RESTORATIVE AGRICULTURE NEAR THE BERNISSE STREAM

Identifying the possible implementations of restorative agricultural systems for the area of the Bernisse stream.

Bsc. Thesis LAR,
Frank Wortelboer, 960223972110
Wageningen University & research center.
Submitted on 25-7-2018

Coordinated by:
Gabriëlle Bartelse,
Kevin Raaphorst,
Sjoerd Brandsma

ABSTRACT

This Bsc thesis uses principles of restorative agriculture to design agricultural systems for the Bernisse stream. These systems are then used as tools for alleviating some of the more local problematics. This design can be a valuable reference for areas with clay soils and peaty soils, especially those in the Dutch river delta, as these have areas of similar character and shape. The design is futuristic and costly, but can easily be implemented in phases. Time is an important aspect of any project of this scale. The report concludes that these systems have the ability to create more lush , diverse and legible landscapes that has both a great recreational and scenic value as well as a high agricultural

Bsc. Thesis LAR,
Frank Wortelboer, 960223972110
Wageningen University & research center.
Submitted on 25-7-2018

Coordinated by:
Gabriëlle Bartelse,
Kevin Raaphorst,
Sjoerd Brandsma

TABLE OF CONTENTS

1. INTRODUCTION
1 Problem Statement 1
2 Thesis Statement 3
3 Concepts, Methods & MaterialS 3
4 Design Methodology 5

2. DEFINING THE BUILDING BLOCK
1 Restorative agriculture 6
2 Shepard's basic systems 8
3 Adaptation to locale 12

3. REGIONAL DESIGN
1 Analysis 13
2 Design Models 17
3 Final Design 20

4. DETAIL DESIGNS
1 Woody crop systems 22
2 The Northern Heart 24
3 The Southern Heart 26

5. EPILOGUE
1 Conclusion 28
2 Discussion 29
3 References

PREFACE

Dear reader,

Before you lies the result of eight weeks of work on my Bsc thesis, and four years of work on my personal development. These years prior to writing this report have been filled with numerous extracurricular rojects regarding event organising, and with design, music and art projects, which all served to further my learning process in one way or another.
With no personal agricultural background, my fascination with restorative agriculture initially struck me as a suprise. The deeper I read into it the more I believe in it. For me, it has shaped a positive outlook of what our planet might look like in an few decades. A designer's outlook *should* be a positive one. It is our job to see chances where others see problems.
Although writing this thesis whilst organising a symposeum and simultaniously recording a musical album was a challenge, it has proven to be an amazing chance to prove to myself what I can do. I would like to thank Kevin Raaphorst en Sjoerd Brandsma for their expertise and support. They have helped me to prioritise, get my thoughts in order and create a coherent and legible report. I hope you enyoy reading this report, as it was a pleasure to create it.

Sincerely,

Frank Wortelboer

1. INTRODUCTION
1 PROBLEM STATEMENT

The Issue with monoculture

Industrial monocultural agriculture, the type most common to the Netherland and the Bernisse area, has turned out to be an environmental disaster. Globally, agriculture makes up 85% of all freshwater use, and directly or indirectly produces half of all greenhouse gasses (Hathaway, 2016). It requires an enormous amount of fertilising input and energy to maintain it while the nature that lies besides these fields grows wild and abundant without any human help. Left alone, our current agricultural systems could never sustain themselves. Slowly but surely industrial agriculture is destroying its own production capacity through the soil degradation monoculture causes. This is mainly due to oxidation and erosion of the bare soil it requires. Annual crops, humanities main food source, are amongst the first plants to colonise new territories. It requires us to maintain an early level of succesion for these plants to thrive. Industrial agriculture has provided us with higher production per acre in weight, but not in nutrients (Hathaway, 2016). Its need for pesticides rests on its weakness to diseases. Without diversity, both between plant species as on a genetic level amongst the same species, it makes an easy target for diseases. Monoculture has also dramatically decreased biodiversity and population resilience. Finally, the landscapes it produces are uniform and bleak. (Hathaway, 2016) (Shepard, 2013) (Foley et al, 2005) (Rhodes, 2015) Industrial agriculture cannot be sustained and is slowly but surely destroying earth's arable lands.

The Location and its history

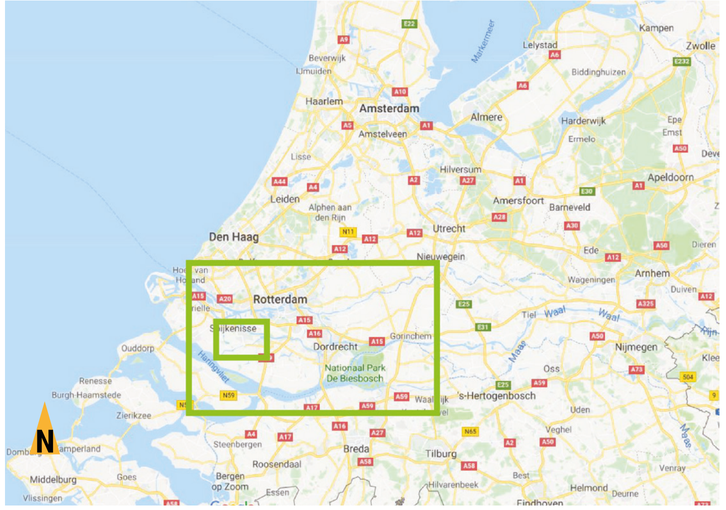


Figure 1: The location within the metropolitan region of "De Randstad", *Adapted from (Google, 2018)*

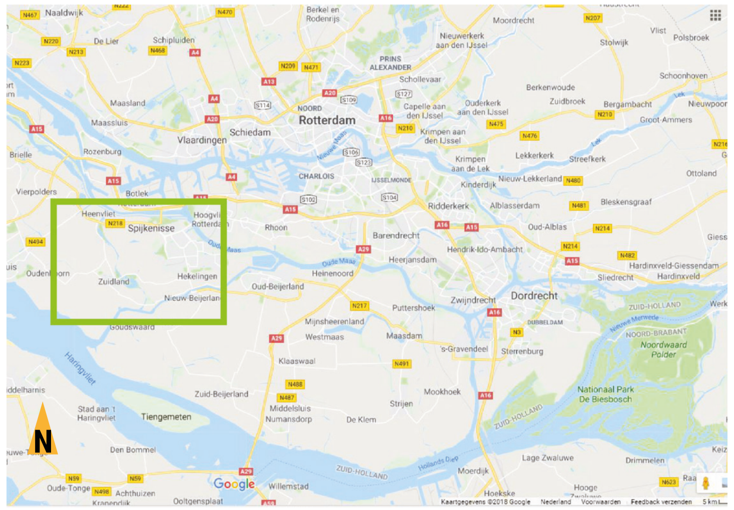


Figure 2: The location within the region of Rotterdam, with the bieschbosch on the lower right corner. , *Adapted from (Google, 2018)*

Figure 3: The Bernisse stream and spijkernisse. *(Esri, 2018)*

The Bernisse streams through the Dutch southern islands and is the agricultural hinterland of the metropolitan region of Rotterdam. (Figure 1) It streams through the Island of Voorne-Putten: (Figure 2) between Rotterdam and its industry in the northeast, and the Haringvliet and the Biesbosch in the southeast. (Figure 3)

Land reclamation

The history of the Dutch Southern Islands, is a history of land reclamation. Here lies the story of the battle against the sea for the gain of arable land. The current landscape is a manifestation of victories in that respect. However: these new vast masses of land have been primarily used for that very type of agriculture that deprives the population of arable land for which they fought so hard to obtain. This is true for similar land reclamations throughout the Netherlands. (Figure 4) Similar approaches may therefore be applied in these regions which have similar landscapes. Redesigning the Bernisse area to deal with the effects of monoculture can serve as a blueprint for the areas highlighted in the map. With that in mind it may be time for the Dutch to take the lead in a completely new age of land reclamation. Reclaiming it from the sun and the air, instead of the water.

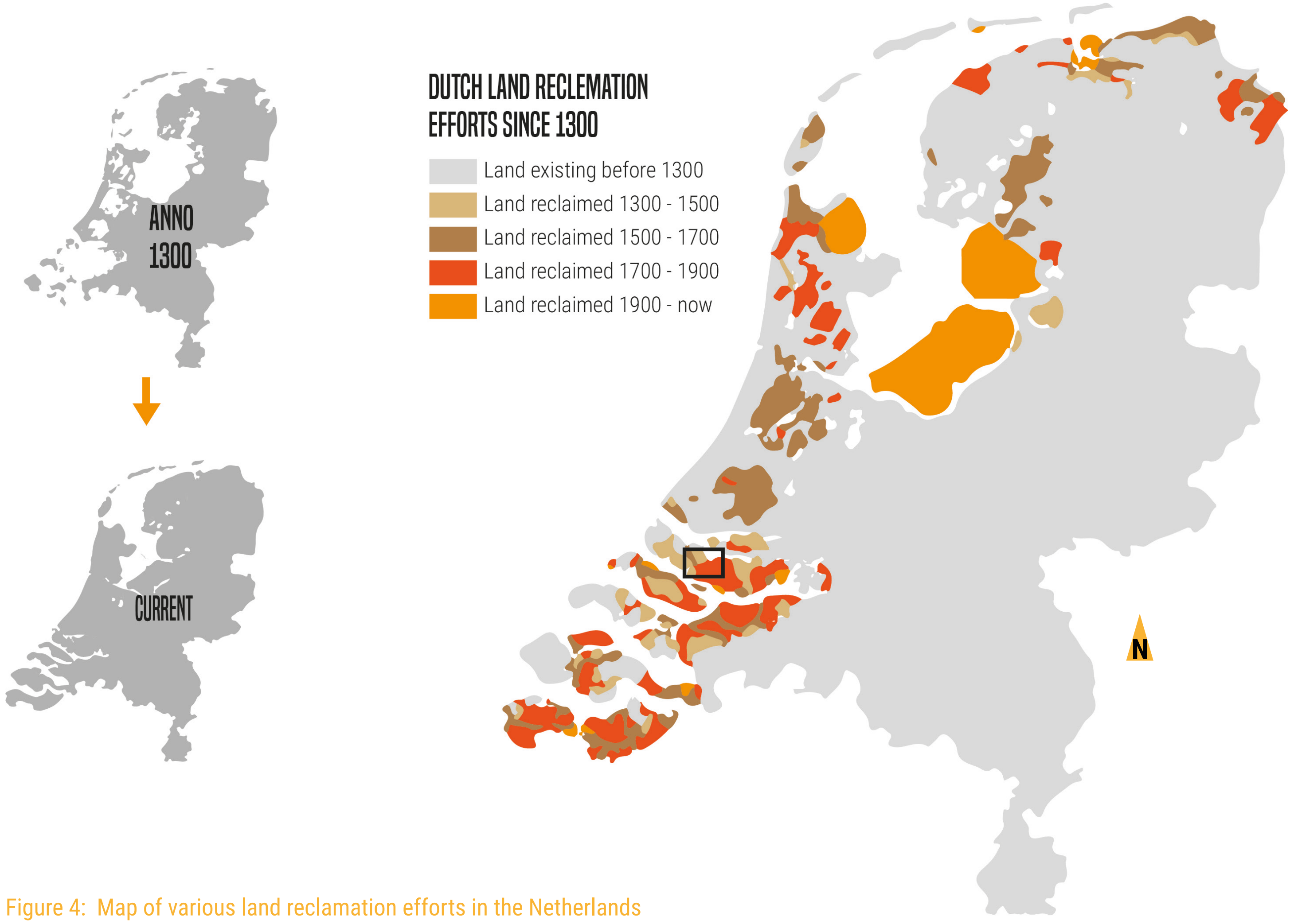


Figure 4: Map of various land reclamation efforts in the Netherlands throughout the centuries, *Adapted from: (Brilliantmaps, 2018)*

Monofunctionality

"The original monofunctional strength of Spijkernisse has to become more multifunctional. The goal is to become resilient. Instead of being dependant, being complementary to the Port of Rotterdam."

- (De Zwarte Hond, 2018) translation by author

This quote shows that the problematics of monofunctionality outscale the agricultural systems alone. Attributing multiple purposes to a single landscape could be another type of land reclamation. As land masses are put to multiple uses, larger surface area for the functions involved are created.

Restorative Agriculture

There is a way to rebuild the soil and ecological worth of an area while still producing food. This type of agriculture, restoration agriculture, mimics natural equilibriums and natural ecosystems to obtain as much biomass production as possible. These are designed to be circular multi-crop systems that have more diverse outputs, often intended for more local use. Luckily, the municipality of Nissewaard has expressed the goal of working on a circular economy, and is taking some steps in sustainability efforts. (Nisewaard, Gemeente, 2015) There are also initiatives in a local food brand with interest from the Rotterdam food council (West8, 2015)

Initiatives in restoring soils and ecosystems through the use of restorative agriculture have proven effective. (Shepard, 2013) (Hathaway, 2016) Other than most sustainable solutions these types of agriculture are not only sustainable, but aim to be restorative. It not only ceases the negative effects of the current agricultural system, it reverses them by storing carbon dioxide in

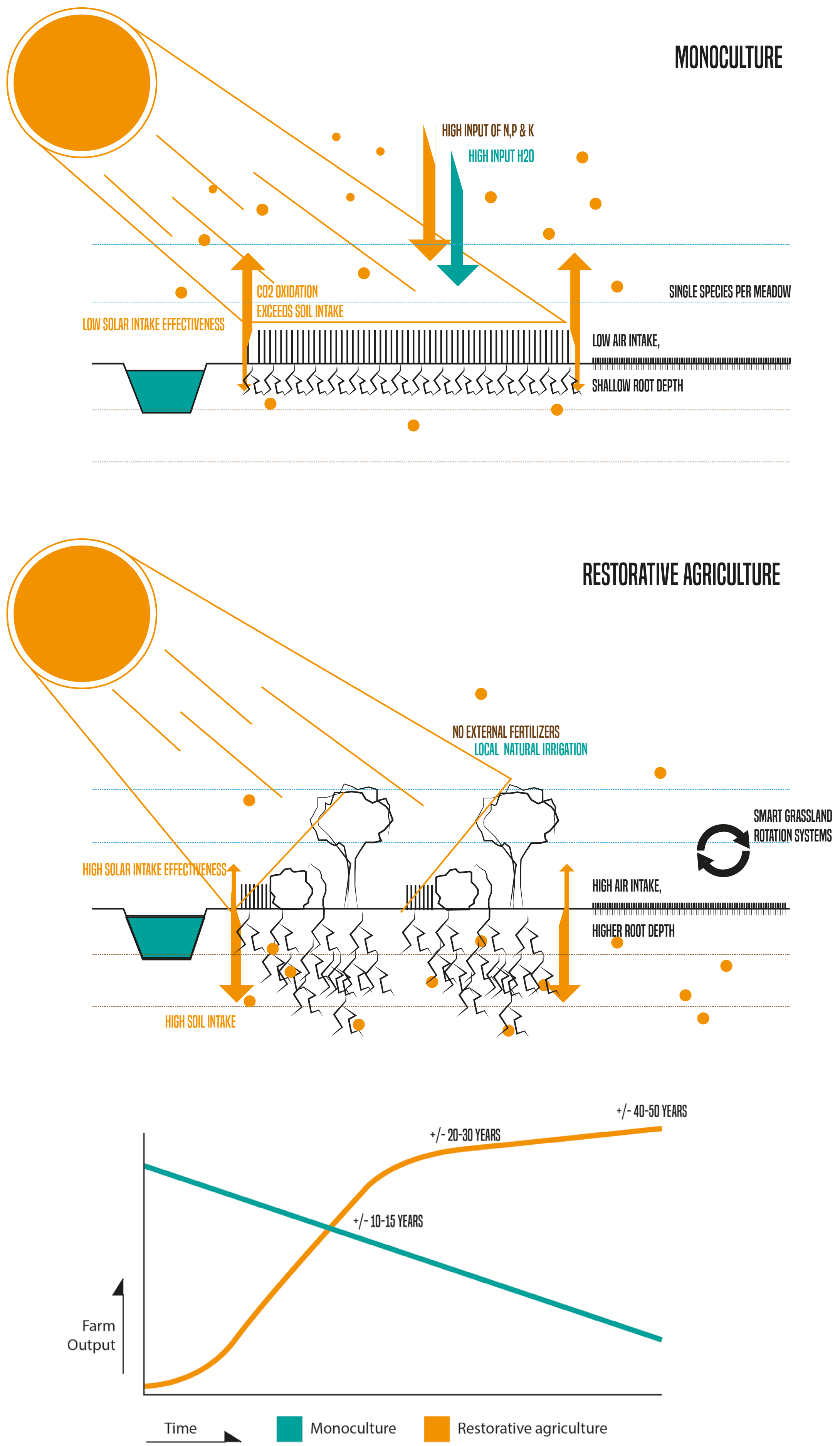


Figure 5: Monoculture, restorative agriculture, and the prospects of long-term yields of both systems as explaned by Shepard, *(Author, 2018)*

the soil. (Rhodes, 2015) (Figure 5) This is in line with the Paris agreement adopted by 195 countries in 2015, which opts for big steps towards decarbonisation. (UNFCCC, 2015)
While restoration agriculture as described by Shepard (2013) in his identically titled book is inspired by the more widespread permaculture, they are not the same thing. Permaculture is often linked to small-scale operations, community gardens and hand-harvested systems. In most of these systems the people involved are still dependant on crops grown form annual, monocultural systems, like wheat and corn.

Permaculture also includes a wide variety of ethics and philosophies that are hard to measure and document, and implementing these ideologies in a scenic manner is beyond the scopus of this thesis. What Shepard proposes is a large scale implementation of these ideas and systems on current farmlands, including the same machinery, in order to reform the entire food production process.

The Urgency

Agriculture will have to make the switch sooner rather than later through phases. Restoration agriculture has a potential higher yield than industrial agriculture, but requires some time to get to its full potential (Figure 5) As the area is also focussed on being a recreational area the added benefits of these systems will likely result in an ecological and scenic value that adds to the recreational experience. These new forms of agriculture can be used as building blocks to advance multiple functions of the area. Therefore it is worth mapping the forms and shapes restorative agriculture could have near the Bernisse stream.

1. INTRODUCTION
2 THESIS STATEMENT

Objective

The objective of this research and design is to play a significant role in the development of regenerative agriculture by using the Bernisse as a prototype of a large scale implementation of regenerative production systems. This prototype could be the starting point for many similar regions. This will be done through making the agricultural land of the Bernisse area a more lush, diverse and legible landscape that has both a great recreational and scenic value as well as a high agricultural production value.

Design question

What type of restorative agricultural systems could be designed for the Bernisse's landscape entities respectively as tools for creating a more multifunctional landscape?

In order to design these systems into the landscape one needs to know more about which systems to apply and where to apply them. The narrative is based upon a new type of land reclamation: protecting and regenerating soils and arable land though restorative farming techniques. The Bernisse area would also benefit from a fortification of its historic landscape values. (West8, 2015) nquires about these values are therefore required to use them for the designs of the agricultural systems.

This produces two research questions:

1. **Which types of restorative agriculture could work for the respective landscape entity types of the Bernisse area?**
For which the answers to the following questions are required:
- Which of the different landscape entities that can be identified in the region and what characterises them?
- Which species will play what parts in the regenerative production systems?

2. **How can these regenerative production systems be applied to create a more multifunctional landscape?**
For which the answers to the following questions are required:
- Where and how can these systems best be applied?
- How can these systems be used to create a more multifunctional landscape?

1. INTRODUCTION
3 CONCEPTS, METHODS & MATERIALS

Key Concepts

In order to continue the research a few concepts central to this design need to be defined and operationalised.

Regenerative agriculture
The pursuit of soil regenerating, zero waste, interrelated agricultural systems with a large variety of species. Within these systems each species serves multiple functions for the others to thrive. These are designed using the system-based approach common in permaculture as explained by Mark Shepard. (Shepard, 2013) These principles will be thoroughly described in the chapters that follow.

Landscape entities
A landscape entity is a distinguishable landscape type within a region with an identity through its form, history and identity. The Bernisse area contains oudland, nieuwland and the stream area. There are also some old creek areas that deserve attention.

Multifunctional landscape
Taking the theories of restorative agriculture, or polyculture, to a higher scale, diversity is something to be sought after in landscapes as well.

"Landscape functions describe the ability of a landscape to provide goods and services to society. Such goods and services include, amongst others, food and timber production, fresh water supply, climate regulation, landscape aesthetics and recreational opportunities. These are all benefits of the landscape that contribute to human well-being."

(Willemen, 2010)

Methods & Materials

The answers to the research questions will be derived from an iterative process of research and design. In order to come to a final conclusion various kinds of data and data collection methods will be used:

Research question

1. **Which types of restorative agriculture could work for the respective landscape entity types of the Bernisse area?**
- Which of the different landscape entities that can be identified in the region and what characterises them?
- Which species will play what parts in the regenerative production systems?

2. **How can these systems be applied to create a more multifunctional landscape?**
- Where and how can these systems best be applied?
- How can these systems be used to create a more multifunctional landscape?

Methodology & Materials

We need to know which entities can be found. By analysing which landscape entities can be identified through map data, their identities, soil types, water conditions, and current vegetation are mapped and described. This requires the use of soil maps and other geographical sources, as well as on site-observations.
We now need to design production systems for these locations. These will be derived from a currently running project. This project will serve as a reference study and will be used to describe the system principles in more detail. A literature study on the subject is also required, and will be done using sources on the implementation of certain species and applicability of these systems in thearea. The restorative systems will then be tweaked to fit the conditions found for the entities respectively.

An analysis of the current functions of the landscape through map data is the first thing on the agenda. Consessions and overlaps between current functions of the landscape are sought to ease in the multifunctionality. Any inherent potential of the landscape is also described, as well as what the current landscape is missing. All of this requires map data analysis.
The question of where to apply these systems is now handled by using the outcomes of the analysis. We explore how to best to use these systems to support these separate functions. The outcomes of these preliminary designs are then assessed and a synergy between them is devised. This is a case of research through design. (Jonas, 2017) The eventual outcome should not be a concession between functions, instead functions should reinforce one another.

Challenges

Most applied regenerative agriculture is on small scales such as gardens or smaller farms, often in name of permaculture. Larger operations are scarce and not well-documented in scientific research. The aim is to grow and harvest efficiently, as community gardening is not the answer to food problematics. (Roncken, Stremke, & Paulissen, 2011) Finding case studies of large scale operations would be reassuring of its potential for the area.

The challenge lies in prioritising the design guidelines. Form over function or vice-versa is a meaningful debate when something is presented as a multifunctional solution. While the sustain and regeneration of soils is the prime-directive of the design, scenic arguments; connectivity arguments and ecological arguments may take over.

4 DESIGN METHODOLOGY

The diagram below (Figure 6) shows the manner in which the design question at hand will be approached. The systems from new forest farm will be taken and distilled into their basic system principles. Using these principles and properties of the different landcape entities, new systems are devised for these respective places. These systems will then be regarded as tools for adapting the landscape and its structure. This helps us to use them as an approach for various issues that came forth from the analysis of the area. With the strenghts and weaknessess of these models in mind, the structure plan is devised. This regional design will then be elaborated upon with detailed designs, which also serve to illustrate the effects that the restorative systems have on the landscape. What follows is a reflection on these designs and a conclusion on whether the research questions have been answered and the design requirements have been met.

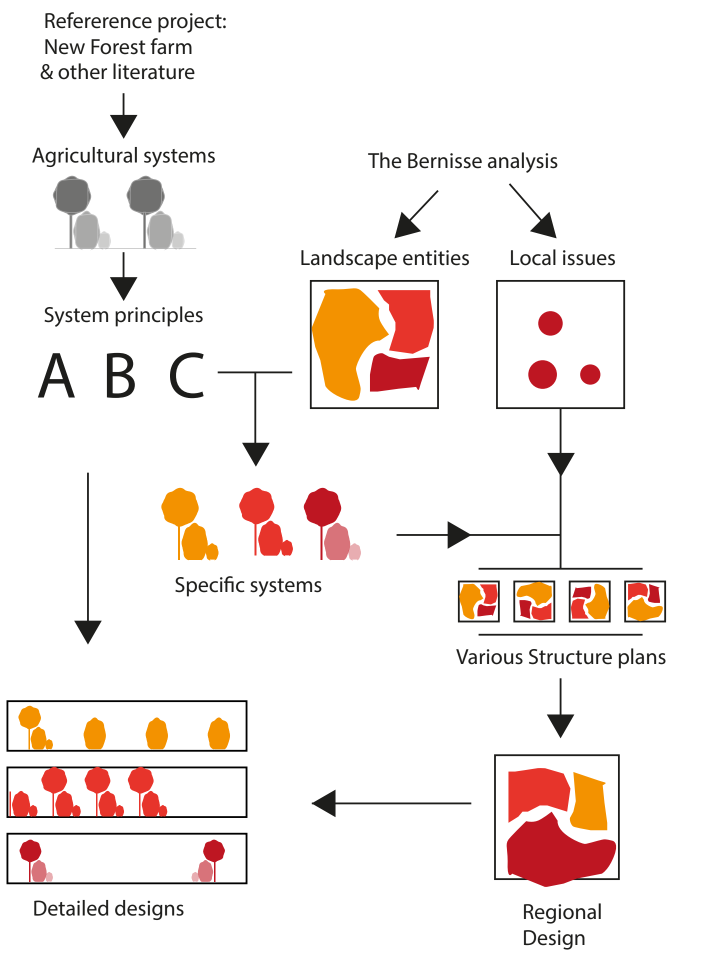


Figure 6: A shematic visualisation of the methods used by the author to devise the design , *(Author, 2018)*

2. DEFINING THE BUILDING BLOCK

1 RESTORATIVE AGRICULTURE

The general design principles

The general idea behind restoration agriculture is to design production systems that are mimicking ecological systems. It requires a three-dimensional system of layered strokes of perennial, woody crops that are more adapt at catching sun and more effective at reaching resources from the air. Deeper roots have more reach to both extract more nutrients from the soil as to put more "waste" in. (Figure 7) Fertilization only comes from within the system, where the idea of silvopasture comes to play a part. Human interventions, if any, only serve to catalyse, organise or harvest from natural processes that will occur regardless of human meddling. Which plants are grown are dependent on the local climate, soil and water conditions instead of altering the conditions to fit the species. Careful plant selection creates symbiotic relations between plants in obtaining resources instead of competing for them. Disease treatment is done by natural selection and breeding for locale by saving the best seeds. (Shepard, 2013)

There are some general principles that can be distilled from Shepard's system approach. They are quite interconnected and will be explained in further detail on the next page. (Figure 8)

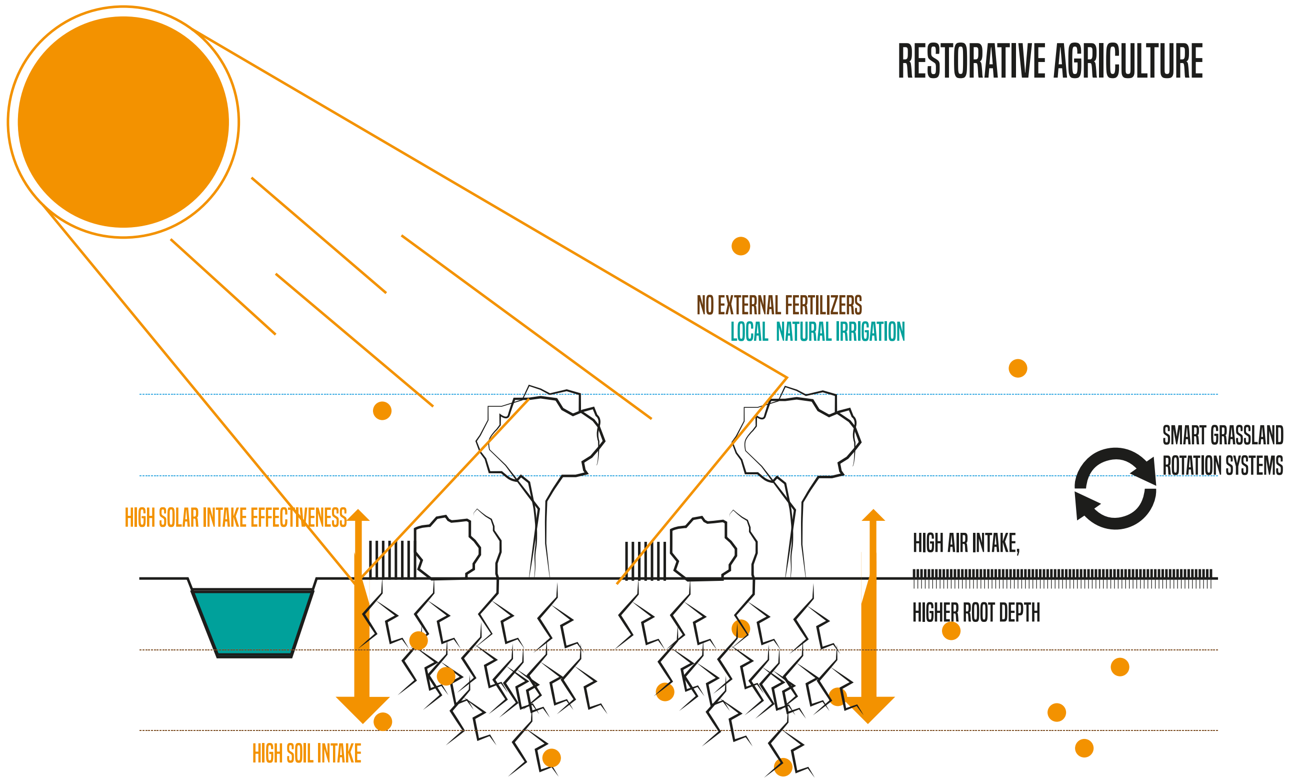


Figure 7: The workings of restorative agriculture, as explaned by Shepard (2013), *(Author, 2018)*

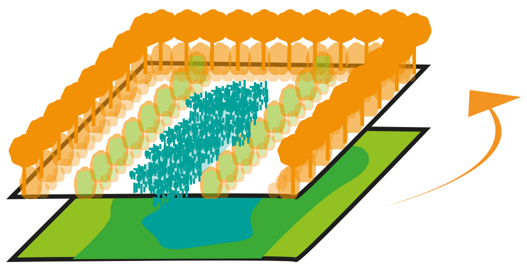
"You don't have a slug problem, you have a duck deficiency"

- Bill mollison

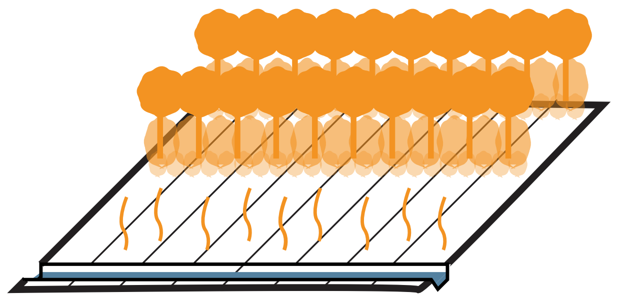
This quote (Dunwell 2016) is taken from Bill Mollison's obituary posted in the guardian. The quote floats around the internet as something the "father of permaculture" has said. Regardless of its true origin, it does a great job at illustrating the way regenerative agriculturalists can approach their issues through the first concept of variety. Turning the problem into a solution for some-thing else is the key to a smart system design. These systems, therefore, are not static. A dynamic stance should be taken in determining the needs and wants of the systems.

maximise natural production input

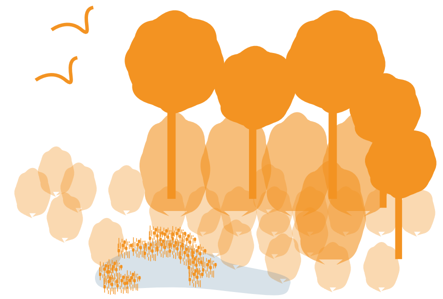
Minimise personal input



local conditions dictate species

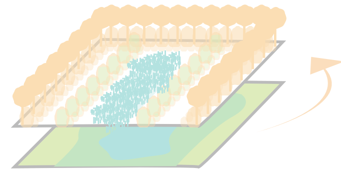


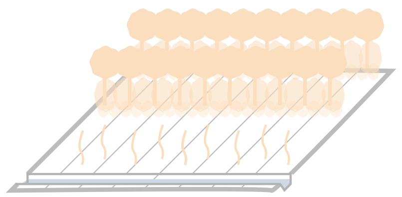
Use perrenials to avoid bare soils



Variety is key

Figure 8: Principles of restorative agriculture, devised from Shepard (2013), *(Author, 2018)*





Maximising production inputs

The goal is to catch as much sun as possible, use as much of the soil as possible and use the water in the most effective manner.

Sunlight
Farmers are in the solar collection business. In line with this principle guidelines for maximising solar panel output are followerd. For maximising sunlight collection the tilt should face true south. Additionally, the best amount of tilt is equal to the local latitude (Kern & Harris, 1975) which is about 51.8 degrees for the Bernisse. Planting heights and distances should correspond to approach that number. (Figure 9)

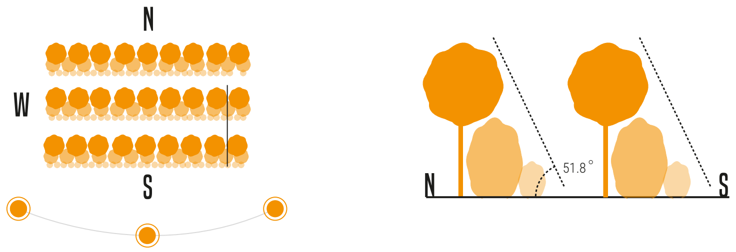
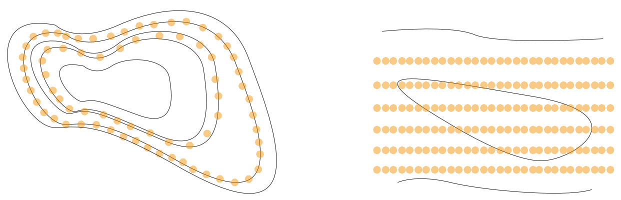


Figure 9: Sunlight collection requirements, *(Author, 2018)*

Water
Water is essential for plants. For dry areas the challenge lies in capturing rainwater and groundwater. For wetter systems the runoff needs to be quick enough to make sure the tree roots don't rot. An alternative is growing wet production crops. (Figure 10)



Planting for retention Planting for runoff

Figure 10: Water runoff and retention methods, *(Author, 2018)*

Minimising personal inputs

What makes these models economically viable, in contrast with the upscaled industrial agriculture, is the self-regulatory nature of the systems. They allow the farmer to minimize their input if species are applied in the right manner. This effectively means that the only time one needs to work the land is in the harvest season. The time, effort, money and fossil fuel that saves make this a more viable system.

Local conditions dictate species

Surviving without our help
These multi-layered systems are as diverse as the world around us and are shaped by soil, water and climate conditions. Any soil can produce an intricate system of food production. (Figure11) Therefore, species within these systems are preferably native to the area, as this raises their chances of survival without aid. They should also have a high utility within this production system. This requires the least input, and maximises natural output.

Figure 11: Any soil can produce a intricate system, *(Author, 2017)*

Use perennials to avoid bare soils

Rainfall, sedimentation and anaerobic conditions
Canopies protect soils from the effects of heavy rain like a multi layered umbrella. Rain is a serious issue for exposed clay soils as rain causes sediment runoff and produces anaerobic conditions, uninhabitable for soil life, affecting soil productivity (Figure 12)

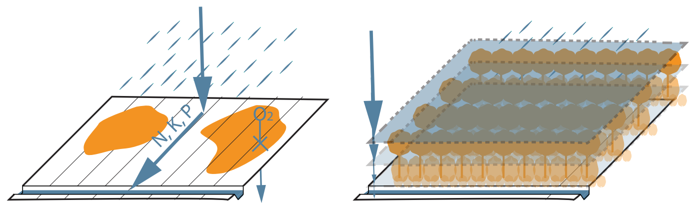


Figure 12: Clay soils and the effects of rain, canopy as an umbrella. *(Author, 2018)*

Oxidation
One of the issues central to monoculture is the oxidation of nutrients in the topsoil. With sufficient ground cover, that process is halted. With perennials, the roots hold the ground and the plants provide cover. Diverse systems also have more active soil life. These make sure that dead plant material is converted more quickly, leaving less time for the sun to oxidise the nutrients inside of them.

Variety is key

While species are mainly known to compete for resources, they can be quite neighbourly. Symbiotic relationships are found everywhere, and help us to make a complete system. One species' waste is food for the other. And any waste streams should be regarded as potential food sources. The role of the farmer is to catalyse the eventual conversion of food to soil.

2. DEFINING THE BUILDING BLOCK

2 SHEPARDS BASIC SYSTEMS

The principles stated here are distilled from systems Shepard utilises on his own living lab: New Forest Farm, which is thoroughly described in his book. (Shepard, 2013) He transformed this 120 Acre area from a recent cornfield to a diverse, economically viable and ecologically noteworthy area. These examples and these concepts are used as a reference study throughout this thesis. Shepard utilises two basic agricultural systems which can be used as a starting point from which to develop local systems. These are divided among:

woody crop systems
(an alternative for industrial agriculture)
and silvopasture
(an alternative for conventional animal husbandry).

This chapter provide an in depth description of these systems and how they operate in light of the principles described before. Localised versions to implement in various regions of the Bernisse will then be devised.

Figure 13: 9 rows per acre, *(Author, 2018)*

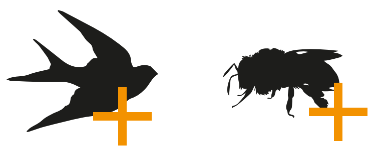


Figure 14: a habitat for birds and bees, *(Author, 2018)*

Woody crop systems

This is the type mostly discussed in the general design principles and earlier chapters of this thesis. It produces about 9 rows of crop groups per acre. (Figure 13) Crops are planted in rows in such a way that they can all be harvested through modern harvesting machinery. The rows can be different from one another in order to enhance the crop diversity. This provides a great habitat for birds and pollinizers. (Figure 9) A system could contain:

1. A type of fagacaea: Such as Oak, beech or chestnut (Figure 15)
Useful as a staple food, these crops are a great alternative for corn in processing in food supplements. It is also useful as a cattle or hog feed. While normal to some cultures, direct human consumption is not common in the Netherlands yet.
2. Apple, malus domestica or pear, Pyrus (Figure 16)
A well-known produce, yet in this system it will not function as an orchard. It requires much less human interference when applied in a natural system.
3. Hazel, Corylus or walnut, Juglans (Figure 16)
These nuts are fit for human consumption, as well as for cattle and hogs.
4. Grape, Vitis vinifera (Figure 16), (Figure 15)
Grapes are a type of vine, which means that they do well in semi shade under sturdy trees like chestnuts or apples. Usually hung from man-made trellises, this is one field of production where taking steps back to its natural environment could be a revolution.
5. Berries, Ribus or Rubus (Figure 16) (Figure 15)
Like raspberries, red currant and most other common berry types. These are common in agriculture, in the Netherlands as well.
6. Fruitbearers, Prunus (currently in none of the examples)
Containing cherries, plums peaches and more.
7. Fungi: Shade tolerant and moisture loving
(applicable to all wood producing systems)
Useful to efficiently catalyse the system of decay of excess wood while making a profit from it.
8. Grasses, poacea family (applicable in all systems)
As a ground cover and cattle feed.

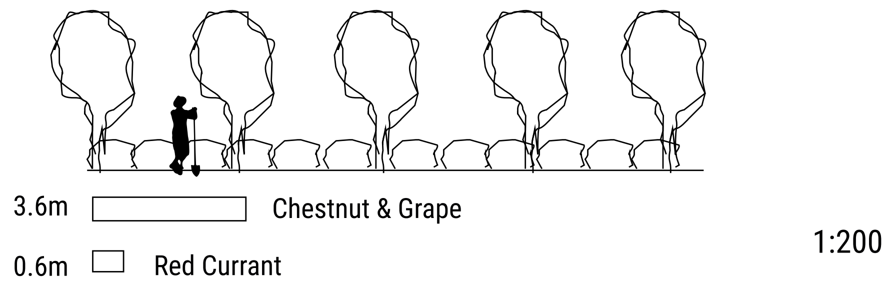


Figure 15: System 1, chestnut, grape, and red currant *(Author, 2018)*

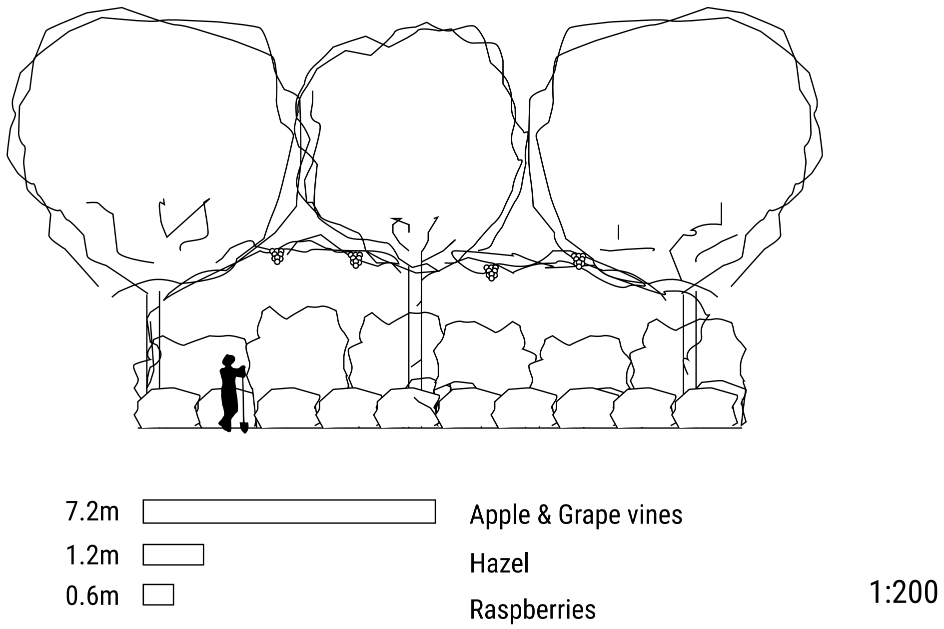


Figure 16: System 2, apple, grape, hazel and raspberries *(Author, 2018)*

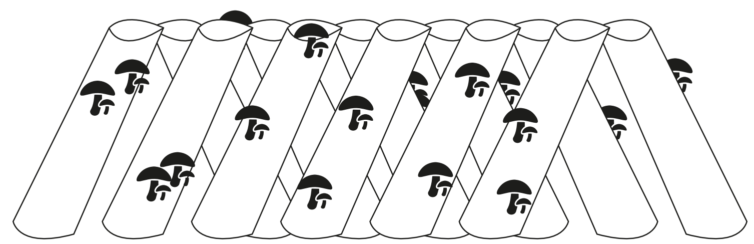


Figure 17: Shitake mushroom production from wood *(Author, 2018)*

Silvopasture

Silvopasture has the looks of wild grasslands but is in fact not that different from a woody crop system. The difference is that the crops grown on these lands serve primarily to produce animal products. The woody crops used in these systems therefore function mostly as a cattle feeder. (Figure 20) The trees serve as a barrier with the added effect of reducing cattle stress and stopping smells and diseases from spreading. (Figure 18) (Shepard, 2013) Adding trees to the fields also brings variety to the diet of the animals, with benefits to their health and disease resistance (Van Eekeren, Luske, Vonk, & Anssems, 2014)

Leader-follower systems

Maintaining a grassland requires supressing the succession so that it can stay that way. Instead of supressing with sprays and other modern input-requiring techniques, Shepard describes a rotation system for animals. Different species eat different (parts of) plants, and moving from calves to cows to pigs and then to sheep and even to geese and chickens allows a farmer to maintain the grassland without external inputs. The total amount of nutrients gained from the soil is higher and the various stomachs and gizzards make for a far quicker processing of the nutrients back into the system. This keeps plants that follow up grassland in succession, like the dandelion (Taraxacum), at bay. This requires for a design in which all of these species can be easily rotated between the following fields. Shepard also stresses the importance of avoiding under- and overgrazing and gives some guidelines on which to rely.

In order to make the most out of a field, smart rotation of the following species in te following leader/follower system is advised: (Figure 19)

around 1 cow per acre
The first group should be the calves, followed by the highest order milk producing cattle, and the lower order milk producing cattle.

2 hogs per cow
They eat the grubs, worms, and plant roots. But also the nuts and fruits from any plants that have missed or that precede the harvest.

2 turkeys per hog
They eat seeds from dung left behind and speed up the fertilization process by spreading it out.

Sheep or geese: the weed control
Although both prefer better quality feed, they are able to eat more fleshy plants like the dandelion, which is a common issue for maintaining grasslands. After they feed up on the succession plants following grass, the grasses can overtake the fields again with a oil that is freshly stocked up on nutrients.

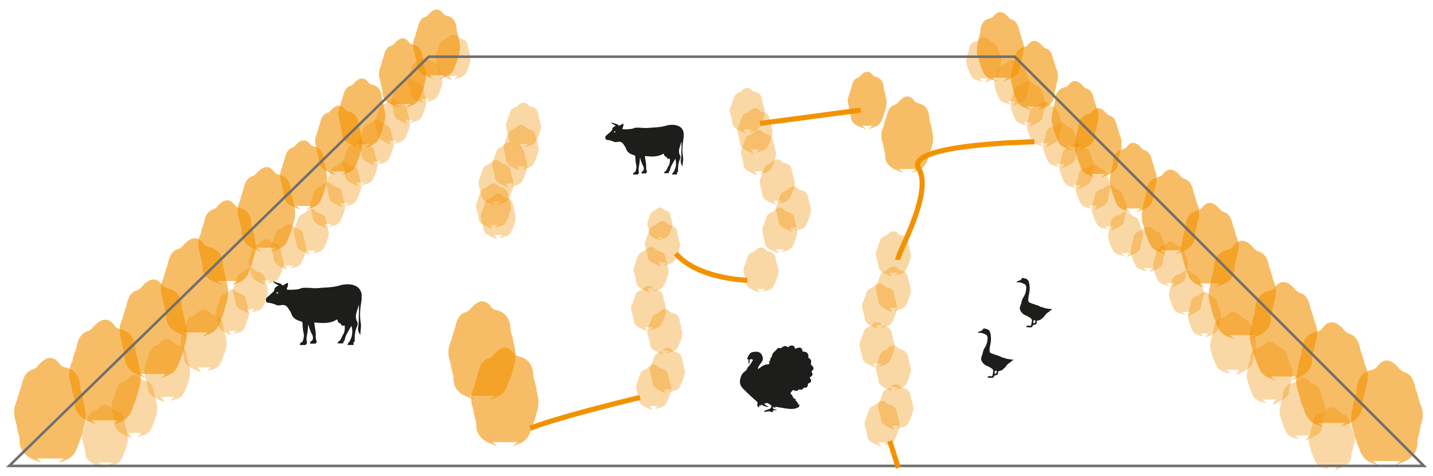


Figure 18: Silvopastures use plants as feeders, allotment borders and ideally make use of a leader-follower system. *(Author, 2018)*

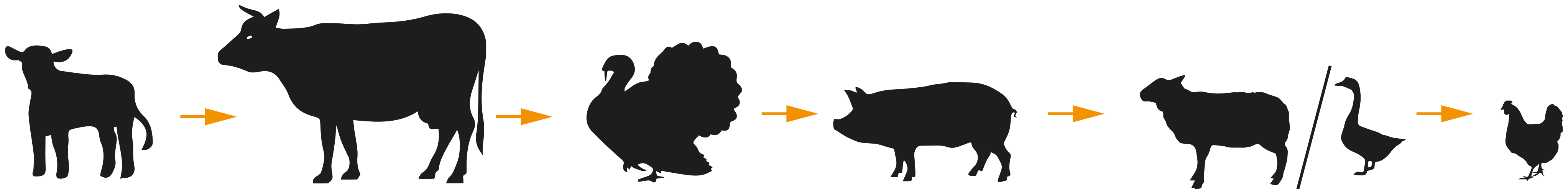


Figure 19: A leader follower system of calves, cows, turkey, pigs, sheep, geese and chicken. *(Author, 2018)*

The balance between silvopasture and woody crop systems

As we've seen throughout this story, combining natural elements can boost their respective production. The same goes for silvopasture and woody crop systems. Animals can be used to consume the products that were either deemed unfit for sale, or the ones that were never harvested in the first place. Letting animals like hogs roam through the woody crops after harvest allows them to harvest any "lost fruits". The pigs, in turn, supply the ground with the nutrients of their stool. (Shepard, 2013) (Figure 21) That is why it is important to have grassland hubs near woody agricultural production and vice versa. The soil condition of the Bernisse might allow us to create such connections where they might otherwise miss.

A layered system of this kind would include a variety of plants, which could have the following functions:

Shaders
To reduce cattle stress and improve solar catch
Fruit feeder
To produce food for the grazing animals. This allows for more freedom than in selecting for just the human taste, which gives chances for enhancing biodiversity.
Leaf feeders
A wide variety of perennial plants are on the menu of the animals listed earlier.

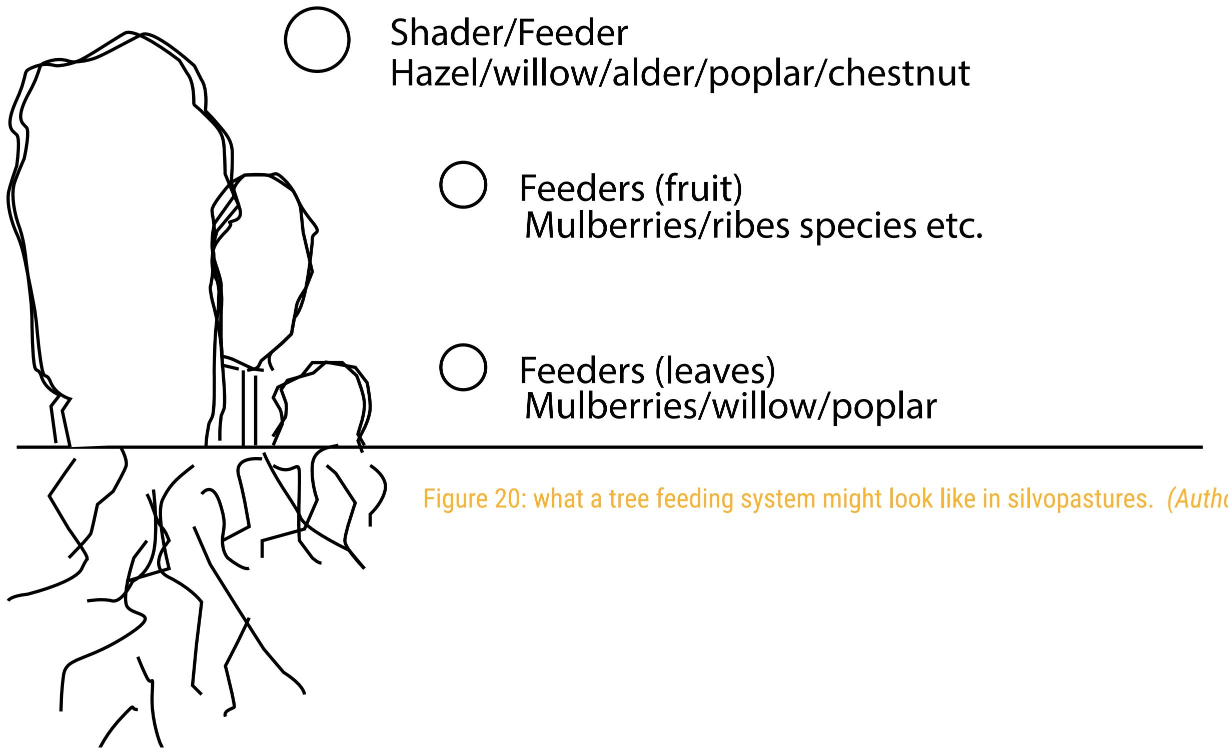


Figure 20: what a tree feeding system might look like in silvopastures. *(Author, 2018)*

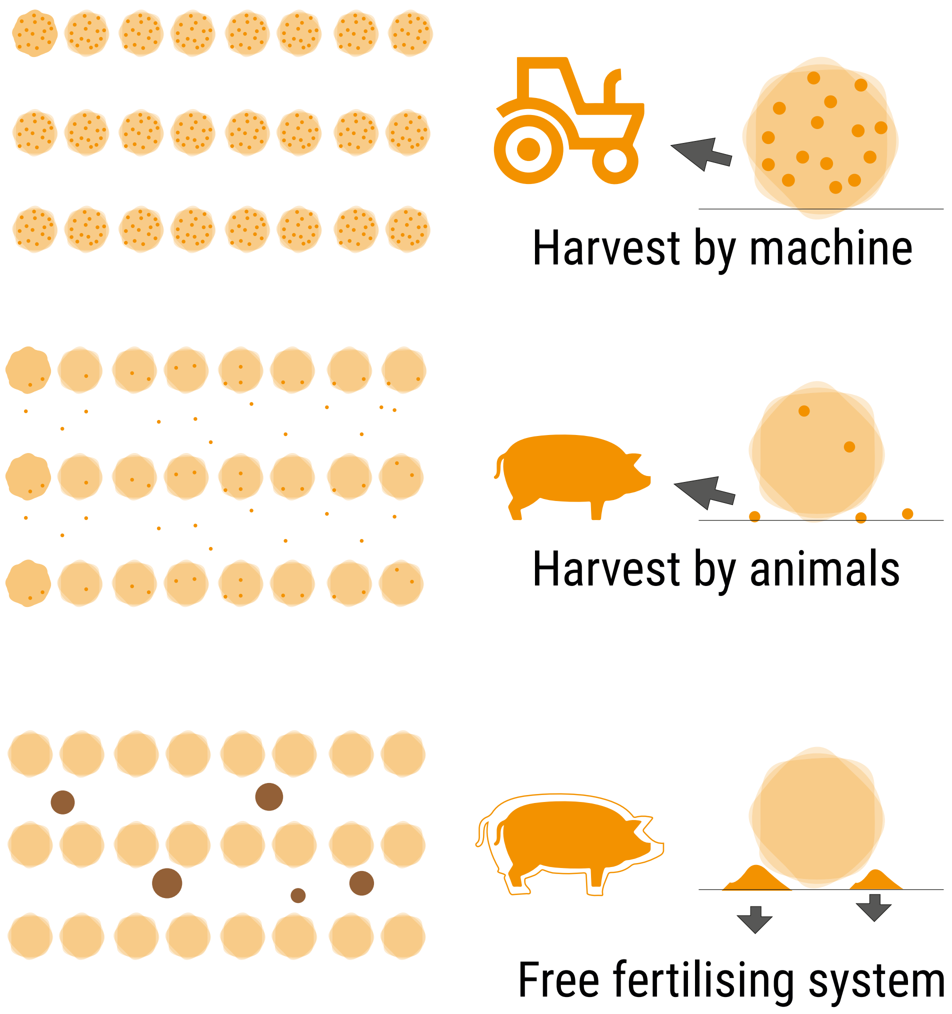


Figure 21: the relationship between woody crop systems and livestock. In this case: using hogs to farm unharvested fruits before they become indible. The hogs repay the system with their poop. *(Author, 2018)*

2. DEFINING THE BUILDING BLOCK

3 ADAPTATION TO LOCALE

General

The farm where these systems are applied lies in Southwest Wisconsin. This is a far warmer and dryer climate than the one near the Bernisse stream. The system will therefore be redefined by swapping out species for their cold-hardy and water loving cousins or by selecting a different local species altogether. Therefore, species are selected from the groups described earlier to build systems fit for local soil, water and lighting conditions.

Soils

We are dealing mostly with sturdy clay soils, which can be roughly divided into two groups: the calcium rich and calcium poor soils. There are also areas of interest that contain wet peat soils. The calcium rich soils are most productive and lie primarily in the 'newland' areas. They contain the highly industrial agriculture that is the leading cause for this thesis. These are the most fertile and dry soils and will be adjusted to contain the perennial woody crop systems.
Calcium deficient clay soils and peat soils are found in the older polders and are currently primarily used as grassland. The calcium deficient soils have a high potential for including silvopastures and the peaty soils can maintain their own signature type of restoration agriculture: paludiculture.

Water

Water near the Bernisse is not as scarce and groundwater is relatively high. As the Netherlands lack steep slopes, swales and terraces for catching water are not required. Dutch irrigation systems, as they are usually dealing with excess water, are instead designed to increase runoff. These patterns will therefore be mimicked instead of using the water retaining systems Shepard describes. (Figure 22)

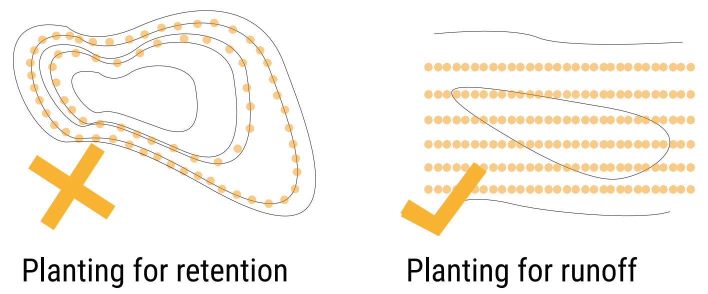


Figure 22: Planting for runoff *(Author, 2018)*

Lighting

The lighting conditions are simple, as there are no large mountain ranges or other barriers to take into account. Ideally crops are grown from east to west in a south to north slope of crop heights. This allows for the maximum collection of light. (Figure 23)

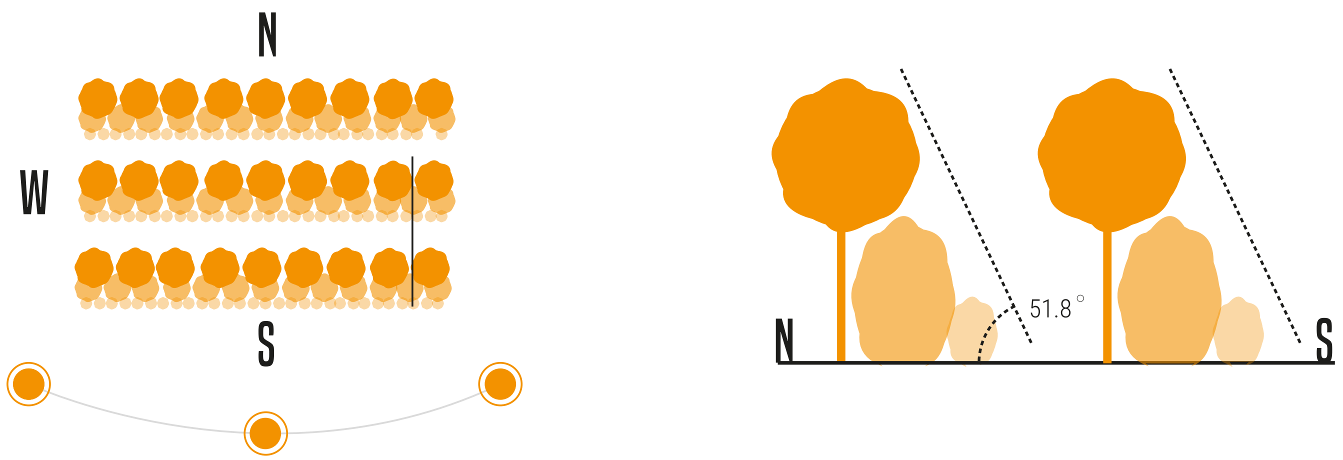


Figure 23: Planting for solar catch *(Author, 2018)*

acounting for harvest

Although water, soil and sun dictate the shapes the agricultural systems should have, benefits come when taking the lot structures int acount. Instead of being resolute in shaping these structures, The process of harvest should be taken into acount, as the other machinalised processes have little to no place in these systems. (Figure 24)

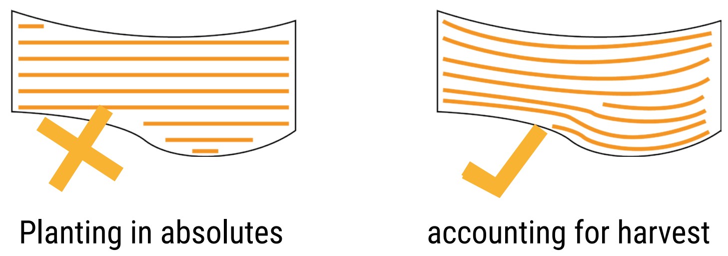


Figure 24: Planting for harvest *(Author, 2018)*

Woody crop systems

The woody crop systems that Shepard describes could actually do remarkably well in the Bernisse, as most of these species have a cold-hardy cousin native to the Netherlands. The Dutch climate supports apples and pears. Grapes won't be an issue either: just east of the Bernisse stream there is already a fully functioning vineyard operating since 1990 (dewijnhoek.nl, 2018) Hazel is also a good option for the Netherlands. It is native to the area, water resistant and, although not common as a mass-produced crop in the Netherlands, cultivars exist that are selected for increased and accelerated nut production and nut quality. (Baltissen & Oosterbaan, 2017) These type of trees are also great cattle feeders, both in leaf and fruit. (Van Eekeren, Luske, Vonk, & Anssems, 2014) Walnut is also a viable option for the Netherlands (Baltissen & Oosterbaan, 2017). Raspberries and are also a common fruit in the Netherlands, an alternative to these could be blackberries. (Figure 25)

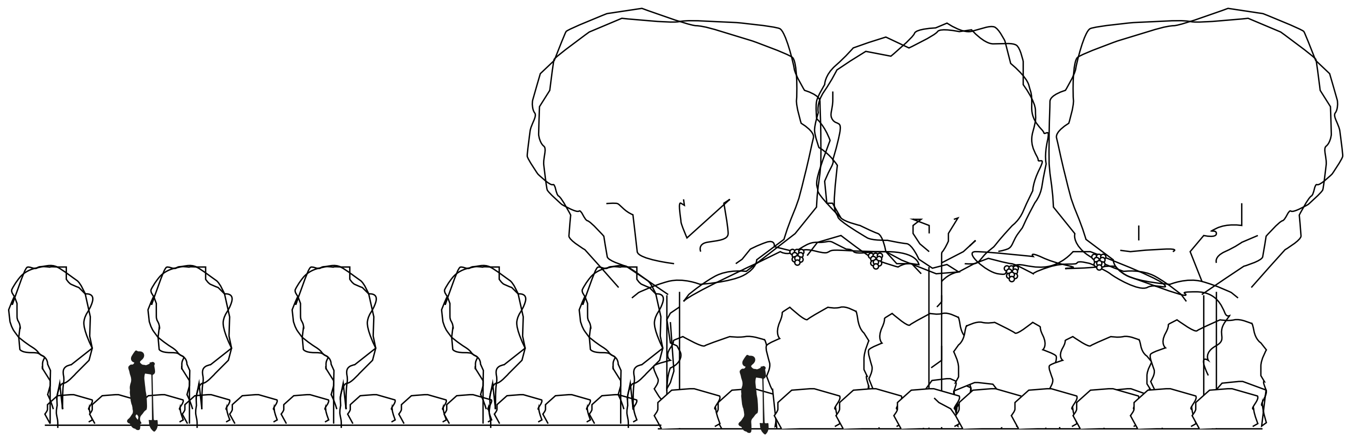


Figure 25 The systems next to one another *(Author, 2018)*

Silvopasture

In finding trees for feeding cattle in a silvopasture system, the Report of the Louis Bolk Institute discussing the potential of trees in Dutch agricultural systems (Van Eekeren, Luske, Vonk, & Anssems, 2014) is of great help. A selection is made from a helpful matrix included in the report to select trees for the conditions of the grasslands. The area has a calcium deficient and quite wet clay ground. Therefore a combination of Salix Alba, Corylus avelana (Hazel) and Alnus Glutinosa would work well for these conditions. These species do well on wet grounds and have high food values for cattle. Rows of Populis Nigra could be applied as well, with a more scenic value fit for accentuating the more dominant structures like the old dikes. (Figure 26)

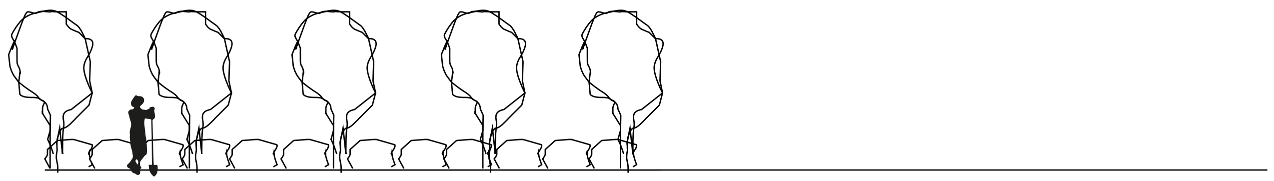


Figure 26: Silvopasture along with woody crop systems *(Author, 2018)*

Paludiculture

Peatlands are being drained in order to maintain as arable land. This is common practice in the Netherlands. The land is not being maintained however, as drained peatland subsides and emits greenhouse gasses and nutrients. Additionally this practice is a danger to biodiversity. 0.3 % of peatland is drained globally, but this practice is responsible for 6% of all human greenhouse gas emissions. (Abel, Couwenberg , Dahms, & Joosten, 2013) Rewetting these peatlands stops these negative impacts. (Joosten, Tapio-Biström, & Tol, 2012) In the light of restoration agriculture, this means potential rather than problem. Rewetting peatlands provides the conditions for a set of plants that do well in these conditions. Producing such crops on peatlands is known as paludiculture.

Producing Alder (Alnus Glutinosa), cattail (Typha) (Figure 27) and common reed (Phragmites Australis) is a tried and tested system that can easily take flight in the peatlands of the Bernisse area. All of these species can be used as a fuel source, among other uses. (Abel, Couwenberg , Dahms, & Joosten, 2013) (Joosten, Tapio-Biström, & Tol, 2012). paludiculture could be the heart of the area as the source of the fuels used in the surrounding areas, with any excess fuel used in the port of Rotterdam. Wetlands can also provide food in the form of cranberries, which are harvested through flooding the landscape. (Shepard, 2013)

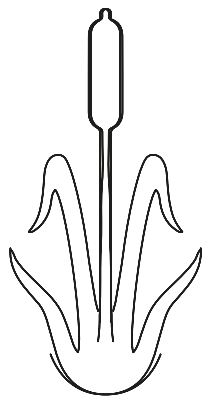


Figure 27: Cattails, alder and reed is a welcome source for biofuel production. *(Author, 2018)*

3. REGIONAL DESIGN

1 ANALYSIS

The problem statement expands

The area of the Bernisse stream has more to deal with than just the potential loss of arable land. Mapping these issues may provide chances in using restoration agriculture elements to take these issues and turn them into solutions. This approach is at the foundation of the philosophy of restoration agriculturalists like Mollison and Shepard, and will therefore play a part in the regional design as well.

Poor recreational use

The municipality has expressed a poor state and limited use of the recreational qualities of the area, although it is intended as a recreational hinterland of the metropolitan area that lies above. (Spacevalue B.V., 2012) This can be linked to the connectivity and monofunctionality of the area. The Bernisse stream itself shows promise but is not very present from surrounding perspectives and is ill-connected to Spijkernisse as the only other recreational route “het Trambaanpad” from Spijkernisse is mostly recreational in name, while taking you through some highly industrial agricultural fields. (Figure 28)

Discrepancies between soil and land use

Because of legislations, subsidies and the benefits of upscaling, a few areas produce more ambitious produce than the soil can naturally provide. The result is a need and thus a certainty of external input which, in the light of restoration agriculture, can no longer be the case. The land use should embody its soil type, which makes the landscape more diverse and more legible in the process. The map below gives insight in what areas do not correspond with the expected or advised land use. (Figure 29)

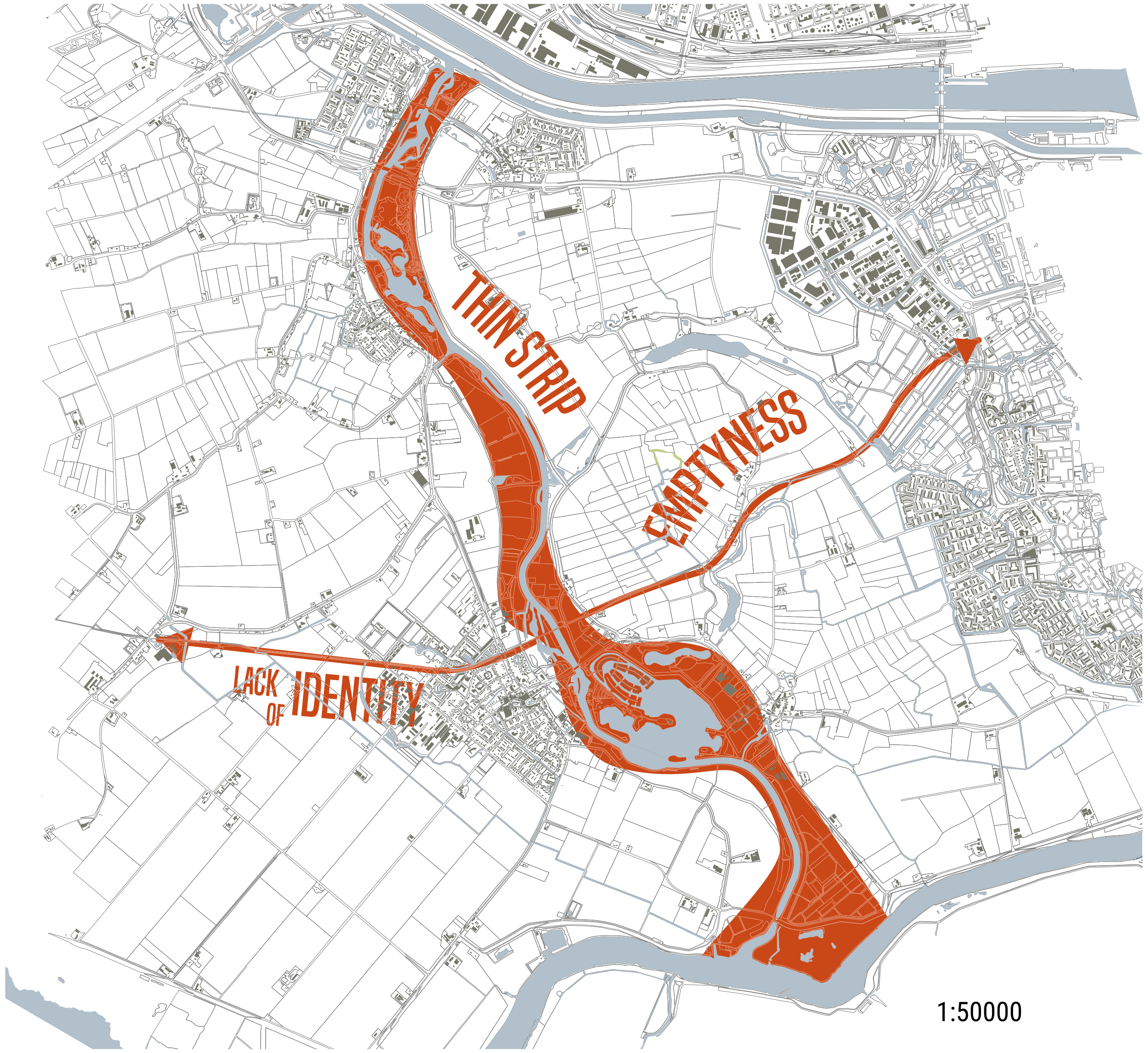


Figure 28: Issues regarding recreation: an industrial desert between the stream and the town. *Adapted from (Esri, 2018)*

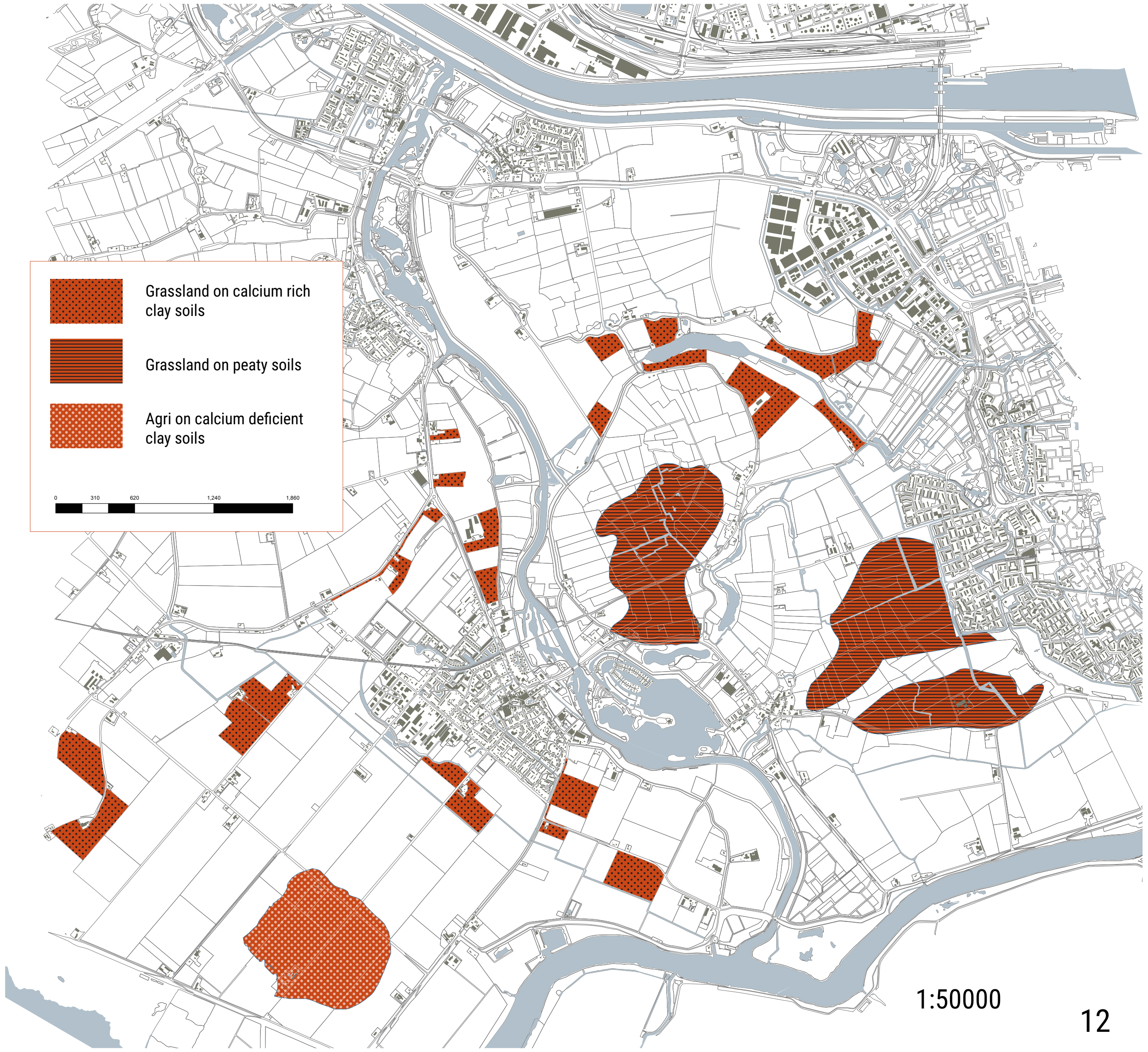


Figure 29: Locations where the soils do not follow their optimal use. *Adapted from (Esri, 2018)*

Poor ecological connections, few ecological hubs

Natural areas, in this context any area with a more complex natural system (including tidal marches, forested areas, streams and wet grasslands) are scarce and fragmented in the area. There are two relatively large forested areas bordering spijkernisse. Most other tree-filled areas can be found along the Bernisse stream. When the areas are this fragmented, species that rely on trees and bushes are less resilient than when there is a connection between habitats. These species include types of birds, bees and other insects. (Figure 30)

Poor visibility of landscape entities and their history

Because of monoculture's two-dimensionality. The lot patterns and shapes hat can be clearly seen on the map are almost invisible to those experiencing the landscape from base level. Apart from the clearly designed landscape directly alongside the Bernisse, few reminders of the difference between the landscape entities can be distinguished. (Figure 31)

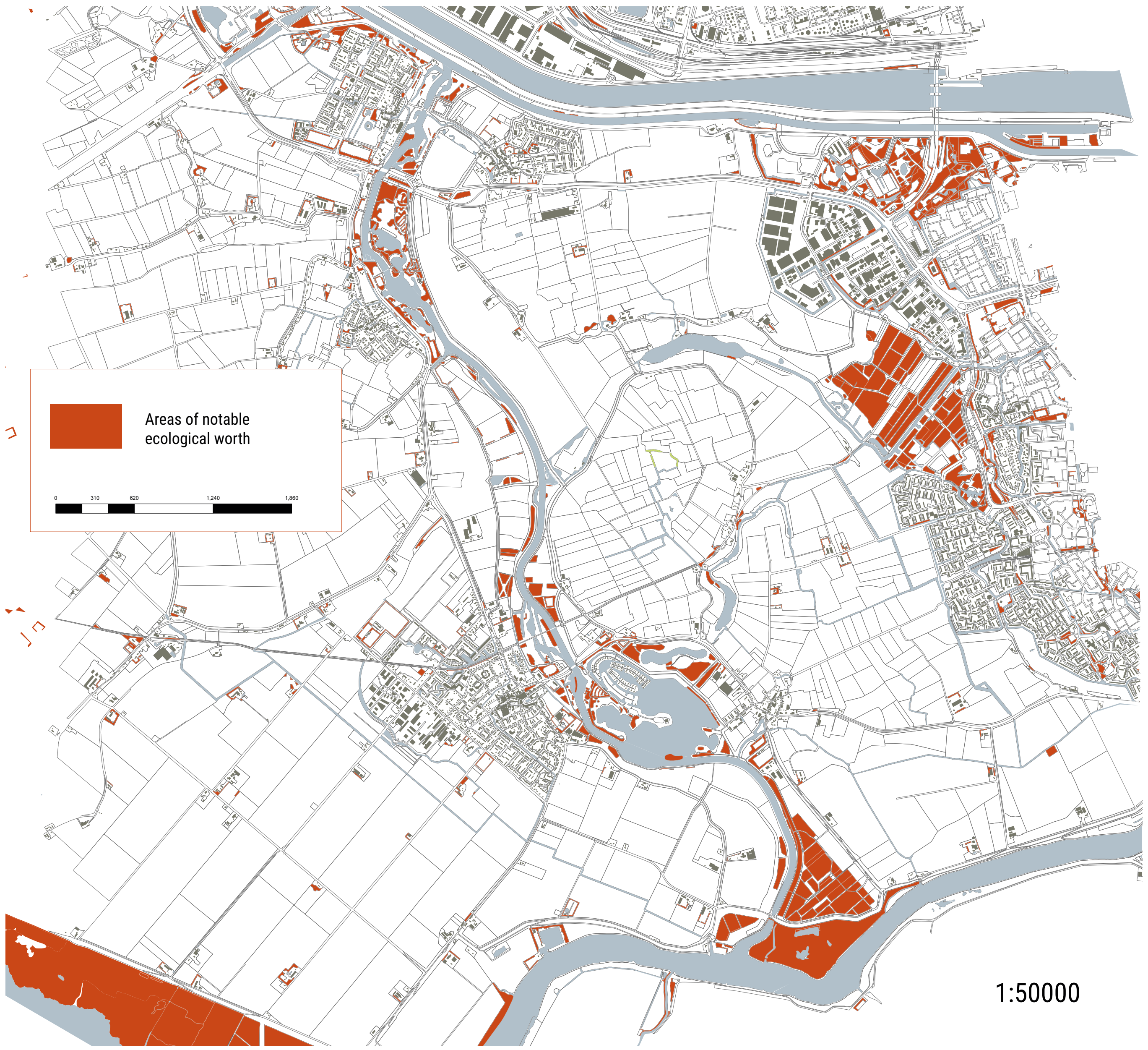


Figure 30: Ecological hubs are scarce and dispersed. *Adapted from (Esri, 2018)*

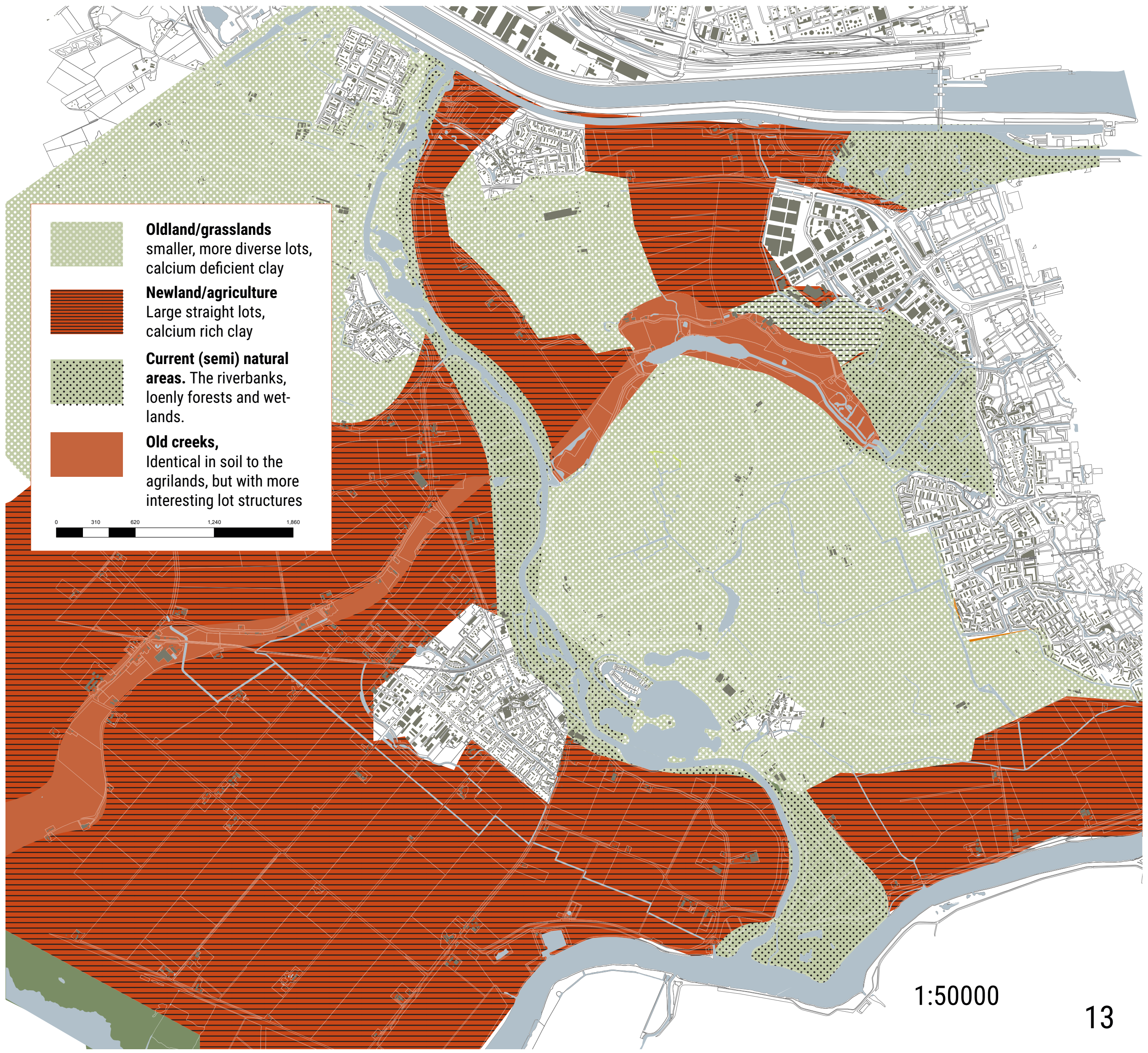


Figure 31: Landscape entities as devised by the author. *Adapted from (Esri, 2018)*

3. REGIONAL DESIGN
2 DESIGN PRINCIPLES

Tackling the analysed issues

In line with issues found within the Bernisse area, some design objectives for the area are developed. These are illustrated below. (Figure 32)

1. To **amplify the recreational value** of the touristic routes by adding scale and structure. additional benefits may also come from fortified ecologies and filtering function of plant roots and paludiculture.
2. To **adapt the agriculture to the conditions** that lie beneath, to achieve a more legible and diverse landscape, but also to ultimately create a more profitable and easier-to-maintain system.
3. To **connect ecological structures** using agricultural systems of a high ecological value.
4. To **amplify historic structures**, as these are currently poorly visible in the landscape. lot structures can be 3-dimensionalised and made something one can experience.

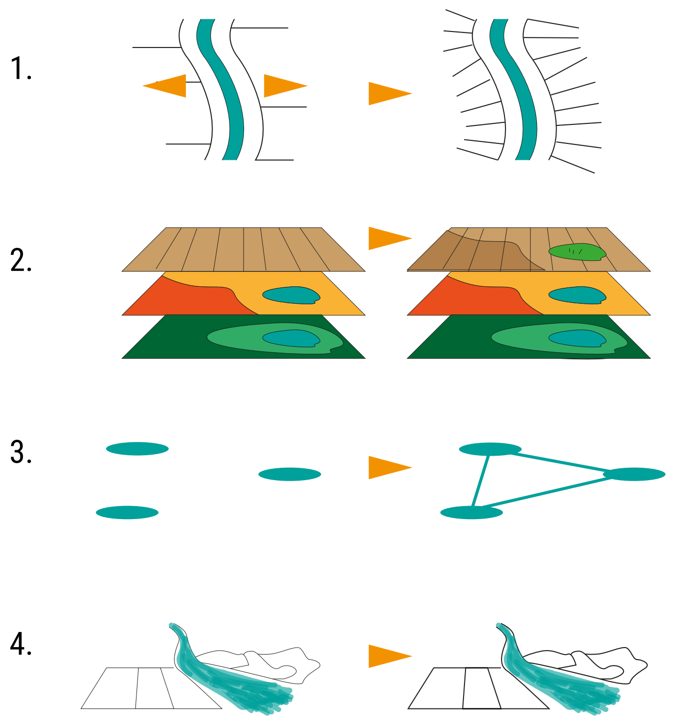


Figure 32: Regional design principles. *(Author, 2018)*

The rationale behind the approach

There is a need for defining these local objectives as 'saving the world from global warming and a global food crisis' is a cause too large to rally a municipality and its inhabitants behind. 'Saving the agricultural lands we fought for' is a better approach, but like mentioned before, this can be applied to any similar region in the Netherlands. These approaches raise questions such as "why us", and "why here instead of there". In order to prevent a NIMBY response to these significant changes, a definition of what restoration agriculture could look like in the Bernisse area is required. The changes need to be in everybody's best interest in order to have the highest chance of successful implementation.

A good example of a failed exercise in that respect is the implementation of windmills in the area: while they directly tackle global issues of energy problematics and global warming, they have not been met with a warm welcome. During the time of visit , May 2018, the region had anti-windmill campaigns hanging in front of various buildings. There is also an active Facebook group protesting against the windmills on the island with articles and references of the dangers of low-frequent sounds and other negative impacts. (Windmolens Voorne-Putten Nee, 2018) These windmills have mainly negative side-effects, at least in the eyes of the population. Finding solutions for local issues using global problem solvers is the directive, instead of creating more problems with them.

There are two types of implementation used, complete implementation and preparation implementation. (Figure 33)

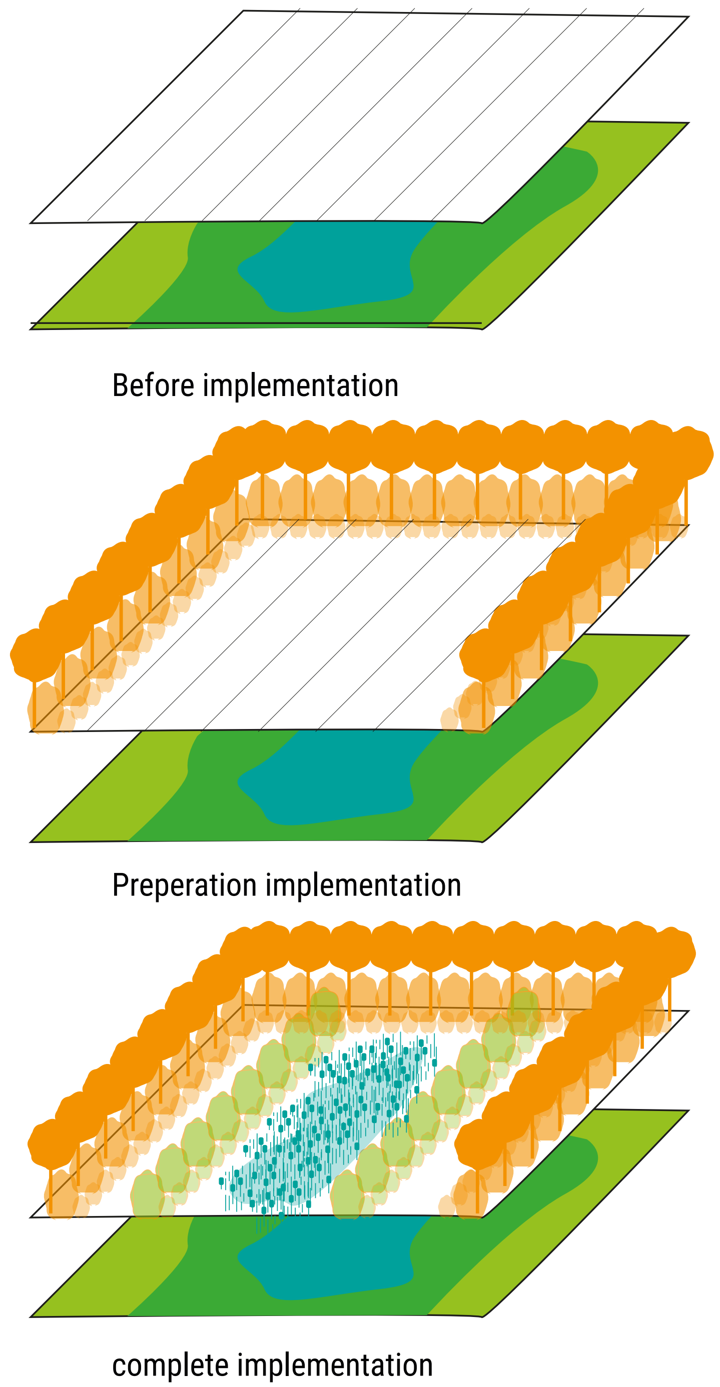


Figure 33: Modes of implementation *(Author, 2018)*

3. REGIONAL DESIGN
3 THE MODELS

The process

With the systems in place for all of the landscape entities, it is time to take a look at how to implement these in the landscape. One needs to know what structures to follow, and which areas the shift in agricultural type makes to most impact, and should therefore be prioritised. This prioritisation follows as a requirement for the design from the perspective of restoration agriculture. It is not a question of whether to adapt the agricultural lands. The question is rather which areas to start with, and how to progress within that shift. The key for finding the answer to that question lies in some of the principles introduced by Shepard, but also in the secondary benefits that restoration agriculture and the landscapes it produces possess.

Method

In the following pages, some approaches for coming to a structure plan are discussed, each is specialised to directly tackle one of the issues discussed in the analysis chapter. The pros and cons of each approach will be adressed. A synthesis of the outcomes into an optimum will be the final step.

Soil and land-use: form follows function

The ideas of restoration agriculture will be leading in this decision making process. This means that soil and water conditions are prioritised over old structures or land uses. Luckily, the Dutch have been working with soil in mind for quite some time. This means that the gross of the structures is already following the subsurface layers. This provides chances to reinstate these original structures where they are still applicable. However, there are some areas in which the soil type does not follow the type of land use most suited for those soils. In the southwest part of the Bernisse area lies a circle of calcium deficient clay soil used for industrial agricultural production. These soils are used as a grassland in the rest of the extent of the land use map for a good reason. These lands have been taken into production due to the scale advantages, but this requires the external input of calcium to the soil, which is something that should be avoided. In the Northeast grasslands, even the more peaty soils are forced into grassland production. These areas have a higher potential for the application of the system called paludiculture described in the chapter “adaptation to locale”. (Figure 35)

Figure 34: locations of main interest for soil discrepancies
Adapted from: *(Esri, 2018)*

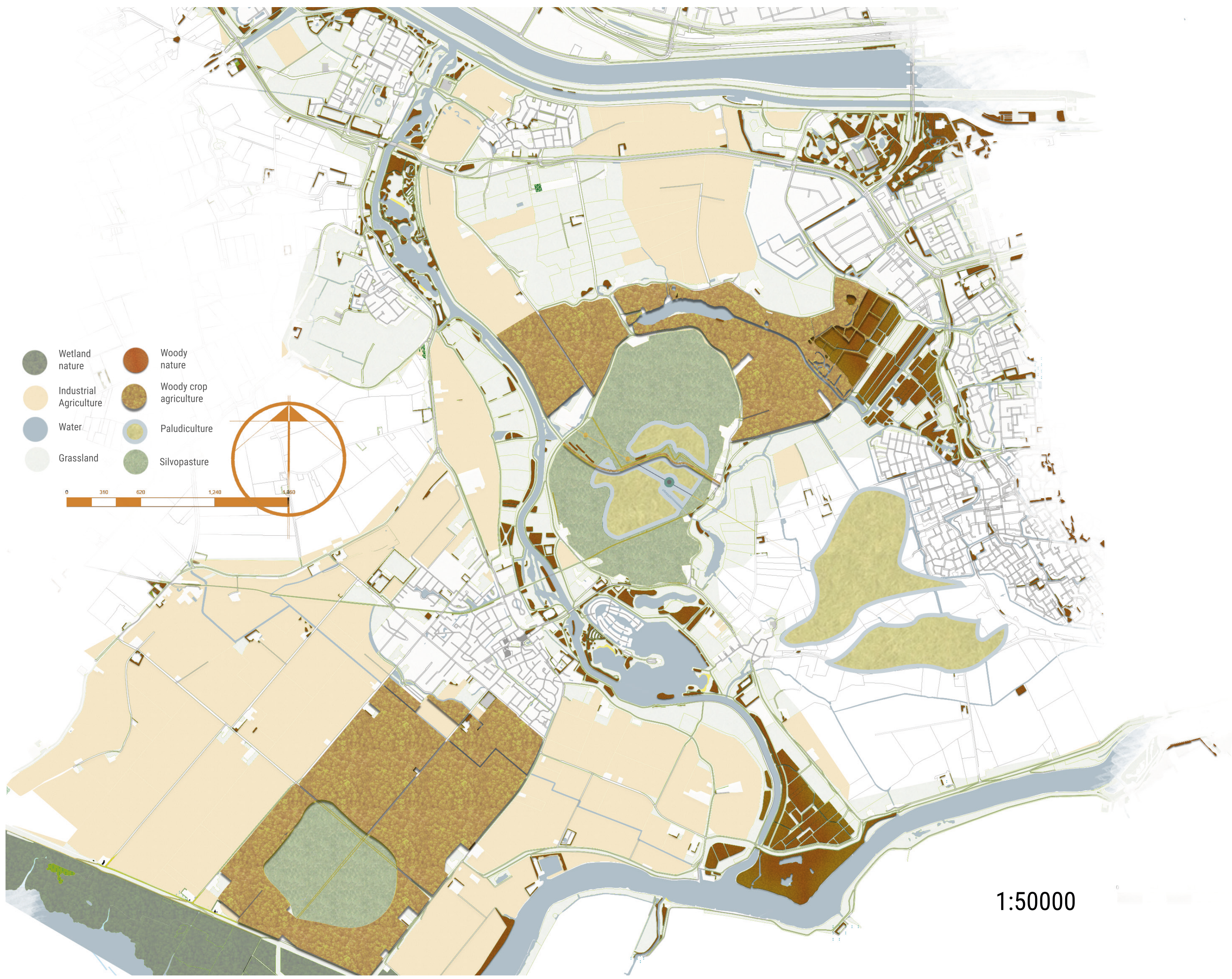


Figure 35: Regional design based primarily on subsoils.
Adapted from: (Esri, 2018)

Pros and Cons

+ Direct conversion of most critical soils

+ Connection between Silvopasture and R.Agriulture

+ Good Showcase for interconnected systems

- seemingly random locations

- creation of new landscape entities as a result of previous use of soils

Agriculture is nature

One of the key concepts is that of a production ecosystem. The ecological worth of these systems is far higher than current agricultural lands. A varied mixture of plants provide a nesting place for a wide variety of birds, bees, insects and even larger land animals, which all sustain one another (Rhodes, 2015) (Schoonhoven, 2015) While these areas are valuable on their own, these areas significantly increase their worth when spatially linked to other areas of notable ecological worth. This increases the population resilience.

The current landscape mostly has woody plants alongside the Bernisse. (Figure 36) There are two other notable forest-like areas as well as some wetlands in the southwest corner. None of these are spatially linked, so that is where a potential arises for fortifying these lonely ecological Islands. (Figure 37)

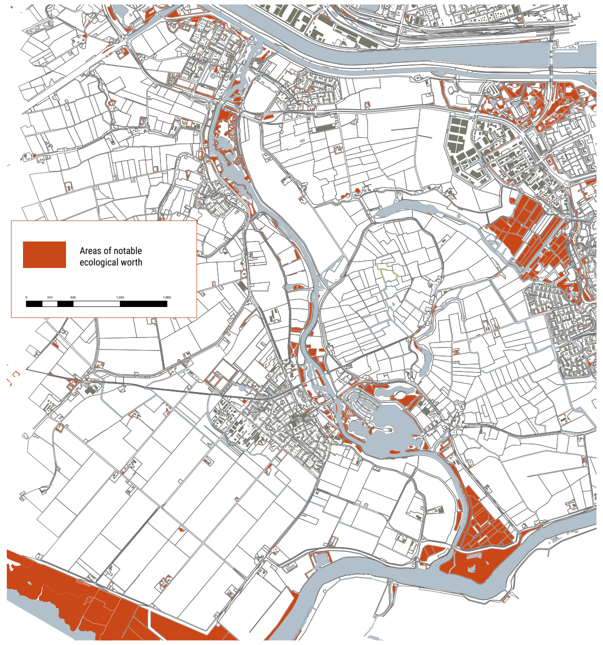


Figure 36: Recap of the analysis of ecology: *Adapted from (Esri, 2018)*

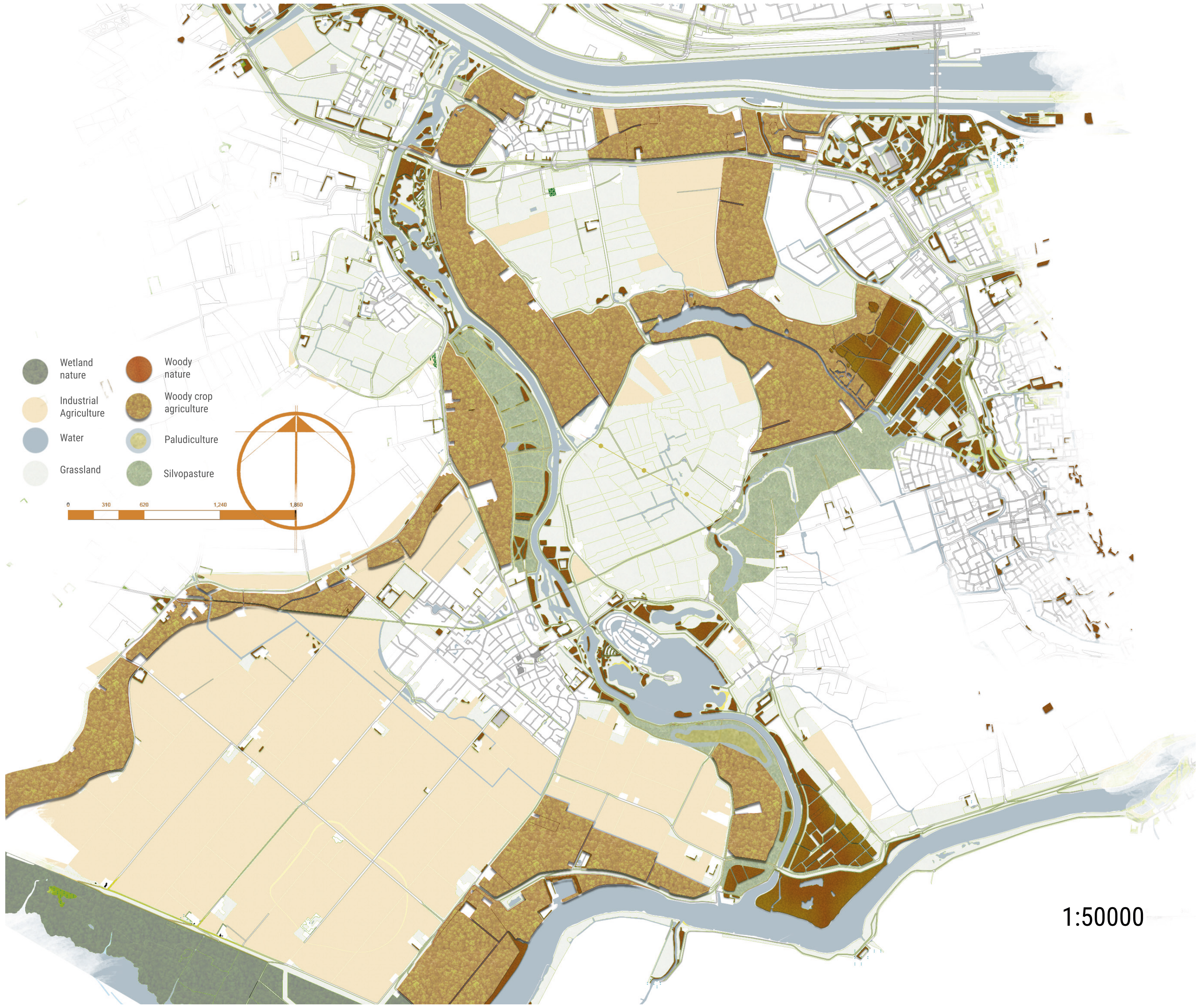


Figure 37: Regional design based upon connecting ecologies *(Esri, 2018)*

Pros and Cons

+ Connected ecologies

+ returned the creeks, fortified the rivers

+/- seductive entrance into the area from spijkernisse, but no gateway into the stream

+/- some connection between Silvopasture and woody crop systems

+/- the systems act as borders between entities.

- No good application of effective paludiculture within these structures

Recreational value

Creating a hybrid between nature and agriculture means developing a form of nature. It means landscapes that are three dimensional and allow for discovery and identities. The landscapes restoration agriculture produces are more pleasing and interesting to the human eye than those of conventional agriculture. The argumentation for this can be found in the discussion in chapter 5. As the area of the Bernisse stream is intended as a recreational area for both the local population as for the people from the metropolitan area of Rotterdam, there is also a huge benefit to be gained from first applying these systems where the recreation is expected and desired. There are two mayor routes for people in the area. The first are the paths alongside the Bernisse itself, these are decent as is but the area itself feels quite thin. There is little to see when one looks beyond the river banks. The second route is the Trambaanpad, which functions as a gateway from Spijkernisse, passing the Bernisse and leading to the historic city of Hellevoetssluis. Currently, there is little to be seen alongside this path but far stretching fields of grass east of the Bernisse, and stretching fields of corn, beetroot and potatoes on the south side. (Figure 38) Developing diverse areas alongside the Trambaanpad first is an approach that has a high impact on the identity of the region and which increases the recreational value directly and instantly. (Figure 39)

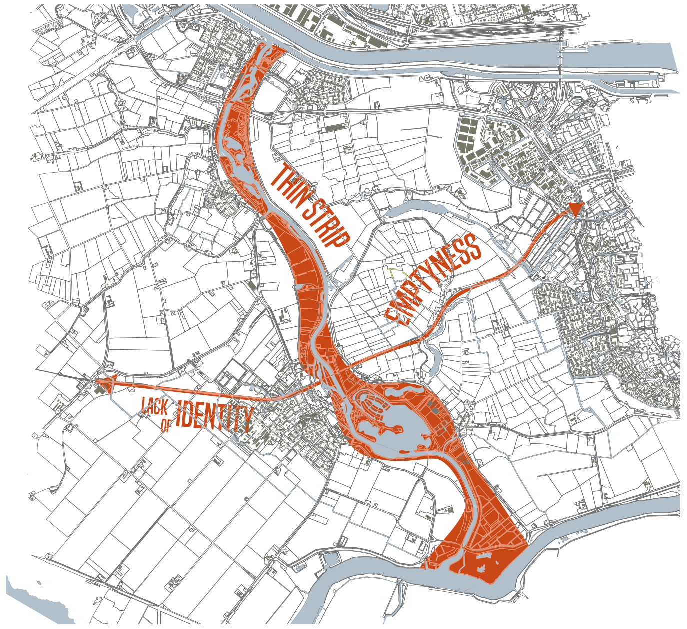


Figure 38: Recap of the analysis regarding recreation: *Adapted from (Esri, 2018)*

Figure 39: Regional design based upon strengething recreational values. *adapted from (Esri, 2018)*

Pro's and Cons

+ Good Showcase, paludiculture as the crossroads

+/ - Decent connection between Silvopasture and R.Agriulture

+/- decently connects ecologies

- Facade-like structure, newland left untreated and creeks ignored.

Using History as guidance

Following the current lot structures and polder shapes is first and foremost the most cheap and easy method of implementation, a feat that should not be overlooked. Dutch irrigation channels and patterns are quite sophisticated already and alterations are mostly unnecessary. At the same time these unique structures are hardly visible unless they're seen from above. Setting up three dimensional production systems can assist as a tool to visualise these structures on a human scale.

Production lanes

This first requires the introduction of a slightly new concept within the "woody crop" restoration agriculture system: production lanes. Generaly, food is produced on square lots, but as 9 lanes of trees go in an acre in these woody crop production systems, 1 line goes in 1/9th of an acre. (Figure 40)

This allows us to create lanes alongside roads and dike structures that are easily harvested in a single trip, with the grandeur of a classic lane of trees. After about 20 years, when the trees start to become a closed canopy, one would allow them to. Usually this is the point where one would start pruning and cutting trees to maintain maximum sun catch. In this particular case, the trees are allowed to continue their succession while the transition within these lanes continues. This allows for a higher diversity of biomes in the area. It also allows us to continue accentuating the old structures when the fields have all shifted towards woody crop systems. These lanes will still be towering over the other food forests. (Figure 41)

Figure 40: Fields can become lines, how stretching lots can become structural scenic elements *(Author, 2018)*

Figure 41: Regional design based upon strengething landscape entity identity and historic structures. *Adapted from (Esri, 2018)*

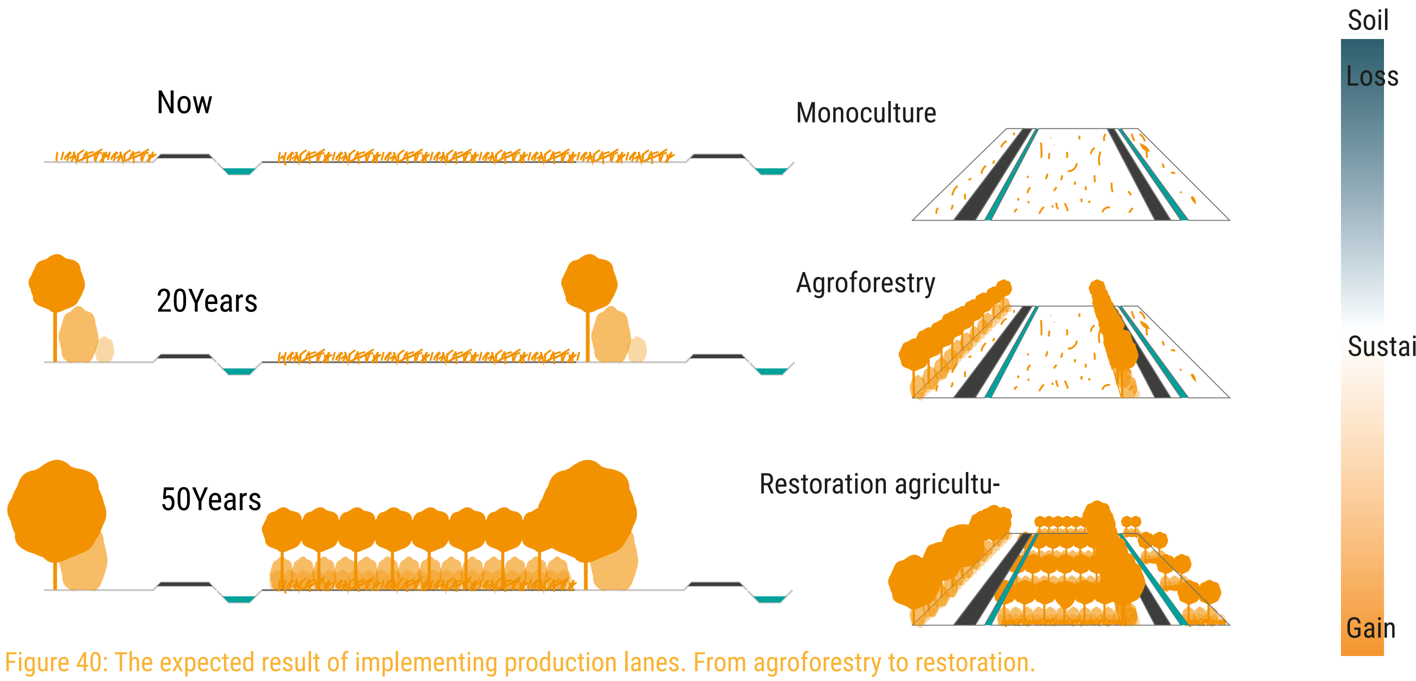


Figure 40: The expected result of implementing production lanes. From agroforestry to restoration. *(Author, 2018)*

Pro's and Cons

+ Add scale and identity to the landscape entities

+ reveals several polder structures with elatively minor interventions

- requires a complicated harvest method/party

- little surface impact

- no good places for paludiculture

3. REGIONAL DESIGN

4 FINAL DESIGN

This Design (Figure 42) is the synthesis of all the approaches discussed above. It seeks to combine the positive aspects of the plans mentioned before while avoiding their negative consequences.

Autumn leaves

Except from the authors desire to break with standards, there is a deeper reason for choosing fall as the season of representation. Central to this design are the bushes and trees. Apart from all that was mentioned before, perennials have one more gift up their sleeve: Autumn leaves. The time of year in which the magnificence of the shed leaf lights up forests like a wildfire, and subsequently makes the interventions quite easy to spot on a map. Dead leaf falls to the earth then covers and protect the soil while the soil life is eating away and producing next year's mulch. Orange and brown are the colours of soils, and an hommage to soils is the focus of this design.

Historic patterns: introducing old friends

The old creeks, visible only in geomorphologic maps and lot structures, have been brought back into existence as the outer reaches of this project. As their soils are identical to those of the newland clay systems, they require the same system. By selecting these creeks and the linings of the water as the first places to implement the systems, they will stay clearly visible for at least 50 years, as their head start in growth will have these areas tower over the others for years to come. As collections of trees have come to mean the presence water in this area, this design seeks to comply. Where water flowed, trees grow. The cower these trees provide also does a good job at covering up the industrial port of Rotterdam, which is an eyesore on the horizon.

Figure 42: The final regional design.
Adapted from (Esri, 2018)

The beating hearts

The first things to catch the eye are without a doubt the two large spaces of contrast. These are a direct consequence of the design principle of letting the local conditions determine land use, without concession.

The upper circle will be a rewetted peaty soil, brought into production via paludiculture. (Figure 43) The profits of these fields will be able to provide the area with biofuel. Any excess production can be used in the port of Rotterdam. It also creates some wonderful, seemingly natural wetlands.

The lower circle, (Figure 44) which is too calcium deficient to function for the selected woody crop system, will be used for silvopasture. This area will be the showcase for the leader follower system and will provide the surrounding area with local manure in exchange for unharvested fruits, nuts, worms and weeds.

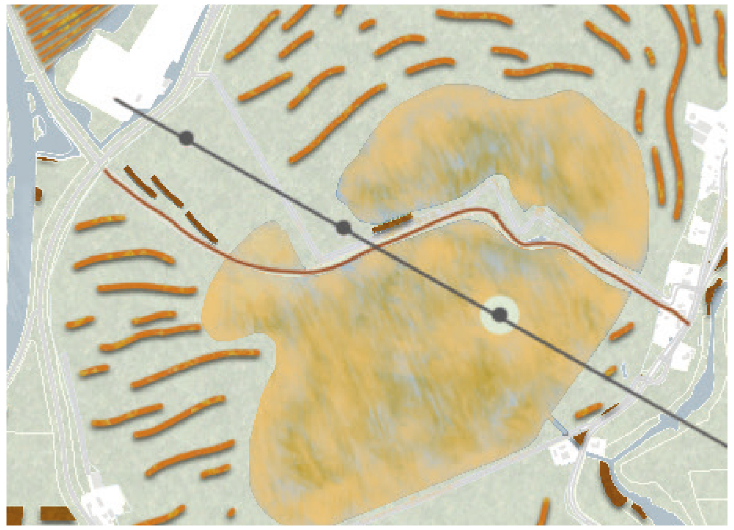


Figure 43: "The Northern Heart' *Adapted from (Esri, 2018)*

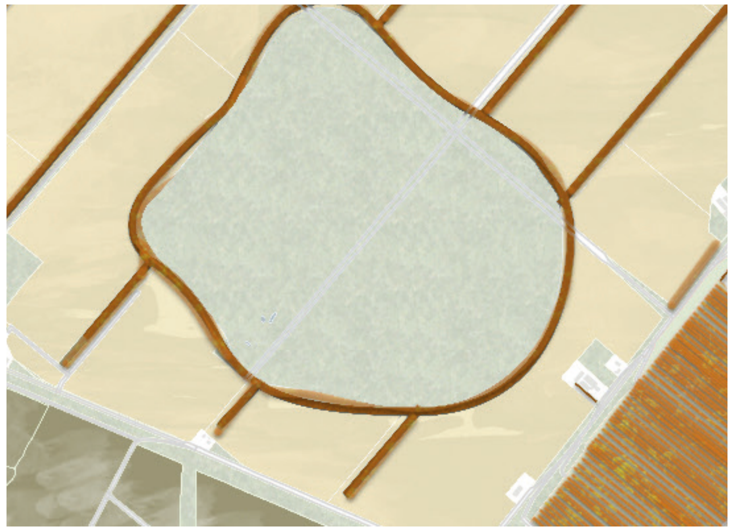


Figure 44: "The Southern Heart' *Adapted from (Esri, 2018)*

Trambaanpad

The recreational area of the Bernisse has two main veins: the Bernisse stream itself, and the Trambaanpad. This path has been severely strengthened. Where it used to take a cyclist through a uniform field of industrial grasslands, it now takes you through all of the amplified landscape entities the Bernisse has to offer.

Fortified identities

Listening to the soil automatically provides us with enhanced identities. These are described along the route of the Trambaanpad:

"Coming from spijkernisse we first pass the forest. One can eventually see the tall and old trees make way for a more orchard-like growth on the right, with a glimpse of the creek's waterbody. For those that enjoy an open sight, the view over the typical Dutch grasslands on the left is vast and Omnious. The Industrial complex of the port of Rotterdam can no longer be seen from here. We continue and pass a rough field riddled with bushes where all types of animals can be spotted. It reminds one of the savannahs seen in nature documentaries and we half expect giraffes to stick their necks out. The trees and bushes seem to take a respectful bow to what can be seen in the distance: a vast wetland with reeds, grasses and cattails. There are sounds of birds and rustling reed in the distance. A deck offers the chance to explore these wetlands and to continue the tour along the Bernisse stream. We decide to ignore the temptation and continue through Zuidland untill we eventually see a glimpse of the vastness of the newland agricultural fields. its sheer scale is made comprehensible by the treelines that escort the rows of corn and wheat, which will eventually also make place for the rows of woody production we now see looming up in the distance. As the canopy closes in, we are reminded that this must be where the creeks once flowed. On our way back to our hotel in Hellevoetsluis we travel through the relative nothingness we encounter as fast as we can. Then we start to wonder why..

Connected ecologies

All ecologies are connected except for the forested area in the upper left corner: a priority for future expansions. Some strips are also slightly thinner than in the ecology oriented pre-design. This is because he fauna in this area is mostly birds and insects. These are able to travel such distances without any issues. the larger land mammals are included in the human management through animal husbandry

Connected systems

As explained in the chapter about silvopasture, these systems can benefit from one another. Therefore it is wise to always have some animals that can be used within the system closeby to the woody crop systems. While the system is maturing, they pose a bigger threat from grazing and trampling than when the trees are already tall and strong. That is why silvopasture and woody crops are now put closeby in the north, and the hub in the south has extra value. It serves as the base of the animals that can be used in the rest of the system. Initially, this will only be in the production lanes of the newland. When the systems mature and expand, they will have to rely less on additional feed, and more on the produce from the woody crop systems.

Figure 45: Profile of the woody crop system with apples, grapes, hazel and berries *(Author, 2018)*

Figure 46: Profile of the woody crop system with chestnut, grapes, and berries *(Author, 2018)*

4. DETAIL DESIGNS

1 Woody crop systems

Applied in most regions of the design, these systems can vary from their tree/secondairy bush and berry types as the farmer sees fit. The selection made here is not binding, it is a starting point. (Figure 45 & 46) The question this design tries to answer is the possible multifunctionality of such designs and what such a system would look like in a landscape. (Figure 48) In the current landscape, where the stream flows, the trees grow. The design therefore fortifies this link between trees and flow near the Bernisse, and utilises this mental connection to show the locations of old creek flows. The orientation of the systems is primarily east-west. However, their orientation is influenced by the streams flow direction. This is a hommage to their source of life but it also includes them into the landscape of the stream. The existance of the stream is now felt from the main road as well. Where once the dike was a hard border between the stream and the agricultural land, it now becomes a route with a view, crossing right through it.

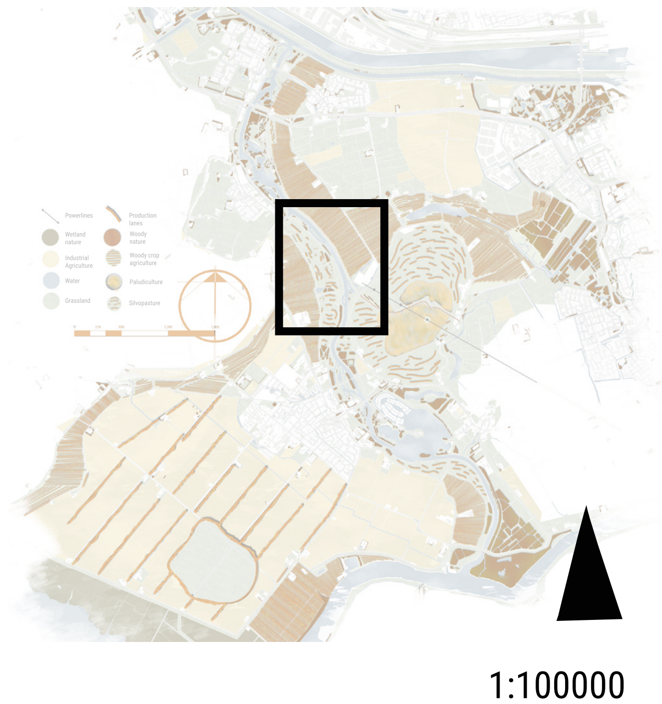


Figure 47: The general location of the details. *Adapted from (Esri, 2018)*

Figure 48: Bird's eye view of the production systems along the Bernisse stream. *Adapted from (Google, 2018)*

4. DETAIL DESIGNS
2 The Northern Heart

Agriculture is nature

The Northern Heart aims to prove that there is no hard line between agriculture and nature. Like any animal and species in the system, humans benefit from a healthy and diverse ecosystem, and the ecosystem benefits from us. To make that idea spatial, the northern heart (seemingly) follows a gradient of cultivation. (Figure 49) In reality, every piece of this land is a highly productive piece of agricultural land.
The organic shapes (Figure 52) are not a man-made facade, they follow the demands of their substrate layers. The center is the first implementation of paludiculture in the area, growing biofuels through Cattail and reeds, and could yield produce in the form of local Cranberry. This provides a arge habitat for bird species that thrive on such sheltered surroundings.

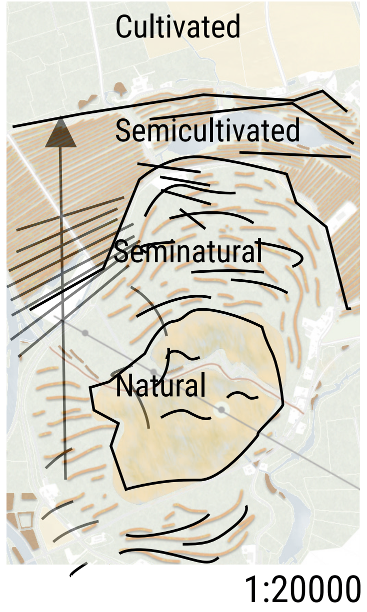


Figure 49: The gradient of cultivation
Adapted from (Esri, 2018)

Silvopasture and sightlines

We can enhance the natural feeling of silvopasture by using the woodwalls to form and masque allotment borders. From the perspective of the trambaanpad or the deck, feeding trees could be used for this. (Figure 53) alternatively, since the area is slowly sloping downward and some of the ground of the center area could be used to cover the rest of the grassland, even ha-ha wall could be applied when the openness is to be protected. The result is the sense of a single stretching field of land with grazing flocks and herds sticking together, while coexisting with the other species. The same type of leader follower system as in the southern heart will be applied, allbeit in a more covert manner.

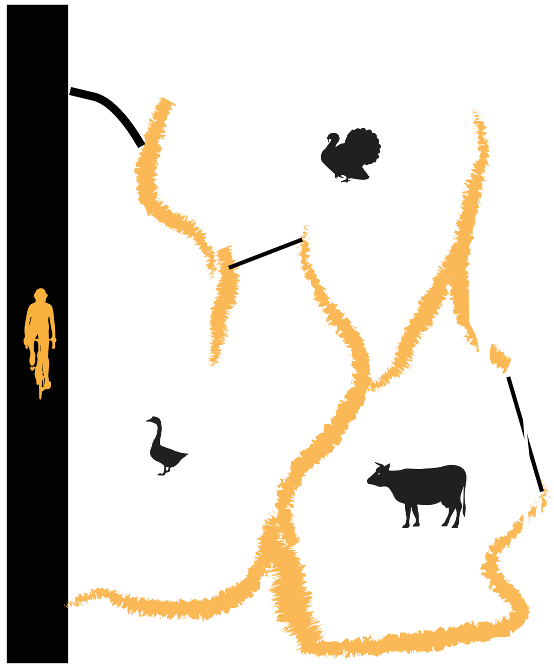


Figure 53:How trees and fences can masque man-made allotment structures *(Author, 2018)*

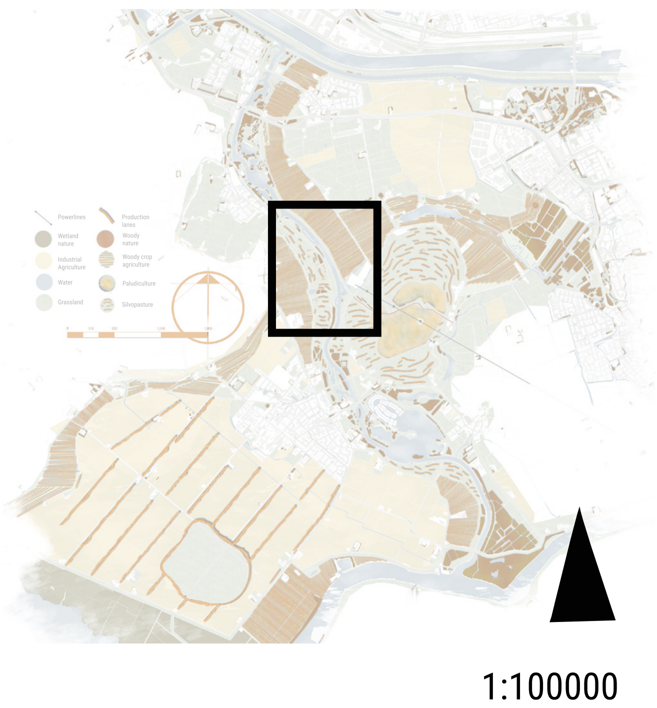


Figure 50: The general location of the details.
Adapted from (Esri, 2018)

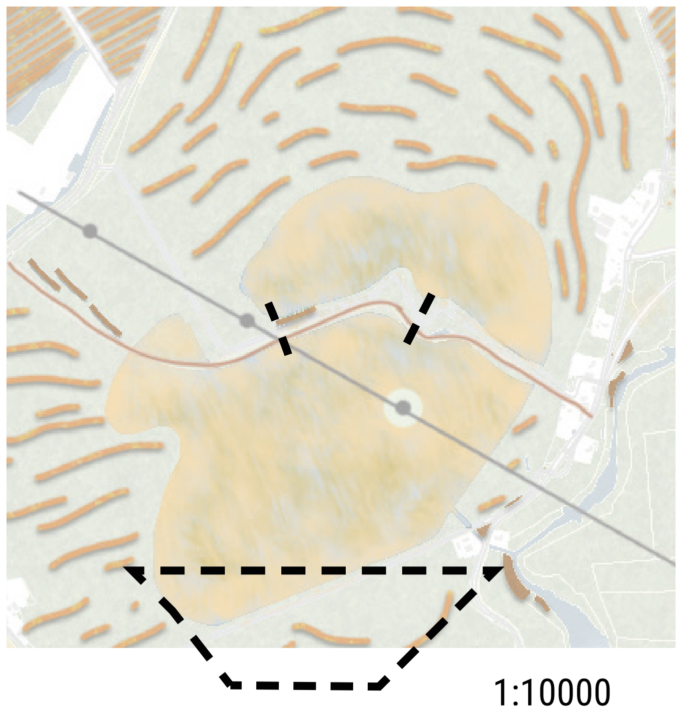


Figure 51: The locations of the bird's eye view and profile details.
Adapted from (Esri, 2018)

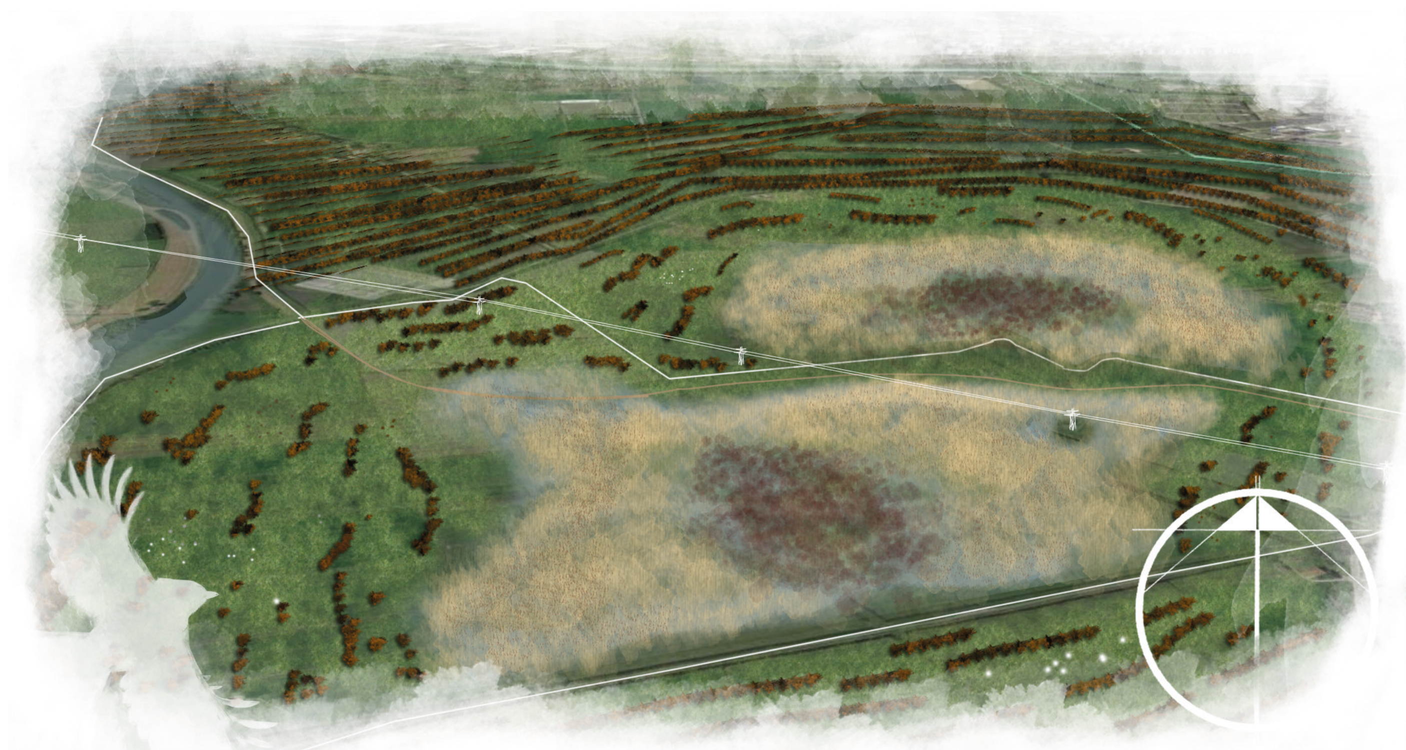


Figure 52: Bird's eye view of the Northen Heart. *Adapted from (Google, 2018)*

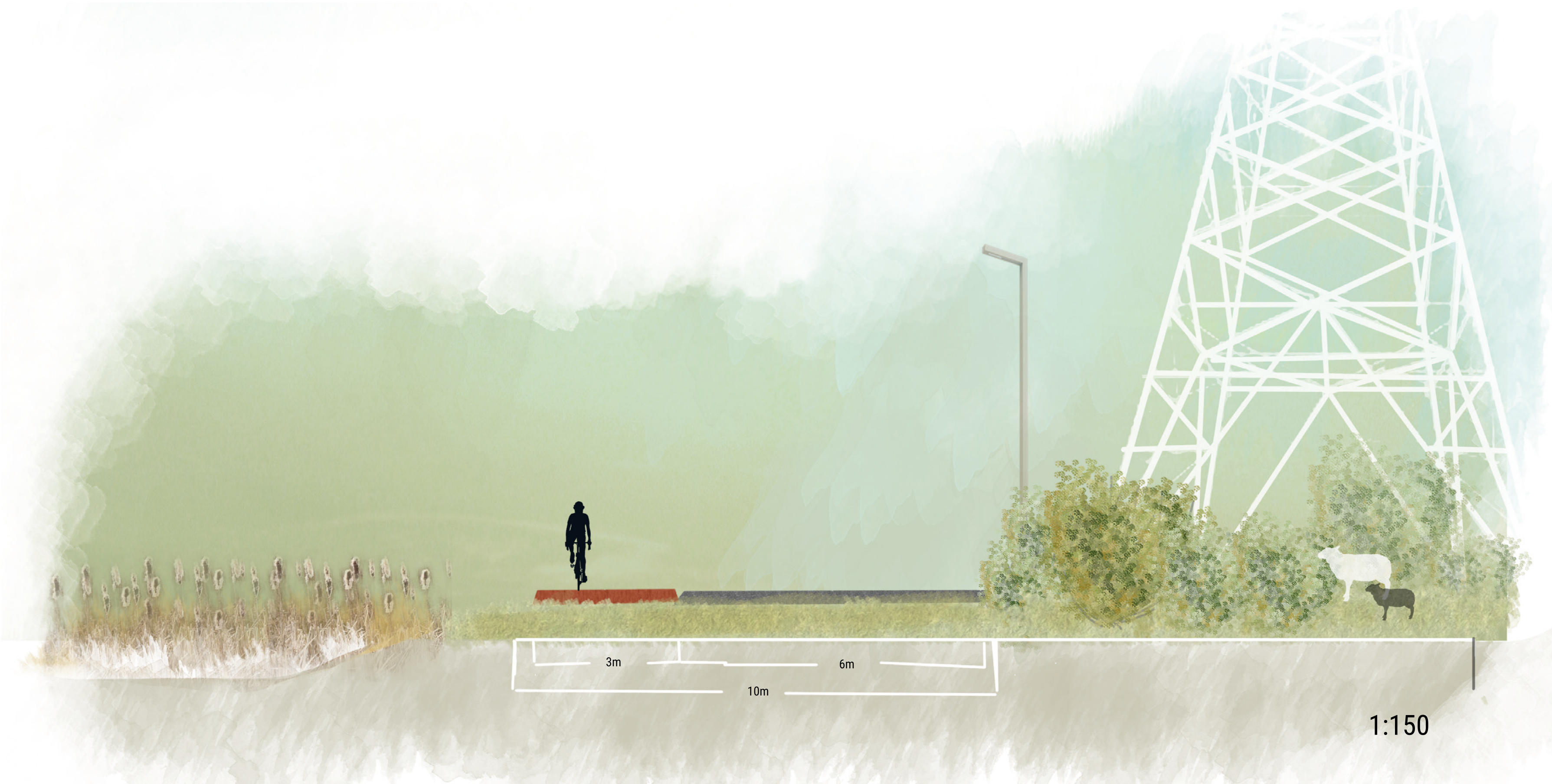


Figure 54: Profile of the Paludicultural area, where the paths run parallel. *(Author, 2018)*

Connecting Spijkernisse to the stream
The deck that crosses the paludicultural fields allows visitors to experience the systems by foot or bicycle. This path, which is seperated from the existing road, lures the visitors into the reed. It also directs the visitor towards the path along the bernisse, towards the northern hamlets. (Figure 64) The path is often aligned alongside the road, (Figure 54) but at times the path takes a wayward turn into the reed in the form of a deck. (Figure 55)

Figure 64: Profile of the Paludi-cultural area, where the paths run parallel. *(Author, 2018)*

The filtering power of plants
One feature of wetland plants not yet discussed thoroughly is that of a measure against eutrophic water. In this case, the water that flows out of northern heart is much cleaner than the water that flows in. The location is not optimal for a filter, as most of the Bernisses water flows right by. Luckily, this is not the main function of these fields. If the regional water authorities could be convinced, the rest of the water flowing through the stream could be forced to flow by these filters as well. For now, the area selected for paludiculture would serve as an inundation area for excess water as well. It relies on its regular flooding in order to make it work.

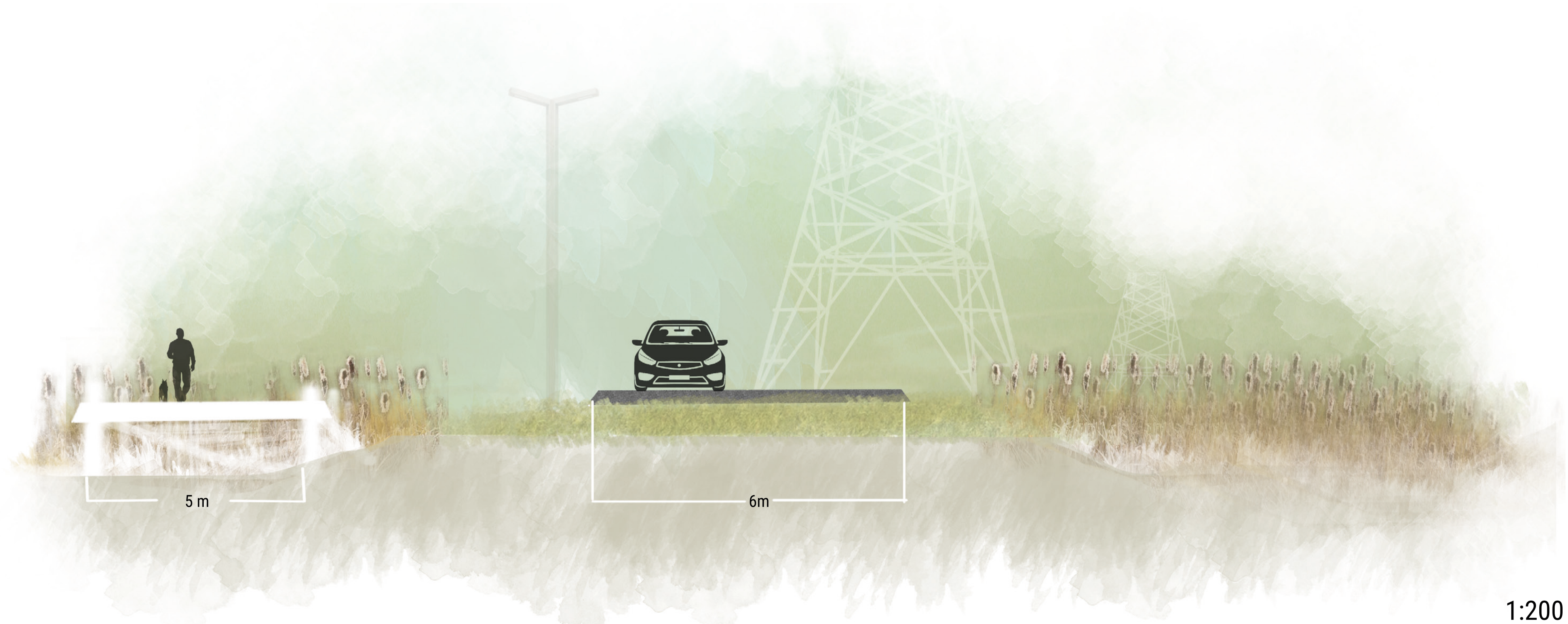


Figure 55: Profile of the Paludicultural area, where the paths run seperately, and the cyclists and pedestrians share a deck. distances between the the road and the deck vary, hence the absence of measurements between them. *(Author, 2018)*

4. DETAIL DESIGNS
3 The Southern Heart

The southern heart is a showcase of the principles of the leader follower system. (Figure 62) The stretched agricultural land it once was offered little guidance for the design. Rotation grazing is therefore materialised into a physical landscape. The outer ring is used for silvopasture with a high degree of diverse feeding trees. These also allow for rotating the livestock at hand. (Figure 57 & 58) The middle ring houses the various livestock in a way that they can be experienced. (Figure 59) Their respective roles and influences on the grassland can be seen first-hand. The inner rings are of a recreational value, with a central mound to overview the fields. (Figure 60) The flower patches are lined with Rubus and Ribes species to provide berries to the visitors. The flower patches aim to provide a nearly year-round food source for local pollinators, while the floral smells aim to masque the livestock's odour.

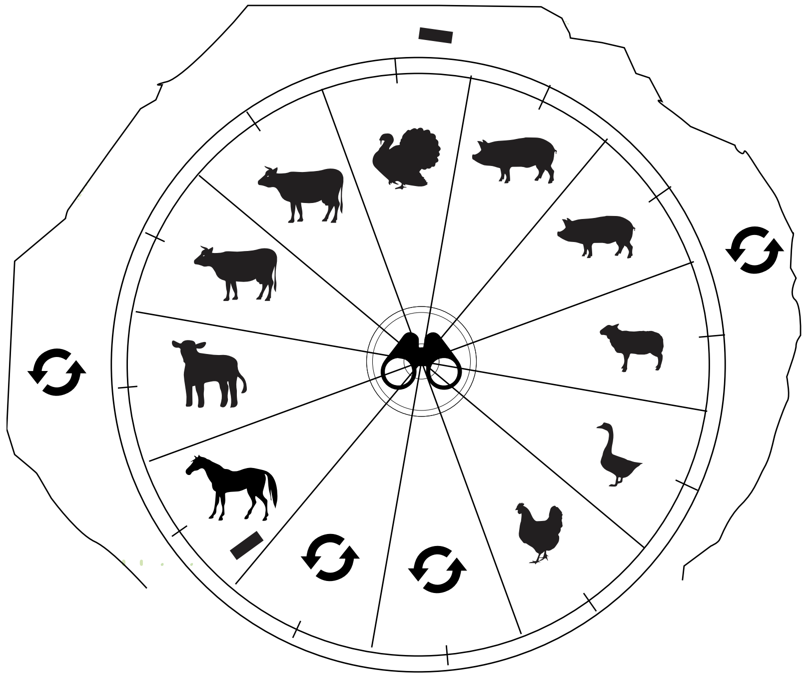
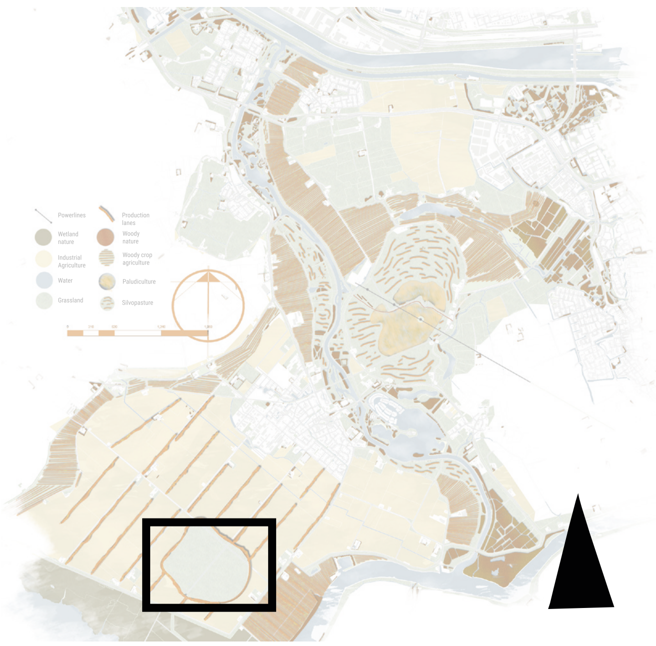
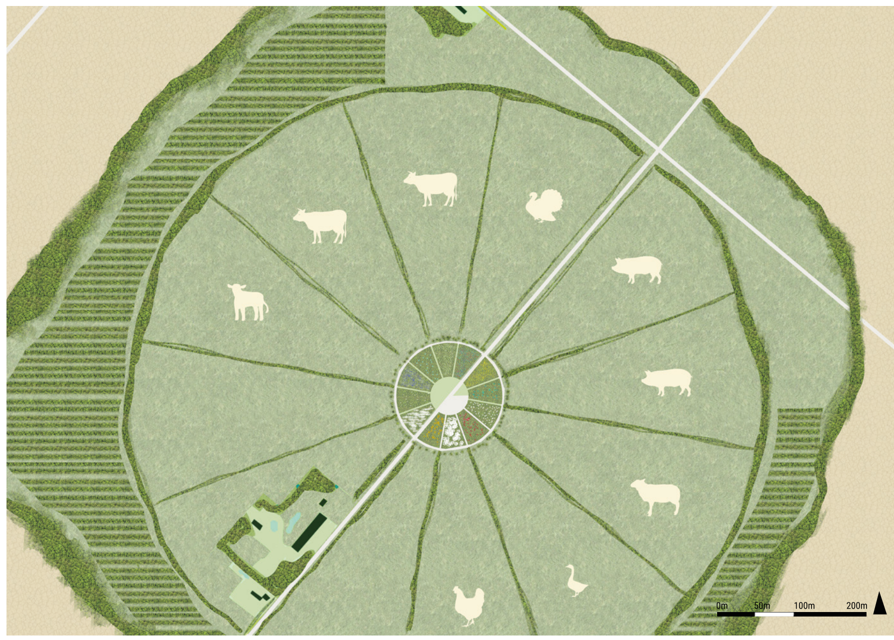


Figure 57: The rotational leader follower system made visual. *Adapted from (Esri, 2018)*



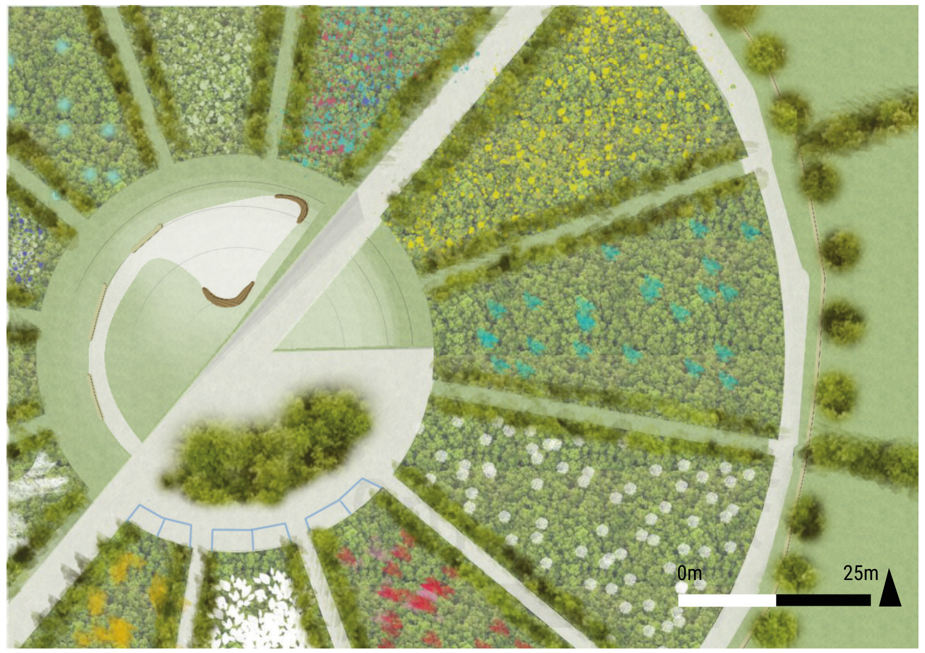
1:100000

Figure 56: The general location of the detail designs of the Southern heart *Adapted from (Esri, 2018)*



1:10000

Figure 58: A closup of the southern heart. *Adapted from (Esri, 2018)*



1:2000

Figure 59: The lookout plaza of the southern heart. *Adapted from (Esri, 2018)*

Figure 60: Profile of the lookout plaza, part 1 *(Author, 2018)*

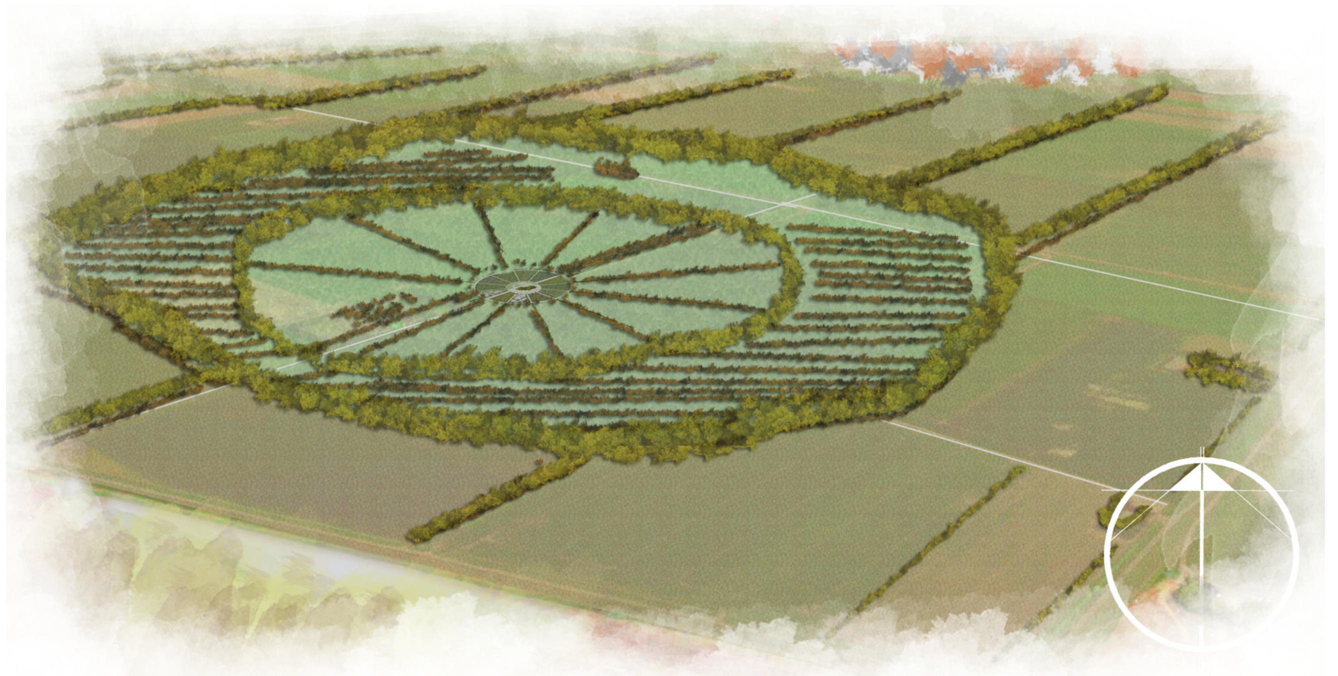


Figure 61: Bird's eye perspective of the Southern heart. *Adapted from (Google, 2018)*

Production lanes
While these harvest lanes were deemed too complicated to apply through the entire area, they are quite easy to apply when focussing on just the newland. This design opts to take up 10 Hectares of the newland area, planted on the side where the machinery currently enters the land. It provides food, scale and identity, but functions as a windwall as well. They also mark the location of the lower heart. (Figure 61)

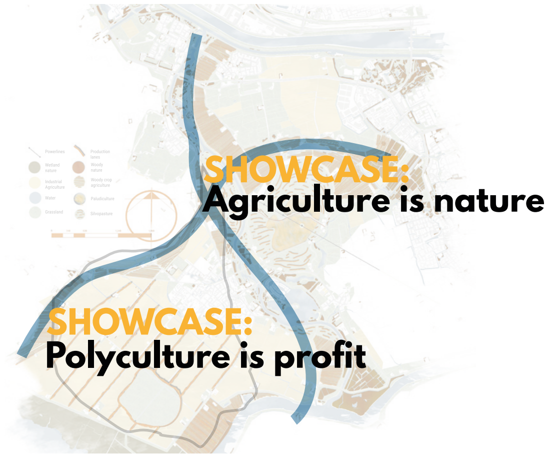


Figure 62: The message the regenerative agricultural areas seek to convey. These are based upon their expected target groups: recreants for the north, farmers in the south. *Adapted from (Esri, 2018)*

5. EPILOGUE

1 CONCLUSION

This chapter will assess whether the objective has been met, the design question has been answered and whether the research questions have been put to full use.

Objective

The objective of this research and design is to play a significant role in the development of regenerative agriculture by using the Bernisse as a prototype of a large scale implementation of regenerative production systems. This prototype could be the starting point for many similar regions. This will be done through making the agricultural land of the Bernisse area a more lush , diverse and legible landscape that has both a great recreational and scenic value as well as a high agricultural production value.

While the influence of the design cannot be measured at this time, the latter statement in the objective has been achieved. If this design were to be carried out, the Bernisse area would be a more diverse, lush and legible landscape with severely enhanced recreational and scenic value as well as high agricultural value.

Design

What type of restorative agricultural systems could be designed for the Bernisse's landscape entities respectively as tools for creating a more multifunctional landscape?

In order to design the agricultural systems, inspiration from Shepard's "new forest farm" has been taken. This is a living lab where his theories are tried and tested in the field. Design principles have been distilled from his literature and these have been defined in a way that would make them operational for the purposes of this report.

What type of restorative agricultural systems could be designed for the Bernisse's landscape entities respectively as tools for creating a more multifunctional landscape?

We have analysed the landscape entities of the Bernisse and seen variety in lot structures, vegetation, shapes, soils and land-use. The following entities were devised:

- Oldland/grassland/calcium deficient clay
- Peatland/grassland/peat
- Newland/agricultural land/ calcium rich clay
- Creekland/agricultural land/ calcium rich clay

We then devised systems for their respective conditions. As the conditions of newland and creekland were the same, The mode and time of implementation was changed. Each of these systems has been implemented in a unique way for each landscape entity respectively:

- Oldland/grassland/calcium deficient clay/ Silvopasture
- Peatland/grassland/peat/ Paludiculture
- Newland/agricultural land/ calcium rich clay/ woody crop production lanes
- Creekland/agricultural land/ calcium rich clay/ woody crop systems

We now come to the last part of the design question:

What type of restorative agricultural systems could be designed for the Bernisse's landscape entities respectively as tools for creating a more multifunctional landscape?

Because the narrative states that regenerative agriculture is something to replace all industrial agriculture; the question is not where; but when to implement the systems first for the best effect. The area has therefore been analysed the area for potential and local issues. Regional design principles for tackeling these challenges were then constructed. Using these, we devised structure plans for each specific purpose. From these a plan that combined these designs in the most effective manner was designed. We sought out to produce a multitude of landscape functions as described by Willemen (2010)

By doing so, the design reinstates the visibility of the old creeks and devises a new landscape entity for the peaty soils. Besides enhancing landscape entity identity and geomorphologic legibility this design connects ecologies, creates various diverse landscapes for recreational purposes, and connects the Trambaanpad from Spijkernisse to the Bernisse more firmly. This is achieved with minimal redesign of infrastructures or allotment, but primarily by instigating a complete overhaul of the agricultural systems. While these changes sketch an alluring image to strive for, achieving this will not be easy to implement. It takes an enormous mentality shift from both the producer as the user. It would require subsidising and governmental aid. The result however is a healthy, multifunctional, productive and resilient landscape. (Figure 63)

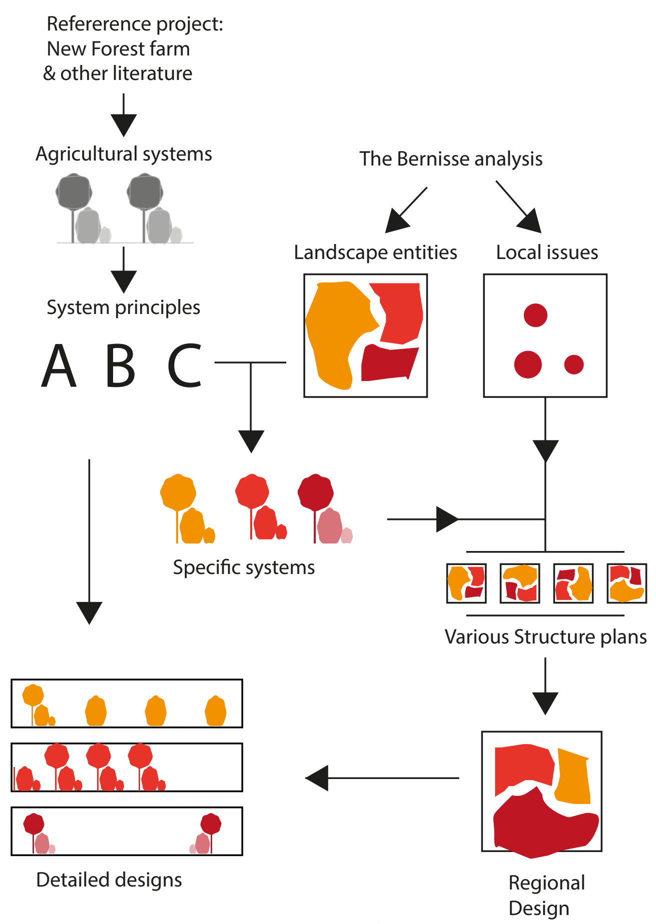


Figure 63: A shematic visualisation of the methods used by the author to devise the design , *(Author, 2018)*

5. EPILOGUE
2 DISCUSSION
Implementation

A futuristic design
The design seen on the structure plan is meant to take place about 30-50 years from now. This is dependent on the speed of implementation. Even if implemented right now, it might take a decade or two before one would get looks like in the visuals of the detailed design. This is not an issue, as landscape transformations of this scale will need time to land with local population. Luckily, trees are slow growers. It might take as long to get used to the chancing landscape as it takes for the trees to grow. While the population is allowed to "ease in" the three-dimensionality of the woody crop systems, there is no such luck within the area designated for paludiculture. Reeds and cattail are amazing biomass producers. One of the reasons for this is that they grow to towering height incredibly fast; it takes them a year to do so. Introducing the paludicultural landscape adaptation will therefore require more regional justification. Some arguments in favour would be that there are no houses in the area itself, it would continue to produce fuels and food, and a natural looking area around will drive up housing prices, provide recreational functions and attract recreational visitor.

Inconsistency
In the case of buying and tranforming agricultural lands he region might come to deal with temporally dispersed implementation of these systems. Instead of getting clear and coherent landscape identities we'll get a spotted diverse landscape. This is not a major issue, as long as the areas selected are prioritised over implementation in other regions by the municipality. This will eventually lead to the map as shown in the structure plan, with the selected areas being of diverse age. However, there are still some comlications to adress. This design seeks to inspire farmers to implement the systems. Should that succeed, the farmers should never be discouraged to implement the systems, as long as they correspond with the soil. The design may lose symbolic strength in the process. Newland may already be filled with complex structures while oldland is still filled with conventional open grasslands. Regardless, the main goal has been achieved. Implementing these systems as fast as possible should be the priority from the authors perspective, with light on the problem statement.

The farmer's perspective
A plan of this scale is not something easily implemented. While high costs are inevitable, it doesn't have to be that way. There is no real need for the municipality to buy up all the land and repurpose it before selling again. This method is the easiest, but also the most costly. If farmers could be convinced that switching to these agricultural types would be profitable, they probably would. The issue lies with the fact that these forms are knowledge intensive. As a multitude of crops are farmed, adaptations will have to be made to the system based upon first-hand observation. (Shepard, 2013) Workkshops and seminars will therefore be required. Another issue is a period of low yields wile waiting for the frutis to come. There are ways to subsidise your nature inclusive agricultural business. These subsidise flower strips for pollinators, as well as crop variety. It will be difficult to get subsidised for the flowering trees if these do not yet blossom. There will therefore have to be some revisions to legislations in order to acount for the amount of nature inclusion proposed in this thesis. These desicions will have to come from either the european union, the state or the province.

Inconistancy
These systems resemble the ones of Shepard and are adapted to fit local conditions. They will still require test runs before implementing on such scales. Fine-tuning planting distances for optimum harvestability, selecting cultivars and groundcovers for optimum plant symbiosis, and finding markets locally as well as in the metropolitan region before the first harvest are all requirements. However, these will have the same visual and scenic effect the restorative systems do. An image of the landscape of the possible future is therefore sketched as an incentive for further research on the matter.

Theory, functions and aesthetics:

The stacking of functions
"The original monofunctional strength of Spijkernisse has to become more multifunctional. The goal is to become resilient. Instead of being dependant, being complementary to the Port of Rotterdam."
- *(De Zwarte Hond, 2018) translation by author*

Ten Brink & Hosper (1989) define three "fundamental values" of nature:

1. **Production, potential and harvest.**
The functional value of nature including oxygen production and its self-restorative power.
2. **Diversity,**
with both ethic and aesthetic motives such as the biodiversity, the rarity, and 'completeness' of a system.
3. **Self-regulation**
based upon ethic, aesthetic, recreational and economic motives.

While industrial agriculture is good at producing calories, it's alarmingly poor at all of the other factors used by (Ten Brink & Hosper, 1989). Restoration agriculture scores higher on all points mentioned above, and can fulfil a multitude of purposes while producing products.

First of all, the restorative effects of restoration agriculture go beyond soil alone. By developing more natural areas and making them something to experience the restorative effect can extend to the local population, albeit with a different meaning. The attention restoration theory by Kaplan and Kaplan states that wandering through natural areas, even by commute, has a positive effect on people's minds. Natural landscapes are easily understood and leave space for processing thoughts. (Kaplan, 1995) Although agricultural fields are easy to process, its barren form will make little impact in achieving the "soft fascination" Kaplan and Kaplan propose. Breaking the openness of these fields is a positive intervention with regard to the prospect refuge theory. This theory states people prefer half-open landscapes over closed or very open ones based upon human evolutionary background. (Appleton, 1996) Studies also show that more forested areas are appreciated over barren biomes such as deserts and grassland (Han, 2007). Therefore, aside from the economic and ecological motives, this type of agriculture is very promising in producing attractive landscapes.

From an ecology viewpoint
There are but a few species that do well on agricultural fields, but these are usually only a nuisance to the systems productivity. Woody crop systems create food and liveable environment for multiple (wild) animals. The most important, and most effective in this list of species is the honeybee. Other pollinators are often overlooked but these thrive on more complex systems as well. As L. M. Schoonhoven describes In the opening chapters of his book "Niet zonder elkaar" (Schoonhoven, 2015), a healthy population of pollinators is essential in a perennial system of plants that require pollination.

Building ecological systems is the point of the exercise at hand. Nonetheless it cannot be denied that these systems are not completely natural and are not nature by its purest definition. These systems operate as ecological systems with agriculture as its main goal. Despite the benefits of this type of agriculture, diversity is key for true ecological health. These systems will provide stronger networks and habitats for certain species. But these systems still mostly represent a certain successional phase. For true diversity the area still requires forests, the later successional stage, as well as some younger forms of succession such as wetlands. This section therefore serves as a warning that these systems should **replace current agriculture. They should**

not replace nature conservation areas.

Eutrophication

Agriculture is currently causing an enormous eutrophication of soils and groundwater. This excess of nutrients eventually end up in water streams. This causes certain algae, like the cyanobacteria found in the Bernisse, to flourish. (Foley et al, 2005) In the case of the Bernisse area, the water flows into the agricultural lands instead of vice versa. (WSDH, 2018) This means that transforming the agricultural system of the Bernisse will not have a large impact on the eutrophication of the stream. This has the benefit that these nutrients present themselves through the groundwater. Any nutrient deficiencies critical at the first stages of implementation of woody crop systems don't require external input apart from the animals in the system. After a while the key species will maintain the soils chemistry. (Shepard, 2013) The crop systems could play a role in the remediation of the eutrophication by growing remediating crops like Mischanthus and Typha within the water system, which can then be transformed into biofuels.

Methods

Research

Although Shepard is an inspiring example, using a wider variety of examples would have been a good addition to the literature argumentation of the system design. Although a variety of sources back up the overall use of restorative systems and permacultural systems, This design mainly uses one example of the large scale implementation thereof. With additional time the whole systems approach of Ben Falk should be taken into acount as well. And firther research into large scale operations is required.

Design

A multitude of apporaches could have also been applied, and more functions taken into acount. For now, the substrate layers, ecology and the recreational values were deemed most important as these are the focal points of either the design or the area's ambitions.

Personal Reflection

During this project I wanted to develop in a few things besides writing in english scientifically. I wanted to approach design in a more technical and scientific way. This has succeeded in my mind. I usually put reason over feelings or aesthetics. Although the design is quite a scenic overhaul, it is mostly a continuous pattern of the technical designs the research has devised. Another learning goal involved thinking more on paper, to quickly adress ideas and thoughts in a visual manner. During these weeks I have always carried pen and paper around, and have made notes on the quirkiest of moments. This helped to harvest inspiration as soon as it came. The last goal involved consistency and quality of visuals. That is something I still need to work on the years to come. The entire project could have been more streamlined in the sense of colour and representation methods. Learning more about synergising Adobe software would be a great help for me.

5. EPILOGUE

3 REFERENCES

Literature

Abel, S., Couwenberg , J., Dahms, T., & Joosten, H. (2013). The Database of Potential Paludiculture Plants (DPPP) and results for Western Pomerania. Plant Div. Evol., 21-228. Opgeroepen op 2018

Appleton, J. (1996). The Experience of Landscape. London: Wiley.

Baltissen, T., & Oosterbaan, A. (2017). Notenteelt in Nederland, Een technisch economische haalbaarheidsstudie. Wageningen: Wageningen Plant Research.

Cambridge University Press. (2018, 5 24). dictionary. cambridge.org/dictionary/english/biodiversity. Opgehaald van Camebridge dictionairy.

De Zwarte Hond. (2018). Nissewaard naar 2040, ontwikkelperspectief voormalige groeikern Spijkernisse. Spijkernisse: Gemeente Nissewaard.

Dunwell, M. (2016, October 10). Bill Mollison obituary. Opgeroepen op 2018, van The Guardian: https://www.theguardian.com/environment/2016/oct/10/bill-mollison-obituary

Ferguson, R. (2014). Permaculture for agroecology: design, movement, practice, and worldview. A review. Agronomy for Sustainable Development : Official journal of the Institut National de la Recherche Agronomique (INRA)(Volume 34. Issue 2. Page 251 - 274.).

Foley et al. (2005). Global consequences of land use. Science(Vol. 309, Issue 5734), 570-574.

Han, K. (2007) Responses to Six Major Terrestrial Biomes in Terms of Scenic Beauty, Preference, and Restorativeness. Environment and Behavior 39: 529

Hathaway, M. D. (2016). Agroecology and permaculture: addressing key ecological. J Environ Stud Sci, 6:239–250.

Jonas, W. (2007). Research through DESIGN through research: A cybernetic model. Kybernetes, Vol. 36 Issue: 9/10, pp.1362-1380.

Joosten, H., Tapio-Biström, M.-L., & Tol, S. (2012). Peatlands - guidance for climate change mitigation by conservation, rehabilitation and sustainable use. Mitigation of Climate Change in Agriculture (MICCA) Programme , the Food and Agriculture Organization of the United Nations. Greifswald: FAO and Wetlands International.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. Journal of Environmental Psychology, 15, 169-182. doi:10.1016/0272-.

Kern, J., & Harris, I. (1975). ON THE OPTIMUM TILT OF A SOLAR COLLECTOR. (U. o. Department of Chemical Engineering, Red.) Solar Energy, VoL 17, 97-I02.

Nee, W. V.-P. (2018, 6 26). Windmolens Voorne-Putten Nee. Opgehaald van Facebook.
Nisewaard, Gemeente. (2015). Duurzaamheidsqgenda Nissewaard, Visie op duurzaamheid in Nissewaard 2015-2020. Spijkernisse.

Rhodes, C. J. (2015). Permaculture: regenarative - not merely sustainable. Science progress(98 (4)), 403-412.

Roncken, P. A., Stremke, S., & Paulissen, M. P. (2011, spring). Landscape machines: productive nature and the future sublime. Journal of Landscape Architecture, 68-81.

Schoonhoven, L. M. (2015). Niet zonder elkaar : bloemen en insecten.

Shepard, M. (2013). Restoration Agriculture. Austin, Texas: ACRES U.S.A.

Spacevalue B.V. (2012). Beleef en bereik Bernisse 'de verbinding van voorne-putten', eindrapportage haalbaarheidsonderzoek ontwikkeling recreatie Bernisse. Gemeente Bernisse, Raadhuisstraat 12. Opgeroepen op 2018

Ten Brink & Hosper. (1989). Naar toetsbare ecologische doelstellingen voor het waterbeheer. H20, (22) 612-617 Nr. 20.
UNFCCC. (2015, December). Adoption of the Paris Agreement. Paris
.

Van Eekeren, N., Luske, B., Vonk, M., & Anssems, E. (2014). Voederbomen in de landbouw. Driebergen: Louis bolk instituut.

West8. (2015). Perspectief op het landschap in de MRDH. MRDH.

WSDH. (2018, 6 12). Opgehaald van WSHD Peilbesluiten: https://wshd.maps.arcgis.com/apps/webappviewer/index.html?id=4eb50e1c1f7141c68d87bcbb44de1bef

Images

Figure 1,2 48, 52 and 61
Google maps. (2018) And Google Earth (2018) Imagery used to produce these visualisations.

Figure, 3, 28-31, 34-39, 41 - 44, 47, 49, 50, 51, 56 - 59 and 62
Esri (2018). Top10NL map data, processed in ArcGIS and Adobe illustrator, Photoshop and Indesign.

Figure 4
Brilliantmaps.com. (2017). Land Reclamation in the Netherlands 1300 Vs 2000. Retrieved 6 1, 2018, from Brilliantmaps.com: https://brilliantmaps.com/netherlands-land-reclamation/

Figure 5, 6-27, 32, 33, 40, 45, 46, 53, 54, 55, 60, 63 and 64
Designed by the author with software from Adobe. (2018)