FLOWSCAPES:

Harvest Studio

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Design region:

PARKSTAD LIMBURG

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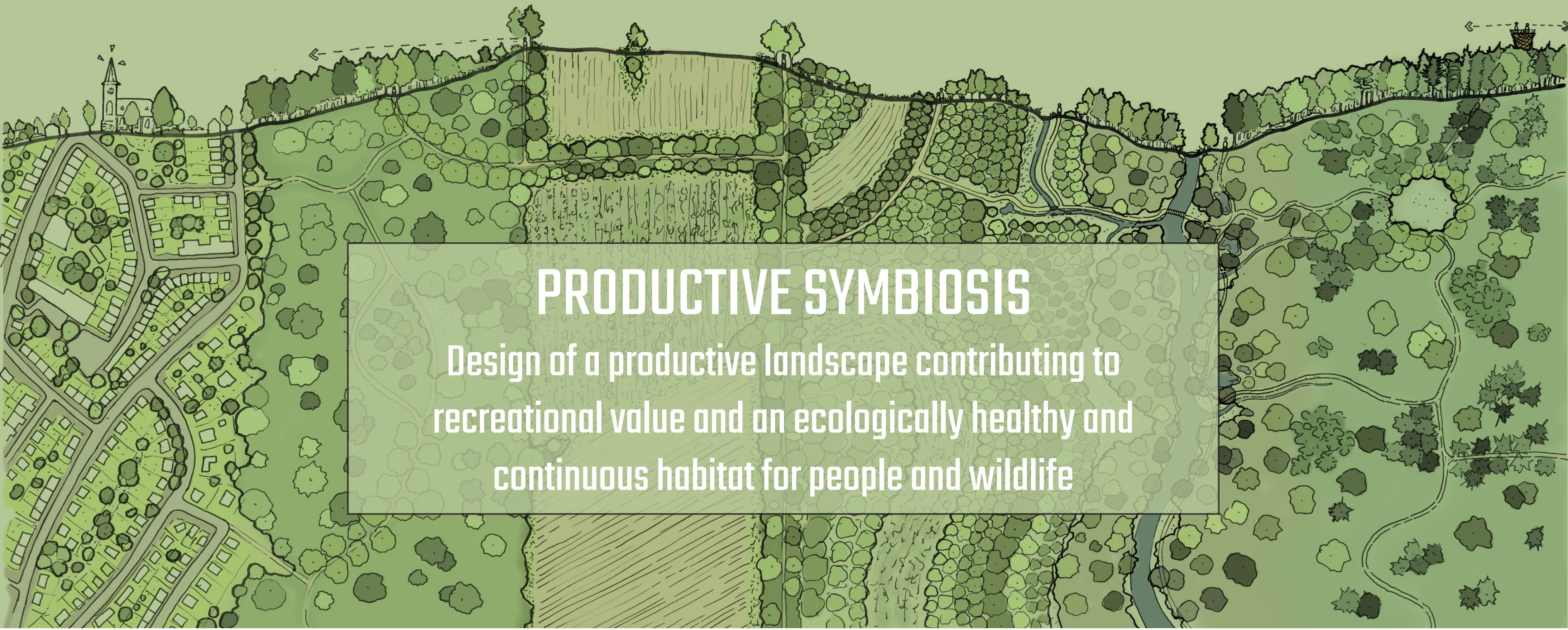


PRODUCTIVE SYMBIOSIS

Design of a productive landscape contributing to recreational value and an ecologically healthy and continuous habitat for people and wildlife

ABSTRACT

In this thesis project, a landscape architectural framework is made for a selected site in the Parkstad Limburg region. The design proposal for this region serves as a possible outcome of this framework, based on design principles and generic objectives.

Parkstad Limburg used to be a wealthy region due to the thriving mining industry. The closing of these mines meant economic decline and the neglect of this region. To counter these consequences, many initiatives focus on the recovery and improvement of the landscapes' qualities. Nature development for recreational use along the brooks, for instance, has started to greenify the landscape.

The agricultural lands, however, are dealing with more challenges than the landscapes' attractiveness. Soil compaction, erosion, and a poor carbon cycle are under discussion. The large scale agricultural practice also influenced the ecological value of these lands. Small landscape elements have been removed, resulting in shrinking biodiversity.

New agricultural models are developing, such as agroforestry, food forests, and carbon farming. Their currently small scale implementations do not achieve great impact. Agroecology should be practiced on a larger scale to realize its potential benefits for food production, recreational experience, and contribution to biodiversity.

The basic design objective is to increase the coverage of the agricultural land with woody plants, such as trees. Especially along the slopes, these reforestations can add value, due to their ability to stabilize the soil and reduce the water run-off. Besides forest coverage, open landscapes are equally important to biodiversity. These open landscapes provide wide views. The allocation of the forested plots should consider these existing valuable views.

For the design of the high and flat plateaus, agroforestry systems are applied, to preserve these views and profit from the flat surface. On these lands, conventional crops can be cultivated. The additions of production forest typologies are placed along the slopes. Food forests are shaped in strips, following the height-lines. This strip-cultivation ensures an easy harvest method. There are also less rationally organized forests which are for wood production. Wood production which supports the development of a sustainable wood industry for high-quality use. Besides tools or furniture, a revolution in wooden architecture is at hand.

The landscape architectural framework aims for the synergy of the ecological processes and the productivity of the landscape. Separation of these systems have caused problems for one another, but working together could be beneficial for both. Combining multifunctional use with recreational experiences increases awareness and support for this shift in our cultivated landscapes. The result is a future proof, ecologically and economically healthy landscape.

Keywords: *ecology, agroecology, biodiversity, agriculture, forestry, land-use, nature-inclusive*

Content

1. INTRODUCTION

Our world is too small to reserve any area purely for production. There should always be synerges with ecological program; we have to share the landscape with other species.

This thesis is part of the Graduation Studio 'Harvest', hosted by Frits van Loon and Nico Tillie. The design region for this thesis is Parkstad Limburg, a large area in the province of South-Limburg, consisting of seven municipalities. In all graduation projects, the student searches for opportunities to 'harvest' from this site, in the widest sense of the word. My major focus is ecological value, combined with recreation and production.

1.1 ECOLOGY

What always fascinated me was the richness of nature and the balanced ecosystems in which nature exists. However, these ecosystems and their biodiversity are harmed by human activities. Therefore I strive for nature inclusive design and development in urban, rural, and natural environments to protect and restore the natural balance.

Designing for ecological developments and to support biodiversity is the main driver in my designs up to now. Whilst designing new experiences for humans, I consider other species equal and in these times maybe even more important than us. We tend to separate ourselves from the natural systems and disconnect to all these other species and their interdependence. We need to rediscover that we are part of the ecology and can have both positive and negative effects on it. In previous design assignments I mostly worked on urban regions, which is something I prefer; reintroducing a 'natural' landscape within the urban environment. The Parkstad Limburg region, however, has to deal with shrinkage instead of densification. This expands my knowledge and design experience. The rural areas still need an ecological impulse and the poor connection to the urban parts of this region can also contribute to the overall ecological value. Besides that, the distinct topography and culture-historical background give a lot of exciting input for the design assignment.

1.2 MANMADE NATURE

Our homes protect us from the natural world; the elements, but also other organisms. Flaws in our previous construction methods, however, created room for insects, birds and small mammals to inhabit our built structures (see image 1). But in our current building traditions (see image 2), we forced nature out by the development of climate control and the resulting sealed building envelope. Our cities, or urban landscapes, are mostly considered to be the human habitat, but I

Image 1 Overgrown architecture (overgrown architecture n.d.)

Image 2 Contemporary architecture, Graaf Floriskade, Delft

consider it to be just a different landscape with a huge potential for ecological development.

Our ancient farmlands were characterized by hedges (see image 3), dividing the landscape into plots where crops could be grown. Not all land was used for farming which resulted in landscape variety, which had great value for ecology. But just as the flaws in our architectural designs, there was room for ecological development; we accidentally invited nature into our cultivated world and lived somewhat symbiotically with other species. But the current large scale monocultures do not meet the wishes of ecology (see image 4). To provide biodiversity, diversity, and a certain stability in the landscape is of great importance.

The main flaw in our flawless contemporary architecture and agriculture is that we only thought of our own wellbeïng and neglected the other inhabitants of our world. We should take our responsibility and consciously practice nature inclusive design in both the built and the unbuilt space (see images 5 and 6) because this does not happen by accident anymore. The challenge is not to be found in megalomaniacal structures or highly productive landscapes, but in the detailed elaboration on symbiotic design for all organisms. Only then, a healthy continuous chain of habitats can be established. Runhaar (2017, p.343) talks about a 'shock event', but hopefully we will not need the extinction of species to favor nature-inclusive design. If we act now, we might prevent such loss.

Image 5 Nature inclusive architecture (Fluxlandscape, n.d.)

Image 3 Orchard & hedgerow, Winthagerweg, municipality Voerendaal

Image 4 Groeneweg, Bingelrade, municipality Beekdaelen

Image 6 Nature inclusive Agriculture, Ketelbroek, (Wildschut, 2019)

1.3 GLOBAL WARMING

The Paris agreement of 2015 aims for a limited increase of temperatures to “well below” 2 degrees celsius. Sectors contributing heavily to this rise in temperature are agriculture, forestry, and other land-uses; they are responsible for about 25 percent of net anthropogenic greenhouse gas emissions (Roe, Streck, Obersteiner, et al., 2019, p.1). This means that these are also the sectors that have a high potential in contributing to the mitigation of these emissions.

The Netherlands aims for a reduction in carbon dioxide emissions in 2030 of 49% compared to 1990. With the agricultural sector contributing for 14% (26,4Mton) to the total Dutch emission, there seems a lot to improve (Selin Norén, Cuperus, De Vries, et al., 2019, p.3). Besides decreasing the meat consumption and reducing food waste, the addition of forested land seems to have a great impact on the reduction of carbon dioxide levels due to the storage of carbon in woody plants. (Roe, Streck, Obersteiner, et al., 2019)

1.4 SUSTAINABLE PRODUCTION

In our society, there is a transition going on towards a revaluation of locally produced products. In our world economy, it is no longer usual to consume or use products from our own soil; almost every product contains items produced or harvested abroad.

We also used to build with local materials like clay and marl, but nowadays the general construction material in The Netherlands is concrete. Not only do we need to excavate and import the components for concrete, but the production process also emits lots of carbon dioxide. Considering the huge housing demand in the Netherlands there should be thought of a more sustainable building method. Wooden buildings made of CLT (Cross Laminated Timber) are on the rise by locking carbon dioxide instead of emitting it. The next step is to make sure this wood is produced nearby instead of imported from far away.

For several years, The Netherlands was listed as the second-largest exporting country of agricultural goods in the world (Jukema, Ramaekers & Berkhout, 2020). Many goods are exported to our neighboring countries, but there is also a lot of import and export which need to travel further. This is, of course, good for our economy, but other factors become increasingly important due to a changing public opinion. The variety of crops grown in our own country is poor when you compare it to the abundancy of choices offered in our supermarkets, but as long as the international business thrives, we will exchange goods with our trading partners and complement one another. However, when we take a look at the carbon footprint of all this food traffic, we should conclude that minimizing the import and export might be a wise decision.

1.5 PARKSTAD LIMBURG

The design location of this graduation project is the Parkstad Limburg region which is a part of the Dutch province South-Limburg. Parkstad Limburg consists of seven municipalities in which the municipalities of Brunssum, Heerlen, Landgraaf, and Kerkrade comprise the urban center, while Simpelveld, Voerendaal, and Beekdaelen consist of farmlands and smaller villages folding around the north and south edge. The urban and rural areas each have their characteristics; qualities and challenges. The Limburg landscape has a rich history embedded in its landscape.

Parkstad used to be part of a coal mining region (see figure 1) in which cities grew rapidly (see figure 2) and economies were thriving. But when these mines were closed in 1968, this backbone of the region was removed. This enormous industry brought welfare to the region and took care of

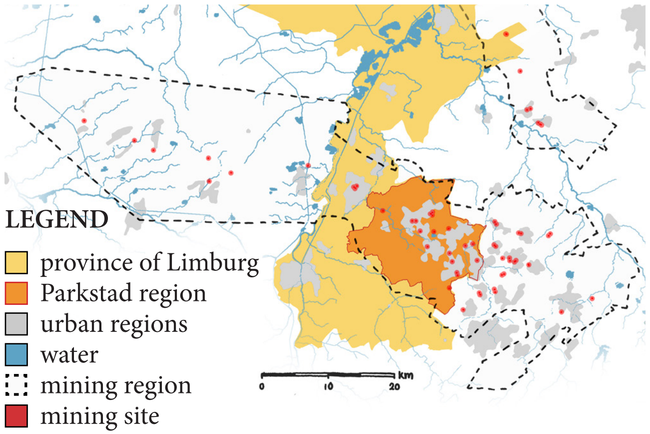


Figure 1 Mining region Limburg

70.000 jobs. When the natural gas extraction in Groningen became the main energy source in the Netherlands, these jobs dissapeared and Parkstad Limburg fell into decline.

Mainly young people left the region which started the shrinkage of Parkstads population. According to predictions made by the CBS and PBL (De Jong & Van Duin, 2010), the Parkstad population is projected to decline with at least 15% from 2009 to 2040. Due to the economic decline since the closing of the mines, the housing market collapsed, resulting in poor housing conditions and abandoned buildings. After the mines closed,

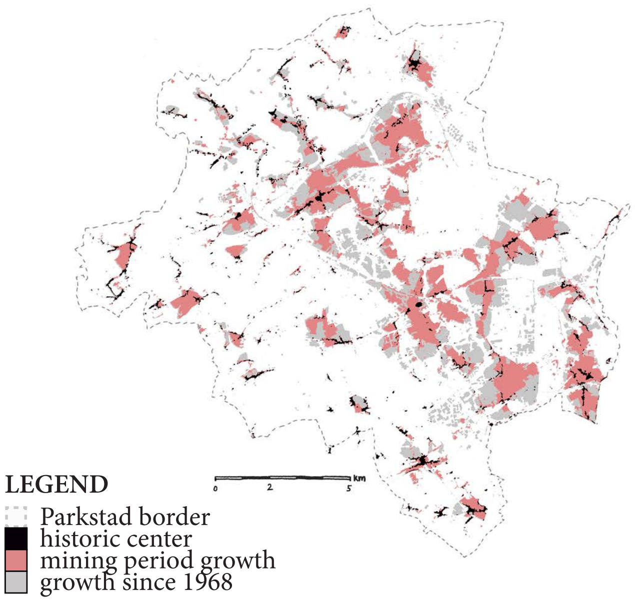


Figure 2 Urban expansion South-Limburg, Parkstad, adapted from Bertholet, 2019

the region wanted to go 'from black to green' (see image 7) and the name Parkstad (Parkcity) builds upon that idea (Bertholet, 2019). By acting as one, this region wants to compete with the surrounding larger municipalities.

1.6 PROBLEM STATEMENT

The challenges posed in previous paragraphs are the base for the problem statements:

- The rural area is under pressure; soil quality and drought, due to climate change, affect the arable lands and biodiversity is decreasing because there is no room made for ecology.

- A huge amount of crops is imported and exported through Europe and the rest of the world, which is bad for our ecological footprint.

Image 7 Green character of Parkstad

- Conventional building methods demand materials that have to come a long way and emit environmentally harmful substances due to this transportation and for instance in the process of making concrete.

- The Parkstad Limburg region is in need of economical progress due to the absence of a clear economic driver.

- Recreational value should increase in order to compete with surrounding regions

1.7 RESEARCH QUESTION

To find solutions to the problems stated in the previous paragraph, research questions are formulated:

Primary research Question:

- What is a landscape architectural framework for the Parkstad region which provides conditions for a multi-layer landscape in which the production of agricultural goods, recreation, and ecological development work together and support the growth of biodiversity?

Secondary research Questions:

- What landscape architectural frameworks and approaches are useful for the development of the Parkstad region?

- What do the current ecological systems and habitats look like in Parkstad?

- What are the biodiversity challenges in the rural area of Parkstad?

- How does Forestry contribute to the decrease of climate change and the increase in biodiversity?

- How can recreational goals be combined with agricultural developments?

- How can we use ecological structures to increase the interconnection between urban ecologies and ecological cores in the agricultural and natural areas?

- How can policy adjustments contribute to sustainable and ecologically friendly agriculture?

- How can agricultural developments support social, economic, and educational developments?

1.8 THESIS OVERVIEW

This thesis report started out with personal fascinations and the introduction of existing challenges in the Parkstad region. In chapters three to six, problems are observed on several scales, the design region is analyzed, literature research is done, case-studies are analyzed and research by design developed into a large scale vision and detailed designs on smaller scales. The following chapter will dive into the method used to get to the design.

2. RESEARCH METHOD

This chapter dives into the theoretical background and framework which supports the spatial design.

2.1 METHODOLOGY STRUCTURE

The scheme (see figure 3) shows the method used to build this graduation project. In the previous chapter, the background is given from which my graduation started. This resulted in a clear aim in the first analysis and together this formed the problem statements and research questions. These are moving interdependent targets that need to be continually adjusted.

To provide an answer to the posed questions, scientific research and example projects provide input for the analysis and design assignment. The extracted design principles lead to a regional landscape framework and several spatial designs. The design is an answer to the research questions, hopefully solving the posed problems. During the design process, design decisions will inevitably influence the analysis and the theoretical framework, because all stages within this method are constantly growing.

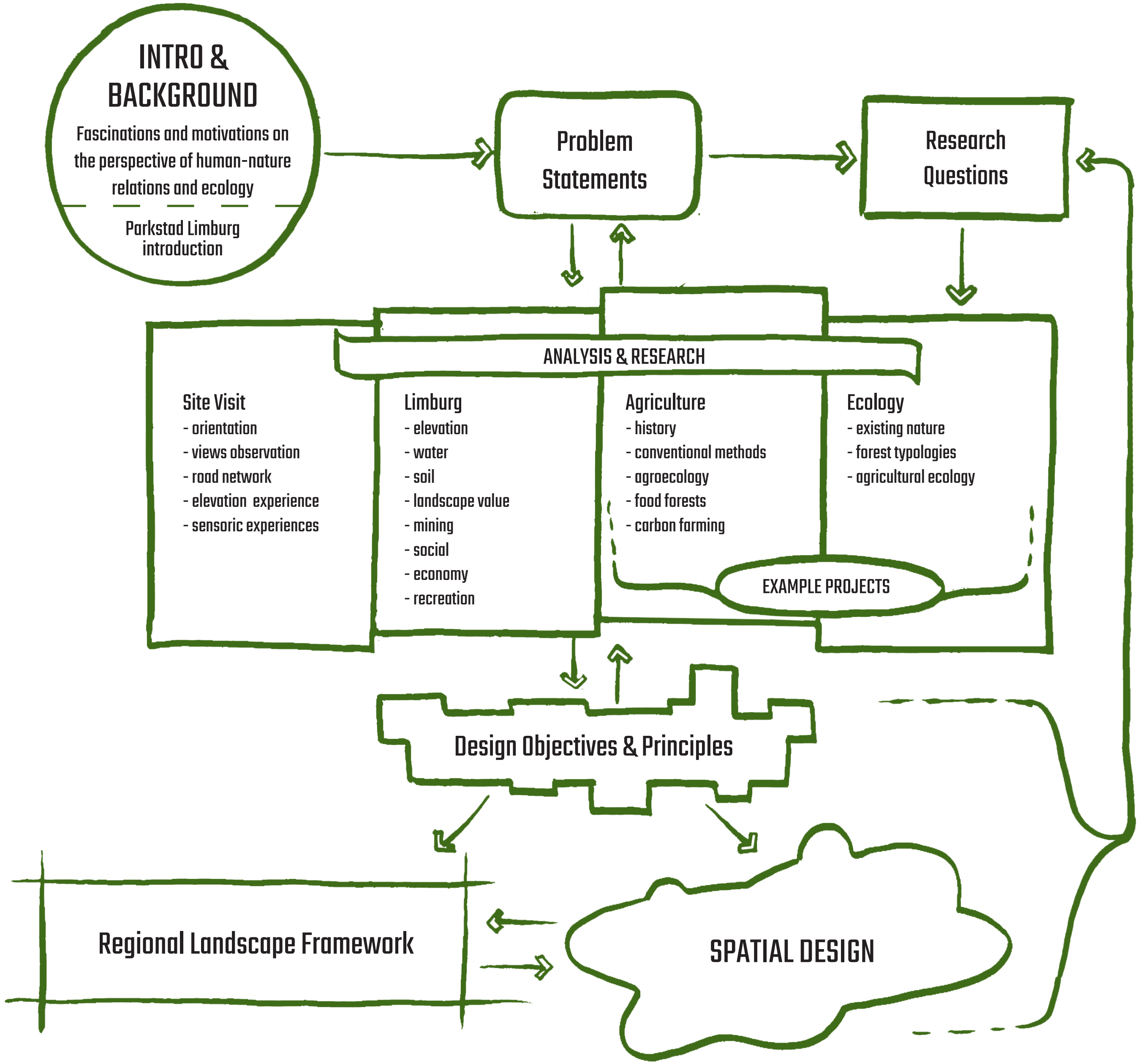


Figure 3 Schematic methodology structure

2.2 RELEVANT DESIGN APPROACHES

For the regional vision, a landscape architectural framework is required and design approaches are needed to support and guide the preferred gradual developments over time. In order to construct this framework, different frameworks and approaches are studied.

2.2.1 Layer approach

The layer approach, described by Dirk Harmen Frieling (Roggema, 2012, p.63-64), considers three layers in spatial planning with a difference in time frame or rhythm; underground, networks, and the occupation layer. Water and soil determine the way in which the underground determines the possibilities of land-use and which spatial elements can be applied. It takes centuries for this first layer to change significantly. A faster rhythm can be found in the network layer. Ecological, water, energy, and traffic networks take about 100 years to evolve into a new shape. The third layer has a varying time frame of 20 to 50 years. The occupation layer develops over generations and consists of heritage, agriculture, economy, recreation, and the way people live and behave.

Giving attention to these different time frames in spatial planning is important in order to preserve their individual value. The agricultural practice, for instance, changed a lot over the past centuries, and together with new infrastructures, the rhythm of the first layer was affected too. In such cases, layers are separated instead of placed on top of each other. It is crucial that all three rhythms do not exclude each other; they co-exist. One of the searches in this report is how to include the ecological layer in layers that traditionally have a faster rhythm; like agriculture and recreational use (infrastructure).

2.2.2 Casco approach (framework model)

'Plan stork' or 'plan ooievaar' (in Dutch) in 1986 introduced the casco landscape approach (framework model in English) which was first of all developed to protect 'weak' natural functions against more dynamic economic functions (Stroeken, 1994, p.4). The difference in dynamics makes natural processes and historical continuity vulnerable for degradation due to rapid changes in for instance infrastructure. Conflicting functions can be separated by zoning based on abiotic factors and functional requirements. But besides that, functions often have to be intertwined and flexible. When also adding the wish for historic continuity, a tension arises which prevents change.

There is a need for innovation in the landscape and the casco approach makes this possible by showing (ecological) coherences and incorporating both landscape structures and infrastructure in integral spatial planning which sets out the 'casco framework'. This framework provides stability where this is needed and leaves room for uncertainties and unpredictable changes. Where possible, functions with low or slow dynamics are separated from high and fast dynamics so they will not be able to frustrate each other. (Stroeken, 1994)

According to Stroeken (1994), such separation is applied to our ecological structures. The allocation of nature is based mainly on hydrology, which means that low and wet conditions are often isolated and given to nature. This results in the absence of nature on dryer grounds and is bad for landscape diversity. Such a process is also described by ARK (2014, p.7) where the agricultural fields in Kempen-Broek under more wet conditions were exchanged with more dry nature areas. The reason for this was the demand for higher groundwater levels in natural areas and the preferred lower water levels in agricultural fields. Besides that, both the agricultural domain and the nature parks would be expanded which meant 'efficiency'. In such cases, however, it should be taken into consideration that dry nature should also find its place, even if this nature is less biodiverse. Every biotope is different, so it is not only important to look at biodiversity, but also what value does a biotope add. And sometimes a pattern of small bushes has a higher ecological value than a large nature park surrounded by an ecological desert.

Stroeken (1994) writes about the ever-changing demands within the agriculture sector and therefore places the agricultural activity under 'fast dynamics'. But maybe by looking at agriculture in such a way, the agricultural practice lost its connection to the slow natural dynamics within the landscape. In this report, an attempt is made to bring nature and agriculture together despite their different dynamics. By doing so, nature is no longer restricted to the brook valleys and enriches a larger surface of the landscape.

2.2.3 Swarm planning

Swarm planning was introduced by Rob Roggema and is to some degree an extension of the layer approach. Roggema (2012) describes five layers in spatial planning; networks, focal points, unplanned space, natural resources, and emerging occupation patterns. Similar to the layer approach, these layers have a certain 'time-rhythm' in which they develop over time, although the occupation layer is given a time frame of about only five years instead of twenty to fifty. Besides the network layer, the natural resources layer is similar to the underground layer and the emerging occupation patterns layer is comparable to the occupation layer.

The focal points (or nodes) and unplanned space are completely new when comparing them to the layer approach. Focal points, in this theory, are identified strategic places in a design based on the analysis of the networks layer. The time frame of focal points is set for about 20 years. The unplanned space layer can change every year and provides self-organization, emergence, and adaptive capacity. By implementing this layer, within the basic principles of design, flexibility, diversity, and resilience in urban and rural systems are increased. This added capacity is introduced in order to establish a system that performs natural swarm behavior, making it more resilient, responsive to uncertainties, and able to deal with the complexity of spatial design (Roggema, 2014, p.131). Swarm planning therefore also adds on to the casco approach. However, this theory considers ongoing changes and a continuous search for a 'fitness landscape'; a landscape in the most optimal stable state. In swarm planning strategies, the large scale and slow time frame of natural processes and climatic changes are linked with small scale and fast-changing spatial elements by adding a flexible layer in between. (Roggema, 2012)

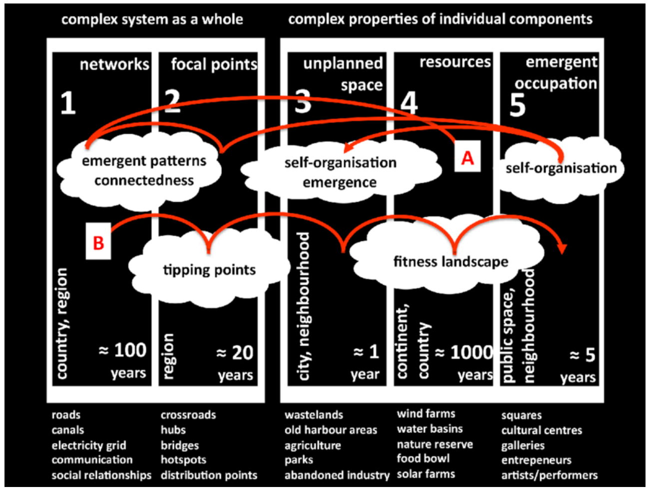


Figure 4 Swarm planning model (Roggema, 2012, p.308)

Roggema (2012) describes two ways to implement swarm planning. The first one (B in figure 4) starts from strategic interventions in the network and the nodes. It identifies the unplanned space that needs to be preserved in order to create adaptive capacity. From there, the occupation layer and space for resources can be allocated. In this report, there will be more similarity to the second option (A in figure 4) which is comparable to the layer approach. This way of implementation builds upon the underground and adds the other layers on top of that; networks, focal points, occupation layer and leaves room for unplanned or flexible space.

Starting from natural processes traditionally conflicts with a flexible agricultural practice. But by implementing a diversity of compositions and structures within the agricultural system, this becomes easier despite the slower rhythm of ecology. Moreover the plan lined out in this report is not a rigid blueprint. It is just one possible elaboration on what could become of the landscape. The design principles guide towards a new landscape typology. This development is dependent on a process which takes decades or even centuries. It is up to the government and regional actors to trigger the transition.

2.2.4 S.U.L.P.

Synergetic Urban Landscape Planning is described by Tillie (2018) in his research on SULP implementation in Rotterdam, aiming for a livable low-carbon city. This approach starts with analyzing systems, flows, data, and mapping to provide the landscape's performance. Actors and facilitators are important to gain insight into stakeholder involvement and the need for certain governance. With the stakeholder's agenda, potential synergies can be explored and challenges and opportunities can be identified. Another building block in this theory is the exploration of alternative futures in order to remain flexible for uncertainties. All these elements together merge into a long term vision and medium-term actions and projects, which stimulate the development of the vision. SULP is an ongoing practice that offers the opportunity to improve due to regular monitoring and adjustments.

For this thesis report, stakeholders have been included, such as farmers (both traditional and experimental), nature organizations, and the Parkstad organization. The different agendas of these parties, together with extensive landscape analysis provided the base for a synergetic approach. The design shows a perspective of what the landscape can be, whereas the report shows what actions are needed to make synergies between stakeholder agendas possible.

2.3 SITE VISIT

Extensive site visits (see figure 5) also served as a method to get familiar with the region as a whole as well as the details of certain areas. The spatial qualities could not be captured by studying maps and the lack of street view images in the agricultural areas made an actual street view essential. Besides spatial experiences, climatic and acoustic experiences could also be absorbed. Hiding places in case of heavy railfall or intense hot weather, for instance, were very important in the open agricultural landscape. The recreational use was also an important observation.

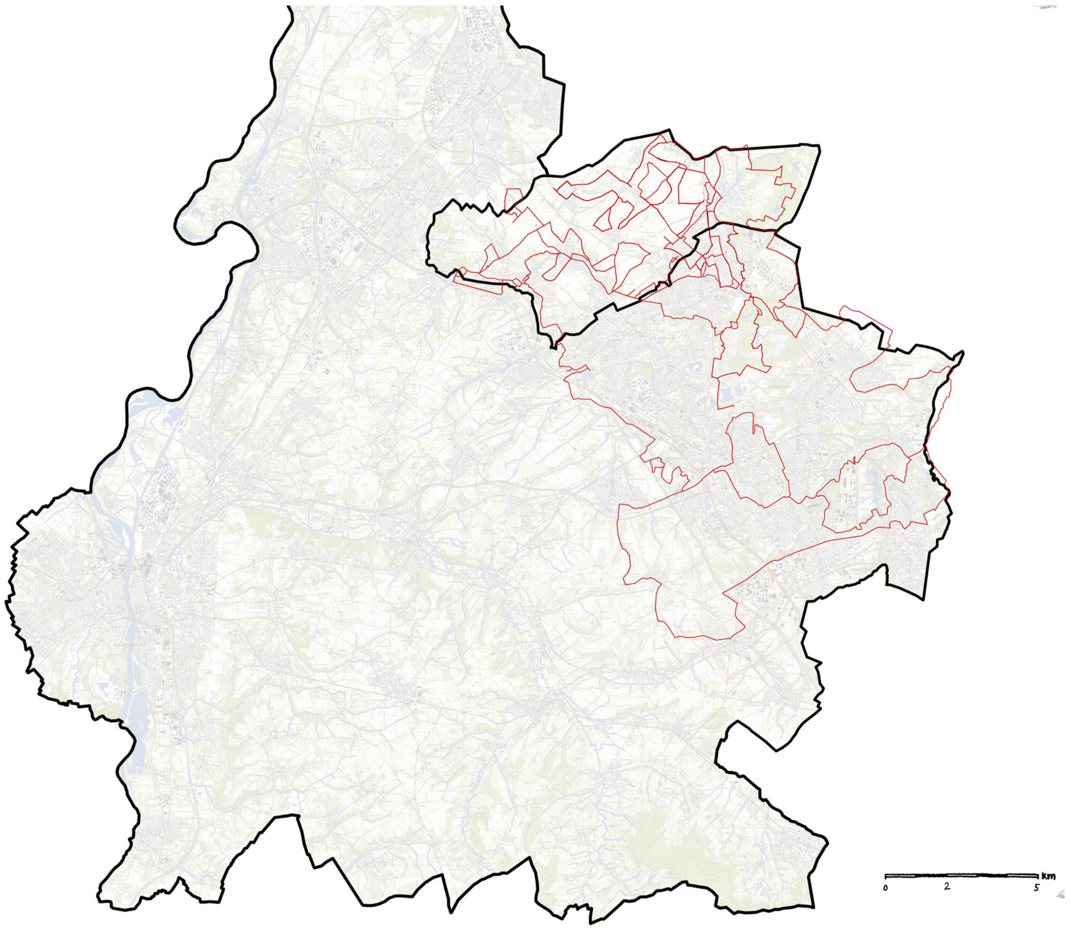


Figure 5 Site visit routes

3. PARKSTAD LANDSCAPE

The inventarisation and analysis of separate layers provides knowledge and input for a design in which these layers are conciously included and combined.

3.1 ELEVATION

The Limburg landscape is characterized by its topographical distinction from the rest of The Netherlands (see figure 6). The originally flat landscape was pushed upwards during the ice ages. (Renes, 1988)

Streams of water cut through the landscape (see figure 7), introducing brook valleys, slopes, and large and flat plateaus in between the brooks. The soil on the slopes is fertile because of the loess which arrived here thousands of years ago.

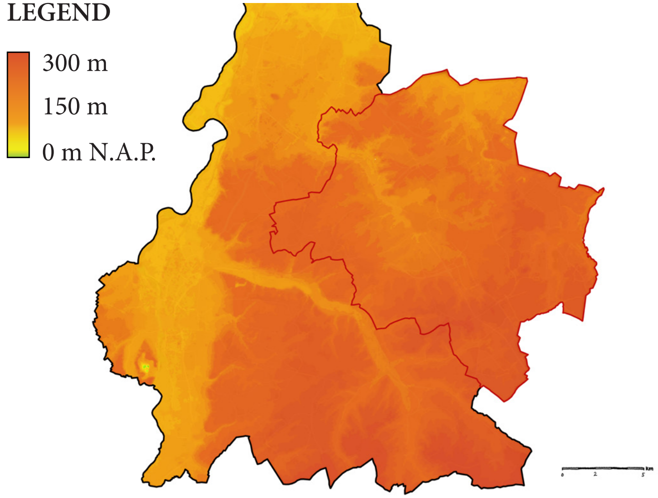


Figure 6 Elevation, Adapted fromAHN, 2017, no copyright needed.

3.2 WATER

Along the brooks (see image 8 & 9), nature has redeveloped because of intensive restoration projects. The brooks themselves are no longer the sewage system of the urban landscape, but a recreational attractor and ecological stronghold. Water, however, arrives from the plateaus. Therefore the entire watercourse should be looked at to attain the optimal water quality. In the farmlands, ditches are mostly used for drainage, but not to capture, use, or purify the water. The water board and municipalities already made some nice water buffers; needed to protect us from water which is not held by our soils up on the plateaus.

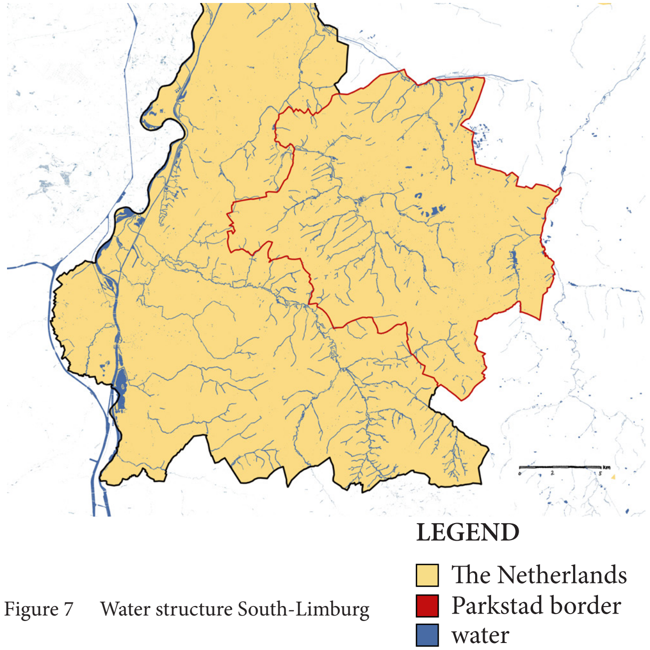


Figure 7 Water structure South-Limburg

Image 8 Brookvalley Geleenbeek, Wingerdweg

Image 9 Brookvalley Worm, Baalsbruggermolen

3.3 SOIL

The soils on the plateau are of good quality, however, the farming activities have degraded the soil. Loess soils have been the oldest known agricultural soils in the Netherlands (Renes, 1988, p.19) and are more fertile than sandy soils. These soils are easy to work with and they retain water but are also easy to drain. When farming activities intensified, these soils had to be fertilized, mainly with lime. Heavy machines, plowing and the use of fertilizer and pesticides are the cause of soil degradation. Soil compaction (see image 10) due to heavyweights means water will not be able to enter the ground and will flush away, sometimes taking good top layer soil with it. Compaction of the soil is also bad for soil life. According to Toesmeier and Herren (2016, p.26), plowing also causes damage to soil organic carbon, losing between 30 and 40 tons of carbon per hectare. But the highest soil degradation in Limburg happened in the early days of Dutch farming activities in the area, mainly during the bronze age and large scale land exploitation in the eleventh to the thirteenth century. Deforestation and a lack of measures to stabilize the soil caused large loess layers to wash away into the brooks and rivers. (Renes, 1988)

Figure 8 shows the vulnerability of the soils. Many areas in the landscape are sensitive to erosion due to water run-off (see image 11). Vegetation protects some of the areas, but in other parts, good soil will be flushed away into the river system. Maintenance is important to protect the top layers of mainly the agricultural territories from degrading and also to prevent flood problems. (RIVM, 2014)

The lack of organisms in soils is one of the reasons why we need fertilizer in our traditional farming system in which there is no ecological balance. An important energy source for this soil life is reduced carbon. This means that soil can store carbon and there is even more carbon stored in our soil than as carbon dioxide in the air. Therefore, soil plays an

Image 10 Soil compaction, Grachtweg, municipality Beekdaelen

Image 11 Soil erosion, Op Het Vogelke, municipality Beekdaelen

LEGEND

water

farmland

little sensitive

sensitive, protected by vegetation

sensitive, temporary protected by vegetation

nature

little sensitive

sensitive, protected by vegetation

sensitive, not protected by vegetation

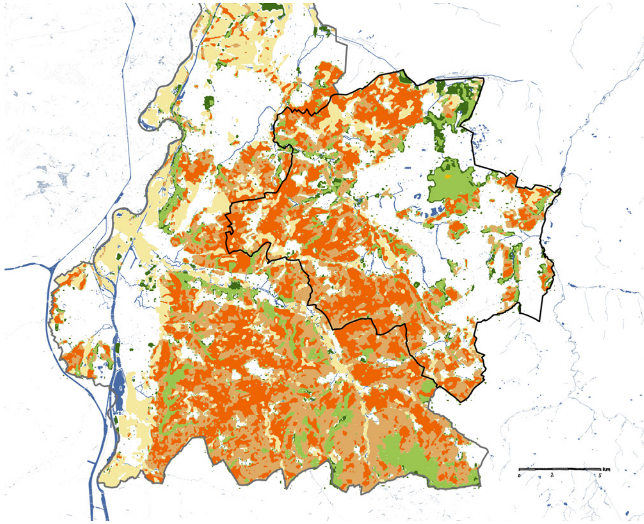


Figure 8 Sensitivity for and protection from water erosion. Adapted from RIVM, 2014a, no copyright needed.

important role in our climate and the carbon cycle. Paragraph 4.3.3 elaborates more on the role of carbon in agricultural systems, but figure 9 shows the current carbon dynamics in the top layer of the soil. (RIVM, 2015)

LEGEND

- Dutch border
- Parkstad border
- urban region

carbon cycle/dynamics in top soil

- much above average
- above average
- average
- below average
- much below average

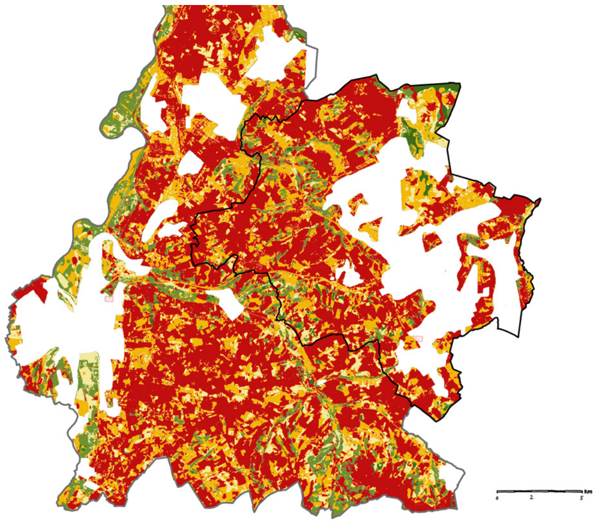


Figure 9 Carbon cycle and dynamics in top soil layer. Adapted from RIVM, 2015, no copyright needed.

3.4 LAND-USE

A landscape dominated by agricultural land and meadows provides wide views but leaves little space for ecological development and a diverse landscape experience. The majority of the unbuilt space in Parkstad is used for agricultural purposes. Forests exist along the brooks and at the Brunsummerheide, but in the rest of the surface, only clumps of trees seem to have survived. The plateaus are covered with large scale croplands and even the slopes are cultivated for the growth of grass as food for our cattle. Figure 10 shows the agricultural impact on biodiversity compared to other degradation causes and other European countries. Figure 11 adds an extra comparison with Europe as a whole and the rest of the world.

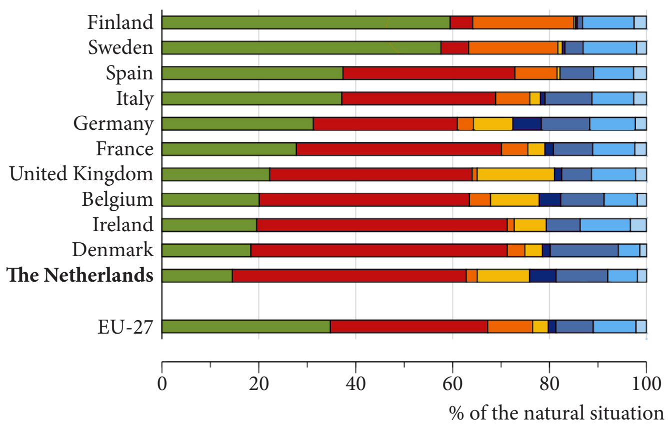


Figure 10 Causes for biodiversity loss in Europe, edited from PBL, 2010b

LEGEND

- remaning population size

domain loss

- agriculture
- forestry
- urban and other

quality loss

- nitrogen deposition
- fragmentation
- disturbance
- climate change

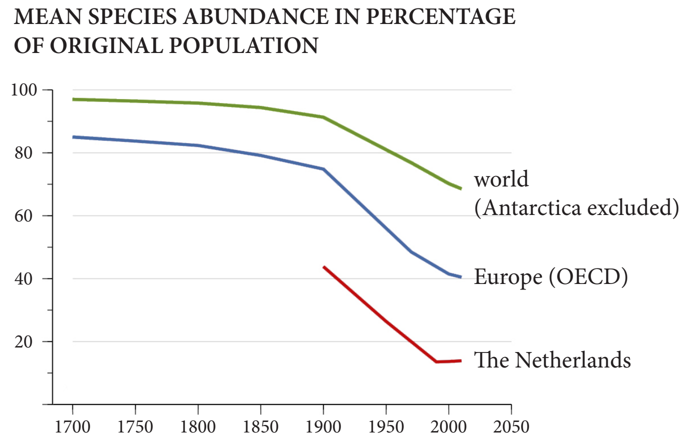


Figure 11 Biodiversity, edited from PBL, 2010a

3.5 LANDSCAPE VALUE

Several studies on landscape value are done in The Netherlands in which grades are appointed to the landscape. These studies selected criteria which they found to be important for our perception of the landscape. The first one is seen in figure 12, in which a prediction is made on how the landscape is experienced. This figure ilustrates the recreational use of the area and the relation of the landscape and the housing prices. In this figure, Parkstad seems to be of high value, especially when the urban edges are not accounted for. But it is also clear that there is a difference between Parkstad and the rest of South-Limburg; there are many more regions in which the landscape is graded below eight.

A similar outcome is seen in figure 13, where a yellow color is found much more within the Parkstad region. The main criteria for this map were the naturalness of the landscape (contributing for 37%), historical characteristics (contributing for 29%), absence of urbanity (contributing for 19%), absence of horizon pollution (contributing for 12%) and age of the landscape (contributing for 3%)(ANK).

The valuation of the landscape is important for the recreational value and therefore important for the economy in the region. According to numbers given by the province (ZKA Leisure consultants, n.d.), tourism in South-Limburg is good for 7,8% of the employment. When thinking about recreation in this province, the landscapes around Valkenburg and Maastricht appeal more to the imagination than the farmlands of Parkstad.

Especially in the northern farmlands much is to be gained when looking at the experience value and landscape attractiveness (see figure 12 and 13). These farmlands are characteristic of the region with its hilly landscape along the slopes and open views on the plateaus. The plateaus can be conceived as less exciting since they are flat and often only consist of monotonous croplands (see image 12). Providing a variety of views is important to provoke the curiosity of the visitor. Elements that establish such curiosity are the church towers

Image 12 Agricultural landscape, Grachtweg, municipality Beekdaelen

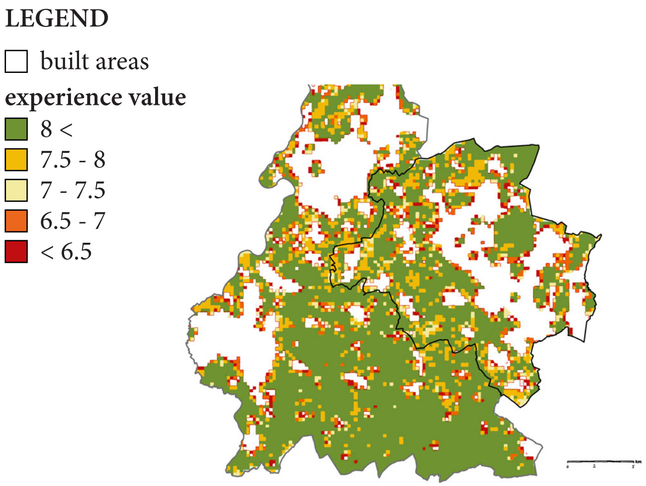


Figure 12 Experience value of the landscape, adapted from RIVM 2014b, no copyright needed.

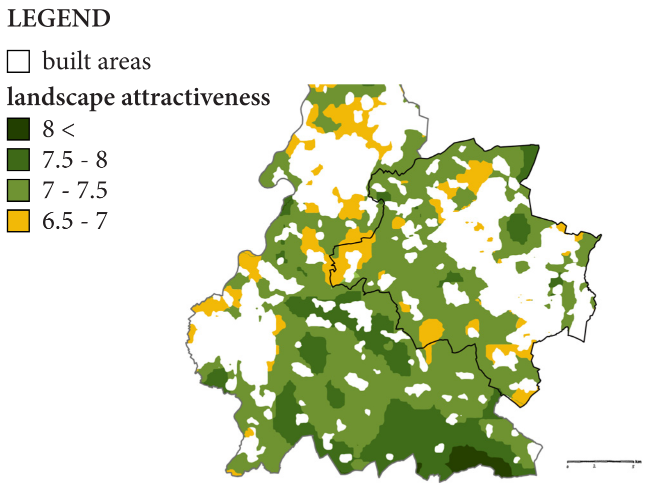


Figure 13 Landscape attractiveness, adapted from CBS et al, 2009, no copyright needed.

Image 13 Visibility of apartment buildings in Brunssum

(see images 14, 15 and 16), which are important for orientation. Especially in the hilly landscape of Limburg, it is important to preserve these vertical elements for their guiding value. Windturbines (see image 17) are rare in South-Limburg, but the horizon shows wind farms on the German side of the border. Similarly, high-rise apartment building in Brunssum are seen from afar (see image 13).

Image 17 Windturbines in Germany

Image 14 Tip of H. Clemens church, Merkelbeek

Image 15 H. Clemens church, Merkelbeek

Image 16 Tip of St. Lambertus church, Bingelrade

images 18, 19 and 20) enrich the bare farmlands. These are typical landscape elements which need to be preserved for their historical and recreational value. In paragraph 5.4.2. there will be elaborated on these small landscape elements.

On an even smaller scale, the loss of characteristic plant species and birds can result in “landscape pain” (Van Druenen, 2018, p.44). In figure 14 and 15 the species diversity in classes is shown for the seven most important groups: vascular plants, amphibians, reptiles, fish, butterflies, dragonflies, and birds. The southern parts of South-Limburg are again doing better than the Parkstad region and the farmlands are clearly poor when it comes to red-listed species.

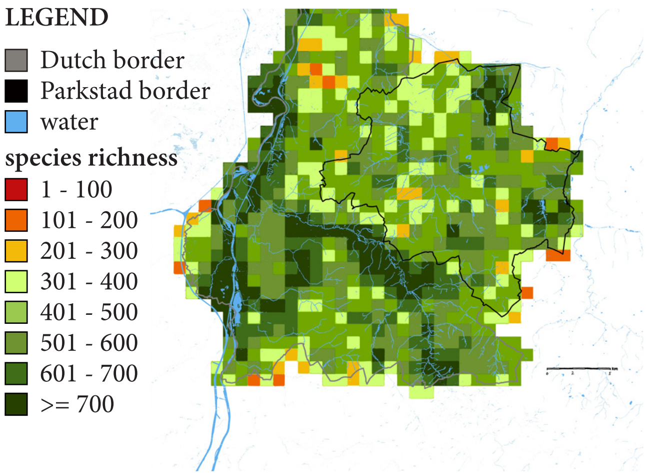


Figure 14 Species diversity. Adapted from NDFF, 2017a, no copyright needed.

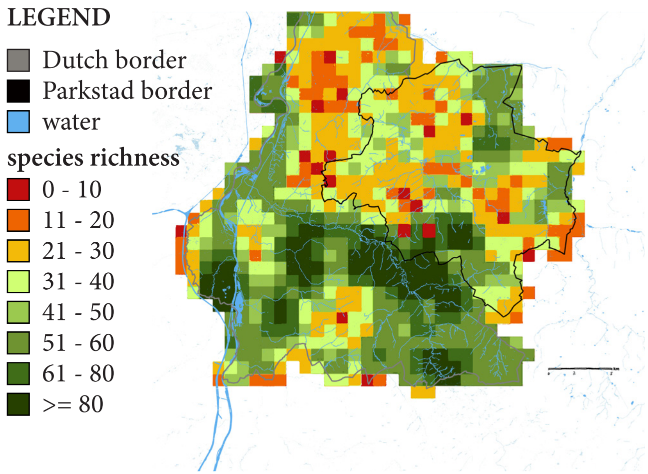


Figure 15 Red listed species diversity. . Adapted from NDFF, 2017a, no copyright needed.

Image 18 High-stem orchard, Winthagerweg, municipality Voerendaal

Image 19 Hollow road, Geerweg, municipality Voerendaal

Image 20 ‘Graft’, Greyertweg, municipality Beekdaelen

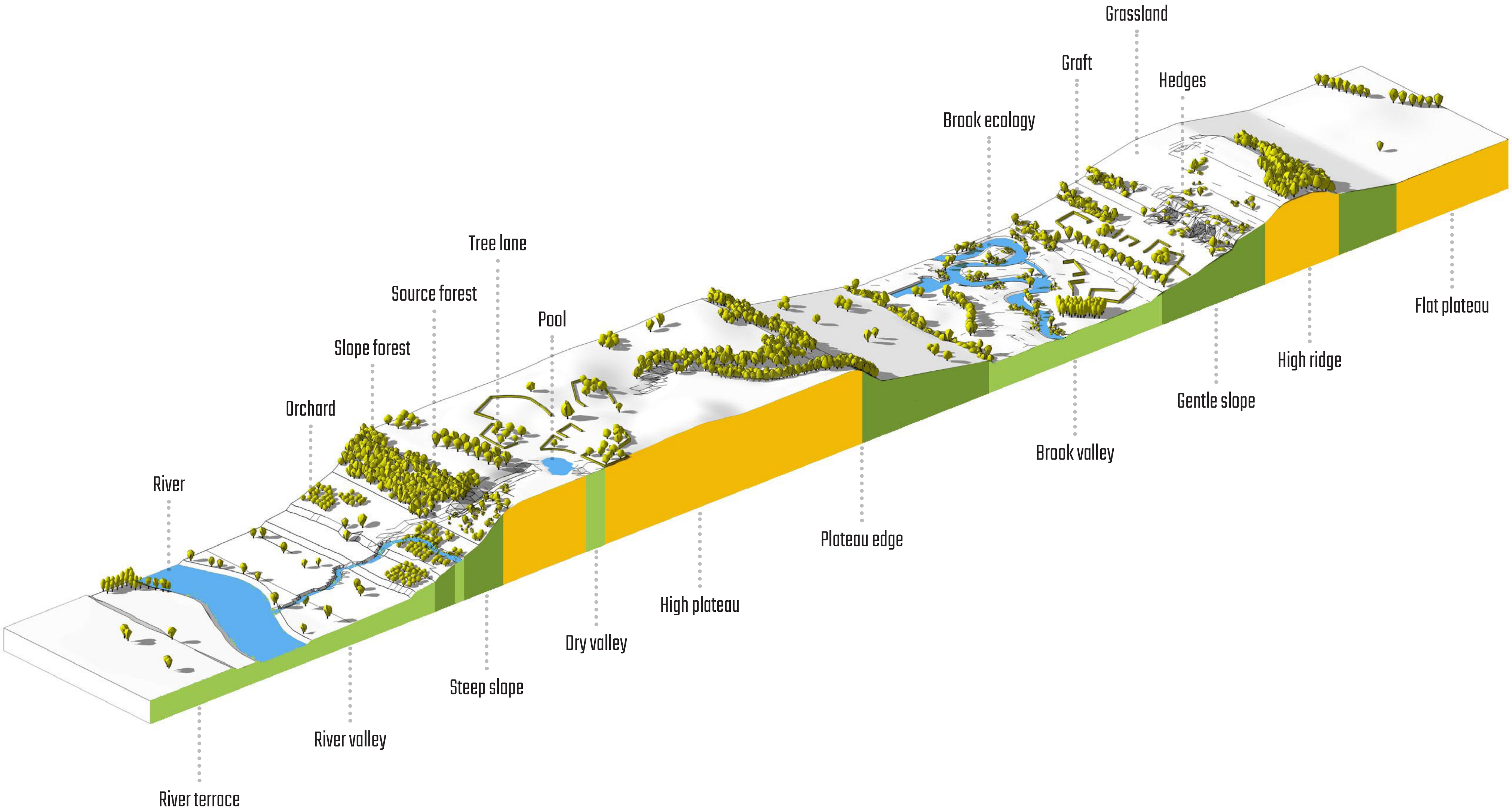


Figure 16 Conceptual section, adjusted from Pinxt et al. (n.d., p.48 and 53)

3.6 SITE SELECTION

The Parkstad region has characteristics similar to the rest of South-Limburg, nevertheless, the region scores less when we look at the recreational use and landscape value of the agricultural lands. Figures 17 to 22 show extractions of previous maps, only showing the worst areas which were identified.

The selected site seems to have a lot to improve and the multilayered landscape which the design aims for will improve all of the colored areas. Figure 23 shows a combined version of all these maps, resulting in a heat map exposing the poor areas in the landscape which require extra attention. These areas are identified in figure 24.

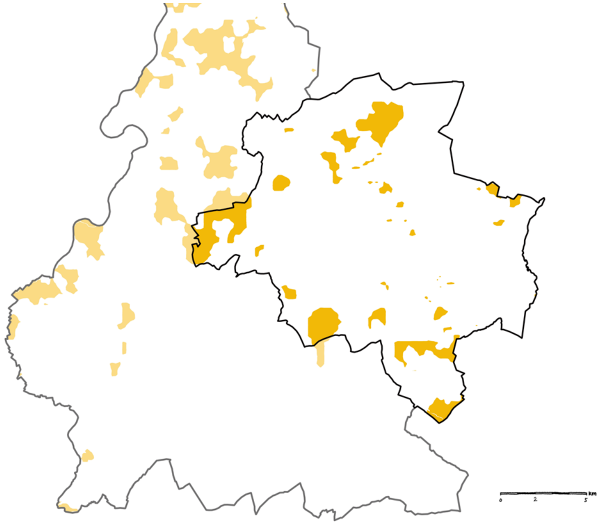


Figure 17 Carbon dynamics much below average

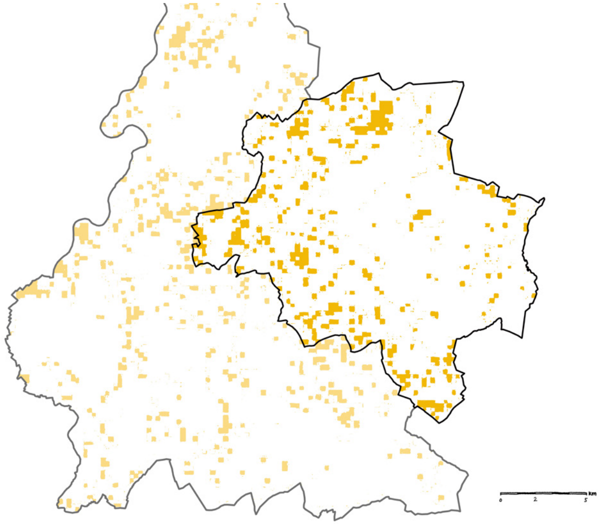


Figure 18 Sensitivity to erosion, only temporarily protected by vegetation

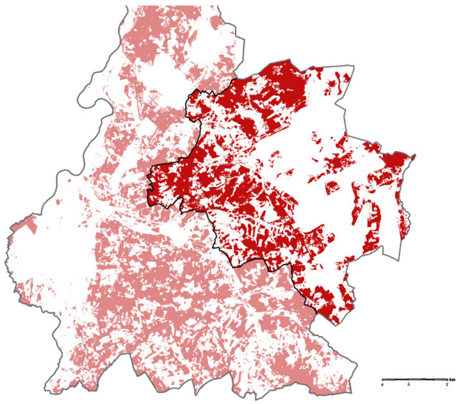


Figure 19 Landscape attractiveness graded below 7

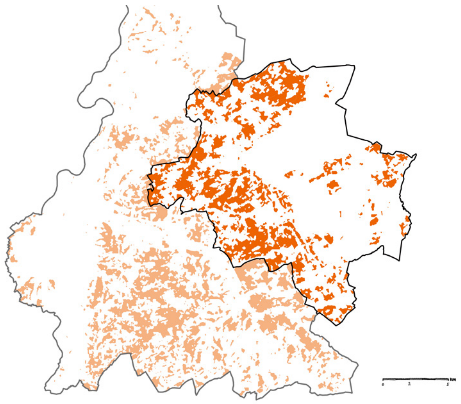


Figure 20 Experience value graded below 8 within the farmlands

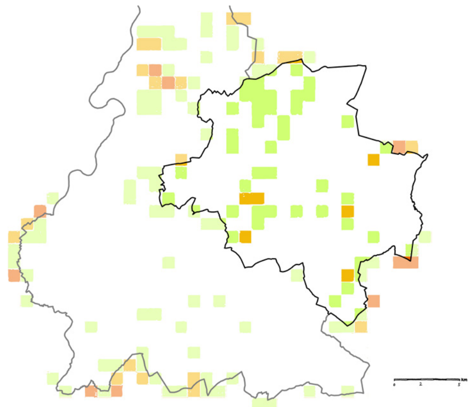


Figure 21 Amount of species below 400

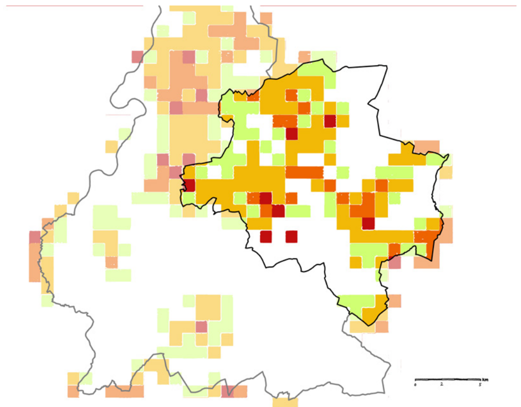


Figure 22 Amount of red listed species below 40

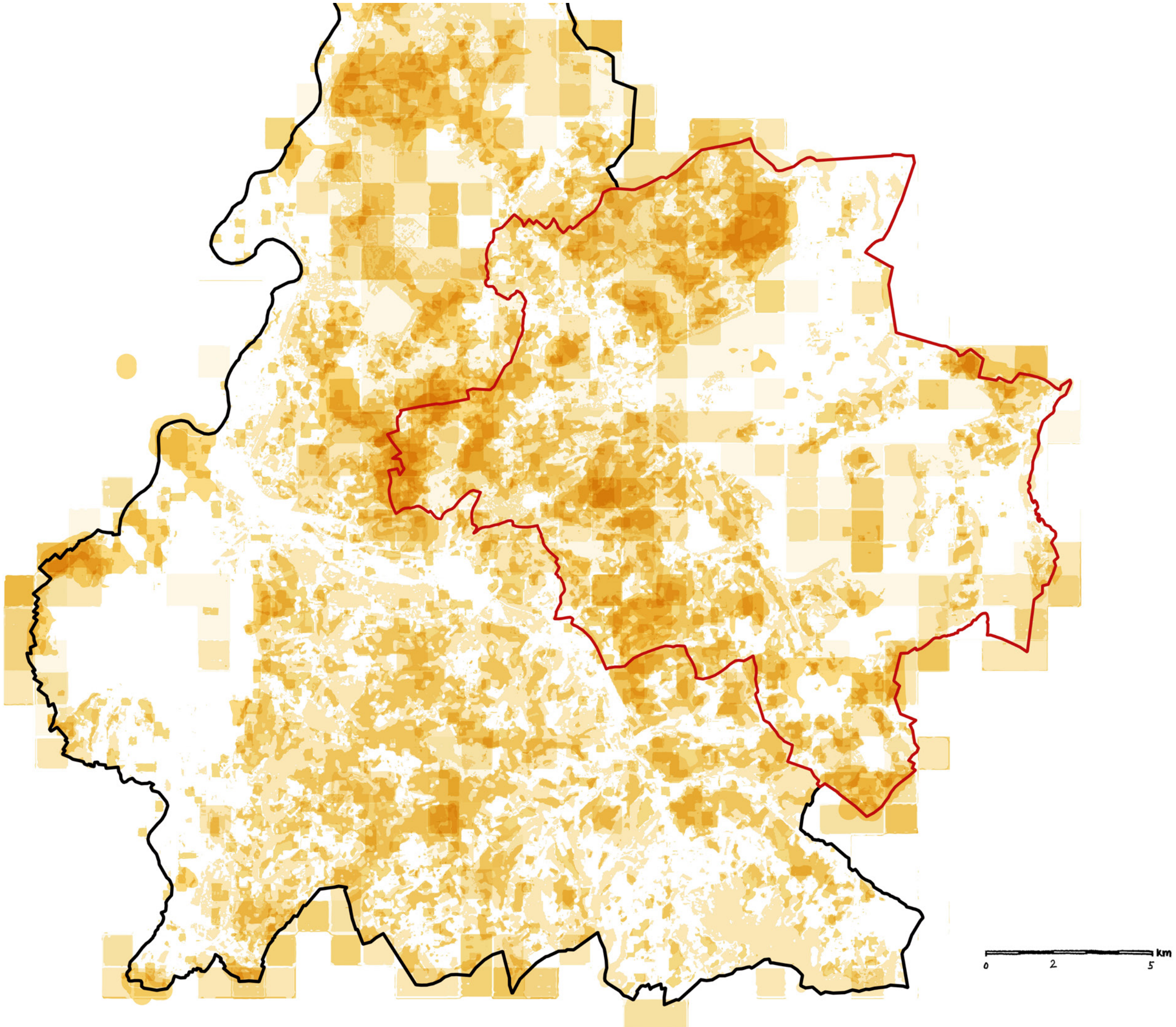


Figure 23 Amount of red listed species below 40

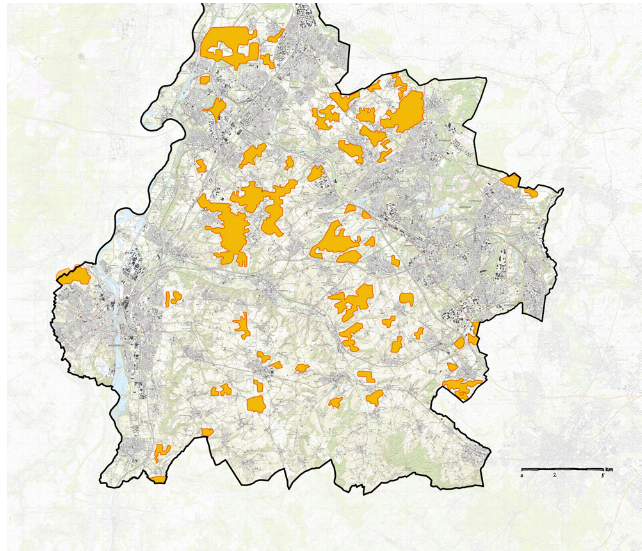


Figure 24 Carbon dynamics much below

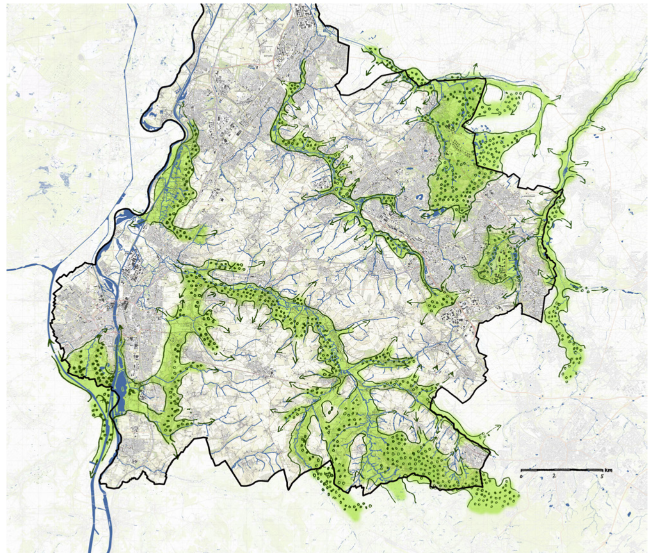


Figure 25 Sensitivity to erosion, only temporarily protected by vegetation

Other criteria for the site selection were proximity of urban areas and infrastructure, but this is the case throughout the entire region. The main criterion was the possibility of attaching the proposed ecological development to existing ecological structures (see figure 25). Within Parkstad (see figure 26), a strip within the municipality of Beekdaelen fits all of these criteria (see figure 27). This strip stretches from the Roode Beek in the northeast to the Geleenbeek in the southwest, making it possible to attach the regional design to these brook ecologies and the forests around Schinveld.

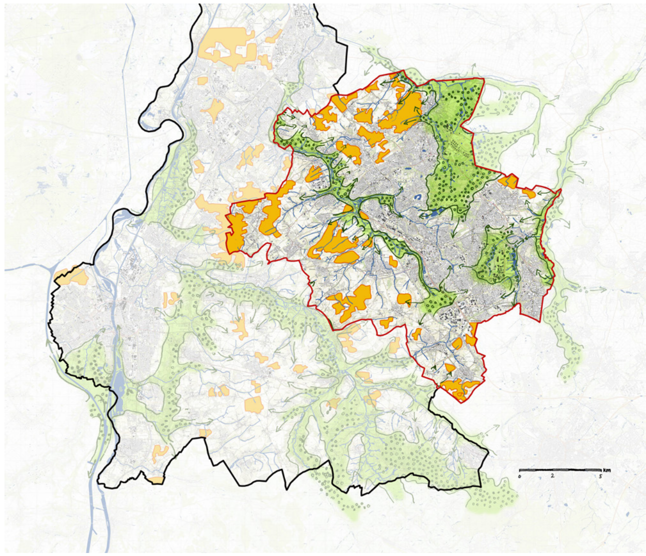


Figure 26 Experience

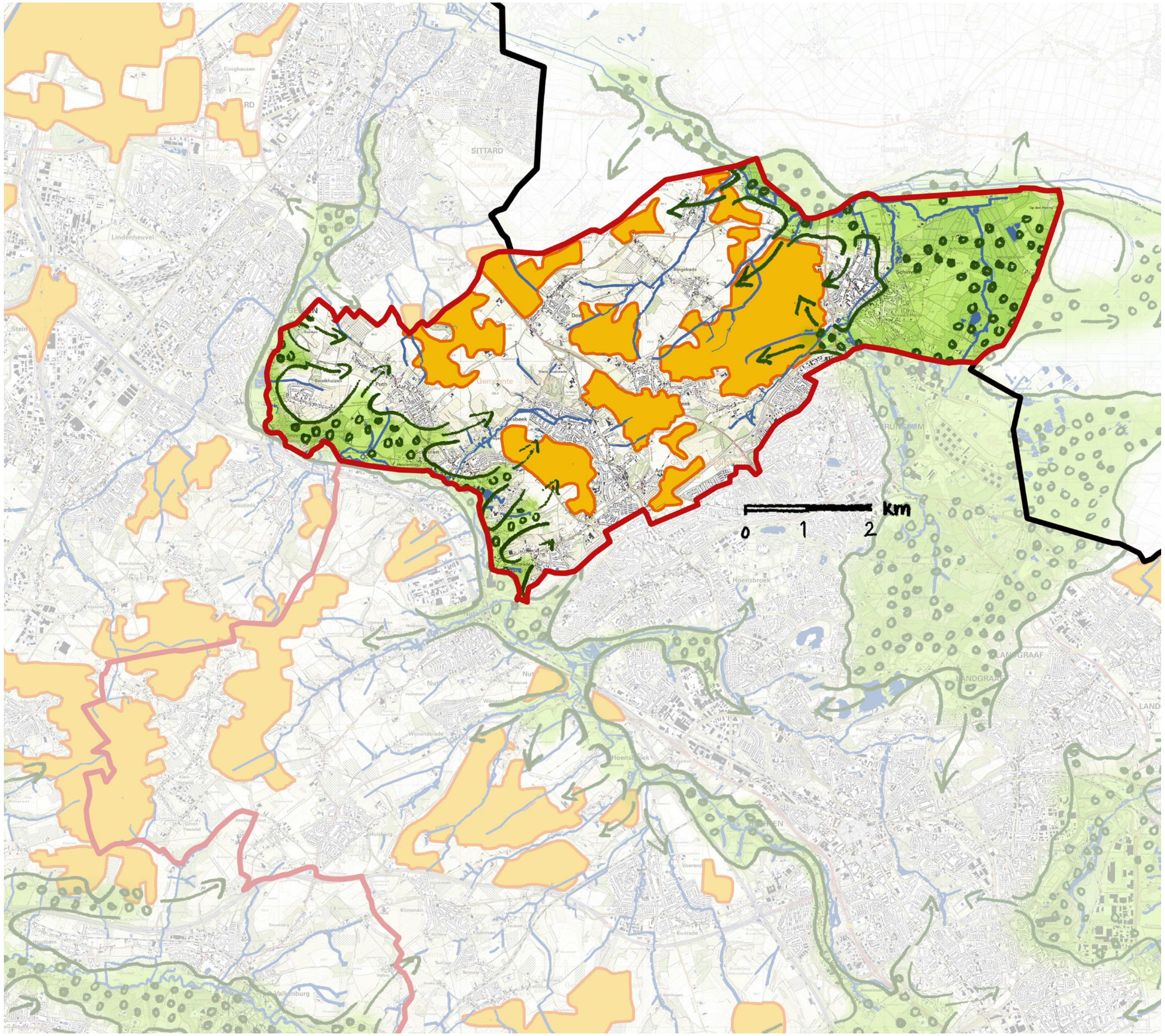


Figure 27 Amount of red listed species below 40

4. AGRICULTURE

"It seems to be becoming more and more difficult to reconcile highly productive and efficient agriculture with nature conservation and the preservation of attractive landscapes in which people like to spend their leisure time and with which they identify themselves." (Runhaar, 2017, p.340)

As told in the previous chapter, Dutch agricultural activities started in South-Limburg (see figure 29). In the early Middle Ages agriculture was the most important economical activity in the region. In this period, forested land (see figure 28) made way for arable lands. According to Jaap Buis (Jansen, Boosten, Winterink, and Van Benthem, 2009) only 100.000 hectares of forest were left at the end of the eighteenth century; an absolute low. From that moment on, the Netherlands started to reforest large parts of the land.

After the Dutch famine of 1944-1945, it was politician Sicco Mansholt who aimed for a strong agricultural sector to ensure food supply and never face food scarcity again. Since that time the government subsidises farmers on a massive scale, our land-use transformed again and a large part of the Netherlands is now used for highly productive agriculture. And we are not only feeding ourselves, but we are feeding across our borders.

4.1 CULTIVATED LANDSCAPE

The agricultural landscapes, although outside the urban environment, are the result of human intervention. The cultivation of our land began a long time ago when humans started to settle. From local production for the community, this grew to production for cross border trade. But also the landscape transformed (see figures 29 and 30). To grow our food, the land needed to be prepared and seeded, but not all parts of the land were useful. Some soils were bad for the growth of crops, some lands were too wet or too dry and another disturbing factor was the workability of the land; some slopes, for instance, were too steep. The limited abilities of our tools and machines also restricted the amount of land cultivation.

But as technology developed, all these obstacles could be countered and agriculture grew bigger. Machines are able to harvest more and faster, pesticides increase the yields, smart systems were developed to regulate the soil humidity and new plowing methods and landscape elements made it possible to grow crops on steeper slopes.

Figure 28 Natural situation along the slopes, (Krekels, et al., 2002, p.22)

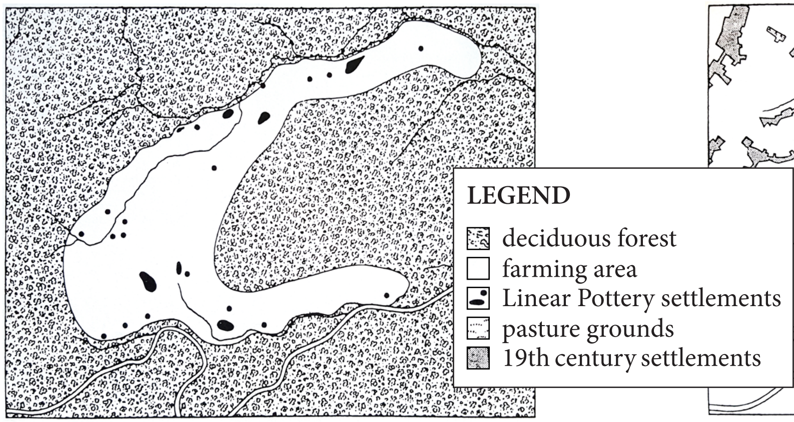


Figure 29 Settlements and cultivated landscape on loess plateau between the Geleenbrook and Meuse river during late Linear Pottery culture age (5500-4500 B.C.), (Bakels in Renes, 1988)

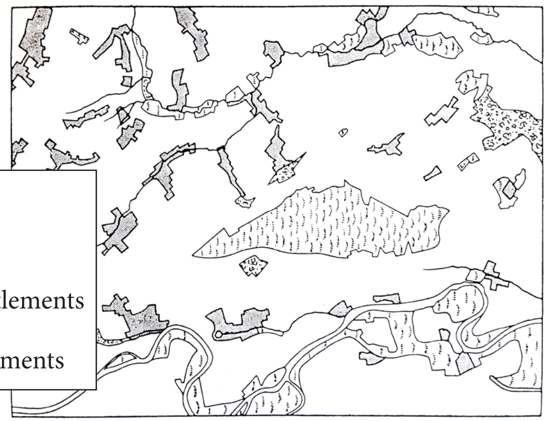


Figure 30 Settlements and cultivated landscape on loess plateau between the Geleenbrook and Meuse river around 1810, (Bakels in Renes, 1988)

4.2 UPSCALING

The biggest shift in our agricultural landscape was land consolidation (see figure 33). It became possible for farmers to exchange land in order to create larger parcels (see figure 31 and 32). Productivity grew even more because the landscape rationalized into a functional structure, but ecologically valuable elements vanished and meandering water streams transformed into straight ditches. (Krekels, Peeters, & Brouwer, 2002)

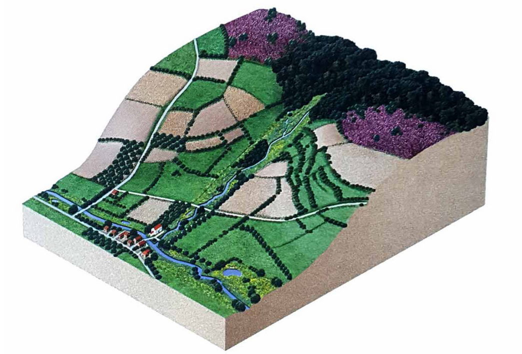


Figure 31 Former cultivated landscape along the slopes in 1850, (Krekels, et al., 2002, p.22)

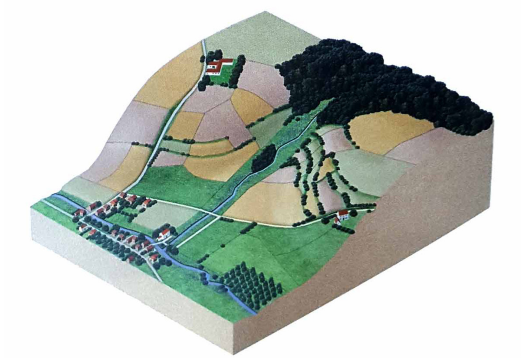


Figure 32 Current situation along the slopes, (Krekels, et al., 2002, p.22)

Together with this land consolidation, technological developments allowed even more intensive food production. The small scale farmlands, with alternating crops and ecological structures like hedges and graften on the slopes, transformed into a large scale production landscape. In this monocultural landscape, there is no room for ecology, as ecological valuable elements have been removed and pesticides poisoned the surface. But a shift is happening in the agricultural sector; monocultures and pesticides are no longer undisputed and the demand for ecological farming is growing.

LEGEND

- land-owner 1
- land-owner 2
- land-owner 3
- land-owner 4
- land-owner 5
- water
- road

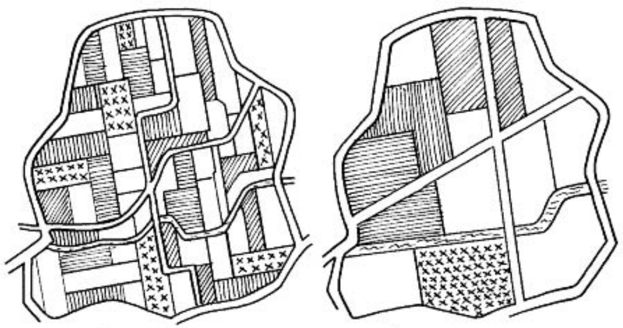


Figure 33 The result of land consolidation, (Van Sabben rentmeesters, n.d.)

4.3 AGROECOLOGY

Collaborating with natural processes in farming methods is a growing idea and a lot of field research is done to test to what degree this offers an alternative for current farming methods. This means a transition towards mixed cultivation (or polycultures) and a layered system in which not only annual crops are grown.

Another change in our agriculture is the way we treat the landscape. In the current tradition, the landscape is adjusted to the crops we want to grow instead of growing crops according to the landscape's specific qualities and identity. Ecological strips are important to cut the large ecologically poor parcels into pieces. These veins ensure biodiversity and could even play a productive role in our agricultural landscape. For the following chapters four factsheets on agroforestry by Selin Norén and contributors (2019) together with the book 'The Carbon Farming Solution' by Toensmeier (Toensmeier & Herren, 2016), have been consulted to gain knowledge about the ecological farming systems.

4.3.1 Layered systems

The first step would be to add ecological borders to the farmlands. In these strips, wildflowers and grasses can grow to support insect life; the pollinators. Hiding places for small mammals are also important to prevent insects from becoming a plague. Such ecological borders are more and more used and funded. However, this is still just a small intervention on the ground level. Biodiversity requires a focus on a multiple vegetative layer. Such polycultures or permacultures are systems that include both an ecological and economical interaction between species. (Van Druenen, 2018, p.45).

Permacultures are layered; consisting of rooting crops, groundcovers, bacteria, fungi, a herbaceous layer, a shrub layer, climbing plants, fruit trees, and nut trees. If possible, cultivation on the water can be added to this list and non-edible 'crops' like pioneer tree species for wood production could also be considered (see figure 34).

The diverse offer in species, flowering periods, heights, and densities attracts a diversity of other species and establishes an ecological balance (see figure 35). The presence of predators, for example, balances the population of other animals. This balance ensures not only a decrease in diseases and plagues but also better and more numerous microclimates and better soil quality (Selin Norén, et al., 2019).

Figure 36 shows the additional effects of a layered system. According to research by Selin Norén, monocultural traditional annual crops do not allow rich soil life, because their roots only enter the top layer of the soil. Some plants in the system might not be harvested and are there to support

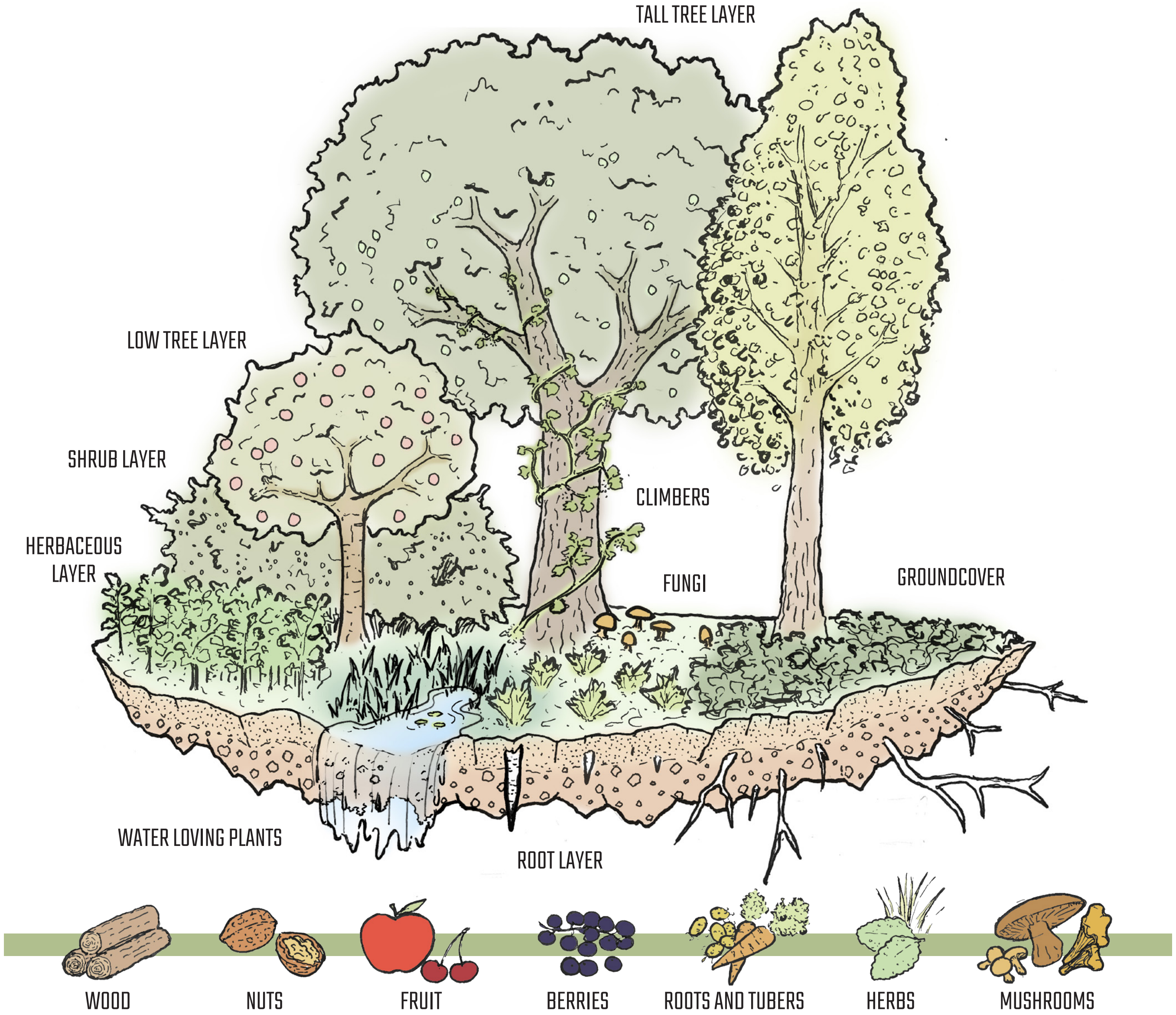


Figure 34 Layered vegetation and a layered harvest

species which are to be harvested. Deep rooting plants are able to absorb nutrients from lower soil layers and when they die, these nutrients become available for the surrounding plants. The addition of different rooting systems also ensures a more stable soil that retains more water and prevents erosion. Especially on the slopes of South-Limburg trees can make a big difference. They can also be used for wind protection and shade. A positive effect of polycultures for farmers is the diverse harvest (see figure 34). In bad years for one crop, other crops may do well to balance the yields and thus ensure a stable income. (Toensmeier, 2016)

The recreational value is high in a layered landscape, due to the seasonal changes (see figures 37 to 40), and due to all the sensoric experiences attached to the diverse species. Colour changes through the year are much more varied than seen in a farmland where only one annual crop is grown and harvested, to leave a plowed landscape behind.

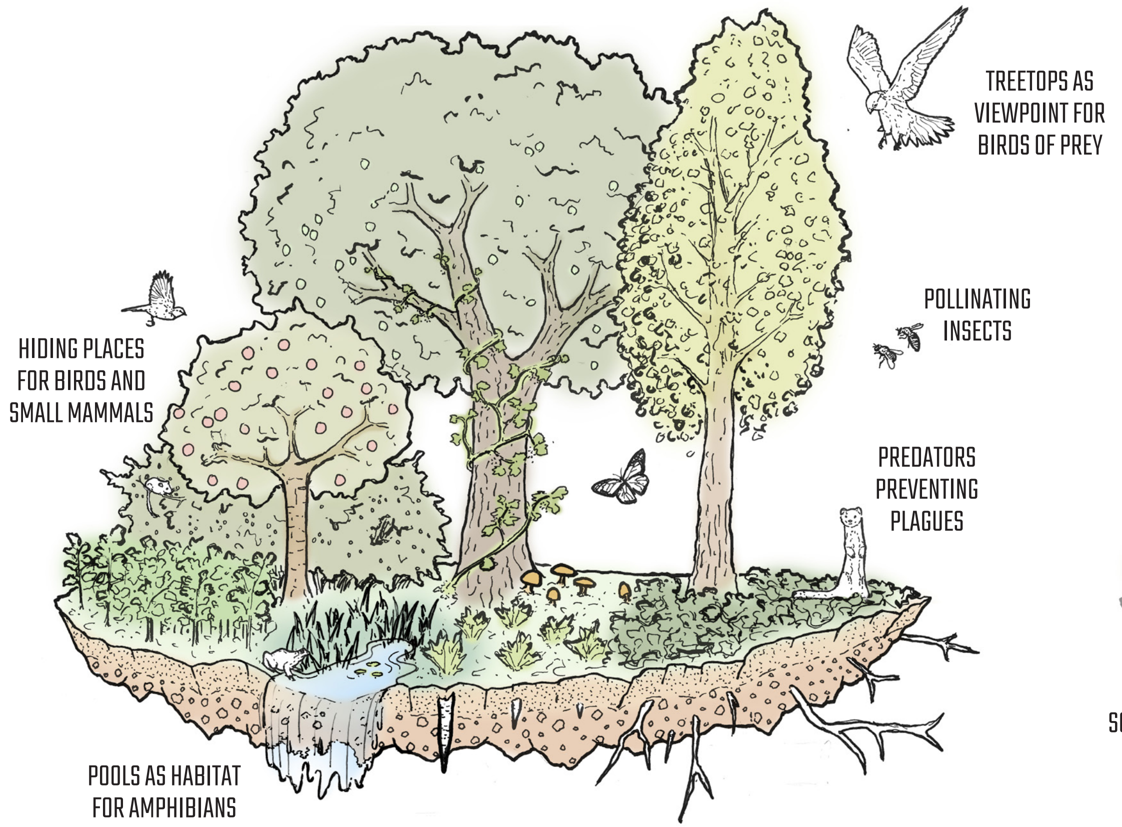


Figure 35 Value for biodiversity and ecological balance

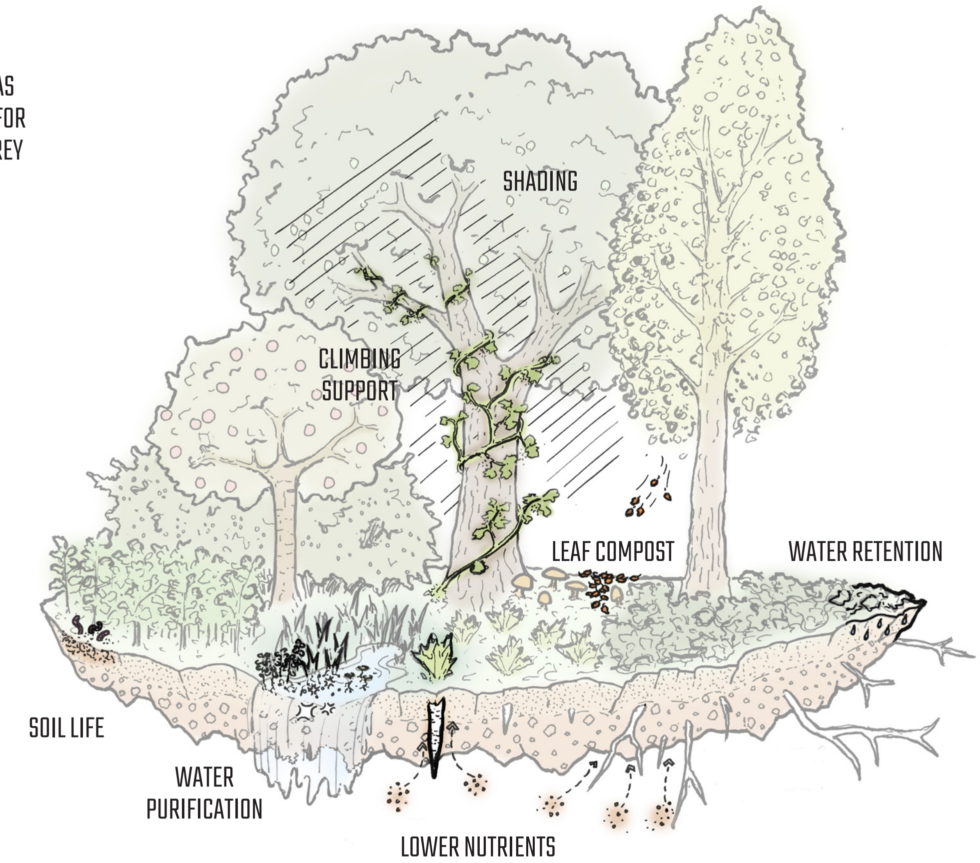
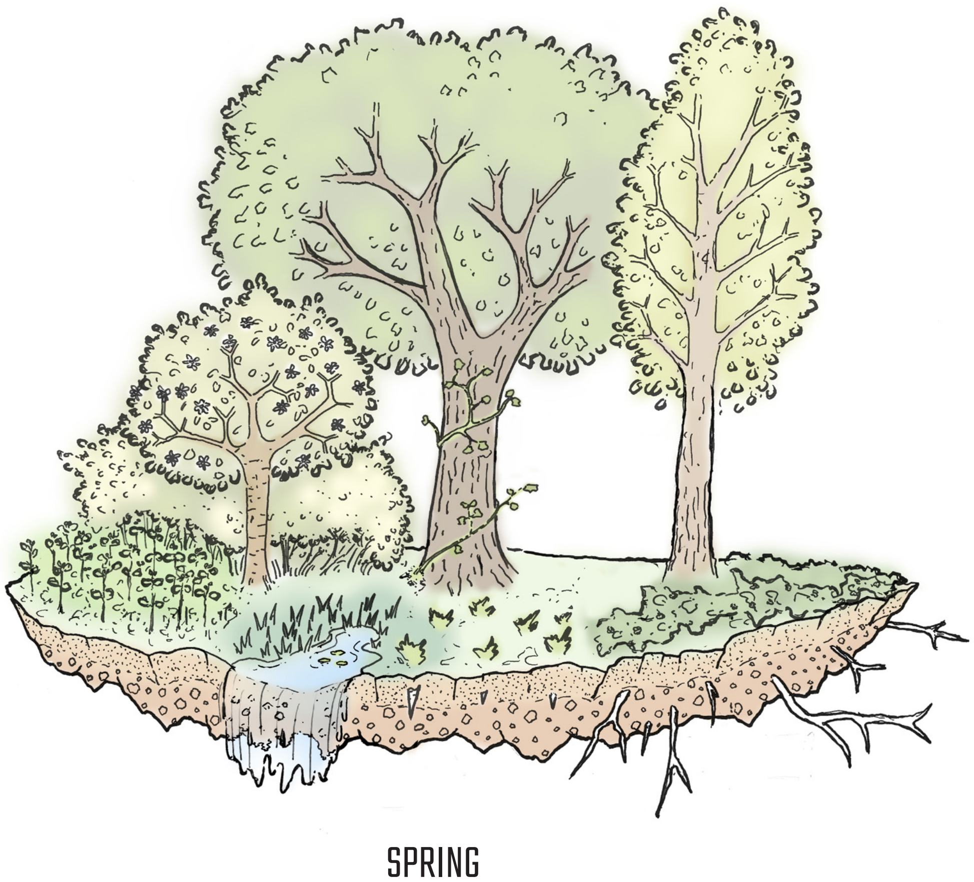


Figure 36 Additional value for climate, biodiversity and production



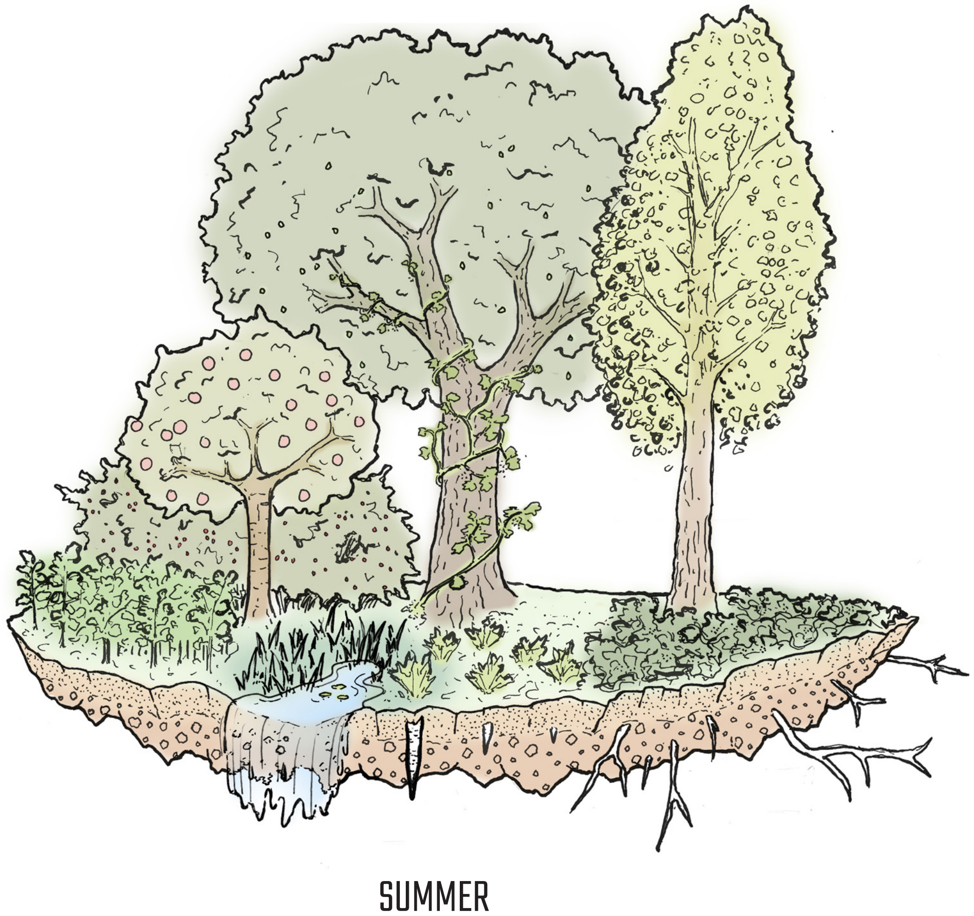
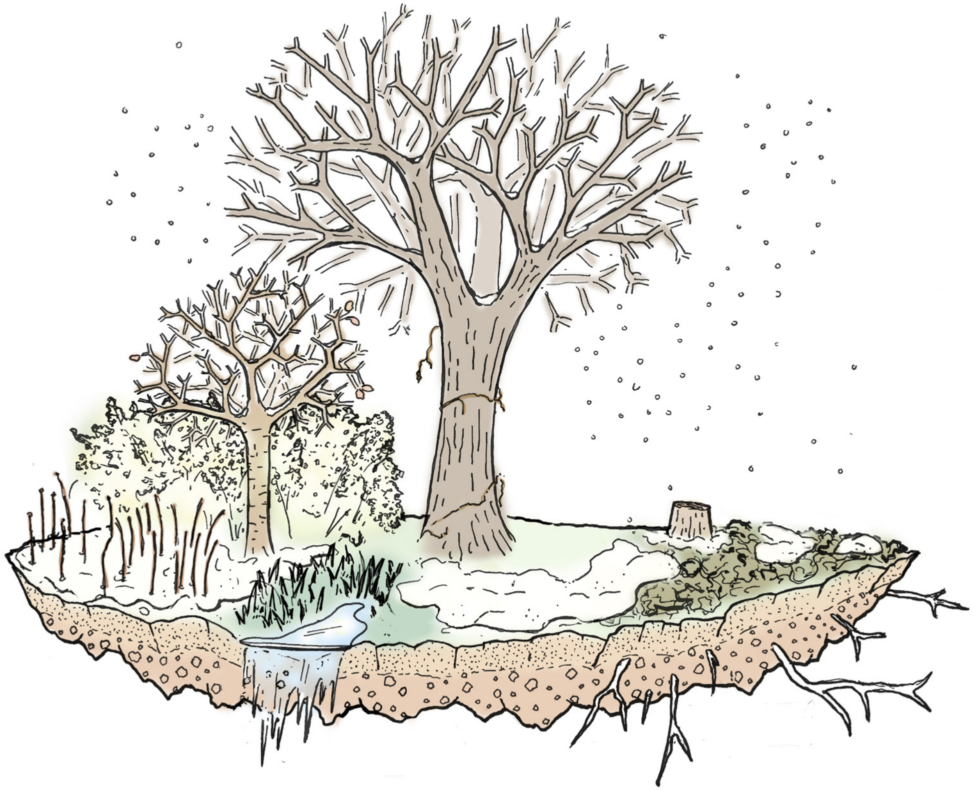


Figure 37 Spring season in a layered system

Figure 38 Summer season in a layered system

AUTUMN



WINTER

Figure 39 Autumn season in a layered system

Figure 40 Winter season in a layered system

4.3.2 Food forests

The result of a layered farming system could be the food forest. These food forests mimic the natural metabolisms of the natural forest in which vegetations support each other and establish a balanced ecosystem. Two types of food forests can be identified; the romantic food forest and the rational food forest. The romantic food forest has a free shape and can host hundreds of plant species, while the rational food forest is placed in strict rows to ensure an easy harvest. Within these rows, there can be an alternation of species. This alternation can, for instance, be part of the growing time by adding pioneering tree species between nut trees. These pioneer species can be harvested for wood at the point where the nut trees are in need of more space for their crown. The biggest food forest in the Netherlands is currently constructed in Schijndel (see figure 41). This should serve as an example of how food forests can be applied as an industry competing with traditional systems. Small scale projects, such as food forest Ketelbroek, have already proven to gain higher yields. This forest is surrounded by traditional farms, but nevertheless, it hosts a huge amount of animal and insect species. In the first years after installation, there were pests, but after some years of patience, a natural balance was established controlling these pests. (Van Eck, W., co-founder of Netherlands Food Forestry Foundation, personal communication, March 12, 2020)

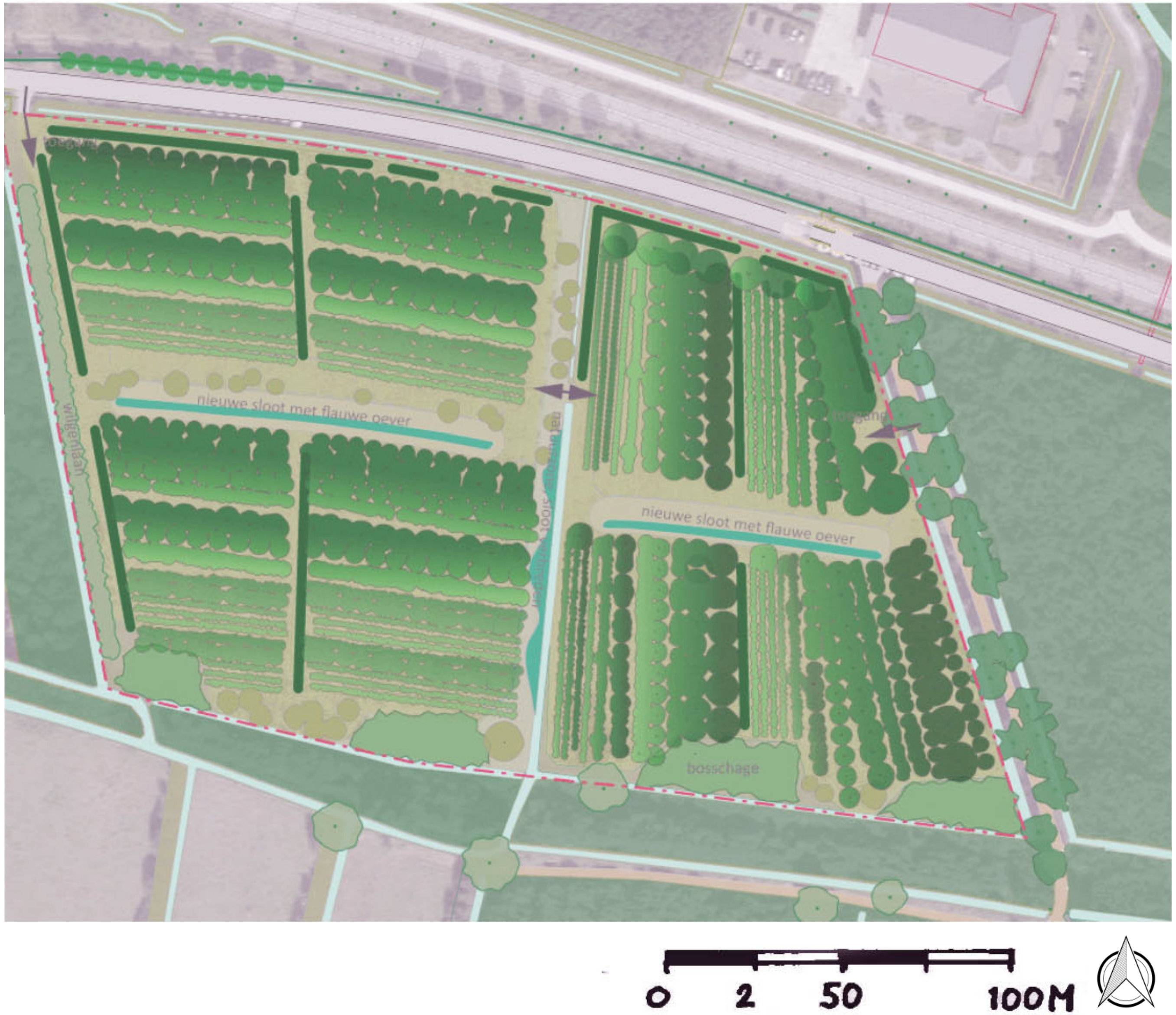


Figure 41 A part of food forest Schijndel, Stichting Voedselbosbouw Nederland, n.d.

4.3.3 Carbon farming

“Deforestation and agriculture have caused the loss of 320 billion tons of carbon from the terrestrial pool in the last 10,000 years, almost half of which has been since 1850. Burning fossil carbon for energy (in the form of coal, petroleum, and natural gas) has moved 292 billion tons of carbon to the atmospheric pool—most of it in the form of carbon dioxide—and is projected to emit another 200 billion tons in the first three decades of the 21st century” (Toensmeier & Herren, 2016, p.23).

All around the world, the reintroduction and addition of trees seem to be a major solution to counter the climate crisis. Besides reducing our energy consumption and exhaustion of greenhouse gasses, trees have the ability to absorb carbon dioxide and turn it back into solid carbon compounds.

“Many studies show that agroecological farms have reduced emissions and sequester more carbon than industrial agriculture” (Toensmeier & Herren, 2016, p.33).

Annual crops and grasslands sequestrate about 1 to 4 tons of carbon dioxide per hectare per year, while deciduous forests capture about 10 tons of carbon dioxide per hectare per year (Selin Norén et al., 2019). New forest plantations are actively capturing this carbon from the air for 20 to 50 years and despite previous notions even in fully grown forests sequestration of carbon continues (Toensmeier, 2016).

We all know that trees can store carbon within their trunk, but their branch and leaf waste, roots, root secretions, and attached organisms induce even higher carbon storage in the soil (see figure 42); “About two-thirds of this material is released into the atmosphere as carbon dioxide as part of the global carbon cycle. The remaining third becomes long-lived soil organic matter” (not included in figure 32, Toensmeier & Herren, 2016, p.34). This biomass is also good for soil fertility, soil structure, water management, and biodiversity.

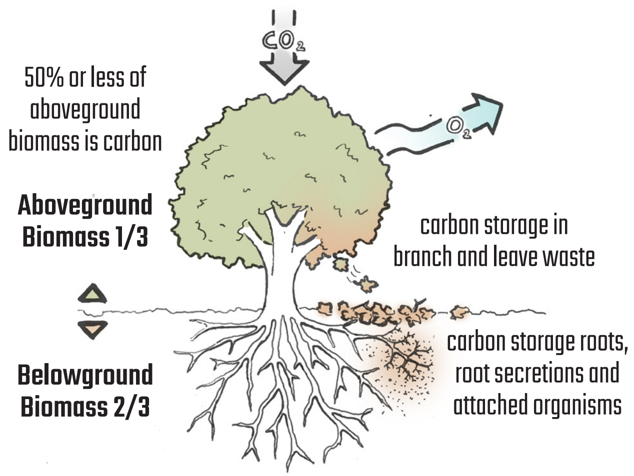


Figure 42 Carbon sink, after the example Toensmeier & Herren, 2016, p.35)

Next to carbon storage in farmland soils, the agriculture and land-use sector also wants to prevent deforestation and enlarge forested lands. These measures together should increase carbon sequestration and keep carbon stored for a longer period of time. By doing this, they hope to reduce emissions with 3,5Mton carbon dioxide equivalence per year. Depending on tree density, species, growth rate, age, climate, management and the durability of the end product, carbon sequestration in agroforestry systems can be even higher than for natural forests in which conditions are less optimal (Selin Norén et al., 2019)

Acting quickly is of great importance because the changing climate might change the role of trees. At a certain point, temperatures rise to a level on which more and more plants get stressed and start to ‘off-gas’ their carbon. At that point, vegetation is contributing to climate change instead of countering it, something which for some plants can already start occurring at two degrees of temperature rise. (Toensmeier, 2016)

4.3.4 Agro forestry design

“We speak about agroforestry when woody perennial crops (trees or shrubs) are consciously mixed with arable farming, vegetable cultivation or grassland, on the same plot. The woody crops can be planted for multiple purposes, for example for production of fruit, nuts or wood” (Selin Norén, Cuperus,

De Vries, et al., 2019, p.2). The addition of trees and shrubs also provides shelter for birds. Trees capture carbon dioxide and can be grown for wood production. Adding (linear) tree elements to agricultural fields might seem loss of good farming space, but when used wisely, it brings more than it damages.

The use of different species provides a diverse supply of food. Some species might even be threatened and others might just assist other species; in agroforestry systems, plants support each other and live as a community. A vegetative layer beneath trees will not only support the trees. But this undisturbed undergrowth also restores and improves the soil and habitat for all kinds of organisms.

Due to diverse vegetation heights and densities in an agroforestry system, there are many microclimates to be found which corresponds to a large number of species. The structure of an agroforestry field fulfills a connecting role in-between nature areas. The Linear structures can provide safe passage. (Selin Norén, et al., 2019)

Agroforestry systems have proved to improve soil quality and to increase the amount of mainly insects and birds. These insects are important for the pollution of crops and fruit trees and together with birds, they prevent vermin (pests) in the agricultural fields. (Selin Norén, et al., 2019)

Nature inclusive farm Slabroek (see figure 43) shows different types of agroforestry. The only type which is not rationally planted in lines is the system in which animals are the main producer. Strip cultivation in which plants, shrubs, and trees are planted in rows is most common because crops remain easy to harvest. The width and composition of these systems differ a lot, but there is always a search for an optimal balance between ecological value and yield.

When the edge of an agricultural field is filled with trees and shrubs, this means a loss of productive land. Studies have shown that in the range of 1,6 times the height of the trees, the production of wheat is 30% lower, but up to 9,5 times the height of the tree, the production rate is 107% (see figure 44). The height of the trees along the field, therefore, determines the distance between the rows of trees to optimize production. To take full advantage of

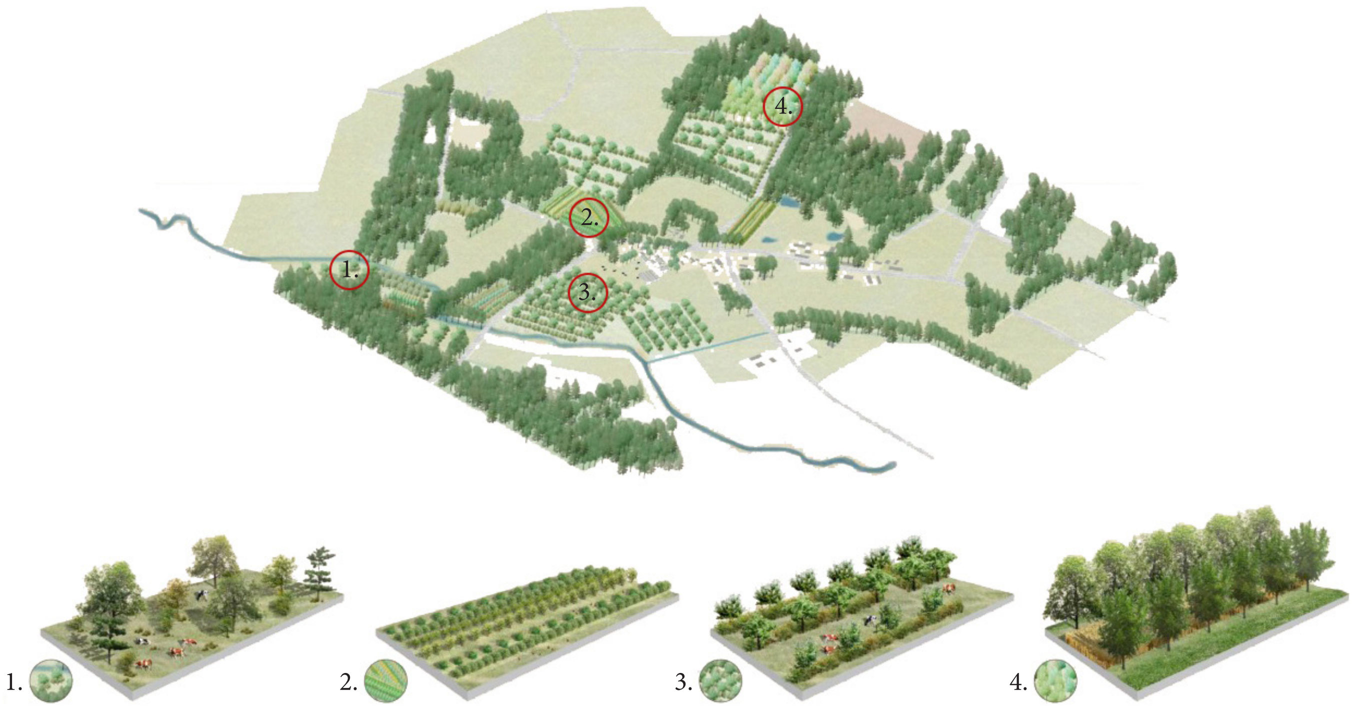


Figure 43 Nature-inclusive farm, Slabroek (Fruitz for life, n.d.)

this production, aim for a distance between the rows of trees (if the trees are all of the same height) of 19 times the height of the trees (situation B in figure 45). When the distance is less, you will have the loss, but you will not use the entire area to compensate for this loss (A in figure 45). When calculating the outcome of a situation B, farmland can provide 100,77% of the original yield without trees. Of course, in many cases, the tree edge is placed inside the original field, and therefore the area of production decreases. But this can be partially countered by using productive trees for wood, fruits, and nuts. (Selin Norén, et al., 2019)

When adding these forested edges, the sun also plays an important role, because the shadow is the main cause of the reduced productivity in close range of the trees (see figure 46.1). Smart placement of the trees could decrease the negative effects of the trees (see figures 46.2,3 and 4).

Another factor to consider is the range in which insects can move because many insects can not travel greater distances than 50 to 100 meters (Selin Norén, et al., 2019). Connecting elements or stepping stones can have a bridging effect on insects. Research on plague control in strip cultivation with distances of 10 to 20 meters showed that on average there were 24% more natural enemies and 25% fewer arthropod pest species (Selin Norén, et al., 2019).

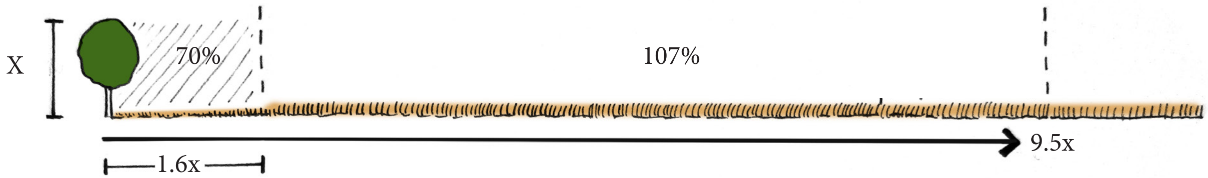


Figure 44 influence of trees on productivity, according to Selin Norén, Cuperus, Dawson, et al., 2019, p.7

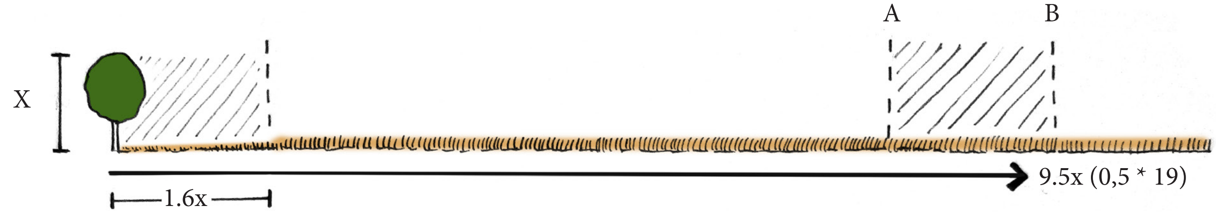


Figure 45 how to make maximum use of the trees influence on productivity, according to Selin Norén, Cuperus, Dawson, et al., 2019, p.7

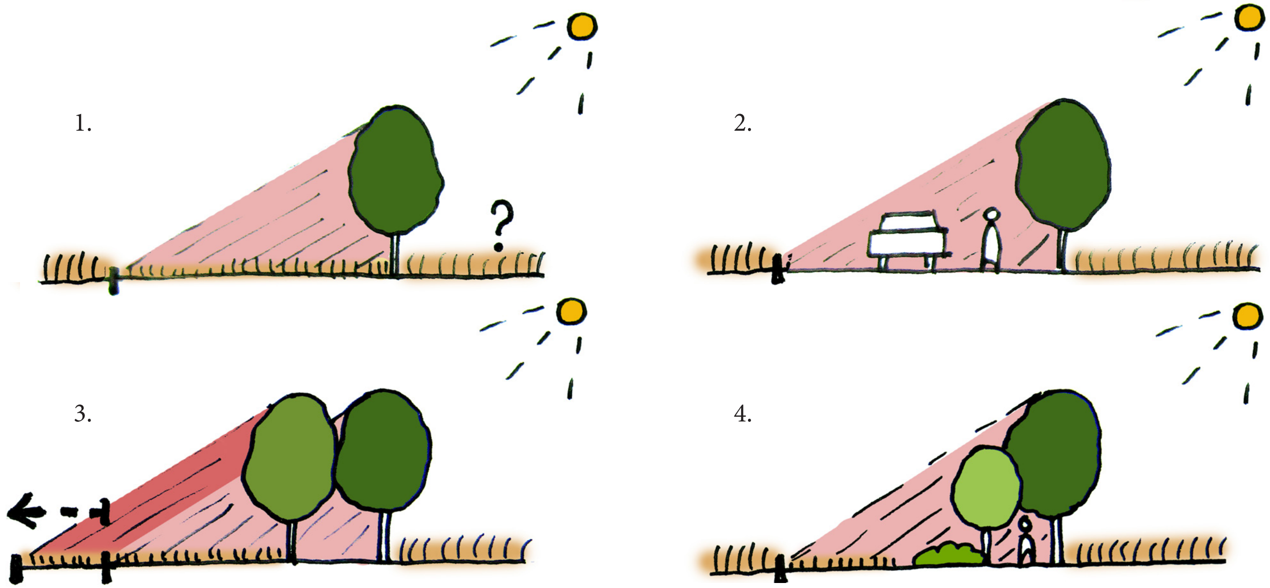


Figure 46 Shadow effects; 1. basic reduced yield range, 2. include infrastructure with areas with allready reduced yield, 3. double row of trees enlarges the loss of productive land and 4. arrange vegetation layers according to the sun if possible

4.4 TREES AS CROPS

Previous examples show how trees could be incorporated within the agricultural sector. The focus in these systems lies in food production, but trees are also a producer of wood. This product used to be a widely used element for tools and the construction of buildings. Plastics, metal, and concrete have taken over the wood in recent decades, but there is a revival at hand.

4.4.1 Wood industry

A revolution in solid wood constructions and Cross Laminated Timber (CLT) has begun and could eventually replace polluting concrete construction methods. By using wood as a building material, carbon is 'locked' for a long period of time. As long as the harvested tree is replaced, this increases the overall carbon storage. Besides that, prefabrication ensures streamlined logistics plus safer and cleaner circumstances (Hendriks, 2019, p.61). Figure 47 shows the chain of wood products from forest to the implementation in the built environment, but it also includes the industry attached, an industry which is currently not that big in the Netherlands.

To support the transition towards the use of high-quality wood products, there is a need for more forested land in the Netherlands. According to Jansen et al. (2009), the Netherlands will never be self sufficient, because we use much more wood than we can possibly grow on our own soils. That does not mean that we should not try to take care of our own wood supply. There are already many initiatives aim for this increase in forest coverage in The Netherlands. Actieplan Bos en Hout (2016), aiming to increase 25% of forest area and 50% of the forests' productivity, is a collaboration between forest owners, wood producers, and processors, the paper and cardboard industry, pallet companies, construction companies, the recycling industries, bio-energy producers and nature, and environmental organizations. The province of Limburg also made a plan for one million extra trees within the province, including agroforestry systems (Actieplan 1 miljoen bomen, 2019).

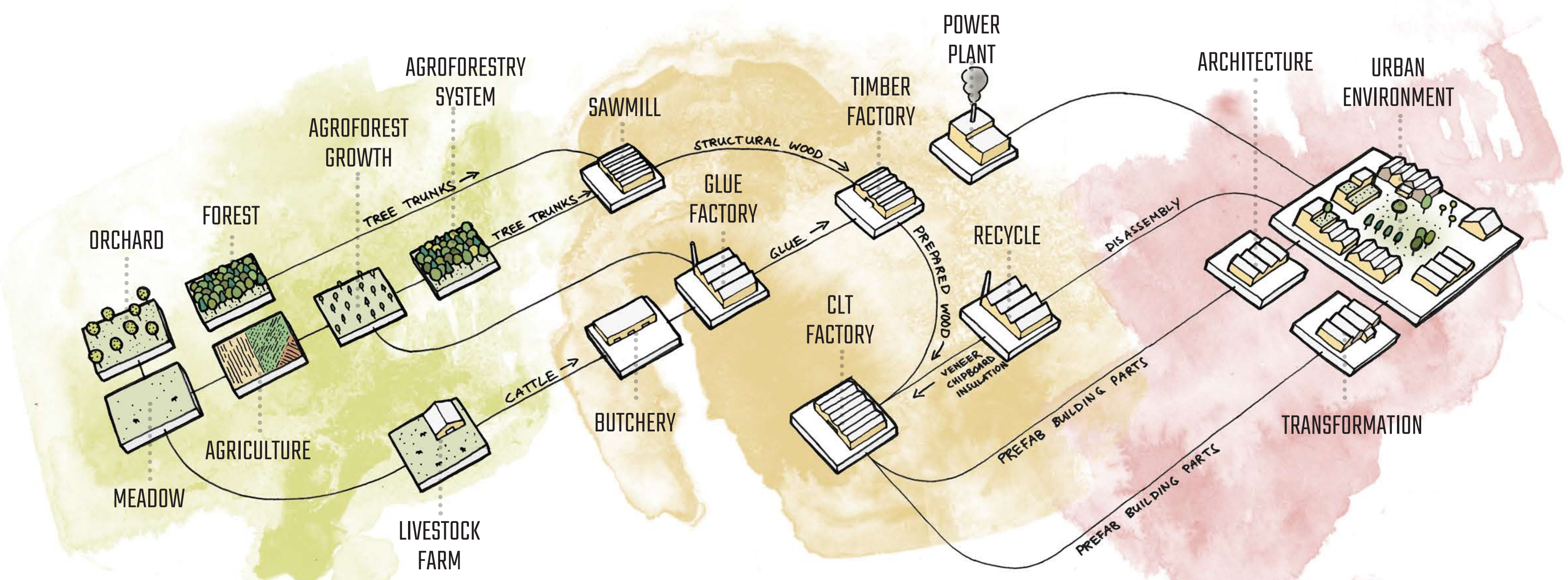


Figure 47 Wood industry from forest to wood implementation in the built environment, adjusted from studio Marco Vermeulen in Hendriks, 2019, p.60

4.4.2 Forestry

Actieplan Bos en Hout (2016) explains that 'Climate Smart Forestry' is necessary to achieve a healthy and sustainable wood industry. Forests therefore also include natural value, biodiversity, and recreational value. *"It is not wise to harness forests for only one purpose, even if it is as important as the mitigation of climate change. The goals of climate change mitigation are best achieved within a balanced combination of services from forest ecosystems"* (Kauppi, Hanewinkel, Lundmark, et al., 2018, p.16).

The lifespan of the tree itself is also an important factor. Fast-growing trees are preferred because they can be harvested earlier. Nevertheless, slow growing trees should be included, because a diverse plantation would mean not only a diverse harvest, but also a diverse habitat. Fast-growing trees can be used smartly when alternated with slow-growing trees. In this way, the gap between the slow growers is filled to the point at which they need more space and the fast-growing tree is ready to be harvested (see figure 48). Another example of smart planting is the use of fruit or nut trees, which yield an annual harvest and will be harvested for their wood at some point. Planting them in (double) rows would be smart in order to harvest easily (see figure 49).

"All trees produce usefull wood ... the quantity and quality of this wood is strongly influenced by composition and management" (Jansen et al., 2009, p.40). Because trees take a long time to grow and are not easily moved, planning for the future is essential. We do not know the amount and kind of wood will be needed by the next generation, but we decide what amount and species are planted. Straight stems are currently the most wanted, because they are easily processed. There are many ways to ensure straight growth, but careful management is needed, because there are also many natural factors that influence their shape. (Jansen et al., 2009)

Tree plantations have the ability to keep the soil together, but trees can also have other influences on the soil. The lime tree (both Tilia platyphyllos and Tilia cordata) for instance, can be used to protect soil from nitrogen acidification. Lime trees have almost vanished from the Dutch forests because their leaves were used as cattle feed, and then the rest of the tree served as firewood. In the East of The Netherlands, there is already a plan for the plantation of 1350 lime trees. (Aanplant 1350 lindes tegen verzuring bosbodems Twente, 2017)

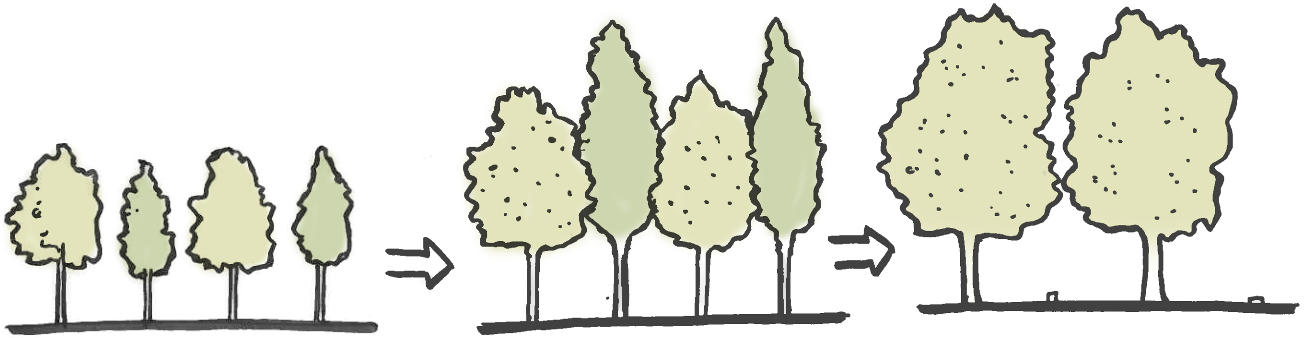


Figure 48 Alternating plantation process

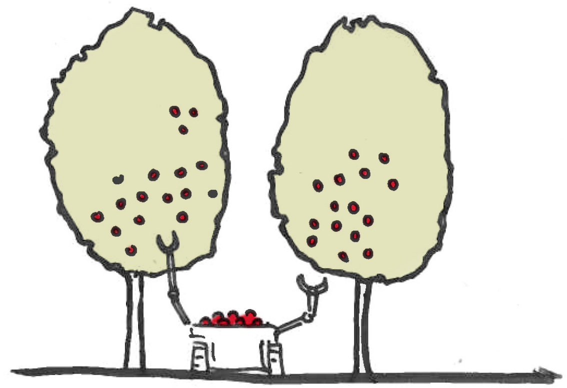


Figure 49 Row plantations for easy harvest

4.4.3 Non-native

The forest types described in chapter 5 should be used as a base for the newly developed forests. This is how the province's plan stimulates the development of such rare forest types on top of rich loess, loam, and clay soils (Actieplan 1 miljoen bomen, 2019, p.13). This does not mean that trees that do not belong to the natural forest type should always be avoided. Proper forest management can even include non-native tree species. These trees, however, are often less valuable to biodiversity since other organisms like insects are not adapted to these species.

Coniferous trees (see image 21) are native to other European countries, but do not belong to the Dutch river delta climate. For wood production, however, these trees were planted in big amounts, because they grow rapidly and with straight stems. For the use as studs in the mining industry, their squeaking served as a warning for the mineworkers when a tunnel was about to collapse. A disadvantage of Conifer forests is their sensitivity to fire. Since 2006, the management of the Brunssummerheide has been striving for a more diverse forest system in which the number of coniferous trees decreases. (Eifelnatur, n.d.)

The coniferous trees are planted mainly as monocultures on sandy soils, while species like Robinia pseudoacacia and the American oak (Quercus rubra, see image 22) are found in forests where native oaks and beech trees grow. These trees are rapidly spreading through South-Limburg, but if managed well, they can add both values for wood production and landscape value. In the more moist areas, different poplar species like Canadian poplar (Populus x canadensis) can be seen near farms and brooks. These trees are fast-growing and therefore used for short-term wood production. Since the second world war there have been planted huge amounts of poplars, but their number is now decreasing, because of the shrinking demand. Poplars with mistletoe are a typical image in South-Limburg (see image 23). Polar wood is most commonly used for short-lived products such as pulp, paper, lumber, veneer, plywood, pallets, and chopsticks, but is currently also used for architectural constructions (Selin Norén, Cuperus, De Vries, et al., 2019, p.4).

Image 21 Deciduous (left) versus conifurous (right), Wildpark Gangelt

Image 22 Invasive American oak, Brunssummerheide

Image 23 Poplars with mistletoes, Wolfhagen

4.5 TRANSITION

Spatial transformation of the agricultural landscape is possible and there are also farmers who want to contribute to the fight against climate change and the loss of biodiversity. Today's ecological farms, however, have a romantic image and little impact.

In order to increase this impact, agroecology should be practiced on a large scale. New technologies to be developed, governmental decisions, policies, and consumer behavior prevent new agricultural models from outgrowing small-scale hobby farming and turn into a strong practice.

4.5.1 Policy

For many farmers who are willing to change their farming methods, the risk of transforming their business is too great. Due to the period of time in which woody plants are still growing and are not harvestable, but also due to policies. Governments should, therefore, choose wisely where investments are made.

Small scale ecological farming should be supported, and it should be profitable to shift towards farming systems including trees. If ecological farming systems would be rewarded on the basis of their contribution to better soil quality, improved water quality, reduction of pesticides, reduction of energy consumption, reduction of greenhouse gasses and its positive effects on biodiversity, it would become easier for farmers to take the step towards these new farming methods (Runhaar, 2017, p.342). By doing so, investments can be made for new harvesting technologies.

An article by the NOS (2020) explains that research by Wageningen University shows that the greening subsidies, over 2 billion euros in six years, do not seem to have a positive impact on biodiversity, due to the lack of "verifiable goals". Under the terms of this grant, farmers should carry out crop rotation, maintain grasslands permanently, and regulate 'ecological focus areas', but these conditions have weakened and farmers therefore need not change a lot to receive the additional funding from the government. However, this does not mean that there is not any progress, but it does show that such subsidies need careful distribution and supervision.

In the agroforestry factsheets by Selin Norén, another problem is described. The price of agricultural land is 2.5 to 3 times higher than land within natural areas. For this reason, the agricultural sector disapproved of Actieplan Bos en Hout which aimed for the replacement for agricultural lands in favor of forests (Bouma, 2018). Woody plants are considered to be 'forest' vegetation and are therefore protected by the Forest Conservation Act. Another counterpoint is that an amount of 50 or more trees on one hectare is considered to be nature (regularly harvestable species excluded) and would, therefore, mean a financial devaluation of the land. There can be concluded that as long as trees are not included in agricultural policy models, they have no chance to fulfill their potential benefits.

4.5.2 Stakeholders

"One of the advantages of nature-inclusive agriculture is the fact that it is not yet defined into only one solution. This means that conversation, collaboration and co-production between stakeholders can be facilitated" (Runhaar, 2017, p.341).

A good showcase of the importance of collaboration is the Hamster protection program coordinated by the Dutch Hamster Committee since 2002. In the early years, farmers were skeptical and only joined when a lot of money was offered. But due to good collaboration, these farmers continued after the compensation was lowered. Problems started to occur when a digital system under new European ministerial rules was introduced in 2012. These problems lead to farmers who did not receive their compensation or even had to refund payments from years before. What followed was distrust in the hamster protection program. Paragraph 5.4.1 will elaborate on the hamster protection program in the design area. (Müskens & La Haye, 2012)

Besides rewarding farmers for ecological farming, or giving fines in less ecological farming practices (which is less desirable), there are also transformations happening in the role of farmers.

'Heerenboeren' (see image 24) is a company that assembles consumers who become owners of agricultural land. These consumers hire a farmer and decide what crops will be grown. The farmer no longer has the risks and consumers are involved with their food and the production landscape. Such structures could also be applied to ecological farms on a small scale. (Plattelandspioniers, 2019)

Another cooperative, called 'Land van Ons', also involves Dutch citizens and makes them 'owner' of a piece of land. Their donation is used to improve agricultural fields and bring back the ecological function these lands used to have. This construction is similar to nature conservation institutions, but unlike other charities it involves ownership and focuses on farmlands. (Land van ons, 2020)

But not every consumer wants to be involved with their food and according to Toensmeier (2016), the carbon footprint of local farms is even higher than from supermarkets, due to all the people traveling by car. Ecologically produced food should be accessible for everyone, but the 'price war' is not something that can be solved within a single country. The fact that we are currently producing food for about 14 billion people (almost double the current population), shows the poor value of food and the amount of food wasted. *"In fact, the main driver for a transformation toward carbon farming will come from the demand side, both for a climate change reversal and for quality and nutritious food"* (Toensmeier & Herren, 2016, p.12).

Awareness about our food has increased greatly, but there is still a large number of consumers which is not prepared to pay more for better food; consumers demand both product and a certain price. Our diets must also change when we aim for more sustainable farming models. There are for instance crops that are far more nutritious than potatoes. Stimulating conversations between, governmental departments, nature organizations, farmers, consumers, and recreational businesses is key to the success of ecological farming (Toensmeier, 2016). And the most important is the start of this process. When this bridge is supported by funding, we can move to a global ecological and self-sustaining farming practice.

Image 24 Consumer involvement at a 'Heerenboeren' (Groeneavonturen.nl, 2016)

5. ECOLOGY

"... it is clear that a substantial part of the plants and animals living in the Netherlands are more or less bound to forests." (Nabuurs, Schelhaas, Oldenburger, et al., 2016)

In this chapter, the ecological layer of the Parkstad region is shown, narrowed down to the ecological structures relevant to the chosen site.

5.1 ECOLOGICAL BACKBONES

To establish an ecologically healthy habitat, there is a need for a stable ecological backbone, on which to build. Expanding the ecological value of an area needs continuity. A landscape containing incidental ecological clumps will not function as a large system en will therefore become less rich in biodiversity. When aiming for expansion of the ecological surface, we should look for existing ecology and add on to this. It is important is to realize that a corridor does not mean uninterrupted homogeneous vegetation. Forest edges, for instance, are as important as the deeper parts of a forest. And a continuous ribbon of forest coverage could also mean a thick border for forest shy wildlife.

5.1.1 Brunssummerheide

The Brunssummerheide is a result of a cultivated landscape. It is often considered as a Nature area, but especially now, it is all controlled by humans. The heather planes (see image 25) have developed when farmers took their sheep to these fields to feed them, but their manure would be collected in the stables and used for the growth of crops. The soil composition changed and trees vanished, resulting in heather fields. But since manmade fertilizers are used and more nitrogen entered our environment, the heather fields are under pressure. The forested areas in the Brunssummerheide are also planted by humans. Only a few spots contain a native tree community, but most of the forests consist of pine trees (see image 26 and 27) which are not native to this area. These trees were used for the mining industry and were often planted in rows and monocultures, just like our croplands. Forest monocultures like in agricultural monocultures are bad for rich ecology.

Image 26 Brunssummerheide coniferous trees

Image 25 Brunssummerheide

Image 27 Brunsummerheide forest

5.1.2 Brooks

Because of the variety in microclimates, brooks are rich in species. But brooks are also very much sensitive to pollution due to polluted rainwater, the use of fertilizers, pesticides in the farmlands, and other dumping of waste. Besides pollution, many brooks have been normalized into channeled and less ecological water structures. As mentioned in paragraph 3.2, the brooks are already taken care of by restoration projects (see image 28, 29 and 30). The main reason for these developments seems to be not only the ecological value but also the recreational value. The water in these brooks arrives from smaller water streams and ditches higher up, also the main source of pollution. (Krekels, Peeters, & Brouwer, 2002, p.116)

Image 29 Roode beek along N300, municipality Beekdaelen

Image 30 Roode beek, Jabeek, municipality Beekdaelen

Image 28 Roode beek, Ganzepool bridge, Brunssum

Image 31 Roode beek, Wildpark Gangelt, , municipality Beekdaelen

Image 32 Roode beek, municipality Beekdaelen

5.1.3 Waterstreams

Water is often seen as something to defend ourselves from, instead of something of great value. Some brooks have been restored, but in some cases, for instance in Jabeek (see image 30) and some water retention areas (see image 33), the main objective seems to be protection from and guidance of the water, instead using and enriching the water.

Brooks are only the end of a watercourse streaming from the plateau and therefore the actual source of the water seems as important to improve. When observing the water channels in the farmland (see images 34 and 35), many of them run dry, because in the surrounding lands the soil package does not retain water, and the lack of vegetation accelerates evaporation. The low water flow rate, height, and lack of vegetation provide poor ecological development in the farmlands water structures (Krekels, Peeters, & Brouwer, 2002, p.221). That is a pity, because water brings variety in the landscape and its vegetation due to microclimatic differences in humidity of the soil. When adding small pools which contain water throughout all seasons, a habitat for amphibians is realised while providing drinking water for birds and mammals.

Water is of great value, but the news mainly focuses on water problems. In wintertime, there is too much water while we face drought during summer. Therefore it is important to store our water and reduce water run-off. Both in the agricultural land and the natural brooks, water scarcity can be fatal; for harvest and ecology. To keep water in the brooks, the municipalities and water boards sometimes ban on the of water from the brooks and ditches by farmers. This seems to help, but farmers are pointing towards other industries, drinking water companies, the German lignite mining, and other sectors because they extract much more water and do it all year round. (L24, 2019)

Groundwater seems to be quite well protected in the northern part of Parkstad because the Roerdalslenk area has a thick layer of clay that does not allow polluted rainwater to enter the groundwater (Limburg.nl, n.d.). But polluted water does get into the brook and river system. There is a great opportunity for the agricultural land because the transformation of the ditches and the agricultural fields can keep water in the area and at the same time purify the water.

Image 33 Water retention, Etzenrade, municipality Beekdaelen

Image 34 Ditch, Grachtweg, municipality Beekdaelen

Image 35 Ditch, Waanderweg, municipality Beekdaelen

5.2 FOREST HABITATS

Almost all forest leftovers in Parkstad are considered a Natura 2000 area (see figure 50), because of their importance for wildlife. This mainly means that these areas strive for a certain natural habitat typology. Sometimes this means that other qualities have to give way, such as wood production. A combination of functions, however, can serve a variety of purposes. Multifunctional forests do not focus on only one aspect, but consist of nature, climate control, cultural history, fine dust reduction, water retainment, recreation and wood production. Such forests can be both valuable for ecology and economy. (Jansen et al., 2009)

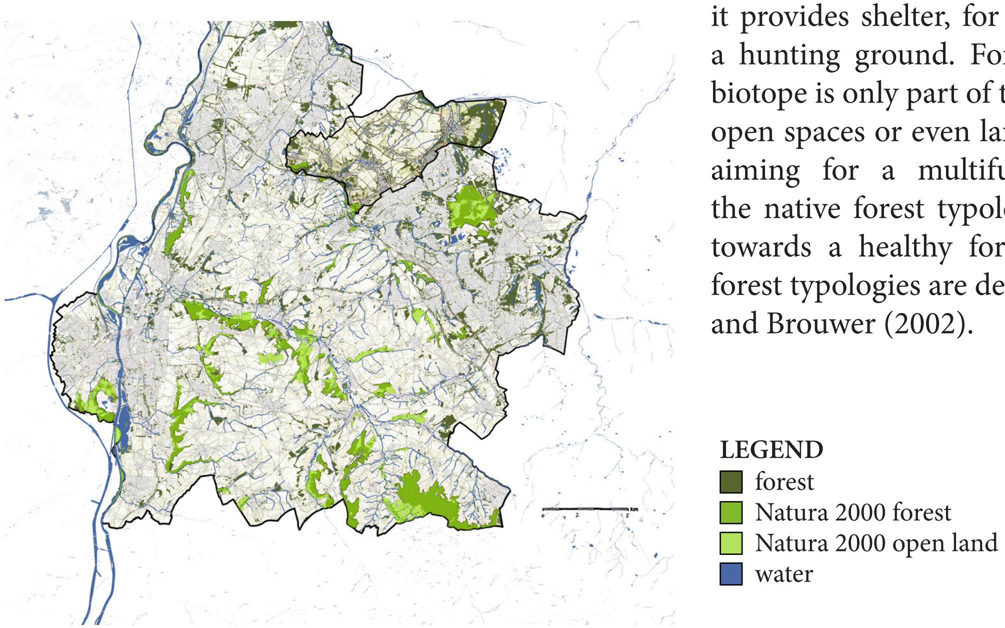


Figure 50 Natura 2000 areas, adjusted from Geodatabeheer GIS Competence Center (2010).

Actual natural forests are scarce and when looking at google maps (see image 36 to 38) you can easily recognize the road system by only looking at the trees. In this patchwork, the forest communities mainly consist of only one or two species of the same age and height.

In a natural forest, there would be diversity in which dense areas alternate with more transparent configurations and open spaces. The differences in light transmittance cause the growth of many different plant species. Besides that, the height of trees provides vertical diversity, and every height corresponds to a different habitat requirement. Some species are dependant on forests because it provides shelter, for others the forest serves as a hunting ground. For many species, the forest biotope is only part of their habitat, they also need open spaces or even large open planes. Allthough aiming for a multifunctional forest typology, the native forest typologies can serve as a guide towards a healthy forest system. The following forest typologies are described by Krekels, Peeters, and Brouwer (2002).

Image 36 Heringsbosch (Google, n.d. a)

Image 37 Groote Heide (Google, n.d. b)

Image 38 Utrechtse Heuvelrug (Google, n.d. c)

5.2.1 Beech-Oak Forest

This forest type could be found on Loess and Loam, nutrient and chalk poor soils, which can be found on the slopes and plateaus of Parkstad. These soils are sensitive for eutrophication; when the soil becomes richer in nutrients, other vegetation will take over. The main tree species in this forest are European beech (Fagus sylvatica) and Cornish oak (Quercus petraea) and sometimes European oak (Quercus robur). This forest has an open character because there is no real shrub layer. Image 39 and 40 show an example of Beech forests at the Brunssummerheide and the Heringsbosch.

5.2.2 Melic grass-Beech forest

Another forest type in which European beech is dominant is the Melic-grass-Beech forests. These forests are found on more chalk rich and moist soils. Besides European beech, there is also room for several other deciduous trees like small-leaved lime (Tilia cordata), large-leaved lime (Tilia platyphyllos), and Scotch elm (Ulmus glabra). The shrub layer is built-up by young trees and common hazel (Corylus avellana).

5.2.3 Oak-Hornbeam Forest

Loess, loam, or sandy clay soils with little to no chalk and higher groundwater levels are the breeding ground for Oak-Hornbeam forests. These forests consist of European oak (Quercus robur) and other species; European ash (Fraxinus excelsior), European beech (Fagus sylvatica), European hornbeam (Carpinus betulus) and Wild cherry (Prunus avium). Common hazel (Corylus avellana) is again dominating the shrub layer. The need for higher groundwater levels makes these forests vulnerable in case of drought.

5.2.4 Birch-Oak Forest

Birch-Oak forests are found on chalk, loam, and nutrient-poor soils. On these sandy soils, birch trees are more present; Silver birch (Betula pendula) and sometimes Downy birch (Betula pubescens). But the dominant tree in these forests is the European oak (Quercus robur). Image 41 shows a forest composition including oak and birch.

Image 39 Beech forest, Brunssummerheide, Brunssum

Image 41 Birch and oak forest, Heringsbosch, municipality Beekdaelen

Image 40 Beech forest, Heringsbosch, municipality Beekdaelen

5.2.5 Bird cherry-Ash Forest

In the brook valleys, the shrub layer is more developed and a different collection of trees can be found. In places which are flooded once in a while, loam, sand and clay substrate provides a home for European ash (Fraxinus excelsior), Black elder (Alnus glutinosa), European oak, (Quercus robur), Wild cherry (Prunus avium), sycamore (Acer pseudoplatanus) and of course Bird-cherry (Prunus padus). This forest is sensitive to drought but can withstand high groundwater levels.

5.2.6 Alder Marshland Forest

High groundwater levels are also found in Alder Marshland forests. The soil consists of sand, loam, or peat and is medium nutrient-rich or poor, but mineral-rich. Black elder (Alnus glutinosa) is ruling these forests because groundwater levels can rise even above ground level. Around the brooks, these forest types can be found. Images 42 to 44 show such wetland forests.

5.2.7 Source forest (Bronbos)

At the source of the brooks (see image 45), small scale development of Black elder and European ash forests can take place. The soil can be sandy, loamy, or peaty, but what it needs is a constant supply of fresh and clean water. Eutrophication and drought can be fatal to these compact forest biotopes.

Image 42 Black alder forest, Jabeek, municipality Beekdaelen

Image 44 Forest with high water levels, Jabeek, municipality Beekdaelen

Image 43 Wetland forest, Wolfhagen, municipality Beekdaelen

Image 45 Roode beek source forest, Brunssummerheide

5.3 SCHRUB- AND GRASSLANDS

Besides forested areas, there are also typologies for open landscapes (see image 46). These shrub- and grasslands are scarce, because an open landscape without trees is easier to transform into agricultural fields or building grounds. But replacing schrub- or grassland typologies by agricultural fields does not replace their value. In open fields, the diversity in specialized plantspecies is enormous. Some of them are living in symbiosis with, for instance, butterflies. This means these open landscapes are indispensable. The following typologies are described by Krekels, Peeters, & Brouwer (2002).

Image 46 Open field, Heringsbosch, municipality Beekdaelen

5.3.1 Common Broom Shrubland

On dry and nutrient-poor sandy loam or decalcified loess, there used to be shrubland in which Common broom (Cytisus scoparius) would be the main shrub. This open landscape is mainly recognized by the brooms yellow flowers showing from May until June, but Common heather (Calluna vulgaris) can also be found.

5.3.2 Heather Grassland

Similar to the Common broom shrubland is the heather grassland with similar soil characteristics; loamy sand, nutrient, and calcium poor, but also demanding mineral and humus-rich and slightly moist soil. These grasslands cannot withstand eutrophication and acidification which are mainly caused by human activity.

5.3.3 Loess Grassland

Loess grasslands are a species-rich biotope on both dry and moist, nitrogen and phosphate poor loess soils. These soil can also contain sand, loam, and sabulous clay. Eutrophication is disastrous for these grasslands and acidification is another added problem. The remaining loess grasslands are found mostly on the gentle slopes in the north of the Heuvelland.

5.3.4 Moderately nutrient-rich grasslands

Hayfields and meadows are moderately nutrient-rich grasslands. A multiplicity of soils are found underneath these grasslands; sand, loamy sand, loam, loess, chalk, sandy clay, sabulous clay, and peat. These grasslands are vulnerable to eutrophication and drought. When applying grazing management, we speak of crested dog's-tail (Cynosurus cristatus) meadow and when a yearly mowing regime is applied to these fields it is called a false oat-grass (Arrhenatherum elatius) hayfield.

5.3.5 Willow Shrubland

A shrubland that can be found in places where groundwater can reach above ground level is the willow shrubland (see image 47). These sand, loamy sand, loam, clay, and peat areas are therefore also dependant on water and vulnerable to drought. Willow species like common sallow (Salix cinera) and the eared willow (Salix aurita) are dominant in these areas, but just as the wetland forests can be overgrown by other willow species and polar trees.

5.3.6 Wet graslands

Wet grasslands on sand, loamy sand, loess, and peat are found in two types; small sedge landscape and chalk grasslands. In the Parkstad region, these grasslands are expected on moist to wet, mineral-rich, and nutrient-poor sand and loess soils.

5.3.7 Moist herbrich grassland

Under nutrient-rich conditions, these moist or wet grasslands can develop into moist herb-rich grassland. When nutrients are extracted from these grasslands, the composition of species will change. The ecological value of these grasslands is less than the previous typologies. Only when these typologies cannot be reached, there should be aimed for a moist herbrich grassland.

Image 47 Willow shrubland, Leiffenderven, municipality Beekdaelen

5.4 CULTURAL LANDSCAPE

The cultural landscape is already discussed in chapter 4, but in this paragraph the emphasis is on the ecological value currently found in farmlands and which should be preserved or expanded. In traditional farmlands, there is little space for the development of the typologies described in the previous paragraph. Krekels, Peeters, and Brouwers (2002) therefore describe the herb-rich grasslands in the cultural landscape. When other typologies are out of reach due to drought and an abundance of nutrients, there should be aimed for dry herb-rich grassland. These grasslands demand dry sand, loamy sand, loam, sabulous clay, clay or peat soils and are considered to be part of the agricultural landscape.

5.4.1 Agricultural fields

Agricultural fields are rationally planted due to the abilities of the machinery. As mentioned in paragraph 4.1 and 4.2, the Netherlands consists of large scale agricultural practices which are monocultural. A characteristic of monocultures is that the life cycle of the growing crop determines the ecological value throughout the seasons. Sometimes there will be an empty field and sometimes it will be fully covered, providing refuge and food. In that second stage, the ecological value can be great, but once harvested, the field is worthless again.

The European hamster (Cricetus cricetus) is a symbol for South-Limburg and protected under the EU habitat directive and the Dutch Flora and Fauna Act (Müskens & La Haye, 2012, p.40). The hamster population declined due to a decrease in wheat farmlands and the way the wheat is cultivated nowadays. This hibernating species prefers common wheat (Triticum aestivum) or lucerne (Medicago sativa) and the only soil which is stable enough to dig holes in are loess soils (Müskens, et al., 2018, p.11).

The use of herbicides and earlier and more efficient harvesting techniques also damaged the hamster population. In 1999, the last hamsters were captured so they could be part of a breeding program in Gaia Zoo (Müskens, et al., 2018, p.9).

Since 2002 there has started a reintroduction program together with farmers. These farmers are funded by the government to compensate for their lost income in the areas where cereal is grown in a hamster friendly way. 'Hamster friendly' means that cereal is harvested later, so the hamsters can build winter storage, and that the blades of the grass remain to provide shelter. Poor use of technology in monitoring these farmers resulted in unjustified fines and therefore a loss of trust in the hamster management trajectory. The largest protected hamster area is found in the municipality of Beekdaelen (see figure 51). (Müskens & La Haye, 2012)

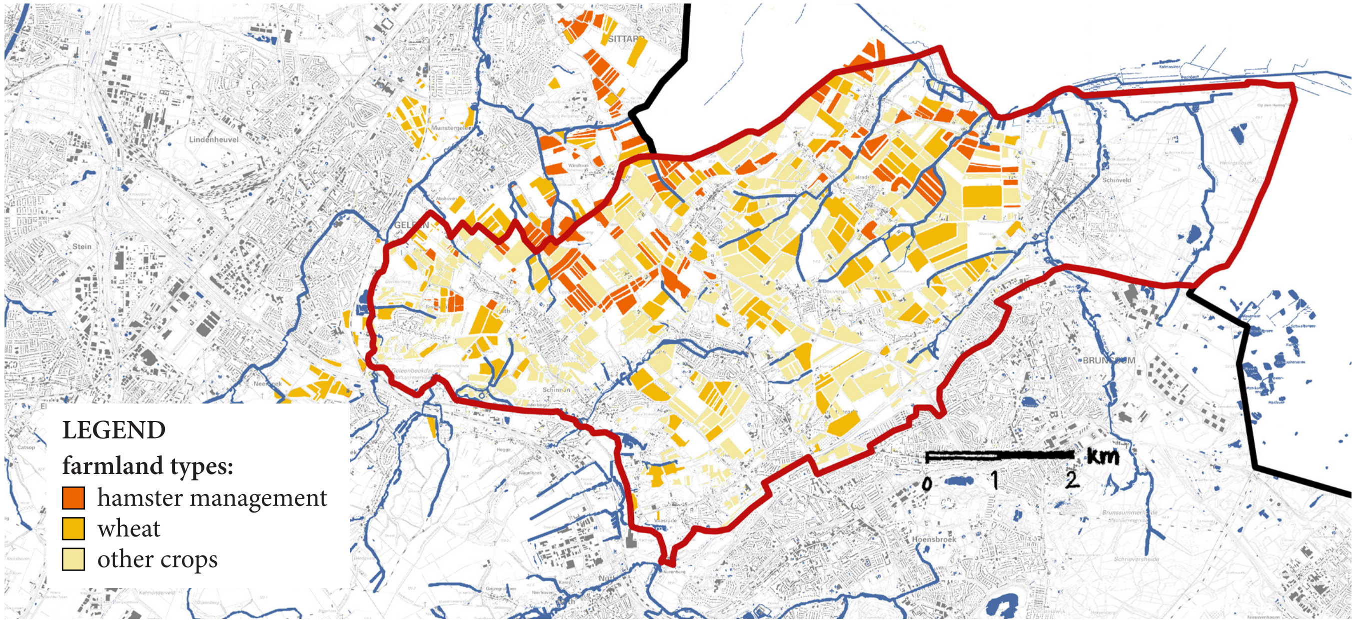


Figure 51 Hamster management in design area, (edited from Müskens, et al., 2018, p.15)

5.4.2 Ecological edges

Ecologically friendly edges are important to improve the ecological value of the farmlands as well (see figure 46). While crops can only provide shelter in limited parts of the year, these corridors can provide shelter all year long. The same goes for the food supply. But currently, there is no healthy percentage of ecological constant strongholds in agricultural land.

A simple and commonly used solution is to add vegetation along the parcel edges, just like along roadsides. While adding ecological structures to the landscape it is important to attach them to already existing elements like hedgerows, thickets (see image 52), and clumps of trees. The numbers of these small landscape elements have decreased, but they play an important esthetic role in the Limburg landscape. These ecological cores also play an important role in controlling pests and diseases in the agricultural land. Therefore it is also a goal to restore and reintroduce these small landscape elements.

In Belgium, they have already started adding around 4000 kilometers of hedges, saying these are *"the highways for animals"* (Torfs, 2019). Hedges, but also thickets are a result of agricultural activity and were used as barriers for cattle and a clear boundary between parcels (Krekels, Peeters, & Brouwer, 2002, p.142). South-Limburg is less used for cattle farming and together with the upscaling of the farms and the decreased economic use of products harvested from these elements, their function got lost and therefore many of these elements have been removed. Hawthorn (Crataegus) and Blackthorn (Prunus spinosa) were used in these elements and had great value for species like the Hazel dormouse (Muscardinus avellanarius) whose numbers also declined due to the loss of habitat. Some species need a certain density and width to inhabit a landscape element, but for others the continuity of the structure as a whole is of greater importance. Bats for instance need these structures for their navigation. (Hermy, Blust, and Slootmaekers, 1997)

Image 48 Thicket structure, Veestraat, municipality Beekdaelen

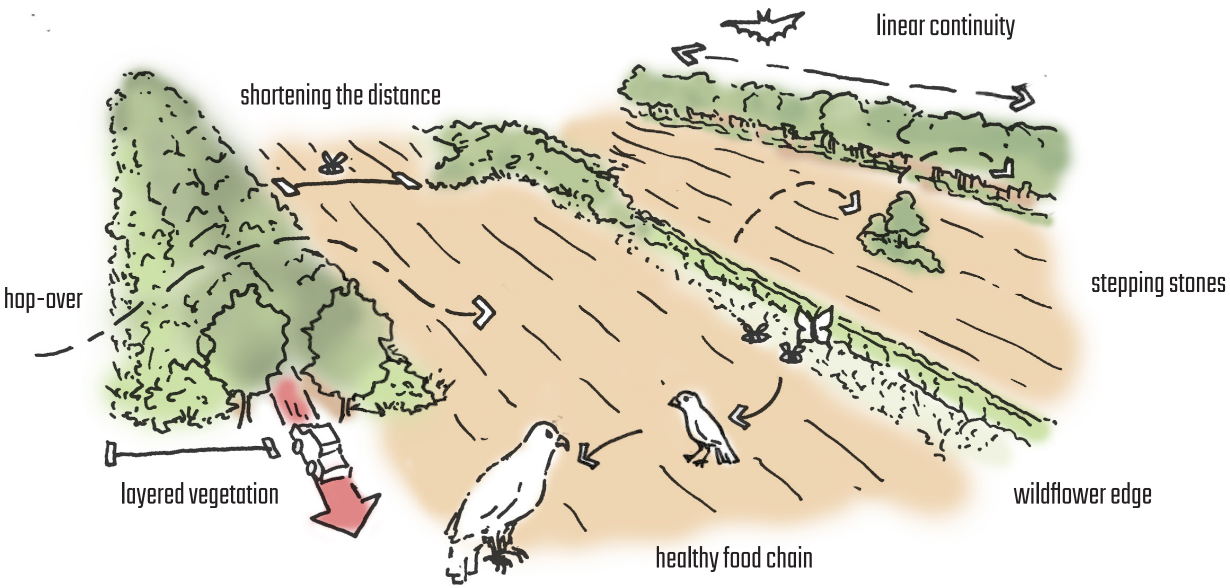


Figure 52 Value and importance of ecolgical edges and elements

Even more characteristic for South-Limburg and the Heuvelland are the hollow roads (see image 49 and 50), graften (see image 51), and high stem orchards (see image 52). Hollow roads developed from water streams into main traffic roads through the agricultural land. These roads eroded and became lower over time, protecting travelers against wind and rain, because these roads were covered by the tree canopy (Krekels, Peeters, & Brouwer, 2002, p.143). The contrast in this tunnel-like element between the enclosed inner world and the wide-open view at the end is impressive. The microclimate in this remarkable element provides a habitat for many particular species. Hollow roads are home to the European badger (Meles meles) and many birds and small mammal species.

Graften know similar residents but are placed along the slopes. These elements were used to counter erosion and to flatten the slope into a terrace-like hillside (Krekels, Peeters, & Brouwer, 2002, p.142). Structures like these, perpendicular to the slope direction, can move water from gullies to drier ridges (Toensmeier & Herren, 2016). Technology and a different plowing method made these graften less useful for agriculture and were therefore removed.

High-stem orchards such as seen in image 43 used to be a common image in the Limburg landscape. But often they are removed or replaced by low-stem orchards which are ecologically comparable to other monocultures.

Image 51 Graft near Bingelrade, municipality Beekdaelen

Image 49 Hollow road, Vielderweg, municipality Beekdaelen

Image 50 Hollow road, Hagendoornweg, municipality Beekdaelen

Image 52 Orchard in Amstenrade, municipality Beekdaelen

6. AGGREGATED DESIGN

In this chapter, a design is shown for a new farming system. Design objectives, principles, and new farmland typologies provide the framework for a spatial design.

6.1 DESIGN OBJECTIVES

The design objectives are partially overlapping with the 'guiding principles' formulated for National Landscape Limburg (Pinxt et al., n.d.). These guiding principles are a tool for interventions in the landscape introduced by the province to prevent degradation of the landscape's characteristics and values. However, the design objectives for this reports' design brief, are not only aimed at preservation and restoration, but also at the adding of new elements.

The main focus in the design is the expansion of habitats and the increase of biodiversity. Therefore ecological corridors need to be formed (see figure 53). An important aim and design objective in adding new corridors or ecological centers is to attach them to the existing ecological structures (see figure 54). When ecological developments take place in isolation, like an island, their value is less and it takes more time to develop a healthy system. The choice for the design location was also based on the available ecological attachment points. There should also be sought for landscape variety (see figure 55) and the restoration of small landscape elements (see figure 56) contributes to this aim.

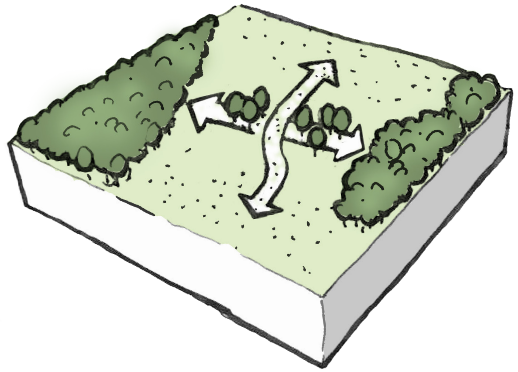


Figure 53 Ecological corridors

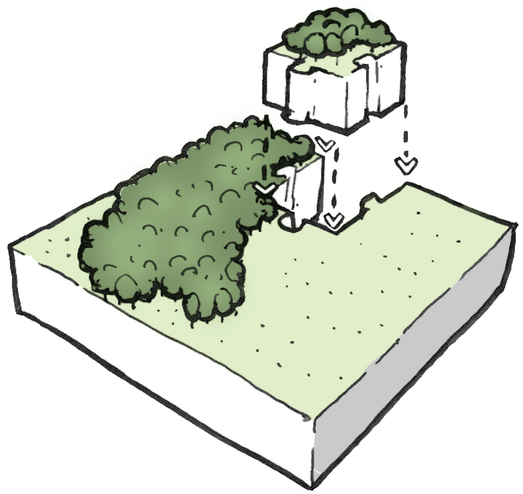


Figure 54 Attach to ecologically valuable areas

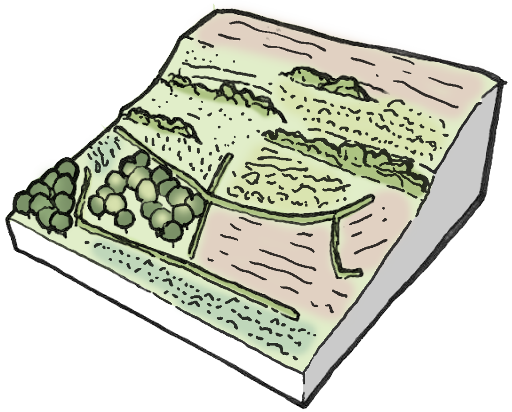


Figure 55 Landscape variety

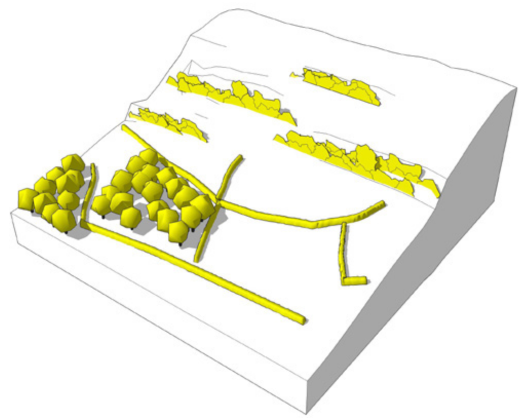


Figure 56 Restoration of small landscape elements (Pinxt et al., n.d., p.64)

Awareness is needed on the possible opposite effect of a corridor; it can be a blocking structure for perpendicular ecological structures. Diversity in the landscape also ensures that such blocking structures are avoided.

The addition of forested slopes (see figure 58) follows the objective of the prevention of erosion (see figure 57). The roots of the trees hep to keep the soil stable. This does not only keep the vertile soils in place, but also prevents mudstreams which can be harmfull for villages, but also to the brook's ecosystem.

The guiding principles described by Pinxt et al. (n.d.) are only considering the wetting of the brook valleys and the restoration of the water sources, but the design objective for the agricultural lands is to retain en use the water which is present in these areas (see figure 59). Besides retaining the water for better agricultural conditions, the diversity in wetness of the soil invites a diversity of plant and animal species.

A wider objective is to increase the recreational experience level (see figure 60), including the increased emphasis on cultural heritage. Besides being safe, ecologically healthy and productive, the landscape needs to be inviting for people to visit the area and enjoy the variety in experiences that can be made.

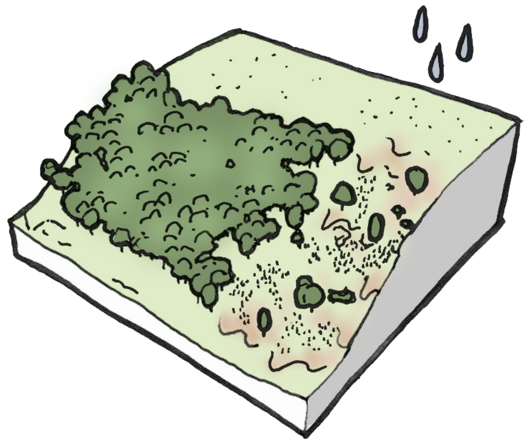


Figure 57 Prevent erosion

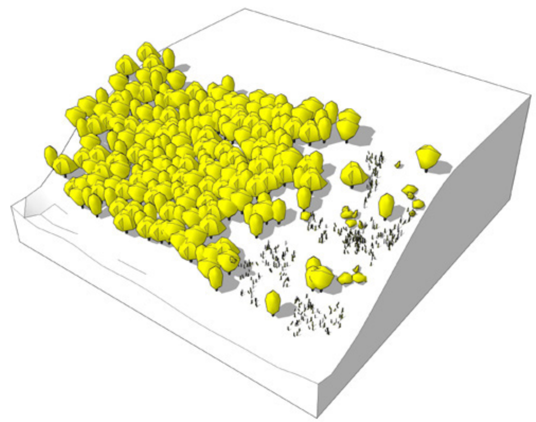


Figure 58 Forest and green compaction along slopes (Pinxt et al., n.d., p.64)

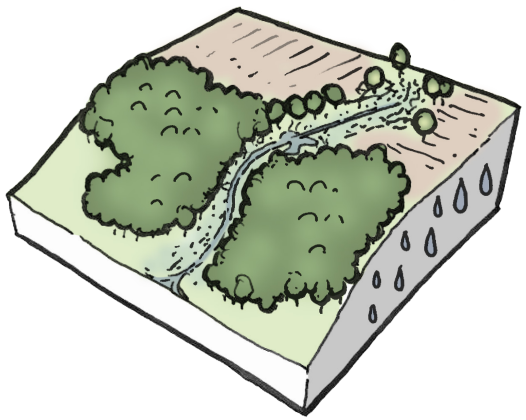


Figure 59 Retain and use available water

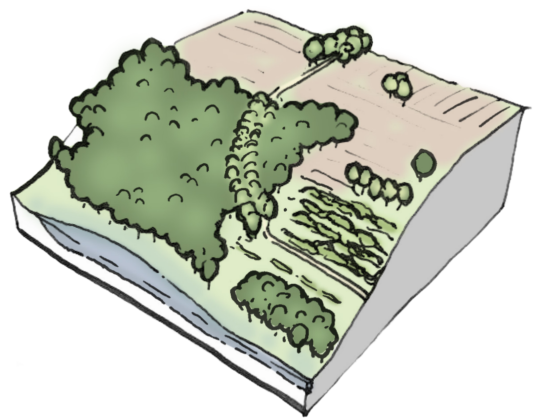


Figure 60 Improve recreational experience level

The emphasis on higher parts of the plateau when looking from the brook valley is another guiding principle by the province. But on top of the plateau the objective to preserve the wide views from these higher parts (see figure 61) is much more important, which is also described by Pinxt et al. (n.d.) for the plateau of Doenrade (which is part of the design area, see figure 62). This means that while reforesting the land, there should be made some clear cuts to assure the impressive wide views. Especially the views to church towers are important to preserve and enhance. Paragraph 6.4.5 will eleborate on the preservation of these views.

There are also several principles shown for the built environment, but this report focuses on the unbuilt space. Greenifying the village edges (see figure 64) however, does become part of the design. This goes hand in hand with raising awareness of the product that are harvested from the landscape and the increase of production for local consumers (see figure 63).

A secondary design objectives are the products that are harvested. Local production should provide more diversity in the food supply and increased wood production. Another less landscape architectonic objective is to increase the storage of carbon.

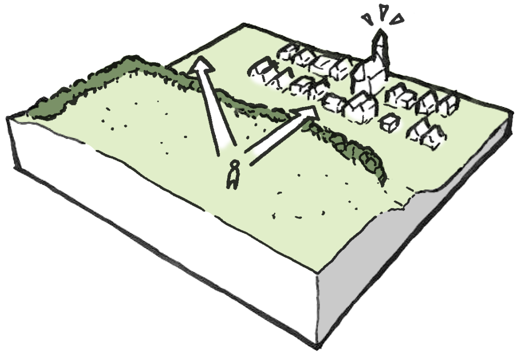


Figure 61 Preserve valuable views

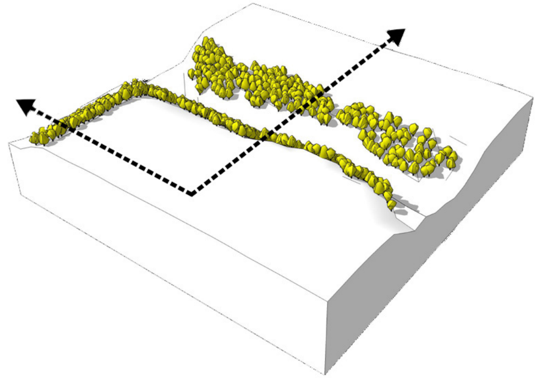


Figure 62 Open plateau tops (Pinxt et al., n.d., p.107)

Figure 63 Increase diverse productivity and local distribution

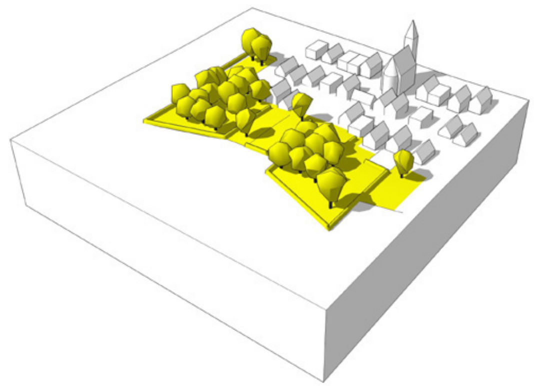


Figure 64 Greenifying the village edges (Pinxt et al., n.d., p.64)

6.2 REGIONAL VISION

The basic structure of the envisioned landscape resulting from the design objectives is shown in figure 66. Nature development happens along the water structure; the veins of the landscape. Forests are added to the hillsides. These forested areas will hold the soil on the slopes together and are attached to the ecological structure along the brooks. The plateau remains semi open, to ensure the wide views will be preserved. The plateaus are most usefull for 'traditional crop' cultivation.

Figure 65 shows what remains of this vision when the urban areas are excluded.

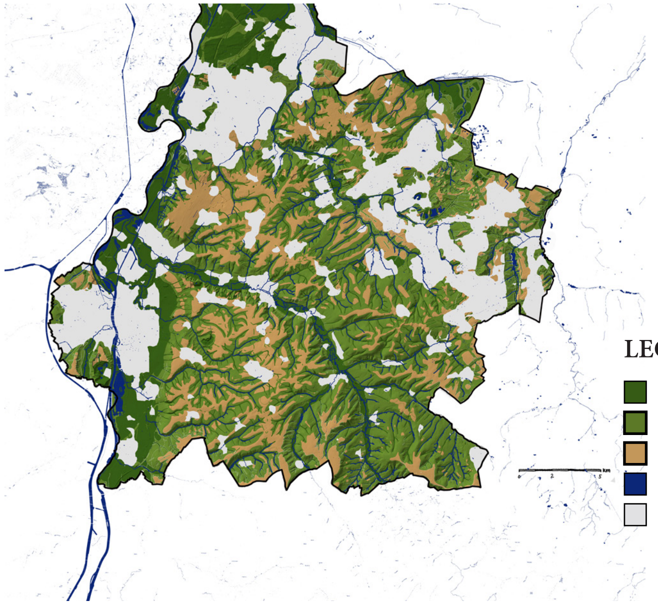


Figure 65 Basic vision, urban areas excluded

Figure 66 Basic vision: nature development along brooks, forested slopes and agricultural practice on the plateau

When zooming in on the design region (see figure 67), the structure becomes more complex, because every slope is different in its orientation and relation to the surrounding land.

The conceptual sections in figure 68 shows that there will also be added green to the plateau. Small scale ecological elements will be reintroduced. But besides their ecological function, they will be harvestable for food or wood. Figure 69 shows the diverse types of forestry along the slopes. Food forests along the contourlines and nut and wood production forests.

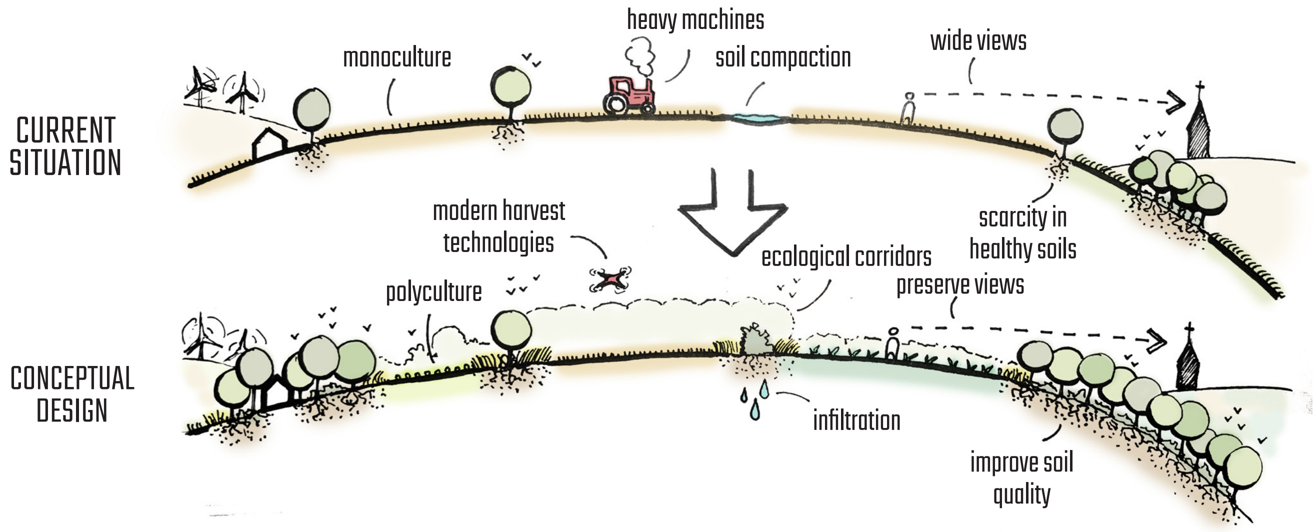


Figure 68 Conceptual section plateau

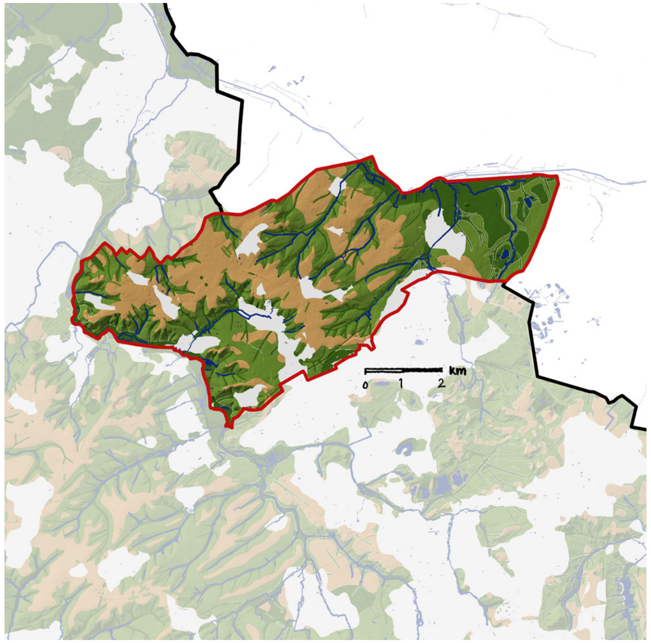


Figure 67 Basic vision selected site

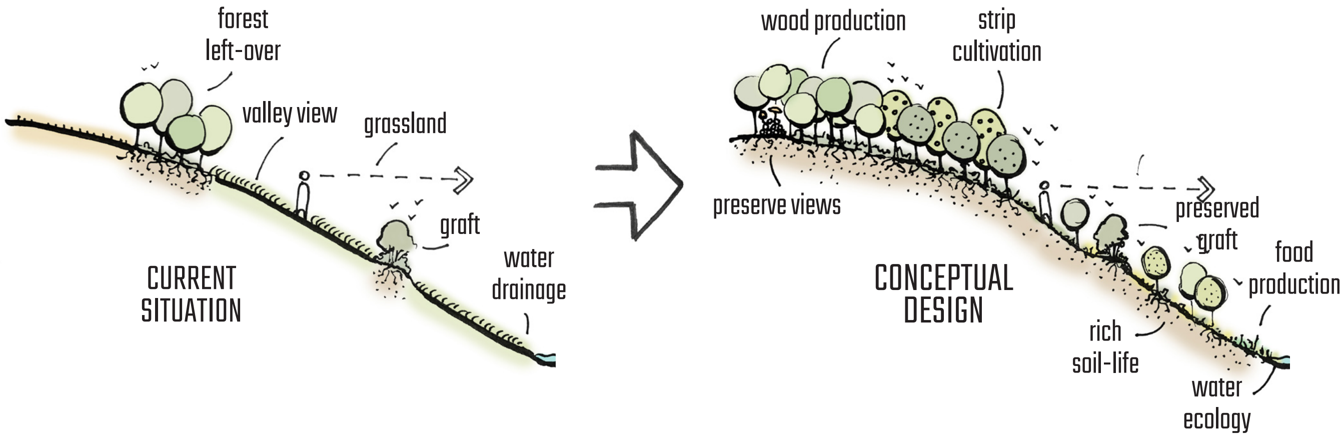


Figure 69 Conceptual section slopes

6.3 NEW TYPOLOGIES

The previously introduced design principles and basic vision resulted in a detailed elaboration in the design region. In the end there are described four new farming typologies; the 'food park', 'rational strips', 'cultivated woods' and 'agroforestry' fields (see figure 70). The detailed elaboration on this patchwork landscape is shown further on. It is important to realize that these design elaborations are only one example of how the design principles can be applied to the area. Besides the variable translation to the site, it should be clear that these transitions will not happen one day to the next; it will be a gruadual transformation of the landscape. Figures 71 to 73 show how such a transition is visualized. As said earlier, there are preferences in how this transition takes place, for instance attaching new development to existing ecological strongholds. But in practice, the developments will never be the ideal situation. Figures 74 and 75 show a detailed map of the possible future.

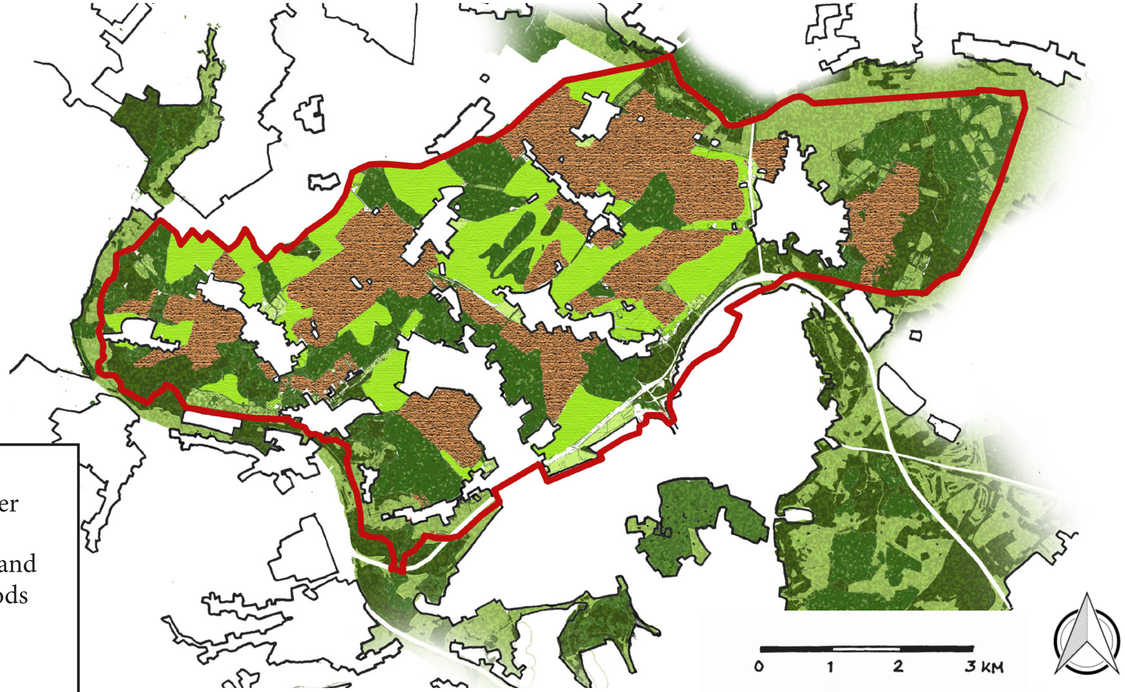


Figure 70 Possible situation of a fully transformed design area in 2050

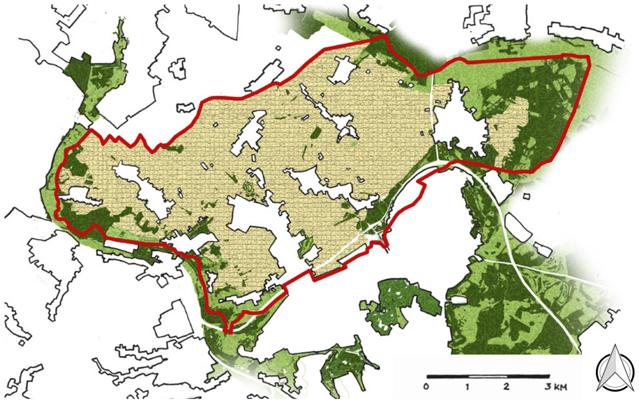


Figure 71 Design area in the year 2020

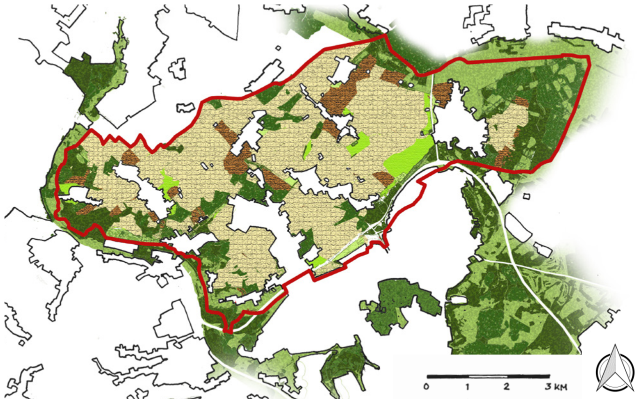


Figure 72 Possible situation of the design area in 2025

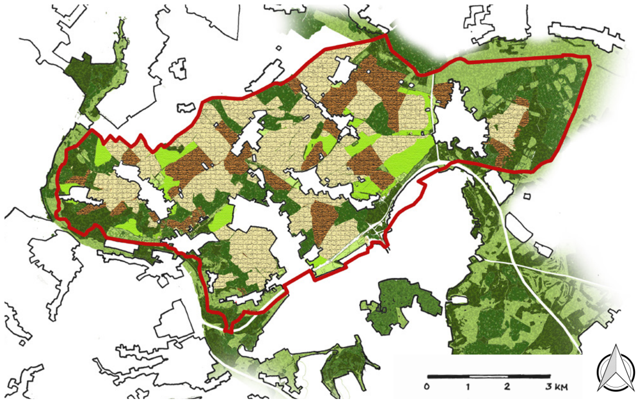


Figure 73 Possible situation of the design area around 2035

Figure 74 Northeastern part of the site, a patchwork of agroecological solutions


0 100
500 M

Figure 75 Southwestern part of the site, a patchwork of agroecological solutions

0 100
500 M

6.4 TEST SITES

Selected zoomin areas are a means to develop design principles and test them in a detailed site specific design brief. The large scale vision was used as a basis for the extracted portions of the region. But the conditions in these sites also had their effect on the regional scale. Switching between scales is essential to establish a strong relationship between them and prevent discrepancy. Four zoomin areas are selected (see figure 76).

The first zoomin (see figure 77), shows a sequence of agro-ecological typolgies; the romantic neighborhood food park, the strip cultivated food forest, agroforestry and the wild production forests.

The second zoomin (see figure 96) shows how wide views can be preserved and emphasized.

Zoomin three (see figure 100) gives an example of the incorporation of waterstructures in the newly developed landscape.

Zoomin four will discuss how existing production forests can be transformed.

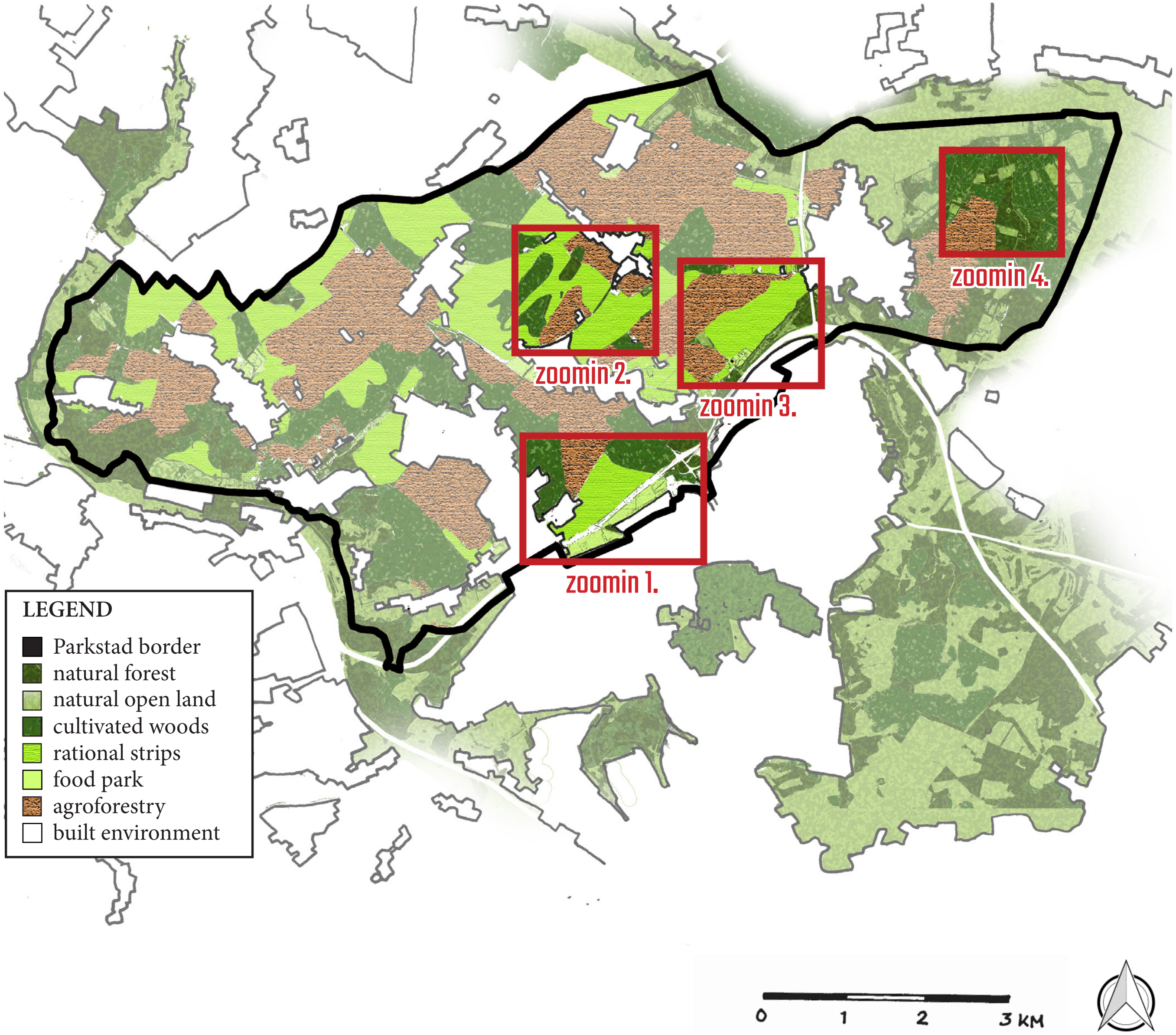


Figure 76 Regional vision with zoomin areas

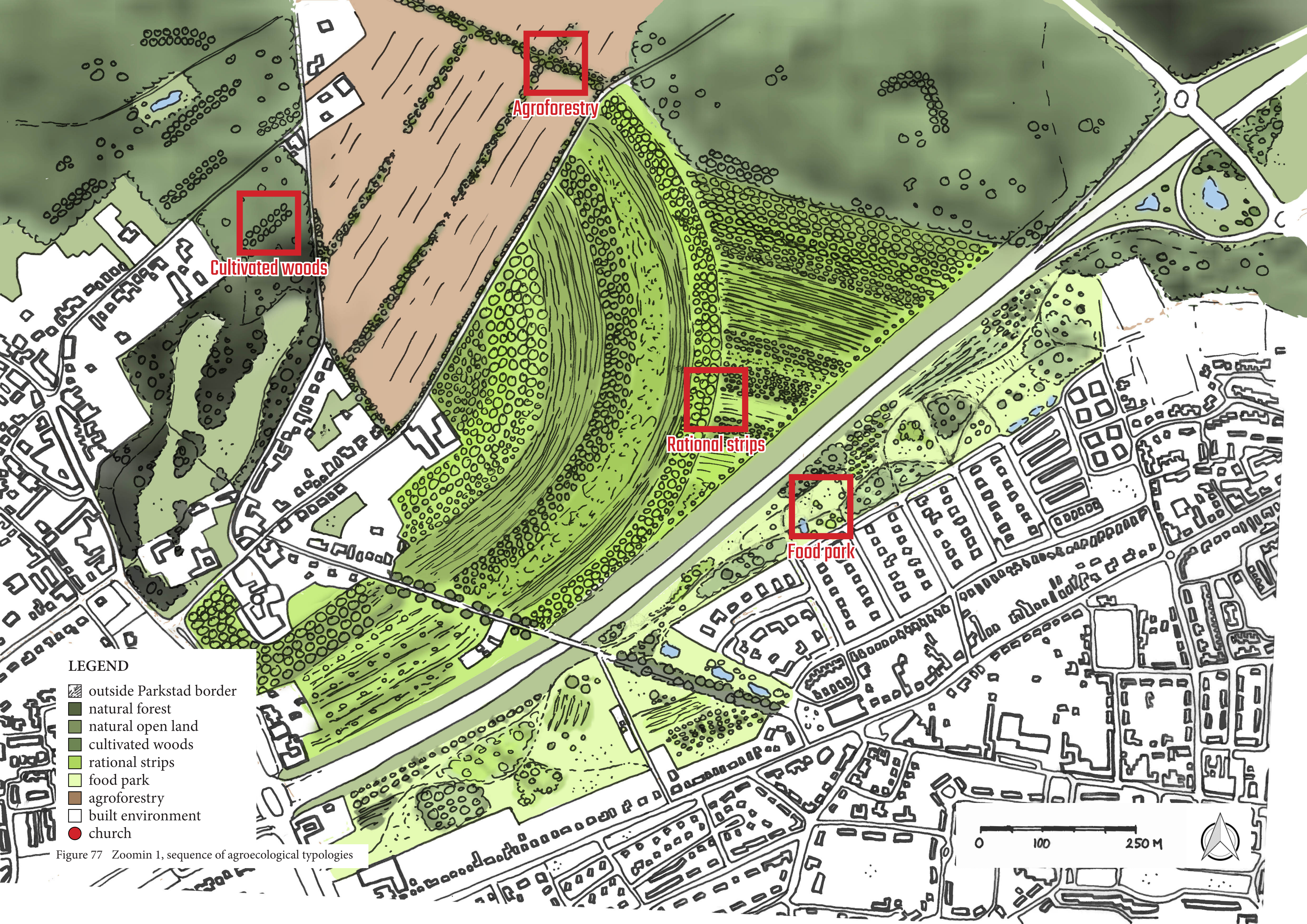


Figure 77 Zoomin 1, sequence of agroecological typologies

6.4.1 Food park

Attached to city edges and villages, food forests can be more than just a food producing patch of land. These food forests are there for your daily walk, for children to play and explore and to get a sense of community.

The food park (see figures 79, 80, 81 and 82) has a wide range of food producing plants and is organised in a more romantic configuration. This park typology offers educational value and a place for inhabitants to connect (see figure 78). Redefining our relationship to nature is a core quality of the food park.

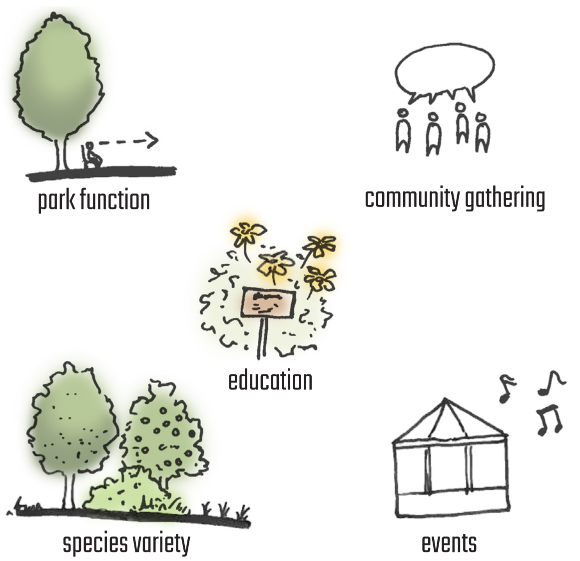


Figure 78 Design principles foodpark

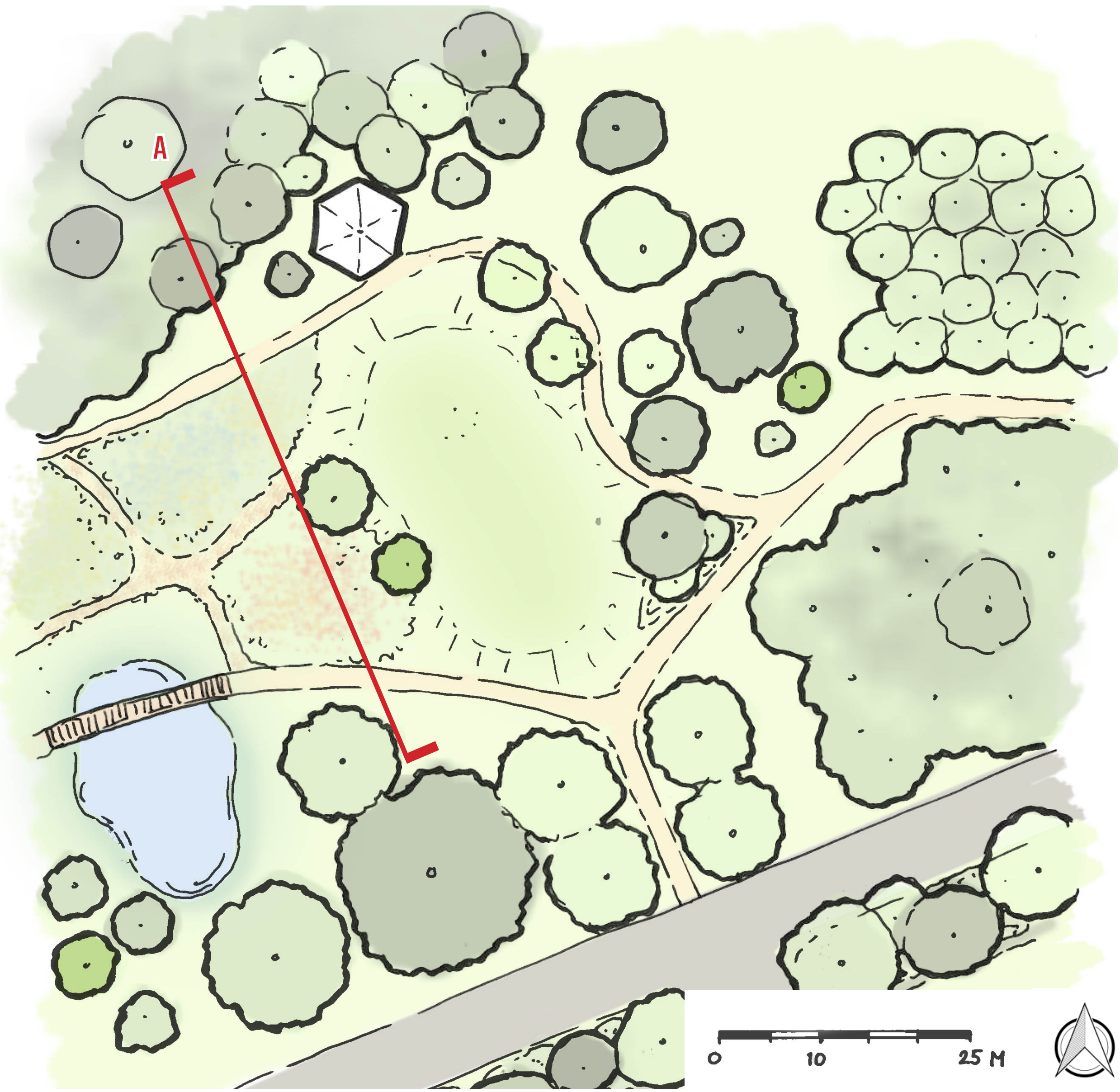


Figure 79 Food park plan

Figure 80 Section A, food park

Figure 81 Foodpark

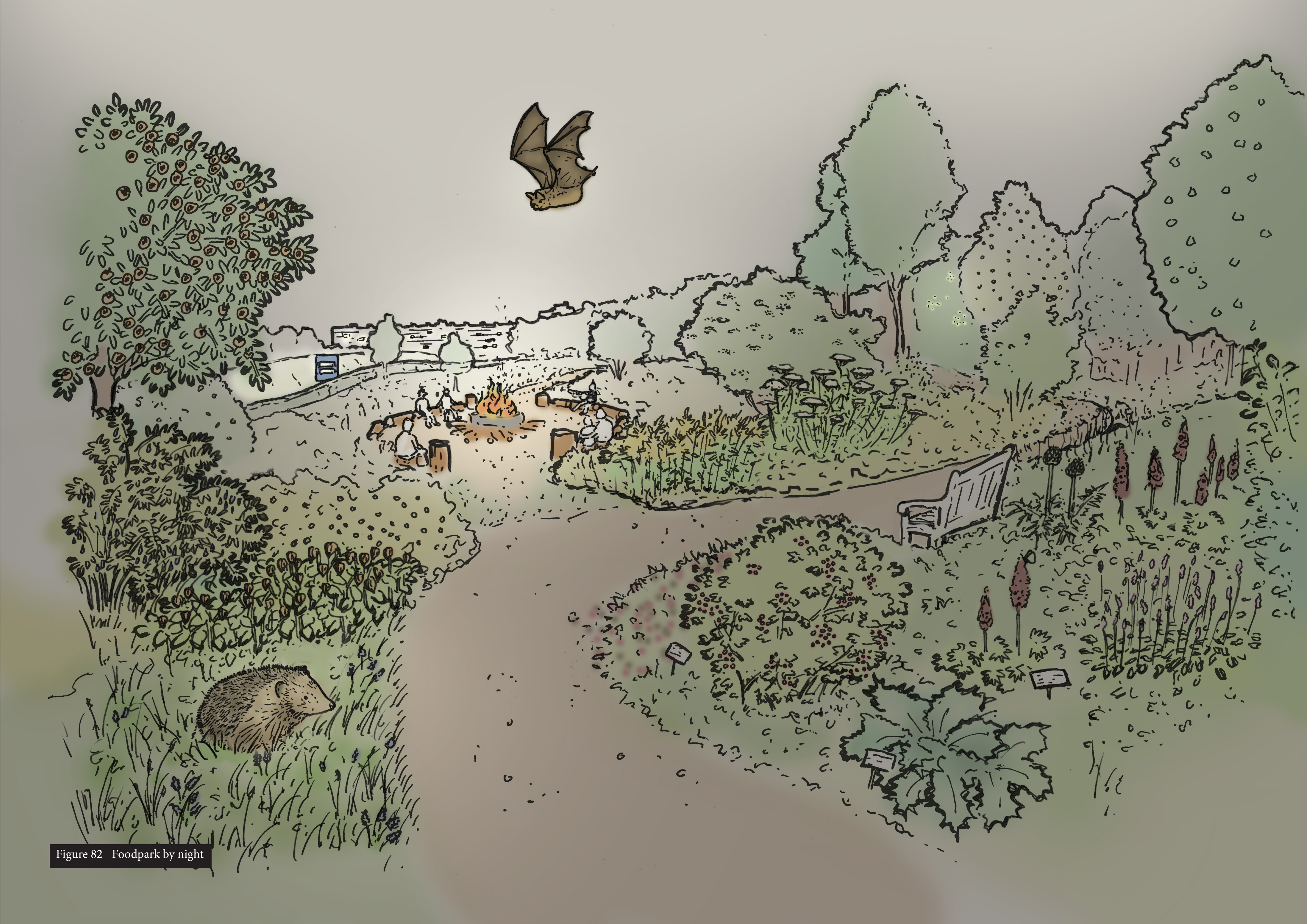


Figure 82 Foodpark by night

6.4.2 Rational strips

The rational food forest (see figures 84, 85 and 86) is filled with linear strips of plantation. The combination of all plantation layers makes a diverse system. The strip cultivation ensures an easy harvest method. Technological developments will help in this transition.

The strips follow the contourlines of the topography in the landscape which prevents water run-off, just like the graften used to do. Alternated plantation of species can be valuable if their growth rate or size are matching, increasing the yields.

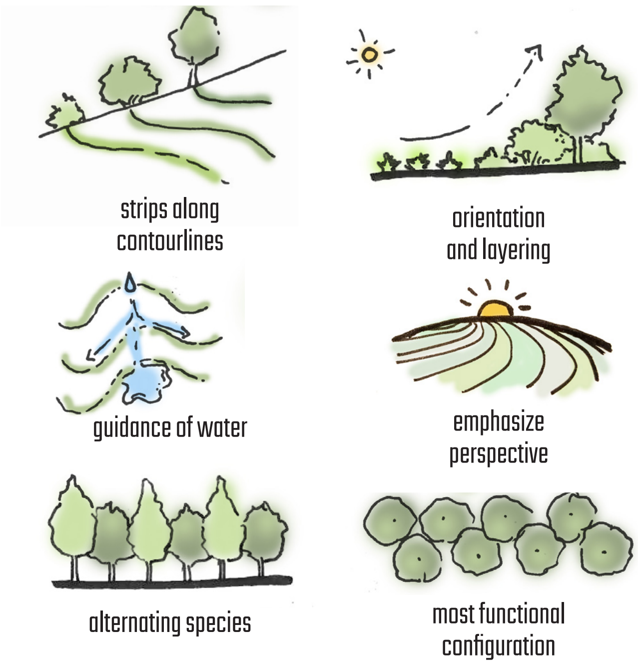


Figure 83 Design principles strip cultivated foodforest

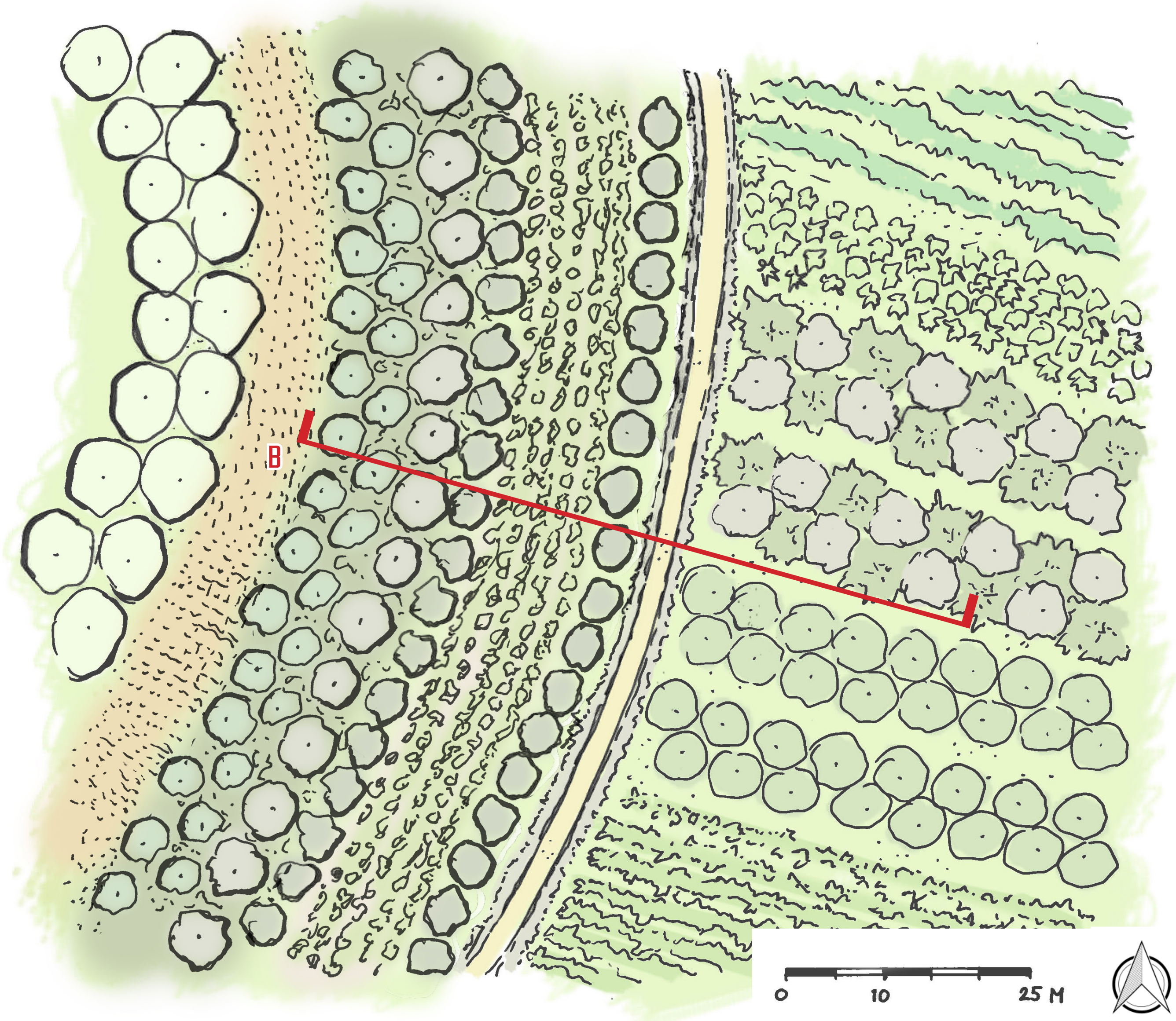


Figure 84 Strip cultivation plan

Figure 85 Section B, rational strips

Figure 86 Strip cultivation

Figure 87 Agroforestry

6.4.3 Agroforestry

The flat plateaus are used for the growth of traditional crops such as wheat and potatoes. The barren landscape, however, is replace by a landscape including small ecological strips; an agroforstry system (see figures 87, 89 and 90).

These strips are used for recreational routes, but they are also good for wind protection, biodiversity and they are productive. Fruit trees, berry-bearing shrubs and wood producing trees are implemented. The position of these elements is based on topography and orientation to the sun, to prevent water run-off and limit the yield-loss along the edges.

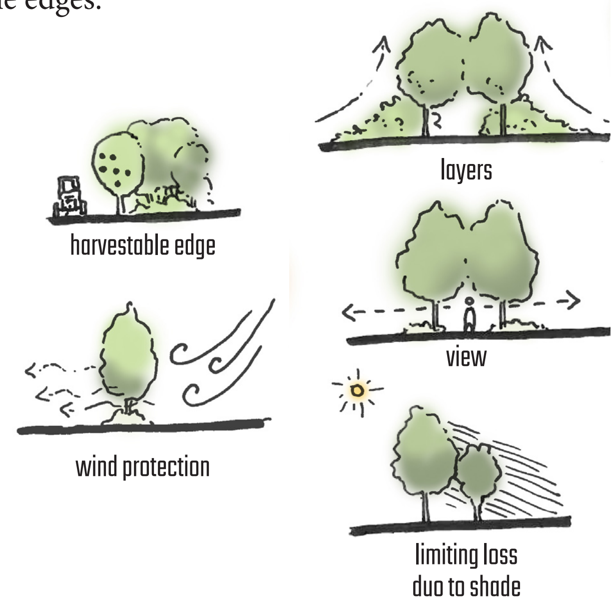


Figure 88 Design principles agroforestry

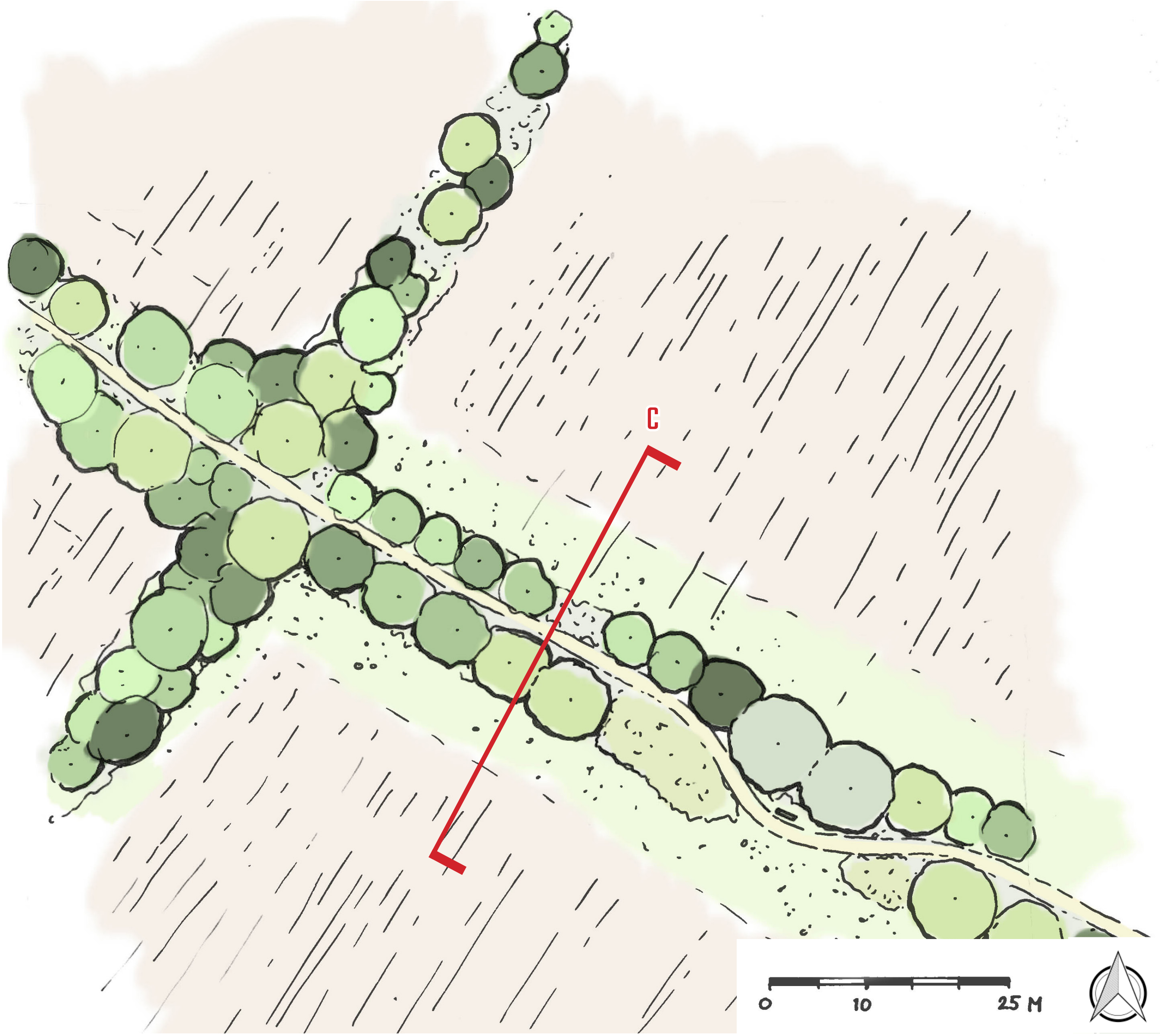


Figure 89 Agroforestry plan

Figure 90 Section C, Agroforetry

6.4.4 Cultivated woods

These slope forests consist of linear plantations of nut and fruit trees and a wild plantation of wood producers. The linear structures are easy to harvest, while the wood is produced in an way which resembles the natural system. Variation in species and ages is important. Fungi cultivation could be added in enrich the harvests from these forests. Tree configurations can add extra visual experiences to the cultivated woods (see figures 92, 93 and 94).

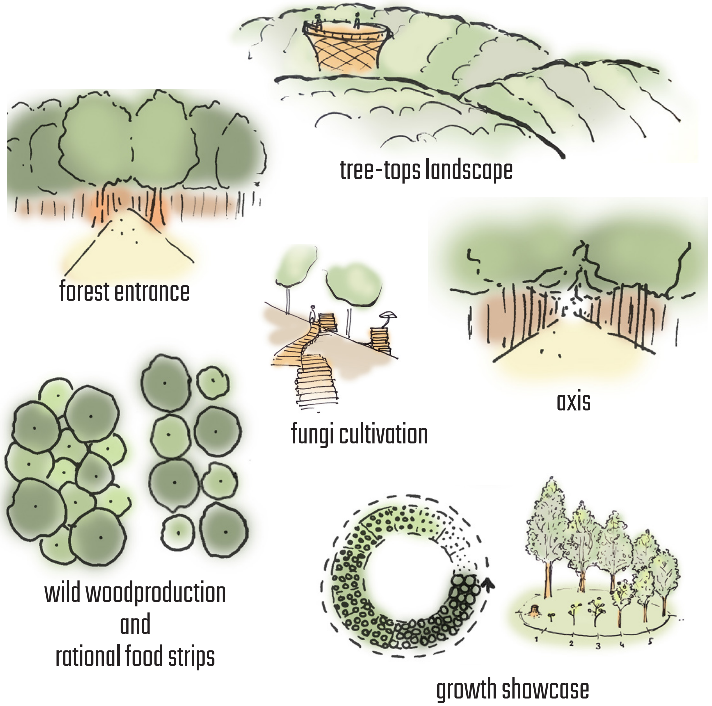


Figure 91 Design principles cultivated woods

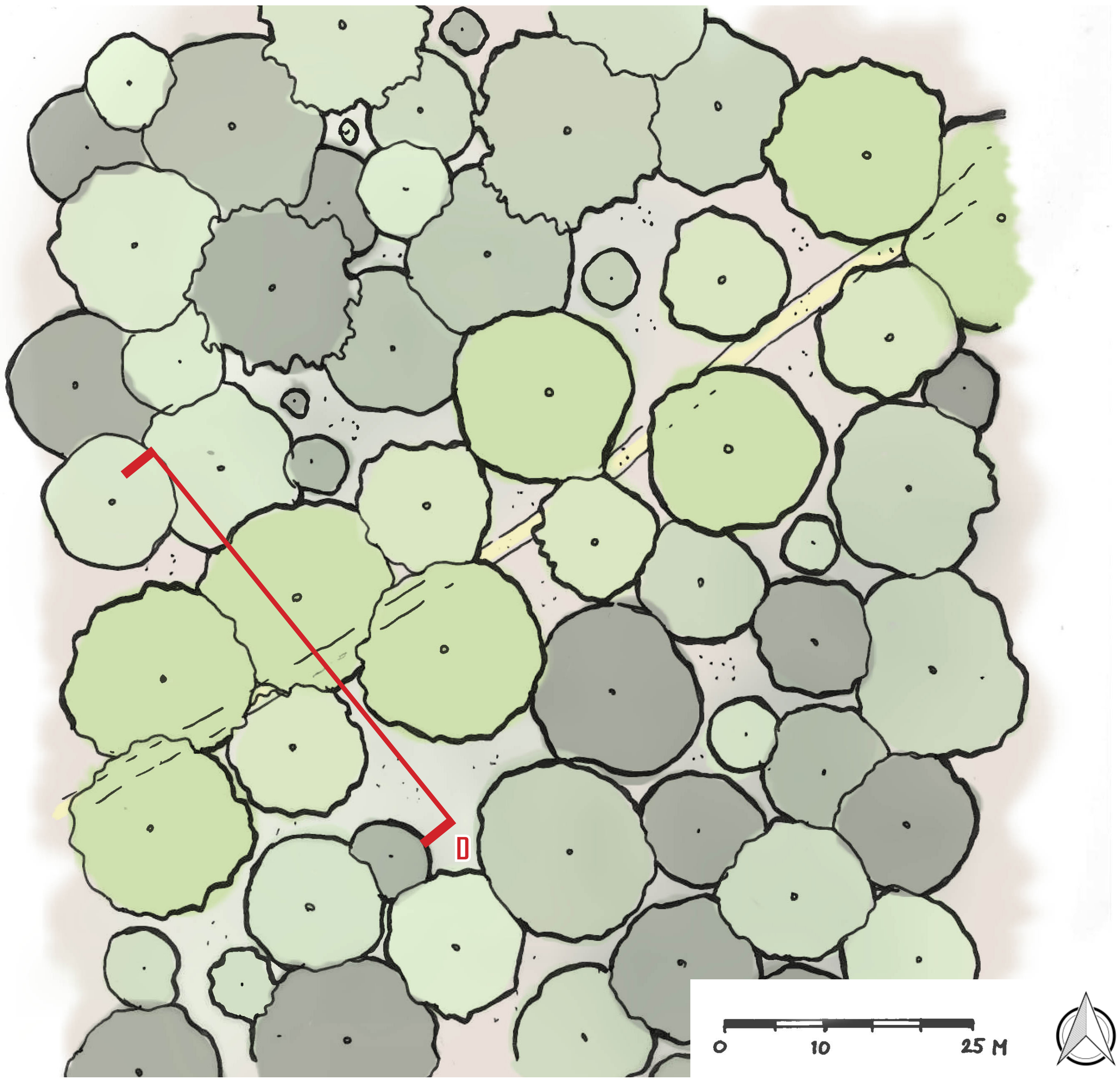


Figure 92 Cultivated wood plan

Figure 93 Section D, cultivated woods

Figure 94 Wood cultivation

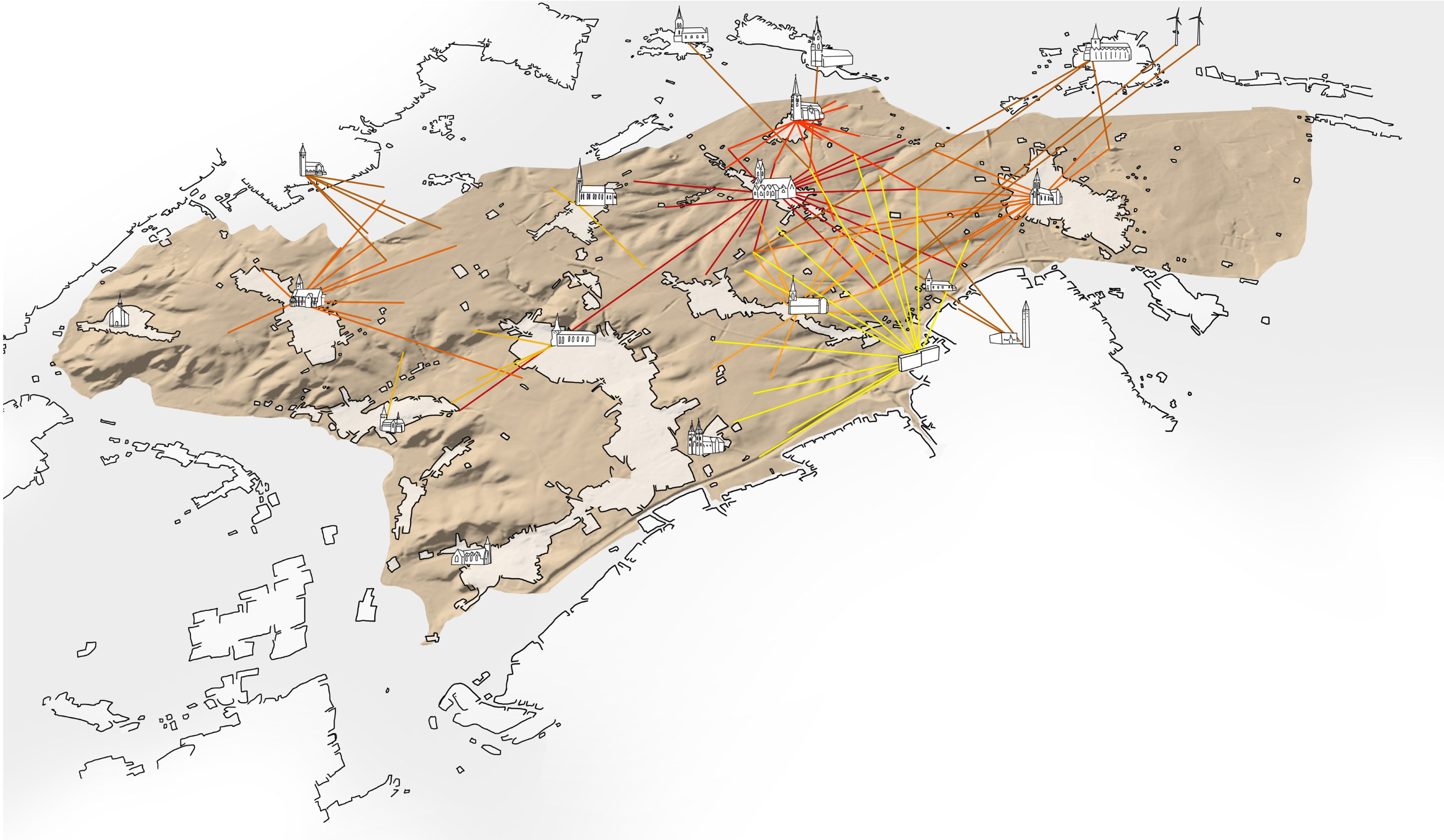


Figure 95 Range of visibility of church towers

6.4.5 View preservation

The open plateau landscape is valuable for the preservation of wide views. These views are important for orientation. Figure 95 shows wide range at which church towers can be seen in the current situation.

Besides preservation, highlighting these elements can add to the landscape experience. Figure 97 shows how cuts in plantations can also establish such emphasis. Figures 98 to 100 show how the view to the church tower is preserved and arouses curiousity

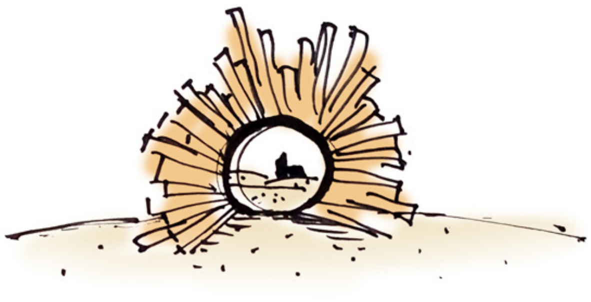


Figure 96 view emphasis

Figure 97 Zoomin 2, church view preservation

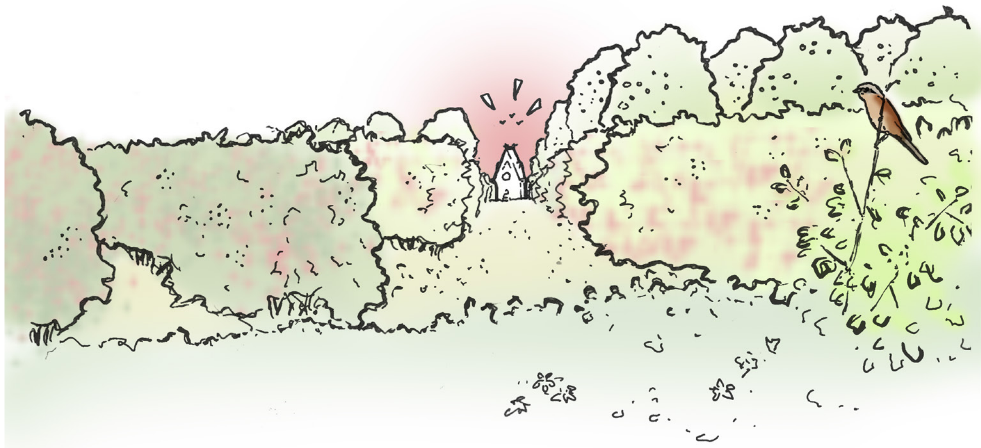


Figure 98 church view 1

Figure 99 church view 2

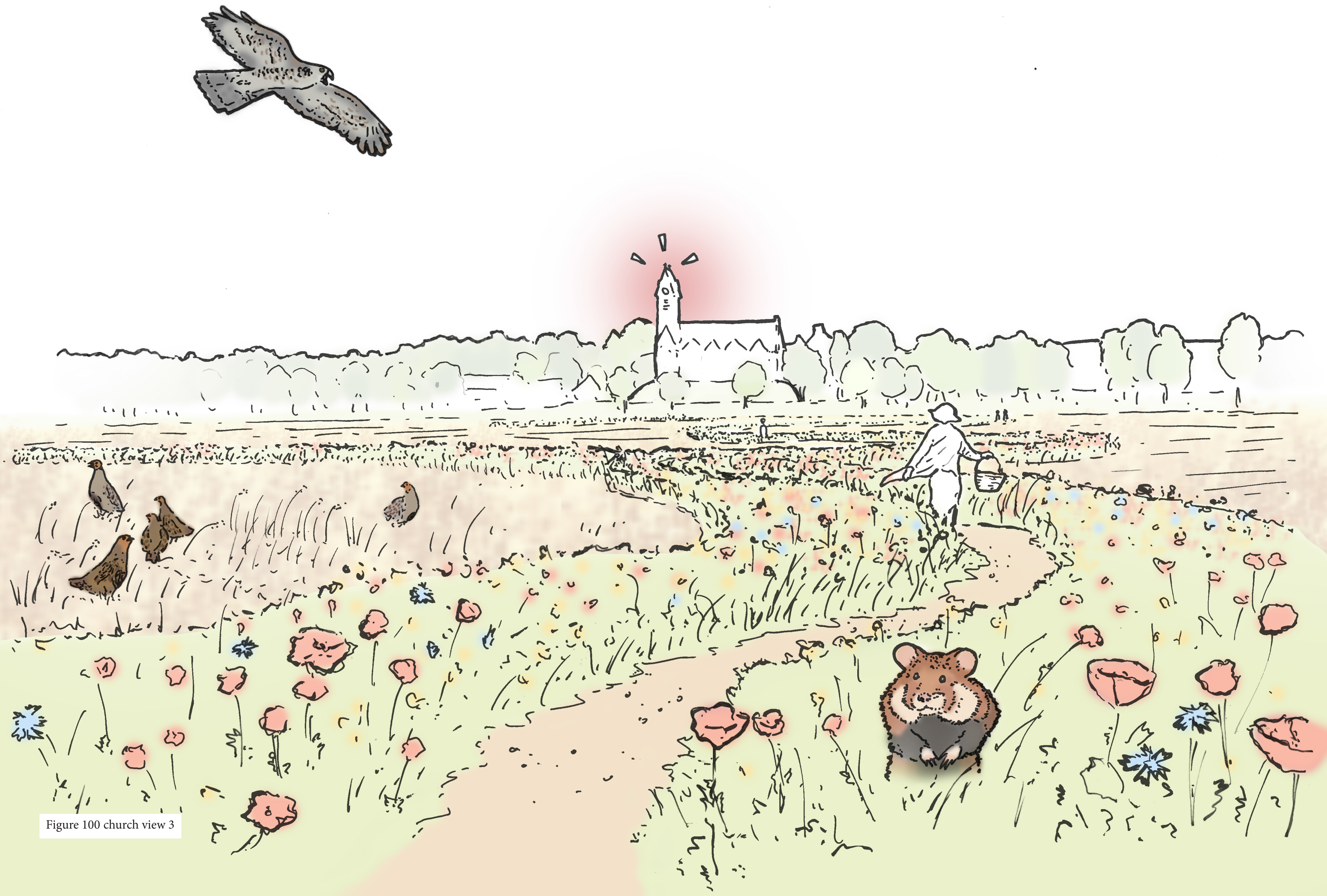


Figure 100 church view 3

Figure 101 Zoomin 3, the role of water

6.4.6 The role of water

Previous paragraphs showed solutions which prevent help the retaining of water in the agricultural land. Nevertheless, water will aggregate in the ditches. The current ditches should transformed from a channeled drainage system into an ecological line structure with gentle sloping edges. Ecological value can be increased by adding small pools where amphibians can settle. Alternation of shaded and sunny parts ensures diversity and the prevention of evaporation. It is important that waterstructures can continue and are not blocked by other infrastructures. Besides ecological value, cultivation in and along the water can be practiced on a smaller scale. These waterstreams will flow into the brook ecosystem (see figures 103, 104 and 105).

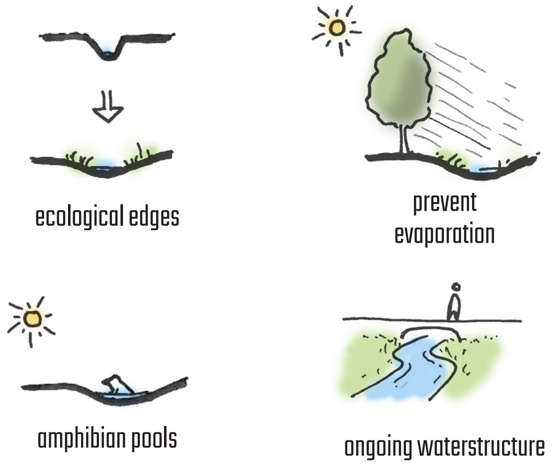


Figure 102 Design principles water

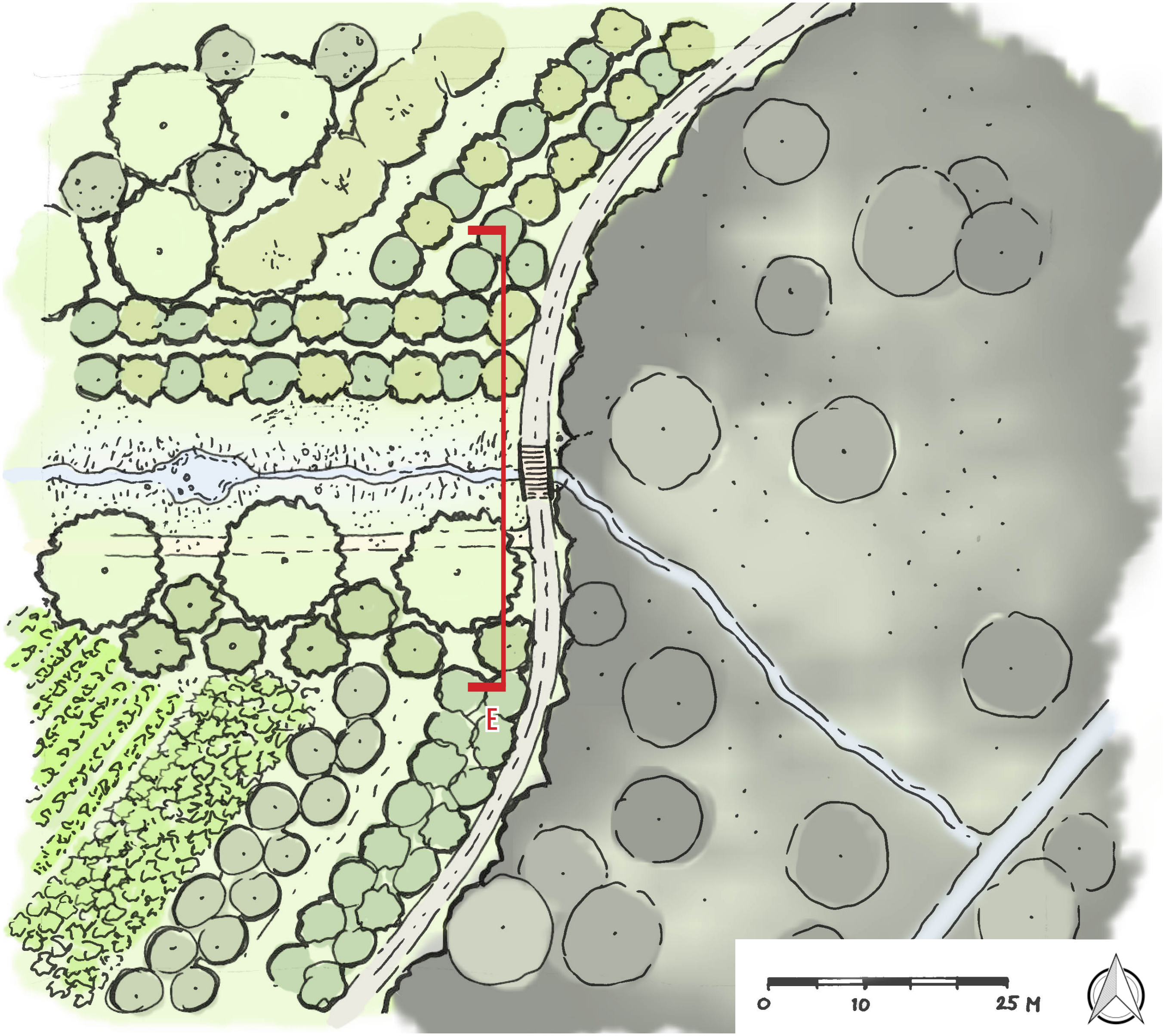


Figure 103 The role of water plan

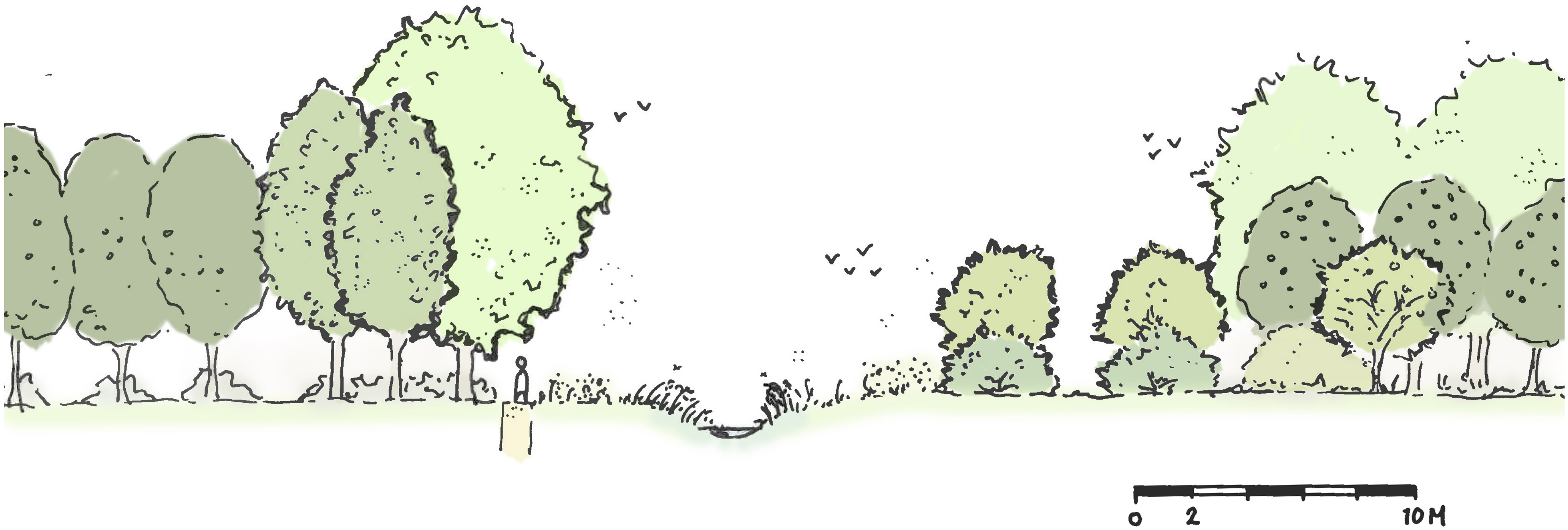


Figure 104 Section E, the role of water

Figure 105 Basic vision, urban areas excluded

6.4.7 Transformed woodproduction

The monocultural coniferous forests in the region should be diversified (see figure 106). The harvest of a part of the coniferous trees will fill the gap of low wood production in the newly developing forests. Once these forests are grown, harvest in the existing production forests can be done at an equal rate. The diversity in species and ages makes sure that ecological value will be continuous. However, there should be a certain system in the plantation, so owners can be sure that there is a yearly and constant harvest and yield.

Figure 106 Production forest transformation

6.5 DESIGN MATERIALS

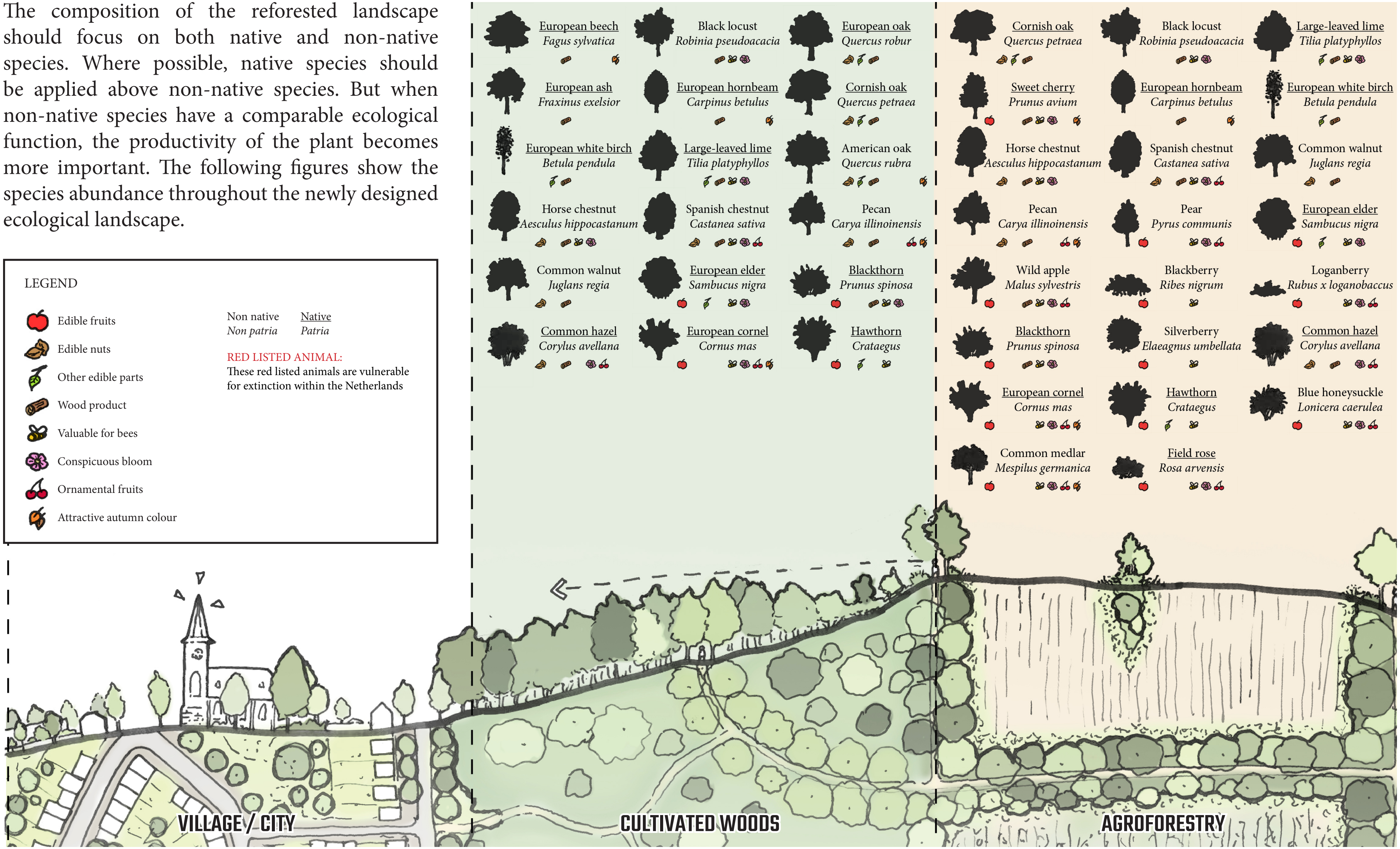
The composition of the reforested landscape should focus on both native and non-native species. Where possible, native species should be applied above non-native species. But when non-native species have a comparable ecological function, the productivity of the plant becomes more important. The following figures show the species abundance throughout the newly designed ecological landscape.

LEGEND

- Edible fruits
- Edible nuts
- Other edible parts
- Wood product
- Valuable for bees
- Conspicuous bloom
- Ornamental fruits
- Attractive autumn colour

Non native / *Non patria* — Native / *Patria*

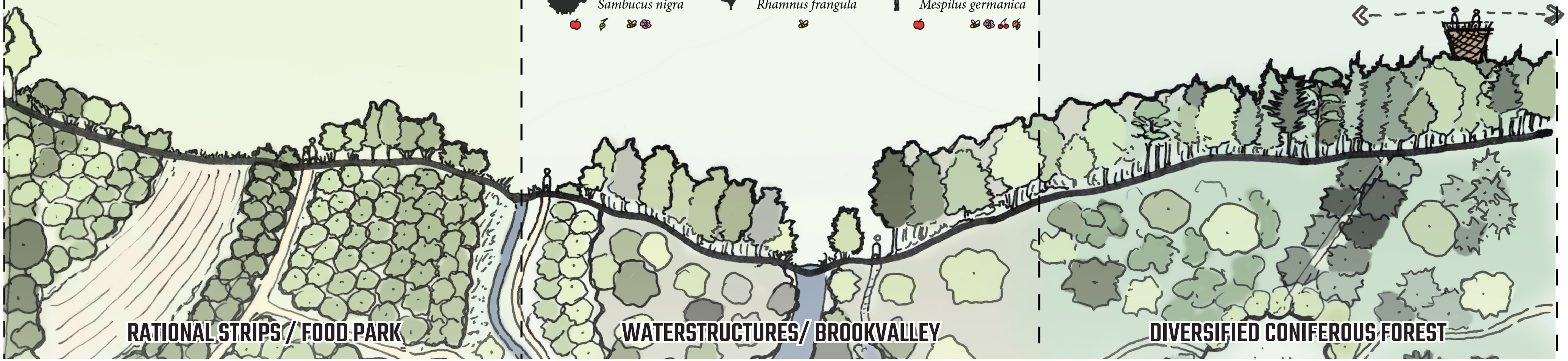
RED LISTED ANIMAL:
These red listed animals are vulnerable for extinction within the Netherlands

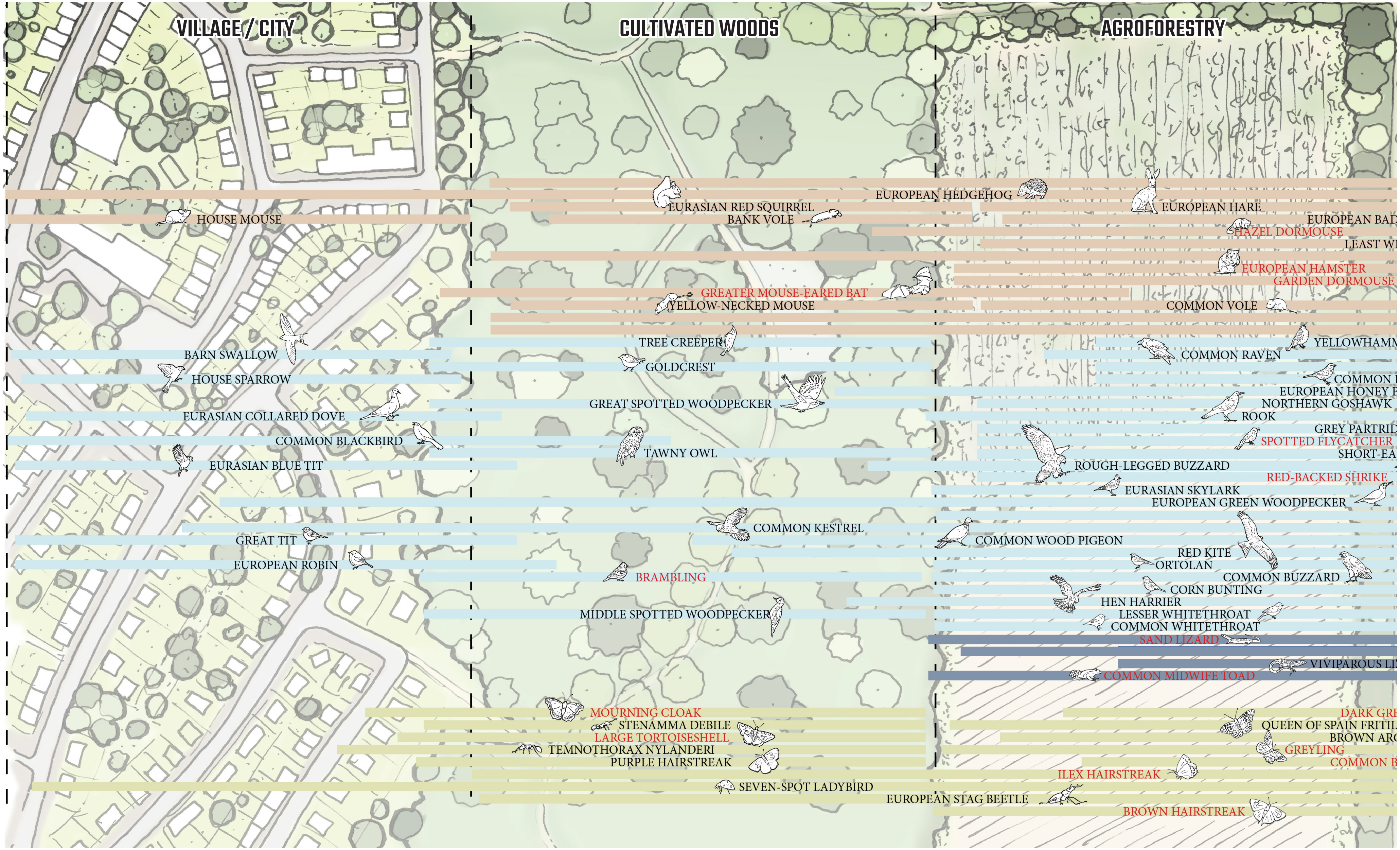


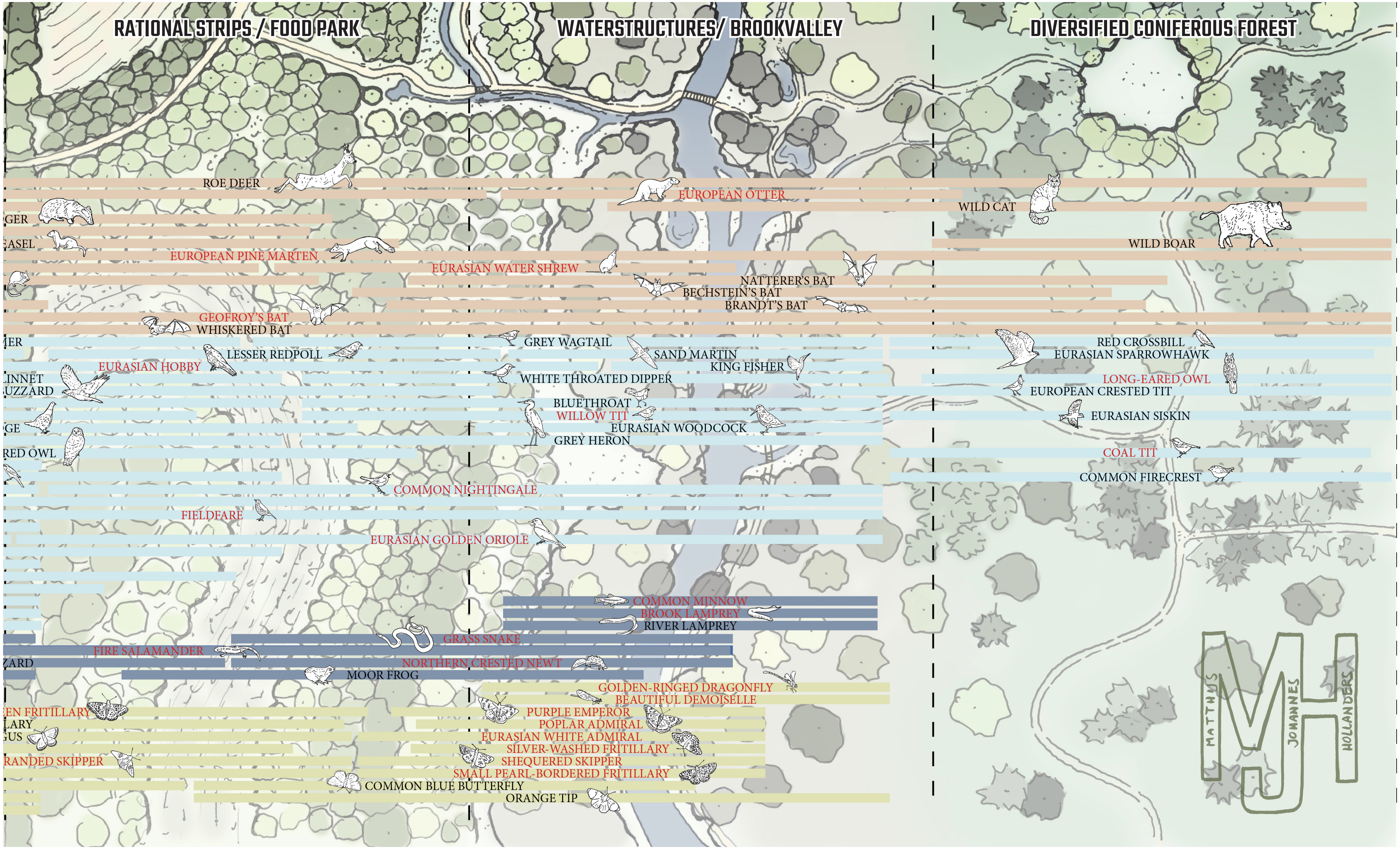
Large-leaved lime *Tilia platyphyllos*
Horse chestnut *Aesculus hippocastanum*
Spanish chestnut *Castanea sativa*
Sweet cherry *Prunus avium*
Common walnut *Juglans regia*
Pecan *Carya illinoinensis*
Common fig *Ficus carica*
Morus *Morus*
Wild apple *Malus sylvestris*
Pear *Pyrus communis*
European elder *Sambucus nigra*
Black chokeberry *Aronia melanocarpa*
Loganberry *Rubus x loganobaccus*
Blackthorn *Prunus spinosa*
Silverberry *Elaeagnus umbellata*
Blue honeysuckle *Lonicera caerulea*
Common hazel *Corylus avellana*
Common medlar *Mespilus germanica*
Field rose *Rosa arvensis*
Grapes *Vitis Vinifera*
Sheepberry *Viburnum lentago*
European cornel *Cornus mas*
Hawthorn *Crataegus*
Date-plum *Diospyros lotus*

European ash *Fraxinus excelsior*
European alder *Alnus glutinosa*
European oak *Quercus robur*
Sweet cherry *Prunus avium*
Canadian poplar *Populus x canadensis*
Common sallow *Salix cinerea*
Downy birch *Betula pubescens*
Large-leaved lime *Tilia platyphyllos*
Eared willow *Salix aurita*
European hornbeam *Carpinus betulus*
Apple *Malus domestica*
Wild apple *Malus sylvestris*
Chinese quince *Pseudocydonia sinensis*
European bladdernut *Staphylea pinnata*
Quince *Cydonia oblonga*
European cornel *Cornus mas*
Aronia *Aronia melanocarpa*
Asian pear *Pyrus pyrifolia*
Pawpaw *Asimina triloba*
Peach *Prunus persica*
Blackthorn *Prunus spinosa*
Sheepberry *Viburnum lentago*
Hawthorn *Crataegus*
Mountain-ash *Sorbus aucuparia*
European elder *Sambucus nigra*
Alder buckthorn *Rhamnus frangula*
Common medlar *Mespilus germanica*

Scots pine *Pinus sylvestris*
Austrian pine *Pinus nigra*
Japanese lark *Larix kaempferi*
European spruce *Picea abies*
Douglas fir *Pseudotsuga menziesii*
European hornbeam *Carpinus betulus*
Cornish oak *Quercus petraea*
European oak *Quercus robur*
American oak *Quercus rubra*
European white birch *Betula pendula*
Mountain-ash *Sorbus aucuparia*
Black locust *Robinia pseudoacacia*
Alder buckthorn *Rhamnus frangula*
European blueberry *Vaccinium myrtillus*




VILLAGE / CITY
CULTIVATED WOODS
AGROFORESTRY
EUROPEAN HEDGEHOG
EURASIAN RED SQUIRREL
EUROPEAN HARE
BANK VOLE
HOUSE MOUSE
HAZEL DORMOUSE
EUROPEAN HAMSTER
GARDEN DORMOUSE
GREATER MOUSE-EARED BAT
YELLOW-NECKED MOUSE
COMMON VOLE
TREE CREEPER
BARN SWALLOW
COMMON RAVEN
GOLDCREST
HOUSE SPARROW
NORTHERN GOSHAWK
GREAT SPOTTED WOODPECKER
EURASIAN COLLARED DOVE
ROOK
COMMON BLACKBIRD
SPOTTED FLYCATCHER
TAWNY OWL
EURASIAN BLUE TIT
ROUGH-LEGGED BUZZARD
RED-BACKED SHRIKE
EURASIAN SKYLARK
EUROPEAN GREEN WOODPECKER
COMMON KESTREL
GREAT TIT
COMMON WOOD PIGEON
RED KITE
EUROPEAN ROBIN
ORTOLAN
BRAMBLING
COMMON BUZZARD
CORN BUNTING
HEN HARRIER
MIDDLE SPOTTED WOODPECKER
LESSER WHITETHROAT
COMMON WHITETHROAT
SAND LIZARD
COMMON MIDWIFE TOAD
MOURNING CLOAK
STENAMMA DEBILE
LARGE TORTOISESHELL
TEMNOTHORAX NYLANDERI
GREYLING
PURPLE HAIRSTREAK
ILEX HAIRSTREAK
SEVEN-SPOT LADYBIRD
EUROPEAN STAG BEETLE
BROWN HAIRSTREAK


RATIONAL STRIPS / FOOD PARK
WATERSTRUCTURES/ BROOKVALLEY
DIVERSIFIED CONIFEROUS FOREST
ROE DEER
EUROPEAN OTTER
WILD CAT
GER
EASEL
WILD BOAR
EUROPEAN PINE MARTEN
EURASIAN WATER SHREW
NATTERER'S BAT
BECHSTEIN'S BAT
BRANDT'S BAT
GEOFROY'S BAT
WHISKERED BAT
IER
GREY WAGTAIL
SAND MARTIN
RED CROSSBILL
EURASIAN SPARROWHAWK
LESSER REDPOLL
EURASIAN HOBBY
KING FISHER
LINNET
WHITE THROATED DIPPER
LONG-EARED OWL
UZZARD
EUROPEAN CRESTED TIT
BLUETHROAT
WILLOW TIT
EURASIAN SISKIN
GE
EURASIAN WOODCOCK
GREY HERON
RED OWL
COAL TIT
COMMON FIRECREST
COMMON NIGHTINGALE
FIELDFARE
EURASIAN GOLDEN ORIOLE
COMMON MINNOW
BROOK LAMPREY
RIVER LAMPREY
GRASS SNAKE
FIRE SALAMANDER
ZARD
NORTHERN CRESTED NEWT
MOOR FROG
GOLDEN-RINGED DRAGONFLY
BEAUTIFUL DEMOISELLE
EEN FRITILLARY
PURPLE EMPEROR
LARY
POPLAR ADMIRAL
GUS
EURASIAN WHITE ADMIRAL
SILVER-WASHED FRITILLARY
RANDED SKIPPER
SHEQUERED SKIPPER
SMALL PEARL-BORDERED FRITILLARY
COMMON BLUE BUTTERFLY
ORANGE TIP
MATTHIJS
JOHANNES
HOLLANDERS

6.6 MASTERPLAN

Figure 107 Northeastern part of the site, a patchwork of agroecological solutions

7. REFLECTION

This thesis project in landscape architecture aims to improveme the agricultural landscape of Parkstad Limburg. The problem statements concern both esthetic and functional imperfections of the contemporary agriculture principles. However, being a part of the flowscapes studio 'Harvest' did not guide this choice for the rural areas. At the TU Delft, the focus is more on the urban environment; one of the reasons why I initially chose Delft instead of Wageningen. But the analysis of Parkstad resulted in the observation of the challenges ahead in the agricultural regions.

The transition of our agricultural landscape was a common topic at the time the graduation year started. And the more I looked into the topic of forestry as an agricultural practice, the greater the relevance. My affinity with ecology and attention to other species was not new, but the questionable role of agriculture was not yet so clear to me before. In previous designs, I strived for a more nature inclusive built environment. But the agricultural lands posed a similar challenge. This even triggered a certain activist approach, due to the often depressing news on climate change, biodiversity loss, and the role of humans. Motivation was therefore not an issue, because the importance of the chosen subject was very clear.

Narrowing down the project's focus was more difficult. Climate change concerns the world, but an intervention in Parkstad Limburg will not solve this global issue. Even national problems which I encountered eventually were not to be solved in the design region. Instead of trying to apply solutions for a widespread problem, the solution had to be derived from site-specific challenges. A lot of research on building with Cross Laminated Timber, for instance, became only a small part of the final report. When I first found out about the revolution in building with wood, this seemed to become the core of the design. But as the project developed, food production claimed an equal role. Designing for ecology was closest to the way I wanted to approach my graduation project. Although this was not clear to me from the start. Ecology eventually turned out to be the main motive that tied the individual components together.

The complexity of spatial design surpassed previous experiences. The wide range of scales was very well known to me, but the agricultural landscape was hard to get grip on. The lack of objects such as seen in the built environment provided an almost blank canvas with a wide range of possible design interventions. In this case, the less visible context came to the foreground; morphology. The understanding of the underlying landscape steered and shaped the design. A shape which had to be invented, because the transitions in our agricultural landscape have only just started. These developments helped to support the project, but the large scale food forest in Schijndel, for instance, is also just a pilot project that has not yet been proven to work. This uncertainty sometimes made it hard to believe in the value of the project. But in the end, it is only a step that might help to trigger the transition.

The design serves as an example of what can become of the landscape. It does not claim to be the only solution, but provides principles that can be applied in many ways. This project is not fixed, but fluid. It is uncertain how the area will develop and in which order growth will happen. While designing it is hard to think about it in such a way because every line you put on paper is fixed and determines the drawing that follows.

The role of the landscape architect also appeared more complex to me than I experienced before. The landscape architect binds different professions together by collecting knowledge from other professions. In the built environment this means collaboration with architects, urbanists, civil engineers, and inhabitants, among others. In the design for the rural area, different professions play an important role, such as farmers, foresters, and ecologists. While entering their field of knowledge, the struggle began on where to draw the line between my profession and theirs. I often asked myself how far I needed to delve into a subject. In the end, it is the task of the landscape architect to assemble knowledge and convert it into spatial design. One way to make sure I did not step out of my role as a landscape architect was to consult others. A trip to Wouter van Eck in Groesbeek, gave input on ecological farming as he is co-founder of the Food Forest association in The Netherlands. A big contrast was the conversation with Peter Erkens, a farmer in Parkstad, who gave insight into local challenges and problems. Combining these views gave a clear and realistic idea of the role farmers had to play in my proposal. I also gathered knowledge on the wood industry by talking to Gerard Ravenhorst and Wolfgang Gard from the department of Engineering Structures Biobased Structures and Materials at the TU Delft. This subject was downgraded, partly due to the realization that I had gone into it too deeply.

Designing often feels like following your intuition, but this intuition is knowledge-based. Early in the design process, I gathered frameworks and approaches to spatial development. But I never consciously thought about using them while designing. Nevertheless, they served as an example and gave structure to the design process. Therefore, defining the methods used was not easy.

Besides theories on spatial development, extensive field research gave important input for the design. This detailed assessment of the landscape also caused difficulty in narrowing down the elaboration of the design. For every single spot in the chosen site, ideas were developed. In previous design assignments, there was a clear border to the project, but in this case, the borders had to be defined by myself. The wide range of interests and abundance of opportunities had to be reduced to the essence. Only then, a clear story could be built.

The spatial design shows just one implementation of the design principles. These principles can be combined in many ways, all having a different result. But the awareness of the site's essential characteristics is the main lesson to be taken into account when developments in the region are about to take place. More detailed elaboration on the cultivation of the land should be done to make this new agricultural model work. This concerns the crops to be used, but also the way stakeholder is involved, the role of the government and how residents are made aware of the landscape. This proposal shows the development of the entire region, but if you zoom in on only a small part, new insights emerge; challenges and opportunities. Nevertheless, this report could serve as a starting point for developments in the rural areas of Parkstad.

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MATTHIJS
JOHANNES
HOLLANDERS