The Dutch versus the water: landscape development and plant use at Vrouw Vennepolder in the Netherlands from the Late Middle Ages until the 20th century

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Chapter 1. Introduction

In this thesis, research has been conducted on pollen found after a coring at Vrouw Vennepolder in Oud Ade. This research is also part of the ongoing project of Land van Ons at the same place.
Pollen research, also known as palynology, is a widely used study in which people examine pollen for various purposes including recreating past landscapes and studying human impact on vegetation in the past (Moore et. al., 1994, p. 1). Pollen remains found under the microscope are noted down and the counts of all pollen together per species or family are put in a pollen diagram (Lowe and Walker 2015, p. 185). With the pollen diagram, one has a clear overview of the absolute or relative quantity of all species that have occurred throughout time.
The next few paragraphs will explain more about what Land van Ons is as well as the site and its history. After that, there will be more information on how pollen research will be used to explain the history, the vegetation and the land use at Vrouw Vennepolder.
The goal of this research is to show how the landscape developed at Vrouw Vennepolder and how one can see that as well as human involvement in the pollen diagram. Along with that, there will be information on how plants shown in the pollen assemblage could have been used by the local population. At last there will be a section on what the consequences are of human involvement in the landscape.

1.1. Land van Ons

Land van Ons is a citizen cooperation aiming to restore the landscape and the biodiversity of agricultural grounds in the Netherlands (Land an Ons, n. d.). The cooperation has many agricultural fields spread over the Netherlands, including Vrouw Vennepolder.
Land van Ons works together with Leiden University and Holland Rijnland on Vrouw Vennepolder. Their goal is to restore the natural landscape in the agricultural land and enhance the biodiversity surrounding Oud Ade. Enhancing biodiversity is not only good for creating a more diverse ecosystem. It could also help with the reduction of CO_2-emissions which are high in subsiding peatlands, including in the Netherlands (Van den Akker et. al., 2010, p. 2).
In the archaeobotany laboratory at Leiden University, the first steps in aid of this research have already been taken in regard to historic landscape reconstruction, albeit preliminary. The research

project involving all parties who work on this together is called PolderLab Vrouw Venne. This project started in 2021 and will go on for 10 years (https://landvanons.nl/).

1.2. Vrouw Vennepolder

Vrouw Vennepolder is located next to Oud Ade in Zuid-Holland. It is part of the municipality of Kaag en Braassem, located on the north east outside of Leiden. As the name says, the site is nowadays being used as a polder. There is a hollow post mill at the site called the Vrouw Vennemolen which is sometimes in use nowadays (Vrouw Vennemolen, n. d.).

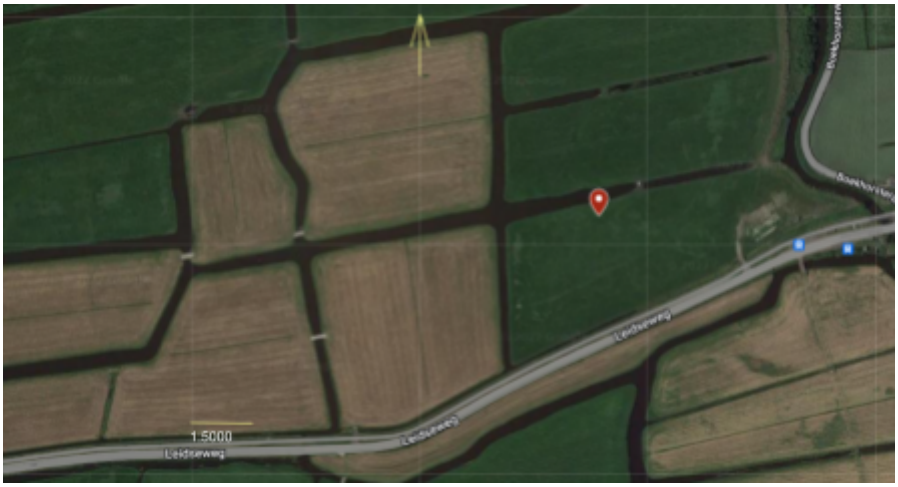

Figure 1. Map of Vrouw Vennepolder with the place of the coring indicated in red (made in Google Maps)

Neither Vrouw Vennepolder nor the surrounding areas aside from Leiden, have been subjected to much research. What is known is that the place has been used as a polder since around the 17th century (Wilbers & de Léon Subías, 2019, p. 9). Vrouw Vennepolder itself was also created around the same period with the fusion of four different polders. In that fusion in 1632, Vrouw Vennemolen became the main mill of the polder, though there had been other mills present at the time too (Molen database, 2019).
The polder has a lake which is also known as Vennemeer. It is part of the Kagerplassen (https://geschiedenisvanzuidholland.nl).

Before the creation of the polder the area was property of the Abdij van Rijnsburg, or the Abbey of Rijnsburg, during the late Mediaeval period (Kaag & Braassem, n. d.). This was a women's abbey in Rijnsburg of which the remains are now located in a village on the east of Katwijk. The Abbey was created in 1133 by countess Petronella, who was the widow of count Floris the 2nd of Holland. It kept on being a property of the abbey until 1620 (Huygens Instituut voor Nederlandse geschiedenis, n. d.). Not much has been available on the ownership of the land

between 1620 and 1872. A little has been said about the influence of the civil jurisdiction of Rijnsburg on Vrouw Vennepolder even after the abbey did not exist any longer (Kaag & Braassem, n. d.). More research on this exact subject has to be conducted in order to know the state of Vrouw Vennepolder during that time.

Fig. 2. Map of Vrouw Vennepolder and the surrounding area from the 17th century made by Floris Balthasaars (https://geschiedenisvanzuidholland.nl)

On the 23rd of March in 1872 ("Verkochte percelen," 1872), 10 plots which were part of Vrouw Vennepolder had been sold to P. van der Meer for 41300 franks. After this, there is another newspaper item published in 27-10-1892 where it says that the owner of the lands is J.van der Poel ("Persoverzicht," 1892). Not much has been published on the ownership of the lands after this period once again. It is now owned by Land van Ons.

The polder has partially gotten its name from the abbey. The other part, venne, is the old Dutch name for peat (Historische woordenboeken Nederlands en Fries, n.d.).

Other research has also backed up the fact that peat has been extracted from the land in and after the 11th century (Wilbers & de Léon Subías, 2019, p. 7). The top of the peat would have already been inhabitable since the Bronze Age, yet people did not live in the area at the moment yet (Koekkelkoren & Moerman, 2012, 15). People would have lived on the edges of the Vennemeer until the 18th century (Koekkelkoren & Moerman, 2012, p. 17). They most probably started living there as they started to extract peat from the area.

The fusion of the four polders to create Vrouw Vennepolder was done between 1626 and 1632 (Molen database, 2019). After that it has more or less only been used as a polder until now where it is being researched.

1.3. Landscape history

Despite the lack of research done on the site, there are still some things to be noted about the site. These remarks are related to the site based on research on the region where the site is located. This would mean either research on the area of Zuid-Holland or research on western Netherlands.

A lot of research has been conducted by Wim Hoek on the vegetation development of the Netherlands from the Late Glacial to the Early Holocene (1997). As it is not possible in the coring done for this thesis to see if those times correlate or not, the focus will be one the more recent developments.

These include how Vrouw Vennepolder is located on the Older Dunes of the Netherlands (Zagwijn, 1971, p. 176). These dunes were more or less done with formation around 0 AD (Zagwijn, 1971, p. 175). Not much is known about the landscape after that. The thesis will be starting with reconstructing the landscape from the 11th century AD onwards.

Aside from the close proximity to the sea, the site is also located close to the old Limes of the Roman Empire. These limes were located close to where the old Rhine streamed. This can be seen in Figure 3. The red square indicates the approximate location of Vrouw Vennepolder.

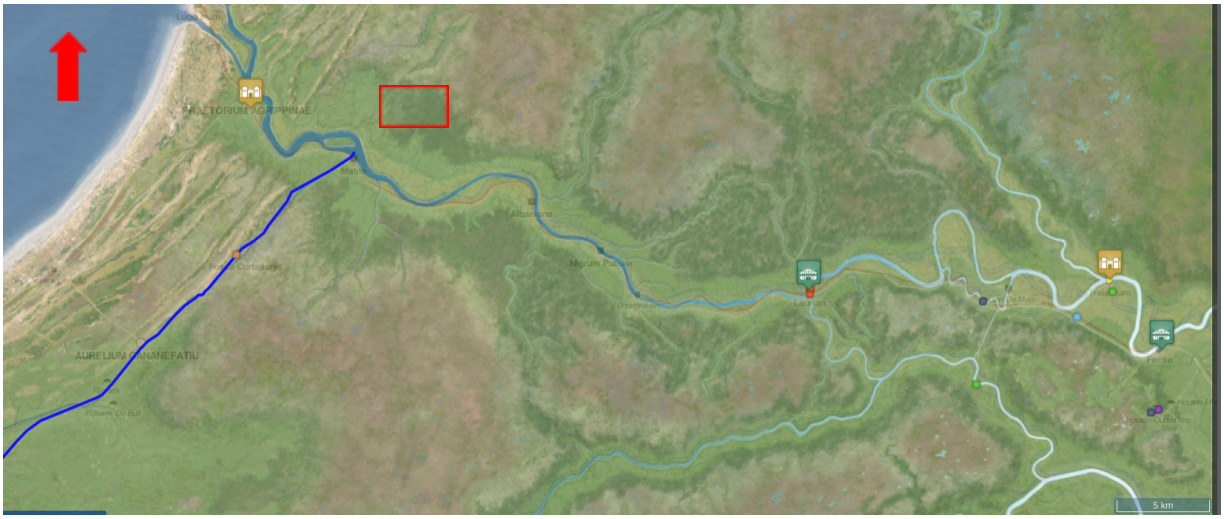

*Figure 3. Limes of the Roman Empire in the Netherlands (*https://vici.org*)*

The landscape would have had influences from two different kinds of soil conditions, especially at times when the Old Rhine was still the biggest stream of the river. Though it would not yet be linked to a certain period in time given, the pollen diagram still provides what the landscape may have looked like before the 11th century AD.

The old Rhine stayed in this part of the land until the 12th century AD when it changed its course again (de Haas et. al., 2018, p. 103).
Still, it would not be wise to go more into this part of the landscape reconstruction until more research has been conducted on the area and a radiocarbon date can be given specifically for Vrouw Vennepolder. Until then, the part will be described, but not assigned to a set time.

1.4. Pollen research and chronology

Preliminary pollen research of a coring done at Vrouw Vennepolder has already been started at the archaeobotanical laboratory in Leiden University. Four layers had been studied by research master archaeology students for a seminar course. The other eight layers have been divided among three bachelor archaeology students for their theses, including my own.
In general, there has not been much research done on peat bogs from the late mediaeval period at around the 11th century to now (Sevink & van Geel, 2016, p. 284). There is close to nothing published on the area itself, though historical documents and pollen research has provided more insight. On top of that, case studies from places with the same ecological conditions can be done and other pollen diagrams can be compared to Vrouw Vennepolder.
With the information of all the layers extracted from the coring, a relative pollen diagram has been made. A relative pollen diagram is a type of pollen diagram which presents the percentages of all plant pollen that have been found within each layer of the assemblage (Lowe and Walker 2015, p. 185). The percentage pollen diagram will be used in researching and answering questions regarding the landscape reconstruction fluctuations and the taxa present at the site.
With landscape reconstructions one can see what the landscape has looked like at a certain moment in time. As the site is now a polder, one can assume that it has been a polder for quite some time. As it is known that polder formation began in the 17th century, the pollen in the assemblage relating to that period of time can be seen and one can get an idea of what a landscape may look like in such conditions.
The start of peat extraction could also be noted in a pollen diagram, looking at changes in plant populations from before and after extraction. This way one also sees a part of the consequences of human influence in regions and this can also be background knowledge for future references regarding landscape reconstructions of polders.

Aside from looking at the land use, the pollen diagram also presents the opportunity for one to think about ways in which people could have used plants that were present in the landscape. This can relate to eating, like in the case of *Cerealia* types or other edible plant types, but also using plants for making artefacts.

From many plants it is already known how they may have been used in the past as such crafts still happen to this date. This can be something like making clogs and broomsticks out of *Alnus* (Harris & Harris, 2009, p. 65).

Chapter 2. Methodology

One coring had been conducted on the 9th of November 2021 by Mike Field, Else Kamerlingh and research master students at Vrouw Vennepolder. The coring was done with a gouge auger with a diameter of four centimetres until 250 centimetres. Samples for pollen preparations were taken from 50 centimetres onwards every 10 to 20 centimetres. Samples were taken in case there were clear differences to be seen in the stratigraphy, like it was done at 167 centimetres. No samples have been taken from above 50 centimetres as that was the made ground. It would have been out of context and too distrubed by recent human involvement and therefore not worth looking into further.

Normally it would have been more favourable to have done multiple corings in order to create a better past landscape and see more of the landscape changes. There was however no possibility of doing multiple corings due to time-related issues. This has been compensated by comparing this to other pollen diagrams of the same region and by backing up the pollen diagram with sources on the history of the site.

After the corings, the sediments have been prepared for microscope slides. The pollen preparation procedure was made especially for peat sediments, which resembles the standard pollen preparation method (Chambers et. al., 2012, p. 6). 20 millilitres of 0,1M sodium tetra pyrophosphate was added to each tube and placed on the heat block for 20 minutes at 100℃, which differs from the standard method.

The remaining residues have been put on microscope slides with silicon oil. All the microscope slides have been seen under a magnification of 400x. Identifications of the pollen and the spores were made based on reference collections of Moore et. al. (1994) and Beug (2004). The agreed upon minimum pollen count was 200 pollen per layer. Pollen counts were written down on Leiden University count sheets and later on transferred into my own personal database on Microsoft Excel. The Excel database in turn was used for plotting the pollen diagram using the

Tilia software. The plotted relative pollen diagram has been attached in the results in figure 5 and in appendix B. The selected pollen diagram can be seen in figure 4 and in appendix A

For the plotting of the diagram, all percentages were relative to the sum of the total land pollen, which from hereon will be referred to as TLP. As is made clear in the diagram, there is a huge presence of monolete psilate pteridophytes present at 50 centimetres. As this is not the biggest point of focus for the total pollen diagram, this could have distorted the percentages. Thus, only trees, shrubs, climbers and herbaceous plants are included in the TLP sum.

Chapter 3. Results

After counting the pollen and processing them through Tilia, a complete relative pollen diagram was made. The full diagram is to be seen in figure 4, on the next page. The assemblage is big as it has a wide variety of families, genera and species-types which were identified under the microscope.

Because of this, another pollen diagram with only the taxa which occurred the most is included too. This diagram is to be seen in figure 3 below. Aside from that, the taxa have also been put in one group if that was possible. This happened with the *Galium*-type which is now part of Rubiaceae, and also with the *Berula erecta* group, *Bupleurum*-type and *Sison*-type which have been added to Apiaceae. At last, Asteraceae *Senecio*-type has been added to *Senecio*-type and *Artemisia* has been fused into Asteraceae.

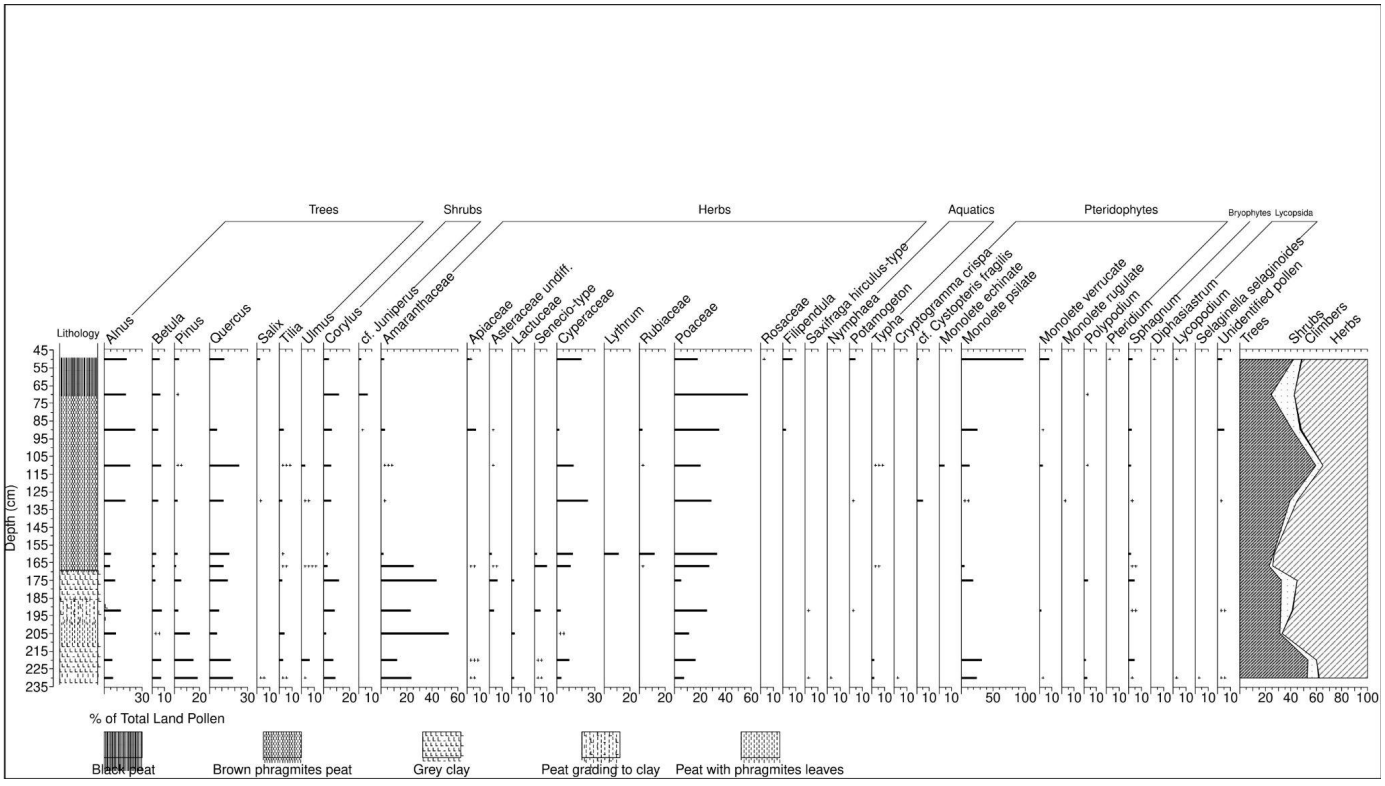

Figure 4. Selected pollen diagram (made with Tilia)

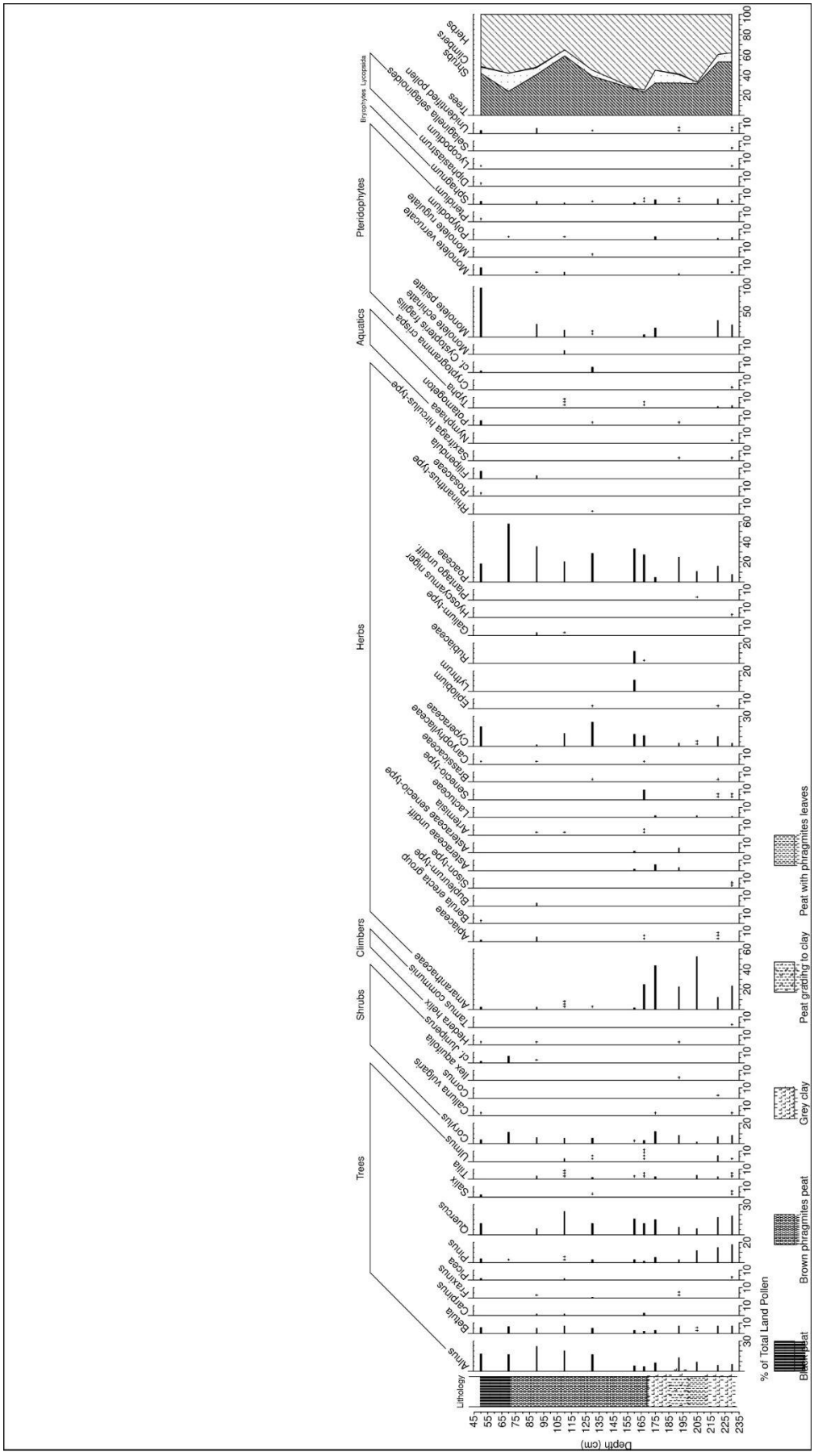

Figure 5. Relative pollen diagram and Total Land Pollen percentages. Sediment stratigraphy is shown on the side. (Made with Tilia)

3.1. Lithological zones

Certain trends are to be noted in the assemblages. These can be split in two zones with two or three adjacent layers. There will be five zones in total starting with the lowest, also the earliest, zone first, which is zone E. Descriptions of the zones will be ascending from zone E to zone A.
Though there is a selected pollen diagram, taxa from the full diagram will still be mentioned as they give out information on the landscape as well. Most of these taxa will mostly be mentioned in detail in the discussion rather than in the results.

Zone E

220 and 225 centimetres are both located in grey clay. The taxa percentage in both layers is almost the same. The landscape would have had equal parts of trees and shrubs as compared to herbaceous plants. Though there are some variations within the plant types in both layers, these do not change what the landscape would have looked like on a first glance.
The taxa types that occurred the most in this zone are *Pinus, Quercus, Corlyus*, Amaranthaceae and Poaceae. Percentually, there was a larger portion of trees and shrubs as compared to the herbaceous plants.

Zone D

192 and 205 centimetres were part of different sediments, namely peat grading to clay and peat with phragmites leaves respectively. Most of the plants in this layer are herbaceous. There is especially a large amount of Amaranthaceae present at 205 centimetres. This does not immediately mean that there were way less other plants present in the landscape at the time though the large percentage of Amaranthaceae may make it seem that way.
Aside from Amaranthaceae, the plant types that one sees the most in these layers are Poaceae, *Alnus, Betula* and *Pinus*.
All in all, the landscape would have most probably been filled with a lot of herbaceous taxa and with some other trees or shrubs present in the near vicinity or at the place itself.

Zone C

Including 160, 167 and 175 centimetres, this is an interesting zone. The lithology changes abruptly at 170 centimetres where it becomes grey clay. Some evident changes are to be noted

with the soil change too. The taxa distribution stays the same for all three layers up until *Tilia* after which the biggest changes are that there is more Amaranthaceae present at 167 centimetres and all levels after that. *Corylus* also increases as we go deeper down in lithology. Although different species, 167 and 175 both have an increase in Asteraceae species. At 167 centimetres, it is *Senecio*-type which is more present in the layer.

All in all, the landscape was mostly herbaceous in this zone. The trees gradually became more present in percentage, though it is not a big change still from the herbaceous landscape.

The plants that one can see the most in this zone are *Quercus, Corylus,* Amaranthaceae, Cyperaceae and Poaceae.

Zone B

Zone B includes 90, 110 and 130 centimetres, located in brown *Phragmites* reed. Though most taxa stay more or less the same in the layers, an increase in Cyperaceae is to be noted as we go deeper in the lithology.

The plant taxa most present in this part are *Alnus, Quercus,* Cyperaceae and Poaceae. From here on out, the amount of *Alnus,* Cyperaceae and Poaceae only seems to be getting bigger as we progress more towards the age of today.

As compared to the zone below, there is a smaller variety of taxa in this zone. This difference can especially be seen in the selected pollen diagram. Amaranthaceae species reach a very low point as compared to what they used to be in this area. *Alnus* on the other hand, has grown more prominent in the landscape.

The landscape is predominantly herbaceous, with the exception of 110 centimetres where there are more *Quercus* and *Alnus* present in the diagram.

Zone A

This zone includes the layers 50 and 70 centimetres which are both located in black peat. As there was not much found on 70 centimetres anyway, that layer only has 7 taxa identifications in total included in the pollen assemblage.

Though there may be differences in the two layers as seen through *Quercus, Corylus*, *Juniperus* and Cyperaceae dispersions, one can still see that the landscape was dominated by grasses and

other herbaceous species. Trees and shrubs were also present, though less dominant than herbaceous plants.
The taxa occurring the most in this zone are *Alnus, Quercus, Corylus,* Cyperaceae and Poaceae. Of these five, especially Poaceae and Cyperaceae to dominate the taxa assemblage. If one looks at the pollen assemblage in this zone, it is way less diverse than before. Even zone B had a somewhat larger diversity of taxa than this layer. Though the plant families that are present the most in this layer may have had a variety of species present in the landscape, the overall variety of different kinds of families has gotten low.

3.2. Non-pollen palynomorphs

Non-pollen palynomorphs are all plant structures that were identified under the microscope and are not included in the TLP count. These structures do not go away after the whole pollen preparation procedure (The palynological society, n. d.). Such structures are put under pteridophytes, bryophytes and lycopsida. The focus of this section will mainly be on pteridophytes and bryophytes, which only consists of Sphagnum moss now.

Pteridophytes are ferns and plants falling under the family of ferns. The ferns are mostly not linked to a fern species but they can be differentiated under the microscope. In this assemblage, there is a big presence of monoletes in the assemblage. Especially psilate monoletes followed up by verrucate and echinate monoletes could be seen in the assemblage at different layers. There is a large presence of monolestes in zone A and a relatively large percentage in zone E too.
There is only one bryophyte in this assemblage and that is the Sphagnum moss. Sphagnum is also known as peat moss and is considered a telling species in northern peatland ecosystems (Shaw el. Al., 2015, p. 365). Despite this, it occurs more often on clay soils in this diagram. It is present in almost every layer still. The presence of peat moss is not as telling for this being peat in this diagram as it does not occur as often as one would expect in a peat landscape.

Other things that have not been included in the TLP sum are aquatics and unidentified pollen. For unidentified pollen it makes sense not to include them as there is no way of knowing whether these were arboreal or shrub related or otherwise climbers or herbaceous.

Aquatics are not part of the non-pollen palynomorphs either, as they are pollen. Aquatics are plants that grow in water like *Typha* which is cattail and Nymphaea which is the water lily, which means that they are not part of the land pollen. Species of these taxa can give aspects of what the landscape looked like, especially in the case of *Potamogeton*, which mostly grows in fresh or brackish water (Honders & Sebald, 2004, p. 374).
The presence of aquatics is also telling of the type of landscape Vrouw Vennepolder was. Presence of water plants means that there was a body or multiple bodies of water nearby on the site. Given that the water plants are also not saline, the water conditions at Vrouw Vennepolder would have been fresh or brackish.

3.3. Chronology

Now that there is a relative pollen diagram, another problem has been presented as well. That problem has to do with the lack of chronology up until now. A charcoal band had been found at 186 centimetres according to notes taken in the field yet no radiocarbon dates could be taken because of the scarcity of the material. It also may have taken too long to have the charcoal radiocarbon dated in such a short period of time.

A solution has been found for the lack of chronology. A radiocarbon calibrated date has been found at Zegbroekpolder, southwest of Kijkduin which is located between The Hague and Scheveningen (TNO, Geological survey of the Netherlands, 1955). Their radiocarbon date was taken at 170 centimetres and amounts to 3155 cal BP with error margins between 3718 cal BP and 2980 cal BP. The table with all the pollen counts correlated with the one at Vrouw Vennepolder, especially around s506327 which would be 1174 cal BP with an error margin between 1454 cal BP and 578 cal BP.

This correlates with 170 centimetres on the pollen diagram presented in this thesis. One can see that in the decline of Amaranthaceae that happens just before that. This decline is also shown at 50 and 60 centimetres in Kijkduin. It is also to be seen in the *Quercus* and *Alnus* increase and decrease which can be plotted the same way in my diagram as well as the Kijkduin diagram. Poaceae also correlates on both diagrams as it starts to decrease once one goes more back in time.

Differences in depths of the correlating layers have to do with different ways of sedimentation or peat accumulation. For Vrouw Vennepolder, a peat sedimentation rate has been calculated from 50 to 170 centimetres. This would be 1 millimetre per year. The accumulation rate has been based on calculations of *Phragmites* peat accumulation made by Lynch and Saltonstall (2002) and Drexler et. al. (2009).

Both the radiocarbon calibrated date and the peat accumulation rate come together at around the 10th or the 11th century on the diagram. This in turn correlates with what Wilbers and de Léon Subías (2019) have said about the chronology at the site.
In the graph below there is a graph with the centimetres and the date that correlates with it.

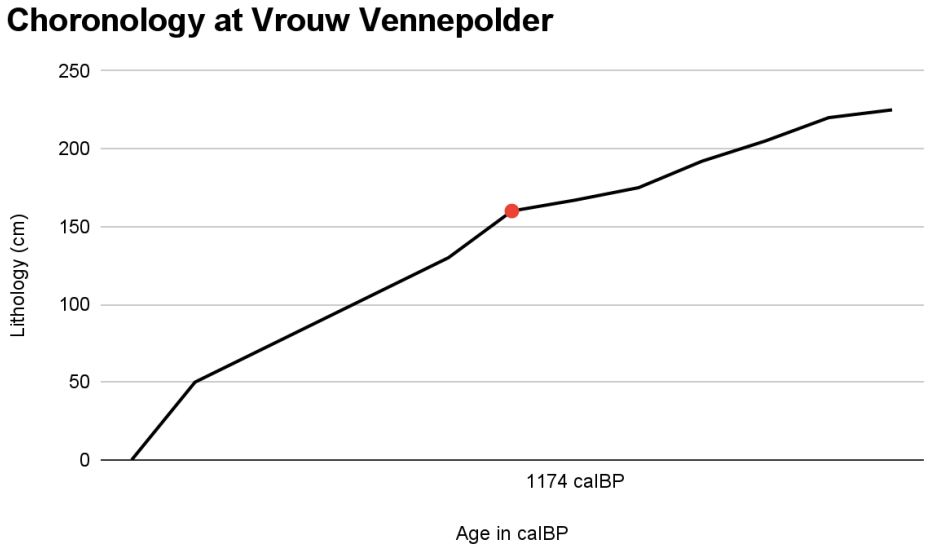

Figure 6. Chronology at Vrouw Vennepolder (made in Excel)

Chapter 4. Discussion

4.1. Regarding the interpretation of the pollen diagram

There has been a lot of extrapolation with the results presented in the previous section. Given the time restraints, it was not possible to be sampling and counting almost every centimetre, though that would have provided a more accurate description of the site and its landscape and landscape development.

The choice for having a selected pollen diagram had to do with the sheer amount of taxa that have been found. Though for creating a more detailed landscape reconstruction, taxa from the complete assemblage were used too. With the selected pollen, one can see better which taxa were more present in the landscape without being crowded by the less present taxa.

One may wonder about the reliability of the graph in figure 5. Realistically a graph like this will not really make sense, as there is only one date and the whole chronology from after the date is assumed based on its linearity. Yet it is still good to assume the linearity of the time frame, as it will be shown later how that correlates with the historical records surrounding Vrouw Vennepolder. Until further research on chronology is conducted, this is the estimated timeline that will be assumed.

4.2. Landscapes throughout time

In order to make an estimation of what the landscape would have looked like, it is a good thing to know about taxa that occur in a certain landscape. Looking at all the plants that are present in one layer of the pollen diagram already shows what the landscape would have been like.

For example, some plants in this diagram are glycophytes. Glycophytes are species growing in places with low soil sodium levels and which maintains low sodium levels in its leaves (Cheeseman, 2014, p. 562). Plants like *Filipendula ulmaria* are bryophytes (Behre, 1991, p. 89). In the Netherlands *Filipendula ulmaria* is known to grow locally around banks and ditches (Honders & Sebald, 2004, p. 133) and on meadows (Bastgen et. al., 2019, p. 63).

In Behre (1991) other plants were also indicated as bryophytes, taxa which are also included in this pollen diagram just like *Rhinanthus (cf. minor)* and *Lythrum salicaria.* Though *Lythrum* only

occurred at 160 centimetres and *Rhinanthus* was only found at 130 centimetres, such plants still indicate that the ground would not have been very saline at the time.

The taxa present per layer were seen in the results. The information of the results will now be presented once again per zone. This time, there will be more focus on what the landscape may have actually looked like in the period of time it correlates with. Zone A, D and E are not compatible with the calculated radiocarbon date nor do they follow the phragmites peat accumulation rates.

Calculating sedimentation rates for clay is not possible as clay can be added extra or erode due to flooding by sea or by fluvial activity. Since the site is located close to the North Sea as well as the Rhine river, there is no guarantee that flooding has happened or not.

Though earlier sediments in zone D and E may correlate with some landscape developments from before the late Middle Ages. These include the clay layer that has been deposited there by the old Rhine river.

As of now, there is no certainty in putting these points in a certain time frame unless charcoal can be found at a later age and be processed for radiocarbon dating. No dates will be assigned to these layers for this reason. The dates will include a whole time frame which looks like a century rather than a fixed point as there is no complete certainty for a fixed year yet.

Figure 7. Map of Vrouw Vennepolder in 1850 (https://www.topotijdreis.nl/)

Zone E

One can state that the landscape in these times would have most likely been a wet woodland. The woodland part can be traced back to the percentage of trees and shrubs compared to the

herbaceous plants. The taxa present in the zone also indicate how the landscape would have been a wet woodland.

Betula pubescens, for example, is known to grow on damp grounds especially in peat grounds (Harris & Harris, 2009, p. 29). *Alnus* is also known to thrive on wet woodlands (Woodland Trust, n. d.). However, *Alnus* remains in the entire assemblage in every layer, which als indicates how *Alnus*, and especially *Alnus glutinosa,* also known as the Black Alder, is a native species in the Netherlands (Tutin et. al., 1964, p. 59).

Pinus, Quercus and *Corylus* were the genera that occurred the most in this zone. *Quercus robur* is a species that is more common in the Netherlands. In contrast to *Quercus petraea* which usually occurs in dry and nutrient-poor grounds (Blamey & Gre-Wilson, 1989, p. 56), *Quercus robur*, or the English Oak, is more common everywhere in the Netherlands and would have had more exposure in a more wet landscape too (Harris & Harris, 2009, p. 148-149).

Given the structure of a Pinus pollen which is bi-saccate and made to fly large distances for pollination, it may be possible that Pinus was not as visible in a local landscape as it may have been in a regional landscape closer to the dunes (Lowe & Walker, 2014, p. 184).

Corylus avellana, hazel, is a species native to the Netherlands (Tutin et. al., 1960, p. 60). Seeing these three occurring as often as they do in this zone only makes sense that way.

At 230 centimetres there is another species that may indicate the type of landscape it was at that moment in time, which is the *Saxifraga hirculus*-type. When looking at plants which have a low pollen count like the *Saxifraga hirculus*-type and *Calluna vulgaris*, one can state that the ground was more acidic. *Calluna vulgaris* is known for loving acidic soils (Honders & Sebald, 2004, p. 213). Other than that, either *Saxifraga hirculus* (Beug, 2004, 143) or *Saxifraga granulata* (Honders & Sebald, 2004, p. 152) could have grown on such grounds as they both like acidic soils too. *Saxifraga hirculus* could have still grown in this period as this falls way before the extinction of the species in the Netherlands, This species is known to grow in nutrient-poor mires (Hedley and Walker, 2015).

Other plants occurring often in this time were Poaceae and Amaranthaceae. Within Poaceae, it could have been possible that *Phragmites* was growing in this region. *Phragmites* is a genus of reedgrasses which grows in wetlands. This would also connect very well with the peat with

Phragmites leaves that follows after this zone. *Typha* would have also grown alongside all these species that love wet conditions.

As has been stated before, it is not possible to link this period to a certain time without any radiocarbon dates. Therefore, the only thing that can be said is that one is looking at a natural landscape which existed before the peat extraction. It would have been a wet woodland yet open enough at places in order for the smaller plants to still grow. A body of water like a lake or a river may have been closeby given the plants that love to grow under wet conditions.

Zone D

Consisting of 205 centimetres and 192 centimetres, this zone has two different kinds of soils. Most of the soil is peat. Given that there were reed leaves found in the peat layer around 205 centimetres, there would be *Phragmites* growing locally.

Right from the start, the large percentage of Amaranthaceae present in the zone catches the eye. It has to be kept in mind that Amaranthaceae could sometimes be overrepresented due to their wind-pollinating nature (Gurjazkaite, 2017, p. 20). Other herbaceous plants in this zone are Poaceae, Lactuceae and Plantago. There are more herbaceous taxa in these layers, making the landscape look different from the wet woodland in Zone E.

With mostly herbaceous plants being represented in this layer, the landscape of this layer still remained a marshland, though no longer a wet woodland. The landscape composition of plants has changed only a little from the layer below and I believe that dispersal of local trees at the site would have been there.

These include trees like Corylus. The species *Corylus avellana* also known as the Hazel, is a plant native to the Netherlands which can grow in many places, including nutrient-poor soils (Harris & Harris, 2009, p. 68).

Zone C

This is the first zone where a date estimation of the site can be made. In this zone, 170 centimetres right at the sharp line dividing the clay layer from the peat layer. According to the

radiocarbon date, a 170 centimetres would have been approximately 776 AD. Taking the error margins into account, this could roughly also be around the 11th century AD. which is when the peat extraction started.

Something that is clearly visible in this zone is the decline of a diverse landscape. Of course there are still different kinds of land taxa present, yet some taxa types slowly start to take over a large percentage.

This layer had the most herbaceous plants as compared to trees, shrubs and climbers. This has a lot to do with most tree and shrub species being presented as less than 5%, with the exception of Quercus. Though once again, it is important to keep in mind that there was a big amount of Amaranthaceae in this layer. According to the pollen counts of 167 centimetres for example, there were 16 *Alnus*, 39 *Quercus* and 88 Amaranthaceae counted. Though in percentage of the total pollen in this layer, the *Alnus* and *Quercus* may appear to be less present, they are somewhat overshadowed by Amaranthaceae species.

Since the soil has gone back to being a reed peat soil again, the landscape would have most likely been a peat marsh with trees like *Alnus,* or the Alder of which *Alnus glutinosa* is known to grow in peatlands in the Netherlands (Harris & Harris, 2009, p. 65) and Oak trees.

One reason why the pollen diagram of Kijkduin correlated with the one here was also the decline of Amaranthaceae in the landscape over time. In this assemblage, this is the last zone where there is still a relatively large amount of Amaranthaceae present. After this, they are barely present in the landscape. One can already see *Lythrum* and Rubiaceae appear more in the landscape instead of Amaranthaceae. The reason for this could be that both Amaranthaceae and *Artemisia* are more present in a place with a slightly marine influence (Verhagen & van der Valk, 1991, p. 12). As the Rhine changed its course around this time too, the influence of both marine and fluvial deposits got lower.

Within the *Lythrum* genus*, Lythrum salicaria* is seen locally in the Netherlands and appears along waterfronts (Honders & Sebald, 2004, p. 158). At 160 centimetres, there is also a considerable lack of tree and shrub taxa to be noted in the assemblage.

Though the chance of it is small at Vrouw Vennepolder itself, this period, from when the peat extraction had started, may have also been the period from when people started to live in this

area. This has to do with the area becoming more interesting to live in because of the work that had been provided there (Koekkelkoren & Moerman, 2012, p. 15).
This is the last zone where the biodiversity of plants in terms of families and genera is still relatively big. The more recent zones had a less diverse pollen distribution. The start of peat extraction would have surely had some influence in that. People needed to extract it by hand and as smoothly as possible. For this they may have cut off a multitude of plant species in order to access the land more easily without there being low herbaceous plants or high trees and shrubs all around them.

Zone B

This zone ranges from around the 12th century at 130 centimetres to the 16th century AD at 90 centimetres. As indicated before, the landscape started to become less diverse in terms of taxa. Within the trees and shrubs there is still a variety of genera present. *Alnus, Betula, Quercus* and *Corylus* were well visible on the diagram in particular.
There is a big decline in Amaranthaceae from here on. Of the herbaceous plants, only Poaceae and Cyperaceae species and genera dominate the landscape now, with the exception of more Apiaceae at 90 centimetres. The extraction of the peat was the start of creating a peat meadow landscape.

Poaceae species may have included some *phragmites* still as the layer was phragmites peat, even though the presence of phragmites may have started to decline after 90 centimetres. This is because of the peat containing no *Phragmites* in zone A.
With the start of peat extraction, there would be more parcels in the land with little ditches flowing between parcels of land. Bigger herbaceous plants or trees may have grown close to the ditches as that would have provided them with more water. It is known that *Alnus* is planted at riverbanks to prevent erosion and offer support to bad or wet soils (Harris & Harris, 2009, p. 65).
As the peat meadow formation has already started, the landscape was not yet used for more than just peat extraction. The tree species present could have been used such as Oak wood for personal use such as tanning hides with the bark (Harris & Harris, 2009, p. 145). Other tree and shrub species can also be used in a variety of ways. More details will be provided on this matter later in the discussion.

Though there is less diversity in plants, certain taxa are still present under 5% in this zone. This includes all tree and shrub species. Other than that there are some herbaceous plants like *Epilobium, Galium-type* and *Artemisia.* Within the *Galium* species*, Galium aparine* is common in the Netherlands (Honders & Sebald, 2004, p. 312).
As the polder formation did not yet start in this part, all the taxa are still more representative of a peatland system with peat extraction taking place on a local level.

Zone A

Consisting of 70 and 50 centimetres and ranging from the 18th century to the 20th century, this is the most recent zone of the entire diagram. It also has the least diverse taxa variation as compared to all the zones that preceded this one.
At 70 centimetres, there was not much to be found in terms of pollen. There were a total of 78 pollen grains counted for this particular layer. Despite the lack of pollen in this layer, a good enough estimation of what the landscape looked like in this period can be made. Most of the landscape would have been grassland. The trees in this assemblage would have most likely been at the edge of the grasslands close to the ditches dug out during the peat extraction period a few centuries before. One can speak of a peat meadow being present in this layer now.
An increase of *Juniperus* is visible in this zone, increasing the diversity of tree taxa present. Juniperus grows in meadows and on dry grounds (Bastgen et. al., 2019, p. 197), which checks out with the peat meadow. *Juniperus communis* is the *Juniperus* species which grows locally in the Netherlands (Harris & Harris, 2009, p. 264). Its berries can be eaten and have been used to make wine in the Netherlands (Bastgen et. al., 2019, p. 197).
This layer was located at the start of black peat formation. The making of the polder would have taken place in the area around or just before this period (Wilbers & de Léon Subías, 2019, p. 9). In order to make a polder, people would have indeed needed a more uniform land than before. The trees could have still been of use to the local population, though now, the land was also really in use for agricultural purposes. The agricultural purposes were not flowing into food cultivation as no *Cerealia* pollen was found. The Poaceae pollen that were there were too small to be considered *Cerealia* (Andersen, 1978, p. 70).

The Poaceae that are present the most in this layer were most likely grasses for cows to eat on rather than *Phragmites* reed. As there was a change of peat colour as well as the understanding of there being an older present in this time, makes it more likely to have been such grasses.

This last layer is, however, the most recent layer of the assemblage with mostly Poaceae and Cyperaceae. The landscape would have been a polder for a long period by this time. Many of the tree and shrub species would be growing either locally close to the ditches or regionally like the Picea.

There is an increase in *Filipendula* in this layer. Along with Poaceae and Cyperaceae one can say that the land would have had mostly small herbaceous plants and some bigger shrub and tree taxa in its close vicinity like along the waterfronts. Another thing that can be concluded from the taxa *Filipendula* and *Potamogeton* together in this zone is that they would have been located around fresh water (Verhagen & van der Valk, 1991, p. 8).

The landscape would have become a peat meadow by this time. Given that it correlates with the time the polderformation started and that one can also see the differences in taxa distribution over land.

4.3. Changes throughout time

All in all, the earliest landscape went from a wet woodland to a marsh. It stayed a marsh for a long time before humans interfered in the landscape and it turned into a peat meadow. Turning into a peat meadow took time and only happened around the time that the polder formation also started. On the pollen diagram that can be seen in zone A with the reduction of biodiversity as compared to earlier zones.

The biggest change one sees is the change of plant distribution as the lithology also changed. With the start of black peat with reed fragments, the peat extraction starts too. With the colour change of the peat, we now know that the polder formation started too. There were no reed remains found in the peat any longer. This could indicate that the people involved at Vrouw Vennepolder removed the *Phragmites* remains as much as they can in order to have a clearer overview over their whole landscape.

Human interference was characterised by the declining biodiversity of the landscape. The decline slowly started at 170 centimetres when the peat extractions started too. The landscape slowly started to have more of the same kind of taxa rather than a variety of taxa. With this, the notion

of certain taxa being overrepresented because of their higher percentage has to be kept in mind. Still there is a visible decline of biodiversity in the landscape, even if one keeps that condition in mind.

Peat is known to be present in all residual channels in the central and the western part of the Rhine-Meuse delta (Stouthamer, 2001, p. 79). Up until the 12th century, the old Rhine would have had some influence in the landscape until it was all dammed and the course of the Rhine changed (de Haas et al., 2018, p. 103). Grey clay occurred in the flood basin deposits of the old Rhine, though in lesser quantities in the western part of the old Rhine (Stouthamer, 2001, p. 81).

What may be worth noticing is the local variations of the types of peat that is present there. It was clear in this assemblage that the peat was *Phragmites* reed peat. This is also backed up with the presence of reed fragments in brown peat parts. However, peat found closer to the Vennemeer was indicated as sedge peat rather than phragmites peat (Koekkelkoren & Moerman, 2012, p. 15). This may mean that there were more Cyperaceae species growing in that part of the polder, closer to the Vennemeer, as compared to the part where the coring for this assemblage had been done.

Of course there were still many plants present under 5%, yet the biggest percentages of plants more or less remained the same. There was an increase in herbaceous species with the influence of people on the landscape. The exception to this being at 110 centimetres where more woody species were present.

Plants during the polder formation era

The plants present during the polder formation era were mostly Poaceae and Cyperaceae with *Betula*, *Quercus, Alnus* and *Corylus* present as the most occurring trees. These plants would have most likely been local as they have been noted to be present in larger amounts in pollen diagrams of other places in the Netherlands too (Sevink & van Geel, 2017, p. 284).

Of the other tree species, *Salix tiandra* could have been present at the polder as the tree is known to grow in polders (Harris & Harris, 2009, p. 116).

Filipendula and *Juniperus* are also relatively more present, especially in the most recent layer of zone A. This seems accurate with how polders look like usually, with mostly grasses and small herbaceous plant species and some trees along the waterside surrounding the polder land.

It is known that Vrouw Vennepolder was made with the merging of four pieces of land between 1626-1632. The making of the polders was done out of necessity to have less big lakes in the area. The lakes were created by people during the peat extraction period for creating agricultural grounds as well as for acquiring fuel (Vrouw Vennemolen, n. d.).

These grounds have in turn been used for agriculture, though there has been no plant cultivation related agriculture. There were no *Cerealia*-type pollen grains distinguished in the entire diagram. With this, the chance of *Centaurea cyanus* being present as one of the Asteraceae plants is slim, though not entirely impossible (Honders & Sebald, 2004, p. 354).

Not only is the lack of agricultural crops an indication of the type of polder it was. Vrouw Vennemolden became the main mill in the polder after 1632. It is a hollow post mill or a "wipmolen." This type of mill originates from around the 16th century during which it was only used in polders for storing water temporarily before releasing it again once the water levels were lower (Kingma, 2009).

All in all, there is no indication of there being crop processing at Vrouw Vennepolder ever. The agricultural activities that took place at Vrouw Vennepolder were therefore mostly related to keeping livestock. This means that people from the close surrounding areas would usually have been dairy farmers (Birks et. al., 1988, p. 329). Trade of milk could have been done with bigger cities around the polders, like Leiden, Gouda and Amsterdam.

This makes sense with the amount and types of herbaceous plant species of zone A. They were all grasses and sedges and some other herbaceous plants like *Filipendula*. Such plants are ideal for animals like cows to graze on.

The presence of cows which were kept on Vrouw Vennepolder is also confirmed with a newspaper from the 27th of October in 1892 ("Persoverzicht," 1892) on the Leidsch Dagblad. In the little piece the writer mentioned that the cows of the farmer at that time had foot-and-mouth disease, also known as Aphthae epizooticae. This viral disease occurs in wild and domestic cloven-hoofed animals, including cattle (Farlax partner medical dictionary, n. d.).

4.4. Alternative land use

Together with the sources on the history of the polder as well as the pollen diagram, it is now known what kind of polder Vrouw Vennepolder was and how one can recognize a polder on a pollen diagram. The interpretation of the pollen in the polder layer has been quite straightforward

so far. The taxa present are known to be growing locally in the Netherlands and one can also see the function of such plants.

From the research done so far, one can say that most of the work on the land would have been related to peat extraction, keeping livestock and trade in dairy products. Keeping livestock and trading in dairy products would have been done especially after the 17th century, once the polder was created.

However, the place has existed way before it got turned into a polder and people have been in touch with the place longer than the polder formation. Besides, people have been busy developing other crafts while polder formation (Birks et al., 1988, p. 327). These crafts may not always have been for selling goods on a large scale. Such crafts could also have been looked into in order to create household items, foods and building materials for farms and sheds.

Alternative ways people could have used the plants that were present in the assemblage are plenty. A table on the taxa present in the diagram and their uses is included below.

Taxa	**Type**	**Uses**
Alnus	Tree	Easily worked when it is dry and used for making clogs and broomsticks (Harris & Harris, 2009, 65)
Betula	Tree	Used for making handles of tools (Harris & Harris, 2009, 28) Honey birch wine made from its sap. Insect repellent made from its oil and furniture made from its wood (Harris & Harris, 2009, 29)
Quercus	Tree	The bark of the tree can be used for tanning hides (Harris & Harris, 2009, 145).
Salix	Tree	Its twigs can be used for making baskets (Harris & Harris, 2009, 116).
Tilia	Tree	Of especially *Tilia cordata,* the wood can be used for

		carving, which can be seen in buildings from the 17th and 18th century. Its flowers are used as medicines for a cold and also just used in tea. (Harris & Harris, 2009, 43)
Corylus	Shrub	Aside from the hazelnut being eaten, the twigs have a long history of being used for weaving. (Honders & Sebald, 2004, 68)
Juniperus	Shrub	The berries of *Juniperus communis* can be eaten and have been used to make wine in the Netherlands (Bastgen et. al., 2019, 197).
Artemisia	Herb	*Artemisia* contains thujone which is poisonous. It can still be consumed in small quantities. *Artemisia absinthium* is used in making absinthe (Bastgen et. al., 2019, 99).
Galium	Herb	There are many types of *Galium* in the Netherlands and 5 of these species are edible too (Bastgen et. al., 2019, 19-21). *Galium verum* contains chymosin which is an enzyme that was used during cheese making (Bastgen et. al., 2019, 20).
Filipendula	Herb	*Filipendula* has been known to be used in mead for taste (Bastgen et al 2019, 63) and also to make a house smell good because of its almond-type smell of the leaves (Honders & Sebald, 2004, 133).

It is quite a speculation to assume that people would have actually used these plants without any other finds to back it up. There is a possibility for this still, as some of the uses listed above have been happening for years before now.

Another thing one may notice is how not all the plants are included in this table. This has to do with multiple reasons. For instance, the relevance of the plant and how much it occurred on the diagram. The amount of information found on the plant itself. The workability of the plant. Taking all these factors into account, these are the taxa that have been selected to highlight alternative uses of plants.

There is a possibility that these uses have also taken place during peat formation and not only during the peat extraction period. Using *galium verum* during cheese making would have been possible and could have possibly also happened at the site.

4.5. Consequences of peat extraction and polder formation

Though it was in the best interest of the local people at the time, peat extraction as well as polder formation did have consequences overall for the landscape. Peat extraction can create a very monotonous landscape, as one can already deduce from the pollen diagram.

Gathering from the pollen diagram, the lack of biodiversity started to happen slowly around the time of peat extraction in the 11th century. The decline seemed to get even worse at the time of polder formation in the 17th century.

Looking into improving the biodiversity as Land van Ons wants to do is a nice idea. With that one has to look well into the taxa that can be included in a peat landscape and do a lot of maintenance in order to keep the landscape diverse.

Chapter 5. Conclusion

Pollen research has been done on Vrouw Vennepolder which is a polder situated close to Leiden. Vrouw Vennepolder is located in a region which has had marine influence as well as deposits from the old Rhine. As such, it has had a variety of plant types throughout the time. The variations of these plants can be seen in the pollen diagram in figure 5, which is also included in the appendix B.

The landscape ahd mostly peat grounds, with brackish to fresh water from the 11th century onwards. In the periods before that, there may have been more salinity in the groundwater, given the distribution of Amaranthaceae which occurs more in slightly saline grounds.

Though the resources were limited, it was still possible to see that the landscape naturally developed from a wet woodland to a salt marsh. With human activity around the 11th century AD it turned into a peat meadow. Further human involvement in the land eventually turned the area into a polder in the 17th century.

The area had peat extractions which were done in the late Middle Ages around the 11th century AD. Polder formations were started in the 17th century which is also seen on the pollen diagram. Given the types of taxa presented during the polder formations and the period of polder works, the area was most probably used for domesticating cows and getting milk for cheese production.

The area close to the polder was inhabited only after the start of peat extraction in the 11th century. This has been proven not only through older research done in the area, but also through the pollen diagram made by students at Leiden University. With this information one can now see a better transition of the plant taxa throughout the time since the 11th century. Vrouw Vennepolder was most likely only used as a polder from the 17th century onwards.

The plant taxa that were represented could also have been used for more than just creating a landscape or just being present in the landscape. Some plants have a history of being used by people for multiple purposes. These purposes range from being used for food to being used as a material for furniture or other objects around the house.

Tree barks and branches could have been used for a variety of things, including making furniture, shoes and baskets. Their flowers or nuts could be used for food. Smaller herbaceous plants could have been eaten or used during food making, just like *Galium* and *Filipendula.*

The peat extractions and the polder formation did have an effect on the landscape, as it decreased the biodiversity. This has to do with the biodiversity regarding the different kinds of families and genera there once were present at the landscape and now are not anymore.

To get a better overview of the landscape developments at Vrouw Vennepolder, one could do another coring or multiple corings at the site and have pollen research done on every centimetre. This could help with creating a better overview of the landscape throughout time and including more nuances in that.
Another thing that can be done is C-14 research in case charcoal has been found in another coring. This would give a better chronology of the site.
At last, more research can be done on the history of the site, especially in regards to the Abbey of Rijnsburg. Research can focus on towns close by and the development of the site over time.

Abstract

After a ground coring was done by Leiden University at Vrouw Vennepolder, pollen research has been conducted by archaeology students. In this bachelor thesis, the pollen diagram which came out as a result of the thesis, has been used to reconstruct the past landscape and to look into ways that the taxa present in the pollen diagram could have been used for multiple purposes. At last, there was something said on the effects this had on the decline of biodiversity in the area.
Vrouw Vennepolder is a site located on the northeast outside of Leiden in the municipality of Kaag en Braassem. The region has had peat extractions from the 11th century onwards. The polder itself was created in the 17th century as a result of merging four pieces of land together.
The plants indicate that they were on slightly saline grounds before peat extraction started in the 11th century AD. After that, the plants representing the layers are mostly fresh or brackish water plants.
Both during the peat extraction and the polder formation, there were taxa present that could have been used by the local population. These plants include a variety of trees, shrubs and herbaceous species that are known for their specific uses both in the past and now.
For the dating of the site, peat accumulation rates and a pollen diagram from Kijkduin have been used. These two factors together gave a good comparison of the time development in the pollen diagram of Vrouw Vennepolder. The development starts at 170 centimetres and ends at 50 centimetres. There is no clear timespan given to the layers below 170 centimetres.
One can see a transition of the plant populations present at the site on the pollen diagram. As the human influence got bigger at the site, the biodiversity declined too. The distribution of trees and shrubs also changed over time, as herbaceous plant species slowly got more represented.

Nadat door de Universiteit Leiden een grondboring was gedaan op de Vrouw Vennepolder, is er pollenonderzoek gedaan door archeologie studenten. In deze bachelorscriptie is het pollendiagram dat naar aanleiding van het proefschrift naar voren is gekomen, gebruikt om het landschap uit het verleden te reconstrueren en om te onderzoeken hoe de taxa in het pollendiagram voor meerdere doeleinden konden worden gebruikt. Uiteindelijk is er ook iets gezegd over de effecten dat dit had op de achteruitgang van de biodiversiteit in het gebied.

Vrouw Vennepolder ligt in het noordoosten buiten Leiden in de gemeente Kaag en Braassem. Vanaf de 11e eeuw wordt turf gewonnen in de regio. De polder zelf is in de 17e eeuw ontstaan door het samenvoegen van vier stukken land.

De planten in het pollendiagram geven aan dat ze op licht zoute gronden stonden voordat de turfwinningen in de 11e eeuw begonnen. Daarna zijn de planten die de lagen vertegenwoordigen meestal zoet- of brakwaterplanten geweest.

Zowel tijdens de turfwinning als de polder formatie waren er taxa aanwezig die door de lokale bevolking gebruikt hadden kunnen worden. Deze planten omvatten een verscheidenheid aan bomen, struiken en kruidachtige soorten die zowel in het verleden als heden bekend staan om verschillende gebruiken.

Voor de datering van de vindplaats is gebruik gemaakt van veen accumulatie snelheden en een pollendiagram uit Kijkduin. Deze twee factoren samen gaven een goede vergelijking van het tijdsverloop in het pollendiagram van Vrouw Vennepolder. De ontwikkeling begint bij 170 centimeter en eindigt bij 50 centimeter. Er is geen duidelijke tijdsaanduiding gegeven aan de lagen onder de 170 centimeter.

Op het pollendiagram is een overgang te zien van de aanwezige planten populaties op de locatie. Naarmate de menselijke invloeden op de plaats groter werden, nam ook de biodiversiteit af. Ook de verspreiding van bomen en struiken veranderde in de loop van de tijd, omdat kruidachtige plantensoorten langzaamaan meer vertegenwoordigd werden.

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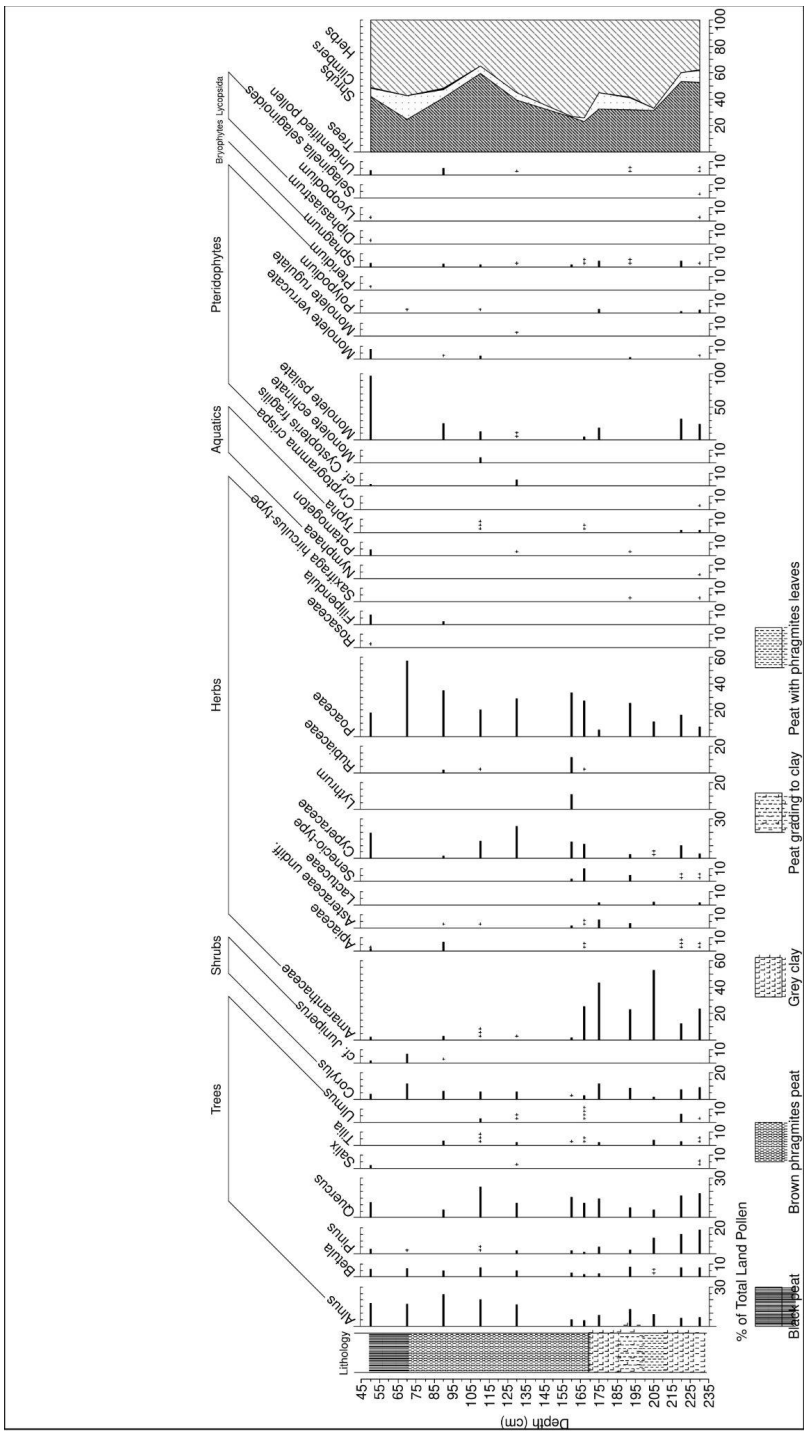
List of Figures

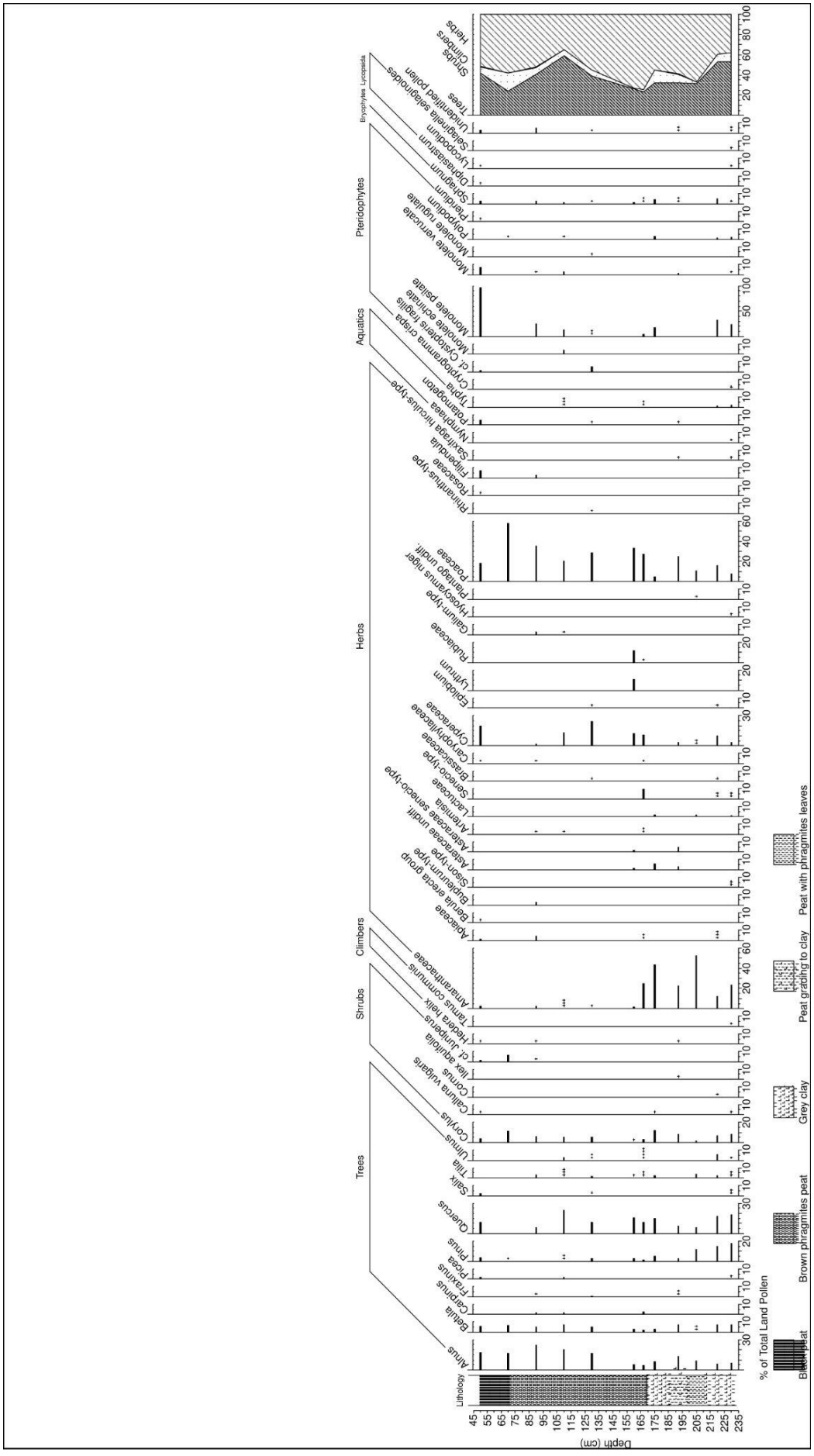
Appendix A

Selected Pollen diagram



Appendix B

Full pollen diagram, seen in the next page.


Depth (cm)
Lithology
% of Total Land Pollen
Black peat
Brown phragmites peat
Grey clay
Peat grading to clay
Peat with phragmites leaves
Trees
Shrubs
Climbers
Herbs
Aquatics
Pteridophytes
Bryophytes Lycopsida
Alnus
Betula
Carpinus
Fraxinus
Picea
Pinus
Quercus
Salix
Tilia
Ulmus
Corylus
Calluna vulgaris
Cornus
cf. juniperus
Hedera helix
Taxus communis
Anacamptaceae
Apiaceae
Betula alecta group
Bupleurum-type
Silaum-type
Asteraceae
Asteraceae undiff.
Artemisia
Lactucaceae
Senecio-type
Brassicaceae
Caryophyllaceae
Cyperaceae
Epilobium
Lythrum
Rubiaceae
Galium-type
Hyoscyamus niger
Plantago undiff.
Poaceae
Rhinanthus-type
Rosaceae
Filipendula
Saxifraga hirculus-type
Nymphaea
Potamogeton
Typha
Cryptogramma crispa
cf. Cyclopeltis fragilis
Monolete echinate
Monolete psilate
Monoleta verrucate
Polypodium
Pteridium
Sphagnum
Diphasiastrum
Lycopodium
Selaginella selaginoides
Undetermined pollen
Trees
Shrubs
Herbs