years trees grow at their quickest rate and store carbon most effectively (Klingen 2020).

In a multisensory aspect, a forest takes years to develop. This has an impact on recreative aspects. The forests present in the landscape of the Netherlands now are about a 100 years old. The newly planted forests will not reach this point within our lifetimes. But we might expect forest to look like the present ones. Luckily, it does not take decades for a forest to be regarded as 'mass' or as 'closed', that only takes about 5 or 6 years, as presented in figure 6, 7 and 8.

'Boompje groot, plantertje dood'

And finally, it should not be forgotten that management goals can already change while the forest is still developing. As Klingen (2017) describes; in the last 50 years, many different views on forestry have developed. They have changed the way forests look and function. This will be very likely to happen in the future as well.

Figure 6: Newly planted forest near Doorwerth. The trees are around 2-3 years of age here. August 2020

Figure 7: One year later, September 2021. Views over the field are already blocked when standing.

Figure 8: Another year later, August 2022. The forest has grown past your head, and at 5 or 6 years, it is experienced as a closed mass of forest.

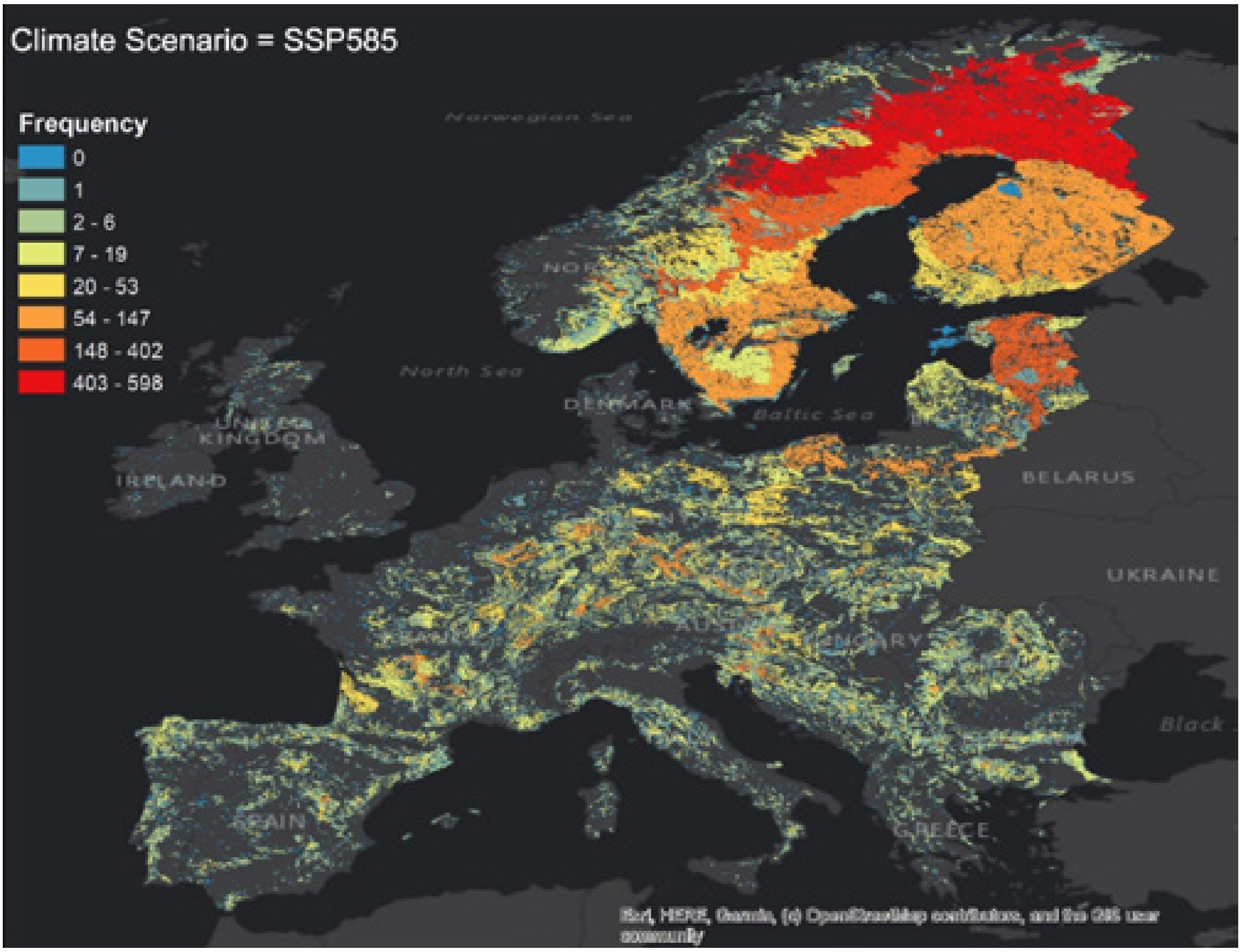


Figure 9 : The potential (frequency) of forested areas to serve as stepping stones for climate-driven range shifts under the most severe (SSP585) climate scenario (Han *et al.* 2021).

Effects of Climate Change on forest

Due to the global rise in temperature, climate zones start to shift, causing species areas to shift. The Dutch climate will become a more 'southern' climate. Higher temperatures and an equal amount of precipitation cause problems with drought. As a result, sensitive species disappear, and new species appear.

However, these climate zones shift much faster than most forest species can migrate. Most forest species have a minor colonization capacity, meaning that they have great difficulty to migrate from one to another forest. The species migration is a necessary condition for maintaining vital populations. (Hermy *et al*. 2004 p. 317) However, isolation of forested areas poses problems for this migration, and Dutch forests seem to be relatively isolated from forested areas in the rest of Europe (see figure 9). Assisted migration could be a solution to ensuring forest vitality.

However, forests in the Netherlands are facing other issues as well, making the Dutch forests struggling for existence. Most forests are located on higher, relatively poor sandy soils where agriculture was not feasible, the forest as 'second best' (Buis 1993 p.178). Soil degradation due to acidification, drought and densification as well as isolation from fragmentation are problematic. On top of that, forests lack species diversity and rejuvenation is hindered by high game pressure. This in turn affects the productivity of forests as well as their ecological and recreative values. Altogether, this will result in higher chances of storm, fire, pests, diseases, a decrease in biodiversity and ecosystem productivity, a disturbed food web and a decreasing vitality of tree stock (VNBL 2021). Focusing on forest vitality and connectivity with existing forests are important takeaways.

Key Points

• A minimum of 4000 ha of extra forest is defined as target, without maximum boundaries.
• A central vision for afforestation is missing, which could result in missing opportunities of true multifunctionality.
• A managed forest, where selective harvest is conducted, can store carbon in its vegetation as well as in its soil.
• Using forests for biomass production is irresponsible.
• Merely compensating for emisions using forest is trying to empty the ocean with a thimble.
• Carbon sequestration and storage alone is not going to save the planet from extinction. Biodiversity should be warranted.
• The production and harvest of high quality wood can store carbon in long term products like furniture, and can substitute for emission-intensive building materials.
• The more biodiversity in a habitat, the more carbon it can store.
• Little knowledge is available on large scale afforestation.
• Lots of time is needed for a forest system to be healthy and established.
• Connectivity between forests is important for maintaining vital populations.

Chapter 2. The Forest system

Part II. Research for Design

The Forest System.

The forest: a complex ecological system

A forest is more than just a collection of different trees. It is also more than the sum of its trees. It is a complex natural and ecological system, with trees, plants, animals, insects, fungi and micro organisms, of which we make use and experience. A forest simply wouldn't be experienced as a forest if it wasn't for the visual sight of trees. But, for a fully immersive experience, all senses are important. While for most visitors a forest looks static (except for its seasonality), it is in constant gradual change. Every year, trees grow larger: an annual ring is added and branches become longer. Because the space inside a forest is limited, trees experience a mutual competition for light and space, mostly in the canopies (Klingen 2017). The development of this forest depends on some abiotic factors, such as soil, water and (local) climate (Klingen 2017).

When a forest develops, the initial amount of trees is high, and over time there are winners and losers, resulting in a reduction in the amount of trees. A tree that can grow higher than its neighbor will win, while the shaded trees will gradually die. Everywhere where there is available light, a tree will grow branches. This also means that in a forest, most light is only available in the canopy, resulting in a bare trunk.

Besides from competition between the trees itself, even though they are part of the same species, there is also competition between different species. Because next to its speed to grow, light requirements of the species play an important part. There are light-species and shadow-species. The trees who can only grow in full light are called light-species, where species that require a lot less light to be able to grow are called shadow-species. When light-species are overgrown by other trees, they will die, whereas if the shadow-species are overgrown, they can still survive and grow. Both types can dominate a forest, but will give different visual experiences. The canopies of light species will let through more light than those of the shadow-species, meaning that this forest type will have more light and undergrowth, often including shadow-species that are ready to take the place of the light-species. Shadow-species on the other hand, cause more shadow and will bring forth darker looking forests. Only other

Figure 10: An example of a forest image dominated by light-species.

Figure 11: An example of a forest image dominated by shadow-species.

shadow-species will be able to grow on ground level, and the forest is characterized by an absence of undergrowth. Light-species will not be able to grow underneath shadow-species, meaning that shadow-species will usually win the competition if forests are not managed (Klingen 2017).

A forest will grow in different stages, and does not have an end. This is called succession; the process by which plant communities grow and gradually change in composition and structure over time (Bell and Apostol 2008 p.51). On open areas pioneer species begin to grow. After the pioneer stage, species that need shelter underneath grown pioneers emerge. Eventually the forest will reach a climax-phase in which most of the trees are fully grown and have reached their maximum height. From this point onwards, trees will gradually die from old age and the decay phase will start. This decay phase is much less dramatic as it sounds, as new forest will always grow again. This means that in a natural forest, all phases are seen next to each other. Besides that, open areas where pioneer species get a chance once again can appear because of natural disasters such as storm, fire or flooding, or because of clear cutting for wood harvest (Klingen 2017).

Ecology of forest design

A forest has its own microclimate and ecology. The temperature and humidity inside a forest can be significantly different than in open areas and this has an impact on the present ecology inside the forest (Vandekerkhove 2020). This microclimate is dependent to the structure and density of the canopy. A dense canopy can help to reduce temperature extremes and therefore preserves the air and soil humidity, which is important for the conservation of certain species that are threatened by desiccation (Vandekerkhove 2020). This microclimate is however also easily affected. A large clearing area, an open spot inside the forest and even an opening in the canopy can change the microclimate, and the composition of species (Vandekerkhove 2020).

The edge of the forest also has an impact on the forest climate, as from the edge, towards the interior of a forest, the humidity and temperature buffer gradually increases. These are called 'edge effects', and they can have a range of 50-100m (Vandekerkhove 2020; Schmidt et al 2017). These edge effects are roughly speaking related to wind turbulences and solar radiation (Schmidt et al 2017). The word edges suggest a sharp line, but can better be defined as a transition zone, that differs in width per forest and per spatial circumstances (Schmidt et al 2017). The edge effects are universally accepted to be of a 100m range (Schmidt et al 2017 p.668; Bell and Apostol 2008 p.53). Because these forest edges experience more wind turbulence, they are also a 'hotspot' for nitrogen deposition and acidification (De Schrijver et al 2007; Vandekerkhove 2020). The deposition in these transition zones can be 4 times higher than in the interior habitat, which can have significant ecosystem damage (De Schrijver et al 2007). The 'interior habitat' of a forest can be defined as the area that is buffered from the edge effects (Bell and Apostol, 2008 p.53).

Out of this information two things can be concluded. The first is that small forest patches have a high edge to interior ratio, meaning that forest patches become 'functional edges' and it no longer has any interior habitat conditions (Bell and Apostol 2008 p.53). The second is that forests, even though far from beneficial to the ecosystem of the forest itself, can probably act as a buffer for nitrogen deposition. It should however be noted that seepage of nitrate into the groundwater, acidification and high nitrogen levels can indeed harm ecosystems and biodiversity if critical loads are exceeded (De Schrijver et al. 2007). This highlights the fact that forests cannot act as a solution for human induced (nitrogen) problems, and that the source of the problems should be tackled.

Open spaces

In the past there has been a strong ecological focus on the interior habitat species of a forest. However, it has recently become clear that the significance of open spaces and edges have been underestimated. In the past decennia, the importance of forest for the survival of non-forest species has increased rapidly. Some of these non-forest species even exclusively exist in forests nowadays. This is caused by the deterioration of half-natural vegetations in the agricultural landscape. Open spaces, ponds, pathways, roads or clearings through forest and edges harbor a much greater diversity of species than the interior habitat itself (Hermy *et al.* 2004 p.337). This illustrates that the total surface of a forest is only a surrogate variable for diversity (Hermy *et al.* 2004 p. 316).

SLOSS-discussion

The SLOSS-discussion stands for "Single Large or Several Small', and it relates to the non-linear relationship between forest surface and species diversity. Two separate forests can have a larger variation in environmental conditions than one forest of the same size. The best strategy for the conservation of species diversity is therefore unclear and undecided, especially in the long term, and can consist both of fewer large reserves or lots of small areas (Hermy *et al.* 2004 p.316).

Forest Vitality

According to Den Ouden (2022), a vital forest is defined by two factors, resilience and adaptivity. Resilience is characterized by the ability to maintain functionality after a sudden disturbance. This disturbance could for example be a storm. Its resistance and capacity to recover determine a forests resilience. Adaptivity is characterized by the adaptive power of a forest to changing circumstances, such as climate change, acidification, eutrophication and drought. These disturbances are chronic in nature.

The conditions for a vital forest are: Variation in species and structures, species that are adapted to its habitat, genetic diversity, complete food webs, fertile soil, soil life and possibilities for exchange between ecosystems (Den Ouden 2022).

Configurations

Patches
A patch is a relatively homogeneous area of vegetation (Bell and Apostol 2008 p.39) If a larger area of forest consists of two completely different succession stadia, they can be considered as two separate patches, even though they might visually be labeled as ‘forest’. (Bell and Apostol 2008 p.39)

Matrix
Often described as the most dominant patch in the landscape by total area or overall connectivity (Bell and Apostol 2008 p.39). We can roughly assume that in the Netherlands the matrix is agricultural landscape.

Edges
An edge is often used differently by species than the interior habitat of a forest. However, many members of the animal community consider and use the edge as a habitat to live in. Some edge species can therefore thrive better in more fragmented landscapes, while the members of the forest biota in the interior habitats can suffer (Bell and Apostol 2008 p.45) (Haila 2002).

Corridors
A corridor is a relatively linear landscape element that can connect two patches together in a dissimilar matrix. It is mostly a conceptual landscape planning tool and its exact effects is often unknown. (Bell and Apostol 2008 p.41)

Stepping stones
Stepping stones are usually considered to be clustered patches that also act as corridors to allow for species to move between habitats. They are mostly important for birds and butterflies in agricultural areas, but can be relevant for forest too. (Bell and Apostol 2008 p.42)

Landscape mozaic
“The spatial configuration of habitats within a landscape formed by patches arranged within a matrix is generally called a landscape mosaic” (Kettunen *et al.* 2007. p.14)

Variegated vs Fragmented
In more variegated landscapes, patches are of low contrast, creating a more continuous landscape, where in a fragmented landscape patches create high contrast. (Bell and Apostol 2008 p.43)

As the text above already suggests, ecological fragmentation of landscapes can range, and do not necessarily have to be a deterioration (Kettunen *et al.* 2007). As Haila (2002) explains, fragmentation is often considered as one unitary phenomenon, as if it is always happening in the same way and having similar consequences. And although the theory has somewhat moved away from the ‘island’-‘sea’ metaphor, there is still a believe that human-influenced environments are essentially different from ‘natural’ environments. However, even in agricultural areas, some species can forage outside forest remnants and include this surrounding area in their home range, no matter how intensive the cultivation methods (Haila 2002). A great example of this would be the wolf.

Next to that, as Ricketts (2001) explains, a surrounding matrix can significantly influence the isolation of a habitat patch, rendering them more or less isolated than the classic theory of distance. Modification of the matrix can therefore also provide opportunities to reduce patch isolation.

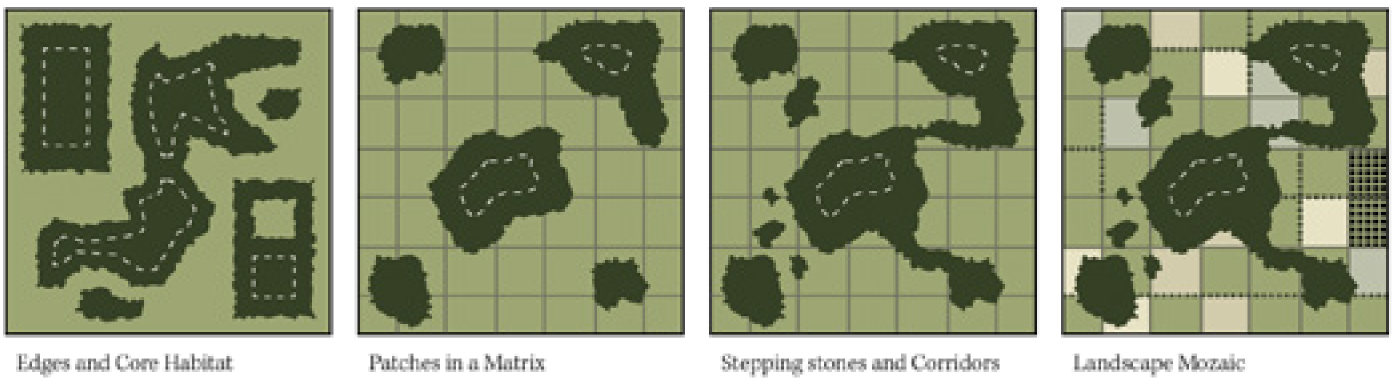


Figure 12: Visual support for the explanation of the ecological concepts: patches, matrix, edges, corridors, stepping stones and landscape mozaic.

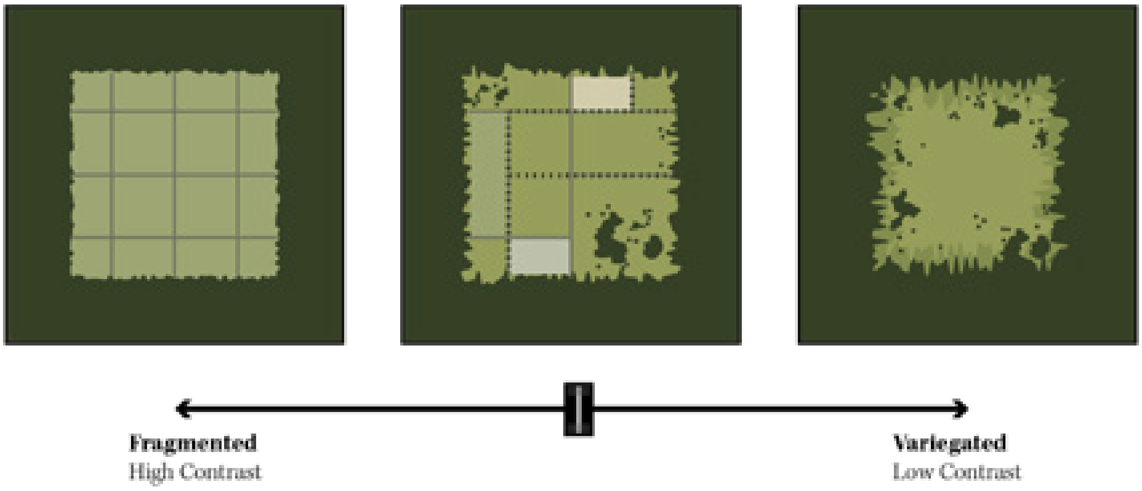


Figure 13: The amount of fragmentation and variagation can be adjusted by switching between high contrast of forest and matrix, or low contrast between forest and matrix

Successful ecological design

Actual success in terms of biodiversity increase and ecological growth cannot be measured easily. Clear objectives and priorities are essential and necessary, as well as a focus on species that are at risk (Kettunen *et al.* 2007). Functional connectivity is therefore much more important than simple structural connectivity. Lastly, treating landscape connectivity as a dynamic property and following an adaptive management approach can help to respond to future changes in for example climate or land use (Kettunen *et al.* 2007).

For this research there are no target species appointed, as the design is not primarily ecological, but approached from a multifaceted perspective. Consequently, little can be said about the success of this design in terms of ecological improvement, as species will not and cannot be directly measured. On the other hand, and seen from a bigger perspective, the information on the patch-matrix theory, edges, European forest connectivity and the dynamic approach towards adaptability can support the design on an ecological base.

Key Points

• Forests are complex ecological systems which are experienced best using all senses.
• There are light-species and shadow-species.
• Edge effects have a range of 50-100m, and edges harbor a great diversity of species.
• The ‘interior habitat’ of a forest can be defined as the area that is buffered from the edge effects, and harbor specific forest biota.
•Different configurations and amounts of fragmentation are not inherently good or bad for species or diversity.

Forest in the Cultural Landscape.

Forest History

It is quite likely that the name 'Holland' originated from the term 'Holtland' (Buis, 1993 p. 7). 'Holtland' meant something like 'land covered with trees'. However, Buis (1993) explains that this situation was nowhere near the large primeval forests of Germany, but that the land wasn't bare either. In the last 1000 years, all this forest, which consisted of about 1 to 3 million ha, has disappeared in a long and complicated history of reclamation and exploitation that now comprises the Dutch Cultural Landscape.

So, why did these forests disappear exactly? Already in the 11th century, most of the forest on the 'Veluwe was cut down to be used in the iron industry as fuel. Not much forest appeared to have remained (Buis 1993 p. 131). After this, forest cover was mainly determined by two things: population size and waterworks.

The population size determined how much wood was being used as building materials and as fuel. The use and prices of wood as a fuel fluctuated through the ages because it was considered a luxury fuel compared to peat and coal. On the farmlands however, wood was usually nearby, in small forest patches on the farmers own property, or from communall forests called the 'Marke'- or 'Malebossen'. Waterworks consisted of dikes and embankments and most of this wood was grown and used nearby where it was needed, along waterways, nearby the banks and near lakes. (Buis 1993 p. 132) Halfway the 18th century, the demand for wood suddenly peaked, as the wood used in the waterworks was heavily affected by a worm, which resulted in the replacement and reconstruction of the waterworks. This also caused a large scale trend of the cultivation of coppice ('hakhout') (Buis 1993 p. 132).

Remarkable however, is the use of wood for shipbuilding. The Netherlands had an impressive amount of ships that made foreign trade possible, but this wood was not provided by the Dutch landscape. Transporting wood via roads was very inefficient and costly, via water however, there were possibilities. Much of the wood used for shipbuilding came from Germany, Norway, and countries along the Baltic Sea, which caused huge amounts of deforestation on our behalf elsewhere. If it wasn't for the presence of peat and foreign wood, the Netherlands would have taken a very different course in history (Buis 1993).

The use of forests throughout time

Forests had many different functions and were interwoven with the practices that shaped the cultural landscape. The most important functions that forests mediated were hunting, grazing and logging.

On the higher sandy soils, a close relationship existed between agriculture and cattle breeding. Cattle manure mixed with sods was needed to fertilize the poor sandy agricultural land. The cattle in their turn needed land to graze. Often these were heathlands, meadowlands along rivers, streams and in lower parts of the landscape, and forests. If there wasn't enough space for cattle to feed, the output of agricultural produce was also limited, an unfavorable relationship. This system lasted for many ages and overexploitation of the heathlands and forests let to the development of drifting sands. Next to that, the transportation of nutrients to the agricultural lands let to land degradation. (Buis 1993 pp.145-148)

Wood cultivation, in particular oak coppice, was also a practice besides agriculture. Small parcels were sometimes sown with acorns that produced oak coppice. After one or two decennia, this wood was harvested and the leaves were mixed with the soil in the hope that it would create a rich top soil (Buis 1993 p.148). The bark of oaks was used in leather tannery.

Forests offered possibilities for hunting, although this was mostly reserved for nobility, as it was a royal right. Nevertheless, many people did not comply to those laws, even though they could face the death penalty as a consequence of their crime (Buis 1993 p.31). Another practice was 'akeren': the fattening of pigs by letting them eat fallen acorns and beechnuts inside the forest (Buis 1993 p.105).

Figure 14: Sticks were used to beat acorns out of trees, so that they could be eaten by pigs, Ca. 1510. (Horenbout *et al.* 2022)

The practices of grazing and logging often resulted in forest degradation, which consequently resulted in the practice of forest maintenance and management. Forests were sometimes 'put in peace'; meaning that it was no longer possible to let cattle graze, in order to rejuvenate and sometimes replant the forest. This sounds like an easy practice, but the population depended heavily on these forests for their food supply as well as fuel, and many forests therefore disappeared (Buis 1993 pp.105-106).

Next to forest management practices (or actually more like forest conservation), there were also forest laws and user rights that determined who could use the forest and how much could be harvested per year (Buis 1993 p.77). The 'Marke- and Malebossen' were communal forests, where, in a 'free forest' the inherited users would all own user rights. Together they would assemble in meetings to make decisions on what should be done in the forest. In some 'Markebossen' the original landowner managed to keep the user rights to himself, meaning that he would determine the course of events (Buis 1993 p.51). Forest outputs would then be distributed among the members (Buis 1993 p.58).

From the 16th century onwards, the attitude towards nature started to change. Nature was no longer an enemy of humankind, but more and more an inspiration. Most of all, it had become pliable to human needs and demands. Gardens and estates were designed with exotic plants and forest avenues were created for aesthetic and recreative reasons (Buis 1993 p.176). The more fortunate in society became interested in the scientific aspect of forestry and even started with afforestation practices (Buis 1993 p.177). This scientific interest was also gaining momentum in attempts to reclaim wastelands: 'woeste gronden'. Unproductive land was forested under the motto of: 'Forest as second best' in the hope that after 25 years, a more fertile soil would remain. Practice unfortunately taught otherwise (Buis 1993 p.178).

These landscape practices would roughly endure until 1850. From then on, different developments caused the landscape and its practices to change. The agricultural system was broken through by the availability of artificial fertilizer, that could also be transported to more remote areas now. For the agricultural practice there was no longer a need for large amounts of grazing areas. These areas could now be reclaimed or forested. The last 'Marke'-law of 1886 (which meant that if one of the members wanted to divide the land, nobody could stop that) resulted in more than 18.000ha of forest or heather land for sale. Many terrains were reclaimed as agricultural land, founded as new estates and the poorest terrains were forested. These forests are now called the 'jonge heidebebossingen'. The drifting sands were contained by afforestation as well and are now called the 'stuifzandbebossingen'. (Buis 1993 p.149)

Around the end of the 19th century and the beginning of the 20th century, natural scenery and beauty, nature and conservation had become part of societal and governmental goals. Recreation soon followed (Buis 1993 p.182). After the Second World War, some afforestation efforts were part of job creation projects. In the 1970's, a trend developed against production-forests, partly in response to storms that destroyed large amounts of forest monocultures. Forest ecology and recreation topics were in the picture and became an important part of forest management (Buis 1993 p.183). In the 80's, it turned out that our forests were deteriorating and that the Dutch forests were far from developed as a stable ecosystem. Just a century before, people had trusted in the restoration of our forests, however, the realization that the large scale forest and nature destruction could not be reversed, kicked in (Buis 1993 p.183).

Figure 15: Land use around 1900. (Knol *et al.* 2004)

Figure 16: Land use around 2000. (Knol *et al.* 2004)

The current Dutch forests

The Netherlands possesses a variety of forests nowadays. These forests can be loosely categorized and originate from different historical land uses. The categories originate from researching local histories of different forests in the Region of Zwolle and finding out if the same forest origins are also present in the rest of the Netherlands.

Polder forest
The afforestation on polders/reclamations are usually located at places where the soil was unsuitable for agriculture. This could be due to high groundwater levels or seepage (sometimes through iron or salt layers), as well as areas where peat or sand was present. Usually these forest were focused on the creation of recreational spaces. Examples are the forests on Flevoland and the 'Robbenoordbos'.

Peat forest
Afforestation usually happened after peat extraction as an extensive land use, or after peat extraction in order to make a living from the remaining soil, that was usually too wet for agriculture. Examples are the 'Weerribben-Wieden' and the forests around 'Hollandscheveld'.

'Woeste grond' Forest
Mentioned earlier in this chapter, afforestation happened on very poor and 'worthless' soils as a way to hopefully make these soils productive. Examples are the 'Dwingelderveld', 'Drents-Friese Wold' and 'Holtingerveld.

Estate forests
Forest was planted on and around estates for a variety of reasons. Oak coppice, production forests, recreational forests, pinetums and arboretums as well as 'star' forests (sterrenbos) for hunting are all common. An example is 'De Eese'.

Job-creation-forest (Werkverschaffing)
Afforestation happened after WWII as a way to create jobs in economic crisis. The main goal for afforestation was often for the production of wood. Examples are the Forest range of 'Staphorst' and 'Hardenberg', as well as the 'Amsterdamse bos'.

Lake Forests
Throughout the Netherlands, small forests can be found around lakes created by sand extraction, peat extraction or clay extraction. Examples are the 'Kralingse bos' and the 'Zuigerplasbos'.

Waste disposal Forests
Some forests have been planted on waste disposal hills, from trash as well as from war debris, especially when they are located closer to cities. Examples are the 'Hogebergsebos' and 'Westerveldsebos'

From this small research can be concluded that most locations used for afforestation are grounded in very pragmatic reasoning. Agricultural land is spared and 'wasteland', has been forested. Many forests are by-products of developments. Their meaning however, has culturally become relevant for recreation as well as biodiversity, as explained before. Besides, it can also be concluded that these forested locations are already 'taken', meaning that for the search for a new location, new or current arguments and reasoning needs to be developed.

Key Points

- Wood has been of great importance in the Dutch history, mainly in regard to fuel, waterworks and ship building.
- Waterways were used as an important transportation method.
- Forests had many different functions and were interwoven with the practices that shaped the cultural landscape.
- Societal views on forest have changed from productivity towards a more ecological and recreative perspective.
- Forests currently present in the Dutch cultural landscape are, generally speaking, by-products of developments, grounded in pragmatic reasoning.
- New or current arguments and reasoning needs to be developed for finding locations for afforestation.

The forest: a complex human experience

The human connection with nature

The relationship between human health and the natural environment, including animals, plants, landscapes and wilderness, asserts that nature is an important component of human well-being, which can briefly be explained in two ways (Curtin 2009). On one hand, it is the human genetic sequence that has been programmed over one million years of evolution to respond positively to natural environments to make us thrive and survive (Curtin 2009). On the other hand, the natural environment provides the most effective restorative environment from day-to-day routines (Curtin 2009). Being in the presence of wildlife can evoke feelings of profound happiness in which a human emotional peak can be achieved through feelings of intention, reciprocity, connectedness, aliveness and harmony (Curtin 2009). In this state of consciousness, people enter a state of 'flow', where the passage of time is distorted and participants are totally absorbed by the activity in the moment (Curtin 2009). 'In this reprieve from everyday reality dwells a still, calm and focused existence bound in the present' (Curtin 2009 p.460). This creates an important and desirable foundation for successful recreational experiences.

According to Curtin (2009), this feeling can vary in degree, and is not an all-or-nothing experience. However, the level of challenge in the activity people take part in should not greatly exceed their level of competence, otherwise frustration invades the feeling of fulfilment. This highlights the importance of eliminating frustration: clear routing or intuitive way-finding, next to a variety of route distances.

But the visual experience is by no means the only sense that is involved, hearing and smell also play an important role in this experience. Being immersed and away from the routines of everyday life facilitates a distancing process that is necessary to achieve a multisensory experience (Curtin 2009). In a forested landscape, positive non-human sounds, such as bird chirping or hearing wind in the leaves, together with positive man-made sounds, like light music or singing, are most helpful at relieving psychological pressure (Liu *et al.* 2019). In an understory landscape (the inside of a forest) the presence of human sounds can give recreants a safer feeling (Liu *et al.* 2019). And do not forget the pleasant earthy smell of a forest soil.

Curtin (2009) also explains that our experiences with nature and wildlife have become a sentimental luxury. In a post-industrialized society, views towards nature have changed towards the believe that nature is fragile and in need of protection. Keeping pets, visiting zoos and watching wildlife offer connection with nature in a controlled setting. Understanding these views on nature is an important component of guiding and managing wildlife-oriented recreation.

Often people appreciate forests for their variety; open or closed, deciduous or coniferous, large lanes or small paths, as well as their 'natural' impression (Klingen 2017 p.81). Trees in a row and remnants of harvesting work can ruin this natural impression and disturbs the experience (Klingen 2017 p.81).

It can be concluded that people prefer a manageable experience, and do not like to be pushed out of their comfort zone. Immersiveness forms the base of a good experience, and matching different levels of competences keep this experience successful. This seems to be supported by the fact that previous research has demonstrated that people prefer landscapes with a function of prospect-refuge; open park-like forests are preferred more than dense and complex stands (Liu *et al.* 2019). However, having large areas of forests where you can be and move for longer periods of time without interruption is important to maintain the 'flow'.

figure 17: An example of poor immersiveness. While being in the forest, the clear boundary where forest meets agricultural fields interrupts the 'flow'.

figure 18: A well established and gradual forest edge can create slow transitioning forest borders, ensuring immersiveness inside the forest.

Unmanaged or Managed forest?

Forest will grow under almost all circumstances; it does not need human interventions to grow. Unmanaged or completely natural forest however, does not offer the possibility for the production of wood and is often inaccessible for users. Forest management offers multiple advantages. When managing a forest, a diverse and structure-rich forest can be developed, where unmanaged forests will be much less variety-rich. This does not only create a more diverse experience, but also ensures that the forest can be adjusted to its users over time. (Klingen 2017 p.61)

Management of forests is a large and complex subject. Complete reports could be written about forest management, however, for this research I will limit the information to a management type called 'Integrated forest management'.

Integrated forest management focusses on a combination between wood production values and ecological values. These go well together, as interventions for the purpose of biodiversity can be combined well with the cultivation of quality wood. Sustainable logging, where single specific trees are harvested in a tempo that resembles natural rates, is the best way of preserving biodiversity while also harvesting quality wood (Attenborough 2020 p.171). The goal of integrated forest management is to create and manage an ecologically rich forest, where once in a while, quality wood can be harvested (Klingen 2017 p. 69).

Key Points

• Forest provides a restorative environment from day-to-day routines
• The level of challenge should not exceed the level of competence, people prefer comfort.
•Immersiveness, clear routing, intuitive way finding, engaging multiple senses and variety are important aspects of a forest experience.
• Managed forests are valuable for ecological, productional and recreational goals.

Conclusion

The forest system is a complex ecological system. There are differences between interior habitats and edge effects. Both contribute to species diversity. Designing patches of forest that are large enough to contain interior habitats, as well as patches that consist only of edge effects are both contributing to species diversity. Different configurations and amounts of fragmentation are not inherently good or bad for species diversity, so designing a variety offers ecological benefits.

But the forest system also has a cultural layer. Wood used to be an important product in Dutch history, as it was used for fuel and as a building material. The transportation of wood was made possible by waterways. Forests had many different functions and was interwoven with the practices that shaped the cultural landscape. Nowadays, forest can become an integral part of the landscape again, as we are slowly relying on wood products for sustainable futures. This is underlined by the societal shift in views on forest. Its recreative and ecological aspects are appreciated more.

The forests that are currently present in the Dutch landscape are relatively young, and located on very pragmatic locations. New arguments and reasoning for the development of forests in the existing landscape is needed. Taking cultural meaning into account when designing adds to the ecological perspective of the forest system, as recreation is a current cultural argument for afforestation, next to is productivity. This recreative aspect is important for the ability to provide humans with a restorative environment from day-to-day routines. When designing forests, a few things should be taken into account to create a pleasant experience. The level of challenge should not exceed the level of competence, as people prefer comfort. Immersiveness, clear routing and intuitive way finding are important design leads. To add to this, variety of different forest types and species can enhance the visitor experiences. An ecologically rich forest can provide its visitor with a multisensory experience, so its biodiversity should not be undermined. In order to balance ecological, recreative and productional aspects of a forest system, management is needed.

Chapter 3. Landscape Analysis

Part II. Research for Design

Landscape Analysis

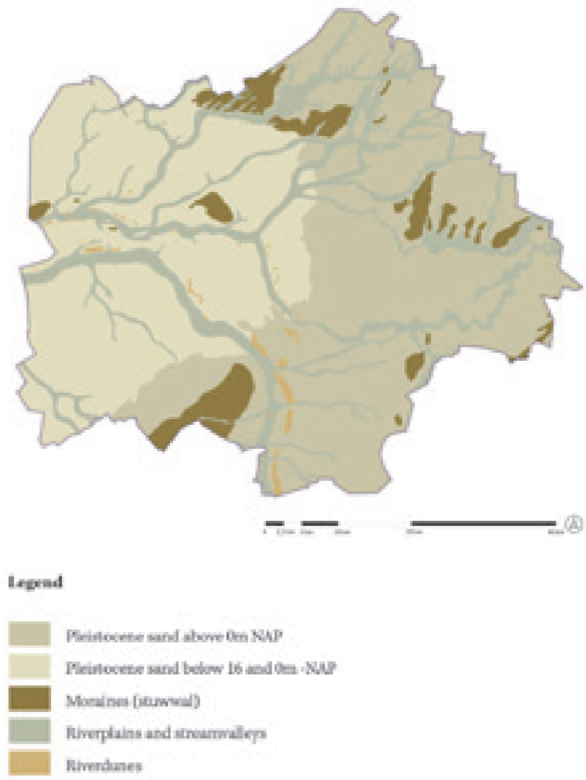
Geomorphological History

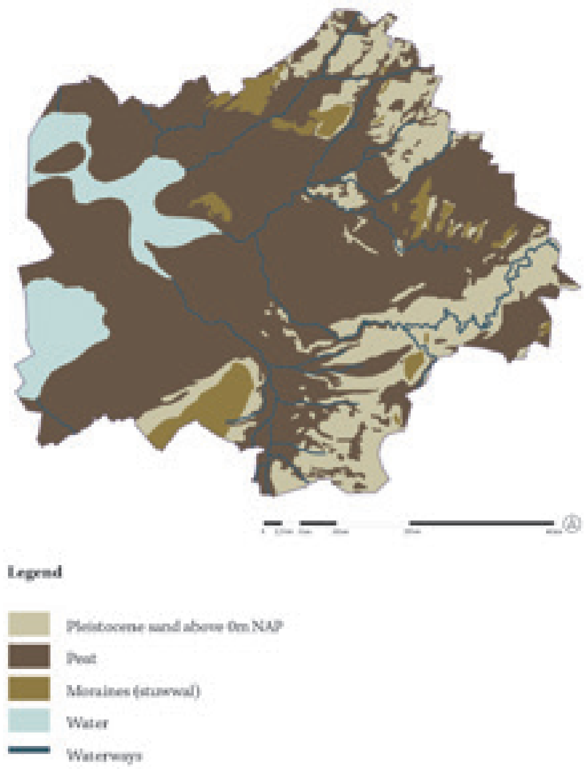
9000 B.C

Around 9000 B.C onwards the Holocene starts. Before this period, in the Pleistocene, many ice-ages or glacial periods took place, with warmer periods called interglacials in between. In the second last glacial period, the Saalien, glaciers from the north cover large areas of land, up until Nijmegen. The ice brought a mix of loam and stones, which, after the ice had melted again, remained on the land surface. The glaciers had eroded valleys and pushed land material forwards and upwards, creating Moraines (Stuwwallen). After the Saalien an interglacial followed, in which parts of the land surface flooded by the rising sea level and sand was deposited. In the last ice age, the Weichselien, no land ice reached the Netherlands. Instead, the climate was extremely cold and dry, with almost no vegetation possible. During storms, large amounts of sand drifted and were deposited in more sheltered areas. These sand deposits are called 'Dekzand'. (Bijhouwer *et al,* 1977)

500 B.C

Ever since the beginning of the Holocene, the interglacial period in which we still live today, temperatures rose, and humidity increased. Sea levels rose and vegetation such as Birch and Pine returned. Lower parts of the landscape became wetter and in the lower sandy swamps, peat started to grow. In the east of the Netherlands, the landscape was barely influenced by the sea, meaning that peat could grow continually. Around 700 B.C the sub Atlantic period starts, in which the sea alternates between calm and more offensive behavior. Around 500 B.C, the more often offensive behavior of the sea correlates with the development of salt marches (kwelders) and the development of mounds. The mounds were raised and enlarged until the 12th century, until the landscape was diked. (Bijhouwer *et al*, 1977)



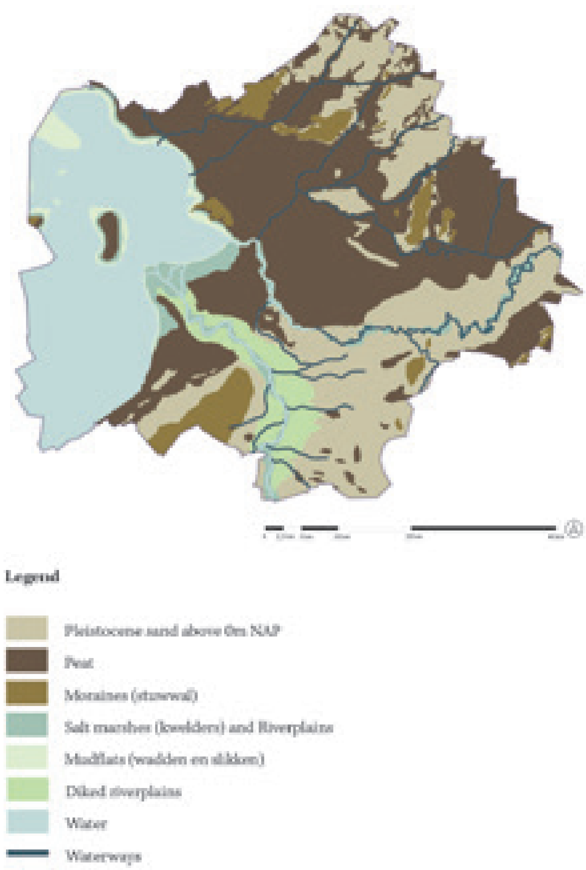


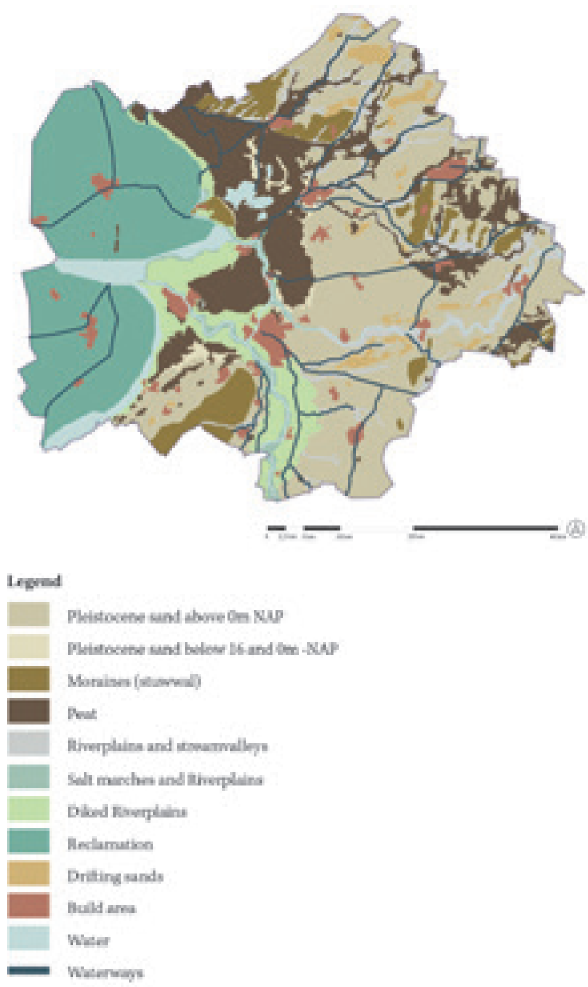
1500

In a calmer period, the rivers are inhabited by Romans and Batavieren. The calm period is ended when around 300 a period of intrusive water starts, where the rivers, as well as the sea have increased water levels. In a following calmer period, humans created dikes to protect themselves from intrusive water. In 1300, the water becomes restless again. It still happened frequently that dikes were breached and that land would be (temporary) lost to the sea. More and more, humans were altering the landscape to protect themselves from water, which started a long tradition of landscape cultivation. (Bijhouwer *et al,* 1977)

2000

The Netherlands is a delta landscape, so intrusive water comes from both the rivers as from sea. The relationship with water has marked much of the landscape as we can find it now. Lowering groundwater levels in order to cultivate the land interrupts the natural process of peat growth, meaning that our land surface does not grow upwards simultaneously with the sea levels anymore, but instead oxidizes and shrinks. How humans have influenced and altered the natural landscape, now forms our cultural landscape. (Bijhouwer *et al,* 1977)





The Cultural Landscape

The Cultural landscape

The Netherlands possesses a rich variety of different cultural landscapes. The cultural landscapes as we know them developed from interactions between the naturally given, such as soil, water conditions, height differences and climate; and human activities over the course of roughly 3000 years. The Region of Zwolle portrays a rich variety of these cultural landscapes.

In the Region of Zwolle, roughly five landscape types can be found: The river-, sand- and peat landscapes the 'Droogmakerijen' and the 'Veenkoloniën'. In the following chapter, the different cultural landscapes that fall under these five landscape types are described.

'Ons vaderland is eene van hare schoonste overwinningen, een gedenkteeken van 's menschen zegepraal over de magt des waters. Ons land is een kunstland; de natuur draagt hier een menschelijk gewaad. En ook dit landschap is in zekeren zin schoon. Onze landschapsschilders hebben het begrepen en hun roem is ons een waarborg daarvoor. Wij ergeren ons niet, wanneer de mensch de hem omringende natuur omwerkt en herschept om er het meeste voordeel van te genieten.'

F.W. van Eeden, 'Het landschap', in: Album der Natuur,1862, pp.205-221 en 225-240; citaat op p.215. (van der Meulen 2009, p102)

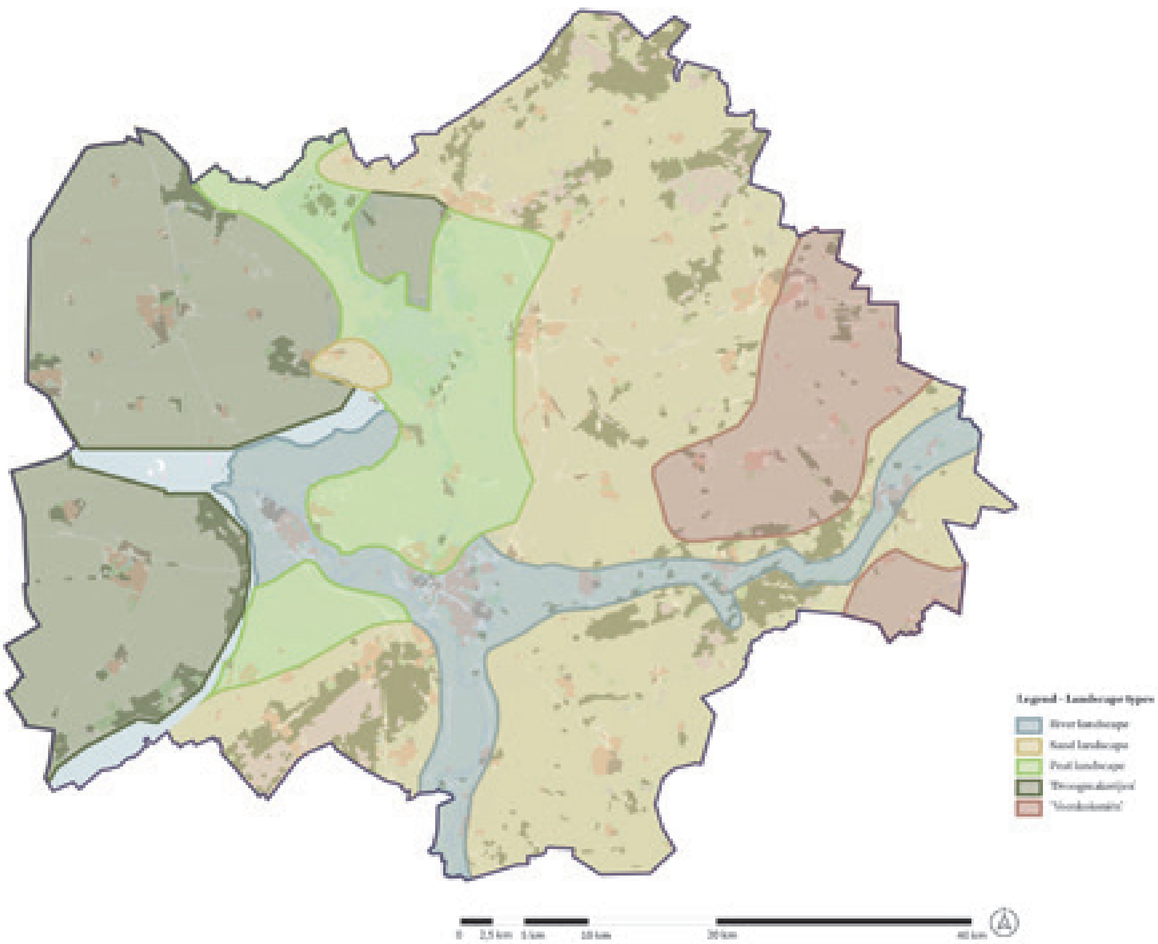


Figure 19: Landscape types

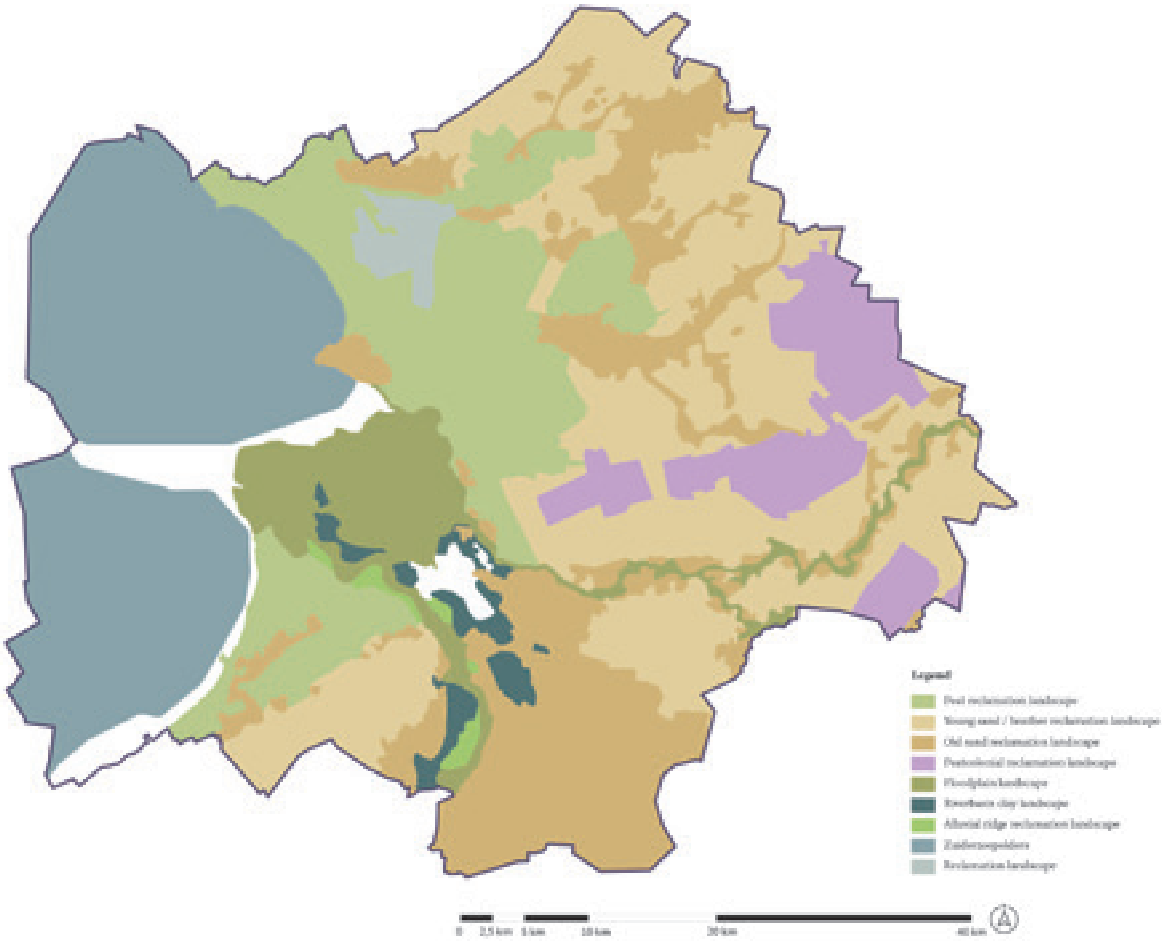


Figure 20: Cultural landscapes

Figure 21: Historical map of 1820

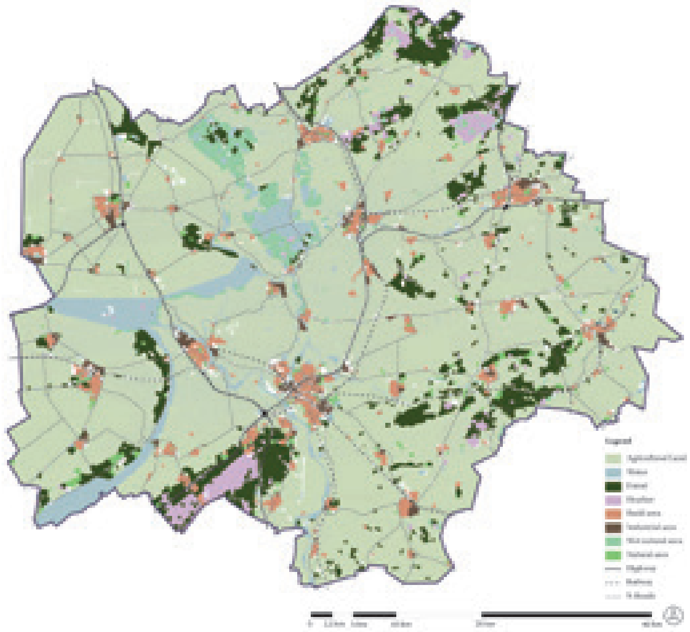


Figure 22: Current land use

The Landscape types of the Region of Zwolle

River landscape

Floodplains

The main function of the floodplains is to catch and store water during high water discharges.
In order to do so, the floodplains need to ensure a certain level of flowability, meaning that obstructions such as vegetation or buildings are relatively scarcely present. Because our rivers are diked, sediment from high water levels are deposited inside the floodplains, instead of how they used to flow towards the 'Komlandschappen': lower laying inland river basin clay landscapes. This means that the floodplains are slowly increasing in height, and now have sand and clay deposits. The 'oeverwallen': alluvial ridges, originated from when the rivers were not diked in yet. They were higher compared to the land behind, due to the deposit of sand close to the river. The higher alluvial ridges were used for habitation and (specific) agriculture, such as orchards, whereas the 'komgronden' served as meadowland. (Bijhouwer 1977)

River basin clay landscape (Komgronden)

The 'Komlandschap' is a landscape that is situated lower than the river and its sandy banks (Oeverwallen). The soil consists of a high percentage of clay that was deposited before dikes were built around the rivers. For the purpose of agriculture, the landscape was reclaimed, resulting in further sinking of the ground level. Because clay is difficult to cultivate, it was mostly used as meadow. (Bijhouwer 1977)

Mound landscape

A unique landscape, that can be roughly considered as a river landscape, and as a sea clay landscape, is the 'Kampereiland'. The landscape is situated at the estuary of the river 'IJssel'. The city 'Kampen', close to the 'Kampereiland', benefitted from the river estuary, as it could trade via the 'IJssel' and because of its direct connection with the North Sea. On the peak of the city its prosperity, the 'Kampereiland', and the rights of accretion were gifted from the Bishop of 'Utrecht to the city of 'Kampen'. The city benefitted from this landscape, because more farmers could move away for the purpose of city enlargement, and because of the rent derived from the farms. From the 13th century onwards, the islands were diked in with small dikes of 2,3 m above NAP. The area flooded during winter, leaving a fertile, but salty layer of clay. This ended when the dikes were heightened in 1862.
However, because of frequent flooding, farms and farmhouses were built on mounds. The construction of the 'Afsluitdijk' ended the need for these mounds. (Hendrikx 1998, p.49).

Figure 23: Floodplains of the IJssel river, near Zalk

Figure 24: Mound landscape of the 'Kampereiland'

Sand landscape

'Esdorp' landscape (Old sand reclamation)

The 'esdorp' landscape is one of the oldest landscape types in the Netherlands. It originated in the sandy areas in the Netherlands, usually on the flanks between the higher sandy soils, such as moraines and lower wetter stream valleys. The flanks were used for agricultural land, the stream valleys for meadowland and the moraines as 'woeste grond'. On the 'woeste grond', sheep would graze during the day, peat was excavated for fuel and sods were excavated to be used in the sheep barn, in a sod-manure system. The sod-manure was used on the agricultural fields, as sand was not very fertile. The esdorp' itself is a village with an open area in the middle, used as a common ground for livestock, for example when the meadowlands were too wet to be grazed on. This landscape type is found in the north of the region of Zwolle, with Diever, Dwingeloo and Vledder as typical 'Esdorpen'. (Bijhouwer 1977)

Heathlands, Drifting sands and Forest

Heathlands were found widespread throughout the Region of Zwolle. This is because most of the sandy soils, which is about half of the regions main soil type, used to be heathlands, either dry or wet in nature. There were called 'Woeste gronden' and they were either a part of the agricultural sod-manure system, or, in the eyes of the Dutch, worthless soils, meaning that they were too far away from inhabitation, too wet to cross and unable to be cultivated. Besides that, when too much of the heathlands would disappear, the sod manure system would collapse. Because many sods were excavated, sometimes the sand underneath would start drifting, creating large drifting sands. These drifting sands were a big threat to habitation and agriculture. Only until artificial fertilizer became available, around 1850 onwards, many heathlands were excavated and cultivated. Many woeste gronden and drifting sands were also forested, as forest was the second-best option besides agriculture. Many of these forests consisted of pine trees, as the sandy soil were very poor in nutrients. Not much of these original locations of heatherfields remain nowadays, however, much of the forests that can be found in the Region are created on former 'woeste gronden'. (Bijhouwer 1977)

Stream Valleys

The stream valleys are situated in lower parts of the moraines, eroded by melt water after the last ice age. They were wet and relatively unpredictable landscapes, as the streams were fed by rainwater. In winter, the valleys were almost permanently flooded. This meant that the stream valleys were used as meadowland and hayfields only. Some areas had small wet, swamp-like forests, called 'Broekbossen'. The wet character of the valleys was a limitation for a long time. From 1850 onwards, a process called 'beeknormalisatie' started, in which the steams were straightened to improve drainage. This indeed drained the landscape upstream quicker, but downstream the landscape often could not store large amounts of water, causing yet again new limitations (van der Meulen 2009 p.162). (Bijhouwer 1977)

'Kampen' landscape (Old sand reclamation)

In between higher sand plateaus, a lower, much flatter sand landscape is present. Many streams cross this landscape and the distance between them is much smaller, giving the farms a different character. The farms are unable to have large sheep flocks, like they have in the 'Esdorpen'landscape, so they have a much more mixed farming character. The streams have broad valleys and the sandy topsoil ('dekzand') has created higher sandy ridges. In some of the wider areas, further away from the streams, wetter conditions can be found, as water stagnates, on a layer of clay or 'keileem'. In these areas, heathlands with varied vegetation and raised bogs were found. On the edges between sand and meadowvalleys, roads and buildings can be found, they have a irregular layout of buildings and fields, so that every farmer can reach their fields optimally. Fields were surrounded by wooded banks and along roads, but also in small forest patches, trees could be found, creating a half-open landscape, also called 'coulissenlandschap'. Many tree lanes have disapeared and streams were straightened to improve drainage. Higher soils became dryer and lower soils wetter. (Bijhouwer 1977)

Young heathland reclamations
Keeping sheep flocks became less and less viable, so in the ‘kampenlandschap there was also a need and ambition to excavate more soils when artificial fertilizer became widespread, mainly the heathlands. They are characterized by a straightforward road system, rectangular structures and farms on bigger distances of eachother. There are differences between dry young heathland reclamations and wet young heathland reclamations. The wet reclamations are often situated between lower stream valleys and higher moraines or sand ridges. These areas were wet in nature due to running water and seepage. (Bijhouwer 1977)

Figure 27: Drifting sands near Besthmen

Figure 25: ‘Esdorp’ along the Vecht river.

Figure 28: Stream valley of the ‘Reest’, near Dedemsvaart.

Figure 26: Wet heathlands along the stream valley of the ‘Reest’.

Figure 29: Young heathland reclamation landscape near Staphorst.

Peat landscape

<u>'Slagen' landscape</u>

The 'Slagenlandschappen' developed in swamp-like areas, also called wilderness, in the (early) Middle Ages. This wilderness was only accessible through small ribbons of clay or sand or at the edge of a sandy soil. Parcels were excavated mostly perpendicular from a road on which houses were build, but never in a perfect 90 degree angle. The landscape was used as meadow, hay land and on the dryer, more clay-like or sandy parts as agricultural land. Somewhere between the hay land and meadow, waterways were dug perpendicular to the parcels, for improved drainage. After removing some forested areas, the sides of the parcels were planted with Alder, for wind-shelter, as cattle enclosures and for the use of wood. An example of this landscape is the 'Staphorst area. The location of the current village is not the original location on which this landscape was founded. The village moved twice, from west to east. Because generations of villagers have lived in 'Staphorst' for centuries, the parcels are extremely narrow due to inheritance. Farms therefore needed to be built behind one another instead of next to each other. The parcels are lined on both sides with Alders, Ash trees or oaks.
An unusual example of this landscape can be found in 'Giethoorn', in which the infrastructure was not focused on roads, but on waterway transport. The excavation therefore happened perpendicular to these waterways, instead of roads. (Bijhouwer 1977)

<u>Peat excavation</u>

Peat excavation happened in the area of the 'Weerribben' and 'Wieden'. The excavated peat served as fuel. After excavation, a certain amount of peatland needed to remain, next to the waterway that was created, to dry the peat in the wind, and to prevent water from washing away the remaining peatland. However, peat was a source of income, and often too much peat was excavated. This created large lakes in the landscape, that would sometimes be drained again, although not always successful.

<u>Polder Mastenbroek</u>

The polder 'Mastenbroek' was from origin a low-lying peat landscape, that was frequently flooded by the river 'IJssel' and the 'Vecht'. The result of that is a small layer of clay on the top part of the soil. During the Middle Ages, the landscape was used as a extensive meadow, and was considered a 'Marke'; a joint property. The excavation of the polder therefore brought forth many fights and discussions. In 1364, after decades of discussion, a definitive division of the polder was determined. Its pattern of excavation is unique, since it was based on a very precise layout of a land surveyor called Frederick Stoyveken. In 1384, the landscape was diked, but rising water in winter was still difficult to control, flooding the whole polder. Therefore, early farms were built on mounds (Hendrikx 1998, p. 101-102). The oldest steam pumping station of the Netherlands is present in this polder. (Bijhouwer 1977)

<u>Veenkoloniën</u>

The 'Veenkoloniën' were also peat excavation landscapes, but they differ from other peat excavation. The peat type was 'hoogveen' (raised bog) instead of 'laagveen', meaning that the growth of peat was 'fueled' by rainwater instead of groundwater, and could grow meters in height. This would mostly happen on wet sandy soils, where on top of a layer of peat, the raised bog would grow.
For a long time, the raised bogs were excavated at mostly the edges of a large area to use as fuel, and sometimes drained to stimulate heather growth instead. Excavation happened more systematically when population kept growing. Peat was exported using channels. The top layer of the raised bogs, mixed with the sand that would remain after excavation happened to create decent agricultural soil which was sold after excavation. However, this topsoil that was mixed in the sand disappeared quickly, leaving a sandy soil with no organic matter. City waste was used to create compost to spread over the soils. The peat colonies of 'Hoogeveen' and 'Dedemsvaart' are considerably older than the peat colonies in the north of the Netherlands. Excavation already began in 1560, before they knew about mixing in the top soil, leading to a very poor soil condition. Because excavation started early, the landscape has a different character then the typical structure of the peat colonies of Groningen. (Bijhouwer 1977)

Figure 30: Rows of Alder along the narrow parcels of Rouveen and Staphorst.

Figure 31: The 'Beulakerweide', a peat excavation lake near Ronduite.

Figure 32: Polder Mastenbroek.

Figure 33: The oldest steam pump of the Netherlands in polder Mastenbroek

Figure 34: Peat colony landscape near Hollandscheveld, after excavations the landscape was forested due to very poor soil conditions.

Droogmakerijen

<u>'Zuiderzee polders'</u>

Around 1936, dikes were built to create the 'Noordoostpolder', the first polder of the 'Zuiderzee'-works was created from former seabed, that would create 150.000 ha of new land. After the 'Noordoostpolder', which created an irreversible water problem of soil dehydration on the mainland, 'Flevoland' would get the 'randmeren': lakes that separate the polder from main land. The construction of dikes for the Eastern 'Flevopolder' started in 1950. The soils in the 'Noordoostpolder' who weren't classified as first-class agricultural soil were forested, along with the creation of village-forests. In the 'Flevopolders', forest would get a more recreative role, with less focus on production alone. In the east-'Flevopolder, infrastructure was focused on a fully motorized population. The landscape is open, large-scaled and with large farms and parcels. Trees can be found around farms, along infrastructure and waterways. Its spatial lay-out is technical and pragmatic, based on soils structures and corresponding uses. (Bijhouwer 1977)

Figure 35: Farm in the open Flevopolder landscape near the 'Ketelhaven'.

Figure 36: Young mixed forest on the rich sandy soils of the Flevopolders.

Figure 37: The slichtly higher edge of 'Schokland', once an island in the Dutch Zuiderzee until the 'Noodoostpolder' was reclaimed.

Contributing factors

After looking at the formation and characteristics of the diverse cultural landscape of the Region of Zwolle, the current landscape conditions will be analyzed in light of afforestation possibilities and limitations.

There are many factors that contribute to afforestation, and this analysis is focused on highlighting as many as possible in relation to the current landscape and its conditions. These contributing factors are based on literature study, and texts written are referenced accordingly. The selection of factors can however not claim to be completely unbiased, as it is an interplay between finding information in literature, as well as finding literature to inform own observations, thoughts and opinions during the research.

Because the landscape is an interconnected and complex system, landscape conditions alone will not suffice as contributing factors to afforestation, but aspects such as functionalities, connectivity and possible programming also need to be taken into account. Therefore, observations during field visits are noted, and strengths, weaknesses, opportunities and threats are described, to create a more complete picture of the Region as a whole.

Observations

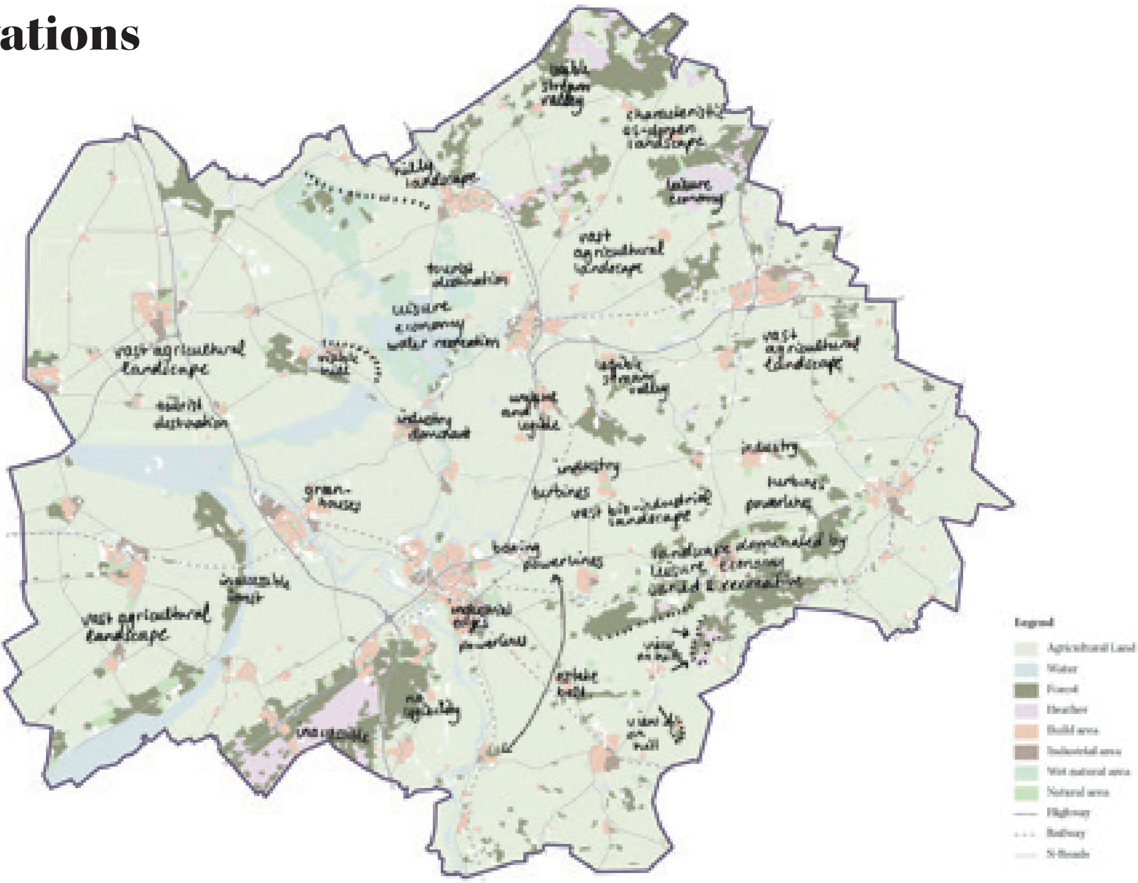


Figure 38: Observations from field visits.

Observations Region of Zwolle

The main purpose of visiting the Region is to get a feeling of the different cultural landscapes. What are important characteristics, qualities and weaknesses? And how would large scale afforestation influence this?

All cultural landscapes consist of interactions between the naturally given and human activities. In some places in the region, this interaction is still legible. Some places are dominated by industrial buildings and infrastructure, other places are rooted in a leisure economy of campings, holiday parks, day trips and recreative infrastructure, while others solely consist of vast open space for agriculture and livestock farming. The landscape outside of villages and towns is extremely car-focused, and many natural areas are reached best by car. Closer to the city edges of Zwolle, 'boxing' and cluttering (definitions explained later) by powerlines dominate the landscape.

Figure 39: Visible alluvial ridge in the landscape near the city edge of Zwolle, visible only because of the openness of the surroundings.

Figure 40: In open sight, the powerlines cause cluttering. Adding trees of forests is helpful for minimizing the effect of man-made elements in the landscape.

Figure 41: Behind the treelane a large forested hill, the 'Lemelerberg', is visible. This image shows how easy visibility of unique features of the landscape can be blocked by trees.

Figure 42: Cluttering of the very open 'Mastenbroek polder' by greenhouses and powerlines.

Figure 43: The visibility of the slopes would get lost when forested.

Figure 44: Slopes in an 'esdorpen' landscape, old remnants of a centuries-long agricultural practice.

Figure 45: The 'Kampereiland', where farms were build on mounds. Through the mist, a characteristic sequence of these farms is visible. Afforestation will block these historical views.

Figure 46: In many places in the Region of Zwolle, natural areas border directly and abrubtly to agricultural land use, strongly reducing immersive feelings.

Contributing factors

Openness landscape

Every landscape type knows its own ratio of openness. This depends on the (historical) use and exploitation of that landscape. The openness of the landscape is determined by objects that are higher than eyesight, blocking views in the wide environment (CBS *et al.* 2018). Differences between landscapes and levels of openness has been greatly decreased in the past century (CBS *et al.* 2018). Forests can take away any visual openness and are therefore seen as mass (Dijkstra and Lith-Kranendonk, 2000). Disappearance of very open (historical) landscapes should be prevented, as

Figure 49: Less than 10 ha visible surface, area around Eese.

Figure 47: More than 300 ha visible surface, area around Dronten.

Figure 50: Up until 300 ha of visible surface, area around Nieuw Leusen.

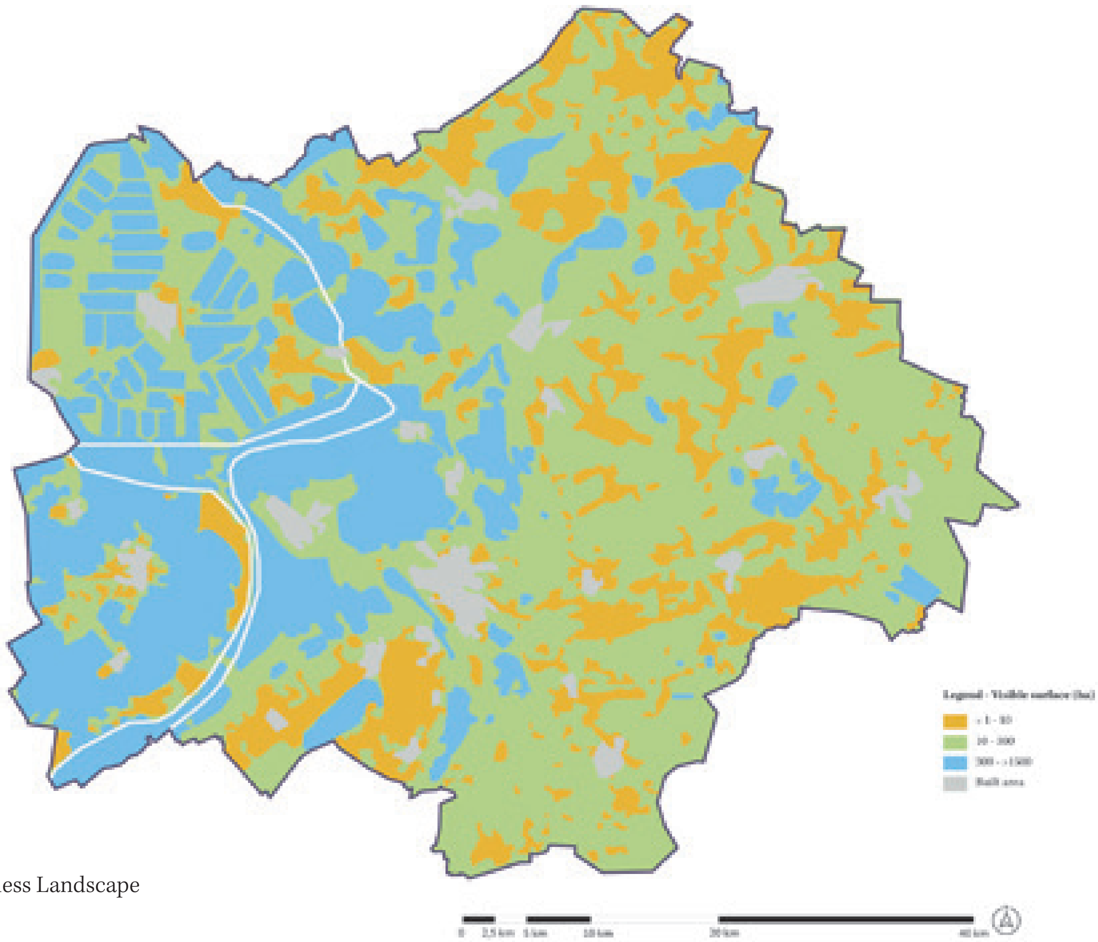


Figure 48: Openness Landscape

it contributes to the disappearance of the rich variations of Dutch cultural landscapes.

The Region of Zwolle is characterized by extremely open landscapes, such as the 'Flevopolders', 'Mastenbroek', 'Kampereiland', and some very open stream valleys, bodies of water and heathlands. Simultaneously, the region also possesses semi-open, mostly agricultural landscapes, and more closed landscapes. The more closed landscapes possess large bodies of forest and more tree density.

Small scaled or Large scaled

Whether a landscape is small or large scaled closely relates to visual openness seen by the observer in relation to size ratios of different objects and patterns in space (Dijkstra and Lith-Kranendonk, 2000). These objects and patterns can be build area, infrastructure and plantings. Note that this is different than just openness, as the density of a road network does not have to block your view.

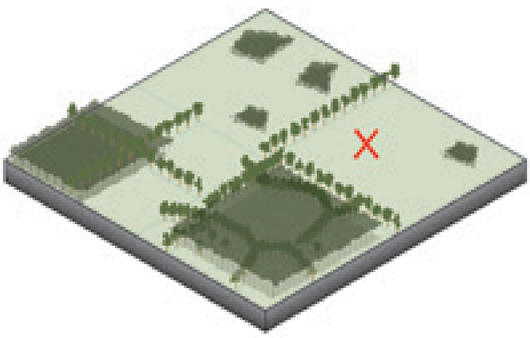
The size of a forest, from a very small patch, towards one large entity and everything in between, should match the characteristics of scale. A large forest matches better in a large or semi-large scaled landscape than in a small scaled landscape. A very large mass of forest can take away landscape diversity in a small scaled landscape. Similarly, a small patch fits better in a small scaled landscape instead of a very large scaled and more open landscape.

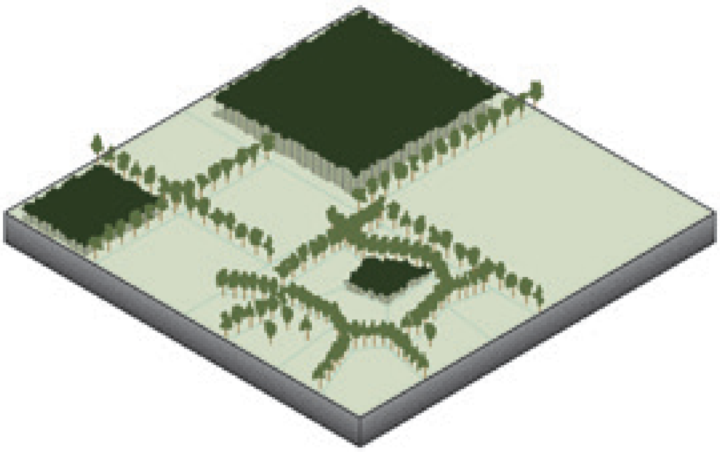
However, two difficulties now arise. Because this thesis is focused on large scale afforestation, the large scaled landscapes seem more suitable. However, large scaled landscapes are often also characterized by their openness and therefore in need of protection. Small scaled landscapes will lose diversity when large masses are planted, but a collection of small patches will likely not reach the objective. Therefore, in the Region of Zwolle, semi-large scaled landscapes might seem more suitable.

Figure 51: Large scaled landscape of polder 'Mastenbroek'.

Figure 52: Medium scaled landscape north-east of 'Zwolle'.

Figure 53: Small scaled landscape west of 'Lemelerveld'.





Water conditions

To ensure a vital forest, water conditions play an important role. Drought and acidification of groundwater will cause forest ecosystems to become vulnerable for pests and diseases, which can lead to a decrease in ecosystem functioning and biodiversity (Wijdeveen *et al.* 2021). Desiccation caused by ground water abstraction and soil drainage also cause vitality problems and biodiversity loss (Wijdeveen *et al.* 2021). These vitality issues will not cause forests to disappear per se, however, carbon storage, climate regulation and wood production will function to a much lesser extent.

Forests can be planted either on dryer or wetter soils, keeping vitality measures to be taken for those locations in mind. There are however some limitations. 'Dryer' sandy soils are more vulnerable for drought, whereas 'wetter' soils such as peat create difficulties for wood production (Vakblad natuur bos landschap, 2021).

Water is a determining factor for living in the Region of Zwolle. The areas where drought and water shortages occur, as well as the areas where water flows in excess via the 'IJssel' and 'Vecht'-delta towards the 'IJsselmeer', are all part of the same water system. In the higher areas of the landscape, infiltration occurs. Via deep regional groundwater flows, water moves in a general direction from east to west. The closer together the isohypse lines are, the faster water flows. Seepage occurs through shallower groundwater flows and determine, in combination with soil types, place specific water conditions, such as stagnation on glacial loam layers (keileem).

In the past, the 'beeknormalisatie' happened, where steams were straightened to improve drainage. This indeed drained the landscape upstream quicker, which was beneficial for agriculture, but downstream the landscape often could not store large amounts of water, especially in times of precipitation surplus (van der Meulen 2009 p.162). The reclamation of large heathlands also further reduced 'sponge' abilities of the landscape (van der Gaast and Massop 2007).

The reclamation of the 'Noordoostpolder', created an irreversible water problem of soil dehydration on the mainland as water flows towards the

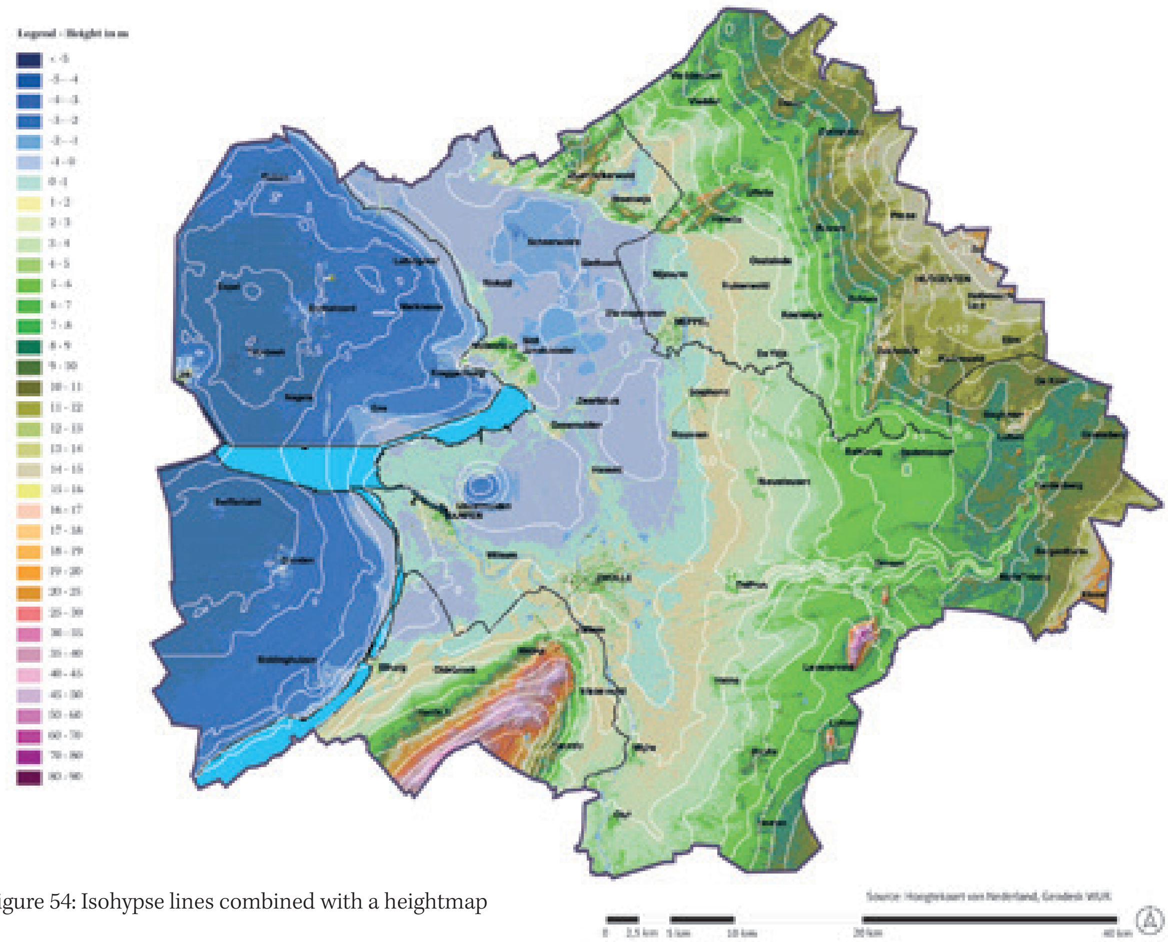


Figure 54: Isohypse lines combined with a heightmap

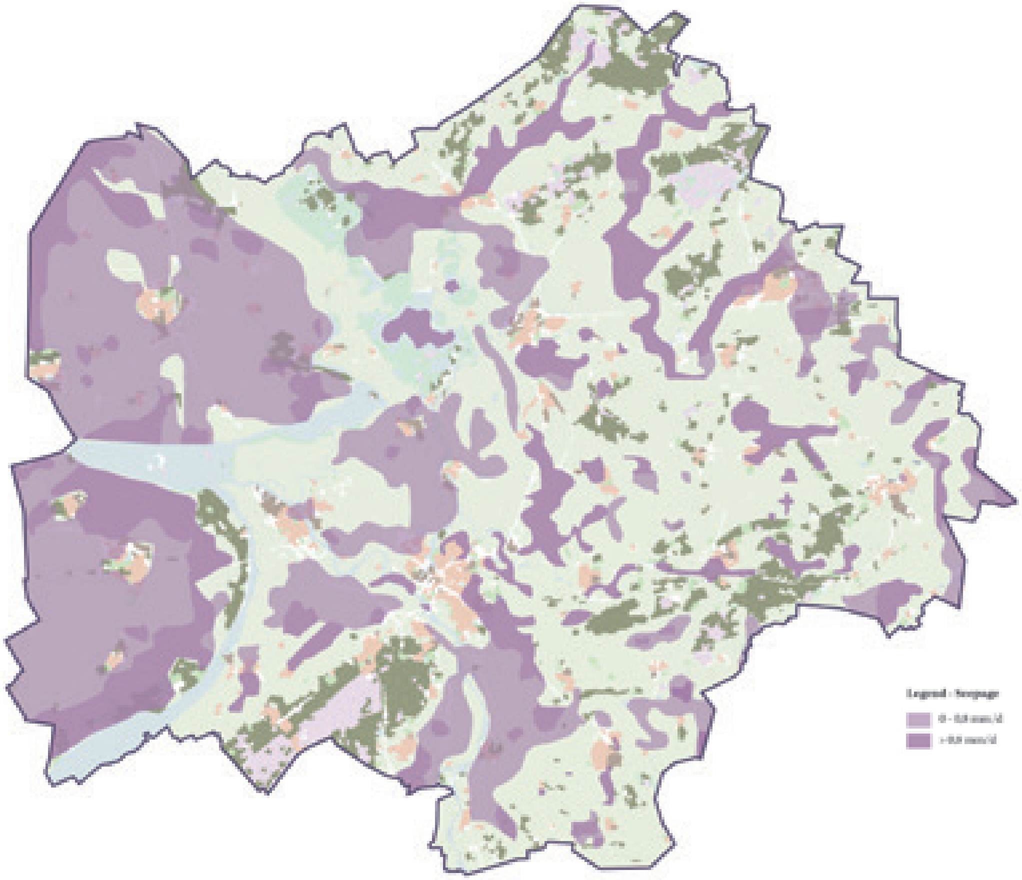


Figure 55: Seepage in mm per day

lower laying landscape of the ‘Noordoostpolder’, instead of the main land. Water flows from higher parts of the landscape via stream valleys towards the ‘Weerribben-Wieden’ area, where, if not enough water is transported, drought can occur, as groundwater continues to seep to the ‘Noordoostpolder’. This can be catastropic for the ecological values of the Natura 2000 areas, as well as for peat oxidation. The ‘Flevopolders received the ‘randmeren’: lakes that separate the polder from main land, to prevent seepage from the mainland towards the ‘Flevopolder’.

Now the region faces 3 main issues (Regio Zwolle n.d). A large part of the Regions groundwater management is determined by the water level of the ‘IJsselmeer’. This water level is likely to change due to sea level rise, drought and salinization issues and is connected to national water management issues. Alternations in the distribution of water via rivers is also likely to change. In times of extreme wetness and sea level rise, it is questionable whether or not water can flow towards the west of the Netherlands, where in times of drought water could be directed towards the west of the Netherlands to prevent salinization. Lastly, water management in the basin of the ‘Vecht’, ‘Sallandse weteringen’ and ‘meppelerdiep’ will change drastically. The focus will shift towards retaining and storing water instead of drainage.

This means that several factors in the region are likely to change current water management, but it is unsure how this will affect the landscape in the long term, as these issues are connected to larges scales of the Netherlands and even neighboring countries. Issues with drought and precipitation surplus in light of climate change cause ambiguous problems, as water needs to be stored for dryer times, while simultaneously preventing flooding issues with proper discharge measures. Different land uses and forms of agriculture are inevitable.

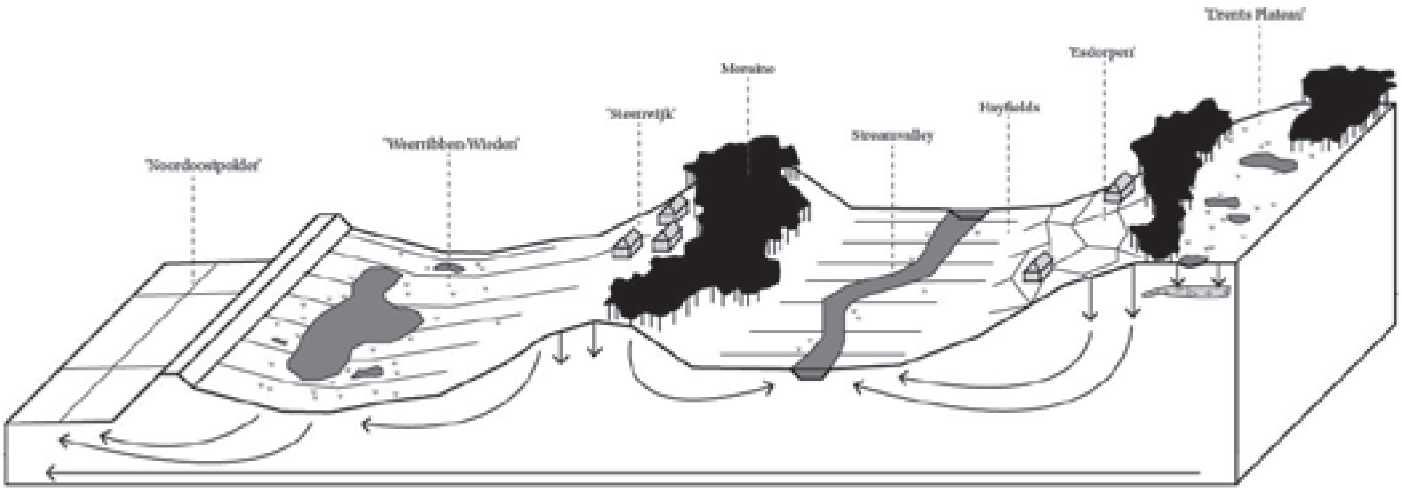


Figure 56: Schematic section of the watersystem between Emmeloord and Dwingeloo. (Has been checked with Roel Dijksma)

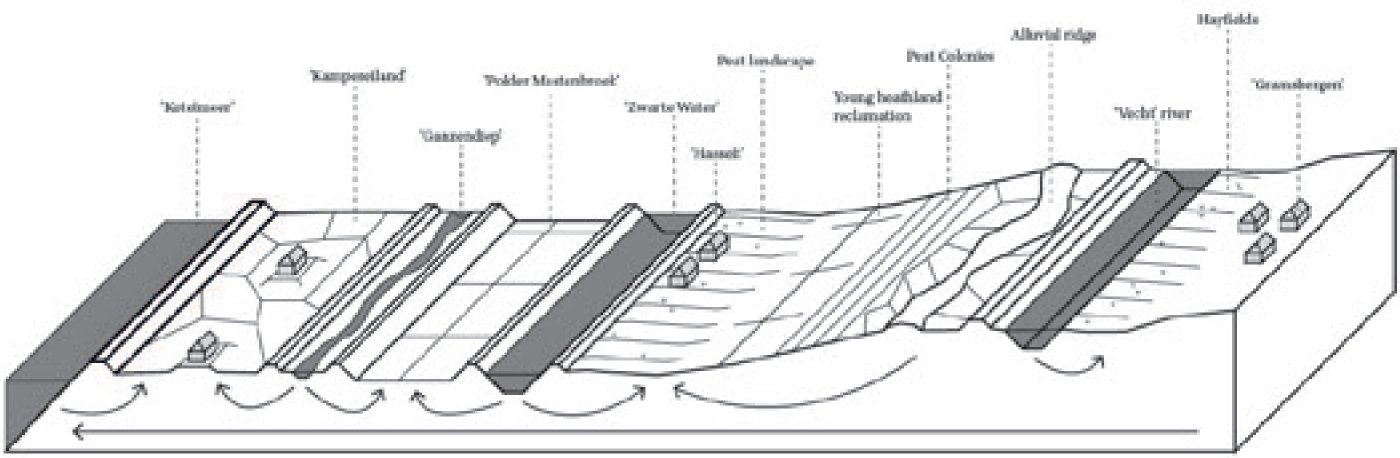


Figure 57: Schematic section of the watersystem between Kampen and Gramsbergen. (Has been checked with Roel Dijksma)

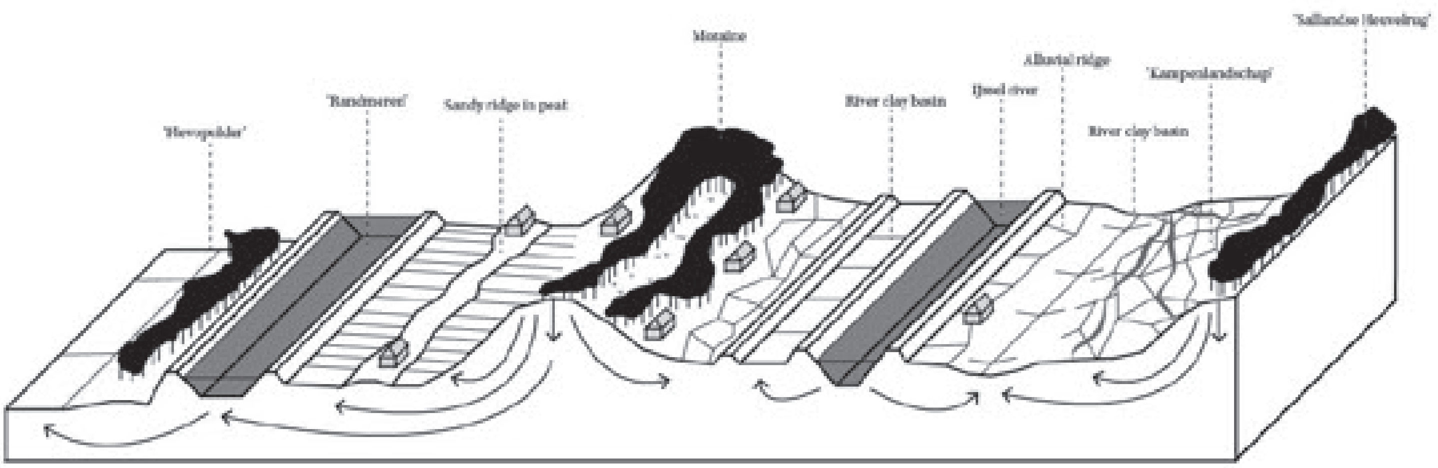


Figure 58: Schematic section of the watersystem between Biddinghuizen and Hellendoorn (Has been checked with Roel Dijksma)

Accessibility & Health

Forests are a great opportunity for increasing natural areas for recreation to meet the current recreational needs. It is therefore important that the designed forest should facilitate a variety of forms of recreation. However, just focusing on recreational uses is only the first step. The way in which the forest is accessible is very important to create more equal health opportunities for the population. We cannot expect everyone to have a car, to be able to ride a bike for short or longer distances or to be mobile in the first place. Increasing the means of transport by looking at public transport is therefore very important, as well as creating good routes and options for different users. This will not only increase the amount of accessible natural green space inside the landscape, but will make it more valuable for a broader human use, increasing spatial quality.

Economic Forest

It can be discussed in what degree forest should contribute to economic profitability or benefits, next to its intrinsic value. Should the forest be profitable in the first place, and on what scale? There are differences between supporting a more local, regional or even national scale of economy. However, according to Bakx *et al.* (2021) the recreational possibilities of the landscape is considered an economic quality in itself. To add to that, one could also argue that the indirect positive effects of forest on humans through recreation is an economic benefit.

It is important to mention that every forest will eventually produce quality wood. All it needs is management and time. The only limiting factor for a larger scale of profitability of quality wood is a poor carrying capacity of the soil, or too little forest. Also, if the production of quality wood is the main argument for afforestation, then the sustainability of the transport of that wood should be taken into account when choosing locations.

Figure 59: Train passing through the estate of 'Mariëndaal' in Arnhem, inspiration for accessible nature via railroads.

Figure 60: Sprinter-train driving through the forest of 'Mariëndaal'. What if there was a station directly in and for the purpose of a forest visit?

Figure 61: A carpark with horsetrailer and a mountainbike trail in the forest near Staphorst.

The better or worse soils

Because the Netherlands is an agricultural economy, much of its surface is in use for agricultural purposes. Afforestation will, without a doubt, take place on agricultural land. Are there better or worse soils for agriculture? And can these soils be excluded or forested?

There are two ways to look at how soils and soil types can be of better or worse quality for agricultural functions. The first is to look at its physical properties, such as fertility, organic matter and water conditions. The second way is to define soil suitable for agriculture and livestock, as fertile, only under the condition that the impact on the environment is minimal, as done by Hack-ten Broeke *et al.* (2008).

So, fertile soils in its physical definition, are soils that have chemical, physical and biological qualities from origin (mineral soils) for the production of crops. Less fertile soils are generally those with a low PH and fewer minerals (ANK n.d).

Next to that, the amount of organic matter is essential for the production function of the soil (Smit *et al.* 2007). A higher amount of organic matter in soils can increase the water storage- and supply capacity (Smit *et al.* 2007). Low amounts of organic matter in agricultural soils can cause a surplus of minerals to wash out, causing eutrophication of surface- and groundwater (ANK n.d). According to Smit *et al.* (2007), soils that are of the type 'Vaaggronden' are more sensitive for the decrease of organic matter, and therefore for eutrophication. However, correct soil management depending on local characteristics of the soil can prevent this from happening, and in the Netherlands there does not seem to be a reason to worry about too little amounts of organic matter in soils (Smit *et al.* 2007). Therefore, organic matter is not a factor to weigh in when classifying soils on their fertility.

Next to soil fertility and organic matter, water conditions play an important role for current and future use of soils for production. With flooding or water shortage, peat soils have the most severe difficulties for either agriculture or livestock farming (Hack-ten Broeke *et al.* 2008). Since fooding and drought are to become more frequent with climate change, this is an important factor to weigh in.

From the perspective of Hack-ten Broeke *et al.* (2008), peat soils score lower than other soil types on usefulness for production for agriculture and livestock farming, due to flooding and drought. Peat soils also scored highest on the impact on the environment in terms of nutrients (phosphate) and heavy metals in the soil.

Data related to Nitrate (N) was not used in their research, however, they did mention that phosphate (P) usually causes problems of washing out in high groundwaterlevels, whereas Nitrate usually causes problems in lower groundwater levels (Hack-ten Broeke *et al.* 2008).

There is a reason why almost all soils are used for agriculture in the Netherlands. Most of the soils can become workable or profitable with smart management, planning and fertilizer. However, problems with eutrophication are generally not caused by natural factors. This means that the sandy soils, who are vulnerable for washout, with their low natural fertility and their lower groundwater levels, have a bigger impact on the environment, and are less sustainable for future use. This also counts for peat soils, as they are heavily impacted by water conditions. The clay soils of the 'Noordoostpolder' and 'Flevopolder' are more valuable for future agricultural use.

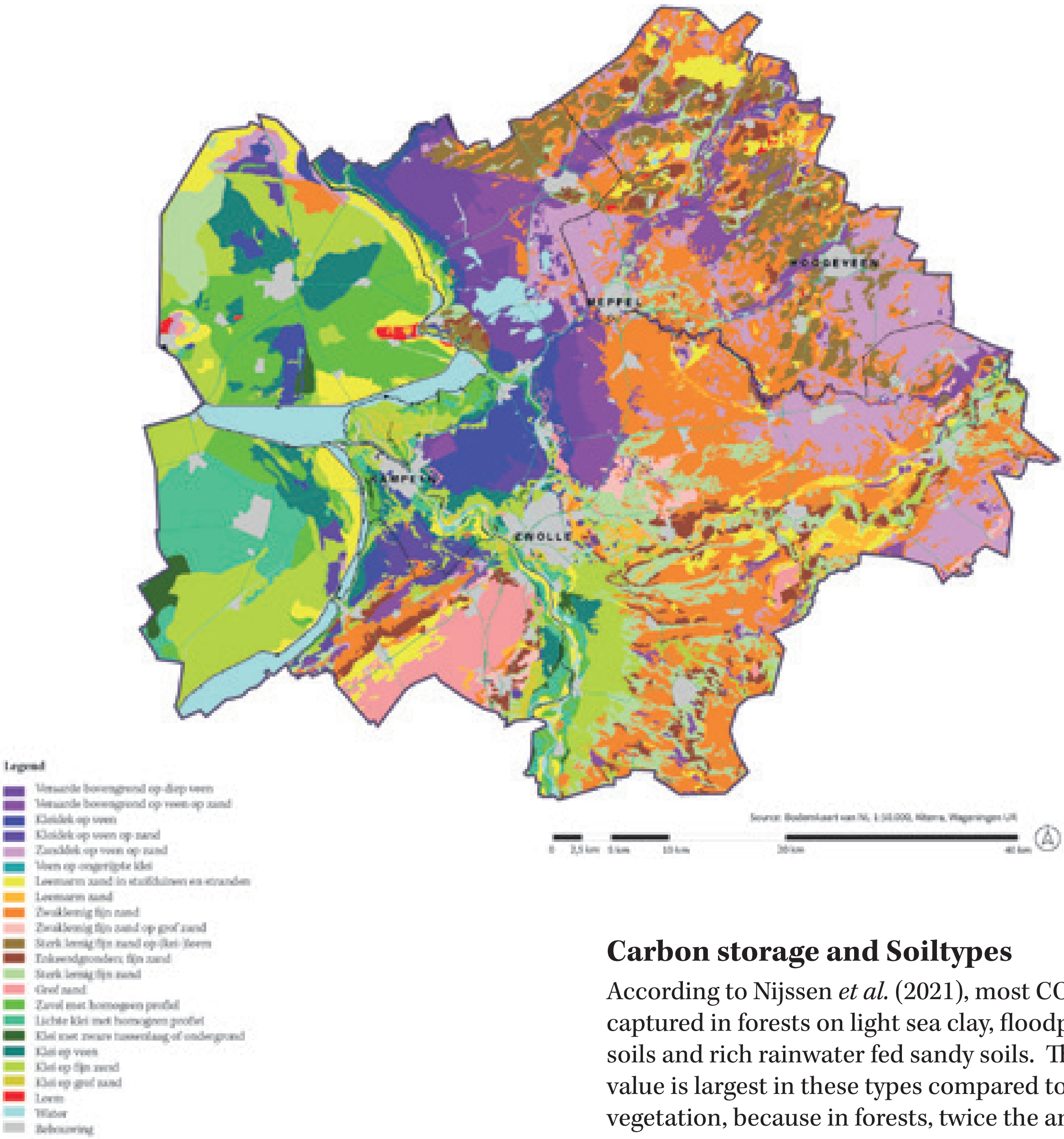


Figure 62: Soiltype map

Carbon storage and Soiltypes

According to Nijssen *et al.* (2021), most CO2 is captured in forests on light sea clay, floodplain river soils and rich rainwater fed sandy soils. The added value is largest in these types compared to open vegetation, because in forests, twice the amount of carbon is stored compared to grasslands. Peat can also store large amounts of carbon. Afforestation on peat soils is an option, but undrained peat soils can store about the same amount of carbon as a forest, so the added value is much less compared to afforestation on for example sandy soils. The same principle goes for forests in stream valleys, forests or meadows there store about the same amount of carbon.

For the production of quality wood, soils need a certain level of carrying capacity for harvest machines. The carrying capacity of a soil will decrease with higher groundwater levels and with higher amounts of clay and peat present in the soil. Sand has the best carrying capacity, clay moderate and peat the worst (RIVMdata 2022).

Forest ecology on soils

Phosphate in the top layer of soils is for many nature types a nuisance, so it is often removed. Forests can grow on any soil type, but it is not clear what the effect of a rich top layer of soil is on the ecology of the forest on the long term. In general, not much is known about the soil-chemical conditions for the development of new forests with a high ecological value. For some special ecological forest types, it is recommended to remove these top soils (Nijssen *et al.* 2021). On different soil types, different species compositions can be found.

Nature Network Netherlands

Some locations in the Region have been appointed as ecologically valuable, like the Natura 2000 areas. Some open areas are important for meadow bird species, and a network of natural areas should connect ecologically valuable nature. In figure x this network is shown. This network extents and connects to a European network. The areas in the network usually have specific management to ensure the existence of certain nature types and afforestation is not always possible in these areas. Large parts of the peat areas left of the A28 have for example been appointed as meadow bird habitats (Drents Overijsselse Delta n.d-a).

Forest Connectivity

Adding forest cover in the Region of Zwolle could be beneficial for the connectivity of forest ecosystems and species migration throughout Europe. Three forested arms reach from Germany towards the border of the region. Connecting to, and strengthening these arms can give the Region of Zwolle a gateway function from other forested areas to a main body of multiple Dutch forests, such as the 'Utrechtse Heuvelrug', 'Horsterwold', the 'Veluwe', the 'Vecht' forests, the 'Sallandse Heuvelrug', 'Staphorsterbos', 'Abbertbos', 'Roggebotzand', 'Dwingelderveld', 'Holtingerveld' and the 'Drents-Friese wold'.

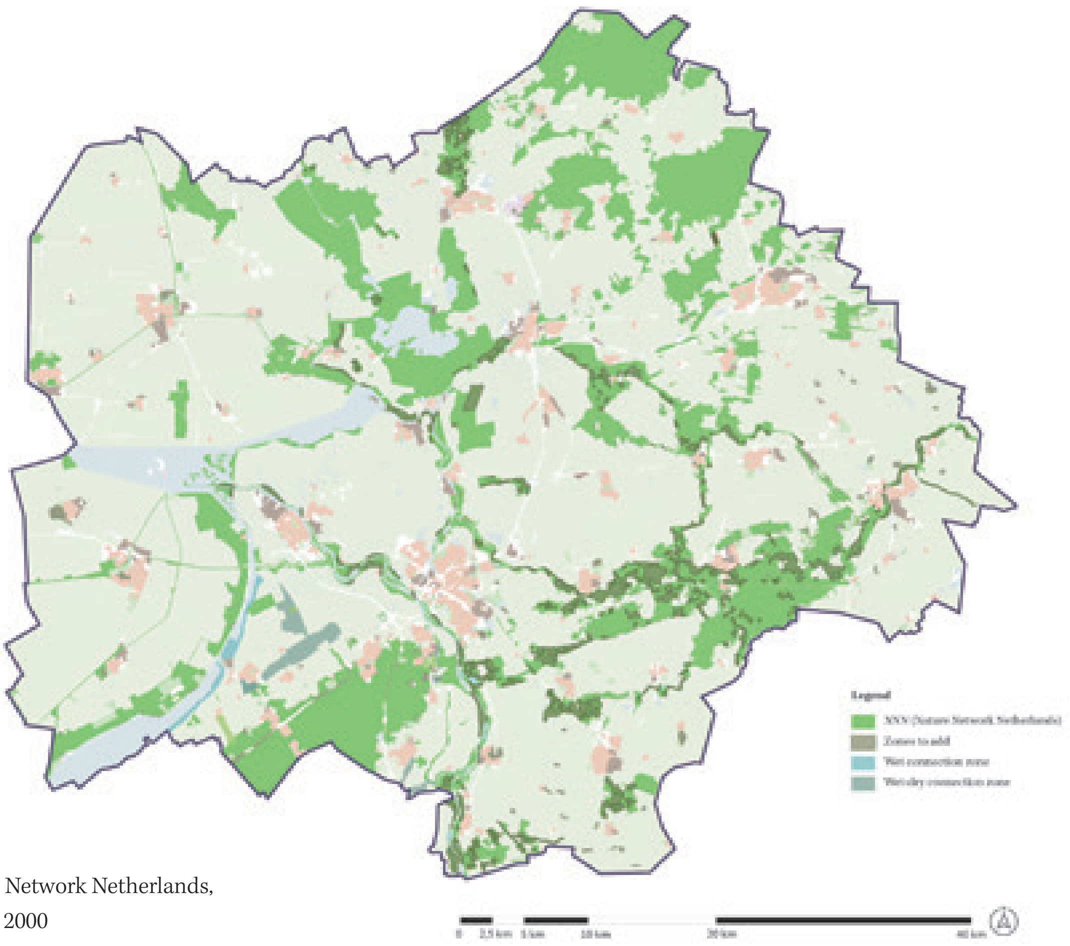


Figure 63: Nature Network Netherlands, including Natura 2000

Figure 64: Forests in the center of the Netherlands can be connected with a network of forests in Germany, through the Region of Zwolle .

Long term locations

When designing and creating new forests, it is important to make sure the forest will stay on a long term. This is because of multiple reasons. A forest is most sustainable and vital if it is of proper age. Most carbon storage happens in old forest soils, and it takes literally ages for a forest soil to fully develop and become fully saturated with carbon. A developed forest soil can capture more water and is most valuable for ecosystems to remain stable, which is especially important in light of climate change. More biodiversity and a higher natural value can be achieved.

However, there is no recipe for finding out which soils or locations have such a long term guarantee. It is up to future generations to make sure the forests stay put. Luckily, once a forest is developed, it is usually a pain for many to see it removed. Two factors could weigh in with determining which locations are more suitable for the long term. The first is that locations around cities might be more vulnerable to speculation. The second factor has to do with the size of a forest. Small patches spread throughout the landscape might be more vulnerable for disappearing than large bodies of forest.

Key points

• In the Region of Zwolle, roughly five landscape types can be found: The river-, sand- and peat landscapes the 'Droogmakerijen' and the 'Veenkoloniën'.
• Some cultural landscapes are still legible, while others are dominated by industry, infrastructure, bio-industry or large scale agriculture.
• The landscape of the Region of Zwolle is car-focused.
• The city edges of Zwolle are extremely cluttered.
• Some areas in the region, especially around forested and natural areas have a strong leisure economy.
• Forest can help minimize the effect of man-made elements in the landscape
• Forest can block views.
• Forest can hide landscape features such as slopes and hills.
• Forests can take away any visual openness and are therefore seen as mass. The disappearance of very open (historical) landscapes should be prevented.
• The Region of Zwolle is characterized by extremely open landscapes, semi-open, mostly agricultural landscapes, and more closed landscapes.
• The size of a forest should match the characteristics of scale.
• Semi-large scaled landscapes might seem more suitable for afforestation.
• Forests can be planted either on dryer or wetter soils, keeping vitality measures to be taken for those locations in mind.
• Seepage occurs through shallower groundwater flows and determine, in combination with soil types, place specific water conditions.
• The region faces 3 main issues. Changes of the water level of the 'IJsselmeer', alternations in the distribution of water via rivers and water managemental changes in the region towards storing water.
• Water needs to be stored for dryer times, while simultaneously preventing flooding issues with proper discharge measures.
• Forest should facilitate a variety of forms of recreation.
• Increasing the means of transport by looking at public transport is important.
• Limiting factors for a larger scale of profitability of quality wood are a poor carrying capacity of the soil, or too little forest.
• Sustainability of the transport of wood should be taken into account when choosing locations.
• Sandy soils, who are vulnerable for washout, are less sustainable for future agricultural use. Peat soils are heavily impacted by water conditions and also less sustainable. The clay soils of the 'Noordoostpolder' and 'Flevopolder' are more valuable for future agricultural use.
• Most CO2 is captured in forests on light sea clay, floodplain river soils and rich rainwater fed sandy soils.
• Sand has the best carrying capacity, clay moderate and peat the worst.
• The areas in the Nature Network Netherlands have specific management and afforestation is not always possible in these areas.
• Locations around cities might be more vulnerable to speculation and small patches might be more vulnerable for disappearing than large bodies of forest.

Historical Timeline

Some of the most influential events that shaped the landscape of the Region of Zwolle are described in the historical timeline below.

Figure 66: 'Hanzestad Kampen' in 1652. (Lichtenberg n.d)

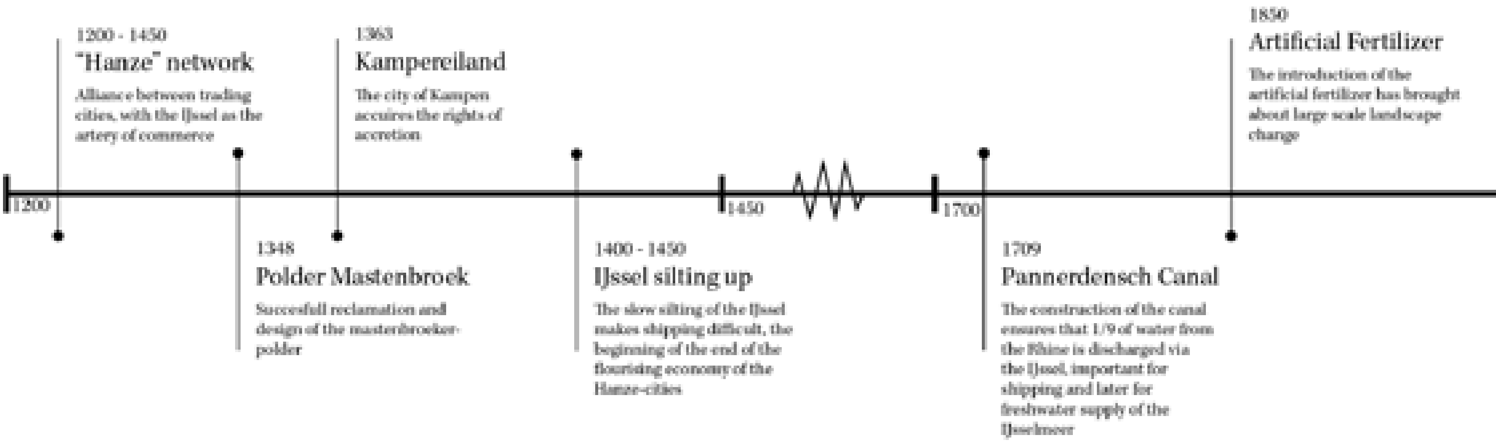


Figure 65: 'Kampereiland', map from 1865. (De Stadserven n.d)

Figure 67: 'Polde Mastenbroek' in 1750. (Canon van Nederland n.d)

Figure 68: Reclamaition of Westerhuizingerveld in 1936. (van der Linde n.d)

Figure 70: 'Reevediep' (VBW Noord Veluwe n.d)

1930 - 1940
Werkverschaffing
Employment projects in crisisyears took place in the Region of Zwolle, such as the forests of Staphorst, Hardenberg, Ruinen and Ommen.

1932
IJsselmeer
Closing the Afsluitdijk in 1932 resulted in the creation of a brackish water lake, that officialy became a freshwater lake 2 years later, in 1934.

1936 - 1942
Noordoostpolder
The succesfull reclamation of a former seabed in a freshwater lake, adding 460,05 km^2 of new arable land to the Region of Zwolle.

1950 - 1957
East-Flevopolder
The third and last reclamation of the 'Zuiderzeewerken'.

2012
Hanzelijn
The construction of the railway between Zwolle and Amsterdam creates a direct connection from the north of the Netherlands to the Randstad, shortening travel times by 20 min.

2019
Reevediep
A new waterconnection between the IJssel and the Drontermeer that serves a drainage solution to highwater extremes from the river IJssel.

Figure 69: 'Pannerdens' Canal (Leven in de Liemers n.d)

Figure 71: 'Hanzelijn' (Armada Mobility n.d)

SWOT Analysis

Strengths

Economical growth
The Region of Zwolle has the biggest economic growth outside of "the Randstad/Brainport". It has economic connections with the North- and East of the Netherlands, 'Noodrijn-Westfalen', 'Nedersaksen' and the Baltic corridor (Regio Zwolle, 2021-a). The Region shows a strong growth of international goods flows (Regio Zwolle 2021-c).

Economic sectors
The most important sectors in the region are Agro-food, e-commerce, health and care, plastics, logistics and the leisure economy. These generate 40% of the total employment opportunities. There are 375.000 employment places, of which 45.000 employers work in the industry sector. There are about 68.000 companies, of which 68% are sole proprietorships. About 70% of the regions population is practically trained, or has had a secondary education (Regio Zwolle, 2021-a). Furthermore, the region of Zwolle has an excellent economic accessibility by train, water, road networks and even digitally (Regio Zwolle 2018).

Accessibility
The city of Zwolle is an important node for public transport into many directions. Only the 'Noordoostpolder' has a poor connection with train networks and the inhabitants of the municipality of 'Westerveld' in the north-east of the region need to travel 10 to 25km to reach a train station (Must, 2020). The rest of the Region of Zwolle is well connected. Since the construction of the new 'Hanzelijn' railway, a better and faster connection with 'Amsterdam' is established.

The cultural landscape
The cultural landscape of the Region of Zwolle is diverse, giving the region a rich history and a pleasant variety of landscapes within short distances, contributing to a pleasant living environment.

Relationship with water
Much of the (economic) development of the Region was linked to the relationship with water. The Rivers and waterways brought trade and prosperity to the Region. The cities of 'Zwolle', 'Ommen', 'Kampen', 'Hasselt' and 'Hattem' are 'Hanze'-cities, which had a trade-agreement (Must 2020). In present day, the region is still characterized by its water and dynamic delta landscape, now also in the new light of climate change and climate adaptation. The harbors of Kampen, Zwolle and Meppel are called the 'Port of Zwolle', and many harbor businesses still trade via water on a large scale (van Rooijen et al, 2018).

E-Bike and small mobility
The Region of Zwolle is characterized by its relatively high use of bicycles compared to the rest of the Netherlands. On average in the Region, 40-45% of the time, bicycles are used for distances shorter than 7,5km. Next to that, the city of Zwolle has the highest percentage (50%) of bicycle use for movements within urban context in the Netherlands. The e-bike is used most often for leisurely rides (49%) and commuting to work (24%) (Harms and Kansen 2018). The Region of Zwolle is also actively stimulating better and more bicycle usage through a multiplicity of projects and campaigns (Regio Zwolle Mobiel 2020).

Figure 72: 'Hanze'-city Hasselt along the 'Zwarte Water' river. The city still has a strong port-based industry.

Weaknesses

Nitrogen
Acidification of soil and groundwater from nitrogen oxides and ammonia emisions are problematic for biodiversity. A large part of the high nitrogen levels come from the administration of artificial fertilizer, animal manure and nitrogen imports in the form of animal feed. Nationally, most nitrogen comes from livestock farming , followed by traffic, industry and consumers (WUR n.d). Agricultural areas in the Region of Zwolle, mainly the area above Zwolle, are heavily affected by national nitrogen measures, especially the lifestock farming sector. The reduction of nitrogen in this area should be 47% to 95%, because of the proximity of Natura 2000 areas (Zwolle Nieuws 2022).

Housing market
The Region is growing and more housing is needed, especially for starters, labor migrants and care recipients (RUIMTEVOLK, 2021-a). On top of that, there is a poor rotation rate in the housing market in the Region of Zwolle (RUIMTEVOLK, 2021-a).

Smaller village connectivity
Accessibility and mobility from and to small villages is under pressure. Mobility is important for livability, for example for the accessibility to employment, nature and other services (RUIMTEVOLK, 2021-b).

Bio Industry
Globally, almost 80 percent of agricultural soil is used for the production of dairy and meat, mostly to cultivate fodder for cows, chickens and pigs. The production of beef is the most harmful. It provides only 2 percent of our calories, but takes 60 percent of our agricultural soils (Attenborough 2020 p.163). The bio-industry is responsible for high nitrogen emissions. The Region of Zwolle is characterized by a high density of livestock farms (RIVM n.d), especially on the cover sand and peat soils.

Opportunities

Ports and Hubs
The region has multiple ports and logistic hubs spread throughout the area. The ports of 'Kampen' and 'Meppel' will be serving as energy producers and circular waste processors in the near future. The 'Hessenpoort will become a testing ground for climate adaptation (Regio Zwolle, 2021-b).

Family oriented
A large number of businesses in the Region of Zwolle are family businesses, or were founded as family businesses. They are strongly rooted in their regional environment and feel connected to the network of people, creating opportunities for the development of a more regional based market (Regio Zwolle 2021-c). A large part of the Region is also part of the National Bible belt, with a strong family mentality, individual responsibility, care for fellow man and a more sober lifestyle (Must 2020).

Leisure Economy
The landscape of the Region of Zwolle is diverse, with many different opportunities for the development of a stronger leisure economy.

Population growth
In 2050, it is expected that 68 percent of the world populations will live in cities (Attenborough 2020 p.195). The expected growth of the regions population and the Dutch population in general asks for more recreational services, especially if more people will live in an urban environment. The municipality of Zwolle has the ambition to build 10.000 new houses before 2030 (Zwolle Nieuws 2022).

Changing views on nature
The desire for new forests isn't just because of increased climate awareness. It also has a lot to do with societies ever-changing image of nature. And of course, the recent pandemic of COVID-19 has developed an increased interest and revaluation of Dutch nature and recreation outdoors. An enormous growth in visitors in nature reserves and a record amount of new members has been observed by Natuurmonumenten (Natuurmonumenten 2021).

Recreational Pressure
In the last 30 years, the recreational pressure on natural areas, especially forests, has been increasing. With the recent pandemic COVID-19, this increase accelerated (de Koe 2021). This shows a societal need for recreational possibilities, especially because more and more people live in cities, and this is not likely to stop.

New industries
Globally, much of the earths surface is used as agricultural soil, and deforestation and reclamation of wild nature is still happening in order to meet the increasing demand for meat. In order to move towards a more balanced lifestyle, and to take less space on the planets surface, there should be a focus on high-tech crop cultivation, regenerative agriculture, agroforestry and silvopasture

(Attenborough 2020 p. 157-160). Cultured meat should be stimulated and approved. The Region of Zwolle could act as a test-base for many of these new industries.

Threats

Loss of cultural landscape
Current technological and ecological developments create many possibilities for uses that are not bound to certain soil and water conditions and can therefore overwrite particularities and identities of places in the landscape (Bijhouwer 1977). These developments, as well as global economies and upscaling can threaten the disappearance of the cultural landscape. Legibility, identity and the existence of green 'un-urbanized' landscape can be lost.

Cluttering and 'Verdozing'
Cluttering of the landscape arises when people regard (man-made) elements in the landscape as disruptive (van der Wulp 2009). However, there are 3 aspects that determine what actually is disruptive: the element itself, the surrounding landscape and the person to judge, so determining whether you can speak about cluttering in specific situations is tricky (van der Wulp 2009). Boxing, or 'verdozing', of the landscape, is a current concern as well. Boxing can be described as the tendency to position large, usually rectangular buildings for the storage and distribution of goods near highways (Ensie 2020).

Climate change
Many threats to the landscape relate to climate change. Sea levels will rise, but also extreme weather conditions, precipitation surplus as well as drought will occur more often (van Rooijen et al., 2018). The delta of the Region of Zwolle is vulnerable for these new weather extremes and higher water levels. Climate change also has a big impact on the agricultural sector. Drought that lasts for weeks in the growing season can be a real challenge and results often in large scale irrigation. This is a real problem, as groundwater as well as surface water is getting depleted. This is especially problematic on the higher sandy soils (Nieuwe Oogst 2020).

The end of Fossil Fuel
According to Attenborough (2020 p.135), we have ten years to switch from fossil fuel to clean (renewable) energy, if we want to limit global temperature rise to 1,5 degree Celsius. In 2019, 85 % of energy was produced by fossil fuels. Renewable energy sources only delivered 4%. The municipality of Zwolle wants to become climate neutral as quick as possible (Zwolle Nieuws 2022).

Figure 73: Remnants of Alder lanes that were once common in 'Slagen' landscapes.

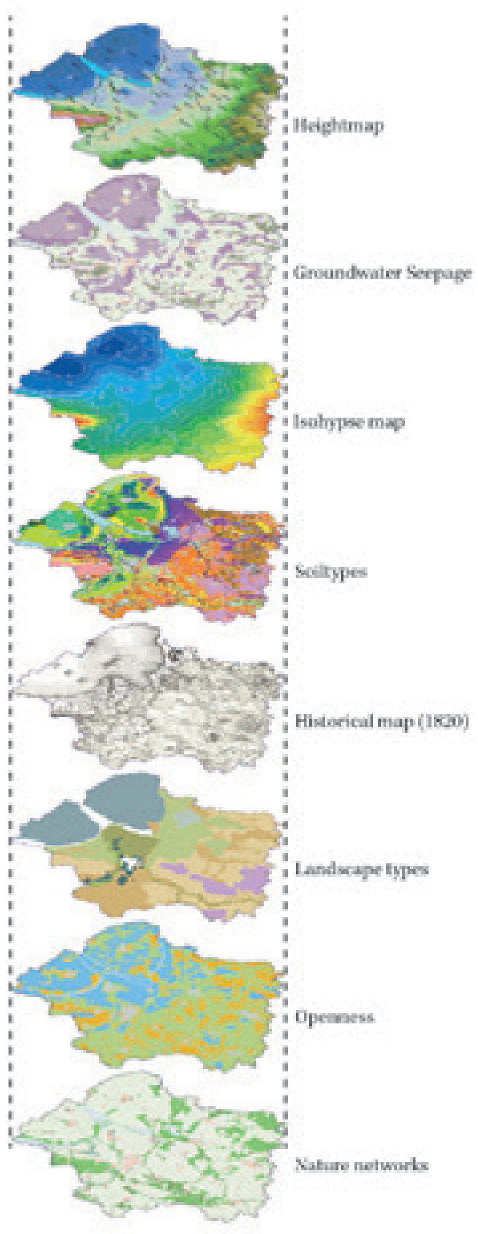
Figure 74: Cluttering of a open landscape by wind turbines, power lines and even railway infrastructure.

Conclusion

The current landscape of the Region of Zwolle is built from different layers. Geomorphological conditions form the base of the current soil and water conditions and have played a role in the formation of different cultural landscapes. These cultural landscapes have a rich history and identity, and the Region of Zwolle possesses a variety of unique landscapes. From the oldest reclamations of the Netherlands to the youngest, from large wet, to high and dry natural areas, early Middle Age (designed) parcellation structures, peat transportation waterways, a new man-made river arm, stream valleys, estates and 'esdorpen. Every cultural landscape has an extensive history, and large scale afforestation is therefore challenging. There are however more and less legible places, with cluttering elements or unsustainable practices such as large scaled bio-industry. These landscapes could benefit from afforestation. Besides, forests themselves also are subject to different conditions and do dictate different preferences or limitations. Both the landscape and the conditions for afforestation play a role in finding locations for large scale afforestation.

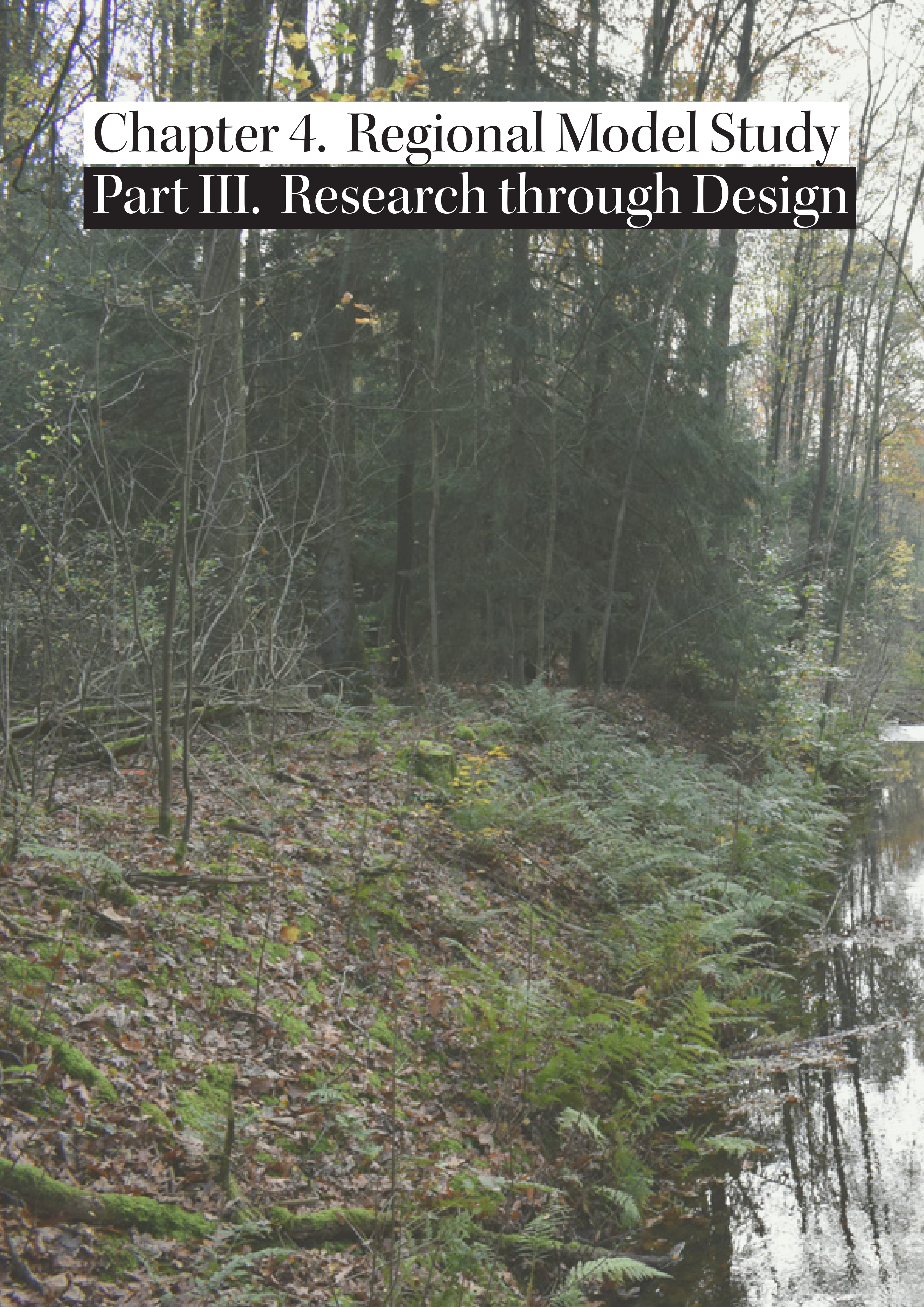
What a forest can do for landscape to enhance spatial quality relies on two things: Its impact on visibility as a 'mass' and its functionality and programming. Openness of the landscape is an important factor to protect, yet the larger scale of very open landscapes simultaneously seem suitable for large scale afforestation. Semi open landscapes might be more suitable. Still, afforestation should be done with care, as forests can block views on the landscape or elements inside it, and can hide landscape characteristics. Functionality-wise, accessibility of new forest is important in the dominantly car-focused region, and can be much more inclusive than it is now. Railways pose real opportunities, especially in combination with housing development and relieving recreative pressure. The delta identity, and the presence of many waterways create opportunities for sustainable transportation of wood, while in addition, forests can help store water in the soil, so linking it to water issues can be real beneficial.

The strengths, weaknesses, opportunities and threats of the Region of Zwolle can be used as a guide while designing, as they provide a picture of current land uses and possible future pathways. The relatively high use of bicycles and e-bikes can for example support accessibility strategies. Changes in water management can contribute to the development of new industries, while the present leisure economies can expand through forest development. Boxing and cluttering, as well as the expected growth in clean energy can be mitigated through afforestation.



Chapter 4. Regional Model Study

Part III. Research through Design



Model Study

Introduction

This chapter will visualize the positioning of large scale afforestation on a regional scale, by using different models to illustrate different options. In order to find the right location, the Research for Design parts of this research have been used to formulate criteria in the form of parameters, to evaluate these models.

The model study consists of two phases. The first phase will have a conceptual character, and is focused on positioning strategies. The purpose of this phase is to narrow down on suitable locations and strategies to position large scale afforestation. In this phase, the models will not be designed into detail, and only illustrate abstracted shapes and sizes. From this first phase, found strategies and possible locations will be gathered and combined into a second model study, to move towards a more detailed scope.

This second model study is needed, because during the research it became clear that every location can be designed into great detail, until it suits that specific landscape and the evaluation criteria, especially because forest can have a very multifunctional character. This was problematic because of two reasons. The first is that finding locations on a regional scale became difficult, as it was easy to lose track of over-arching arguments. Secondly, there would be no end to what could be researched by designing. By first conducting a conceptual, strategy focused model study, insight was brought into what strategies would work on what location. Each landscape type and cultural landscape has different characteristics, meaning that some strategies on that location will work and others don't, while on a different location the strategy might be suitable. The conceptual models therefore helped to maintain an over-arching systemic regional approach towards large scale afforestation and showing and explaining this phase helps to ensure a certain level of transparency and legibility towards the readers.

The second phase consists of a model study where a selection of these regional strategies are applied to and on a location, that have been narrowed down and selected from the first model study. In this phase, slightly different criteria are used to evaluate the models, as they move towards a more location specific scale. For example, where accessibility as a parameter in the first phase will say something about how easy it is to reach forests for recreational purposes, in the second phase experiential diversity is added next to accessibility to evaluate how broad that recreational aspect can be on location. Eventually, from these models, a combination model is formulated as a preference model, which will be designed further, and acts as a design synthesis.

The process model formulation has been a very long and cyclical process and moving back and forth between scales, locations and arguments have not been in a linear, chronological order. This means that while the formulation of the criteria come from the research for design part of this research, the eventual selection of criteria has been part of the research through design practice.

In the first model phase, the formulated models will be tested by the following criteria:

1. Protecting extreme openness and denseness

Very open (300-more than 1500ha visibility), and very closed landscapes (less than 10ha visibility) should be protected. Developments are preferred in a semi-open landscapes (10-300ha visibility).

2. Easily accessible

Forests should be accessible for human use to relieve recreational pressure. Accessibility is scored better if there are multiple modes of transport possible (car, bicycle distances, train, walking distances) so that different user groups can reach the forest.

3. Preserving fertile agricultural soil

Less fertile soils are generally those with a low PH and fewer minerals, with a higher negative impact on the environment, or soils with impeding water conditions (ANK n.d). Fertile soils are the soils that are most sustainable for agricultural use in the future. This makes the sandy- and peat soils more suitable for afforestation, as they are less fertile soil type. Clay soils in this region should be preserved.

4. Production of quality wood

Soils need a certain level of carrying capacity for harvest machines. The carrying capacity of a soil will decrease with higher groundwater levels and with higher amounts of clay and peat present in the soil. Sand has the best carrying capacity, clay moderate and peat the worst (RIVMdata 2022).

5. Achieving critical mass

A larger forest has a larger area of interior habitat. Interior habitats are important for healthy forest ecosystems; they have a different microclimate and can accommodate larger and specific forest populations. Larger forests have a better chance of long-term existence, which is important to establish a stable ecosystem, for the development of a valuable forest soil and the production of quality wood. Forests with a size big enough to have an interior habitat is preferred.

6. Proximate to other natural areas

A forest adjacent to other natural habitats can enlarge natural areas and increase species mobility. Areas adjacent to natural areas, natural networks as well as areas in or adjacent to the NNN are preferred. A forest that 'lives' also creates a better multisensory experience.

7. Respecting existing nature

Valuable nature types such as bird meadows, heathlands, raised bog moors or stream valleys are not reduced in ecological value by afforestation efforts. Appointed areas that are in protection of the European Bird- and Habitat guidelines are Natura 2000 reserves and can not be forested.

The evaluation is based on two aspects. A criteria can be well met (++), met (+), not met (-) or certainly not met (--). However, sometimes the criteria cannot be valued, or only valued, in that way, so the evaluation is extended by adding another aspect. This aspect takes into account what the model has to offer in terms of design possibilities. The criteria can have many possibilities with design (++), possibilities with design (+), little possibilities with design (-) and almost no possibilities with design (--)

Model phase I

The new ‘Markerwadden?

It is important to immediately eradicate the argument that we could just build another island, like the ‘Markerwadden, for the creation of nature, or, in this case, new forest. Creating an island is mostly a save escape plan, so that we do not have to make room for forest or nature in the ‘human economic landscape’, that is the mainland.

So, let’s turn the argument around. What if we build that new island for more agriculture, warehouses, industry, housing and recreation, and then give the barely useful ‘old’ agricultural land, new forest. Not only do you create more biodiversity, but this forest could also connect to already existing and struggling natural structures within the landscape. It would decrease the use of agricultural input, such as fertilizers, benefitting soil-, water- and biodiversity conditions, that you would otherwise keep intact in the current system. It can create large accessible recreational areas, close to the cities and large enough to see and experience wildlife.

So, if creating new land would really be the only solution to the problem of a national lack of space, we should not create this island for forest only. This means, that even if we nationally decide to construct new land, the largest amount of forest would and should still be placed on the mainland, and only a fraction of it on the imaginable new land. Therefore, this thesis will focus on implementing forest in the landscape that already exists.

Figure 75: ‘Aandikbos’ (Thickening forest)

‘Aandikbos’ (Thickening forest)

This model aims to strengthen existing forests by thickening their edges with new forest. The border that is created around the existing forests can be used as a buffer for edge effects. In this new forest edge, nitrogen is deposited, that will not end up in the existing nature. It can help to protect and enhance existing nature and biodiversity. Because the new forested border will be planted around existing forest, a backdrop of forest is already present. This will help to integrate new forest in the landscape. However, the new border will overlap specific landscapes, such as the ‘esdorpen landscape, and can disregard old cultural interactions with the landscape if not designed with care. The existing forests will be strengthened, but not further ecological connections between these areas are made. There are also little possibilities for enhancing the forests accessibility.

Figure 76: ‘NNN-bos’ (NNN Forest)

‘NNN-bos’ (NNN Forest)

This model aims to create new forested corridors, stepping stones and interior habitats to increase biodiversity throughout the region, and connecting the region to forests outside of the region as well. This creates lively forests that contribute to species migration. This strategy can enhance human recreative networks as well. Longer walks and bicycle-rides through the forested landscape are possible. However, the forests will be constantly fragmented by infrastructure, and if the forest only consists of small patches, recreational possibilities are limited, especially if these patches are located on private property. On top of that, the production of quality wood might be limited due to nature conservation and management.

Figure 77: ‘Kanalenbos’ (Canal forest)

‘Kanalenbos’ (Canal forest)

This model aims to use the regions strength of connectivity via waterways to transport and distribute quality wood products. Forest is created adjacent to large canals. It can give the region a new economical drive. The forests can connect existing forests to enlarge these, while connecting them to waterways. The production aspect of these forests is dominant, which could mean that recreational aspects might be in oppression. Besides, most of the forests are now planned on the most fertile soils in the region, the ‘Noordoostpolder’ and ‘Flevopolder.

Figure 78: ‘Sprinterbos’ (Sprinter forest)

‘Sprinterbos’ (Spinter forest)

This model aims to create extremely accessible forests. Getting out of a train, preferably a sprinter instead of an intercity, is enough to be in the middle of a forest. This creates opportunities for those who do not have a car, that cannot cycle (long distances) or those who just want to be in a forest without physical activity. They could sit and watch nature from a station-café. The presence of a station creates possibilities for housing development, as a new station often brings new economic environments. However, the forests should be connected to existing natural areas, and should be adjusted and designed into the cultural landscape in order to not feel randomly placed. Next to that, housing development can also cause the forest to step into the background, or to even disappear in the long term. Housing types should be adjusted to be able to integrate into the forest.

Figure 79: ‘Zwollewoud’ (forest of Zwolle)

‘Zwollewoud’ (forest of Zwolle)

This model aims to create an accessible forest for the inhabitants of the city of Zwolle. The forest can act as a counterpart for densification of the city, and can attract new visitors and inhabitants as it creates a pleasant living environment. Connections with the ‘Vecht’-area will be created to strengthen the leisure economy there, and to act as a real escape from the city into the landscape. Ecologically, this connection also set a better connection with the ‘Veluwe’ in motion. However, recreative benefits of this forest are predominantly reserved for the inhabitants of Zwolle, as no forest is added throughout the rest of the region. As the forest invites new inhabitants, new housing development might treathen the existence of forest around the city edges. The forest will also be planted on relatively expensive soil, as speculation might put pressure on the location. Landscape-wise, the forest will be located on river clay basins and in the sandy ‘Kampen’landscape. Implementation should be done with care, as local characteristics might get lost.

Figure 80: 'Anti-Urban Sprawl bos' (Anti Urban Sprawl forest)

'Anti-Urban Sprawl bos' (Anti Urban Sprawl forest)

This model aims to create a forested border around cities, to enhance recreative possibilities while preventing cities to expand into the remaining cultural landscape. This creates recreative possibilities for more cities instead of only Zwolle. The forested border can help to provide a cool environment, to provide escapes from urban heat. It brings biodiversity closer to cities, enhancing biodiversity inside cities as well. However, these borders are by no means an actual guarantee that urban sprawl will not happen, let alone that it will happen outside of these cities on itself. The borders could disappear by urban expansion, defeating its purpose. Next to that, some city views from within the city to the surrounding landscapes can be quite unique and attractive. Foresting the city edges will need to be done with care.

Figure 81: 'Beekdalbos' (Streamvalley Forest)

'Beekdalbos' (Stream valley Forest)

This model aims to create forests in wet, peat-like soils, to create water storage as a buffer for downstream areas. These soils are wet and difficult to use for agricultural purposes, only livestock farming is possible. Keeping these soils wet prevents carbon release and foresting them will create possibilities for specific stream valley ecology. Forests in these stream valleys were once common in the cultural landscape, but have disappeared because of reclamation and 'Beeknormalisatie'. Bringing these forests back can pose opportunities for landscape restoration, as well as stepping stone functions for ecology. However, these patches will not create accessible forests for recreation and can mostly only serve as 'backdrop' greenery. On top of that, the production of quality wood is compromised by wet and unstable conditions of the soil. Lastly, these cultural landscapes were, apart from the presence of small forests, predominantly open, with many hayfields. Afforestation might be possible, but large scale afforestation is much less suitable.

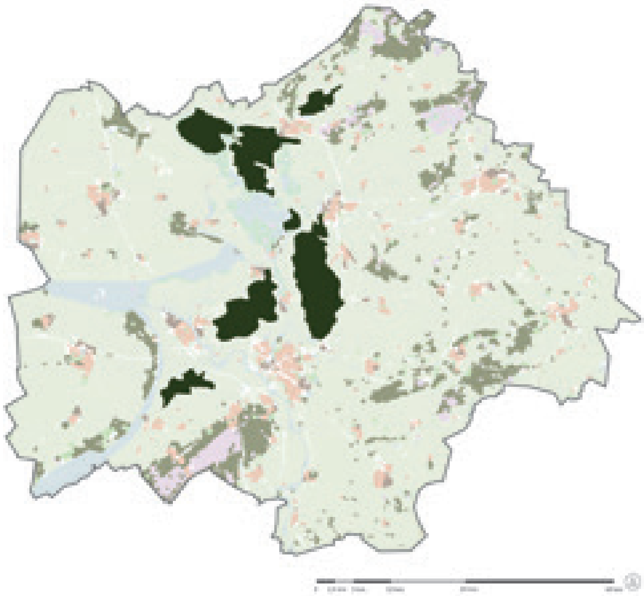


Figure 82: 'Veenbos' (Peat forest)

'Veenbos' (Peat Forest)

The aim of this model is to position forest on peat soils. In combination with raising water levels, carbon can be stored in the peat soil as well as in forests. It will help to prevent soil subsidence, which increases water safety in the Region of Zwolle. It prevents the use of sandy soils, which suitable for the construction of houses. However, the soils are unstable and therefore unsuitable for the production of quality wood. For recreational purposes, boardwalks or raised paths should be constructed. Bigger problems relate to the fact that afforestation on these soils reduce the openness of the landscape drastically. Some valuable historical landscapes, such as the 'Mastenbroeker polder' and the 'Weerribben-Wieden will lose their centuries old character. On top of that, meadow bird territory is destroyed.

Figure 83: 'Jonge natte heideontginnings bos' (Young wet heathland reclamation forest)

'Jonge natte Heideontginnings bos' (Young wet heathland reclamation Forest)

The aim of this model is to position forest in the wet heathland reclamation landscape. These landscapes used to be vast areas of wet heathland. These heathlands were reclaimed last in the Netherlands, due to poor water conditions. Water stagnated and flowed out of these areas in a very slow pace. Nowadays, the landscape faces problems with low amounts of organic matter and occasional drought due to drainage. Fertilizer is needed to make the land arable. Land is now predominantly used for livestock farming and bio-industry, which contributes to large amounts of nitrate emissions. Using this landscape for afforestation can create win-win situations, where fertilizer is no longer causing eutrophication and nitrate is emitted less, while storing carbon in forests, restoring 'sponge' functions of the landscape. The production of quality wood is possible on a large scale, as these soils are stable and wide. The added values are favorable. However, it is a very economically valuable landscape, which is hard to compensate for.

Figure 84: 'Uiterwaardenbos' (Floodplain forest)

'Uiterwaardenbos' (Floodplain forest)

This model aims to add forest to the floodplains of the 'IJssel. The rich floodplain and river basin soil can bear fast growing species, ideal for a quick forest image, and the production of quality wood. The forest types native to this landscape have disappeared due to proper flow measures, but are ecologically valuable to add back to the landscape once again. This can create a unique and dynamic forest landscape, that floods every once in a while. The forests can provide better connections between the Veluwe and the river landscapes, enhancing nature networks. However, because rivers still need to be able to flow, large amounts of forests are not suitable in the floodplain landscape, and producing quality wood is challenging. The open character of the river basin landscape can be compromised if not designed with care.

	Aandlikbos	NNN bos	Kanalenbos	Sprinterbos	Zwollewoud	Anti-Urban sprawl bos	Beekdalbos	Veenbos	Natte Jonge heideontg. bos	Uiterwaardenbos
1. Protecting extreme openness & denseness	- -	+	-	-	+	++	-	- -	++	+
2. Easily Accessible	-	-	+	++	++	++	- -	+	-	-
3. Preserving fertile agricultural soil	-	+	-	+	+	-	++	++	++	+
4. Production of quality wood	++	+	++	+	-	-	- -	- -	++	- -
5. Achieving critical mass	++	-	+	+	+	-	-	++	++	-
6. Proximity to other natural areas	+	++	+	-	+	- -	+	+	-	+
7. Respecting existing nature	+	+	+	+	+	+	-	- -	++	+
	2	4	4	4	6	0	-4	0	8	0

++	Criteria well met	/	Many possibilities with design	2 pt.
+	Criteria met	/	Possibilities with design	1 pt.
-	Criteria not met	/	Little possibilities with design	-1 pt.
- -	Criteria certainly not met	/	Almost no possibilities with design	-2 pt.

Figure 85: Evaluation of the first model phase using the defined criteria.

Conclusion

After evaluating the models, it is clear that the wet young heathland reclamation landscape is the most suitable for positioning large scale afforestation. This landscape is also sensible for large scale changes in light of the improvement of spatial quality, as the areas are prone to cluttering and often harbor unsustainable farming practices. It is however in need of better accessibility and connections to other natural areas. Next in line is the 'Zwollewoud' model, who has some serious benefits, but has shortcomings when it comes to the production of quality wood. The exclusion towards the inhabitants of the rest of the region is also a shortcoming. Next, three models have scored the same amount of points: the 'NNN bos', 'Kanalenbos' and 'Sprinterbos'. These models can be seen as strategies that can be adjusted to, and can adjust the location. Using the NNN to connect natural areas is a good strategy to combine with chosen locations, but not so strong on its own. The 'Kanalenbos' can be used as a coupling strategy, to link large scale afforestation to a water network for transportation opportunities. Finally, the 'Sprinterbos' model poses opportunities for improved accessibility, and can also be used as a coupling strategy. One train station could suffice for creating good accessibility and housing development opportunities.

These five models will be used as a starting point for the second model phase, where they will be elaborated and combined.

Model phase II

In the second model phase, five models are used as a starting point for model formulation. From the first model study, the wet young heathland reclamation landscape came out as the most suitable landscape type for afforestation. This information serves as the base for the second model phase, onto which the four different strategic models are applied and combined. Because it is known from the first model study what forest in this landscape type has to offer, the second model phase will not repeat the same criteria, but will instead focus on a couple other more specific criteria. The models will be evaluated using the following criteria:

1. Easily accessible

The forest should be accessible by different modes of transport, including train infrastructure, cycling infrastructure and car infrastructure, to ensure a broad range of local and regional visitors as well as tourists. Forests adjacent to larger roads, train stations and a multiplicity of cities and towns are scored higher.

2. Achieving critical mass

Achieving a significant amount of forest cover is important to create a unique and well-established forested landscape, that can produce quality wood and other products to support regional economies. Larger forested landscapes can mediate a variation of recreational possibilities, with full immersive experiences. Visitors have a broad range of places to discover. Larger forest bodies with less fragmentation due to the presence of (provincial) roads and railways are scored higher.

3. Ecological diversity

Ecological diversity can be accommodated by differences in soil and water conditions, a variation of patch sizes, as well as the use of corridors, stepping stones and core habitats.

4. Experiential diversity

Diversity in experiences is achieved by using the multifunctional character of forests by interweaving it with human activity. Different vegetation- and landscape types create diversity in forest types to experience. Forests are scored higher when there are more differences in soil conditions, when it stretches over different landscape types and when it is adjacent to city or town edges.

5. Protecting characteristics of the cultural landscape

Landscape characteristics such as scale and openness should be considered and protected, as current existence is a continuum between the past and future. Forest should not eradicate small scaled or extremely open landscapes. Semi-open and large scaled landscapes are preferred.

6. Concealing cluttering

Concealing current cluttering elements in the landscape while possibly avoiding or intercepting future cluttering can be a great opportunity in designing landscapes and should be taken into account. Locations with a higher amount of cluttering elements are preferred over uncluttered landscapes.

The evaluation is based on two aspects. A criteria can be well met (++), met (+), not met (-) or certainly not met (--). However, sometimes the criteria cannot be valued, or only valued, in that way, so the evaluation is extended by adding another aspect. This aspect takes into account what the model has to offer in terms of design possibilities. The criteria can have many possibilities with design (++), possibilities with design (+), little possibilities with design (-) and almost no possibilities with design (--)

‘Zwollewoud’

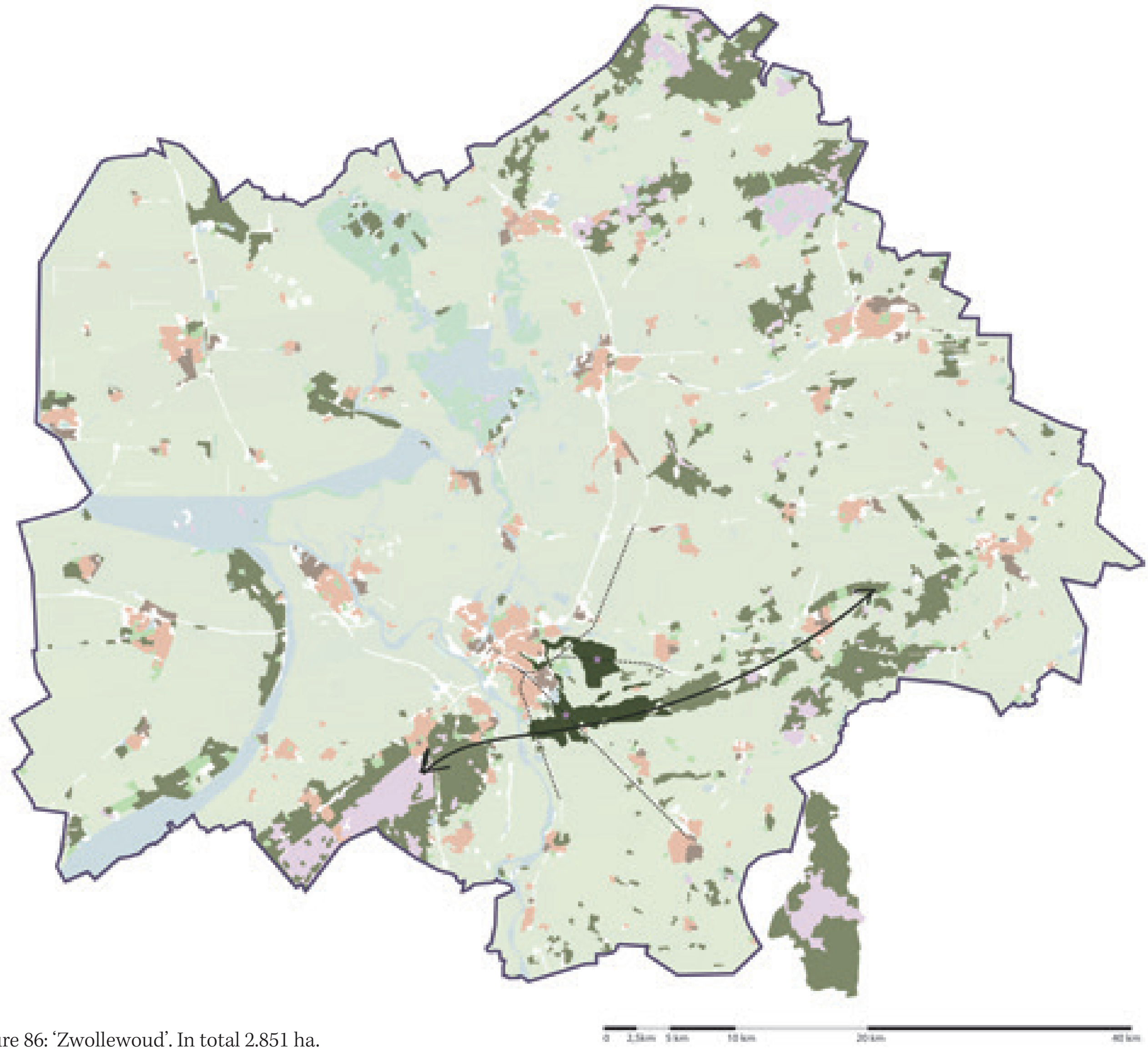


Figure 86: ‘Zwollewoud’. In total 2.851 ha.

This model is an articulation and combination of three strategies (NNN, Sprinterbos and Zwollewoud). In essence, the focus lies on creating accessible recreational green space around the city edge of Zwolle. Two new stations for sprinter trains create quickly accessible forests, along with the possibility of housing development. The forest of the ‘Vecht’ area is extended towards the floodplains of the ‘IJssel river, to create better ecological connectivity with forest of the ‘Veluwe’. Closer to the city edge, forest will have a more park-like identity, so that the space can have a more multifunctional character.

‘Nieuwleusen-Woud’

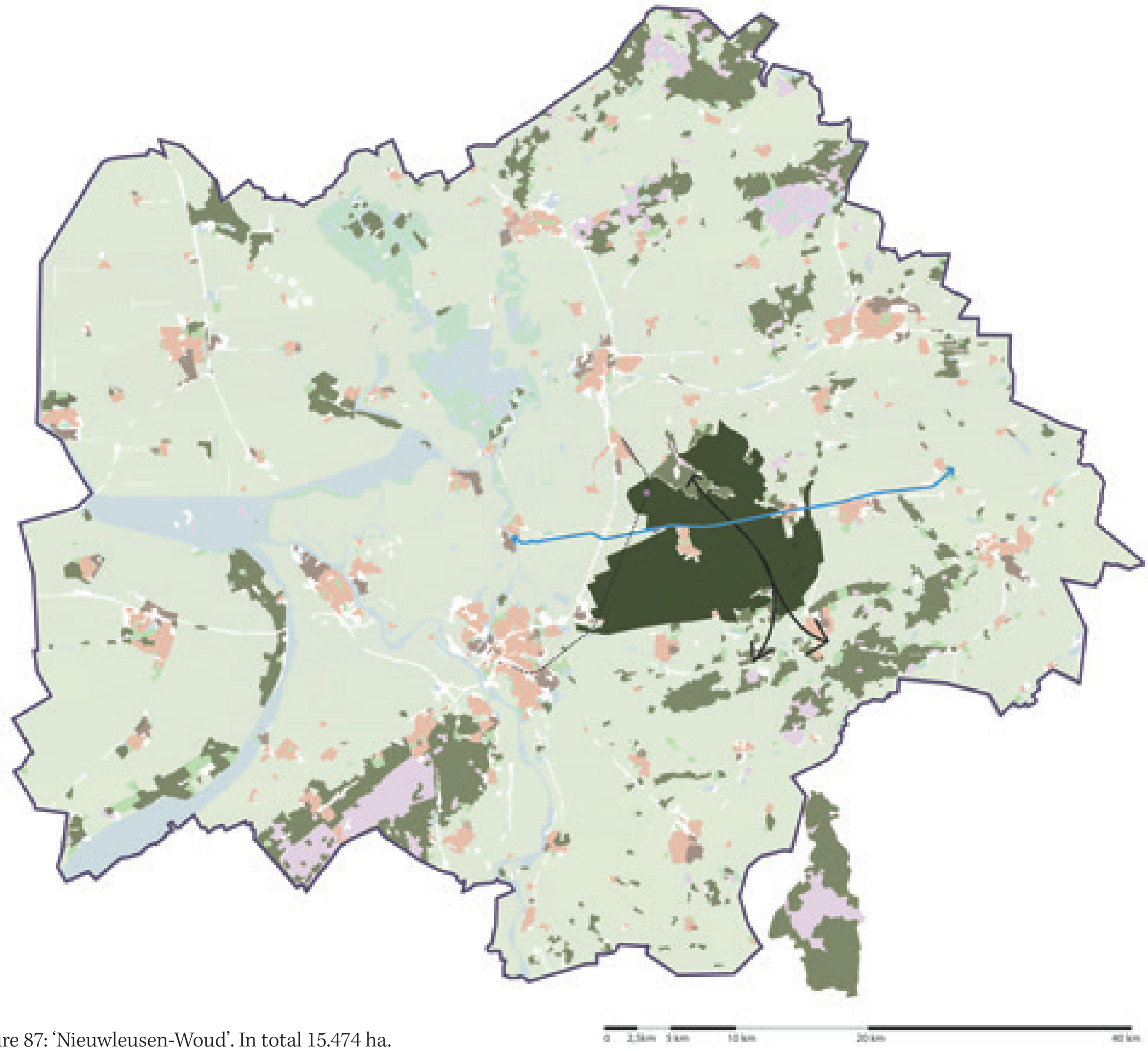


Figure 87: ‘Nieuwleusen-Woud’. In total 15.474 ha.

This model focusses on creating critical mass in a vast inapproachable landscape of bio-industry and cluttering elements. The large areas of sandy soils allow for a stable environment for afforestation, especially with a productional focus, but still located central in the region, relatively close to the city of Zwolle. The former canal of the ‘Dedemsvaart is restored as a complete entity to act as a transportation vessel to the north of the Netherlands as well as towards the industrial harbour of Hasselt. A intercity station can give access to the forest, although intercity railways are not ideal. The forest improves ecological connections between the north and south parts of the Region.

‘Salland-Vecht bos’

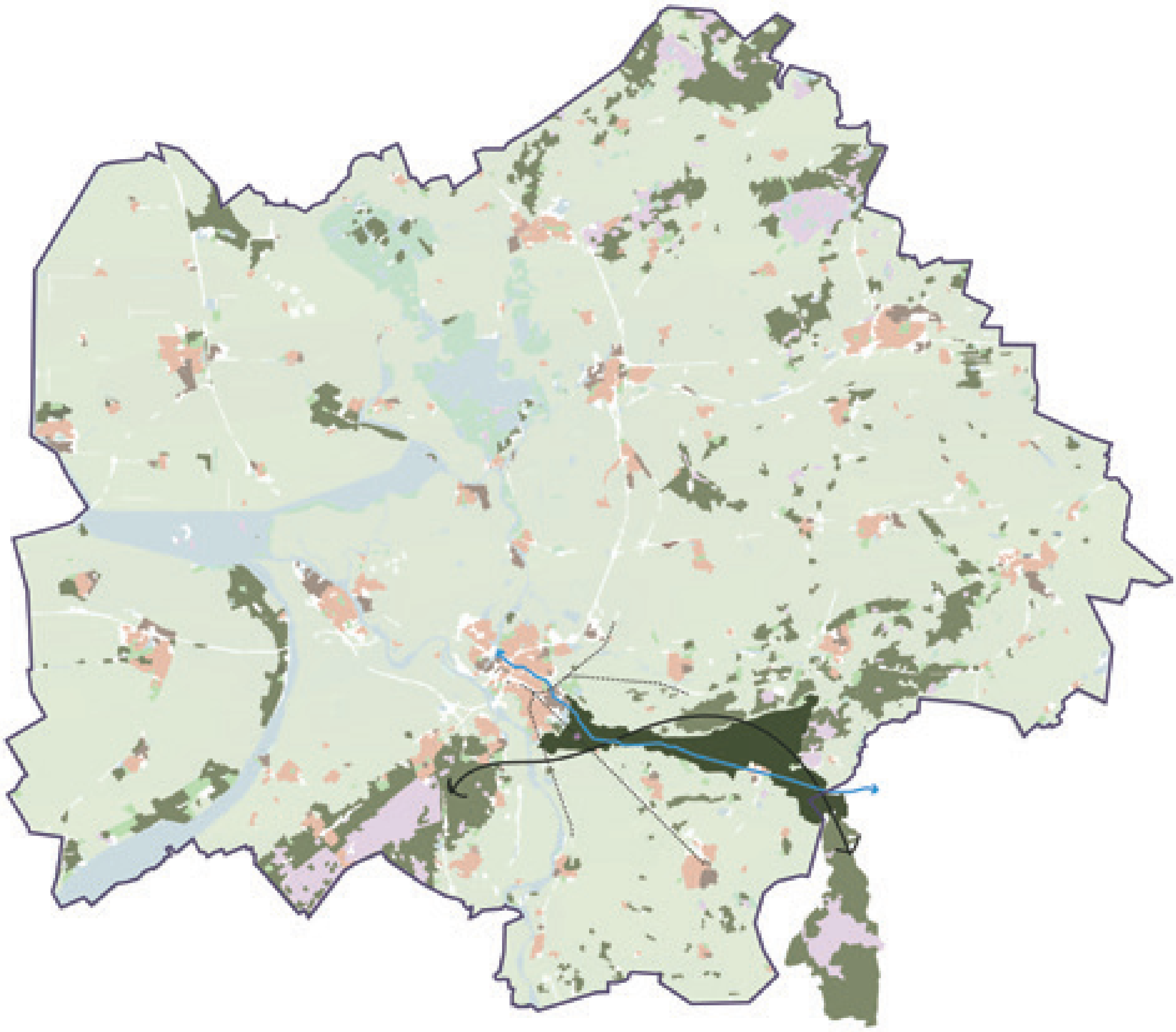


Figure 88: ‘Salland-Vecht bos’. In total 6.151 ha.

In this model, inhabitants of Zwolle can directly cycle to the ‘Sallandse Heuvelrug’ along a restored transportation canal that ships wood products directly to the center of Zwolle. The forest can become part of the identity and branding of the city of Zwolle, as wood is visibly present in the heart of the city. Three forested areas are connected, the ‘Veluwe’, the ‘Sallandse Heuvelrug’ and the ‘Vecht’ area. A new sprinter station ensures accessibility and can create possibilities for housing development. The biggest mass of the forest is located in a wet young heathland reclamation landscape.

Preference Model

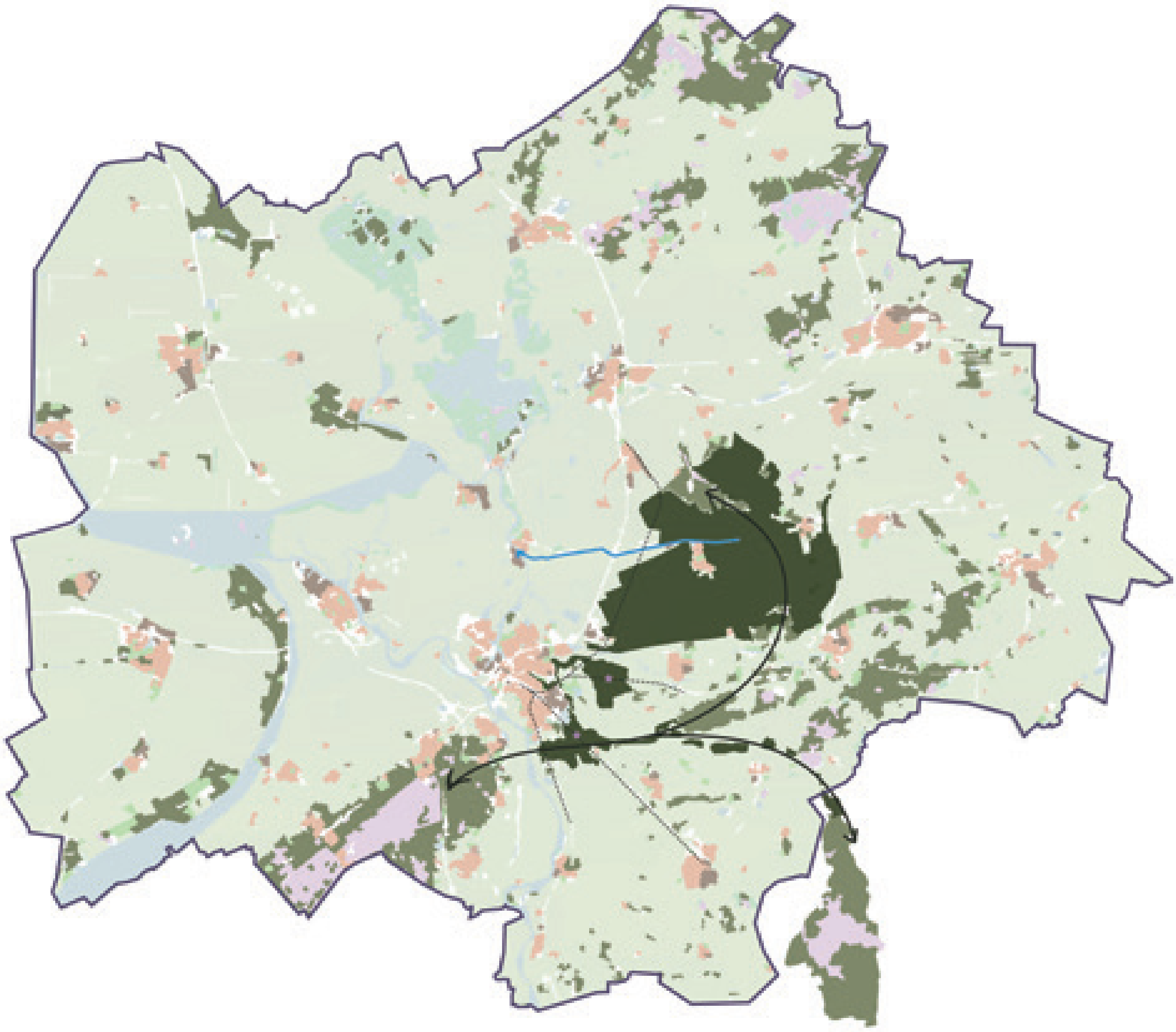


Figure 89: Preference model. In total 18.315 ha.

This model is a combination of the best assets of each of the three previous models. Critical mass is achieved in the wet young heathland reclamation landscape with a transportation canal that is restored from within the heart of the forest towards the harbor of Hasselt. New sprinter stations create direct accessibility for the city dwellers to forests, and inhabitants of new housing development benefit from quick access towards the city center. Stepping stones create ecological connectivity between the North of the region, the ‘Veluwe, the ‘Vecht’ area and the ‘Sallandse Heuvelrug’ without blocking views from the open landscape on the hills of the ‘Lemelerberg’.

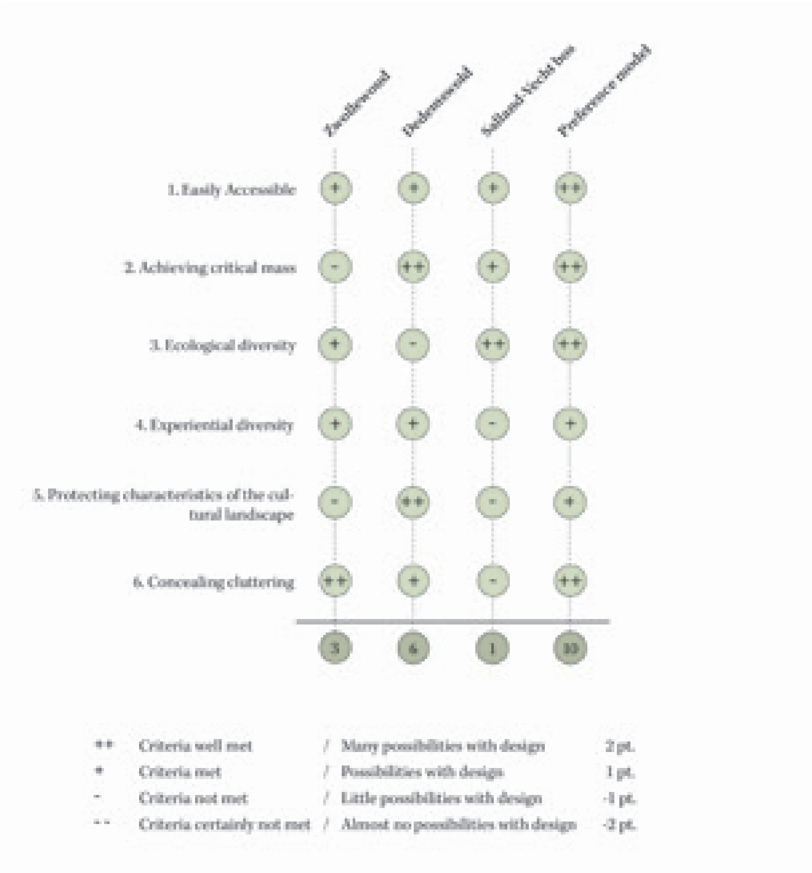


Figure 90: Evaluation of the second model phase using the defined criteria.

Conclusion

In this chapter, several different models have been tested within the landscape of the Region of Zwolle. These models have been evaluated and scored using parameters. From the first model study, one preferred landscape type has been selected, along with 4 other models that proved to be useful as strategies. In the second model study, these five models have been combined to create 3 different models. A combination model has been made from these models, and is concluding for the model study as a preference model.

The formulation of models has guided the process of narrowing down the research to a specific location that can serve as a test base to develop a design synthesis. The model study proves to be useful for connecting and weighing different aspects of afforestation when a multitude of stakes and complex relationships are at stake, to create a well-informed decision process.

The unapproachable wet young heathland reclamation landscape north-east of the city of Zwolle, with its semi-open, cluttered and industrialized character, is proven to be a suitable location for the design of a masterplan. Its partnership with the city edges of Zwolle adds accessible green space close to densifying cities, while offering possibilities for housing development. Ecological connectivity is achieved by stepping stones, that connect the 'Sallandse Heuvelrug' with some of the biggest forested areas close by. Choosing stepping stones ensures that landscape features are respected, the view on the hilly landscape of the 'Lemelerberg' is unique. The preferred model successfully combines the reasons for large scale afforestation; aspects such as production of quality wood, recreation, accessibility and biodiversity have been landed in place inside the landscape. With that, regional landscape characteristics have been taken into account, such as characteristics of the cultural landscapes, its current issues and future pathways.

Chapter 5. Design Synthesis

Part III. Research through Design

Site Introduction

In the previous chapter, the most suitable model has been defined for large scale afforestation. In this chapter, the preferred model will be elaborated into a masterplan landscape design. The site will be introduced by diving into a small part of its historical development, soil- and water conditions.

The current landscape

The site is located in the middle of the Region of Zwolle, in the province of 'Overijssel'. In the north, it borders the small stream valley of the 'Reest', in the east it borders to 'Dedemsvaart'. The south is bordered by three towns, 'Lemelerveld', 'Heino' and 'Wapenveld', and the tip of the 'Sallandse Heuvelrug'. In the west, the tip of the 'Veluwe' is present, and a boundary is drawn with the A28 highway.

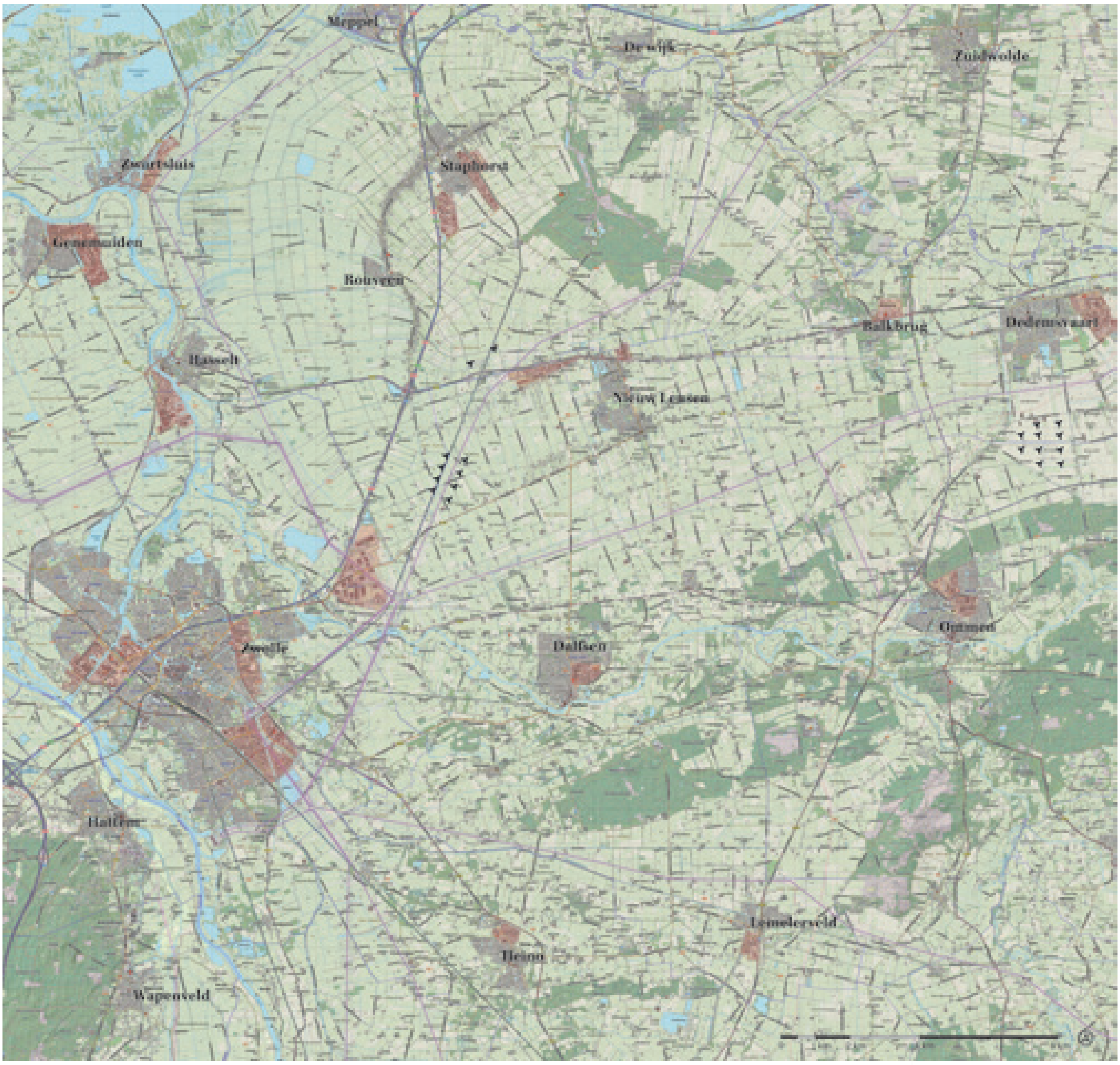


Figure 91: Overview of the site. Industrial areas, power lines and existing wind turbines are clarified. (Adjusted from Opentopo)

The capital city of the province of 'Overijssel' is the city of Zwolle, while throughout the area different medium sized towns are present. 'Dalfsen' and 'Ommen' are characterized by their touristic identity, drawing recreational visitors towards the leisure landscape of the 'Vecht' area. 'Nieuwleusen' and 'Dedemsvaart' originate from the former peat excavation colonies. 'Staphorst' and 'Rouveen' are characterized by their religious seclusion and are part of the National bible belt. 'Hasselt' and 'Hattem' are, together with Zwolle, former 'Hanzesteden', who prospered from trade via water in the fourteenth century.

The landscape between 'Staphorst', 'Dedemsvaart' and 'Dalfsen' is characterized by a rectangular shaped parcellation structure with straight roads, accompanied by tree lanes and large, mostly bio-industrial farms. To the west of the area, cluttering elements such as powerlines, wind turbines, infrastructure and industrial buildings are dominating the landscape. Along the 'Dedemsvaart', nowadays mostly transformed in a provincial road, lots of buildings are found, including industrial areas. The road is important for the logistic sector, used by large trucks, connected to the A28 highway in the west. The landscape overall is not welcoming for leisurely purposes and is almost exclusively used by inhabitants of the area.

The landscape between Zwolle, 'Dalfsen' and 'Heino' is from origin a 'Kampen' landscape, characterized by irregular parcellation structures where a mix of meadows, agricultural fields, estates and small forests can be found. Subtle height differences can be found as remnants of alluvial ridges. The east borders of the city of Zwolle are industrialized and cluttered by powerlines.

The area above 'Lemelerveld' is again a heathland reclamation landscape, with the same characteristics as the area of 'Nieuwleusen', however, the forested borders in the north and east give a more closed and inviting feeling despite the openness of the landscape.

Lastly, the area between 'Dalfsen' and 'Ommen' is part of the 'Vechtdal' where the rainfed river the 'Vecht' flows between forests. The landscape contains many recreational accommodations such as campings and bungalowparks, and is intersected with many recreational walking- and cycling routes. This area prospers true its leisure economy.

Landscape History

The area between the 'Vecht' and the 'Reest', from 'Coevorden' until 'Hasselt' was once a inaccessible wilderness of peat swamps. A layer of peat grew on top of cover sand, and thinned out towards the south. It was called the 'Ommer moer'. 'Nieuwleusen' was a small village that was located on top of a sandy ridge, that stuck out from the peat. (Wikipedia 2022)

In 1631, inhabitants of Zwolle and 'Kampen' decided to start the excavation of this peat swamp. The pioneering inhabitants of 'Nieuwleusen' mostly took initiative to start this process. The first settlements were located along a path, nowadays called 'Oosterveen'. (Wikipedia 2022)

Figure 92: Boat in the 'Dedemsvaart' near 'Hasselt'. (Canon van Nederland (n.d)

The excavation of the 40 km long 'Dedemsvaart' canal began in 1809, by the baron Willem Jan van Dedem, who was born in the city of Zwolle. The canal was meant to function as a transportation route for peat. Van Dedem did not see this canal as just a personal economic endeavor, but noticed that canals were usually the source of work for the people in need, as side channels and ditches brought new settlements and arable land. However, the inhabitants of Zwolle initially stopped the development of the canal, as it was seen as competition with the trade they had with Germany via the 'Vecht'. The 'Dedemsvaart' ran from 'Hasselt' to 'Gramsbergen', and thus connected the 'Zwarte water' with the 'Vecht', and was completed in 1825. The canal was of great importance for the development of the area, as peat excavation supplied work for skippers and peat workers. Many villages and settlements were created. (Canon van Nederland n.d-a)

Along the ‘Dedemsvaart’ canal, a railway was developed for a steam powered tram, that connected Zwolle with the town ‘Dedemsvaart’. Eventually, in the second half of the twentieth century, the canal lost its econonomic meaning, as most peat was excavated from the area, and new forms of transport, such as cars and busses became more widespread. Parts of the canal were transformed into roads, now the N377, and some parts of the canal are currently still visible. The ‘Hulsterplas was created as it provided the sand for closing parts of the canal. (Wikipedia 2022)

Figure 94, 95, 96 and 97 show a sequence of historical maps in which the excavation and reclamation of the landscape can be seen. In figure 94 the large swamp area is shown, where in figure 95 the first settlements were created in this area. In 1875 (figure 96), still large parts of the landscape remained ‘untouched’. These were mainly heathlands, that contained much less peat. In 1925 (figure 97) the landscape is almost completely reclaimed.

<u>The ‘Ommerschans’</u>

The ‘Ommerschans’ was once a fortification for the protection of the south borders of ‘Groningen’, ‘Friesland’ and ‘Drente’. It has has multiple functions and owners throughout history. After the ‘Ommerschans’ lost its defense function, it became one of the biggest ammunition storage of the Netherlands (Vereniging de Ommerschans n.d). In the nineteenth century, in 1818, the ‘Maatschappij van Weldadigheid’ is founded, with the purpose to educate all sorts of people towards a moral existence, from paupers to beggars, vagabonds, foundlings and orphans. The ‘Ommerschans’ is used as a location for one of these places, however, here the people who cannot, or did not want to work were placed. They lived under a coercion system, and were obligated to work. They had to excavate the surrounding land, that was later leased to successful colonists from the ‘free’-colonies. Seventeen farms were created. In figure 93 the original layout of this excavation landscape is shown. (Canon van Nederland n.d-b)

Figure 93: Map of the ‘Maatschappij der Weldadigheid’ 1842
(Maatschappij van Weldadigheid 1842)

Figure 94: Map of 1638 (Janssonius 1638)

Figure 95: Map of 1692 (Coronelli 1692)

Figure 96: Map of 1875 (Topotijdreis)

Figure 97: Map of 1925 (Topotijdreis)

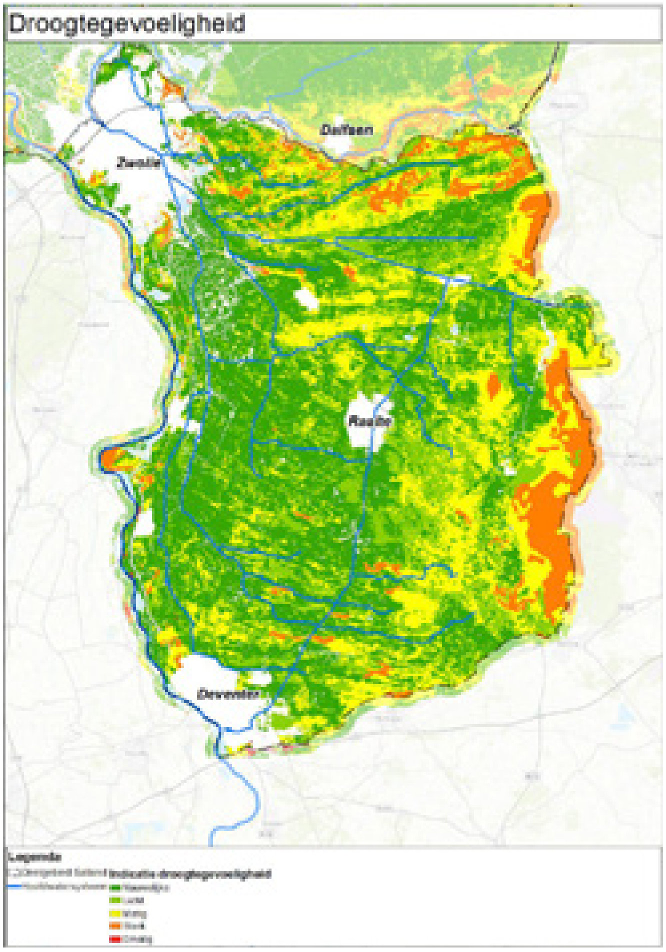


Figure 98: Drought sensitivity map, ranging from barely (green) to severe (red). (Drents Overijsselse Delta n.d-b)

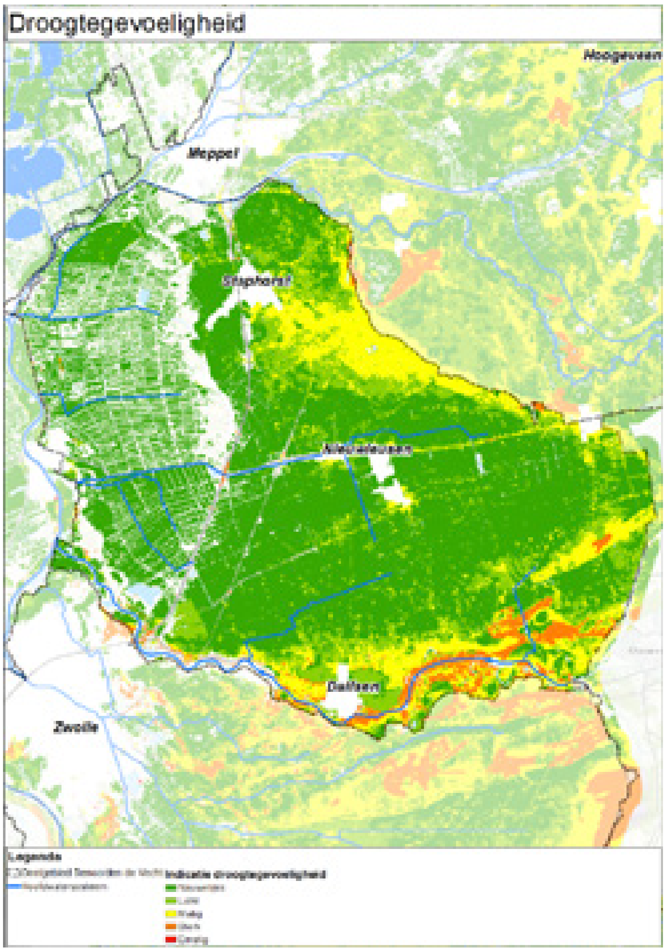


Figure 100: Drought sensitivity map, ranging from barely (green) to severe (red). (Drents Overijsselse Delta n.d-a)

Figure 99: Water map (PDOK)

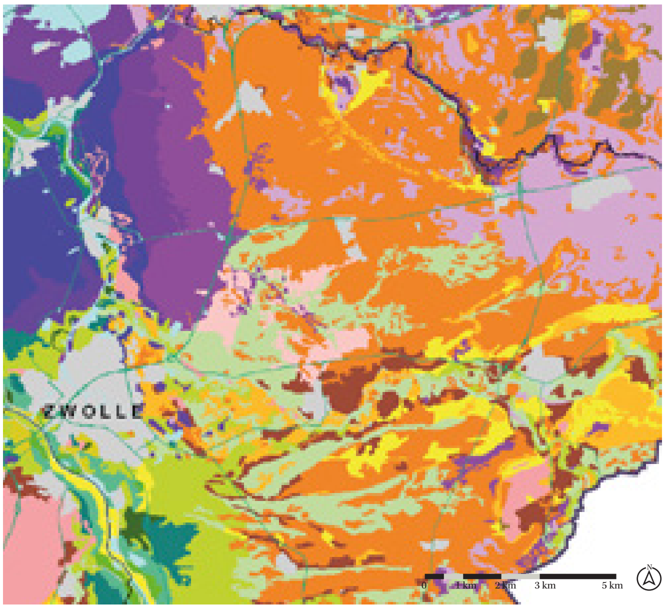
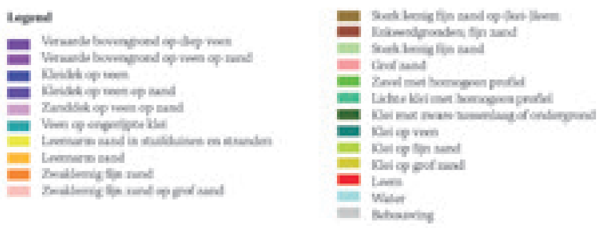


Figure 101: Soil type map



Water system

The site consists of two subareas that can be seen as hydrological units, the area above the 'Vecht' (figure 100) and the area below the 'Vecht' (figure 98). First, the area above the 'Vecht' is discussed.

The area above the 'Vecht' contains many dug ditches, pipes and canals, like the 'Dedemsvaart'. The valley of the 'Vecht' river is characterized by a wide meandering river landscape in which nature, estates and agricultural soils are alternated. On alluvial ridges towns and cities are located. The river 'Vecht is rainwater fed. The 'Vecht' and the 'Zwarte Water' join together in this area. The main waterways have a draining function in times of precipitation surplus. The draining water system is connected to pumping stations that drain the water towards the 'Vecht' and 'Zwarte Water'. In times of drought, water is let in from the 'Zwarte Water', the 'Hoogeveense vaart', the 'Vecht' and the 'Twentekanalen'. The sandy areas east of the A28 work with target water levels. Drinking water is extracted in 'Witharen'. A part of the area has been disconnected and now drains via the 'Dalfserveldwetering' towards the 'Vecht', making the water system more robust. (Drents Overijsselse Delta n.d-a)

The second subarea is called 'Salland'. The area consists of lower laying stream valleys and higher east-west oriented cover sand ridges. In the east part of the area the moraine of the 'Sallandse Heuvelrug' is situated. The 'IJssel' river flows in the west, with its floodplains and river clay basins. The 'Sallandse weteringen', the main waterways, drain precipitation surpluses via the city canals of Zwolle towards the 'Zwarte water', towards the 'IJsselmeer'. This drainage happens under free descent, as the area slopes down from the 'Sallandse Heuvelrug' towards the 'IJssel' river. Closer to the lower laying area around 'Zwolle' pumping stations are used for drainage. In times of drought, water is let in from the 'IJssel' river, the 'Vecht' and 'Twentekanalen'. The higher moraines are dryer in general than the lower laying areas. The 'Overijssels kanaal' is appointed as the most important waterway for letting in water. In the past years, the subarea has received many water storage locations to make the water system more robust. More water can be stored locally, and water surplus in the lower laying areas is therefore intercepted and prevented. (Drents Overijsselse Delta n.d-b)

Soil

The area above the 'Vecht' is characterized by a much more uniform sandy soil landscape than the area below the 'Vecht'. These large sandy parts have minor differences of amount of loam present in the sand, and only a few parts have a different grain size. The amount of loam is the sand influences the water retention capacity; more percentages of loam usually have a better water retention capacity. Below the 'Vecht', clay and clay on peat soils provide variety within the present sandy soils.

Vision/Design aims

The aim of this chapter is to provide an answer to the following design question: How can afforestation deliver collateral benefits to the landscape and/or society?

The enormous landscape provides an endless variation of design options for the implementation of forest. A couple of aims and pathways are used as guidance for the design process.

Current issues and threats to the landscape should be connected to the implementation of forest, in order to improve spatial quality. The fact that forest can be seen as mass should be used to its advantage when it comes to concealing eye-sores in the landscape. Besides, looking at it from this perspective, the avoidance of the establishment of cluttering elements might not be needed.

Forests can be seen as a separate whole, or interwoven in space. Being able to integrate and interweave forest inside the landscape and its functions give opportunities to use the multifunctional character of forest sytems to its advantage. Interweaving forests with the tissues of the landscape can create opportunities to finding collateral benefits.

The extreme large scale of the forest has the potential to accommodate many different places and functions to discover. Being able to move through the landscape and come across a varied landscape structure can be real valuable for its visitors. The significance the dichotomy of open spaces should therefore not be undermined.

The creation of meaningful and immersive nature to recreate in should be a priority, as it is the main aspect of a forest that every individual can experience. This nature needs to be accessible and preferrably right on your figurative doorstep. Combining afforestation with housing development can pose opportunities for this, but existing landscape occupation should be able to benefit from afforestation as well.

The implementation of large scale design challenges the area to enhance its connectivity through new legible routes, especially outside of the 'Vecht' valley, inside the vast spaces between towns, villages and cities. This changes the unapproachable landscape into a welcoming one by extending the recreative tissues.

The implementation of forest can feel like a tabula rasa for the underlying landscape structures. features or characteristics. However, can these structures, features or characteristics be kept and used instead?

And lastly, forests take centuries to form and develop, where the needs of society have a much quicker and less predictable turn-over rate. Endless scenarios for the future are possible, thus flexibility to change or adapt programming to these needs is important to make a large scale landscape development supported. The removal of large amounts of forest cover for the possible change of programming is not approved as flexible. Are there ways to incorporate flexibility?

The Design Synthesis

In the following sections, the design synthesis is explained as a masterplan design. The design is an execution of the preferred model, but also more than that. It proposes the implementation of large scale afforestation in an existing landscape, where forest acts as a carrier of new developments regarding ecological connectivity and biodiversity increase in the landscape, accessibility within the regions living and working environment, broadening recreative aspects, as well as interweaving and anticipating on further (economic) functions. Using forest as an incentive for development can stimulate the enhancement of the overall landscape experience and spatial quality.

The masterplan design is a complex interplay of many different components, and cannot simply explained by one concept or narrative. This is because the design is built from a systemic approach, where the whole is more than its individual components together. The same can be said for the masterplan design. The design celebrates that its components interact and complement each other. This is underlined by the multifunctional character of forests. It will therefore be explained part by part, using diagrams, sections and visualizations.

Masterplan 1:5000

Legend

- Existing Forest
- Heathlands
- Towns and cities
- City name
- Built area
- Diked floodplains
- Main cycling infrastructure
- Flooding forest
- Forest structure of Voids
- Ridge forest
- Windturbine forest
- Touristic Center
- Sallands Cider Brewery
- Experimental forest
- Railway
- New station and medium rise housing
- New station
- Existing Estates
- Car infrastructure
- Road numbers
- Car park
- Power lines
- Water
- Tree lanes
- Red Beeches tree lanes


IJhorst
N48
N377
Balkbrug
Dedemsvaart
Nieuwleusen
N36
Oudleusen
N340
Ommen
Dalfsen
Hoonhorst
N341
Lemele
Lemelerveld
Heino
N347
N35
N348
Luttenberg

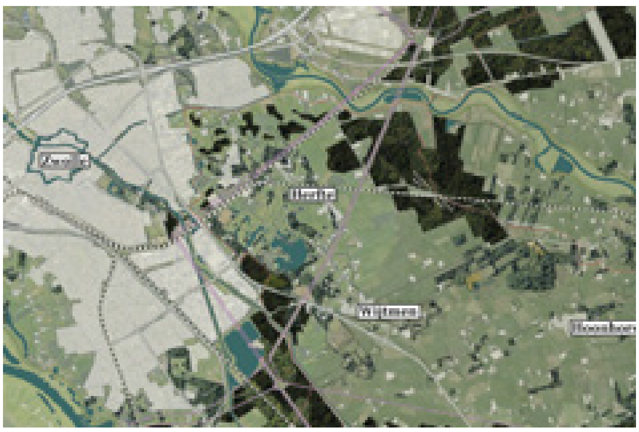
Figure 102: A large mass of forest is connected to the 'Veluwe', the 'Sallandse Heuvelrug', and the 'Vecht' area by corridors and stepping stones

Living landscapes

A large mass of forest is connecting the 'Veluwe' the 'Sallandse Heuvelrug', the 'Boswachterij Staphorst' and the 'Vecht' area by large core habitats, corridors and stepping stones. These stepping stones and corridors add variety to the forest structures, so that a variety of species, forest biota as well as non-forest species, can be advantaged in the landscape. This gives the landscape an 'upgrade' in terms of biodiversity and ecological services. The new forests can be experienced as 'alive'.

Because the 'Vecht' area is connected and continued in Germany, ecological connectivity is extended over the borders as well.

Figure 103: The forest stretches over four different landscape types.



Landscape types

The forest stretches over four different landscape types. It is mainly situated in the wet young heathland reclamation landscape. The peat colonial landscape type is mainly present in the center of the forest above the 'Vecht' and largely preserved, as occupation and reclamation of the landscape started from this area. Leaving this part of the landscape open brings the former colony back into a vast 'wilderness'. This contrasts and underlines the open exavational origin of the area.

The area below the 'Vecht', is situated both in the old sand reclamation landscape, or 'Kampen' landscape, as well as the river basin clay landscape. The 'Kampen' landscape there is characterized by its irregular parcellation structures and old alluvial ridges where first occupation in the form of small villages happened. These ridges are still occupied more densely than the surrounding sandy landscape. These landscape relationships are less visible nowadays, but the height differences of the ridges are still visible in some parts. The presence of estates makes the landscape attractive and varied. The designed forests are therefore avoiding the ridges and estates. The river clay landscapes are very open, so only parts have been forested. Areas around the city edges are heavily cluttered with powerlines and forest is used to conceal these.

Structure of Voids

The large mass of forest contains a structure of Voids. These voids give space to functions and are meant to create flexibility for programming. The voids are situated closer to cities and towns in order to accommodate for higher dynamics. The voids are shaped to respect and make use of the underlying landscape structures. In most areas around the voids, some of the original road layout is kept. Keeping these roads instead of erasing them creates the ability to harbor different programming options within the voids. While forest grows, some of the original farms can be kept, and will remain accessible. In the future, bio-industry will disappear from the area, and a more mixed landscape will emerge within the voids, as a test base for new forms of agriculture. Extensive livestock farming, orchards with chicken farming, hayfields, agroforestry and silvo-pasture are some of the more agricultural land uses, but the voids can also be used for creating bungalow parks, camping sites or even for festivities such as (music)festivals. In another future scenario, parts of these voids might become vacant, for example if the 'countryside' is abandoned and people move to cities. Or the rewilding vision might receive more followers. The voids can slowly close by spontaneous rejuvenation and still create an interesting, varied landscape. The mix of all these possibilities is the strength of these structures of voids, as visitors come across all these different land uses, while moving through a forested landscape.

Figure 104: Voids give space to functions

Figure 105: Voids are clustered near towns, villages and (rail) infrastructure

Figure 106: Possibilities include housing development, festival terrains and orchards.

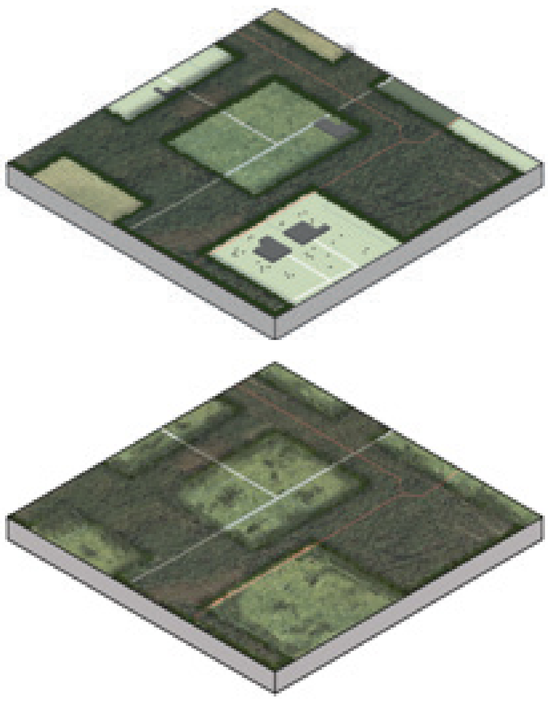


Figure 107: These figures show two different scenarios for the voids: a more mixed agricultural landscape, or a vacant rewilding countryside. Both desirable options.

Figure 108: The large scale bio-industry will dissappear and become more extensive

Figure 109: Extensive forms of agriculture

Figure 110: Entirely different functions are imaginable

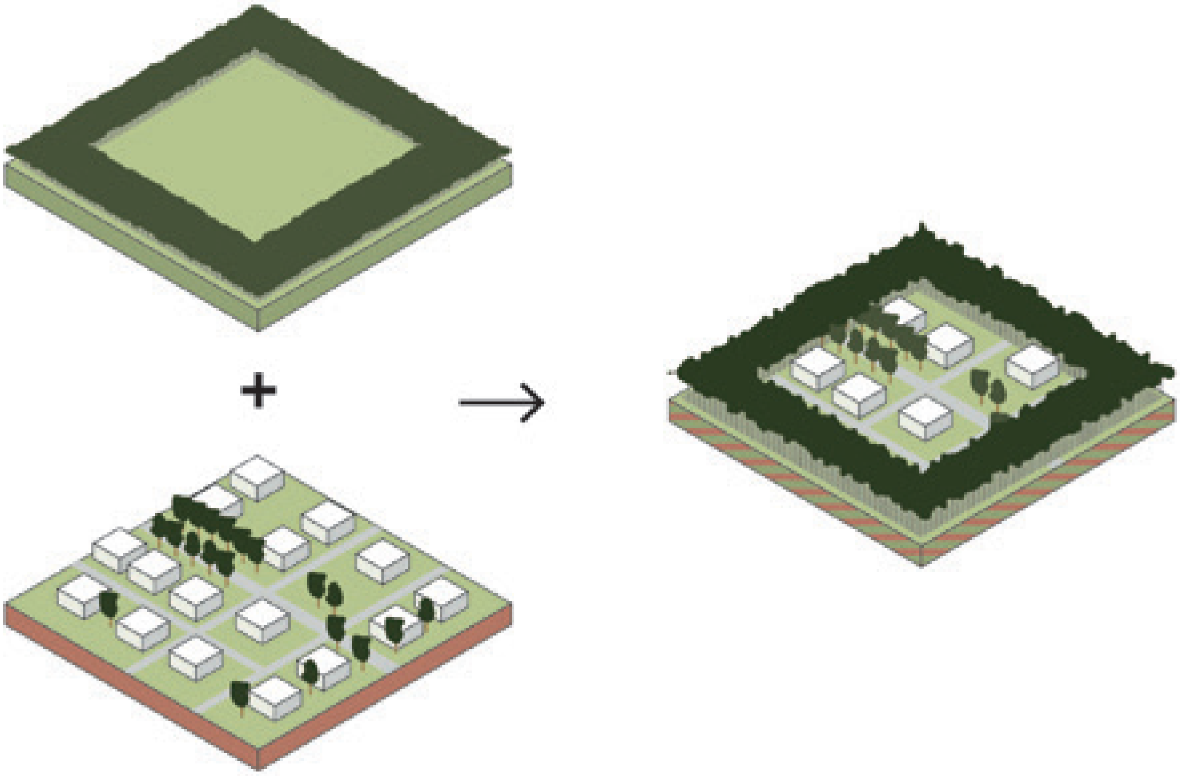
Figure 111: Leaving intentional space for expansion of new industries

Intentional expansion

Space is left for the expansion of industrial activity to prevent the removal of forest. This space is mainly located around important logistic routes for proper accessibility, and on visible locations along highways. This creates the possibility for the region's economy to continue growing. Boxing and cluttering due to industrial buildings is limited to sights from highways and roads, where these buildings actually want to be seen. With the removal of bio-industry in the area, perfect opportunities arise for the region to invest and pioneer in the cultured meat industry. The region will become a Silicon Valley for sustainable lifestyles, with afforestation for quality wood, a test base for new forms of agriculture inside the voids, housing development inside ecologically rich landscapes and creative ways of using rail infrastructure for recreation.

Housing development in voids

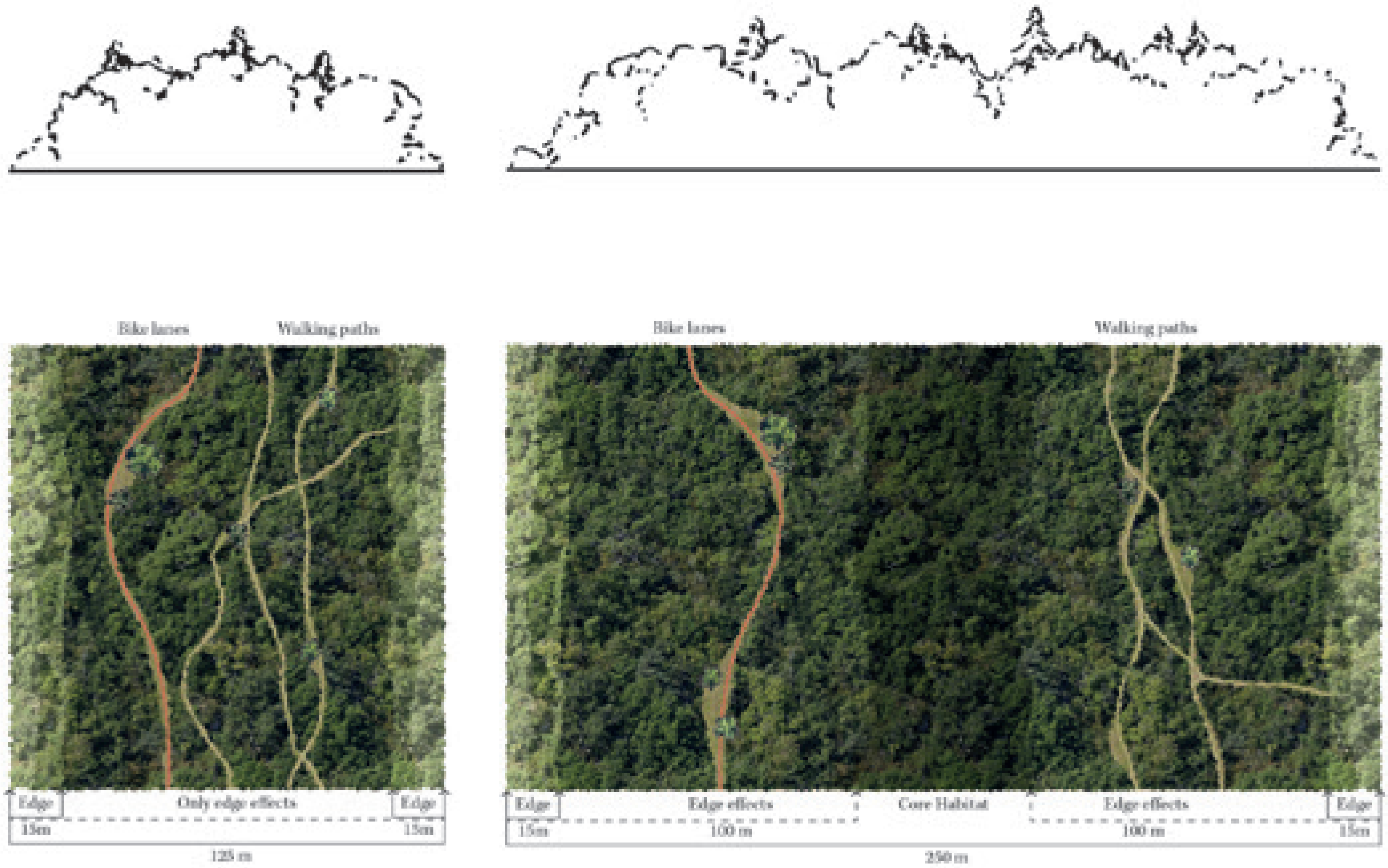
The development of new housing is a valuable option for the voids. Suitable locations for city expansion inside these voids are at the south-east border of Zwolle. While new neighbourhoods are planned, the forest structure can begin growing. A new sprinter-station ('Forestation') connects the inhabitants of Zwolle directly to this forest when they are in need of a natural environment. At the same time, the new inhabitants have qualitative green space at their doorstep, while still being able to profit from the luxuries of the city, as the 'Forestation' brings these inhabitants directly to the city center and beyond. This creates a pleasant living environment that can attract new inhabitants to the region.



∧ Figure 112: Residential expansion with a neighbourhood identity can be placed inside qualitative forested borders, which creates an urban environment veined with natural surroundings.

The inside

The inside of the forest around the voids has a minimal width of 125 meters. This width ensures an immersive forest experience, especially with the presence of broad and gradual forest edges. These edges will ensure visual continuity of forest, also in winter. The broader forest structures around the voids contain interior habitat that is sheltered from edge effects. This ensures the continuation of forest biota migration.



Λ Figure 113: Section of the inside of the forest around the void structure.

V Figure 114: Housing development inside the void, bordering the forest structure. The forest surrounds neighbourhoods with a green backdrop that can be used for recreational purposes.

Living inside forest

Aside from urban development in voids, housing development can also take place inside forest. This requires a specific housing type (Appendix 1), to minimize the impact on the forest and in order to have a distinct feeling of being surrounded by forest. Two different housing types are elaborated as an example, both accommodating the same number of residents, but with a significant difference in surface space taken. If housing development does take place inside the forest, only mid-rise buildings are allowed. At a second new Forestation on the sprinter line between 'Zwolle' and 'Dalfsen', these types of residential areas are found. This location actually used to have a station, but it has dissappeared. Mid-rise appartement buildings are 'compensated' by being surrounded by forest, creating a housing type that is in direct contact with its natural surroundings. Again, the Sprinter can bring residents to the city of 'Zwolle', creating a high standard of living.

V Figure 115: This image loosely illustrates the Forestation concept of stepping directly into a forest while leaving your train, a unique experience.

∧ Figure 116: Mid-rise buildings surrounded by qualitative green space.

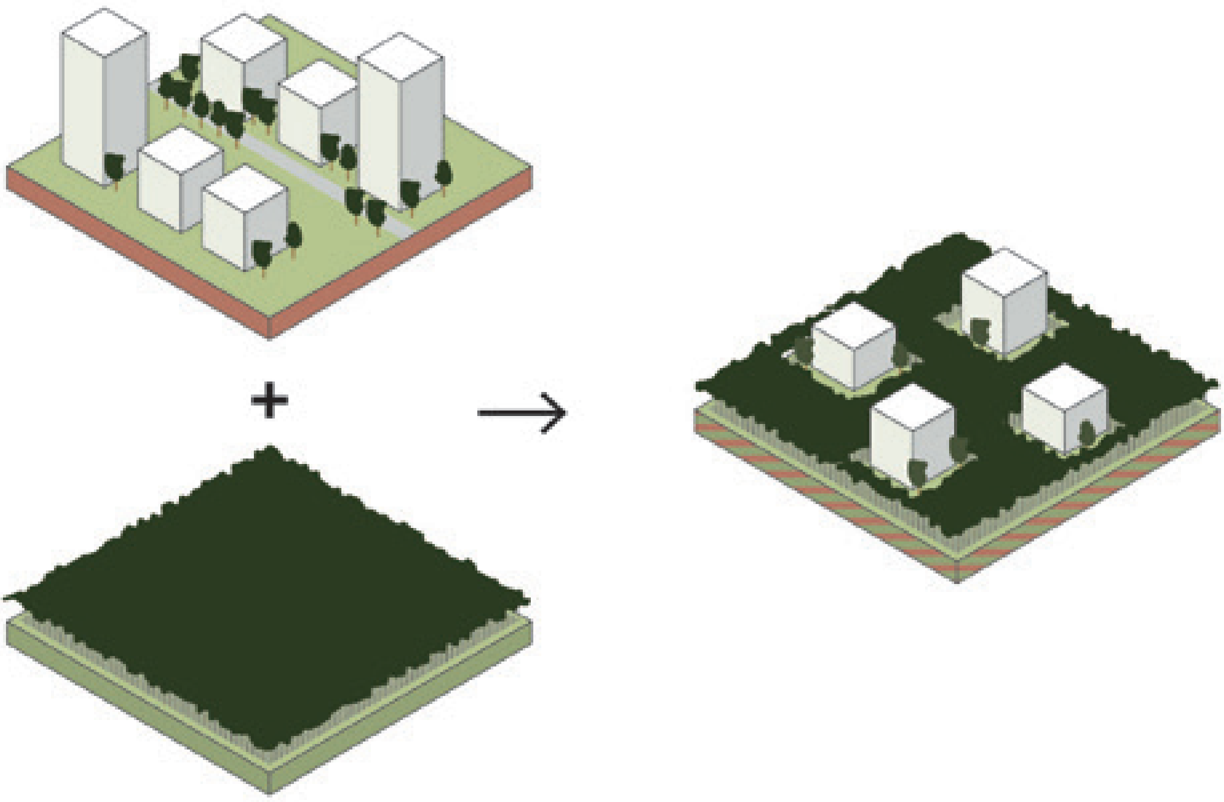


Figure 117: Mid-rise buildings can be placed inside forest, creating a natural environment with residential functions.

Figure 118: Soil and water conditions guide differences in forest types

Figure 119: Diversity is increased by translocating top soil and adding heathlands

Figure 120: Inaccessible experimental forest free of any (water) management

Forest diversity

Differences in soil and water conditions guide differences in species composition. This creates a variety of forest types to experience, that can thrive due to suitable conditions. On the clay soils, forest will grow quicker due to the presence of fast-growing species like poplars and willows. This is beneficial for the recreants from city of Zwolle, as forest is quickly developed and close by. Besides from forest types, more variety is added through two interventions. Heathlands provide natural open space and connect the existing heathlands in the north of the design to the 'Vecht' area via steppingstones. Heathlands were dominant in the landscape before reclamation and their history is celebrated through locating a large heathland area where heathlands disappeared last, around 'Oudleusen', one of the oldest settlements in the area. The heathlands have coppice trees spread over, as a hint to the historical use of trees. In the second intervention, topsoil is removed and translocated to the east edge of the forest. Here the soil is used to create height differences, to strengthen a historical ridge in the landscape. This ridge is currently only visible on heightmaps but used to function as a pathway through the wet wilderness once. These minor differences in the landscape were once observed, as they were of vital importance. These ridges are accentuated by several cutouts, where roads and cycling infrastructure passes through. The ridges have a bumpy character, inviting visitors to walk in the ridge forest. This forest will have a slightly dryer soil, resulting in a different species composition. A dryer forest type can thus be found in a relatively wet environment.

Lastly, an experimental forest is created, that serves as the ultimate ecological heart of the area. This forest is completely inaccessible, as no pathways are designed, and forest management is absent. All ditches are removed in order to monitor what happens to a forest system in extreme conditions.

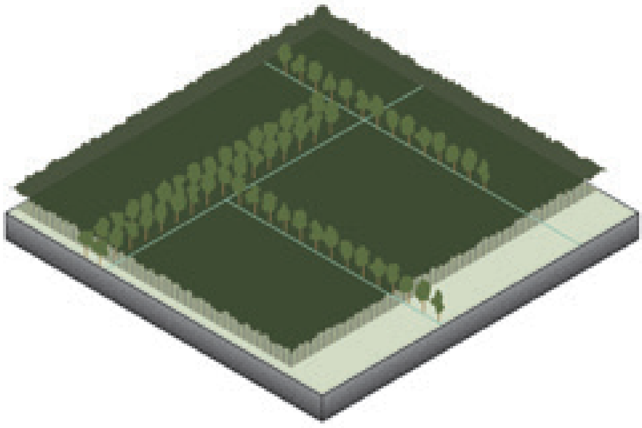


Figure 121: Keep already existing treelanes to create places of interest. These trees will age faster than its surrounding forest.

Figure 124: Keeping existing trees is inspired by the ‘Wodanseiken’ in ‘Wolfheze’. These oak trees were once planted in open heathland, about 500 years ago.

Figure 122: Section of the ridge cutout along the main cycling route. No visibility into the forest makes the visitor wonder what could be happening inside the forest.

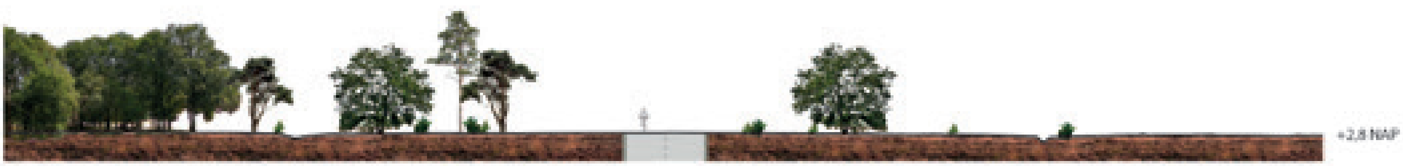


Figure 123: The main cycling infrastructure route passes through the open heathlands before entering the forest again. The heathlands are surrounded by pine trees mixed in the forest species composition.

The flooding forest

Where soil is removed, a lower and wetter zone emerges, as groundwater levels are closer to the surface. Again, water conditions guide species composition. Here, forest resemble 'Broekbossen'. These forests are characterized as wet and occasionally flooded, and these types of forest used to be present in the landscape before reclamation. The area is connected by the 'Dalfserveldwetering' with a sluice that works two ways, water can be let in from the 'Vecht' river, or water can be drained into the 'Vecht' river. In times of extreme precipitation surplus, the area functions as a storage for water. If the 'Vecht' reaches extreme high-water levels, water can be let into the storage area. This can flood the whole area occasionally. If needed, the water can be slowly drained back into the 'Vecht' in times of drought. Water can also be stored in the area to keep surrounding water levels higher in times of drought. In this way, the effects of climate change can be experienced by a forest type that resembles the dynamic nature of floodplains, while increasing water safety and availability.

Figure 125: A lower and wetter zone emerges from the removal of top soil. The new surface level will have valuable micro-relief, and functions as a floodplain in times of precipitation surplus.

Figure 126: The flooded forest seen from one of the elevated main roads in regular conditions.

Figure 127: The flooded forest in flooded state.

Figure 128: Open entrance area with an interactive landmark to introduce the wind turbine district.

Figure 129: The placement of wind turbines inside forest

Wind turbine district

Wind turbines are added to the landscape and placed inside forest. This can provide the region with renewable energy. Depending on where you are, the wind turbines are hidden or visible (Appendix 2). From parts of the highway a scenery of wind turbines sticking out of forest is seen. Inside the forest, the wind turbines are almost invisible, unless you are close by its base. From a view tower in the center of the forest, an overview of these turbines is seen from above.

Intentionally designed open spaces inside the district give occasional views on the wind turbines. In figure x, one of these open spaces is visible. This area functions as an entrance to the wind turbine district. The artwork illustrates the layout of the wind turbines. Its poles are decorated with red lights on top, that light up when the turbines move and produce energy. The red color symbolizes the red light that can be seen on top of these turbines at night. By walking past the poles, light shines brighter, making it an interactive landmark. Forest is used to conceal and play with the experience of turbines, so that they can be integrated inside the landscape in higher numbers.

∧ Figure 130: The shipped wood can be experienced inside the forest

Figure 131: In the main forestry terrain, quality wood products are transported via the renewed 'Dedemsvaart' canal

Transportation of Quality wood products

The benefit of using integrated forest management consists of being able to shift the focus per area. In the north part of the masterplan, forest has a more productional focus. This does not mean that there are monocultures or clearcutting, this is not allowed. However, more species that are suitable for the production of quality wood are mixed in. Wood can be transported to a sawmill in the center of the forest or transported directly to the harbor of 'Hanzestad Hasselt' via the partly restored 'Dedemsvaart' canal. The canal is designed above the original route, so that the N-road and its occupation can remain. A part of an existing waterway is deepened, and a sluice is installed. As a result, the canal can be experienced inside the forest, without disrupting the water system. The transportation of wood via water is an old practice and used to be the most efficient method. This history is restored in the region, and the boats can return to the 'Dedemsvaart'. The center of the forest is now also accessible via a recreational water network. Because the region is connected via waterways, wood can be transported throughout the region and beyond.

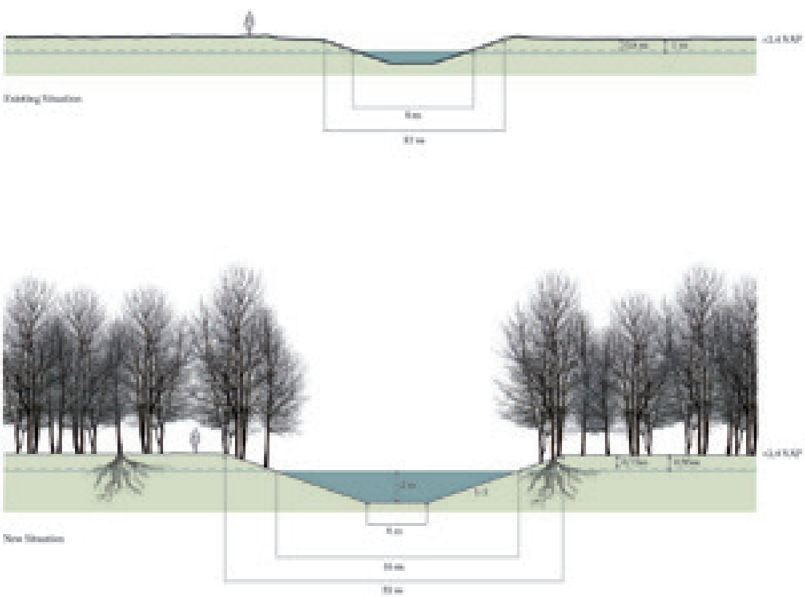


Figure 132: The original layout of an existing waterway is deepened for the purpose of transportation. In the center, the waterway is shaped around a sawmill and visitors center. Water is let in from an existing waterway in the east via a weir.

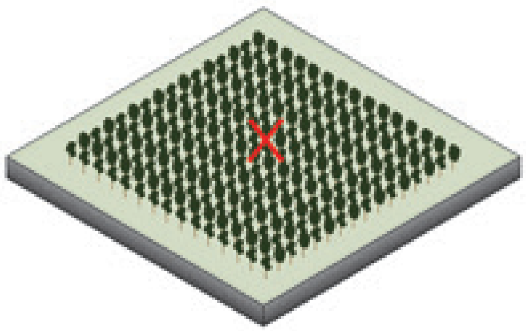


Figure 133: Monocultures are avoided

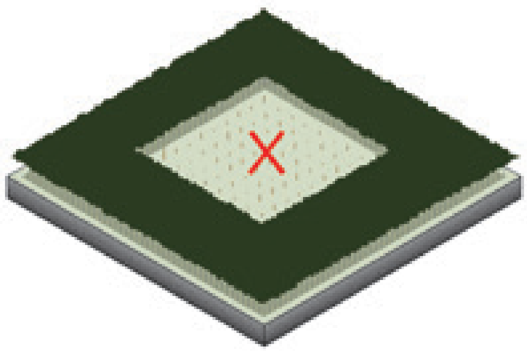


Figure 134: Clear cutting is avoided

Figure 135: The diverse forest landscape can be experienced best by using cycling infrastructure that directly connects regional inhabitants to the landscape

Figure 136: Car use is discouraged and entries with bike rentals are located at trainstations and car parkings

Main cycling infrastructure

All different forest districts are experienced best by using the main cycling routes that weave through the landscape. These routes connect towns and cities with the different forest districts. At the car parking close to the highway, and at the trainstations of 'Dalfsen' and 'Ommen' bike rentals are offered. This discourages car use and encourages the use of cycling infrastructure to explore the forest. The routes are made intuitive and legible by indicating the different districts on the edge of the bikelanes. This is visible in figure x. Bike lanes that are not part of the main route will not have these indicative edges. The pioneering route is a recreative lap that connects the different forests above the 'Vecht', while the estate route is a lap that connects different forests with estates in the area below the 'Vecht'. The 'Vecht' area itself is also in possession of many recreative routes. This provides visitors and tourists with a multitude of routes to choose from, and even encourages overnight stays. This can strengthen the leisure economy in the region.

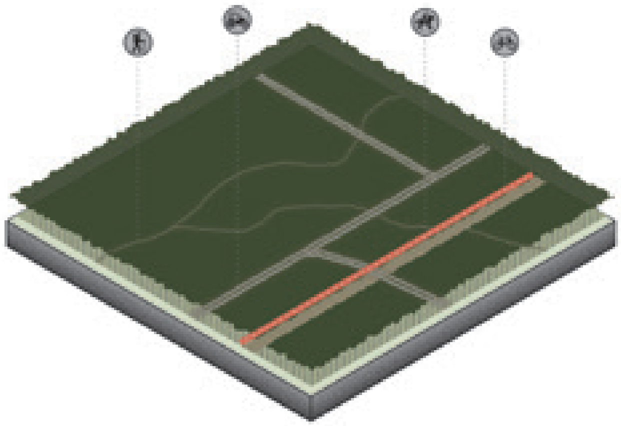


Figure 137: Recreational paths are seperated from management paths

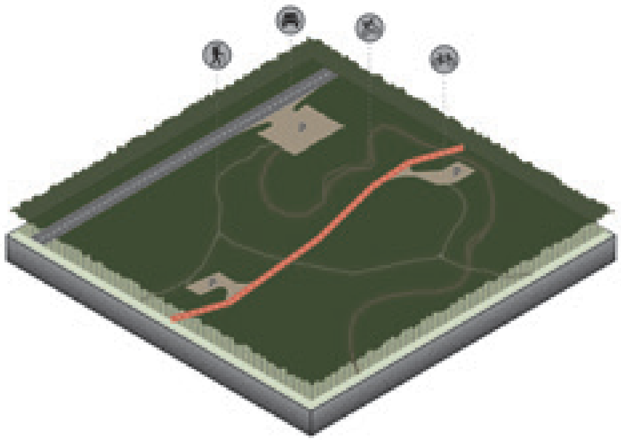


Figure 138: Along main routes there are frequent stops, (bicycle) parkings and entrances into the forest

Figure 139: Tourist destinations include 'The Center' where stories of the cultural landscape are told, and 'The Brewery' where local 'Sallands Cider' is produced and enjoyed

Tourist destinations

At two important crossings, tourist destinations can be found. The center is designed for getting to know the history and story of the landscape. The Visitor-center provides information on the history of reclamation, reflected in its outside surrounding landscape. Heathlands are designed on raised beds to show historical surface levels before reclamation, and a huge axis shows the openness of the landscape as it used to be before afforestation. This axis can be experienced best by standing on the view tower, that overlooks the whole landscape. The canal is extended into the center, and a sawmill can be visited. At the center, a car parking with bike rental is present as well, to encourage further exploration. A local cider can be enjoyed in the sun and when you are interested, the cider brewery is your next destination.

At the second crossing, the local cider brewery can be found where 'Sallands Cider' is produced. The brewery can be visited, and you can also enjoy a freshly brewed cider among the orchards.

City forest

Close to the city edge of 'Zwolle', and at the west border of Nieuwleusen, the forest will have a more park-like character. Trees are spead out so that it is possible to look further away. This also allows grass to grow, making the space slightly more multifunctional to cater to the needs of the city dweller.

Figure 140: Open park-like forest structure that can be found around the eastern city edge of Zwolle

Conclusion

With the design of a final masterplan design for the Region of Zwolle, the aim was to generate insight on how large scale afforestation can be implemented in the Dutch cultural landscape.

The final design has been more than just choosing a location for afforestation. It interplays and interacts with the fabric of the existing landscape and its uses. The forest is interwoven wtih the landscape while integrating functions such as recreation, housing development, renewable energy, water storage, quality wood production and possibilities for new industries.

The design responds to regional identities and economies, such as the delta identity and leisure economy. Cluttering elements are concealed to enhance the landscape.

The multifunctional character of the design offers the user a broad range of experiences. Different forest types, tourist destinations and routes all offer diversity and variety. The mix of landscapes, from open meadows, to orchards, urban development and flooded forests create an ever-changing landscape experience.

Public transport and bicycle rentals have been used to enhance accessibility for city dwellers, regional visitors and even tourists. The forest can therefore act as a real attraction factor for the region. Qualitative green space on doorsteps act as an invitation towards the forested landscapes. The use of rail stations give visitors accessible green space, while not having to compromise on the luxuries of the city center or even the Randstad, as Zwolle is well connected with Amsterdam.

The structure of voids guarantees flexibility for future uses, while ensuring ecological connectivity. This ability to respond and change to unpredictable futures creates sustainable design.

Chapter 6. Conclusion

Conclusion

In this chapter, the conclusion will be given by answering the research questions. After the conclusion, the process and results of the research will be discussed.

> *In which way could large scale afforestation be implemented and articulated in the diverse cultural landscape of the Region of Zwolle?*

Large scale afforestation has been implemented by using a variety of shapes, mainly by achieving critical mass. This relates to the ability of this forest to store carbon most optimal, and because of the presence of interior habitat. The size and impact of the mass-like character of forest have proposed the need to protect and exclude certain (cultural) landscapes. Especially openness and levels of scale have been influential for this exclusion, but the presence of existing nature and unique historical features have also played a role. Suitability of forest on certain soil- and water conditions in combination with the ability of forest to produce quality wood and its recreative accessibility have further narrowed the scope. Eventually, the pros and cons of different locations and strategies never came out completely unambiguously. However, after being able to combine aspects of different strategies and locations, a preference concept (model) emerged. Young wet heathland reclamations were the most suitable for large scale implementation of forest for mainly carbon storage reasons and quality wood products, while other locations mainly related to housing development, accessible recreational space and ecological connectivity. Eventually, with designing a synthesis, the implementation has been focused on intertwining and responding to the context of the landscape system on these locations.

KQ1. What components does a forest system consist of and how can it be used in landscape design?

The nature of a forest system is more than the mere sum of its parts. They are complex ecological systems, that are only partly understood. Its configurations are not inherently good or bad for species diversity. Historically, forests have been used intensively, mainly as building materials and fuel, something that can nowadays be of renewed importance. These uses were interwoven with the practices that shaped the cultural landscape. In the last century, views on how a forest system should benefit society has changed from this historically embedded productional function to a recreative and ecological perspective. This makes forest systems truly multifunctional for humans and nature, and this cannot be seen apart from each other. Forests provide a restorative environment from day-to-day routines especially because of its natural character, and recreational benefits are dependent on the multisensory experience. The management of a forest system is therefore required, in order to balance these different components.

KQ2. What factors are contributing to the implementation of forests and what can be expected in the future?

There are many factors that contribute to the implementation of forest. First of all, afforestation from a more national point of view comes with challenges such as costs, how to claim space for forest within the landscape among the other spatial claims and the aspect of time.

The location for afforestation is determined by factors such as the diversity of present landscape types with their historical characteristics and functions. Every cultural landscape has an extensive history, and large scale afforestation is therefore challenging. There are however more and less legible places, with cluttering elements or unsustainable practices such as large scaled bio-industry. These landscapes could benefit from afforestation.
Next to that, landscape conditions such as water, soil, scale and openness form an important set of arguments to determine where forests can be implemented best. Besides, forests themselves also are subject to different conditions and dictate different preferences or limitations. The openness of the landscape is an important factor to protect and semi open landscapes might be more suitable for afforestation. The implementation of forest should be done with care, as forests can block views on the landscape or elements inside it, and can hide landscape characteristics.

Functionality and possible programming of forests is dependent on factors such as national and regional current and expected trends and strengths, weaknesses, opportunities and threats to the regional landscape. These factors dictate how improvement of the landscape can be achieved and possibly combined with the task of afforestation. Accessibility, housing development, renewable energy, the delta identity, recreational pressure, 'boxing' and cluttering are all themes that can be addressed. The design and shapes of afforestation is dependent on factors such as ecological values and its configurations, as well as the human connection and experience of a forest. The totality of these factors serve as input for the formulation of parameters and models, as well as site specific masterplan design.

DQ1. Can suitable locations and strategies be derived from model formulation in order to design a regional masterplan as a design synthesis?

In total, 10 models have been formulated in the first model phase to find suitable locations and strategies within the Region of Zwolle. These models were evaluated by a set of 7 parameters. An additional three models and one preference model have been formulated in order to combine strategies that can be used as a starting point for the final design synthesis and were evaluated with 6 separate parameters. The aim of the model study was to take an explorative approach to the research, by designing a multitude of options for large scale afforestation. Evaluating these models with formulated criteria gave insight into different configurations, sizes, why locations are less or more suitable for afforestation and possible afforestation strategies. The models therefore mainly worked as a catalyst for finding regional specific strategies and arguments, who were eventually translated into a design synthesis.

The models showed that the Young wet heathland reclamation landscape type had the most suitable conditions for large scale afforestation. Different strategies that were found in the model study were the use of water infrastructure as a transportation method for quality wood products, accessibility through public transport, occasional experiences of a flooding forest as a result of water storage, ecological connectivity for a healthy forest ecosystem and a lively forest experience, protecting landscapes with better spatial quality and improving landscapes that are less attractive, concealing cluttering landscape elements and the added value for city inhabitants of forest touching city edges. These strategies have been used and articulated in the design process for the final synthesis.

DQ2. How can afforestation deliver collateral benefits to the landscape and/or society?

Through the process of designing lots of insights have been gained. This includes the model study as well as the further design process of the design synthesis. These insights concern the use, formulation and articulation of the multifunctional character of forest, to ultimately improve spatial quality and deliver a desirable new regional landscape. To conclude this design question, 4 main themes are specified:

1. The integration of functions inside forest

The final design is more than simply choosing a location, as its interplays and interacts with the fabric of the landscape and its use. Instead of seeing the forest as a separate whole, it is interwoven with the landscape. Functions such as recreation, housing development, renewable energy, water storage, quality wood production and possibilities for new industries are integrated inside the designed forest. The organization of the different functions is based on the interaction with the existing landscape patterns and uses as well as logical movement within the newly designed landscape. The design responds to regional identities and economies, like the delta identity and the regions leisure and logistics economy. This embeds the multifunctional character of a landscape inside the multifunctional character of a forest.

2. Combining functions with experiences

The multifunctional character of the design is meant to offer its users a broad range of experiences. The functions participate in the forest experience. Next to that, the design provides visitors with a multitude of experiences by offering different forest types, tourist destinations, routes and activities. From open meadows, temporary flooded forests to deep dark forests, the design offers an ever-changing experience. It responds to the existing leisure economy to attracts visitors from within and outside of the region. Tourists are able to reach the forested area with its tourist destinations easily by public transport and bike rentals.

3. The forest acts as an attraction factor

By focusing the design on connectivity and accessibility, forest can be a real attraction factor for the region and city of Zwolle. Space coupled to new train stations is reserved for housing development to catch expected growth, as well as the accommodate the current housing need. Qualitative green space is touching the city edges of Zwolle, as an invitation towards rural forested landscapes. The structure of voids offers a new view on prioritizing green space and ecological connectivity before housing development. This concept offers future inhabitants relatively matured recreative green space next to their homes, while not having to compromise on connectivity with the city center, or even the Randstad, as Zwolle is well connected with Amsterdam. This can be a boost for the regional economy.

4. Flexibility to change economics

Possible future developments regarding the boost of the regional economy, as well as other unpredictable factors regarding climate change, societal ideals and needs, disasters, prosperity and unknown factors ask for flexibility. The forest itself as well as the integrated functions within need to be able to respond and change in order to be a sustainable design. The structure of voids offers space for all sorts of interpretations, from bio industry towards more inclusive forms of livestock farming, orchards, festivals, campingsites, gradual naturalization, etc. The design leaves opportunities for industrial growth with proper logistic connections, while simultaneously hiding cluttering elements and offering large areas of qualitative natural environment.

The creation of added value of the mutual reinforcement of shapes and functions by combining them in space and time is therefore the main approach to improving spatial quality. This design research has been a succesful attempt to comply to the demands of the present, as well as being resilient towards future developments, while respecting the past.

Discussion

This thesis researched in which way large scale afforestation could be implemented and articulated in the diverse cultural landscape of the Region of Zwolle. An important aim of this research has been to articulate the design synthesis in such a way that the result can inspire people to further explore the many options large scaled design can bring to a landscape and its interactions, moving away from short term, procedural decision making, towards desirable and feasible proposals for the future.

The result of this research was never intended to be set in concrete nor was it meant to be built in real life. Its main function was to explore all kinds of possibilities, strategies, shapes, locations and interactions. The final design synthesis is a layered accumulation, articulation and formulation of all sorts of information. Its importance lies within this explorational character. The choice for an explorational research comes from the passion and love I have for forests. Its multifaceted character creates an extremely interesting layered experience, that can easily be felt, but is much more difficult to analyze, let alone designed and imagined for a long term future. I wanted to explore the things that could be designed, the things that could be imagined. It came from a friction that I experienced to see strategies that would envision the return of tree lanes or the use of waste-corner-spaces instead of envisioning the experience, desire and the embrace of the multifaceted character of a forest. My personal position as a researcher is a key instrument in the research and has to be mentioned therefore.

As much as I have tried to separate personal choices in this research, the formulation of models and parameters are heavily influenced by personal design iterations, and the process of designing cannot claim to be unbiased. If someone else had conducted the same research, different results would have been found, because different people put different foci on different aspects. This is however also due to the fact that designers often deal with 'wicked' problems, in which all the necessary information is not, or will never be, available to the problem solver, meaning that there can never be a guarantee that the 'correct' solution is found.

A few other aspects regarding this research need to be mentioned. There are a couple of topics that have not been shown in this research. Specific species compositions are not researched in detail, and therefore not mentioned either. There are many different species compositions as forest can grow anywhere. By visiting many forests in the Netherlands, and by being surrounded by people in the knowledge field, I have gained a general understanding of forest compositions and structures. However, for the scale of this research, providing correct detailed information on species (including fauna) has not been feasible.

Although I have done extensive research into gaining a basic understanding of forestry and forest management, I have chosen to make management subordinate to the design, to include only a small portion of the chapters I have written. I am well aware that, were this design to be happening in a non-research environment, management and design would have gone hand in hand from the start.

Since I am being a key instrument in the research, I have to mention that I decided not to focus this research on carbon storage per se, but on the much more multifunctional character of forests and its societal benefits. Storing carbon without reducing emissions is like emptying an ocean with a thimble. In the same way, I have not researched which species store more or less carbon.

Furthermore, I have chosen to focus on large scale afforestation. This means that you might have noticed that I have rarely mentioned other forms of forest use, such as agroforestry. I have categorized this as a form of agriculture rather than a forest system.

A few aspects are left out of this research. I have not conducted any research into fire-hazards, -prevention or -safety. There is no information provided on how the forest in this design will develop over time, and the provision of specific revenue models is lacking. These aspects are not unimportant, but due to the explorative broad nature of this research, boundaries had to be drawn.

Besides, many people to whom I have spoken during the time I worked on my thesis have asked how institutions like municipalities, provinces and local inhabitants would be involved. I have repeatedly answered that the strength of this research lies within the ability to explore freely. This means that I have also disregarded municipality or provincial borders.

The research process

During the process of this research, I have noticed a few things. The extremely large scale of this case study has guided me in several ways. The overwhelming amount of information that is present in the landscape, as well as the never-ending amount of shapes, configurations and choices, made this research very complicated. Distilling and generalizing information was absolutely necessary, but has also caused generalizations that do not have to be 'black or white'. Take for example the aspect of openness. I have designed many models, including forest implementation in open landscapes. These models were designed to fit the landscape at hand, and did not necessarily result in 'faulty' or bad design. However, these open landscapes were in general less suitable on the scale of Dutch landscapes. Eventually this resulted in the criteria that open landscapes should be preserved.

In the same way, this regional scale of design directed in many ways what would make sense in the design process and what would not. I have tried for weeks on end to find unifying stories, a common identity or even a structure within the regional landscape to ground the design in. This was however a process without result, until I realized that the regional scale had dictated me to find different kind of approaches towards designing. Integrating desire into the process of design was rooted in systematically organizing functions and shaping locations rather then telling stories or designing tangible site specific experiences. Desire can also be grounded in a more argumentative approach towards design.

There is also a discrepancy in the large amount of information that can be found on forest management as opposed to forest design. Much of the information on forest design is limited to smaller scales, that have been difficult to implement on larger scales and systems. This research often felt as if I was pioneering. I have definitely been stuck in an analysis paralysis therefore. During the model phases, i have noticed that the formulation of models could be an endless process. Choices had to be made. These choices have eventually been personally charged, as a selection of models have made it into the report to serve the path I wanted to take. The parameters are also a reflection of personal choices. This endless process is simultaneously a strength of explorative design, as well as a pitfall. Not frontloading your research causes freedom to explore, and also a lack of clear boundaries.

The power of this research lies in the attempt to be as transparent as possible, especially because the research has been grounded in abductive reasoning, where it feels like you are making a jigsaw puzzle: working with multiple pieces at once. The argumentation of this research, its parameters and the synthesis are as solid as it could be for the time being, and are always open for discussion.

The strategies and main set-up of this research can be generalized to explore options for large scale afforestation in the rest of the Netherlands to a certain extent, but place specific research should always be conducted in order to create designs.

References & Appendix.

Attenborough, D. (2020) *Een leven op onze planeet, een terugblik en een toekomstvisie,* Amsterdam: Luitingh-Sijthoff.

ANK (n.d) *Bodemvruchtbaarheid*. RIVM, available: https://www.atlasnatuurlijkkapitaal.nl/natuurlijk-kapitaal/bodemvruchtbaarheid [accessed 12 May 2021].

Bakx, M., Lenzholzer, S., Hermans, T., Krijgsman, A., Dam, N. (2021) 'Ruimtelijke kwaliteit van kringlooplandbouw : definities en perspectieven door verschillende actoren', Wageningen: Wageningen Environmental Research (Rapport / Wageningen Environmental Research, 3118). Available at: https://doi.org/10.18174/557083 [Accessed: December 2, 2021].

Bell, S., Apostol, D. (2008) *Designing Sustainable Forest Landscapes*, London and New York: Taylor & Francis Group.

Beunen, R. and Barba Lata, I. (2021) "What Makes Long-Term Perspectives Endure?: Lessons from Dutch Nature Conservation," Futures, 126(2021). doi: 10.1016/j.futures.2020.102679.

Bijhouwer, J. T. P., van Keulen T. H. M., Klaasen, I., Diepraam, W. (1977) *Het nederlandse landschap*. 2E dr. / edn. Amsterdam: Kosmos.

Boosten, M., Hamming, G., Lokin, L. (2020) *Bosuitbreiding in Nederland: hoe pakken we deze uitdaging aan?* Bosberichten #4, Probos. Available: https://www.probos.nl/bosberichten-2020 [Accessed 8. Dec 2020]

Buis, J. (1993). *Holland Houtland: Een geschiedenis van het Nederlandse bos.* Amsterdam: Prometheus.

Canon van Nederland (n.d-a) *De Dedemsvaart, turf als bron van welvaart,* available: https://www.canonvannederland.nl/nl/overijssel/salland/zwartewaterland/de-dedemsvaart- [Accessed 16 September 2022]

Canon van Nederland (n.d-b) *Bedelaarskolonie de Ommerschans, een weldadige mislukking,* available: https://www.canonvannederland.nl/nl/overijssel/overijssel/ommerschans [Accessed 16 September 2022]

Capra, F., Luisi, P. L. (2014) "Connecting the dots: Systems thinking and the state of the world," in The Systems View of Life: A Unifying Vision. Cambridge: Cambridge University Press, pp. 362–393. doi: 10.1017/CBO9780511895555.023.

Capra, F. (1997) *The Web of Life: A New Scientific Understanding of Living Systems*, New York: Anchor books.

CBS, PBL, RIVM, WUR (2018). 'Openheid landschap, 2017' (indicator 1022, versie 04 , 24 april 2018). Centraal Bureau voor de Statistiek (CBS), Den Haag; PBL Planbureau voor de Leefomgeving, Den Haag; RIVM Rijksinstituut voor Volksgezondheid en Milieu, Bilthoven; and Wageningen University and Research, Wageningen, available: https://www.clo.nl/indicatoren/nl1022-openheid-landschap. [accessed 11 May 2021]

CBS Statline (2018) *Bodemgebruik; uitgebreide gebruiksvorm, per gemeente*, Available: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/70262ned/table?fromstatweb [accessed 09 Oct 2020]

CLO (2013) *Landschapstypologie*. Retrieved from: https://www.clo.nl/indicatoren/nl1005-landschapstypologie [accessed 2 September 2022]

Cross, N. (2006) *Designerly ways of knowing.* London: Springer-Verlag London Limited. Available at: https://doi.org/10.1007/1-84628-301-9 [Accessed: September 20, 2022].

Curtin, S. (2009) "Wildlife Tourism: The Intangible, Psychological Benefits of Human-Wildlife Encounters," *Current Issues in Tourism*, 12(5-6), pp. 451–474. doi: 10.1080/13683500903042857.

Dauvellier, P. (1991) 'Ruimtelijke kwaliteit: de oorsprong en toepassing van een begrip', WLG. Nr. 3, pp. 7-14.

Deming, M. E. and Swaffield, S. R. (2011) *Landscape architecture research : inquiry, strategy, design.* Hoboken, New Jersey: John Wiley & Sons.

Den Ouden, J. (9 Februari 2022) *Revitalisering: Verrijking van het bos,* available: https://www.vbne.nl/productdetails/bijeenkomst-revitalisering-van-bos-in-de-praktijk-februari-2022 [Accessed September 5 2022]

Dieterich, M., Straaten, J. van der (2004) *Cultural landscapes and land use : the nature conservation-society interface.* Dordrecht: Kluwer Academic.

Dijkstra, H. and Lith-Kranendonk, J. van (2000) *Schaalkenmerken van het landschap in nederland : monitoring kwaliteit groene ruimte (mkgr).* Wageningen: Alterra, Research Instituut voor de Groene Ruimte (Alterra-rapport, 040). Available at: http://edepot.wur.nl/139041 [Accessed: 11 May 2021].

Drents Overijsselse Delta (n.d-a) *Gebiedsuitwerking BENOORDEN DE VECHT WBP 2022 – 2027,* available: https://www.wdodelta.nl/waterbeheerprogramma [Accessed 16 September 2022]

Drents Overijsselse Delta (n.d-b) *Gebiedsuitwerking SALLAND WBP 2022 – 2027,* available: https://www.wdodelta.nl/waterbeheerprogramma [Accessed 16 September 2022]

van Eeden, F. W. 'Het landschap', in: Album der Natuur,1862, pp.205-221 en 225-240; citaat op p.215. (van der Meulen 2009, p102)

Engbers, S. (September, 2019) Z*ienswijze Zwolle ontwerp NOVI. Overdracht College-Raad - 19 september 2019,* available: https://ibabsonline.eu/Agenda.aspx?site=Zwolle&agendaid=d515136d-71ee-4f1b-97b1-2f32d7702a8e&FoundIDs= [Accessed 9 September 2020].

Ensie (2020) *Verdozing*, available: https://www.ensie.nl/anw/verdozing [Accessed 8 September 2022]

Hack-ten Broeke, M. J. D. Rietra, R.P.J.J., Romkens, P.F.A.M., de Vries, F. (2008) *Geschikte of vruchtbare landbouwgronden in nederland en europa : een overzicht en synthese van bestaande informatie.* Wageningen: Alterra (Alterra-rapport, 1693). Available at: http://edepot.wur.nl/42722 [accessed 6 May 2021].

Haila Y. (2002) "A Conceptual Genealogy of Fragmentation Research: From Island Biogeography to Landscape Ecology," *Ecological Applications*, 12(2), pp. 321–334.

Harms, l. Kansen, M. (2018) *Fietsfeiten.* Kennisinstituut voor Mobiliteitsbeleid KiM, available: https://www.kimnet.nl/publicaties/brochures/2018/03/16/fietsfeiten [accessed 8 September 2022].

Hendrikx, J. A. (1998) *De ontginning van nederland : het ontstaan van de agrarische cultuurlandschappen in nederland.* Utrecht: Matrijs.

Hermy, M., De Blust, G., Slootmeakers, M. (2004) *Natuurbeheer*, Leuven: Davidsfonds i.s.m, Argus, Natuurpunt and IN

Hooimeijer, P., Kroon, H. J. J. and Luttik, J. (2001) *Kwaliteit in meervoud : conceptualisering en operationalisering van ruimtelijke kwaliteit voor meervoudig ruimtegebruik.* Gouda: Habiforum.

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

Kettunen M., Terry A., Tucker G., Jones A. (2007) "Guidance on the maintenance of landscape features of major importance for wild flora and fauna. Guidance on the implementation of Article 3 of the Birds Directive (79/409/EEC) and Article 10 of the Habitats Directive (92/43/EEC)". Institute for European Environmental Policy (IEEP), Brussels, 114 pp.

Klingen, S. (2017) *Twaalf boslessen, inzicht in bosbeheer,* Uden: Incido.

Klingen, S. (2020) *Zeven vragen over Bos en Klimaat*, Uden: Incido.

Koe, J. de (2021) "Recreant Snakt Naar Meer Bos," Vakblad natuur bos landschap / Stichting Vakblad Natuur Bos Landschap 18 (172): 41. Available: https://edepot.wur.nl/542398 [Accessed 2021].

Konijnendijk, C. C. (2018) *The forest and the city : the cultural landscape of urban woodland*, 2nd ed. Cham: Springer (Future City, v. 9).

Lenzholzer, S., Duchhart, I. and Koh, J. (2013) "Research through Designing' in Landscape Architecture," *Landscape and Urban Planning*, 113, pp. 120–127.

Liu, Y., Hu, M. and Zhao, B. (2019) "Audio-Visual Interactive Evaluation of the Forest Landscape Based on Eye-Tracking Experiments," *Urban Forestry & Urban Greening*, 46. doi: 10.1016/j.ufug.2019.126476.

Mander Ülo, Helming, K. and Wiggering, H. (2007) *Multifunctional land use : meeting future demands for landscape goods and services*. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg. Available at: https://link-springer-com.ezproxy.library.wur.nl/content/pdf/10.1007/978-3-540-36763-5.pdf [Accessed: September 1, 2022].

Ministerie van LNV (February, 2020) *Ambities en doelen voor Rijk en provincie voor de bossenstrategie.* Ministerie van LNV. Available: https://www. rijksoverheid.nl/documenten/kamerstukken/2020/02/03/bijlage-hoofdlijnen-ambities-en-doelen-van-de-bossenstrategie-van-rijk-en-provincies [accessed 09 Oct 2020].

Must (2020) *Atlas Regio Zwolle*, available: https://regiozwolle.info/atlas-regio-zwolle/ [accessed: November 24, 2021].

Natuurmonumenten (2021) *Achterban Natuurmonumenten groeit fors*, available: https://www.natuurmonumenten.nl/nieuws/achterban-natuurmonumenten-groeit-fors [Accessed: January 12, 2021].

Nieuwe Oogst (2020) *Plant meer bomen in de landbouw,* available: https://www.nieuweoogst.nl/nieuws/2020/12/01/plant-meer-bomen-in-de-landbouw [accessed 7 Dec. 2020].

Nijssen, M., Delforterie, W., Termaat, T. (2021) "Waar passen bossen voor klimaat en biodiversiteit?," *Vakblad natuur bos landschap / Stichting Vakblad Natuur Bos Landschap 18 (177): 20 - 23*. Available at: https://edepot.wur.nl/553914 [Accessed: Januari 11, 2022].

Pistorius, R. and Vries, S. M. G. de (2013) *Bomen aan den einder : onze bomen en bossen door de eeuwen heen.* Wageningen: Centrum Genetische Bronnen (CGN). Available: http://edepot.wur.nl/276611 [Accessed: December 8, 2020].

Regio Zwolle (2018) *Regio Zwolle stapt over eigen grenzen: de beweging naar meer slagvaardigheid*, available: https://regiozwolle.info/atlas-regio-zwolle/ [accessed 24 November 2021].

Regio Zwolle (2021-a) *De 10 meest gestelde vragen*, available: https://regiozwolle.info/10-meest-gestelde-vragen/ [accessed 24 November 2021].

Regio Zwolle (2021-b) *Project 9. Port of Zwolle: logistieke hub voor circulaire bedrijvigheid*, available: https://regiozwolle.info/project-9-port-of-zwolle-logistieke-hub-voor-circulaire-bedrijvigheid/ [accessed 24 November 2021].

Regio Zwolle (2021-c) *Ondernemersklimaat*, available: https://regiozwolle.info/ondernemen/ondernemersklimaat/ [accessed 24 November 2021].

Regio Zwolle (n.d) *Regio Zwolle laat Nederland klmaatbestendig groeien*, available: https://regiozwolle.info/wp-content/uploads/2021/04/Samenvatting-NOVI-gebied-Regio-Zwolle.pdf [accessed 12 September 2022].

Regio Zwolle Mobiel (2020) *Fietsprojecten in regio Zwolle*, available: https://www.regiozwollemobiel.nl/mobiliteitskeuzes/fiets/ [Accessed 8 September 2022].

Reichgelt, A., Kremers, J. and Oldenburger, J. (2020) "Meer hoogwaardig gebruik van Nederlands hout", *Bosberichten / Stichting Probos (5): 1 - 4.* Available: https://www.probos.nl/bosberichten-2020 [Accessed 7 December 2020].

Ricketts, T. H. (2001) "The Matrix Matters: Effective Isolation in Fragmented Landscapes," *The American naturalist*, 158(1), pp. 87–99. doi: 10.1086/320863.

Rijksoverheid (June, 2019) *Klimaatakkoord*. Den Haag. Available: https://www.klimaatakkoord.nl/documenten/publicaties/2019/06/28/klimaatakkoord [accessed 30 August 2022].

Rijksoverheid (September, 2020). *Nationale Omgevingsvisie, Duurzaam Perspectief Voor Onze Leefomgeving*. Den Haag: Ministerie van Binnenlandse zaken en Koninkrijksrelaties. Available: https://denationaleomgevingsvisie.nl/default.aspx [Accessed 23 September 2020].

RIVM (n.d) *Veehouderij in Nederland*, available: https://www.rivm.nl/ggd-richtlijn-mmk-veehouderij/veehouderij-nederland [Accessed 8 September 2022].

van Rooijen, A., Jansen, G., Postma, R., Edith Camerik, E., Wijnja, L. (2018) *Welkom in de Demo Delta van regio Zwolle*, available: https://docplayer.nl/199320088-Welkom-in-de-demo-delta-van-regio-zwolle-meerwaarde-maken-we-samen.html [accessed 26 November 2021].

RUIMTEVOLK (2021-a) *Toekomstbeeld wonen Regio Zwolle*, available: https://www.ruimtevolk.nl/projecten/toekomstbeeld-wonen-regio-zwolle/ [accessed 24 November 2021].

RUIMTEVOLK (2021-b) *Bestemming Verrijkt: ontwerpend onderzoek mobiliteitshubs Overijssel*, available: https://www.ruimtevolk.nl/projecten/ontwerpend-onderzoek-mobiliteitshubs-overijssel/ [accessed 24 November 2021].

Schmidt, M. Jochheim, H., Kersebaum, H. C., Lischeid, G., Nendel, C. (2017) "Gradients of microclimate, carbon and nitrogen in transition zones of fragmented landscapes–a review." *Agricultural and Forest Meteorology,* 232 (2017), pp. 659-671.

De Schrijver, A. Devlaeminck, R., Mertens, J., Wuyts, K., Hermy, M., Verheyen, K. (2007) "On the Importance of Incorporating Forest Edge Deposition for Evaluating Exceedance of Critical Pollutant Loads," *Applied Vegetation Science*, 10(2), pp. 293–298.

Selman, P. (2009) "Planning for Landscape Multifunctionality," *Sustainability : Science, Practice, & Policy*, 5(2), pp. 45–45.

Smit, A., Beek, C. van, Hoogland, T. (2007) *Risicogebieden voor organische stof : ontwerp van een methodologie voor het aanwijzen van 'risk areas' t.b.v. de eu kaderrichtlijn bodem.* Wageningen: Alterra (Alterra-rapport, 1582). Available: https://edepot.wur.nl/23680 [accessed 12 May 2021].

Staatsbosbeheer (2020) *De natuur is goed voor ons - maar andersom? Buiten Bijtanken.* Available: https://www.nederlandscultuurlandschap.nl/interview-jaap-dirkmaat-in-staatsbosbeheer-magazine/ [accessed 15 Oct 2020].

Teeuwen, S., Reichgelt, A. and Oldenburger, J. (2020) *FACTSHEETS Kostenindicatie aanleg nieuw bos en landschapselementen, Rekenhulpmiddel voor het ramen van de kosten voor aanplant van verschillende beplantingstypen*, Stichting Probos, available: https://www.vbne.nl/klimaatslimbosennatuurbeheer/uploads/kostenindicatie-factsheets.7a1e57.pdf [accessed 23 Nov. 2020]

Thompson, I. H. (2012) "Ten Tenets and Six Questions for Landscape Urbanism," *Landscape Research*, 37(1), pp. 7–26. doi: 10.1080/01426397.2011.632081.

Vakblad natuur bos landschap (2021) "Het Landschappelijk Effect Van Meer Bos" *Vakblad natuur bos landschap / Stichting Vakblad Natuur Bos Landschap 18 (172): 18.* Available: https://edepot.wur.nl/542390 [accessed 11 May 2021]

Gaast, J. W. J. van der, & Massop, H. T. L. (2007) *Reconstructie van de historische hydrologie : pilotstudie voor een stroom in hoog nederland.* Wageningen: Alterra (Alterra-rapport, 1466). Available: http://edepot.wur.nl/41116 [Accessed 15 September 2022].

Van der Meulen, D. (2009) *Het bedwongen bos. Nederlanders & hun natuur*. Amsterdam: SUN.

Vandekerkhove, K. (2020) 'Coldspots' in bossen: belangrijke 'hotspots' voor bosgebonden soorten', *Bosrevue 86a, 1-11.* Available: https://bosrevue.bosplus.be/bosrevue/editie/2020/06/12/Coldspots-in-bossen-belangrijke-hotspots-voor-bosgebonden-soorten [accessed 17 Nov. 2020].

Van Der Wulp, N. Y. (2009) "Verrommeling Van Het Landschap: De Rol Van Storende Elementen," *Landschap : tijdschrift voor landschapsecologie en milieukunde 26 (3): 132 - 144.* Available at: https://edepot.wur.nl/190456 [Accessed 15 December 2021].

VBNE (2022) *Gereedschapskist klimaatslim Bos- en Natuurbeheer*, available: https://www.vbne.nl/klimaatslimbosennatuurbeheer/maatregelen/bosaanleg [accessed 30 August 2022].

Vereniging de Ommerschans (n.d) *De bedelaarskolonie*, available: https://ommerschans.nl/ [Accessed 16 September 2022].

Verkerk, P. J., Costanza, R., Hetemäki L., Kubiszewski, I., Leskinen, P., Nabuurs, G. J., Potocnik, J., Palahí M. (2020). 'Climate-smart forestry: the missing link'. *Forest Policy and Economics*, 115.

Wijdeveen, S., Delforterie, W., Boosten, M., Thomassen, E., & Nyssen, B. (2021) "Revitalisering Nederlandse Bossen," *Vakblad natuur bos landschap / Stichting Vakblad Natuur Bos Landschap 18 (172): 28 - 32.* Available: https://edepot.wur.nl/542394 [accessed 11 May 2021].

Wikipedia (2022) *Nieuwleusen*, available: https://nl.wikipedia.org/wiki/Nieuwleusen [Accessed 16 September 2022].

WUR (n.d) *Dossier Nitrogen*, available: https://www.wur.nl/en/Dossiers/file/Nitrogen.htm# [Accessed 8 September 2022].

Zwolle Nieuws (June 11 2022) *Landbouw ten noorden van Zwolle kan het wel vergeten met de nieuwe stikstofplannen*, available: https://zwolle.nieuws.nl/nieuws/42517/landbouw-ten-noorden-van-zwolle-kan-het-wel-vergeten-met-de-nieuwe-stikstofplannen/ [Accessed September 8 2022].

RIVMdata (May 2022) *Draagkracht-zettingsgevoeligheid,* available: https://data.rivm.nl/meta/srv/api/records/f65776db-a457-416e-b2f7-b7de4a85fb34 [Accessed 20 August 2022].

Figures

All figures without references have been made by the author. All other referenced figures are listed below:

Armada mobility (n.d) *Hanzelijn,* available: https://www.armadamobility.nl/nl/projecten/projecten-railinfra/hanzelijn/ [Accessed 13 September 2022].

Canon van Nederland (n.d) *De Mastenbroeker polder, grootschalige ontginning*, available: https://www.canonvannederland.nl/nl/overijssel/overijssel/mastenbroek [Accessed 13 September 2022].

Canon van Nederland (n.d-a) *De Dedemsvaart, turf als bron van welvaart*, available: https://www.canonvannederland.nl/nl/overijssel/salland/zwartewaterland/de-dedemsvaart- [Accessed 16 September 2022].

CLO (2013) *Landschapstypologie*, available: https://www.clo.nl/indicatoren/nl1005-landschapstypologie [accessed 2 September 2022].

Coronelli, V. M. (1692) *Tran-siselana*, available: https://utrechtuniversity.on.worldcat.org/oclc/980451198 [Accessed 15 September 2022].

De Stadserven (n.d) *Kampereiland historie*, available: https://hetkampereiland.nl/ontdek-het-kampereiland/historie [Accessed 13 September 2022].

Han, Q., Keeffe, G. and Cullen, S. (2021) "Climate Connectivity of European Forests for Species Range Shifts," *Forests*, 12(7), pp. 940–940. doi: 10.3390/f12070940.

Horenbout, G., Bening, A. and Bening, S. (2022) *November, Brevarium Grimani, fol. 12v*, available: https://commons.wikimedia.org/wiki/File:Breviarium_Grimani_-_November.jpg [accessed on September 6 2022].

Janssonius, J. (1638) *Ditio Trans-Isulana*, available: https://utrechtuniversity.on.worldcat.org/oclc/980450187 [Accessed 15 September 2022].

Knol, W.C., H. Kramer & H. Gijsbertse. 2004. *Historisch Grondgebruik Nederland; een landelijke reconstructie van het grondgebruik rond 1900.* Wageningen, Alterra, Alterra-rapport 573. 91 blz. 74 fig.;16 tab.; 11 ref.

Leven in de Liemers (n.d) *Het pannerdens kanaal*, available: https://levenindeliemers.nl/verhalen/41-het-pannerdens-kanaal [Accessed 13 September 2022].

Lichtenberg, L. (n. d) *De IJsselkogge: de Hanze en Kampen*. Isgeschiedenis, available: https://isgeschiedenis.nl/nieuws/de-ijsselkogge-de-hanze-en-kampen [Accessed 13 September 2022].

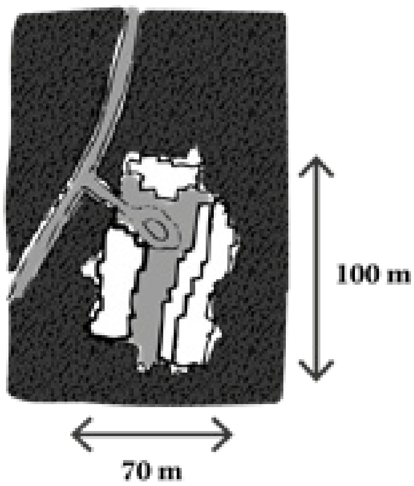
Maatschappij van Weldadigheid (1842) *Kaart voorstellende de ligging der eigendommen van de Maatschappij van weldadigheid*, available: https://utrechtuniversity.on.worldcat.org/oclc/980444954 [Accessed 15 September 2022].

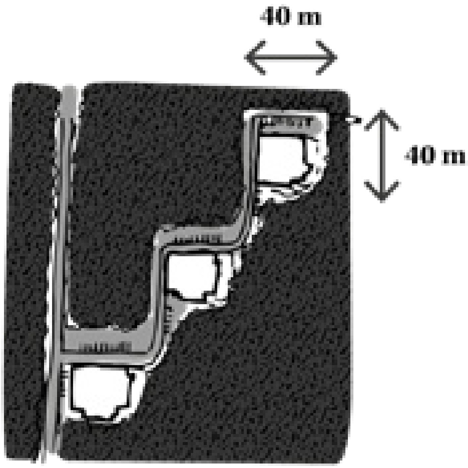
Ministerie van LNV (2020) *Bos voor de toekomst, Uitwerking ambities en doelen landelijke Bossenstrategie en beleidsagenda 2030*, Rijksoverheid, available: https://www.rijksoverheid.nl/ministeries/ministerie-van-landbouw-natuur-en-voedselkwaliteit/documenten/kamerstukken/2020/11/18/uitwerking-ambities-en-doelen-landelijke-bossenstrategie-en-beleidsagenda-2030 [Accessed 23 Nov. 2020].

van der Linde, M. (n.d) *Fedde Zijlstra: 'Het Westerhuizingerveld is in de jaren dertig ontgonnen',* MijnStadMijnDorp, available: https://mijnstadmijndorp.nl/app/vooruitboeren/verhalen/fedde-zijlstra-het-westerhuizingerveld-is-in-de-jaren-dertig-ontgonnen [Accessed 13 September 2022].

VBW Noord Veluwe (n.d) *Nazomerexcursie langs de IJsseluiterwaarden,* available*:* https://www.vbwnoordveluwe.nl/events/nazomerexcursie-langs-de-ijsseluiterwaarden-2/[Accessed 13 September 2022].

Appendix 1





100m x 70m = 7000m2
One building block has 20 adresses, 2 floors
20-80 inhabitants

40m x 40m = 1600 m2
One high-rise building has 40 adresses, 9 floors
40-80 inhabitants

Two types of residential buildings inside forest, both on the same scale (located in Doorwerth). Both types can accomodate the same maximum amount of people, but the surface area per type differs immensly. Medium rise buildings are therefore the preferred building type inside forests. A smaller amount of apartment space is compensated by qualitative green space.

Appendix 2