Master's Thesis – master Water Science and Management

Assessing the usefulness of the ecohydrological model Waterwijzer Natuur 3.0 in developing an ambition map within the Province of Overijssel.

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13-07-2022

Acknowledgements
First of all, I would like to thank Remco van Ek for his extensive guidance during my internship and for helping me bring this project to a successful conclusion. Also, the help of Martin Wassen in supervising the whole thesis and the borrowing of equipment, on behalf of the Utrecht University, for fieldwork is much appreciated. In addition, I must thank KWR (Edu Dorland in particular) for making WWN 3.0 available at an early stage, without which this project would not have been possible.
I would also like to thank Emy Visser for introducing me to the Province of Overijssel and helping me to start my work there. Finally, I am also grateful that the Province of Overijssel could provide me with a car to get to the fieldwork locations, which otherwise would not have been accessible to me.

Abstract
The Province of Overijssel has to comply with goals set in the national Natuurnetwerk Nederland project. In order to do so, the province needs a map (ambition map) which indicates how nature can be restored and further developed. A consortium was engaged to develop this ambition for which they decided to use the new ecohydrological model Waterwijzer Natuur 3.0. However, no documentation on the reliability of this model had been released yet and the project provided little time for the project team to assess the usefulness of the Waterwijzer Natuur 3.0. This thesis aims to fill this gap by answering the question how the Waterwijzer Natuur 3.0 can be useful in developing the ambition map. Not only was this relevant for the Province of Overijssel, but ecohydrological science could also profit from this thesis, since a new, easy to use model is being assessed. When Waterwijzer Natuur proves to be a useful model, it can be used in comparable research. The usefulness assessment has been done by performing Landscape Ecological System Analyses (LESAs) in the field and comparing field data with the Waterwijzer Natuur 3.0 results and the input it receives. Results showed that the input data for Waterwijzer Natuur 3.0 was regularly incorrect, often caused by the supply of outdated data. As a result, the quality of the Waterwijzer Natuur 3.0 results was too low to directly use them for defining ambitions for the ambition map. But it was also found that when Waterwijzer Natuur 3.0 input was reasonably correct compared to field data, the predictions from WWN 3.0 were mostly correct as well. Therefore has been concluded that results from WWN 3.0 can be used to support the formulation of ambitions for the ambition map, but only when an expert is assessing these results before formulating the ambitions.

Contents

1 INTRODUCTION

1.1 Background

The Natuurnetwerk Nederland (NNN, Nature Network the Netherlands), formerly known as the Ecologische Hoofdstructuur (EHS, National Ecological Network), is a Dutch national network of existing nature reserves and new nature development areas responsible for the conservation and improvement of biodiversity in the Netherlands. For example, the network helps to prevent the extinction of flora and fauna in isolated areas, thereby preventing nature areas from (partially) losing their value. Each Dutch province is responsible for the delineation and development of this nature network within their provincial borders (IPO, 2018). In the Natuurpact (Nature Pact) (Ministerie van Algemene Zaken, 2018), the provinces and the State have also agreed to set up a total of 80,000 new hectares of nature by 2027, which means that the minimum area within the NNN will come to a total of approximately 736,000 hectares as of 1 January 2027 (CBS et al., 2020).

As one of the twelve Dutch provinces, Overijssel has also agreed to this Natuurpact. Through their Natuurbeheerplan (nature management plan) (Provincie Overijssel, 2020), this province aims to achieve the goals set by the NNN for 2027. According to their nature management plan (Natuurbeheerplan), decisions on nature management should be taken on the basis of an ambition map, which indicates the direction in which the nature of Overijssel should develop in order to achieve these goals. However, the Province has found that their ambition map is not detailed enough, leading to problems in implementation of nature management. These problems include (but are not limited to) the inability to estimate the total costs of conforming with the NNN guidelines and the inability to manage diversity in different types of nature (Scholten et al., 2021). The Province of Overijssel has therefore engaged a consortium consisting of Procap-Ecogroen, Witteveen+Bos and Mapgear (NNN Overijssel, n.d.) to develop a more detailed ambition map in 2021 and 2022. While developing this ambition map, the consortium will collaborate with many stakeholders involved, including land management organizations (TBOs, Terreinbeherende Organisaties), landowners, water boards, provinces and municipalities.

The ambition map will indicate development opportunities for nature areas within the NNN, in order to maintain or increase the value of already existing nature areas and, where possible, create additional nature areas. By creating new nature, existing nature reserves can be linked together to stimulate greater biodiversity and thus healthier nature. Based on the ambition map and policy targets in the Natuurbeheerplan, definitive choices will be made with respect to the maintenance of nature and the realisation of new nature. In this way, the ambition map takes on a prominent role in complying to the guidelines of the NNN project. To have added value for nature, it is of great importance that the ambition map is correct and consequently sets achievable goals. Because it takes too much time and it is too costly to have each plot on the ambition map critically examined by an expert in the field before arriving at the right form of nature management, the consortium decided to make use of a model to speed up this process. The ecohydrological model Waterwijzer Natuur[1] (WWN, Water Probe model for Nature), which is fed with information about geohydrology, soil types and land use, was chosen for this purpose. The latest version, WWN 3.0, has been used.

Problem description
Given the importance of a correct ambition map in achieving NNN targets, the desired use of WWN 3.0 requires that its results be accurate. However, at the time WWN 3.0 was made available to the consortium, it had not yet been officially released. Because of this, here was no documentation available on the reliability of the model, nor were there any comparable studies that already had used WWN 3.0. The consortium was thus

[1] https://waterwijzer.nl

faced with the question to what extent WWN 3.0 actually could be useful in creating a detailed ambition map. Therefore, to check the reliability of WWN 3.0 predictions, a comparison with actual field data had to be made. Due to a lack of verified, recent field data to perform this check on the correctness of model results, there was a need to conduct field visits in order to obtain the required data. From this need stems this thesis.

1.2 Aim and research questions

The aim of this thesis was therefore to find out what the added value of WWN 3.0 could be in the development of a detailed ambition map for the Province of Overijssel. This results in the following main research question:

How should the ecohydrological model Waterwijzer Natuur 3.0 be used in the development process of a detailed ambition map for the Natuurnetwerk Nederland project within the Province of Overijssel?

Ideally, the answer to this question would be that the ambition map could be based directly on results from WWN 3.0, meaning that the predictions from WWN 3.0 would seamlessly match reality. The first sub-question therefore served to assess whether this was true or not:

1 How do results from the Waterwijzer Natuur 3.0 compare to data collected during field visits?

As any model will only be a simplified approximation of reality, which is especially true for an untested model like WWN 3.0, there was a high probability of finding differences between predictions and reality. In that case, it would be interesting to know where these differences came from. This led to the following two sub-question:

2 If the Waterwijzer Natuur 3.0 result prove to be (partly) incorrect, what is causing this?

By answering the two sub-questions, the main research question could be addressed. On the basis of this, the consortium could be advised on the use of WWN 3.0 in delivering a detailed ambition map for the Province of Overijssel.

1.3 Relevance of the research

Social relevance

It is becoming increasingly clear that climate change (Solomon et al., 2009) and its impacts, such as changing ocean salinity (Durack et al, 2016), alteration of mountain forests (Albrich et al., 2016), and the decline of icesheets (Gregory et al., 2020) are irreversible. The world will therefore have to mitigate and adapt to climate change in order to limit its impact (Delgado et al., 2011; Lal et al., 2011). An important contribution to this can be made by nature itself. Jones et al. (2011) describe that ecosystem-based approaches can make use of nature's buffering capacity, in which conservation and restoration of nature are important. By maintaining and interconnecting natural environments, nature becomes more resistant to the effects of climate change, such as long-term drought, changing temperatures and an abundance of nutrients such as nitrogen (Jones et al., 2011). The interconnection of natural areas also allows for the survival of more flora and fauna, as well as an increase in genetic exchange which enhances natures robustness. By helping to develop a detailed ambition map for nature development in the Province of Overijssel, this study contributes directly to the conservation and restoration of nature and thus to climate change mitigation and adaptation as well.

Scientific relevance
Although modelling can be a valuable tool for solving complex scientific questions, ecohydrological models often require a lot of specific input, the collection of which is time-consuming and costly. However, the WWN model has been developed in such a way that it can calculate very quickly on the basis of readily available data, which makes it very easy to use for the implementation of projects for the benefit of nature. It is therefore scientifically relevant to evaluate whether WWN 3.0 is a useful model for the current NNN project. If the use of WWN 3.0 proves to be successful, it can be applied to issues similar to this project and thus play a relevant role in future ecohydrological research.

1.4 Overview of appendices

The appendices contain extensive results of field visits (quick scan LESAs) per sub-area (A-E) and can be consulted by whoever would like to know more about a specific area visited during this research. Furthermore, overviews of all nature management types (F), ecotope groups (G), soil types (H) and flora (I) treated in this report and legends of LGN and WWN 3.0 are provided (J). Although most terms or the usefulness of certain information has not yet been clarified in this introduction, it is good to know what data is available in the appendices during further reading of this thesis

2 THEORY

This chapter explains the theories used in this research. It also explains concepts used in these theories and why they are relevant.

2.1 A history of ecohydrology

In literature, opinions differ on the emergence of the interdisciplinary science of ecohydrology. For example, at the beginning of the 21st century, ecohydrology was considered the new paradigm for integrated water resources management (Hannah et al., 2004; Zalewski, 2000; Zalewski & Robarts, 2003), while Mackay (2019) later on concluded that aspects of ecohydrology had already been studied for over a century before that. In scientific research, the term was first used by Ingram (1987), but no specific mention was made of what ecohydrology exactly comprises. Some years later, initial definitions were given by Pedroli (1989), who described ecohydrology as the interdisciplinary field of research directed to the application of hydrological knowledge to landscape ecology, while Heathwaite et al. (1993) referred to the interrelationship of mire ecology, its flora and fauna, with the water balance. However, according to Hannah et al. (2004), ecohydrology was first clearly defined by Wassen and Grootjans (1996, p.1), who stated that "ecohydrology is an application driven discipline and aims at a better understanding of hydrological factors determining the natural development of wet ecosystems, especially in regard of their functional value for natural protection and restoration", thus focusing on wetlands. Grootjans et al. (1996) gave a more general definition of ecohydrology, saying it is the science of the hydrological aspects of ecology; the overlap between hydrology and ecology, studied in view of ecological problems. Baird and Wilby (1999) also expanded on Wassen and Grootjans (1996) definition of ecohydrology by including interactions in ephemeral dryland, forest, stream, river and lake systems. In more recent literature, ecohydrology is defined as the interdisciplinary science that explores interactions between the structure and function of ecological systems and the movement and quality of fresh water (Guswa et al., 2020), andno longer distinguishes between landscape types.

Given the definitions stated above, ecohydrology is therefore a logical line of approach in this study, which is endorsed by Wassen and Grootjans (1996) who emphasised the functional value of ecohydrology for natural protection and restoration, which is precisely the purpose of the ambition map. Over the past two decades, a huge amount of ecohydrological relevant data has become available due to rapidly developing technologies in sensing, storing and transferring data (e.g., Tauro et al., 2018). At the same time, there has also been an enormous growth in our ability to model the environment to better account for increasing complexity of ecohydrological research (Asbjornsen et al., 2011; Popp et al., 2009), which has consequently resulted in being able to better manage water resources (Guswa et al., 2020). As the development of the ambition map also depends on copious amounts of data that need to be processed, it was decided to use an ecohydrological model to do so.

According to Witte et al. (2008), ecohydrological models can be divided into three categories: correlative models; mechanistic models (with causal relationships); and semi-mechanistic models (with both correlative and causal relationships). They concluded that for practical and generally applicable ecohydrological issues, the semi-mechanistic approach is preferable for which several models are available (e.g., DEMNAT, NICHE, Waterwijzer Natuur). The development of the ambition map being a practical issue and the fact that it makes use of nature management types (paragraph 2.2), led to Waterwijzer Natuur being selected, since this model can predict the probability of certain ecotope groups (paragraph 2.2), which can be translated into nature management types.

2.2 Waterwijzer Natuur 3.0, ambition map and key concepts involved

Waterwijzer Natuur in general

A first version of Waterwijzer Natuur (WWN-1) was released in 2018 by Wageningen Environmental Research, KWR Watercycle Research Institute and Deltares and could be used at regional or local scale to quantify the effects of water management and climate on terrestrial nature (Witte et al., 2018). A next version (WWN-2) was released in 2020. This version of the Waterwijzer Natuurcould also make predictions on spatial patterns of vegetation based on soil pH calculated within the model in a process-based manner (Witte et al., 2020). The most recent version (WWN 3.0) has only just become available. The WWN 3.0 can predict soil nutrient richness more accurately, which makes the model suitable for restoration and management projects for nature reserves (Nijp et al., 2022), making it a useful model for this study.

The calculation software of WWN 3.0 is housed in a user-friendly shell that generates results in the form of maps and tables. Input data as well as output results are easily visualized directly within the shell. Thanks to the use of meta-relations and an economical programming technique, the computation time on a simple laptop for a catchment area of effectively half a million computation cells takes only a few minutes maximum. Fast computing allows the use of a high resolution in spatial modelling. This is particularly relevant for nature reserves due to the high spatial variability in site conditions. At the moment, WWN 3.0 consists of two components. The component 'WATERNOOD' tests whether the water regime of an area under the current climate is in accordance with intended vegetation targets, while the prediction module 'PROBE' (Witte et al., 2015, 2020) is used to predict spatial patterns of vegetation in dependence on hydrology, soil, land use and climate. Since this study focuses on predicting nature management types, PROBE has been used here.

PROBE

As this study used the 'PROBE' module of WWN 3.0, this module will be discussed in more detail. In order to make predictions, PROBE needs a series of input (Figure 1).

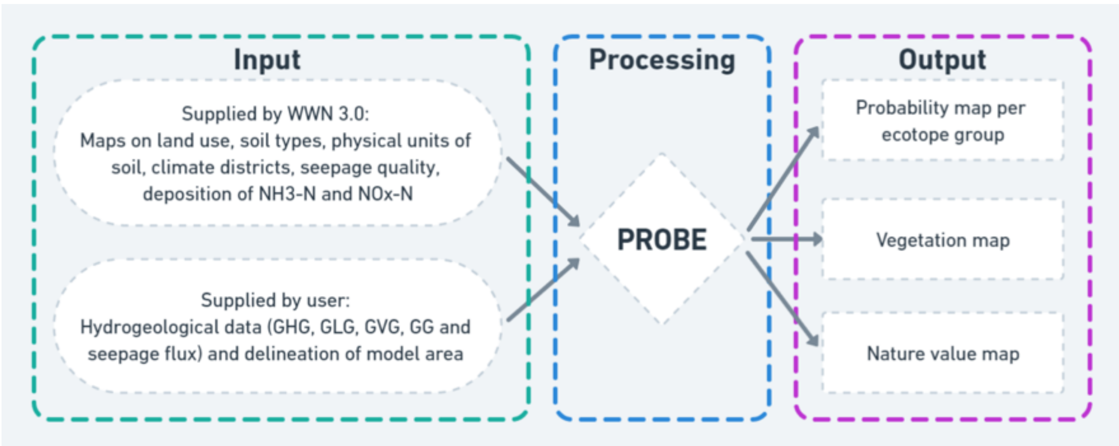

Figure 1: Flow diagram showing the input needed for a PROBE calculation within WWN 3.0 and the output it produces.

Some of these series are part of the model by default and can only be changed by the developers on request. These default series of input consist of maps of national land use (Landelijk Grondgebruik Nederland, LGN), soil types (BRO soil map), physical units of the soil (BOFEK), climate districts, quality of seepage and deposition of NH3-N and NOx-N. In addition to the default input, the user needs to delineate the area to be modelled by supplying maps, one defining the total model area and one indicating the nature reserves. Lastly, the user must provide the necessary hydrological data:

- Mean highest groundwater level GHG (meter minus ground level);
- Mean lowest groundwater level GLG (meter minus ground level);
- Mean spring groundwater level GVG (meter minus ground level);
- Mean groundwater level GG (meter minus ground level);
- Seepage flux (mm/d, where a positive value indicates upward seepage of groundwater, a negative value indicates infiltration).

This study uses input from the geohydrological model MIPWA version 3.0 as it provides all necessary data and covers the complete province of Overijssel.

When all input is provided, PROBE simulates changes in transpiration stress, oxygen stress, nutrient fertility and soil acidity, based on both expert knowledge and process-based models. The changes in these factors that the model predicts are then translated into indicative values and probability values of different vegetation typesThe current WWN version uses indication values (describing physical requirements that plants demand from their environment) based on Runhaar et al. (2004) as the basis for thirty-three ecotope groups (Appendix G). Central to this classification is the concept of an ecotope: a spatial unit that is homogeneous in vegetation structure and the main abiotic site factors (salinity, moisture, nutrient richness and acidity). An ecotope group is then a collection of ecotopes with distinct stages of vegetation development, but with similar abiotic properties (Claessen et al., 1991). In PROBE the use of ecotope groups, which is a quite coarse classification, was chosen because it is irresponsible to make predictions at a detailed vegetation level (e.g., plant communities) based on only three habitat factors (moisture condition, nutrient richness, acidity of the soil) (Witte et al., 2018). In addition, each unit should be quite homogeneous in terms of indicator values (describing physical requirements that plants put on their environment), whereas units from plant sociology at a higher level ('verbonden', 'klassen') are often too diverse (Witte, 2002).

WWN 3.0 predicts the probability in occurrence of each individual ecotope group in a map form. These separate maps per ecotope group, can also be combined into one vegetation map by selecting the ecotope group with the highest probability. However, because this technique would result in a predominance of certain more common ecotope groups and the absence of rarer ones, the model also makes a nature value map. This map is created by multiplying the nature value of an ecotope group with the probability of occurrence of that ecotope group. The nature value of an ecotope group is the value attributed to it from the perspective of nature conservation. When determining the nature value of an ecotope group, rareness is an important weighing factor, as are the species of flora and fauna that depend on it.

Ambition map and nature management types
The intention is to use the results of WWN 3.0 to develop an ambition map, for which ecotope groups have to be translated into nature management types (Appendix F), which are defined by BIJ12[2]. The delineation of nature management types is intended to guide management and is based on vegetation structure, abiotic conditions and occurrence in geographical regions. The classification is on a scale often used by nature managers (generally 1:25,000) and within a certain nature management type, forms of maintenance and maintenance costs are comparable. Because the ambition map is based on results of WWN 3.0, it visualises where opportunities lie to increase the nature value of areas compared to their current nature management types. As such, the ambition map has a guiding effect in the development of nature and contributes to complying with the guidelines of the NNN for 2027 in the Province of Overijssel.

2.3 Landscape Ecological System Analysis (LESA)

With the importance of WWN 3.0 results for the ambition map being clear, it was necessary to know to what extent these results corresponded with the situation in the field. By investigating this, the answer to the first sub-question 'How do results from the Waterwijzer Natuur 3.0 compare to data collected during field visits?' could be given. To answer the second sub-question 'If the Waterwijzer Natuur 3.0 result prove to be (partly) incorrect, what is causing this?', it was also important to compare the input data used (e.g., hydrological data, soil types) with data from the field. This meant that field visits had to be made to take measurements of hydrological data and soil characteristics to check the WWN 3.0 input (e.g., soil map, MIPWA 3.0 values). In the Netherlands, in projects such as this one, where maintenance and restoration of nature is prioritised, it is usual to use a Landscape Ecological System Analysis (LESA). For example, Jansen et al. (n.d.) state that it is advisable to use a LESA in restoration strategies for nature and Bijlsma et al. (2016) describe that many area analyses of Natura-2000 areas also make use of it. A LESA concisely looks at how an area was formed, how it functions and which processes determine the occurrence of plants and animals in the area (Van der Molen et

[2] https://www.bij12.nl/onderwerpen/natuur-en-landschap/index-natuur-en-landschap/natuurtypen/

al., 2010). Relevant information from different disciplines, such as geology, hydrology, hydrochemistry, soil science and ecology can be used. For each project, the right questions need to be asked and it is important to determine how extensive the LESA should be in answering them. A LESA can look at eight different components, being: 1. Climate 2. Lithology 3. Relief 4. Hydrology 5. Soil and recent land use 6. Flora 7. Fauna 8. Historical land use. Within this research it was decided to leave lithology out of consideration because of limited time and the deep location of lithic layers in the province of Overijssel. Fauna was also not included in this study, as it was not possible to do so within the available time frame. The other six factors were included in the LESAs, in varying degrees of detail. How this was conducted is explained further in chapter three.

3 METHODS

This chapter explains how field visits were prepared, what data was collected and in what way. It also explains how this data is used and how this has led to answering the research questions. Finally, briefly is discussed what should be included in the discussion chapter and whether there are any ethical issues related to this research.

3.1 Data collection

3.1.1 Preparation for fieldwork

Areas of interest

In order to conduct LESAs, a number of field visits had to be done. To this end, Witteveen+Bos and Ecogroen compiled a list of eighteen locations where they had questions about the results WWN gave or the input it used and where limited field data was available to check them. Field visits were combined with additional analysis of available spatial data to investigate possible mismatches between WWN 3.0 results or model inputs and the actual state in the field. The eighteen locations are visualized in **Error! Reference source not found.** and named in Table 1.

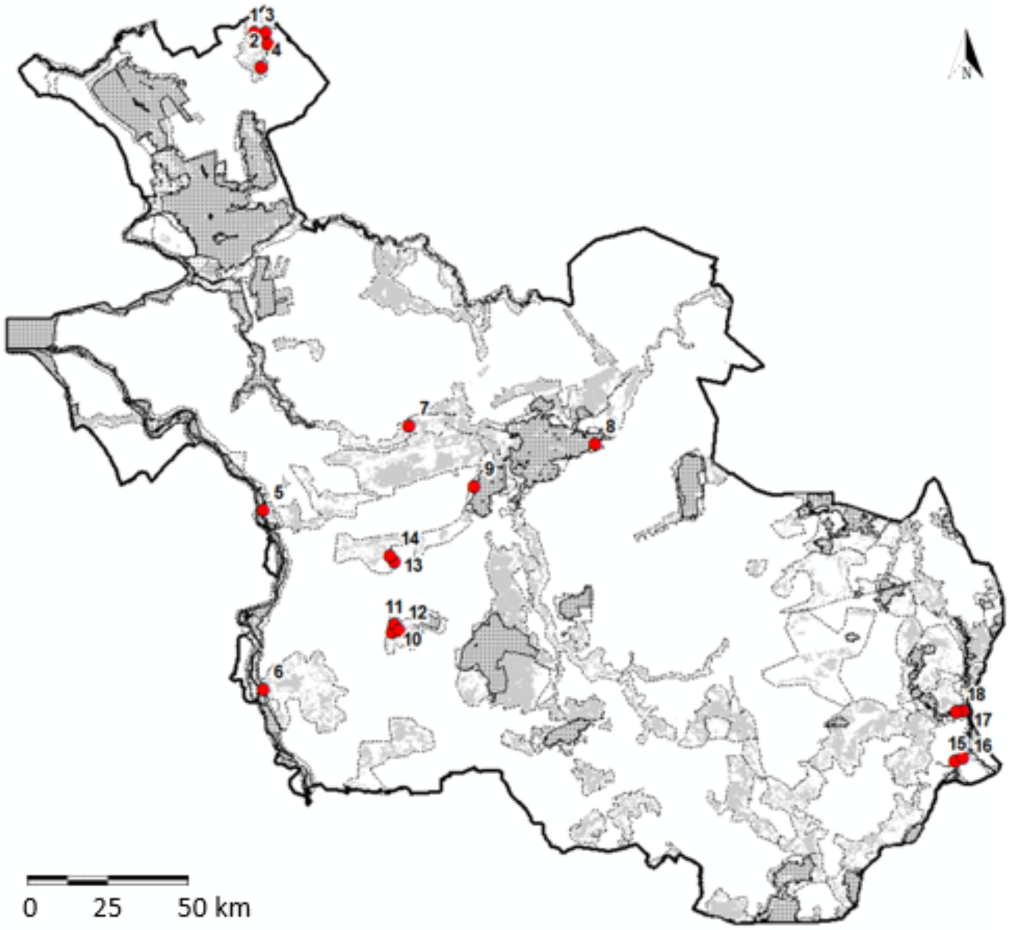

Figure 2: Map showing the eighteen locations within the province of Overijssel for which Landscape Ecological System Analyses have been conducted.

Table 1: Overview of visited locations with location numbers referring to **Error! Reference source not found.**.

Location number	Description	**RD-Coordinates** (point within area of interest)	Appendix
1	Woldberg/Eese planted forest	204401, 538746	A.1
2	Woldberg/Eese heathland	204641, 537779	A.2
3	Woldberg/Eese moist meadow	203430, 538727	A.3
4	Woldberg/Eese grassland rich in herbs and fauna	204057, 535696	A.4
5	Floodplains IJssel forest plots	204231, 496399	B.1
6	Floodplains IJssel moist meadow	204244, 480424	B.2
7	Overijsselsche Vecht valley moist meadows	217183, 503812	C.1
8	Overijsselsche Vecht valley heathlands and oligotrophic ponds	233653, 502249	C.2
9	Overijsselsche Vecht valley moist heathland	222916, 498425	C.3
10	Salland estates suggested limestone marsh	215710, 485514	D.1
11	Salland estates Boetelerbroek	215851, 486228	D.2
12	Salland estates Schoonheten	216129, 485593	D.3
13	Salland estates moist meadow	215834, 491784	D.4
14	Salland estates boglands	215509, 492230	D.5
15	Dinkel valley moist meadow 1	265652, 474033	E.1
16	Dinkel valley moist meadow 2	266305, 474291	E.2
17	Dinkel valley wet nutrient-poor grassland	266377, 478535	E.3
18	Dinkel valley moist heathland	265908, 478456	E.4

Examination of spatial data

Prior to a field visit, the exact locations to be visited were determined on the basis of available spatial data and WWN 3.0 input and output. These locations were pinpointed in an app (Topo GPS), using the RD coordinate system (Rijks Driehoek) as used by the Dutch geographical service, so that they could be targeted directly during the field visit.

The following spatial data and WWN 3.0 input and output have been used in conducting LESAs:

- www.topotijdreis.nl: This website provides annual aerial photos from 2006 on, which can tell a lot about recent changes like deforestation or excavation of plots. Annual topographic maps dating back to 1815 are also available, providing insight to historic land use and conditions.
- Google Maps: Another source for recent aerial photographs, sometimes clearer than Topotijdreis. Street view pictures can also be of added value.
- LGN (Landelijk Grondgebruiksbestand Nederland, available at www.wur.nl): Maps providing information on (recent) land use (e.g., natural grassland, deciduous forest). Information from LGN6 (years 2007/2008, used by WWN 3.0) and LGN2020 (year 2020, most recent version) have been studied.
- BRO soil map (Basis Registratie Ondergrond, available at www.pdok.nl): The BRO soil map (called Dutch soil map from now on) provides information on soil types up to 1,20 meters below ground level at a 1:50.000 scale and is used as input for WWN 3.0. It is useful to compare this data with soil profiles made during field visits.
- AHN (Actueel Hoogtebestand Nederland, available at www.ahn.nl): Digital map providing information on ground level and height differences (if wanted, height profiles along transects can be shown). In this study, AHN-3 has been used (when not available, AHN-2).
- Groundwater monitoring data (available at www.dinoloket.nl): (Historic) data from groundwater monitoring wells, used to compare with data from field visits when there was recent data on wells close to the plot in question.
- Hydrological data from MIPWA 3.0 (input, provided by Witteveen+Bos) has been compared with measurements conducted during field visits.
- WWN 3.0 results in the form of ecotope groups with highest probability (vegetation map) have been compared with data from field visits as well.
- In some cases, Witteveen+Bos and/or Ecogroen provided supplemental (spatial) data for specific plots.

Example

A short example of examination of spatial data prior to a field visit is shown below (part of LESA). **Error! Reference source not found.** shows that WWN 3.0 predicted a combination of K68, K62 and K61, while the current nature management type is N12.02:

- K68: Pioneer vegetation, grasslands and shrublands on dry, moderately nutrient-rich soils (undergrowth in heavily fertilised fields, ruderal vegetation along rivers).
- K62: Pioneer vegetation and grassland on dry, nutrient-poor, slightly acidic soils (dry heathland and grey hair-grass grasslands).
- K61: Pioneer vegetation and grassland on dry, nutrient-poor, acidic soils (dry heathland).
- N12.02: Grasslands rich in herbs and fauna.

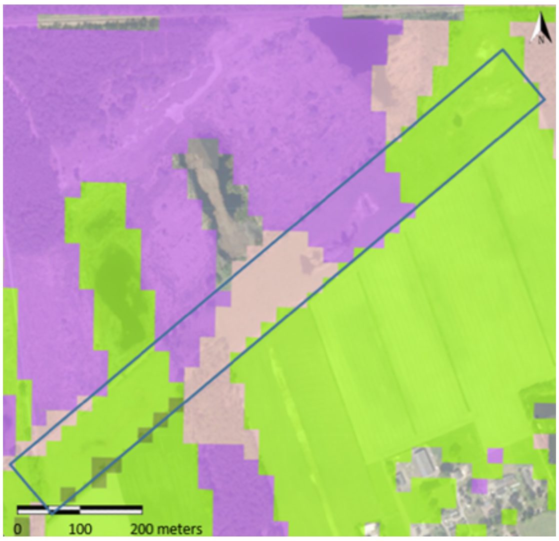

Figure 3: WWN 3.0 results of ecotope groups with highest probability. Light green = K68, dark green = K48, purple = K61, beige = K62. For legend and full descriptions of ecotope groups, see Appendices G and J. Area within rectangle.

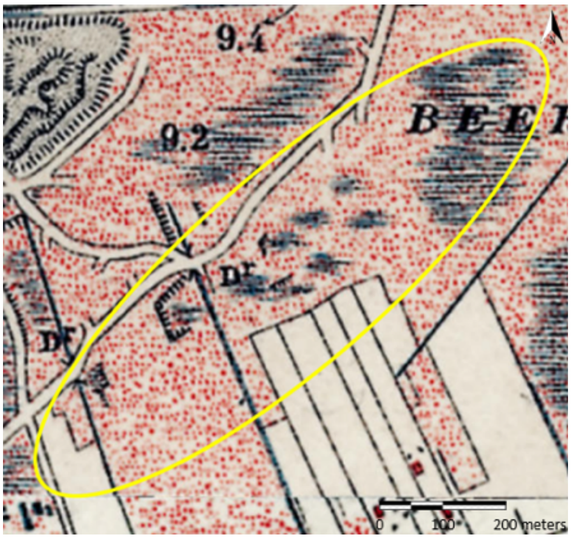

Figure 4: Map from Topotijdreis 1914, where the area (within yellow oval) was wet and part of the Beerzerveen (veen = bog).

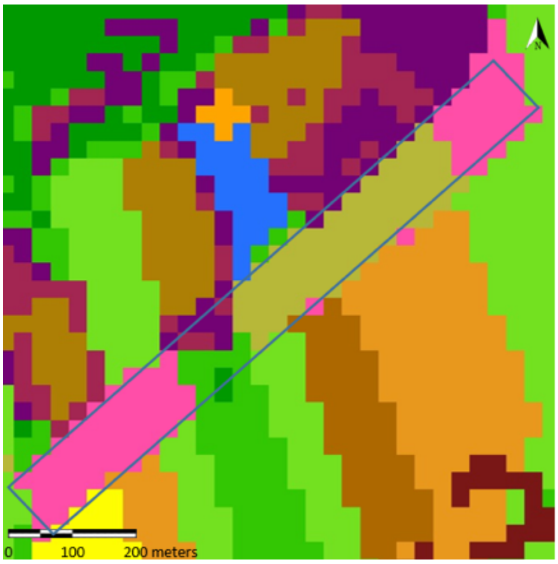

Figure 5: According to LGN6 partly natural grasslands (beige) and partly other crops (pink). For full legend, see Appendix J. Small part with green and red/purple not of interest.

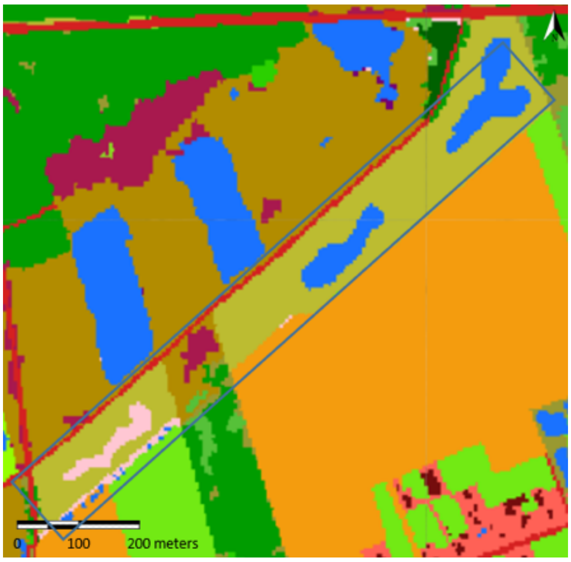

Figure 6: According to LGN2020 natural grasslands (beige), fresh water (blue) and other swamp vegetation (light pink). For full legend, see Appendix J (brown/red not of interest).

WWN 3.0 predicts that part of the plot (K62 and K61) has the potential to become dry heathland (translates to nature management type N07.01), which has a higher nature value than the current N12.02. When looking at historical data (Figure 4), it can be seen that the area was wet and part of a bog in 1914. LGN6 (Figure 5) and LGN2020 (Figure 6) contradict each other as well. While LGN6 shows that the plot consists of natural grassland and cropland, LGN2020 states that presence of natural grassland with freshwater surfaces and some swamp vegetation. Height data from AHN (Figure 7a) and an aerial photo from Topotijdreis 2020 (Figure 7b) are more in line with LGN2020, although the freshwater surfaces seem to be mostly absent. Other types of spatial data that will be examined include MIPWA 3.0 data (GLG, GVG, GHG, GG, seepage flux), soil types, groundwater monitoring data (when available), height profiles and aerial photos from the past.

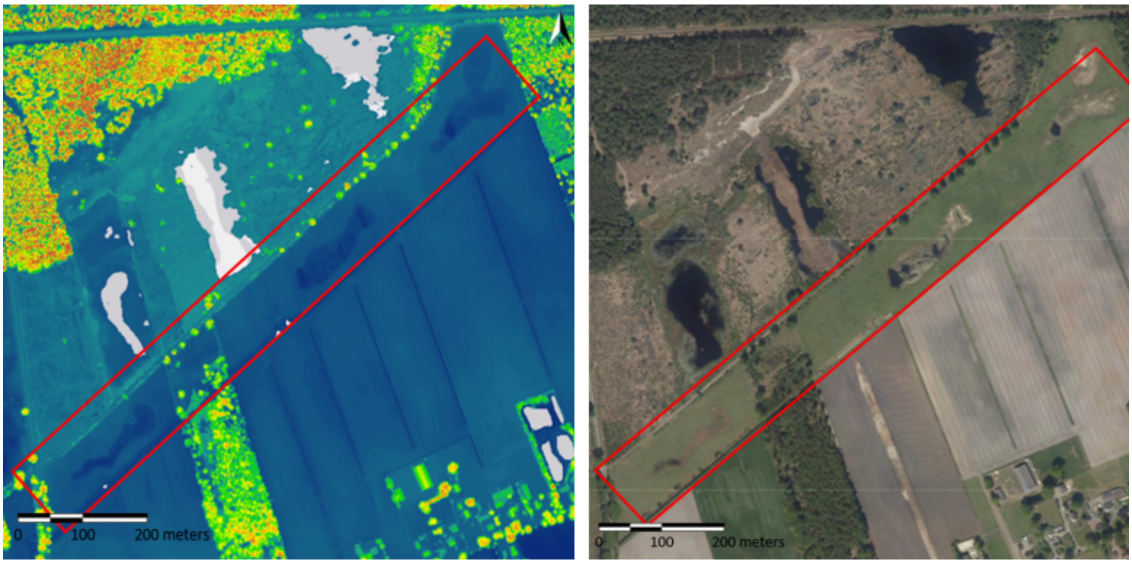

Figure 7: a) Height data from AHN, showing low-lying parts. b) Aerial photo from Topotijdreis 2020.

Given the inconsistencies of the above data and to further perform the LESA, a field visit should be conducted to answer outstanding questions such as: What could measurements on the acidity of soil and groundwater reveal? What is the actual situation regarding drainage and land use of this plot? Can certain plant species be identified in the field that indicate promising site conditions? Are the predicted ecotope groups likely to develop given the circumstances? By answering those questions, the LESA could be completed and both input and results from WWN 3.0 were checked at the same time.

3.1.2 Fieldwork

Activities in the field

Fieldwork consisted of both visual inspections and taking various measurements and took place between October 15th, 2021 and December 3rd, 2021. For example, a visual inspection could consist of determining/verifying an ecotope group or determining if certain flora were present. Information about ecotope groups (Appendix G) has been used for characterisation in the field. Besides determining what ecotope groups were present, the subsurface has also been examined by making soil profiles. For certain areas, borehole measurements were conducted with an auger and hydrological characteristics of the soil were determined. In addition, direct measurements of the groundwater level were conducted as well as measurements on the acidity of soil and groundwater.

Use of equipment

An auger (Figure 8) has been used to make boreholes and create soil profiles by placing extracted soil in order. The profiles were described and documented (including pictures). Groundwater levels were measured manually by means of a plopper ('dompelklokje', Figure 9), which makes a plopping sound when it hits the groundwater table in a borehole after which the depth can be read from the measuring tape attached. The pH of soils and surface water was determined with pH paper (Figure 9) and purified water. Also, all exact locations were recorded using the app Topo GPS. For visual inspection own knowledge and reference work in the form documents (on vegetation types and soils) and the app ObsIdentify (which identifies flora, assessed by an expert as well) have been used.

Figure 8: Soil profile with the topsoil on the left. Measuring tape and auger have been used as reference for depth.

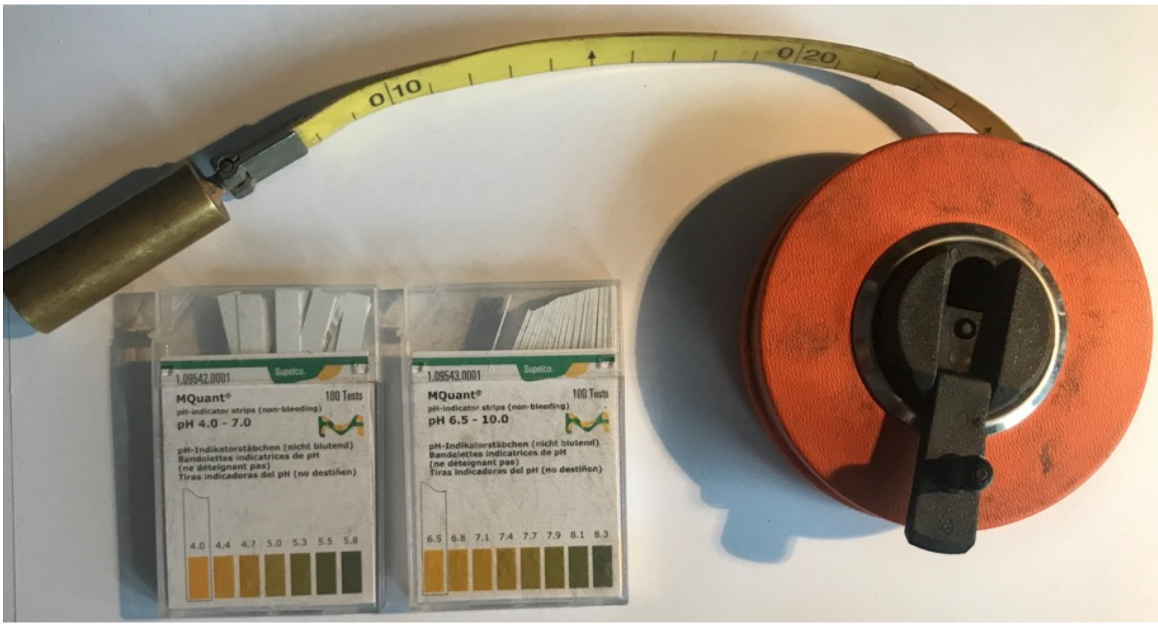

Figure 9: Plopper with measuring tape and pH paper, both used in the field.

3.2 How to use the data to answer research questions

Results fieldwork

Each of the eighteen locations has thus been assessed in detail separately. This has been done by conducting LESAs in order to get a more complete understanding of each location, which resulted in gathering the required data to answer the research questions. As this has resulted in over a hundred pages with (repetitive) text and figures, the worked out details on each field visit are enclosed in Appendices A-E. Main findings per location are presented in the main text in chapter 4.

Comparing results from the field visits with both WWN 3.0 input and results formed the basis for answering the sub-questions. Figure 10 shows the flow diagram on how this process took place.

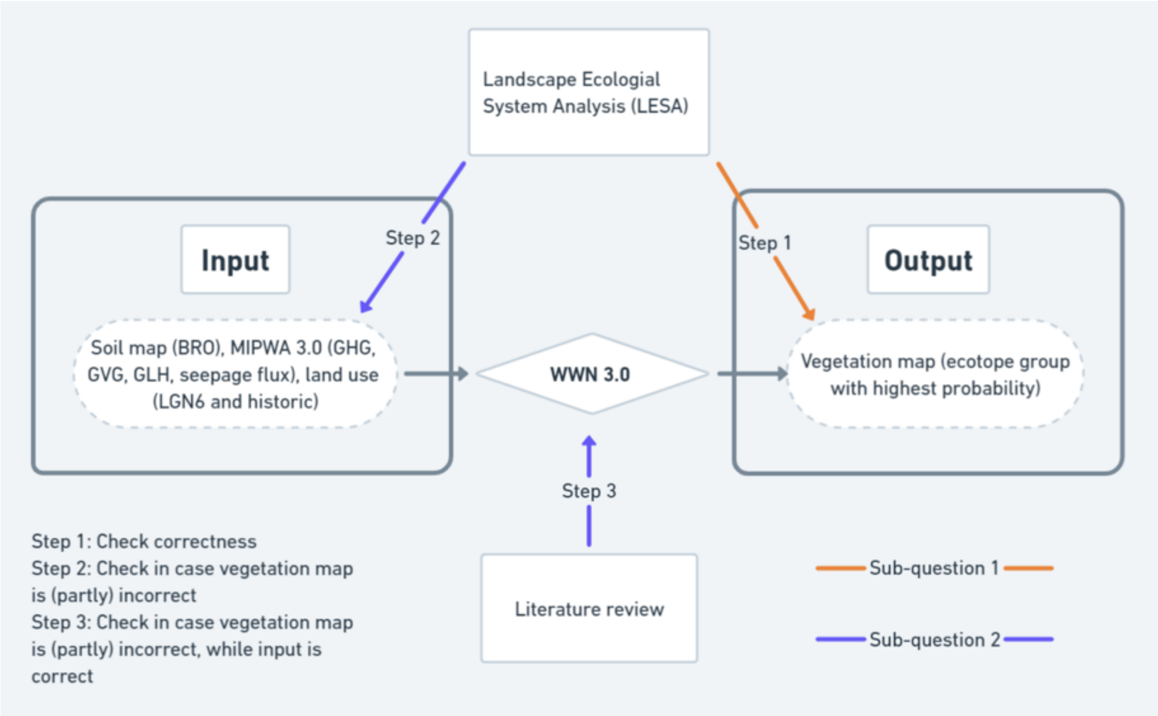

Figure 10: Flow diagram on how the sub-questions have been answered:

1 How do results from the Waterwijzer Natuur 3.0 compare to data collected during field visits?

2 If the Waterwijzer Natuur 3.0 result prove to be (partly) incorrect, what is causing this?

Answering the first sub-question

Answering the first sub-question has been approached by comparing results from WWN 3.0 with data obtained by means of LESAs (step 1 in Figure 10). Regarding the results of WWN 3.0, the vegetation map was used to compare, because it was assumed that it is easier to check in the field than the nature value map. Also, the consortium primarily wants to use the vegetation map in developing the ambition map. By comparing the descriptions of a suitable soil for the predicted ecotope groups (Appendix G) with measured data from the field (moisture conditions, nutrient-richness and pH of the soil), an estimate was made of the likelihood that the predicted ecotope group can be realised without major interventions. A three-part classification has been chosen, namely correct (+), partially correct (+/-) and incorrect (-). When all data from the field corresponded with the description of a suitable soil for the predicted ecotope group, a prediction was considered correct. In case one factor deviated slightly to moderately the prediction was considered to be partly correct and in case several factors deviated or one factor deviated considerably, the prediction was considered to be incorrect.

Answering the second sub-question

If the vegetation map would turn out to be completely correct, answering sub-question two would not be necessary. However, since a model is always an approximation of reality and WWN is also new, it was expected that the output of WWN 3.0 would not be completely correct. In that case, the second question would be answered by first comparing the input of WWN 3.0 that could be checked in the field (soil types, GLG, GHG, GVG, seepage flux and land use) with data from these field visits (soil profiles, groundwater table, land use) (step 2 in Figure 10). If these inputs were found to be correct and incorrect outputs were nevertheless generated, processes in the model itself would be examined by means of literature research (step 3 in Figure 10). If the input turned out not to be completely correct, the processes in the model would not be examined in depth, because in order to assess the correctness of the processing of the input, the input has to be correct.

In assessing the correctness of WWN 3.0 input, the same three-part classification of the first sub-question was used (+, +/- and -) and it was determined in a comparable way which of the three classifications was given.

After the sub-questions had been answered separately, a conclusion could be drawn regarding the main research question: 'How should the ecohydrological model Waterwijzer Natuur 3.0 be used in the development process of a detailed ambition map for the Nature Network Netherlands project within the Province of Overijssel?

3.3 Ethics

Most fieldwork sites are owned by land management organizations (TBOs) or private owners and receive subsidies from the Province of Overijssel. This gives the province the right to conduct inspections, which can also include this fieldwork. However, when a plot very clearly belonged to a specific house, the owner(s) were informed on the spot to avoid disagreements.

After a field visit, boreholes have been filled up in order to leave the site tidy and not to pose any danger to wild animals or cattle that could otherwise break their legs in a borehole.

4 RESULTS

In this chapter, all results are presented in a logical order so that the sub-questions can be answered, by following the methods described in section 3.2.

4.1 Assessment of by WWN 3.0 predicted ecotope groups

This paragraph has as goal to answer the first sub-question: 'How do results from the Waterwijzer Natuur 3.0 compare to data collected during field visits?' This has been done by comparing descriptions of suitable soils for by WWN 3.0 predicted ecotope groups with field data regarding the moisture conditions, nutrient-richness and acidity of the soil (see paragraph 3.2 for further elaboration). The results have been summarized in Table 2Table . For each ecotope group, a brief description has been given in the table, full description can be found in Appendix G. The worked out versions of each LESA can be found in the appendices to which is referred in the first column of Table 2.

Table 2: Overview of the assessment of WWN 3.0's predictions in terms of ecotope groups. Green (+) means that the predicted ecotope group was interpreted as being correct, orange (+/-) as being partly correct and red (-) as being incorrect.

Loca-tion	Predicted eco-tope group(s)	Keywords of ecotope group description	Landscape Ecological System Analysis (LESA)
1 (A.1)	K68	Moderately nutrient-rich, dry soil.	The soil was indeed dry and moderately nutrient-rich, so K68 should be possible to realize and is therefore correct.
2 (A.2)	K68	Moderately nutrient-rich, dry soil.	Correct in that soil was dry, but part of the plot had nutrient-poor soil due to excavation, other part of the plot indeed moderately nutrient-rich. Therefore, K68 was partly correct.
3 (A.3)	K61	Acidic, nutrient-poor, dry soil.	The soil was very wet and moderately nutrient-rich, resulting in K61 being incorrect.
4 (A.4)	K68, K62	Moderately nutrient-rich, dry soil --- slightly acidic, nutrient-poor, dry soil.	The soil was dry and mostly moderately nutrient-rich, resulting in K68 being correct and K62 being partly correct, which results in the overall prediction being partly correct.
5 (B.1)	H22, H27	Wet, respectively nutrient-poor soil --- wet, slightly acidic, moderately nutrient-rich soil.	The part with H27 was correct, while the part with H22 was rather moderately nutrient-rich and therefore partly correct, which results in the overall prediction being partly correct.
6 (B.2)	K42	Moderately nutrient rich, weakly acidic, moist soil.	Overall, the soil is indeed moderately nutrient-rich, weakly acidic and moist. Only some slight deviations at some places, but too minor for K42 not being correct.
7 (C.1)	K22, K41, K42	Wet, nutrient-poor, slightly acidic soil --- moist, nutrient-poor, acidic soil --- moderately nutrient rich, weakly acidic, moist soil.	The different predictions are spread over eight different plots. These plots are nearly everywhere moist to wet, all (slightly) acidic and between nutrient-poor and moderately nutrient-rich. Although there were some slight deviations and the distribution was not perfect, the general predictions are considered to be correct.
8 (C.2)	K61, K62, K68	Dry, nutrient-poor, acidic soil --- slightly acidic, nutrient-poor, dry soil --- moderately nutrient-rich, dry soil.	Part of the plot was excavated and moist to wet, so for those parts the prediction was incorrect. For the unexcavated parts, K68 was correct, but K61 and K62 were not as the soil was too nutrient-rich. So, overall, the predictions were incorrect.
9 (C.3)	K68	Moderately nutrient-rich, dry soil.	The soil was dry, but due to excavations nutrient-poor, so the prediction is only partly correct.
10 (D.1)	K48	Moist, very nutrient-rich soil.	For one plot, K48 is correct. A second plot was excavated and now is nutrient-poor and wet, so K48 is incorrect there. Since half of the area is incorrect, the overall prediction is considered incorrect as well.

11 (D.2)	H47	Moist, moderately nutrient-rich soil.	The soil was indeed moist and moderately nutrient-rich, so the prediction was correct.
12 (D.3)	H47	Moist, moderately nutrient-rich soil.	No soil profiles were made and no groundwater table measurements were done, so the prediction could not be verified.
13 (D.4)	K28	Wet, very nutrient-rich soil.	The soil was indeed wet, but due to excavation only moderately nutrient-rich, resulting in K28 being only partly correct.
14 (D.5)	K28	Wet, very nutrient-rich soil.	The soil was indeed wet, but due to excavation rather moderately nutrient-rich to moderately nutrient-poor, resulting in K28 being only partly correct.
15 (E.1)	K21, K22, K42	Wet, nutrient-poor, acidic soil --- wet, nutrient-poor, slightly acidic soil --- moderately nutrient rich, weakly acidic, moist soil.	The soil was very dry and also very nutrient-rich, so K21, K22 and K42 all were very wrong predictions.
16 (E.2)	K48	Moist, very nutrient-rich soil.	The soil was very nutrient-rich, but rather dry than moist, resulting in K48 being only partly correct.
17 (E.3)	K22	Wet, nutrient-poor, slightly acidic soil.	Indeed wet, nutrient-poor soil. The pH was slightly alkaline, but since the difference is minor, K22 was considered correct.
18 (E.4)	K41	Moist, nutrient-poor, acidic soil	The soil was dry and nutrient-rich, so K41 was a wrong prediction.

Conclusion

From Table 2 becomes clear that in only five out of eighteen (excluding location 12) locations, the predicted ecotope group was likely to be realized, based on the characteristics of the soil. In seven out of seventeen locations, the predicted ecotope groups were only partly correct and therefore less likely to be realized, and in five out of seventeen locations the predictions were so incorrect that the predicted ecotope groups were unlikely to be realized, when no major interventions in the landscape were to be performed. Since the predictions cannot be considered good, the answer to the first sub-question: 'How do results from the Waterwijzer Natuur 3.0 compare to data collected during field visits?', has been answered as follows:

The results from WWN 3.0 in the form of ecotope groups most likely to be realized, do not compare well to data collected during field visits in most cases. The results therefore are considered to be insufficient.

4.2 Assessment of WWN 3.0 input

The goal of this paragraph is to answer the second sub-question: 'If the Waterwijzer Natuur 3.0 result prove to be (partly) incorrect, what is causing this?' This has been done by comparing WWN 3.0 input (soil types, GLG, GHG, GVG, seepage flux and land use) with data from field visits (soil profiles, groundwater table, land use) (see paragraph 3.2 for further elaboration). To this end, first data from LGN have been compared with the land use encountered in the field. After that, the Dutch soil map has been compared with soil types encountered during field visits. Third, MIPWA 3.0 data (GLG, GHG, GVG and seepage flux) have been compared with data on groundwater tables and seepage flux measured during field visits. The results have respectively been summarized in Tables 3-5 and some examples of the assessments are given in Box 1-3.

LGN (land use) assessment

For MIPWA 3.0, LGN6 is used as input for defining the land use of a plot. To check the correctness of the input, a comparison was made with both aerial photos and/or maps and with the land use encountered during field visits. The results are summarized in Table 3 which is thus a check whether LGN6 provides correct input on land use. Simultaneously, LGN2020 has been checked since all data to compare it to, had been gathered already, making it an easy comparison. Although it was not needed for answering the research question, it was considered to give some insight into whether better input data was around, which could feed the discussion chapter.

Table 3: Overview of comparison of LGN6 and LGN2020 with land use encountered during field visits. Green (+) means that LGN was interpreted as being correct, orange (+/-) as being partly correct and red as being incorrect (-).

Location	Aerial photo / maps	LESA	LGN6	LGN2020
1 (A.1)	Planted forest	Production forest	-	+/-
2 (A.2)	Shrubland and grassed heath-land	Shrubland and grassed heathland	-	+
3 (A.3)	Grassland	Natural grassland	+	+
4 (A.4)	Agricultural fields	Grains and a strip of natural grass-land	-	+
5 (B.1)	Forest	Deciduous forest, partly harvested	+	+/-
6 (B.2)	Natural grassland	Natural grassland	+	+
7 (C.1)	Mostly grass and Juncus sp.	Natural grasslands with Juncus sp.	+/-	+
8 (C.2)	Natural grassland with wet parts	Natural grasslands with wet parts	-	+
9 (C.3)	Excavated plots	Excavated, barren plots	-	-
10 (D.1)	Natural grassland	Natural grassland	-	+
11 (D.2)	Forest/shrubland/heathland	Forest/shrubland	+/-	+/-
12 (D.3)	Forest and grasslands	Production forest, grasslands and reed beds.	-	-
13 (D.4)	Natural grassland	Natural grassland	+/-	+
14 (D.5)	Mown reed beds	(Partly) mown reed beds	-	+
15 (E.1)	Natural grassland	Natural grassland with Juncus sp.	+	+
16 (E.2)	Natural grassland	Natural grassland	+/-	+
17 (E.3)	Natural grassland	Natural grassland with Juncus sp.	+	+
18 (E.4)	Natural grassland	Natural grassland	+	+

From Table 3 immediately became clear that LGN2020 generally scores better than LGN6, with correct data for thirteen out of eighteen areas compared to six out of eighteen. This was mainly because LGN6 is often outdated, whereas in 2007/2008 it was mostly correct. The fact that data can become outdated very quickly is especially evident at location 5, where even LGN2020 is no longer correct. Also, LGN2020 is sensitive to misidentification of forest types and that more detail is counterproductive in some cases. More information can be found in Box 1 below. The legends for LGN6 and LGN2020 can be found in Appendix J.

***Box 1**: Examples of LGN assessment from Table .*

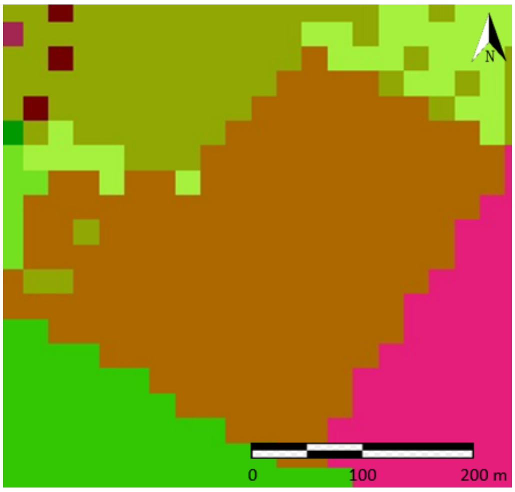

Figure 1: According to LGN6, the plot of location 2 was a potato field (dark brown).

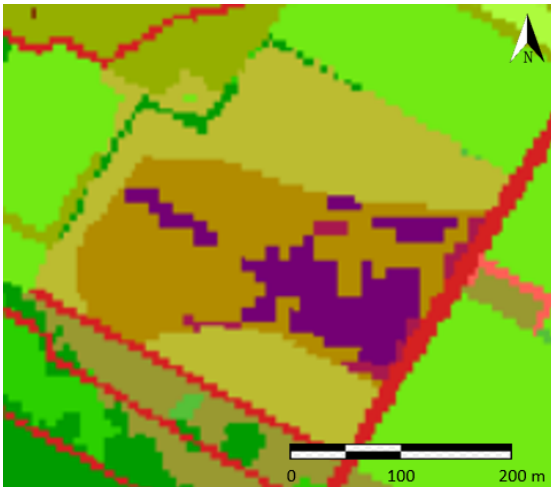

Figure 2: According to LGN2020, the plot of location 2 contained heathland (purple), heavily grassed heathland (brown), natural grassland (golden yellow along the edges of the plot) and some moderately grassed heathland (purple/red patches).

Box 1 continued.

Figure 3: Aerial photos from Topotijdreis for 2007, 2009 and 2020 of location 2.

Figure 4: (Partly grassed) heathland at centre of the plot of the plot at location 2.

Figure 5: Shrubland along the edges of the plot of location 2.

Figure 1 and Figure 2 show that LGN6 and LGN2020 indicated very different types of land use. A field visit showed that the plot consisted partly of (grassed) heathland (Figure 4) and partly of shrubland (Figure 5), resulting in LGN6 being incorrect and LGN2020 being correct. When taking a look at aerial photos from different years (Figure 3) however, it became clear that LGN6 was correct in 2007/2008 (the years on which it is based), but that LGN6 just is outdated. The same principle applied for location 14, where LGN6 (Figure 6) indicated agricultural grass while LGN2020 (Figure 7) indicated a swamp vegetation. From Topotijdreis (Figure 8) it became clear that while LGN2020 is correct nowadays, LGN6 was indeed correct before 2007. Other places where this applies included locations 1, 8, 10 and 16.

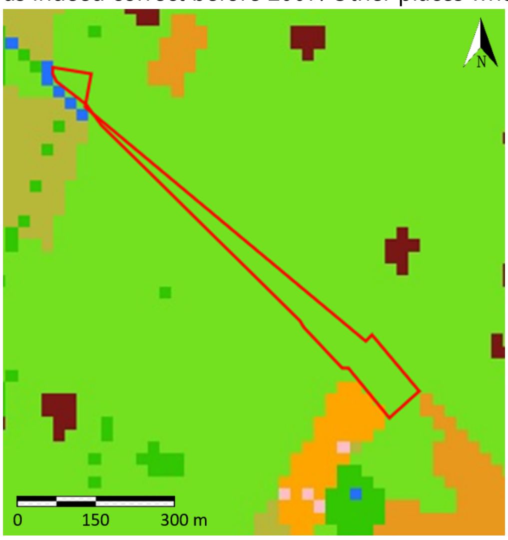

Figure 6: LGN6 indicates that the plot at location 14 consisted of agricultural grass (outlined in red).

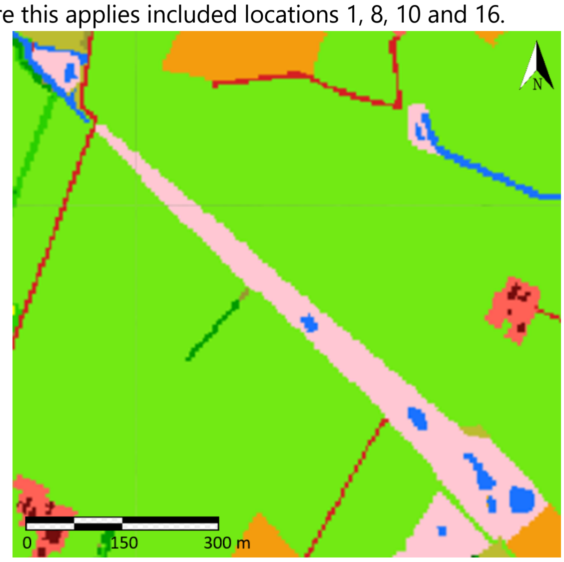

Figure 7: According to LGN2020, the plot of location 14 consisted of 'other swamp vegetation' (pink) and some freshwater surfaces (blue).

Box 1 continued.

Figure 8: Aerial photos for different years from Topotijdreis for location 14.

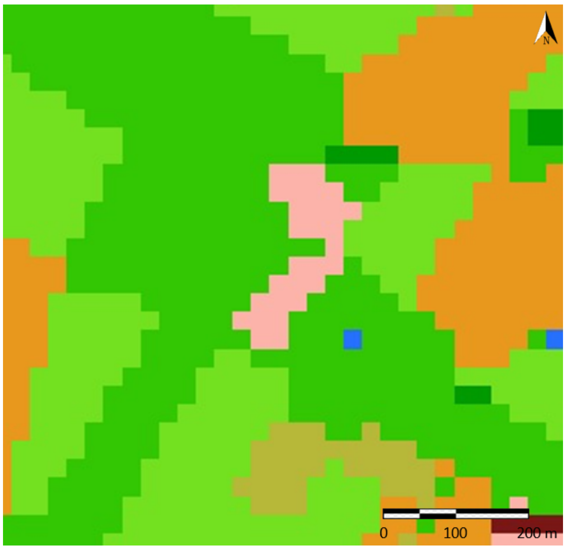

Figure 9: For location 12, LGN6 indicated deciduous forest (medium green) and natural grassland (beige).

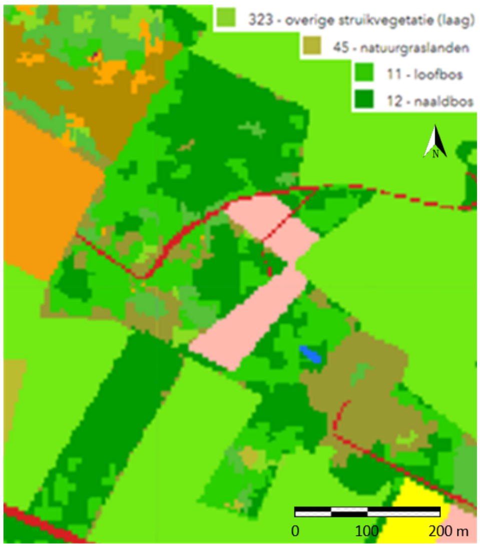

Figure 10: For location 12, LGN2020 indicated that the plots consist mostly of deciduous forest (11) and coniferous forest (12), but also some natural grasslands (45) and other shrubbery (low, 323).

For location 12, LGN6 (Figure 9) proved to correct back in 2008 (Figure 11) but is outdated as multiple plots have been felled since. LGN2020 (Figure 10) was more detailed and also correctly showed grassland and shrubbery on felled plots, but indicated that most of the forest now is coniferous forest, which during a field visit was proven to be incorrect. LGN2020 struggled at all locations with forest (1, 5, 11, 12) to correctly indicate whether a forest is coniferous or deciduous. This emphasises that more detail does not mean progress in all cases.

A field visit to location 5 once more showed that LGN data can get outdated quickly. LGN2020 indicated a mix of coniferous and deciduous forest, but during the field visit the plot was barren. With Google Maps street view could be seen this only happened back in spring or summer of 2021 (Figure 12). As the plot in question was only very small, LGN6 actually missed it and indicated natural grassland, what coincidentally resulted in LGN6 being correct, while LGN2020 was not. Also, as already mentioned, LGN2020 wrongly indicated the presence of coniferous forest while LGN6 indicated deciduous forest. This results in this being the only case where LGN6 was closer to reality than LGN2020, mostly due to LGN2020 being more detailed.

Box 1 continued.

Figure 11: Aerial photos for location 12 from Topotijdreis.

Figure 12: Photo from Google Maps street view taken in June 2021 at location 5 (Google Maps, 2022).

Dutch soil map assessment

For MIPWA 3.0, Dutch soil map data is input for defining the soil type of a plot. To check the correctness of this input, a comparison was made to the soil profiles sampled during field visits. The results are summarized in table 4, which is thus a check whether the soil map used as input for WWN 3.0 is correct. In Table 4, brief descriptions of the soil types have been given, the full descriptions can be found in Appendix H. Furthermore, the complete results from LESAs can be found in the Appendices to which are referred in the first column of Table 4.

Table 4: Overview of the comparison between data from the field with the Dutch soil map. Green (+) means that the soil map was interpreted as being correct, orange (+/-) as being partly correct and red (-) as being incorrect.

Location	Dutch soil map	Brief description	Landscape Ecological System Analysis (LESA)
1 (A.1)	Hn23	Veldpodzolsoils	Might have been an Hn23 once, but now heavily disturbed soil with a mineralized peat layer underneath.
2 (A.2)	Hn23	Veldpodzolsoils	Upper soil excavated, only small layer (15 cm) from potato field soil still present. For the rest, the soil is indeed an Hn23.
3 (A.3)	cHn23	Laarpodzolsoils	Nearly the complete humus rich A horizon has been excavated, so no longer a cHn23.
4 (A.4)	Hn21	Veldpodzolsoils	Although a clear veldpodzolsoil was recognizable, the thick enriched topsoil results in the soil not completely being an Hn21 anymore.
5 (B.1)	AM, Rn45A, Rn95A	Mengelsoils, Calcareous poldervaagsoils (2x)	The AM mengelsoils were incorrect, as the soil was no mix of sand and clay. The Rn95A was also incorrect, while the Rn45A could not be checked.
6 (B.2)	Zb21	Vorstvaagsoils	The soil was indeed a Zb21, but with a lot of coarse sand where the standard is fine sand. The topsoil is also quite nutrient-rich for a Zb21, but falls within the limits.
7 (C.1)	fZn21, fZn23, Zb21	Vlakvaagsoils (2x), vorstvaagsoils	Most of the plots indeed consisted of vorst- or vlakvaagsoils, but the sand was often coarse, likely due to the areas being old stream beds. One plot was neither a vorst- nor vlakvaagsoil. Also, most plots had a nutrient-rich top layer of 5-15 cm due to former cultivation.
8 (C.2)	Hn21, AS, zWp	Veldpodzolsoils, Stuifzandsoils, wetland podzolsoils	The soil consisted of Hn21 and zWp, but the excavated areas cannot be labelled as such anymore. Also, no AS was found, but only a small area was predicted to be so.

9 (C.3)	vWp, Hn21	Peaty podzolsoils, veldpodzolsoils	Although there was a peaty layer in one of the soil profiles, none of the soils was a vWp or Hn21 due to recent excavations.
10 (D.1)	fpZg23, vWz	Beekeerdsoils, peaty eerdsoils	The soil of the western plot indeed was an fpZg23, on the eastern plot the top layer had been removed. On the part with vWz, no soil profile was made.
11 (D.2)	fpZg23, vWz	Beekeerdsoils, peaty eerdsoils	Both soil types were indeed present, only the exact distribution was a bit different than in-dicated. The upper layer was quite enriched, but both soil types do have a nutrient-rich upper layer.
12 (D.3)	fpZg23, vWz	Beekeerdsoils, moerige eerdsoils	No soil profiles were made, but as locations 10 and 11 are very close and the Dutch soil map was (partly) correct, it can be expected it will be here as well.
13 (D.4)	fkpZg23	Beekeerdsoils	The soil indeed had an iron rich layer (f) and a clay layer (k), but is nowadays an incom-plete pZg23 due to excavation of most of the A horizon.
14 (D.5)	fkpZg23	Beekeerdsoils	The same applies here as for 13, but only this time no clay layer was found. This clay layer could have been excavated, but nonetheless the Dutch soil map is not entirely correct an-ymore.
15 (E.1)	pZg23	Beekeerdsoils	The soil indeed was a clear beekeerdsoil, but the topsoil is heavily enriched in such a way that it cannot be completely called a pZg23 anymore.
16 (E.2)	ABk	Clayey beekdalsoils	The soil indeed consisted of a nutrient-rich upper soil on a humus-poor lower soil and a clay layer was present. The nutrient-rich layer is quite thick due to former cultivation, but this can be part of an ABk.
17 (E.3)	ABk	Clayey beekdalsoils	The soil had a nutrient-rich upper clay layer on a nutrient-poor lower sandy soil, making it indeed a beekdalsoil.
18 (E.4)	Hn21	Veldpodzolsoils	Formerly a clear veldpodzolsoil, but due to the heavily enriched upper soil (A-horizon) due to former cultivation it cannot be called so anymore.

It is evident that in most cases (thirteen out of eighteen) the soil map was not (completely) correct and thus provides poor data to WWN 3.0. In many cases, the soil appeared to have been originally what the Dutch soil map indicated, but the upper layers have been excavated, resulting in the soil no longer be classifiable in that way. In many cases, the predicted soil type was still present, but over time agriculture had added such a nutrient-rich layer that the soil type could no longer be classified as such. Furthermore, there were a few lo-cations where the soil map indicated the wrong soil type in any case, or where the exact distribution of the soil types was not correct. For more details, see box 2 below.

Box 2: *Examples of the Dutch soil map assessment from Table .*

Both the soils from Figure 13 and Figure 24 came from location 8, where the Dutch soil map indicated that the soil was an Hn21 (veldpodzolsoil) or a zWp (peaty podzolsoil). The soil from Figure 133 was sampled at an unexcavated part of the plot and indeed was a zWp, whereas the soil from Figure 144 was sampled at an excavated part of the plot, which resulted in the soil not being a zWp anymore. This is a very clear example of the Dutch soil map correctly indicating the type of soil that once was present, but where excavations changed the soil significantly. This was often the case, for example at locations 3, 9, 10, 13 and 14.
Another recurring issue was the opposite, where the Dutch soil map correctly indicated the soil type but nowadays a thick enriched layer lies on top of it due to extensive cultivation, often in the past. One example was a soil profile from location 4 (Figure 155), which was indeed an Hn21 (veldpodzolsoil), but could not be labelled as such anymore due to the thick layer of very nutrient-rich soil. The same problem applied at locations 1, 7, 15 and 18.
Although most of the time human intervention resulted in the Dutch soil map not being correct, in some cases the soil type was just a different one than indicated. At location 5 for example, for one plot an Rn95A (calcareous poldervaagsoil; heavy silt and light clay) was predicted, but the soil profile (Figure 16) did not contain any calcareous matter and had a very heavy clay layer and therefore was no Rn95A. The same situation applied for a plot at location 7 and for AS soils at location 8. Also for some plots, the indicated soil types were correct, but their exact distribution was not (e.g. location 11).

Box 2 continued.

Figure 13: Soil profile from unexcavated part of location 8.

Figure 14: Soil profile from excavated part of location 8.

Figure 15: Soil profile at location 4.

Figure 16: Soil profile at location 5.

MIPWA 3.0 assessment

WWN 3.0 uses data from MIPWA 3.0 for GVG, GHG, GLG and GG (together called GxG) values and the amount of seepage flux. This data has been assessed by comparing it with groundwater table data gathered during field visits. For the GxG this has been done by making a borehole and measure the depth of the groundwater table by using a plopper ('dompelklokje'). The presence of a positive seepage flux (groundwater reaching the surface) has been looked for by looking for positive seepage flux indicators. This has been done by looking for speficic flora (in this research, Hottonia palustris, Scirpus sylvaticus and Equisetum fluviatile have been used), which thrive in circumstances where groundwater reaches the surface (positive seepage flux). Another indicator that has been used is the presence of an iron film on water in ditches and puddles, which has been carried along by groundwater reaching the surface.

Since all locations were only visited once, it was important to make an estimation of how the measured groundwater table compared to the GxG data from MIPWA 3.0. To do so, freely available precipitation data (KNMI, 2022) from two meteorological weather stations in de Province of Overijssel (Twenthe and Heino) and one close to its border (Marknesse) have been analysed to get a general idea for the province of Overijssel (Figure 19). The data is visualized in monthly precipitation graphs for the years 2018-2021 (Figures 27-29). Here it was noticeable that although 2021 was not an exceptionally wet year, the summer was relatively wet and there was a lot of precipitation in October, resulting in high groundwater levels. Since most of the fieldwork was conducted between 15 October and 12 November (only D.1-5 a few weeks later), it is likely that the groundwater levels measured were a better approximation of the GHG/GVG than the GLG. The GG could not be compared to field measurements since little can be said about an average annual groundwater table based on one measurement. Table 4 summarizes the results of this assessment and includes clarifying remarks per location. More information on the LESAs conducted per location can be found in the Appendices, to which are referred in the first column of table 5. Table

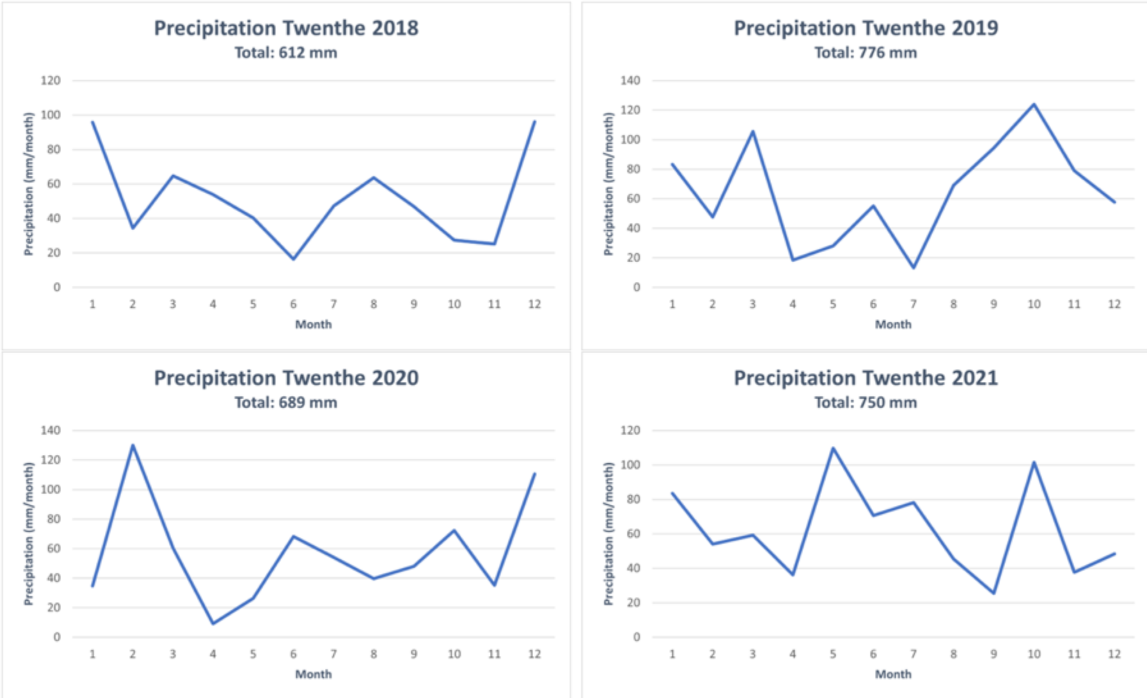

Figure 17: Precipitation data for weather station Twenthe (KNMI, 2022).

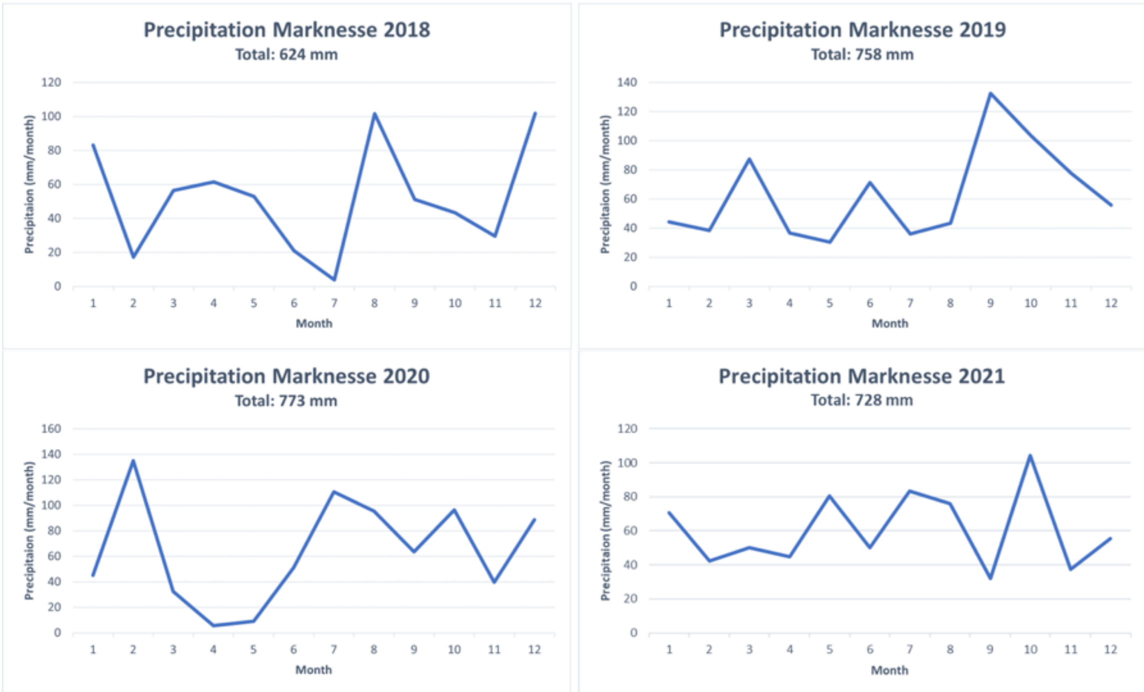

Figure 18: Precipitation data for weather station Marknesse (KNMI, 2022).

Figure 19: Overview map of Dutch meteorological weather stations (KNMI, 2009).

Table 5: Overview of the comparison between field data and MIPWA 3.0 data on groundwater levels and seepage flux. Green (+) means MIPWA data was interpreted as correct, orange (+/-) as being partly correct and red (-) as being incorrect. A negative seepage flux indicates water infiltrating into the soil, while a positive seepage flux indicates groundwater flowing to the surface.

Loca-tion	**LESA ground-water table** (cm below ground level) (date of meas-urement)	**GLG**	**GVG**	**GHG**	**Seepage flux** (MIPWA 3.0)	**Remarks**
		All in cm below ground level. The first value (range) indicates the data for the whole plot, while the value (range) between brackets indicates the data at the exact location(s) of measurement.				
1 (A.1)	> 125 (28-10-21)	250-450 (350)	150-320 (210)	110-270 (165)	Negative	No groundwater table was found within the first 125 cm, which is in line with MIPWA 3.0 data. Rust and mineralized peat layer indicate high groundwater levels in the past, up to 40 cm below ground level. Groundwater levels were too deep to confirm and therefore are assumed to be correct.
2 (A.2)	110 (28-10-21)	275-400 (350)	150-300 (220)	130-250 (190)	Negative	Groundwater table found to be only 110 cm below ground level, making GVG and GHG incorrect and therefore GLG most likely as well. Rust indicated higher groundwater lev-els in the past. No indicators of upward seeping groundwa-ter were found.
3 (A.3)	95-105 (28-10-21)	650-1030 (650-760)	600-950 (600-700)	525-920 (525-620)	Negative	Judging by the enormous differences, probably a perched groundwater table was present. No indicators of upward seeping groundwater were found.
4 (A.4)	95-(>125) (29-10-21)	130-310 (130-235)	100-300 (100-215)	95-275 (95-200)	Negative	The depth of the measured groundwater along the transect nicely followed the pattern and values from MIPWA 3.0 for the GHG and GVG. The depth of the GLG was too deep to confirm but is assumed to be correct as well. The soil type indicates high groundwater levels in the past
5 (B.1)	25-45 (4-11-21)	40-105 (45-65)	5-85 (15-50)	(-5)-75 (5-45)	Positive	The measured groundwater depths were in line with the GHG and GVG and seepage flux was indeed positive. The soil profiles showed the GLG to be plausible as well.
6 (B.2)	100-100 (4-11-21)	80-140 (80-90)	30-70 (30-40)	15-50 (15-30)	Negative	Even though the groundwater table could be expected to be close the GHG/GVG values due to a wet summer (Figure 18), it was found deeper than the indicated GLG. Also, indi-cations for slightly upward seeping groundwater were found. Rust in the soil also indicated higher groundwater levels in the past.
7 (C.1)	10-85 (8/10-11-21)	45-135 (60-120)	15-135 (25-120)	5-125 (15-110)	Negative	The groundwater tables matched well with GVG/GHG data on most plots, which can be explained by the wet summer (Figure 18), but at some plots were found to be somewhat higher than indicated. For the GLG data, the lower bound-ary values were the same as for the GVG/GHG and are therefore more plausible. Also, indications for slightly up-ward seeping groundwater were found and rust indicates that past groundwater levels were higher.
8 (C.2)	10-(>125) (12-11-21)	65-260 (170-230)	45-215 (105-175)	40-180 (85-170)	Negative	For the unexcavated parts MIPWA 3.0 data were correct, while the groundwater table at the excavated parts was much shallower than indicated, likely as a result of MIPWA 3.0 not taking into account the excavation. No indications for upward seeping groundwater were found and the soil (peat present) indicated very wet conditions in the past.
9 (C.3)	85-(>125) (11-11-21)	140-250 (180-245)	80-200 (100-200)	70-175 (100-170)	Negative	At one spot, the groundwater table was somewhat lower than expected, most likely due to the recent excavation, but for the rest MIPWA 3.0 was correct. The presence of a thin peat layer indicates a higher groundwater level in the past.

10 (D.1)	5-50 (30-11-21)	70-95 (75-85)	45-70 (45-60)	35-60 (35-50)	(Mostly) positive	For the unexcavated part, the groundwater table was in line with GVG/GHG data, while the groundwater table at the excavated part was a few decimetres higher than expected, likely due to MIPWA 3.0 not taking the excavation into account. Upward seeping groundwater was found indeed.
11 (D.2)	10-60 (29-11-21)	50-145 (70-95)	30-120 (50-70)	20-105 (35-50)	Varies	At 3 out of 4 locations the measured groundwater table corresponded very well to GHG/GVG data from MIPWA 3.0, which can be explained by the wet summer (Figure 18). At the fourth location, the groundwater table was even higher. Rusty soils indicated even higher groundwater levels in the past. The high pH of surface water and the presence of iron films and Equisetum fluviatile showed that nearly the complete plot had upward seeping groundwater.
12 (D.3)	No data (30-11-21)	50-145 (n/a)	30-125 (n/a)	20-110 (n/a)	Varies	Since no soil borings were done here, no clear statement can be made about the correctness of MIPWA 3.0. Based on the water level in ditches, GxG data seem plausible. Furthermore, the presence of iron films and Hottonia palustris indicated the presence of upward seeping groundwater, albeit mostly clustered around/in the ditches only.
13 (D.4)	0 (3-12-21)	20-45 (35)	5-35 (10)	(-5)-30 (0)	Positive	The measured groundwater tables where only very slightly higher than MIPWA 3.0 indicated for the GHG/GVG, most likely the result of excavation of the topsoil, and a strong upward seeping groundwater was indeed present.
14 (D.5)	0-0 (3-12-21)	15-80 (20-40)	0-70 (5-25)	(-5)-60 (0-20)	(Mostly) positive	Again, the groundwater table was slightly higher than MIPWA 3.0 indicated, likely due to excavation. Strong upward seeping groundwater was present, while MIPWA 3.0 indicated part of the area had infiltrating groundwater.
15 (E.1)	>125 (15-10-21)	40-80 (75)	25-60 (50)	20-50 (40)	Negative	No indicators for upward seeping groundwater were found, but the groundwater table was way deeper than MIPWA 3.0 data on GxG indicated, despite the wet summer (Figure 18). The low groundwater table is the result of the plot being drained extensively. Soil characteristics indicated high groundwater levels in the past.
16 (E.2)	>125 (15-10-21)	100-135 (100-135)	60-110 (60-110)	55-95 (55-95)	Around zero	The groundwater table was significantly lower than MIPWA 3.0 indicated for the GHG/GVG and will be even lower for the GLG, making MIPWA 3.0 incorrect. No indicators of upward seeping groundwater were found at all, so it is more likely that there is (slight) infiltration than seepage being around zero. The soil type and the presence of rust indicated higher groundwater levels in the past.
17 (E.3)	50 (15-10-21)	50-75 (55)	20-45 (20)	10-35 (10)	Varies	The high pH and the presence of Juncus acutiflorus indicate strong upwards seeping groundwater. The groundwater table was expected to be found around the GHG (and GVG) value due to the wet summer, but was somewhat lower. The GLG value seems to be correct however due to the location directly next to higher grounds, which will keep the groundwater table relatively high. Rust present in the soil indicated even higher groundwater levels in the past.
18 (E.4)	105 (15-10-21)	105-155 (130)	70-130 (85)	55-115 (75)	Negative	Although the groundwater table after a wet summer was found to be somewhat lower than indicated by MIPWA 3.0 for the GHG at the exact location of measuring, the measurement did fit into the range for the whole plot, resulting in the data still being reasonably correct. Also, no signs of upward seeping groundwater were found. The soil type and the presence of iron concretions indicated high groundwater levels in the past.

In addition to LGN6 and the Dutch soil map, the input from MIPWA 3.0 also appeared to be incorrect in many cases. This was usually due to human intervention in nature by (extensively) draining the plots or by elevating or excavating them. Also, the existence of perched groundwater tables has not been processed in MIPWA 3.0, which in one case led to incorrect data as well. Furthermore, there were also some plots where no clear causes for incorrect data were found, which means that it can be concluded that MIPWA 3.0 in some cases provides incorrect data anyway. Finally, it also appeared that data concerning seepage flux were not always correct, as strange patterns were regularly predicted, which turned out not to be correct during field visits. See Box 3 below for some examples.

Box 3*: Some examples of the assessment of MIPWA 3.0 data from Table .*

Figure 20: Deep ditch at location 15.

Figure 21: Situation at location 8.

Figure 22: Situation at location 3.

Figure 23: Iron film on water at location 14.

The most common cause of incorrect MIPWA 3.0 data was ditches draining the area, usually due to agriculture or the road network. A clear example was found at location 15 (Figure 21), where a ditch about 2 metres deep heavily drained the plot directly into the river Dinkel in favour of the road network which completely encircled the plot. Similar cases have been found at nearly all locations, in varying intensity.

Another cause was found at location 8, where MIPWA 3.0 stated that the GHG was at least 85 cm below ground level. This was true for the unexcavated parts of the plot, but Figure 21 shows the situation at an excavated part, clearly indicating wet soils with high groundwater tables. It thus seems that MIPWA 3.0 does not take excavations into account, resulting in incorrect data here. The same principle applied more often (locations 10, 13, 14), although it did not always lead to incorrect data.

A third reason likely has been encountered at location 3 (Figure 223), where MIPWA 3.0 indicated that the groundwater table always was deeper than 5 m below ground level. A field visit however showed wet/moist soils with shallow groundwater tables and clay layers, which points to a perched groundwater table. Furthermore, at all locations the possible presence of seepage was examined by looking for iron films on water (Figure 234), the pH of the soil and water and fauna that favours a positive seepage flux.

Assessments overview

Table 6 brings together all assessed inputs and outputs to try to find links between quality of inputs and outputs. To do so, the assessments of the different forms of MIPWA 3.0 input (GHG, GLG, GVG, seepage flux), were combined into a single value (+, +/- or -). It appeared that incorrect results could not be directly traced to one of the types of input being incorrect. What was striking however, was that of the four cases where no form of input was considered incorrect, there were three cases where WWN 3.o output was correct, while this only happened in five out of eighteen cases This means that when the input was (reasonably) good, the results were often correct and that incorrect input in most cases led to bad output. The model is thus very sensitive to the quality of the input.

Table 6: Overview of conducted assessment for WWN 3.0 input and output. Green (+) means that the data was interpreted as being correct, orange (+/-) as being partly correct and red (-) as being incorrect.

Location	LGN6 (input)	Dutch soil map (input)	MIPWA 3.0 (input)	WWN 3.0 ecotope group prediction (output)
1 (A.1)	-	-	+	+
2 (A.2)	-	+	-	+/-
3 (A.3)	+	-	-	-
4 (A.4)	-	+/-	+	+/-
5 (B.1)	+	-	+	+/-
6 (B.2)	+	+	-	+
7 (C.1)	+/-	+/-	+/-	+
8 (C.2)	-	+/-	+/-	-
9 (C.3)	-	-	+	+/-
10 (D.1)	-	+/-	+/-	-
11 (D.2)	+/-	+	+/-	+
12 (D.3)	-	n/a	n/a	n/a
13 (D.4)	+/-	+/-	+	+/-
14 (D.5)	-	+	+	+/-
15 (E.1)	+	+/-	-	-
16 (E.2)	+/-	+	-	+/-
17 (E.3)	+	+	+/-	+
18 (E.4)	+	+/-	+	-

Discussion and conclusion

It has become clear in this paragraph that not only the LGN6 input, but also the Dutch soil map input and MIPWA 3.0 input are often incorrect. Because of this finding, the processes in the model itself were not examined in detail, because in order to assess the correctness of the processing of the input, the input has to be correct (see section 3.2 for further clarification). Because it has now been demonstrated that the input of WWN 3.0 is in many cases incorrect, the answer to the second sub-question 'If the Waterwijzer Natuur 3.0 result prove to be (partly) incorrect, what is causing this?

The fact that the results of WWN 3.0 (in the form of predicted ecotope groups) are often incorrect, is caused by the input of WWN 3.0 (in the form of land use, soil type, GLG, GHG, GVH and seepage flux) being also often incorrect.

5 DISCUSSION

This chapter reflects on the methods used and what could be improved in a following, comparable research. Also discussed are the quality of data collected, assumptions that were made and how exact modelling results have to be. Furthermore, a short review on complex processes in modelling is given and the reliability of the results is considered. Finally, the contribution of this research is discussed and recommendations for follow-up research are made.

5.1 Reflection on methods

Uncertainties

Landscape Ecological System Analyses (LESAs), for which locations were only visited once, have been used to assess input data and predicted ecotope groups. However, most data collected (e.g., groundwater table, flora) in the field is highly dependent on circumstances such as the season, the (recent) weather or human activities such as mowing. An attempt has been made to take this into account by quantifying the effects of the circumstances during the field visit by means of both review of available spatial data and indications in the field, but this will always remain less accurate than visiting a location several times. Measurements of the groundwater level and description of soil profiles have also been carried out in 5 cm increments, but this was considered accurate enough to describe the ecohydrological situation and to assess input data and results. It should also be noted that own knowledge (mostly concerning flora and soil types) was not always sufficient, but to overcome this shortcoming, both experts (for flora, via the mobile phone app ObsIdentify) and literature have been consulted.

Assumptions have also been made, especially with regard to abiotic preconditions. In this research, BIJ12 data has been used, which provides abiotic ranges within which nature management types can flourish. In reality, however, these preconditions are strongly interrelated and there is a greater variety of factors that influence flora and thus nature management types, like temperature and light intensity (Hill et al., 1999). Nevertheless, the use of abiotic preconditions has been beneficial in this research because it provided a framework to work within and it was not feasible to assess all factors.

Furthermore, the eighteen locations visited in reality cover only a very small part of the Province of Overijssel. These locations were selected by Witteveen+Bos, which means that there were already doubts on the model performance for these eighteen areas. As a result, the image of the reliability of WWN results may be worse than it is on average, because areas where the results seemed logical have not been visited. This should be seriously considered when interpreting the results and drawing conclusions.

Method improvements

The methods could have been improved by visiting areas more often under different conditions. This way, a more complete assessment of occurring plant species or groundwater levels could have been made. Also, visiting more areas that have been randomly selected would improve the reliability of the results, as this would reduce the effect of only visiting areas where there were already doubts about the model performance.

5.2 Complex processes in modelling

Although the processes in WWN 3.0 itself were not considered when answering the research questions, some of them are discussed here in order to provide a starting point for possible follow-up research.

Geohydrology

Geohydrological processes are some of the main driving forces behind ecohydrology. These processes are generally very difficult to model and therefore often not modelled at all, or insufficiently. For example, MIPWA 3.0 does have a module to simulate perched groundwater tables, but this module is not implemented (Hunink & Borren, 2018). This shows as wet spots on ice pushed ridges, as indicated by aerial photographs and the occurrence of plant species bound to wet site conditions, are not shown in MIPWA 3.0. Therefore, these spots with perched groundwater tables cannot be taken into account by WWN 3.0, resulting in prediction of incorrect ecotope groups.

Another process that is modelled insufficiently is the ecohydrologically relevant seepage. In MIPWA 3.0, seepage is defined as the vertical flux between model layers 1 and 2 (F. Versteegen, personal communication, November 25, 2021). In reality, this vertical flux says little about seepage in the root zone, while, from an ecohydrologically perspective, this flux in the root zone is more important than the flux between model layers 1 and 2. Besides the fact that seepage flux map from MIPWA 3.0 is thus being wrongly used to determine ecohydrological relevant seepage, the influence of positive seepage flux (upward flowing groundwater) also depends on soil characteristics (Klijn & Witte, 1999), which are only partly taken into account in the form of capillary rise. Related to this, the quality of groundwater and seepage is very important as well. Although WWN 3.0 does use a seepage quality map, it turned out to be difficult to implement correctly, resulting in relationships between vegetation types and seepage remaining partly unclear (Nijp et al., 2022).

Soil characteristics

Within the WWN model, several processes related to soil characteristics have also proven to be difficult to model. For example, soil acidity is co-dependent on rainwater lenses, phosphate in the soil and oxidation and reduction, but these factors play hardly to no role at all in acidity modelling (Nijp et al., 2022). Also, the nutrient richness in WWN is based on knowledge rules and not on phosphate and nitrogen mineralisation, while this is very relevant in a nutrient-poor vegetation. Finally, various soil chemical processes are not included because the input is often incomplete, which means that complex interactions between water, soil chemistry and soil life cannot be addressed in great detail (Nijp et al., 2022).

Vegetation management and landscaping

For a number of nature management types, interventions take place in the form of sod cutting ('afplaggen'), 'uitmijnen' (planting a specific crop to, e.g., remove pollution from the soil) and mowing and discharging of vegetation to maintain desired conditions. These processes cannot be simulated by WWN 3.0, resulting in a predicted accumulation of nutrients and thus a change in nature management type (succession). Also, a process like inundation cannot be simulated.

Schematisation of the subsurface

MIPWA 3.0 makes use of the REGIS II model for schematization of aquifers and aquitards. The REGIS II model is a three-dimensional model of the layer structure of the moderately deep subsurface of the Netherlands. It is based on the interpretations of DGM borehole descriptions and layer model (Vernes et al., 2005). In REGIS II, lithostratigraphic units are further subdivided into hydrogeological units (Hummelman et al., 2019). However, as a result of dividing the subsurface into such layers, the permeability of the subsurface is too homogeneous, which negatively affects the simulation of seepage flux and groundwater quality (Van Ek et al., 2012). They suggest that the subsurface model GeoTOP, which is still in development, could lead to a better description of the hydrological processes. GeoTOP schematizes the subsurface (50 m in depth) with voxels, spatial units of 10x10.0.5 m, and has a higher resolution than REGIS II. Also, many more drill samples were used and newly interpreted, which together resulted in a much more heterogeneous description of subsurface permeability (Stafleu et al., 2020). As the model is still under development, it is not currently available for the Province of Overijssel, but it will be in the near future. It could then be a good replacement for REGIS II in MIPWA 3.0 for the upper fifty meters of the subsurface.

5.3 Reliability of results

As discussed, the results of WWN 3.0 are not a perfect reflection of reality due to errors in input data and complex processes (paragraph 5.2) that are not included in the model. These processes include the absence of perched groundwater tables in WWN 3.0 and the inability to model changes in input due to excavation, inundation, etc. However, modelling results not being perfect will always be the case because it is simply not feasible to get results to be so reliable that no form of expert verification is required and results can be implemented immediately. The developers behind WWN 3.0 also state that the model is suitable for making global statements for nature reserves and that the user should be careful not to judge the result per pixel (Nijp et al., 2022). Although the latter has been attempted to approach in this study given to the small area of some of the sites visited, the realisation that this is not the purpose of WWN 3.0 is nonetheless prevalent. This is also known within the NNN project, where the WWN 3.0 results are not taken as a basis for developing the ambition without consideration (Scholten et al., 2021). For this reason, an expert judgement is always made per location when interpreting model results and their significance. Because of this view on the use of WWN 3.0, the results of this study are considered reliable enough to answer the research questions. Confidence in the conclusions is also high because alternative explanations do not seem possible due to thorough research, or have already been refuted.

5.4 Scientific implications

Contribution of this research

This research aimed at contributing to climate mitigation and adaptation by maintaining and interconnecting natural environments, thereby increasing natures robustness. By contributing to the development of the ambition map, this goal has been achieved.

Another ambition was to contribute to ecohydrological science by assessing the usefulness of an easy to use model, which has been successful. With WWN 3.0 proving to be a useful model, the way has been cleared for it to be used in similar research in the future.

Further research

In future research, it would be very useful to focus on how complex processes (paragraph 5.2) and meta-relations can be better simulated in WWN and the modules it uses, in order to achieve better results in future versions of WWN. It would also be good to investigate whether the Waterwijzer Landbouw (Water Probe Model for Agriculture) could perhaps be better used in areas that are currently or until recently have been used as farmland, as this has not been looked at in this study. Finally, in future studies it would be good to visit field sites several times under different conditions and to not only focus on areas where model results are questionable.

6 CONCLUSION

This thesis aimed to assess what the role of the ecohydrological model Waterwijzer Natuur 3.0 should be in developing an ambition map for the Province of Overijssel. This has been done by answering the research question: 'How should the ecohydrological model Waterwijzer Natuur 3.0 be used in the development process of a detailed ambition map for the Natuurnetwerk Nederland project within the Province of Overijssel?'

This question has been answered based on assessments of WWN 3.0 input data and results, which have shown that when input was reasonably correct, WWN 3.0 output was most often correct as well. Therefore has been concluded that the Waterwijzer Natuur 3.0 can be a useful instrument in developing a detailed ambition map for the Province of Overijssel, as long as its results will be assessed by an expert before starting to formulate ambitions for nature restoration and development.

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APPENDIX A: WOLDBERG/EESE

A.1 Woldberg/Eese planted forest

The location of the investigated site is indicated by the red circle in the figure below and was visited on October 28, 2021.

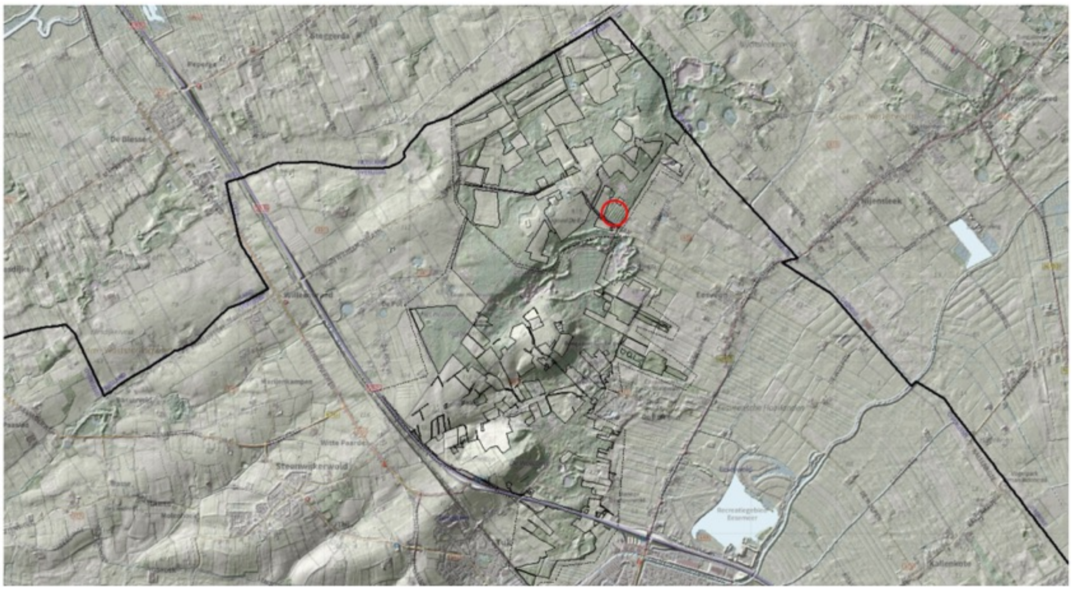


Figure A.1.0: Location 1 (see Figure 2 in paragraph 3.1)

Specific questions were stated to be investigated for this site. In preparation direct available spatial information was checked before visiting the site in the field.

Questions

1. Is there forest or grassland present on the plot? Is this in accordance with the data from LGN6 used in WWN 3.0? And what does LGN2020 indicate?
2. What is the soil profile like and is it in accordance with the Dutch soil map 1:50,000?
3. Are the predictions from WWN for the current situation correct?
4. Is the estimation of the former undisturbed hydrology likely, e.g. is the ambition feasible?

Preparation

Recent aerial photography and topographical maps where checked. Figures A.1.1 and A.1.2 support the theory that the plot currently consists of planted forest, with clear rows of trees. The height data from AHN3 (figure A.1.3) shows that the site is located in an depression in the landscape on the flank of the moraine. Locally the surface has been changed in order to promote drainage.

Figure A.1.1: Map from Topotijdreis 2020.

Figure A.1.2: Aerial photo from Topotijdreis 2020.

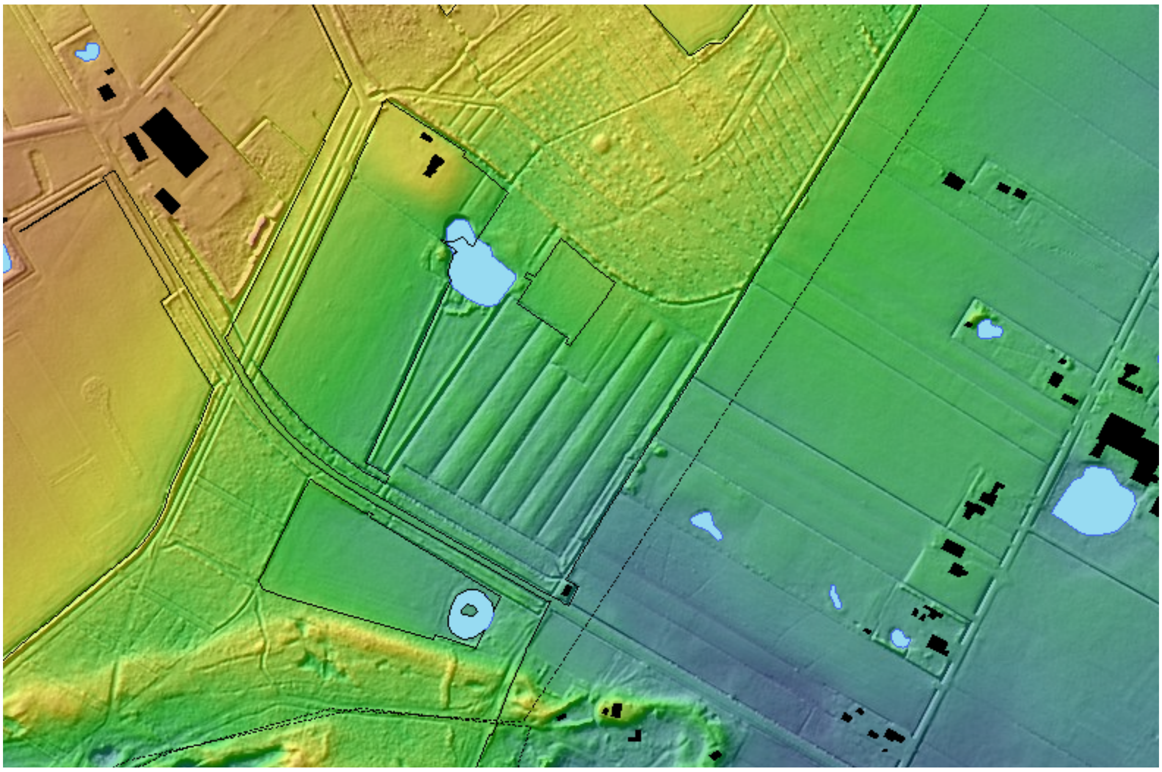


Figure A.1.3: Height data from AHN3 (orange is elevated area, blue is low lying area).

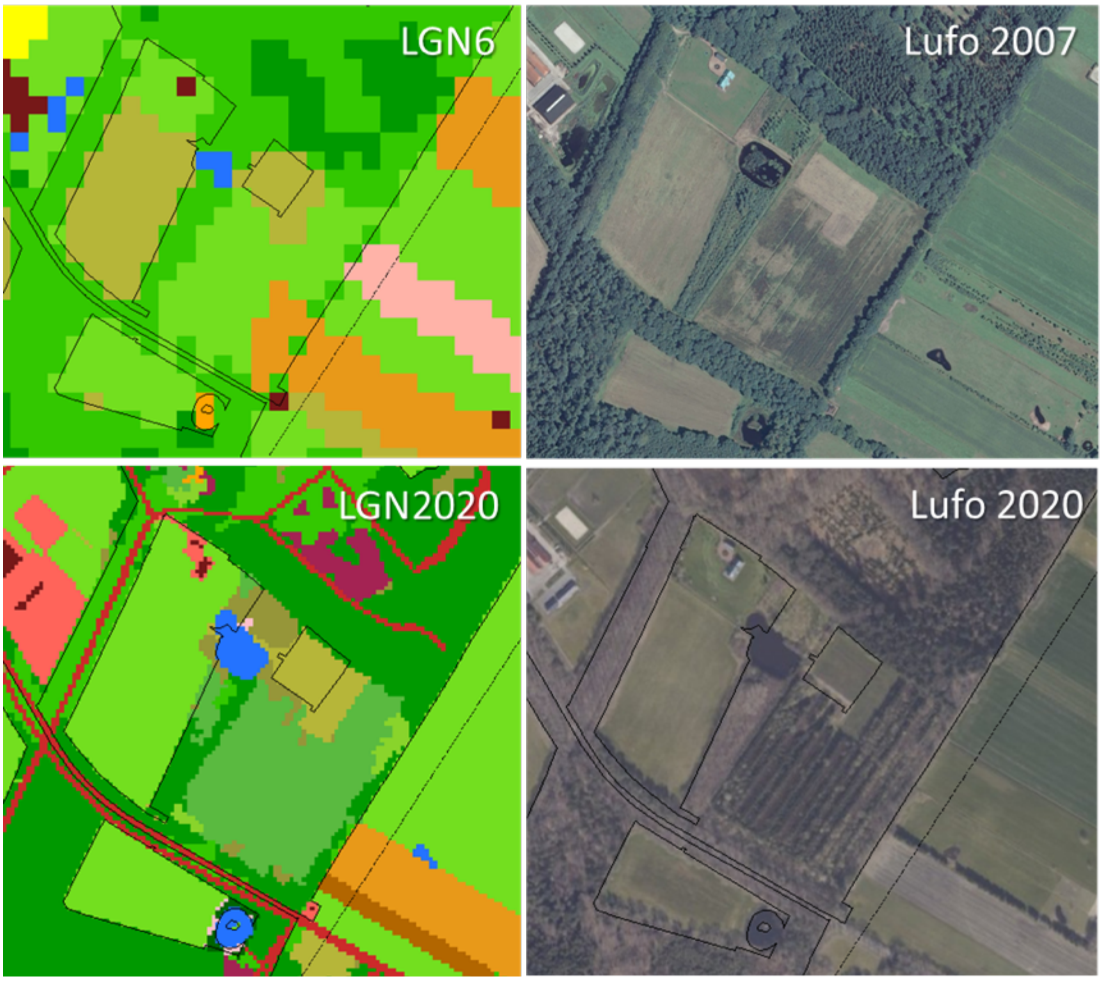


Figure A.1.4: LGN data and corresponding aerial photographs for LGN6 and LGN2020.

Figure A.1.4 shows data on LGN6 and LGN2020 with corresponding aerial photographs. In LGN6 the indicated landuse for the site is 'agricultural grass' (pixel value = 1) whereas in LGN2020 it is 'other woody vegetation - high' (pixel value = 333). The site has been planted with trees which have grown in the periode from 2007 to 2020. The LGN data seems to be mostly accurate but the LGN6 data is outdated.

The Dutch soil map 1:50,000 indicates that the soil consists of Hn23 or 'Veldpodzolsoils; loamy fine sand'. MIPWA 3.0 indicates that both the GHG and GLG are mostly > 1.25 m below ground level on the site and upward seepage is absent. Based on this input WWN 3.0 predicted K68 or 'Pioneer vegetations, grasslands and shrublands on dry, moderately nutrient-rich soils' as most likely. This mostly corresponds to N12.02 (grassland rich in herbs and fauna) and N12.06 (rougth vegetation). Application other hydrological input (undistrurbed hydrology) does not change te WWN projection.

According to DINOloket, there are no wells on or near the plot to check the output of the MIPWA model. Both the current nature management type and the nature ambition are N16.03 or 'dry production forest'. This does not correspond with LGN6 but does correspond with LGN2020. When trees are harvested it can however lead to a temporary absence of trees, so in that sense the results for LGN6 and LGN2020 are somewhat logical.

Approach

In the field observations where made on the vegetation(structure), soil type and hydrology. Several locations have been visited (see Figure A.1.5).

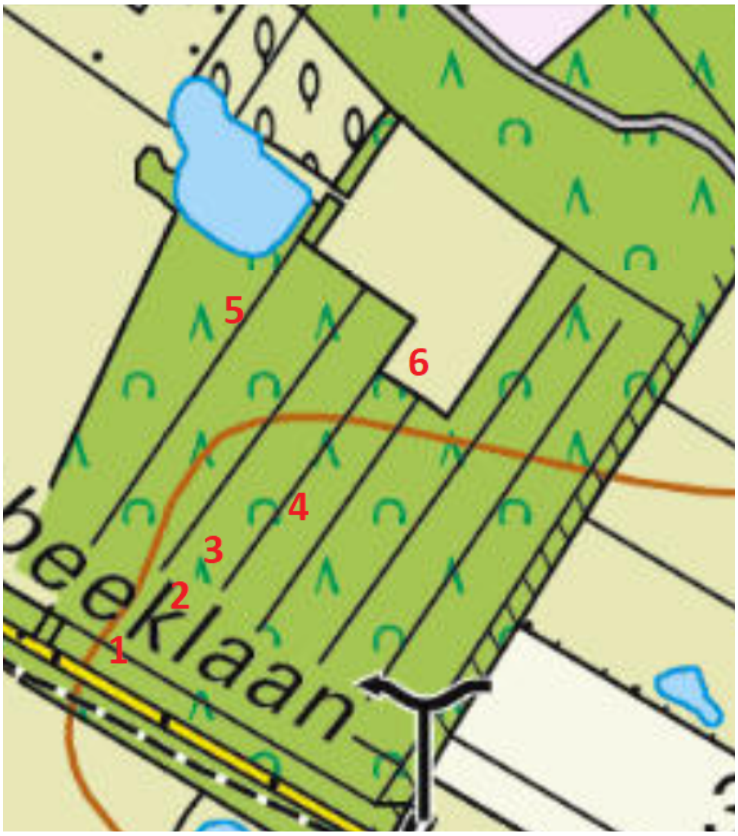


Figure A.1.5: Topographical map 2020 with in red the locations (see results).

Results

The results of the field visit is summarized in tabel A.1.1. From the locations visited photographs have been made to get an impression of the situation (Figures A.1.6-12).

Table A.1.1: Field data corresponding to the locations in Figure A.1.5.

Location (Error! Reference source not found.**5)**	**RD-coord.**	**GWT (cm)**	**PH (-)**	**Description**
1	204315, 538695	n/a	5.2 (water)	Ditch of 1.20m depth with 5 to 10 cm running water (Figure A.1.6). Large deciduous trees on the side of the road, lower deciduous trees on the other side, shrubs and plants such as *Impatiens glandulifera*.
2	204346, 538711	n/a	n/a	Dry ditch of 70 cm depth (Figure A.1.7). On the side of the road just described, on the north-east side planted forest.
3	204362, 538728	n/a	n/a	Planted forest consisting of rows of alternating conifers, deciduous trees and semi-open areas with smaller trees (Figure A.1.8). Between rows of trees also dry ditches of 50 to 80 cm deep (Figure A.1.9), which can be seen in figure A.1.5 as diagonal black lines.
4	204401, 538746	>125 cm	5.2 at 10 cm 4.9 at 110 cm	Between two rows of trees a borehole was made (Figure A.1.10) - 0-25 cm: dark, fine soil. - 25-55 cm: light-coloured, fine sand mixed with dark fine soil with some rust between 40 and 50 cm. - 55-90 cm: mineralized peat. - 90+ cm: very fine light-coloured sand.
5	204368, 538853	n/a	n/a	Damp ditch of 1.20m deep with a few cm of stagnant water (figure A.1.11) between the field with planted production forest and more open deciduous forest on the southwest side of the black line in Figure A.1.8.
6	204461, 538819	n/a	n/a	Between planted forest and field a dry ditch 60 cm deep (Figure A.1.12). On the field Ranunculus repens,

Figure A.1.6: Ditch of 1.20m deep with 5 to 10 cm running water.

				bitter dock, Achillea millefolium and Cirsium palustre. Also, a strip of sown flowers (visible in figure A.1.2 as brown strip).

Figure A.1.7: Dry ditch of 70 cm depth.

Figure A.1.8: Planted forest.

Figure A.1.9: Dry ditches between 50 and 80 cm of depth.

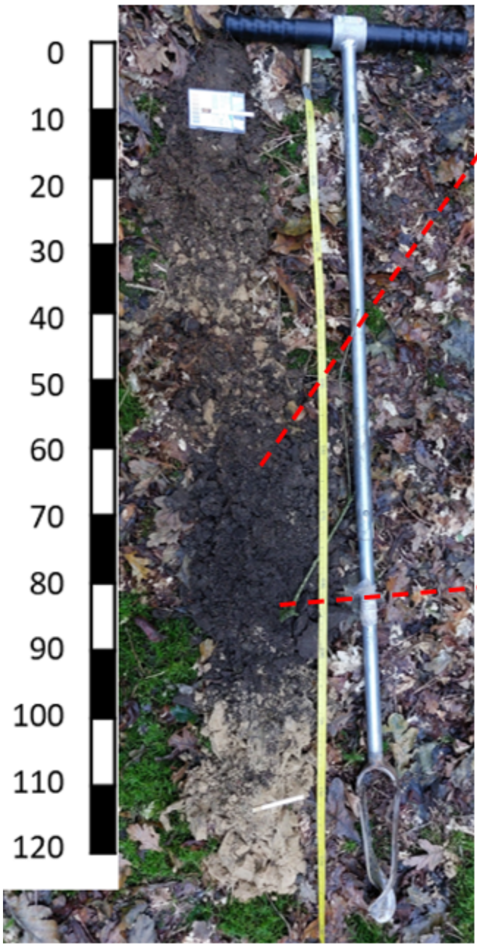


Figure A.1.10: Soil profile, topsoil at auger handle.

Figure A.1.11: Close up of the soil between 55 and 90 cm depth, which is mineralized peat.

Figure A.1.11: Ditch of 1.20 m deep with a few cm of stagnant water.

Figure A.1.12: Field with strip of sown flowers (location 6).

Discussion and conclusions

The site is heavily drained by ditches and consists largely of dry production forest. A field is present in the northern part with a strip of sown flowers (Figure A.1.2 and Figure 1.12). LGN6 data appears to be outdated, has less spatial resolution and appears to have a larger error. LGN2020 appears mostly correct and accurate. The WWN projection is based on the outdated landuse and yields to K68 'Pioneer vegetation, grasslands and shrublands on dry, moderately nutrient-rich soils'. The vegetation stucture does not correspond with the current situation but the site conditions appear to be correct. The topsoil has been antrophogenically altered. In the soil profile there is a mineralized peat layer present, which indicates that the site was wet in the past. Probably for agricultural use sand may have been deposited on top of the peat layer. The top layer has been optimized for agricultural use and is not original. Rust present between 40 and 50 cm is a sign that iron and oxygen is present at this depth. The data from MIPWA 3.0 seems to be correct based on the borehole measurement.

The current nature management N16.03 'dry production forest' are therefore in accordance with findings from the field. The peat layer and the presence of drainage indicates that the site used to be wetter. Rewetting the location may be difficult and also requires design measures (topsoil removal). Without extensive measures a nature ambition based on dry conditions (e.g. forest) is therefore considered to be reasonable. Conversion of N16.03 'dry production forest' to N15.02 'more natural dry forest' is expected to increase the nature value of the site.

A.2 Woldberg/Eese heathland

The location of the investigated site is indicated by the red circle in the figure below and was visited on October 28, 2021.

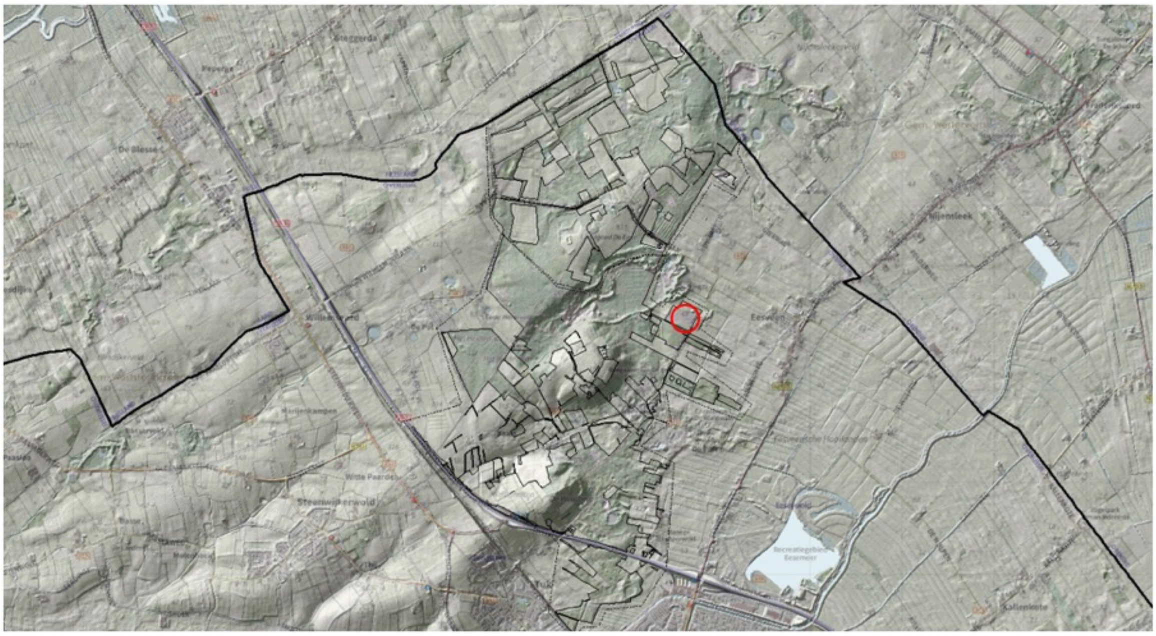


Figure A.2.0: Location 2 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site.

Questions

- Is there heathland or grassland on the plot? Is this in accordance with the data from LGN6 used in WWN 3.0? And what does LGN2020 indicate?
- What is the soil profile like and is it in accordance with the Dutch soil map 1:50,000?

Preparation

- The elevation data from AHN (Figure A.2.1), the maps and aerial photos from Topotijdreis (Figure A.2.2) all show the plot, with a somewhat lower part that looks like a field. The edges are a bit higher and look like a shrubland.
- According to WWN 3.0 results, the whole plot is predicted to be suitable for K68 or 'Pioneer vegetation, grassland and shrublands on dry, moderately nutrient-rich soils', which corresponds to a N12.XX (rich grasslands and fields). The outcome for the past, undisturbed situation is the same.
- Figure A.2.2 shows the LGN6 map, the whole plot consists of potatoes.
- Figure A.2.2 shows the LGN2020 map. According to this map, the lower part of the plot consists of heathland, moderately grassed heathland and strongly grassed heathland and the edges are natural grassland.
- Although no unambiguous prediction can be made based on Figures A.2.1-2 about what is on the plot. LGN6 seems to be outdated anyway, as at least the edges around the lower-lying part cannot consist of potatoes, based on the aerial photo from 2020.
- The Dutch soil map 1:50,000 indicates that the plot should consist of Hn23 or 'Veldpodzolsoils; loamy fine sand'.
- MIPWA 3.0 indicates that both the GG and the GVG are >1.5 m below ground level on the plot and the seepage flux is negative.
- The current nature management type is N07.01 or dry heathland for the lower-lying part and N12.06 or shrublands for the edges. The nature ambitions are unchanged.

Approach

- Identifying flora in the field to determine which version of LGN is correct.

- Making a soil profile and determining the groundwater level. Also measure the pH at a depth of 10 and 110 cm and check the Dutch soil map.
- Determining whether the plot is drained.
- Determine whether WWN's predictions are correct with regard to the current nature management types and nature ambitions.

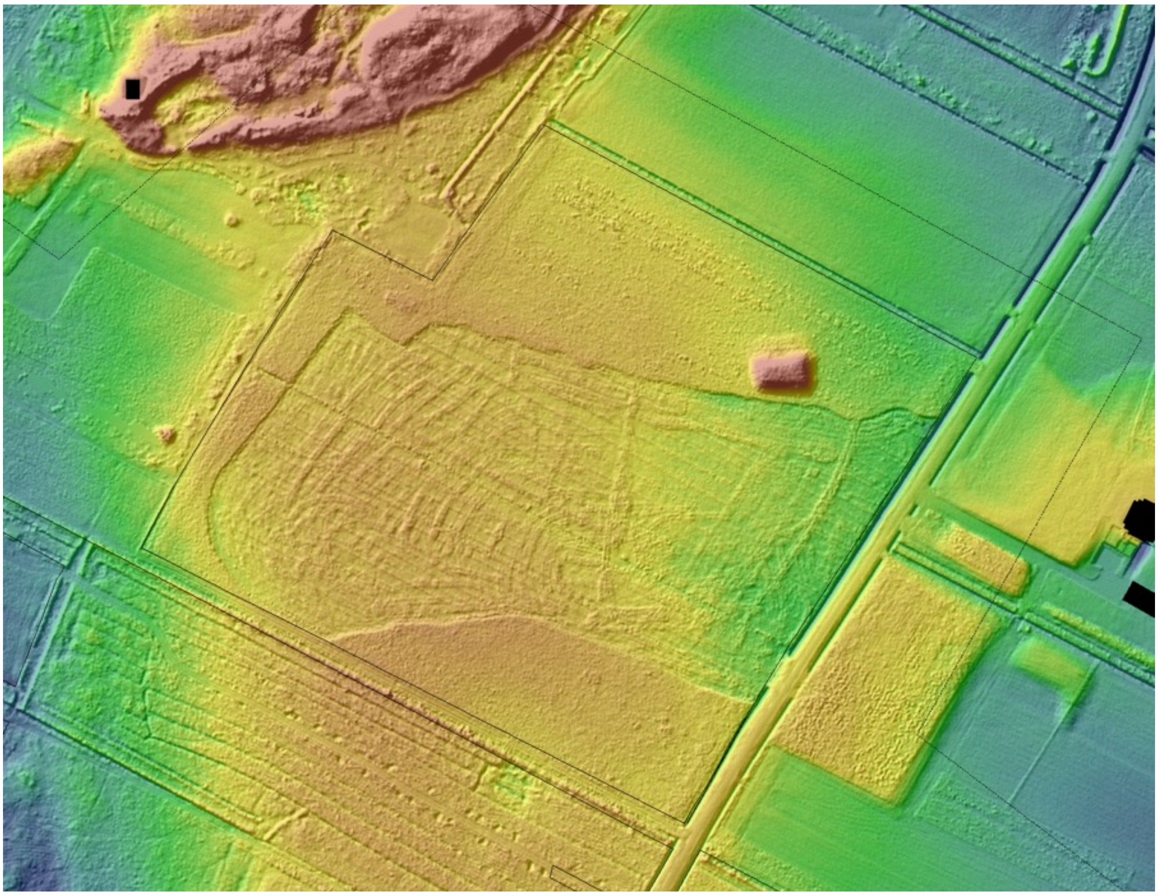


Figure A.2.1: The elevation map shows that the site is located on a spot that is somewhat more elevated compared to its surrounding (orange is elevated, blue is low lying areas). In a central part the topsoil has been removed (approx. 30 cm).

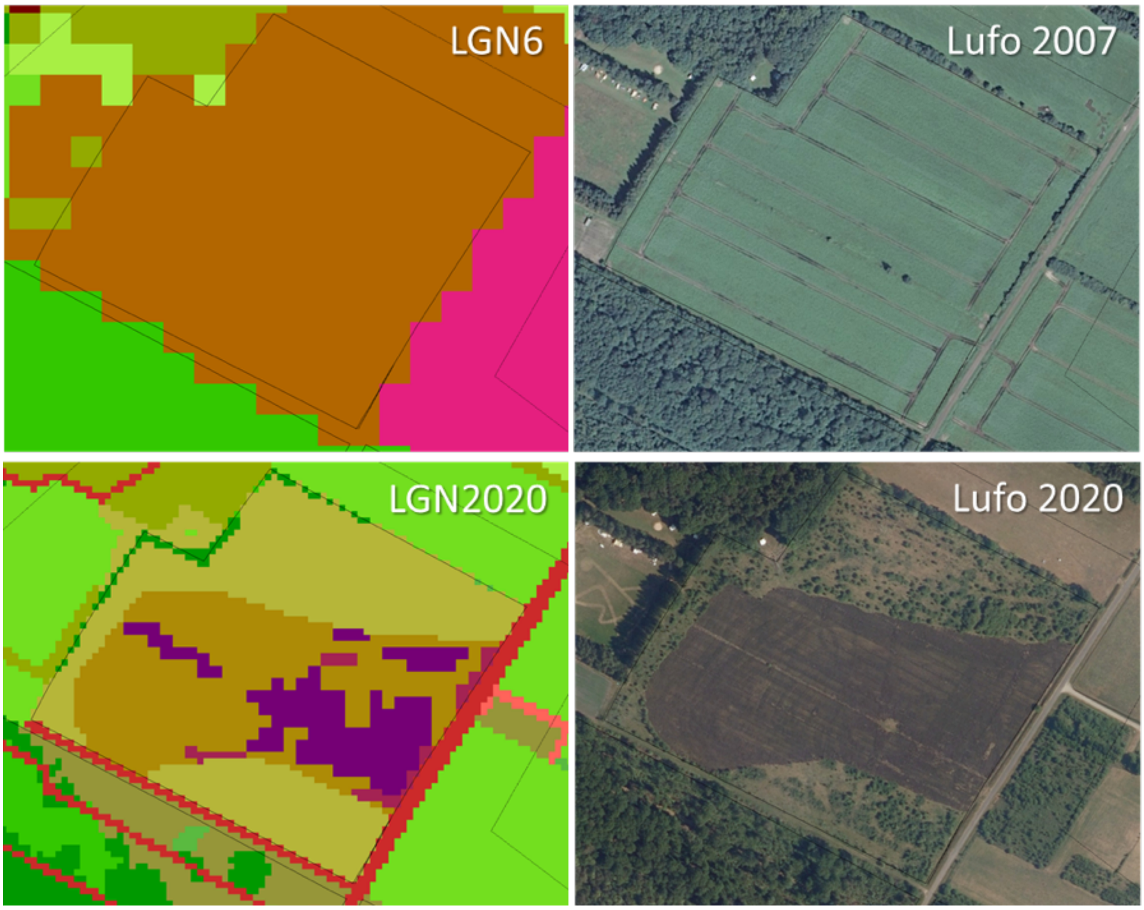


Figure A.2.2: LGN data and corresponding aerial photographs for LGN6 and LGN2020. The brown colour in LGN6 indicates a potato field which may be correct considered the arial photograph taken in 2007.

Figure A.2.3: Aerial photographs from 2007, 2009 and 2020 show that the removal of the top layer of the soil occurred in 2009 and resulted in the development of dry heathland.

In de Dino-database piezometers in the surrounding have been checked. The groundwater levels are all lower than 1 m below surface level.

Results
The results of the field visit is summarized in tabel A.2.1. From the locations visited photographs have been made to get an impression of the situation (Figures A.2.6 to A.2.7).

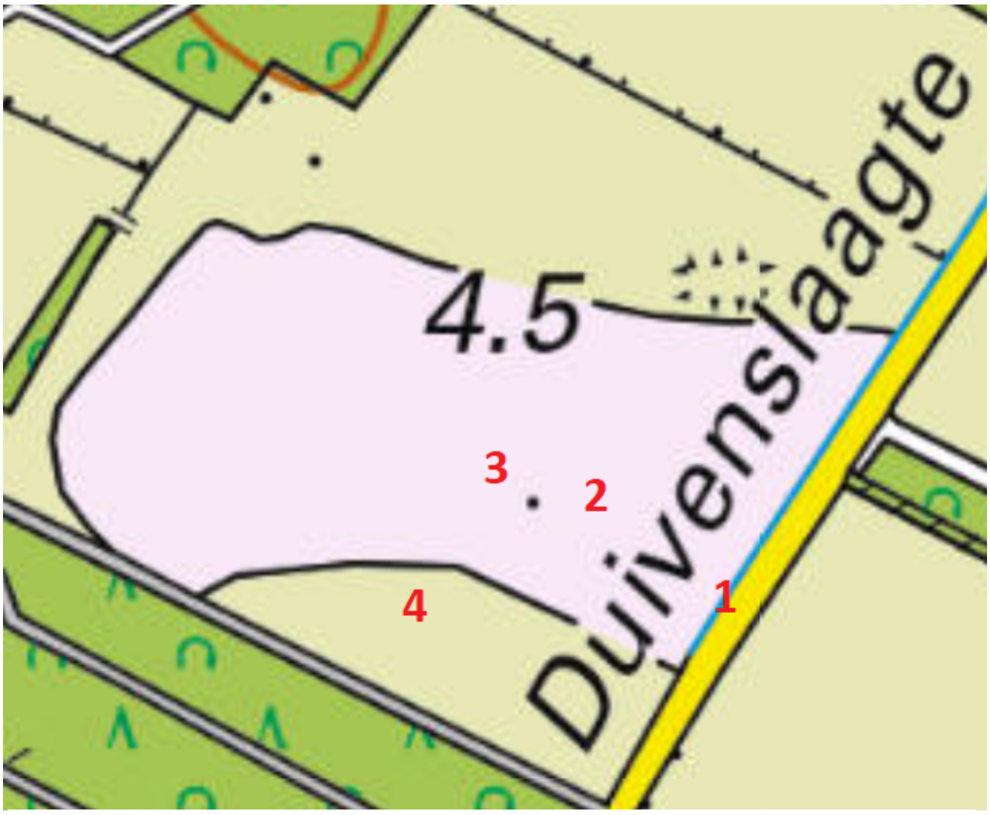


Figure A.2.4: Map from Topotijdreis 2020 showing points of interest.

Table A.2.1: Field data corresponding to the locations in Figure A.2.4.

Location (fig. A.2.4)	RD-coord.	GWT (cm)	PH	Description
1	204773, 537726	n/a	5.8 (water)	Ditch of 80 cm deep with 30 cm of water.
2	204680, 537765	n/a	n/a	Heathland (Figure A.2.6) with Erica tetralix, Polytrichum spec., Potentilla erecta, Galium saxatile, Juncus effusus, Senecio sylvaticus, Cirsium arvense and towards the ditch Angelica sylvestris.
3	204641, 537779	110	4.7 at 10cm ≤4 at 110cm	Soil boring in the middle of heathland (Figure A.2.5). - 0-15 cm: fine black soil. - 15-40 cm: moderately fine golden-brown sand. - 40-65 cm: very fine light-coloured sand. - 65+ cm: very fine very light-coloured sand. Gradually wetter and sometimes a little rusty.
4	204602, 537728	n/a	n/a	Shrubland (Figure A.2.7).

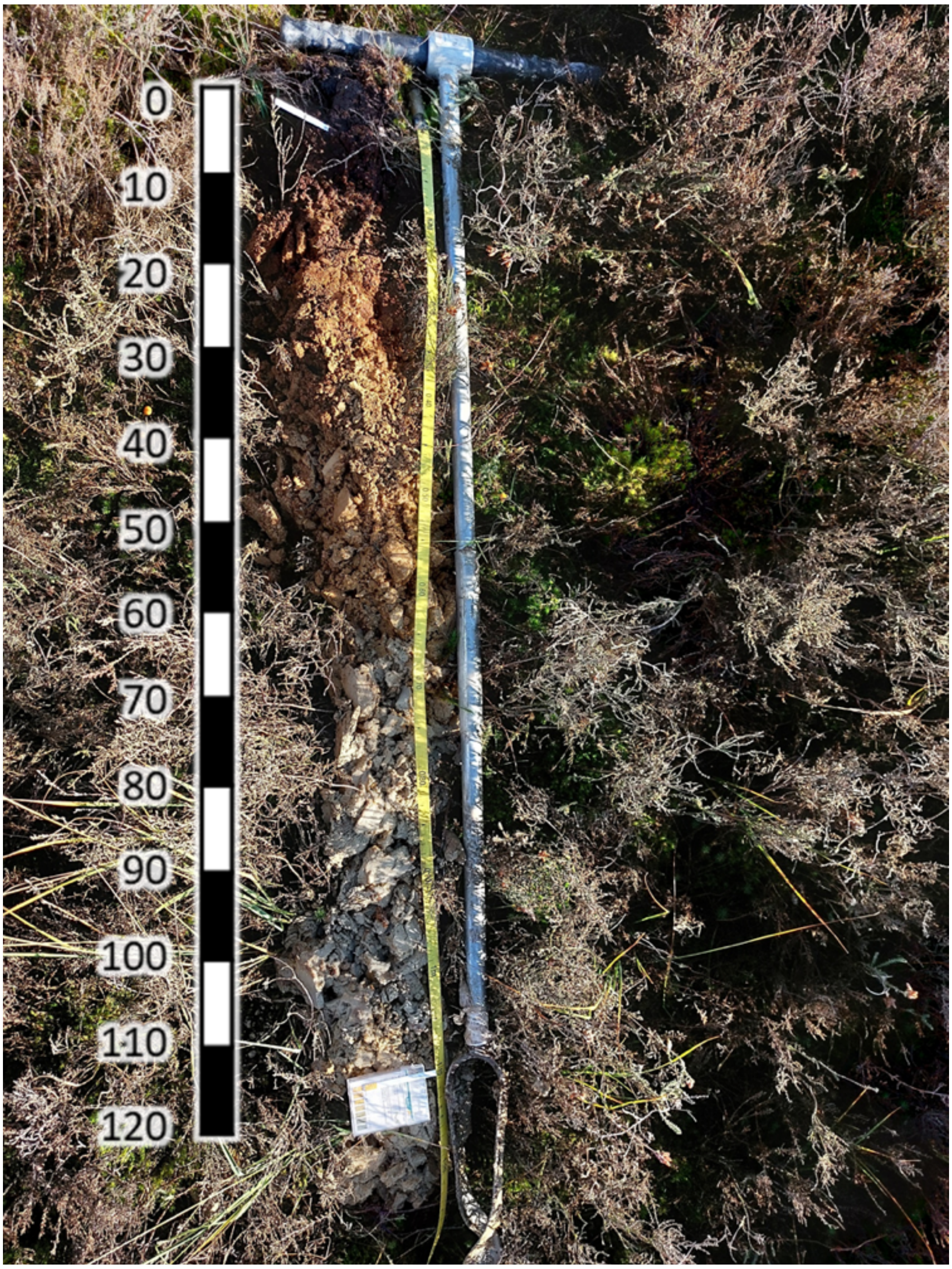


Figure A.2.5: Soil profile, topsoil at auger handle.

Figure A.2.6: Heathland with grassy patches.

Figure A.2.7: Shrubland.

Discussion and conclusions

- The plot is slightly drained on the side of the road and consists of heathland with patches of grassed heathland in the lower part and areas of shrubland along the higher edges.
- LGN6 indicated 'potato field' as land use. This is consistent with aerial photography for 2007-2008. However aerial photography shows an intervention in 2009 where parts of the top layer have been removed (Figure A.2.8). In 2020 the vegetation has changed to a more natural vegetation. In the field it turned out that the plot consisted of dry heathland and shrublands which corresponds with the LGN2020 data. Conclusion is that LGN6 is outdated.
- The results of WWN 3.0 are reasonably accurate, but cannot be copied 1:1. K68 (Pioneer vegetation, grassland and shrublands on dry, moderately nutrient-rich soils) is correct for the shrubland, but K61 (Pioneer vegetation and grasslands on dry, nutrient-poor, acidic soils (dry heathland)) would have been more appropriate for the heathland.
- The soil profile is indeed a veldpodzolsoil as indicated by the Dutch soil map. There is a thin layer of 15 cm which is nutrient-rich and is probably a remnant of the potato cultivation from LGN6, after which part of it was excavated, which would also explain why the section of heathland is lower than the shrublands. The thin layer of nutrient-rich soil also corresponds well to K61 or a nutrient-poor, acidic soil, although the nutrient-rich layer is still relatively thick resulting in the grassing up of parts of the heathland. The shrublands have probably not been excavated, thus have a thicker nutrient-rich layer of soil and are therefore suitable for K68 or a moderately nutrient-rich soil.
- The measured groundwater table was 110 cm below ground level. The rust just above indicates that the groundwater level was also slightly higher in the past.
- This means that the data from MIPWA 3.0, predicting ground water levels deeper than 150 cm below ground level, are incorrect. Even though the groundwater level is higher than expected, it remains a dry plot as the groundwater level is still quite deep. Furthermore, no signs of positive seepage flux were found.
- Both the current nature management types and the nature ambitions N07.01 (dry heathland) and N12.06 (shrublands) are correct and can be maintained for the coming years.

Figure A.2.8: Aerial photos from Topotijdreis for 2007, 2009 and 2020.

A.3 Woldberg/Eese moist meadow

The location of the investigated site is indicated by the red circle in the figure below and was visited on October 28, 2021.

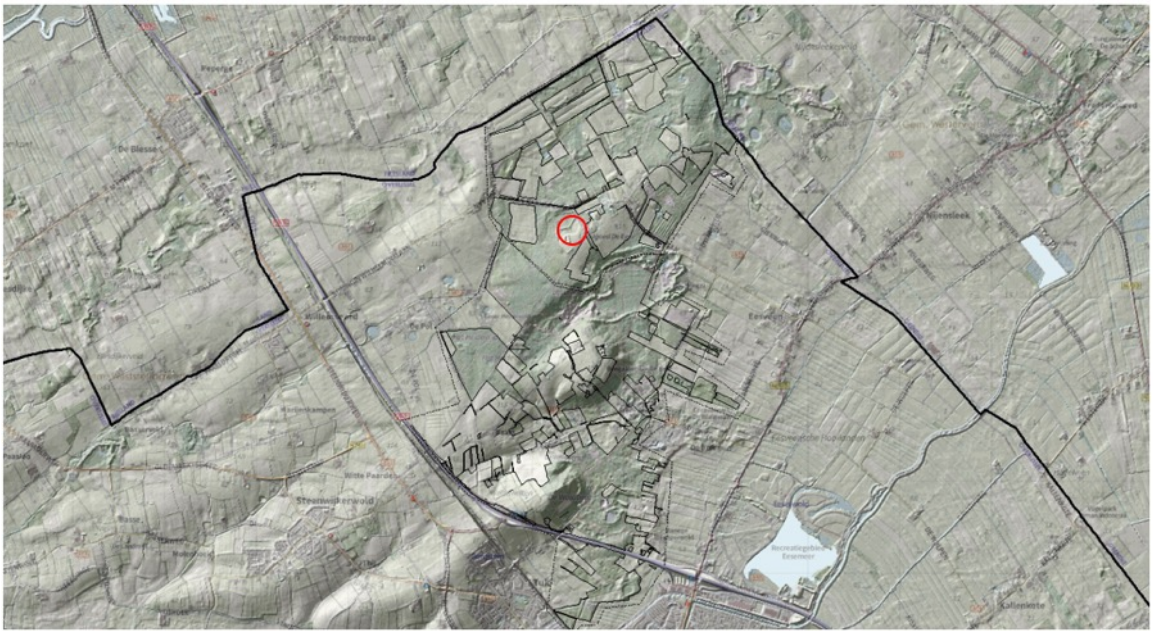


Figure A.3.0: Location 3 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site.

Questions

- Part of the plot has been lowered and is now managed as N10.02 (moist meadow). What is the groundwater level?
- Does the soil type (texture) give an indication of the moisture situation?
- What does the soil profile look like and is it in accordance with the Dutch soil map 1:50,000?
- Are WWN's predictions correct with regard to the current and past, undisturbed situation?

Preparation

- Figures A.3.1-3 show the plot and it seems correct that the north-western part has been lowered. Two small ponds and a wooded bank in the shape of a horseshoe are also noticeable.
- Figure A.3.4 shows the output of WWN 3.0. The results are identical for the current and past, undisturbed situation, namely for the whole plot K61 or 'Pioneer vegetation and grasslands on dry, nutrient-poor, acidic soils (dry heathland)'. This corresponds to N07.01 (dry heathland).
- Both the LGN6 and the LGN2020 map indicate that the plot consists of natural. LGN2020 also indicates two water bodies, unlike LGN6. Looking back to 2013 (Topotijdreis), it appears that the waters did not exist back then.
- The plot is divided into three categories in both the current nature management types and nature ambitions, the boundaries of which are clearly visible on the aerial photo from 2020 in Figure A.3.2:
    - N10.02 (moist meadow) for the excavated north-western part.
    - N12.06 (shrubland) for the horseshoe-shaped wooded bank plus the enclosed part.
    - N12.02 (grasslands rich in herbs and fauna) for the remaining, south-eastern part.
- So, the prediction of WWN 3.0 does not correspond to the current nature management types.
- The Dutch soil map 1:50,000 indicates that the plot consists of a cHn23 or 'Laarpodzolsoils; loamy fine sand'.
- MIPWA 3.0 states that both the GVG and GG are more than 6 m below ground level and the seepage flux is negative.

Approach

- Making a soil profile and determine the groundwater level. Also measure the pH at a depth of 10 and 110 cm and check the Dutch soil map.
- Determine whether the plot is drained and whether the data from DINOloket or MIPWA is correct.
- Determine whether the predictions of WWN are correct or whether the current nature management types are more realistic.
- Describing the flora as good as possible.

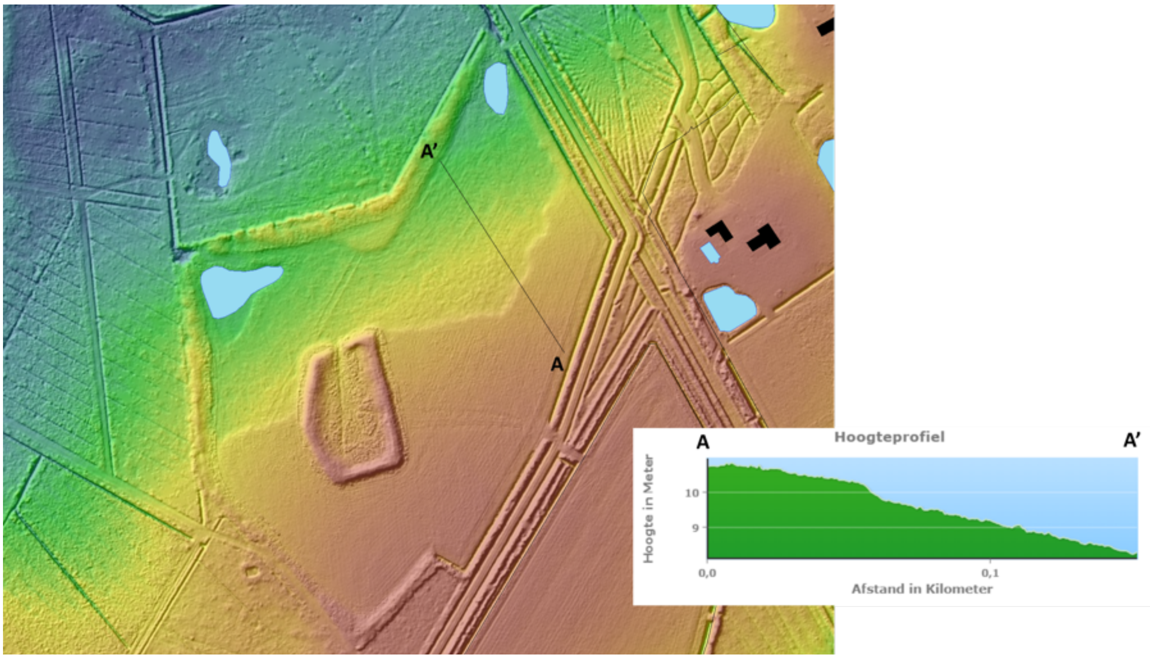


Figure A.3.1: Height data including a height profile from AHN.

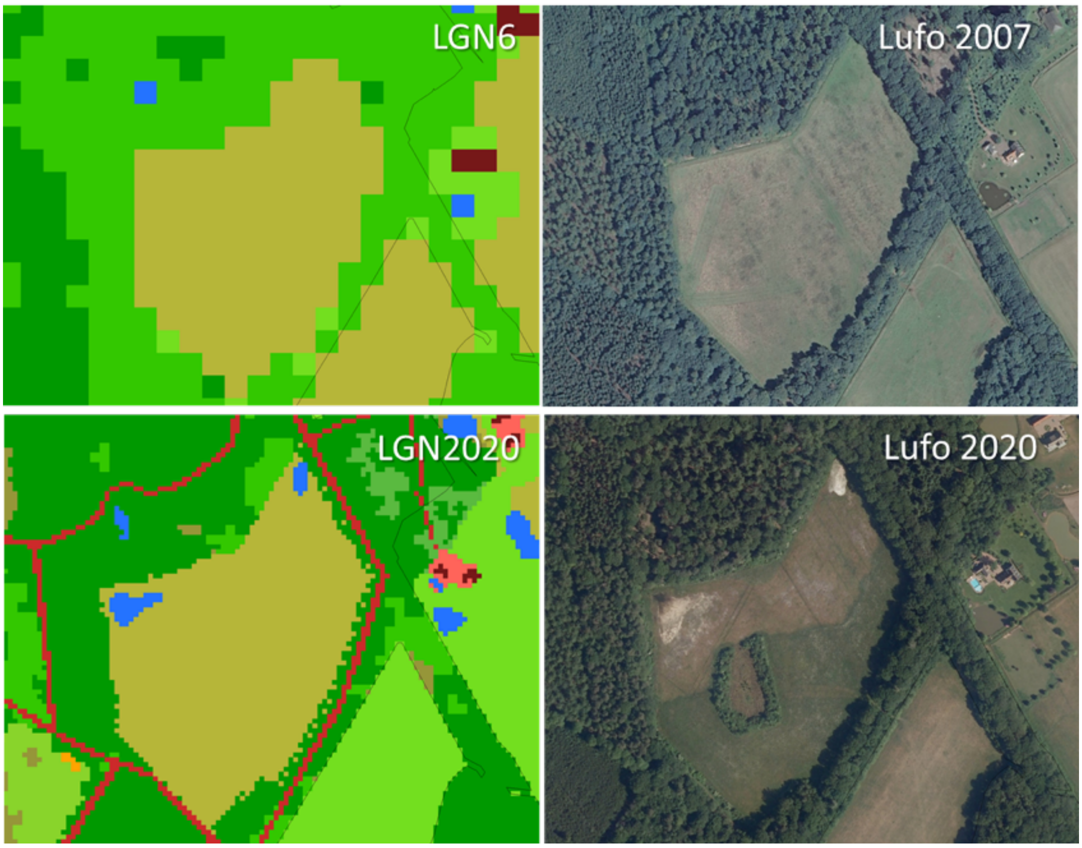


Figure A.3.2: LGN data and corresponding aerial photographs for LGN6 and LGN2020. Both versions show 'natural grassland' (pixel value = 45).

Results

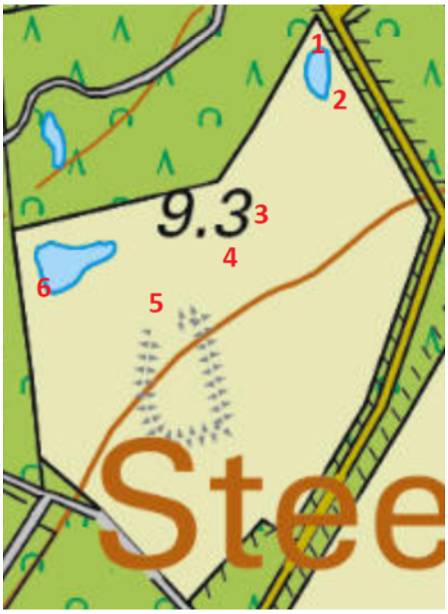


Figure A.3.3: Map from Topotijdreis 2020 showing points of interest.

Table A.3.1: Field data corresponding to the locations in Figure A.3.3.

Location (fig. A.3.3)	RD-coord.	GWT (cm)	PH (-)	Description
1	203477, 538862	n/a	n/a	Oligotrophic pond about 1 m deep with Juncus spec. along the sides (Figure A.3.9).
2	203486, 538839	95	5.4 at 10cm 4.4 at 110cm	Soil boring right next to the oligotrophic pond just above water level (Figure A.3.12). - 0-10 cm: Fine, wet, grey soil. - 10-25 cm: Light grey, very fine, wet sand. - 25-70 cm: Mixture of light grey and orange-coloured - (rust) very fine, silty sand. - 70-85 cm: Mixture of light grey and orange-coloured (rust) very fine, silty sand, but here very solid and difficult to penetrate with a drill. - 85-100 cm: Same, but now very soft and very wet. - 100+ cm: Same as 70-85 but more orange (rust).
3	203439, 538743	105	5.0 at 10cm 4.2 at 110cm	Soil boring in the middle of excavated area (Figure A.3.13). - 0-5 cm: Dark, wet soil. - 5-15 cm: Golden brown, fine sand, wet. - 15-75 cm: Very fine, mixture of white and increasingly - orange (rust) sand. - 75-100 cm: Rock-hard, very fine silty sand, almost entirely orange with clear iron concretions. Close to clay. - 100-110 cm: Very soft, very fine white sand with much rust. - 110+ cm: Rock-hard, same as 75-100 with even more rust.
4	203430, 538727	n/a	n/a	Many puddles in field, almost soggy everywhere in excavated part (Figure A.3.10). In excavated part Achillea millefolium, Centaurea jacea, Hypochaeris radicata, Ranunculus repens, Cirsium palustre, ragged-robin, Potentilla anglica, Plantago lanceolata, dandelion, Lotus corniculatus, Rhytidiadelphus squarrosus, Leucanthemum vulgare, Tanacetum vulgare, Salix spec., Calluna vulgaris and Trifolium pratense.
5	203366, 538685	n/a	n/a	Shrubland, tending to overgrow (Figure A.3.11).
6	203389, 538693	n/a	5.8 (water)	Oligotrophic pond about 1 m deep with Juncus spec. along the sides (Figure A.3.9).


Figure A.3.4: Oligotrophic pond of approximately 1m deep.


Figure A.3.5: Puddles and soggy soil on excavated part of plot.


Figure A.3.6: Shrublands in middle of field.

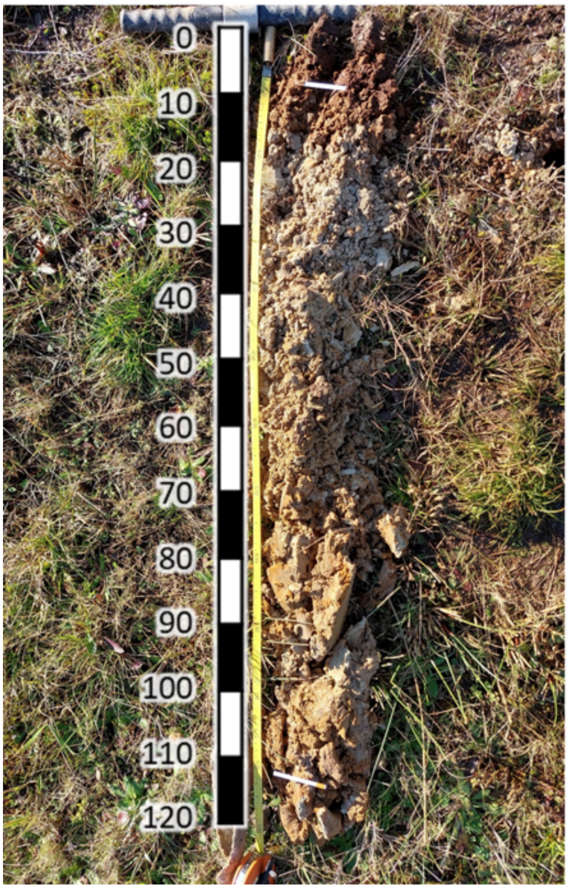


Figure A.3.7: Soil profile from the middle of the plot.

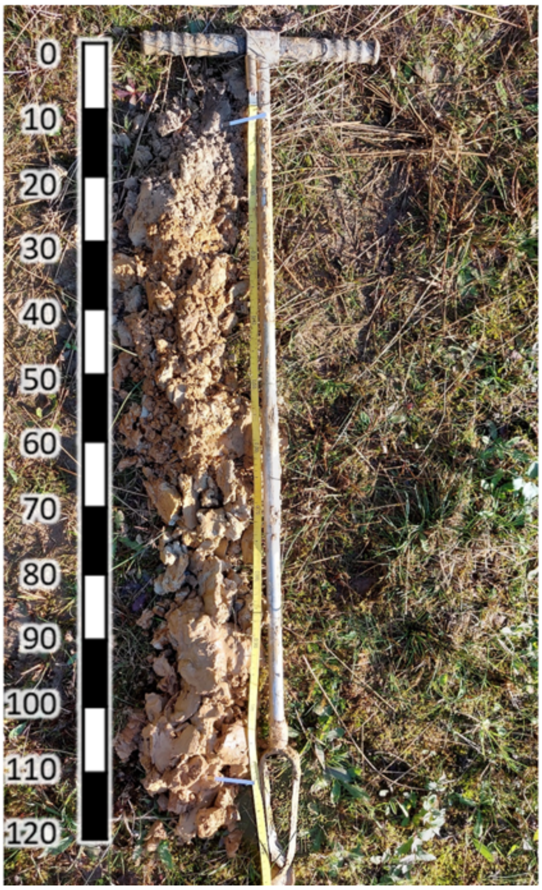
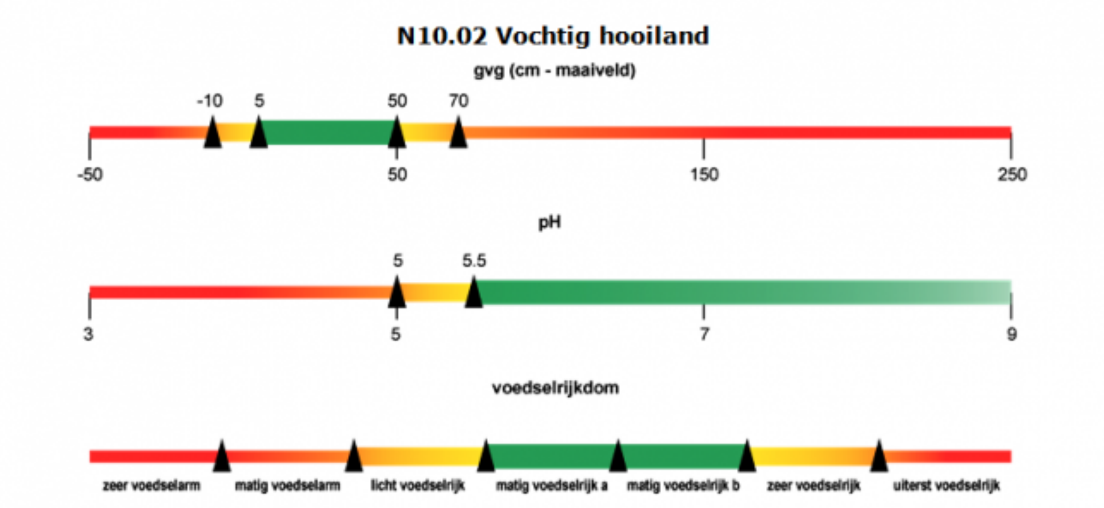


Figure A.3.8: Soil profile near oligotrophic pond from figure A.3.4

Discussion and conclusions

- The plot is not being drained in the direct vicinity and indeed consists of natural grassland, as indicated by both LGN versions. The oligotrophic ponds in LGN2020 are also present. Both versions of the LGN have not mapped the shrubland, but since this can be part of a natural grassland, this is not necissarily incorrect. Both versions are therefore correct.
- The plant species on the excavated part of the field are partly characteristic of a moist meadow (birdsfoot trefoil and Ranunculus repens).
- Figure A.3.9 shows the suitable conditions for a moist meadow. Based on the flora and soil profiles, the nutrient richness of the soil is suitable. The groundwater level was measured between 95 and 105 cm, but since these measurements were taken in October, it is likely that the GVG is about 50 cm below ground level. The rust in the soil profiles also supports this. The pH of the soil (at 10 cm) is on the low side at 5.0 and 5.4, but still falls within the yellow range in Figure A.3.9. The pH of 5.8 in the oligotrophic pond also indicates that the pH falls within the green range.
- The shrubland is in accordance with the current nature management type, but is in danger of becoming overgrown.
- In the remaining part of the field, no soil boring was done, but there were no puddles and the flora included characteristic plants such as ragged-robin and catsear.- In the remaining part of the field, no soil boring was done, but there were no puddles and the flora included characteristic plants such as ragged-robin and catsear. Also, the ground level is about one metre higher (Figure A.3.1) than the excavated part, so the water table is expected to be lower. Therefore, a grassland rich in herbs and fauna seems a suitable management type.
- The prediction of WWN 3.0 is incorrect. Where dry heathland (K61 or N07.01) was predicted, the plot turns out to consist of different nature management types that do not resemble this. Looking at the input in WWN 3.0, the MIPWA 3.0 data used indicates that the both the GVG and GG are deeper than 6 m below ground level. Since MIPWA 3.0 does not take account of perched groundwater tables, it is possible that a perched groundwater table has been found here. This shows that the data used in MIPWA 3.0 is not always correct. As a result, it is logical that WWN 3.0 predicts K61 instead of a wetter soil.
- The soil profile in the excavated part does not consist of a laarpodzolsoil, possibly due to the (partial) excavation of the A horizon, which should be thick and dark in colour. The fine, partly loamy sand underneath is present, however. This seems to indicate that the plot used to be regularly saturated.
- All in all, the results of WWN 3.0 are not correct and the current nature management types N10.02 (moist meadow), N12.06 (shrubland) and N12.02 (grassland rich in herbs and fauna) are correct and can be retained for the coming years.



N10.02 Vochtig hooiland. Ranges waarbij voor vochtig hooiland kenmerkende vegetaties kunnen voorkomen voor gemiddelde voorjaarsgrondwaterstand (GVG), zuurgraad (pH) en voedselrijkdom.

Figure A.3.9: Suitable conditions for moist meadow according to BIJ12

A.4 Woldberg/Eese grassland rich in herbs and fauna

The location of the investigated site is indicated by the red circle in the figure below and was visited on October 28, 2021.

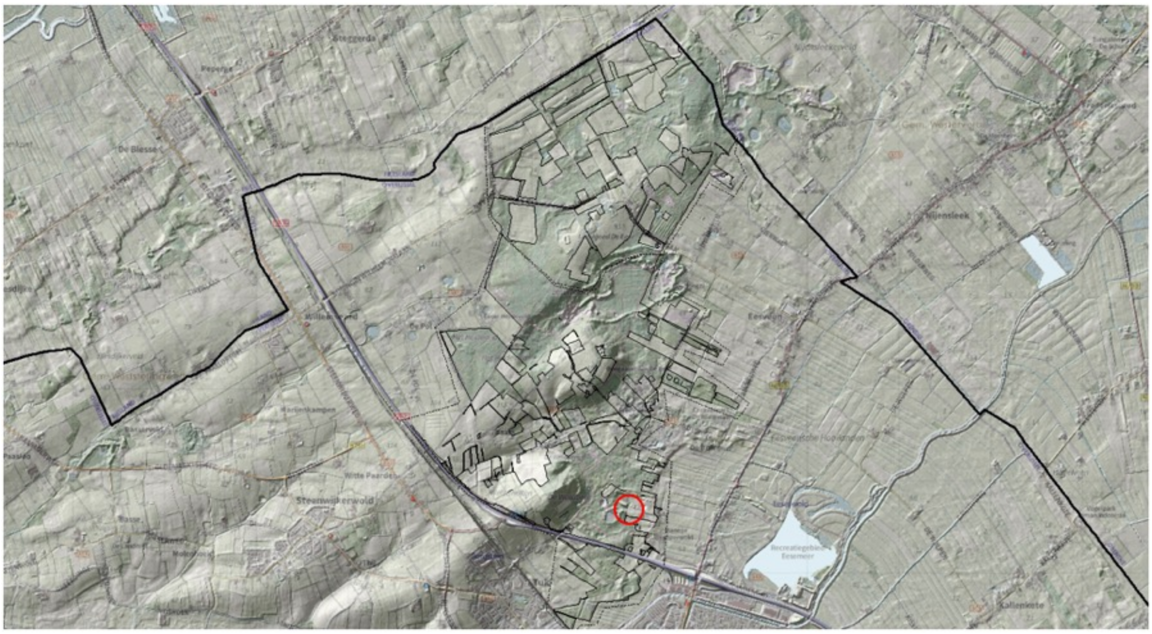


Figure A.4.0: Location 4 (see Figure 2 in paragraph 3.1)

Specific questions were stated to be investigated for this site.

Questions

- The depression on the flank used to be wet/moist (Figure A.4.4). What is its present condition?
- What soil type is present and can anything be said about the past moisture conditions of the soil?
- Are WWN's predictions regarding the current and past, undisturbed situation correct?
- Also take some pictures near the collapsed pingo and the oligotrophic pond.

Preparation

- Figures A.4.1-2 show the plot (which used to be wet/moist). Now it appears to be a field with two water surfaces. The height profile shows that the surface of the water is almost one metre below the adjacent ground level. The higher part of the field appears drier on Figure A.4.2.
- LGN6 and LGN2020 (Figure A.4.2) both indicate a strip of natural grassland in the middle part of the plot and otherwise agricultural land (agricultural grass and grain respectively). The two bodies of water are missing in LGN6, which is supported by aerial photos from 2008.
- The current nature management types are N12.05 (herb- and fauna-rich field) and N16.03 (dry production forest). The ambition proposal (Figure A.4.7) is to transform N12.05 into N12.02 (grasslands rich in herbs and fauna).
- For the current situation, WWN predicts K68, which can be an N12.05, and K62, which can be an N07.01 (dry heathland) (Figure A.4.5).
    - o K62: pioneer vegetation and grassland on dry, nutrient-poor, slightly acidic soils (dry heathland and grey hair-grass grasslands).
    - o K68: pioneer vegetation, grasslands and shrublands on dry, moderately nutrient-rich soils (undergrowth in heavily fertilised fields, ruderal vegetation along rivers).
- For the past, undisturbed situation WWN predicts largely the same (Figure A.4.6), but also some K42, K48 and K61, which mainly means wetter conditions than K62 and K68.
    - o K42: pioneer vegetation and grasslands on moist, nutrient-poor, weakly acidic soils (violion caninae grassland, calcium-poor dune valleys).
    - o K48: pioneer vegetation and grasslands on moist, very nutrient-rich soils (agricultural fields, roadsides, factory grounds).
    - o K61: pioneer vegetation and grassland on dry, nutrient-poor, acidic soils (dry heathland).

- The Dutch soil map 1:50,000 indicates that the plot consists of Hn21 or 'Veldpodzolsoils; loam-poor and slightly loamy fine sand'.
- MIPWA 3.0 states that the GG and GVG lie between 100 and 150 cm below ground level for the norther part of the transect and deeper than 150 cm for the southern part. Also, the seepage flux should be negative.

Approach

- Perform a number of soil borings on a transect, describe these soil profiles and check the Dutch soil map.
- Determine pH and groundwater level and check whether the plot is drained.
- Assess predictions of WWN 3.0 and test current and proposed nature management types.
- Describe flora as well as possible.
- Take pictures of the collapsed pingo and oligotrophic pond (mere) and measure pH of water.

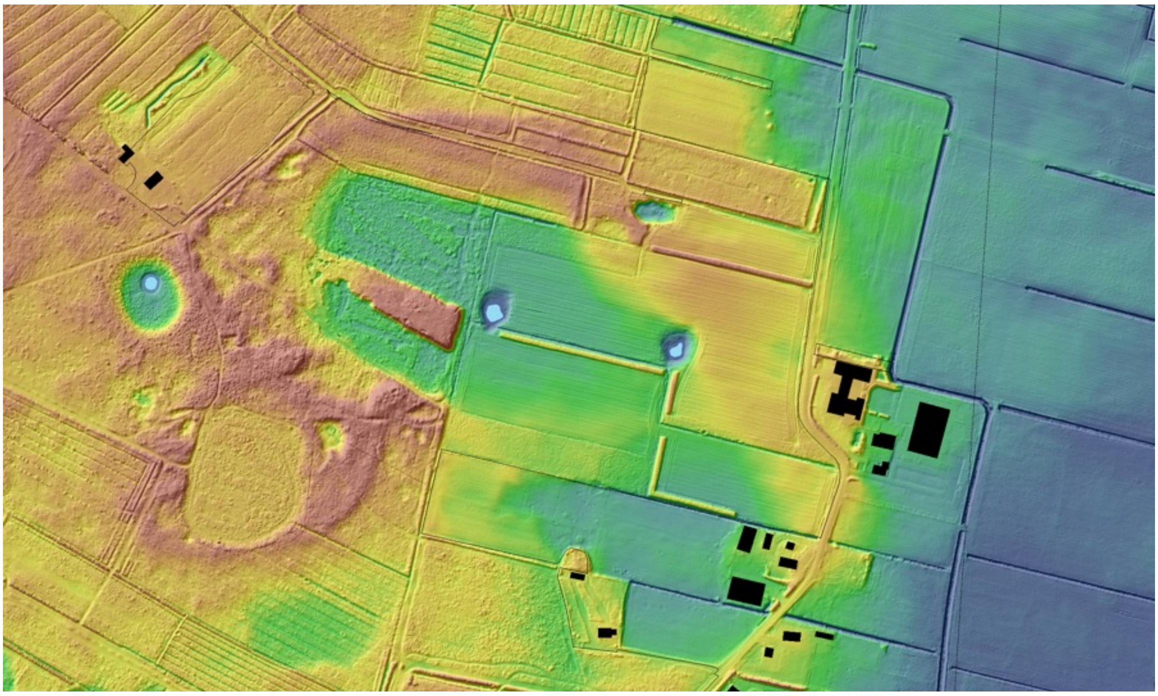


Figure A.4.1: The elevation map shows that the site is located on a spot that is somewhat more elevated compared to its surrounding (orange is elevated, blue are low lying areas). In a central part the topsoil has been removed (about 30 cm).

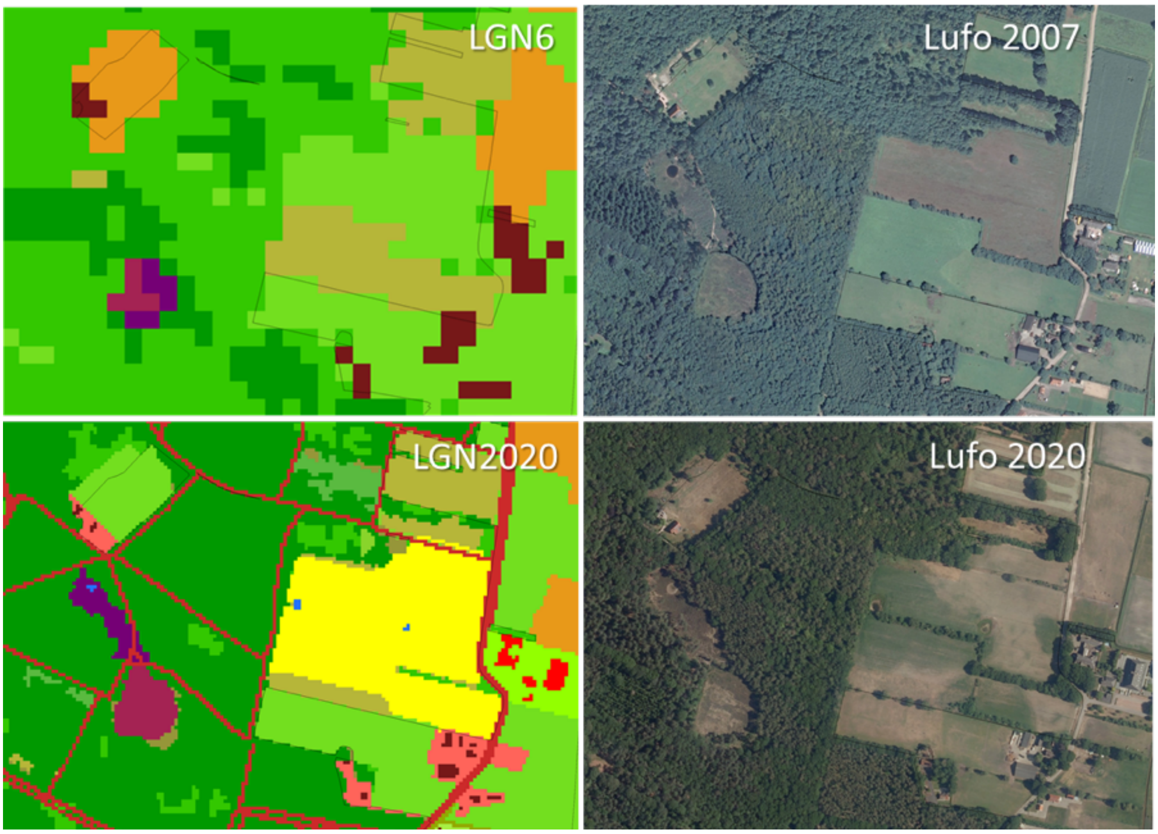


Figure A.4.2: The elevation map shows that the site is located on a spot that is somewhat more elevated compared to its surrounding (orange is elevated, blue are low lying areas). In a central part the topsoil has been removed (approx. 30 cm).

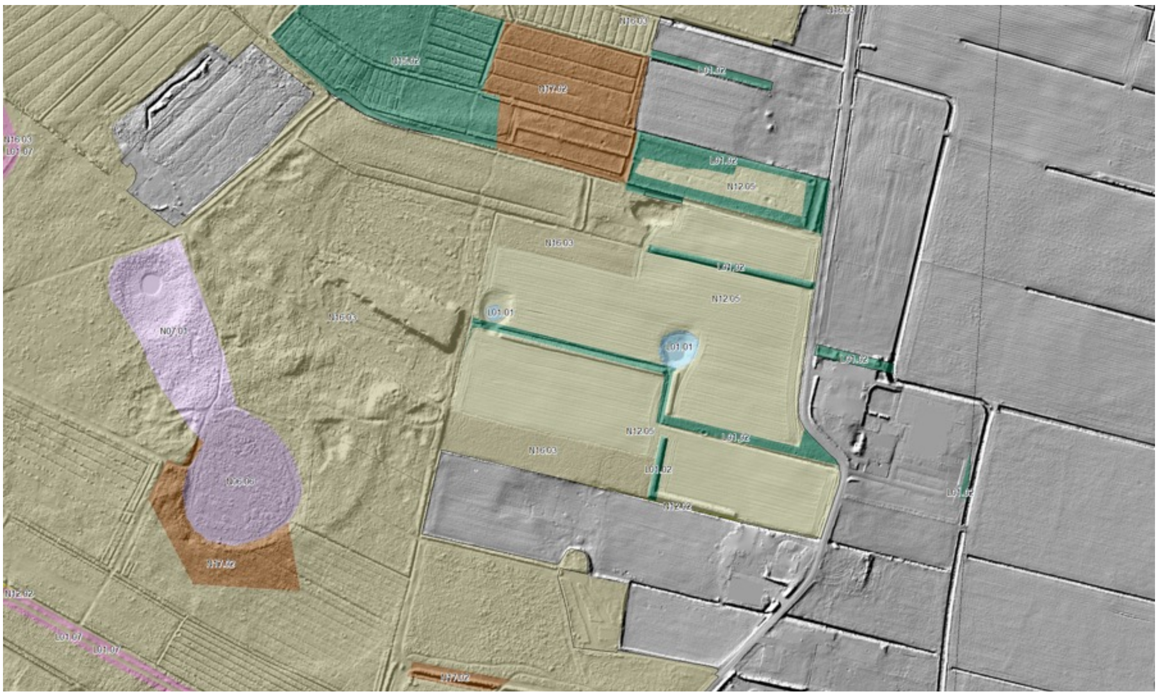


Figure A.4.3: The elevation map shows that the site is located on a spot that is somewhat more elevated compared to its surrounding (orange is elevated, blue are low lying areas). In a central part the topsoil has been removed (about 30 cm).

Figure A.4.4: An old topographical map from Topotijdreis (1930), shows that the plots were most in earlier times.

Figure A.4.5: For the current condition, WWN predicts K68 (light green) for the northern and southern field and K62 (light pink) for the middle field.

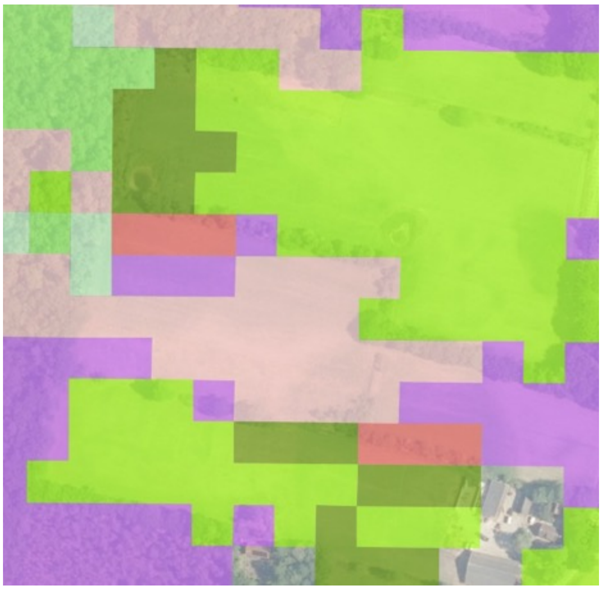


Figure A.4.6: For the past, undisturbed situation, WWN predicts mostly the same as for the current situation, but also some K48 (dark green), K42 (reddish) and K61 (purple) in the fields.

Figure A.4.7: Proposals nature management types.

Results

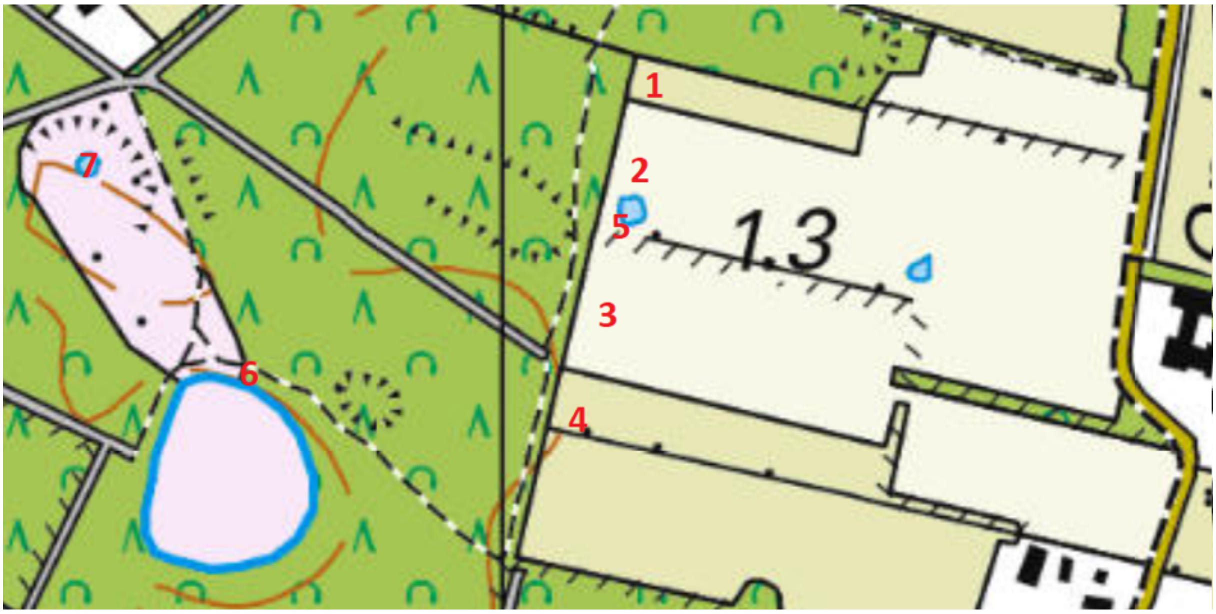


Figure A.4.8: Topographical map 2020 with in red the locations (see results).

Table A.4.1: Field data corresponding to the locations in figure A.4.8.

Location (fig. A.4.8)	**RD-coord.**	**GWT (cm)**	**PH (-)**	**Description**
1	204089, 535809	95	4.9 at 10cm 4.8 at 110cm	Soil profile (Figure A.4.13) on strip between field and forest (Figure A.4.9). Between the strip and the woods is a dry ditch of 1.30 m deep. The strip is covered with grass, Ranunculus repens, Rumex obtusifolius, Stachys palustris and small trees. Looks more like a shrubland than a N12.02 or N12.05. - 0-40 cm: fine black soil.

				- 40-80 cm: fine black sand with gradually finer red-brown sand. - 80+ cm: very fine light-coloured sand, becoming increasingly wet.
2	204079, 535768	105	4.7 at 10cm 4.4 at 110cm	Soil profile (Figure A.4.14) in a field right next to an oligotrophic pond. The field has been used for growing grain and now contains grass with Rumex obtusifolius, Rumex acetosella, Ranunculus repens, Achillea millefolium, vetch and Stellaria media. - 0-15 cm: very fine black soil. - 15-50 cm: fine brown-red sand, gradually becoming lighter in colour. - 50+ cm: very fine light-coloured sand, increasingly wet.
3	204057, 535696	>125 cm	5.0 at 10cm 4.2 at 110cm	Soil profile (Figure A.4.15) in the middle of the field with grass, Rumex obtusifolius, Achillea millefolium, chickweed, Ranunculus repens, Galeopsis spec. and Cirsium arvense. - 0-45 cm: fine black soil. - 45-70 cm: reddish brown fine sand, gradually becoming lighter in colour. - 70+ cm: light-coloured fine sand, gradually becoming very fine. Quite moist at the deepest point, but no groundwater table was encountered.
4	204043, 535627	>125 cm	4.7 at 10 cm 5.0 at 110cm	Soil profile (Figure A.4.16) on nutrient-rich grassland (Figure A.4.10) with some Hypochaeris radicata and along the edges some Dryopteris filix-mas, Lonicera periclymenum and Rumex acetosella. - 0-35 cm: dry, grey soil. - 35+ cm: light-coloured, fine sand, gradually becoming very fine. Fairly moist at the end, but no groundwater table was encountered.
5	204061, 535745	n/a	5.3 (water)	Small oligotrophic pond with some Polytrichum spec. on the side. Water surface approx. 1 m below ground level.
6	203867, 535661	n/a	4.8 (water)	Collapsed pingo surrounded by an oligotrophic pond with grass pollen, ferns and Menyanthes trifoliata (seepage indicator). Land surrounded by the oligotrophic pond appears dry with some trees/shrubs and Calluna vulgaris (Figure A.4.11).
7	203775, 535773	n/a	5.0 (water)	Oligotrophic pond in a depression in dry heathland with Erica tetralix and heather.


Figure A.4.9: Shrubland at location 1 (figure A.4.11)


Figure A.4.10: Nutrient rich grassland at location 4.

Figure A.4.11: Collapsed pingo surrounded by an oligotrophic pond, location 6.

Figure A.4.12: Oligotrophic pond in low surrounded by dry heath, location 7.

Figure A.4.13: Soil profile at location 1.

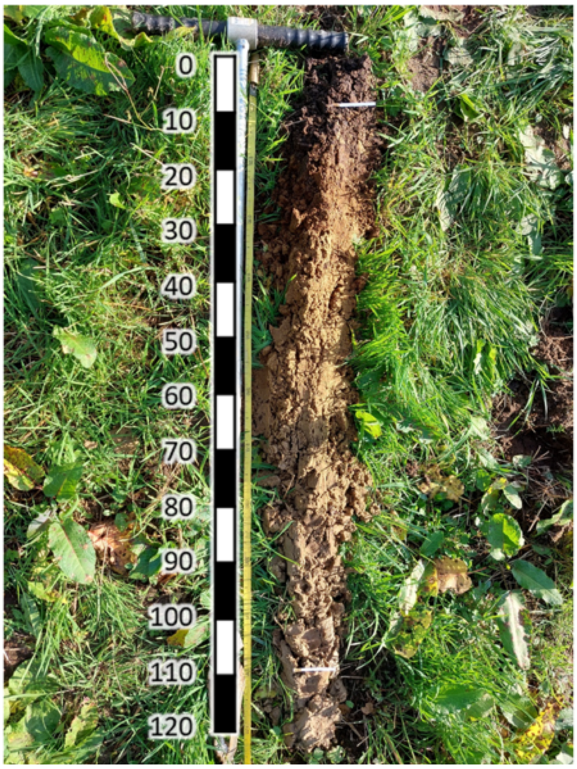


Figure A.4.14: Soil profile at location 2.

Figure A.4.15: Soil profile at location 3.

Figure A.4.16: Soil profile at location 4.

Discussion and conclusions

- The plot is being drained on the north side by a ditch of 1.30 m deep, otherwise there is no drainage in the direct vicinity.
- LGN6 incorrectly indicates the presence of mostly natural grassland instead of the grain field found and still misses the small oligotrophic ponds. LGN2020 is correct.
- The depression on the flank that used to be wet/moist is no longer wet/moist. The transect that was surveyed still has a groundwater table about 1 metre below ground level at the beginning, but later the groundwater table is no longer found and thus deeper than 125 cm below ground level. Looking at the height map of the plot and the water level in the small oligotrophic pond on the transect, this is logical. This is also in good agreement with MIPWA 3.0, although the actual groundwater level is slightly higher than indicated, but only by a few decimetres in the northern part. Also, no signs of positive seepage flux have been found.
- The soil indeed once consisted of an Hn21 or 'Veldpodzolsoils; loam-poor and slightly loamy fine sand', although as a result of agriculture a thicker humus-rich layer is present, resulting in the soil no longer completely being an Hn21. As a veldpodzolsoil originates in a humid area, this indicates that the plot was humid in the past.
- Figures A.4.11-12 in combination with data from Table A.4.1 confirm the presence of a collapsed pingo surrounded by an oligotrophic pond and an oligotrophic pond in a depression surrounded by dry heathland. The presence of raised bog could not be confirmed as access to the collapsed pingo was not possible due to the surrounding oligotrophic pond.
- WWN's K68 prediction for the current situation is correct, but the K62 prediction is not. Here K68 is also more suitable because of the nutrient-rich and acidic soil layer present.
- The predictions for the past, undisturbed situation should in theory all be achievable, but with larger areas of one type. For example, for K48 only an past, undisturbed situation is needed, while for K62, K68 and K61 the top layer would have to be excavated. For K42, both the top layer would have to be excavated and the groundwater table raised.
- Conversion of N12.05 to N12.02 is possible if no crops are grown anymore and fertilisation stops.
- The two plots labelled with N16.03 (dry production forest) would remain so in the current proposal, but in the field it turned out that there is no forest here at all and according to Topotijdreis it has not been so in recent decades either. The northern field looks more like a shrubland (N12.06), but because of its small size, it can also be classified as part of the larger plot according to BIJ12. The southern plot is already an N12.02, but with few herbs.
- The whole plot therefore has the potential to become an N12.02 (grassland rich in herbs and fauna).

APPENDIX B: FLOODPLAINS IJSSEL

B.1 Floodplains IJssel forest plots

The location of the investigated site is indicated by the red circle in the figure below and was visited on November 4, 2021.

Figure B.1.0: Location 5 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site. In preparation direct available spatial information was checked before visiting the site in the field.

Questions

- What kind of forest or tree species are present on current N14.02 (raised and low bogland forest) and N16.04 (moist production forest) plots? Do these plots differ?
- What is the groundwater level and soil type, and are the plots being drained?
- Are WWN's predictions correct with regard to the current and past, undisturbed situation?

Preparation

- LGN6 (Figure B.1.1a) indicates that plots 1, 2 and 4 consist of deciduous forest and plot 3 of agricultural grass. LGN 2020 (Figure B.1.1b) indicates that plots 1 and 2 consist of forest in marshland and plots 3 and 4 of a mix of coniferous and deciduous forest.
- Furthermore, the elevation map of AHN (Figure B.1.1c) and the aerial photo of Google Maps (Figure B.1.1c) indicate that there is forest on all plots, while the map of Topotijdreis 2020 (Figure B.1.1d) shows no forest on plot 3.
- DINOloket shows a well right next to plot 3 with recent groundwater levels (Figure B.1.2) varying between 10 and 170 cm below ground level.
- There are also records of a well just north of plot 4 (Figure B.1.3) with groundwater levels varying between 0 and 160 cm below ground level, although these records are several decades old.
- Figures B.1.4-5 show the groundwater levels input from MIPWA 3.0. The GG lies mostly between 20 and 60 cm below ground level. For plots 1 and 2, the GVG even lies between 0 and 20 cm below ground level. For plot 1-3 a slightly positive seepage flux is indicated and a strong one for plot 4.
- According to the Dutch soil map, plots 1 and 2 consist of AM or 'mengelsoils', plot 3 of Rn45A or 'calcareous poldervaagsoils; heavy clay' and plot 4 of Rn95A or 'calcareous poldervaagsoils; heavy silt and light clay'.
- WWN predicts the same for the 4 plots for both the current and the past, undisturbed situation (Figure B.1.1f). For plot 2, mainly H22 is predicted (forest and shrublands on wet, nutrient-poor, slightly acidic soils) and a part H28 (forest and shrublands on wet, very nutrient-rich soils). For plot 4, H27

(forests and shrublands on wet, moderately nutrient-rich soils) is predicted. Plot 3 is not included in the calculation, while plot 1 is mostly without results.
- For all four plots the ambition proposal is N14.02 (raised and low bogland forest).

Approach
- Make a soil profile for each plot, determine pH and groundwater table.
- Describe trees and plants per plot as accurately as possible.
- Check whether the plots are drained by means of ditches.

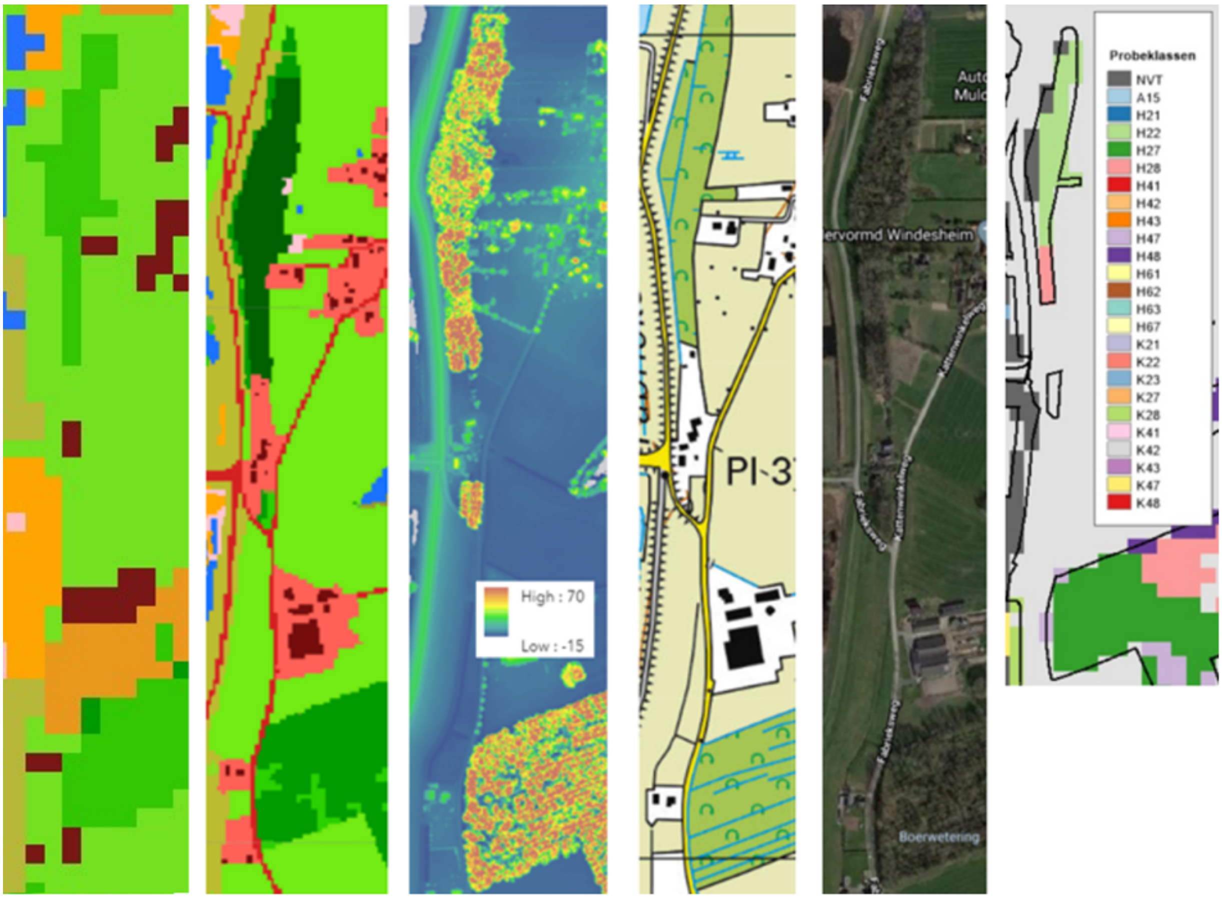


Figure B.1.1: a) LGN6 map, on which plots 1, 2 and 4 are deciduous forest and plot 3 is agricultural grass. b) Map LGN2020, on which plots 1 and 2 are forest in marshland and plots 3 and 4 are a combination of deciduous and coniferous forest. c) Height map of AHN. d) Map from Topotijdreis 2020. e) Aerial photo from Google Maps. f) Results WWN for both the current and past, undisturbed situation.

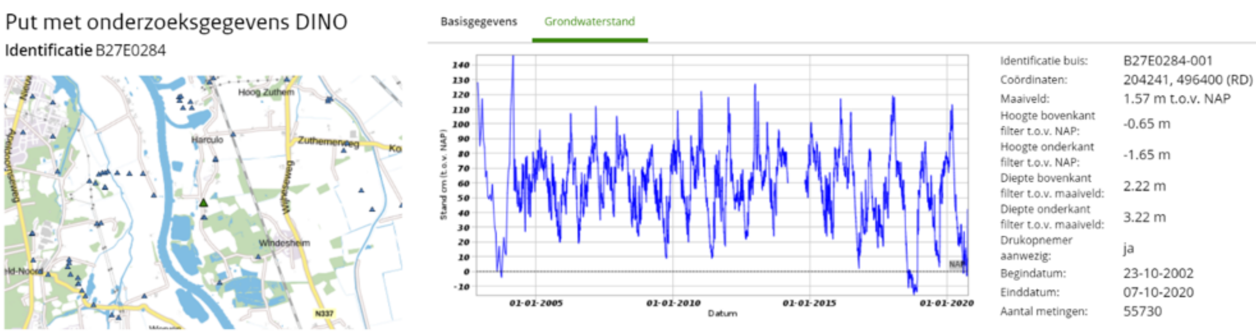


Figure B.1.2: Groundwater levels right next to plot 3 from 2002 to 2020.

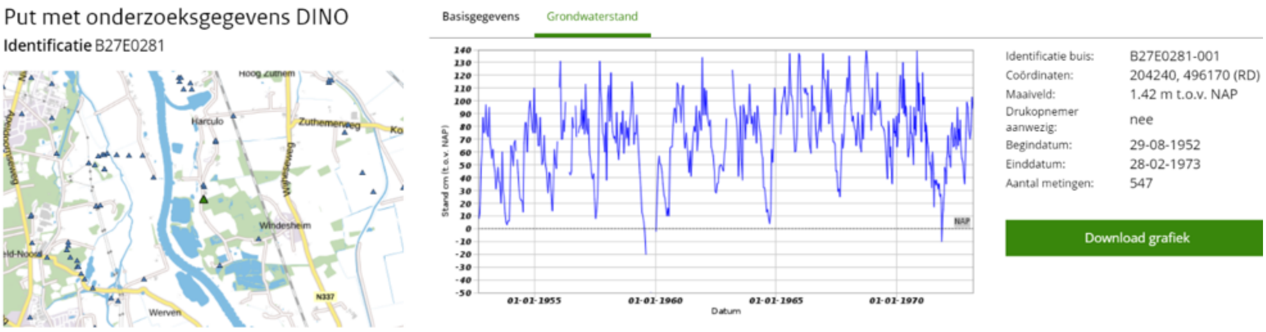


Figure B.1.3: Groundwater levels directly above plot 4 from 1952 to 1973.

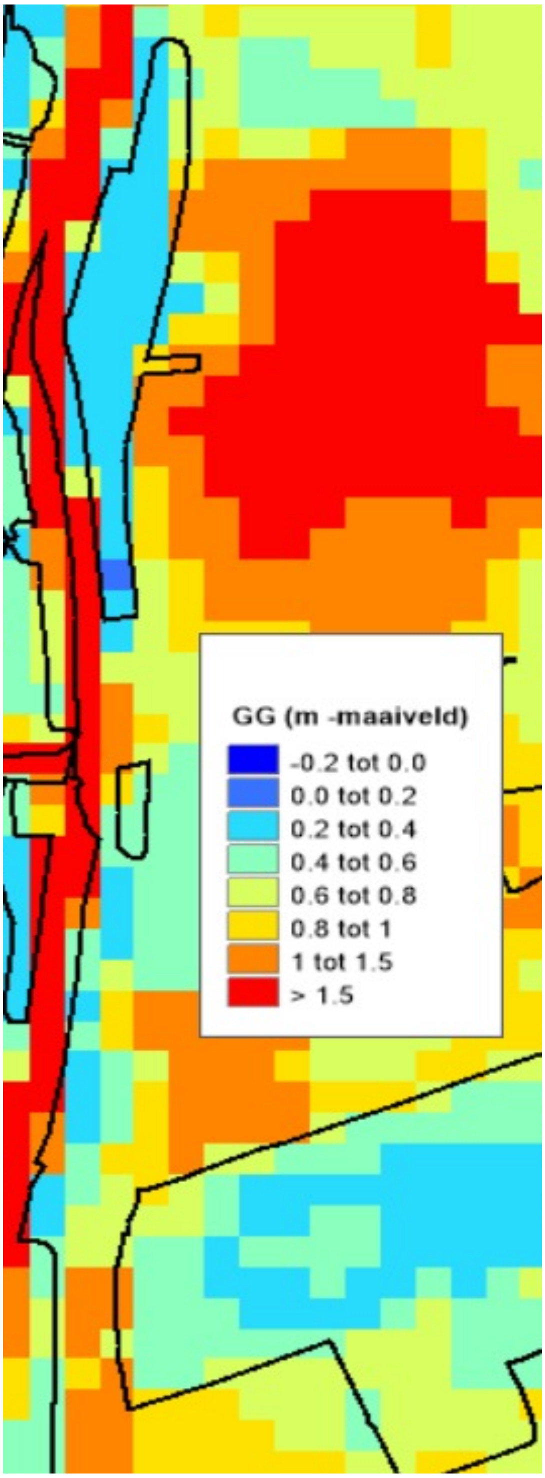


Figure B.1.4: MIPWA 3.0 input for the GG.

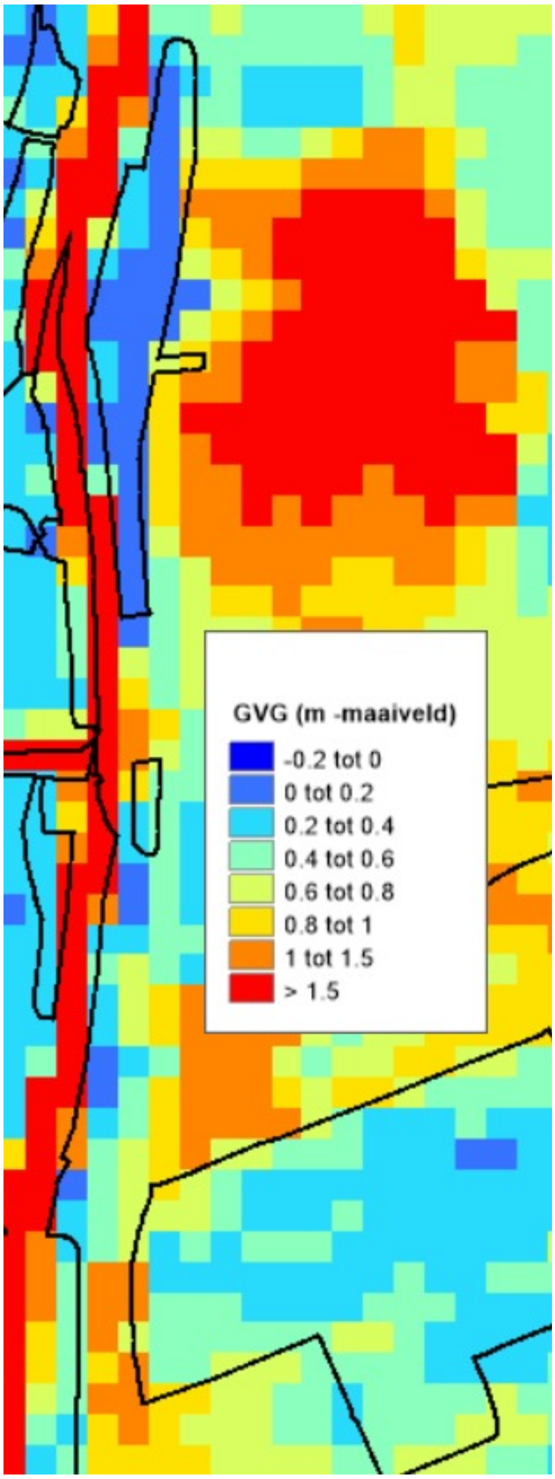


Figure B.1.5: MIPWA 3.0 input for the GVG.

Results

Table B.1.1: Field data of the locations corresponding with Figure B.1.6.

Location (fig. B.1.6)	RD-coord.	GWT (cm)	PH (-)	Description
1	204198, 496898	45	5.3 at 10cm 7.3 at 110cm	Undergrowth slightly less dense than location 2, mainly Urtica spec. and sycamore (Figure B.1.10). Trees same as location 2 with sometimes a Salix triandra in between and a lot of dead wood. The ditch between location 1 and 2 is almost completely filled in and very soggy. No clear indications of forest being used for wood production. Soil profile (Figure B.1.7): - 0-10 cm: black soil. - 10-50 cm: very fine soil, slightly peaty and fairly moist. Gradually more rust with around 50 cm a lot of rust. - 50-90 cm: fine to slightly coarse sand, yellowish and moist. - 90-105 cm: fine, light grey, very moist sand. - 105+ cm: clay.
2	204225, 496880	25	5.5 at 10cm 7.5 at 110cm	Forest with large numbers of Urtica spec. and Rubus spec. (disturbance species). Furthermore, Fraxinus excelsior, Lamium galeobdolon subsp. argentatum, Crataegus spec., Humulus lupulus, Alnus glutinosa, Phragmites australis, Populus spec. and Acer pseudoplatanus (Figure B.1.11). No clear indications of forest being used for production. Much dead wood on plot. Soil profile (Figure B.1.8): - 0-55cm: Peaty, dark and wet soil with around 20cm some iron concretions. Very soggy and spongy material, auger can be pushed right through and groundwater in borehole reacts to the slightest footstep. - 55+ cm: fine to slightly coarse, light grey sand, very moist.
3	204231, 496399	n/a	7.7 (water)	First there were big trees, now they have been cut down (Figure B.1.12). The soil feels firm, not like peat. Drained on the two long sides by ditches of 80 cm deep with 20 cm of water. The plot now contains thick grasses, Plantago lanceolata, Lapsana communis, Glechoma hederacea, Taraxacum spec., Lythrum salicaria, Equisetum palustre, Trifolium arvense and Trifolium repens.
4	204225, 496142	n/a	n/a	Plot 4 is heavily drained by a ca. 3 m wide ditch of ca. 2 m deep with 50 cm of water (Figure B.1.15).
5	204239, 496031	40	8.0 (water) 6.5 at 10cm 7.4 at 110cm	Production forest (Figure B.1.13) with every few metres a ditch about 80 cm deep with 20 cm of water with a pH of 8.0 due to seepage (Figure B.1.14). Much dead wood, often cut, sometimes fallen over. More accessible than plots 1 and 2, but a lot of Urtica spec. Trees include the Viburnum opulus, Acer campestre, Euonymus europaeus, Ulmus spec., Fagus sylvatica, Corylus avellana, Populus spec., Crataegus monogyna, Fraxinus excelsior, Salix spec., Acer spec. and sometimes Betula spec. and Quercus spec. Soil profile (Figure B.1.9): - 0-40 cm: silty, slightly peaty, brownish grey. - 40-70 cm: silt, grey with increasing amounts of rust. - 70+ cm: wet clay.
6	204223, 495959	n/a	n/a	Along the road there is a deep ditch with reeds, but due to the dense vegetation it is impossible to determine how deep and how much water.

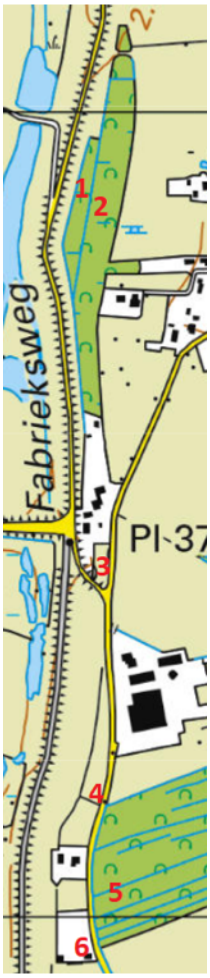


Figure B.1.6: Map of Topotijdreis 2020 with points of interest.

Figure B.1.7: Soil profile at location 1.

Figure B.1.8: Soil profile at location 2, topsoil at plopper/dompelklokje instead of auger handle

Figure B.1.9: Soil profile at location 4.


Figure B.1.10: Forest at location 1.


Figure B.1.11: Forest at location 2.


Figure B.1.12: Trees cut down at location 3.


Figure B.1.13: Forest at location 4.

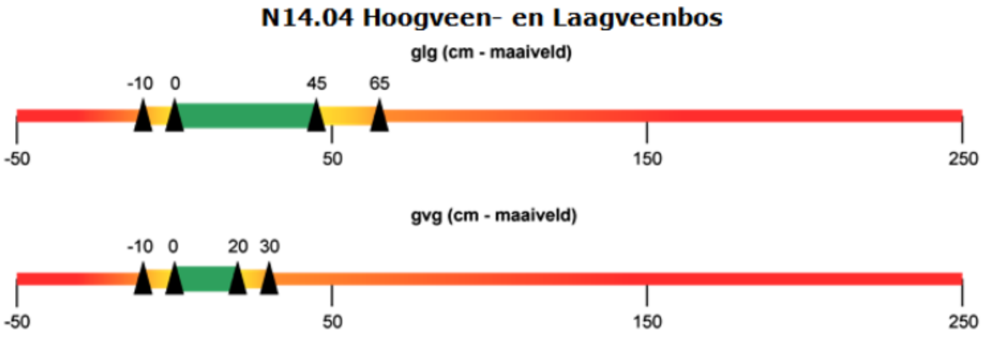

Figure B.1.14: Iron film at location 4.


Figure B.1.15: Deep ditch next to plot 4.

Figure B.1.16: Street view photo in June 2021 (Google Maps, 2022).

Discussion and conclusions

- In this case, LGN6 is closer to the current reality than LGN2020, as there is no forest on plot 3 and no coniferous forest. However, this is due to the lower accuracy of LGN6 compared to LGN2020, which allows for fewer errors, and the fact that the forest on plot 3 has been cut down very recently (Figure B.1.16), while it was still there in 2007/2008. The fact that LGN6 is now more accurate is therefore no more than a coincidence for this specific area.
- The tree species per plot are described in Table B.1.1, from which it is clear that there are no trees on plot 3. The tree species on plots 1 and 2 are practically the same. On plot 4 there are also larger, thicker trees such as *Quercus spec.*, *Populus spec.* and *Fagus sylvatica* (probably for production purposes because of the logging activities). The trees on plots 1 and 2 fit well with N14.02 while the trees on plot 4 fit better with N16.04.
- The groundwater levels on plots 1, 2 and 4 are respectively 45, 25 and 40 cm below ground level, which all fits within the ideal conditions of N14.02 (Figure B.1.17). Given the water level in the ditches of plot 3, it is likely that the groundwater level also falls within this range here.
- Plots 1 and 2 are not drained in the direct vicinity. Plot 3 is drained by small ditches, while plot 4 is heavily drained by deep ditches. Yet the groundwater level here is relatively shallow, which can be explained by the thick clay layer (Table B.1.1. and Figure B.1.9).
- MIPWA 3.0 data proved to be pretty accurate, the groundwater levels were sometimes 10-20 cm higher than the GG indicated. As this is only a slight difference and the GG indicates an average, the data can be considered reliable. Furthermore, the conditions on plots 1 and 2 do indeed indicate a slight positive seepage flux and on plot 4 strong seepage flux with the surface water pH being 8.0
- The soils of plots 1 and 2 do not belong to the predicted AM mengelsoils, given the lack of mixing of layers and the absence of sand in clay. The soil of plot 4 is also no Rn95A since no indications of calcium were found and the clay was not light but heavy and the top layer is peaty and dark in colour. Since no soil profile was made at location 3, the predicted Rn45A cannot be verified there. In general, the Dutch soil map is
- The predictions of WWN for plot 2 are fairly accurate as it is a forest on wet soil. However, the peaty soil is quite rich in nutrients, so an H27 would have been more suitable than an H22. For plot 4 this is the same, so the predicted H27 is correct.
- With regard to the ambition proposal N14.02 (raised and low bogland forest) for all four plots, it has become clear that plot 2 in particular is suitable given the vegetation and soil. This was also the only plot already classified as N14.02. Plot 1 also contains some peat and is moist, so it also has the potential to become N14.02. For plot 4, the same applies in principle, only now it is clearly used for wood production of species like Quercus spec., Fagus sylvatica and Populus spec., which would have to change. Plot 3 is currently not a forest and therefore cannot become a high or low moorland forest in the coming years.



N14.04 Hoogveen- en Laagveenbos. Ranges waarbij voor hoog- en laagveenbos kenmerkende vegetaties kunnen voorkomen voor gemiddelde laagste grondwaterstand (GLG) en gemiddelde voorjaarsgrondwaterstand (GVG).
Bij het bepalen van de range van de GVG is uitgegaan van het habitattype H91D0 Hoogveen-bossen.

Figure B.1.17: Suitable conditions for raised and low bogland forest according to BIJ12.

B.2 Floodplains IJssel moist meadow

The location of the investigated site is indicated by the red circle in the figure below and was visited on November 4, 2021.

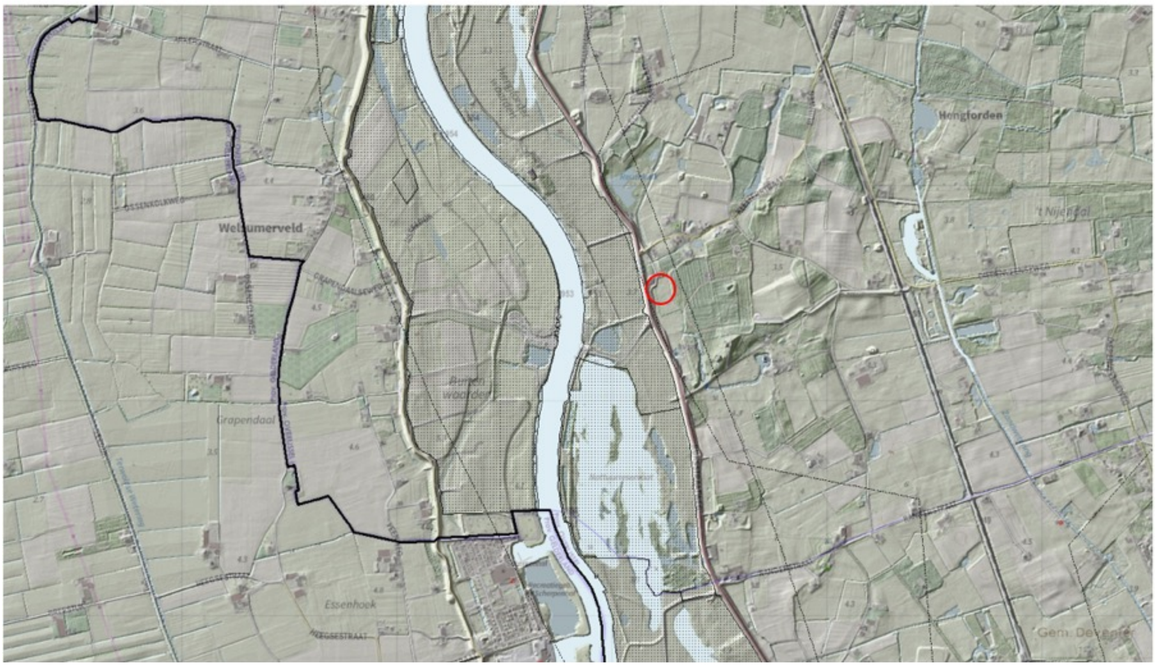


Figure B.2.0: Location 6 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site. In preparation direct available spatial information was checked before visiting the site in the field.

Questions

- The current nature management type of the plot is N12.02 grasslands rich in herbs and fauna. Excavation of part of the plot is being considered to create N10.02 moist meadow. What kind of soil and groundwater level will be found here?
- WWN indicates potential seepage and moist nutrient-poor habitat (K42). What can be seen of this in the field and what is the pH?
- Are WWN's predictions correct with regard to the current and past, undisturbed situation?

Preparation

- Figures B.2.1a-b and B.2.4 show a field with a hedgerow with a ditch and a small pond. On the height profile (figure B.2.2), the part that might be excavated seems to be already slightly lower, but this is only about 10 centimetres. On the aerial photo, circular shapes can be seen under the hedge, which could be moist spots.
- Both LGN6 and LGN2020 indicate that the plot consists of natural grassland (Figures B.2.1c-d).
- For the current situation (Figure B.2.3) WWN predicts predominantly K42 or 'pioneer vegetation and grassland on moist, nutrient-poor, slightly acidic soils (violion caninae grassland, calcium-poor dune valleys)' and partly K41 or 'pioneer vegetation and grasslands on moist, nutrient-poor, acidic soils (wet heathland and bogs)', which is almost the same.
- For the past, undisturbed situation (Figure B.2.4) WWN predicts for almost the entire plot K21 or 'Pioneer vegetation and grasslands on wet, nutrient-poor, acidic soils (wet heathland and raised bogs)', which is the wetter version of K42 and K41.
- According to DINOloket, there is no well with groundwater levels on or near the plot.
- MIPWA 3.0 states that the groundwater level is between 40 and 60 cm below ground level for the GG and between 20 and 40 cm below ground level for the GVG and that the flux is slightly negative.
- According to the Dutch soil map, the soil consists of a Zb21 or vorstvaagsoils; loam-poor and weak loamy fine sand.

Approach

- Making soil profiles on the plot and determining the groundwater level. Also measure pH, of both soil and water as well as ditch.
- Search for seepage indicators (iron film or flora such as Hottonia palustris, Equisetum fluviatile).
- Determine the nutrient richness and check whether the field is drained.
-

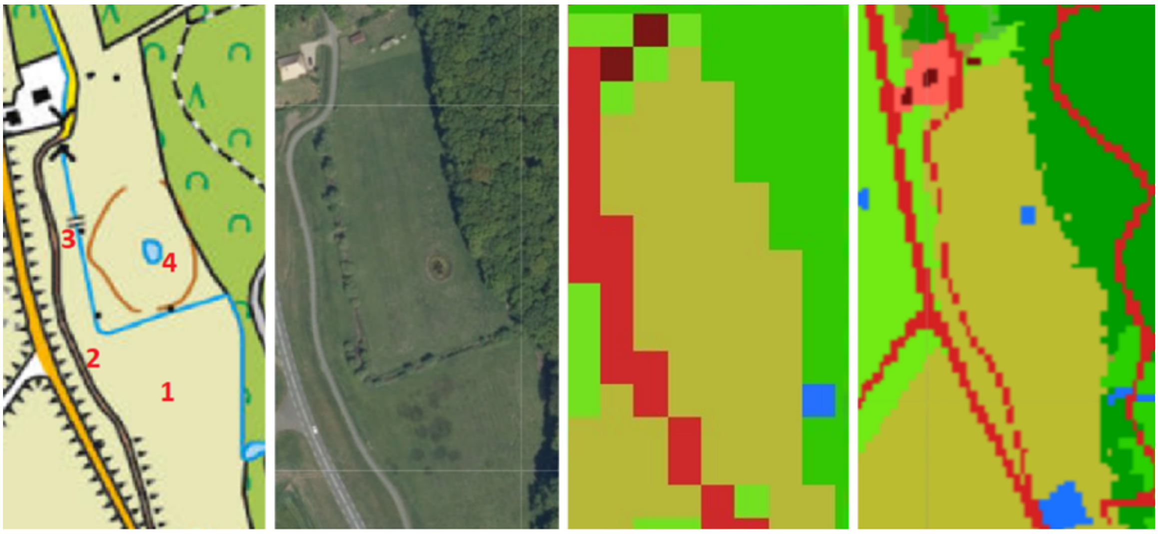


Figure B.2.1: a) Map from Topotijdreis 2020 with points of interest. b) Aerial photo of plot from Topotijdreis 2020. c) According to LGN6 natural grasslands. d) According to LGN2020 natural grasslands and a water surface.

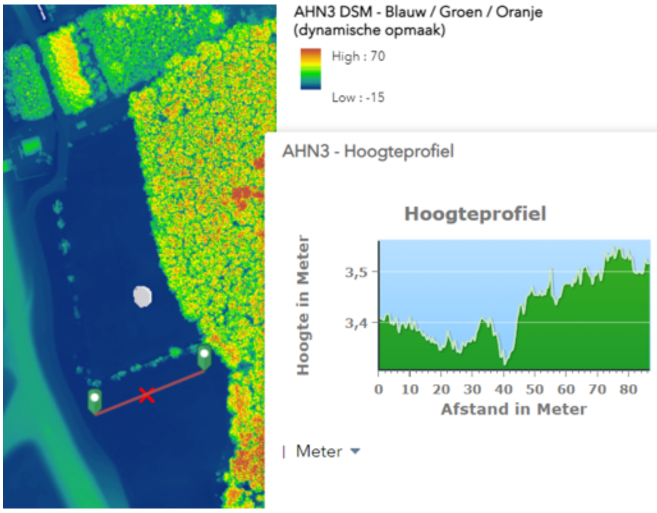


Figure B.2.2: Height data including a height profile from AHN.

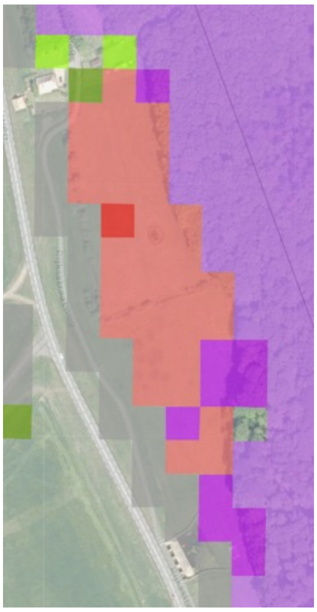


Figure B.2.3: WWN predicts K42 (light red) and some K41 (medium purple) for the current situation.

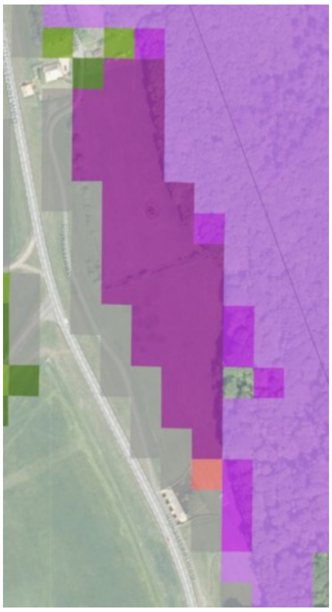


Figure B.2.4: WWN predicts K21 (dark purple) for nearly all of the plot for the past, undisturbed situation.

Results

Table B.2.1: Field data of the locations corresponding with Figure B.2.1a.

Location (fig. B.2.1a)	RD-coord.	GWT (cm)	PH (-)	Description
1	204271, 480354	100	5.0 at 10cm 7.5 at 110cm	Moderately nutrient-rich meadow with sheep (Figure B.2.5). Short grass with large patches of Juncus acutiflorus and Juncus effusus. Also, a lot of Ranunculus repens and Trifolium spec. and Taraxacum spec. Soil profile (Figure B.2.9): - 0-15 cm: fine, dark brown soil. - 15-45 cm: fine, light-coloured sand with small pebbles (a few mm). - 45-70 cm: moderately coarse sand with pebbles (a few mm) with a lot of rust - 70+ cm: alternating between fine to coarse sand, in coarser sand also some pebbles (a few mm). Up to 1 m very little rust. Beginning slightly moist, end very moist.
2	204221, 480376	n/a	n/a	Hedge (Figure B.2.6) with pollard Salix spec., small Quercus spec., Alnus glutinosa, Rubus spec. and Urtica spec. Dry ditch 60 cm deep.
3	204204, 480467	100	5.3 at 10cm 7.4 at 110cm	Grasses more predominant (Figure B.2.7), otherwise same flora as location 1 with occasional small patch of Juncus acutiflorus and Juncus effusus. Soil profile (Figure B.2.10): - 0-30 cm: dark soil. - 30-55 cm: grey-brown, fine sand. - 55-80 cm: initially fine, then coarse sand with some pebbles (a few mm) and a lot of rust. - 80-120 cm: very fine, light grey sand with some very small pebbles. Beginning quite moist, end very moist. - 120+ cm: very light-coloured, coarse, moist sand.
4	204277, 480449	n/a	6.7 (water)	Water surface 1m below ground level (Figure B.2.8). Meadow same as location 1 & 3. Along the water's edge Rorippa amphibia, Lysimachia nummularia and Galium spec.


Figure B.2.5: Surroundings at location 1.


Figure B.2.6: Hedgerow at location 2.


Figure B.2.7: Surroundings at location 3.

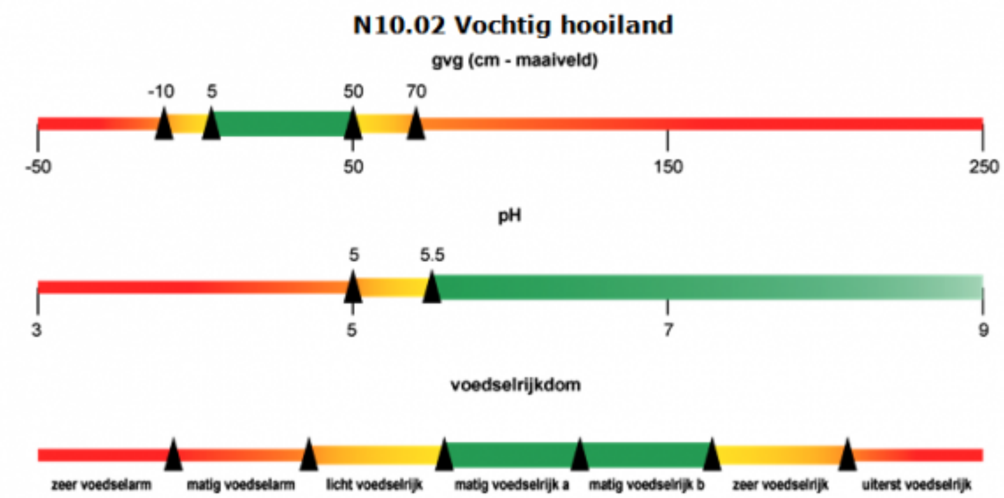

Figure B.2.8: Oligotrophic pond at location 4.


Figure B.2.9: Soil profile at location 1.


Figure B.2.10: Soil profile at location 3.

Discussion and conclusions

- No direct indications of seepage in the form of an iron film or flora were found. However, the pH of the oligotrophic pond (6.7) and the pH at a depth of 110cm of around 7.5 indicate the presence of seepage, so we assume that it is indeed present in contradiction to what MIPWA 3.0 indicated.
- The field is drained by a ditch of 60cm depth that is currently dry.
- With the groundwater table found to be 100cm below ground level, it becomes clear that MIPWA 3.0 data are too wet, which may explain why WWN arrives at moist conditions. LGN6 and LGN2020 correctly indicate missed the oligotrophic pond.
- The soil indeed resembles a Zb21 with humus-poor, yellow-brown to orange-yellow deeper layers, but has a lot of coarse sand where a standard Zb21 consists of fine sand.
- WWN's prediction for the current situation is quite accurate. The field can indeed be called a violion caninae, nutrient-poor grassland, only at location 3 it is rather moderately nutrient-rich and the pH in the upper 10cm is on the acidic side for a K42. But in general, conditions are pretty good when compared to BIJ12 criteria for an N10.02 (figure B.2.11).
- The prediction K21 for the past, undisturbed situation is correct if the groundwater level would rise somewhat and the plot would be excavated 10 to 20 cm. With that, the ambition proposal to transform the plot into N10.02 (moist meadow) is feasible, but quite a lot of work still needs to be done.



N10.02 Vochtig hooiland. Ranges waarbij voor vochtig hooiland kenmerkende vegetaties kunnen voorkomen voor gemiddelde voorjaarsgrondwaterstand (GVG), zuurgraad (pH) en voedselrijkdom.

Figure B.2.11: Ideal conditions for a moist meadow according to BIJ12.

APPENDIX C: OVERIJSSELSCHE VECHT VALLEY

C.1 Overijsselsche Vecht valley moist meadows

The location of the investigated site is indicated by the red circle in the figure below and was visited on November 8 and 10, 2021.

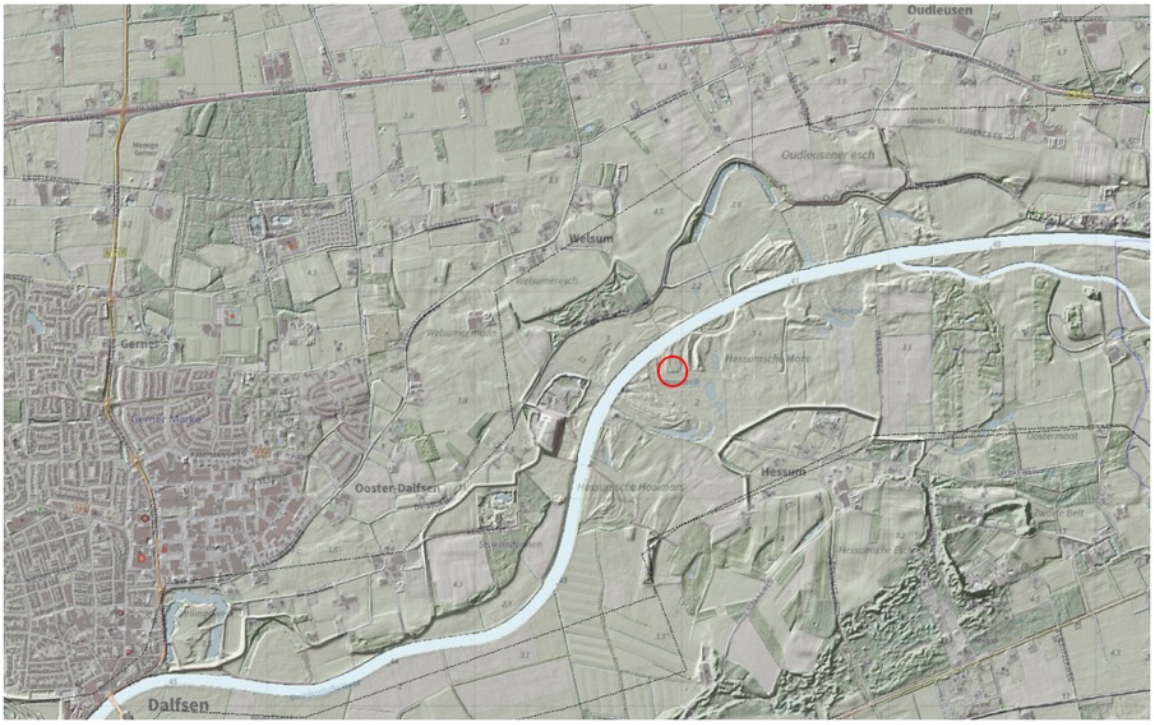


Figure C.1.0: Location 7 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site. In preparation direct available spatial information was checked before visiting the site in the field

Questions

- For all eight plots (Figure C.1.1), how does the soil profile look like and what is the groundwater level? Is this suitable for N10.02 (moist meadow)?
- To what extent is MIPWA 3.0 (for GHG and GLG) correct?
- Are the predicted nature management types by WWN for the current and past, undisturbed situation feasible?

Preparation

- Figure C.1.1 shows the 8 plots of interest, Figure C.1.2 shows the height map including a height profile through two of the plots. It shows that the plots of interest are lower than surrounding fields. When looking at the historical map from 1910 (Figure C.1.3), it turns out that most parts of the lower plots were part of the Overijsselsche Vecht, which later was canalized (Figure C.1.4). The same can be seen on the aerial photograph in Figure C.1.5.
- Figure C.1.6 shows the current nature management types. Plots 1 and 4 are currently N12.02 (grasslands rich in herbs and fauna), plot 2 is already an N10.02 (moist meadow), plots 5-8 are N11.01 (dry nutrient-poor grassland) and plot 3 is a combination of them.
- The ambition is to transform all 8 plots into N10.02. As can be seen in Figures C.1.3-4, the area was and is part of the Hessumsche Mars (mars = marsh, wetland), which supports this ambition well.
- Figure C.1.7 shows the results from WWN for the current situation, while Figure C.1.8 shows the results for the past, undisturbed situation. For the current situation, most part of the 8 plots consists of K22, K42 and K41. For the past, undisturbed situation, this is even more. Furthermore, K21, K28, K48, K61 and K68 are present.
    - K22: Pioneer vegetation and grasslands on wet, nutrient-poor, slightly acidic soils (sphagnum reed lands, floating mat, Sesleria albicans grasslands, calcium-poor dune valleys).
    - K42: Pioneer vegetation and grasslands on moist, nutrient-poor, weakly acidic soils (violion caninae grassland, calcium-poor dune valleys).

    - K41: Pioneer vegetation and grasslands on moist, nutrient-poor, acidic soils (wet heathland and raised bogs).
    - K21: Pioneer vegetation and grasslands on wet, nutrient-poor, acidic soils (wet heathland and raised bogs).
    - K28: Pioneer vegetation, grasslands and shrublands on wet, very nutrient-rich soils (shrub-lands along rivers and ditches, wet cultivated grassland).
    - K48: Pioneer vegetation and grasslands on moist, very nutrient-rich soils (agricultural fields, roadsides, factory grounds).
    - K61: Pioneer vegetation and grasslands on dry, nutrient-poor, acidic soils (dry heathland).
    - K68: Pioneer vegetation, grasslands and shrublands on dry, moderately nutrient-rich soils (undergrowth in heavily fertilised fields, ruderal vegetation along rivers).
- Figure C.1.9 shows the MIPWA 3.0 data for the GVG. It is very variable for the different plots, with groundwater levels between 0 and 20 cm below ground level for plot 5 and between 125 and 150 cm below ground level for the southern part of plot 4. Only for the southern part of plot 5 a slightly positive seepage flux is indicated, for the rest of the plots it is slightly negative.
- According to LGN6 (Figure C.1.10), most of the plots consist of natural grasslands and part of the plots also of corn fields and grass in secondary built-up area. According to LGN2020, all plots consist of natural grasslands.
- DINOloket shows no wells with groundwater data near the plots.
- The Dutch soil map 1:50,000 indicates that plots 1-4 and 6 consist of fZn21 while plots 5, 7 and 8 are a combination of fZn21, fZn23 and Zb21.
    - The f stands for 'locally iron-rich, starting within 50cm and at least 10cm thick'.
    - Zn21: Vlakvaagsoils; loam-poor and weak loamy fine sand.
    - Zn23: Vlakvaagsoils; loamy fine sand.
    - Zb21: Vorstvaagsoils; loam-poor and weak loamy fine sand.

Approach

- Make a soil profile for all 8 plots and determine groundwater level and pH of the soil at 10 and 110 depth and if present of surface water.
- Describe flora at each plot and look for drainage of plots.

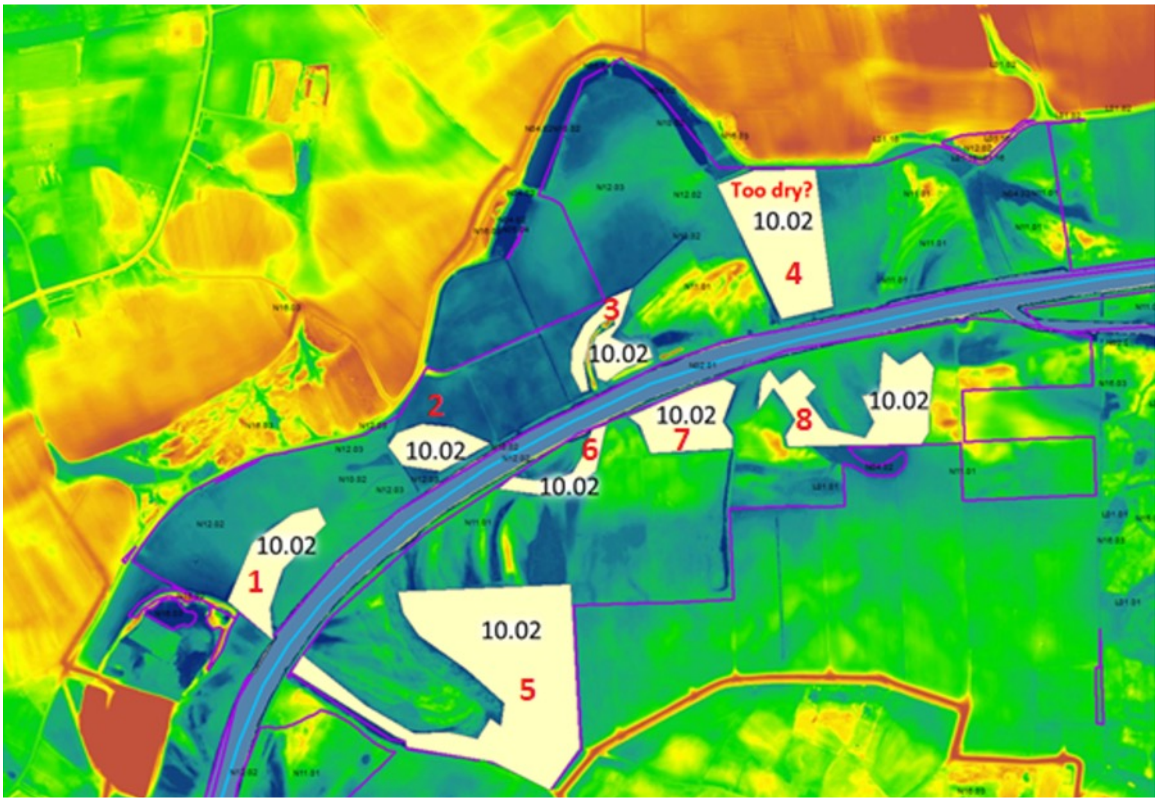


Figure C.1.1: Overview map (provided by Witteveen+Bos) of all 8 plots for which it is proposed to transform them into N10.02 (moist meadow).

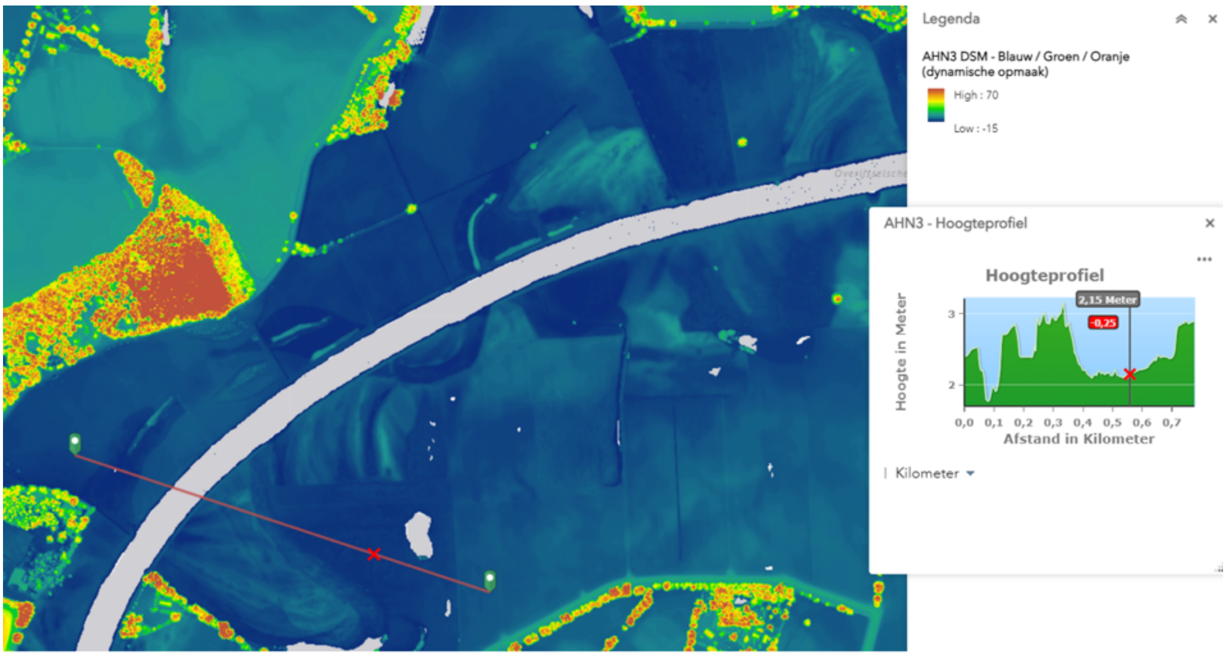


Figure C.1.2: Height data from AHN including a height profile.

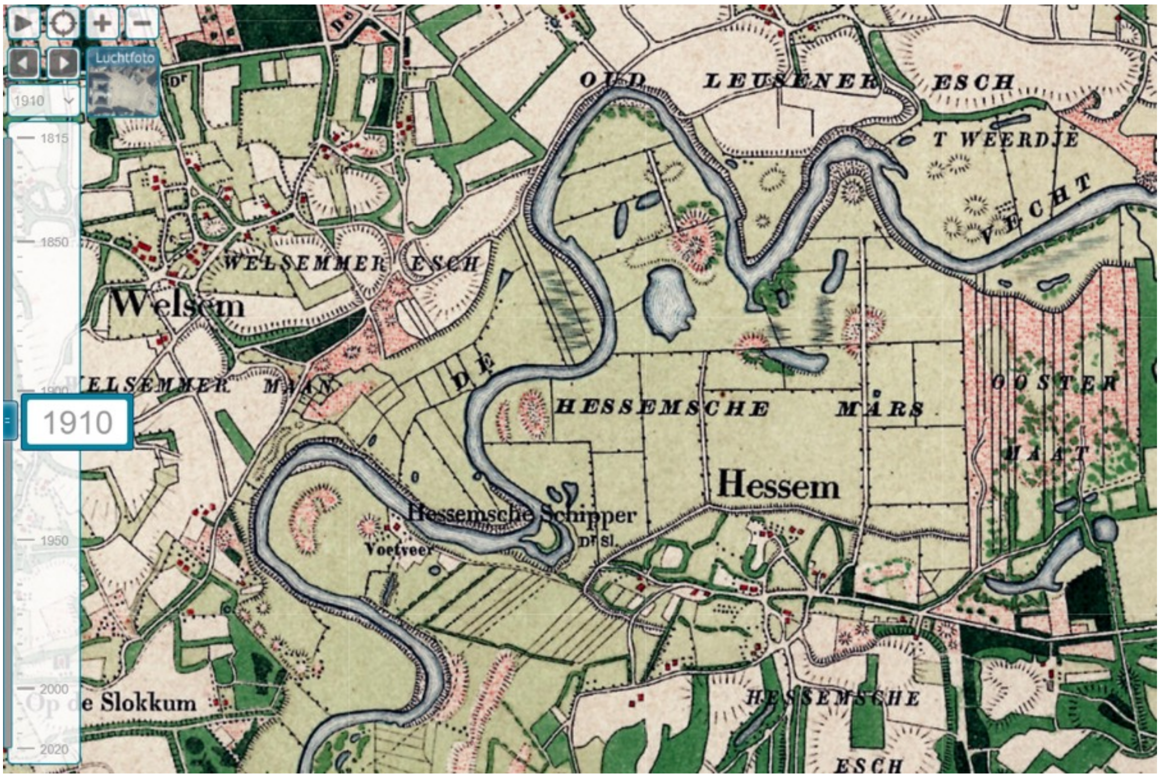


Figure C.1.3: Map from Topotijdreis 1910, showing the old meanders of the river Overijsselsche Vecht across the plots, part of the Hessemsche Mars (=marsh, wetland).

Figure C.1.4: Map from Topotijdreis 2020, showing the current course of the Overijsselsche Vecht. Plots are still part of the Hessumsche Mars.

Figure C.1.5: Aerial photo from Topotijdreis 2020. The old meanders are still partly visible.

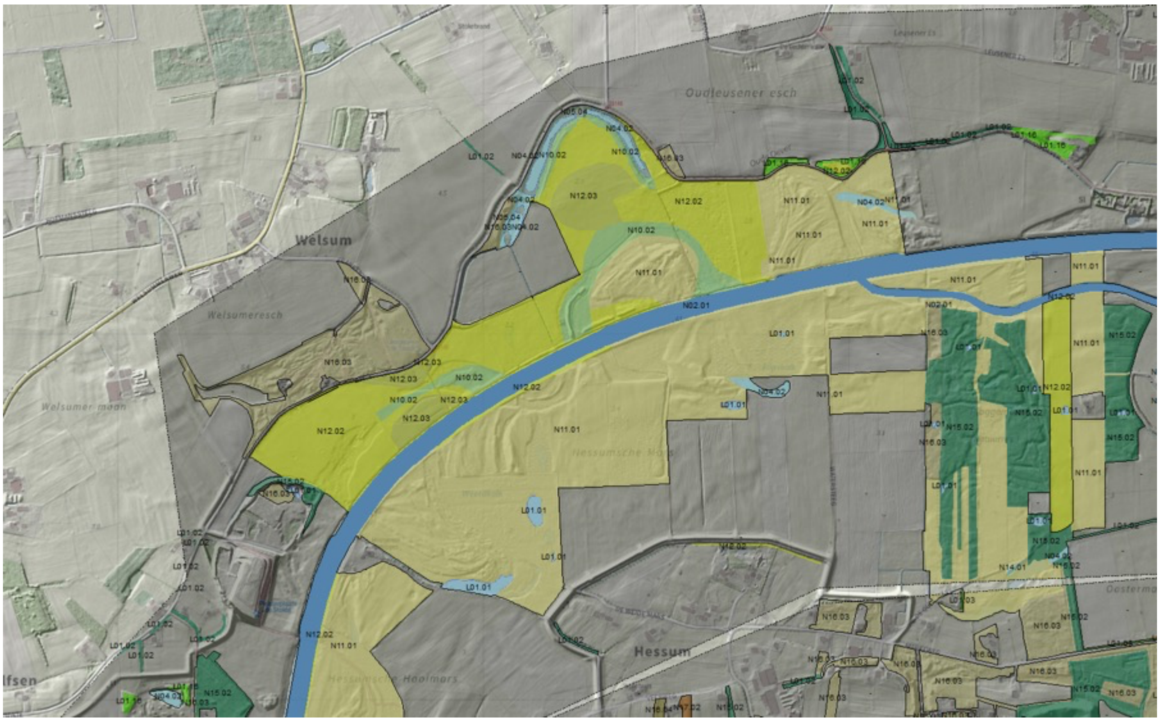


Figure C.1.6: Map showing the current nature management types (provided by Witteveen+Bos).

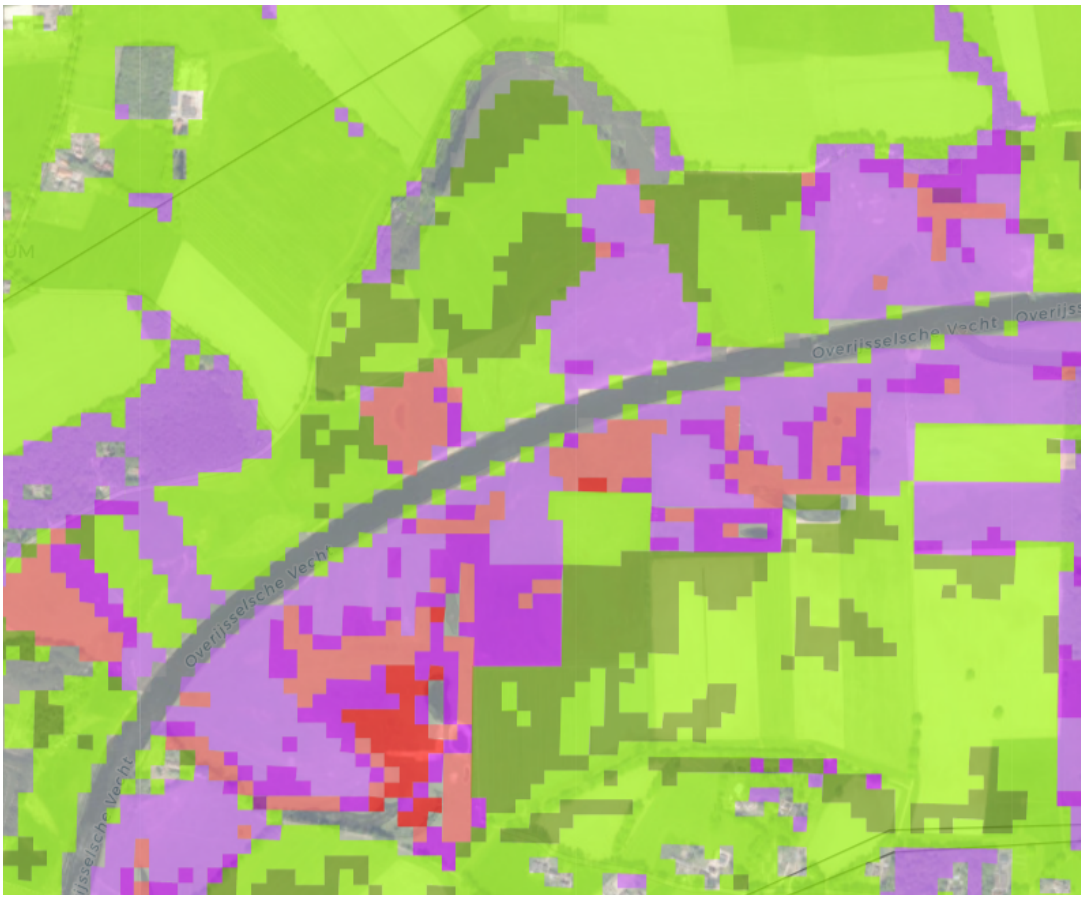


Figure C.1.7: Results from WWN for the current situation (red = K22, pink = K42, light green = K68, medium green = K48, dark green = K28, light purple = K61, medium purple = K41, dark purple = K21).

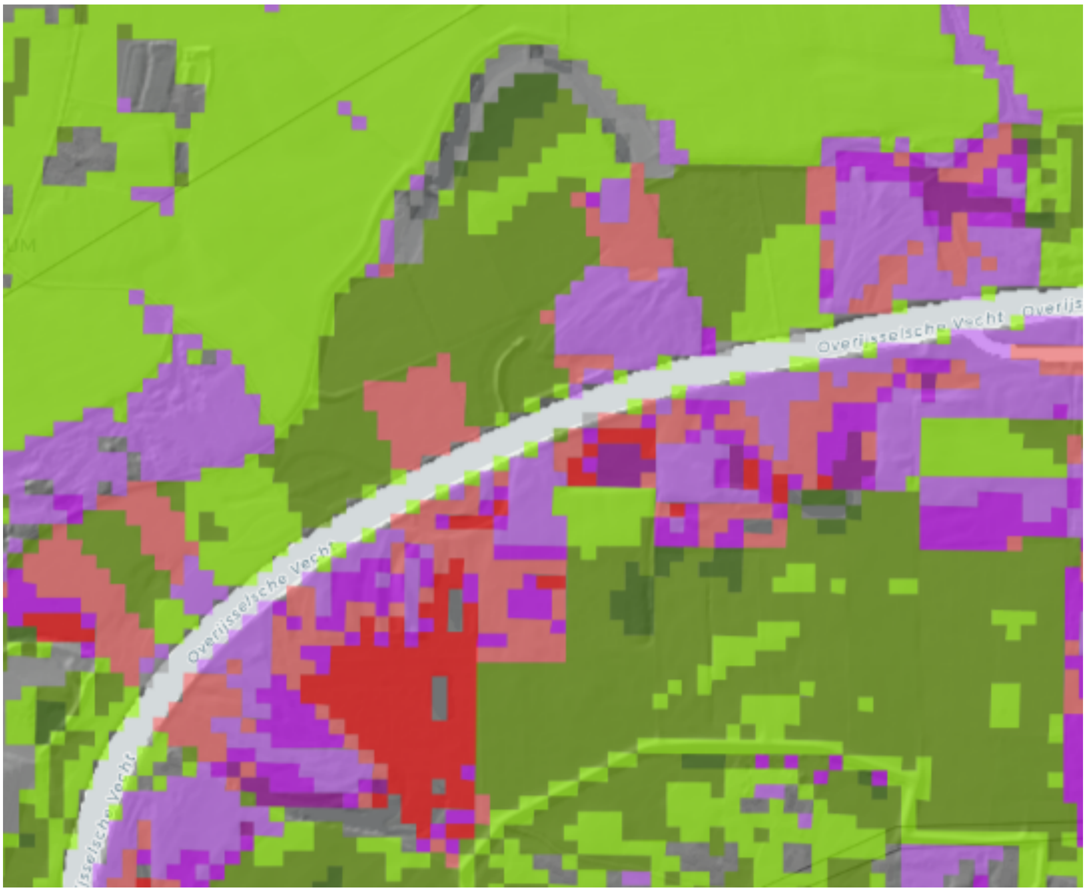


Figure C.1.8: Results from WWN for the past, undisturbed situation. Colour scheme same as for figure C.1.7.

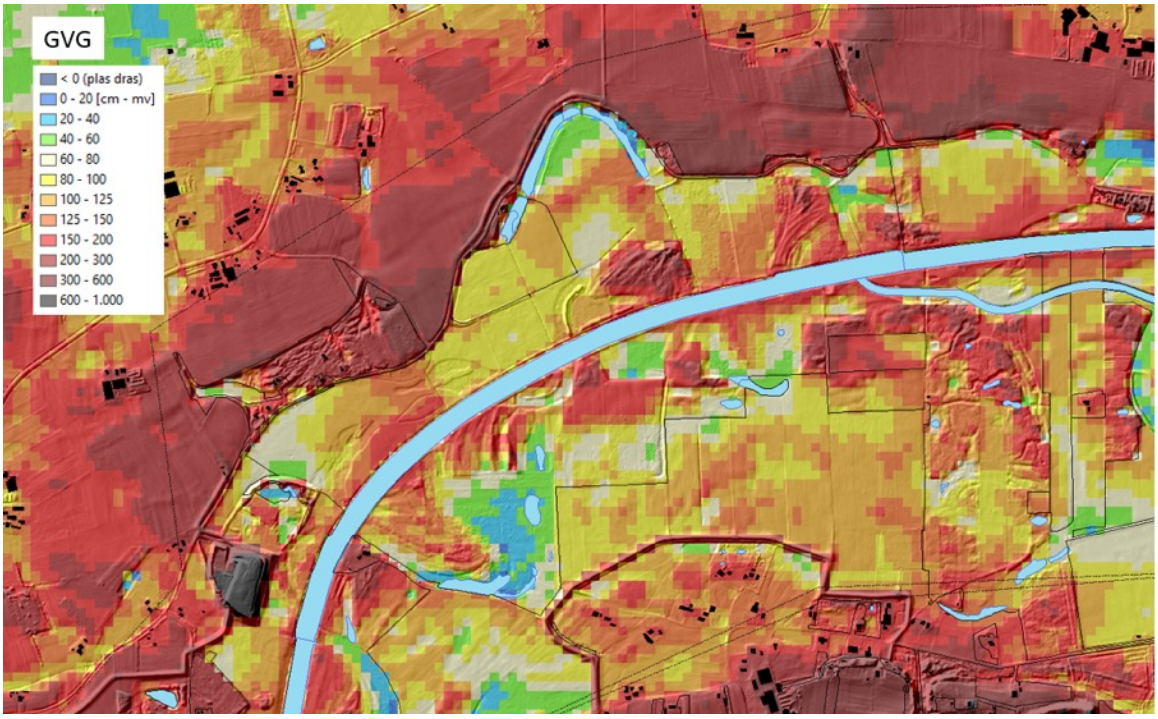


Figure C.1.9: Map provided by Witteveen+Bos showing the MIPWA 3.0 data for the GVG.

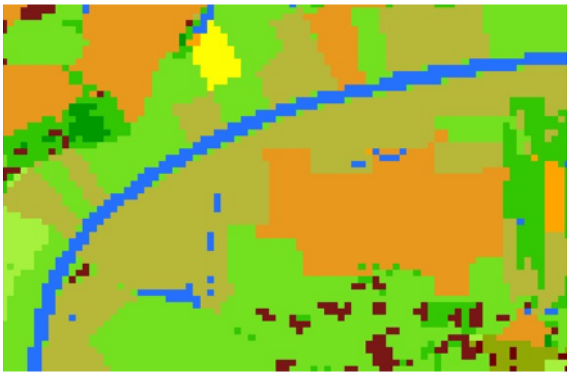


Figure C.1.10: According to LGN6 mostly natural grasslands (golden yellow), partly corn (orange) and grass in secondary built-up area (light green)

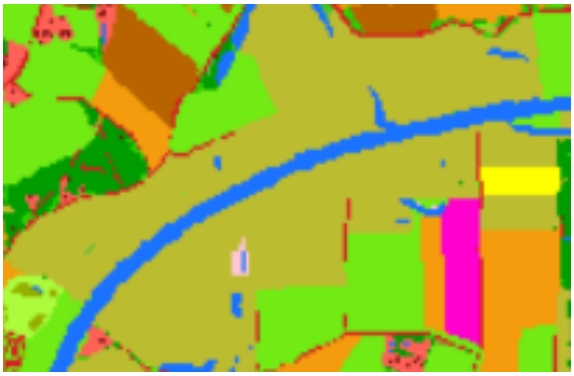


Figure C.1.11: According to LGN2020 nearly completely natural grasslands (golden yellow).

Results

Table C.1.1: Field data of the locations corresponding with Figure C.1.4.

Location (fig. C.1.4)	RD-coord.	GWT (cm)	PH (-)	Description
1	216623, 503641	10	5.4 at 10cm 6.1 at 110cm 6.7 (water)	Part of old stream channel, stagnant water in the middle. The higher surrounding land is much more monotonous grassland. Cows are regularly present. North-eastern part is a shrubland (Figure C.1.20) with Phragmites australis, Lycopus europaeus, Salix spec., Alnus glutinosa, Betula pendula. In field Taraxacum spec., Salix spec., Plantago major, Plantago lanceolata, Lythrum salicaria, cuckoo flower, Cardamine spec., Hypochaeris radicata, Ranunculus repens, Epilobium spec., Trifolium repens. In water Callitriche spec., Myosotis scorpioides, Juncus effusus, Ranunculus sceleratus, Ludwigia grandiflora. Soil profile (Figure C.1.12): - 0-20 cm: very coarse, wet sand with iron bands.

				- 20-30 cm; moderately coarse to coarse sand, some rust, wet. - 30-75 cm: fine to medium sand, very black and wet. - 75+ cm: very coarse sand, brown to black. Seems to be a river deposit.
2	216930, 503878	50	5.5 at 10cm 6.3 at 110cm	Also, part of old stream channel (Figure C.1.21), cows present. In the field Trifolium repens, Juncus effusus, Plantago major subsp. major, Plantago major subsp. intermedia, Crepis capillaris, Rumex acetosa, Sonchus asper, Cirsium arvense, Lotus corniculatus, Filipendula ulmaria, Gnaphalium luteoalbum. Soil profile (Figure C.1.13): - 0-20 cm: coarse sand with a lot of rust. - 20-40 cm: coarse sand with a little rust. - 40-90 cm: fine to moderately coarse sand with a lot of rust in the beginning, then less. - 90-110 cm: very fine grey sand with some iron concretions. - 110+ cm: moderately coarse sand, very wet.
3	217262, 504020	85	5.8 at 10cm 6.5 at 110cm	Near a swampy depression and about 30m from the Overijsselse Vecht, cows are present. In the field Cirsium arvense, Ranunculus repens, Trifolium pratense, Salix spec., Artemisia vulgaris, Jacobaea vulgaris, Plantago lanceolata, Tanacetum vulgare, Eupatorium cannabinum, Leontodon saxatilis, Achillea millefolium, Juncus effusus, Filipendula ulmaria, Solidago gigantea, Taraxacum spec., Vicia spec. Soil profile (Figure C.1.14): - 0-10 cm: black soil. - 10-60 cm: moderately coarse sand with some iron concretions. - 60-75 cm: fine, wet sand with iron concretions. - 75-105 cm: very fine, wet, silty sand with black fragments (plant remains). - 105+ cm: moderately coarse, reddish brown, wet sand.
4	217610, 504315	75	5.1 at 10cm 6.6 at 110cm	Field with height differences of approx. 1 metre, lowest parts have water in them with Persicaria hydropiper, Callitriche spec., Veronica scutellata. In field Plantago lanceolata, Filipendula ulmaria, Rumex spec., Cardamine pratensis, Ranunculus acris, Taraxacum spec., Crepis capillaris, Silene flos-cuculi, Trifolium pratense, Jacobaea vulgaris, Cirsium arvense, Juncus effusus, Achillea millefolium. Soil profile (Figure C.1.15): - 0-5 cm: dark soil. - 5-35 cm: fine sand with many iron concretions. - 35-75 cm: very fine sand, silty with many iron concretions. - 75+ cm: very fine sand, silty, wet. Around 95 cm depth pieces of wood.
5	217059, 503477	40	4.5 at 10cm 6.6 at 110cm	Area with many flooded patches, cows present. Very large fields with Juncus effusus and grass within many places a layer of water of 10-15 cm, but also large dry areas. On wet parts Juncus effusus, Urtica spec., Rumex crispus, Cirsium arvense, Epilobium spec. and Taraxacum spec. On dry parts also Ranunculus acris, Plantago lanceolata, Potentilla anserina, Lysimachia nummularia, Hypochaeris

				radicata, Rumex acetosa and Rumex acetosella. Soil profile (Figure C.1.16): - 0-15 cm: brown soil with some rust around 10 cm. - 15-45 cm: moderately coarse, light sand with some iron concretions and some plant remains, quite wet at the bottom. - 45+ cm: dark grey, fine, drenched sand.
6	217183, 503812	60	5.0 at 10cm 6.8 at 110cm	Old stream channel (Figure C.1.22), cows present. Lots of Juncus effusus, Urtica spec. and Potentilla anserina. Also, Taraxacum spec., Ranunculus acris, Rumex acetosa, Glechoma hederacea, Plantago lanceolata, Hypochaeris radicata, Cardamine pratensis, Rumex crispus. Soil profile (Figure C.1.17) - 0-15 cm: brown soil. - 15-40 cm: moderately coarse, dark grey sand, initially a very small amount of rust. - 40-60 cm: fine to medium fine dark grey sand, fairly wet. - 60+ cm: fine, very wet light grey sand.
7	217412, 503930	55	5.1 at 10cm 6.8 at 110cm	Low-lying land, probably an old stream channel. Sometimes cows present. In some places soggy with a layer of water and lots of Juncus effusus, some places shorter grassland with lots of Juncus effusus and Urtica spec., also Rumex crispus, Cardamine pratensis, Cirsium arvense, Potentilla anserina, Ranunculus repens, Rumex acetosa, Glechoma hederacea, Ranunculus acris, Trifolium spec., Plantago lanceolata, Lysimachia nummularia, Taraxacum spec. Soil profile (Figure C.1.18) - 0-10 cm: brown soil. - 10-20 cm: moderately coarse, light-coloured sand. - 20-40 cm: moderately coarse sand, almost completely rusty. - 40-110 cm: fine sand, light grey, begins with some rust up to 60 cm, becomes increasingly wet and darker towards the end. - 110+ cm: moderately fine, dark grey, wet sand.
8	217819, 503937	45	5.0 at 10cm 6.7 at 110cm	Very densely vegetated field, old stream channel, nutrient-rich, sometimes cows are present. Lots of Juncus effusus and Urtica spec., also Cardamine pratensis, Epilobium spec., Lythrum portula, Galium palustre, Callitriche spec., Veronica scutellata, Persicaria hydropiper, Ranunculus acris, big chickweed, Crepis capillaris, Cirsium arvense, Myosotis scorpioides, Lycopus europaeus, Trifolium repens, Lysimachia nummularia, Potentilla anserina, Ranunculus flammula, Glechoma hederacea, Rumex crispus. Soil profile (Figure C.1.19): - 0-15 cm: brown soil. - 15-30 cm: fine brown sand with soil and some rust. - 30-65 cm: fine, dark grey sand with some plant remains. - 65+ cm: very fine, dark grey sand with some plant remains. Starts wet, ends soaking wet.

Figure C.1.12: Soil profile at location 1.

Figure C.1.13: Soil profile at location 2.

Figure C.1.14: Soil profile at location 3.

Figure C.1.15: Soil profile at location 4.

Figure C.1.16: Soil profile at location 5.

Figure C.1.17: Soil profile at location 6.

Figure C.1.18: Soil profile at location 7.

Figure C.1.19: Soil profile at location 8.

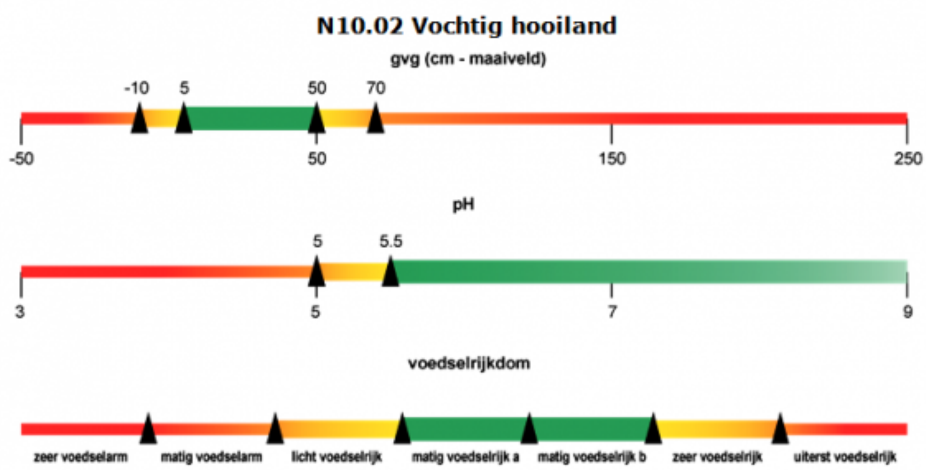
Figure C.1.20: Surroundings at location 1

Figure C.1.21: Surroundings at location 2

Figure C.1.22: Surroundings at location 6.

Discussion/conclusions

- LGN6 is outdated, LGN2020 is correct for the current situation. The plots are not being drained by means of ditches.
- No clear signs of positive seepage flux were found, although the pH at 110 cm depth was quite high (between 6.3 and 6.8) and the pH of surface water was found to be 6.7. The groundwater levels ranged between 10 and 85 cm below ground level, which matches pretty good with the GVG data from MIPWA 3.0 (Figure C.1.9). The biggest difference was the value of 125-150 cm for plot 4, which in reality was only 75 cm below ground level. But since the measurements were taken at the end of autumn, it can be expected that the groundwater level in spring will be somewhat higher. It can therefore be concluded that values from MIPWA 3.0 indicate slightly too low groundwater levels, which also applies to the GVG and GHG. However, since this is a relatively small difference, the data can be called reasonably reliable.
- Plots 1-4 and 6 indeed consist of loam-poor sand with often an iron-rich layer, but the sand is not always fine, especially for plots 1-3. Plots 5 and 7 show the same characteristics. Plots 3 and 5 also have some plant remains. Plot 8 is different from the other soils and is neither a vlak- nor vorst-vaagsoil. In general the Dutch soil map is correct for this area, but the sand is not always fine. This might be due to the areas of interest all being old riverbeds where coarse sand generally is deposited.
- The current nature management types are correct for plots 2-4 and 6-7. Plots 1 and 5 were closer to an N10.02 and plot 8 to an N12.02.
- WWN's predictions for the current situation are mostly correct, with the plots consisting mainly of moist pioneer vegetations. The prediction for the past, undisturbed situation seems logical as well, since the indicated ecotope groups shift towards the wetter version (amount of K22 for example increases).
- Figure C.1.23 shows the ideal conditions for a moist meadow. Only the groundwater levels for plots 3 and 4 were a bit too low at the moment of measuring, but the expectation is that in spring this will not be the case anymore. The pH at a depth of 10 cm is rather low (between 4.5 and 5.8) but increases quickly with depth (between 6.3 and 6.8 at 110 cm depth), resulting in conditions that just about meet the requirements. Plots 1-7 are light to moderately nutrient-rich, only plot 8 is too nutrient-rich and will need an excavation of around 10-20 cm.
- Overall, it can be concluded that plots 1, 2 and 5-7 are suitable to become N10.02 (moist meadow). Plots 3 and 4 need a slightly higher groundwater level, but this will be most likely be the case in spring. Only at plot 8 the topsoil should be excavated by about 10-20 cm.



N10.02 Vochtig hooiland. Ranges waarbij voor vochtig hooiland kenmerkende vegetaties kunnen voorkomen voor gemiddelde voorjaarsgrondwaterstand (GVG), zuurgraad (pH) en voedselrijkdom.

Figure C.1.23: Ideal conditions for moist meadow according to BIJ12.

C.2 Overijsselsche Vecht valley heathlands and oligotrophic ponds

The location of the investigated site is indicated by the red circle in the figure below and was visited on November 12, 2021.

Figure C.2.0: Location 8 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site. In preparation direct available spatial information was checked before visiting the site in the field.

Questions

- Are the current nature management types correct? And the ambitions? Check mainly on pH of the soil and describe the soil types. The soil might be processed too much for N07.01 (dry heathland).
- Are the oligotrophic ponds acidic? Are they nutrient-poor or is there high vegetation?
- Are the predictions from WWN 3.0 correct for the current and past, undisturbed situation?

Preparation

- Figures C.2.1-4 all show the plot and make clear that the plot consists of a field with 3 excavated areas where some water is present, although the maps show different areas of water. The current nature management type is N12.02 for the whole plot, while the ambition is to transform parts of it to N07.01 (dry heathland), N06.04 (moist heathland) and N06.06 (acidic or raised bog oligotrophic pond). The ideal conditions for N06.06 and N06.04 are shown in Figures C.2.9-10.
- Figure C.2.5 shows that the plot has been part of the Beerzerveen (veen = bog), indicating that moist/wet conditions should be possible.
- For the current situation, WWN 3.0 predicts (Figure C.2.6a) mostly K61, K62, K68, which are all dry pioneer vegetation and grasslands, and some K48. For the past, undisturbed situation (Figure C.2.6b) there are only some subtle changes; there is a bit more K48 and also very little K41, K42 and K28, which are all moist or wet pioneer vegetation and grasslands.
    - K61: Pioneer vegetation and grasslands on dry, nutrient-poor, acidic soils (dry heathland).
    - K62: Pioneer vegetation and grasslands on dry, nutrient-poor, slightly acidic soils (dry heathland and grey hair-grass grasslands)
    - K68: Pioneer vegetation, grasslands and shrublands on dry, moderately nutrient-rich soils (undergrowth in heavily fertilised fields, ruderal vegetation along rivers).

    - K48: Pioneer vegetation and grasslands on moist, very nutrient-rich soils (agricultural fields, roadsides, factory grounds).
    - K41: Pioneer vegetation and grasslands on moist, nutrient-poor, acidic soils (wet heathland and raised bogs).
    - K42: Pioneer vegetation and grasslands on moist, nutrient-poor, weakly acidic soils (violion caninae grassland, calcium-poor dune valleys).
    - K28: Pioneer vegetation, grasslands and shrublands on wet, very nutrient-rich soils (shrublands along rivers and ditches, wet cultivated grassland).
- According to LGN6 (Figure C.2.7) the plot consists of half natural grasslands and half other crops, while LGN2020 (Figure C.2.8) states that the plot consists of natural grasslands with two bodies of freshwater and one patch of other swamp vegetation.
- Figure C.2.11 shows groundwater table data for the dry heathland just north of the plot being a few decimetres below ground level. Figure C.2.12 shows data at the edge of the plot, where the groundwater level in winter is often above ground level. It stands out that last three summers, the groundwater table dropped significantly. MIPWA 3.0 on the other hand states that both the GG and GVG are more than 1 metre below ground level, except for along the southern border of the plot, and also indicates a slightly negative seepage flux.
- The Dutch soil map states that there are three different types of soil present at the plot, mostly Hn21 and also some AS and zWp:
    - Hn21 or 'veldpodzolsoils; loam-poor and slightly loamy fine sand'.
    - zWp or 'moerige (peaty) podzolsoils with a humus-bearing sand layer and a moerige inter-layer'.
    - AS or 'stuifzandsoils (inland-dune sand soils)'.

Approach

- Make soil profiles at multiple locations, measure the groundwater table and determine pH of the soil. Also look whether the plot is being drained.
- Measure pH of the oligotrophic ponds and determine the nutrient-richness.
- Describe flora on the plot and check both the current nature management types and ambitions.

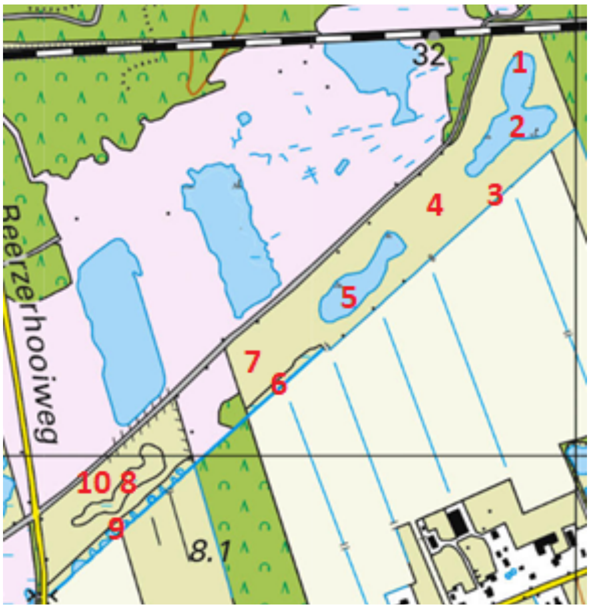


Figure C.2.1: Map from Topotijdreis 2020.


Figure C.2.2: Aerial photo from Topotijdreis 2020.

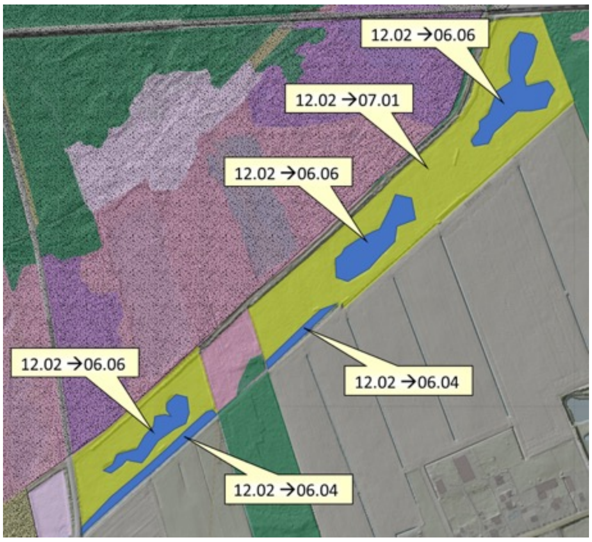


Figure C.2.3: Current nature management types and ambitions.

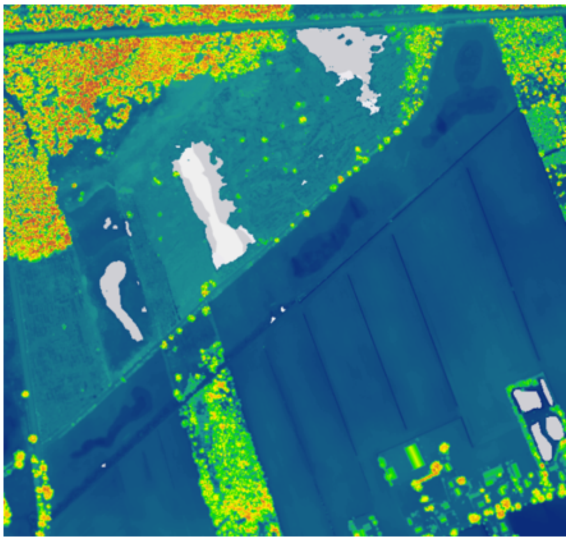


Figure C.2.4: Height data from AHN.

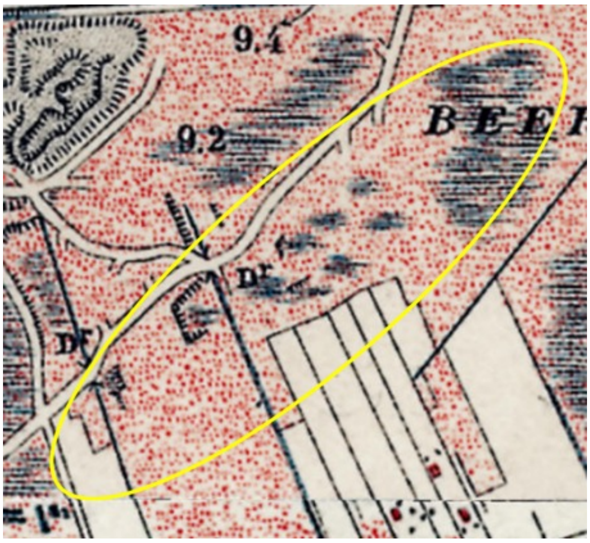


Figure C.2.5: Map from Topotijdreis 1914, where the area (within yellow oval) was wet and part of the Beerzerveen (veen = bog).

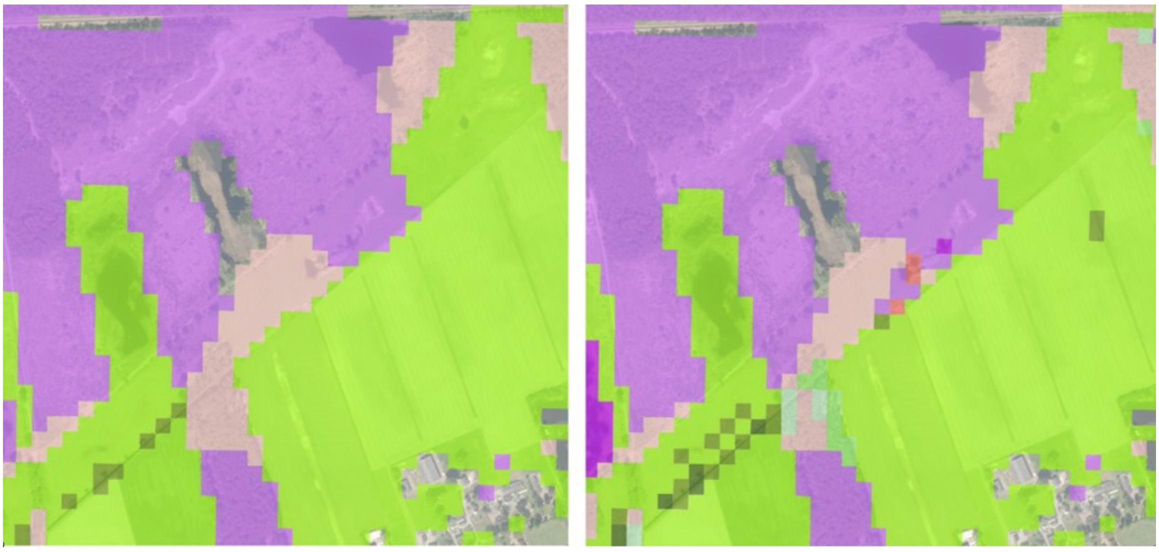


Figure C.2.6: a) Prediction from WWN 3.0 for current situation. b) Prediction from WWN 3.0 for past, undisturbed situation. (light green = K68, medium green = K48, dark green = K28, light purple = K61, medium purple = K41, reddish-purple = K42, beige = K62).

Figure C.2.7: According to LGN6 partly natural grasslands (beige) and partly other crops.

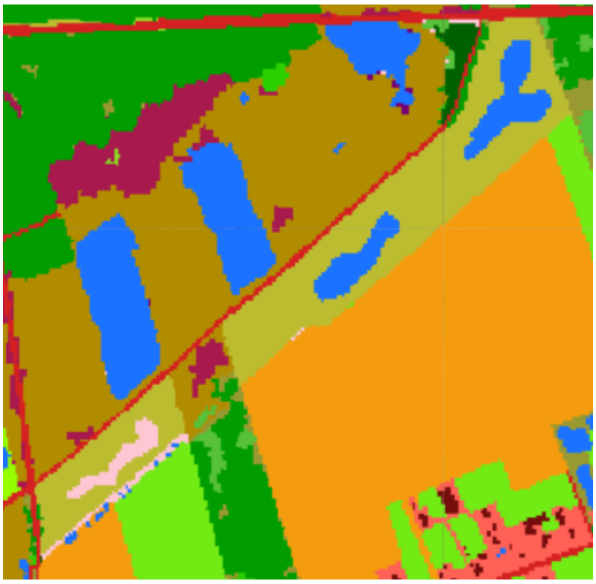


Figure C.2.8: According to LGN2020 natural grasslands (beige), fresh water (blue) and other swamp vegetation (light pink).

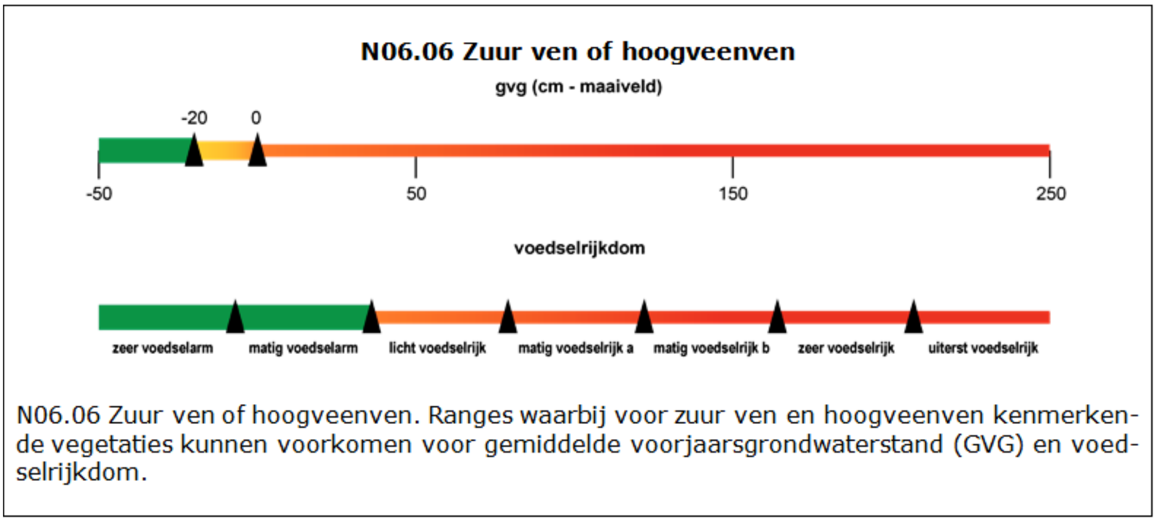


Figure C.2.9: Ideal conditions for N06.06 acidic or raised bog oligotrophic pond.

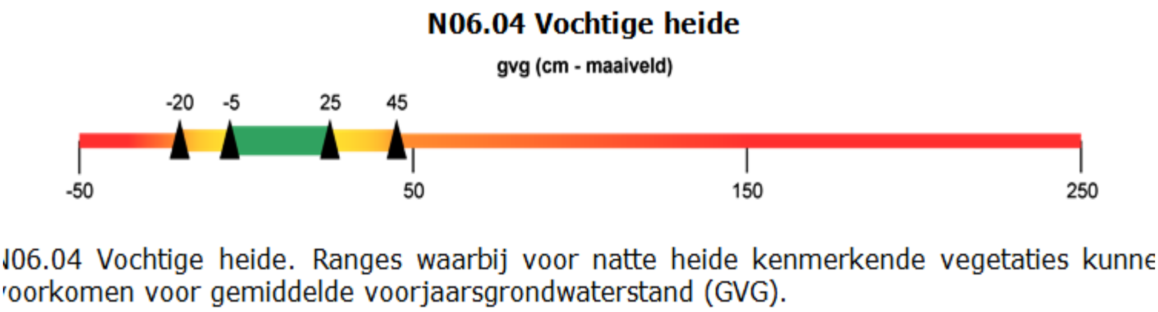


Figure C.2.10: Ideal conditions for N06.04 (moist heathland).

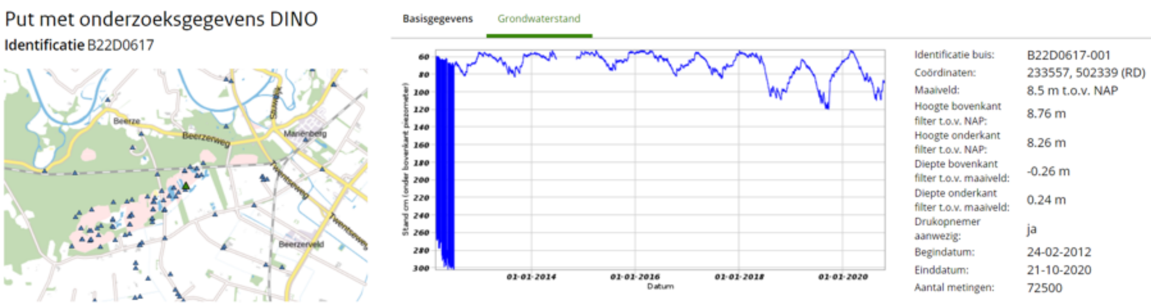


Figure C.2.11: Groundwater table data from dry heathland just north of the plot, at the green triangle (DINOloket).

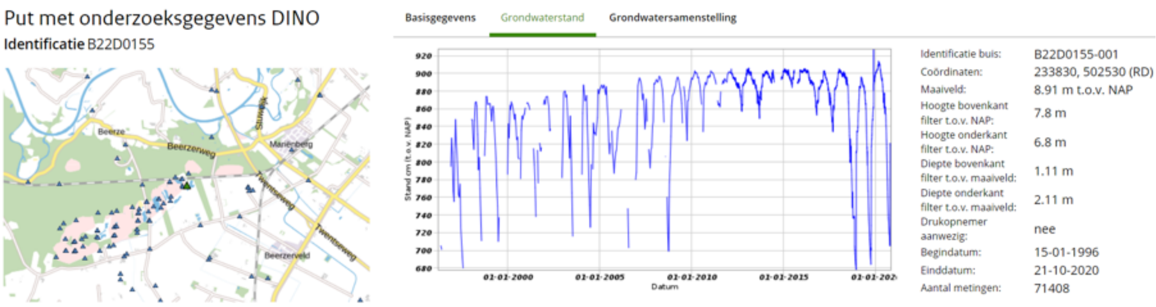


Figure C.2.12: Groundwater table data on the border of the plot, at the green triangle (DINOloket).

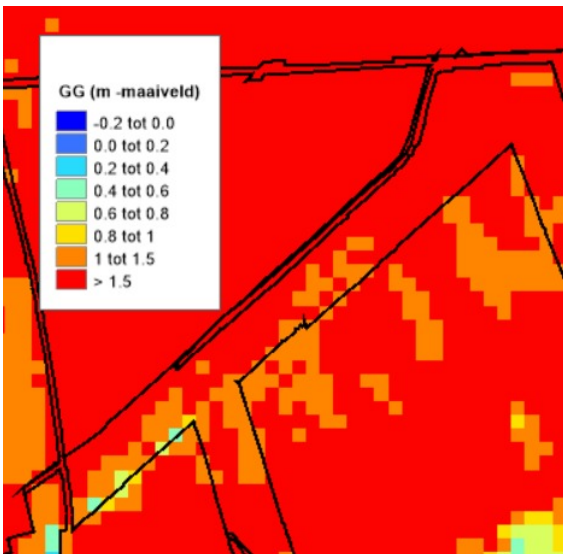


Figure C.2.13: MIPWA 3.0 data on GG.

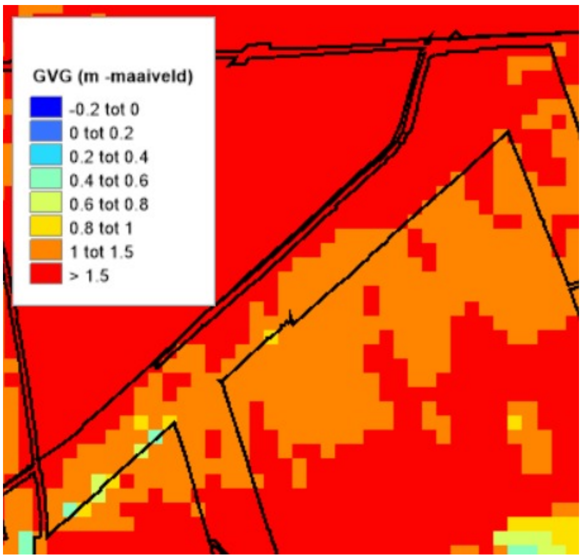


Figure C.2.14: MIPWA 3.0 data on GVG.

Results

Table C.2.1: Field data of the locations corresponding with Figure C.2.1.

Location (fig. C.2.1)	RD-coord.	GWT (cm)	PH (-)	Description
1	233921, 502597	n/a	4.9 (water)	On northern part of excavated area ca. 30 cm of water (Figure C.2.17), only seems temporary, rest of excavated part dry. Epilobium spec., Rumex spec. and Ranunculus repens present. Looks moderately nutrient-rich, but soil is nutrient-poor.
2	233908, 502499	105	4.5 at 10cm 4.7 at 110cm	Dry, not soggy. When walking towards location 1 increasingly wetter and more Juncus effusus. Trifolium spec., Rumex acetosella, Achillea millefolium, Plantago major, Spergula arvensis, Scorzoneroides autumnalis, Hydrocotyle vulgaris, Hypochaeris radicata, Jacobaea vulgaris, Ranunculus repens, Taraxacum spec., Lycopus europaeus. Soil profile (Figure C.2.15): - 0-5 cm: black soil. - 5+ cm: fine light-coloured sand, very fine towards the end. Starts dry, ends wet.
3	233883, 502406	n/a	n/a	Ditch of 1.10m deep (Figure C.2.18) along south-eastern side of plot, 60cm of water. Partly being held back by a weir.
4	233794, 502381	>125	4.6 at 10cm 4.3 at 110cm	Higher part of plot with lots of Jacobaea vulgaris and Cirsium arvense, furthermore Urtica spec., Trifolium spec., Taraxacum spec., Plantago major, Tanacetum vulgare and Rumex acetosa. Soil profile (Figure C.2.16): - 0-20 cm: fine, black-grey soil. - 20-35 cm: fine, light grey sand. - 35-40 cm: fine, brown sand. - 40-80 cm: rock-hard, black fine peat (Figure C.2.19). - 80 cm: fine, reddish-brown sand, initially still mixed with soil.
5	233653, 502249	10	4.4 at 10cm 4.6 at 110cm 5.4 (water)	Second excavated part. Soggy, some patches with 20-30 cm of water. Moderately nutrient-rich. Gnaphalium luteoalbum, Ranunculus repens, Hypochaeris radicata, Trifolium spec., Veronica scutellata, Epilobium spec., Hydrocotyle vulgaris, Plantago major, Juncus acutiflorus, Myosotis laxa/scorpioides, Jacobaea vulgaris, Mentha aquatica, Bidens frondosa, Juncus articulatus, Scorzoneroides autumnalis, Galium palustre, Juncus effusus, Plantago lanceolata. Soil profile (Figure C.2.23): - 0-30 cm: fine, black-grey soil. - 30+ cm: fine brown sand, more compact and somewhat blacker at the end.
6	233550, 502107	30	4.4 at 10cm 6.0 at 80cm	Lower-lying part along the ditch with small water inlets (Figure C.2.20). Lots of small Salix spec. and Betula spec., furthermore Juncus effusus, Hypochaeris radicata, Trifolium spec., Taraxacum spec., Jacobaea vulgaris, Trifolium pratense, polytrichum spec., Hieracium spec., Rubus spec. and a little bit of Calluna vulgaris and Erica tetralix. Soil profile (Figure C.2.24) - 0-15 cm: fine, dark soil. - 15+ cm: fine, brown sand, later very fine and lighter in colour.

7	233511, 502134	n/a	n/a	Looks exactly the same as location 4.
8	233319, 501949	75	4.6 at 10cm 4.4 at 110cm	Third excavated part, completely dry (Figure C.2.21). Trifolium spec., Scorzoneroides autumnalis, Cerastium glomeratum, Ranunculus repens, Jacobaea vulgaris, Trifolium repens, polytrichum, Juncus effusus, Plantago major, Gnaphalium luteoalbum, Hydrocotyle vulgaris. Soil profile (Figure C.2.25): - 0-5 cm: light grey, fine soil. - 5-30 cm: fine, yellow-gold sand. - 30+ cm: fine, light-coloured sand, very fine and wet towards the end.
9	233306, 501888	n/a	n/a	Almost the same as location 6, only somewhat less Betula spec. and Salix spec. and some Rorippa amphibia present.
10	233269, 501949	>125	4.6 at 10cm 4.3 at 110cm	Almost same as location 4, only no Cirsium arvenses. Soil profile (Figure C.2.26): - 0-25 cm: fine grey soil, at bottom some fine light grey sand. - 25-65 cm: rock-hard black peat (Figure C.2.22). - 65+ cm: fine sand, initially reddish brown, then light-coloured.

Figure C.2.15: Soil profile at location 2.

Figure C.2.16: Soil profile at location 4.


Figure C.2.17: Ca. 30 cm of water on part of the excavated area.


Figure C.2.18: Ditch of 1.10 m deep with 60 cm of water.


Figure C.2.19: From soil profile at location 4, dry peat.


Figure C.2.20: Inlet with water at location 6.


Figure C.2.21: Excavated part at location 8.


Figure C.2.22: From soil profile at location 10, dry peat.

Figure C.2.23: Soil profile at location 5.

Figure C.2.24: Soil profile at location 6.

Figure C.2.25: Soil profile at location 8.

Figure C.2.26: Soil profile at location 10.

Discussion/Conclusions

- LGN6 is clearly incorrect or outdated, as no crops are being cultivated anymore. LGN20220 indicates mostly natural grasslands, which is correct. It also indicates two bodies of water and an area with swamp vegetation. While this was not found to be so, aerial photos from Topotijdreis (i.e., 2014, 2015 and 2018) show that this regularly is the case, likely in spring. Therefore, LGN2020 can be labelled as correct.
- The plot is being drained significantly by a ditch of 1.10 m deep, containing 60 cm of water (Figure C.2.18). This might result in the excavated areas being relatively dry.
- The two soil profiles sampled at unexcavated areas (locations 4 and 10) are characteristic veldpodzolsoils, but with a clear peat layer which makes that they also can be classified as moerige (peaty) podzolsoils. The other soil profiles are clearly partly excavated and show only the lower layers found at locations 4 and 10, so they are no longer moerige or veldpodzolsoils. Inland dune soils have not been found at all, but only should have been on a small part of the plot. So, in general the Dutch soil map was correct, but the excavations changed this so nowadays it is only partly correct.
- The presence of the peat layer shows that the area formerly was very wet, which is also confirmed by the map from Topotijdreis 1914 (Figure C.2.5), where the plot was part of the Beerzerveen (veen = bog). Also, the wet area just north of the plot shows that the plot could easily be wet had there not been extensive drainage.
- MIPWA 3.0 stated that the GG is nearly everywhere deeper than 1.5 m and the GVG nearly everywhere deeper than 1 m below ground level, and often even over 1.5 m as well. For the unexcavated parts of the plot, this turned out to be true, but for the excavated parts the ground water table varied between 10 and 105 cm below ground level and even some small oligotrophic ponds were present. It is therefore likely that MIPWA 3.0 does not take the excavation into account, resulting in incorrect data at those places. No indications for positive seepage flux were found.
- WWN 3.0 predicted for the current situation mostly K61, K62 and K68, which are all dry pioneer vegetation and grasslands, and a small strip of K48 (moist, very nutrient-rich). For the unexcavated parts, K68 is correct, but K61 and K62 are not as the soil is too nutrient-rich. For the excavated strips along the ditch only the part with K48 is close, but K47 or even K21 would have been better. For the other excavated parts, K21 or maybe A11 (in case the areas fill up with water in winter/spring) would have been suitable. Since WWNs predictions only were partly correct for the unexcavated parts, it can be concluded that the results are incorrect.
- For the past, undisturbed situation, the results are even worse as only some small parts are predicted to become wetter, while it might be expected that big parts of the plot will become wet when the groundwater table rises.
- Currently, N12.02 is correct as nature management type as the plot consists mostly of varied grasslands with some small, shallow waterbodies.
- The ambition plans can be divided into three parts:
    - For a big part of the unexcavated area the ambition is N07.01 (dry heathland). The soil is dry indeed, but at the moment too nutrient-rich and processed. This can be solved by excavating a layer of 20-25 cm.
    - For the two excavated strips along the ditch the ambition is N06.04 (moist heathland). Some Calluna vulgaris and Erica tetralix is already present and the groundwater table is suitable, but the soil is too nutrient-rich at the moment. By excavating around 10 cm, this can be solved.
    - For the other three excavated areas, the ambition is N06.06 (acidic or raised bog oligotrophic pond). The nutrient-richness is quite low (only the middle one has higher nutrient-rich soil) and therefore suitable, which also is the case for the pH of the water (4.9 and 5.4). On the other hand, the ground water table was too low at the moment of measuring (autumn). While it will be higher in spring, data from DINOloket (Figures C.2.11-12) showed that in summer the plot is being drained extensively over the last few years, which should stop in order to ensure the quality of the oligotrophic ponds.
- Thus, all three ambitions should be achievable, but a lot of excavating needs to be done for N07.01 and N06.04 and the groundwater table has to rise for N06.06, at least during summer/autumn, which means draining by the ditch along the south-eastern border has to stop.

C.3 Overijsselsche Vecht valley moist heathland

The location of the investigated site is indicated by the red circle in the figure below and was visited on November 11, 2021.

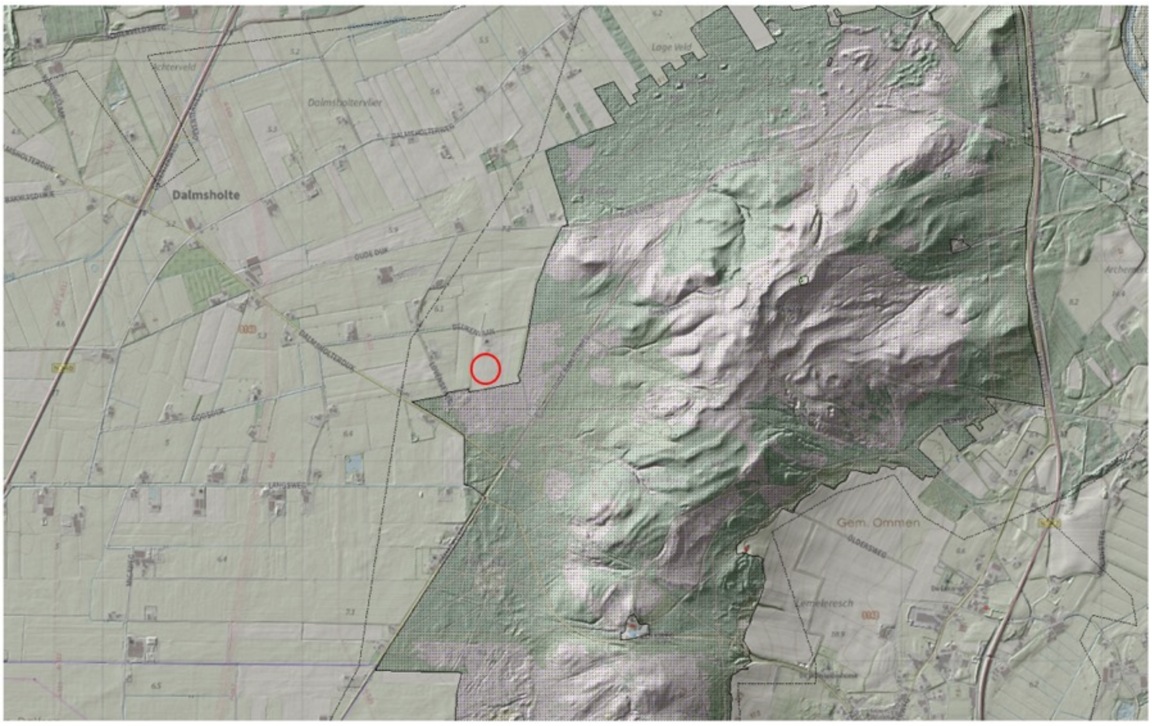


Figure C.3.0: Location 9 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site. In preparation direct available spatial information was checked before visiting the site in the field.

Questions

- A lot of ground has been moved. What does the area look like now and do the nature ambitions fit the current state of the area?
- How do the soil profiles look like and how deep is the groundwater table?

Preparation

- Figure C.3.1 shows the two plots of interest. The western plot is currently an N12.02 (grassland rich in herbs and fauna), the eastern plot is currently an N07.01 (dry heathland). The ambition is to transform both plots into N06.04 (moist heathland). Both north and south of the plots are parts of N06.04 already.
- From height data (Figure C.3.2) it becomes clear that the eastern plot is about 1 m higher than the western plot, which at its lowest around a small ditch.
- Figures C.3.3 shows a map from Topotijdreis 2020, while Figure C.3.4 shows an aerial photo from Google Maps. Here can clearly be seen that ground has been moved recently. Also, there is a road showing, as well as something that looks like something is going to be built. Furthermore, a dark, moist area is visible, which now is an N06.04 (moist heathland).
- According to LGN6 (Figure C.3.5), the plot consists of other crops and agricultural grass, while LGN2020 (Figure C.3.6) indicates the presence of agricultural grass and a potato field.
- MIPWA 3.0 states that the GG (Figure C.3.7) is mostly between 1 and 1.5 m below ground level for the western plot and more than 1.5 m below ground level for the eastern plot. The GVG is more or less the same, only for the western plot the groundwater table is between 60 and 100 cm below ground level for a small area (Figure C.3.8). Figure C.3.9 shows data from DINOloket from a well just south of the plots, indicating a slightly higher groundwater table than MIPWA 3.0, but still matching pretty well.

- According to the Dutch soil map (Figure C.3.10), the soil on the plots consists of both vWp or 'moerige (peaty) podzolsoils with a moerige upper soil' and Hn21 or 'veldpodzolsoils; loam-poor and slightly loamy fine sand.
- WWN 3.0 predicts that for the current situation (Figure C.3.11), most of the plots will consist of K68 and a small part of the western plot of K48. For the past, undisturbed situation, the area of K48 increases to roughly half of the western plot, while the eastern plot remains K68 (Figure C.3.12).
    - K48: Pioneer vegetation and grasslands on moist, very nutrient-rich soils (agricultural fields, roadsides, factory grounds).
    - K68: Pioneer vegetation, grasslands and shrublands on dry, moderately nutrient-rich soils (undergrowth in heavily fertilised fields, ruderal vegetation along rivers).

Approach

- Describe some soil profiles and determine the pH of the soil and the depth of the groundwater table.
- Describe the flora present and how the area looks after the moved ground.
- Determine whether the plot is being drained.

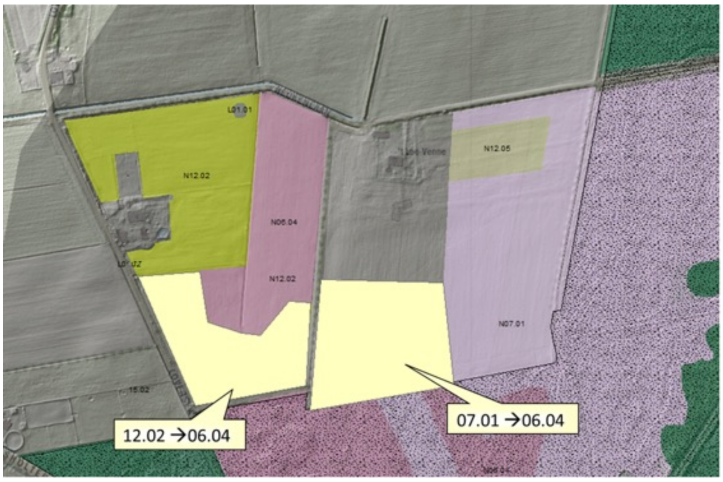


Figure C.3.1: Current nature management types and ambitions.

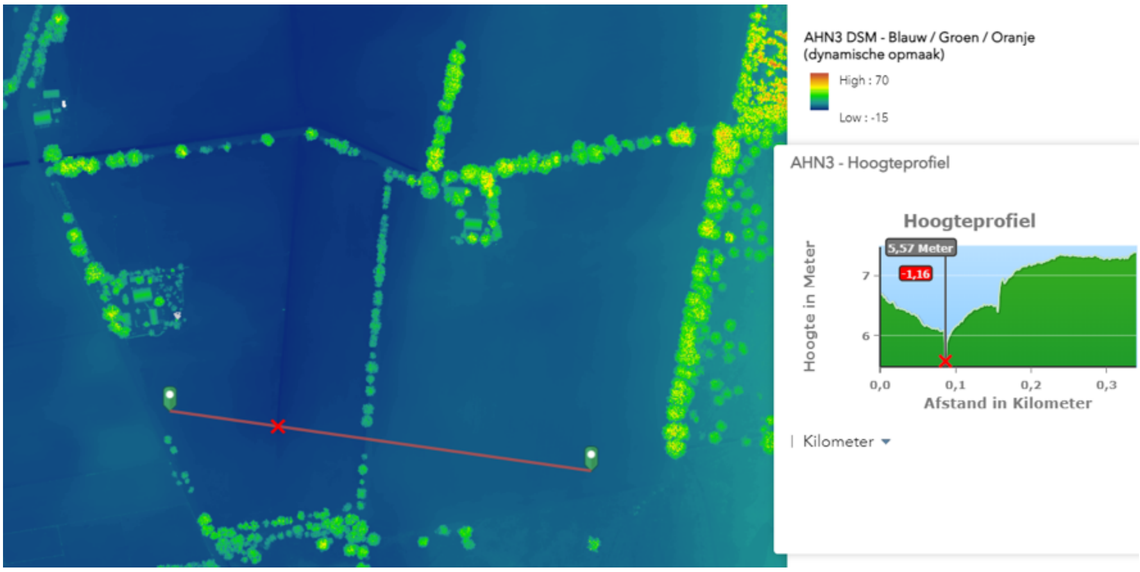


Figure C.3.2: Height data from AHN, including a height profile across the plots.

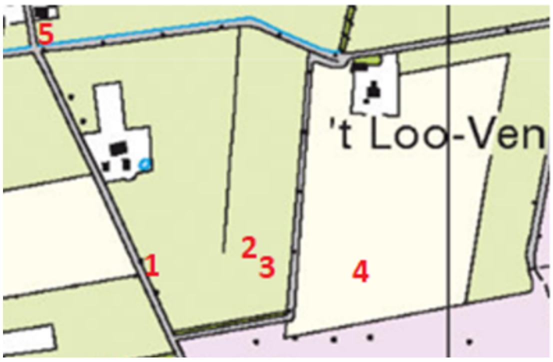


Figure C.3.3: Map from Topotijdreis 2020 with points of interest.

Figure C.3.4: Aerial photo from Google Maps.

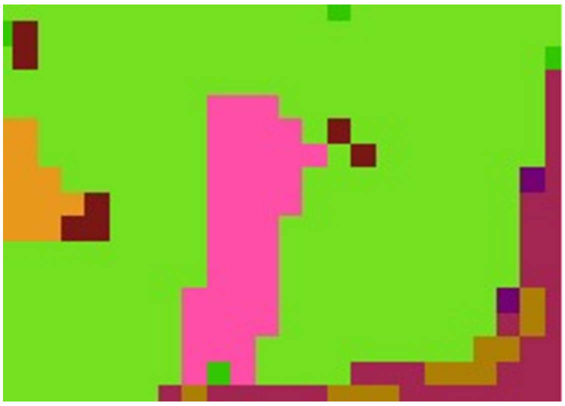


Figure C.3.5: According to LGN6 mostly other crops (pink) for the western plot and agricultural grass (light green) for the

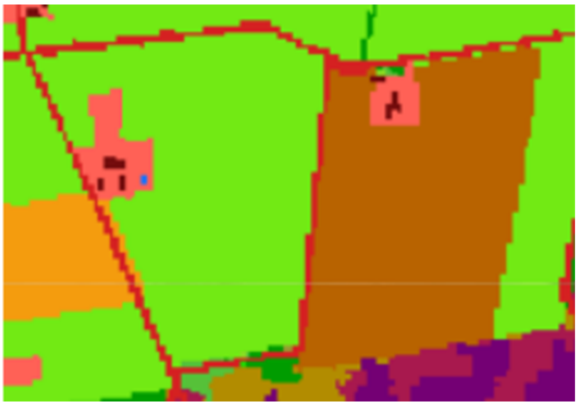


Figure C.3.6: According to LGN2020 agricultural grass for the western plot and a potato field for the eastern plot (brown).

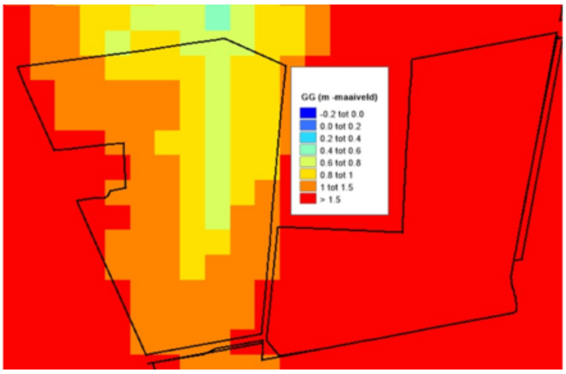


Figure C.3.7: MIPWA 3.0 data on GG.

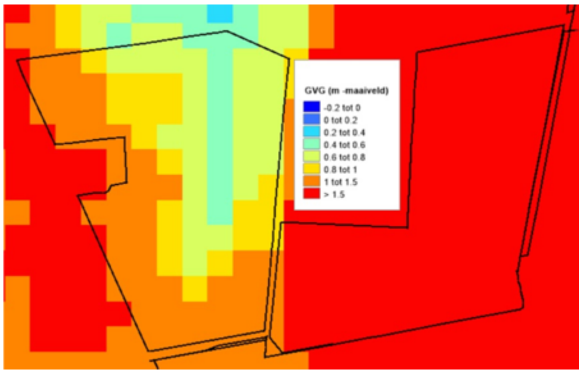


Figure C.3.8: MIPWA 3.0 data on GVG.

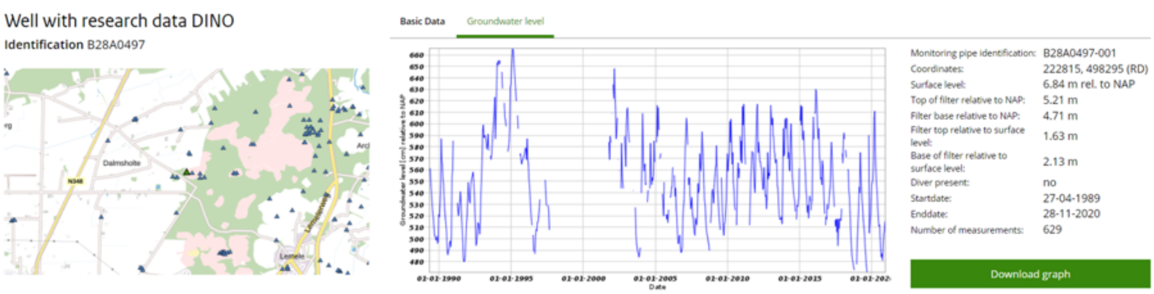


Figure C.3.9: Data from DINOloket for a well (green triangle on map) just south of the plot

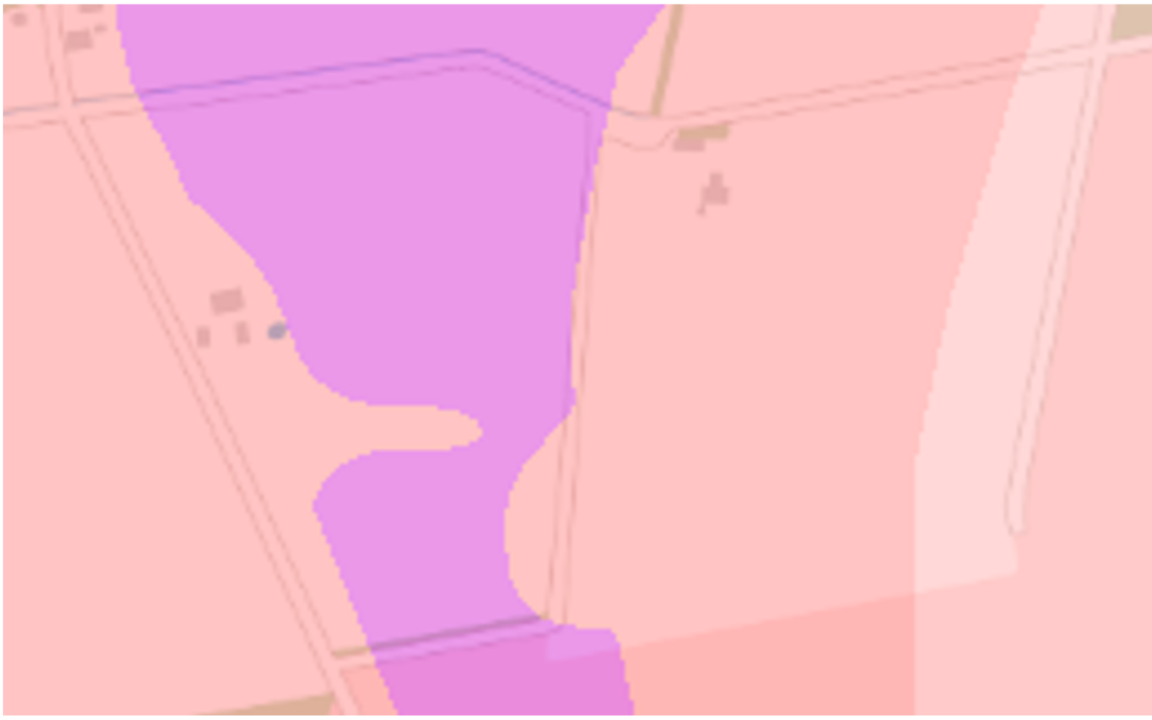


Figure C.3.10: According to the Dutch soil map, the eastern plot consists of Hn21 (veldpodzolsoil, pink), while the western plot is also partly an vWp (moerige podzolsoil, purple).

Figure C.3.11: WWN predicts for the current situation mostly K68 (light green) with some K48 (medium green) for the western plot

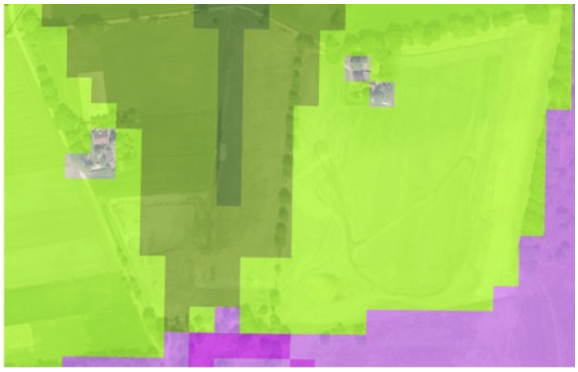


Figure C.3.12: WWN predicts still K68 for the eastern plot and both K68 and K48 for the western plot

Results

Table C.3.1: Field data of the locations corresponding with Figure C.3.3.

Location (fig. C.3.3)	**RD-coord.**	**GWT (cm)**	**PH (-)**	**Description**
1	222699, 498419	105	4.6 at 10cm 4.8 at 110cm	Part of the moved ground is still present as a pile on the western plot. The rest of the plot has just been sown with a mixture of herbs and flowers (Figure C.3.15). Soil profile (Figure C.3.13): - 0-5 cm: fine, black sand/earth. - 5-70 cm: fine, golden sand. - 70-85 cm: peat, very hard (Figure C.3.16). - 85+ cm: fine, wet, light-coloured sand with pebbles (1 to 3 mm). I spoke to the owner and he pointed out that the groundwater level is often much higher in winter, last winter they were able to ice skate on the plot.

2	222797, 498434	n/a	n/a	Dirt road, looking on a wetter part. According to owner moist heathland with Succisa pratensis (Figure C.3.17).
3	222813, 498422	85	4.7 at 10cm 4.9 at 110cm	Also just sown, only small strip still grass (Figure C.3.18). On grass Polytrichum juniperinum, Succisa pratensis, Hypochaeris radicata, Centaurea jacea. Soil profile (Figure C.3.14): - 0+ cm: begins fine, ends very fine. Yellowish sand. Between 60 and 100 cm small pebbles (1 to 3 mm). According to owner, ambition is now to turn it into herb- and fauna-rich grassland as a transition to heathland.
4	222916, 498425	>125	4.6 at 10cm 4.9 at 110cm	Excavated part of plot (fig. C.3.20), where a new house seems to be built. Only some Juncus effusus, Solanum nigrum, Rumex acetosella, Hypochaeris radicata. Soil profile (Figure C.3.19): - 0+ cm: fine, light-coloured sand. From 100 cm onwards, some small pebbles (1 to 3 mm) and also some larger ones (appr. 2 cm).
5	222576, 498648	n/a	n/a	Ditch about 2 m deep (Figure C.3.21). Drained the plots, but nowadays interconnecting culvert is said to be closed.

Figure C.3.13: Soil profile at location 1.

Figure C.3.14: Soil profile at location 3.

Figure C.3.15: Pile of moved sand next to just sown field (location 1).

Figure C.3.16: Peat from soil profile at location 1.

Figure C.3.17: Dirt road (loc. 2) across plot, field is moist heathland.

Figure C.3.18: Just sown field, part still grass (location 3).

Figure C.3.19: Soil profile at location 4.

Figure C.3.20: Clearly excavated area (location 4).

Figure C.3.21: Ditch about 2 m deep north of the plots.

Discussion/conclusions

- At the moment of visiting, the plot was barren due to excavation, making both LGN6 and 2020 outdated and therefore incorrect. When looking back in time on Topotijdreis however, it shows that LGN6 was correct in 2007/2008 and LGN2020 was correct in 2019.
- MIPWA 3.0 data showed to be pretty accurate and field data were closely related to data from DINOloket (Figure C.3.9). Only for the western plot MIPWA 3.0 indicated a slightly too low groundwater table as the groundwater level was found to be 85 – 105 cm below ground, whereas 100 – 150 was predicted. This is likely the result of the recent excavations. Overall, it can be concluded that MIPWA 3.0 is correct for this case.
- The soils do not represent a veldpodzolsoil in any way, due to the recent excavations. The soil at location 1 did have a moerige layer (peat layer in this case) of 15 cm however, but no moerige upper soil, also due to excavation. So, as a result of excavation the Dutch soil map showed to be incorrect.
- The predictions of WWN 3.0 with K68 (and small part K48) for the current situation are mostly correct with regard to 'dry (and small part moist) pioneer vegetation and grasslands', but incorrect in the 'moderately to very nutrient-rich soils. This however is only the result of the recent excavations which could not have been incorporated in input yet. This results in the prediction being only partly correct.
- The prediction for the past, undisturbed situation looks partly the same as for the current situation, only being wetter, which is logical. Once again however, the K68 and K48 are too nutrient-rich.
- The plot is being drained by a small, dry ditch close to the plot (Figure C.3.2) and by a ditch of about 2 m deep north of the plots (Figure C.3.21).
- On the eastern plot it looks like a new house or barn is being built (Figure C.3.20), which could interfere with nature ambitions.
- The current nature management type for the western plot is correct (N12.02) as grasses and herbs just have been sown again. The same happened on the eastern plot, making the current N07.01 incorrect.
- The ambition to transform both plots into N06.04 (moist heathland) seems hard to accomplish due to the low groundwater table, whereas the GVG has to lie between -5 and 25 cm below ground level according to BIJ12 (Figure C.3.22). Also, the owner of the plots indicated that a mixture of herbs and flowers recently was sown, which translates to N12.02 (grasslands rich in herbs and fauna). It would be a waste to turn this into moist heathland right away, but could be transformed into one over time. But for an N06.04, the ditch north of the plot (Figure C.3.21) has to get filled in, which might be hard due to agricultural activities. When it turns out this ditch will not get filled in, N07.01 seems like a more suitable ambition, as an adjacent plot currently is an N07.01 as well.

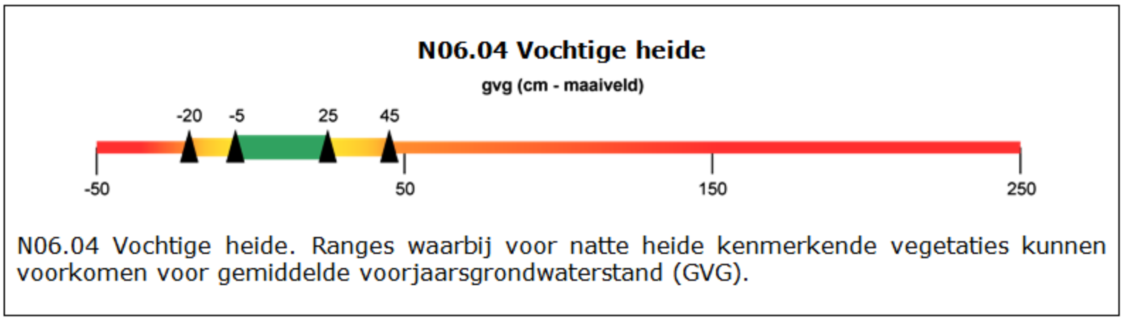


Figure C.3.22: Ideal conditions for N06.04 according to BIJ12.

APPENDIX D: SALLAND ESTATES

D.1 Salland estates suggested limestone marsh

The location of the investigated site is indicated by the red circle in the figure below and was visited on November 30, 2021.

Figure D.1.0: Location 10 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site. In preparation direct available spatial information was checked before visiting the site in the field.

Questions

- Two plots, currently N12.02, might have the potential to become a limestone marsh (nature management type N05.03 or bogland), while the nature ambition now is N10.01 (wet nutrient-poor grassland). What's the current situation like?
- Is the groundwater table in accordance with MIPWA 3.0.
- How do soil profiles look like and is there a chalk-rich layer?

Preparation

- Figure D.1.1 shows the current nature management type of the plots, which is N12.02 or grassland rich in herbs and fauna. It is remarkable that the eastern plot is only part of a field.
- Figures D.1.2-3 show a map and an aerial photo of the plots, where some ditches can be seen, and no difference is showing on the field of the eastern plot which could result in different nature management types.
- From height data (Figure D.1.4) it becomes clear that the eastern plot is about 50 cm lower than the western plot and also is lower lying than other surrounding fields, which suggests the plot has been excavated.
- According to LGN6 (Figure D.1.5), the plots consist of corn, while LGN2020 (Figure D.1.6) suggests that the plots consist of natural grassland (and a small patch 'other grass'). When looking at Figure D.1.3, is looks like LGN2020 is correct.
- MIPWA 3.0 states that the GG (Figure D.1.7) between 0.4 and 0.8 m below ground level, while the GVG (Figure D.1.8) is slightly higher, but still between 0.4 and 0.8 m below ground level. The seepage flux (Figure D.1.9) is slightly to moderately positive. Only for the southern part of the eastern plot, the seepage flux should be slightly negative, which looks odd on the map.
- DINOloket and Vitens both show no wells close to the plot.

- According to the Dutch soil map, the soil mostly consists of fpZg23 (beekeerdsoils; loamy fine sand (locally iron-rich, starting within 0.5 m and at least 0.1 m thick)) and some vWz (moerige (peaty) eerdsoils with a moerige upper soil on sand) for the southern part of the eastern plot.
- WWN 3.0 predicts K48 (pioneer vegetation and grasslands on moist, very nutrient-rich soils (agricultural fields, roadsides, factory grounds)) for the current situation (Figure D.1.10). For the past, undisturbed situation (Figure D.1.11), mostly K28 (pioneer vegetation, grasslands and shrublands on wet, very nutrient-rich soils (shrublands along rivers and ditches, wet cultivated grassland)) is predicted, which is the wetter version of K48.

Approach

- Make a soil profile on both plots, determine pH of the soil and the groundwater level.
- Determine whether a chalk-rich layer is present with a 1M solution of hydrochloric acid.
- Describe the flora and determine pH of ditches and puddles.
- Determine whether the plot is being drained.

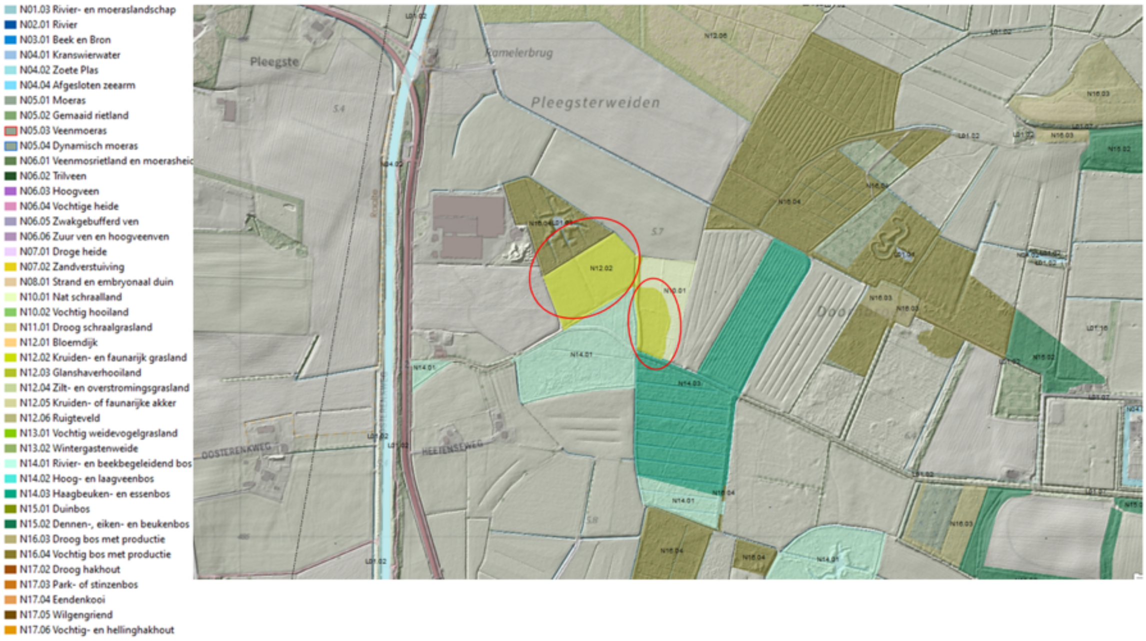


Figure D.1.1: Overview map showing the current nature management types for the plots.

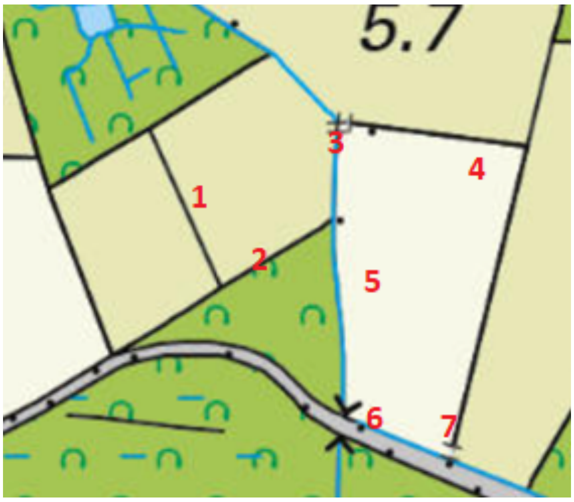


Figure D.1.2: Map from Topotijdreis 2020.

Figure D.1.3: Aerial photo from Topotijdreis 2020.

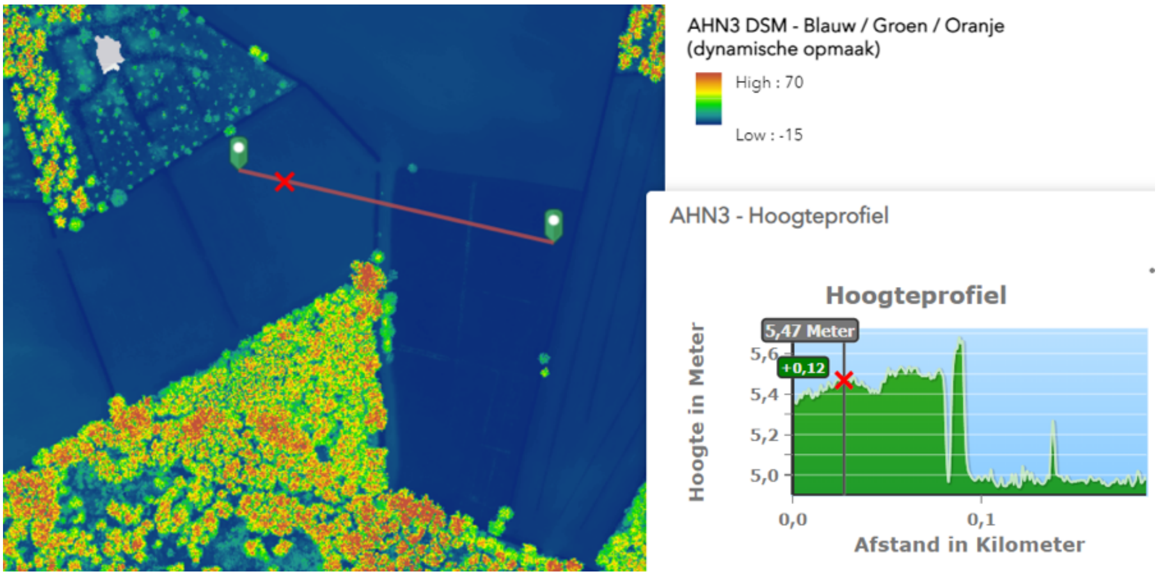


Figure D.1.4: Height data including a height profile from AHN.

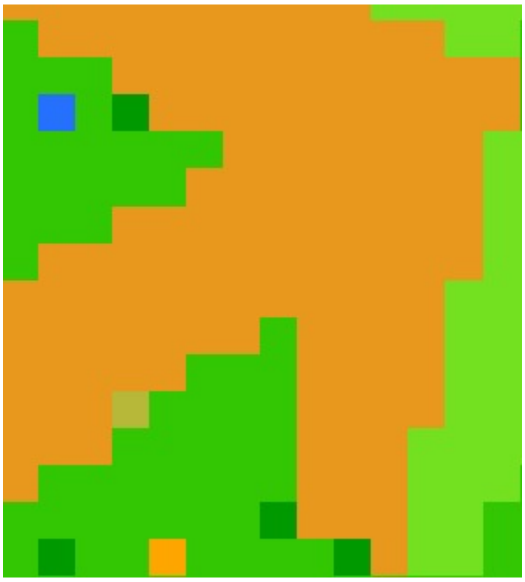


Figure D.1.5: According to LGN6 corn field.

Figure D.1.6: According to LGN 2020 natural grasslands and a small patch of 'other grass'.

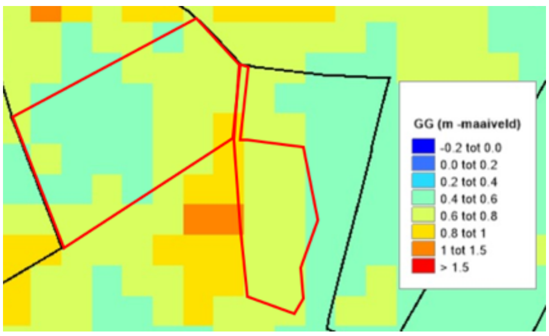


Figure D.1.7: MIPWA 3.0 data on GG (plot outlined in red.

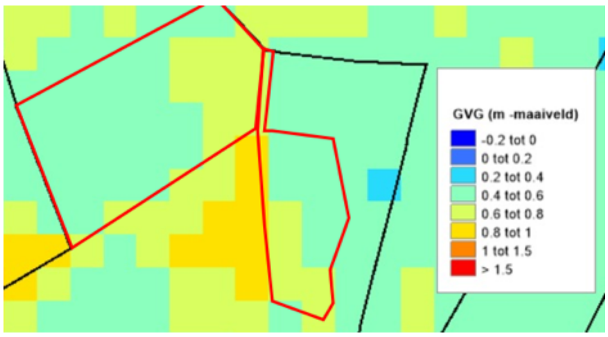


Figure D.1.8: MIPWA 3.0 data on GVG (plot outlined in red).

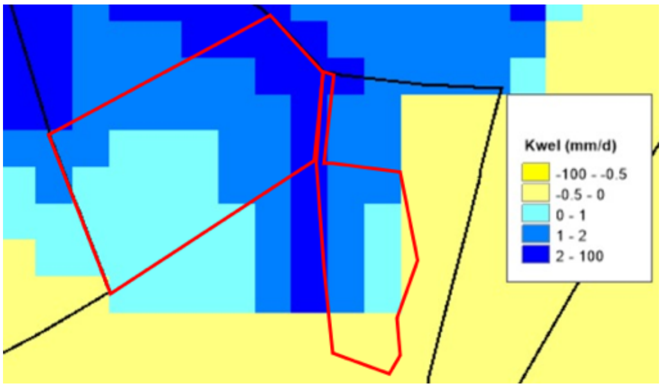


Figure D.1.9: MIPWA 3.0 data on seepage flux (plot outlined in red).

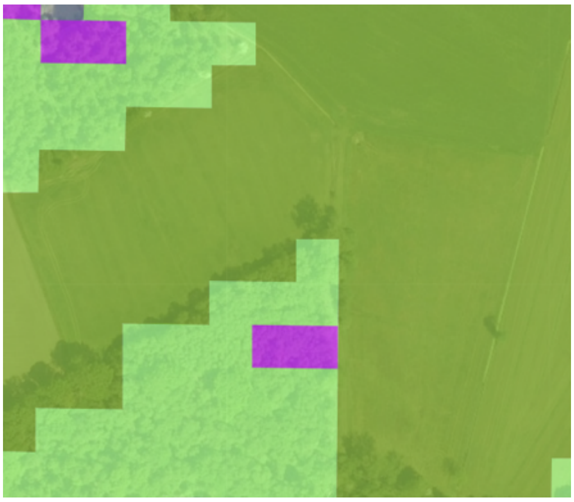


Figure D.1.10: WWN 3.0 predicts K48 (medium green) for the current situation.

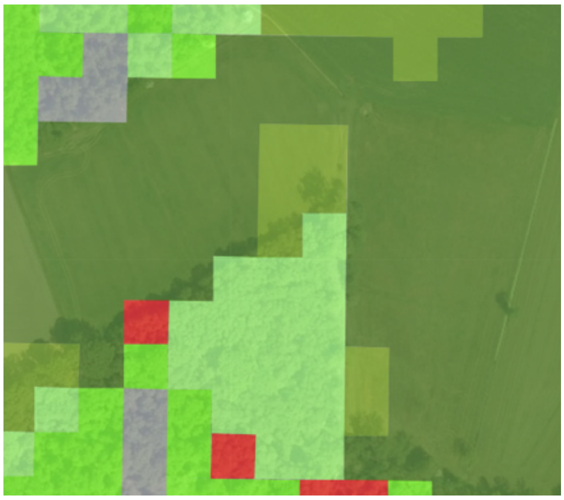


Figure D.1.11: WWN 3.0 predicts mostly K28 (dark green) and a bit K48 (medium green) for the past, undisturbed situation.

Results

Table D.1.1: Field data of the locations corresponding with Figure D.1.2.

Location (fig. D.1.2)	**RD-coord.**	**GWT (cm)**	**PH (-)**	**Description**
1	215710, 485514	50	5.0 at 10 cm 6.3 at 110cm	Non-excavated grassland, surrounded by ditches on all sides with stagnant water tables between 30 and 45 cm below ground level. Field on southwest had corn on it. On field lots of grass, some patches Juncus effusus and Ranunculus repens, furthermore Rumex acetosella, Cirsium spec., Taraxacum officinalis and Ranunculus flammula. Soil profile (Figure D.1.12): - 0-25 cm: brown soil. - 25-35 cm: mixture of brown soil and fine, grey sand with some iron concretions. - 35+ cm: grey sand, from fine to very fine and gradually wetter. None of the soil reacted with hydrochloric acid.
2	215744, 485475	n/a	n/a	Ditch with stagnant water, surface 35 cm below ground level.
3	215793, 485555	n/a	6.1 (water)	Ditch of 1.3 m deep with 85 cm of water, lots of Phragmites australis (Figure D.1.14).
4	215879, 485533	n/a	n/a	Officially not on part of interest (Figure D.1.15), but does not look very different from locations 5 and 6. Maybe slightly drier, but not much. Wetter than location 1.

5	215826, 485464	5	6.8 at 10cm 6.8 at 110cm 5.2 water puddle	Probably excavated. Large puddles up to 15 of depth (fig. D.1.16). Moist plot with lots of moss and some grass, also patches of Juncus effusus. Furthermore, Taraxacum officinalis, Cirsium palustre, Trifolium spec., Silene flos-cuculi, Ranunculus repens, polytrichum, Lotus pedunculatus and Hypochaeris radicata. Soil profile (Figure D.1.13): - 0-15 cm: grey, moderately coarse sand with a little silty soil. Some rust and white fragments reacting with hydrochloric acid, indicating chalk. - 15-35 cm: grey, moderately coarse sand with some rust. - 35+ cm: grey sand. Begins fine, ends very fine.
6	215815, 485373	n/a	7.1 (water)	Ditch about 70 cm deep with 40 cm of very slowly flowing water (Figure D.1.17)
7	215872, 485359	n/a	n/a	Ditch, also around 70 cm deep with 40 cm of water, flowing even slower (Figure D.1.18). This part of the field (Figure D.1.19) does not look different when compared to location 5.

Figure D.1.12: Soil profile at location 1.

Figure D.1.13: Soil profile at location 5.


Figure D.1.14: Ditch between the two plots, location 3.


Figure D.1.15: View on eastern plot, location 4.


Figure D.1.16: Surroundings at location 5.


Figure D.1.17: Ditch at location 6.


Figure D.1.18: Ditch at location 7.


Figure D.1.19: View on eastern plot from location 7.

Discussion/conclusions

- In the field it turned out that the plots indeed consisted of natural grasslands, resulting in LGN6 being incorrect, while LGN2020 is correct. When looking back to 2007/2008 on Topotijdreis, it seems plausible that the plots had corn on them back then.
- The eastern plot indeed seemed to be excavated, as no nutrient-rich topsoil was present, which is otherwise strange as the plot has had crops on it.
- The plots are being drained rather intensively by multiple ditches, of which two along the eastern plot are flowing very slowly.
- The MIPWA 3.0 data on the GG and GVG are correct for the western plot. For the eastern plot, the groundwater table was found to be around ground level instead of 40 – 80 cm below it, making MIPWA 3.0 incorrect, probably due to the excavation of this plot. Furthermore, the pH of the soil and water also suggests the presence of positive seepage flux, namely weak on the western plot and strong on the southern plot. This fits well with MIPWA 3.0, except that the sudden transition from strong to no seepage on the eastern plot does indeed seem to be incorrect, given the pH of 7.1 in the ditch there.
- The soil profile on the western plot was indeed a beekeerdsoil, mostly with fine sand, albeit not very loamy. Also, an iron rich layer was found, resulting in fpZg23 being correct. For the eastern plot however, the A horizon has been excavated, for the rest the soil was a beekeerdsoil as well. No soil profile was made on the part where vWz was predicted, so it has to be concluded that the Dutch soil map is correct on that part. Thus, the Dutch soil map is partly correct due to excavation.
- The eastern plot indeed had a chalk-rich layer in the upper 15 cm of soil, the western plot did not have such a layer.
- For the western plot, WWN 3.0's prediction for the current situation (K48) was very correct, but for the eastern plot it was not as the soil was nutrient-poor and wet instead of only moist, making K22 or K23 more suitable. This however is the result of the excavation that took place, otherwise K48 would have been correct here as well most likely.
- For the past, undisturbed situation, WWN predicted K28, which again is correct for the western plot but incorrect for the eastern plot for the same reasons.
- The current nature management type N12.02 is correct for the western plot. For the eastern plot, the ambition N10.01 (Figure D.1.21) is more suitable already as all criteria have been met.
- Therefore, the ambition N10.01 is already achieved for the eastern plot and is achievable as well for the western plot by excavating the top 30 cm of the soil, which results in a nutrient-poor soil and a higher groundwater table. The adjacent corn field could be a threat for the minimum pH of 5 (it is exactly 5.0 now at 10 cm depth), so it might be better to transform this field into an N12.02 or something similar.
- Since the eastern plot has a chalk-rich layer and is very wet, a limestone marsh (or bogland, N05.03) should be achievable as well (Figure D.1.20), but only when the ditches that drain the plot will be filled in. For the western plot, N05.03 should be achievable as well, but it will take more effort. First of all, no chalk-rich layer in present, which means the plot can only become a regular N05.03. Also, the upper 50 cm of soil has to be excavated and the surrounding ditches have to get filled in. The adjacent corn field can be a threat as well, as the plot will be higher and can provide unwanted nutrients, so than it would be best to transform that plot to an N12.02 for example. Therefore, it seems more achievable to turn the western plot into an N10.01.
- All by all, the current N10.01 ambition is easy to realize. N05.03 is possible as well, but needs a lot more effort for the western plot, where N10.01 seems more achievable.

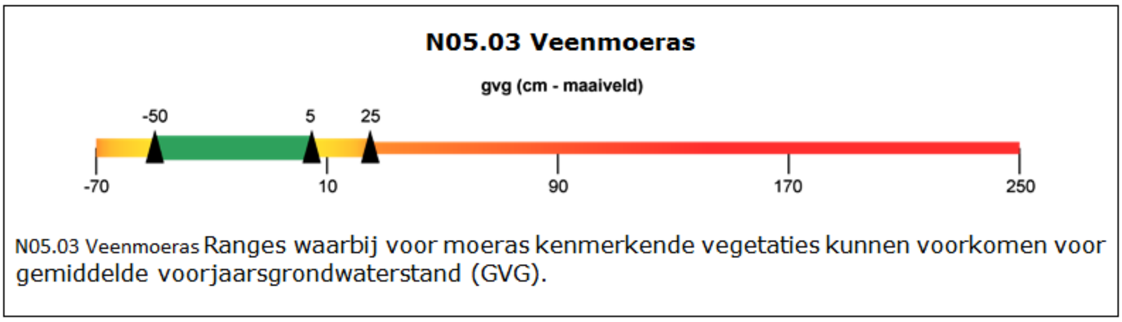
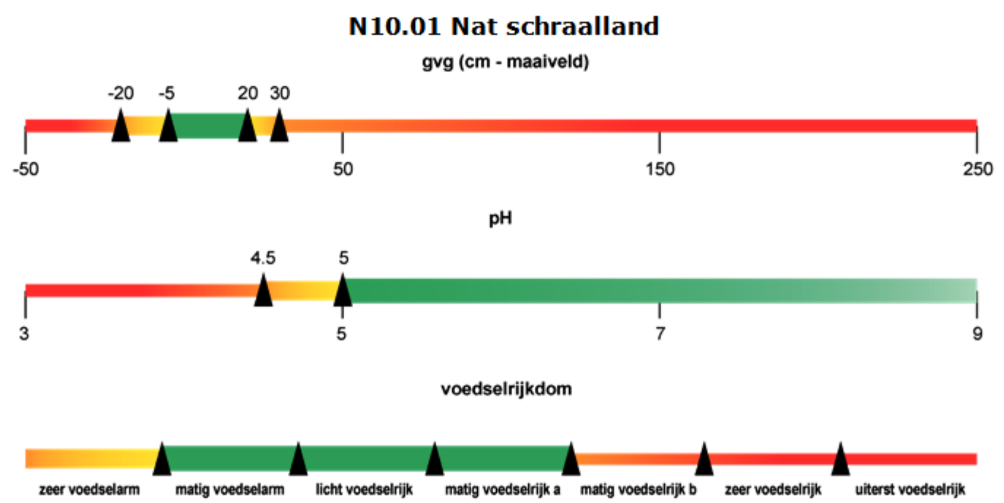


Figure D.1.20: Ideal conditions for an N05.03 or bogland, according to BIJ12.



N10.01 Nat schraalland. Ranges waarbij voor nat schraalgrasland kenmerkende vegetaties kunnen voorkomen voor gemiddelde voorjaarsgrondwaterstand (GVG), zuurgraad (pH) en voedselrijkdom.

Figure D.1.21: Ideal conditions for an N10.01 or wet nutrient-poor grassland, according to BIJ12.

D.2 Salland estates Boetelerbroek

The location of the investigated site is indicated by the red circle in the figure below and was visited on November 29, 2021.

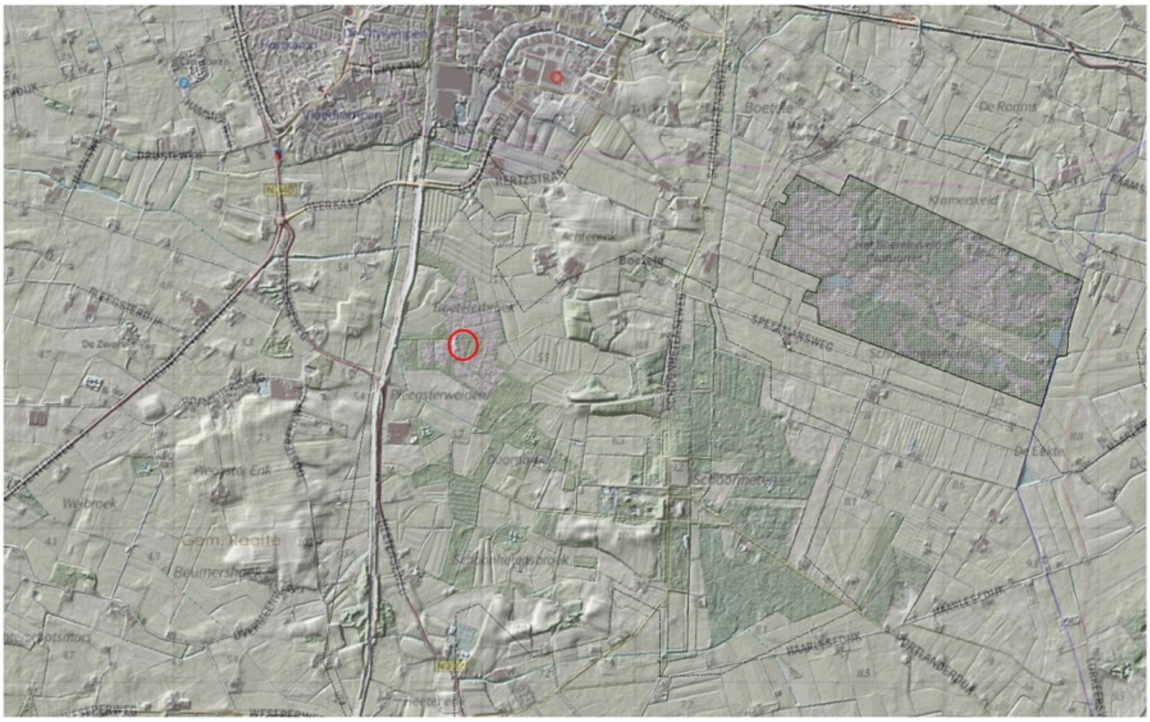


Figure D.2.0: Location 11 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site. In preparation direct available spatial information was checked before visiting the site in the field.

Questions

- Currently, the area has nature management type N12.06 (shrubland), which remains unchanged in the ambition, but it might have the potential to become a 'blauwgrasland' (Sesleria albicans grasslands), which is part of N10.01 (wet nutrient-poor grassland).
- How does the area look like now? Forests and heathland? Is the area heavily being drained?
- Are there any positive seepage indicators, such as an iron film or plants such as Hottonia palustris, *Scirpus sylvaticus* or Equisetum fluviatile.
- Is the groundwater table in accordance with MIPWA 3.0?

Preparation

- Figures D.2.1-4 all show the area of interest. N12.06 seems to be correct when looking at the maps and aerial photos, which show a mix of bushes, some higher trees and some open areas which could be patches of heathland or just grasses.
- According to LGN6 (Figure D.2.5), the plot consists completely of deciduous forest. LGN2020 (Figure D.2.6) indicates a lot of different nature types, including deciduous forest ,coniferous forest, moderately grassed heathland, strongly grassed heathland, reed bed vegetation and other shrubbery (low). Judging by Figure D.2.3, LGN2020 is closer to reality than LGN6.
- MIPWA 3.0 states that the GG mostly is between 60 and 80 cm below ground level (Figure D.2.8) and the GVG mostly lies between 40 and 80 cm below ground level (Figure D.2.9). In the southwestern part of the plot there should be a positive seepage flux, while in the rest of the area the flux is negative (Figure D.2.10).
- Figure D.2.7 shows measurement data from a well on the plot, but only for 4 months in 2008. The groundwater table was 55-75 cm below ground level, which is in good accordance with MIPWA 3.0 data.

- According to the Dutch soil map (Figure D.2.11) the soil consists of fpZg23 (beekeerdsoils; loamy fine sand (locally iron-rich, starting within 0.5 m and at least 0.1 m thick)) and vWz (moerige (peaty) eerdsoils with a moerige upper soil on sand).
- Figure D.2.12 shows WWN 3.0's predictions for the current situation, which is almost completely H47. For the past, undisturbed situation (Figure D.2.13), a mix of H47, H21, H22 and H27 is predicted. H21, H22 and H27 are the wetter versions of H47, which is logical for the past, undisturbed situation.
    - H47: Forest and shrublands on moist, moderately nutrient-rich soils (older stinsen forests and other park-like forests on river clay, loam and loamy sand soils).
    - H21: Forest and shrublands on wet, nutrient-poor, acidic soils (raised bog forests)
    - H22: Forest and shrublands on wet, nutrient-poor, slightly acidic soils (ash-alder woods)
    - H27: Forest and shrublands on wet, moderately nutrient-rich soils (alluvial and wet sloped forests)

Approach

- Make some soil profiles throughout the area and describe how it looks like in terms of flora.
- Determine pH of soil and water and look for positive seepage flux indicators (iron film and specific flora).
- Determine groundwater level and compare this to MIPWA 3.0 and DINOloket data.
- Check whether the plot is being drained by ditches.

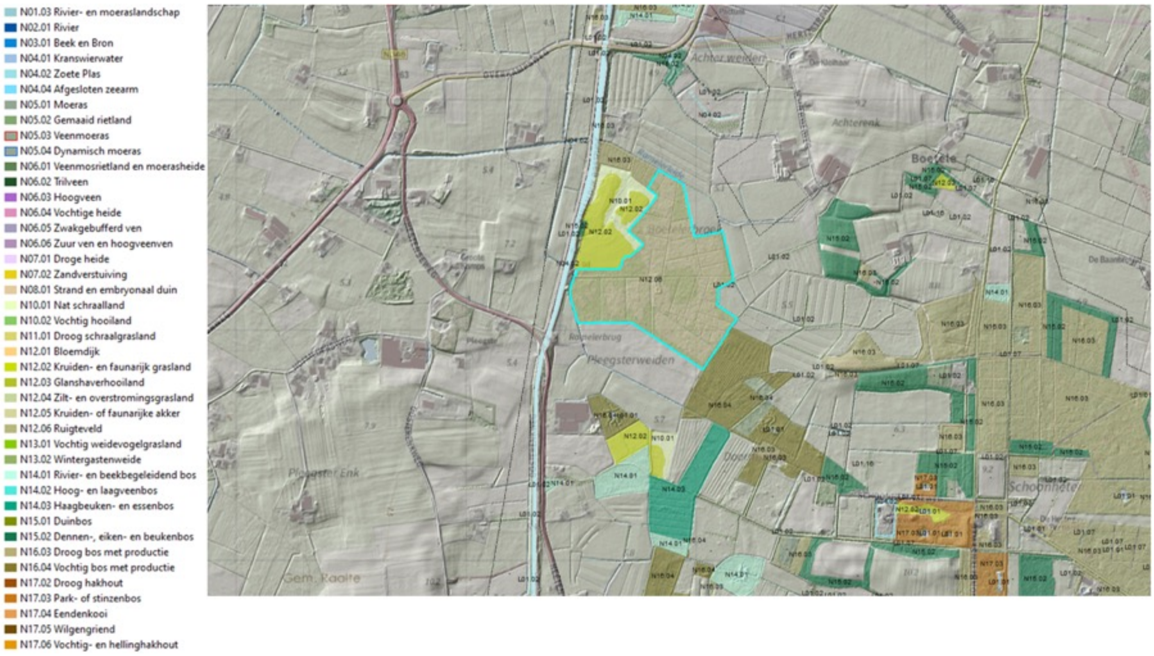


Figure D.2.1: Map showing the area of interest with 12.06 (shrubland) as current nature management type.

Figure D.2.2: Map from Topotijdreis 2020 showing the area with points of interest.

Figure D.2.3: Aerial photo from Topotijdreis 2020.

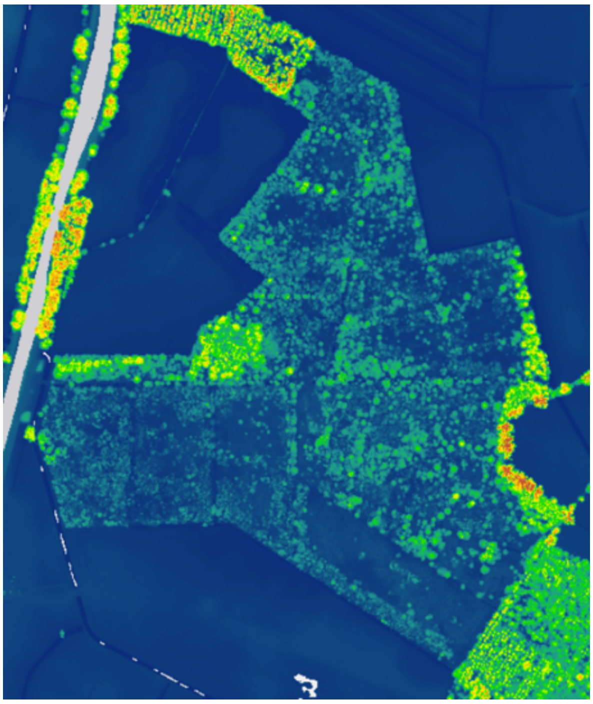


Figure D.2.4: Height data from AHN.

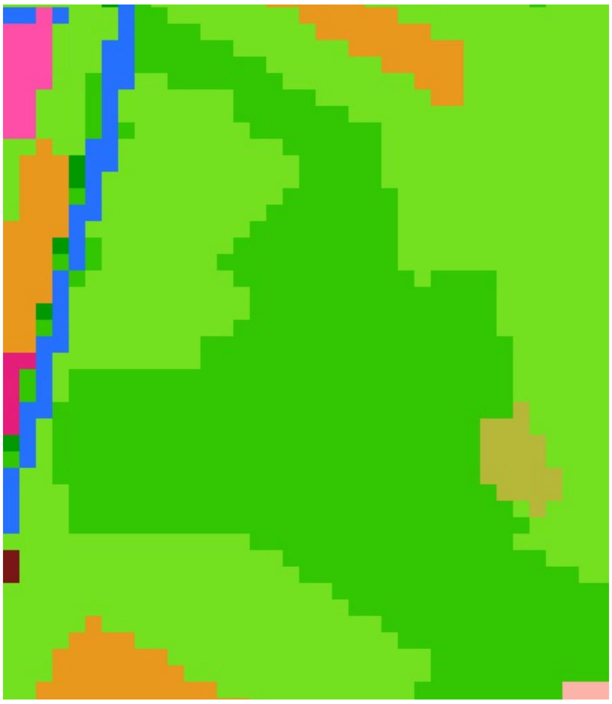


Figure D.2.5: According to LGN6, the whole area consists of deciduous forest.

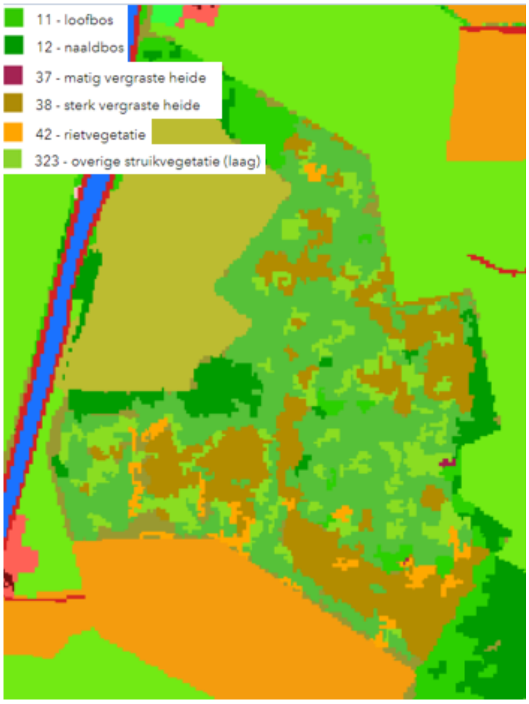


Figure D.2.6: According to LGN2020, the area consists of deciduous forest (11), coniferous forest (12), moderately grassed heathland (37), strongly grassed heathland (38), reed bed vegetation (42) and other shrubbery (low) (323).

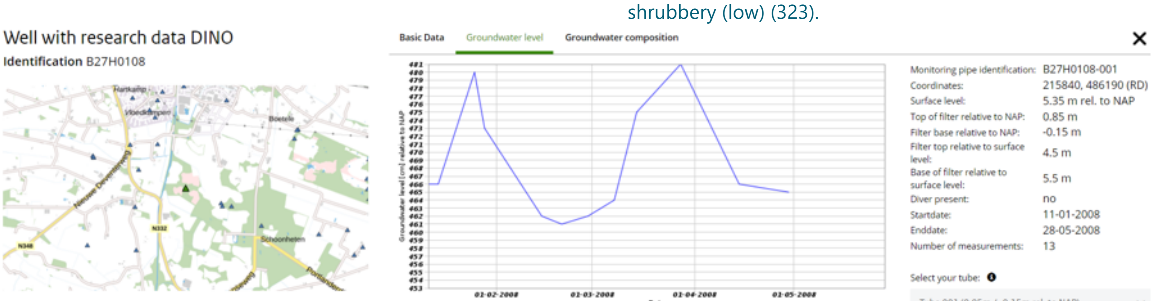


Figure D.2.7: Data from a well from DINOloket in the middle of the area (green triangle on map).

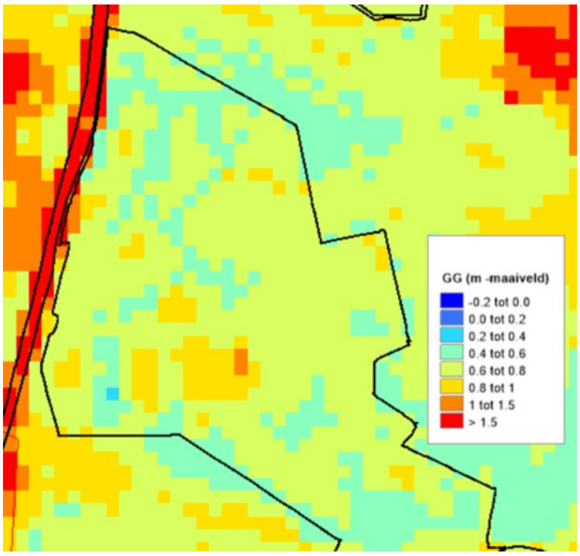


Figure D.2.8: MIPWA 3.0 data on GG.

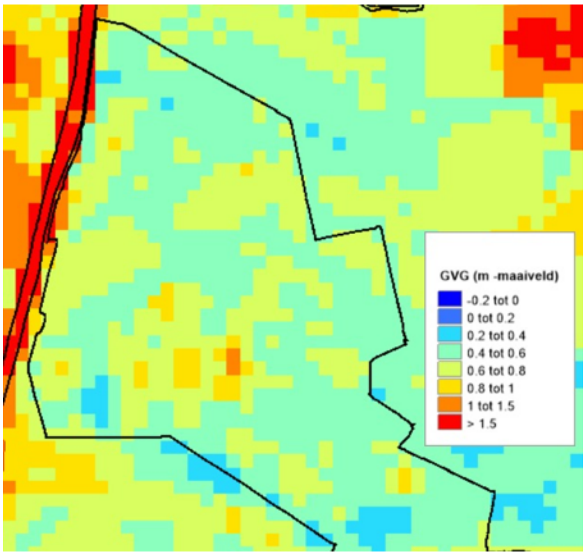


Figure D.2.9: MIPWA 3.0 data on GVG.

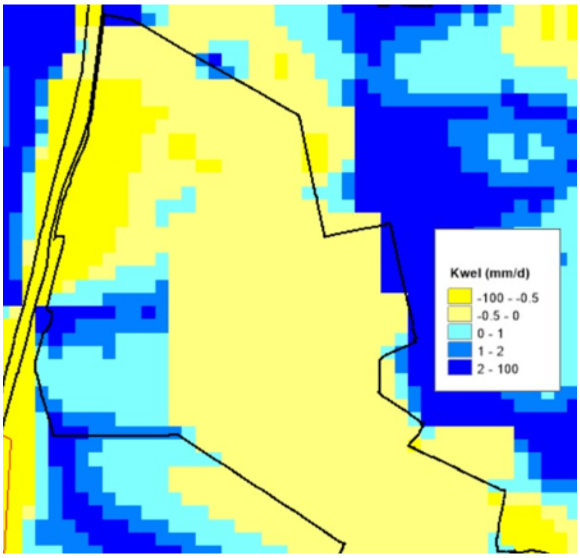


Figure D.2.10: MIPWA 3.0 data on seepage flux.

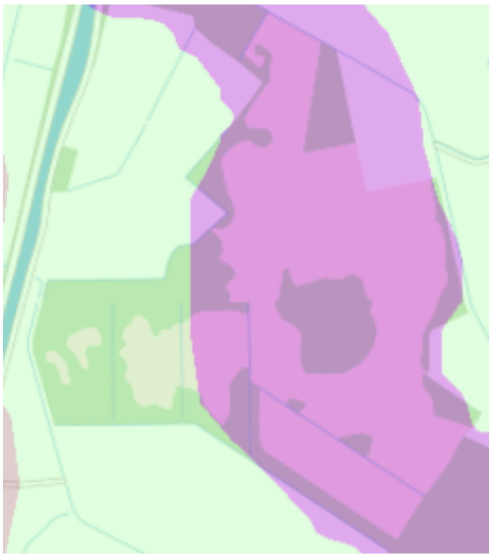


Figure D.2.11: According to the soil map, part of the area has a fpZg23 soil (greenish) and part vWz (purple).

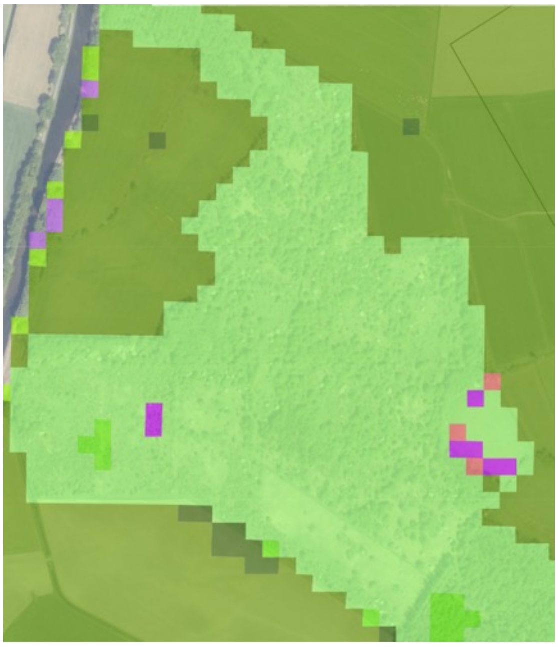


Figure D.2.12: WWN 3.0 predicts H47 for the current situation.


Figure D.2.13: WWN 3.0 predicts H47 (lightest green), H27 (light green), H22 (red), H21 (dark purple) and some 'unknown' (light purple).

Table D.2.1: Field data of the locations corresponding with Figure D.2.2.

Location (fig. D.2.2)	RD-coord.	GWT (cm)	PH (-)	Description
1	215465, 486223	n/a	7.0 (water)	Deep, fast-flowing ditch at outer edge of the area (Figure D.2.14), (about 1.5 m deep with 70 cm of water) with an iron film (Figure D.2.15). Along the side of the ditch Glechoma hederacea, Elodea nuttallii, Ranunculus acris, Anthriscus sylvestris, Heracleum sphondylium, Cardamine pratensis, Rumex acetosella, Urtica spec., Achillea millefolium, Plantago lanceolata.
2	215604, 486228	n/a	6.7 (water)	Small, stagnant ditch (10 cm of water, water surface 70 cm below ground level of path, but only 30 cm on the other side of the ditch) with iron film along path in bushy area (Figure D.2.16). Arctium lappa, Equisetum palustre, Galium saxatile, Heracleum sphondylium, Dryopteris filix-mas.
3	215719, 486229	n/a	n/a	Same ditch, still with iron film. Also, Equisetum fluviatile present, seepage indicator.
4	215911, 486510	~60	≤4 at 10cm 6.8 at 110cm	Open forest with mainly Quercus spec. and Betula spec. (Figure D.2.17). Also, Rubus spec., Dryopteris carthusiana/dilatate. Soil profile (Figure D.2.33): - 0-35 cm: fine, brown sand with rust from 15 cm. - 35-60 cm: fine sand, mixture of grey and golden brown with rust. - 60+ cm: fine, light grey sand, towards the end very fine and increasingly wet. Contains wood residues. The measurement of the groundwater level has been lost, but judging from the photograph and the described profile, probably around 60 cm below ground level, in any case less than 80 cm.
5	215971, 486514	n/a	6.7 (water)	Ditch of 70 cm deep with 30 cm of water (compared to field, ground level at location 4 is higher). No iron film, but Equisetum fluviatile present. Field is nutrient-rich (Figure D.2.18).
6	215876, 486348	n/a	6.8 (water)	Ditch of 60 cm (Figure D.2.19) along path (Figure D.2.20) with 30 cm of water. No iron film, but Typha latifolia and Equisetum fluviatile (seepage indicator) present.
7	216155, 486248	n/a	7.0 (water)	Slow-flowing ditch (Figure D.2.21) of 1.20 m deep with 30 cm of water with slight iron film. Bubbles regularly rise from the bottom. Callitriche spec., Ranunculus acris, Plantago lanceolata, Rumex acetosella.
8	216071, 486261	50	4.6 at 10cm 6.6 at 110cm	More open area (Figure D.2.22) with many fat grasses, ferns, Urtica spec., Heracleum spec., some patches of Juncus effusus and some small trees. Soil profile (Figure D.2.34): - 0-35 cm: fine, brown soil with some rust. - 35-60 cm: fine, light brown/grey sand with branch residues and rust. - 60+ cm: moderately fine to very fine, light grey sand, increasingly wet and with wood residues.
9	215954, 486234	n/a	n/a	Larger trees, ditch along path (Figure D.2.23).
10	215851, 486228	n/a	6.8 (water)	Somewhat deeper ditch (1.30 m deep with 65 cm water) with iron film (Figure D.2.24). Equisetum fluviatile (Figure D.2.25), Cerastium glomeratum and Cerastium fontanum subsp. vulgare.
11	215936, 486005	10	4.6 at 10cm 6.0 at 110cm	Big reed bed (Figure D.2.26) with moss, nettle spec., fat grasses, Cirsium vulgare and Cirsium arvense. On other side of ditch more of a shrubland (Figure D.2.27). Soil profile (Figure D.2.35): - 0-30 cm: soaking wet, brown soil. - 30+ cm: very fine, grey, wet sand with some wood residues.

12	215760, 486138	n/a	n/a	Shrubland (Figure D.2.28), looks the same as location 8 with Juncus effusus, Phragmites australis, grasses and small trees.
13	215699, 486160	n/a	6.7 (water)	Ditch of 60 cm deep with 20 cm of water (Figure D.2.29) with Equisetum palustre. No iron film.
14	215559, 486265	n/a	6.8 (water)	Ditch of 60 cm deep with 25 cm of water (Figure D.2.30) at the outer edge of the area. No iron film.
15	215560, 486240	55	4.8 at 10cm 6.0 at 110cm	Small bush with lots of Rubus spec., Urtica spec. (Figure D.2.31) and along the path Phragmites australis. Soil profile (Figure D.2.36): - 0-35 cm: moist, brown soil. - 35-60 cm: damp, fine, brown sand with wood residues and pebbles. - 60+ cm: very fine, light grey sand, increasingly wet with wood residues.
16	215438, 486221	n/a	7.1 (water)	Channel along the border of the area (Figure D.2.32). Water surface seems to be higher than ground level of the area. Together with the high pH, this could be a source of the seepage flux present in the area.

Figure D.2.14: Deep, fast-flowing ditch at location 1.

Figure D.2.15: Iron film on water at location 1.

Figure D.2.16: Ditch along path at location 2.

Figure D.2.17: Quercus spec. and Betula spec. at location of soil boring (loc. 4).


Figure D.2.18: Ditch along nutrient-rich field (location 5).


Figure D.2.19: Ditch along path (location 6).


Figure D.2.20: Path at location 6.


Figure D.2.21: Slow-flowing ditch with slight iron film (location 7).


Figure D.2.22: More open area at location of soil profile (location 8).


Figure D.2.23: Ditch along path and larger trees (location 9).

Figure D.2.24: Somewhat deeper ditch at location 10.

Figure D.2.25: Equisetum fluviatile at location 10.

Figure D.2.26: Reed bed at location of soil profile (location 11).

Figure D.2.27: More of a shrubland on the other side (location 11).

Figure D.2.28: Shrubland at location 12.

Figure D.2.29: Small ditch with Equisetum palustre at location 13.

Figure D.2.30: Small ditch at the edge of the area (location 14).

Figure D.2.31: Small bush with lots of blackberry spec. and Urtica spec. at place of soil boring (location 15).

Figure D.2.32: Channel (location 16) along border of the area (visible on the far right of the picture), water surface seems to be higher than ground level of the area.

Figure D.2.33: Soil profile at location 4.

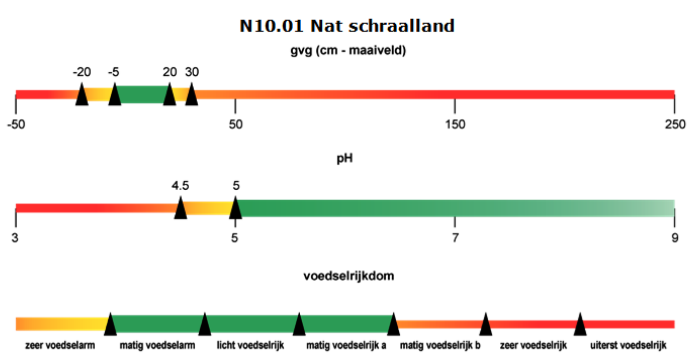
Figure D.2.34: Soil profile at location 8.

Figure D.2.35: Soil profile at location 11.

Figure D.2.36: Soil profile at location 15.

Discussion/conclusions

- The area is being drained quite extensively by deep, slow- to fast-flowing ditches on some of the outer edges (locations 7 and 16) and also by shallow ditches within the area itself, although the water in those ditches does not flow.
- The field visit showed that the plot did have parts that could be described as a deciduous forest, but other parts could not be labelled as such as there were too few trees, making LGN6 only partly correct. LGN2020 showed much more detail, but this detail turned out to be periodically incorrect. Some patches of coniferous forest (Figure D.2.6) were indicated for example, but only deciduous trees were present. Also, no heathland was found at all, but reed beds were more dominant, as well as 'other' shrubbery. So, LGN2020 has more detail than LGN6, but is still only partly correct.
- Assuming that the groundwater level was indeed 60 cm below ground level on location 4, this means that on 3 out of 4 measurement locations the results (50-60 cm below ground level) correspond well to MIPWA 3.0 for both the GG (60-80 cm below ground level) and the GVG (40-80 cm below ground level). Only the measurement at site 11 was very high (10 cm below ground level), but as this was only local, it can be concluded that MIPWA 3.0 is correct with respect to the groundwater table for this area. Both MIPWA 3.0 and field data are comparable with DINOloket data (Figure D.2.7) as well.
- With respect to the seepage flux however, MIPWA 3.0 is incorrect. It states that most of the area has a negative seepage flux, while the widespread presence of Equisetum fluviatile and an iron film on water in ditches indicates otherwise. Also, the pH in the ditches is between 6.7 and 7.1, once again showing that MIPWA 3.0 is wrong on this aspect.
- The soil profiles at locations 8, 11 and 15 do have a moerige upper soil on sand and all have wood residues within the first 80 cm, but also have an enriched upper layer. They can thus be classified as vWz (moerige eerdsoils). The soil profile at location 4 consists of fine sand and has an iron-rich layer and can be classified as an fpZg23 (beekeerdsoil), but with an enriched upper soil. So, the Dutch soil map indicated the right soil types, but the distribution was not completely correct (4 and 15 were the other way around). Still, it can be concluded that the Dutch soil map is reasonably correct.
- For the current situation, H47 is perfect as the plot indeed consists of forest and shrubland on a moist, mostly moderately nutrient-rich soil, so WWN 3.0 is correct.
- Since the area likely will become wetter when it is not being drained, it is logical that WWN predicts also H21, H22 and H27 for the past, undisturbed situation, next to parts that remain H47. H22 is the most predicted new type and is also the most credible of the three, as the soil is slightly acidic at the moment of measuring. Therefore, WWN 3.0 seems to be correct.
- All by all, the area has a patchwork of more open parts, forest, reed beds and other low vegetation. All these patches together fit perfectly under the description of an N12.06 (shrubland), so both the current nature management type and ambition are correct.
- For an N10.01 (wet nutrient-poor grassland) the pH is on the low side (<4-4.8) at a depth of 10 cm, while 4.5 is the minimum (Figure D.2.37). With depth, the pH increases quickly however (6.0-6.8 at 110 cm). At the moment, both the groundwater table and the nutrient-richness of the area are insufficient for an N10.01. This could be solved by reducing the amount of drainage significantly, removing all trees and bushes, and excavating the topsoil by about 35 cm. But as this is very labour-intensive and the area already is an N12.06, this seems excessive. A cheaper option would be to cut back the drainage to a large extent and turn the area into for example a marsh or wet forest.



N10.01 Nat schraalland. Ranges waarbij voor nat schraalgrasland kenmerkende vegetaties kunnen voorkomen voor gemiddelde voorjaarsgrondwaterstand (GVG), zuurgraad (pH) en voedselrijkdom.

Figure D.2.37: Ideal conditions for N10.01 (wet nutrient-poor grassland), according to BIJ12.

D.3 Salland estates Schoonheten

The location of the investigated site is indicated by the red circle in the figure below and was visited on November 30, 2021.

Figure D.3.0: Location 12 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site. In preparation direct available spatial information was checked before visiting the site in the field.

Questions

- In general terms for the estate: The condition of the forests can say something about the hydrological functioning of the area. If the area (periodically) dries out, this will be reflected in disturbance species in the forest. What do the forest plots on (periodically) wet locations with a stocking of indigenous trees look like? Well developed? (So, few disturbance species and a species composition according to the descriptions of indigenous forest communities that can be expected at that location (alder brook woodland or alder-ash wood))? Or dried up (with many disturbance species like Rubus spec., Urtica spec. and/or Dryopteris dilatata)? Or is there for example a mosaic of undisturbed and disturbed parts?

Preparation

- For this estate, no soil borings will be done since the question is focusing on plant and tree species,
- Figure D.3.1 shows the area and its current nature management types (ambitions unchanged), which are N14.03 (hornbeam and Fraxinus excelsior forest), N16.03 (dry production forest) and mostly N16.04 (moist production forest). While AHN (Figure D.3.2) and Topotijdreis 2020 (Figure D.3.3) indeed indicate the presence of forest on all the plots, the aerial photo from Topotijdreis 2020 (Figure D.3.4) suggests that the forest on part of the plots have been cut down recently.
- The soil of the plots does, according to the Dutch soil map (Figure D.3.5), consist of vWz (moerige (peaty) eerdsoils with a moerige upper soil on sand) and fpZg23 (beekeerdsoils; loamy fine sand (locally iron-rich, starting within 0.5 m and at least 0.1 m thick), but as no soil profile will be made, this will not be verified.
- According to LGN6, all plots consist of deciduous forest (Figure D.3.5), except for one, which should be a natural grassland. LNG2020 indicates a mix of deciduous and coniferous forest and some natural grasslands (Figure D.3.6). For both versions, the pink area is a tree nursery, but they are not part of the area of interest.

- Figures D.3.7-8 show the GVG and GG data from MIPWA 3.0. It is clear why 2 plots are N16.03 (dry) while the other plots are N16.04 (moist). Figure D.3.9 shows data from DINOloket for a well close to the area. The graph is in good accordance with MIPWA data.
- Figure D.3.11 shows the prediction from WWN 3.0 for the current situation, which mostly is H47 and some H27. For the past, undisturbed situation (Figure D.3.12), mostly H21, H22 and H47 are predicted, but also some H27, K22, K41 and K42.
    - H21: Forest and shrublands on wet, nutrient-poor, acidic soils (raised bog forests)
    - H22: Forest and shrublands on wet, nutrient-poor, slightly acidic soils (ash-alder woods)
    - H27: Forest and shrublands on wet, moderately nutrient-rich soils (alluvial and wet sloped forests)
    - H47: Forest and shrublands on moist, moderately nutrient-rich soils (older stinsen forests and other park-like forests on river clay, loam and loamy sand soils).
    - K22: Pioneer vegetation and grasslands on wet, nutrient-poor, slightly acidic soils (sphagnum reed lands, floating mat, Sesleria albicans grasslands, calcium-poor dune valleys).
    - K41: Pioneer vegetation and grasslands on moist, nutrient-poor, acidic soils (wet heathland and raised bogs).
    - K42: Pioneer vegetation and grasslands on moist, nutrient-poor, weakly acidic soils (violion caninae grassland, calcium-poor dune valleys).

Approach

- Check all the forest plots for tree species where possible and whether there are many disturbance species like Rubus spec., Urtica spec. and/or Dryopteris dilatata present.
- Also look for drainage by ditches and the pH of them and whether plants are present that indicate seepage

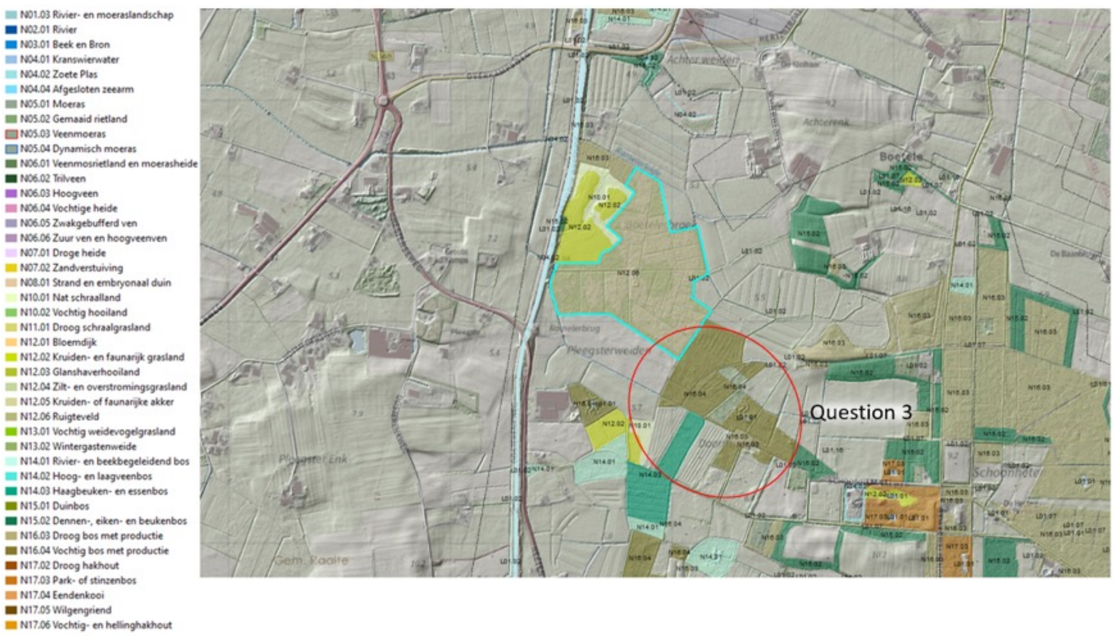


Figure D.3.1: Current nature management type map (ambitions unchanged), estate of interest outlined in red.

Figure D.3.2: Map from Topotijdreis 2020 with points of interest.

Figure D.3.3: Aerial photo from Topotijdreis 2020.

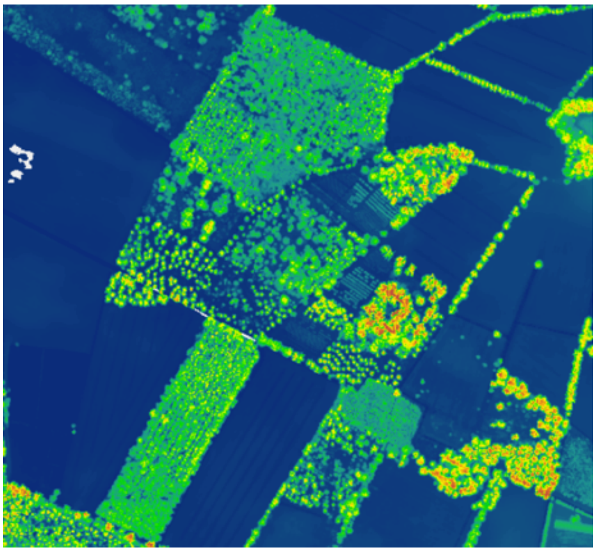


Figure D.3.4: Height data from AHN.

Figure D.3.5: Dutch soil map (purple is vWz, green is fpZg23).

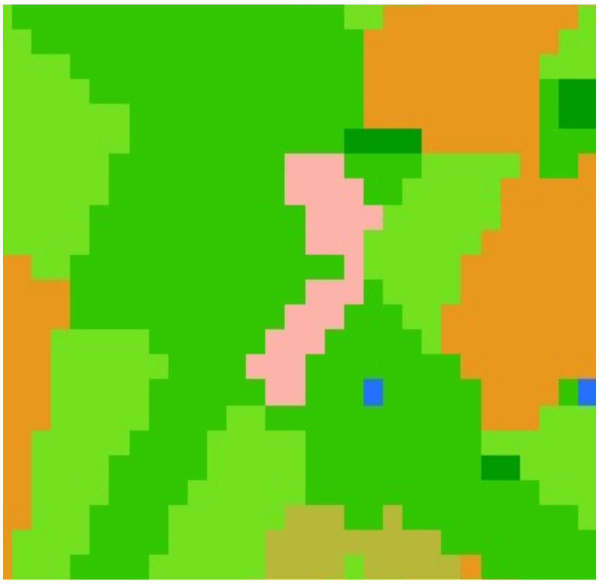


Figure D.3.6: According to LGN6, all plots consist of deciduous forest (medium green), except for one, which should be a natural grassland (beige).

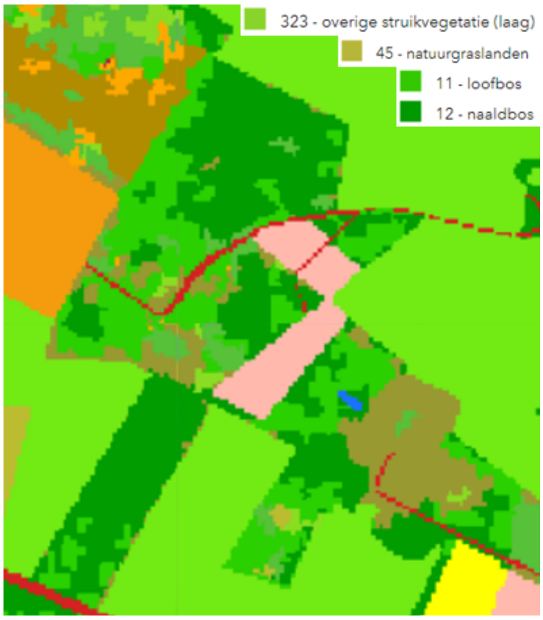


Figure D.3.7: According to LGN2020, the plots consist mostly of deciduous forest (11) and coniferous forest (12), but also some natural grasslands (45) and other shrubbery (low, 323).

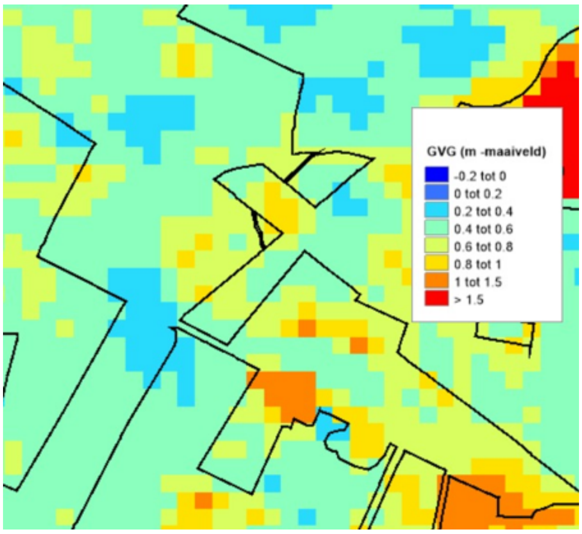


Figure D.3.8: MIPWA 3.0 data on the GVG.

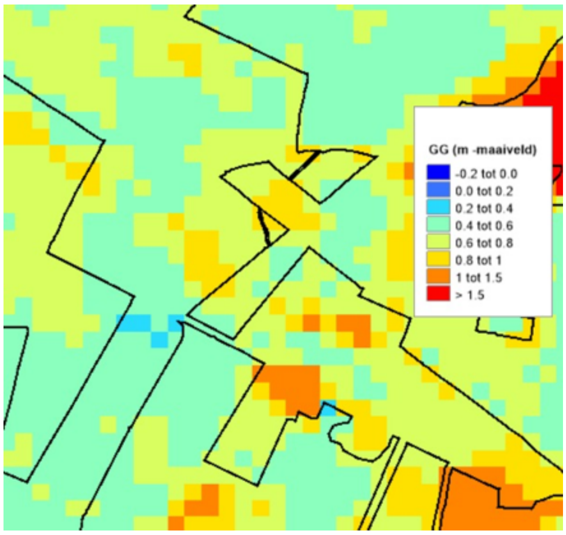


Figure D.3.9: MIPWA 3.0 data on the GG.

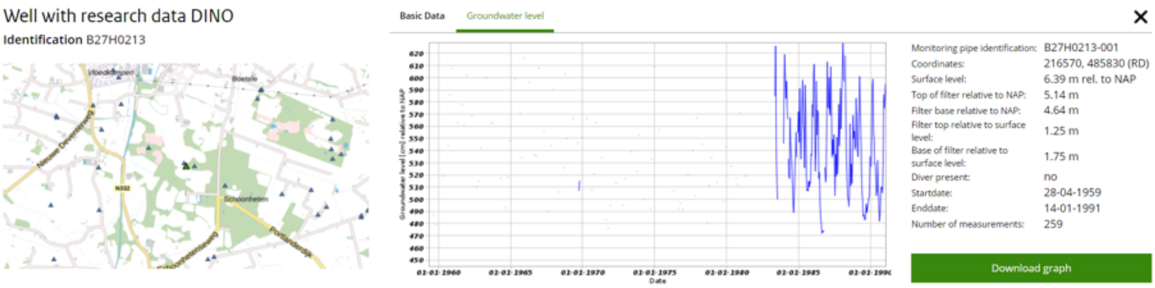


Figure D.3.10: DINOloket data from a well near the plots (green triangle).

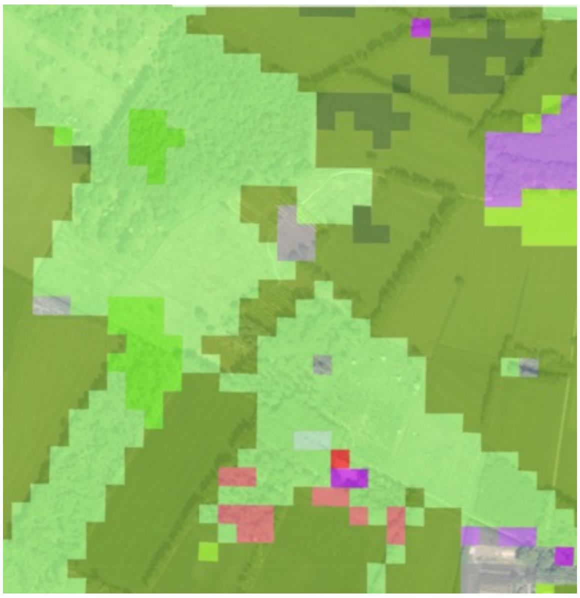


Figure D.3.11: For the current situation, WWN 3.0 predicts mostly H47 (lightest green), some H27 (light green) and also some K-ecotope groups (purple/red).

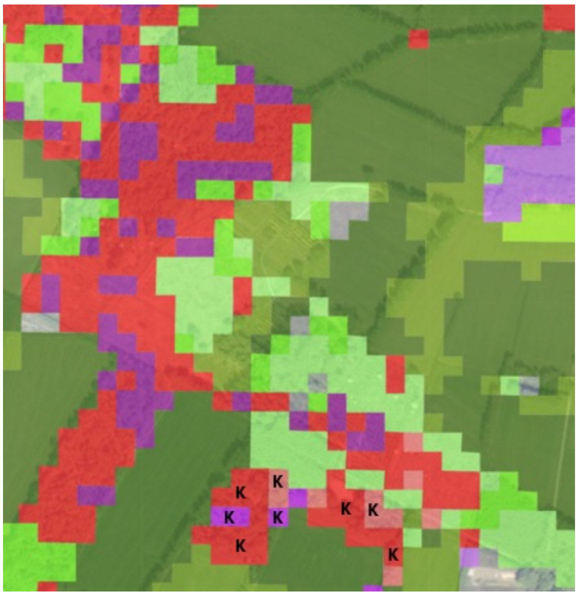


Figure D.3.12: For the past, undisturbed situation, WWN 3.0 predicts a lot of H22 (red), H21 (purple) and H47 (lightest green). Also, some H27 (light green), K22 (red labelled with K), K41 (purple labelled with K) and K42 (pinkish labelled with K).

Table D.3.1: Field data of the locations corresponding with Figure D.3.2.

Location (fig. D.3.2)	RD-coord.	PH (-)	Description
1	215984, 485302	n/a	Almost only Quercus spec. with a lot of undergrowth of Rubus spec., Urtica spec. and Glechoma hederacea. Further also Euonymus europaeus, Arctium lappa, Heracleum spec., Rubus idaeus and Fraxinus excelsior (Figure D.3.13). Is being drained by a ditch of 1.2 m deep with 30 cm of water, flowing very slowly (Figure D.3.14).
2	216060, 485399	n/a	Now also Carpinus spec (Figure D.3.15) on the plot. Drainage is stronger at this spot; a ditch of 1.5 m deep, 2 m wide with 40 cm of water flows around 1.5 m/10s.
3	216137, 485532	n/a	Now Quercus spec. are gone and Alnus glutinosa is present. Also, Phragmites australis and other shrubbery (Figure D.3.16).
4	216129, 485593	n/a	Big reed bed with freshly planted trees (Figure D.3.17). Heavily drained by a ditch of 1.5 m deep, 3 m wide with 50 cm of water.
5	216258, 485664	6.8 (water)	Now also Rubus spec., grass, and small Alnus glutinosa spec. (Figure D.3.18). Also, a ditch (of 90 cm with 30 cm of water) with Hottonia palustris (seep indicator) along the border of the plot.
6	216186, 485872	n/a	In the middle of a forest, lots of Betula spec.., Quercus spec., Alnus glutinosa and smaller trees like Salix spec., Euonymus europaeus and other species (Figure D.3.19). Also, lots of Rubus spec., fern, grasses, Urtica spec. and some Juncus effusus. Along the edge of the forest, a ditch is draining the plot and on the plot itself, shallow, dry ditches are present.
7	216266, 485807	n/a	Ditch from location 6, 1.5 m deep with 50 cm of water and Hottonia palustris (Figure D.3.20)
8	216307, 485805	n/a	Freshly planted Quercus spec. Furthermore grasses, Juncus effusus and Rubus spec. present (Figure D.3.21).
9	216375, 485634	n/a	Open forest with Alnus glutinosa, Populus spec., small Quercus spec. and lots of Rubus spec., Urtica spec. and Phragmites australis (Figure D.3.22). The plot is being drained on all four sides. On two sides the ditches are 90 cm deep with 30 cm standing water, the other two sides 1.3 m deep, 1 m wide with 30 cm of water flowing at 3m/10s. The two deep ditches do have an iron film and Hottonia palustris (Figure D.3.23)
10	216433, 485586	n/a	Planted, monotonous plot with Populus spec., Urtica spec., Rubus spec. and grass (Figure D.3.24). Drained on 3 sides, partly by flowing ditches from location 9. 1 side is stagnant, clearly iron film present and Hottonia palustris is growing.
11	216507, 485488	n/a	Trees felled, no new planting (yet). Many fat grasses, Juncus effusus, Urtica spec., Rubus spec. (Figure D.3.25). Drained by 1 fast-flowing ditch of 1.30 m with 30 cm of water.
12	216553, 485418	n/a	Planted Betula spec. forest with lots of Rubus spec. and Urtica spec. and Euonymus europaeus (Figure D.3.26), drained by a small, fast-flowing ditch.
13	216425, 485407	n/a	Coniferous trees drained by a small ditch, along the side of the plot lots of Rubus spec., ferns, Urtica spec. and Phragmites australis (Figure D.3.27).
14	216342, 485478	n/a	Drained by same ditch as locations 12 and 13, also Rubus spec., Urtica spec. and ferns present. This plot should be N16.04, while most of the plots were N16.03, but is looks more or less the same (Figure D.3.28).
15	216254, 485382	n/a	Lots of Urtica spec. and Rubus spec. bushes (Figure D.3.29). The only plot that lacks deep, flowing ditches. Existing ditch is stagnant and water surface is only a few decimetres below ground level (Figure D.3.30).

Figure D.3.13: Forest at location 1.

Figure D.3.14: Ditch draining forest at location 1.

Figure D.3.15: Forest at location 2 being heavily drained.

Figure D.3.16: No Quercus spec. any more here on plot 1 (loc. 3).

Figure D.3.17: Reed bed with freshly planted trees (location 4).

Figure D.3.18: Same Phragmites australis bed, water violet (seepage indicator) present in the ditch (location 5).

Figure D.3.19: Forest at location 6.

Figure D.3.20: Ditch draining forest of location 6 (location 7).

Figure D.3.21: Freshly planted Quercus spec. at location 8.

Figure D.3.22: Forest with large cottonwood spec. at location 9.

Figure D.3.23: Deep ditch with water violet and iron film (location 9).

Figure D.3.24: Betula spec. forest at location 10.

Figure D.3.25: Trees felled, no new planting yet (location 11).

Figure D.3.26: Betula spec. forest at location 12.

Figure D.3.27: Coniferous trees at location 13.

Figure D.3.28: Currently N16.03, but does not look different from other plots (location 14).

Figure D.3.29: Only plot not being drained by deep, flowing ditches (location 15).

Figure D.3.30: Stagnant ditch, water surface only a few decimetres below ground level of plot (location 15).

Discussion/conclusions

- Since no soil borings were carried out, nothing can be said about the accuracy of the Dutch soil map. However, since the area is situated next to Boetelerbroek (Appendix D.2), it is likely that the same soil types are present here, which would mean that the Dutch soil map should be fairly good to good.
- LGN6 proved to be wrong at the time of the field visit (30-11-21) as multiple plots did not have a forest on them and location 13 had coniferous instead of deciduous forest on it. LGN2020 also proved to be incorrect, as only part of the plots without trees were mapped correctly. Also, it was stated that nearly half of the plots consisted of coniferous forest, but only one small plot indeed was a coniferous forest, while the other plots with forest were deciduous ones.
- When we look at Figure D.3.31 however, it becomes clear that LGN6 was indeed correct in the year 2008, as all plots of interest had forest of them (except for one, where natural grasslands where indicated, which was also correct). The only small mistake at the time was that the small area with coniferous trees (location 13) was missed.
- No clear statement can be made with respect to the GVG and GG from MIPWA 3.0, since the groundwater table was never measured. However, based on the water level in the ditches, it can be said that the data are plausible and, in any case, not completely incorrect. With respect to seepage, MIPWA 3.0 stated that part of the area had a strong positive seepage flux (Figure D.3.32), but most of the area had a slightly negative seepage flux. In the field however it showed that many ditches in the area had iron films and Hottonia palustris on/in them, which indicates positive seepage flux. Also, the pH of one of the ditches was measured to be 6.8. But as most of the water was flowing, coming from the east, it could also be that this transport of water resulted in the presence of iron films and Hottonia palustris, while the seepage flux underneath indeed was negative.
- WWN 3.0's prediction of mostly H47 for the current situation is reasonably well for the forest plots, as most of them indeed were moist forest. But for the H27 parts, H47 would have been better as well and the K-ecotope groups were also incorrect, which most likely is the result of LGN6 indicating the presence of natural grassland instead of forest on that specific plot. Furthermore, multiple plots did not have forest on them anymore, but some pioneer vegetation for which K47 (pioneer vegetation on moist, moderately nutrient-rich soils) fits better. All by all, WWN 3.0's prediction for the current situation is largely incorrect when compared to the current state of the plots, but this is mostly caused by deforestation.
- For the past, undisturbed situation, the same principle applies with respect to deforestation of some plots. For the forested plots, especially the prediction of H22 and H47 is correct, whereas H22 should rather have been H21 as well due to the presence of a positive seepage flux. Also once again, the prediction of K-ecotope groups on the same plot as for the current situation is wrong, as there actually is forest present. So, WWN 3.0's prediction for the past, undisturbed situation is also largely incorrect, but also here this is mostly caused by deforestation.
- The current nature management types seem to be correct for the plots that had forest on them, as the N14.03 indeed had Carpinus spec on the plot and the tree species for N16.03 and N16.04 were as could be expected as well. Only the plots labelled as N16.04 did not seem particularly moist, but this was the case on 30-11-21, while in spring those plots could be very well moist indeed. As has been shown, some plots don't have forest on them anymore (locations 4, 5, 8 and 11), but only on the plot of location 11 no new trees had been planted yet. Therefore, the plots with freshly planted trees have the correct nature management type, but the plot of location 11 should be changed to an N12.02 or new trees have to planted in the short term.
- As the ambitions remain unchanged, the same story applies here.
- The forest plots are reasonably well developed in terms of characteristic tree species, which correspond fairly well to alder brook woodland and alder ash wood, but the groundwater level seems to be well too low for an alder brook woodland. Also, the ubiquitous disturbance species (Rubus spec., Urtica spec. and ferns) show that the area is hydrologically seen functioning poor. This is most likely due to the large-scale drainage.

Figure D.3.31: Aerial photos from Topotijdreis for the years 2006, 2008 and 2020.

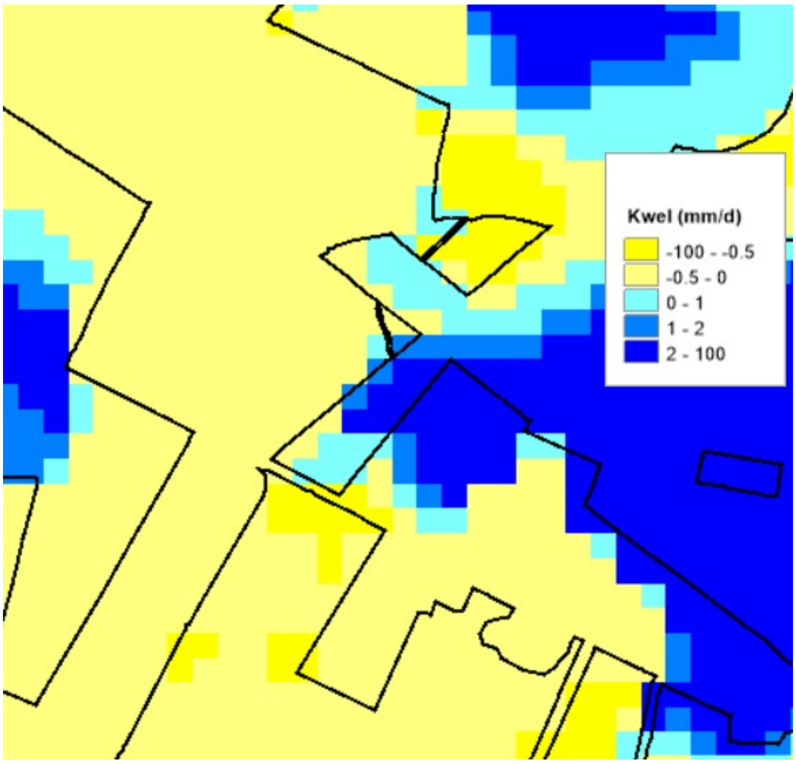


Figure D.3.32: MIPWA 3.0 data on seepage.

D.4 Salland estates moist meadow

The location of the investigated site is indicated by the red circle in the figure below and was visited on December 3, 2021.

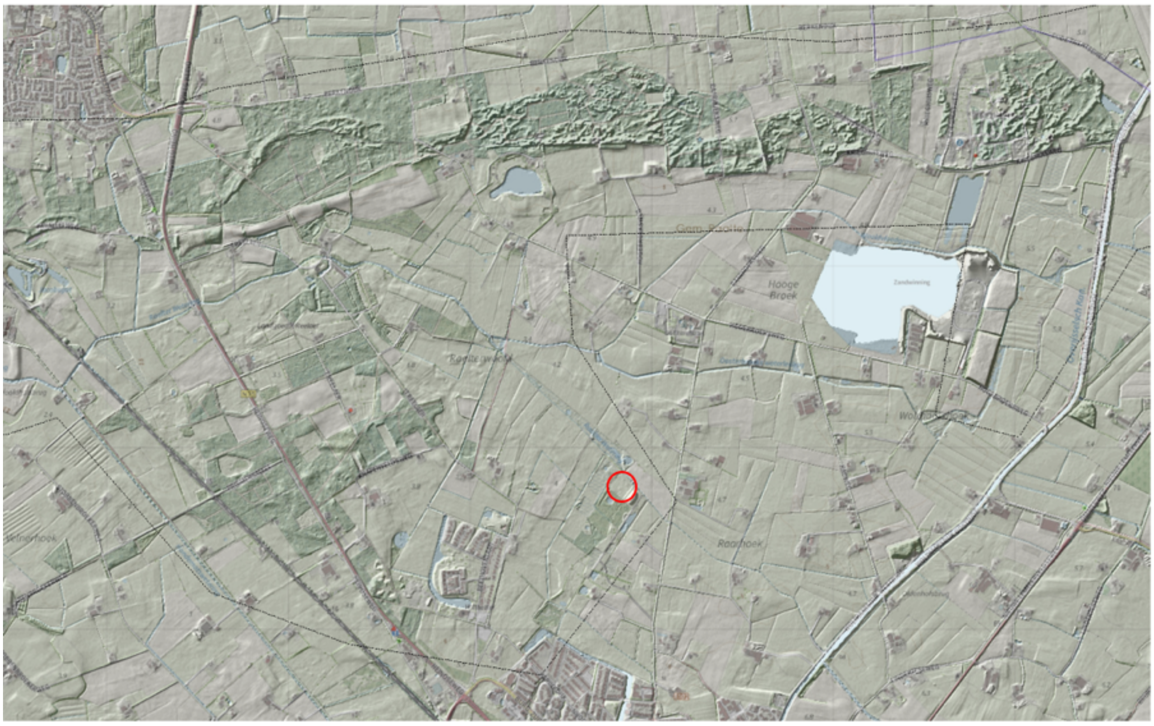


Figure D.4.0: Location 13 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site. In preparation direct available spatial information was checked before visiting the site in the field.

Questions

- On this N10.02 (moist meadow) plot, *Liparis loeselli* has been found. This generally indicates strong seepage flux, clean water and the presence of chalk. Are there indications of seepage and chalk?
- How does the soil look like and is the groundwater table in accordance with MIPWA 3.0 data?

Preparation

- Figure D.4.1 shows the current nature management type (N10.02), which also is the nature ambition. Figures D.4.2-3 show the map and an aerial photo from Topotijdreis 2020. The plot seems to be a grassland.
- Figure D.4.4 shows height data from AHN, including a height profile. The plot is lower than most surrounding plots, so it seems to be excavated in the past. The western part is the lowest.
- LGN6 indicates that the plot consists of agricultural grass (Figure D.4.5), while LGN2020 indicates that the plot is natural grassland (Figure D.4.6), which, judging from the aerial photo, both could be correct.
- The Dutch soil map indicates that the soil consists entirely of a fkpZg23. A pZg23 stands for 'beekeerdsoil; loamy, fine sand'. The f stands for 'locally iron-rich, starting within 0.5 m and at least 0.1 m thick' and the k for 'sandy clay or clay layer, 15-40 cm thick'.
- No well with data is close to the plot according to DINOloket and Vitens.
- According to MIPWA 3.0, the groundwater table is between 0 and 20 cm below ground level for the western part of the plot for both the GVG and GG (Figures D.4.7-8) and 20-40 cm for the rest of the plot. Also, the seepage flux is positive for the entire plot (Figure D.4.9), starting strong on the north-eastern part of the plot and getting weaker towards the south-western part, but remaining positive.

- WWN 3.0 predicts for both the current and the past, undisturbed situation K28 (pioneer vegetation, grasslands and shrublands on wet, very nutrient-rich soils (shrublands along rivers and ditches, wet cultivated grassland) for the complete plot (Figures D.4.10-11).

Approach

- Make a soil profile at the middle of the plot and measure pH and the groundwater level.
- Test whether the soil contains chalk by using a 1M solution of hydrochloric acid.
- Look for an iron film or plants that indicate seepage (e.g., *Liparis loeselli*, *Hottonia palustris*).

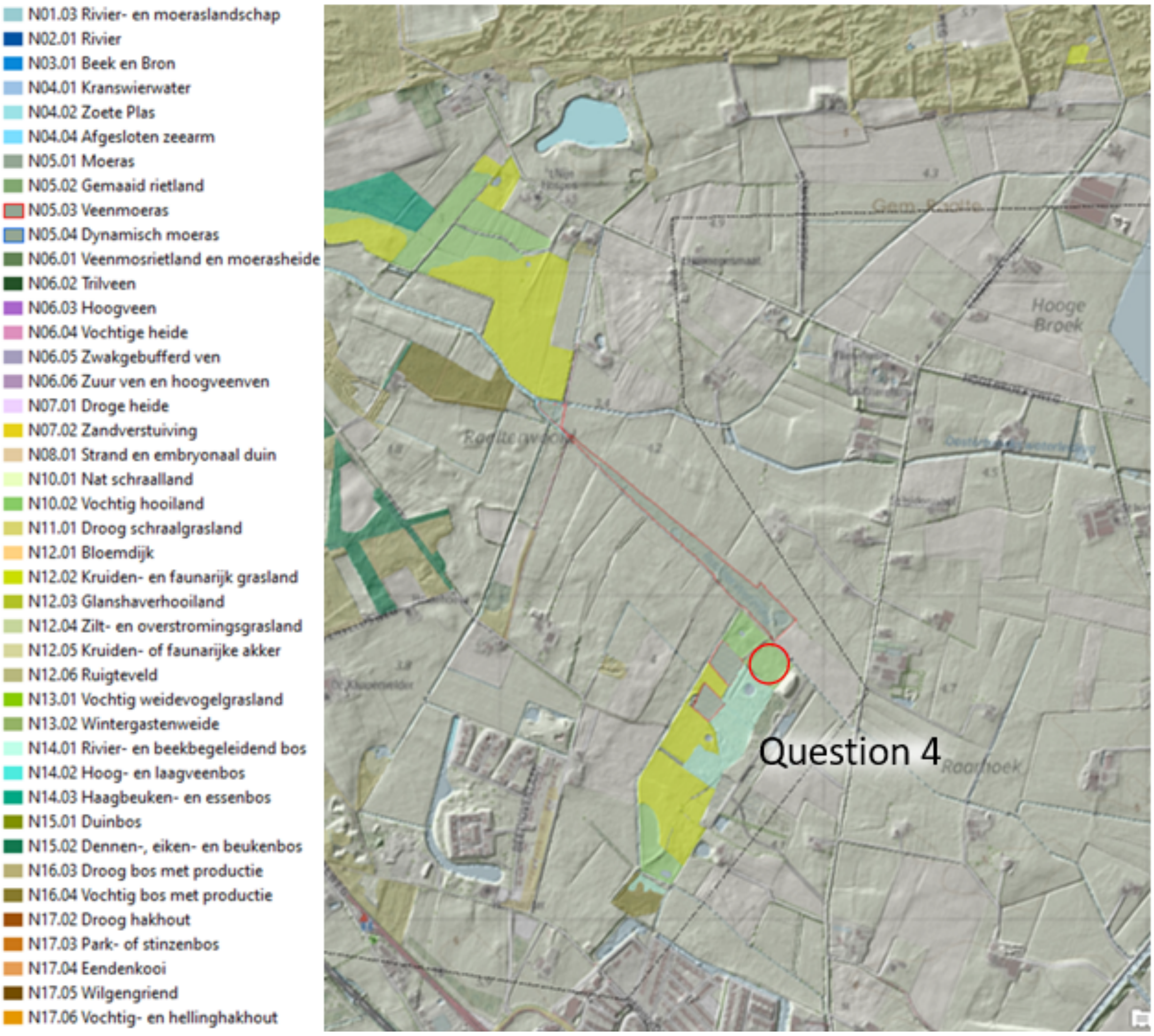


Figure D.4.1: Map showing the current nature management types (N10.02 for this plot).

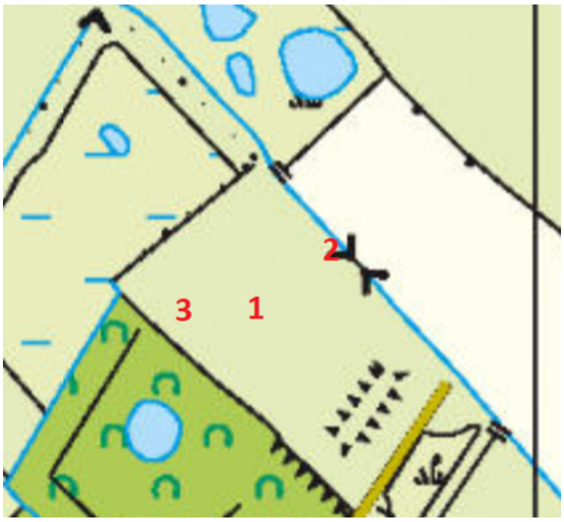


Figure D.4.2: Map from Topotijdreis 2020 with points of interest.

Figure D.4.3: Aerial photo from Topotijdreis 2020.

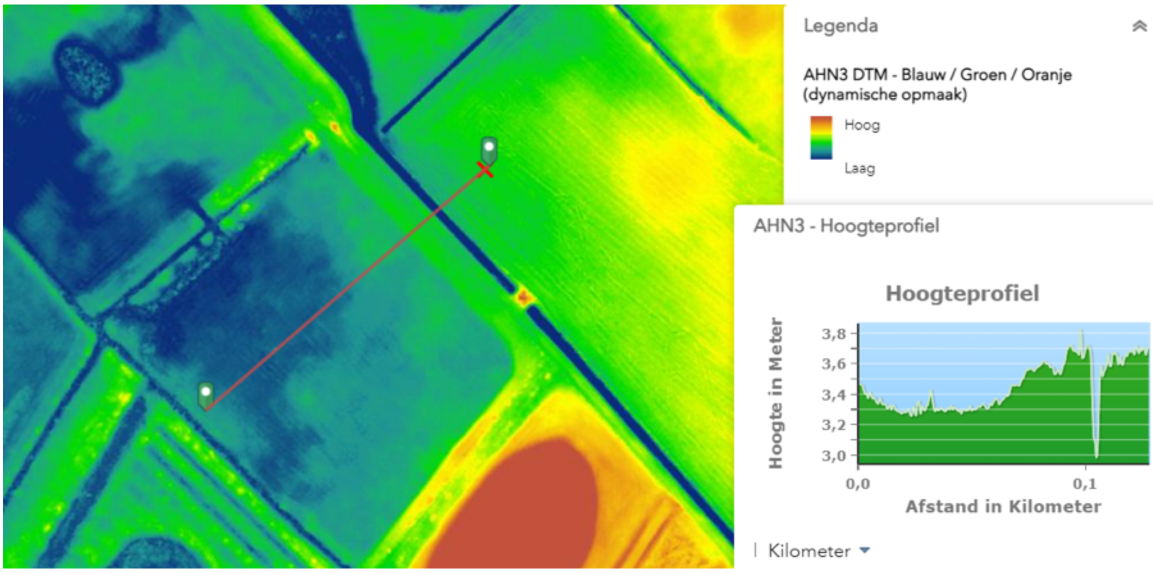


Figure D.4.4: Height data including a height profile across the plot (AHN).

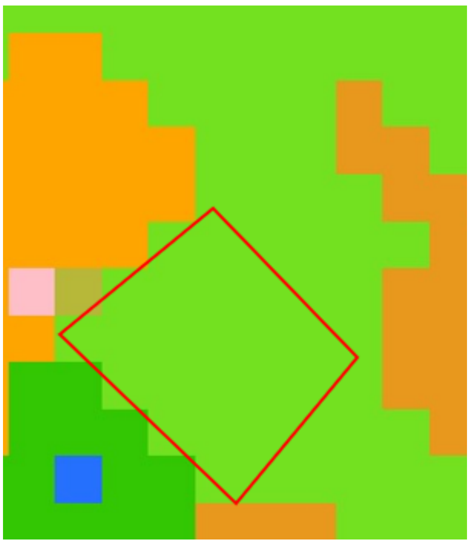


Figure D.4.5: According to LGN6, the plot consists of agricultural grass.

Figure D.4.6: According to LGN2020, the plot consists of natural grassland.

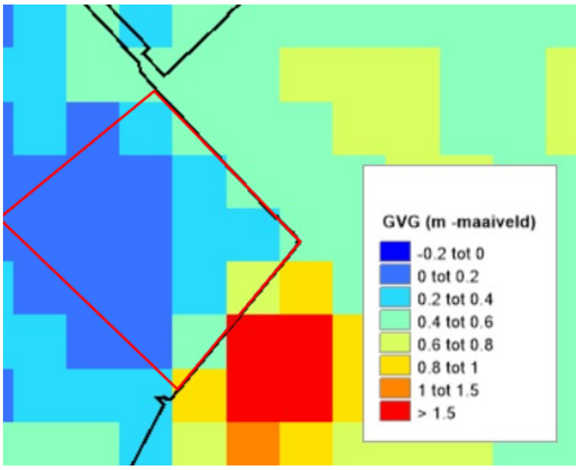


Figure D.4.7: MIPWA 3.0 data on GVG.

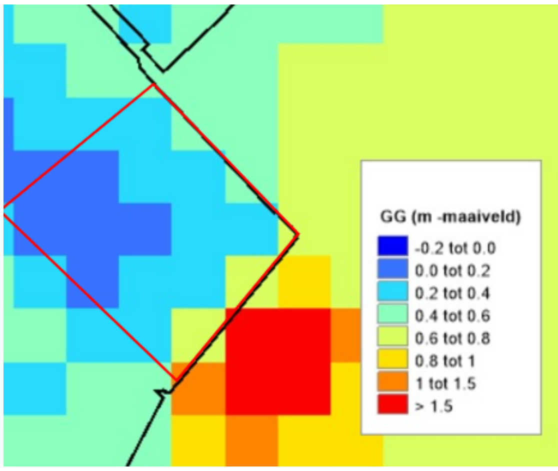


Figure D.4.8: MIPWA 3.0 data on GG.

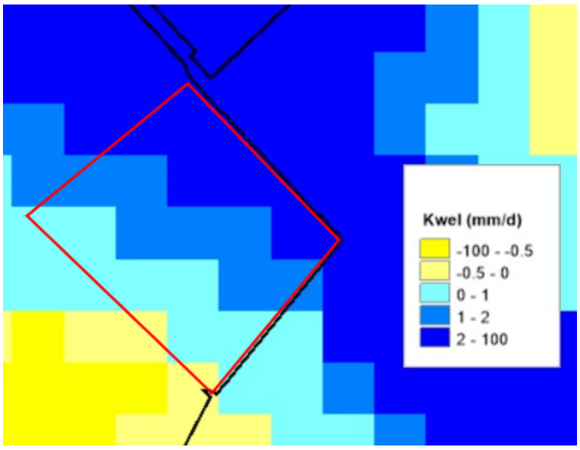


Figure D.4.9: MIPWA 3.0 data on seepage flux.

Figure D.4.10: For the current situation, WWN 3.0 predicts K28 (dark green).

Figure D.4.11: For the past, undisturbed situation WWN 3.0 still predicts K28 (dark green).

Results

Table D.4.1: Field data of the locations corresponding with Figure D.4.2.

Location (fig. D.4.2)	RD-coord.	GWT (cm)	PH (-)	Description
1	215834, 491784	0	5.0 at 10cm 6.8 at 110cm	Mown, except for a small area (Figures D.4.12-13). On field a thick layer of moss, further Ranunculus repens, Ranunculus flammula, Hypochaeris radicata, Rumex acetosa and on not-mowed part a lot of Juncus effusus, Salix spec., Alnus glutinosa and some Phragmites australis. Soil profile (Figure D.4.14): - 0-15 cm: red clay (iron). - 15-30 cm: silt with something that looks like chalk on top, but does not react to hydrochloric acid. Many iron concretions. - 30-110 cm: fine at the beginning, very fine towards the end, grey sand with a lot of twig remains. - 110+ cm: very fine, yellow-grey sand.
2	215876, 491818	n/a	n/a	Photo from higher part on the edge of the plot (FIGURE).
3	215790, 491785	n/a	n/a	Lower part of the plot under 10cm water with very thick iron film (Figure D.4.15), upper part is just dry.

Figure D.4.12: Not-mowed part of plot at location 1.

Figure D.4.13: Overview of mostly mowed plot (location 2).

Figure D.4.14: Soil profile at location 1.

Figure D.4.15: Thick iron film on water at location 3.

Discussion/conclusions

- LGN2020 showed to be correct, as the plot indeed is a natural grassland. LGN6 nowadays is only partly correct, as the plot indeed consists of grassland, but a natural on instead of an agricultural one. In 2008 (see Figure D.4.16), the plot also looked like a natural grassland. So, back then LGN6 was also only partly correct.
- The soil map correctly indicated ‘fk’, as both an iron-rich layer and a clay layer were present. For the rest, the thick layer of fine to very fine sand can resemble a pZg23, but with the dark-coloured, humus-rich layer excavated. As the topsoil seemed to be excavated (Figure D.4.4), this means that the soil indeed most likely was a complete pZg23, but is incomplete now. So, the Dutch soil map indicated a fkpZg23 only partly correctly due to the excavation.
- On location 1 (middle of the plot), the groundwater table was found exactly at ground level, which is in accordance with MIPWA 3.0 data bot for the GVG and GG (Figures D.4.7-8). The distribution of the groundwater level also follows the height of the plot (Figure D.4.4) very nicely, making the MIPWA 3.0 data very plausible. At the moment of measuring (03-12-21), the western part of the plot even had a groundwater table 10 cm above ground level, which also fits perfectly into this pattern. This is somewhat higher than MIPWA indicated, but still very close. The clear presence of the iron film on the water and the high pH (6.8 at 110 cm depth) also confirm the presence of strong positive seepage flux, which was also indicated by MIPWA 3.0.
- WWN 3.0 predicted for both the current and past, undisturbed situation K28, which is a nutrient-rich soil. In the field it turned out however that the soil was (moderately) nutrient-poor, as a result of excavation most likely. This means that K22 (pioneer vegetation and grasslands on wet, nutrient-poor, slightly acidic soils (sphagnum reed lands, floating mat, Sesleria albicans grasslands, calcium-poor dune valleys)) or K27 (Pioneer vegetation, grasslands and shrublands on wet, moderately nutrient-rich soils (meadows in the fen and the middle course of stream valleys)) fit better for the current situation. The same goes for the past, undisturbed situation, where the soil might become even wetter.
- The current nature management type (N10.02) is correct, as all factors (Figure D.4.17) were suitable at the moment of measuring (03-12-21). The ambition to keep it as a N10.02 is also achievable.
- It is not possible to directly use the results from WWN 3.0 to come to this ambition however, as WWN 3.0 did not know that the upper soil had been excavated. Would this not have been the case however, then WWN 3.0’s prediction would have been correct most likely.
- All by all, there was indeed a strong seepage flux present, judging by the iron film and the pH of 6.8 at 110 cm depth. At first, it also looked like that chalk was present in the soil, but this could not be proven since it did not react with hydrochloric acid.

Figure D.4.16: Aerial photograph from Topotijdreis 2008.

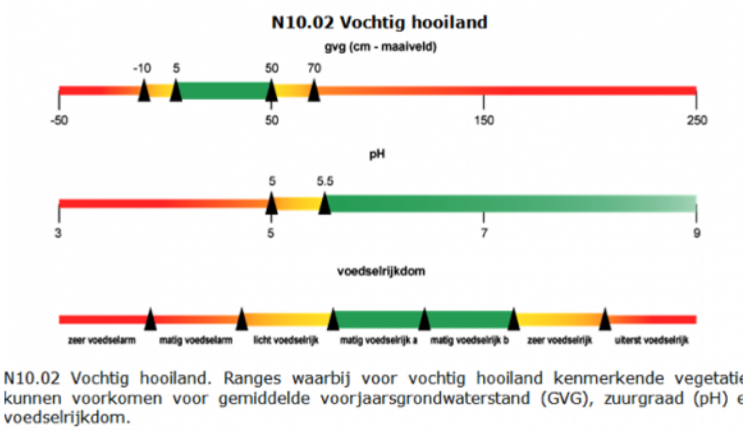


Figure D.4.17: Ideal conditions for N10.02 (moist meadow) according to BIJ12.

D.5 Salland estates boglands

The location of the investigated site is indicated by the red circle in the figure below and was visited on December 3, 2021.

Figure D.5.0: Location 7 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site. In preparation direct available spatial information was checked before visiting the site in the field.

Questions

- This area has management type N05.03 (bogland). What does that area look like?
- Are typical bogland characteristics present and how does the soil look like?

Preparation

- Figure D.5.1 shows the current nature management type of the area, which is N05.03 (bogland). The ambition is also N05.03.
- Figure D.5.2 shows aerial photos from Topotijdreis for the years 2006, 2007 and 2020, from which it becomes clear that the area got its shape in 2007 and did not change after that.
- The map from Topotijdreis 2020 (Figure D.5.3) also indicates some ponds and a creek on the plot.
- When looking at the height data from AHN (Figure D.5.4), it becomes clear that the plot is lower-lying than its surroundings and therefore most likely has been excavated by about 40-70 cm, which also is supported by the aerial photos from Topotijdreis 2006/2007.
- According to LGN6 (Figure D.5.5), the area consists of agricultural grass, while LGN2020 (Figure D.5.6) states that the area consists of 'other swamp vegetation' and 'freshwater surfaces'.
- The Dutch soil map indicates that the soil consists entirely of a fkpZg23. A pZg23 stands for 'bee-keerdsoil; loamy, fine sand'. The f stands for 'locally iron-rich, starting within 0.5 m and at least 0.1 m thick' and the k for 'sandy clay or clay layer, 15-40 cm thick'.
- MIPWA 3.0 states that both for the GG (Figure D.5.7) and the GVG (Figure D.5.8), the groundwater table is mostly between 0 and 40 cm below ground level, being only somewhat higher for the GVG.
- Also, for most of the area, a strong positive seepage flux is indicated (Figure D.5.9), while there also is a small area where it should be negative.
- Both DINOloket and Vitens show no well data close to the plot.

- WWN predicts for both the current (Figure D.5.10) and past, undisturbed situation (Figure D.5.11) K28 (pioneer vegetation, grasslands and shrublands on wet, very nutrient-rich soils (shrublands along rivers and ditches, wet cultivated grassland)).

Approach

- Make some soil profiles over the length of the plot and determine the pH of the soil and the depth of the groundwater table.
- Describe the characteristics of the plot and compare with the description of N05.03.

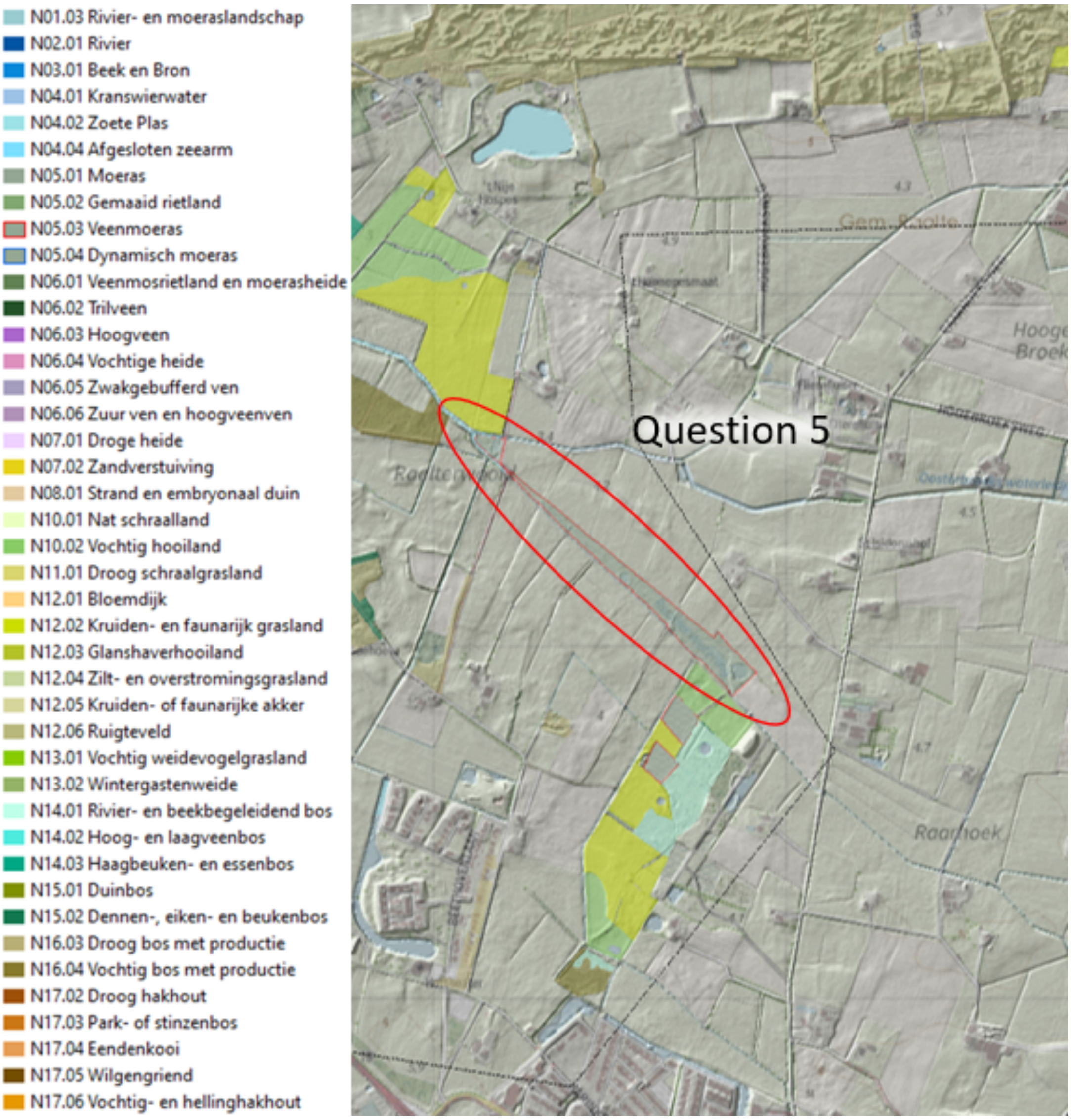


Figure D.5.1: Map showing the current nature management types.

Figure D.5.2: Aerial photos from Topotijdreis showing the emergence of the area as it looks like today.

Figure D.5.3: Map from Topotijdreis 2020.

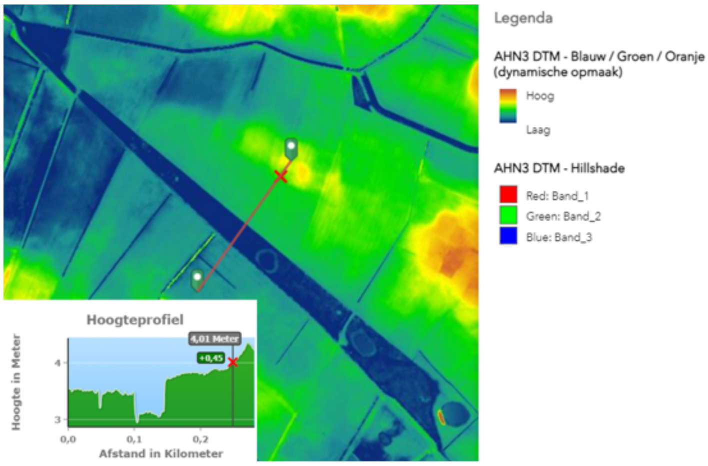


Figure D.5.4: Height data from AHN including a height profile.

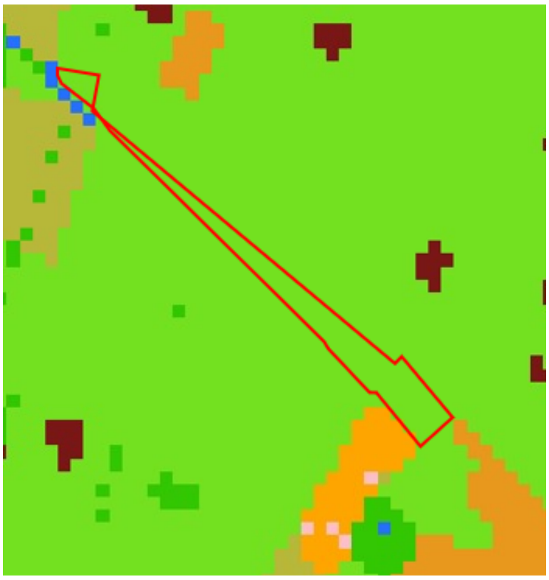


Figure D.5.5: According to LGN6, the area (outlined in red) consists entirely of agricultural grass.

Figure D.5.6: According to LGN2020, the area consists of 'other swamp vegetation' (pink) with some freshwater surfaces (blue).

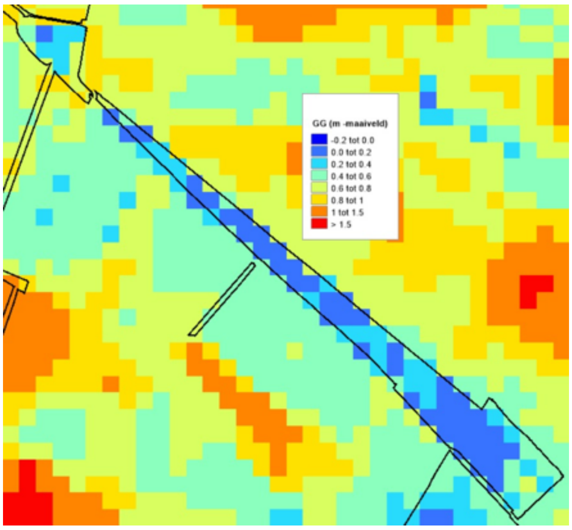


Figure D.5.7: MIPWA 3.0 data on the GG.

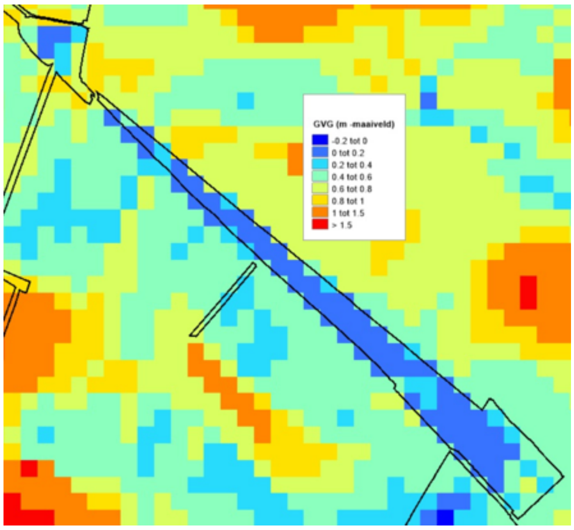


Figure D.5.8: MIPWA 3.0 data on the GVG.

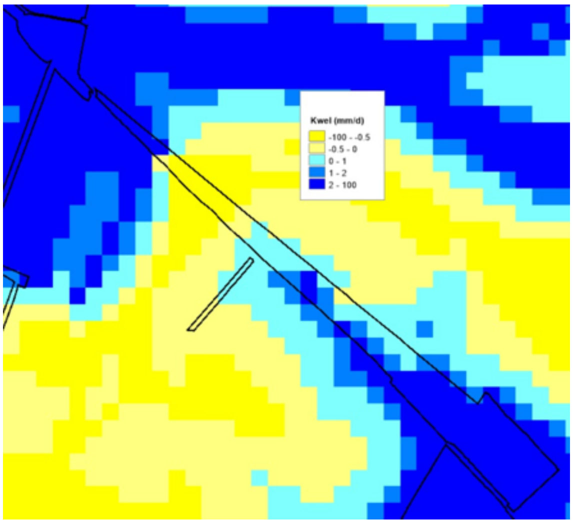


Figure D.5.9: MIPWA 3.0 data on seepage flux.

Figure D.5.10: WWN 3.0 predicts K28 for the current situation.

Figure D.5.11: WWN 3.0 predicts K28 for the past, undisturbed situation.

Results

Table D.5.1: Field data of the locations corresponding with Figure D.5.3.

Location (fig. D.5.3)	**RD-coord.**	**GWT (cm)**	**PH (-)**	**Description**
1	215180, 492408	n/a	n/a	Ditch close to the area of interest with a very clear iron film (Figure D.5.12).
2	215148, 492583	0	6.8 at 10cm 7.4 at 110cm 6.7 (water)	Seems to have been excavated. Swampy bottom with thick layer of moss and puddles of water with iron film and small ponds with Phragmites australis (Figures D.5.13-14). Plot is drained on 2 sides (see loc. 3) and the following plants are growing: Cirsium palustre, Carex paniculata, Lysimachia nummularia, Lotus spec., Rumex conglomeratus, Epilobium spec., Cardamine pratensis, Ranunculus repens, Salix aurita, Berula erecta, Plantago lanceolata, Filipendula ulmaria, Glechoma hederacea, Typha latifolia, Bellis perennis, Galium palustre, Symphytum officinale. Soil profile (Figure D.5.22): - 0-10 cm: fine sand with some humus, malleable, peaty. - 10-30 cm: very coarse sand with patches of malleable fine sand (peaty), from 25 onwards some rust. - 30-50 cm: very fine grey and reddish-brown sand with plant residues and rust, sticky, peaty. - 50+ cm: very fine, silty, grey sand, up to 70 cm some rust.
3	215111, 492617	n/a	n/a	Two ditches (Figure D.5.15). The left one is 5 m wide and 70 cm deep, water is flowing at 1.5m/10s (0,525 m3/s). The right one is 5 m wide and 50 cm deep, water is flowing at 1.3 m/10s (0,325 m3/s).
4	215214, 492487	n/a	n/a	Excavated, mowed grass/reed bed land (Figure D.5.16) with big puddles with very heavy iron film (Figure D.5.17). Ground level is only 20 cm above water surface in ditch. At the culvert, the water flow is 1.5 m wide, 50 cm deep and is flowing at 4 m/10s (0,3 m3/s). This is the same ditch as the right ditch in Figure D.5.15, which had a volumetric flow rate of 0,325 m3/s.
5	215301, 492397	n/a	n/a	A stream has been created with the help of buried tree trunks (Figure D.5.18).
6	215509, 492230	0	6.7 at 10cm 6.5 at 110cm	Mowed Phragmites australis/grass field (Figure D.5.19), wet layer of moss with puddles with light iron film, soil is firm. Ground level 20 cm above water surface ditch of 3 m wide, 50 cm deep, water flows at 2.5 m/10s (0.375 m3/s). Plants: Ranunculus acris, Cardamine pratensis, Rumex acetosella, Plantago lanceolata, Trifolium spec., Equisetum palustre, Equisetum fluviatile, Epilobium spec. Soil profile (Figure D.5.23): - 0-40 cm: mixture of fine and moderately coarse, grey and sometimes red-brown sand with a lot of plant residues. Can be broken into pieces and is fairly malleable, peaty. - 40-60 cm: coarse and moderately coarse grey sand with plant residues and a very small amount of rust. - 60+ cm: fine to moderately fine, grey sand, less and less plant remains. From approx. 100 cm onwards, the auger vacuums up during boring and cannot be pulled out, only unscrewed.
7	215666, 492084	n/a	n/a	Phragmites australis bed with ponds (Figure D.5.20).
8	215846, I491861	n/a	n/a	Inaccessible Phragmites australis bed with a corn field upstream (Figure D.5.21).

Figure D.5.12: Ditch with heavy iron film at location 1.

Figure D.5.13: Phragmites australis bed with small ponds at location 2.

Figure D.5.14: Phragmites australis bed at location 2.

Figure D.5.15: Two flowing ditches draining the plot at location 3.

Figure D.5.16: Clearly excavated plot, now mowed Phragmites australis/grass bed (location 4).

Figure D.5.17: Puddles with heavy iron film at location 4.


Figure D.5.18: Small, man made creek at location 5.


Figure D.5.19: Mowed Phragmites australis/grass field at loc. 6.


Figure D.5.20: Phragmites australis bed with small ponds at location 7.


Figure D.5.21: Phragmites australis bed with corn field upstream, location 8.


Figure D.5.22: Soil profile at location 2.


Figure D.5.23: Soil profile at location 6.

Discussion/conclusion

- At the moment of the field visit (03-12-21), LGN 6 proved to be wrong, while LGN2020 was right. When looking at old aerial photos (Figure D.5.2), it becomes clear that LGN6 was already incorrect in 2007/2008, as the plot already had been excavated by then.
- The soil does have a layer with some rust, so the 'f' is correct. The k on the other hand is incorrect, as no clay layer was found. The pZg23 is correct in general, but the sand is not solely fine and the humus-rich, dark upper soil has been excavated. So, the soil cannot be classified as an fpZg23 anymore due to excavation, making the Dutch soil map only partly correct.
- The groundwater table was found at ground level, resulting in the data from MIPWA 3.0 for the GG and GVG being very close, but a few decimetres too low at some places, most likely is the result of the excavation. Also, a positive seepage flux seemed to be present everywhere on the plot, judging by the pH of the soil and water ranging between 6.5 and 7.4 and the thick iron films on water, while MIPWA 3.0 indicated a negative seepage flux on a small part of the plot. In general, however, MIPWA 3.0 was mostly correct for this area.
- For the current situation, WWN 3.0 correctly predicted that the soil consisted of a wet soil, but due to the excavation, the soil now is rather nutrient-poor, resulting in WWN 3.0 only being partly correct. K22 (pioneer vegetation and grasslands on wet, nutrient-poor, slightly acidic soils (sphagnum reed lands, floating mat, Sesleria albicans grasslands, calcium-poor dune valleys or maybe K27 Pioneer vegetation, grasslands and shrublands on wet, moderately nutrient-rich soils (meadows in the fen and the middle course of stream valleys) would have been better fits.
- For the past, undisturbed situation, the same situation applies.
- As the area indeed consisted of a swampy vegetation with a very high groundwater table at the end of autumn (03-12-21) and the soil was slightly acidic, the current nature management type N05.03 is correct and can also be maintained in the nature ambition for the coming years. The groundwater table has to rise slightly to become ideal (Figure D.5.24) in spring for the GVG, but a rise of only 5 cm is needed, this most likely will be the case.

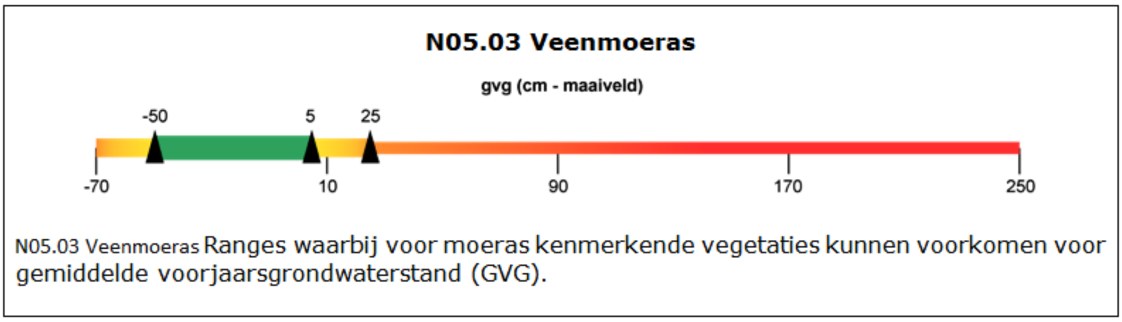


Figure D.5.24: Ideal conditions for N05.03 (bogland) according to BIJ12.

APPENDIX E: DINKEL VALLEY

E.1 Dinkel valley moist meadow 1

The location of the investigated site is indicated by the red circle in the figure below and was visited on October 15, 2021.

Figure E.1.0: Location 15 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site. In preparation direct available spatial information was checked before visiting the site in the field.

Questions

- This plot (currently N12.02 or grassland rich in herbs and fauna) seems to have potential to become N10.02 (moist meadow). What can be seen of this nature ambition in the field?
- Can the plot flood and what is the moisture and pH of the soil?

Preparation

- Figure E.1.1 shows a map from Topotijdreis 2020, clearly displaying that the plot is completely enclosed by roads. From the aerial photo (Figure E.1.2), it looks like the plot consists of natural grassland, which is supported by both LGN6 and LGN 2020 (Figures E.1.3-4). Figure E.1.5 shows height data for the plot and its surroundings, where it is striking that the plot is over 2 metres lower than the field on the western side and that the Dinkel stream is very low-lying.
- Figure E.1.6 shows a historical topographic map from the year 1906 compared to 2020. Back in 1906, the plot was part of a wet stream valley, so the N10.02 potential seems reasonable.
- MIPWA 3.0 states that for most of the plot, the GVG (Figure E.1.7) lies between 20 and 60 cm below ground level and the GG (Figure E.1.8) between 20 and 80 cm below ground level. The seepage flux (Figure E.1.9) should be negative, except for maybe a very small strip along the Dinkel stream. Figure E.1.10 shows data for a well just north of the plot for the years 1970-75, showing groundwater levels somewhat lower than MIPWA 3.0 indicates.
- The Dutch soil map indicates that the soil is a pZg23 (beekeerdsoils; loamy fine sand).
- WWN 3.0 predicts for the current situation (Figure E.1.11) wet conditions (mostly K21/K22 with some K42) and for the past, undisturbed situation (Figure E.1.12) also wet (mostly K22 with some K21).
    - K21: pioneer vegetation and grasslands on wet, nutrient-poor, acidic soils (wet heathland and raised bogs).
    - K22: pioneer vegetation and grasslands on wet, nutrient-poor, slightly acidic soils (sphagnum reed lands, floating mat, Sesleria albicans grasslands, calcium-poor dune valleys).

- K42: pioneer vegetation and grasslands on moist, moderately nutrient-rich (embankment slopes, false oat-grass meadows).’

Approach

- Make a soil profile, determine pH of the soil and the groundwater table.
- Look at flora present and whether the plot is being drained.

Figure E.1.1: Map from Topotijdreis 2020 with points of interest.

Figure E.1.2: Aerial photo from Topotijdreis 2020.

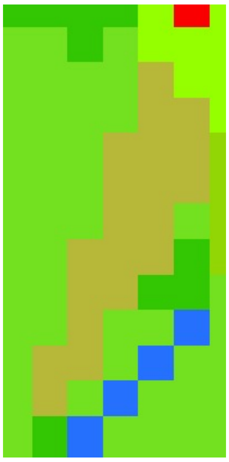


Figure E.1.3: According to LGN6, the plot consists of natural grasslands.

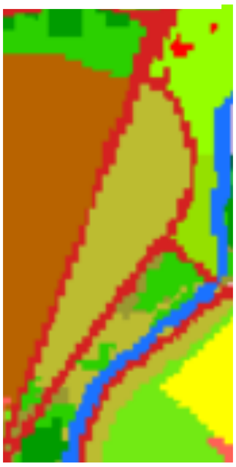


Figure E.1.4: According to LGN2020, the plot consists of natural grasslands.

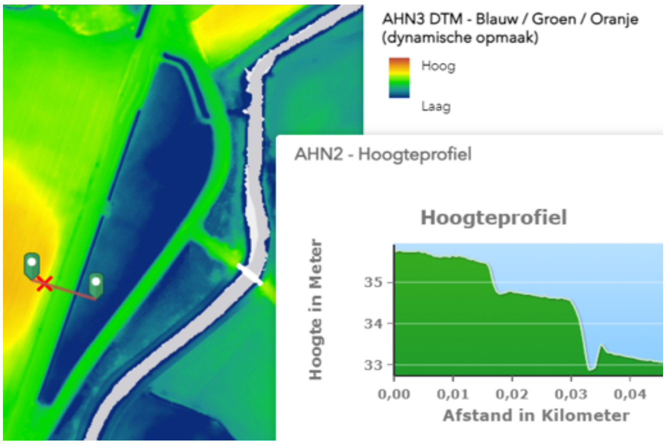


Figure E.1.5: Height data from AHN, including a height profile.

Figure E.1.6: Topographical maps from Topotijdreis for the years 1906 and 2020. In 1906, the plot was part of the wet stream valley.

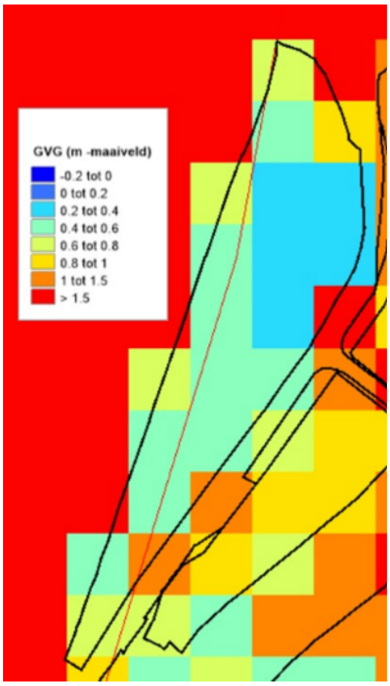


Figure E.1.7: MIPWA 3.0 data on the GVG.

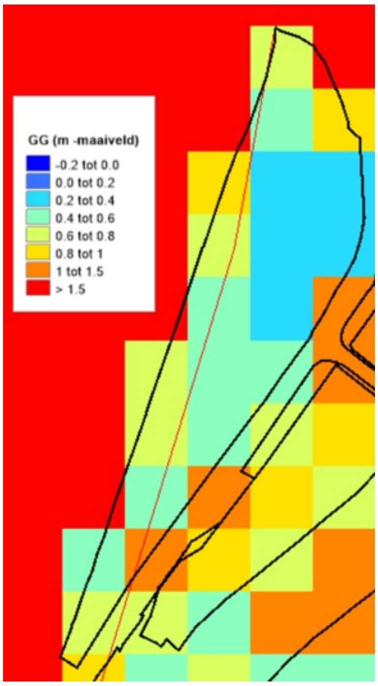


Figure E.1.8: MIPWA 3.0 data on the GG.

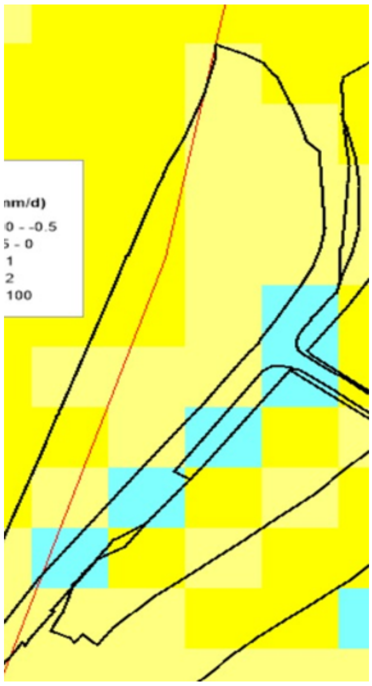


Figure E.1.9: MIPWA 3.0 data on seepage.

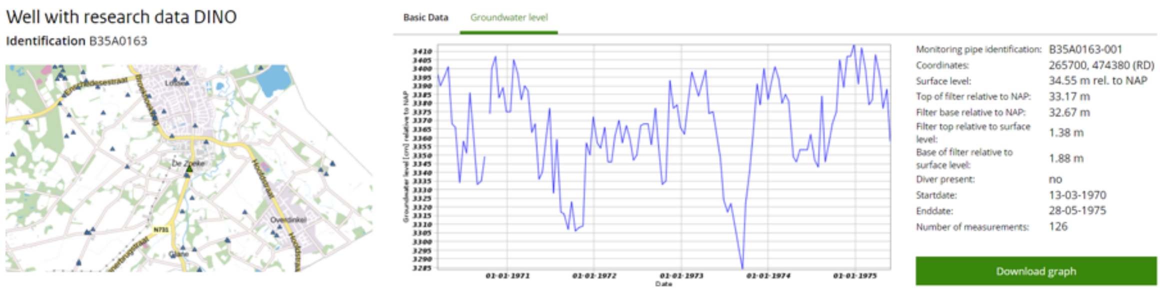


Figure E.1.10: Data from a well just north from the plot for the years 1970-75 (DINOloket).

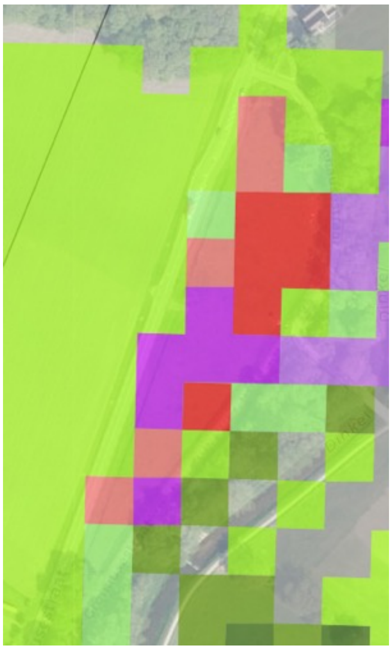


Figure E.1.11: WWN 3.0's prediction for the current situation, red is K22, dark purple is K21, and pink is K42.

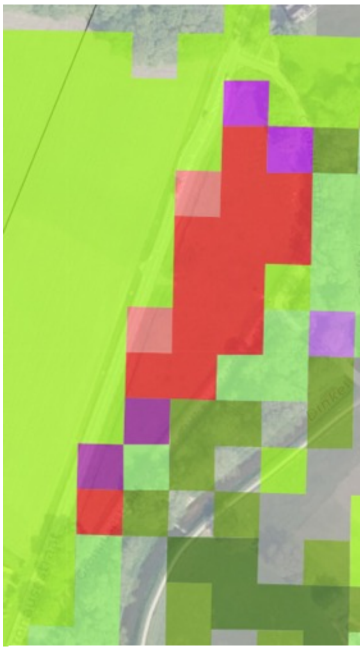


Figure E.1.12: WWN 3.0's prediction for the past, undisturbed situation (mostly K22).

Results

Table E.1.1: Field data of the locations corresponding with Figure E.1.1.

Location (fig. E.1.1)	RD-coord.	GWT (cm)	PH (-)	Description
1	265652, 474033	>125	4.7 at 10cm 5 at 60cm 5.2 at 110cm	Field with two cows. Nutrient-rich, fat grasses, barely anything interesting. Soil profile (Figure E.1.13): - 0-25 cm: Dark brown soil. - 25-55 cm: Coarse sand, rusty. - 55-90 cm: grey, clayey and rusty. - 90+ cm: light coloured coarse, wet sand.
2	265651, 474068	n/a	n/a	Roadside (Figure E.1.14) did have some interesting flora, including Centaurea jacea, Oenothera spec., Malva moschata, Lysimachia vulgaris, Achillea ptarmica and Tanacetum vulgare. Between field and roadside is a ditch of about 1 m deep to drain the road. Upstream of the plot, a corn field was found.
3	265683, 474156	n/a	n/a	Ditch of about 2.5 m deep (Figure E.1.15) for drainage of the road. Water is transported directly to the Dinkel.
4	265753, 474022	n/a	7.1 (water)	The Dinkel (Figure E.1.16) (volumetric flow rate of ca. 1 m3/s) is very low-lying when compared to surrounding fields, resulting in strong drainage of those fields. This low-lying position also can be clearly seen in Figure E.1.5.

Figure E.1.13: Soil profile at location 1.

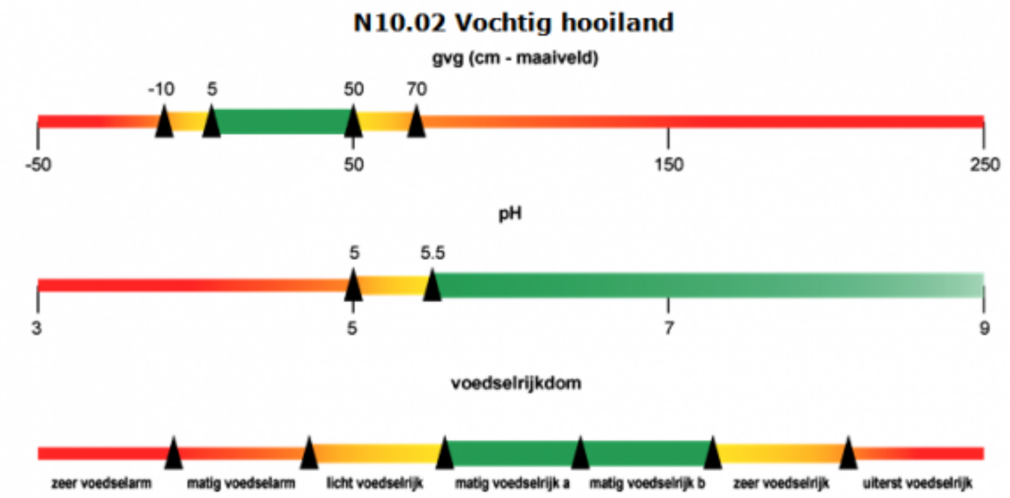
Figure E.1.14: Roadside with ditch of about 1 m deep (location 2.)

Figure E.1.15: Ditch of about 2.5 m deep, flowing directly into the Dinkel (location 3.

Figure E.1.16: The Dinkel, very low-lying when compared to surrounding fields (location 4).

Discussion/conclusions

- The plot indeed consisted of natural grassland, so both LGN6 and LGN2020 were correct.
- No seepage indicators were found, so MIPWA 3.0 was right about the flux being negative. The groundwater table was not found within 125 below ground level (15-10-21), which means that MIPWA 3.0 data on GVG and GG was very wrong, as it should be between 20 and 80 cm below ground level. This low groundwater table is the result of extensive drainage in favour of the roads enclosing the plot and the fact that the water surface of the Dinkel is very low-lying.
- The Dutch soil map was correct that the soil indeed formerly consisted of a pZg23, but due to the topsoil being heavily enriched it cannot completely be called so anymore.
- WWN 3.0 predictions for the current situation are very wrong, as the soil is dry instead of wet and also nutrient-rich instead of nutrient-poor. K67 or K68 would have fitted better (both dry, moderately nutrient-rich grasslands).
- The predictions for the past, undisturbed situation also are highly doubtful, as the field will not easily become wet and nutrient-poor, and the pH is too low.
- All by all, the current nature management type N12.02 is correct, while the nature ambition to transform the plot into a moist meadow (N10.02) is not achievable, as none of the criteria for ideal conditions (Figure E.1.17) are met at the moment of measuring (15-10-21). This is due to the drainage for the surrounding roads and the low-lying Dinkel, draining the area as well. Also, the corn field lying upstream of this plot results in a low pH.



N10.02 Vochtig hooiland. Ranges waarbij voor vochtig hooiland kenmerkende vegetaties kunnen voorkomen voor gemiddelde voorjaarsgrondwaterstand (GVG), zuurgraad (pH) en voedselrijkdom.

Figure E.1.17: Ideal conditions for a moist meadow (N10.02) according to BIJ12.

E.2 Dinkel valley moist meadow 2

The location of the investigated site is indicated by the red circle in the figure below was visited on October 15, 2021.

Figure E.2.0: Location 16 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site. In preparation direct available spatial information was checked before visiting the site in the field.

Questions

- Based on its location right next to the Dinkel, this plot (currently N12.02) could have the potential to become an N10.02 (moist meadow). What can we say about this in the field?
- Is the plot being drained and what is the depth of the groundwater table?

Preparation

- Figure E.2.1 shows an aerial photo from 2020, where the plot appears to be a grassland. Figure E.2.2 shows height data, from which it becomes clear that the Dinkel is 1-1,5 m lower than the ground level of the plot, but there is also a sand ridge southwest of the plot.
- In 1960, the plot was part of the wet stream valley (Figure E.2.3), which makes N10.02 a logical ambition. In 2020, the plot seems to be drained by a small ditch flowing into the Dinkel.
- LGN6 (Figure E.2.4) indicates that the plot consists of agricultural grass, while LGN2020 (Figure E.2.5) indicates natural grassland.
- According to the Dutch soil map, the soil consists of an ABk or clayey beekdalsoil (beekdal = stream valley).
- Both DINOloket and Vitens show no well with data close to the plot.
- Figures E.2.7-8 show MIPWA 3.0 data on GG and GVG, both indicating a groundwater table between 0.6 and 1.5 m below ground level. The seepage flux (Figure E.2.6) is around zero, but on average slightly negative.
- WWN 3.0 predicts for both the current (Figure E.2.9) and the past, undisturbed situation (Figure E.2.10) mostly K48 and some K47, which are both moist conditions:
  - K48: Pioneer vegetation and grasslands on moist, very nutrient-rich soils (agricultural fields, roadsides, factory grounds).
  - K47: Pioneer vegetation and grasslands on moist, moderately nutrient-rich (embankment slopes, false oat-grass meadows).

Approach

- Make one soil profile close to the Dinkel and one close to the sand ridge and determine the depth of the groundwater table and the pH of the soil.
- Check for drainage of the plot.

Figure E.2.1: Aerial photo from Topotijdreis 2020.

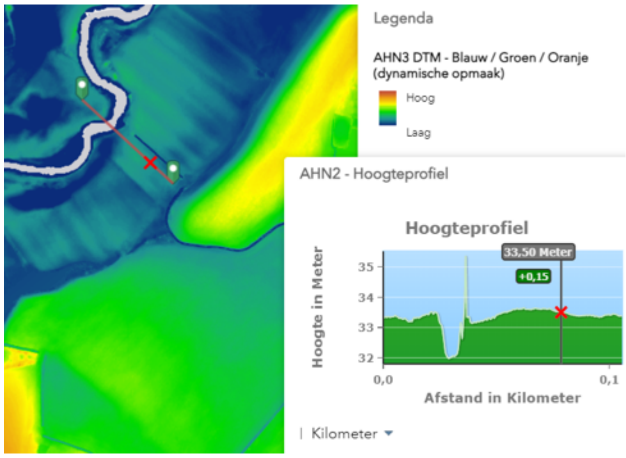


Figure E.2.2: Height data including a height profile of the plot (AHN).

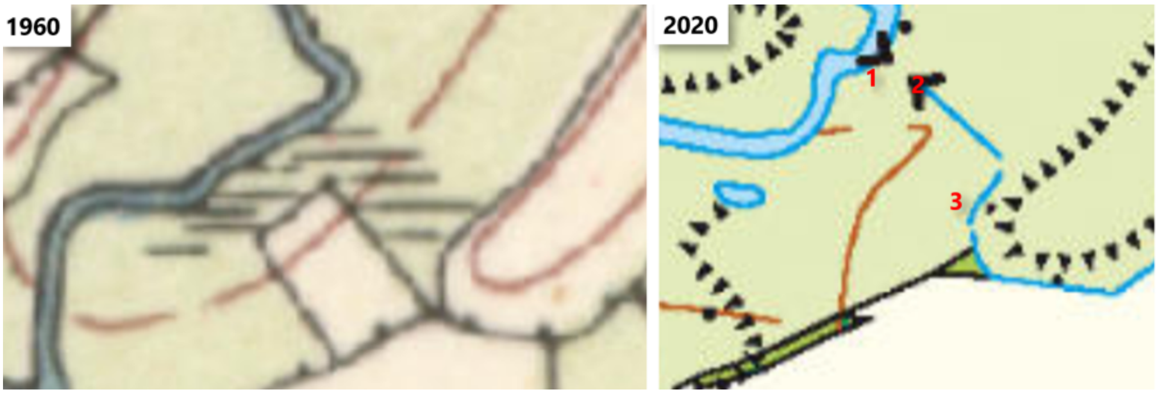


Figure E.2.3: Maps from Topotijdreis, showing that the plot was part of the wet stream valley in 1960.

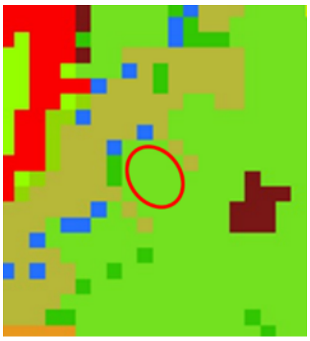


Figure E.2.4: Agricultural grass according to LGN6.

Figure E.2.5: Natural grassland according to LGN2020.

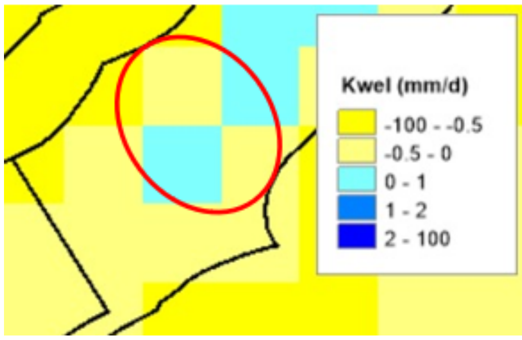


Figure E.2.6: MIPWA 3.0 data on seepage flux.

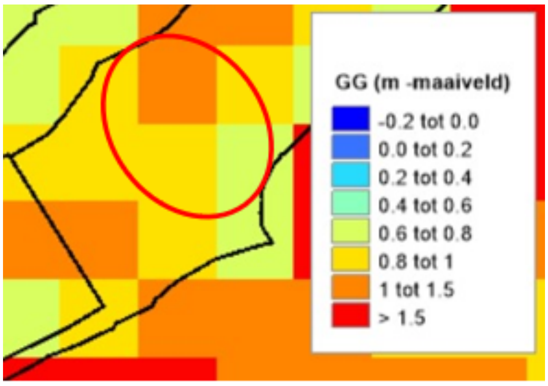


Figure E.2.7: MIPWA 3.0 data on the GG.

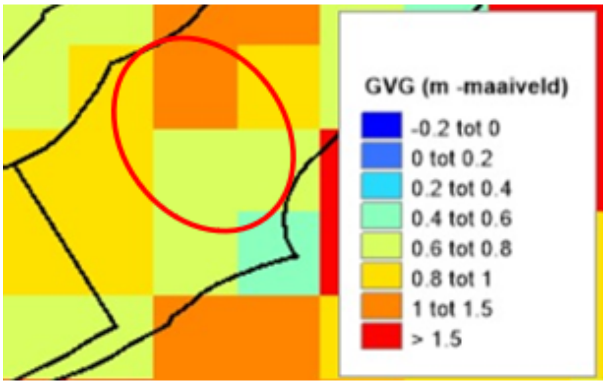


Figure E.2.8: MIPWA 3.0 data on the GVG.

Figure E.2.9: WWN 3.0 predicts K48 (dark green) and some K47 (greyish green) for the current situation at the plot.

Figure E.2.10: WWN 3.0 predicts the same for the past, undisturbed situation at the plot.

Results

Table E.2.1: Field data of the locations corresponding with Figure E.2.3

Location (fig. E.2.3)	RD-coord.	GWT (cm)	PH (-)	Description
1	266274, 474351	>125	5.5 at 10cm 5.5 at 100cm	Nutrient-rich field (Figure E.2.13) close to the Dinkel, which is deeply incised. Soil profile (Figure E.2.11): - 0-50 cm: Dark grey, fine sand with soil on top. - Around 50 cm, thin clay layer with iron. - 50-80 cm: slightly lighter grey sand with some rust. - 80cm+: light-coloured, fine sand.
2	266288, 474341	n/a	n/a	Ditch of 1.20 m deep with 10 cm of water, which can flow into the Dinkel (Figures E.2.13-14)
3	266305, 474291	>125	? at 10cm 5.0 at 90cm	At the first borehole, construction debris was encountered (roofing tiles), so a borehole was drilled a few metres further on (Figure E.2.12): - 0-40 cm: dark soil. - 40-55 cm: slightly lighter coloured sand, rusty. - 55-95: silty clay with rust. - 95+ cm: moderately fine sand, light coloured, small amount of rust.

Figure E.2.11: Soil profile at location 1.

Figure E.2.12: Soil profile at location 3.

Figure E.2.13: Ditch at location 2.

Figure E.2.14: Culvert at location 2.

Discussion/conclusions

- At the moment of the field visit (15-10-21), the plot consisted of natural grassland, which makes LGN2020 correct. LGN6 was partly correct by indicating agricultural grassland.
- The Dutch soil map proved to be correct as the soils had a humus-containing upper soil on a humus-poor, rusty lower soil and did contain some clay/silt.
- No indications for a positive seepage flux were found, so MIPWA 3.0 was right in indicating an (on average) negative seepage flux. For the groundwater table however, MIPWA 3.0 turned out to be wrong, as no groundwater table was found within the first 125 cm below ground level, while it was predicted that it was less than 100 cm below ground level for most of the plot.
- WWN's prediction for the current situation was fairly good, but the plot showed to be dry rather than moist, so K67/68 might have been a better fit than K47/48.
- For the past, undisturbed situation, K47/K48 is a valid prediction, however.
- At the moment of the field visit (15-10-21), the current nature management type (N12.02) proved to be correct.
- As the GVG for a moist meadow (N10.02) ideally is only between 5 and 50 cm below ground level, it will not be easy to transform the complete plot into an N10.02 due to the Dinkel being deeply incised into the landscape (or the depth of the complete Dinkel should be decreased by filling it up partially). When the small ditch gets filled in or the culvert is closed however, it should be achievable to transform the lower-lying part of the plot close to the sand ridge (Figure E.2.2) into an N10.02.

E.3 Dinkel valley wet nutrient-poor grassland

The location of the investigated site is indicated by the red circle in the figure below was visited on October 15, 2021.

Figure E.3.0: Location 17 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site. In preparation direct available spatial information was checked before visiting the site in the field.

Questions

- Both the current nature management type and nature ambition are N10.02 (moist meadow), but this plot could have the potential to become an N10.01 (wet nutrient-poor grassland). What can be seen of this in the field?
- How deep is the groundwater table and what is the pH of the soil?

Preparation

- Figures E.3.1-3 show that the plot is a low-lying grassland close to a small stream. The fields north of the plot are around 1.5 m higher than the plot itself.
- Both LGN6 (Figure E.3.4) and LGN2020 (Figure E.3.5) indicate that the plot is a natural grassland.
- According to the Dutch soil map, the soil on the plot is an ABk or 'clayey beekdalsoil'.
- For the GG, MIPWA 3.0 states that the groundwater table is mostly between 20 and 60 cm below ground level (Figure E.3.6) and the GVG between 0 and 40 cm below ground level (Figure E.3.7). The seepage flux varies over the plot, from slightly positive to strongly negative (Figure E.3.8).
- Figure E.3.9 shows data from a well close to the plot, which correlates well with MIPWA 3.0 data.
- WWN 3.0 predicts both for the current (Figure E.3.10) and past, undisturbed (Figure E.3.11) situation mostly K22: Pioneer vegetation and grasslands on wet, nutrient-poor, slightly acidic soils (sphagnum reed lands, floating mat, Sesleria albicans grasslands, calcium-poor dune valleys).

Approach

- Make a soil profile on the plot and determine the soil type, pH and depth of the groundwater table.
- Look for seepage indicators.

Figure E.3.1: Map from Topotijdreis 2020.

Figure E.3.2: Aerial photo from Topotijdreis 2020.

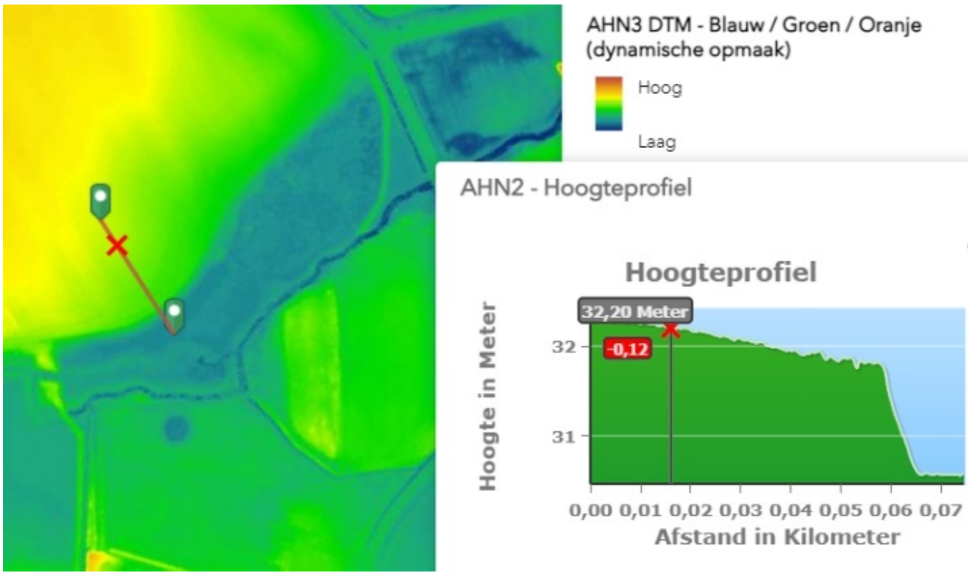


Figure E.3.3: Height data from AHN, including a height profile.

Figure E.3.4: According to LGN6 the plot consists of natural grassland.

Figure E.3.5: According to LGN2020 the plot consists of natural grassland.

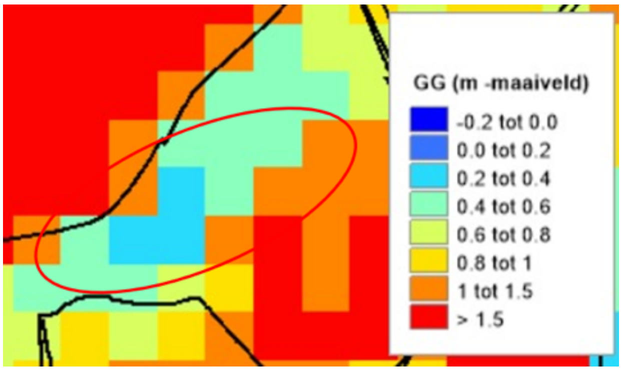


Figure E.3.6: MIPWA 3.0 data on the GG.

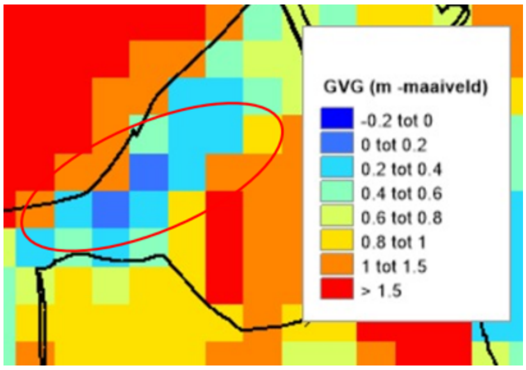


Figure E.3.7: MIPWA 3.0 data on the GVG.

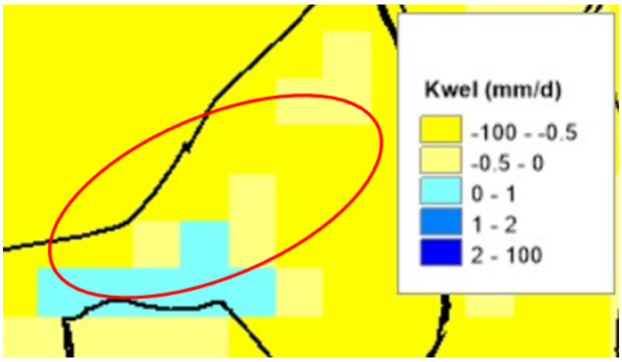


Figure E.3.8: MIPWA 3.0 data on seepage flux.

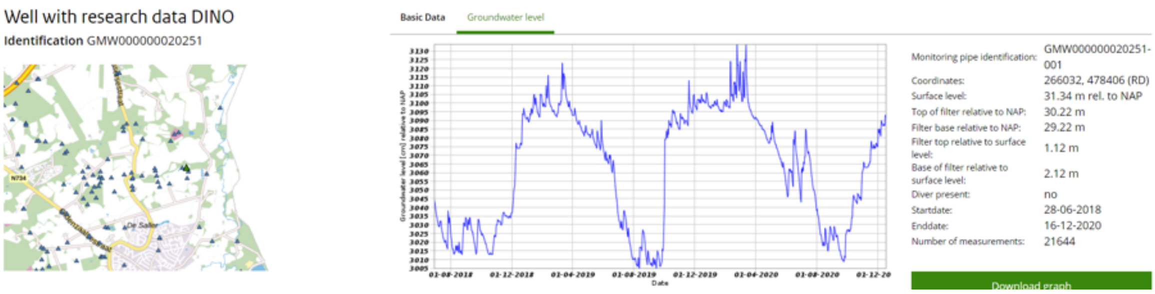


Figure E.3.9: Data from DINOloket for a well close to the plot (see map).

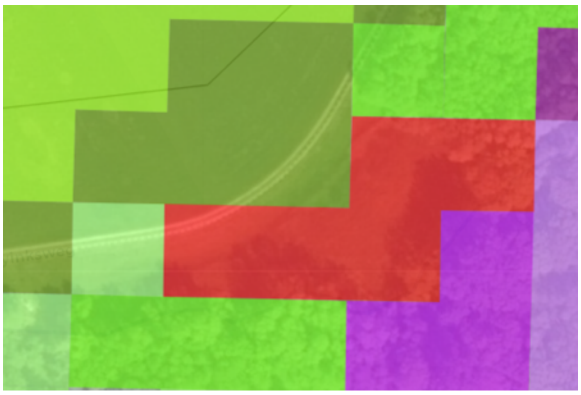


Figure E.3.10: WWN 3.0 predicts K22 (red) for the current situation.

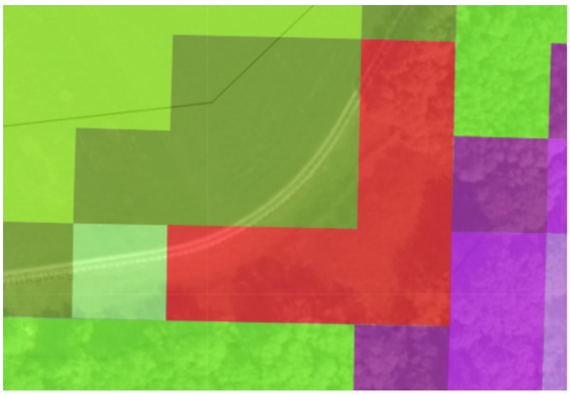


Figure E.3.11: WWN 3.0 predicts K22 (red) for the past, undisturbed situation.

Results

Table E.3.1: Field data of the locations corresponding with Figure E.3.1.

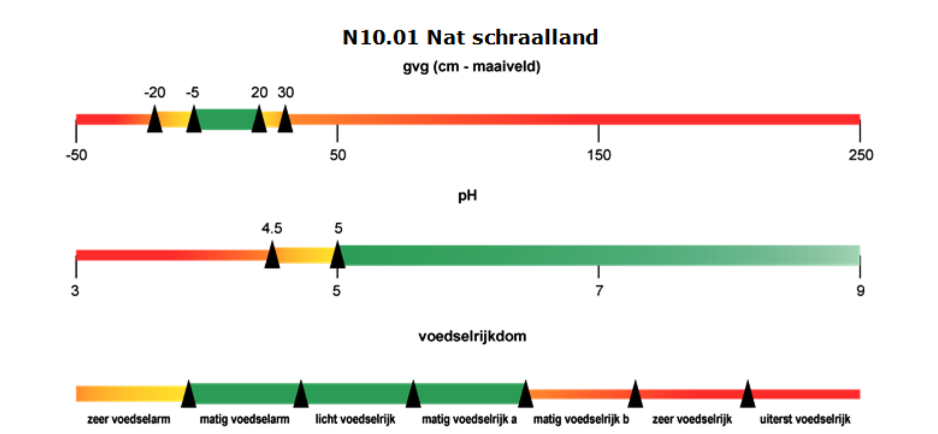
Location (fig. E.3.1)	RD-coord.	GWT (cm)	PH	Description
1	266377, 478535	50	8.0 at 60cm	Low-lying field with some grasses, Juncus effusus and Juncus acutiflorus (indicator of lateral groundwater flow). Soil profile (Figure E.3.12): - 0-15 cm: brown clay. - 15+ cm: Very coarse sand with small pebbles and a very small amount of rust.
2	266215, 478462	n/a	n/a	This picture was taken close to the plot and had the same vegetation and looked the same (Figure E.3.13).

Figure E.3.12: Soil profile at location 1.

Figure E.3.13: Photo close to the plot, but with the same vegetation and same look as the plot itself.

Discussion/conclusions

- The plot consisted of a natural grassland, which means that both LGN6 and LGN2020 were correct.
- The soil indeed consisted of an ABk (beekdalsoil), as the upper soil contained humus and the lower soil consisted of a rust-containing sand layer and a clay layer was present as well.
- At the moment of measuring (15-10-21), the groundwater table was found at 50 cm below ground level, so MIPWA 3.0 was correct on the GG. The presence of rust at a depth greater than 15 cm also indicates that the groundwater table rises in spring, so the GVG was also correct. Based on the high pH of the soil, the ABk soil and the presence of Juncus acutiflorus, there is strong seepage present on the plot. MIPWA 3.0 did indicate some seepage on the plot, but in reality, it was stronger and more widespread. Overall, the data from MIPWA 3.0 for this plot is good.
- WWN 3.0's prediction for the current situation is very correct, as the soil is indeed nutrient-poor and wet. The pH is even somewhat higher than needed, but still very correct for a K22 as the pH at root depth is most likely a bit lower than the measured 8.0 at 60 cm depth.
- Little is likely to change in the past, undisturbed situation, so K22 is correct here as well.
- According to BIJ12, Juncus acutiflorus fields are part of N10.02, so the current nature management type is correct and so is the nature ambition, as it is N10.02 as well.
- BIJ12 also states that a Juncus acutiflorus field can be part of N10.01 and all criteria are met (Figure E.3.14), so the plot can be both an N10.01 or an N10.02 for the coming years.



N10.01 Nat schraalland. Ranges waarbij voor nat schraalgrasland kenmerkende vegetaties kunnen voorkomen voor gemiddelde voorjaarsgrondwaterstand (GVG), zuurgraad (pH) en voedselrijkdom.

Figure E.3.14: Ideal conditions for an N10.01 (wet nutrient-poor grassland) according to BIJ12.

E.4 Dinkel valley moist heathland

The location of the investigated site is indicated by the red circle in the figure below was visited on October 15, 2021.

Figure E.4.0: Location 18 (see Figure 2 in paragraph 3.1).

Specific questions were stated to be investigated for this site. In preparation direct available spatial information was checked before visiting the site in the field.

Questions

- Both the current nature management type and the nature ambition for this plot is N12.02 (grassland rich in herbs and fauna), but judging by old maps, it could have the potential to become an N06.04 (moist heathland). What can be seen in the field?
- What does the soil look like and at what depth is the groundwater table?

Preparation

- Figure E.4.1 shows an aerial photo from the plot, from which it becomes clear that the plot consists of grassland. Figure E.4.2 shows height data, where it stands out that the western part of the plot is relatively high when compared to the eastern part of the plot. Also, a small stream can be seen flowing at the south-eastern border of the plot.
- Until 1954 (Figure E.4.3), the plot was heathland, which supports the question whether this plot could become a moist heathland.
- Both LGN6 (Figure E.4.4) and LGN2020 (Figure E.4.5) state that the plot consists of natural grassland.
- According to the Dutch soil map, the soil consists of an Hn21 (veldpodzolsoils; loam poor and slightly loamy fine sand).
- MIPWA 3.0 indicates that the GG (Figure E.4.6) is between 0.8 and 1.5 m and the GVG (Figure E.4.7) between 0.6 and 1.5 m below ground level and that the seepage flux (Figure E.4.8) is negative.
- Data from a well close to the plot (Figure E.4.9) show more or less the same image as MIPWA 3.0.
- WWN 3.0 predicts K41 for the current situation (Figure E.4.10) and a combination of K41 and K42 for the past, undisturbed situation (Figure E.4.11):
    - K41: pioneer vegetation and grasslands on moist, nutrient-poor, acidic soils (wet heathland and raised bogs).
    - K42: pioneer vegetation and grasslands on moist, nutrient-poor, weakly acidic soils (violion caninae grassland, calcium-poor dune valleys.

Approach

- Make a soil profile and determine the pH of the soil and the depth of the groundwater table.

Figure E.4.1: Aerial photo from Topotijdreis 2020.

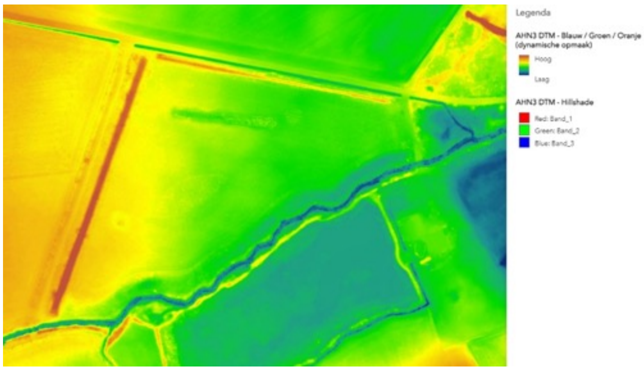


Figure E.4.2: Height data from AHN.

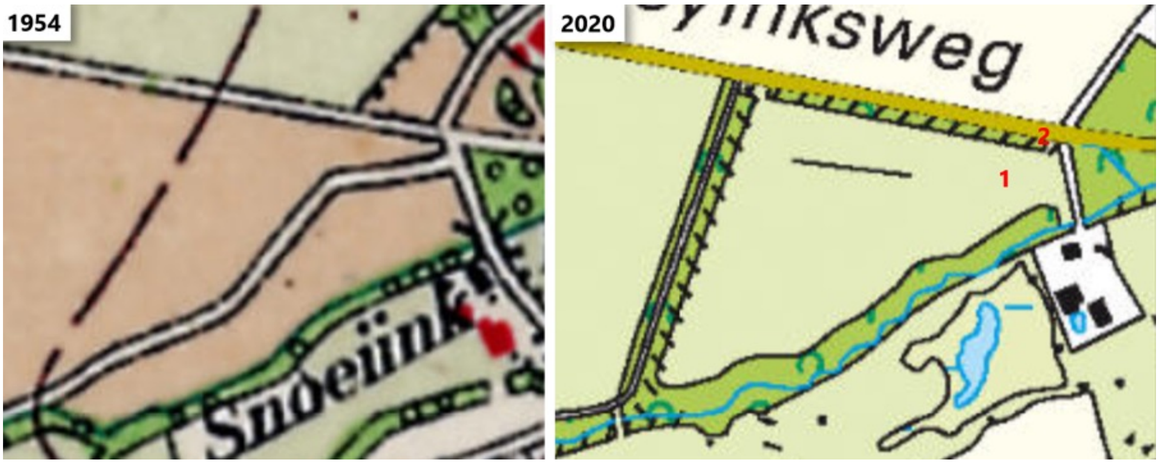


Figure E.4.3: Maps from Topotijdreis for the years 1954 and 2020.

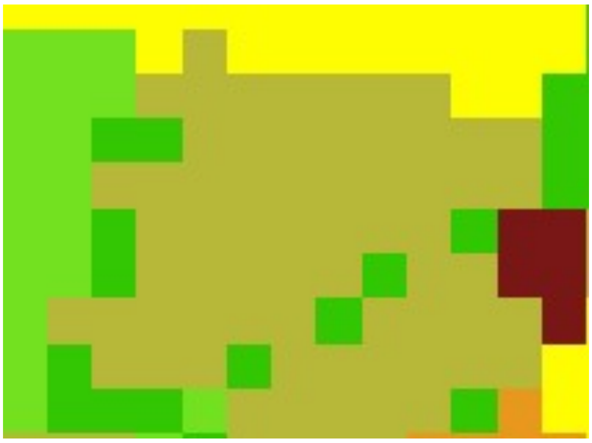


Figure E.4.4: Natural grassland according to LGN6.

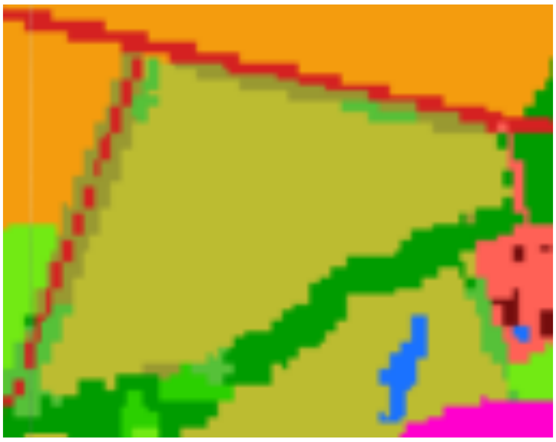


Figure E.4.5: Natural grassland according to LGN2020.

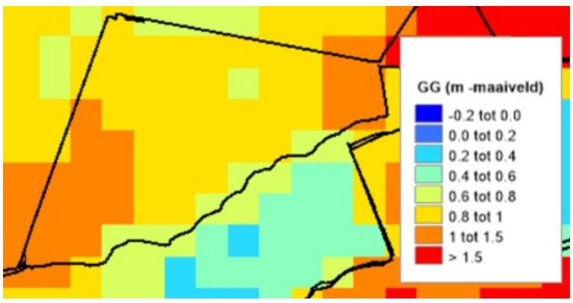


Figure E.4.6: MIPWA 3.0 data on the GG.

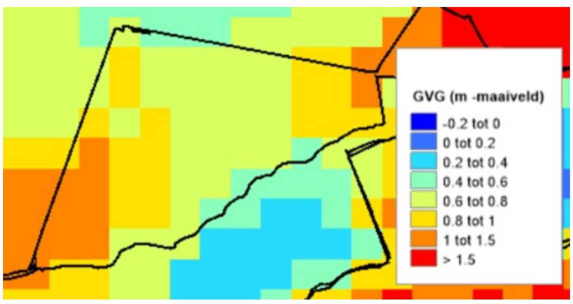


Figure E.4.7: MIPWA 3.0 data on the GVG.

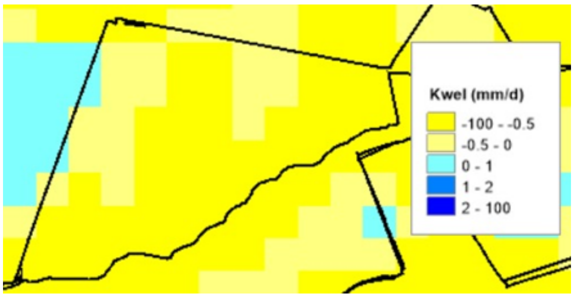


Figure E.4.8: MIPWA 3.0 data on seepage flux.

Figure E.4.9: Data from DINOloket for a well close to the plot (green triangle on map).

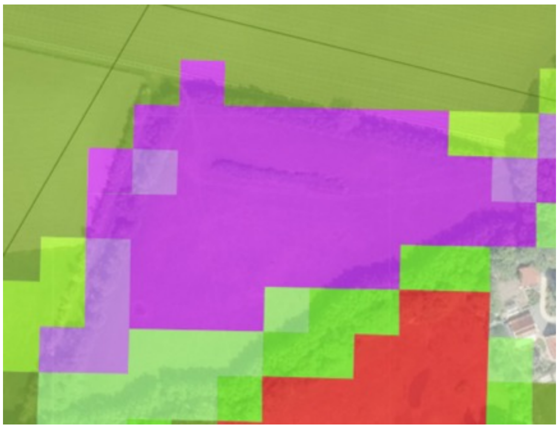


Figure E.4.10: WWN 3.0 predicts K41 (medium purple) for the current situation.

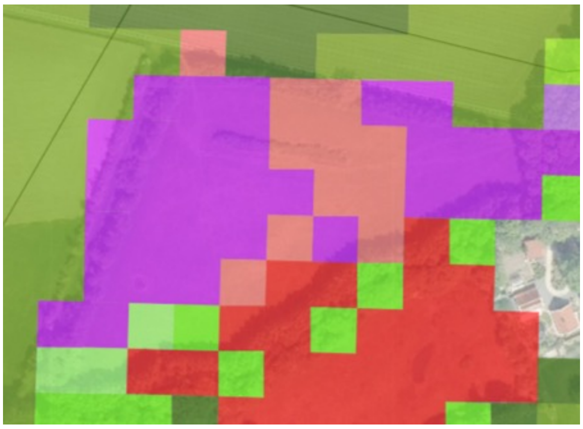


Figure E.4.11: WWN 3.0 predicts K41 (medium purple) and K42 (pinkish) for the past, undisturbed situation.

Results

Table E.4.1: Field data of the locations corresponding with Figure E.4.2.

Location (fig. E.4.2)	RD-coord.	GWT (cm)	PH	Description
1	265908, 478456	105	5.0 at 110cm	Food-rich grassland with enriched topsoil. Soil profile (Figure E.4.12): - 0-40 cm: grey-black soil. - 40-65 cm: dark grey soil with rust. - 65-90 cm: fine, aeolian sand, very iron-rich, iron concretions. 90+ cm: very fine, aeolian sand, wet, no iron concretions.
2	265928, 478478	n/a	n/a	Ditch of 1 m deep with 20 cm of water (Figure E.4.13).

Figure E.4.12: Soil profile at location 1.

Figure E.4.13: Ditch of 1 m deep at location 2.

Discussion/conclusions

- In the field it turned out that the plot consisted of a natural grassland, so both LGN6 and LGN2020 were correct.
- In general, the soil indeed consisted of a clear Hn21 with the obvious presence of rust due to drainage of the plot. However, the topsoil is heavily enriched due to past agriculture and the leaching layer was not present (which is very common for a veldpodzolsoil) as it might have been mixed with the upper soil due to ploughing. So, despite it being clear that the soil once was a clear Hn21, it nowadays cannot be called one anymore.
- With the groundwater table being 105 cm below ground level (at 15-10-21), the MIPWA 3.0 data seems to be correct for the GG and most likely for the GVG as well, also looking at the data from DINOloket (Figure E.4.9). Also, no signs for a positive seepage flux were found, so MIPWA 3.0 was correct there as well.
- WWN's prediction for the current situation is wrong, as the soil is neither moist nor nutrient-poor. K67/68 (dry, moderately nutrient-rich soils) would have been a better fit.
- For the past, undisturbed situation, K41/K42 could be correct, but to get to this point now, the ditch draining the plot must be filled in and the enriched top 40 cm of the soil must be excavated.
- So, although LGN6, the Dutch soil map and MIPWA 3.0 were all correct, the predictions for the current situation are still incorrect. This is most likely the result of MIPWA 3.0 not taking into account the enriched topsoil and the excessive drainage, although the groundwater table data were correct.
- At the moment, N12.02 is the right nature management type and can remain so for the coming years. Despite the plot being a heathland in the past, it will not be easy to transform the plot into an N06.04 (moist heathland) as the groundwater table has to rise significantly and the topsoil has to be excavated. Due to close by agricultural fields, filling in the ditches most likely will not be happening. Therefore, it will be easier achievable to transform the plot into an N07.01 (dry heathland), as in that case only the topsoil has to be excavated.

APPENDIX F: NATURE MANAGEMENT TYPES

A complete list of all nature management types treated in this, including the codes, English name and original Dutch name as named by BIJ12 (https://www.bij12.nl/onderwerpen/natuur-en-landschap/index-natuur-en-landschap/natuurtypen/).

Table F.1: Complete list of all treated nature management types in this research.

Code	English name	Dutch name
N05.03	Bogland.	Veenmoeras.
N06.04	Moist heathland.	Vochtige heide.
N06.06	Acidic or raised bog oligotrophic pond.	Zuur ven of hoogveenven.
N07.01	Dry heathland.	Droge heide.
N10.01	Wet nutrient-poor grassland.	Nat schraalland.
N10.02	Moist meadow.	Vochtig hooiland.
N11.01	Dry nutrient-poor grassland.	Droog schraalgrasland.
N12.02	Grassland rich in herbs and fauna.	Kruiden- en faunarijk grasland.
N12.05	Herb- and fauna-rich field.	Kruiden- en faunarijke akker.
N12.06	Shrubland.	Ruigteveld.
N14.02	Raised and low bogland forest.	Hoog- en laagveenbos.
N14.03	Hornbeam and ash forest.	Haagbeuken- en essenbos.
N16.03	Dry production forest.	Droog bos met productie.
N16.04	Moist production forest.	Vochtig bos met productie.

APPENDIX G: ECOTOPE GROUPS

A complete list of all ecotope group codes and extended description treated in this research as used by WWN 3.0 (https://www.kwrwater.nl/wp-content/uploads/2018/09/Handleiding-WWN-Stowa.pdf).

Table G.1: Complete list of all ecotope groups treated in this research.

Code	Extended description
A11	Hydrosere and freshwater vegetations of nutrient-poor, acidic waters (acidic oligotrophic ponds, raises bog ponds).
H21	Forest and shrublands on wet, nutrient-poor, acidic soils (raised bog forests).
H22	Forest and shrublands on wet, nutrient-poor, slightly acidic soils (ash-alder woods).
H27	Forest and shrublands on wet, moderately nutrient-rich soils (alluvial and wet sloped forests).
H28	Forest and shrublands on wet, very nutrient-rich soils (floodplain forests and osier beds).
H47	Forest and shrublands on moist, moderately nutrient-rich soils (older stinsen forests and other park-like forests on river clay, loam and loamy sand soils).
H67	Forest and shrublands on dry, moderately nutrient-rich soils (planted forests on former agricultural land on sand).
K21	Pioneer vegetation and grasslands on wet, nutrient-poor, acidic soils (wet heathland and raised bogs).
K22	Pioneer vegetation and grasslands on wet, nutrient-poor, slightly acidic soils (sphagnum reed lands, floating mat, Sesleria albicans grasslands, calcium-poor dune valleys).
K23	Pioneer vegetation and grassland on wet, nutrient-poor, alkaline soils (wet dune valleys).
K27	Pioneer vegetation, grasslands and shrublands on wet, moderately nutrient-rich soils (meadows in the fen and the middle course of stream valleys).
K28	Pioneer vegetation, grasslands and shrublands on wet, very nutrient-rich soils (shrublands along rivers and ditches, wet cultivated grassland).
K41	Pioneer vegetation and grasslands on moist, nutrient-poor, acidic soils (wet heathland and raised bogs).
K42	Pioneer vegetation and grasslands on moist, nutrient-poor, weakly acidic soils (violion caninae grassland, calcium-poor dune valleys).
K47	Pioneer vegetation and grasslands on moist, moderately nutrient-rich (embankment slopes, false oat-grass meadows).
K48	Pioneer vegetation and grasslands on moist, very nutrient-rich soils (agricultural fields, roadsides, factory grounds).
K61	Pioneer vegetation and grasslands on dry, nutrient-poor, acidic soils (dry heathland).
K62	Pioneer vegetation and grasslands on dry, nutrient-poor, slightly acidic soils (dry heathland and grey hair-grass grasslands).
K67	Pioneer vegetation, grasslands and shrublands on dry, moderately nutrient-rich soils (undergrowth in grain fields, ruderal vegetation in dry dunes).
K68	Pioneer vegetation, grasslands and shrublands on dry, moderately nutrient-rich soils (undergrowth in heavily fertilised fields, ruderal vegetation along rivers).

APPENDIX H: SOIL TYPES

A complete list of all soil type codes and descriptions treated in this researh, as named by the BRO (Basis Registratie Ondergrond) (https://basisregistratieondergrond.nl/inhoud-bro/registratieobjecten/modellen/bodemkaart-sgm/).

Table H.1: Complete list of all soil types treated in this research.

Code	Description
ABk	Clayey beekdalsoils.
AM	Mengelsoils.
AS	Stuifzandsoils (inland-dune sand soils).
cHn23	Laarpodzolsoils; loamy fine sand.
fkpZg23	Beekeerdsoils; loamy fine sand (locally iron-rich, starting within 0.5 m and at least 0.1 m thick) (sandy clay or clay layer, 15-40 cm thick).
fpZg23	Beekeerdsoils; loamy fine sand (locally iron-rich, starting within 0.5 m and at least 0.1 m thick).
fZn21	Vlakvaagsoils; loam-poor and weak loamy fine sand (locally iron-rich, starting within 50cm and at least 10cm thick).
fZn23	Vlakvaagsoils; loamy fine sand (locally iron-rich, starting within 50cm and at least 10cm thick).
Hd21	Haarpodzolsoils; loam-poor and slightly loamy fine sand).
Hn21	Veldpodzolsoils; loam-poor and slightly loamy fine sand.
Hn23	Veldpodzolsoils; loamy fine sand.
pZg23	Beekeerdsoils; loamy fine sand.
Rn45A	Calcareous poldervaagsoils; heavy clay, profile gradient 5.
Rn95A	Calcareous poldervaagsoils; heavy silt and light clay, profile gradient 5.
vWp	Moerige (peaty) podzolsoils with a moerige upper soil.
vWz	Moerige (peaty) eerdsoils with a moerige upper soil on sand.
Zb21	Vorstvaagsoils; loam-poor and weak loamy fine sand.
zWp	Wetland podzolsoils with a humus-bearing sand layer and a wetland interlayer.

APPENDIX I: FLORA

Complete list of Latin, English and Dutch names of all flora named in this research.

Table I.1: Complete list of all flora treated in this research, alphabetically ordered by Latin name.

Latin name	English name	Dutch name
Acer campestre	Field Maple	Spaanse aak
Acer pseudoplatanus	Sycamore	Gewone esdoorn
Acer spec.	Maple spec.	Esdoorn spec.
Achillea millefolium	Common yarrow	Duizendblad
Achillea ptarmica	Sneezewort	Wilde bertram
Alnus glutinosa	Alder	Zwarte els
Angelica sylvestris	Wild Angelica	Gewone engelwortel
Anthriscus sylvestris	Cow Parsley	Fluitenkruid
Arctium lappa	Greater burdock	Grote klit
Artemisia vulgaris	Mugwort	Bijvoet
Bellis perennis	Common Daisy	Madeliefje
Berula erecta	Lesser Water-parsnip	Kleine watereppe
Betula pendula	Silver Birch	Ruwe berk
Betula spec.	Birch spec.	Berk spec.
Bidens frondosa	Beggarticks	Zwart tandzaad
Callitriche spec.	Water starwort spec.	Sterrenkroos spec.
Calluna vulgaris	Heather	Struikhei
Cardamine pratensis	Cuckooflower	Pinksterbloem
Cardamine spec.	Bittercress spec.	Veldkers spec.
Carex paniculata	Greater Tussock-sedge	Pluimzegge
Carpinus spec.	Hornbeam spec.	Haagbeuk spec.
Centaurea jacea	Brown Knapweed	Knoopkruid
Cerastium fontanum subsp. vulgare	Big chickweed	Gewone hoornbloem s.s.
Cerastium glomeratum	Sticky Mouse ear	Kluwenhoornbloem
Cirsium arvense	Creeping Thistle	Akkerdistel
Cirsium palustre	Marsh thistle	Kale jonker
Cirsium spec.	Plume thistle spec.	Vederdistel spec.
Cirsium vulgare	Spear Thistle	Speerdistel
Corylus avellana	Common hazel	Hazelaar
Crataegus monogyna	Hawthorn	Eenstijlige meidoorn
Crepis capillaris	Smooth Hawk's beard	Klein streepzaad
Dryopteris carthusiana + Dryopteris dilatata	Narrow/Broad Buckler fern	Smalle stekelvaren + Brede stekelvaren
Dryopteris dilatata	Broad Buckler fern	Brede stekelvaren
Dryopteris filix-mas	Male-fern	Mannetjesvaren
Elodea nuttallii	Nuttall's Waterweed	Smalle waterpest
Epilobium spec.	Willowherb spec.	Basterdwederik spec.
Equisetum fluviatile	Water horsetail	Holpijp
Equisetum palustre	Marsh horsetail	Lidrus
Erica tetralix	Cross-leaved Heath	Gewone dophei
Euonymus europaeus	Spindle	Wilde kardinaalsmuts

Latin name	English name	Dutch name
Eupatorium cannabinum	Hemp-agrimony	Koninginnekruid
Fagus sylvatica	European beech	Beuk
Filipendula ulmaria	Meadowsweet	Moerasspirea
Fraxinus excelsior	Ash	Es
Galeopsis spec.	Hempnettle spec.	Hennepnetel spec.
Galium palustre	Marsh-bedstraw	Moeraswalstro
Galium saxatile	Heath bedstraw	Liggend walstro
Glechoma hederacea	Ground-ivy	Hondsdraf
Gnaphalium luteoalbum	Jersey Cudweed	Bleekgele droogbloem
Heracleum spec.	Cowparsnip spec.	Berenklauw spec.
Heracleum sphondylium	Hogweed	Gewone berenklauw
Hieracium spec.	Hawkweed spec.	Havikskruid spec.
Hottonia palustris	Water Violet	Waterviolier
Humulus lupulus	Hop	Hop
Hydrocotyle vulgaris	Marsh Pennywort	Gewone waternavel
Hypochaeris radicata	Cat's-ear	Gewoon biggenkruid
Impatiens Glandulifera	Himalayan Balsam	Reuzenbalsemien
Jacobaea vulgaris	Common Ragwort	Jakobskruiskruid
Juncus acutiflorus	Sharp flowered rush	Veldrus
Juncus articulatus	Jointed Rush	Zomprus
Juncus effusus	Common rush	Pitrus
Juncus spec.	Rush spec.	Rus
Lamium galeobdolon subsp. argentatum	Variegated yellow archangel	Bonte gele dovenetel
Lapsana communis	Common nipplewort	Akkerkool
Leontodon saxatilis	Lesser hawkbit	Kleine leeuwentand
Leucanthemum vulgare	Ox eye Daisy	Margriet
Liparis loeselii	Fen orchid	Groenknolorchis
Lonicera periclymenum	European honeysuckle	Wilde kamperfoelie
Lotus corniculatus	Common Bird's-foot-trefoil	Gewone rolklaver
Lotus pedunculatus	Greater Bird's-foot-trefoil	Moerasrolklaver
Lotus spec.	Trefoil spec.	Rolklaver spec.
Ludwigia grandiflora	Uruguayan Hampshire-purslane	Waterteunisbloem
Lycopus europaeus	Gipsywort	Wolfspoot
Lysimachia nummularia	Creeping-Jenny	Penningkruid
Lysimachia vulgaris	Garden yellow loosestrife	Grote wederik
Lythrum portula	Water-purslane	Waterpostelein
Lythrum salicaria	Purple loosestrife	Grote kattenstaart
Malva moschata	Musk mallow	Muskuskaasjeskruid
Mentha aquatica	Water mint	Watermunt
Menyanthes trifoliata	Bogbean	Waterdrieblad
Myosotis laxa/scorpioides	Tufted/water forget me not	Zomp/Moerasvergeet-mij-nietje
Myosotis scorpioides	Water Forget me not	Moerasvergeet-mij-nietje
Oenothera spec.	Evening primrose spec.	Teunisbloem spec.
Persicaria hydropiper	Water pepper	Waterpeper
Phragmites australis	Common reed	Riet
Plantago lanceolata	Ribwort Plantain	Smalle weegbree
Plantago major	Common plantain	Grote weegbree
Plantago major subsp. intermedia	Plantago major subsp. intermedia	Getande weegbree
Plantago major subsp. major	Greater plantain	Grote weegbree s.s.
Polytrichum juniperinum	Juniper haircap moss	Zandhaarmos

Latin name	English name	Dutch name
Polytrichum spec.	Hair moss	Haarmos
Populus spec.	Cottonwood spec.	Populier spec.
Potentilla anglica	Trailing Torm	Kruipganzerik
Potentilla anserina	Silverweed	Zilverschoon
Potentilla erecta	Erect cinquefoil	Tormentil
Quercus spec.	Oak spec.	Eik spec.
Ranunculus acris	Meadow Buttercup	Scherpe boterbloem
Ranunculus flammula	Lesser Spearwort	Egelboterbloem
Ranunculus repens	Creeping buttercup	Kruipende boterbloem
Ranunculus sceleratus	Celery-leaved Buttercup	Blaartrekkende boterbloem
Rhytidiadelphus squarrosus	Springy turf-moss	Gewoon haakmos
Rorippa amphibia	Great Yellow-cress	Gele waterkers
Rubus idaeus	Raspberry	Framboos
Rubus spec.	Blackberry spec.	Braam spec.
Rumex acetosa	Garden sorrel	Veldzuring
Rumex acetosella	Sheep's Sorrel	Schapenzuring
Rumex conglomeratus	Sharp Dock	Kluwenzuring
Rumex crispus	Curled dock	Krulzuring
Rumex obtusifolius	Broad leaved Dock	Ridderzuring
Rumex spec.	Dock spec.	Zuring spec.
Salix aurita	Eared willow	Geoorde wilg
Salix spec.	Willow spec.	Wilg spec.
Salix triandra	Almond willow	Amandelwilg
Scirpus sylvaticus	Wood club-rush	Bosbies
Scorzoneroides autumnalis	Autumn Hawkbit	Vertakte leeuwentand
Senecio sylvaticus	Heath Groundsel	Boskruiskruid
Silene flos-cuculi	Ragged Robin	Echte koekoeksbloem
Solanum nigrum	Black nightshade	Zwarte nachtschade
Solidago gigantea	Giant goldenrod	Late guldenroede
Sonchus asper	Prickly Sow thistle	Gekroesde melkdistel
Spergula arvensis	Corn Spurrey	Gewone spurrie
Stachys palustris	Marsh Woundwort	Moerasandoorn
Stellaria media	Chick Weed	Vogelmuur
Succisa pratensis	Devil's-bit Scabious	Blauwe knoop
Symphytum officinale	Common comfrey	Gewone smeerwortel
Tanacetum vulgare	Tansy	Boerenwormkruid
Taraxacum spec.	Dandelion spec.	Paardenbloem spec.
Trifolium pratense	Red clover	Rode klaver
Trifolium repens	White clover	Witte klaver
Trifolium spec.	Clover spec.	Klaver spec.
Typha latifolia	Lesser Reed-mace	Grote lisdodde
Ulmus spec.	Elm spec.	Iep spec.
Urtica spec.	Nettle spec.	Brandnetel spec.
Veronica scutellata	Skullcap speedwell	Schildereprijs
Viburnum opulus	Guelder-rose	Gelderse roos
Vicia spec.	Vetch spec.	Wikke spec.

APPENDIX J: LEGENDS LGN AND WWN 3.0 ECOTOPE GROUPS

Legends of LGN6, LGN2020 and ecotope groups results of WWN 3.0.

Legend

1 - agrarisch gras	Agricultural grass
2 - mais	Corn
3 - aardappelen	Potatoes
4 - bieten	Beets
5 - granen	Cereal
6 - overige landbouwgewassen	Other crops
8 - glastuinbouw	Greenhouse cultivation
9 - boomgaarden	Orchards
10 - bloembollen	Flowerbulbs
11 - loofbos	Deciduous forest
12 - naaldbos	Coniferous forest
16 - zoet water	Fresh water
17 - zout water	Salt water
18 - bebouwing in primair bebouwd gebied	Buildings in primarily built-up area
19 - bebouwing in secundair bebouwd gebied	Buildings in secondary built-up area
20 - bos in primair bebouwd gebied	Forest in primarily built-up area
22 - bos in secundair bebouwd gebied	Forest in secondary built-up area
23 - gras in primair bebouwd gebied	Grass in primarily built-up area
24 - kale grond in bebouwd gebied	Bare land in built-up area
25 - hoofdwegen en spoorwegen	Main roads and railways
26 - bebouwing in het buitengebied	Buildings in rural areas
28 - gras in secundair bebouwd gebied	Grass in secondary built-up area
30 - kwelders	Salt marshes
31 - open zand in kustgebied	Open sand in coastal area
32 - duinen met lage vegetatie	Low vegetation dunes
33 - duinen met hoge vegetatie	High vegetation dunes
34 - duinheide	Dune heathland
35 - open stuifzand en/ of rivierzand	Open shifting sand and/or river sand
36 - heide	Heathland
37 - matig vergraste heide	Moderately grassed heathland
38 - sterk vergraste heide	Strongly grassed heathland
39 - hoogveen	Raised bogland
40 - bos in hoogveengebied	Raised bogland forest
41 - overige moerasvegetatie	Other swamp vegetation
42 - rietvegetatie	Reed bed vegetation
43 - bos in moerasgebied	Forest in marshland
45 - natuurgraslanden	Natural grassland
61 - boomkwekerijen	Tree nurseries
62 - fruitkwekerijen	Fruit nurseries

Figure J.1: LGN6 legend in Dutch and English.
(http://webdocs.alterra.wur.nl/internet/geoinformatie/lgn/AlterraRapport2012.pdf)

Figure J.2: LGN2020 legend in Dutch and English.

https://www.wur.nl/nl/onderzoek-resultaten/onderzoeksinstituten/environmental-research/faciliteiten-tools/kaarten-en-gisbestanden/landelijk-grondgebruik-nederland/versies-bestanden/lgn2020/legenda-lgn2020.htm

Figure J.3: Legend of ecotope group results of WWN 3.0 (Provided by Witteveen+Bos).