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Knowledge for Informed Choices

Tools for more effective and efficient selection of valuable archaeology in the Netherlands

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R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers and J. van Doesburg (eds.)

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Nederlandse Archeologische Rapporten 55

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Editors: R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers and J. van Doesburg

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Preface

Choices are inevitable in archaeological heritage management. There is nothing wrong with this, provided they are made in a well-informed, transparent and participative way. This idea is gaining more and more support internationally, and indeed it lies at the core of a recent European Archaeological Council (EAC) Action Plan prompted by the 15th annual EAC symposium held in Amersfoort, the Netherlands, in 2014.

In the Netherlands, care of the archaeological heritage is primarily the responsibility of local authorities. The signing of the Valletta Convention and the national legislation enacted as a result have had a major impact on the way we deal with archaeology. It is now an explicit element of the process of spatial planning, with the first option being to preserve remains *in situ*. If this is not realistically possible, the developer pays not only for an investigation but also for the publication of the information represented by the remains that are in danger of being lost. This approach has led to an increase in archaeological research, most of which is performed by commercial agencies. Local authorities play a key role in this. In spatial developments, they are the ones who largely decide the extent to which archaeology must be taken into account, how intensive any archaeological investigation should be, and what research questions should be taken into the field. The Cultural Heritage Agency supports local authorities in this task, providing specialist knowledge of archaeological heritage management and of the heritage itself.

Some years ago the Dutch State Secretary for Education, Culture and Science commissioned an evaluation of the effects of the archaeology legislation. It found that, though a great deal of good had been done, there were still areas requiring improvement. One of the conclusions was that the knowledge gained was not yet adequately reflected in local authority archaeology policy. It was clear that there was much to be gained by developing tools for local authorities and the agencies working on their behalf to ensure that: new insights obtained in archaeological investigations, and concerning the subsurface and past land use, lead to more accurate predictions of where traces of human habitation can be found;

- it becomes clear which supralocal questions about our past can be addressed by local research;
- insight is provided into what methods are most appropriate for tracing archaeological remains or verifying predictions, given the landscape and the remains thought likely to be found;
- an overview of the information and local authority archaeology maps is provided;
- overview studies are produced synthesising the many fieldwork reports into new knowledge of our past.

After a discussion in parliament the State Secretary commissioned the Agency to take action to strengthen the current archaeological system.

The present volume reports on the products developed to provide ‘knowledge for informed choices’ as part of the Archaeology Knowledge Kit programme. They include datasets, maps, methods, guidelines, best practice and web-based applications to facilitate the effective and efficient selection of valuable archaeological remains. These products have been developed by specialists and consultants at the Agency, in collaboration with local authorities, archaeological agencies, universities and other research institutions, a national farmers’ organisation and other parties.

I hope that this volume includes matters of interest to you and, above all, that it will prompt you to join the discussion about the development of knowledge products that help us achieve the best possible standard of archaeological heritage management for the future.

Susan Lammers
Director, Cultural Heritage Agency of the Netherlands

Summary

Archaeological heritage management benefits from well-informed and transparent decision-making. With the aim of providing 'knowledge for informed choices', a series of tools have been developed for archaeological heritage management in the Netherlands. They include digital maps, datasets, methods, guidelines, best practice and web-based applications to facilitate the effective, efficient and transparent selection of valuable archaeological remains. The tools relate to archaeological predictions, disturbances by agriculture and other activities, archaeological heritage maps, prospection methods, research questions, and scientific syntheses to close the archaeological heritage management cycle. They are examined in the various chapters in this publication. The tools were developed as part of the Cultural Heritage Agency's 'Archaeology Knowledge Kit' programme, in response to an evaluation of archaeology legislation that entered into force in the Netherlands in 2007, implementing the Valletta Convention. The evaluation concluded that though many things are going well in archaeological heritage management, there are several points that are open to improvement. The State Secretary for Education, Culture and Science therefore commissioned a series of improvement activities.

Some of these activities have been performed as part of the 'Archaeology Knowledge Kit' programme. Chapter 1 outlines the goals of the programme, in the context of the legislation and the archaeological heritage management system in the Netherlands, as well as its constituent projects, the products it has yielded and the intended users. The organisational form chosen – a coherent programme with collaboration between projects that clearly overlap – has proved successful. It makes for better exchange and input of knowledge and information, allowing project teams to work more effectively, and undoubtedly raising quality. It is also a very pleasant way of working.

Chapter 2 presents 'tools' that were needed to develop the applications for archaeological heritage management discussed in later chapters: a chronology, a grouping of assemblage types and a map. Part 2.2 presents a new, simplified chronological classification of the archaeology of the Netherlands comprising four periods: hunter-gatherers and early farmers, early farming societies, late farming societies and state societies. This classification is based on similarities and differences in methods of subsistence and how the archaeological remains are manifested in the soil. In 2.3, the many assemblage types in the Basic Archaeological Register (ABR) are grouped into four main themes: settlement, burial, economy and infrastructure, and ritual practices. This was necessary for the 'Land Use in Layers' and 'Prospection Made-to-Measure' applications discussed in chapters 3 and 6. The new Archaeological Landscapes Map of the Netherlands is presented in 2.4. It distinguishes 26 landscapes with 39 different landscape zones. These zones are based both on landscape features and also various archaeological characteristics.

Predictions are the focus of chapter 3. The first contribution in this chapter (3.2) looks at the creation of the 12 palaeogeographical maps of the Netherlands for different points in time over the past 10,000 years. The reconstruction is based on the analysis and interpretation of tens of thousands of corings, research into the formation and age of geological deposits in the soil, and archaeological information. Part 3.3 explains how vegetation maps and reconstructions have been produced for various periods in the past on the basis of pedological, palynological and archaeological data. In parts 3.4 and 3.5 the focus is on how to make maps that show the probability of encountering archaeological remains from different periods, and at different depths. Part 3.4 discusses a way of reconstructing buried landscape zones used by humans in the past on the basis of a multitude of data on the coastal plain subsurface of the Netherlands (to twenty metres below the surface). Part 3.5 then considers the provision of information on how humans used these landscape zones – some of which are now buried – in the past. The final part of this chapter (3.6) looks at the development of predictive archaeological models for the urban countryside based on historical town maps produced by Jacob van Deventer in the second half of the 16th century.

Soils disturbed to such an extent by soil excavation or agricultural activities that they contain no useful information about the past need not be subjected to archaeological investigation. Part 4.4 discusses ways of

producing local maps that show the probability of disturbance. Prior to this, part 4.2 describes the impact of various agricultural and horticultural cultivation activities on the soil, and part 4.3 presents an overview of national and regional datasets containing information on locations that may be disturbed. Finally, part 4.5 presents a model showing how, in an urban context, the soil might be disturbed or preserved under various types of residential area constructed since the nineteenth century.

Local authority archaeological resource maps and predictive maps vary markedly, even in adjacent municipalities. This makes it difficult to compare them or use them in combination. Chapter 5 describes how the local authority maps – totalling more than 1500 – have been surveyed and analysed to gain an insight into the information they contain and how they were compiled. The results of the analysis provide a starting point for discussions with the makers and users of the maps, with the aim of establishing how they can be better coordinated so that more uniform maps are produced.

For years, archaeologists have been debating the correct way to locate find spots in the varied landscape of the Netherlands. Although a lot of experience has been gained with archaeological prospection in the past few decades, choosing the most appropriate method is neither simple nor clear-cut. Each method of prospection has its own applications, potential and limitations. Chapter 6 looks at the background and the creation of the Prospection Made-to-Measure online information system that provides advice on the most suitable methods.

Chapter 7 is devoted to the new National Archaeological Research Agenda 2.0, which sets out the most important archaeological research questions affecting multiple regions in the Netherlands. This chapter looks at the background to and creation of this user-friendly online agenda. It is centred around 117 specific research questions addressing the most pressing issues at this time. Practical guidance on each question suggests suitable approaches to fieldwork in order to answer the questions.

The goal of the Valletta Harvest project (chapter 8) was to synthesise the results of development-led archaeological research into new knowledge of the history of the Netherlands. The subjects of the syntheses were determined by the 'knowledge opportunities' identified by determining which areas, themes and archaeological periods had been reported on most, and then selecting questions from the national archaeological research agenda that could be answered using these reports. The results of the first syntheses were used to determine what we can learn about the scientific synthesis of development-led research reports and what recommendations might be made for further improvements to excavation and reporting.

The completion of the 'Archaeology Knowledge Kit' programme does not mean the end of all the activities. Over the coming period the products of the programme will be evaluated and improved where possible.
In addition add-ons and some entirely new products will be generated for the effective and efficient selection of valuable archaeological remains.

Samenvatting

De archeologische monumentenzorg is gebaat bij feitelijk goed verantwoorde en transparante besluitvorming. Onder de leus 'Kennis voor keuzes' is voor de archeologische monumentenzorg in Nederland een reeks tools ontwikkeld. Het gaat om digitale kaarten, datasets, methodieken, handleidingen, best practices, web toepassingen, et cetera die bijdragen aan een zo effectief en doelmatig mogelijke en transparante selectie van waardevolle archeologie. Het zijn tools op het gebied van archeologische verwachtingen, verstoringen door onder andere de landbouw, archeologische erfgoedkaarten, methoden van prospectie, onderzoeksvragen, en het sluiten van de archeologische monumentenzorg cyclus door wetenschappelijke syntheses. In de voorliggende publicatie worden deze tools behandeld in afzonderlijke hoofdstukken. Ze zijn gemaakt binnen het ontwikkel programma 'Kenniskaart Archeologie' van de Nederlandse Rijksdienst voor het Cultureel Erfgoed.

Aanleiding was de evaluatie van de archeologie wetgeving die in 2007 in Nederland van kracht werd en die onder andere invulling gaf aan het verdrag van Valletta. De conclusie van de evaluatie was dat er veel goed gaat in de archeologische monumentenzorg, maar dat het op verschillende punten nog beter kan. De staatssecretaris van Onderwijs, Cultuur en Wetenschap gaf daarom opdracht een reeks verbeteracties uit te voeren.

Een deel van deze verbeteracties zijn uitgevoerd binnen het programma 'Kenniskaart Archeologie'. Hoofdstuk 1 schetst, tegen de achtergrond van de wetgeving en de inrichting van de archeologische monumentenzorg in Nederland, de doelen van het programma, de daaronder vallende projecten, de opgeleverde producten en de beoogde gebruikers. De gekozen organisatievorm, een coherent programma waarbinnen verschillende projecten samenwerken die duidelijke raakvlakken met elkaar hebben, pakt goed uit. Het levert een betere uitwisseling en input van kennis en informatie op, waardoor effectiever en ongetwijfeld kwalitatiever kan worden gewerkt. Daarnaast is het ook een zeer plezierige vorm van werken.

In hoofdstuk 2 worden 'hulpmiddelen' gepresenteerd die nodig waren voor enkele verderop besproken toepassingen binnen de archeologische monumentenzorg: een chronologie, een clustering van complextypen en een kaart. Bijdrage 2.2 presenteert een nieuwe, vereenvoudigde chronologische indeling van de archeologie van Nederland in vier perioden: jager-verzamelaars en eerste boeren, vroege landbouwsamenlevingen, late landbouw samenlevingen en staatssamenlevingen. Deze indeling is zowel gebaseerd op overeenkomsten en verschillen in bestaanswijze als op de wijze waarop de archeologische resten zich manifesteren in de bodem. In 2.3 zijn de vele in de Nederlandse archeologie gebruikte complextypen uit het Archeologisch Basis Register (ABR) gegroepeerd in vier hoofdthema's: bewoning, begraving, economie en infrastructuur en rituelen. Deze clustering was nodig voor de in hoofdstuk 3 en 6 besproken toepassingen 'Landgebruik in Lagen' en 'Prospectie op Maat'. De nieuwe Archeologische Landschappenkaart van Nederland wordt gepresenteerd in 2.4. Op deze kaart worden 26 landschappen onderscheiden en daarbinnen 39 landschapszones. Deze zoneringen zijn niet alleen gebaseerd op landschappelijke kenmerken, maar ook op verschillende archeologische karakteristieken.

Verwachtingen staan centraal in hoofdstuk 3. Het eerste artikel (3.2) behandelt het vervaardigen van de 12 paleogeografische kaarten van Nederland van verschillende tijdstippen van de laatste 10.000 jaar. Deze reconstructie is gebaseerd op de analyse en interpretatie van tienduizenden grondboringen, onderzoek naar de vorming en ouderdom van geologische afzettingen in de bodem en archeologische informatie. Bijdrage 3.3 betreft het vervaardigen van vegetatiekaarten en -reconstructies voor verschillende perioden uit het verleden op basis van bodemkundige, palynologische en archeologische gegevens. De onderdelen 3.4 en 3.5 zijn er op gericht kaarten te kunnen maken waarop, uitgesplitst naar periode en diepte, de kans op het aantreffen van archeologische resten wordt aangegeven. In 3.4 wordt beschreven hoe, gebruikmakend van een veelvoud aan gegevens over de ondergrond van de Nederlandse kustvlakte (tot twintig meter onder het maaiveld), onderscheiden landschappelijke zones gereconstrueerd kunnen worden die in het verleden door de mens gebruikt werden.

Bijdrage 3.5 beschrijft vervolgens hoe informatie geboden wordt over hoe de mens gebruikmaakte van deze, deels nu op diepte liggende, landschappelijke zones. De laatste bijdrage uit dit hoofdstuk (3.6) behandelt het vervaardigen

van archeologische verwachtingsmodellen voor de stadsrand op basis van historische stadsplattegronden vervaardigd door Jacob van Deventer in de tweede helft van de zestiende eeuw.
Bodems die door ontgrondingen of landbouwactiviteiten zodanig verstoord zijn dat ze geen of zeer weinig bruikbare informatie opleveren over het verleden kunnen worden vrijgesteld van archeologisch onderzoek. Bijdrage 4.4 bediscussieert methoden om te komen tot lokale kaarten waarop de kans op verstoring is aangegeven. Dit artikel wordt voorafgegaan door een bijdrage waarin de effecten op de bodem van verschillende teelthandelingen uit de land- en tuinbouw worden beschreven (4.2) en een waarin een landelijk overzicht wordt gepresenteerd met landelijke en regionale datasets met informatie over plaatsen die verstoord kunnen zijn (4.3). Tot slot (4.5) wordt een model gepresenteerd van hoe in stedelijke context de bodem verstoord of bewaard kan zijn onder diverse typen woonwijken uit verschillende perioden vanaf de negentiende eeuw.
Gemeentelijke archeologische waarden- en verwachtingskaarten verschillen onderling sterk van elkaar, zelfs bij gemeenten die aan elkaar grenzen. Hierdoor is het lastig om ze te vergelijken of in combinatie met elkaar te gebruiken. Hoofdstuk 5 beschrijft hoe de ruim 1500 gemeentelijke kaarten zijn geïnventariseerd en geanalyseerd om inzicht te krijgen in de inhoud van de kaarten en de manier waarop ze tot stand zijn gekomen. De resultaten van de analyse zijn het uitgangspunt om met de makers en de gebruikers van de kaarten in gesprek te gaan en uit te zoeken hoe partijen tot een betere afstemming en meer uniforme kaarten kunnen komen.
Archeologen discussiëren al jaren over het op de juiste wijze opsporen van vindplaatsen in het afwisselende Nederlandse landschap. Hoewel in de afgelopen decennia veel ervaring is opgedaan met archeologische prospectie, is de keuze van de meest geschikte methode geen eenvoudige of vanzelfsprekende zaak. Elke prospectiemethode heeft zijn eigen toepassingsgebied, mogelijkheden en beperkingen. Hoofdstuk 6 gaat in op de achtergronden en de totstandkoming van het digitale informatiesysteem Prospectie op Maat dat adviseert over de meest geschikte methoden.
Hoofdstuk 7 is gewijd aan een nieuwe Nationale Onderzoeksagenda Archeologie 2.0 (NOaA 2.0) met de belangrijkste bovenregionale onderzoeksvragen op het gebied van de archeologie van Nederland. De bijdrage gaat in op de achtergronden en de totstandkoming van deze gebruiksvriendelijke, digitale agenda. Centraal daarin staan 117 concrete onderzoeksvragen die de meest prangende kwesties van dit moment aangeven. Praktische handreikingen per vraag geven suggesties voor de aanpak in het veld om de vragen ook beantwoord te krijgen.
Doel van het Oogst voor Malta project (hoofdstuk 8) was het synthetiseren van de resultaten van Malta-onderzoek tot nieuwe kennis over de Nederlandse geschiedenis.
De onderwerpen voor syntheses werden bepaald door zogenaamde ‘kenniskansen’. Deze werden geïdentificeerd door vast te stellen over welke gebieden, thema’s en archeologische perioden de meeste rapporten zijn geschreven en vervolgens zijn vragen uit de nationale archeologische onderzoeksagenda geselecteerd die hiermee beantwoord kunnen worden. Op basis van de resultaten van de eerste syntheses is gekeken wat we kunnen leren over het wetenschappelijk synthetiseren van informatie uit rapporten van Malta-onderzoek en wat de aanbevelingen zijn om de praktijk van het opgraven en het rapporteren daarover verder te verbeteren.
Het afsluiten van het programma ‘Kenniskaart Archeologie’ betekent niet het beëindigen van de activiteiten. In de komende periode zullen de ontwikkelde producten worden geëvalueerd en waar mogelijk verbeterd. Ook worden aanvullende en nieuwe producten gemaakt gericht op een zo effectief en doelmatig mogelijke selectie van waardevolle archeologie.

1 Knowledge for informed choices. Tools for decision making in archaeological heritage management in the Netherlands

R.C.G.M. Lauwerier[1]

Abstract

The development programme 'Archaeology Knowledge Kit' has produced a number of tools for archaeological heritage management in the Netherlands. They include maps, datasets, methods, guidelines, best practice and web applications to facilitate the effective and efficient selection of valuable archaeological remains. The products relate to archaeological predictions, disturbances by agriculture and other activities, archaeological heritage maps, methods of prospection, research questions and scientific syntheses to close the archaeological heritage management cycle with. The programme was launched in response to the evaluation of archaeology legislation that entered into force in the Netherlands in 2007, putting the Valletta Convention into effect. This chapter outlines the goals of the programme and its constituent projects, the products they have yielded, the organisational form of the programme and the intended users, in the context of the legislation and the structure of archaeological heritage management in the Netherlands.

Keywords: Archaeological heritage management, policy evaluation, applied knowledge, archaeological maps, the Netherlands

1.1 Introduction

The practice of archaeological heritage management is determined by the government's policy choices and, to a large extent, by knowledge and information. This knowledge concerns the archaeological heritage itself, the physical and social context in which that heritage exists, methods of locating, identifying, protecting and investigating it, and knowledge of the effects of heritage policy.

The evaluation of the archaeology legislation that entered into force in the Netherlands in 2007 prompted the State Secretary for Education, Culture and Science to commission the Cultural Heritage Agency of the Netherlands (RCE) to develop and provide access to knowledge and information to strengthen archaeological heritage management in the Netherlands. Some of the resulting activities were brought together in the 'Archaeology Knowledge Kit' programme with the aim of achieving the most effective and efficient selection of valuable archaeological heritage. The programme focused on a number of themes: predictions, disturbances, archaeological heritage maps, methods of prospection, research questions, and scientific syntheses to close the archaeological heritage management cycle.

This chapter outlines the context of the programme: how European legislation has been implemented in Dutch law and the archaeological system in the Netherlands. The focus then turns to policy research in the Netherlands, particularly the evaluation of the archaeology legislation introduced in 2007, which resulted in the Cultural Heritage Agency's commission. The core focus of this chapter is the objectives and activities of the 'Archaeology Knowledge Kit' programme and its constituent projects. The objectives and activities of the projects and the organisation are described and a rough outline of the results is presented. Finally, a number of conclusions are presented concerning the results, with reference to the goals at the outset, and concerning the organisational form adopted. This chapter also serves as an introduction to the subsequent chapters, which examine the individual projects and their products and other results in more detail.

1.2 The European Convention and archaeology in the Netherlands

The organisation of archaeological heritage management in the Netherlands has changed radically since the European Convention on the Protection of the Archaeological Heritage (Treaty of Malta or Valletta Convention) was signed in 1992.[2] Developments set in motion after the signing of the Convention eventually resulted in the introduction in 2007 of new archaeology legislation: the Archaeological Heritage Management Act (*Wet archeologische monumentenzorg*, WAMZ) and the Archaeological Heritage Management Decree (*Besluit archeologische monumentenzorg*, BAMZ).[3] In July 2016 this legislation was incorporated into the Heritage Act (*Erfgoedwet*), which provides for the protection of the entire cultural heritage:

1 Corresponding author: r.lauwerier@cultureelerfgoed.nl.
2 Council of Europe 1992.
3 Government Gazette (*Staatsblad*) of the Kingdom of the Netherlands 2007, 293.

museums and their collections, monuments, historic buildings and archaeology.[4] The key points relating to archaeology in this legislation are: 1) preservation *in situ*; 2) early involvement of archaeology in the spatial planning process and 3) the 'developer pays' principle. Under the influence of the neoliberal politics of the 1990s, two further elements were added: 4) devolvement of responsibility for heritage management from central government to other authorities, such as provincial and – above all – local authorities; and 5) the commercialisation of archaeological practice.[5]

This legislation and the archaeological system must be seen within the context of the Netherlands as a small country, with an area of just 41,543 km^2, approximately the size of a German state or a British county. Furthermore, 18% of this area is water. Some seventeen million people live here, which equates to over four hundred inhabitants per km^2 (almost five hundred if we exclude the water), making this one of the most densely populated countries in the world. In 15% of the country there is a high probability of encountering archaeological finds. In 2007 there were 12,996 known sites with archaeological remains, 1770 of which were national listed monuments.[6] Since an archaeological monument sometimes comprises several sites, according to the Heritage Monitor, at the end of 2015 there were 1435 listed archaeological monuments in the Netherlands.[7]

Cultural heritage management in the Netherlands is seen as a joint responsibility of public authorities, companies and private individuals. Decentralisation of policy has meant that the government, the twelve provincial authorities and around 390 local authorities all play a role. Central government focuses mainly on the preservation, sustainable management and improvement of access to the heritage. Provincial authorities and, above all, local authorities are responsible for the implementation of policy at regional and local level. They also have their own additional policies, and thus play a key role in the protection of archaeological find spots. The vast majority of excavations are performed by commercial parties;[8] some 25 local authorities also carry out excavation work,[9] as do universities and the Cultural Heritage Agency, albeit only on a very small scale. In mid-2016 over seventy institutions hold an excavation licence. There are also several dozen archaeological agencies, most of them small, that do not perform excavations, but specialise in areas like physical anthropology, archaeobotany, the study of pottery, popularisation, project management and advice. Around 1335 people work in archaeology in the Netherlands, fifty per cent of whom are employed by commercial agencies or are self-employed.[10]

A quality assurance system has been established to ensure this system is managed properly. It is based partly on legislation and partly on self-regulation.[11] In this way, central government and provincial and local authorities ensure that the archaeological heritage is cared for appropriately. To ensure that only parties who are properly equipped for the task are involved in archaeological field research, excavations may be performed only with a licence issued by the Agency. Starting in mid-2016, this licensing system is being transformed into a certification-based system. A Dutch Archaeology Quality Standard has been developed to guide the quality of research.[12] The Heritage Inspectorate monitors the Dutch heritage and central government's information management systems. The Cultural Heritage Agency of the Netherlands lists national archaeological monuments and develops knowledge products to assist those working in the field. Provincial authorities monitor the work of different administrative authorities and assess whether local authority heritage policy complies with the statutory requirements.[13] This system has gradually taken shape since the European Convention was signed in 1992. Initially, archaeology and heritage management were practised 'in the spirit of Malta', but in 2007 a statutory basis was created in the form of the Archaeological Heritage Management Act and the Archaeological Heritage Management Decree. When this legislation was introduced, the minister made a commitment to parliament that it would be evaluated after a number of years.

4 Government Gazette (*Staatsblad*) of the Kingdom of the Netherlands 2015, 511.
5 E.g. Bazelmans 2011; Van den Dries 2011.
6 De Boer *et al.* 2009.
7 www.erfgoedmonitor.nl.
8 Verbruggen 2016.
9 Wesselingh 2016.
10 Van Londen *et al.* 2014.
11 Willems 2005.
12 *Kwaliteitsnorm Nederlandse Archeologie* (KNA), www.sikb.nl; Willems & Brandt 2004.
13 www.archeologieinnederland.nl/regels-en-beleid/wie-doet-wat-0 (in Dutch).

1.3 Evaluation of policy

There is a fairly good tradition of policy research and evaluation in the Netherlands, but since the 1990s it has gradually become a structural part of the central government policy cycle.[14] More and more evaluation and monitoring are also being performed in the archaeological heritage management system. The first Archaeology Review was published in 2002, followed in 2009 by the first Heritage Review, and since 2009 the Heritage Monitor has presented indicators that provide an insight into the development and state of the heritage, the operation of the system and the effects of heritage policy.[15] Universities, the Heritage Inspectorate and the Agency have all performed incidental studies into certain aspects of archaeological heritage management.[16] As mentioned above, when the new Archaeological Heritage Management Act and Decree were introduced, the minister undertook to evaluate their impact; indeed, section IVa of the Act stipulates that the legislation must be evaluated within four years of its entry into force.

An independent commercial research agency, RIGO Research en Advies BV, was therefore commissioned in 2010 to evaluate the effectiveness of the legislation, and address the question: Do the Act and Decree make an effective contribution to the protection of archaeological values, as a source of the collective memory and as an instrument for historical and scientific study, as referred to in the Valletta Convention? Furthermore, the agency was asked to consider the phenomenon of insidious degradation, the erosion of archaeological remains not caused by any directly identifiable mechanism such as desiccation or slope erosion.[17] The study was divided into four parts: spatial planning for the purpose of prevention, the financial framework, the liberalisation of the archaeological sector and the associated quality assurance system, and the knowledge structure. After the report was submitted, the State Secretary for Education, Culture and Science presented it to the House of Representatives.[18] Briefly, the outcome of the evaluation can be summarised as follows: there is much that is going well, but some things could be improved. In early 2012 the State Secretary sent his response to parliament, along with proposals designed to support the system, so that they could be discussed along with the report.[19] After discussion with parliament an implementation plan with action points was drawn up with the aim of strengthening the existing archaeological system. The majority of the action points were to be implemented by the Cultural Heritage Agency.[20]

1.4 Improvement actions and Knowledge Kit

1.4.1 Items and aims

The actions to improve the archaeological system in the Netherlands referred to in the minister's commitment to parliament, and worked out in further detail in the implementation plan, covered the following categories, which were assigned to different projects or programmes:

- 'Archis': revision of the central archaeological information system Archis 3.0, the national database containing information on archaeological sites and fieldwork. The aim was to optimise the provision of information to the field to enable statutory duties to be performed better, faster, more transparently and more cheaply, and to enhance the exchange of information and knowledge in the field of archaeological heritage management;
- 'Archaeology for local authorities': enhancing the specialist and strategic knowledge of local authorities in order to improve their ability to consider archaeological interests in spatial decisions;
- '*In situ*': obtaining a reliable picture of the extent of preservation *in situ* achieved through the process of archaeological heritage management in spatial planning;
- 'Top sites': the generation of knowledge concerning sustainable preservation and management on the basis of specific sites preserved *in situ*, for the purpose of curbing or preventing insidious degradation;
- 'Maritime archaeology': giving management of this part of the archaeological heritage the same status as the rest of archaeology in the Netherlands;

14 Leeuw 2009; Houppermans, Van Hoesel & Van Nispen 2015.
15 Lauwerier & Lotte 2002; Van Dockum & Lauwerier 2004; De Boer *et al.* 2009; www.erfgoedmonitor.nl.
16 E.g. Van den Dries 2016; Van Londen 2014; Lauwerier & Brinkkemper 2012; Lauwerier *et al.* 2006, 2011; Theunissen & Deeben 2011; Van den Dries & Zoetbrood 2007; Van den Dries & Zoetbrood 2008.
17 Van Os & Kosian 2011.
18 Van der Reijden, Keers & Van Rossum 2011.
19 Letter to the House of Representatives of the States-General, 7-2-2012, '*Beleidsreactie evaluatie archeologiewetgeving*' ('Policy response to evaluation of archaeology legislation'), 7-2-2012, no. 373781. (House of Representatives, 2011-2012 session, 33 053, no. 3.).
20 De Wit 2014; De Bruijn 2012.

- 'Certification': replacing the licensing system for archaeological investigations with a system of certification, giving the archaeology sector itself maximum responsibility for assuring the quality of research;
- 'End central government's role as safety net': ending the central government grant scheme to cover excessive costs of archaeological investigations, to highlight the financial responsibility of local and provincial authorities with regard to developers.

In addition, the State Secretary committed to a further two actions: to produce a new 'archaeological knowledge kit', and to ensure syntheses were written, under the title 'Valletta Harvest'. These two initiatives were combined to form the development programme known as 'Archaeology Knowledge Kit' which, under the slogan 'knowledge for informed choices', aimed to provide knowledge to facilitate the effective and efficient selection of valuable archaeological remains in the process of archaeological heritage management (Fig. 1). Much of this knowledge is particularly important for local authorities, as it enables them to take archaeological interests more fully into account in spatial planning. They need to be given the necessary tools: access to datasets, research methods, guidelines, best practice, overview maps etc. The Agency had overall responsibility for the programme, but implementation occurred in collaboration with local authorities, archaeological agencies, universities, other research institutions, a national farmers' organisation etc.

Six subjects relating to the various parts of the archaeological heritage management cycle were the focus of these actions: predictions, disturbances, archaeological heritage maps, methods of prospection, research questions and syntheses to close the archaeological heritage management cycle. These themes were the focus of several projects (Fig. 1):

1. Predictions: Predictions in Layers project, which aimed to classify archaeological predictions by landscape zone, period and depth.
2. Disturbances: Mapping Disturbances project, which aimed to identify the likelihood that archaeological remains will be disturbed so that unnecessary costs associated with archaeological investigations can be avoided.
3. Archaeological heritage maps: Maps in Abundance project, which aimed to harmonise local authority archaeological heritage maps.
4. Prospection: Prospection Best Practice project, which aimed to recommend the most appropriate method or combination of methods for locating and assessing archaeological sites, given the landscape and the predicted archaeological remains.
5. Research questions: National Archaeological Research Agenda 2.0 project, which aimed to define questions at national and international level, in the hope that they would be considered during any excavations and used as arguments for protecting sites.
6. Syntheses to close the archaeological heritage management cycle: Valletta Harvest project, which aimed to synthesise information from development-led reports to produce new knowledge of the past and make knowledge accessible to academics and the public.
7. Portal. Although analogue products have also been produced, the goal was to make the products of these projects available online as far as possible, via a single website functioning as a central portal. Although setting up and structuring the portal was not strictly part of the programme, it was so closely connected with the programme activities that it could not be seen in isolation.

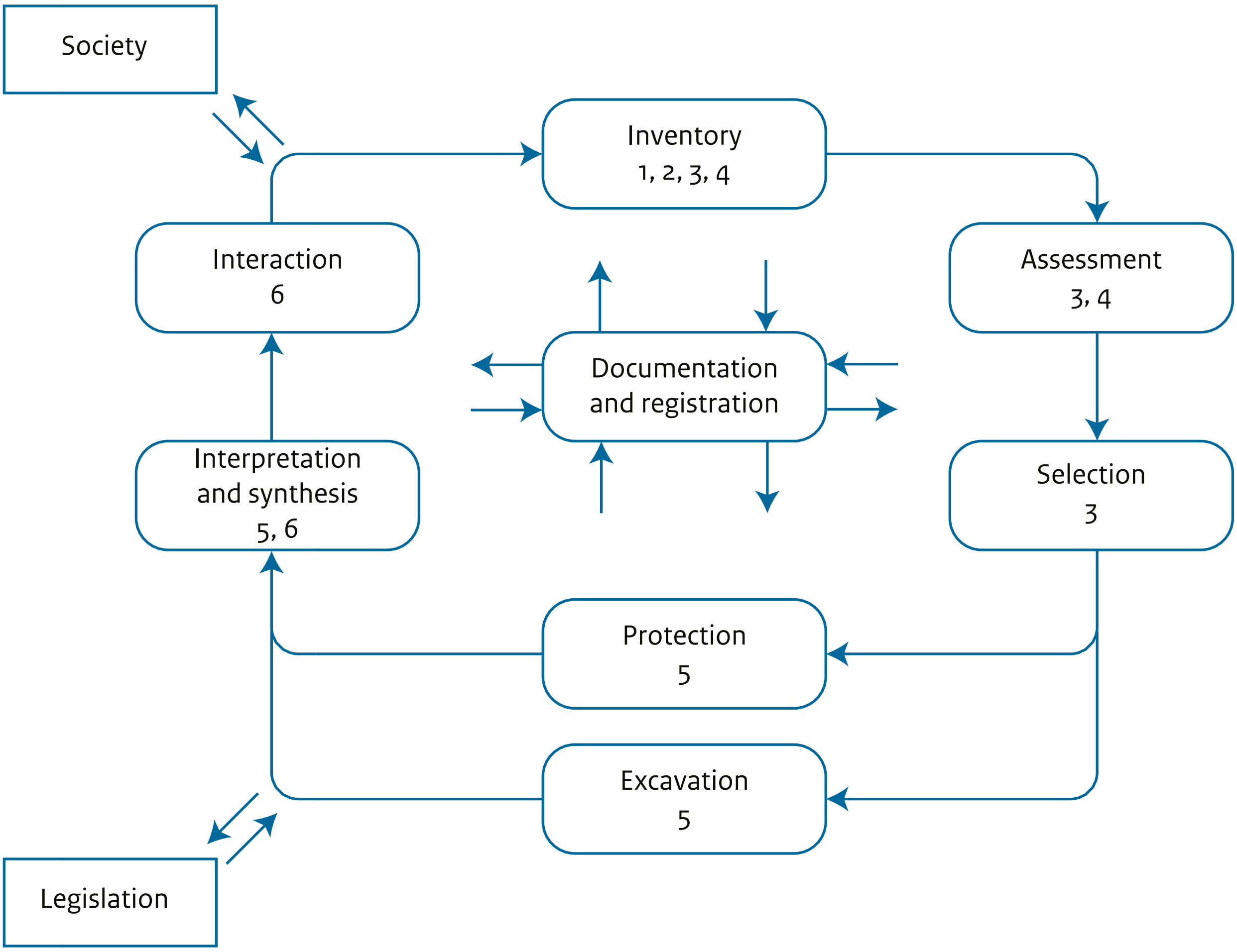

Figure 1 The archaeological heritage management cycle (after Willems 1997). The figures indicate how the project relate to different parts of the cycle: 1. Predictions in Layers; 2. Mapping Disturbances; 3. Maps in Abundance; 4. Prospection Best Practice; 5. National Archaeological Research Agenda 2.0; 6. Valletta Harvest.

1.4.2 Organisation

To achieve and preserve coherence between the different actions performed as part of the projects, a programmatic approach was chosen.[21] The programme objective – more effective and efficient selection of valuable archaeological remains – was one of the principles guiding the design of projects. The core of the programme was the programme team, consisting of a programme manager, six project managers and a communications officer. Regular consultations as a team and between individual team members meant plans and results could be discussed and knowledge and experiences shared. The consultations also meant that, where appropriate, a joint approach could be taken to matters affecting more than one project. For example, a new archaeological landscapes map, an overall periodisation of Dutch archaeology and grouping of archaeological site types were all designed and implemented jointly.[22] The programmatic approach was chosen in order to gain a number of advantages: 1. to raise the quality of the products thanks to the rapid organised sharing of knowledge and experiences, on matters both of substance and of organisation; 2. to promote collaboration and enhance the efficiency of project implementation; 3. to make working on the project a pleasant experience, thanks to the formal and informal sharing of ideas and

21 Wijnen & Van der Tak 2002.
22 Groenewoudt & Smit 2017: this volume 2.2; Rensink & Van Doesburg 2017: this volume 2.3; Rensink *et al.* 2017a: this volume 2.4.

experiences. Projects were set up on the basis of the project-driven creation principle.[23]
In the definition phase of the programme, the programme plan and the various project plans were discussed with a number of parties and adapted where necessary. Discussions took place both in smaller workshops and in consultations with representatives of local or provincial authorities and companies, for example, or during sessions organised as part of the programme and more general conferences and symposia. Such discussions, which continued throughout the programme and into the final phase, and requests for comments on certain elements of products regularly led to adjustments, fine-tuning and improvements to both plans and products. The aims of the programme and the various projects remained the same.

The actions forming part of the projects were performed by staff of the Agency itself, or contracted out to external parties, or a combination of the two. To pool as much expertise as possible, staff from different departments at the Agency were brought together. External commissions were awarded to archaeological consultancies, universities, other research institutions, a research unit at a local authority, the National Museum of Antiquities, and a national farmers' organisation. Regular reports on progress, the results achieved and the programme finances were submitted to the management of the Cultural Heritage Agency and the Cultural Heritage Department of the Ministry of Education, Culture and Science throughout the programme. At the end of the programme period (2012-2016) the products were evaluated with reference to the original

[23] Bos & Harting 2006.

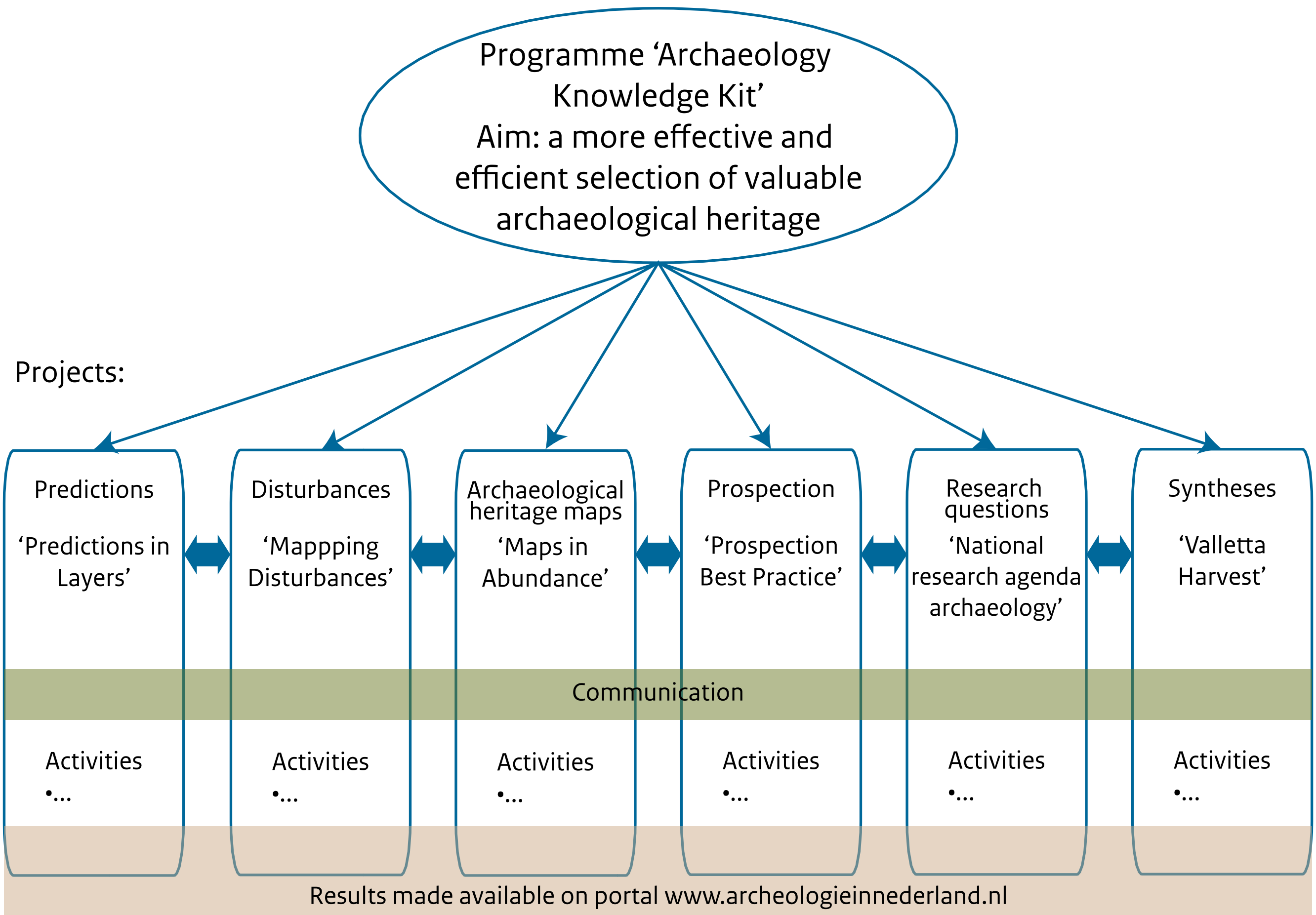

Figure 2 Organisational structure of the Archaeology Knowledge Kit programme

plans and any adjustments made. A further evaluation has been scheduled for one year after the end of the programme to assess the extent to which the products delivered by the programme are being used, and how effective they are, as the minister also undertook to monitor whether the aim of the programme – facilitating more effective and efficient selection of valuable archaeological remains – is being achieved. Since the programme will be followed up after 2016, the evaluation will also provide input for new and ongoing projects.

1.5 Results

As planned, the various projects led to a series of products. A brief impression of these products is given below. Chapters 2 to 8 examine them in further detail. The appendix 'list of products' contains an overview by way of a summary.

General[24]
A four-period system of archaeology was designed, site types were grouped into four main themes and a nationwide map of archaeologically relevant landscapes was produced for a number of applications, including 'Prospection Made-to-Measure' and 'Land Use in Layers'. As the applications were being developed, it was found that the detailed chronological classification commonly used in the Netherlands did not match the desired resolution of the applications. A rough classification into four periods was therefore defined: hunter-gatherers and early farmers (up to 3400 BC), early farming societies (3400-1500 BC), late farming societies (1500 BC-AD 900), and state societies (AD 900-1950). The classification includes some exceptions.[25]

For the same reason, the extensive list of site types used in Dutch archaeology (barrow, settlement, religious site, road etc.) was grouped into four themes: settlement (including defences), burials, economy and infrastructure, and rituals.[26]

Furthermore, it was found that a detailed nationwide archaeological landscapes map was needed as a source on which to base archaeological predictions, to use as the top layer in the Land Use in Layers application, and as an aid for determining the most appropriate prospection method(s). The Archaeological Landscapes Map distinguishes 26 landscapes, and numerous landscape zones within each of them. The zones are not only based on landscape features but also on various archaeological features, and as such they are archaeologically relevant units.[27]

Predictions[28]
As part of the Predictions in Layers project, research institute Deltares produced twelve revised palaeogeographical maps of the Netherlands at different points in the past (from 9000 BC), with an explanation of the methods and sources used.[29] In addition, several time depth profiles were produced.

A financial contribution to an external study enabled publication of a methodology for the production of palaeo-vegetation maps based on a combination of pollen data, soil data and topography.[30] Artist's impressions were also made of these landscapes.

Thanks to the combined efforts of research institutes TNO and Deltares and Utrecht University, three 'in-depth' archaeological landscape maps were also produced, in addition to the Archaeological Landscapes Map of the Holocene Netherlands.[31] Archaeologists from the Cultural Heritage Agency then added to the landscape units on these maps information about land use in the different periods. The maps and models were integrated into a digital application that has been made accessible for general use via the Agency's archaeology portal.[32] In addition, an attempt has been made to produce a predictive archaeological model for the urban periphery based on 16th century maps.[33]

Disturbances[34]
As part of the Mapping Disturbances project, relevant studies and other activities by third parties on the issue of disturbance of archaeological remains due to agricultural activities and excavation works was conducted. An analysis of datasets useful for the production of disturbance maps was also performed, focusing particularly on the dataset from Wageningen University and Research Centre's 'Reworked Soils' (*Vergraven Gronden*) information system. Initially, the plan was to produce a nationwide map showing the likelihood that subsurface archaeology would be disturbed.

24 Chapter 2, this volume.
25 Groenewoudt & Smit 2017: this volume 2.2.
26 Rensink & Van Doesburg 2017: this volume 2.3.
27 Rensink *et al.*2017a: this volume 2.4.
28 Chapter 3, this volume.
29 Vos & De Vries 2017: this volume 3.2; Vos 2015.
30 Van Beek *et al*. 2017: this volume 3.3.
31 Cohen *et al*. 2017: this volume 3.4.
32 Smit & Feiken 2017: this volume 3.5.
33 Bouwmeester 2017: this volume 3.6.
34 Chapter 4, this volume.

A business case drawn up by Wageningen UR showed that purchasing and processing costly map material showing historic land use and other factors on a national scale would not be an appropriate way of producing reliable maps showing the likelihood of disturbance. Another approach was therefore chosen, which involves providing a list of useful sources and methods that reveal the likelihood of disturbance at the level of individual land users.[35] Three institutions – RAAP BV (a commercial archaeology consultancy), Wageningen UR (a university) and ZLTO (a farmers' organisation) – were commissioned to develop methods, independently of each other, for producing such local disturbance maps based on these and other sources. These results have been subjected to a joint appraisal by all the parties involved, and field investigations have now started to test elements of the methods in the field.[36]

In addition, a study has been made of disturbance in built –up areas, focusing on the new neighbourhoods built in urban expansion projects since 1875.[37] Wageningen UR's Plant Research International (PPO/PRI) has identified and described potentially disruptive current and historical farming techniques.[38]

Archaeological heritage maps[39]

In 2014 1477 archaeological maps (value, predictive and policy maps and cultural heritage maps) were gathered from 390 local authorities in the Netherlands and georeferenced. In addition, 559 underlying documents were collected. To provide better access to this information, the maps were made accessible online via links on a map of the Netherlands. A cartographic representation was also produced showing the types of maps published by the different local authorities. Finally, the maps were analysed in terms of their quality, quantity and graphic representation. This analysis was published and made available via the Agency's portal. To round off the project, the results of the analysis will be discussed with the field, in order to produce joint recommendations for new and updated local authority maps in the future.

Prospection[40]

For Prospection Best Practice, a conceptual framework for the terminology used in prospection was defined, and an inventory survey of existing methods and techniques produced. A summary of prospection characteristics of archaeological sites was produced and cross-referenced with the general classification into four periods and four themes mentioned above. A user-friendly digital application was designed which recommends a suitable prospection method based on the archaeology likely to be present and the local circumstances. The application also refers to guidelines and best practice in the form of reports on such studies produced by companies. This application, known as 'Prospection Made-to-Measure', has been made accessible via the Agency's archaeology portal.

Research questions[41]

A new compact national archaeological research agenda focused exclusively on national and international research questions was made accessible via the Agency's archaeology portal on 1 April 2016. For this purpose, a conceptual framework for research themes was defined and a modular digital infrastructure designed, built and tested. The 1500 research questions from the old national archaeological research agenda from 2006 were divided into modules and 'slimmed down'. The draft questions were discussed with archaeologists at universities, authorities and commercial agencies and restructured into approx. 150 questions of relevance at national and international level for defining the image of the Netherlands' history. Over a hundred professional archaeologists from inside and outside the RCE contributed to the final result.

Syntheses to close the archaeological heritage management cycle[42]

Based on the concept of 'knowledge opportunities' – situations in which 'piles' of informative reports on development-led research match one or more 'national' geographical, chronological or thematic gaps in the knowledge featured in the national research agenda – twelve synthesis projects were selected and defined, and then contracted out to external parties. The basis for this exercise was an analysis of the archaeological knowledge acquired in the Netherlands over the period 2007-2014. Some of the syntheses have since been published as monographs. Besides providing new knowledge about the past, the syntheses also serve as input for new questions

35 De Vries & Maas 2017: this volume 4.3.
36 Lascaris & Huisman 2017: this volume 4.4.
37 Bouwmeester, Abrahamse & Blom 2017: this volume 4.5.
38 Van Reuler 2017: this volume 4.2.
39 Van Doesburg *et al.* 2017: this volume chapter 5.
40 Rensink *et al.* 2017b: this volume chapter 6.
41 Groenewoudt *et al.* 2017: this volume chapter 7.
42 Eerden *et al.* 2017: this volume chapter 8.

for the archaeological research agenda. Working with these reports as part of a synthesising study also yielded various recommendations for improvements to excavation practice and reporting. These experiences will be shared with the field in presentations and publications.

This project also involved making the results of the synthesising studies available to the public. Since there was no online overview of the archaeology of the Netherlands for the public, the possibility of creating such an overview and incorporating the individual results was explored. As a result the National Museum of Antiquities was commissioned to create a website providing information about the most characteristic subjects in the archaeology of the Netherlands via interactive maps.

Portal and communication

To be able to serve the fairly heterogeneous target audience of archaeology and archaeological heritage management in as focused a manner as possible, the Agency has set up a knowledge portal: www.archeologieInNederland.nl or www.archaeologieInNL.nl (Archaeology in the Netherlands). The portal gives access to most of the products resulting from the Archaeology Knowledge Kit programme, and also to maps, guidelines etc. developed for this group in other contexts.

Although communication is a means of obtaining feedback on plans, interim products and end products from potential users of the products, and of bringing them to users' attention, we also regard communication as a result, a product, of the programme. Dozens of presentations, workshops, conference sessions and the like have been organised, and we have contributed to events organised by others. A series of newsletters has been published containing items about the activities of the programme, and papers have been published in journals intended for the heritage sector, and for fellow research and development professionals.

1.6 Conclusions and follow-up

At the time of publication, the various products we planned in 2012 to facilitate effective and efficient selection of valuable archaeological remains have been delivered and made available to the archaeological field. During the research and development process some aims were achieved more or less as envisaged, such as the national research agenda, the 'Prospection Made-to-Measure' application and the syntheses based on excavation reports. Other products eventually took a different form from that envisaged at the outset, though they fulfil the same aims. This applies to the disturbances and predictions applications, and the accessibility of local authority archaeological maps. The programme has also yielded some 'by-products' that were not initially planned, such as the archaeological landscapes map and the simplified general classification of archaeological periods. These were necessary in order to deliver other products, but have also proved very useful in themselves. Other spin-offs include studies or developments by third parties related to the subjects of the projects which were realised thanks to financial contributions from the programme. Examples include the revised palaeogeographical maps and the vegetation reconstructions based on pollen data. By producing syntheses and serving the public, neither of which is stipulated in the legislation, we have helped close the archaeological heritage management cycle. In terms of output, therefore, the programme may be regarded as a success.

However, what is more important is whether the products are used, whether they are regarded as useful, and above all whether they facilitate the most effective and efficient possible selection of valuable archaeological remains in the process of archaeological heritage management. Initial reactions have been positive, but an evaluation a year on should provide more information, so that products can be further improved and adapted to the way they are used and to the users. The results to date and the experience gained during the implementation of the projects have now led to a follow-up which will further develop and raise the profile of various products, and put into action new plans in line with the programme's objectives.

The organisational form – a coherent programme within which there is collaboration between projects that clearly have some overlap – appears to have been successful. This has been enhanced by the fact that the projects were staffed by people from different parts of the organisation: researchers, advisers and communications officers. This produces better exchange and input of knowledge and information, enabling more effective working and undoubtedly raising quality. It is also a very pleasant way to work.

The delivery of the results does not mean we are done with the programme. In March 2014, for example, a symposium of the European Archaeological Council (EAC) took place in Amersfoort. The central aim of the symposium was to set out a strategic agenda to meet the current challenges facing archaeological heritage management in Europe.[43] This agenda which builds on the Valletta Convention and the Faro Convention,[44] is based on three themes: embedding archaeology in society, dare to choose, and managing the sources of European history. One of the challenges in the follow-up to the Archaeology Knowledge Kit programme will be to contribute to the further development of these themes.

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43 Schut, Scharff & De Wit 2015.
44 Council of Europe 2005.

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2 Periods, assemblage types and the Archaeological Landscapes Map

2.1 Introduction

This chapter contains papers on a simplified period system for Dutch archaeology, on the grouping of assemblage types into main themes, and on the new Archaeological Landscapes Map of the Netherlands. These three products of the Archaeology Knowledge Kit programme were needed for the online applications for prediction (Land Use in Layers) and prospection (Prospection Made-to-Measure) discussed in chapters 3 and 5, but they are also suitable for other uses.

The first part of this chapter (2.2) presents a four-period system of archaeology. This new, simplified chronological classification of the archaeology of the Netherlands is based on similarities and differences in methods of subsistence and in the way in which archaeological remains manifest themselves in the soil. The four combined periods are: hunter-gatherers and early farmers, early farming societies, late farming societies and state societies.

The second part (2.3) describes how the many assemblage types used in Dutch archaeology have been grouped into four main themes: settlement, burial, economy and infrastructure, and ritual practices.

The new Archaeological Landscapes Map of the Netherlands is the subject of the final contribution in this chapter (2.4). The map distinguishes archaeologically relevant landscape units. At the largest scale, 26 landscapes have been distinguished. The zoning is based not only on landscape features, but also on different archaeological characteristics.

2.2 Four-period system of archaeology

B.J. Groenewoudt[1] *and B.I. Smit*

Abstract

A new, simplified chronological classification of archaeological periods has been made for the Netherlands. This classification is based on differences in subsistence methods, and on the way archaeological remains are manifested in the soil (archaeological characteristics). A classification of this kind was needed for archaeological heritage management purposes. Every classification has its limitations, of course. Exceptions have been made in specific cases where it was not possible to place certain phenomena in mutually exclusive categories.

Keywords: chronology, periodisation, archaeological characteristic, archaeological heritage management.

2.2.1 Introduction

Like other countries in Europe, the Netherlands has divided its past into certain periods. Beginning with the Stone Age, we progress through the Bronze Age, Iron Age, Roman period and Middle Ages, and eventually arrive in the Modern period.[2] The oldest archaeological remains ever excavated in the Netherlands, in the Belvedere quarry near Maastricht, are approx. 250,000 years old.[3] Despite its small size, chronological and cultural variations exist at a very detailed level in the Netherlands. One notable difference is that between the part of the Netherlands to the south of the Rhine, which was part of the Roman Empire, and the part to the north of the river, which was not. There was regional differentiation in prehistory, too (Fig. 1). The classification into periods and the associated terminology also differ in some cases from those used in neighbouring countries.[4] Figure 2 shows an example of this.

Such specific period classifications are not always entirely effective for archaeological applications. Every archaeologist knows how difficult it can be to attribute a find – whether it be a flint artefact, a potsherd or a metal spearhead – to a specific period. This is generally only possible after excavation and thorough analysis of the material culture, plus radiometric or dendrochronological dating. In archaeological heritage management, however, a detailed chronological framework is not always useful when it comes to things like comparing the value of sites or tracing archaeological remains. During the initial phases of prospective research only a handful of finds is generally available, and usually no radiometric or dendrochronological dating will have been performed yet. The focus of Dutch

1 Corresponding author: b.groenewoudt@cultureelerfgoed.nl.
2 Louwe Kooijmans *et al.* 2005; Brandt *et al.* 2002.
3 Roebroeks *et al.* 1993.
4 Arnoldussen & Fokkens 2008.

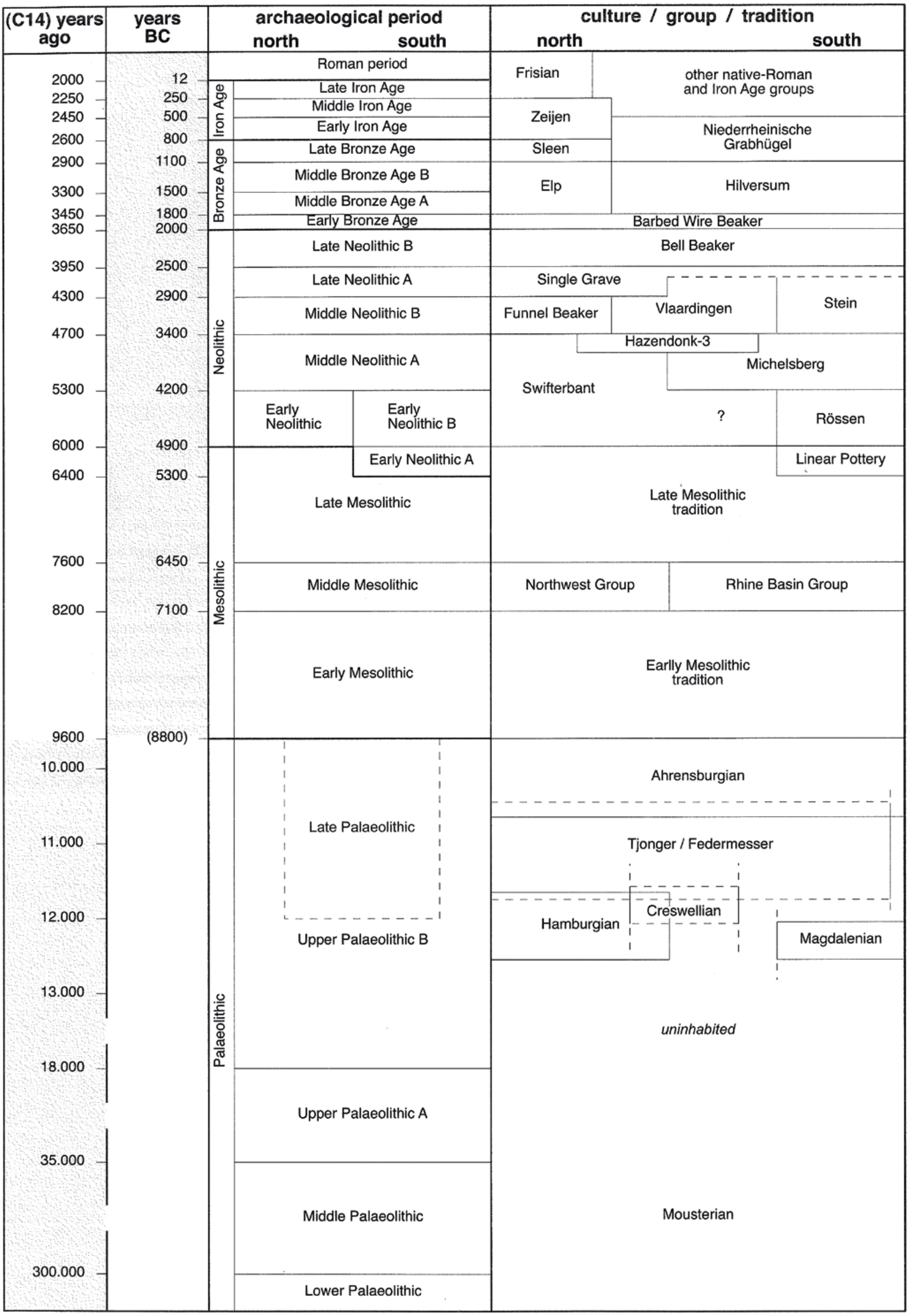

Figure 1 Chronological and cultural variations between the northern and southern parts of the Netherlands (after Louwe Kooijmans et al. 2005 Fig. 1.10).

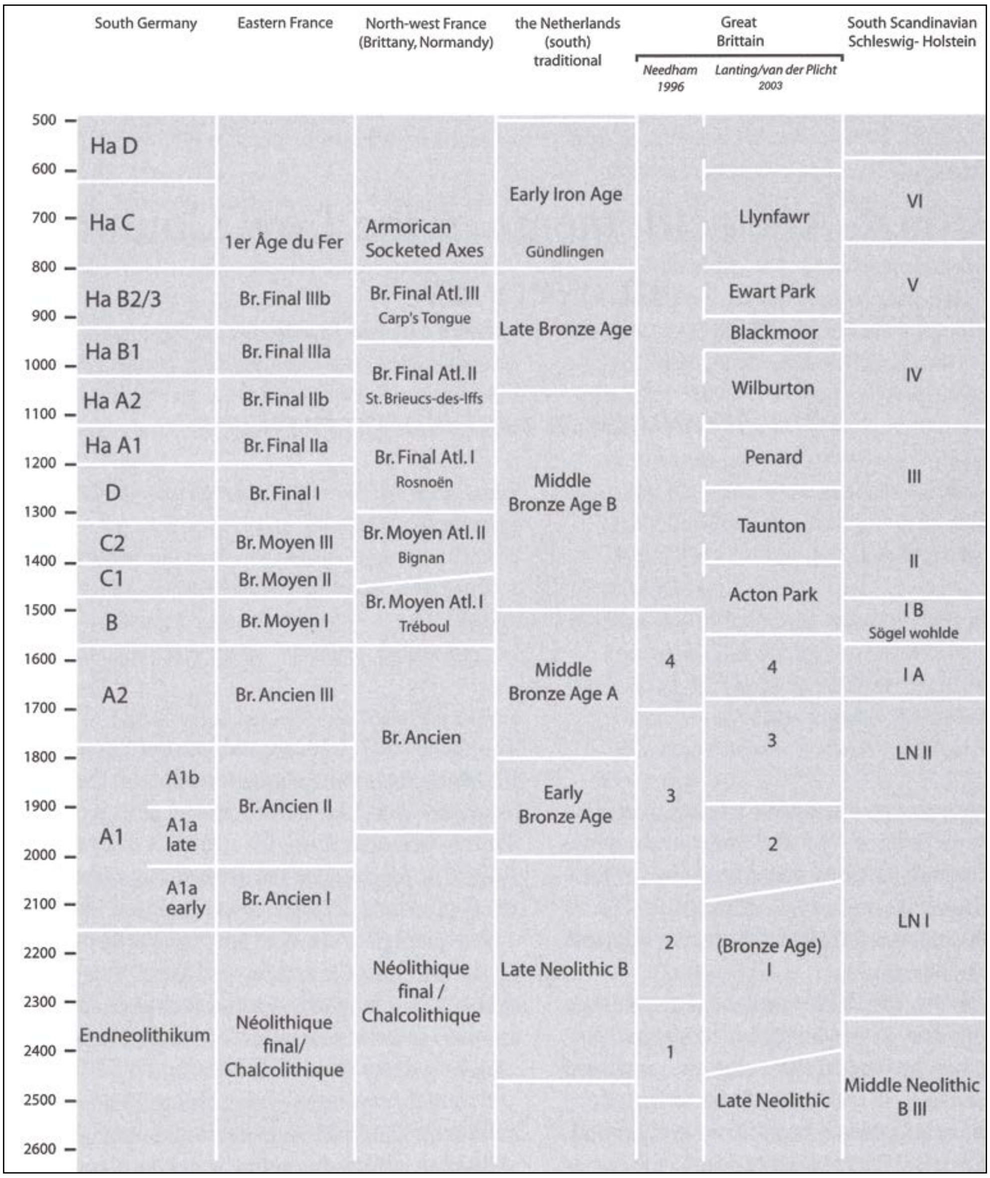

Figure 2 Chronological phases during the Late Neolithic and Early Iron Age in the Netherlands and surrounding areas (after Arnoldussen & Fokkens 2008 Fig. 2.1).

heritage management, furthermore, is to preserve archaeological sites *in situ*. As a result, as little as possible is investigated and there is not always enough find material to establish a date.

To address the above problems, a simplified classification into four periods has been produced, as described in this chapter. These phases provide a workable classification of the whole of prehistory, up to and including the recent period.

2.2.2 Method

This simplification takes account both of differences in subsistence methods and of essential differences in archaeological characteristics (prospection characteristics).

In the subsurface archaeology of the Netherlands there is a clearly visible difference between the archaeological remains of mobile hunter-gatherers and sedentary farming societies. The former are characterised in archaeological terms by the presence of artefact scatters and the almost total absence of archaeological features. From the moment that farming societies emerged, sites with archaeological features become more common. The intensity of features and structural elements (such as ditches, walls etc.) grows as the history of the Netherlands progresses. In a simplification process, there will always be elements that do not precisely fit the new classification. The exceptions in each phase have been described. One example is the Neolithic Linear Bandkeramik culture that appears for the first time around 5300 BC in the loess region of South Limburg, at the southernmost tip of the Netherlands. These agrarian communities clearly have different archaeological characteristics than the communities of mobile hunters and gatherers who at that point, and until well into the fifth millennium BC, occur in the other parts of the Netherlands. In terms of archaeological characteristics, these early farming communities are therefore a better fit with the period of early farming societies (period II; see 2.2.3), even though on the basis of absolute chronology they belong in the preceding period. The main dividing lines concur with the archaeological periodisation produced by Brandt *et al*. and Louwe Kooijmans *et al*.[5]

2.2.3 Four-period system of archaeology

The result of the simplification exercise is presented below (Table 1). The chronological timescale, method of subsistence, archaeological characteristics and any exceptions are described for each individual period.

I Hunter-gatherers and early farmers
Period: Palaeolithic to Middle Neolithic A (3400 BC).

Method of subsistence: this period is characterised by communities that specialised in the seasonal exploitation of natural food sources. It ranges from hunters/fishers and gatherers to communities that supplemented their livelihood using domesticated species (of plants and animals), known as an 'extended broad spectrum economy'. These communities were initially highly mobile (their movements determined largely by the seasonal availability and nature of their food sources); mobility declined towards the end of this period.

Archaeological characteristics: small to large find scatters (palimpsests) of mainly stone and flint and, to a much lesser extent, carbonised animal bone. Pottery appears at the end of the period. Archaeological features (particularly pits) are rare or difficult to identify, with the exception of hearth pits. Burials are few, and cremations even rarer.

II Early farming societies
Period: Middle Neolithic B (3400 BC) to Middle Bronze Age A (1500 BC).

Method of subsistence: this period is characterised by farming communities with a largely sedentary existence and farming on a small scale. Settlements were moved periodically.

Archaeological characteristics: settlement remains from this period typically include find scatters (often with great time depth). Pottery assumes a major role in the find spectrum. Flint still dominates the lithic find material, stone axes and early metal objects (bronze, gold). Archaeological features, including from buildings, are rare (or poorly visible). During this period, funerary customs become more visible in the archaeological record: dolmens (*hunebedden*), stone coffins, barrows and flat graves.

Exception: The Linear Bandkeramik (LKB) culture, which is limited to South Limburg, is included in this period because its archaeological characteristics are more consistent with period II than with period I.

III Late farming societies (with Roman intermezzo south of *limes*)
Period: Middle Bronze Age B (1500 BC) to Early Middle Ages C (AD 900).

Method of subsistence: fully developed and intensified agrarian way of life, with more fixed settlements, robust farms and extensive 'structured', parcelled out field complexes. 'Familiar Landscapes' emerge in this period.[6] In short, large parts of the landscape were structured by these communities. During this period, different forms of small industry and trade developed, and communities were no longer fully self-sufficient. Development of settlements focused on trade and handicrafts.

[5] Brandt *et al*. 1992; Louwe Kooijmans *et al*. 2005.
[6] Arnoldussen & Fontijn 2006.

Table 1 Relationship between the four-period system and the chronological classification of Dutch archaeology (after Brandt *et al.* 1992).

Timescale	Period	Four period system
After 1850	modern period	State societies
1650-1850	early modern period B	
1500-1650	early modern period A	
1250-1500	late middle ages B	
1050-1250	late middle ages A	
900-1050	early middle ages D	
725-900	early middle ages C	Late farming societies
525-725	early middle ages B	
450-525	early middle ages A	
350-450	late Roman age B	
270-350	late Roman age A	
150-270	middle Roman period B	
70-150	middle Roman period A	
25-70	early Roman period B	
12 BC- AD 25	early Roman period A	
250-12 BC	late iron age	
500-250 BC	middle iron age	
800-500 BC	early iron age	
1100-800 BC	late bronze age	
1500-1100 BC	middle bronze age B	
1800-1500 BC	middle bronze age A	Early farming societies
2000-1800 BC	early bronze age	
2450-2000 BC	late neolithic B	
2850-2450 BC	late neolithic A	
3400-2850 BC	middle neolithic B	
4200-3400 BC	middle neolithic A	Hunter-gatherers and early farmers
4900-4200 BC	early neolithic B	
5300-4900 BC	early neolithic A	
6450-4900 BC	late mesolithic	
7100-6450 BC	middle mesolithic	
8800-7100 BC	early mesolithic	
18000-8800 BC	late palaeolithic B	
35000-18000 BC	late palaeolithic A	
300000-35000 BC	middle palaeolithic	
Before 300000 BC	early palaeolithic	

During the course of this period, centrally controlled regional or supraregional authorities emerged (Roman Empire/Frankish Empire in the Early Middle Ages). Certain degree of social differentiation (emergence of local identities) and specific forms of acculturation (Romanisation, adoption of Frankish customs) and eventual Christianisation.

Archaeological characteristics: settlements are characterised by remains of houses (some stone-built), animal stalls, auxiliary buildings, workshops, wells etc., and are rich in finds and archaeological features. Finds are often concentrated in pits (waste pits). Thrown pottery starts to emerge alongside hand-formed pottery. Pottery from this period is often harder (more resistant) than earlier pottery. Metal objects become increasingly common. Infrastructure, both local and regional, becomes visible in the form of stone structures (some monumental) such as bridges, roads, canals etc. Funerary practices become more visible in archaeological terms: barrows, flat graves, urnfields, cemeteries and reuse of older burial sites. Some monumental burials. Also religious sites like temples, early churches, chapels and monasteries.

Exception: The Roman period has been included in period III, though it can be regarded as a state society. In this case, the absolute chronology has been adhered to. The Roman period in the Netherlands, including the Roman administration, actually only affected to the parts of the Netherlands to the south of the Rhine. It is also a relatively short period.

IV State societies

Period: Early Middle Ages D (AD 900) to modern period (1950).

Method of subsistence: rapid expansion of inhabited areas, large-scale organised land reclamation. Settlements and property boundaries become fixed. Domanial system until the 13th century, after which a market economy emerges. Further increase in social differentiation and formation of elites. Rise of market economy leads to specialisation (agrarian, crafts, small industry etc.), population growth leads to intensification and increased production. Rural settlements develop into villages from the Late Middle Ages. Large complex settlements emerge that function as centres (towns). Specialised trading settlements along rivers. Population growth and specialisation lead to dependence. Economy based on large-scale extraction of gravel, sand, clay and peat. Domestic and international trade by land, rivers and sea. Various types of state formation: counties, provincial territories.

Archaeological characteristics: remains from this period are characterised by dense archaeological feature clusters and stone buildings. Progression from wood construction to stone construction, much earlier in urban areas than in the countryside. After 1300 timber framed buildings become almost invisible in archaeological terms. Heightening layers and waste layers occur in urban areas. The entire range of material culture (from cottage industry to large-scale industry) is present; pottery, ceramics, glass, metals, stone etc. Progressive Christianisation: monasteries, churches, chapels, graveyards etc. Burials without grave gifts. Elites: ‘moated sites’, including castles, later country houses and stately homes. Specialised crafts, incl. mills, potteries, breweries etc. Territoriality and conflict, including land defences, fortifications, battlefields.

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2.3 Grouping archaeological assemblage types by main theme

E. Rensink[7] and J. van Doesburg

Abstract
The nine groups of assemblage types in the Dutch Basic Archaeological Register (ABR) have been further grouped into four main themes. Five of the groups have been incorporated into the main theme of 'economy and infrastructure', and two into 'ritual practices'. 'Habitation (including defence)' and 'burial' were retained and adopted as main themes. The new main themes constitute appropriate units for determining the prospection characteristics of find spots, and for describing land use models. They have been used in the Prospection Best Practice and Predictions in Layers projects.

Keywords: assemblage types, main themes, prospection characteristics, archaeological heritage management

2.3.1 Introduction

The Basic Archaeological Register (ABR) plays an important role in Dutch archaeology.[8] It defines, describes and explains the most commonly used archaeological terms. Each term also has a unique code. The ABR is thus a frame of reference that archaeologists in the Netherlands use to describe investigations, finds and features. The terms are also presented in the form of a thesaurus.

The ABR distinguishes over 120 different assemblage types, categorised into nine overarching groups or themes.[9] Examples of themes include habitation, burial, infrastructure, agrarian production and food supply, shipping and cultus sanctuary. Camp, dwelling mound (*terp*) and castle (included in habitation) and bog trackway, bridge, dike and harbour (included in infrastructure) are examples of assemblage types.

The assemblage types in the ABR had to be grouped into four rather than nine main themes for the Prospection Best Practice and Predictions in Layers projects. The resulting main themes are: habitation (including defence), burial, economy and infrastructure, and ritual practices. This simplification was performed in order to facilitate analysis at national level, making it clearer and more effective.[10] In the Prospection Best Practice project the main themes were used to determine the prospection characteristics (type of indicators) of assemblage types and groups of assemblage types.[11] The main themes were used in the Predictions in Layers project to devise land use models for different time slices.

This chapter briefly describes how the groups were formed. The main themes provide a workable classification extending from early prehistory to the end of the Modern Period.[12]

2.3.2 Method

Groups (or themes) from the ABR were categorised into main themes (Fig. 1). Five groups distinguished in the ABR (agrarian production and food supply, raw material extraction, industry, shipping and infrastructure) were combined to form the main theme of 'economy and infrastructure'. The groups cultus sanctuary and hoard were incorporated into the ritual practices theme. No further grouping was required for habitation (including defence) and burial, both of which are main themes in the new classification.

2.3.3 Grouping assemblage types

The result of this simplification exercise is presented below. The assemblage types from the ABR grouped in each main theme and each main period (in accordance with the archaeological four-period system) are listed.

I Habitation (including defence)
None of the groups of assemblage types in the ABR were further grouped to form this main theme. In other words, the main theme 'habitation' is the same as the 'habitation' theme in the register. The associated assemblage types for each main archaeological period are:
- Hunter-gatherers and early farmers: two assemblage types (camp and habitation, indeterminate) have been distinguished;

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7 Corresponding author: e.rensink@cultureelerfgoed.nl.
8 Brandt et al. 1992.
9 De Wit & Sloos 2008.
10 Rensink & Van Doesburg 2015.
11 Rensink *et al.* 2016.
12 See Groenewoudt & Smit 2014; 2017: this volume 2.2 for the archaeological four-period system used.

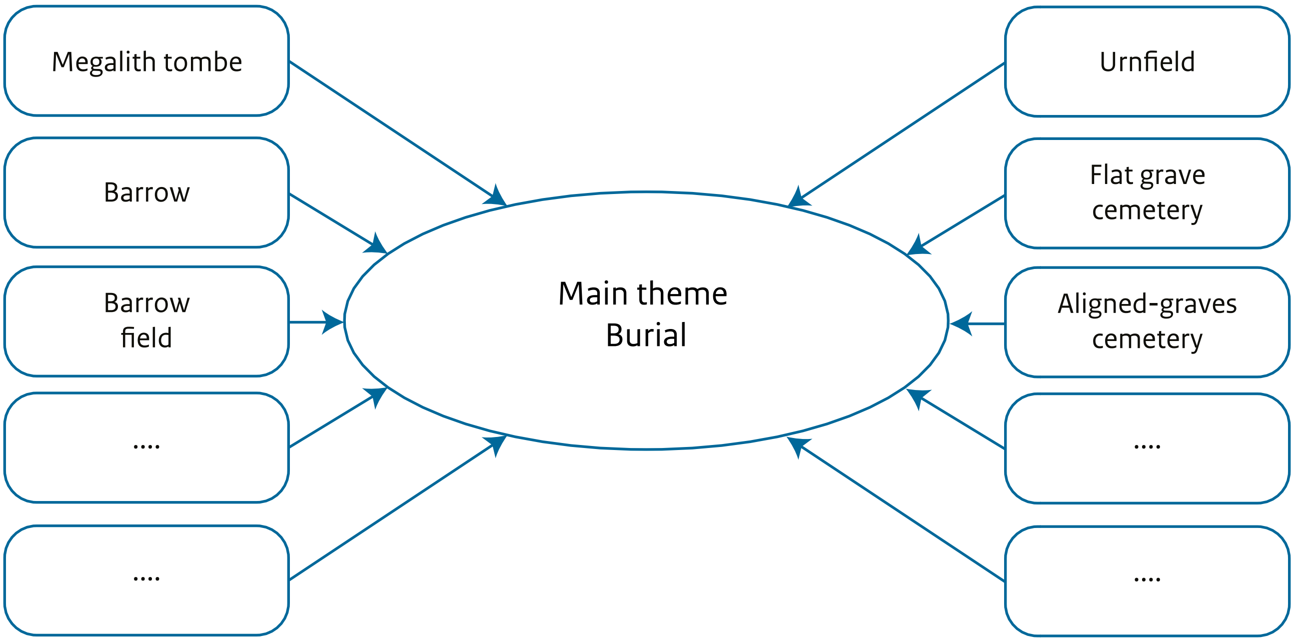

Figure 1 Example of the grouping of ABR themes into main themes (burial).

- Early farming societies: in addition to camp and habitation (indeterminate), the group includes the assemblage types earthwork enclosure, individual farmstead (not raised) and rural settlement (not raised);
- Late farming societies: assemblage types deemed typical of the Roman period are *castrum, castellum, burgus, vicus, villa* and *thermae*. Other new assemblage types in this main period are: ring fortress, battlefield, house terp/dwelling mound, terp and settlement with urban character;
- State societies: the following assemblage types have been distinguished in addition to assemblage types from the preceding main periods: motte-and-bailey castle, castle, moated site, fort, sconce, bastion, *landweer* (defensive line) and trench.

II Burial

As in the theme of 'habitation', none of the groups of assemblage types in the ABR were further grouped to form the main theme of 'burial'. The associated assemblage types for each main archaeological period are:

- Hunter-gatherers and early farmers: assemblage types burial (indeterminate), flat grave and animal burial;
- Early farming societies: in addition to burial (indeterminate), flat grave and animal burial, megalithic grave, barrow or burial mound, barrowfield and flat grave cemetery have also been included in the burial category;
- Late farming societies: in addition to the above assemblage types, the following have also been distinguished: cinerary barrowfield, urnfield, cemetery with aligned graves (row grave field), churchyard and Christian/Jewish cemetery;
- State societies: one assemblage type – execution site/gallows hill – has been added to those in the preceding three main periods.

III Economy and infrastructure

The main theme of 'economy and infrastructure' encompasses five groups from the ABR: agrarian production and food supply, raw material extraction, industry, shipping and infrastructure. The assemblage types in this main theme for each main archaeological period are:

- Hunter-gatherers and early farmers: assemblage types belonging to the agrarian production and food supply group are fishing weir and agrarian production and food supply (indeterminate). Flint mining comes under raw material extraction, and flint knapping falls in the industry category. Various types of simple wooden vessels are counted as shipping, and fords and roads represent infrastructure in this period;

- Early farming societies: the number of assemblage types is significantly greater in this period than in the hunter-gather and early farmers period. Field, corral/sheepfold, watering place and agrarian production and food supply (indeterminate) comprise the agrarian production and food supply group. There are also more assemblage types associated with raw material extraction, including clay extraction, flint mining and sand mining. Industry in this period also comprises metalworking (non-ferrous), pottery workshop and flint knapping. As in the previous period, shipping encompasses various types of simple vessel. Assemblage types now occurring in the infrastructure group include drainage channel/inundation channel/ channel/ditch, bog trackway and bridge;
- Late farming societies: in this period the agrarian production and food supply group includes two new assemblage types: Celtic field and garden/vegetable garden. The raw material extraction group comprises gravel extraction, limestone or marl quarrying, iron ore extraction and peat extraction(including saline peat for salt production), and the industry group covers glass production, lime kiln, metalworking (ferrous), pottery workshop, salt production and charcoal burning. The following assemblage types occur in the infrastructure group: canal, harbour, quay/wharf, floodgate, culvert/ drainpipe, dike, breakwater, anchorage and shipyard/slipway;
- State societies: assemblage types from the preceding periods also occur in the state societies period. This period also features several new assemblage types, such as duck decoy (agrarian production and food supply), timber production (raw material extraction), brewery, windmill, watermill (industry), vessels with iron hulls and iron frames (shipping) and lock and dock (infrastructure).

IV Ritual practices

Cultus sanctuary and hoard from the ABR have been combined to form the main theme ‘ritual practices’. The associated assemblage types for each main archaeological period are:

- Hunter-gatherers and early farmers: single hoard and multiple hoard;
- Early farming societies: assemblage types additional to single and multiple hoards are open-air cult site and cultus sanctuary (indeterminate);
- Late farming societies: new assemblage types in the cultus sanctuary group are temple, church, chapel and monastery;
- State societies: this period includes one new assemblage type relative to the previous main period: synagogue/mikveh.

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2.4 The Archaeological Landscapes Map of the Netherlands. A new map for inventory and analysis at the archaeology-landscape interface

E. Rensink[13], H.J.T. Weerts, M. Kosian, H. Feiken and B.I. Smit

Abstract

The Cultural Heritage Agency of the Netherlands (RCE) has produced a new map: the Archaeological Landscapes Map of the Netherlands. It features 26 landscapes encompassing 39 landscape zones. These new units have been defined on the basis of physical geographical and archaeological features. As such, the map is suitable as a basis for national inventories and analyses involving archaeology and landscape, focusing for example on the prospection characteristics of find spots in specific landscapes and landscape zones. The map can also be used as a basis for archaeological desk-based assessment for the purpose of producing more detailed maps on a provincial and municipal scale, for example. This will require the addition of regional and local sources and maps.

Keywords: archaeological landscapes map, landscapes, landscape zones, physical geographical, archaeological, the Netherlands

2.4.1 Introduction

The Cultural Heritage Agency of the Netherlands (RCE) published the Archaeology Review in 2002.[14] It distinguished 17 archaeological regions (or 'archaeoregions') based on differences in landscape features and occupation history. During preparations for the projects in the Archaeology Knowledge Kit programme, it became clear that archaeoregions are relatively large geographical units and that there is a large degree of variation within each region in terms of landscape and archaeology. The archaeoregions would therefore have to be refined for two digital applications being developed in the programme – 'Prospection Made-to-Measure' as part of the Prospection Best Practice project, and 'Land use in Layers' as part of the Predictions in Layers project.[15]

This coincided with an initiative under the Living Landscape programme, part of the RCE's Vision for Heritage and Spatial Planning. A start had been made on a digital landscape atlas as part of this programme in 2013.[16] One of the purposes of the atlas was to represent the abiotic landscape in the form of a new national map layer with newly defined units. It would not only reflect landscape variables such as genesis, geomorphology, hydrology and the age of the sediments found at the (sub)surface, but also the relevance of these variables (individually or collectively) from the perspective of human occupation history. This objective fit perfectly with the need for a new national map for the Archaeology Knowledge Kit programme. A national perspective was explicitly adopted for the refinement of the archaeoregions.[17] The digital version of the Geomorphological Map of the Netherlands 1:50 was therefore taken as the starting point (see 2.4.3). The product of the exercise is a new national map: the Archaeological Landscapes Map of the Netherlands, on a uniform scale. This paper considers the background to the map, the procedure and the end result.[18]

2.4.2 Relationship between landscape and humans

The Dutch landscape is highly varied. The impact of land ice, wind, water (sea, rivers, groundwater) over many thousands of years and large-scale reclamation operations (carried out by humans) has slowly but surely given the landscape its current form. Wherever you are in the Netherlands, the landscape shows clear signs of its genesis: the ice-pushed ridges of the central Netherlands (caused by land ice in the Saalian), the coversand landscape of the eastern Netherlands (caused by the wind in the Weichselian), the river terraces beside the river Meuse (caused by incisions cut into the landscape by the river in the Late Glacial and Early Holocene), the levees and river dunes along the Rhine, the peatlands in the western Netherlands (which resulted from sea-level rise in the Holocene) and the polders of Flevoland (recently created by humans).

The variation in the landscape is also reflected in the way people used it in the past. Regional archaeological studies always stress

13 Corresponding author: e.rensink@cultureelerfgoed.nl.
14 Lauwerier & Lotte 2002.
15 Rensink *et al.* 2017: *this volume chapter 6; Smit & Feiken 2017: this volume 3.5.*
16 www.cultureelerfgoed.nl and www.landschapinnederland.nl.
17 The marine archaeoregions (Waddenzee/IJsselmeer-Markermeer, Voordelta/Zeeland current and Continental shelf) are not included in the Archaeological Landscapes Map. Rijkswaterstaat (RWS) and RCE have in a joint initiative commissioned an archaeological potential map for Continental shelf (North Sea), and data sources and toolkits are being developed as part of the Vision for Heritage and Spatial Planning. The same is being done for Waddenzee/IJsselmeer-Markermeer as part of the RCE's Maritime Programme.
18 See also Rensink *et al.* 2016b.

the importance of the natural landscape for the way people used it in prehistoric and historic times.[19] Landscape zones such as plateaus, coversand ridges and brook valleys provided opportunities for and placed constraints on settlement, burial, the economy and infrastructure, and ritual practices. The substrate, in the sense of the landscape form (geomorphology and relief), soil fertility, permeability, groundwater depth and accessibility, has always placed constraints on human activity to some extent or other. Two examples:

- The presence of high, relatively flat plateaus combined with good soil fertility and large numbers of streams and springs was the decisive factor that led the farming communities of the Linear Bandkeramik (LBK) to colonise the loess territories to the north of the Geul river in Zuid-Limburg around 5300 BC. There are considerably fewer streams and springs to the south of the river, and there are no LBK settlements there.
- The presence of rivers and other watercourses played an important role in determining the locations of defence structures and settlements, for example. The Romans chose the Rhine, a clearly recognisable natural barrier, as the frontier of their empire and built castella, watchtowers, roads etc. along it. The presence of an active river course (part of the Rhine) allowed Dorestad (now Wijk bij Duurstede) to flourish from AD 700 onwards. The silting up of the Oude Rijn and the changing course of the rivers further upstream in the delta (leading to the creation of the IJssel, for example), led to the demise of Dorestad and to the rise of the Hanseatic towns later in the Middle Ages.

Despite its significance, the natural landscape should not be seen as the 'static backdrop' to human activity in the past.[20] The relationship was more dynamic, with interaction between humans and the biotic and abiotic landscape, and changes in it, from the earliest occupation into the Early Modern period. The physical geographical landscape placed physical constraints on human activity (and indeed still does to this day), but it did not dictate it completely. As technology developed, giving humans more control over the natural landscape, the influence of these physical constraints abated. A good example of this is the creation of dwelling mounds (*terpen* and *wierden*) in the coastal region of the northern Netherlands from the Iron Age to the Middle Ages (Fig. 1). These artificial mounds allowed the inhabitants of the region to live there all year round, even at times when the sea flooded the coastal plain during spring-tides or storms. Before they were constructed, the coastal region was uninhabitable. Another example concerns the wetlands of the coastal peat area of Noord- and Zuid-Holland and the low-lying floodplains in the Rhine-Meuse delta. These areas were barely suitable for habitation for much of the Holocene. Towards the end of prehistory (Iron Age), and increasingly in the Roman period, we see the first attempts at reclaiming land and concentrations of occupation in the peatlands, in the area around Vlaardingen and in Midden-Delfland, for example. It was not until the large-scale land reclamation operations of the Middle Ages that the vast peat areas and floodplains were permanently settled and exploited, for farming and other purposes.

From the point of view of archaeological prospection, the fact that human intervention in the landscape had implications (intentional or otherwise) for the 'visibility' of relics of old landscapes and the associated archaeological remains is important. In the 'Droogmakerijen' (polders) landscape in the western Netherlands part of the Pleistocene and Early Holocene landscape 'reappeared' as a result of large-scale reclamation in the Middle Ages and the Early Modern Period. Peat formation and sedimentation due to sea-level rise had buried them and rendered them invisible for a long time. One example is the prehistoric creek systems now visible on the bed of the polders. A similar situation occurs on the Pleistocene sandy soil, where peat could form in relatively flat areas with poor drainage in the course of the Holocene. This peat was dug for fuel on a large scale from the Middle Ages onwards (reclaimed peatlands). In those areas, a Pleistocene coversand landscape now lies at the surface which, for much of the Holocene, was covered in peat. Clearly, these changes will have had major implications for the visibility of archaeological remains and features, transforming them from a subsurface in situ archaeological record to one visible at or close to the current surface.

19 See for example Groenewoudt & Ankum 1990; Deeben *et al*. 1997; Deeben, Hallewas & Maarleveld 2002; Van Beek 2009; Peeters 2007; Spek 2004; Spek *et al*. 2015.
20 Peeters 2007.

Figure 1 Dwelling mound at Hogebeintum in the coastal region of the northern Netherlands.

2.4.3 Landscapes and landscape zones

Introduction

The Archaeological Landscapes Map distinguishes two levels of scale: landscapes and landscape zones. It features 26 landscapes (Fig. 2) and 39 landscape zones (Fig. 3). The combination of the two produces a detailed map on a scale of 1:50 000, with over 200 legend items.

A landscape in the Archaeological Landscapes Map is defined as an area that can be characterised by a specific landscape genesis and its own distinct occupation history, where the set of differences within the landscape is smaller than those between this and other landscapes. The landscapes were given unique names, like "Rhine-Meuse delta" or "Rur valley graben". A landscape zone is a geomorphological unit within one (or more) landscape(s). It is referred to in physical geographical/geomorphological terms: coversand ridges, salt marsh plains, brook valleys, high coastal dunes.

The digital Geomorphological Map of the Netherlands scale 1: 50 000 was the main source consulted when it came to defining the boundaries of the 26 landscapes (Fig. 4). The 39 landscape zones were distinguished on the basis of differences in geomorphological features and additional pedological, geological and historical maps. To ensure the homogeneity of the map, any more detailed digital regional or local information (e.g. scale 1:25 000 or 1:10 000) was not used, even if it was digitally available.[21] A number of landscape zones occur widely in the Netherlands, and are not therefore related to one specific landscape. The most obvious example of this is coversand ridges, which occur in 18 of the 26 landscapes.[22] Other widely distributed areas are referred to as 'built-up area' and 'water' on the Geomorphological Map of the Netherlands. Both these units were not mapped on the basis of their geomorphological characteristics in the Geomorphological Map of the Netherlands 1:50 000, and have therefore been left blank on the Archaeological Landscapes Map.

21 References to more detailed datasets are given in Rensink *et al.* 2016b.
22 See Kosian 2016, technical manual.

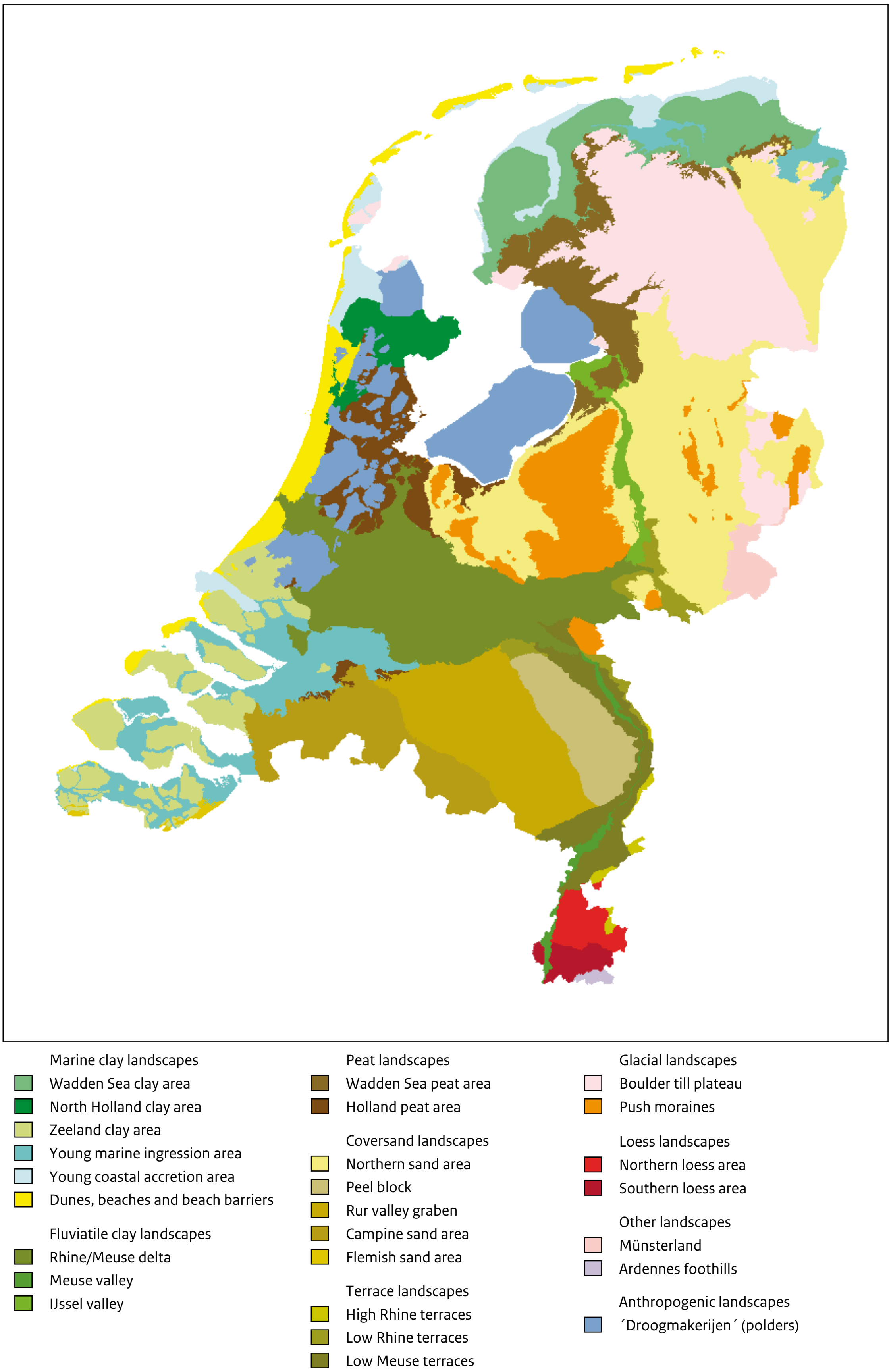

Figure 2 The Archaeological Landscapes Map of the Netherlands with the 26 newly defined landscapes.

Figure 3 The Archaeological Landscapes Map of the Netherlands with the 39 newly defined landscape zones (for legend see www.archeologieinnederland.nl).

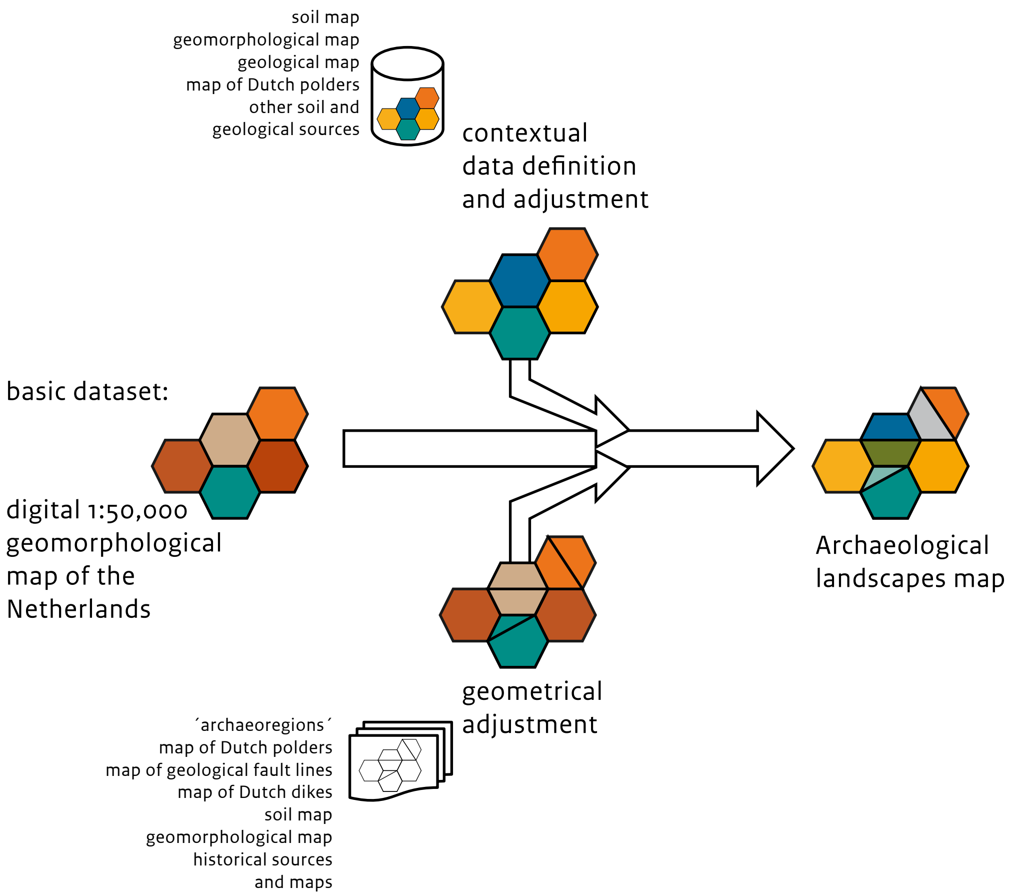

Figure 4 Flow diagram of sources used and procedure for compiling the Archaeological Landscapes Map.

Archaeological verification

The project included the archaeological verification and description of the 26 newly defined landscapes. Archaeologically important distinctive features of each individual landscape were described, initially at the level of archaeoregions. If parts of one and the same landscape occur in two or more archaeoregions, the descriptions were later combined and edited to produce a single comprehensive text. One example, the description of the Rhine-Meuse delta, is presented in section 2.4.4.

To verify the newly defined landscape zones within the landscapes, matrices were produced for four main archaeological periods[23] and four main themes within each period.[24] Scores were then assigned to the landscape zones in each landscape (Table 1). This was used as a basis for deciding whether the landscape zones on the Archaeological Landscapes Map are actually relevant units from an archaeological perspective.[25] Only landscape zones that differ in at least one of the archaeological categories were maintained within the landscapes.

23 Groenewoudt & Smit 2014; 2017: this volume 2.2.

24 Rensink & Van Doesburg 2015; 2017: this volume 2.3.

25 The predicted presence or absence of find spots was simply scored on the basis of expert judgment. No quantitative calculations were performed relating numbers or densities of find spots to the landscape zones.

Table 1 Completed matrix for activity in the late farming societies period for the Northern sandy area landscape in the Drenthe sandy area archaeoregion.*

Landscape zone	Main theme			
	Settlement	Burial	Economy and infrastructure	Ritual practices
Brook valleys	1	1	1	2
Coversand plains	1	0	1	0
Coversand ridges and river dunes	2	1	1	1
Reclamation-deformed peat lands	0	0	2	2
Coversand depressions	0	0	0	0

* Score 0 = not present/predicted; score 1 = little present/predicted; score 2 = lots present/predicted.

2.4.4 Description of landscapes

Introduction

The description of each landscape includes one or more representative map detail(s) and an explanatory text, each of which is structured as follows: 1) Landscape, 2) Boundaries, 3) Relationship to adjacent landscapes in other countries, 4) Soil, subsurface and hydrology, and 5) Archaeology. By way of illustration, the full description (with the exception of the section 'boundaries') of the Rhine-Meuse delta landscape is given below.

Landscape 14: Rhine-Meuse delta

Landscape

The Rhine-Meuse delta is the largest contiguous landscape in the Netherlands (Fig. 5). It is characterised by higher-lying alluvial ridges and crevasse ridges alternating with lower-lying floodplains (flood basins) in which large quantities of peat occur to the west of Vianen. Peat soils (*koopveengronden*) with a thin cover of floodplain clay were included in this landscape zone 'Reclamation deformed peat lands'. They have not been attributed to the Holland-Utrecht peat area because their genesis is closely related to the formation of the river deposits in this part of the delta and not to the formation of peat domes outside the delta. River dunes also occur in the Rhine-Meuse delta. The following landscape zones also occur: embanked floodplains, residual channels, dike-breach overwash fans (*overslaggronden*) , silted-up estuary (around the mouth of the Oude Rijn river at Katwijk and Leiden), coversand ridges, and coversand ridges and river dunes. The landscape is generally flat, with local relief of less than 1 m. The landscape is slightly undulating only where there are river dunes and coversand ridges, where the relief is sometimes relatively pronounced, as at Bergharen. The elevation of the landscape gradually declines downstream from approx. 14 m NAP at Lobith to 1.5 m –NAP in the peaty floodplains of the Krimpenerwaard and Alblasserwaard. Detailed landscape information is available on the embanked floodplains.[26]

Boundaries

A detailed description and explanation of the boundaries assigned to the Rhine-Meuse delta landscape is given in Rensink *et al.* (2016), as for all the other landscapes. The description includes the position of the Rhine-Meuse delta relative to the adjacent landscapes, and a list of the landscape and historical map sources used. Given its local significance, the description has not been included here.

Relationship to adjacent landscapes in other countries

This landscape extends into Germany, in a narrowing strip right through to Bonn, as the *Jung- Mittel- und Altholozän*[27] or the *Flussauen*.[28]

Soil, subsurface and hydrology

The region is characterised by the presence of river clay soils, dike-breach overwash fans and, in the west, peaty soils. They consist of fluvial deposits from the Echteld Formation, with frequent intercalations of peat from the Nieuwkoop Formation, especially in the downstream part of the delta. The thickness of these deposits increases from 1 m at the German border to approx. 15 m near Rotterdam. It lies on

26 See http://archeologieinnederland.nl/bronnen-en-kaarten/verwachtingskaart-uiterwaarden-rivierengebied, based on Cohen *et al.* 2014; *see also Berendsen & Stouthamer 2001 for descriptions of the genesis of the Rhine-Meuse delta.*
27 Klostermann 1992.
28 Gohl 1972.

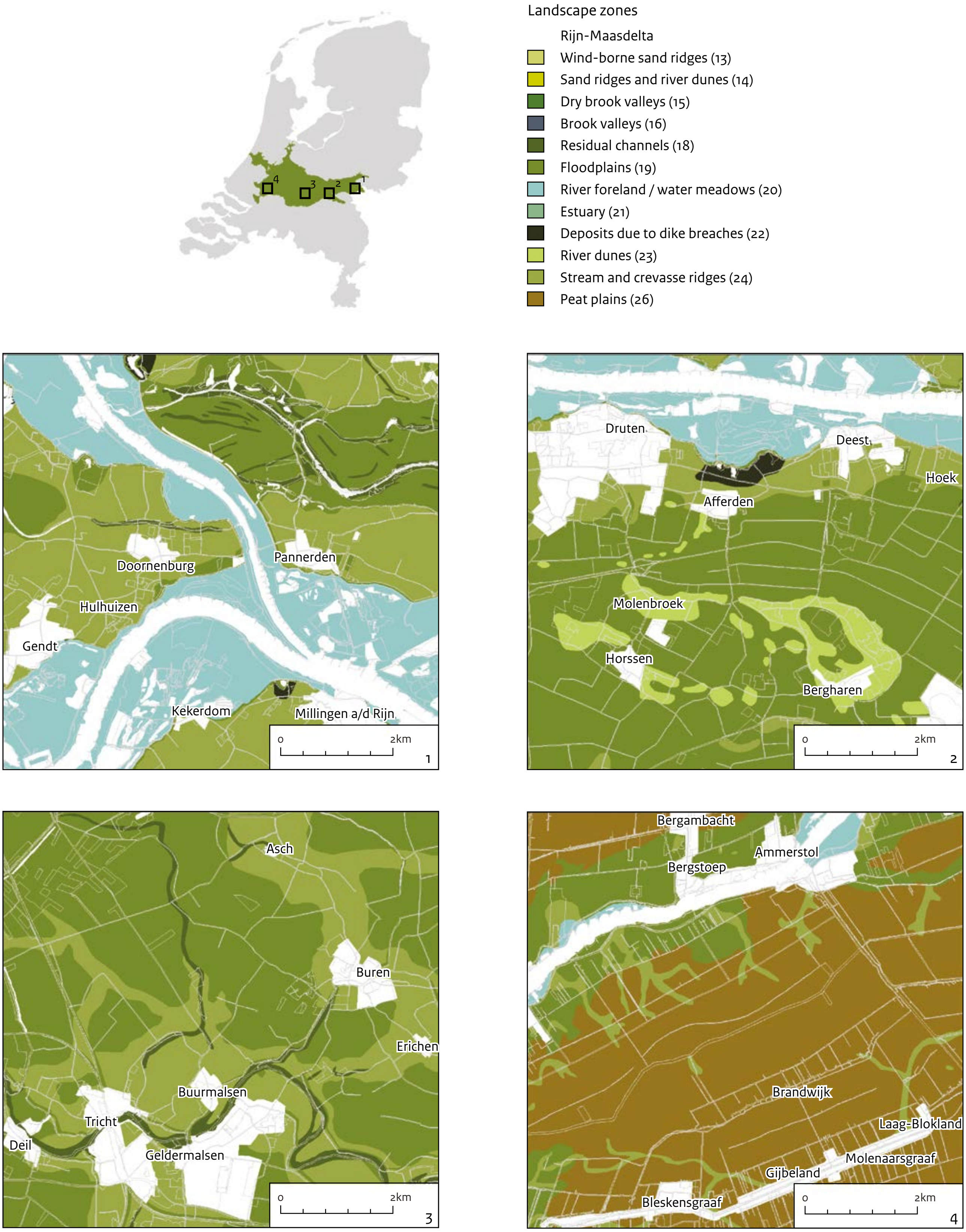

Figure 5: Rhine-Meuse delta landscape and distribution of landscape zones in four indicated areas. Between brackets: ID numbers of landscape zones (see Smit & Feiken 2017, this volume 3.5: Table 3).

5 to 30 m thick stacked fluvial sand and gravel from the Kreftenheye Formation. Aeolian river dunes from the Boxtel Formation also occur there. The region is wet to very wet, particularly on the reclamation-deformed peat lands. The water table is artificially controlled in order to allow farming. Along with the reclaimed *copes* (parcels of land) in the west, this is one of the oldest cultural landscapes in the Netherlands.

Archaeology

The archaeological remains are mainly concentrated in the Holocene (7000 BC onwards) fluvial deposits and landforms, such as alluvial ridges of the Meuse, Rhine and Waal rivers. This landscape was subject to a great deal of erosion and sedimentation as a result of the dynamics of the rivers. The risk of flooding is reflected in the number of find spots (settlements, cemeteries) in higher parts of the landscape. It was not until after the reclamations, poldering operations and dike building of the Middle Ages from the 12th century onward that the lower-lying parts could also be used.

Find spots from the Late Neolithic, Bronze Age (which are more numerous) and later periods are found mainly on alluvial ridges and crevasse ridges. They indicate that the region was used (and attractive) for occupation and farming from late prehistory onwards. There are abundant indications of how the landscape was used, mainly based on ‘off-site’ phenomena. Castella, watchtowers and infrastructure belonging to the Roman *limes* were built on the alluvial ridges of the Rhine. In the immediate hinterland, settlements developed where trade and crafts played a key role. Remains of ships indicate that the rivers were used as transport routes and the remains of temples (for instance at Empel and Elst) point to ritual activities. One Roman find spot that is close to the coast yet is still part of the Rhine-Meuse delta landscape is Katwijk. Early Medieval trading settlements also occur, foremost among them being Dorestad, now Wijk bij Duurstede. One key characteristic of the landscape is the good preservation conditions for archaeological remains (features and finds). Later, *cope* reclamations took place in the western part of the Rhine-Meuse delta. The Nieuwe Hollandse Waterlinie system of water-based defences, consisting of forts and fortified towns, runs across the region from Weesp to Gorinchem.

Distinctive features relative to adjacent landscapes:

- landscape context of archaeological find spots (Holocene river landscape);
- absence of Late Palaeolithic, Mesolithic and Neolithic find spots at the surface (characteristic of Rur valley graben landscape);
- stratified landscape, including good preservation of archaeological remains (incl. organic remains) and archaeological layers (in contrast to Push moraines landscape and Rur valley graben landscape);
- find spots that are part of the Roman *limes* (in contrast to ice-pushed ridges and Ruhr valley);
- great diversity of settlement types from Early Middle Ages onwards;
- archaeological remains associated with use of the Rhine, Meuse and Waal as a transport route (trade, exchange of goods) and as a source of food and resources such as clay for brick manufacture.

Buried landscapes: occupation traces from early prehistory (Mesolithic-Neolithic transition) have been found on river dunes covered by peat and clay. Some lie deep below the current surface in the western part of the Rhine-Meuse delta (Hardinxveld-Giessendam). There are also buried landscapes, including successive generations of alluvial ridges and crevasse ridges, and associated archaeological remains from more recent periods.

2.4.5 Use

The procedure for creating the Archaeological Landscapes Map is just one way of dividing the Netherlands into units relevant in landscape and archaeological terms. The scale of the map is 1:50 000, which means that the boundaries of the landscapes and landscape zones are meaningful only at this scale or at a smaller scale. The map is therefore primarily suitable for analysis at a national and regional scale. The map can serve as a point of departure for desktop analyses on a larger scale, such as 1:25 000 or 1:10 000, but additional, more detailed information will be needed for instance for any specified archaeological expectation to be made during desk-based assessment.

The Archaeological Landscapes Map will be improved, refined and supplemented over the coming years. An inventory, analysis and assessment of the depths, intactness and preservation of archaeological remains in relation to the pedological and hydrological properties of the defined map units will be undertaken in 2017. This information can then be translated into a separate digital map layer that may indicate the likely physical quality of the in situ archaeological record in the Netherlands. An analysis and archaeological interpretation of the maritime regions and blank areas (built-up areas) will also be launched in 2017. A projection of the position of historic town and village centres would be an important first step in the blank areas. An activity for the longer term would be the compilation of a list of the position and boundaries of areas of driftsand dunes and plaggen soils (*plaggendekken*) and their graphic representation in the form of a separate digital layer of the Archaeological Landscapes Map. Last but not least, over the coming years, efforts will be made to check and improve the boundaries of the landscape zones using additional sources, such as the Elevation Map of the Netherlands (LiDAR, version 2) and data from the Dinoloket.[29]

[29] See ahn.maps.arcgis.com and www.dinoloket.nl.

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3 Archaeological predictions in layers

3.1 Introduction

The specification of archaeological predictions – presenting arguments in support of the likely presence of archaeological remains in the soil – is an important step in archaeological heritage management in the context of spatial developments. Both national and local predictive archaeological maps are used for the purpose (see for example chapter 5 on local authority archaeological maps). These maps generally present probability categories – high, medium and low, for instance – for the presence of archaeological remains. However, they often fail to distinguish the archaeological period or the depth at which the remains might lie, despite the fact that there are considerable differences in the depth at which remains from different periods are likely to be found. In the Holocene part of the Netherlands, for example, archaeological remains from early periods can lie as deep as 15-20 m below the surface (Figs. 1 and 2). There is therefore a need for producing maps and datasets that can provide an insight into the depth of archaeological remains, preferably categorised by period. This chapter bundles five contributions that explore this issue.

The first (3.2) looks at the production of twelve landscape reconstructions of the Netherlands at different points in time over the past 10,000 years. These palaeogeographical maps are based on the analysis and interpretation of tens of thousands of borehole surveys, research into the formation and age of geological deposits in the subsurface, and archaeological information. The next part (3.3) considers vegetation maps and reconstructions, describing how such maps and reconstructions can be made for different periods in the past using pedological, palynological, and archaeological data.

Parts 3.4 and 3.5 focus most directly on producing maps showing the probability of encountering archaeological remains from certain periods at certain depths. Part 3.4 describes how maps of buried landscapes in the Holocene part of the Netherlands are generated (by a scripted workflow process) on the basis of parent maps (basemaps), that store original geological and geomorphological information.

The result of 3.4 is an overview of buried landscapes with information on the depth and an indication of the preservation of these palaeosurfaces. It is one of the building blocks used in the web-based application presented in part 3.5. This contribution goes on to explain how information is presented concerning the way humans used these landscapes, some of which are now buried and lie deep below the surface. It describes the ‘Land Use in Layers’ application, which indicates which activities were probably performed in (roughly) which period in each landscape zone, and at what depth the archaeological remains probably lie. The final part of this chapter (3.6) looks at the making of predictive archaeological models for the urban countryside in the Middle Ages on the basis of historical town maps produced by Jacob van Deventer in the second half of the 16th century.

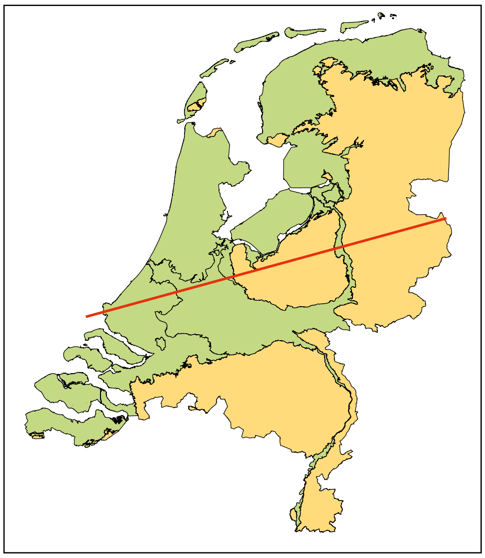

Figure 1 Map of the Netherlands showing the relatively higher Pleistocene areas and the low-lying Holocene areas. The line indicates the location of the cross-section in figure 2.

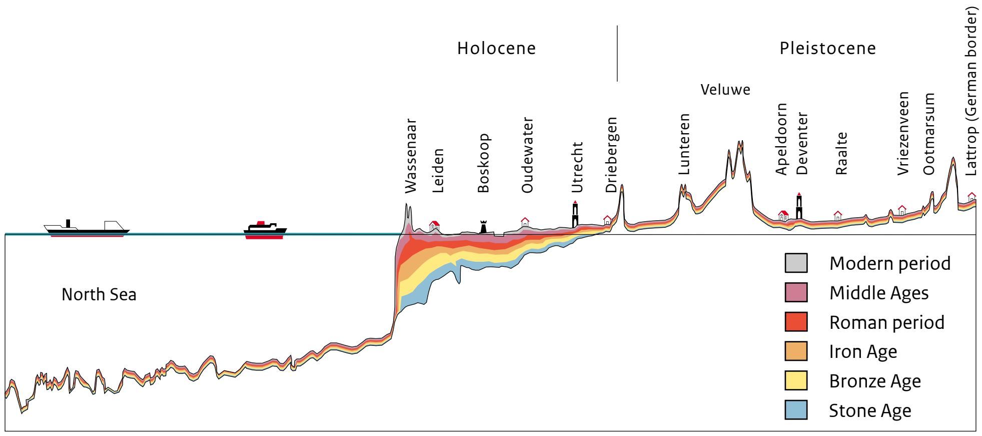

Figure 2 Schematic cross-section of the Netherlands, from the North Sea coast to the German border, indicating the depth at which remains from different periods lie.

3.2 Applied palaeolandscape research as a tool in archaeological heritage management. Modelling the Holocene coastal evolution of the Netherlands

P. Vos[1a] and S. de Vries[a]

Abstract

Palaeogeographical map reconstructions are a useful tool for providing insight into former coastal environments which were suitable for prehistoric habitation. These palaeolandscape locations are covered with younger sediment ('buried landscapes'). These hidden landscapes can be reconstructed with the help of geological, historical and archaeological data. This paper describe how such palaeogeographical maps have been compiled, what the driving mechanisms were behind coastal evolution and how the coastal landscape changed during the Holocene.

Keywords: palaeogeography, geoarchaeology, Holocene coastal evolution, archaeological heritage management, archaeological prediction and prospection surveys

3.2.1 Introduction

Knowledge of past landscapes, which are often hidden, and their development is important for an effective understanding of human behaviour in the past.[2] Given the complicated genesis of the present (and past) landscape during the Holocene, insight into this development process is vital for archaeological research and archaeological heritage management in the Netherlands. Fortunately, the Netherlands has a long tradition of making reconstructions of the palaeolandscape. Arnoldus Buchelius' (1565-1641) manuscript map of the Roman period in the Netherlands can be considered our oldest palaeogeographical map. It was compiled on the basis of landscape descriptions by Roman historians such as Tacitus and Pliny the Elder.

Palaeogeography deals with reconstructions of landscapes in the past. Regional palaeogeographical maps are a valuable tool for the prospection of our subsurface archaeological heritage ('buried landscapes'). A palaeogeographical map can be considered a predictive map for a specific archaeological period because it shows palaeolandscapes, some of which will have been suitable for human settlement and specific human activities. Archaeology ('key sites'), in turn, can supply information about the palaeoenvironment and the age of the deposits, basic information for the map reconstructions.

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2 See Vos 2015 for an extensive overview of the palaeogeography of the Netherlands and for background information on the topic of this article.

Applied palaeolandscape research provides input not only for archaeology but also for coastal management (flood protection), landscape policy, hydrogeology, and public information and education. Landscape reconstructions provide knowledge about the mechanisms that drove the evolution of coastal and river areas. Knowledge of the causes and effects of morphological changes in the past is key to understanding future changes in delta areas. Regional palaeogeographical maps (retrospective visualisations of the landscape) are used as benchmarks for decisions about future interventions in coastal and river landscapes. Palaeolandscape maps show that in the past the Dutch delta was subject to continuous change, and that there was never a fixed point of departure or baseline situation to which we should return.

3.2.2 History of palaeogeographical mapping in the Netherlands

The practice of making more detailed palaeogeographical map reconstructions of the coastal landscapes of the Netherlands developed after the Second World War when a lot of regional geological and soil science mapping programmes were carried out by government institutions and universities.[3]

The first Holocene coastal map reconstructions of the Netherlands on a regional scale (coastal area, Noord-Holland and Flevoland) were made during the 1950s and 1960s.[4] Zagwijn improved the Holocene coastal reconstructions and the ten national palaeogeographical maps in Zagwijn's book have been the standard for twenty years.[5]

In the period between 2005 and 2015 the existing palaeogeographical maps were updated and improved. The results of these activities – palaeogeographical map series and Pleistocene top maps – were published in the '*Atlas van Nederland in het Holoceen*'.[6] This publication was intended for educational purposes and for a broad audience interested in the landscape history/ landscape archaeology of the Netherlands. The Atlas describes landscape evolution and human intervention in the landscape in general terms.

Recently, the palaeogeographical maps of the Netherlands were further improved (Fig. 1) and several age profiles have been integrated and published.[7] The tidal landscape on the palaeomaps was for example differentiated into sub-, inter- and supratidal landscape units.

3.2.3 The compilation of the Holocene palaeogeographical maps

Several scientific disciplines are involved in compiling palaeolandscape maps. Geology supplies the basic information: the composition and distribution of lithological units in the subsurface (lithostratigraphical framework). In the next step of the reconstruction, the depositional environments are identified, and their age determined. Sedimentological data and proxies from geobotany (including palynology, diatoms) and palaeofauna (including molluscs) are used to determine the palaeoenvironment. Organic deposits can be dated using radiocarbon techniques (^{14}C), and sands can be dated using optically stimulated luminescence (OSL). Archaeology also provides valuable data on the age of deposits. Historical sources (texts and maps) provide indispensable information on the history of the coastal area during the past millennium. Research into the genesis of the Holocene coastal systems of the Netherlands is thus multidisciplinary and performed on different spatial and temporal scales. Insufficient data – and in some cases none at all – were available for some areas and time periods, due to subrecent erosion by fluvial or tidal channels, for example. Expert judgment and data from the surrounding area and indirect geological information from later periods and/or adjacent areas is used to fill such gaps, making palaeogeographical maps subjective to a certain degree.

The representation of a palaeolandscape on a map depends on the definitions of the landscape types (in the legend), which are related to the purpose of the map. The styling and the degree of detail on the map depend on the scale of the reconstruction and the available data.

Three categories of palaeogeographical maps have been distinguished:

- maps on a national scale (1:500 000 to 1:1 500 000);
- maps on a regional scale (1:25 000 to 1:50 000);
- maps on a local scale (1:1000 to 1:10 000). Bird's-eye view reconstructions of archaeological sites also fall into this category.

3 See Vos 2015 for an overview.
4 Pons & Wiggers 1959-1960.
5 Zagwijn 1986.
6 Vos *et al.* 2011.
7 Vos 2015; www.archeologieinnederland.nl

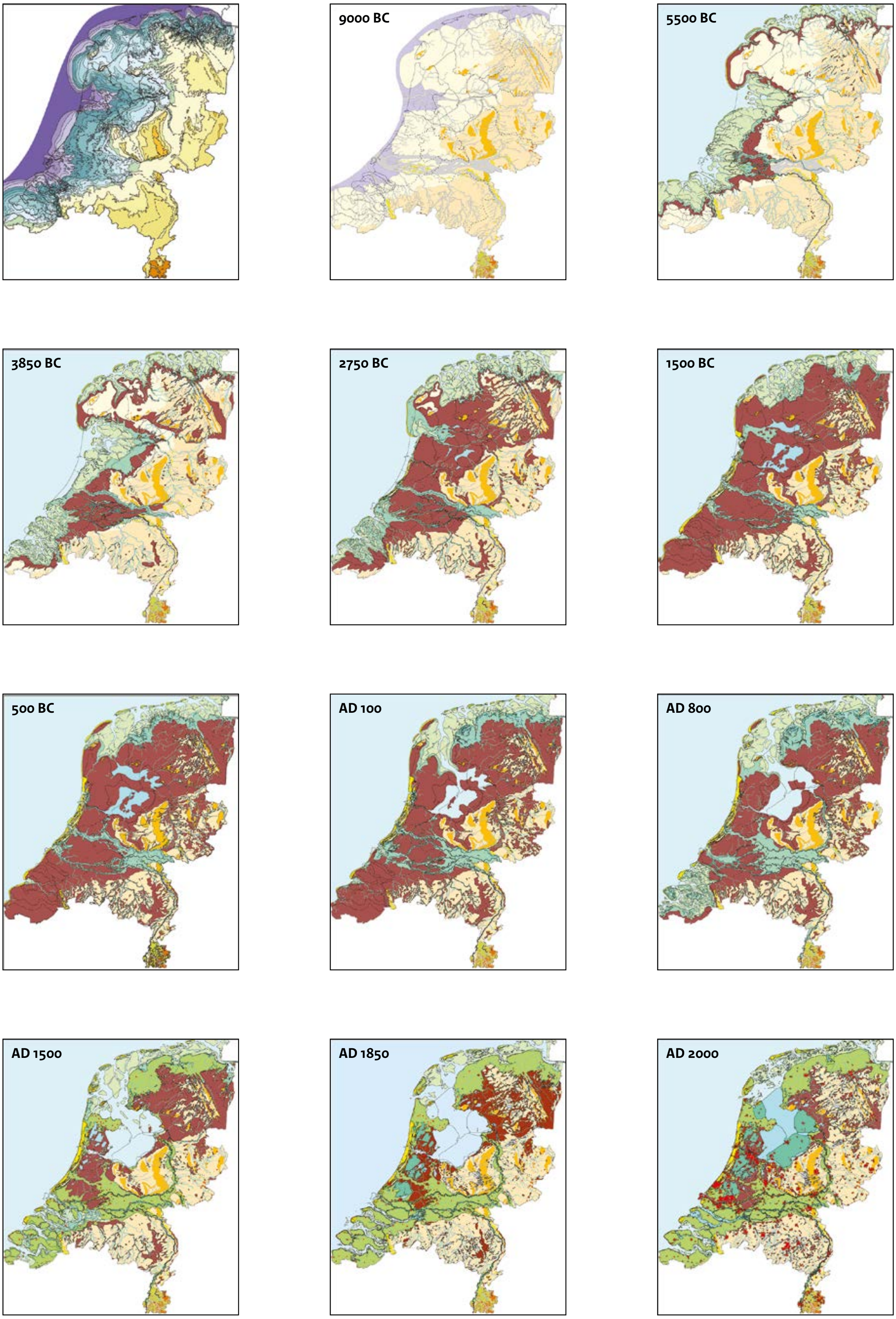

Figure 1 Overview of the palaeogeographical maps of the Netherlands.

Data and knowledge concerning three basic elements are generally required for a palaeogeographical reconstruction of a study area:

- lithostratigraphy: geological sequence of the subsurface;
- chronostratigraphy: age of the layers in the sequence;
- lithofacies: palaeoenvironmental conditions during and after the deposition of the layers (synsedimentary and post-sedimentary processes).

The lithostratigraphy provides the framework for the landscape reconstruction. The distribution of sand, clay and peat layers in the geological record can be translated to the presence of different lithofacies in the subsurface such as dunes, coastal barriers, tidal and river channels, tidal flats, floodplains and marshes.

An adequate time framework (chronostratigraphy) in the geological record is essential for reconstruction. Only if the age of the sediments is known can the formation of the lithofacies and, with that, the palaeoenvironmental changes, be located in time. The sediment layers can be dated using several techniques. The most important techniques used for dating Holocene coastal deposits are radiocarbon dating (organic material), luminescence dating (sand) and dendrochronology (tree rings). Archaeological materials can also be very valuable for dating the sediment layer in which they are found. In building a time framework for the geological sequence, it is important to bear in mind that a specific lithological layer found at different locations is not necessarily indicative of one and the same time period of deposition. The Basal Peat layer on top of the Pleistocene deposits is a good example of such a diachronous sediment unit. At a lower level the Basal Peat layer is older than the same stratigraphical peat layer at another place where this layer is in a higher position.

Several tools or proxies can be used for the reconstruction of the sedimentary environment (lithofacies) in which the different layers of the subsurface were formed. In the first place the lithology (e.g. grain size) itself supplies information about the depositional environment, such as the transport mechanism (e.g. aeolian or aquatic). In addition, sedimentary structures and molluscs supply information about the sedimentary environment (e.g. channel deposits) and environmental conditions during deposition (e.g. salinity). In geological mapping programmes such as that in the Netherlands, the basic lithological information for the lithofacies reconstruction is largely derived from borehole descriptions. It is not only important to describe the lithology; the recognition of palaeosoils (soil formation) in the boreholes is equally relevant for determining periods of non-deposition.

Geobotanical specialisms such as the proxies of macro-plant remains, palynology and diatoms are the main tools used for more detailed palaeoenvironmental reconstructions. These tools supply information about local and regional vegetation and the depositional environment of the past. Micromorphology is also a valuable tool for the reconstruction of micro-processes in deposition, e.g. soil formation and anthropogenic disturbance.

Open pits, often archaeological excavations, can provide a lot of local palaeoenvironmental data. In the first place, pits provide an opportunity to perform stratigraphical and sedimentological research on the exposed deposits, and to take samples for additional laboratory investigation (palaeoecological and dating). In the case of an excavation, the archaeological finds supply information about the age layers in which they are found.[8]

The presence of an archaeological site itself (e.g. 'Flachsiedlung') also supplies information about the palaeoenvironmental conditions. For example, when humans settled in a salt-marsh area, the site they occupied will not have been flooded, or at least not frequently.[9]

Open pits and archaeological excavations are called key sites or building stones in the landscape reconstruction if they supply information about the palaeoenvironment in a certain time period. The minimum requirement for a site to qualify as a 'key site' is that the lithofacies and the age of the deposits are known.

Geomorphological structures which can be recognised at the surface are very important palaeolandscape features. The morphology supplies information on the final phase of sedimentation when the feature was formed. For the Holocene coastal deposits the final phase of deposition generally varies between 2500 and 1000 years ago, the time period before the large-scale formation of levees. During the past ten years the LIDAR elevation maps have become a very powerful tool for visualising the surface morphology. The genesis of the morphological features (sedimentary environment and age) can be reconstructed in combination with other geological (lithology / lithofacies of the morphological feature), historical (e.g. old maps) and key site information.

The palaeogeographical map series is based mainly on existing regional map data, such as geological and soil maps, LiDAR elevation maps, and regional palaeogeographical reconstructions. Thus the national palaeogeographical maps are not based on raw data (e.g. boreholes), but on already structured/ mapped geological and palaeogeographical information. All the individual map sources were converted to a single scale: 1:100 000. These pieces of information were brought together, assessed in terms of which time slice they applied to (based on the age of the geological features), and then synthesised into individual palaeogeographical maps.

Palaeogeographical maps were produced for the time intervals 9000, 5500, 3850, 2750, 1500, 500 BC and AD 100, 800, 1500, 1850 and 2000 (Figs. 2, 3, 4).[10] This series of maps and the supplementary information on the genesis of the Dutch landscape during the Holocene are important for archaeological research in the context of archaeological heritage management.

3.2.4 Perception of Holocene coastal evolution

From 1950 to 1980, geoscientists and archaeologists in the Netherlands, Belgium and Germany assumed that clastic and organic deposits in the tidal basins corresponded in time, and that the formation of these deposits was associated with periods of strong and weak marine influence (i.e. transgressions and regressions).[11] During transgressions, marine influence in the coastal area increased and mainly clastic sediments (sand and clay) were deposited. During regressions the sea retreated, parts of the tidal area fell dry, and soils and peat layers developed in the hinterland. Transgressions would occur during periods of relatively rapid sea-level rise and regressions during periods of slower rise or a relative sea-level fall. The transgression and regression model suggests that fluctuations in the global climate would have been the main driving force behind the supra-regional changes. According to this view, these fluctuations had a cyclicity of about 500 to 600 years.

Archaeologists and historians used the cycle model to explain the different occupation phases in the coastal area.[12] During regression phases, the relatively low sea level allowed the higher, silted-up parts of the marine clay area to fall dry so that they became habitable. During transgression phases the sea level rose rapidly and these parts of the coastal area were flooded again and became uninhabitable.

At the end of the 1970s and in the 1980s ideas about the landscape genesis of the NW European coastal plain gradually changed. More importance was attached to local factors determining the processes – and thus coastal development and opportunities for occupation – in a coastal region.[13]

The concept of cyclical supra-regional transgression and regression phases has not been completely rejected, however. The Holocene sea-level curve for the southern North Sea by Behre shows marked fluctuations which he relates to the Calais and Dunkirk transgression phases.[14] Van den Berg also recognises a cyclical development in the coastal area of the Netherlands with a return period for regressive developments of 260 years.[15] However, not all tidal basins responded to each regressive event in the same way. This is logical, while at the same time isostatic subsidence in response to the melting of the Scandinavian ice differed along the coast.[16] Moreover, a rising sea level induces changes in the tidal regime in the North Sea, which differ from one place to another, (cf. the palaeogeographical reconstructions of the coastal area between Marsdiep and Weser).[17]

8 Louwe Kooijmans 1974; 1980.
9 Groenendijk & Vos 2002; Vos & Gerrets 2004.
10 Vos 2015. These maps were recently transformed to serve as a basis for a website presenting major archaeological finds made in the Netherlands. See https://www.archeologieopdekaart.nl/. The website was created by the National Museum of Antiquities (RMO) in collaboration with the Cultural Heritage Agency (RCE) as part of an initiative to present archaeological information to the public. See Eerden *et al.* 2017: this volume chapter 8.
11 E.g. Bennema 1954; Tavernier & Moorman 1954; Pons & Wiggers 1959-1960; Hageman 1969; Behre 1986.
12 E.g. Van Es, 1970; Dekker, 1971; Boersma, 1972; Louwe Kooijmans 1974.
13 E.g. Baeteman 1981, 1983; Westerhoff *et al.* 1987.
14 Behre 2003.
15 Van den Berg 2013, Box 17.10.
16 Kiden, Makaske & Van de Plassche 2008.
17 Vos & Knol 2015.

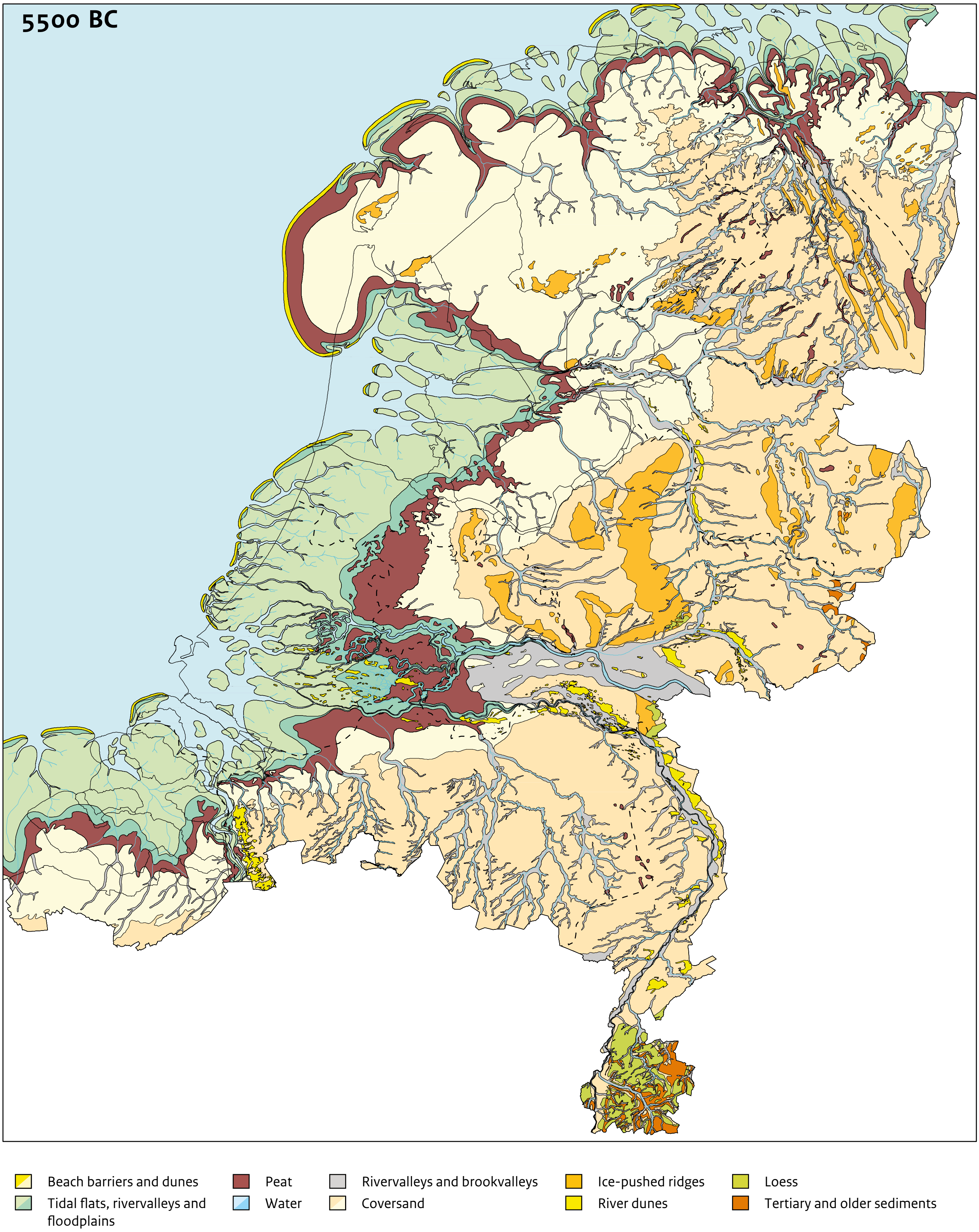

Figure 2 Palaeogeographical map of the Netherlands around 5500 BC.

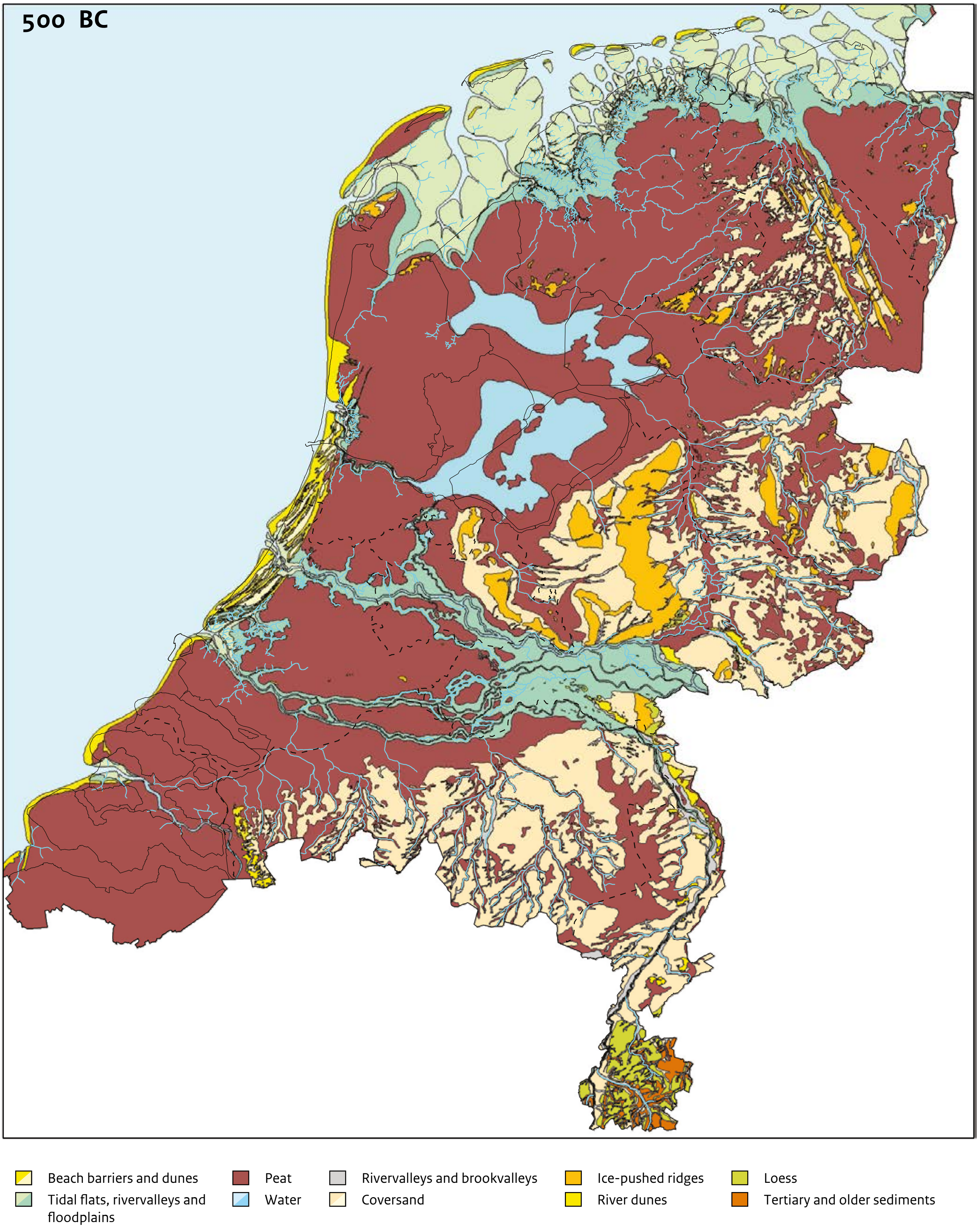

Figure 3 Palaeogeographical map of the Netherlands around 500 BC.

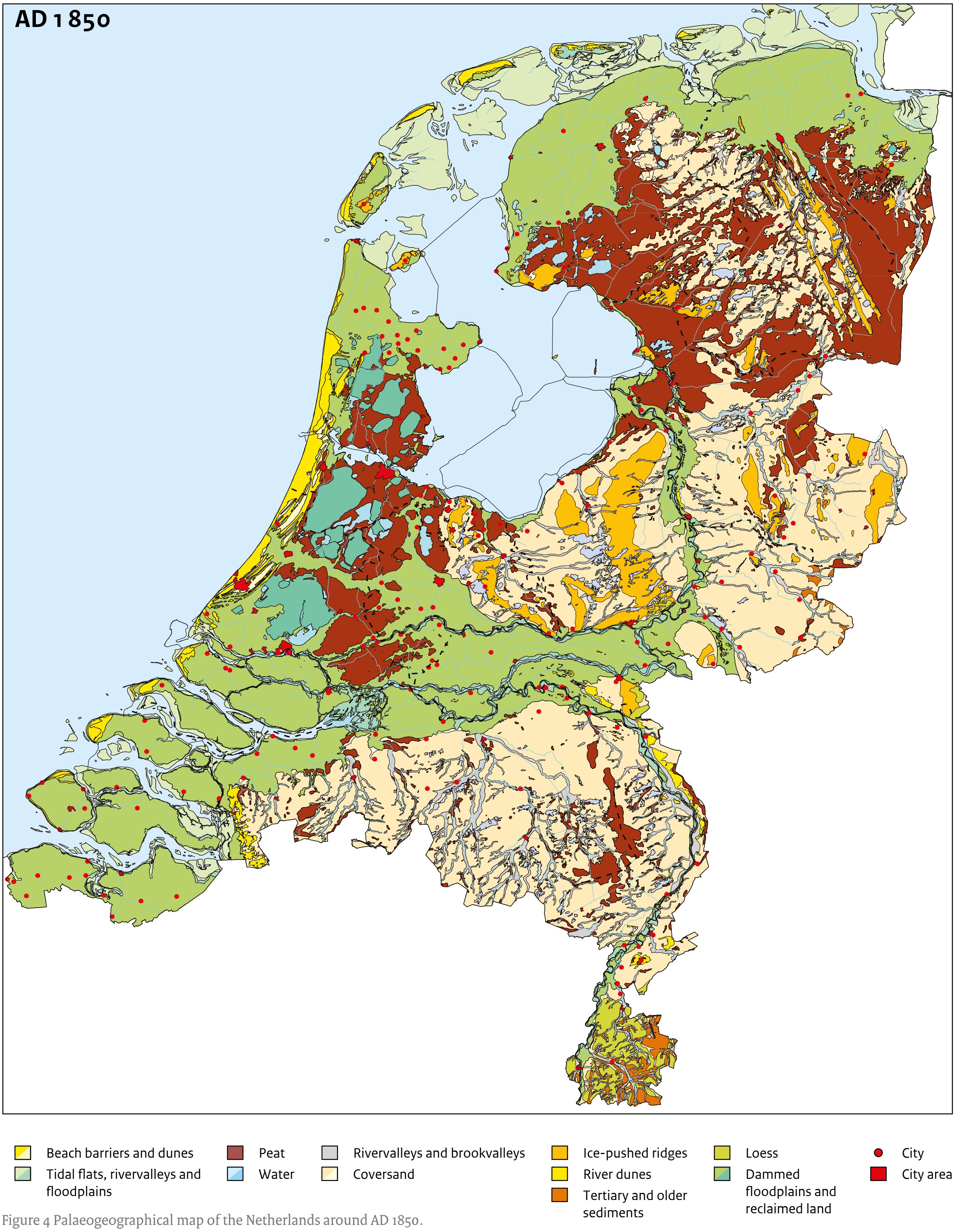

Figure 4 Palaeogeographical map of the Netherlands around AD 1850.

3.2.5 Driving mechanisms

Long-term Holocene coastal evolution is defined by several forcing factors. Relative sea-level rise, for the greater part due to climate warming and melting of ice after the last ice age, was the main cause of marine inundation in the Netherlands. The mean sea level rose rapidly as a result of this eustatic sea-level rise of more than 100 cm at the beginning of the Holocene.[18] In this period, the North Sea area was inundated, the southern and northern North Sea became connected and the low-lying Pleistocene valley systems flooded.

After 7500 BP eustatic rise reduced markedly. Since then sea-level rise in the Netherlands has mainly been determined by tectonic subsidence. In the Middle Holocene relative sea-level rise was still approximately 30 cm per century and during the last 2000 years it has declined to 5 to 10 cm per century.[19]

Forcing factors affecting the coastal architecture during the marine inundation were the geometry (relief) of the Pleistocene surface at the beginning of the Holocene, sediment supply, tidal forces and human influence in the coastal area.[20]

The sea initially penetrated the Dutch coastal area through the low-lying Pleistocene valley systems and these valley systems changed into tidal basins and estuaries. The geomorphology of the coastline and tidal basins changed continuously over time due to the filling of the tidal basins and the erosion of the Pleistocene headlands in the course of the Holocene.

The Pleistocene headlands and the shallow seabed of the North Sea were the major sources of sediment which filled the tidal basins during the Holocene. The sediment was transported by tidal and wave action.

The Rhine and Meuse rivers transported sand and clay to the estuarine delta and the North Sea. Compared to the amount of sediment from the North Sea area (headlands and seabed), the proportion of river sediment is relatively low, at about 10% to 11%.[21]

An important sediment source of *local origin* was peat. As a result of peat formation, in the Late Holocene peat bogs constituted a large proportion of the total sediment volume in the coastal landscape. Apart from plant material, peat consists largely of water. The water content in 'living' peat varies between 60% and 90%. Peat volumes in the coastal zone are therefore very vulnerable when drained. When drained, the peat is oxidised and compacted and the land surface subsides significantly. Erosion of peat also has major consequences. If peat is eroded due to changes in the shore or river patterns, the eroded peat volume largely disappears from the system because it mainly consists of water, while the organic matter is oxidised, in contrast to a sand volume which after erosion is transported from one place in the tidal system to another.

During the Holocene, the role of humans in the rural landscape became increasingly important. Anthropogenic influence on the landscape began in the Mesolithic with the start of agriculture, which caused local disturbance to the natural vegetation. During the Bronze Age, human impact on natural erosion continued, and sedimentation processes became noticeable, as large forested areas were logged.[22] As a consequence of the disappearance of the forest, the soil was no longer held by the tree roots, and became vulnerable to erosion. During intensive rainfall soil material was washed away and transported via local rivers to major rivers. The increase in the sediment load of the rivers enhanced sedimentation in the lower part of the river delta.

A second important anthropogenic influence was drainage by ditches, which had a particularly major impact on peat areas. Due to the subsidence which resulted from the ditches and canals dug by humans, the sea penetrated into the coastal area and the tidal volume of the coastal systems increased. These anthropogenic ingressions have been noticeable in Zeeland, Friesland and Groningen since the Roman period and the Middle Ages.[23]

A third anthropogenic intervention that was instrumental in shaping the coastal landscape was the large and systematic building of dikes in the salt marshes and in the river floodplains, and the damming of natural water courses. The water could no longer expand over these large water storage areas at times of high water levels (floods). This caused a sharp reduction in flood-basin storage capacity in such areas. In response to the loss of storage volume, the flood water was dammed up against the dikes during storms and periods of high river discharge, occasionally leading to catastrophes.

18 Hijma & Cohen 2010.
19 Jelgersma 1979; Van de Plassche 1982.
20 Beets, Van der Spek & Van der Valk 1994; Van der Spek 1994; Vos & Van Heeringen 1997; Beets & Van der Spek 2000.
21 Beets, Van der Spek & Van der Valk 1994; Beets & Van der Spek 2000.
22 Erkens 2009.
23 Vos & Van Heeringen 1997; Vos & De Langen 2008; Vos & Bungenstock 2013.

3.2.6 Long-term coastal evolution of the Netherlands

The clastic coastal deposits in the Netherlands were formed during two major transgressions: a sea-level driven transgression in the first half of the Holocene and human-driven transgressions (or ingressions) in the final part of the Holocene.

The enlargement of water storage capacity during flooding events was the driving factor in these transgression and ingressions. In the Early and Middle Holocene the rapid relative sea-level rise was largely responsible for creating water storage capacity in the inundated Pleistocene valley systems, which led to the creation of the tidal basins and the Rhine-Meuse estuary.

At the landward margin of these tidal systems, seepage water from the higher Pleistocene sand area caused a rise in the water table. The wet conditions in this marginal zone induced the formation of peat. Due to the continuing sea-level rise, the marine area and peat bogs shifted more and more landward, and tidal sediments were deposited on top of the previously formed Basal Peat layer.

Between 9000 and 7000 BP, the palaeo-coastline was probably located some 10 km west of the present coastline between The Hague and Zandvoort. Seismic surveys show that in the subsurface of this part of the North Sea area large tidal channel (inlet) fills occur at a depth of 25-30 m –NAP.[24] Beach-barrier ridges formed between the inlets. These barriers were probably overtopped due to the rapid sea-level rise and therefore eroded away. After 7000 BP the coastal barrier was located close to the present coastline.

Rapid delta aggradation took place in the Rhine-Meuse region. Clastics, sand and clay, were deposited near and in the meandering river channels. The channel belt deposits and crevasses consisted mainly of sand, and clays largely filled the adjacent floodplain.[25] Further away from the channels clayey peat bogs developed. Peats filled large parts of the delta, and were responsible for a large proportion of the estuarine delta aggradation.

During the course of the Middle Holocene sea-level rise declined, which reduced water storage capacity. Around 5500 BP, the balance between the deposition in tidal basins and inundation by sea-level rise tipped towards sedimentation, and the tidal basins in the western Netherlands gradually silted up.[26] This led to an expansion of the salt marshes and a reduction in the tidal volume of the basins. Because the tidal volume (prism) is directly related to the cross-sectional area of the channels, this decline caused a strong reduction in these tidal channel systems, and the coastal barriers expanded seaward. In the hinterland the silting-up of tidal channels and creeks led to a considerable decline in the natural drainage of coastal peat lands in the western Netherlands. Due to the poor drainage, peat growth expanded and peat covered the salt marsh areas. Large coastal peat bogs developed, growing to several metres above the adjacent tidal area. The central parts of these peat lands were no longer inundated by nutrient-rich water, making rain the only source of water. This led to the formation of oligotrophic peat.

Around 4750 BP the coastline of the western Netherlands was almost closed and behind the beach ridges a huge area of peat land had evolved. Inlets were present where rivers drained the hinterland; from north to south, they were the West Frisian tidal inlet system, the Oer-IJ, Oude Rijn river and Meuse estuary. In Zeeland the coastline was not yet closed but there, too, peat bogs in the hinterland expanded.[27]

While the coastal plain of Holland silted up and became overgrown with peat, the transgressive coastal development in the northern Netherlands continued. The coastline of the northern Netherlands remained open and the tidal basins of the northern Netherlands reached their maximum extent around 4750 BP.

The coastline in the northern Netherlands remained open and the basins were not completely filled with sediment for a number of reasons:

- Glacio-tectonic subsidence in the northern Netherlands was stronger than in the central and southwestern Netherlands; thus, more sediment was needed to compensate for the relative sea-level rise. In addition, the seabed along the coast deepens more rapidly to the north than to the west, impeding sediment transport towards the coast in the north.
- Although northwesterly storms are the most severe, westerly and southwesterly winds are more frequent, so wave-driven sand transport

24 Rieu *et al.* 2005.
25 Berendsen & Stouthamer 2001; Cohen *et al.* 2012.
26 Beets & Van der Spek 2000.
27 Vos & Van Heeringen 1997.

from the North Sea to the western coastline was greater than to the northern coastline.
- In the southwestern Netherlands sediment was supplied by the Rhine and, to a lesser extent, by the Meuse.[28]

Peat formation also expanded in the Pleistocene area of the high Netherlands. These peat bogs joined up with the bogs in the coastal area and huge peat lands evolved. The peat bogs reached their maximum extent around 2500 BP.

From about 2000 BP, humans played a significant role in creating new water storage capacity in the coastal peat lands. By constructing artificial drainage and digging out the peat, they caused the peat surfaces to subside, which in turn caused marine ingressions. The low-lying peat land was flooded regularly. This led to the deposition of clay, and the weight of the clay layer caused further subsidence of the peat bogs. This again resulted in even more frequent inundations and more clay deposition (autocompaction).

In the southwestern Netherlands, subsidence of the peat surface, together with the fact that the sea could penetrate directly into the centre of the peat lands through drainage canals and ditches, had catastrophic consequences. Canals and ditches changed into tidal channels and creeks which further eroded the peat. Unlike sand, upon erosion peat is largely lost from the sediment balance of a tidal system because its main constituents are water and organic matter. The tidal volume in the area increased significantly due to subsidence and erosion. The cycle of subsidence, increase in tidal volume, growth of tidal channels and peat erosion was a self-perpetuating process.[29] About 1500 BP almost the whole province of Zeeland was inundated. In about 800 AD, after several centuries of inundation, the elevation of the land due to sedimentation gradually outstripped the effect of subsidence and sea-level rise. Large parts of the tidal areas of Zeeland silted up to salt-marsh level and became suitable for habitation again.

In the Late Middle Ages humans became the dominant factor in shaping the Dutch landscape. Salt marshes and floodplains in coastal and river areas were diked, and almost the entire peat landscape was reclaimed. Human interference in the coastal landscape led to catastrophic situations. Due to embankment, the salt marshes diminished drastically and the storm surge storage capacity in these areas declined significantly. During storms the flood waters could no longer spread out over the marshes, but backed up against the dikes, leading to a sharp rise in maximum water levels. This created disastrous conditions, because when a dike breached, floodwater entered the embanked and artificially lowered peat polders on the landward side of the dikes with great force. Examples of such catastrophes include the Saint Elizabeth's Day Flood of 1421 in the Groote of Zuidhollandsche Waard and the Saint Felix Day Flood of 1530 in the Verdronken Land van Zuid Beveland. In the northern Netherlands, the major flooding in the former peat polders in the Dollard region in 1509 was a huge disaster.[30]

The common factor in these flood disasters was that they extended over large areas, and that land was lost permanently or for many centuries. In the coastal area these permanent losses were the result of the strong subsidence of the peat polders, which had fallen below the mean high water level. After a dike breach, tidal waters raced in and out of the inundated peat polders every tidal cycle, creating large tidal channels which could not be repaired at that time.

3.2.7 Climate and coastal environmental changes

Climate and sea-level change were the main driving forces in the major environmental changes during the glacial and interglacial periods of the Pleistocene. However, during the Holocene the magnitude of climate fluctuations was limited. The influence of climate variations on the morphological changes of coastal depositional systems is difficult to detect because many natural and/or anthropogenic driving factors are involved in the architecture of these systems.

The Holocene climate changes were too small to generate eustatic sea-level fluctuations causing transgressive and regressive cycles. The many storm-surge disasters in the 15th to 17th centuries are more related to hazardous situations created by humans (lowering of the polders and increase in the extreme HW level) and poor maintenance of dikes due to political and socioeconomic problems, than to climate change in the Little Ice Age.

28 Erkens 2009; Vos 2015.
29 Vos & Van Heeringen 1997.
30 Vos 2015.

The magnitude of climate fluctuations is too small for any great impact on the sedimentary systems. Autonomic and self-enhancing processes within these systems predominated over climate effects. Natural and anthropogenic morphological changes in tidal systems during the Late Holocene led to regional changes in MHW and EHW levels of a greater order than the relative sea-level rise at that time.

3.2.8 Palaeogeography in the future

A palaeogeographical map is never 'finished'. When new data become available the maps have to be reconsidered and, if necessary, modified. Because a palaeogeographical map is a multidisciplinary product, new data come from many different sources: geology (e.g. boreholes), geomorphology, datings, palaeoecology/palaeoenvironment (e.g. from proxies), and historical data and maps.

The latest palaeogeographical maps of the Netherlands can already be improved on. New geological, geoarchaeological and historical studies produced in the last two years for the coastal areas of Westland-Delfland, Noordoost Polder, Northern North-Holland and Friesland have supplied new regional palaeolandscape data which will allow the existing maps to be refined.

Regional improvements to palaeoenvironmental maps are of great value to archaeological prospection models – and therefore to archaeological heritage management – since they provide firmer foundations for the proposed distribution of habitable landscape types.[31]

One expected future development is 4D palaeogeographical modelling. Palaeolandscape reconstructions are presented in the form of 'flat' maps (2D). Adding depth information to two-dimensional maps allows expansion to a three-dimensional model (3D). When time is also added, a four-dimensional reconstruction (4D) can be generated. 4D techniques allow the driving mechanisms to be reconstructed and modelled. Spatial models of past coastal environments will in future allow medium- and long-term morphodynamics of tidal systems to be better understood and forecast – *the past is the key to the future*. However, producing 3D and 4D reconstructions in coastal modelling is very labour-intensive. The first initiatives to produce such spatial palaeocoastal simulations have recently been launched.[32]

31 Smit & Feiken 2017: this volume 3.5; Doesburg *et al.* 2017: this volume chapter 5.

32 Cohen *et al.* 2017: this volume 3.4; Pierik, Cohen & Stouthamer 2016.

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3.3 A glimpse into the past. Mapping regional vegetation developments since the Late Glacial in Twente (the Netherlands)

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Abstract

This study offers a regional and diachronic perspective on the development of the landscape, vegetation and habitation of the Twente region of the Netherlands since the Late Glacial. A detailed search for existing pollen data yielded 125 sites containing information from a wide variety of sampling contexts. A series of six evidence-based regional vegetation maps were constructed by analysing relationships between pollen data, soil data and topography. The maps serve as first-stage generalised models that predict regional trends in vegetation development and land use, will allow for subsequent testing and place site-specific archaeological data in a wider context. The method developed is applicable to other regions. A comparison with contemporary habitation patterns, based on archaeological and historical data, reveals spatio-temporal trends in human influence on vegetation and in physical factors influencing site location. Five maps have been 'translated' into artist's impressions.

Keywords: regional vegetation maps, palynology, Late Glacial and Holocene, habitation patterns, Twente

Figure 1 Location of Twente region (marked in grey).

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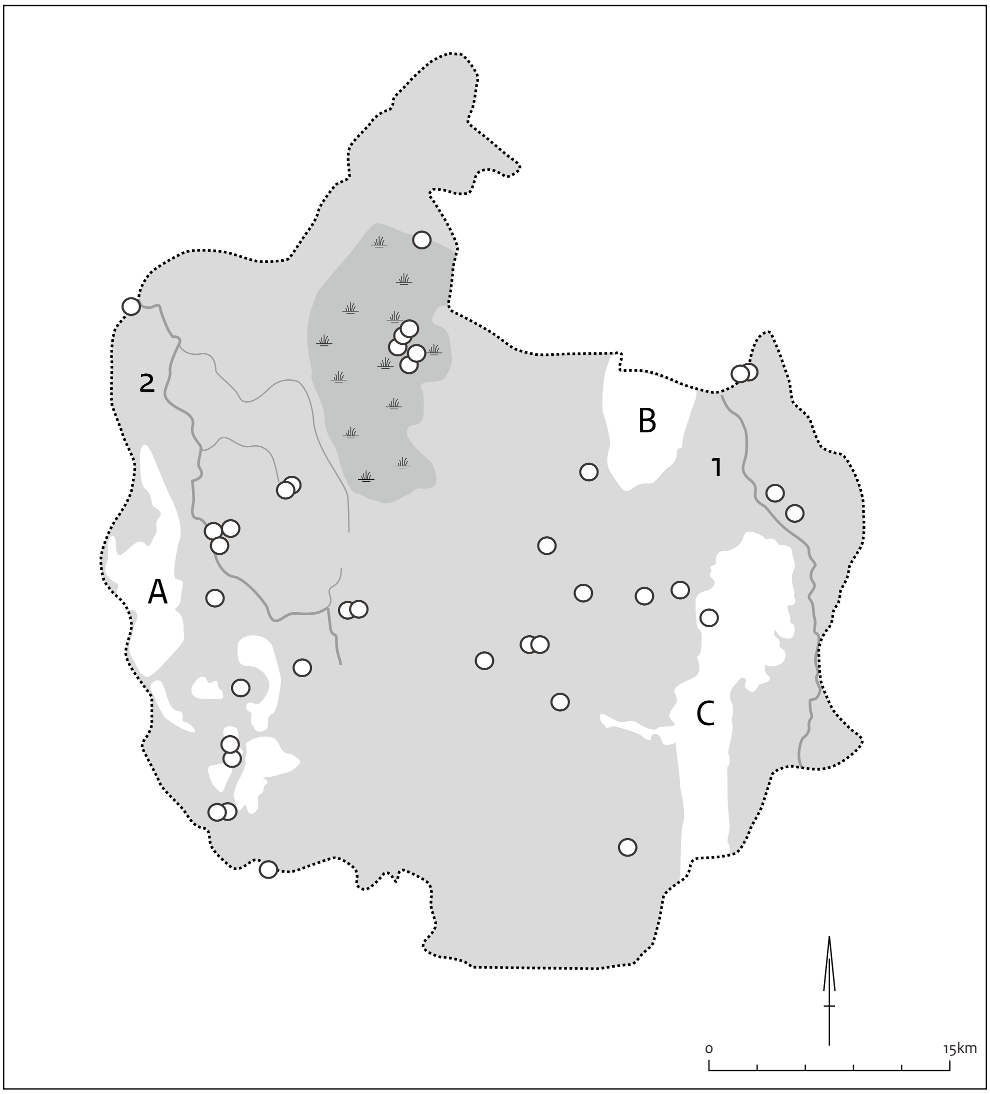
3.3.1 Introduction

Detailed interdisciplinary research on regional diachronic landscape developments is rare in the Netherlands. Most studies focus either on specific time frames or on individual sites. So far, geological and botanical data have been used mainly to substantiate our image of the environment of settlements and cemeteries, to explain habitation patterns, to reconstruct human influence on the landscape or to create local vegetation reconstructions. As a result of the heavy emphasis on settled areas, there are virtually no fully representative images of the structure and development of Holocene landscapes. The study presented in this paper aimed to extend our view beyond the boundaries of settlements, cemeteries and single site reconstructions by analysing long-term vegetation developments on a regional scale.[34] The Twente region in the eastern



Ice-pushed ridge
Sandy/morainic areas
Raised bog (Almeler Veen)
River
Palynological sampling site

Ice-pushed ridges: A Markelo-Nijverdal
B Ootmarsum
C Oldenzaal

Rivers: 1 Dinkel
2 Regge

Figure 2 Simplified map of the most important landscape characteristics of the study area.

[34] This article is a concise version of Van Beek, Gouw-Bouman & Bos 2015. That paper presents a catalogue of all inventoried palynological sites, as well as all the full series of vegetation maps. See Bouman, Bos & Van Beek 2013 for an extensive report on this research.

Netherlands was selected as a pilot area (Fig. 1, 2). Regional vegetation maps were developed for six phases, based on a combination of palynological, geomorphological, hydrological and historical data. These maps were used to study vegetation change and to analyse human-land relationships by comparing them to archaeological and historical geographical data. Five maps were 'translated' into digital, evidence-based artist's impressions.

No landscape reconstructions on this spatio-temporal scale have ever been made in the Low Countries. A small number of vegetation maps have been published,[35] but these focus on smaller areas and/or shorter time spans, and are based on smaller datasets. Hoek, for example, mapped the distribution of individual Late Glacial species in the Netherlands.[36] Some regional vegetation reconstructions have been performed in neighbouring parts of northwest Europe. Burrichter reconstructed the 'potential natural vegetation' of the Münsterland area of Germany, mainly based on geological data.[37] Stobbe did the same for the Wetterau area in Germany, based on palynological data and using a modelling approach.[38] Nielsen *et al*. reconstructed the landscape openness and distribution of selected species in northern Germany and Denmark.[39] However, none of these studies included a discussion of contemporaneous habitation data.

3.3.2 Study area

Twente (Fig. 1, 2) has an area of approximately 1500 km² and is part of the European Sand Belt.[40] Its major geological features formed as a result of the combined activity of wind, water and ice during the Saalian and Weichselian Ice Ages. The expansion of land ice in the Saalian led to the formation of three ice-pushed ridges in the western, southeastern and northern parts of the research area. All other areas can be classified as coversand landscapes. Their basic structure dates from the Pleniglacial, when sand drifts led to the formation of numerous sandy ridges. Many of these ridges, especially the larger ones with fertile soils, were favourable settlement locations throughout prehistoric and historic times. The coversand landscapes are intersected by various valleys. From the late Atlantic and Subboreal periods onwards raised bogs developed in various flat, poorly drained areas.

3.3.3 Methodology

Palynological data

The data were collected in a literature survey, from palynological archives and by contacting various research institutes and universities. A total of 125 sites containing Late Glacial and Holocene palynological data were found, scattered over the eastern Netherlands and adjacent parts of Germany (northwest Westphalia and southwest Lower Saxony). Thirty of the sites are situated in Twente. The others have been included because of their proximity to the region (none more than 50km away, and most much closer) and comparable landscape setting. Both 'natural' (n = 91) contexts, such as lakes, bogs and residual channels, and 'anthropogenic' (n = 34) contexts such as wells are represented. The analysis of samples from anthropogenic contexts is not without problems.[41] However, when treated carefully valuable additional information can be obtained that complements data from 'natural' sources.[42] The palynological sites are distributed more or less evenly over the research area. Most locations only contain information on parts of the Late Glacial and Holocene. The distribution and composition of palynological information for any given phase therefore varies.

Vegetation reconstructions

Although abundant palynological information is available from the study area, a lot of the data are not suitable for use in common models of vegetation reconstruction.[43] Most models require uniform data (with regard to pollen sums) from large lakes or mires, whilst our data are highly variable in terms of sampling context and the applied research methods. A new method was therefore designed to identify regional trends in vegetation development and land use. The methodological basis is formed by the inherent relationships between the abiotic landscape, vegetation and human activity, and the assumption that these links are consistent in a relatively uniform area. Based on these generalised relationships, local pollen-based vegetation reconstructions were extrapolated to a regional scale.

35 E.g. Van der Hammen & Bakker 1971; Neefjes & Willemse 2009.
36 Hoek 1997.
37 Burrichter 1973.
38 Stobbe 1996.
39 Nielsen *et al*. 2012.
40 Koster 2009.
41 E.g. Groenewoudt *et al*. 2007.
42 Cf. Dimbleby 1985.
43 E.g. Sugita 2007; Bunting & Middleton 2005; Gaillard *et al*. 2008; Nielsen *et al*. 2012.

There are several potential pitfalls when comparing and integrating samples from various locations and environmental settings. Most problems occur due to various well-known factors influencing the composition of a pollen assemblage (e.g. the source area, dispersal and preservation of pollen, the vegetation characteristics, sediment accumulation).[44] These will not be discussed in detail here, but most of these biases were minimised by interpreting each dataset individually. The vegetation reconstructions are not therefore directly based on pollen data but rather on assumptions and relationships derived from the pollen record. A second set of problems relates to variations in data structure. The analyses were performed by different researchers with varying methods and aims, which is reflected in the variety of pollen sums. It was impossible to compare pollen percentages of specific species in different diagrams, because the original data were not always available. The dominance of species and their relative ratio at each site were therefore used to estimate the spatial distribution of species and their relative importance. In addition, we based the reconstructions on vegetation communities instead of on individual species. Vegetation communities are groups of plant species that prefer comparable conditions and frequently occur together in present-day vegetation.[45] A tailor-made set of vegetation communities was defined for each time slice map (Fig. 3).

The basic methodology consisted of three steps:

1. obtaining a regional overview of vegetation development using a selection of well dated pollen records with a high temporal resolution. This overview functioned as a general reference and as a basis for estimating the relative age of undated sequences, based on the overall vegetation composition and the presence of key species. Samples from 'anthropogenic' settings were mostly dated by archaeological evidence.
2. reconstructing the vegetation around each sampling site. The neighbouring vegetation communities were defined using the pollen data and the original ecological interpretations. The vegetation communities were ascribed to specific geomorphological units. Areas with an average diameter of three kilometres were analysed.
3. deducing relationships between geomorphology and vegetation from the small-scale site-based reconstructions (step 2) and the regional vegetation overview (step 1). Using a detailed geomorphological map[46] these insights were used to 'fill in' the areas between the sampling site, and thus produce regional maps.

Regional vegetation maps were constructed for six time slices. The selection of these phases is based on significant changes in vegetation composition, the availability of palynological data and (to a lesser extent) developments in habitation history. The selected time slices were:

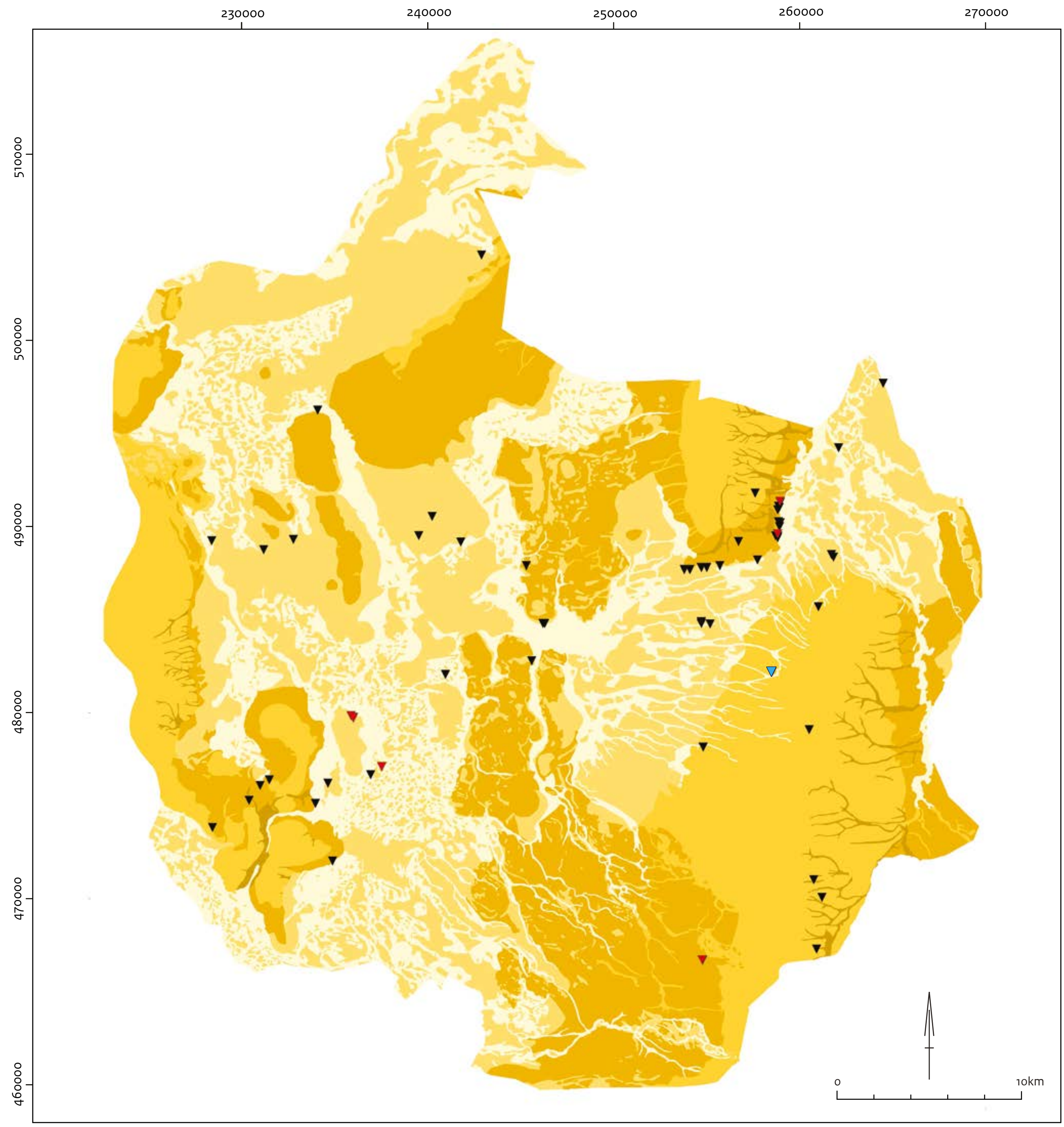
1. Younger Dryas, Late Palaeolithic, c. 10,000 BC (Fig. 3)
2. Atlantic period, Early/Middle Neolithic, c. 4.000 BC
3. Subboreal period, Middle Bronze Age, c. 1500 BC
4. Subatlantic period, Roman period, c. AD 200
5. Subatlantic period, Late Middle Ages, c. AD 1500 (Fig. 4)
6. Subatlantic, submodern period, c. AD 1900

Map 6 differs from the others because it is derived from detailed historical vegetation survey maps[47] rather than palynological data.

Habitation patterns

The relationships between habitation patterns and vegetation development were analysed.
A selection of archaeological data was plotted on the first four maps. These data were chiefly derived from national databases kept by the Cultural Heritage Agency of the Netherlands, plus a literature survey. The site plots do not offer fully reliable representations of former settlement patterns because they are biased by various factors (e.g. erosion and sedimentation, land-use history, research history). Furthermore, the 'archaeological' dates given to each vegetation map are only approximations. The site distribution patterns and their relation to vegetation therefore provide only general insights into human-land relationships, and should be seen as working models. All farmsteads mentioned in detailed historical sources have been plotted on the fifth map, which depicts the vegetation at approximately AD 1500.[48] The sixth map (c. AD 1900) has not been compared to habitation patterns.

44 E.g. Groenewoudt *et al*. 2007; Van Beek, Gouw-Bouman & Bos 2015.
45 Janssen 1972.
46 Van Beek 2009, appendix 1. This map was created by G. Maas and B. Makaske (Alterra, Wageningen University).
47 Grote Historische Atlas 2005.
48 Werkgroep Historische Kaart van Twente 1991.



Open birch-pine woodland with scattered dwarf shrubs and herbaceous vegetation
Open birch woodland with scattered dwarf shrubs and herbaceous vegetation
Open herbaceous vegetation with heather and dwarf shrubs on dry soil
Open herbaceous vegetation dwarf shrubs on moist soil
Bare plain with dwarf shrubs, birch and pine along the edges

Archaeological site (no cultural assignation)
Federmesser site
Hamburg site

Figure 3 Reconstruction map of the vegetation in the Younger Dryas period, approximately 10,000 BC. The plotted archaeological sites date to the Late Palaeolithic period and mainly consist of flint scatters.

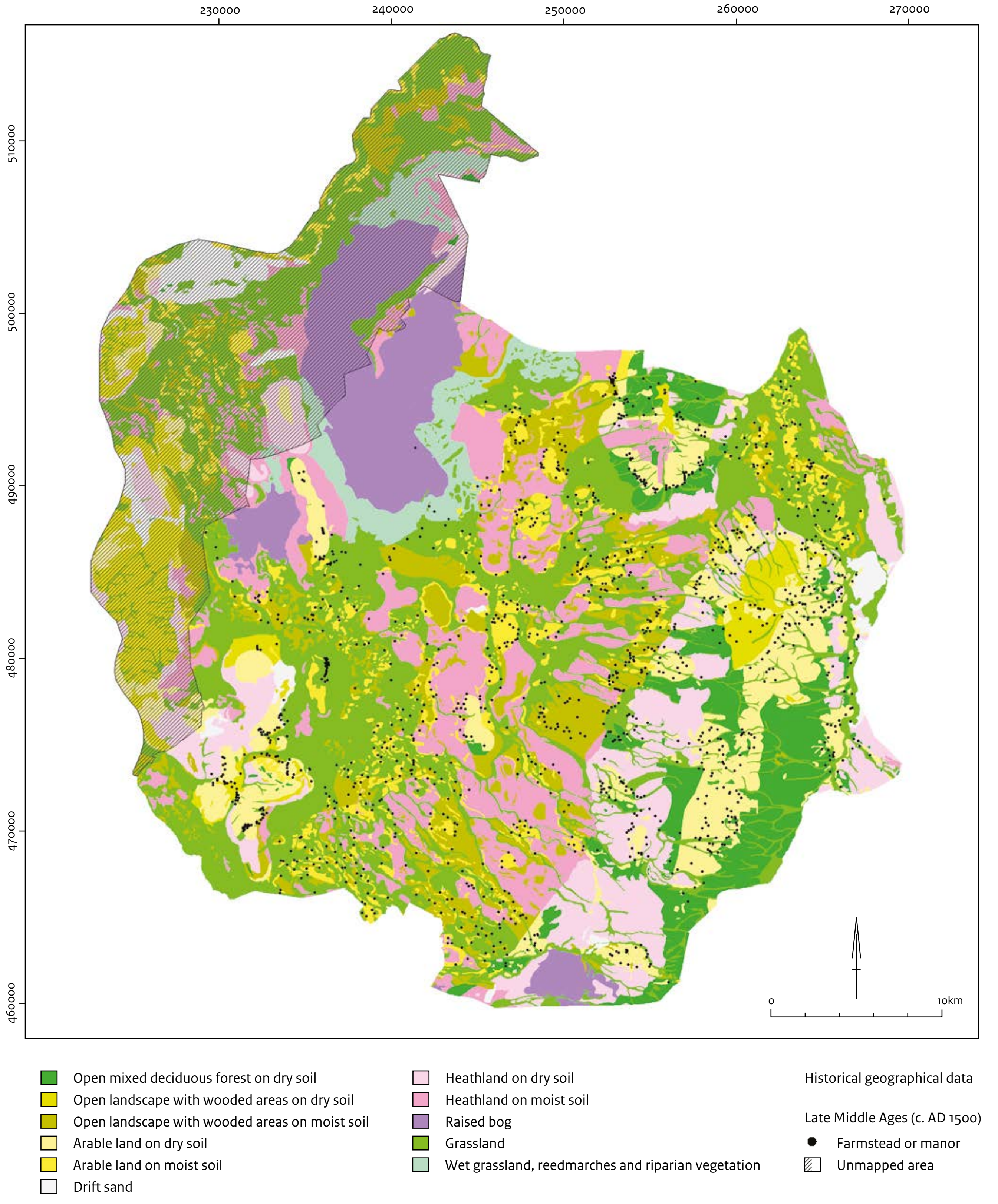


Figure 4 Reconstruction map of the vegetation in the Late Middle Ages, around AD 1500. Historical sources indicate that the landscape, which had become very open due to intensive and prolonged human land use, was dotted with numerous farmsteads. For the other four vegetation maps, see Van Beek *et al.* 2015.

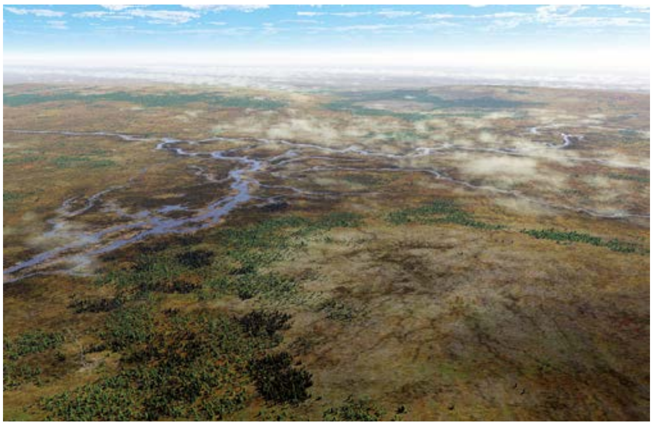


Figure 5 Artist's impression of the landscape in the Younger Dryas period, approximately 10,000 BC.

Artist's impressions

The first five maps have been 'translated' into digital artist's impressions (Fig. 5-9) which can be used to inform a wider audience, but are also of interest to experts. They were produced by an archaeological illustrator in close collaboration with the other members of the project team, including an archaeologist, a palaeoecologist and a physical geographer/palaeoecologist. The viewpoint is approximately the centre of the research area, looking in an easterly direction.

Figure 6 Artist's impression of the landscape in the Atlantic period, approximately 4000 BC.

Figure 7 Artist's impression of the landscape in the Subboreal period, approximately 1500 BC.

Figure 8 Artist's impression of the landscape in the Subatlantic period, approximately AD 200.

Figure 9 Artist's impression of the landscape in the Subatlantic period, approximately AD 1500.

3.3.4 Results and discussion

The main trends in the Late Glacial and Holocene vegetation development of Twente are broadly similar to those in neighbouring parts of northwest Europe.[49] Spatio-temporal differences in vegetation development in our research area mainly originate from climate change, variations in elevation, soil and hydrology, and human activity. Human interventions have had a more noticeable and permanent impact on vegetation since the Bronze Age, in particular. The geological heterogeneity characterising the study area led to a great spatial variety in vegetation, at different scales, and ultimately to the present-day mosaic of landscapes in Twente.

The main aim of the study was to offer a new regional perspective on the structure and development of one of the Low Countries' sandy regions by developing and applying a new research method. Within a northwest European context, this study mainly stands out for the combination of its spatio-temporal scale, the incorporation of data from different sampling contexts, the assessment of links between 'environmental' and cultural phenomena and the creation of a series of evidence-based maps. The vegetation maps can be used as first-stage models to be tested against future palynological research. The research method can also be applied to other regions, provided an adequate number of palynological sources (preferably high-quality) are available. Not one single new pollen sample was taken in this study, indicating that the cataloguing and analysing of 'old' data has high research potential – provided that the data are used in a scientifically sound way and their limitations are acknowledged.

3.3.5 Acknowledgements

This research was initiated as part of the project *Deconstructing Stability. Modelling changing environmental conditions and man-land relations in the Pleistocene landscape of Twente* (2850-12 BC) of the Faculty of Archaeology at Leiden University, financed by the Netherlands Organisation for Scientific Research (NWO). Additional funding was provided by the Cultural Heritage Agency of the Netherlands (RCE; project *Kenniskaart Archeologie*), Overijssel provincial authority (Zwolle) and the Foundation for Anthropology and Prehistory in the Netherlands (SNMAP; Amsterdam). The method of vegetation mapping was developed by the second author and currently constitutes part of her PhD research at the Faculty of Geosciences at Utrecht University. She has successfully used the method to produce vegetation maps of the Rhine-Meuse delta as part of her research.

[49] E.g. Lang 1994; Berglund *et al*. 1996.

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3.4 Mapping buried Holocene landscapes. Past lowland environments, palaeoDEMs and preservation in GIS

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Abstract
In a geological GIS-data recombination project, a digital map was produced that contains information on the Netherlands' former coastal and delta plain landscapes over the last 14,000 years: the Holocene and the very end of the Pleistocene. The polygon map product is accompanied by a set of palaeoDEMs (Digital Elevation Models) indicating the attention depth for buried land surfaces and aquatic deposits for four time slices. This paper provides conceptual background information on the legend and construction principles behind the polygon maps and the palaeoDEMs, i.e. the decisions taken during the making of. It also provides a basic overview of the map product: landscape structure, burial depth and preservation, visualised for the four time slices in the RCE's Archaeology Knowledge Kit. The text links coastal plain buried landscape mapping for four time slices to the other Knowledge Kit activities described in this volume, notably that of the Archaeological Landscapes map (for the most recent time slice in the coastal plain area of the Netherlands, and for all time slices in the Pleistocene uplands).

Keywords: Buried landscapes, geology, geomorphology, digital mapping, palaeosurfaces

3.4.1 Introduction

This contribution describes the making of a series of digital map layers that contain information on the Netherlands' former coastal and delta plain landscapes. The map series was commissioned for the Predictions in Layers project, part of the Archaeology Knowledge Kit programme discussed elsewhere in this volume.[51] The map series aimed[52] to summarise information on buried former landscapes as known from geological mapping in such a way that it is compatible with the Archaeological Landscapes map,[53] the parallel product for the landscape structure of the modern surface. Given the time slice approach of the Predictions in Layers project, having just the latter map would have excluded earlier periods from the dissemination of meaningful, regionally diversified landscape-archaeological knowledge.

This chapter first outlines the goals and means of map production, and then highlights the different approaches needed when mapping buried landscapes as opposed to surficial geomorphological mapping. The remainder of the chapter focuses on describing the methodology used to construct the maps and palaeoDEMS.

Map production goals and means
The aim of the project was to produce a uniform series of maps (Fig. 1), distributed in the form of a GIS dataset, detailing the buried landscape structure and burial depth for four consecutive time slices. In line with the systems used in the other Archaeology Knowledge Kit products described in this volume, it makes use of an archaeological periodisation system that divides the time since 12,000 BC into four consecutive time slices (T1 to T4).[54] Combined with an initial 'Top Pleistocene' landscape state (at time slice T0), the full periodisation scheme is as shown in Table 1:

The GIS dataset was produced following a systematic - i.e. repeatable and automated - procedure that combined and converted existing digital map data available from past geological mapping (location, depth and age of deposits) and palaeogeographical research projects (past landscape functioning, landform inheritance, reconstruction of eroded landscape, links with past sea levels and groundwater tables). Importantly, the workflow was stored in a series of scripts, which serves to document the map production process, thus making it reproducible and maintainable.

The workflow used two spatial classification schemes in addition to time slicing. The coastal plain was divided into nine sectors (or regions) based on differences in the Pleistocene substrate and Holocene landscape evolutionary history (tidal, peaty and riverine parts of the plain; till affected vs. sandy substrates), while within each sector, the landscape structures within each region were mapped as 'landscape zones' (as on

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51 Lauwerier 2017: this volume 1; Smit & Feiken 2017: this volume 3.5.
52 Cohen & Schokker 2014; Dambrink *et al.* 2015; Cohen *et al.* 2017a, b.
53 Rensink *et al.* 2017: this volume chapter 6; Smit & Feiken 2017: this volume 3.5; Cohen 2017.
54 Groenewoudt & Smit 2014 2017: this volume 2.2.

the Archaeological Landscapes map). The threefold division of time slice, sector/region and landscape zonation, served digital map visualisation by applying one legend to consecutive fields of the same polygons. It also serves polygon-level linking of bits of other tabulated contents to the map, so that relevant snippets of web-formatted information can be served to a user following a click on the map (envisaged portal functionality).

Buried landscape versus surficial geomorphological mapping

Although buried landscape mapping and surficial landscape mapping of past to present states of the Holocene coastal plain can use a shared end-result legend, the data sources and types of reasoning involved differ greatly from each other. One could say that the Holocene Buried Landscapes maps describe the natural landscape evolution of the Dutch lowlands up to c. AD 900,[55] whereas the Archaeological Landscapes map describes the human-induced transformations of that natural landscape since then. Differences in the making of these two maps extend beyond the triviality of dealing with differences in data availability and quality. They extend to the factors time (age and preservation) and humans (reclamations, man-made land).

Age is essentially a property of geomorphological mapping where it is witnessed by degrees of surficial soil formation and landform freshness. In geological mapping, however, it is treated more like a dimension than a property, and this dimension is considered partly interchangeable with depth. Further differences in dealing with the factor time exist between mapping present-day situations and past situations, and concern how preservation is taken into account. This is a given for maps documenting the present-day surface, but it is something to consider when mapping past surfaces, which buried surfaces are by their very nature.

Regarding human impact, the present coastal plain is dominated by human-modified landforms to such an extent that the standard geomorphological map legend for the Netherlands does not contain classes of the unaltered natural landforms. For example, the active riverine landforms recognised are the human-modified 'embanked flood plains' (Dutch: *uiterwaarden*) and 'water/river beds', complemented by fossil 'alluvial ridges' and 'residual channels'. Non-embanked flood basin and non-modified active meandering river beds do not exist as legend units. In the same way, deteriorated peat wetlands (Dutch: *veenvlakte, veenglooiing*) constitute a unit, while active peat-forming reed lands do not. What also happens is that cultivated, former salt-marsh polder land is mapped as the same geomorphological unit as remaining salt-marsh on the seaward sides of dike-protected areas. In other words, human presence has been regarded as a given in geomorphological mapping.

Data availability for buried landscapes reduces, the deeper the landscape is buried, and increases where the area is more densely built up. We know more about the subsurface of the city and port of Rotterdam than we do about more rural northern parts of Holland, despite their similar burial depth. For surficial natural landscape mapping, data availability is lower where the landscape has been historically built. Where the natural surface cannot be surveyed

Table 1 Overview of classification into archaeological periods.*

Periodisation	Archaeology	Geology / Palaeogeography	Map product
T4: AD 900 to present	State societies	Surficial reclamation landscape	RCE-T4
T3: 1500 BC to AD 900	Late farming societies	Late Holocene buried landscapes	T0123 – this paper
T2: 3400 to 1500 BC	Early farming societies	Late Holocene buried landscapes	T0123 – this paper
T1: 7000 to 3400 BC	Hunters, gatherers, earliest farmers	Middle Holocene buried landscapes	T0123 – this paper
T0: 12,000 to 7000 BC	Hunters, gatherers	'Top Pleistocene' buried landscape	T0123 – this paper

* In accordance with Groenewoudt & Smit 2014; this volume 2.2; their time slice T1 is equivalent to our time slices T0 + T1).

55 Cohen & Schokker 2014.

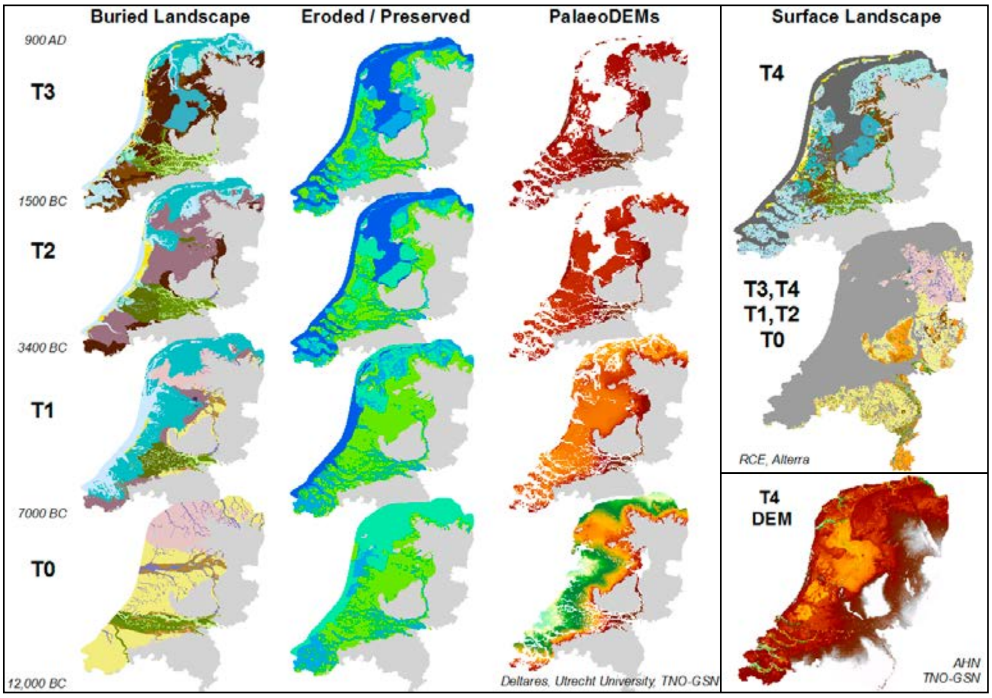

Figure 1 Full set of buried landscape zonation, erosion status and palaeoDEMs for time slices T0123 (this chapter) and RCE-T4 (Rensink *et al.*, this volume 2.4), from the 'buried landscapes' and 'archaeological landscapes' mapping projects.

from the air (traditional relief mapping, LiDAR mapping) and has been excluded from soil map surveying (not agricultural or forestry land), borehole data from geological mapping and archaeological digs have to be used to supplement geomorphological mapping.

The above has given rise to differences in the science practitioner paradigms underlying the Holocene geomorphological and geological mapping in the Netherlands, as approached by different institutions in the 1960-1980s.[56] As a result, the Wageningen school of classic pedological and geomorphological mapping[57] that echoes through in the patterns of the Archaeological Landscapes map (referred to as RCE-T4 in the remainder of this text), differs from that of the map datasets underlying the Holocene Buried Landscapes maps (referred to below as T0123), i.e. geological profile-type mapping as developed at the Geological Survey (RGD)[58] and profile-type mapping[59] and architectural mapping[60] as developed at Utrecht University (that echoes through in many municipal landscape archaeological maps in the Dutch coastal plain).

The map series described here is not the first national-scale palaeogeographical map series[61] showing the evolution of the Netherlands' coastal plain, but it is the first such map series that has been systematically produced and that is explicit in considering erosion/preservation issues. The map combination and mapping integration potential of the current digital era (2015) and broad professional demand for geological-geomorphological maps that communicate integrated knowledge regarding landscape *and* subsurface, called for a syncing of the map products from all these schools.

Thus, the 'Prediction in Layers' called for a map product covering the coastal plain buried landscapes was an opportunity for Utrecht University (UU), TNO - Geological Survey of the Netherlands (TNO-GSN) and Deltares to work on map production solutions that would achieve such syncing. Overcoming critical issues regarding legend setup and naming units became an exercise in recognising and overcoming the differences resulting from the paradigms of the surficial and the buried Holocene landscape mapping schools in the Netherlands, especially when it came to the design of the production workflow.

56 E.g. Berendsen 2007; Van der Meulen *et al.* 2013.
57 Maarleveld, Ten Cate & De Lange (eds.) 1977; Koomen & Maas 2004; Alterra 2006.
58 Geological map sheets, e.g. Westerhoff; De Mulder & De Gans 1987; Verbraeck 1984.
59 Berendsen 1982; Berendsen, Törnqvist & Weerts 1986; 'geomorphogenetic mapping'.
60 Berendsen & Stouthamer 2001; Gouw & Erkens 2007; Cohen *et al.* 2012.
61 Vos 2015 mentions Pons & Wiggers 1959-1960 and Zagwijn 1986 as precursors to the Vos *et al.* 2011 (v1) and Vos & De Vries 2013 (v2) map series. See also Vos & De Vries 2017: this volume 3.2.

3.4.2 Materials and Methods

The buried landscape maps and palaeoDEMs[62] were produced in a digital workflow carried out in GIS (developed in ESRI ArcGIS 10). This workflow was fed with existing digital map data, notably those of the 3D geological mapping programme at TNO-GSN (GeoTOP national scale 3D modelling[63]), datasets from UU palaeogeographical research (Delta Evolution[64]) and the Netherlands in the Holocene map series[65] (produced by Deltares, TNO and RCE).

After prototyping the methodology, the eventual series of technical steps was stored in a series of scripts. These scripts can be re-executed and thus not only document the production steps in coded statements, but also make the production process reproducible. The full digital product consists of the newly created maps (T0123 shapefile and a set of palaeoDEM grids) with standard layout files, and of the sets of scripts (ESRI ArcMap Toolsets) and input maps (i.e. copies of their live versions at UU and TNO-GSN). In other words, both the maps and the production methodology were solicited output in this project.

The input maps are referred to below as base maps, and the output product T0123 as a derived map. The approach using base maps and derived maps was previously deployed for reconstructive mapping of the Rhine-Meuse delta. The approach was pioneered between 1998 and 2012, when a single base map of channel belts was developed to generate a derived-map time series of river network development.[66] In 2013-2014, the approach was used to generate predictive archaeological maps for embanked flood plains in ten time slices as derived maps, from a base map of floodplain age between river and dikes.[67] Over the period 2011-2016, the suite of base maps was expanded to cover the Netherlands' coastal plain outside the riverine area too, introducing base maps holding information on pre-deltaic valley landforms, tidal channel belts, intertidal areas (wadden), areas of supratidal cover (salt marsh), and fluvial natural levee complexes. The main purpose for the expansion, had been to generate palaeogeographical time series as interactively interrogatable and reproducible derived maps.[68] The current project is however the first to create derived map products combining several base maps obtained from multiple institutes.

The design of the map-production workflow involved conceptual decisions besides technological steps. These decisions were responses to issues such as how to code things and what landscape zones to map explicitly, and what to merge and map only implicitly. The technological steps were practical execution rules, such as what polygon(s) to select, copy, intersect, merge and relabel. Some of the conceptual and technological solutions were predetermined, i.e. intrinsic to the process of incorporating information from the base maps and the systematics in them as decided upon in past studies. Examples are the lithostratigraphical system in TNO-GSN's geomodelling and the age encoding system in the UU palaeogeographical GIS approaches. The conceptual and technical decisions thus also addressed the question of the extent to which existing UU or TNO-GSN coding and workflow should be used, and from which point to tap in and append new scripts.

This section describes the workflows for 1) derivative mapping of the geomorphological zonation of buried landscapes (past geomorphology) and their erosion status, and 2) the palaeoDEM construction from combining 3D geological mapping information with accommodation space 3D interpolations (past elevation).

3.4.3 Buried Landscape map production and legend setup

The workflow to calculate the T0123 map and associated palaeoDEMs (Fig. 2) comprises a long series of logical steps, completed in parallel paths. The first path covers the mapping of landscape zonations, the second the mapping of erosion status, and the third the production of the palaeoDEMs (section 2.3). Throughout the workflow, the paths use the same input map data. Both mapping paths comprise long series of actions that involve selecting features from multiple input maps, extracting them from the input files, storing intermediate recombined results per time slice and converting their encoding.[69]

For the landscape maps, the final step of the workflow is to merge the partial results on

62 DEMs are Digital Elevation Models, also known as digital terrain models, often for modern surfaces but equally for buried surfaces. PalaeoDEMs are DEMs for past situations. The term is used in various earth surface modeling and palaeo-environmental reconstruction user communities.
63 Stafleu *et al.* 2012; Van der Meulen *et al.* 2013.
64 Cohen *et al.* 2012; Pierik, Cohen & Stouthamer 2016.
65 Vos *et al.* 2011, Vos & De Vries 2013; Vos 2015.
66 Berendsen & Stouthamer 2001; Berendsen 2007; Erkens 2009; Cohen *et al.* 2012.
67 Cohen *et al.* 2014.
68 Pierik, Cohen & Stouthamer 2016, in prep.
69 Cohen *et al.* 2017a,b.

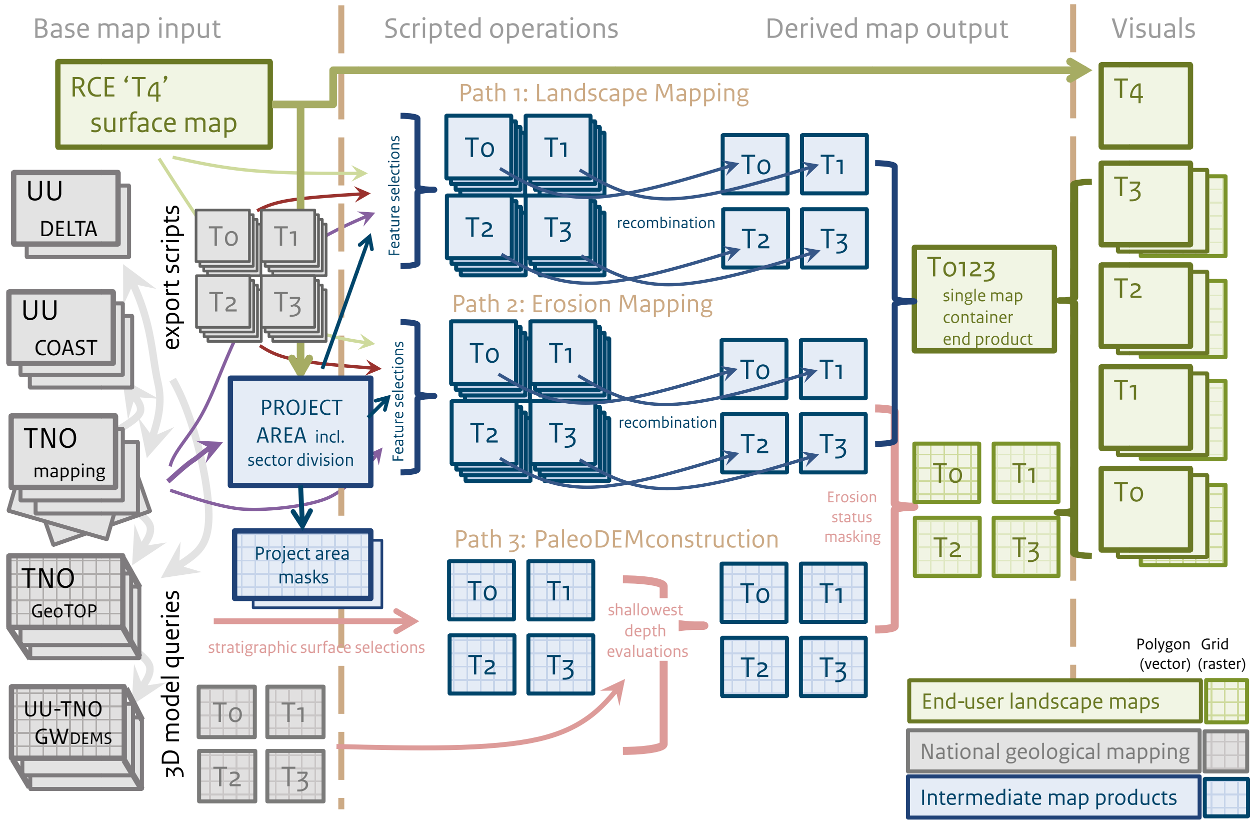

Figure 2 Flow diagram of the production of the buried landscape maps and palaeoDEMs: base map input, processing paths, output data files and visuals.

landscape mapping and erosion zonation and store it in a single polygon mosaic in digital map format, which is the end product. Each polygon in this digital map holds encoded information stored in a series of attribute columns (nine in total, see below). To visualise the series of maps, the legend is recycled through these attribute columns, i.e. for each successive time slice, the legend is applied to the following attribute. All map visualisations for each time slice are thus based on one and the same parent file.

A first single attribute *H_B_HFD* is used to distinguish the regions[70] that share similar buried landscape development over the period under consideration. Next, the attributes *LZ_0, ..1, ..2* and *..3* hold the information on landscape zonation maps for the T0, T1, T2 and T3 cycle. Similarly, the attributes *T0.., T1.., T2..* and *T3_EROD* hold the information on erosion status. For this purpose, the LZ.. fields have numeric values between 1 and 45, whereas the attributes in the ..EROD attributes have numeric values between 1 and 4. The *H_B_HFD*, LZ.. and ..EROD attributes together are the 1 + 2 x 4 = 9 attribute columns referred to in the previous paragraph.

The legend for landscape zone display uses a uniform polygon fill colour scheme and encoding in the LZ.. field. The colour scheme and numeric encoding are shared[71] with those used on the RCE-T4 map (its LSCPZONE field; see Table in Smit and Feiken).[72] The landscape zone encoding covers, for example, alluvial ridges (#24), salt marshes (#29), beaches (#32), types of peat land (#26, 43, 44, 45), types of inland dune (#13, 14, 23, 40).

The legend for erosion status uses half-transparent overlay signatures in black-and-white (Fig. 1, Fig. 3). Anything preserved retains the landscape zone legend colour, anything partially reworked a hatch overlay signature, and anything fully eroded is masked out - based on the values of the ..EROD attribute. This field has no equivalent in the RCE-T4 map and the numeric scheme has been introduced for the

70 Cohen 2017. Regions labeled #51-60, adding to regions 1-26 in RCE-T4.
71 LZ#1-38: Rensink *et al.* 2016; LZ#40-45: Cohen 2017.
72 Smit & Feiken 2017: this volume 3.5: their Table 3.

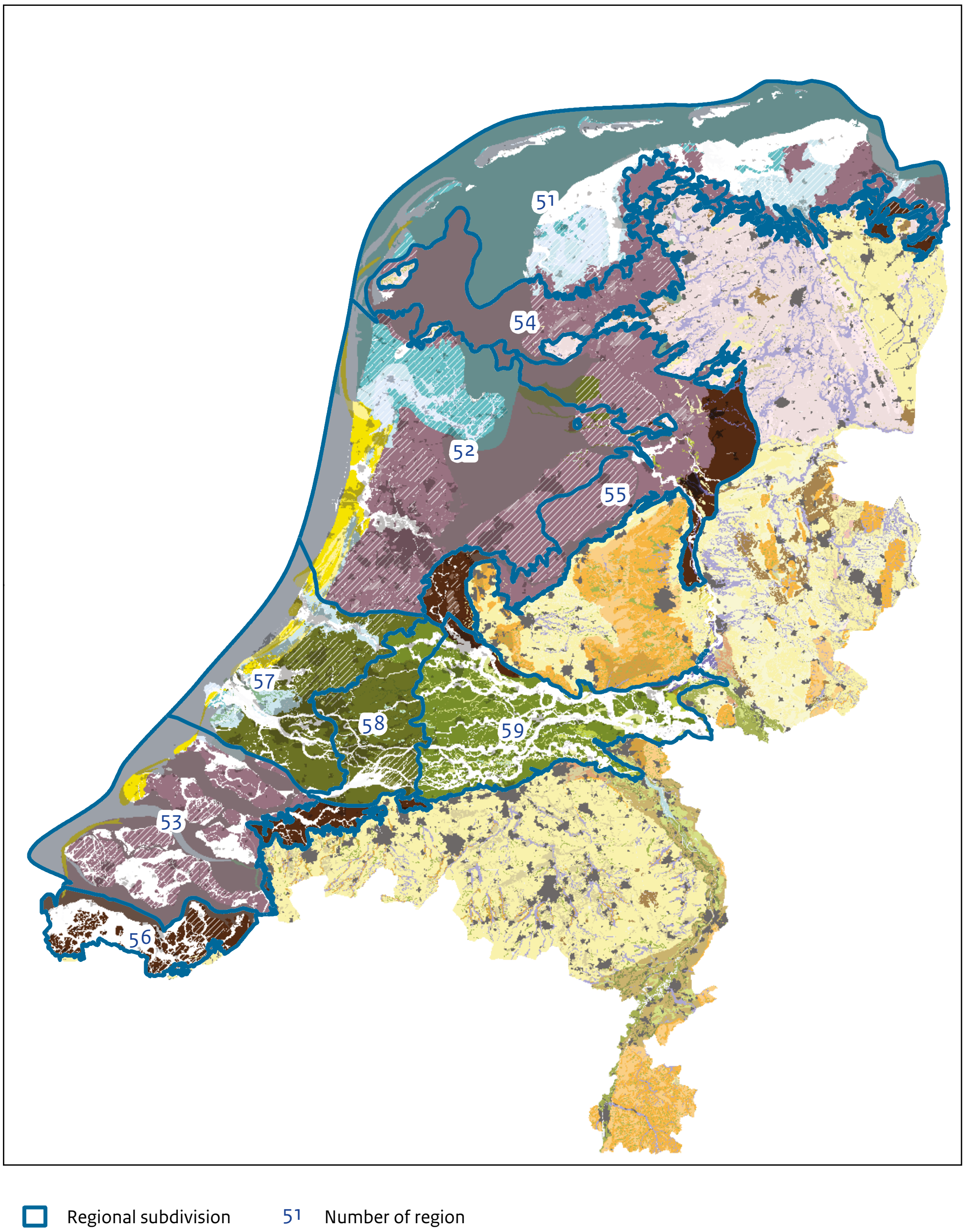

Figure 3 Buried landscape mapping for time slice T2: regional subdivision in nine sectors (blue outlines, #51-59), landscape zonation and erosion status. Full series in Figure 1. Landscape zonation legend same as archaeological landscape map (see Rensink *et al*. 2017, this volume 2.4). White masking and hatching: eroded, resp. partially eroded land surface area.

buried landscape part of the Prediction in Layers project specifically. The four classes in this legend indicate whether in more recent times the landscape has 1) been preserved, was 2) partially eroded / shallowly reworked, 3) fully eroded / intensively reworked, or 4) was never a terrestrial surface.

Workflow steps and overcoming conceptual problems

Designing the technical workflow for the buried landscape maps, involved the following actions:

1. Collecting and selecting the input data (TNO, UU, Deltares) for the project.

2. Defining the T0123 project area, as a selection of regions (*LSCPHFDEEN*) from the RCE-T4 map: part of the Netherlands buried in the Holocene.
3. Manually inspecting and partially updating the input data and RCE-T4, checking for inconsistencies and where feasible fixing them (synchronising).
4. Defining and manually encoding (polygon labelling) a regional subdivision of the project area, resulting in nine sectors/regions, differing in the nature and timing of gross Holocene development (Fig. 3).
5. Defining and manually encoding (polygon labelling) an *a-priori* blanket landscape zone and erosion status value, for each region and time slice.
6. Determining the order in which to process and combine input data in the automatic procedures (honouring stratigraphic order, honouring time slicing)
7. Sequentially executing 'feature selection' and 'attribute calculation' steps, per input data set, per time slice, for landscape zonation, for erosion status.
8. Combining the above prepared partial data, in the correct order, using 'Union', 'Combine' and 'Dissolve' operations – resulting in the T0123 shapefile.
9. Preparing layout and legend files to correctly display maps per time slice. The layout and legend design in GIS discloses the integrated map content, and allows for interactive inspection and export of graphics. As such, this is a prototype data viewer, of direct use to GIS-trained professionals and our way of transferring the product to developers of the Archaeology Knowledge Kit portal (see Discussion).

The above steps encompass the selection, merging and conversion scheme for polygons that originally outlined subsurface geological features (i.e. bodies of deposits), and relabelled them to geomorphological features (i.e. landscape zones). This process of translation involved making conceptual design decisions as well as technical IT decisions, and when deciding on solutions the map maker weighs up various bits of knowledge. This includes knowledge of the original descriptions of sediments and the associated dating information (quality of the underlying data, understanding of past mapping practices), as well as knowledge of the successive depositional environments during the Late Glacial and Holocene epochs, essentially Quaternary geological textbook knowledge.[73]

The workflow design dilemmas that we encountered were not entirely new. They have been experienced by earlier authors in verbal, written and graphic translations, when they introduced landscape settings in words or print in reports, scientific papers, map sheet memoirs, popular books, animations and hand-drawn maps. The difference in this project is the extra step needed to capture the response to the dilemmas in strict decision rules and conversion schemes. In the earlier contexts, decisions and conversions were usually ad-hoc, while the issues surfaced when part of the map was processed (either on paper or digitally), and not necessarily followed up in a systematic way over the entire map area. Nor were they fully documented everywhere.

In this project, the rules and schemes were to function as instructions to a computer to execute the process as an automated workflow – ensuring that, once formulated, they would be executed consistently over the entire map area and would be written up. Solutions to dilemmas were not always implemented as procedures in the same step where the issues first surfaced. Possible ways of dealing with the dilemmas were explored during the prototype workflow design, and the most pragmatic was selected. This could be either a manual edit to a base map, or a code fix in scripts for the derived map calculations. Some of the dilemmas we came across are presented below by way of illustration. They are presented as questions and the answers are linked to the technical workflow steps.

Should we attempt automatic map production at all?
This was assessed at the very beginning of the project (Steps 1 and 2). Feasibility was judged to be good because the breaks between the four time slices for which buried landscapes maps were needed from an archaeological perspective matched moments in time known to have been distinct breaks in the coastal plain build-up from a geological perspective. This was especially important for the breaks between T0-T1 and T1-T2, time periods for which palaeogeo-graphical base maps that allow age-based selections are not as well developed as for the

[73] E.g. De Mulder *et al.* 2003; Wong, Batjes & De Jager 2007; Stouthamer, Cohen & Hoek 2015.

more recent time periods. The fortunate semi-synchronous matching of the archaeological and North Sea coastal sedimentary changeovers meant that TNO-GSN lithostratigraphical distribution maps could be used to supplement UU palaeogeographical mapping systems, so that the full project area for each of the time slices had suitable base map cover. It would not have been possible to split time slice T1 or T2 into shorter divisions and produce buried landscape maps consistently across the entire Netherlands, because no age-encoded base map for tidal systems is yet available for that time.[74]

How to deal with inconsistencies in input data from different sources?

Input data inspection and problem area identification was the first phase in the execution of the project (Step 3). Mismatches resulting from mapping inaccuracies could be fixed by correcting one of the base maps (and informing the owning institute about it). Mismatches that resulted from applying principally different mapping criteria were simply listed as to be dealt with at a later stage. Such issues were resolved in steps 6 to 8, either by selecting the feature from one input map only (other mapping ignored) or by selecting from all input maps (maximising the local feature areas).

How to partition the study area for buried landscape mapping?

In discriminating sectors/regions with similar buried landscape sequences (Step 4), we complied with established lithostratigraphical division schemes for the Netherlands and distribution maps based on them from shallow geological mapping. Applying three simple gross-scale architectural criteria (which can overlap) to the coastal plain area allowed nine adjacent sectors to be distinguished: 1) Seaward coastal plain sectors with T1 and/or T2 tidal sediments (four out of nine sectors are tidal, one of them fluvio-tidal). These are the regions with relatively thick, complex architecture with erosive and depositional landforms, where relatively large burial depths were distinguished from inland regions dominated by peat formation, where thinner, mostly depositional landforms and shallower burial depths are common (four other sectors, one of them fluvio-organic). 2) The Rhine-Meuse delta plain (three out of nine sectors are fluvial, one of them fluvio-tidal, one fluvio-organic, one exclusively fluvial) as characterised by freshwater clay deposition was distinguished from non-fluvial coastal plain sectors. 3) Coastal plain regions overlying Pleistocene areas with glacial till near the surface located in the Northern Netherlands (two sectors, one tidal, one organic) were distinguished from the rest of the coastal plain, which has a predominantly sandy Pleistocene substrate (the other seven sectors, whether tidal, organic, fluvial or combined). This ensured that coversand ridges and brook valleys on till plateaus, for example, with their particular hydrology and soil conditions, archaeological site taphonomy, types of gravel resources, etc., could be treated separately from those in sandy areas. Figure 3 illustrates the resulting partitioning for time slice T2, Figure 1 the consistency between time slices.

The nine-fold partitioning of the study area was helpful for the mapping of erosion status, not least because of the notion that the time slice T1 and T2 tidally-influenced part of the coastal plain is also the area where the Pleistocene substrate (T0 buried landscape) is found at the greatest depth, out of reach of erosion for all but the bottoms of the largest-deepest channels as we know them today. This means that the T0 surface could be regarded as beyond the reach of reworking from the channel systems (estuaries, alluvial ridges, rivers) appearing on the maps of T2, T3 and T4 in these seaward sectors, and thus relatively well preserved (Fig. 4), whereas in inland sectors these same rivers are known to have eroded the Pleistocene subsurface.

Specifically mapped features or envelope map units?

When legends of geomorphological maps are analysed, some units tend to be area-extensive landforms (e.g. flood plains, coversand plain), whereas others are smaller landforms recognised within them (e.g. alluvial ridges, coversand ridges). This is also the case in the RCE-T4 legend (and its parent the Geomorphological Map of the Netherlands). What often happens is that the smaller landform map units are explicitly mapped ('outlined'), whereas the area-extensive map unit is the remaining surrounding area ('enveloping'). The latter are the more suitable for a-priori coding (needed in Step 5) because in the later steps of the workflow (Steps 6-8) they will be replaced by feature selections drawn from

[74] Cohen & Schokker 2014.

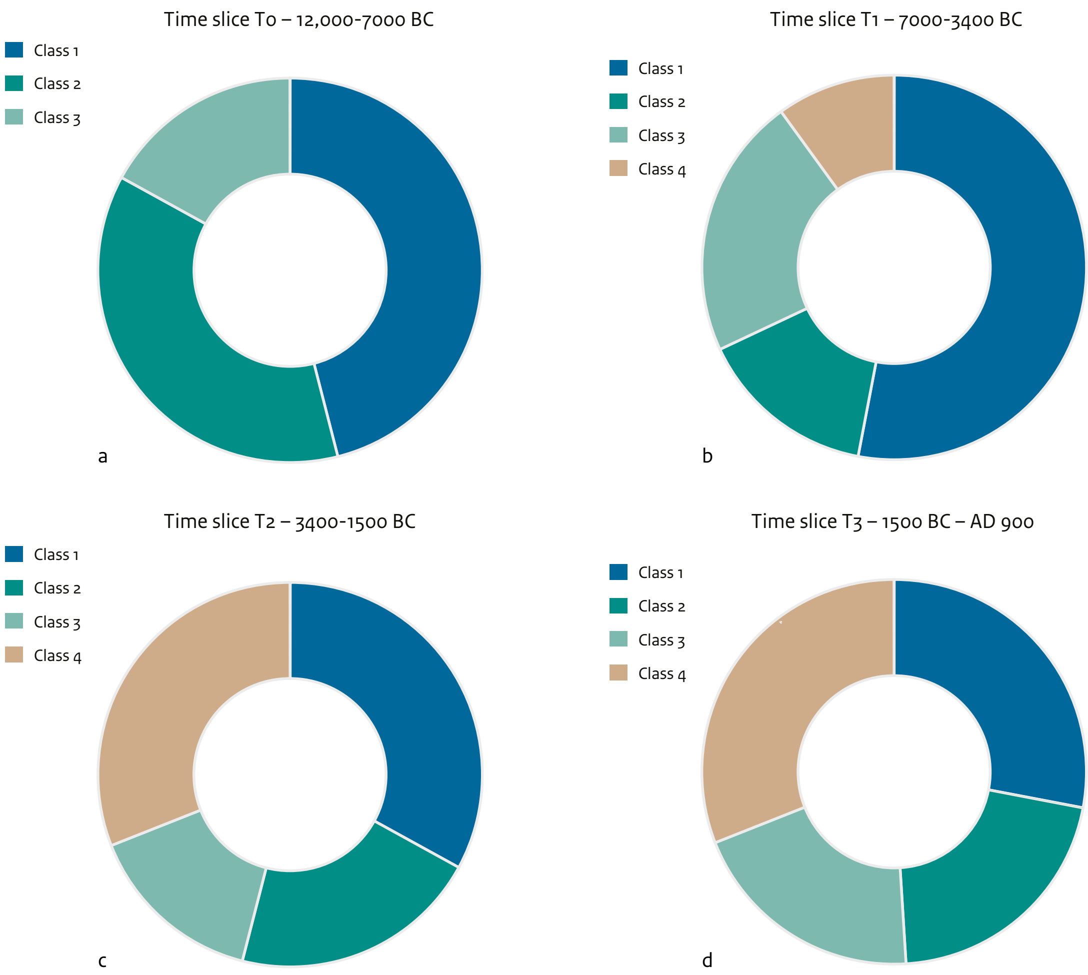

Figure 4 Pie charts showing coastal-plain total areal preservation statistics for buried surfaces from four time slices. Class 1: preserved land surface; 2: partially eroded / shallowly or surficially reworked land surface; 3: fully eroded / intensively reworked land surface; 4: originally subaquatic surface area. Depending on the application, class 4 is included or excluded in reporting statistics.

other input maps that contain explicitly mapped features. For example: the Rhine-Meuse valley and flood plain in each time slice is first considered a large 'flood plain' (Step 5; a-priori value for attributes in the *LZ..* field), and in Steps 6 to 8 ribbon-shaped smaller polygons of mapped channel belts are queried (from a base map storing their age, as time-slice dependent selections), and pasted into the map, replacing 'flood plain' with 'alluvial ridge' where appropriate. The filling of the erosion status attributes (*..EROD*) was based on the same principle.

In what order should the various features from multiple sources be assembled?

Here the decision was taken in two parts. First, the landscape-zone mapping and erosion status mapping were parallel workflows. This made it possible to work from the 'bottom up' in the buried landscape workflow (Steps 5, 6 and 7), honouring the aggradation process so typical of the Holocene coastal plains. Assigning landscape zones on the map to each successive, more recent, time slice starts with the assigned result for the previous time slice. Where appropriate, the workflow replaces landscape zones with those from the newly established environment, and where change has not yet happened, the previous assignment is retained. The parallel workflow for erosion status mirrors this. Here, it is the mapping of more recent features that should be considered when assigning preservation status to older surfaces, especially where channel and barrier system landforms are concerned ('top down'). However, dissection of a buried landscape surface is not the only form of erosion in the workflow: the loss of old coastal plain landscapes due to human reclamation is also included. Areas labelled with a certain reclamation history on the RCE-T4 map are copied over to the maps for T3 and T2 as areas with 'non-preserved' or 'disturbed' erosion status.[75]

How to individually classify landscape zones for time slices lasting millennia, in which multiple palaeo-environments are known to have succeeded each other?

This question is most relevant for time slices T1 and T2 (several millennia long, with several metres of relative sea-level rise occurring *during* the time slice),[76] but it applies in principle to all time slices. Note, however, that the question applies to landscapes in dynamic natural conditions (actively forming) that are not the landscape zones featured on the RCE-T4 map (whose legend covers the many forms of reclaimed and man-managed land as it has existed since time slice T4, but not the pre-drainage/pre-reclamation natural counterparts). Such active natural landscapes, by their very nature, represent diachronic states in a succession of landscape zones. Part of the solution was to introduce additional landscape zones, for use on the T0123 map, completing the RCE-T4 legend.[77] These landscape zones relate to actively forming coastal plain tidal and peat landscapes, which include stages of succession (as the individual descriptions make clear). Such active coastal landscape zones first developed in T1 and T2 (owing to relative sea-level rise) and in the area under consideration ceased to exist around the T3/T4 time slice break (owing to the scale of human impact), as explained in section 3.

How to individually classify landscape zones over consecutive time slices, while diachronic landscape change occurred across time slice breaks?

While the small number of time-slices (decided on at the outset) and the introduction of six active landform units (as a solution to the previous problem) reduced this problem, additional rules-based decisions were needed where the succession in the landscape zonation occurred across the time slice breaks. These were executed as late as possible in the procedure, in Step 7. When designing these rules (evaluations at polygon level), we considered and weighed up three issues: (i) 'What was the landscape zone at the end of the time slice?' (T1: SW Netherlands and Rhine delta: fairly silted-up tidal area, freshening and forming terrestrial surfaces early; NW and N Netherlands: slower to silt up, brackish open water rather than land at the end of T1); (ii) 'Which of the successive landscape zones existed the longest?' (during T1: intertidal environments seaward and reed peatland in inland sector; during T2: salt marsh and reed peatlands in seaward sectors, freshwater peats and emerging bogs in inland sectors); (iii) 'What was the landscape zone in the previous time slice?' and 'What will the landscape zone be in the next time slice?' (do not favour the same option in each of the time slices; tweak the age-based selection criteria so that river avulsion and marine ingressions that occur very late in T2 or T3 are transferred to the start of T3 and T4). In most cases the choice was relatively straightforward (go for supratidal or reed peat in T2 if the area was intertidal in T1), but in a few cases it was a decision that one may choose to alter in the future, for example after confronting the derived maps with archaeological distributions for the area and time period (by modifying the scripted rules and generating a new version of the map product).

What legend to use for erosion status when mapping the full coastal plain?

When working at the scale of an archaeological dig or a detailed cross-section reconstruction, one would typically observe and map erosion status as a Boolean phenomenon: the feature is either preserved or not. In national mapping campaigns, however, erosion status must be addressed over larger areas between patchy observation locations, on the basis of features that are mapped on a coarser scale. This means that the assignment is no longer based on direct observation, but on conceptual knowledge and appreciation of the spatial scale and depth ranges of erosion. Like the legend choices when mapping landforms and subsurface features (what phenomena to map individually, which to combine into bulk units), the legend choice for

75 Conversely, in the deep polder areas (Dutch: Droogmakerijen), tidal landscape features from time slice T1 were copied over to the surficial map (i.e., landscape zone #41 appears in the T4 map).

76 Van de Plassche 1982; Van Dijk *et al.* 1991; Van de Plassche *et al.* 2010

77 Overview in Table 3 in Smit & Feiken 2017: this volume 3.5.

mapping erosion status thus boils down to the mappability of features at current data availability.

Geological mapping and dating of the Netherlands delta and coastal plain explicitly resolves the larger landforms with erosive bases such as recent ingressive tidal channel sand bodies, fluvial channel belts, and beach barrier sand bodies. The depth to which these elements eroded at the time of their formation, generally exceeds 5 metres below the present surface / water level. Where these are mapped, one can thus presume full erosion of surfaces from the previous time slice. The known age-depth relations for relative sea-level rise and associated water table rise (see also section 2.3) place the surfaces produced in late T1, T2 and T3 within approx. 5 metres of the eventual coastal plain water table (modern base level; mean water level in rivers and estuaries). The surface from time slice T0 in the seaward sectors of the study area lies deeper than and can be considered unaffected by recent channel erosion. Thus far, the Boolean (Yes/No) approach to erosion status works.

Erosion due to human reclamation of wetland areas (oxidation of peaty topsoils in areas drained by ditches) is omnipresent in the Netherlands. It is known to have fully erased peat surfaces from time slice T3 in the parts of the coastal plain mapped as 'peat area' polders on the RCE-T4 map, and also to have deteriorated Iron Age and Roman Age drained surfaces that were flooded and buried beneath sediment in Medieval periods (owing to marine ingression and river avulsion). In the Northwestern and central Netherlands considerable expansion of lake, lagoon and wadden tidal areas occurred during time slices T3 and T4, not just centred around deep cutting channels as mentioned above, but also due to calving and diffuse erosion along shallow lake and lagoon edges. This fully erased terrestrial surfaces from time slice T3 (and also T2in the western Wadden Sea), but affected T2 and T1 surfaces more diffusely. Here the Boolean (Yes/No) approach no longer works. Given the fact that, at the scale of mapping, preservation was partial, a third, intermediate, 'fuzzy' class of erosion status was introduced.

The final system for encoding the erosion status of patches of coastal-plain buried former land surface thus considers these four classes: (1) has been preserved, (2) partially eroded/shallowly reworked, (3) fully eroded/intensively reworked, (4) never a terrestrial surface. The fourth and final class was introduced to deal with areas in the seaward fringes of the study area that, with transgression, became near-shore underwater landscapes and in some time slices thus neither represent a Pleistocene remnant landform nor fresh coastal plain land.

3.4.4 PalaeoDEM map series production

The palaeoDEMs are a calculated set of raster maps. They were created using a scripted workflow that combines features from multiple input raster maps.[78] The workflow used to create each of the DEMs comprises a path of logical steps (Fig. 2) that combines three types of source data (all in grid format):

1. Buried geological surfaces (GeoTOP-DEMs), such as 'Top Pleistocene', 'Top coastal barrier sand', 'Top Wormer Member tidal deposits / base of Holland Peat' – used in 3D national geological mapping programmes[79] at TNO-GSN. The elevations are expressed in metres +/- NAP.[80]
2. Interpolated palaeogroundwater levels (GW-DEMs), based on ^{14}C dates of peat where sampled at compaction-free positions from studies of relative sea-level rise and provision of accommodation space,[81] and calculated in the same environment and grid as the geological mapping [in m +/- NAP]. Near the coastline, the groundwater level correlates with former sea-level positions. In-land a gentle water table slope exists. The GW-DEM for the end of T3 (1000 AD) was manually reconstructed (correcting for T4 polder drainage effects that dominate groundwater levels today[82]). It intersects the Pleistocene surface along the inland boundary of the project area at an elevation of approx. 1 m NAP (outside the Rhine-Meuse delta). The GW-DEMs for T2, T1 and T0 were interpolated (3D trend fitting + kriging of residuals[83]). These intersect the Pleistocene surface at increasing depth and seaward position, inside the study area.
3. Masking grids, allowing the output palaeoDEMs to be restricted to those parts of the study area where a terrestrial

[78] Dambrink *et al.* 2015.
[79] www.dinoloket.nl/en; Stafleu *et al.* 2012; Van der Meulen *et al.* 2013.
[80] Netherlands' O.D.; 0 m NAP ≈ present MSL.
[81] Cohen 2005; Koster, Stafleu & Cohen 2016.
[82] Erkens, Van der Meulen & Middelkoop 2016; Rensink *et al.* 2016, 2017: this volume 2.4.
[83] Cohen 2005; Koster, Stafleu & Cohen 2016.

palaeosurface is reckoned to have survived – produced from the T0123 mapping described in section 2.1 above.

The scripts producing the palaeoDEMs first collect partial surfaces from the GeoTOP 3D model and aggregate them to a single composite palaeosurface. For example, the Top-Pleistocene geological surface, which is the composite GeoTOP-DEM for time slice T0, is derived for part of the area by mapping the presence of periglacial aeolian coversand (Boxtel Formation, particularly the Wierden Member), while for adjacent areas it is derived by mapping Rhine-Meuse valley deposits (Kreftenheye Formation, incl. Wijchen Member). For time slice T1 different selections of formations are processed by the scripts, and for time slices T2 and T3 yet further selections, including subdivision of channel systems into generations.[84] As in steps 1 and 2 of the vector mapping, this is also the step where the time-slice breaks are tied to mapped geological surfaces, a measure whose feasibility was assessed at the very start of the project. It was adjudged to be feasible because the archaeological scheme breaks happened to match distinctive coastal-plain geological breaks (between T0 and T1 and between T1 and T2).

The second step of the palaeoDEM production was to evaluate whether the geological mapped surface (GeoTOP-DEM) or the palaeogroundwater table (GW-DEM) was at the shallowest buried position (in m +/- NAP). Because the GeoTOP-DEMs were based on tracing lithological boundaries (e.g. the top of sand), in some areas covered they represent positive topographic terrestrial relief (coversand inland dune field undulations, flood plain terraces), whereas over other areas they represent bathymetric underwater relief (the bed of brooks and river channels, thaw lake bottoms). The former are land surfaces on which we locally find terrestrial archaeological sites (settlements, camps, burial sites, farmsteads, houses, hearths etc.) in styles, densities and distribution patterns that differ from one time slice to another. The latter are areas of water and wetlands during these same time slices, where channel fill and lake fill deposits collected (subaqueous muds and organics, peats).

The purpose of the PalaeoDEMs was to indicate from what depth onwards one should expect to encounter land surfaces (existing in the time slice in question), including wetland and local lake/channel fill deposits (accumulated during the time slice in question). Accordingly, the indicative metric stored in the PalaeoDEM is called Attention Depth[85] and calculated as: PalaeoDEM = MAX (GeoTOP-DEM, GW-DEM).

In the final step, the PalaeoDEMs for the four time slices were clipped using the masking grids, constraining the output to 1) the project area inland border, 2) the GeoTOP coastline model limit, 3) the areas mapped as 'preserved' or 'partially reworked' for the given time slice in the T0123 polygon map. The latter means that no PalaeoDEM value is provided for areas that have been subject to large-scale erosion – such as marine ingressions, recent fluvial channel belts, human extraction of peat, clay and sand (Fig. 1). The GW-DEMs do cover these areas.

3.4.5 Map series description

For each time slice, the maps present information on 1) the structure of the buried landscape (i.e. landscape zones) prior to burial and as burial was happening; 2) the depth of the buried landscape, as defined by the surface elevation at the beginning and end, and the water table at the beginning and end of the time slice; and 3) whether the buried landscape has been preserved.

Buried landscapes from time slice T0

In this first time slice (Fig. 1), coastal landscape zones (beaches, tidal flats etc.) are still absent from the study area, and terrestrial landscapes dominate. Sea-level rise from the Last Glacial Maximum low stand was ongoing at this time, but nowadays one needs to go to offshore areas to find coastal environments from the Late Glacial and the earliest part of the Holocene (west and east of Dogger Bank or between the cliffs of Dover and Calais).[86]

The landscape during T0 (12,000-7000 BC) consisted in part of landforms inherited from earlier ice-age stages. These include vast sandy terrace plains and boulder-clay till plateaus, and both are topped with sheets of local wind-blown coversand. Confluent networks of active streams dissected the older Pleistocene landscape. These networks follow directions inherited from earlier

84 Dambrink *et al.* 2015: their Fig. 3.

85 After Berendsen *et al.* 1994, who introduced this term in the context of mapping 'depth-to-sand' of alluvial ridges in the Rhine-Meuse delta plain. See also: Cohen *et al.* 2009.

86 It becomes feasible to map this area for this time slice using the same methods and legend as the maps described – Gaffney, Thomson & Fitch 2007; Peeters, Murphy & Flemming (eds.) 2009; Hijma *et al.* 2012; Peeters & Cohen 2014; Cohen *et al.* 2014; 2017; Moree & Sier 2015. This was not within the scope of this project, however.

Pleistocene stages, notably the deglaciation episode at the end of the Saalian ice age, approx. 150,000 years ago. These networks comprise larger rivers (Rhine, Meuse), smaller rivers (Scheldt, Vecht, Ems) and local rivers or brooks. As a result of snow-affected hydrology (spring melt peak discharge), the gradual thawing of permafrost (affecting infiltration of precipitation), and lag effects between climate change and vegetation development (gradual establishment of forest cover and soil A-horizons), the brook and river valleys in time slice T0 are relatively large in terms of their active width.[87] As time passed, this active width shrank. In the latter part of time slice T0 all rivers and streams had adopted a meandering style and concentrated their routing of discharge through single main channels.[88]

The land surface of time slice T0 is encountered at 10 to 20 metres below NAP in the most seaward sectors. Considerable regional relief (4-7 metres' depth difference measured cross-valley) separates the Early Holocene valley floor of the Rhine-Meuse and Noord-Holland main palaeovalleys from the interfluve coversands on terraces (SW Netherlands; central western Netherlands) and the till plateau (northern Netherlands). Considerable local relief is present owing to inland dune forms, which are especially well developed along river channels dated to this time slice (the sand in these aeolian dunes is sourced from bars in the then active rivers).

The buried surface of time slice T0 is fairly well preserved in the northern, northwestern, central and downstream parts of the Rhine-Meuse delta (Fig. 1), owing to the relatively great burial depth and wider spacing of dissecting channel systems. Some 60 to 80% of the original surface in these sectors has been preserved.[89] Surface preservation is considerably poorer in the southwestern Netherlands (dense network of ingression channels) and in upstream parts of the Rhine-Meuse delta (shallower burial depth; channel belts of delta trunk rivers, from multiple rounds of avulsion in relatively narrow flood plain), but still represents approx. 55% of the original surface (Fig. 4).

Buried landscapes from time slice T1

During this second time slice, transgression proceeded and coastal landscape zones (beaches, tidal flats, inland coastal plain peat etc.) established themselves from the west, while terrestrial landscapes persisted in the most inland parts of the study area. The sea level rose from below -20 m to about -5 m NAP during T1 (7000 to 3400 BC). In the western Netherlands, the maps show a still very recent barrier coastline, with a narrow beach and coastal dune zone and a broader back barrier tidal zone. In the northern Netherlands, the embryonic barrier coastline of time slice T1 lay further offshore and the map features only a tidal back-barrier zone there. The southwestern and central sectors show a peatland fringe on the inland side. The Rhine-Meuse delta is shown as a freshwater flood basin area in which new networks of rivers were established through avulsion[90].

Time slice T1 was a major aggradation period, so Pleistocene surfaces between 20 and 5 metres below NAP, which had been at the surface in time slice T0, were now buried in the coastal plain. This applies both to the depressions in the former landscape such as the Late Glacial and Early Holocene brook valleys and river channels, and to higher features such as inland dunes and coversand ridges. Depending on the location and moment in time, burial took place due to deposition of flood plain river clay, local peat formation, or subaqueous muddy tidal sediments.[91] In the inland zones, sedimentation and peat growth was generally able to keep pace with the provision of accommodation space, so multiple land surfaces of the period were preserved, stacked on top of each other. Even in the inland zones, however, fenland and swampy flood plain 'wetland' environments dominated. Landforms suitable as hunter-gather camping grounds could be found only locally in the delta and coastal plain. They included natural levees along channels and flanks of half-buried Pleistocene relief,[92] including the infamous T0-inherited inland dunes, many of which are rich Mesolithic and Neolithic sites.[93] Owing to the aggradational conditions, the buried surface of time slice T1 is fairly well preserved throughout the study area. If the western open water fringe is excluded from the calculations, preservation exceeds 50% of the original surface in the southwestern sectors and inland Rhine-Meuse delta (for the same reasons as discussed for T0), and exceeds 75% in the other sectors. This includes shallow subaquatic landscape zones such as intertidal environments ('wadden'), reed-rimmed lakes and other types of fen and marsh wetlands.

87 Vandenberghe 1995; Berendsen *et al.* 1995; Van Huissteden & Kasse 2001.
88 Hijma *et al.* 2009; Cohen *et al.* 2012; Isarin *et al.* 2015.
89 Cohen *et al.* 2017a,b.
90 Berendsen & Stouthamer 2001; Hijma & Cohen 2011.
91 Jelgersma 1961; Van de Plassche 1982; Van der Woude 1984.
92 Louwe Kooijmans 1974; Van der Woude 1983.
93 E.g. Hazendonk and Swifterbant cultures.

Buried landscapes from time slice T2

In this time slice, rates of sea-level rise had reduced greatly and the coastal configuration approached equilibrium conditions.[94] The sea level rose from approximately 5 to 1.5 m NAP during time slice T2 (3400 to 1500 BC). The beach barrier and low coastal-dune system widened considerably in the western sectors and amalgamated into a complex interrupted by estuarine tidal outlets only (all back barrier areas of tidal inlets lacking a hinterland river silted up, and the inlets themselves were plugged with beach barrier sand). In the northern Netherlands, the barrier system migrated to more or less the position it occupies today. The Pleistocene headland of Texel was subjected to wave erosion from the north and southwest, but still separated the back barrier tidal areas of the western and northern Netherlands. The Rhine-Meuse delta is shown as a freshwater flood basin area, with new networks of rivers (alluvial ridges) becoming established as a result of avulsion.[95]

Time slice T2 was a period of coastal plain stabilisation and consolidation (Fig. 3). Relative sea-level rise was only 3.5 metres and occurred at a more modest rate than before, meaning that tidal flood basins could silt up and lake and lagoon areas could be filled in with organics (reed fields and swamp forest expanding from the sides). Remaining inherited Pleistocene highs were buried under coastal plain and deltaic deposits, to levels slightly higher than contemporary open sea water levels, due to the gentle slope of the groundwater level and flood plains in the inland sectors of the study area.

Owing to the relatively shallow burial depth of the surface in time slice T2, the preservation of surfaces from this time period (with established Neolithisation in the coastal plain) is less complete than in time slice T1. Even with seaward open water fringes excluded from the calculations, preservation drops to below 35% of the original surface in seaward sectors, where the environments would have been dominated by difficult to dwell on salt marshes and peaty wetlands besides more habitable low dunes of the coastal barrier proper. In the inland sector of the Rhine-Meuse delta some 66% of the original surface is estimated to have been preserved, including considerable areas of alluvial ridge landscape. The central Netherlands sector (present-day 'Flevoland') and the perimarine sector of the Rhine-Meuse delta (today's 'Groene Hart'), have approx. 75% preserved, giving this sector the most complete preservation in this time slice.

Buried landscapes from time slice T3

From this time slice onwards, it is evident that the most recent phases of burial of coastal landscapes were not down to natural causes alone. The natural background conditions of a slowly sinking North Sea basin collecting sediment certainly continued to contribute, but from the Iron Age onwards sediment supply received from the Rhine and Meuse hinterland and human occupation strategies of the river[96] and coastal[97] flood plains had an increasing bearing on where and why old surfaces were buried (moderately, below approx. 1 metre of recent tidal or river levee clay) and where they were eroded (often completely, by channel bank and lakeshore migration processes).

Medieval storm surge ingressions (historic and proto-historic natural disasters), in particular, appear to be coastal system expansion responses to an excessive eagerness on the part of humans to occupy coastal land. This explains the relatively poor preservation of T3, T2 and T1 land surface area in the SW Netherlands (all <50%). The oldest ingressions are visible on the T3 map and occurred before organised embankment began. Storm surge ingression continued in time slice T4, interacting with dike raising and repair activities (see the relevant chapter). Surfaces from T3 are also poorly preserved in peatland areas of the northern (<60%), western (<50%) and central (<40%) sectors. This is due to ditch cutting and drainage activities in these areas since the end of time slice T3.[98]

The land surface is relatively well preserved in the Rhine-Meuse delta. The exception to this are zones immediately along rivers that were active during the last 2000 years, known to have been of strategic military and commercial importance in the Roman and Carolingian periods. Where these river branches continue to be active today, these zones have seen considerable erosion of T3 surfaces.[99] Where the branches were abandoned in Early Medieval times - a process that is associated with the final stages of increased deposition of overbank fines[100] - surface preservation in the Bronze Age, Iron Age, Roman Age and Early Medieval times is quite good, at 75%.

94 Hageman 1969; Beets & Van der Spek 2000; Vos 2015.
95 Berendsen & Stouthamer 2001; Hijma & Cohen 2011.
96 Willems 1986; Gouw & Erkens 2007; Pierik & Van Lanen 2017.
97 Vos & Van Heeringen 1997; Vos 2015; Pierik *et al.* 2017; This volume 3.2.
98 Vos 2015; Erkens, Van der Meulen & Niddelkoop 2016.
99 Willems 1986; Cohen *et al.* 2014; Pierik, Cohen & Stouthamer in prep.
100 Toonen, Kleinhans & Cohen 2012; Cohen, Toonen & Weerts 2016; Van Dinter *et al.* 2017.

3.4.6 Discussion

Use in archaeology

National-scale maps such as the landscape zone maps and palaeoDEMs in this paper compile abundant raw data on past landscapes (corings, datings, sections, specialist nomenclature) into a more accessible form. In previous cases, such maps have readily been used in applied (statutory), governmental (heritage management) and academic (thematic research) archaeology contexts[101] - regardless of what type of application the maps were originally intended for. Maps at a national scale are not intended to replace source maps at regional scale of the same actuality with legend and feature inclusion tailored to the region, but over time insights from regional mapping should percolate into national mapping, and vice versa.

The socioeconomic and governmental demand for such maps stems from the fact that the Holocene coastal and deltaic plain, especially the western Netherlands (Randstad) is densely populated and under constant pressure from infrastructural works, expanding urban and commercial activity, water management and so on. These works and activities are not restricted to the upper metres, but typically extend 5 to 8 metres below NAP, and even deeper in city centres (multi-storey underground parking), and in tunnels and harbours (navigation depth). Effective archaeological heritage management in the coastal plain must therefore consider the local age-depth relations of past landscapes when advice is given and building permits are issued (often at local authority level), and when prospecting for and analysing finds (in landscape archaeology, at a local to regional scale, e.g. for a municipality, province or city). This triggers decision-making processes that require information at the national, regional and local scales.

In the past, multiple map and cross-section products would need to be consulted in this process. Different sources would have to be used to answer questions on either 'past landscape', 'burial depth', or 'age of depositional and erosional features'. In some parts of the country this would be taken from dedicated regional studies, whereas in others it could be derived from national mapping products. The new maps provide a summarised entry point for such an exercise. The split landscape maps feature for subsequent periods may be a novelty to many local users. For parties dealing with archaeological projects in many different parts of the country and involving many different local authorities, the uniform legends of the buried and surficial landscape maps in the Predictions in Layers suite should eventually prove beneficial, however. After a period of using them as new products, shared experiences of the maps should speed up the process of starting up new local projects involving renewed comparison (or put more firmly: confrontation) with the national maps. Viewed in this light, perhaps the legend schematics, rather than the map visuals, might become a standard.

This mapping project was launched in response to the need for digital maps as part of a portal interface to archaeological information at a national scale.[102] In the 'Archaeology Knowledge Kit' portal, users can browse and query the maps and click through to other types of information linked to them, such as pointers to regional literature and datasets and texts on best practice for given archaeological periods. Such entry-level usage is envisaged in applied, governmental and academic contexts. The downloading of the actual GIS-dataset and supporting documentation may allow the map products to be used for more advanced purposes by GIS-trained professionals in applied or scientific research project teams.

Diverse applications are envisaged at the local scale, with users comparing the mapping process with that of earlier maps at provincial and municipal (i.e. local authority) scale. As a product of the implementation of the EU Valletta Convention, first-generation maps of this kind produced in the 2000-2010s are in widespread use and form part of the local decision-making structure for building permits, for example.[103] Many local authorities are considering revising these maps on the basis of new insights and experience of their use for administrative purposes. The national maps (and their legend schemes) can be used as starting points for such improvements.

Intercomparison of the national maps and the local maps would be a logical step, both when it comes to advising parties applying for building permits, and for the officials dealing with the applications, as well as for local

101 E.g. Berendsen & Stouthamer 2001; Vos *et al.* (eds.) 2011; Cohen *et al.* 2012.
102 Lauwerier 2017: this volume 1; Smit & Feiken 2017: this volume 3.5.
103 Van Doesburg *et al.* 2017: this volume 5.

mapmakers. Intercomparison of the national and local mapping is likely to identify mismatches related to mapping errors or differences in conceptualisation, besides differences in scale and local data knowledge. Dealing with such mismatches and fixing those that are non-trivial will require consideration of the workload involved in updating, and how frequently this should be done. We attempted to reduce the former with an automated workflow (section 2). The latter will depend on the update cycles of the various base maps used, and on the level of archaeological usage and number of issues identified.

In addition to use at a local scale, the availability of systematically produced nationwide time-sliced landscape maps should be considered a great improvement in our ability to objectively assess landscape-archaeology relations. The potential for supporting such assessments with areal and other spatial statistics has been enhanced thanks to the uniform legend setup of the map and periodisation system, which actually provides a way of standardising such analyses. Spatial statistics will be useful for studying the distributions of actual finds, and how this may differ between regions and time slices (descriptive archaeology), as well as for defining and defending regional deviations from heritage management policy (predictive archaeology). Contributions elsewhere in this volume present further thoughts on archaeological applications.[104]

Use in earth sciences

The archaeological community are not the only users of the here described landscape maps and their underlying geological and geomorphological source maps. Other important users of the derived maps include engineers, water managers and ecologists, for example – and the earth science community itself is the prime contributor and user of the source maps. As said in section 1.2, in this age of increased digital data availability and computerized map production – synchronizing and integrating the information of the latest maps from different institutes is a constant quality management challenge, that the base map/derived map approach and scripted map production are GIS-methodological responses to.

Of course one can only start compiling derived maps once a suitable base map has been created (one cannot start calculating from zero), and one still needs to edit base maps and/or scripts to update the derived map (maintenance is not zero). The potential benefit in the use of base maps to produce derived maps lies in the fact that a single instance of creation allows multiple use (economical for the person creating and updating maps), improves the reproducibility of the mapping results (traceable by reading the calculations in the scripts), and prevents the unintended introduction of mismatches when one zooms in too far (unit boundaries on derived maps are exact copies of those on input maps).

In the case of the buried landscape map, the base maps that were available at the outset are updated as part of long-running programmes at TNO-GSN (national mapping / 3D modelling campaign) and UU (Delta Evolution research line) respectively. In this particular project, distinguishing between base maps and derived maps also helped formalise shared ownership and copyright on map products between the government and non-government parties involved. The scripted workflow and the T0123 output ownership have been transferred to the party that commissioned the study (RCE), while the input maps and the systematics behind them remain the institutional property of the parties that executed the project (TNO-GSN, resp. UU, Deltares).

One important property of the scripted production method is that it should allow for fairly fast execution of update rounds as far as generating time-sliced maps for the archaeological applications is concerned. One potential issue related to updates will be the revisions (partial or otherwise) of underlying base maps. The maintenance of base maps is partly covered in long-running national geological mapping programmes (TNO-GSN geological base map datasets) and over the past ten years academic and national-scale applied research project opportunities have emerged, generating additional funding (UU palaeogeographical base map datasets). If budgets continue to be allocated for the updating of geological and geomorphological base maps, updates of the time-sliced mapping will also benefit.

[104] Rensink *et al.* 2017: this volume 2.4; Smit & Feiken 2017: this volume 3.5.

3.4.7 Conclusion

A geological GIS-data recombination project produced a digital map that contains information on the Netherlands' former coastal and delta plain landscapes. The polygon maps are accompanied by a set of palaeoDEMs indicating the 'attention depth' for buried land surfaces and aquatic deposits. The user and/or interface developer can visualise the stack of maps in various ways, either in a desktop GIS or through the portal viewer. When used in this way, they are linked with other Archaeology Knowledge Kit products and activities.

The production workflow was stored in a series of scripts that document the map production process make it reproducible and maintainable, and lay the groundwork for the future release of updated map series. Technical production is a matter of combining and converting several geological map products and their legends, following a series of steps. In the methodological sections, this paper has highlighted conceptual dilemmas in the making of the maps. The production workflow is dependent on starting point decisions regarding the time slices (T0, T1, T2, T3, consistent with the periodisation system used throughout this volume), which were of unequal length and had breaks that matched important moments in the geomorphological evolution and resulting geological build-up of the coastal plain.

The conceptual decisions involved drawing a distinction between actively forming landscape zones and naturally fossilised and human-reclaimed landforms. The actively forming landscapes were needed to visualise transgressive coastal environments with dynamic tidal flats and organic wetlands undergoing successive development of marsh, fens, swamps and bogs. These types of landscapes dominate the buried coastal plains of time slices T1, T2 and T3. They buried landforms inherited from the Pleistocene which naturally fossilised owing to climate change (such as coversand dunes) and sea-level rise (buried valleys). A considerable proportion of the modern coastal plain landscape is a man-made reclaimed landscape. This is why, in the Holocene part of the Netherlands, the aforementioned 'Archaeological Landscapes Map' is fairly representative of the most recent archaeological period landscapes (T4, parts of T3), but conceals most landscape structures from preceding periods. Our additional buried landscape maps are therefore needed for the earlier periods (T0, T1, T2, T3).

Aided by the inclusion of the time-sliced buried landscape maps in the Archaeology Knowledge Kit portal, it is envisaged that the new national maps will be used in projects at the provincial and municipal scale. This is expected to generate topical feedback and drive a wish for future revision of the maps. In this respect, production and distribution of the maps is seen as a half cycle in a cyclical process of mapping improvement, with use and feedback comprising the other half. One important property of the scripted production method is that it should allow for fairly fast execution of update rounds as far as generating time-sliced maps for archaeological applications is concerned.

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3.5 Land Use in Layers. A digital insight into the complex occupation history of the Netherlands

B.I. Smit[105] and H. Feiken

Abstract

A web-based application has been developed to help professional archaeologists, policymakers and developers access the archaeological potential of a given area. Not every part of the Netherlands was used by humans in the same way during the different periods in the past. Insights into different types of land use in different periods is presented on the basis of four themes: settlement, burial customs, ritual practices, and the economy and infrastructure. Past activities are all related to some extent to the landscape of the time. The landscape features from these different periods that remain on or below the surface of the Netherlands have been modelled and archaeological information has been incorporated into the models. The models also indicate the depth below the present surface at which these buried landscape features lie. Knowledge of the depth at which archaeological remains might be present is very useful information.

Keywords: past land use, web-based application, desk-based assessment, modelling of past landscapes and palaeo DEMs

3.5.1 Introduction

A brief glance at the occupation history of the Netherlands shows that by no means all parts of the landscape currently visible and in the subsurface were used and inhabited by humans in the same way in the past.[106] Even in the dry Pleistocene areas of the Netherlands, settlement and use varied during the Holocene period. This was the result of cultural choices and developments, but also of water table rise and the growth of peat, as well as of desiccation and sand drift. This probably applies even more to the Holocene parts of the Netherlands, which were covered with fluvial and marine sediments as a result of structural water table rise caused by relative sea-level rise. Despite the rise in the water table, dry areas in this part of the Netherlands were inhabited and used in prehistory. Parts of these formerly dry regions were inundated and covered with sediment. Knowledge of the various uses of the accessible landscape in the past is vital when it comes to estimating the likely presence of archaeological remains in an area.

These days, most archaeological investigations in the Netherlands take place in the context of archaeological heritage management. Investigations are generally divided into a number of steps, the first of which is to assess the archaeological potential of an area. The desk-based assessment performed at this stage relies to a large extent on predictive archaeological maps.[107]

Archaeological predictions and predictive maps are a product of processual archaeology. This approach strongly emphasised reasoned generalisations about past human behaviour and prediction of the location of archaeological sites.[108] It was used from the mid-1990s onwards to produce nationwide predictive archaeological maps, three generations of which, known by the acronym IKAW, were published.[109]

As a result of the devolvement of responsibility for archaeological heritage management, most local authorities now have their own local or regional predictive archaeological maps, which they use in their spatial planning policy. This might be viewed as a reason to stop producing nationwide maps. However, given the specific Holocene development of the Netherlands, the associated occupation history and the fact that previous versions of predictive archaeological maps focused on predicting settlement locations, it would in fact be useful to produce more refined and layered national overviews. This would provide a framework for the fragmented information currently found on the many local authority maps that exist.[110] Finally, there has long been a desire to provide information on the depth at which subsurface archaeological remains are likely to be found, certainly in the Holocene parts of the country. This aspect was indeed emphasised in the plan of action drawn up in response to the evaluation of the Archaeological Heritage Management Act.[111]

In short, considering the above, it was decided that a new, nationwide predictive map should be produced. This 'map' represents a break

105 Corresponding author: b.smit@cultureelerfgoed.nl.
106 Louwe Kooijmans *et al.* 2005.
107 Van Doesburg *et al.* 2017: this volume chapter 5; Deeben & Smit 2015.
108 Van Leusen & Kamermans 2005.
109 Deeben, Hallewas & Maarleveld 2002; Deeben 2008; Deeben & Smit 2015; Willems 1997; Van Leusen & Kamermans 2005.
110 Van Doesburg *et al.* 2017: this volume chapter 5.
111 De Bruijn (ed.) 2012.

with the past, as the new version does not predict the density of sites in a particular area. Instead, it gives a qualitative impression of land use there. It is also entirely digital, a web-based application known as *Land Use in Layers*, in which users can request information how an area was used in the past and the predicted depth of archaeological remains. They can then 'translate' this information into archaeological predictions, using other (regional, local) knowledge, maps and information sources too, of course. This application, available via the www.archeologieinnederland.nl portal, offers users information that can be used to draw up a specified archaeological prediction during a desk-based assessment, the first step in the archaeological heritage management cycle.

3.5.2 Goal of the Land Use in Layers project

The goal of the Land Use in Layers project was to build an application that provides insight based on archaeological knowledge of past land use in specific areas of the Netherlands. The application presents this information for landscape units throughout the country, with the exception of water and parts of built-up areas. The information can be used to form an initial idea of the archaeological potential of an area. Land use is described and categorised by period and theme. The aim is to alert users to the possibility of archaeological remains by presenting a generalised impression of land use in the past. The intention is not to provide an exhaustive account of all knowledge available on a particular area and period. The impression of land use describes how humans used specific parts of the landscape in the past, and what activities they performed there. In short, it focuses on cultural use in the past. It is not a description of the archaeological characteristics (prospection characteristics) of the area.[112]

3.5.3 Basic principles

Grouping of archaeological periods and activities

To offer information covering the entire country in a single application, a number of parameters and basic principles were set out at the start, to bring together, integrate and generalise the enormous variety of archaeological and landscape information available. Firstly, the periodisation of the occupation history of the Holocene was simplified into four periods (hunter/gatherers and early farmers, early farming societies, late farming societies and state societies, Table 1).[113] This simplification was based on similarities and differences in subsistence methods in the past, and the nature of the archaeological remains from the different periods.

The different types of activities performed in the past have also been summarised into four land use themes: settlement, burial, ritual practices and economy and infrastructure (Table 2).[114] These themes allow a generalised but more or less comprehensive overview of activities in the past to be presented.

Relationship between human habitation and landscape

Since human behaviour depended in part on the opportunities afforded by the landscape, and in order to provide differentiated information on past land use for the whole of the Netherlands, we decided to relate this information to landscape units.

Studies have found a relationship between the morphology of the landscape and use of the landscape by humans in both the past and the present.[115] The geomorphology (form) of the substrate and its characteristics in terms of soil fertility, water permeability and accessibility, as well as proximity to water, elevation and moisture levels, determined to some extent what humans were able to do.[116] The natural landscape cannot be regarded simply as a backdrop against which human behaviour took shape; there is a continuous dynamic relationship and interaction between humans and the landscape. There is therefore a relationship between land use and geomorphology, and thus an association between archaeological remains and landscape units.

However, erosion and sedimentation can cause landscape units to disappear or be covered, along with the archaeological remains they contain. From the point of view of heritage management, the only relevant fact is where archaeological remains are located today, not where they may have been in the past.

112 This may be added in the future.
113 Groenewoudt & Smit 2017: this volume 2.2; 2014.
114 Rensink & Van Doesburg 2017: this volume 2.3; 2015.
115 *Inter alia* Louwe Kooijmans *et al.* 2005; Peeters 2007; Van Beek 2009.
116 Rensink *et al.* 2016.

Palaeogeographical reconstructions and insight in geogenesis have been used to gain an understanding of why morphological units have disappeared or remained preserved. They also help us understand the occupation history of the Netherlands, and they can help explain human behaviour in the past. Explaining human behaviour has less priority when it comes to managing the archaeological heritage; it is more important to be able to conclude what type of archaeological remains might be present. During this project information on the development of the landscape in the past, in the form of geogenesis, was used to present an overall impression of land use. Landscape on the geomorphological map were used to relate this impression to the landscape. They have been incorporated into the Archaeological Landscapes Map.[117] Landscape units that are no longer visible, which have been covered by Holocene deposits and lie in the deeper subsurface, were used in this project to describe land use in earlier periods.[118]

3.5.4 Landscape zones as basis for impressions of land use

The landscape zones on the current surface have been defined on the Archaeological Landscapes Map.[119] Landscape zones in the subsurface were defined and modelled in the framework of this project by Utrecht University's Physical Geography Department, TNO Geological Survey of the Netherlands and Deltares (UU/TNO/Deltares).[120] The Archaeological Landscapes Map is based mainly on the geomorphological map and describes the information in the top 1.2 m of the soil. It therefore represents virtually all the archaeology one can expect to encounter in the Pleistocene parts of the Netherlands (mainly the northeast, east and south).[121] Some of the archaeology in the Holocene parts of the Netherlands (mainly the north, west and middle of the country) lies deeper, however. UU/TNO/Deltares have reconstructed the spread of buried landscape zones and developed palaeoelevation models (palaeoDEMs),[122] using available data on the subsurface, most of which comes from boreholes, national geological maps and subsurface models such as the model of the Rhine-Meuse delta.[123] To model the subsurface landscape zones, data on the subsurface were combined with data on and insights into the age of deposits and insights into the geogenesis of the landscape.[124] The maps generated for four different time periods to predict the type of landscape, and indicate where the landscape is not likely to be present now because of later erosion and other impacts. The unique aspect of this new set of maps lies in the fact that they

Table 1 Overview of classification into archaeological periods.*

Number	Period group	Timescale
I	hunters, gatherers and early farmers	12,000-3400 BC
II	early farming societies	3400-1500 BC
III	late farming societies	1500 BC-AD 900
IV	state societies	AD 900-present

* In accordance with Groenewoudt & Smit 2014.

Table 2 Overview of classification into themes.*

Themes	Description
Settlement	all land use activities and archaeological remains related to the domestic sphere
Burial	all land use activities and archaeological remains related to dealing with the dead
Economy and infrastructure	all land use activities and archaeological remains related to economic activities and transport
Ritual practices	all land use activities and archaeological remains related to cosmological and spiritual practices

* In accordance with Rensink and Doesburg 2015.

117 Rensink *et al.* 2017: this volume 2.4; 2016.
118 Cohen & Schokker 2014; Cohen *et al.* 2017a: this volume 3.4, 2017b, c; Dambrink *et al.* 2015.
119 Rensink *et al.* 2016
120 Cohen *et al.* 2017a: this volume 3.4.
121 This applies to virtually all archaeology from the Late Palaeolithic to the present. Archaeological remains from the Middle Palaeolithic may lie deeper in some cases. Given the specific character of the buried archaeological resource from the Middle Palaeolithic, however, and the relative scarcity of finds from this period, it has been decided not to include this resource in this project.
122 Cohen *et al.* 2017a: this volume 3.4.
123 Cohen *et al.* 2012.
124 Cohen *et al.* 2017a: this volume 3.4; 2017b, 2017c; Cohen & Schokker 2014.

have been made according to a 'scripted workflow' method, so they are reproducible. This means that if new data become available on the subsurface new map images can be generated quickly and efficiently.

Besides insight into the landscape units that might potentially be present in the subsurface of the Netherlands, an indication of the depth at which they lie is also vital. To determine their depth, palaeoelevation models were constructed on top of the ground surface at a specific point in time, in this case the points in time used in the Land Use in Layers application. Information on the geology of the Netherlands has therefore been combined with data on sea-level and water-table rise during the Holocene. These datafiles were also generated by means of a scripted workflow.

As a result of these efforts by UU/TNO/Deltares and the RCE, we not only have a huge quantity of data and new map images, we have also defined and mapped 44 unique landscape zones to which information about past land use can now be linked.

The Archaeological Landscapes Map distinguishes 26 landscapes and 39 landscape zones. One example of a landscape is the coastal zone of the Netherlands, within which the following landscape units have been distinguished: salt marsh tidal creeks and gullies, salt marsh plains, beach barrier plains, beach barrier ridges and low coastal dunes and high coastal dunes. The same landscape zones were used where possible for the datasets produced by UU/TNO/Deltares. However, given the resolution of the subsurface data, it is not always possible to obtain a similar level of detail, and the subsurface contains landscape zones that do not occur at the surface. Five additional (less detailed) landscape zones have therefore also been defined for the subsurface maps: submerged inland dune base, wadden (mainly intertidal area), tidal channels (mainly subtidal area), reed marsh and fen peatlands and swamp and bog peatlands.[125] This means a total of 44 'unique' landscape zones have been defined for the maps (Table 3). These landscape units, in the form of landscapes and landscape zones, provide the basis for the archaeological information in the 'Land Use in Layers' web-based application.

3.5.5 Land use impressions: procedure

Archaeological information was added to the temporal and spatial elements, linking the occupation history of the Netherlands to the spatial dimension of the landscape. Such descriptions have been produced for various periods or regions in the past. Distribution maps and settlement models exist for the Stone Age. Similar models are also available for later periods of prehistory, though certainly not for all regions in the Netherlands. Figure 1 shows a schematic version of a land use model. Ideas – and also models – exist of where in the landscape settlements and burial sites from more recent periods like the Roman period and the Middle Ages are likely to be found. A generic impression of land use can be distilled from these models and descriptions. Together, all these elements provide an account of the occupation history of the entire country, and the whole of the Holocene.

The combined data can be used to produce a set of generalised and generic descriptions of land use in a certain period in a certain area: the land use impressions.

The focus has traditionally been on settlements, so development-led archaeology has a strong bias towards settlements. By focusing on land use in a broad sense, it becomes possible to consider other past activities performed by humans, creating a more differentiated picture of the past. It also provides an opportunity to focus on archaeological remains that generally receive little attention, such as those associated with infrastructure or ritual practices. Focusing on them gives us a more complete picture of the past. Considering land use in different landscape zones, including the zones that were less intensively used in the past addresses the distorted picture that has arisen from concentrating on areas where there is a high probability of finding archaeological remains, i.e. areas where the density of archaeological remains is highest.

The land use impressions distinguish between different, though sometimes related, activities in which people engaged in the past, and the locations where they did so.

[125] Cohen 2017; Cohen *et al.* 2017a: this volume 3.4; Cohen & Schokker 2014.

Activities
For each period and theme a limited set of activities that will have been performed in a landscape zone has been defined to provide input for the land use impression. The application shows these activities so that the user has an idea of which activities were performed in the past. The description of activities can best be compared with the 'rules' sometimes used in predictive models, such as: hunting for large game; availability of open water for fishing; burial generally occurs near settlement; fabrication of household pottery within settlement, storage of food within settlement, in houses and barns etc. An example of a set of generalised activities is presented below for late farming societies, on the theme of burial:

- construction of monumental graves (barrows, later graves of natural stone)
- creation of urnfields and cemeteries with aligned graves, partly along routes and/or near settlement
- animal burials (e.g. horses, dogs)

Location
The location of land use is important for the descriptions. Location is interpreted in two ways, and allows for further differentiation within the landscape zones, which is necessary to accommodate the variation in land use in the past. For example, one of the units is coversand ridges. The large coversand complexes in eastern Groningen and the southern Netherlands are however of an entirely different order than the small-scale coversand areas and islands in the Gelderse Vallei and the eastern Netherlands. The variation in coversand areas in the eastern and central Netherlands led to different patterns and development of settlements than those seen on the large coversand complexes in the southern and northern Netherlands.[126] Besides morphology, therefore, physical geographical developments in an area or region also helped determine the opportunities and limitations for settlement and use of the landscape by humans. The coarse sand ice-pushed moraines in the central Netherlands, for example, have a different settlement pattern than the ice-pushed moraines of Salland, which consist of finer

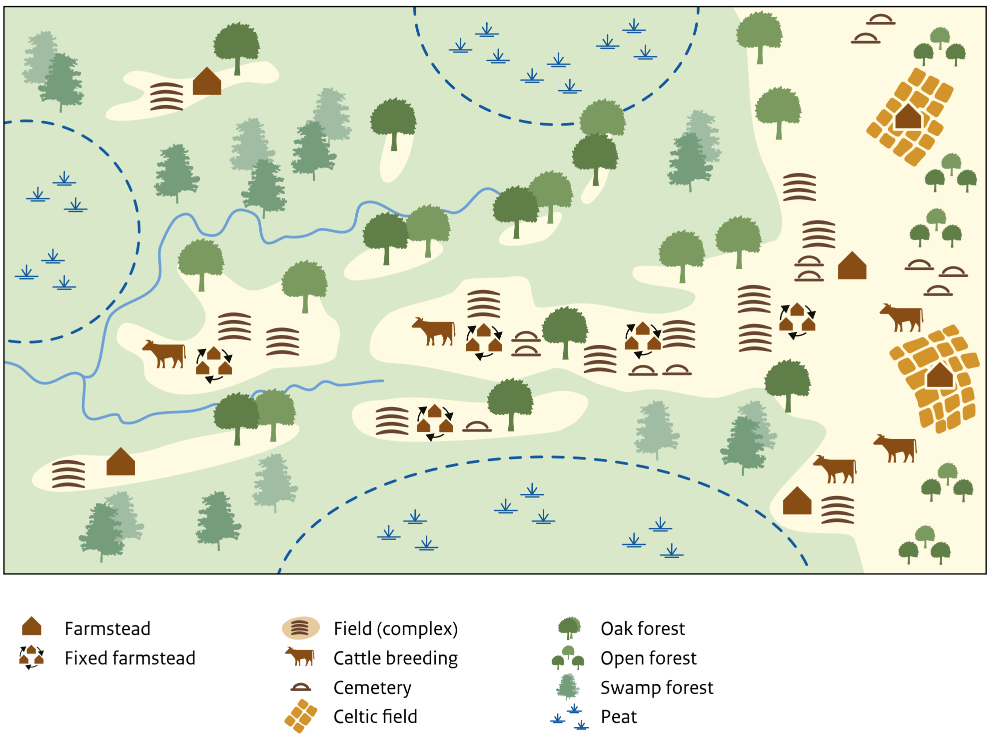

Figure 1 Land use model of occupation in the Gelderse Vallei (eastern Netherlands) in the Late Iron Age (after: Scholte Lubberink, Keunen & Willemse 2015, fig. 6.4).

[126] Van der Velde 2011; Van Beek 2009.

Table 3 Landscape zones distinguished for each period/map image (after Rensink *et al.* 2016; Cohen *et al.* 2017b).

Id number	Landscape zone (LSCPZONE / LZ)	Landscape zone (in Dutch)	Period and map (T number)				
			Onset Holocene	Up to 3400 BC	Up to 1500 BC	Up to 900 AD	Nowadays
			TO	T1	T2	T3	T4
1	hill slopes	hellingen	-	-	-	-	+
2	river terraces	terrassen	+	+	+	+	+
3	river terrace fragments	terrasresten	+	+	+	+	+
4	plateaus	plateaus	-	-	-	-	+
5	ice-pushed ridges	stuwwallen	-	-	-	-	+
6	outwash fans (sandur)	sandrvlakten	-	-	-	-	+
7	outwash plains	smeltwatervlakten	-	-	-	-	+
8	collapsed pingos	pingoruïnes	-	-	-	-	+
9	boulder clay plains	keileemvlakten	+	+	+	+	+
10	boulder clay ridges (flutes)	keileemruggen	-	-	-	-	+
11	coversand plains	dekzandvlakten	+	+	+	+	+
12	coversand depressions	dekzandlaagtes	-	-	-	-	+
13	coversand ridges	dekzandruggen	-	-	-	-	+
14	coversand ridges and inland dunes	dekzandruggen en rivierduinen	+	+	+	+	+
15	dry valleys	droogdalbodems	-	-	-	-	+
16	brook valleys	beekdalbodems	+	+	+	+	+
17	brook- and dry valley sides	beek- en droogdalhellingen	-	-	-	-	+
18	residual channels	restgeulen	+	+	+	+	+
19	floodplains and floodbasins	rivier overstromingsvlakten	+	+	+	+	+
20	embanked floodplains	uiterwaarden	-	-	-	-	+
21	silted-up estuary	verzand estuarium	-	+	+	+	+
22	dike-breach overwash fans	overslaggronden	-	+	+	+	+
23	inland dunes	rivierduinen	+	+	+	+	+
24	alluvial ridges and crevasse ridges	stroom- en crevasseruggen	+	+	+	+	+
25	gravel bars	hoge grindkoppen in holocene riviervlakte	-	-	-	-	+
26	reclamation-deformed peat lands	veenvlakten	-	+	+	+	+
27	reclamation-deformed peat bog lands	veenglooingen	-	-	-	-	+
28	salt marsh tidal creeks and gullies	kreken en prielen	-	-	+	+	+
29	salt marsh plains	kwelders	-	+	+	+	+
30	salt-marsh storm berms and creek levees	kwelder- en kreekruggen	-	-	+	+	+
31	tidal creek ridges / levees	kreekruggen	-	-	+	+	+
32	beach barrier plains	strandvlakten	-	+	+	+	+
33	beach barrier ridges and low coastal dunes	strandwallen en lage duinen	-	+	+	+	+
34	high coastal dunes	hoge duinen	-	-	-	-	+
35	lagoon fringe plains	Zuiderzee afzettingen	-	-	-	-	+
36	deep polders (former lagoon rim)	kusttalud	-	-	-	-	+
37	deep polders (former lagoon floor)	voormalige Zuiderzeebodem	-	-	-	+	+
38	deep polders (former lake floor)	droogmakerijen	-	-	-	-	+
40	submerged inland dune base	rivierduinvoet	-	+	+	+	-
41	wadden (mainly intertidal area)	Waddengebied / verdrinkend getijdengebied	-	+	+	+	- (+)
42	tidal channels (mainly subtidal area)	getijdegeul (subgetijdelandschap)	-	+	+	+	-
43	reed marsh and fen peat lands	verdrinkend veenlandschap (transgressief)	-	+	+	-	-
44	swamp and bog peat lands	verlandend veenlandschap (regressief)	-	+	+	+	-
45	deltaic lakes, reed and swamp peat lands	perimarien venig rivierlandschap	-	+	+	+	-

material. Similar factors also have a bearing on the boundaries of landscape zones. Landscape zones like coversand ridges and ice-pushed moraines which border on the rivers area have a different pattern of settlement and land use that the same landscape zones elsewhere. In early and late farming societies and state societies factors like soil fertility, the workability of the subsurface and mineral resources in the subsurface will have played an important role in the choice of locations for growing crops. Another aspect that is likely to have played a role in location choice is the presence or proximity of connecting watercourses, which may or may not have been navigable.

Association

It is important to realise that in many cases there is an association or relationship between activities and specific parts of the landscape. Hunter-gatherers, for example, camped mainly on higher dry ground, though they generally lived within 150-200 m of water (brook, fen) in 'gradient zones'.[127] Such associations, relationships, situations and nuances are described in the land use impressions. This approach allows for information to be provided free of any scale constraints. For example, if it is found that hunter-gatherer settlements are generally found on coversand ridges, a user can call up coversand ridges from other sources of landscape information, such as soil maps, satellite images etc., to apply the land use impression to those sources, too. Equally, if a 'new' coversand ridge is discovered in the field, the land use impression can be applied to it immediately. Another example is the possibility of extrapolating land use impressions to covered landscapes. Covered levees, for example, will be described according to their age and cultural use. A land use impression can act as a model or a null hypothesis for a landscape zone, which may or may not be covered, and thus serve as a basis for field research.

3.5.6 Sources used for land use impressions

The information used to compile the land use impressions is based on three sources:

1. synthesising archaeological research
2. key and reference sites[128]
3. distribution maps

Synthesising archaeological research is archaeological publications such as excavation reports for major excavations, academic papers, doctoral theses and compendiums.[129] Key and reference sites are thoroughly investigated sites that can serve as a reference for the user. In short, a site that serves as a model of a specific period or theme. The definition of key sites is: excavated and published sites situated within the landscape zone/landscape in question, which contain important information concerning the main period in question related to choice of location in the past and the nature of activities performed there (in terms of settlement, burial, economy/infrastructure and ritual practices). The definition of reference sites is the same as that for key sites, except that these sites are not in the landscape zone in question, but are in the immediate vicinity or in similar landscapes in other parts of the Netherlands, or in another country ('eye-openers').

In areas of the Netherlands where little excavation or synthesising research has been performed, distribution maps were used to gain an insight into the limited number of well-documented excavations. Data such as those in ARCHIS were used for this purpose.[130]

[127] Deeben, Hallewas & Maarleveld 2002. A gradient zone is an area where there is a transition from different ecological niches to another (cf Huston 1994).
[128] In this study the term archaeological site is used for a find spot whose location, nature (assemblage type), date and size have been determined.
[129] The inventory performed in order to identify gaps in the archaeological knowledge for the national research agenda (Theunissen & Feiken 2014) was for example used.
[130] ARCHIS inventory, July 2015.

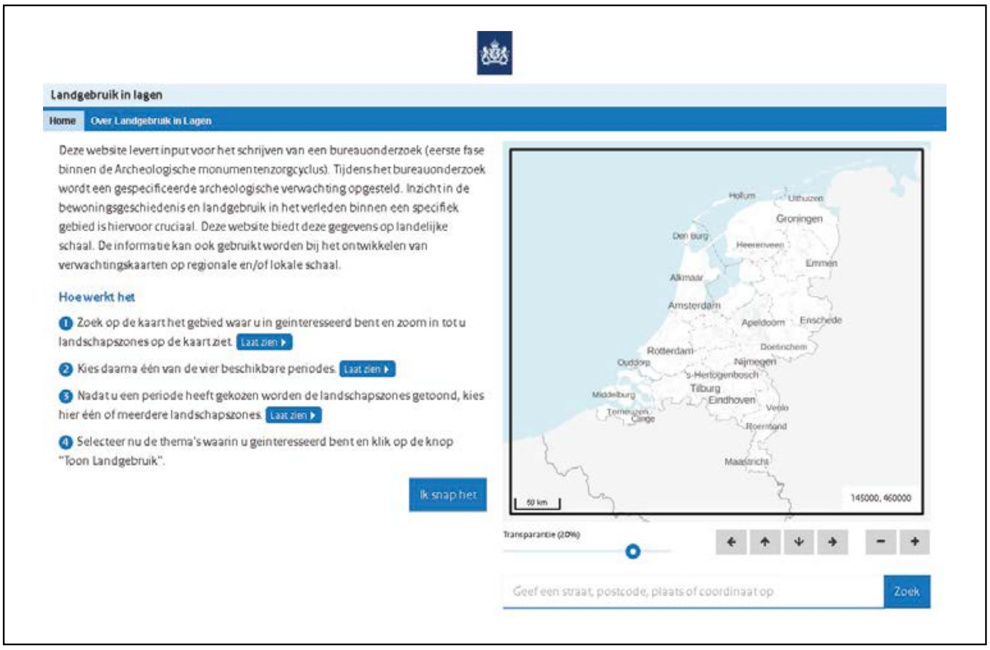

Figure 2 Screenshot of opening screen of Land Use in Layers application.

3.5.7 How the application works

When the user opens the application he or she is invited to zoom in on the map of the Netherlands to the desired research area and landscape zone. The user then chooses a period and theme by ticking the options. Once this series of choices has been made the application automatically presents the land use impression and references to further information sources pertaining to the area, landscape zone, period and theme (Fig. 2). Once the user has zoomed in sufficiently, a click on a landscape zone is enough reveal the depth of the zone in question. This information is presented in a pop-up.

Two examples of output from the application for searches for land use in a specific area, period and theme are given below. The examples show the land use impression for various landscape zones in different parts of the Netherlands, and for various themes and periods.

The first example concerns a land use impression from the Delft area (western Netherlands). The information requested pertains to late farming societies, the theme is ‘settlement’ and the landscape zone is ‘salt marsh tidal creeks and gullies’ (Box 1, Fig. 3).

The second example of a land use impression concerns the Assen area (northern Netherlands). The query concerns the theme ‘economy and infrastructure’ in early farming societies in brook valleys (Box 2, Fig. 4).

The user can use the information shown to estimate the archaeological potential of a particular area, and form an idea of what kind of archaeological remains might be encountered during any investigation undertaken.

Box 1 Output from the Land Use in Layers application: Delft area, late framing societies, theme 'settlement', landscape zone 'salt marsh tidal creeks and gullies'.

Description: development from individual farmsteads and self-sufficient communities towards communities with specialisation that also produced a surplus. Various raw material were processed within the settlement for use in households and workshops. Farms built (mainly of wood) on the edges of gullies and other higher parts of the landscape. Channels dug around houses and farmsteads. Wells dug on and around farmsteads and silos constructed for the storage of materials and food. In some cases, the land was raised before houses and barns were built on it. During the Roman period all kinds of buildings were constructed at strategic locations (watchtowers, *castella*), including at transport intersections (roads, waterways).

Activities performed during the late farming societies period:
- houses and auxiliary buildings built mainly of wood, in certain specific cases of stone (villas, palaces), on individual farmsteads or close to existing houses;
- water pits and wells dug in or on the periphery of settlements;
- channels dug in or on the edge of settlements to drain water from the settlement;
- various domestic chores and crafts performed within the settlement;
- pits dug for storage or waste;
- raised areas created (using materials like clay, peat, reeds) on which to build houses and barns;
- fortified and moated settlements and defensive structures with a specific and military function built (*castella*, watchtowers, fortresses), some at strategic locations, e.g. near transport intersections (roads, waterways).

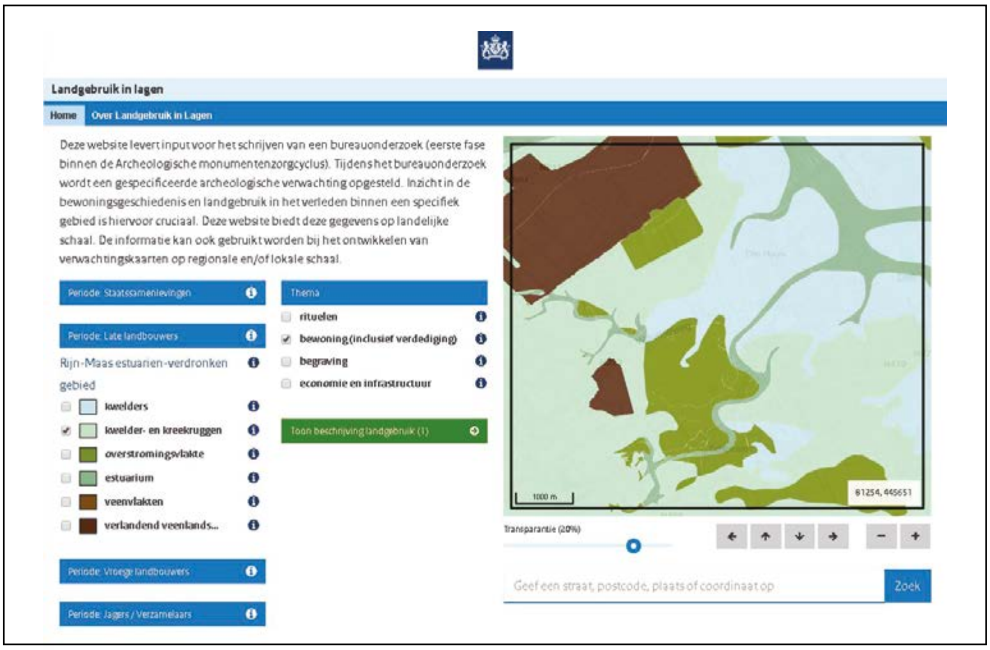

Figure 3 Screenshot of Land Use in Layers result of search for settlement theme in late farming societies period in the vicinity of Delft (western Netherlands).

3.5.8 Notes for users

The application provides information on a national scale. This naturally has implications for the level of detail presented. As a result of lower data density, the landscape units modelled for the deeper subsurface are not as detailed as the units that can still be seen at the surface.

The depth information is a conservative estimate of the level at which archaeological remains might be present. In other words, this will have to be investigated in the field if necessary. Finally, we should underline the fact that this application is only one of the many sources that can be used to assess the archaeological potential of a specific area. Examples of other sources, such as vegetation maps, palaeogeographical maps and disturbance data are discussed elsewhere in this volume.[131] Regional and local archaeological knowledge will also need to be used in order to form a good impression of what kind of archaeological remains from what periods are likely to be present.

3.5.9 Concluding remarks

The Land Use in Layers application is believed to be a valuable addition to the numerous tools available to archaeologists working in development-led archaeology. As we have said, this application is built on numerous building blocks, each one of which is likely to be further developed based on new archaeological and geological knowledge, and with the aid of user-generated comments in the future. As a result, the application will also be extended and improved in the years to come.

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[131] Van Beek *et al*. 2017: this volume 3.3; Van Beek, Gouw-Bouman & Bos 2015; Vos & de Vries 2017: this volume 3.2; Lascaris & Huisman 2017: this volume 4.4.

Box 2 Output from the Land Use in Layers application: Assen area, early farming societies, theme 'economy and infrastructure', landscape zone 'brook valleys'.

Description: the boulder clay region has little relief. Settlements and cemeteries were established on higher features in the landscape (coversand and boulder clay ridges) connected by roads. The brook valleys that transversed the boulder clay region were used as transport corridors in prehistory, and the adjacent lower-lying areas will have been used as pasture and hay meadows. Fish could be caught in streams, and game could be hunted.

Activities performed during the early farming societies period:

- extraction of clay and loam for making pottery and sealing walls, for example;
- keeping cattle;
- laying fish weirs and traps;
- hunting animals;
- creating fords, trackways, roads and jetties in water or boggy depressions/peat bogs;
- Navigating waterways.

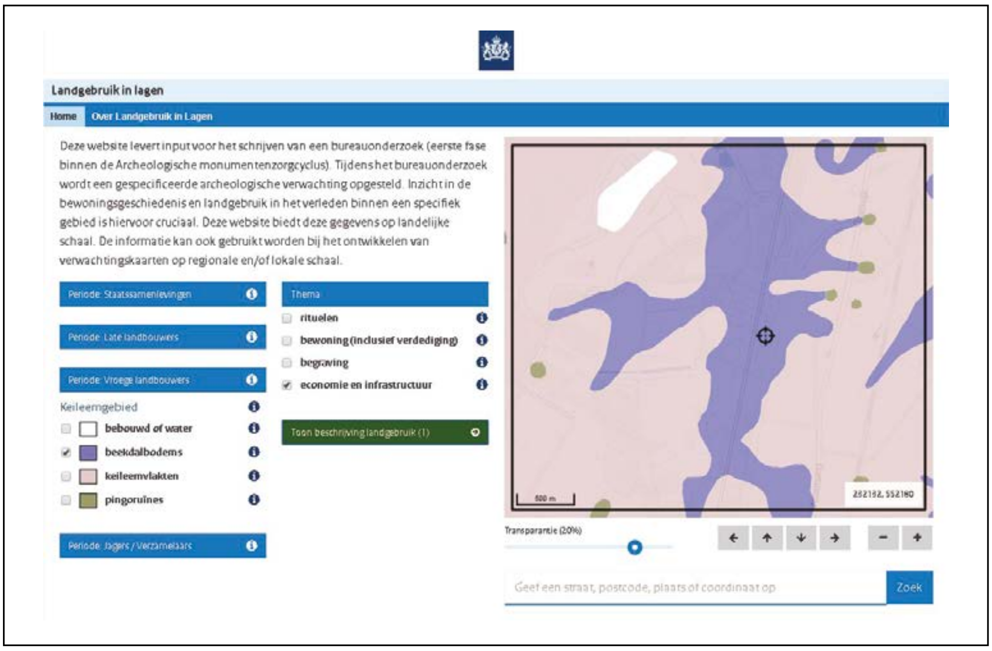

Figure 4 Screenshot of Land Use in Layers result of search for the theme 'economy and infrastructure' in early farming societies in the area around Assen (northern Netherlands)

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3.6 Modelling the 16th-century urban countryside. A zone of influence and interaction

H.M.P. Bouwmeester[132]

Abstract

In a pilot project, an attempt has been made to produce a predictive archaeological model for the urban periphery (or 'urban countryside') based on the historical town maps produced by Jacob van Deventer in the second half of the 16th century. The maps of Alkmaar, Deventer and Nijmegen have been analysed, and all the different built sites featured on the maps around the towns categorised. By far the largest category are houses and windmills. As well as the nature of the sites, their distance from the town walls has also been determined. On this basis, the urban countryside can be divided into three zones. The further the distance from the town, the lower the diversity and number of archaeological sites. Access to the sites via roads and waterways was also an important factor in choice of location.

Keywords: predictive model, Jacob van Deventer's map, built structures, Medieval town, urban countryside

3.6.1 Introduction

Many local authorities in the Netherlands have a predictive archaeological map that indicates which zones in the municipality have an archaeological prediction, and how likely it is that archaeological remains are situated there. In some cases, this has been specified in terms of type of find spot and period. Local authorities can use predictive models to develop specific policies on how to manage the archaeological heritage within the different zones. Good predictive models are therefore important because they considerably enhance the probability that find spots will be preserved *in situ* or *ex situ*. They are also important for society, as they allow unnecessary costs of archaeological investigations to be avoided. This applies to sites both within and outside the built-up area.

A predictive model predicts the location of archaeological find spots or objects in an area based on a sample of that area, or on basic principles underlying human behaviour.[133] Dutch archaeology has a long tradition of predictive archaeological models. In the 1990s the State Service for Archaeological Investigations (ROB) produced the first Indicative Map of Archaeological Values (IKAW).[134] Archaeological data were linked to features of the landscape to provide the basis for a predictive model indicating the likely presence of archaeological remains. The picture was refined with the development of IKAW2 and IKAW3.[135] The IKAW was made for use on the scale of entire landscapes – too large to be used at provincial and local level. Local and provincial authorities therefore developed their own predictive models. After the devolvement of responsibility for archaeological heritage management, the number of local and regional predictive maps grew rapidly. A digital model was recently devised that can categorise predictions in terms of landscape zone, period and depth.[136]

A predictive archaeological map consists of a topographical base layer on which zones with a certain level of probability of containing archaeological remains are indicated. The probability is determined by combining data from various sources: soil maps, geomorphological maps, elevation maps, historical maps and archaeological data (ARCHIS).[137] This is used as a basis for pinpointing which areas within a municipality have a low, intermediate or high probability of containing archaeological remains. The historic centres of towns are generally regarded as a single zone. Sometimes the peripheral zone around the town is automatically included. In other cases a separate prediction is made for this zone.

A predictive map shows areas where remains such as settlement features or cemeteries from a certain period can be expected. This prediction is often based on finds already made in the zone in question. Much more precise archaeological predictions can be given for remains from the historic periods – particularly the Late Middle Ages and Early Modern period – than for other periods, thanks to the greater availability of written sources. This applies in rural areas, but even more so in towns and their immediate vicinity. Nevertheless, many predictive models go no further than a very general model for these

132 Corresponding author: J.bouwmeester@cultureelerfgoed.nl.
133 After Verhagen & Whitley 2012, 52; Kohler & Parker 1986, 400.
134 Deeben *et al.* 1997.
135 Deeben, Hallewas & Maarleveld. 2002; Deeben 2008.
136 Smit & Feiken 2017: this volume 3.5.
137 ARCHIS is a national GIS database with details of all archaeological observations and excavations. Roorda & Wiemer 1992.

areas, such as a single zone encompassing the entire town in which remains of habitation, burials and economic and ritual practices can be expected. The reason for such general predictions lies in the idea that there are large differences between towns, so it is not possible to produce a specific prediction. The question is whether it is possible to produce a more specific prediction for historic centres and the zone surrounding them.

This study is a pilot project which considers whether patterns can be identified in the presence of archaeological remains around towns. From the late 19th century, in particular, old urban peripheral zones were built on as towns expanded. A large proportion of the old remains have therefore been disturbed or lie under current buildings. During this era of urban expansion, no structural archaeological investigations took place. We therefore know little about the archaeological potential of this zone. However, given that there was a close relationship between the town and the urban countryside, such areas could yield a great deal of historical information about the town itself.

The pilot project is limited to the urban countryside around three towns, in one specific period, the second half of the 16th century. The three selected towns are Alkmaar, Deventer and Nijmegen. The maps that Jacob van Deventer made of these towns in the second half of the 16th century have been analysed (Fig. 1). Now that the pilot project is complete, the study could be extended to other towns and to town centres themselves.

It is possible to some extent to create a predictive archaeological model for the zone surrounding towns. There is a direct correlation between distance from the town wall and the nature and number of sites. It is not however possible to determine precisely where in relation to the town and the landscape the remains in question are likely to be located, as there are too many variations in landscape, and in historical circumstances that dictated whether or not certain activities took place near a town.
This paper first explains the method used and the potential and limitations of the study. The results are then discussed.

3.6.2 Principles underlying the study

Urban countryside

This pilot project is limited to the urban countryside around three selected towns. This peripheral zone is the area immediately outside the boundary – usually a wall – of the town.[138]

How far this zone extends is difficult to define in absolute terms. The town would have had a major influence over this zone and the more distant countryside. In the past, residents of the town would own a lot of land in the surrounding countryside. In the mid-16th century, 25% of land in Holland was owned by town dwellers. If urban institutions are included, the figure rises to over 35%.[139] Residents of towns also owned capital goods like windmills and brick kilns. The town would also intervene in administrative matters in the countryside, attempting for example to impose restrictions on crafts and trades, such as brewing and weaving. The lower production costs and absence of taxation meant products were cheaper there than in town. To craftsmen and merchants in the town, this seemed like unfair competition.[140] On the other hand, however, towns themselves used cheap production in the countryside and in the textile industry urban manufacturers had goods produced in the countryside of Brabant (around Tilburg) and the eastern Netherlands as long ago as the 17th century.[141] Furthermore, villages in the vicinity were subjected to town law and the town's courts, and seigneurial rights over villages were purchased, subjecting them even further to the influence of the town.[142]

Various activities initiated by the town took place in the urban countryside. Renes divides these activities into two groups: '... urban activities removed from town but still dependent on it, and rural activities dependent on an urban market. The first group includes activities that require a lot of cheap space, such as bleaching fields and urban meadows. It also includes activities that may pose a hazard, such as leper homes and gunpowder factories, and businesses that cause pollution or unpleasant odours, such as fulling mills. The second group mainly comprises market gardens'.[143] Two further groups can be added. When a town grew rapidly new settlement clusters would form outside the

138 Renes 2008, 42.
139 Hoppenbrouwers 2002, 146.
140 Hoppenbrouwers 2002, 146-147; 't Hart 2004, 88-92.
141 Hart 2004, 92-94.
142 Hoppenbrouwers 2002, 148.
143 Renes 2008, 44.

walls for people who could not yet be accommodated within the walls. There might also be monasteries and church hospitals outside the walls, or inns for travellers arriving too late to enter the town.[144]

The close relationship between the town and its immediate environs is also reflected in the crops grown nearby. The countryside played an important role in feeding the town. It was not incidentally the case that the countryside could always supply all of the town's food. It has been suggested that towns had to specialise in order to import food via a trading network. Urban growth was not at any rate a direct result of trading the surplus produced in the hinterland.[145] Besides produce like grain, meat and dairy products, the hinterland could also provide raw materials for products manufactured in the town. Evidence of hop growing has for instance been observed in the countryside around Deventer and Zutphen.[146] It has been suggested that the hops were produced for the breweries in the towns. However, we cannot rule out the possibility that beer was also brewed in the countryside. The countryside not only produced for the town; the town also supplied products to the surrounding area, including merchandise or specialist products made in the town. Dung and urban waste were also transported out of town and used to fertilise fields or heighten the land.[147] The town therefore had close ties with its immediate surroundings.

After 1560 major changes occurred within the town boundaries. The Reformation began in the final quarter of the 16th century, causing many monasteries to disappear or change function. At the same time, the Eighty Years War against Spanish rule was in full swing. Towns became important fortifications in the defence of the Republic, and so became more involved in national politics. As a result, urban defences were adapted and expanded on several occasions, and towns and their immediate surroundings were exposed to the violence of war.[148] No large buildings were allowed outside the fortifications. However, urban allotments did develop outside towns. They can be identified archaeologically by the beds in which the crops were grown, and can clearly be seen in a view of

Figure 1 Map of Deventer by Jacob van Deventer (map: Jacob van Deventer).

144 De Kievith & Jacobs 2013, 280-281.
145 Lesger 1990; Lesger 2001; Brand 2012, 40.
146 Bartels 2006, 145-147; Groothedde 2008, 298.
147 Bitter 2009, 60-61; Bartels 2006, 141-142; Van Oosten 2013, 235.
148 Rutte & Abrahamse 2016, 192.

Deventer in 1615 by Claes Janszoon Visscher (Fig. 2).[149] Other structures can also be seen outside the town, such as a bread oven, wood sheds, millstones, a crane and the east side of a new rampart.

Technological developments also led to the appearance of industrial sites outside towns, particularly in the 19th century. The introduction of the *Vestingwet* (Fortifications Act) in 1874 meant many towns could expand, and housing and industry grew rapidly on the edge of these towns.[150] Fortifications were transformed into large parks, individual mills disappeared to be replaced by larger industrial complexes, residential areas and a station (Fig. 3).

The maps

Around the mid-16th century Jacob van Deventer surveyed and mapped a large number of towns in the Netherlands on the orders of King Philip II of Spain.[151] He measured the streets using chains, so the maps are very accurate. This applies particularly to the area inside the town walls, where there were many road junctions and forks. Outside the town, roads were mainly thoroughfares, and here the maps may deviate somewhat from reality. All kinds of buildings and structures outside the town can be recognised on the maps, which also show many special buildings, generally with their name.

The 16th-century maps of Jacob van Deventer are often regarded as a cartographic depiction of the Medieval town. In many cases the 16th-century layout of the towns was the same as in the preceding centuries, and the same applies to many buildings and structures, such as farms, churches, monasteries and windmills. The maps date from before the Reformation, so most churches and monasteries still appear on them. Of course there will have been local transformations in the course of the Middle Ages, the end result of which is shown on the map. Many towns underwent one or more expansions, and monasteries and other buildings appeared and disappeared. Certain activities, such as bleaching fields, are not always visible on the map. Nevertheless, the structure and variety of buildings, roads etc. on Jacob van Deventer's maps give a good impression of the character of the area in the preceding centuries.

Jacob van Deventer's maps therefore give a fairly accurate and complete overview of the town and its immediate surroundings in his time, making them an ideal source for this study. If archaeological observations had for example been used for the purpose, it would have created a highly distorted image. Many of the buildings and structures on the map have never been excavated, or even discovered.

The towns

By way of a pilot project, the town maps of Alkmaar, Deventer and Nijmegen were analysed. The maps were produced by Jacob van Deventer between 1558 and 1575. In 1560, these three towns had a population of 8000,[152] 7700[153] and 10,000[154] respectively. In terms of population, at that time Alkmaar was the twelfth biggest town in the country, Deventer the fourteenth biggest, and Nijmegen the ninth biggest. The largest town in the country in 1560 was Amsterdam, with a population of 30,000, followed by Utrecht with 27,500 and 's-Hertogenbosch with 17,500.[155] The results of the survey were randomly checked against maps of Utrecht, Zutphen and Delft to ascertain whether certain types of site had been omitted. This was not found to be the case.

This study examined what Medieval sites may be encountered in the urban countryside, on the basis of Jacob van Deventer's 16th-century maps. 'Site' refers to a collection of features and/or finds that together comprise the imprint of a specific activity in the past. This may have been a short-lived activity such as a burial, or longer-term activity such as habitation. All sites outside the town that were visible on the map were included. Each was given its own code, and processed in Mapinfo. Additional information was entered into an Excel table: the nature of the site, name of the town, location in proximity to geographical structures (roads, waterways), other sites in the immediate vicinity and the rough distance from the town walls.

The sites can be divided into four themes: habitation, burial, economy and infrastructure, and ritual practices.[156] This categorisation has been used across all time periods to interpret the remains of human activity. It is also used for the Middle Ages and the Early Modern period.

149 Profiel van Deventer, drawing by Claes Jansz. Visscher 1615. Collection of the Rijksmuseum Amsterdam (www.rijksmuseum.nl).http://hdl.handle.net/10934/RM0001.COLLECT.514416.
150 Rutte & Abrahamse 2016, 218.
151 Vannieuwenhuyzen & Lisson 2012, 5.
152 Lourens & Lucassen 1997, 54.
153 Lourens & Lucassen 1997, 71.
154 Lourens & Lucassen 1997, 25.
155 The figures come from an analysis of population numbers in Lourens & Lucassen 1997.
156 Categorised after Rensink & Van Doesburg 2017: this volume 2.3.

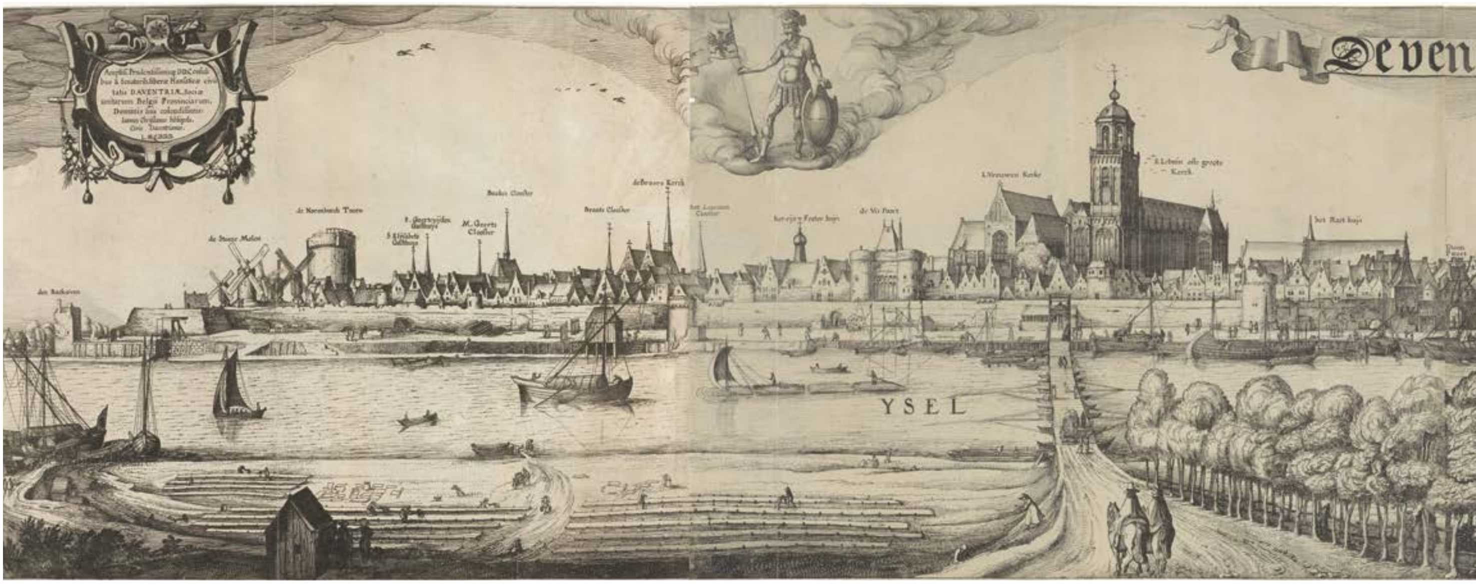

Figure 2 View of Deventer by Claes Janszoon Visscher (1615) clearly showing urban allotments (collection of the Rijksmuseum, Amsterdam).

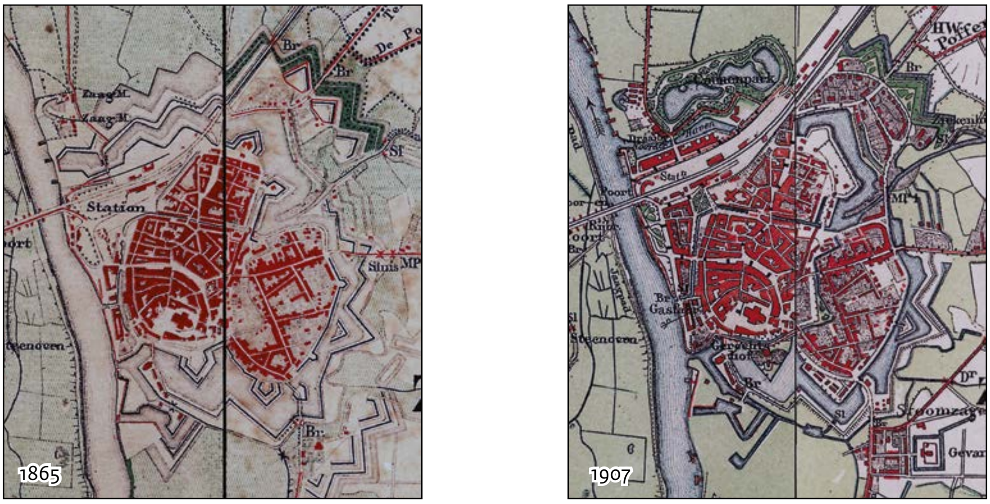

Figure 3 Two maps of the town Zutphen. Left: before the Fortifications Act (1874), right: afterwards. Outside the medieval town town parks appear, industry (for example a steam sawmill), residential quarters and a prison (map: Bonnebladen).

3.6.4 Results

Site types
A total of 13 different types of site were found on the maps (Table 1), some of which require further explanation. We distinguish, for example, between a house and an habitation zone. An habitation zone is a prominent clustering of buildings. In most cases, this represents urban construction immediately outside the walls of the town. A house is a site type that covers various types of building, but which cannot be identified as such on the map. These may be farms, tollhouses or hostels. A horreum (warehouse) was a place for storing crops. Some are isolated, while others form part of a larger cluster. The same applies to windmills. Deventer had both a tight cluster of

windmills and two clusters of horrea outside its walls. Crosses can also occur in isolation, or as part of a row, which may be stations of the cross, as has been found in Nijmegen.[157] A 'drying ground' is an area where there were racks over which sheets were laid to dry.

Number of sites

A total of 189 sites have been included and divided into 13 types (Table 1). A further two sites whose character is not entirely clear were observed on the map of Nijmegen. They were not included in the survey. Deventer clearly had more sites than Alkmaar and Nijmegen. Deventer also had the largest number of different types.

Analysis of the relationship between sites and roads did not produce any clear picture. A system of roads can be seen around the towns. The roads form a kind of web of routes that eventually connect with a number of through roads to the hinterland. Only a few roads seem to lead directly out of the town from the gate. Most outbound routes start with several roads that eventually meet. At this scale, therefore, it is difficult to identify main routes and secondary roads. A good example can be seen in the case of gallows. The gallows to the north of Deventer stands beside a road to the north, which runs parallel to the IJssel river. This appears to be a through road on the map, but the real road to Zwolle is further on; the road shown on the map eventually connects with it. The question is whether the road along the river was also a through road to the north, if the location beside the river was seen as more important, or if the site of the gallows could also be seen from the road to Zwolle. Houses, mills and horrea lie between main roads, but also sometimes beside the main road. It is not possible to demonstrate a direct link between roads and the location of sites, apart from the fact that all the sites are accessible by road.

The two largest categories of site are houses (57%; n=107) and windmills (19%; n=36). The other sites occur in much lower numbers (1 to 8), representing a proportion of 0 to 5%. In short, therefore, this survey suggests that if archaeological remains are found in the zone around the town, there is an approx. 57% probability that they will be houses (including farms), an approx. 19% probability that they will be from a windmill, and approx. 24% that they will represent another type of site. Some reservations apply, of course. The likelihood that a watermill will be found in the middle of a piece of land is for example 0%.

Number of sites by theme

To enable comparison with earlier periods, the various sites identified in this study were categorised into the four groups habitation,

[157] Gorissen 1956, 115.

burial, economy and infrastructure, and ritual practices.[158] Choices had to be made as to which sites should be allocated to which group. A tannery, for example, or a mill, can fall under either habitation or economy, as both combine a dwelling with a place of work. It was decided that crafts, and also mills and horrea, for example, should be categorised as economy. Monastery sites and gallows were placed in the ritual group. This means that 56% (n=97) of sites fall into the habitation category, 27% (n=47) into economy, 10% (n=18) into ritual and 6% (n=10) into burial (Table 2).

Distance from the town

In general terms, it was not possible to correlate the location of the sites with any particular distance from the town. The same type of site may be close to the walls or further away. Leper houses were not located immediately outside the town walls, though in Nijmegen, at just over 300 m away, the distance was not all that great. However, the leper house in Deventer was almost 1.5 km from the town wall. It is not therefore possible to draw any general conclusions regarding the distance of any particular site type from the town. One exception is pillories. They are all around 300 m from the town. This might be associated with the fact that these places were 'easier' for people to access than the boundary of the towns' jurisdiction, which is where the gallows generally stood.[159]

A comparison of the different types of site highlights a number of things (Fig. 4). Most sites are situated close to the town, within a radius of approx. 600 m from the town wall. Almost all windmills are for example found within this zone. Beyond this, there are some sites, though in much lower numbers, up to approx. 1300 metres from the wall. The density of sites is low beyond 1300 metres.

The above results allow the Medieval urban countryside to be divided into three zones (Table 3). The first zone, extending to approx. 600 metres outside the walls, has a relatively highly number of fairly diverse sites. It is the area immediately adjacent to the town. The second zone, between 600 and 1300 metres, has a much lower number of sites and lower diversity, though a relationship with the town can be assumed. This area is typified by the presence of different types of site and more habitation relative to the area beyond the 1300 metre boundary. Though this last area beyond 1300 metres (and up to 1600 metres) was under the influence of the town – the leper house would for example be located there – generally speaking the urban countryside ended here.

Table 1 The different types of site found in the three towns.

Type of site	Alkmaar (N)	Deventer (N)	Nijmegen (N)	Total (N)	Total (%)
Habitation zone	8	-	-	8	4
Gallow	1	2	1	4	2
Horreum	-	2 (zones)	3	5	3
House (incl. farm)	29	46	32	107	57
Castle	1	-	-	1	0
Church	-	2	2	4	2
Monastery	3	-	-	3	2
Cross	-	1	5	6	3
Leper house	1	1	1	3	2
Pillory	-	1	5	6	3
Drying ground	-	1	-	1	0
Watermill	-	5	-	5	3
Windmill	10	13	13	36	19
Total	**53**	**74**	**62**	**189**	

158 Rensink & Van Doesburg 2017: this volume 2.3.
159 Baas, Mobach & Renes 2005, 50.

3.6.5 Discussion

Jacob van Deventer's maps are highly detailed, in terms both of their scale and of the buildings and objects depicted. Nevertheless, they remain mid-16th century observations that were made for a purpose entirely different from that for which they have been used in this study. This therefore limits the source's usefulness and colours it to some extent. Van Deventer undoubtedly made choices as to what he would include, objects may have been overlooked, and this is merely a snapshot. Changes that occurred before or afterwards cannot be seen. Furthermore, the features on the maps have been examined and interpreted for this study. Some buildings or structures can be clearly identified and interpreted, particularly if they are named on the map. Things are less clear when it comes to some other buildings and structures, however. Some cannot be interpreted at all. With structures like the crosses near Nijmegen interpretation only proved possible after further research.

In addition, the archaeological characteristics of the sites could be more complex than initially thought. For example, one might wonder where, in the case of places of execution, the dead were buried and whether the different types of execution all took place in close proximity, or at different locations. The maps appear to suggest the latter. In the case of houses, what was the function of the different buildings visible on the map? Are they farms, or do they include buildings that were used for other purposes, such as ferry houses, tollhouses and inns? Such information cannot be derived directly from the map. Apart from information about a few structures outside the town, we have remarkably little archaeological information about the relationship between the nearby countryside and the town. Were crops grown for the town there and, if so, what were they? What kinds of crafts were practised in the area around the town? These are questions from the new National Archaeological Research Agenda (version 2.0) and a number of 'Valetta Harvest' projects.[160]

It is not always easy to categorise sites into the four thematic groups habitation, burial, economy and infrastructure, and ritual practices. In the Middle Ages there was greater specialisation in terms of activities that were much more commonly practised in the home in prehistory. A tanner produced leather, and a cobbler made shoes from it. This type of specialisation caused an exponential increase in the variety of sites. This is enhanced even further by the fact that sources of information such as

Table 2 Relationship between the four different groups of sites.

Group	Number	%
Habitation	97	56
Burial	10	6
Economy and infrastructure	47	27
Ritual practices	18	10
Total	**189**	**100**

160 Groenewoudt *et al.* 2017: this volume chapter 7; Eerden *et al.* 2017: this volume chapter 8.

archived documents and maps are available, alongside archaeological evidence. This makes it easier to identify different types of sites. When it comes to categorisation into groups, one therefore has to choose whether one type of site – a cobbler's home and workshop, for example – is best categorised as habitation or as economy. A similar problem occurs with monasteries. These are communities where people lived and engaged in certain crafts and religious activities, or care of the sick. It was decided to categorise monasteries in the ritual group, but this is of course open to question. Some degree of uniformity is desirable to allow comparison with earlier periods, though this can produce a somewhat artificial picture.

In this study we have tried to define the boundaries of the urban countryside slightly more precisely on the basis of the occurrence of sites. It was initially thought that the urban countryside consisted of a single zone. The information in this study suggests, however, that there is a divide between sites close to the town and sites slightly further away. Windmills, for example, mainly occur close to the town. The density of houses is also higher in the first zone than at a slightly greater distance from the town. The outer boundary of the urban countryside can clearly be seen at approx. 1300 metres. The density and diversity of sites beyond that is very low. It would be interesting to explore how the urban countryside related to the territory of the town. Gallows often stood at the edge of the town's jurisdiction, but does that mean that the urban countryside, the outer periphery of the town, also ended there? Initial impressions suggest this was not the case. This study is a pilot project involving three towns. Further analysis of more towns might help focus and test this initial picture.

3.5.6 Conclusions

The pilot project involving three towns has produced useful results. No demonstrable relationship has been observed between the location of sites and the landscape, apart from the fact that the sites are all easily accessible by road, and some also by water. Sites are distributed throughout the area surrounding the town and their distribution does not seem to follow any universal laws. There is however a

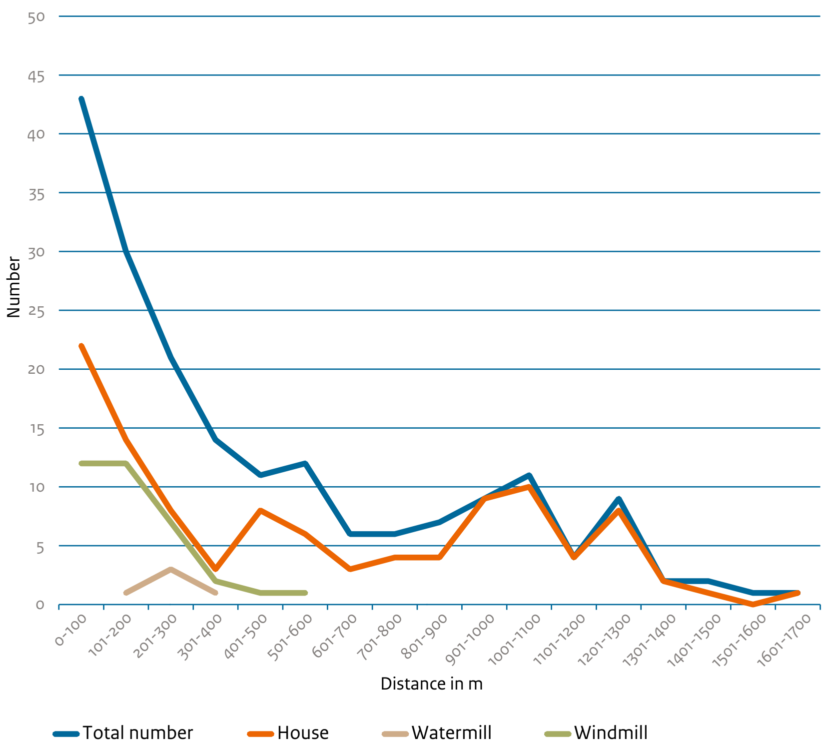

Fig. 4 Distance (in metres) from the town wall of all sites situated outside the town, and the distance of houses and mills to the wall.

Table 3 The three zones of the urban countryside with the number of sites found in each zone.

Zone	Site type	Number	Total number per zone
Zone 1 (0-600 m)	habitation site	6	132
	gallow	2	
	horreum	5	
	house	61	
	church	3	
	monastery	1	
	cross	5	
	leper house	1	
	pillory	6	
	drying grounds	1	
	watermill	5	
	windmill	35	
Zone 2 (600-1300 m)	habitatation site	2	51
	gallows	2	
	house	42	
	castle	1	
	church	1	
	monastery	1	
	cross	1	
	windmill	1	
Zone 3 (>1300 m)	house	4	6
	monastery	1	
	leper house	1	

correlation between the occurrence of sites and distance from the town. The number and variety of sites both decrease the greater the distance from town. Based on the towns examined, two clear boundaries can be identified. The first lies approx. 600 metres from town. Most sites are concentrated within this area. A number of sites such as windmills and drying grounds rarely occur beyond this distance, if at all. The second boundary lies at 1300 metres. The area beyond this, where the number and variety of sites is low, cannot really be referred to as urban countryside.

It is recommended that this picture be further assessed by analysing the maps of more towns. One might explore whether it also applies to the period after the 17th century. Finally, while some universal laws have been observed outside town, what was the situation within the walls?

Research has shown that archaeological remains in 19th- and 20th-century urban expansion zones around towns may still be relatively intact. If the results of this study were combined with such information, it would allow the archaeological potential of these zones around towns to be exploited effectively. It is recommended that this be taken into account in future investigations. Studies of the urban countryside could provide information about the functioning of the town itself.

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4 Disturbance of the soil and of archaeological remains

4.1 Introduction

The developer pays, but the soil and remains affected by a development may in some cases already have been disturbed in the past. If this is the case, it makes no sense to pay for further archaeological investigation. Landowners can be exempted from the obligation to perform and archaeological investigation if their land has been so disturbed by large-scale soil excavation or agricultural operations that the probability of finding any useful information about the past is minimal. Farmers, in particular, are pressing for better information on this phenomenon. Archaeology beneath buildings may also be disturbed, however. The papers in this chapter explore the relationship between soil disturbance and the information value of archaeological remains.

The first part (4.2) looks at the effects of different cultivation activities such as ploughing and grading on the soil. It not only considers current techniques, but also those used in the past. For the next part (4.3), an inventory of national and regional datasets containing information on places that may be disturbed was compiled. This information has been made accessible online. How to get from this information to actual maps showing sources of disturbance is the subject of part 4.4. Three parties in different sectors – a specialist archaeological agency, an agricultural university and a farmers' association, were asked to develop methods for making such maps. The results of this exercise are presented, along with an analysis of the methods by a group of experts. Finally (part 4.5), a model showing how the soil may have been disturbed or preserved in an urban context under different types of residential area built since the late nineteenth century is presented.

4.2 Disturbance of soil and of archaeological remains resulting from soil tillage in the Dutch agricultural and horticultural sector

H. van Reuler[1]

Abstract

The Dutch agricultural and horticultural sectors perform various soil cultivation activities. Some of these activities affect the soil down to a depth below the usual 30 cm, as a result of which archaeological remains or features may be disturbed. Van Reuler *et al.* have catalogued the effects of the actions on the soil.[2] In most types of cultivation, regular annual tillage extends no further than the top 30 cm of soil. However, for a limited number of crops, the soil is commonly worked down to a deeper level. Soil may also be disturbed by activities not linked to cultivation. These activities sometimes also extend beyond 30 cm below the surface, working a deeper layer that is regarded as detrimental to the functioning of the soil or as restricting crop growth. Another point considered is the fact that soil is removed with some crops when they are harvested, eventually leading to a fall in the ground surface level.

Keywords: tillage, soil disturbance, soil removal, archaeology and agriculture

4.2.1 Introduction

The Netherlands is the second biggest exporter of agricultural produce in the world, after the United States. The high yields achieved in the Dutch agricultural sector are the result of decades of scaling up, high levels of fertiliser and pesticide use, and far-reaching mechanisation involving intensive tillage, especially in arable farming.

This paper describes a number of soil tillage activities that disturb the structure of the soil to some extent or other. In theory, any archaeological remains or features present in the soil will be more severely disturbed or damaged, the deeper and more intensive the disturbance to the soil. A number of soil tillage activities are considered:

Regular tillage

Since antiquity, land has been tilled after the harvest to prepare it for the next crop. This takes place once a year or several times a year, depending on whether the crop in question is an annual or perennial. There are also crops that do not generally require frequent tillage. This applies, for example, to permanent or semi-permanent grasslands. The soil only needs to be worked when the grass is resown (to improve it), when the existing grass cover is ploughed under and the soil is prepared in the same way as arable land. For most crops, regular tillage does not extend any deeper than 30 cm. Since the soil

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[2] Van Reuler *et al.* 2014.

Table 1. Development in land area used (ha) to grow agricultural and horticultural crops outdoors in 1980, 2000 and 2015.

	1980	2000	2015
Arable farming	705,000	634,440	505,665
Outdoor horticulture			
• Vegetables	-	22,378	25,337
• Flower bulbs	14,342	22,513	24,842
• Trees and perennials	6,163	12,64	17,713
• Fruit	23,323	20,600	19,770

Source: http://agrimatie.nl/

is worked intensively during this type of cultivation activity, and such activities are performed frequently, it must be assumed that the archaeological remains originally present in this layer of soil will have disappeared wherever crops are grown.

Incidental deep tillage

Deep tillage involves soil cultivation activities that extend beyond the regular tillage depth of 30 cm. In all cases, it involves occasional tillage in order to work a deeper layer that is regarded as detrimental to the functioning of the soil or as limiting crop growth. These activities are generally repeated every few years. Such incidental deep tillage does not occur everywhere, though archaeological remains can be assumed to have been disturbed down to this depth in large areas of the country.

Removal of soil during harvest

When some crops – like sugar beet, potatoes, lilies, trees – are harvested soil is removed along with the plant. This eventually causes the ground surface level to fall, and in the next round of tillage part of the hitherto undisturbed subsoil is incorporated into the cultivated layer to maintain its depth. Frequent and long-term cultivation of crops that involve the removal of earth when harvested can therefore result in damage to archaeological remains in soil layers that were originally deeper below the surface.

Agricultural interventions

The movement of earth and deep tillage intended to prepare a plot of land and/or entire area for the cultivation of crops or raising of livestock. Such large-scale interventions are one-off events, which take place when land is reclaimed and also when existing agricultural land is converted to other crops or uses. They often involve deep interventions and the movement of vast amounts of earth, so the impact on any archaeological remains present can be considerable. Since the location of such interventions is generally known, and they are not generally carried out by growers themselves, they are not considered further in this paper.

This paper describes the above cultivation activities in more detail for several types of outdoor crops (Table 1).

4.2.2 Arable farming and outdoor vegetable production

Regular tillage on arable fields

After the crop is harvested the soil is prepared for cultivation of the next crop. The first step is to work in the remains of the crop, otherwise known as stubble ploughing. This also prevents weed growth. Then the main tillage operation will commence, generally using a plough, followed by shallow seedbed preparation and further shallow activities to prepare the soil. Main tillage and seedbed preparation are sometimes combined. Main tillage operations, carried out down to a depth of 20 to 30 cm, are the deepest regular tillage activities performed in arable farming, outdoor vegetable production and fodder production. Other tillage operations are less deep, and are not therefore considered any further here. In the main tillage operation, the soil will be turned using a plough, prepared without inversion using a rigid tine cultivator or subsoiler, or worked by some intermediate form of ploughing and loosening using a spading machine. Ploughing is however by

Table 2. Area, yield and soil tare of three arable crops and lowering of ground surface in 2015.

	Area[a] ha	Yield[a] t/ha	Soil tare %	Soil tare t/ha	Surface lowering[d] mm/harvest
Arable crops					
• Potatoes	155,661	42.7	3[b]	1.3	0.1
• Sugar beet	58,436	83.3	10	6	0.6
• Carrots	5,959	69.6	14[c]	10[c]	0.7

Sources: [a] http://agrimatie.nl/; [b] KWIN (2012); [c] CIW (2003); [d] Wösten *et al.* (2001).

far the most commonly used method. The aim is to remove any compaction which will hamper crop growth, and to work under any weed seeds and/or crop residues in order to create a clean seedbed.

The depth of 20 to 30 cm does not apply to all main tillage operations. It is, for example, known that in the 1970s maize was grown on the same plots of land for many years consecutively, particularly on sandy soils. To work manure into the soil and prevent compaction, farmers ploughed to a depth of 35 to 45 cm.

Incidental deeper tillage on arable fields and horticultural land

In current cultivation systems, many growers use deeper tillage on an incidental basis to loosen compacted earth beneath the topsoil. Compaction occurs as a result of heavy machinery driving across the land, particularly in wet conditions. An excessively compacted layer beneath the topsoil can reduce the crop yield, by restricting root depth and creating poor conditions for growth or for work in the fields as a result of water stagnation in the soil.

Farmers and growers are showing increasing interest in ways of preventing compaction. One method is to reduce tyre pressure, and others include harvesting only in favourable circumstances, more crop rotation, cultivation of deep-rooted leguminous crops, digging instead of ploughing, non-inversion tillage, and use of fixed paths for heavy machinery access. Attention has also turned to more variation on individual plots of land. If necessary, compaction can be tackled locally. However, there is huge variation in terms of the occurrence and frequency of such deeper tillage operations, depending on soil type, region and grower, and there may even sometimes be variation on one farm, depending on the type of soil.[3]

Deeper tillage was also used in the past to break up stagnating layers beneath fields and gardens. This would involve ploughing the same furrow twice, for example. Later, special 'subsoilers' became available which could loosen the soil down to a depth of 45 cm. Importantly, doubts were also raised about the effect of deep tillage. A lack of knowledge of the effects of deep tillage led to different ideas about the value of this method in research and guidance, as well as among farmers.

Much deeper tillage was advised for a number of horticultural crops from the early 20th century onwards. Both double digging (40 to 50 cm) and triple digging (60 to 70 cm) were used in outdoor vegetable production. Deep tillage has traditionally been recommended to prepare ground for crops like asparagus and scorzonera[4] and also other crops, including leeks and chicory roots.

Removal of soil during harvesting in arable farming and horticulture

Soil is removed with some crops when they are harvested, leading to a gradual fall in the ground surface level. The degree of subsidence per harvest varies sharply, from 0.1 mm in the case of potatoes, to 0.7 mm for carrots. A fall in the ground surface level can be reduced or prevented in a number of ways. Removal of soil when sugar beet is harvested can for example be reduced by harvesting the beets in two stages. This allows the soil on the beets to dry off a little, making them easier to clean in the harvester. Another option is to grow a variety that does not ramify much, which means less soil clings to the beet. Two-stage harvesting is also suitable for potatoes. New cultivation systems are currently being developed whereby some crops are grown on water, for example.

3 Hack-ten Broeke *et al.* 2009.
4 Turkenburg ca. 1915.

4.2.3 Flower bulbs

Tillage for flower bulb cultivation
For most crops grown in the bulb fields along the coast, fields are ploughed annually down to a depth of 35 to 40 cm. Deeper tillage does however occur on some plots of land used for growing flower bulbs, when the soil is inverted to combat soil-borne diseases in the topsoil. Deep digging brings clean, generally calcium-rich subsoil to the surface. The second or third layer is brought to the surface, and the top layer is dug under to replace it. This is also known as 'vertical crop rotation'. The same effect can be achieved by deep ploughing, though this is reported to occur only on an incidental basis. Sometimes layers from 2 m deep are brought to the surface if found suitable. This used to be done by hand, but draglines have been used since the 1960s. One important development has been the introduction of stricter regulations on chemical soil pollutants, so more and more 'fresh land' is rented for flower bulb cultivation. If none is available nearby, land is rented elsewhere in the country. This process is known as the 'travelling flower stall', and is particularly common in lily cultivation.

Removal of soil in bulb growing operations
Soil is lost from the land in two ways in the bulb growing industry: wind-blown dispersal of sandy soils and the soil tare when bulbs are lifted on both sandy and clay soils.

Dispersal occurs mainly in the period immediately after planting. Growers are obliged to take measures to curb the process, applying straw, green manure, compost or paper cellulose to the bare fields, for example.

When bulbs are lifted, soil is removed from the land. There are no data on how much soil is lost, but it is estimated that 6 mm to 30 mm is lost every time a crop of lilies is harvested. It is assumed that 95% of the soil removed when the bulbs are cleaned is returned to the plot in question, often to the lowest parts, which helps level the land. To ensure that flower bulbs dry as efficiently as possible, the grower will strive to achieve the lowest possible soil tare percentage. Developments are also focused on adapting the machines used to harvest bulbs to ensure that as much soil as possible remains on the fields.[5]

4.2.4 Trees

Tillage at tree nurseries
A wide variety of trees are grown at tree nurseries, from large avenue trees to perennial shrubs. The majority of plants grown at tree nurseries are perennials. This means that a lot of effort goes into preparing the land before planting.

If the surface is uneven, it will be levelled before planting, in order to prevent localised flooding. If there are layers in the profile that are likely to hamper root growth, they will be broken up. The depth of these layers determines the depth of tillage. Compacted layers at a depth of 20 to 40 cm will be broken up using a spading machine. If the profile is unfavourable – sand on a loam or clay subsoil for example – it will be inverted. Peaty soils can be made firmer by the addition of sand. This method can also be used on reclaimed peat soils by deep ploughing. Sand is also sometimes brought up from greater depths, between 2 and 4 m.

After planting, the soil profile can still be altered down to a depth of more than 30 cm when trees are lifted, for example.

Soil removal at tree nurseries
Various trees and shrubs are lifted with a root ball, particularly avenue and park trees, ornamental shrubs, ornamental conifers and boxwood. As a result, the soil is lost from the land. Sometimes it is replaced, and sometimes the surrounding earth is used to fill the hole, thus lowering the surface. The extent to which this can be controlled and the amount of earth lost depends on the size of the plants, the duration of cultivation and the soil composition. Different types of trees and shrubs are traditionally grown in certain regions. The Boskoop region, for example, is an important location for the cultivation of ornamental shrubs and conifers. Subsidence is occurring there due to decay (=mineralisation) of the peat. Soil is also lost when trees and shrubs are lifted with a root ball. As a result, there can be as much as 20 mm subsidence when trees and shrubs are grown in nurseries for two years.[6] Filler soil is regularly brought into the region to keep the ground surface at the appropriate level.

5 Personal communication from Paul van Leeuwen (Wageningen University & Research, Flowerbulbs, Nursery stock & Fruit).
6 Maas & Van Reuler 2008.

In the interests of sustainability, ways of reducing the removal of soil tare from tree nurseries are being explored. Possibilities include a different cultivation method (not in the soil), such as growing in pots and containers, or in root bags, or shaking off the roots soon after the plant is lifted, and replanting it quickly, or dipping it in a liquid that prevents them from drying out. It is important to reduce soil loss not only from the point of view of sustainability, but also for the sector itself. Such crops are mainly grown on rented land, and the loss of fertile soil makes many landowners reluctant to rent to tree nurseries, or likely to raise the rent.

4.2.5 Fruit

Tillage in fruit farming

Between 1950 and 2015, the area used for growing fruit such as apples, pears, cherries and plums fell from 65,000 to 17,000 ha. However, greater tree density and other changes in cultivation have brought about a huge increase in the yield per hectare, and in the total quantity of fruit produced. The process of intensification began with the development of low-vigour rootstock in the UK in the 1920s. The use of this rootstock allowed open compact trees with high yields to be cultivated. It also allowed standard trees to be replaced by dwarf apple trees, sharply increasing the density and yield per hectare.

The agricultural literature recommends various tillage methods before fruit trees are planted. Good drainage and well aerated soil are essential for the development of the orchard. It is also recommended that an uneven plot be levelled before trees are planted and that deep tillage be carried out in the form of deep ploughing (to 45 cm) or deep digging.[7] Pijls mentioned the possibility of improving soil structure and moisture-retention by bringing up calcareous clay or sand, inverting the entire profile down to a depth of 1.2 m if necessary.[8] It is not known to what extent these recommendations were actually put into practice.

The growth of the trees must be inhibited during the cultivation period. The roots are cut mechanically using a straight, slanting or semi-curved blade, generally at a depth of 25 to 40 cm. Depending on the vigour of the vertical growth, the roots will be trimmed annually, every other year, or on alternate sides of the tree.

The impact on the soil when the trees are lifted is related to the depth of the roots, which depends on the variety, the method of cultivation, measures carried out during cultivation and the lifting method. Pear trees have considerably deeper roots than apple trees, for example. Since the introduction of dwarf fruit tree orchards, low-vigour rootstock has been used. The growth of the trees is also inhibited by cutting the roots. When the trees are lifted the entire root system can be removed, or part of it left behind, and perhaps worked into the soil. As a result of these developments, when dwarf trees are lifted the impact on the soil is less deep than was the case with the traditional standard fruit trees, which have now virtually disappeared.

4.2.6 Conclusions

Annual tillage for most crops grown in arable farming, outdoor vegetable production and fodder production affects only the top 30 cm of the soil. Ploughing is usually deeper (30-45 cm) for flower bulb production than other arable and horticultural crops. The soil is always worked down to a considerable depth for some vegetables grown on limited areas of land, such as asparagus,.

Arable farming and horticulture can also disturb the soil as a result of non-crop-related deeper tillage, which is usually performed during crop rotation. Deep tillage also occurs occasionally on land used to grow flower bulbs, and at tree nurseries and fruit orchards, where it is above all the lifting of trees that disturbs the soil.

When some crops are harvested, soil is removed from the land with the produce. This is particularly true of potatoes, sugar beet, carrots, flower bulbs (lilies) and a number of nursery trees. The quantity of soil removed varies substantially.

Farmers also take measures to prevent soil disturbance, however. More and more is being invested in measures to prevent compaction, so that compacted layers no longer need to be broken up from time to time. An agricultural

7 Sprenger 1948.
8 Pijls 1953.

entrepreneur will also generally strive to achieve a sustainable cultivation layer, so will take measures to prevent fertile soil from being lost. Nevertheless, the trend towards renting plots of land for only a few years for different crops, necessitating intensive tillage and/or causing the removal of large quantities of soil, is a worrying development.

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4.3 Mapping sources of soil disturbance information relevant to archaeology

F. de Vries[9] [a] and G.J. Maas[a]

Abstract
In a densely populated country like the Netherlands all kinds of activities disturb the soil, and therefore also any archaeological information present. To enable decisions to be taken concerning the necessity and benefits of archaeological investigation, it is therefore important to estimate in advance the extent to which a site has remained undisturbed. The 'Sources of Disturbance Map' is a step forwards to a database of potentially disturbed sites.

Keywords: soil map, disturbed soils, archaeological remains, map resources, meta-information, Subsurface Register

4.3.1 Introduction

To obtain more insight into databases that can provide information on soil interventions, the RCE commissioned Alterra to produce an inventory. This resulted in the 'sources of disturbance map', a digital geographical map with national and regional datasets.[10] The overview available in GIS shows the area to which each dataset refers and contains meta-information concerning the type of information in the dataset, how recent and detailed the information is, and whether it is possible to derive information about soil disturbance from it.

4.3.2 Soil disturbances

Regular working of the soil has had an impact on agricultural land down to a depth of approx. 30 cm. Any soil features present in this ploughsoil will have been wiped out and any finds at the very least displaced. This paper considers the layers below the 30 cm of ploughsoil which have been moved, churned or removed by soil working activities. Soil is disturbed by:

- excavation and large-scale sand, gravel and clay extraction (Fig. 1);
- building of infrastructure such as roads and waterways (Fig. 2);
- laying of gas and water pipelines (Fig. 3);
- urban expansion and building of sports complexes;
- restructuring operations involving interventions to improve the division and drainage of agricultural land;

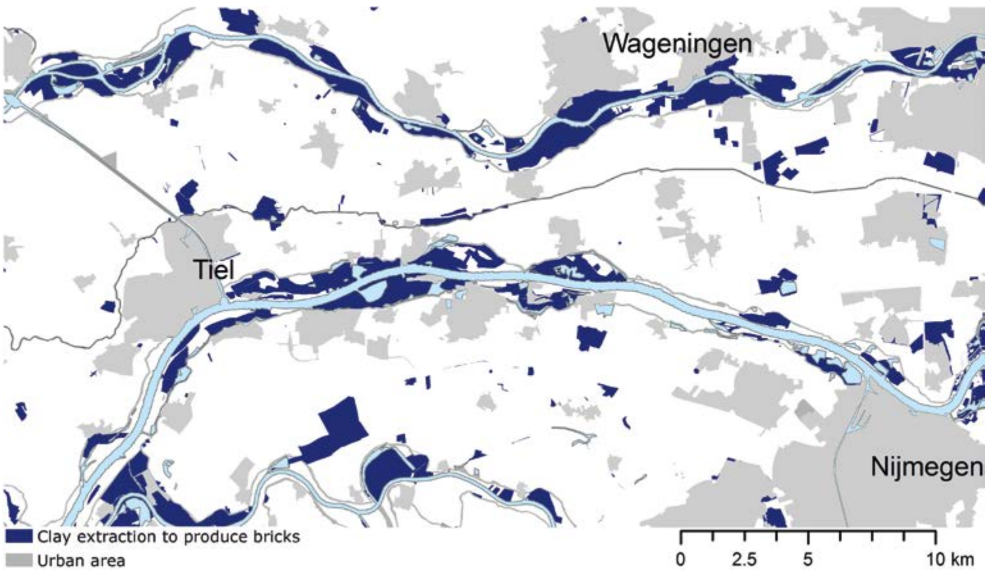

Figure 1 Map of the eastern river area of the Netherlands showing locations of excavation work to supply the brick industry (map: Wageningen Environmental Research, Alterra).

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[10] Available at www.archeologieInNederland.nl.

Figure 2 Excavation work in Nijmegen prior to the construction of a side channel of the Waal river (photo: www.ruimtevoordewaal.nl).

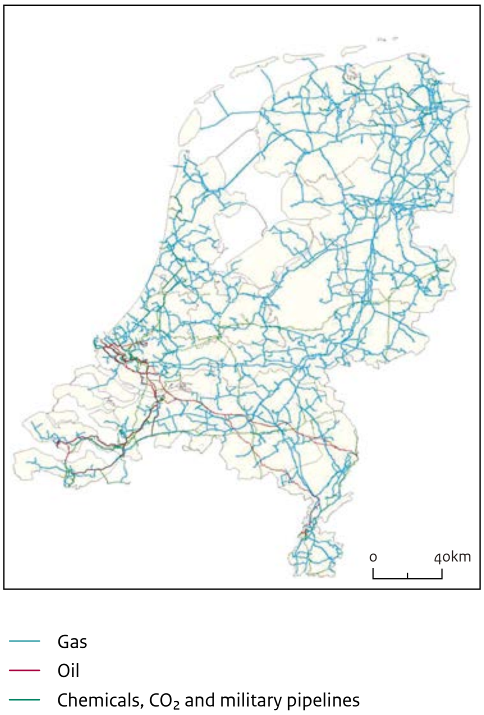

Figure 3 Map of the Netherlands showing the location of pipelines carrying hazardous substances (map: www.buizenzone.nl).

- tillage to break up stagnating layers in the soil profile to allow deep-rooted crops such as asparagus, trees and fruit to be cultivated;
- interventions when new nature conservation areas are created.

4.3.3 Link with reworked soils map

In 2012 Alterra performed an inventory of 'deep' tillage, excavation and heightening operations.[11] This inventory, known as 'Reworked Soils' is easy to access using a map viewer on the website.[12] The files can also be downloaded and viewed with the aid of a GIS programme.

Reworked Soils categorised disturbances on the basis of a number of themes: mineral resources, storage sites, pipelines, modified natural habitats, soil processing, urban developments and water. They can be found in the map viewer as legend units. The themes were compiled on the basis of various sources, including soil maps and records of excavation permits issued by provincial authorities. Since the quality of the underlying sources is highly variable, the Reworked Soils themes cannot be directly applied for archaeological purposes (nor was this the aim of Reworked Soils); in all cases the sources themselves must be consulted. Furthermore, Reworked Soils was a snapshot, the most recent sources dating from 2011. Later interventions are not therefore included.

11 Brouwer & Van der Werff 2012.
12 http://www.bodemdata.nl/.

4.3.4 Sources of soil disturbance information

Inventory
The sources of disturbance map should provide insight into sources relevant to archaeology, and facilitate access to these databases. The sources of disturbance map identifies national and regional databases which, on the basis of their content, can be divided into:

- databases containing specific information on soil disturbances, such as records of the position of areas that have been excavated;
- databases containing indirect information on soil disturbances, such as those containing data on land use, whereby it can be assumed that certain types of use will have involved deep tillage, e.g. for growing asparagus or avenue trees.

Databases containing specific information
Specific information on soil disturbance can be found in GIS soil map databases and provincial records of interventions involving excavation work.[13]

Soil maps
The soil map of the Netherlands, scale 1:50 000, has a number of categories that refer to soil disturbance, such as excavations, deep tillage and heightening. Given the scale of the map, it is not possible to define the boundary of every plot where disturbance has occurred. In areas where, according to the map, the soil has been reworked, the majority of plots will have disturbed soil. The map was produced in the period 1960-1995, and the inventory of soil reworking operations also dates from this period. Over the past few decades all kinds of technical interventions have been performed in agricultural areas in connection with land redivision operations (to enlarge parcels of land) and improvements to drainage. The national soil map does not therefore give a comprehensive, up-to-date overview of areas where soil has been reworked.

Detailed soil maps on a scale of 1:10,000 to 1:25,000 are available for a considerable proportion of the Netherlands. The legends for soil reworking operations are compatible with those on the 1:50,000 map. The reworked areas have been meticulously defined. As with the national soil map, soil disturbances that occurred after the map was compiled have not been included. These maps therefore also provide only a snapshot.

When the Reworked Soils map was compiled, the soil map information on soil disturbance available at the time was used.[14] Only more recent soil maps provide additional information, therefore.

Records of location-specific interventions
Almost all provincial authorities in the Netherlands have one or more lists detailing the locations of excavation operations, soil repositories and landfill sites. Their position is accurately recorded in a GIS. Excavation operations often involve the removal of thick layers of soil, even leading new bodies of water to form in some cases. Any archaeological remains present therefore also disappear. The creation of landfill sites and soil repositories also cause disturbance. In many provinces, a permit is required for the excavation of more than 10,000 m^3 of soil. The Netherlands has more than 5000 km of pipelines for gas and all kinds of liquids. The laying of these pipelines generally affects a strip 25 to 50 metres wide. The depth of disturbance varies within this strip from a few dozen centimetres to more than 2.5 metres. Gas distribution network Gasunie has a database showing the position of gas pipelines.

Databases containing indirect information
Certain types of agricultural land use involve working the soil to a depth greater than the 30 cm of ploughsoil. This applies for example to the cultivation of asparagus, for which the soil has to allow root penetration down to a depth of 80 to 100 cm. To make this possible, the soil is worked down to this depth when the land is prepared. Tree nurseries provide trees with a large clump of earth round the roots, measuring 40 to 60 cm depending on the size of the tree. Fruit farming also sometimes involves deep tillage.

A number of national geographical databases exist that contain land use data, such as the LGN (national land use map of the Netherlands) and the BRP (basic plot register). The LGN map distinguishes a large number of crops at plot level, including fruit farms and tree nurseries.[15] A new version has been released every four years since 2006. The BRP distinguishes a large number of crops, which can be used to estimate the tillage depth at plot level.

13 Maas *et al.* 2016.
14 Brouwer & Van der Werff 2012.
15 Hazeu *et al.* 2014.

Database availability
The sources of disturbance map pools the meta-information from the various databases. This information from most of the datasets is available online via the National or Provincial Georegister (NGR and PGR). Background information is also available for a large number of provincial datasets. The URLs of these datasets are included in the meta-information.

4.3.5 Discussion

The inventory has shown that several datasets are available that can help locate areas of soil disturbance. It is not however possible to produce a comprehensive and up-to-date overview on this basis.

The national soil map is an important source, but it gives only a snapshot and the scale (1:50,000) does not allow any detailed representation of plots that have been disturbed, and those that have not. The detailed maps give a more accurate picture, but again no interventions have been added since they were compiled.

Provincial records give information on important interventions like excavations, landfills and soil repositories. However, these records also tend not to be complete, as regulations were less stringent in the past and fewer incidences of soil disturbance were reported. A permit is needed only for excavations involving 10,000 m^3 or more. Smaller-scale excavations must be notified, but it is not clear whether such notifications have been included in the records.

Land use databases allow the degree of disturbance to be assumed on the basis of general assumptions on tillage depths applying to different crops. Though these assumptions have been documented, no validation studies have been performed to confirm their accuracy. Land use databases refer to the period since 2000. Information on land used to grow soil-disturbing crops in earlier periods is not available in GIS format.

Archaeological remains can be present at different depths in the soil. Soil disturbance does not therefore necessarily result in disturbance of the archaeology present. The degree of disturbance also depends on the nature of the archaeological remains. The impact of soil disturbance on intactness needs to be assessed in conjunction with the landscape and the archaeological context.

4.3.6 Recommendations

Registration of soil disturbing interventions needs to be improved. No permit is required for small excavation operations (< 10,000 m^3), soil disturbance in ordinary agricultural practice and disturbance as a result of the development of new nature reserves, though a reporting obligation does apply. It is recommended that such notifications be recorded and entered in a GIS. Central registration could take place as part of the BRO (Basic Subsurface Register), especially given the fact that information on archaeology may be included in the BRO in the future.

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Hazeu, G.W., C. Schuiling, G.J. Dorland, G.J. Roerink, H.S.D. Naeff & R.A. Smidt 2014: *Landelijk Grondgebruiksbestand Nederland, versie 7 (LGN7). Vervaardiging, nauwkeurigheid en gebruik*, Wageningen (Alterra-rapport 2548).

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4.4 Towards a predictive model for disturbances caused by agricultural land use

M.A. Lascaris[16] *and D.J. Huisman*

Abstract
In order to avoid unnecessary archaeological investigations, it is important to know where the soil has already been disturbed by land excavation or agricultural activities. A lot of information about disturbances of this kind in the Netherlands is available online, or can be easily accessed by other means. Nevertheless, no suitable method currently exists for estimating the probability that the soil in a particular plot has been disturbed. To address this shortcoming, the Cultural Heritage Agency commissioned three parties to develop a model for estimating the probability and apply it in a test area. The results of the three studies were then discussed with a group of experts with knowledge and experience of soil disturbance and archaeology. This paper describes the methods developed, and presents the results of the analysis of the methods by the group of experts.

Keywords: method research, disturbances, probability of disturbance, desk-based assessment, sources of disturbance

4.4.1 Introduction

Disturbance of the soil as a result of land excavation or deep ploughing, for example, can reduce or even destroy the information value of archaeological remains. Lack of awareness of such disturbances can lead to archaeological investigations being undertaken unnecessarily. Although the scale of the problem is not entirely clear, it is known that knowledge of locations where soil has been excavated or disturbed prevents unnecessary archaeological excavation and ensures that archaeological interests are more effectively taken into account in the spatial planning process. This knowledge is used to predict the probability of disturbance on the basis of generally accessible information such as maps.

As part of efforts to develop such a method, three organisations were asked independently to devise a method and apply it in a test area. Organisations working in different disciplines were deliberately chosen: Alterra, which performs research on agriculture and landscape; RAAP Archaeological Consultancy, which is involved in archaeology; and the Southern Division of the Dutch Federation of Agriculture and Horticulture (ZLTO), the professional association for the agricultural and horticultural sector.[17] The results of the three studies were discussed at an expert meeting attended by representatives of the three organisations, staff of the Cultural Heritage Agency (RCE) and various specialists from the field with knowledge and experience of soil disturbance and archaeology.

The commission awarded to the three organisations is first discussed below, after which a brief description of the three methods is given. The methods are then analysed on the basis of the results of the expert meeting, with a particular focus on use of sources and the specification of the probability of disturbance.

4.4.2 The commission

The study focused on soil disturbance. The relationship between disturbance and archaeological prediction (including the depth of the archaeological layer) was deliberately excluded. Nor were precise specifications given, to leave the three organisations free to decide on their own approach. A requirement was however included stipulating that the method developed should be tried out in test areas in a municipality selected by the RCE. Alterra was to conduct its testing in Ede, ZLTO in Weert and RAAP in Sudwest Fryslân. Part of the commission was to determine how large a pilot area needs to be in order to obtain a good picture of the problem and the method. The organisations were also required to use the sources of disturbance map discussed elsewhere in this publication.[18] They were also encouraged to use other relevant sources, provided they are theoretically accessible to all, or can be made accessible. The methods developed were also to be applicable at the scale of individual plots of land. The organisations were also requested to refrain from contact with the other two organisations involved in the study, to ensure each based its method on its own perspective as much as possible.

16 Corresponding author: m.lascaris@cultureelerfgoed.nl.
17 Since 6 September 2016 Alterra has been known as Wageningen Environmental Research.
18 De Vries *et al.* 2016; De Vries & Maas 2017: this volume 4.3.

4.4.3 Alterra method

The method developed by Alterra calculates the probability of soil disturbance at different depth projections.[19] The probability is expressed as a percentage. The method involves four stages. First, any large-scale single interventions such as excavation for mineral resources, soil remediation or the creation of soil repositories are identified. Then any instances of multiannual cultivation involving an initial intervention are identified. This includes cultivation of crops like asparagus or avenue trees. Step three involves determining any disruption caused by other agricultural activities, such as breaking of the plough pan for maize cultivation (every five years) or flower bulbs (every 20 years). Finally, the probability of soil disturbance is calculated.

The degree of likely soil disturbance was estimated for each individual type of tillage and expressed as a percentage for each depth category. A number of examples are shown in table 1.

The table shows how the interventions have been categorised according to the frequency with which they are carried out:

- Single interventions such as the initial installation of drainage or deep ploughing after land is reclaimed.
- Regular interventions or tillage: annual tillage linked to the cultivation of the crop, such as ploughing. The disturbance is generally limited to the ploughsoil. Such activities are not therefore included in table 1.
- Periodic interventions: tillage operations which are repeated every few years, linked to the cultivation of the crop. The probability of disturbance per year is obtained by dividing the total disturbance of the periodic intervention by the number of years between interventions.

The total probability of soil disturbance is calculated on the basis of the probability of disturbance by a single intervention and the probability of periodic interventions. Where:

- P40cm_total: total probability of soil disturbance to 40 cm below ground surface;
- P40_single: probability of soil disturbance to 40 cm below ground surface due to single intervention;

Table 1. Probability of soil disturbance associated with a number of multiannual crops.

Crop category	Tillage	Probability of disturbance (%) for each depth category (cm below surface)		
		40 cm	40–60 cm	>60 cm
Avenue trees	initial development of nursery (1500 – 2500 trees per ha). Tillage to 40 cm below ground surface	100	0	0
	periodic lifting. Lifting with root ball once every 5 to 8 years (>40 cm below ground surface) followed by tillage and levelling to fill holes	100	20	0
Orchard	initial development of dwarf fruit tree nursery (1000–2000 trees per ha). Tillage to 40 cm below ground surface	100	0	0
	periodic lifting. Trees lifted due to age after 12 to 15 years. Root system removed as completely as possible (tillage in each row deeper than 40 cm below ground surface.)	100	20	0
Asparagus	initial development of asparagus field. Tillage to more than 40 cm below ground surface. Planting and ploughing up of asparagus beds	100	80	0
	plants exhausted after 10 to 14 years. Plants are removed and field is levelled. Tillage < 40 cm below ground surface. No replanting	100	0	0
Drainage	one-off installation of drainage pipes 5 to 25 m apart, at a depth of 80 to 140 cm below ground surface. Various machines are used for this purpose. Trenchless machines cause less disturbance than machines that dig a trench approx. 25 cm wide	5	5	5

Source: (De Vries *et al.* 2016, 13 Table 2, and 18 Table 3).

[19] De Vries *et al.* 2016.

- P40_periodic: the accumulated probability of soil disturbance to 40 cm below ground surface due to periodic interventions over a certain period.

For example, Alterra finds that, for a drained plot of land used to grow arable crops for five years, the probability of shallow soil disturbance (to 40 cm below ground surface) can be calculated as 5% + (1 - (5 / 100) x 15%) = 5% + 14% = 19%. The probability of disturbance at moderate depth (40–60 cm below ground surface) and at greater depth (>60 cm below ground surface) is thus 5% + (1 - (5 / 100) x 0%) = 5% + 0% = 5%.

The look of the map by Alterra showing the probability for the different plots of land in the Ede Driesprong test area is presented in figure 1.

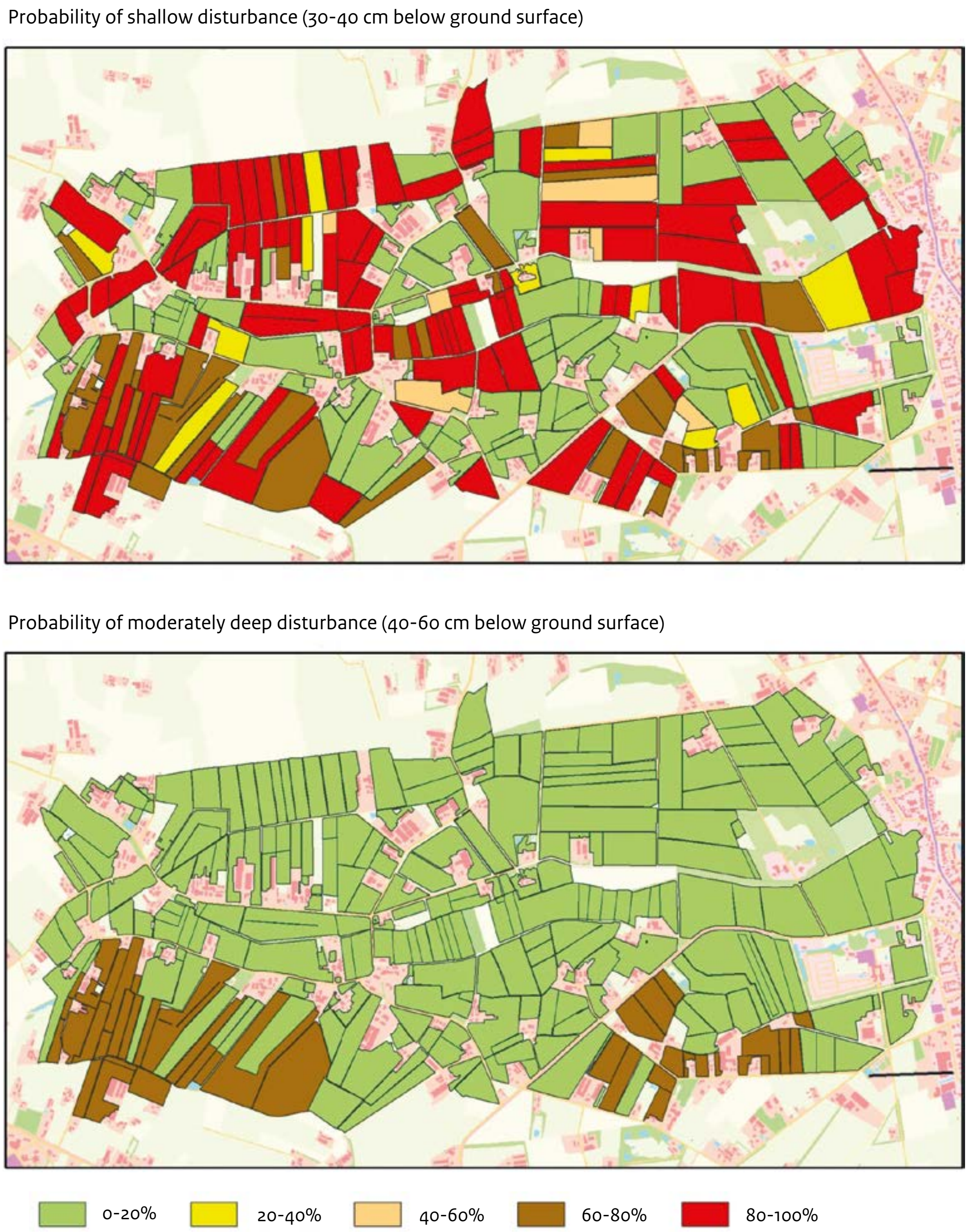

Figure 1 Probability of shallow (30-40 cm below ground surface) and moderately deep disturbance (40-60 cm below ground surface) in the Ede Driesprong test area (De Vries 2016, 24). No soil disturbance deeper than 60 cm below ground surface occurs in the area.

4.4.4 ZLTO method

The method developed by the Southern Division of the Dutch Federation of Agriculture and Horticulture (ZLTO) consists of the following steps.[20] First, an inventory of relevant agricultural activities that disturb the soil is made. This step was performed mainly by ZLTO consultants in the pilot areas near Weert. Then the local factors influencing the degree of disturbance are identified for each agricultural activity. In the pilot areas, a major difference was found in the impact of some tillage operations on sandy and clay soils. Experts on agricultural land use then determine the disturbance factor, which ranges from no disturbance (0%) to completely disrupted (100%). Finally, a decision is made as to whether each disturbance should be mapped as a point, a line or an area. The various agricultural activities are then ranked in a table for incorporation into a GIS (Table 2).

If two disruptive activities occur on the same plot, the highest probability of disturbance determines the classification on the map. The probability of disturbance is also mapped on the basis of current parcelling, and is shown in ranges (Fig. 2). A GIS programme is therefore also needed to show how the ZLTO disturbance factor is determined for a particular plot. A plot may consist of several parcels of land on which various tillage operations have been performed.

Table 2. Some examples of agricultural activities and their disturbance factor.

Category	Agricultural excavation or cultivation activity	Probability of disturbance (in %)	
Infrastructural	irrigation pipes installed horizontally	100	
	irrigation pipes installed vertically	20	
	paved paths present	30	
	paved path removed	80	
Cultivation	reclamation	100	
	grading/levelling	70 + depth factor	
	soil excavation	60 + depth factor	
	drainage in trenches	60	
	drainage in v-ditch	70	
	digging of ditches	50	
	filling of ditches	80	
	tillage / Profile improvement	100	
Crop-specific from 2015 in accordance with Basic Crop Register (>30 cm)		**Sand**	**Clay**
	potatoes for consumption	0	50
	seed potatoes (NAK certified)	0	50
	asparagus, surface, not yet productive	70	70
	asparagus, surface, productive	70	70
	asparagus seeds and propagation material	70	70
	bushes and hedge plants, outdoor cultivation	70	70
	flower bulbs	70	70
	box, outdoor cultivation	60	60
	christmas trees	70	70
	perennials, outdoor cultivation	50	50
	fruit trees, nut trees, outdoor cultivation	60	60
Crop-specific 2009-2014 (>30 cm)			
	outdoor vegetable production (including vegetable seeds)	40	40

Source: Peekel *et al.* 2016, 20 Table 2.

[20] Peekel *et al.* 2016.

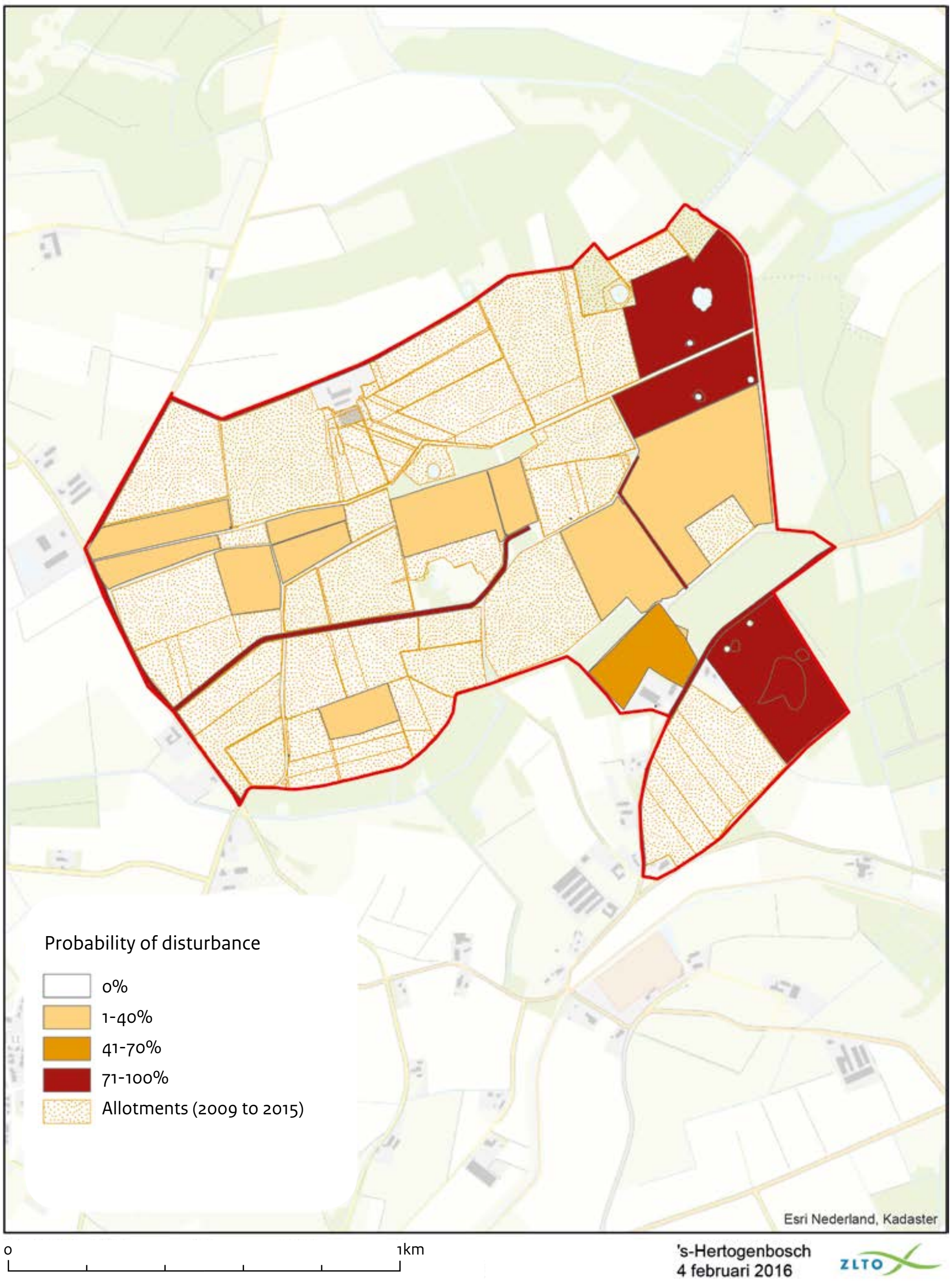

Figure 2 Probability of disturbance on plots in De Krang pilot area, Weert (Source: Peekel *et al*. 2016, 23).

4.4.5 RAAP method

The method developed by RAAP consists of roughly three steps.[21] First, relevant geo-information is sought on soil disturbance in a broad sense. The information is drawn from sources covering the entire country, such as the Soil Map of the Netherlands, the Geomorphological Map, the National Land Use Database (LGN) and the Historical Landscape Information System (HISTLAND), and also data that can be accessed via the provincial environmental information map (Geoloket). A description of the geology and soil in the area, an analysis of the agricultural history and an analysis of the cultural landscape and the underlying landscape formation processes are then produced. The spatial information gathered is then studied and entered in a GIS. Since the sources can vary widely in terms of their quality and accessibility, the disturbance data are articulated for each individual source. When the data are entered, a distinction is made between primary information (direct information about disturbances) and secondary information (indirect information, derived from historic land use, for example). The third category of information is data from landowners and tenants. The GIS also includes an indication of the reliability of the information on area boundaries and depth, which can be classified as 'fairly certain', 'neutral' or 'uncertain'.

The study did not produce a method for estimating the degree of disturbance on one or more plots of land. While developing the method RAAP came to the conclusion that it is not always possible to assign a single disturbance category to a map area or plot of land because of the diversity of sources. Soil disturbance information must therefore always be used on a source by source basis. The probability of disturbance was therefore worked out for each individual source and/or layer in the form of the likely depth and area of the disturbance, and the reliability of the information (Table 3).

RAAP_ID is the plot code assigned by RAAP. Soil improvement is one of the categories of disturbance identified. Top_dev is the estimated deviation from the exact location in metres. Area_dev is the standard deviation in area in %. Ave. depth is the average depth of disturbance. Max. depth is the maximum depth. Depth_dev is the estimated standard deviation of that depth in cm. Certainty is the level of certainty that the soil improvement measure has indeed caused disturbance (1 uncertain, 2 neutral, 3 certain).

4.4.6 Expert meeting: discussion of methods

After reports were submitted on the three methods, they were discussed by the people who had devised and tested them and a group of professional archaeological experts.[22] The purpose of the expert meeting was to distil the best points from the three studies to serve as a basis for the further development of a method for producing disturbance probability maps. The results of this exercise are summarised in the table 4.

The discussion with experts made it clear that the Alterra pilot had made critical use of a wide range of sources and clearly translated them into a disturbance model with an indication of depth. The lack of time depth and the unclear definition and operationalisation of the percentage disturbance were less positive aspects of this method.

One positive element of the method developed by ZLTO is the close involvement of the agricultural sector and the use of its knowledge. The methodology and output are both clear and easy to understand, but the method makes no use of historical information. The key drawback is, however, the fact that it is not clear how the data gathered are translated into a probability of disturbance (related to depth). Using the map legend and the plot division, a plot of land can potentially be categorised as more heavily disturbed than is justified on the basis of the sources. For instance, the red plot in the southeast of 'De Krang' is 71-100% disturbed, according to the map (red in Fig. 2), whereas this is in fact undisturbed grassland with one instance of deep disturbance caused by a well in the centre.

The RAAP method draws on many sources, which it considers critically. As in the ZLTO method, RAAP uses farmers' knowledge of local tillage operations. The history of land use is also roughly determined, for a better understanding of

21 Willemse *et al.* 2016. This publication in fact distinguishes seven steps which are summarised as three here to make the method clearer and more comparable with the Alterra and ZLTO methods.

22 26-2-2016: Gilbert Maas & Folkert de Vries (Alterra Wageningen UR), Arno Peekel (ZLTO), Nico Willemse (RAAP), Jan Breimer (A&M), Fokko Kortlang (ArchAeO), Huib-Jan van Oort (organisation of municipal archaeologists), Carla Soonius (Archeologie West Friesland), Chris Sueur (Buro de Brug), Boudewijn Voormolen (gemeente Katwijk), Hans Siemons (gemeente Den Haag). Jos Bazelmans, Hans Huisman, Michel Lascaris, Roel Lauwerier and Bertil van Os (all RCE).

Table 3 Excerpt from RAAP GIS table for the soil improvement layer.

RAAP_ID	Soil improvement	Period	Type of source	Top_dev	Area	Area_dev	Ave depth	Max depth	Depth_dev	Certainty
1	subsoil pan 70 cm	1990-2014	respondent	5	80	5	60	70	10	3
2	subsoil pan 70 cm	1990-2014	respondent	5	80	5	60	70	10	3
3	subsoil pan 70 cm	1990-2014	respondent	5	80	5	60	70	10	3
4	subsoil pan 70 cm	1990-2014	respondent	5	80	5	60	70	10	3
5	subsoil pan 70 cm	1990-2014	respondent	5	80	5	60	70	10	3
6	subsoil pan 70 cm	1990-2014	respondent	5	80	5	60	70	10	3
7	subsoil pan 70 cm	1990-2014	respondent	5	80	5	60	70	10	3
8	levelled	1990-2014	respondent	5	80	5	20	40	10	3
9	NW section 50 cm excavated	1990-2014	respondent	5	40	3	40	60	10	3
10	E section 80 cm deep ploughing and levelling	1990-2014	respondent	5	80	3	60	90	10	3
11	grading + soil improvement to 60 cm in event of reparcelling	1990-2014	respondent	5	80	5	50	60	10	1
12	grading + soil improvement to 60 cm in event of reparcelling	1990-2014	respondent	5	80	5	50	60	10	1
13	grading + soil improvement to 60 cm in event of reparcelling	1990-2014	respondent	5	80	5	50	60	10	1
14	grading + soil improvement to 60 cm in event of reparcelling	1990-2014	respondent	5	80	5	50	60	10	1
15	grading + soil improvement to 60 cm in event of reparcelling	1990-2014	respondent	5	80	5	50	60	10	1
16	grading + soil improvement to 60 cm in event of reparcelling	1990-2014	respondent	5	80	5	50	60	10	1
17	grading + soil improvement to 60 cm in event of reparcelling	1990-2014	respondent	5	80	5	50	60	10	1
18	grading + soil improvement to 60 cm in event of reparcelling	1990-2014	respondent	5	80	5	50	60	10	1
19	grading + soil improvement to 60 cm in event of reparcelling	1990-2014	respondent	5	80	5	50	60	10	1
20	grading + soil improvement to 60 cm in event of reparcelling	1990-2014	respondent	5	80	5	50	60	10	1
21	grading + soil improvement to 60 cm in event of reparcelling	1990-2014	respondent	5	80	5	50	60	10	1
22	grading + soil improvement to 60 cm in event of reparcelling	1990-2014	respondent	5	80	5	50	60	10	1
23	grading + soil improvement to 60 cm in event of reparcelling	1990-2014	respondent	5	80	5	50	60	10	1
24	grading + soil improvement to 60 cm in event of reparcelling	1990-2014	respondent	5	80	5	50	60	10	1
25	grading + soil improvement to 60 cm in event of reparcelling	1990-2014	respondent	5	80	5	50	60	10	1

RAAP_ID: plot code assigned by RAAP; Soil improvement: one of the categories of disturbance identified; Top_dev: estimated deviation from the exact location in metres: Area_dev: standard deviation in area in %; Ave. depth: average depth of disturbance; Max. depth: maximum depth; Depth_dev: estimated standard deviation of that depth in cm; Certainty: the level of certainty that the soil improvement measure has indeed caused disturbance (1 uncertain, 2 neutral, 3 certain).

potentially disruptive activities in the past. The AHN is used as a primary source for mapping changes in the ground surface level over the period 1998-2014. This shows, among other things, that the filling of ditches may have disturbed large areas because farmers were keen to keep the ploughsoil intact as far as possible. The ploughsoil is often first ploughed to a considerable depth or pushed to the side before a ditch is filled.

Critical use of sources led to an unwillingness at RAAP to draw conclusions about the overall disturbance to a particular plot. The method is also time-consuming and therefore costly.

4.4.7 Expert meeting: general insights

The interaction with experts on the methods developed highlighted several matters that are relevant to any attempt to identify the likely degree of disturbance. For instance, the methods do not use a uniform vocabulary. The different meanings attributed to the term 'disturbance' is particularly striking, and represents a potential risk, not only in the development of a model, but also when it comes to publicising the results of studies like this.

Several participants wondered why the Cultural Heritage Agency had separated the development of a method of mapping disturbance from the relationship between disturbance and archaeological prediction (including the depth of the archaeological layer). This was a deliberate choice at this stage, based on a desire to make the methods more comparable, and offer non-archaeological organisations the opportunity to propose a method for identifying disturbance.

It is also clear that it will be a big step from a probability of disturbance map to local authority policy maps showing disturbances or probabilities of disturbance in any useful way. At the moment, for example, there are major differences of opinion as regards the potential position and implications of a 'standard method' for mapping soil disturbance issued by the Agency, both for local authority policy and zoning plans, and for consultancy work by external agencies. Nevertheless, there is consensus over the fact that a disturbance study in the field prior to archaeological investigation increases costs unless the field assessment makes clear that there is no point in proceeding with the investigation. On the other hand, performing fieldwork focused on disturbances in order to produce an archaeological values and predictions map or a probability of disturbance map could reduce the costs of archaeological research in a municipality.

4.4.8 Conclusions

It is not yet possible to derive a new standard from the good points in the three methods developed in the study. The plan was originally to validate the three methods in the field, but this element has now been abandoned in the face of doubts as to the verifiability of the results. Nevertheless, the study has produced a whole range of insights that may be useful in the further development of methods for identifying the probability of disturbance. It is, for example, clear that this can best be done or commissioned by the local authority. At this level, it has the potential to be a useful way of reducing the costs of archaeological investigation. The relationship between disturbance and archaeological prediction (including the depth of the archaeological layer) is also a point to consider in the future. Another is the importance of a uniform definition of certain concepts. Currently, there is not even consensus on the meaning of the term 'disturbance'. Finally, it is important to underline the importance of working with the farming community. Collaboration between archaeologists and farmers is vital, both because local farmers have information about land use that is not readily available elsewhere, and because it helps promote mutual understanding of each other's views and interests.

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Table 4 Summary of similarities and differences in the three methods.

	ZLTO	RAAP	Alterra WUR
Framework			
Does the method include a definition of disturbance?	yes, but concept not precisely defined	no/barely	yes
Does the method include a definition of the probability of disturbance?	yes, but concept not precisely defined	no	yes
Sources used			
Soil map of the Netherlands 1:50 000	yes	yes	yes
Soil map of the Netherlands 1:50 000, update	yes	yes	yes
Detailed soil map < 1:50 000	no	yes	yes
Geomorphological Map of the Netherlands 1:50 000	no	yes	
Historical Land Use Map(HGN)	no	no**	yes
National Land Use Database (LGN)	no	yes	yes
RCE sources of disturbance map	unclear	yes	yes
Installation of drainage (local authority permits, Netherlands Hydrological Instrument)	yes	yes	yes
Excavation: surface sand or clay extraction (provincial ordinance)	yes	yes	yes
Deep sand or clay extraction (provincial ordinance)	no	yes	yes
Deep ploughing/subsoiler (provincial ordinance)	no	yes	no
Plot improvement (provincial ordinance)	no	yes	no
Development of conservation area (provincial ordinance)	no	yes	no
Register of reparcelling and land redevelopment	no	yes	no
AHN used to verify other sources (www.pdok.nl)	yes	yes	no
AHN used as primary source by comparing AHN1 - 2 and 3, for example (www.pdok.nl)	no	yes	no
Topographical maps 1832-present, changes in parcelling (topographical service, land registry, Statistics Netherlands)	no	yes	no
Topographical maps 1832-present, changes in land use (topographical service, land registry, Statistics Netherlands)	no	yes	no
Interventions to create water storage, water retention facilities, new conservation areas, watercourse remediation (water authorities)	no	yes	no
Flood defences (water authorities)	no	yes	no
Interview (land user/expert)	yes	yes	no
Basic register of arable land, regular tillage (Netherlands Enterprise Agency)	yes	yes	yes
Information on disturbance identified in archaeological investigations (ARCHIS: currently not accessible)	no	yes	no
Disturbance due to archaeological investigation (ARCHIS: currently not accessible)	no	yes	no
Information on disturbance identified in borehole surveys (DINO)	no	no***	no
Local interventions: aerial photographs	no	no	no
Gas pipelines (Gasunie)	?	yes	yes
Local and provincial records of dredging spoil and sludge repositories	?	?	yes
Irrigation pipes	yes	?	no
TOP10NL (topographical map 1:10 000)	yes; for various info	yes	no
Probability of disturbance			
Does method include reasoned formulas or calculations of probable area affected by source of disturbance?	no; expert judgement expressed as %	no	yes
Does method include reasoned formulas or calculations of probable depth of disturbance by source of disturbance?	no	partly	yes
Has a cumulative probability of disturbance map / model been produced?	no; greatest prob. of disturbance determines classification	no	yes
Are localised and wide-area tillage operations considered separately?	?	n.a.	yes
Reuler publication (inventory of cultivation operations) used?	no	no	yes

AHN Elevation Map of the Netherlands (LiDAR)
ARCHIS Archaeological Information System
DINO Data and Information on Subsurface of the Netherlands
* RAAP does not explicitly define what it regards as disturbance, though a definition can be derived from the features of each map database used (report, p. 58, Table 7).
** The HGN was not used, but historical land use was included in some detail in the study, eventually resulting in a more detailed picture than the one presented in the HGN.
*** The results of archaeological borehole surveys were however studied.

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4.5 Mapping Disturbances. Potential disturbance of archaeological remains in built-up areas

H.M.P. Bouwmeester[23], J.-E. Abrahamse and A.M. Blom

Abstract
A significant proportion of the Netherlands is built up. Nevertheless, archaeological remains might be situated in these built-up areas. Both the nature of this subsurface archaeological resource and the nature of the disturbance resulting from construction work differ from those common in rural areas. This paper describes the results of a study of disturbance in built-up areas, focusing on the new neighbourhoods built in urban expansion projects since 1875. The study distinguished between predicting disturbance at neighbourhood level – related to the density of buildings, for example – and the disturbances themselves, such as the digging and laying of foundations. Knowledge of the extent and depth of soil disturbance can lead to a more responsible and efficient approach to archaeological remains, thus reducing costs for developers and builders. The initial conclusion is that intact archaeological remains can be found under neighbourhoods, and that a thorough knowledge of disturbance caused by the layout and construction of a new neighbourhood can help predict the actual disturbance to those remains.

Keywords: building density, disturbances, foundations, urban archaeology, urban design, neighbourhood typology

4.5.1 Introduction

Archaeological remains may be present in the subsurface. This buried archaeological resource is not always intact. Find spots have often been disturbed, either partially or in their entirety. The better the location and scale of disturbance is known, the more customisation is possible when interventions are planned. This can reduce costs for the developer. After all, if a resource has been severely disturbed and has lost most of its information value it need not be subjected to further investigation. This study looked at the probability of disturbance at the level of entire residential developments or neighbourhoods, and of individual buildings or blocks. The focus is on neighbourhoods built since 1875. This date has been chosen in connection with the Fortifications Act of 1874, which permitted the dismantling of the walls around many towns, allowing them to expand. The emphasis is also on direct physical disturbance. Indirect disturbance, such as changes in the water table, has not been considered in this study. Disturbance to the soil in rural areas is examined in another contribution to this volume.[24]

This paper first outlines the development of residential neighbourhoods, and also considers later dynamics within these areas. Then, twenty neighbourhoods are taken as an example in order to study the correlation between building density and the characteristics of the neighbourhood. We then zoom in on the disturbance that is likely to have occurred beneath buildings, considering activities to prepare the ground for building work, the digging of construction pits and laying of foundations, changes while the neighbourhood is in use, the effects of demolition and the problem of fragmentation of the subsurface archaeological resource. Conclusions and recommendations are then presented on the basis of this analysis.

4.5.2 Development of residential neighbourhoods 1850-2016

Developments up to 1850
An understanding of how residential neighbourhoods developed is important for our understanding of what has happened in the soil. Most towns in the Netherlands were established between 1100 and 1400, but for a long time after that they expanded very little, if at all. Between 1400 and 1700 a small number of cities expanded, particularly in the west of the country. But after 1700 urban development came to a standstill for a long period there, too. Most towns and cities therefore experienced a very long period of stagnation, from the Late Middle Ages until well into the nineteenth century. Only in the cities in the provinces of Noord-Holland, Zuid-Holland and Groningen was this period of stagnation shorter, lasting from the seventeenth to the nineteenth century.[25]

23 Corresponding author: j.bouwmeester@cultureelerfgoed.nl.
24 Van Reuler 2017: this volume 4.2; De Vries & Maas 2017: this volume 4.3; Lascaris & Huisman 2017: this volume 4.5
25 For an overview of the development of the urban pattern in the Netherlands and the form towns and cities took, see Rutte & Abrahamse 2016.

Figure 1 The Oude Pijp working-class neighbourhood of Amsterdam (photo: G.J Drukker 1984, collection Cultural Heritage Agency).

1850-1900
Towns began to grow again after 1850 under the influence of new infrastructural, technical and economic developments prompted by the industrialisation of the Netherlands. A highly diverse range of neighbourhoods were built between 1850 and 1900, adapted to the structure of the existing landscape and the intended residents. The working-class and middle-class neighbourhoods from this period are very densely built (Fig. 1). Spacious, affluent residential areas were also built around the country, both close to cities and in attractive rural areas with good transport connections, such as Het Gooi and the dune areas. Towards the end of the eighteenth century urban design became gradually less connected to the underlying landscape, and began to feature basic star-shaped layouts, for example.

1900-1945
In the early twentieth century urban and architectural designs began to be commissioned by a single party, leading to larger-scale designs and projects. Under the influence of the garden city philosophy, fairly spacious working-class neighbourhoods were designed on the edges of towns and cities or at locations outside town (Fig. 2). These typically featured a strong, comprehensive design and a geometric structure separate from the landscape. Such areas were also designed for wealthier residents, with larger homes.

After 1945
After the Second World War urban design practice changed dramatically under the influence of Modernist ideas, which had already taken hold before the war. The Modernist ideal of building in open green spaces was introduced on a wide scale, in combination with the idea of neighbourhood units, in order to provide light, airy and spacious places for people to live in. The amount of public space expanded rapidly, particularly after 1965, leading to a significant reduction in the built-up surface area. The advent of the car as a mass means of transport, bringing with it large-scale road infrastructure and high-rise buildings, led to a further decline in the building density in neighbourhoods. From the early 1970s, as opposition to large,

Figure 2 Example of a mixed suburban neighbourhood inspired by the garden city idea (Tuindorp 't Lansink, Hengelo) (photo: A.J. Van der Wal 1992, collection Cultural Heritage Agency).

Figure 3 Suburban 'Vinex' development, Kattenbroek in Amersfoort (photo: P. Van Galen 2002, collection Cultural Heritage Agency).

standardised Modernist developments grew, many new types of neighbourhood developed in rapid succession. Neighbourhoods with a 'cauliflower structure', or 'tree structure', with streets as social spaces and irregular, small-scale architectural designs were followed in the 1980s by residential developments on a larger scale, where the underlying landscape again determined the look and layout (Fig. 3).[26] Around this time it also became standard practice to conduct an archaeological investigation when residential developments were planned. However, the basic concept has never changed: residential neighbourhoods are still laid out in accordance with the neighbourhood unit idea developed in the 1940s, with similar types of homes (mainly family homes and apartments) and, compared with historic town and city centres, a very low building density.

4.5.3 Disturbance at neighbourhood level

Dynamics of neighbourhoods 1875-present

Disturbance of archaeological remains can occur when neighbourhoods as described above are built, altered and demolished. During the construction phase, this is associated in particular with preparation of the ground and the laying of foundations (see below), and also with the installation of utility connections and roads. But use of neighbourhoods and the demolition of buildings also entail interventions in the soil. After a development has been built, it is therefore mainly the dynamics of use that have a bearing on any impact on the buried archaeology there. Dynamics in this context mean demolition, replacement or major renovation of buildings.

Generally speaking, the spacious, affluent residential areas built in 1875-1940 have undergone few changes. Nevertheless, the larger houses have often been divided into offices and apartments, or are now used as care institutions. Many of the plots also have new auxiliary buildings and parking facilities. Middle-class and working-class neighbourhoods (1870-1940) have also seen a low level of dynamics. Many of the homes were replaced and/or renovated during the urban renewal period in the period 1975-2000. The older urban renewal projects are now themselves in need of renovation.

On the other hand, however, dynamics have been high in the post-war developments (1945-1970), particularly in socially deprived areas. These neighbourhoods consist largely (50-80%) of social housing. Many local authorities and homeowners regard this as undesirable. Some of these homes have been replaced since the introduction of urban regeneration. This process will continue now the economy is reviving, particularly in the west of the country and in cities. In areas where the population is shrinking, the amount of built-up area is declining as buildings are demolished. As in the older middle-class and working-class neighbourhoods, a large proportion of the homes (50-60%) in late post-war neighbourhoods (1975-2008) are social housing, but since they are less old the dynamics there are fairly low. One example of a neighbourhood with high dynamics is Zanden- en Riffenbuurt in Delfzijl, which has been facing population decline for years. Since 2000 parts of the area have been demolished. Another example of a post-war neighbourhood with relatively high dynamics is Westelijke Tuinsteden in Amsterdam, where large-scale replacement and renovation are taking place because of the poor condition of the homes.[27]

Building density

The ratio of built-up to unbuilt area provides a rough indication of the likely disturbance at neighbourhood level. As suggested above, the building density of a neighbourhood depends on when it was built, the type of buildings, the design and the socioeconomic background of the original residents. Each area has its own urban design structure, but we can generally distinguish between working-class neighbourhoods, middle-class neighbourhoods, affluent residential areas, high-rise developments and mixed neighbourhoods. These neighbourhoods can be further categorised into those in an urban, suburban or non-urban setting, neighbourhoods with (predominantly) social housing and neighbourhoods with largely owner-occupied homes. This is of course based more on characteristics than on any sharply defined typology, whereby one excludes the other. Based on these characteristics, twenty neighbourhoods built after 1874 were selected. The circumference of the neighbourhood was determined using a GIS on the basis of the Statistics Netherlands

26 These were known as 'Vinex developments', after the Supplement to the Fourth Policy Document on Spatial Planning (known by the acronym Vinex), issued by the Dutch Ministry of Housing, Spatial Planning and the Environment.

27 Nio, Reijndorp & Veldhuis 2008; Nio *et al.* 2016.

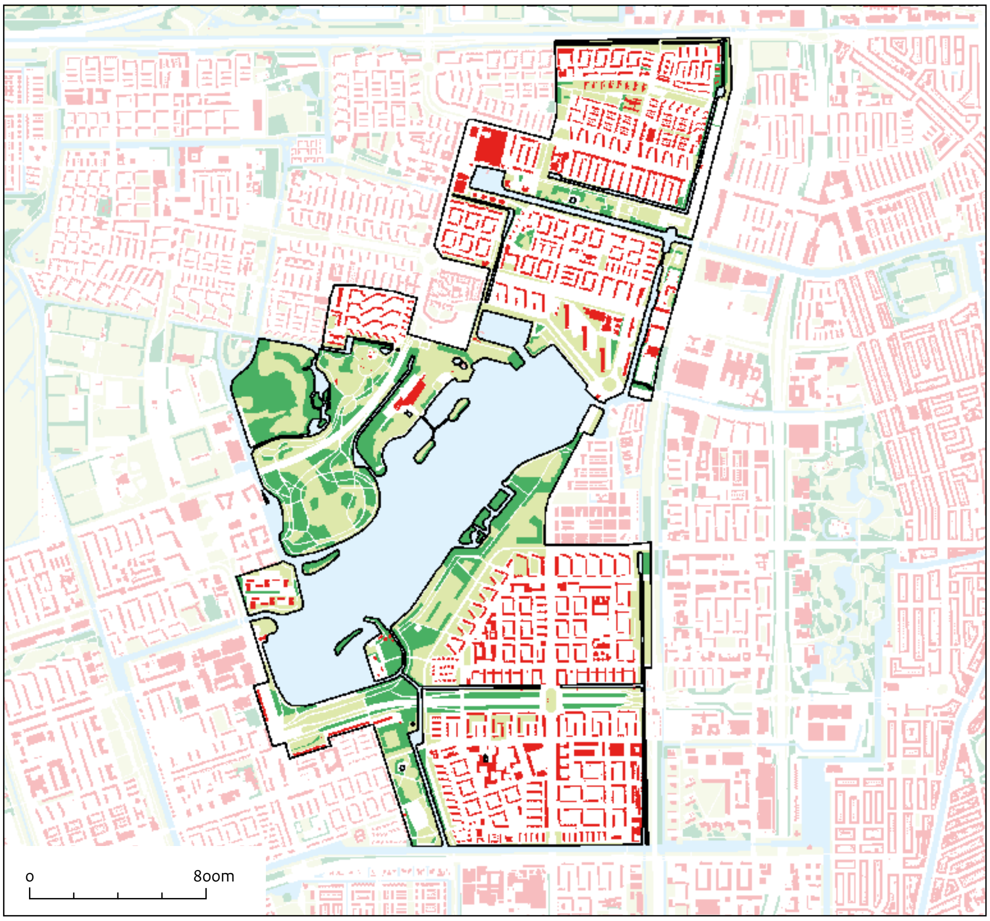

Figure 4 Westelijke Tuinsteden, Amsterdam. Example of the method used to calculate the total area and the area that has been built on.

Neighbourhood Map 2015. Mapinfo was then used to calculate the total area and the area that has been built on. The selection is not statistically representative but it does give an indication of the likely building density in similar areas. The building density is represented as the current proportion of built-up area relative to the total area of the neighbourhood (Fig. 4; Table 1).

The building density is determined above all by the setting and, secondly, by the typology of the neighbourhood and the period. The Oude Pijp neighbourhood of Amsterdam has the highest density (working-class/urban) at 57%, followed by the Archipelbuurt in The Hague (mixed/urban) with a density of 34%, and Zuilen-Elinkwijk in Utrecht (working-class, urban), with a building density of 28%. The fact that the setting is more significant than the originally intended residents is evidenced by the urban affluent area of Zuiderpark in Groningen. There, the building density is considerably higher (18%) than the village of Budel-Dorpplein, designed for working-class families (2%) and the suburban working-class neighbourhoods of Brunssum (9%) and Emmen (9%). The built-up area is not incidentally a direct indication of the number of homes. The number of homes by area is significantly higher in a neighbourhood with only social housing than in an affluent, spacious neighbourhood.

Table 1 Characteristics and building density of twenty Dutch neighbourhoods.

Name	Built in	Type of neighbourhood	Setting	Type of building	Rented/ owner-occupied (when first built)	Area (ha)	Building density (%)
Amsterdam - Oude Pijp	1875-1900	working-class	urban	medium-rise	social housing	62.3	57
Amsterdam - Westelijke Tuinsteden	1950-1965	working-class	urban	medium- and low-rise	largely rented social housing	379.4	12
Brunssum - various former mining villages	1900-1940	working-class	suburb	low-rise	largely rented social housing	187.5	9
Budel-Dorplein	1875-1930	working-class	village	low-rise	rented	221.7	2
Emmen - Emmermeer, Angelslo, Emmerhout	1955-1960	working-class	suburb	largely low-rise	largely social housing	844.1	9
Heerlen - Vrieheide	1959-1970	working-class	suburb	low-rise	social housing	33.4	15
Utrecht - Zuilen-Elinkwijk	1890-1920	working-class	urban	largely low-rise	social housing	15.2	28
Amersfoort - Kattenbroek	1985-1995	Vinex	suburb	mixed	largely owner-occupied	147.8	20
Arnhem - Geitenkamp	1920-1930	mixed	suburb	low-rise	rented	51.6	21
Hengelo - Tuindorp 't Lansink	1910-1930	mixed	suburb	low-rise	rented	42.5	14
Hilversum - Plan Oost	1920-1940 1945-1965	mixed	urban	low-rise	largely rented	104.2	20
Hoorn - Grote Waal, Buurt 13 07	1966-1984	small-scale, streets as social spaces	suburb	low-rise	social housing	36.9	13
Rotterdam - Ommoord	1960-1970	high-rise development	urban	high-rise	rented and owner-occupied	120.2	13
The Hague - Archipelbuurt	1870-1900	mixed	urban	medium- and low-rise	rented and owner-occupied	30.9	34
The Hague - Ypenburg	1985-2000	Vinex	suburb	mixed	largely owner-occupied	445.3	12
Delft - Agnetapark	1875-1900	mixed (mainly working-class)	suburb	low-rise	rented	2.8	17
Groningen - Korrewegwijk	1910-1940	mixed (south: middle-class, north: working-class)	urban	medium- and low-rise	rented	55	27
Amersfoort - Bergkwartier	1900-1940	affluent, spacious	urban	low-rise	owner-occupied	19.5	9
Apeldoorn - De Parken	1875-1940	affluent, spacious	suburb	low-rise	owner-occupied	107.5	13
Groningen - Zuiderpark	1880-1900	affluent, spacious	urban	low-rise	owner-occupied	39.5	18

4.5.4 Buildings and disturbance

Disturbance during preparation for construction

While a site is being prepared for construction the ground may be heightened or the soil replaced. The impact of heightening on any underlying archaeological remains can be either positive or negative. The layer of soil on top of the remains can act as a protective blanket. On the other hand, heightening might compress and deform the archaeological remains, and may affect the water table, causing a deterioration in the burial conditions.[28] The likelihood of damage to any archaeological remains present is much greater when the soil is replaced, however. This involves partially or fully excavating and removing any soil that cannot be built on.

The size of the site being prepared is important. When larger areas are prepared, they are often levelled, which can cause major localised disturbance to the soil. The site layout is also important. This includes the laying of roads and underground infrastructure in the form of cables and pipelines. Green zones and water features are also often created during this process. All these activities can disturb the soil.

Disturbance caused by the laying of foundations

Foundation trenches or construction pits are generally dug in preparation for building work. When a construction pit is dug the soil is excavated down to the load-bearing substrate. If the building includes a cellar or basement, several metres more may be excavated. After this preparation work, the foundations are laid. There is a direct relationship between the type of foundation, the nature of the subsurface and the building's mass.[29] Sand and gravel soils, clay and loam soils, peaty soils and mixed soils all have different load-bearing capacities. Sand, for example, generally provides a good subsurface for buildings, whereas peat cannot be built on directly. Roughly speaking, the most common types of foundation can be divided into two categories: foundations on steel and foundations on concrete or wooden piles. In the case of foundations on steel, the foundation structure is laid directly on the load-bearing substrate. This type of foundation can be further divided into trench or strip foundations (beneath load-bearing walls), foundations on pillars and slab foundations (Fig. 5).

In the case of trench or strip foundations, the excavations might be limited to trenches where the foundations are to be laid. If the load-bearing layer is too deep for foundations on steel, the foundations will be laid on piles. Piles are generally only needed where load-bearing walls are to be built, so there will be no need to excavate the entire construction pit. However, the soil will be severely disturbed at the positions of the piles. The soil in the zone immediately adjacent to the pile can become compressed. The extent of the disturbance depends above all on the number of piles driven and their dimensions.[30]

Disturbance during use

Once the homes are in use, disturbance continues as residents make occasional alterations to their home and garden. This may include demolition, the moving or expansion of outbuildings, the building of extensions, or digging of ponds. Utility connections such as gas and electricity also change occasionally. The location and scale of such disturbances are difficult to predict.

Disturbance during demolition

When buildings are demolished the foundations are sometimes left in place, or they too may be removed, and possibly also the zones without foundations between them. The manner of demolition depends among other things on what the site is to be used for. Foundation piles can be removed or cut, the latter causing less disturbance. The removal of foundations can damage archaeological remains under or near them, particularly if heavy machinery is used, in which case demolition can be more disruptive than construction. Walls and pillars are mechanically extracted or excavated.

Disturbance due to fragmentation

Besides direct physical disturbance, residential developments can also disturb archaeology through fragmentation. The fragmentation caused by dispersed disturbances resulting from the laying of pipelines and foundations and the construction of cellars is like a page in a book in which holes have been punched (Fig. 6).

28 Huisman 2009.
29 Heijm 1982, 114.
30 Huisman *et al*. 2011, 18-19, 39-40.

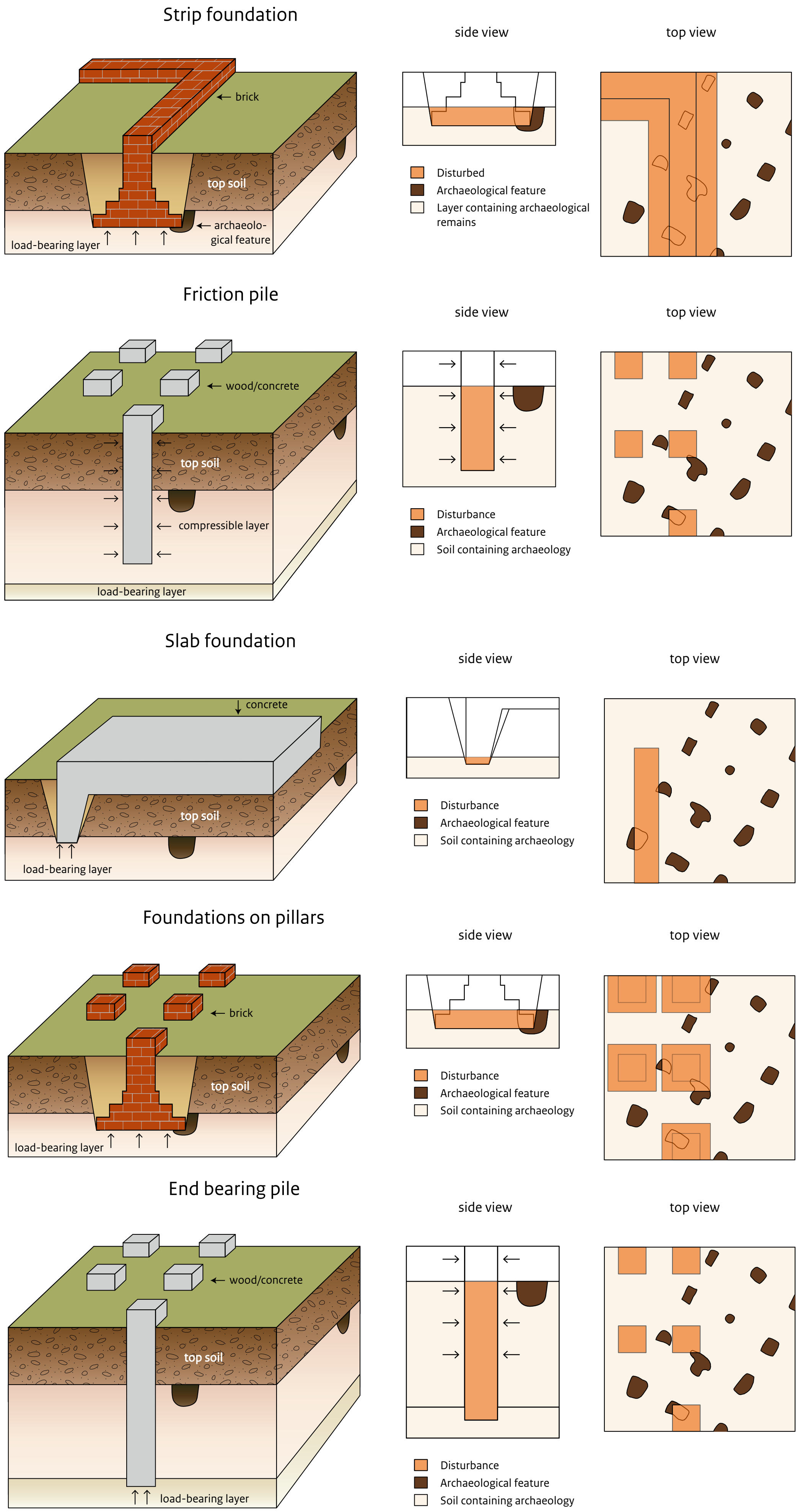

Figure 5 The most common types of foundations found beneath buildings in relation to archaeology.

Figure 6 Foundations of a medieval hospital complex (Geertruidengasthuis, Kampen), only slightly disturbed by piles.

Whether the text is still readable depends on the number and position of the perforations. Another source of disturbance occurs when sites are split up and sold off to different parties. Before a new residential development is built, there is one big site with a single owner, but after it is complete the site consists of many different plots, each with a different owner. As a result, it becomes highly unlikely that the original large site can ever be investigated in its entirety, though this is of course preferable from an archaeological point of view.

4.5.5 Conclusions

It will be clear from the above that the archaeological heritage in residential neighbourhoods and under buildings need not necessarily be completely disturbed. It is not however easy to draw reliable conclusions as to the degree of disturbance that is likely to have occurred. If the neighbourhoods investigated in this study are taken as a basis, the greatest building density is 56% (Oude Pijp in Amsterdam). In most cases, however, the building density is much lower, at less than 30%. The disruption as a direct result of construction work may not be too bad in many cases, therefore. Clearly, however, a general feature like building density gives only a rough indication of the likely degree of disturbance.

Knowledge of actual disturbance remains essential. Only if an entire site has been prepared for construction, with full excavation of deep construction pits and deep structures like cellars can we say with any certainty that the soil there will have been disturbed. Less rigorous soil excavation work such as the digging of foundation trenches may have left remains worth preserving *in situ*. This is also possible in areas with a higher building density.

However, a number of remarks can be made regarding this general picture. To make and keep houses habitable, utilities have to be provided and buildings have to be accessible by road. These are additional sources of disturbance whose scale and depth are less easy to estimate, partly because they are not always on the same scale. Furthermore, after new homes have been built, residents make alterations to their house and garden over the years. This also causes disturbance. We also often have no idea about the fragmentation due to multiple ownership and the disturbance caused by demolition work. Finally, the effect of the disturbance naturally depends on the nature, size and type of find spot, and its information value.

Given the fact that residential developments cannot be dismissed as a source of information merely on the basis of building density, and that archaeological remains may be preserved under buildings, depending on what type of foundations they have, from a cost and efficiency point of view it is advisable to make a good estimate of the likely degree of disturbance before performing any archaeological investigation prior to new construction or demolition work. This can be done, for example, by establishing how old the residential development is and how the site was prepared for construction, and then studying the foundations and ascertaining whether there are any cellars and other deep structures.

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5 Mapping the Past for the Future. Local authority predictive maps and archaeological heritage management

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Abstract
Since 2007, virtually all local authorities in the Netherlands have used archaeological resource maps, predictive archaeological maps and policy maps to help them meet their responsibility for heritage management. The Cultural Heritage Agency gathered and systematically analysed the maps in use: a total of 1666 maps and 611 accompanying reports. Subsequently national overviews of each type of map were produced. The predictive archaeological maps are based on predictive modelling combined with expert judgment. It is often unclear what predictions are actually based on. It was found that, when maps are fitted together, they do not match well in terms of either form or content. Differences between maps raise questions when it comes to projects that straddle municipal boundaries. The discrepancies are associated with the almost complete lack of overall detailed guidelines for map production, differences in the predictive models used, the sources consulted, the design and conditions imposed by the authorities commissioning the maps, as well as in the financial resources available. Central government is therefore keen to encourage local authorities to ensure that their predictive maps are more compatible in the future. Further, verifying the predictive models on the basis of resources identified in new field research could help enhance archaeological heritage management. This will enhance local authorities' ability to make informed choices in their archaeology policy.

Keywords: archaeological heritage management, local authority predictive maps, national overview, predictive modelling, comparison of map form and content

5.1 Introduction

With a population of just over 17 million and more than 500 inhabitants per km², the Netherlands is one of the most densely populated countries in the world.[2] It is proving more and more difficult to protect archaeological find spots in the face of spatial developments. One of the problems lies in the fact that most archaeology in the Netherlands is subsoil archaeology. Visible archaeological relics, like barrows, dolmens (*hunebedden*) and castle mounds represent only a very small proportion of our country's archaeological heritage.[3] Most archaeological remains are buried, sometimes several metres deep, covered by Holocene deposits or, in the Pleistocene areas of the country, by man-made layers such as plaggen soils (Fig. 1). Where these covering layers are very thin or absent, the archaeological features and finds lie close to the surface. Various

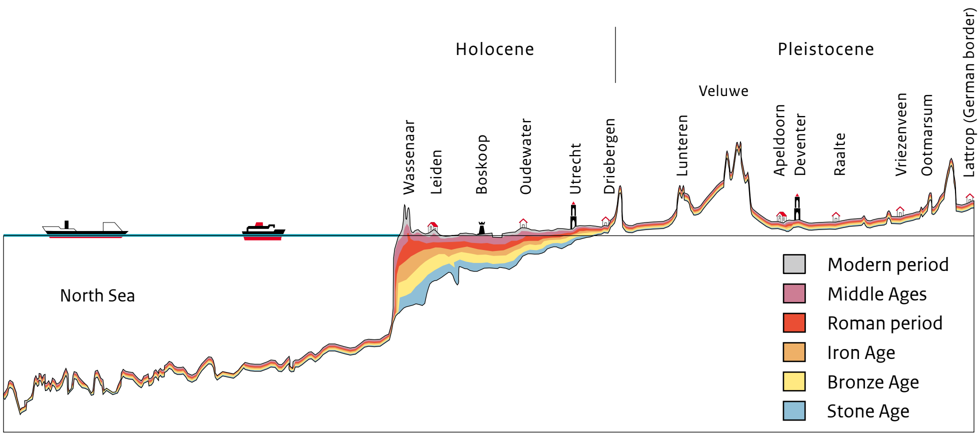
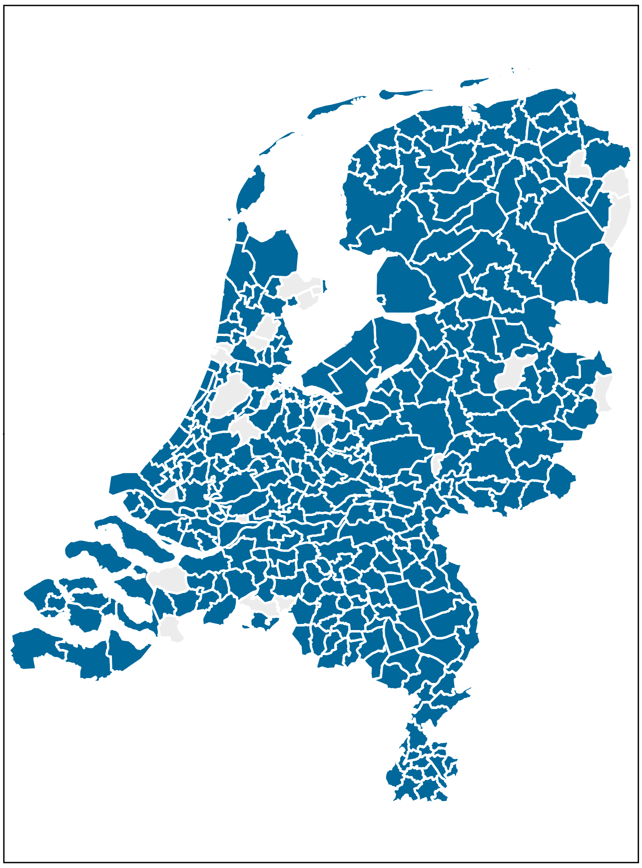


Figure 1 Schematic cross-section of the Netherlands, from the North Sea coast to the German border, indicating the depth at which remains from different periods lie.

1 Corresponding author: b.speleers@cultureelerfgoed.nl.
2 2016 figures.
3 Zoetbrood *et al.* 2006.



Municipalities that have archaeological maps (2016)

Figure 2 Map of the Netherlands showing all local municipalities that have archaeological maps.

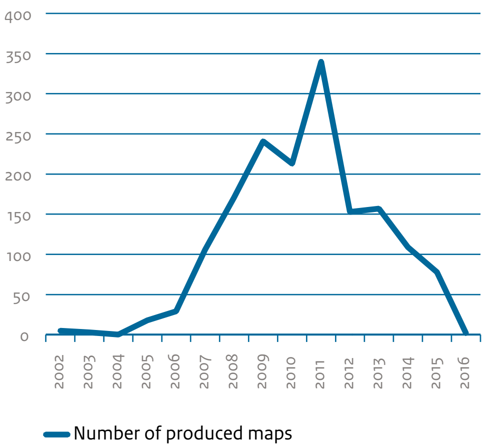


Figure 3 Production dates of local authority archaeological maps in the Netherlands, to September 2016.

methods and strategies are used to locate 'invisible' archaeological sites, the most common of which are systematic borehole campaigns and trial trench surveys.[4] It would be impossible, however, to map the archaeological record of the entire country by means of field research, as this would simply be too labour-intensive and costly. Since the early 1990s, therefore, predictive modelling has been used in cultural heritage management. In this respect, the Netherlands differs from most other countries in northwest Europe, where predictive modelling plays a more modest role in archaeological heritage management.[5]

Predictive modelling plays a vital role in the production of predictive archaeological maps. Such maps were initially made on a nationwide level, and then at provincial level, but since 1 January 2008 responsibility for the production of predictive maps has been completely devolved to the local level. Section 38a of the Monuments and Historic Buildings Act 1988 provides for buried archaeological resources actually or likely to be present to be taken into account by the local council in zoning plans.[6] To meet this responsibility for archaeological heritage management, local authorities have opted to compile heritage maps. They have vigorously set about the task and over the past few years hundreds of archaeological maps – resource maps, predictive maps and policy maps – have been produced. Currently, 95% of local authorities have one or more maps showing archaeological resources and predictions (Fig. 2).[7]

The fact that almost all municipalities now have archaeological maps in use could be a reason to be satisfied from the point of view of archaeological heritage management, but the devolvement of the responsibility for heritage management does have a downside. Administrative freedom has led to major differences between local municipality maps. As long as they are used only within the municipality itself, this should not be a problem. But as soon as situations arise that affect more than one municipality – such as large infrastructural projects for which maps have to be compared and combined – problems occur. There for the Minister of Education, Culture and Science commissioned the Cultural Heritage Agency to perform the Maps in Abundance project to identify the scale of, and analyse the problems associated with local authority archaeological

4 Rensink *et al.* 2017: this volume Chapter 6.
5 This paper does not consider the advantages and disadvantages of predictive modelling in archaeology, about which much has already been written. See Deeben *et al.* 1997; Groenewoudt & Bloemers 1997; Deeben, Hallewas & Van Maarleveld 2002; Van Leusen & Kamermans 2005; Verhagen 2007; Deeben & Groenewoudt 2012; Verhagen & Whitley 2012; Deeben & Smit 2015.
6 The Monuments and Historic Buildings Act 1988 has now been incorporated into the Heritage Management Act. Section 9.1 of the Heritage Management Act states that 'until such time as the Environment and Planning Act enters into force Chapter V, paragraph 1 will remain in force'. Section 38a of the Monuments and Historic Buildings Act will therefore remain applicable in its current form until the introduction of the Heritage Management Act.
7 Including accompanying reports.

maps, and make recommendations as to how the maps can be better coordinated in the future.[8] The purpose of the project was categorically not to evaluate local authorities' archaeology policy, but to help them perform their archaeological heritage management tasks more effectively. The Maps in Abundance project collected 1666 maps and 611 accompanying reports between January 2014 and October 2016.[9]

5.2 The municipal level

The Netherlands is divided into twelve provinces, with 390 municipalities.[10] They range from rural farming municipalities comprising several population centres to densely populated cities, and their size varies from 7.84 km² to more than 400 km². There are hidden archaeological sites in all municipalities. Local authorities are responsible for heritage management within their municipal boundaries.[11] In order to meet this responsibility properly, most local authorities have drawn up their own archaeology policy in recent years, consisting of policy rules, in many cases combined with a policy map.[12] Local authority policy is there for based on archaeological resource maps and predictive maps.[13] These in turn are based on, or have superseded, the national indicative map of archaeological values (IKAW),[14] the national database of archaeological sites (ARCHIS) and the provincial maps of archaeological monuments (AMK).

Most of the maps have been compiled by commercial archaeological agencies, and some by municipal archaeologists and regional services. In some cases, maps of several adjacent municipalities have been produced by the same organisation. The oldest maps in use date from 2006-2007. However, the majority were produced or updated between 2008-2011 (Fig. 3).

In certain parts of the Netherlands provincial authorities played an active role in the production of local authority archaeological maps in 2006-2007, awarding grants for the purpose, and sometimes issuing guidelines. In a number of provinces, deliberate attempts were made to ensure the maps of individual local authorities were compatible.[15] Some local authorities also have one or more maps showing other cultural heritage features, such as historical landscape

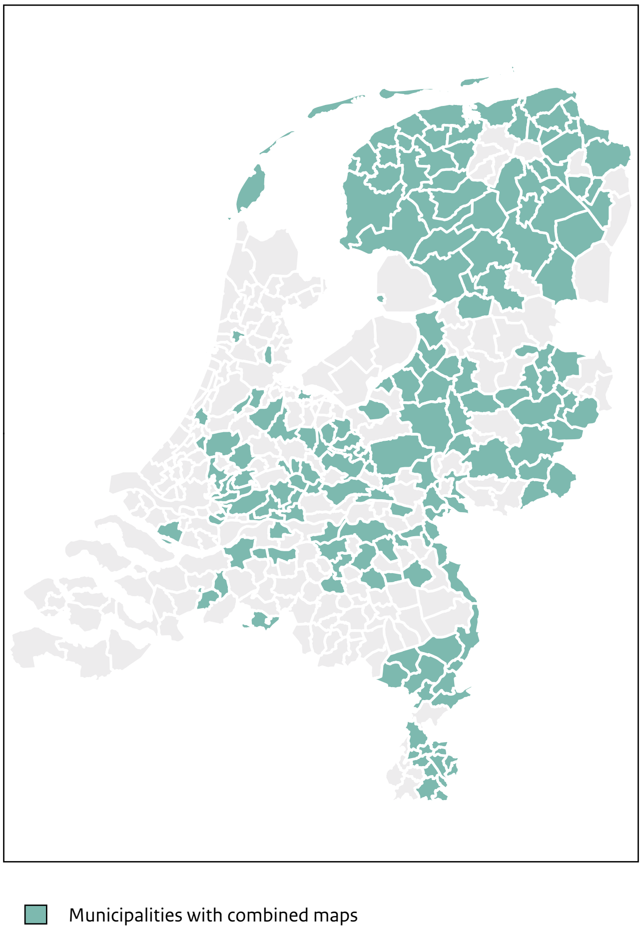


Fig. 4 Local municipalities with maps combining archaeology and other cultural heritage features.

elements and built heritage, listed monuments and historic buildings, conservation areas and historic parks and gardens (Fig. 4). There has been a particular increase in such broadly oriented cultural maps in recent years. The increase in the number of archaeological maps featuring remains from the Second World War (1940-1945) is striking, and is associated with growing public interest in this period of history.

Archaeological and other cultural heritage maps can be referred to in their entirety as 'heritage maps'. In order to allow comparison between different types of archaeological map, they have been divided into three categories:

- maps showing known archaeological resources, if find spots locations, evaluated sites and/or listed archaeological monuments are listed in the legend;

8 Letter to the House of Representatives of 7 February 2012, 2011-2012 session, 33 053, no. 3.
9 Boshoven 2015.
10 In 2016.
11 Central government is responsible for the operation of the system as a whole. It advises the parties involved and makes knowledge available via the RCE. Central government also lists national archaeological monuments and issues permits relating to them.
12 See RCE 2015, 4, fig. 2.
13 Friesland is an exception. There, most local authorities use the Frisian Archaeological Monuments Map Extra (FAMKE). A few Frisian authorities have compiled their own map, or have commissioned such a map.
14 The first generation of the IKAW dates from 1997, the second from 2001. The second generation map also includes underwater archaeology and improvements to parts of the Holocene area of the Netherlands and the central rivers area; see Deeben *et al.* 1997; Deeben, Hallewas & Maarleveld 2002; Deeben & Groenewoudt 2012, 329-31. Also Deeben & Smit 2015.
15 This did not always prove successful, however, see Van Doesburg *et al.* 2016.

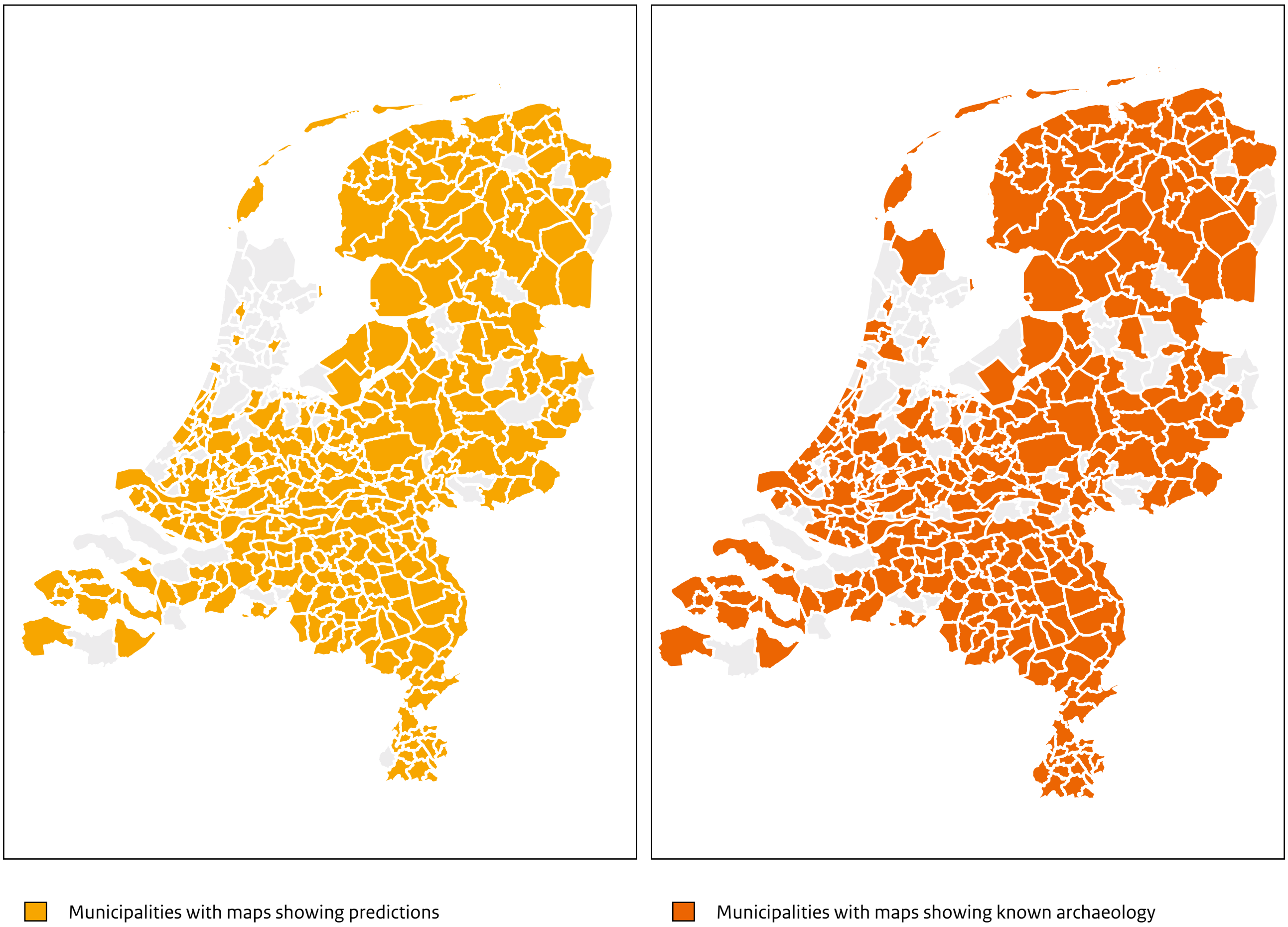


Figure 5 Local municipalities with maps showing archaeological predictions (left) and known archaeology (right). Situation in 2014.

- maps showing archaeological predictions, if the legend at least shows high, medium and low probability of encountering archaeological remains;
- maps indicating policy on archaeology, if the legend mentions policy rules such as exemptions or mandatory investigation for a certain depth or area.

Sometimes separate maps have been made for the three categories, but most commonly combinations of two or even three categories occur on a map. The legends have been used to classify the maps into the three categories listed above. National overview maps have been produced for each category, showing at a glance what categories of map exist for which municipalities, and which local authorities have a map (Fig. 5).[16]

5.3 Map images

For this project, sections of the maps were digitally extracted, georeferenced, and converted into tiff files. The maps showing archaeological predictions were joined up and four different regions of the Netherlands were selected for further analysis. In the interests of representativity and geographical distribution and visual variation, regions in both the Holocene and the Pleistocene landscapes, and in urban and rural regions have been selected. Regions where archaeological maps were produced by a large number of different parties – such as commercial archaeological agencies, municipal archaeologists and regional services – were sought, as well as regions where it would

[16] Some maps have been used several times, in view of the multiple categories.

be possible to examining the collaboration between local authorities and the role of the provincial authorities also played a role selecting the case study regions. Each regional case study comprised an average of ten municipalities. The map images and reports associated with them were then analysed.

5.4 Form

The first thing one notices is the large variation in titles. This is largely due to the fact that the maps have been made by a range of different parties. In most cases, the name of the map is consistent with its content, though in some cases there is a big discrepancy between the title and what is actually presented on the map.

Different scales have also been used. The most commonly used are 1:10 000, 1:15 000 and 1:25 000, though maps on a scale of 1:17 500, 1:20 000, 1:30 000 and 1:50 000 also exist. On several maps, no scale is indicated. In some cases, little consideration has been given to the constraints imposed by the scale of the source material. Many maps enlarge parts of the soil map and geomorphological map (scale 1:50 000) to a scale of 1:10 000, 1:15 000 or 1:25 000. This suggests that the map is accurate down to plot level, though it can actually only be used at regional or provincial level as a tool for value assessment or policymaking.

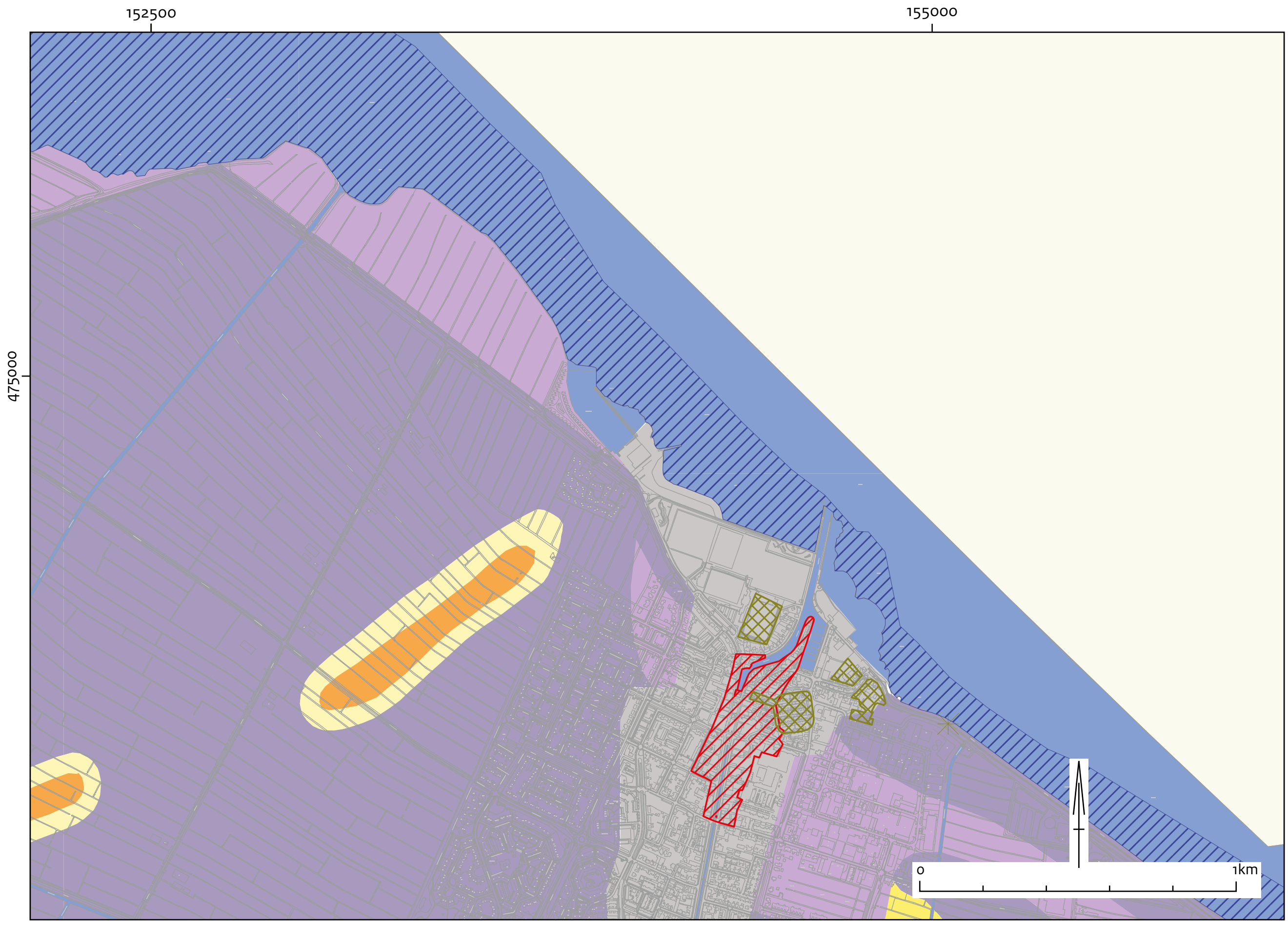
The archaeological maps have good readability on the whole. There is wide variation in the colours used, ranging from pastel shades to primary colours. The colours yellow, orange and red on the National Indicative Map of Archaeological Values (IKAW) are used in many cases. Any lack of clarity is generally the result of colours that are too similar, an excessive density of information, or symbols that are too similar in shape or too small. There is often no direct relationship between the type of archaeological map (predictive or resource) and the number of legend items, though maps showing known archaeology (resource maps) generally have many more items than predictive maps. Archaeological maps showing other cultural heritage features too have the greatest number of legend items. This is probably because there is no consensus as to which elements, patterns or structures should appear on such maps. In terms of the built heritage, for example, some maps indicate all historic buildings with one symbol, while others distinguish between types of buildings (castles, churches, farmhouses, pumping stations, bridges etc.) or period (Medieval, nineteenth-century, Second World War etc.).

5.5 Content

Various sources have been used to produce heritage maps. Most of them are nationally available, some of them are accessible online, such as the soil map, geological map and geomorphological map (all 1: 50 000). Digital sources such as the national geological data repository (Dinoloket), the National Archaeological Monuments Map (AMK), register of finds ARCHIS, the National Indicative Map of Archaeological Values (IKAW), LiDAR images, aerial photos and topographical maps have also been used. The rest are provincial, regional and local analogue and digital sources and datasets. One important source of information is the provincial Cultural Heritage Network (CHS), which describes cultural heritage resources and areas where there are lots of these resources. Regional and local sources also include amateur and museum collections. The archaeological, physical-geographical, historical and historical-geographical literature has also been used, ranging from doctoral theses to excavation reports and articles in local and regional cultural heritage magazines. In some cases, old maps and other pictorial sources have been consulted, including the original land registry maps from 1832 and photographs from the Second World War.

There is clearly no consensus regarding what exactly should appear on an archaeological map. Every mapmaker decides for him- or herself, sometimes guided by the specific wishes of the local authority commissioning the map or the guidelines that are the condition for funding from the provincial authority.

Archaeological resource maps feature known and confirmed archaeological resources. Many of these maps also show other cultural heritage features, such as buildings, historical landscape elements, historic parks and gardens. They may also include geological phenomenon’s. Archaeological predictions are also indicated in some cases.



	Archaeological prediction	
	Hunter-gatherers	Farmers
Western peat area	unknown	low
Slope area coversand ridge	middle high	middle high
Unkown soiltype	unknown	unknown
Coversand ridge	high	high
Eastern peat area	unknown	unknown
Valley of the Eem and coastal zone	low	low
Water	-	-
Historic villages and farmyard	high	
Grebbelinie defence line, redoute and batteries	high	
Submerged soil bed with prediction	high	

Figure 6 Example of predictive archaeological map showing different probability categories.

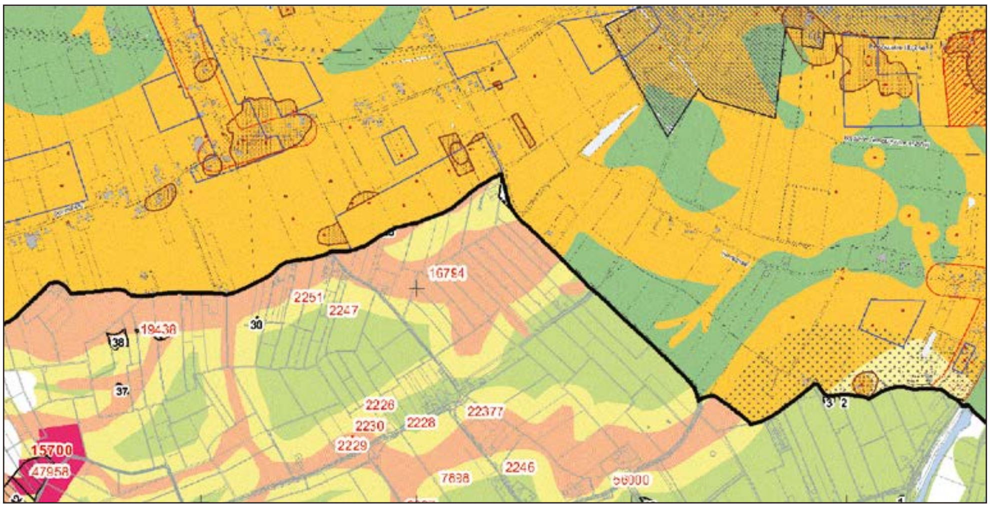


Figure 7 Example of incompatible local authority archaeological resource maps.

Predictive archaeological maps show predictions in the form of zones. As on the IKAW, many of the maps use high-medium-low probability categories, sometimes further itemised by archaeological period or, particularly in the Holocene part of the Netherlands, by depth. Occasionally, a map will feature more categories of prediction. Interestingly, surface waters such as lakes, streams and rivers are often not assigned any predictive value and are even considered disturbed.[17] Most predictive models consider only terrestrial archaeology, not archaeological finds in river and sea (Fig. 6).[18] Some predictive maps also show known archaeological sites, sometimes combined with details of soil excavation operations and excavated sites. Areas of interest are sometimes outlined or shaded.

There is relatively little differentiation in terms of the actual or predicted depth of archaeological remains, and any differentiation is limited largely to the Holocene landscape. Differentiation by period is indicated on fewer than half of local authority maps. The number of periods differs markedly, as do the date ranges of the periods themselves.

A number of predictive archaeological maps show predictions only for the countryside, showing built-up areas and village and town centres as areas of unknown or low probability.

When predictive maps are joined, the categories and the contour lines sometimes match up well, but more often they do not (Fig. 7).[19] This is caused above all by the different ways in which mapmakers model archaeological predictions. In most cases the modelling method is explained only briefly in the reports associated with the maps. Most do not clearly indicate how the archaeological value assessment was made. A 'black box' situation exists, in fact: the sources used are known but how they have contributed to the prediction and demarcation of the polygons on the maps cannot be reconstructed. Since the method of assessment is not clearly described, it cannot be verified or reproduced by others. In virtually all cases, soil and geomorphological maps appear to be compared with archaeological datasets to ascertain whether site locations are linked to soil types and groundwater classes. The data are sorted and predictions made on the basis of expert judgment. Soil, geomorphological and palaeogeographical elements are grouped in different ways by different mapmakers. Sometimes several items are combined to produce one prediction category, while in others items will have different values. Some mapmakers work with buffer and gradient zones, while others do not. It is observed that predictive models tends only to evolve slowly on

17 Boshoven 2015, 17; Houkes 2015.
18 Boshoven 2015, 17; Houkes 2015.
19 Van Doesburg *et al*. 2017.

the basis of new archaeological research, so improved understanding does not lead automatically to improved and refined models, which risk becoming static as a result.

Predictions for the Middle Ages and the Early Modern Period are based mainly on historical sources and map material, old aerial photographs, LiDAR images and satellite images. Soil and geomorphological maps play a less important role in predictive models for these periods.

5.6 Accessibility of maps

Less than half of the heritage maps are accessible online and via local authority websites; in some areas they are accessible via the website of a regional service.[20] The 2016 analysis found that a quarter of all the local authority archaeological maps gathered were accessible on the internet. Only 20% of the maps that provide the basis for a policy map (including maps showing predictions and known archaeology) are accessible via the internet. A test of the URL's found that 20% were no longer valid only two months after the first check, or the map had been removed from the local authority's website.[21] Since online access seems to change so rapidly, this is a clear weakness in terms of information provision.

5.7 Conclusions and prospects for the future

Local authorities in the Netherlands have had responsibility for the cultural heritage for approximately ten years now. They have made a start on identifying and recording archaeological resources and predictions on maps, which serve as a basis for local authority archaeology policy. A considerable number of local authorities also have one or more cultural heritage maps. Only 21 of the 390 municipalities have no heritage map at all.[22] All the local authority heritage maps are more detailed than the existing national and provincial maps, and are thus more appropriate as a basis for well-considered decisions concerning archaeological heritage management.

Showing national overviews of the various categories of heritage maps might encourage these authorities to produce heritage maps in the future.

The research conducted in four pilot areas turned out that local authority heritage maps differ in a number of ways. The causes of these differences were investigated. They were caused, among other things, by the fact that there is virtually no general guidance on the making of maps, and in differences in the predictive models used, the sources consulted, the design, wishes and requirements of the organisations commissioning or funding the maps, and the financial resources available.

Given the adaptation by local authorities it can be concluded that in the Netherlands predictive modelling is a useful tool for archaeological heritage management on the local level. Mapping the known archaeological sites and the prediction at a local level might also be useful in other parts of Northwest Europe, particularly where there are similar landscapes. It has however become clear that descriptions of predictive archaeological maps provide little insight into the structure and application of the models. The way statistical analyses, models and expert judgment are used to determine how landscape units are used in assigning specific levels of probability is generally not properly recorded. The way that mapmakers can make different choices in this matter, result in predictive maps which are often incompatible.

Comparing the maps by category and highlighting the differences might encourage local authorities to more cooperation with each other when making heritage maps in the future. At present the Cultural Heritage Agency together with archaeologist involved in making heritage maps and local authorities combined forces to develop a national quality standard for heritage maps. This may lead in the future to more uniform heritage maps. Though a certain degree of coordination and standardisation is needed, we must guard against overstandardisation, however, which could lead to stagnation and even a decline in the acquisition of new knowledge concerning predictive modelling. It would however be wise to evaluate current predictive models, and thus revive the debate on the role and value of predictive modelling in archaeological heritage management in the Netherlands, and also elsewhere. Furthermore, local authorities have their own responsibility,

20 See Boshoven 2015, 6-12
21 Van Doesburg *et al*. 2017.
22 Situation september 2016.

and decide how they manage the heritage.

The idea is to continue collecting new and revised maps over the coming years, since they also play a role in archaeological heritage management at national level, in the heritage review for example, which describes every four years the state of heritage management.

Finally, it is recommended that local authority heritage maps remain publicly available online, so that anyone who wants or needs to, can make use of them.

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6 Prospection Made-to-Measure. A digital information system for archaeological prospection methods

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Abstract
For years, archaeologists have been debating the right way to detect archaeological find spots in the varied landscape of the Netherlands. And rightly so, for prospection is the foundation of archaeological heritage management. Despite the fact that a great deal of experience has been gained with archaeological prospection in the Netherlands over the past few decades, choosing the most suitable method is by no means easy or obvious. Every prospection method has its own applications, potential and limitations. Which methods are good, and how do they relate to the characteristics of the find spots one can expect to encounter? This issue has been addressed as part of the Archaeology Knowledge Kit programme, resulting in a digital information system known as Prospection Made-to-Measure. This chapter explores the background to the development of this national system. Prospection Made-to-Measure advises users about the most suitable methods, thus helping to further improve prospective research in the Netherlands.

Keywords: archaeological heritage management, archaeological field evaluation, prospection method, prospection characteristics, research modules, digital information system

6.1 Introduction

Prospection is an important link in the chain of processes involved in the management of the archaeological heritage. In the Netherlands, hundreds of prospection studies are carried out each year in the context of spatial developments, as part of the cycle of archaeological heritage management. The aim of these archaeological field evaluations is to obtain an insight at an early stage of the planning process into the presence or absence of archaeological find spots. If find spots are indeed present, one must then consider the value of what has been found. The main factors one must consider when assessing the value of a find spot are its nature, size, date and quality (both scientific and physical).[2] Borehole surveys and trial trench surveys are often used to detect find spots; geophysical methods are used less frequently. Trial trenches are the most common method used to assess the quality of find spots. Although the number of borehole surveys and trial trench surveys performed has fallen in recent years, field evaluations still account for almost 60% of the archaeological investigations performed in the Netherlands (Fig. 1).

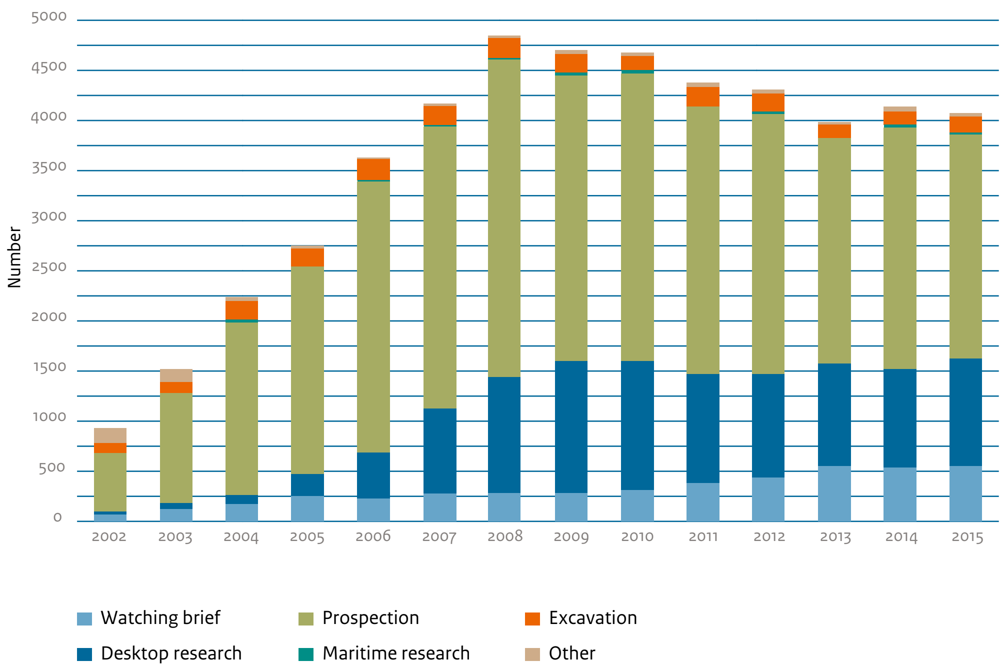

Figure 1 Archaeological investigations in the Netherlands 2002 to 2015.

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2 According to the Dutch Archaeology Quality Standard (Stichting Infrastructuur Kwaliteitsborging Bodembeheer 2013).

In recent years a number of interesting publications, including two PhD theses, in the Netherlands have considered the applicability, reliability, effectiveness and efficiency of field evaluations.[3] Rightly so, for the results of these investigations are used as a basis for crucial choices concerning the archaeological heritage: preservation *in situ*, excavation or release for development. Along with desk-based assessment, prospection forms the basis of the archaeological heritage management cycle.

The Cultural Heritage Agency's (RCE) Prospection Best Practice project, part of the Archaeology Knowledge Kit programme, was launched in response to these discussions, and was designed to advise on suitable methods for locating and assessing specific archaeological heritage. The aim was to improve both the application of prospective fieldwork in the Netherlands, and the basis for the choice of a particular method. It was envisaged that a digital information system would be developed that would be easy to use and accessible for a large group of users.[4] The group of intended users is highly diverse, ranging from private developers with absolutely no background knowledge of archaeology to archaeological specialists. The information system should be suitable above all for policy officers working at local and provincial authorities, and those actually carrying out prospection work. The Prospection Made-to-Measure system went online in September 2016. It can be accessed via the website www.archeologieinnederland.nl.

This chapter explains the background to the system: what prospection methods are regarded as appropriate? How do they relate to the characteristics of the find spots one can expect to encounter? What is the system like? And what ideas are relevant for development in the future?

6.2 Archaeological prospection in the Netherlands

In accordance with the Dutch Archaeology Quality Standard,[5] a distinction is drawn between various forms of archaeological investigation that form part of the cycle of archaeological heritage management. The common procedure is to perform a desk-based assessment to gather information about known and predicted archaeological values in the area in question. This produces a 'specified archaeological prediction', a description of seven properties of the predicted find spots (date; site type; size; depth; location; external characteristics; and potential disturbances). These properties are used to make a prediction concerning the prospection characteristics of the find spots so that a well-founded decision can be taken as to the most suitable follow-up.

The prediction is then tested in the field in an archaeological field evaluation, which can take the form of a survey (mapping phase) or a value assessment (valuating phase). Efficient use of methods and a reliable outcome are vital at this stage. After all, these results are used as a basis for choices concerning the archaeological heritage: whether to preserve the find spot *in situ*, excavate it, or release the site for development. Despite the fact that a great deal of experience has been gained with archaeological prospection in the Netherlands in recent decades, choosing the most appropriate method is not a simple or obvious matter. Various prospection methods exist, each of which has its own applications, potential and limitations. Some methods, such as borehole and trial trench surveys, have been commonly used for a long time in this country. Less common, 'new' field evaluation methods also exist, such as remote sensing and geophysical survey. Which method is most suitable in a given situation depends on the potential and limitations of the method itself, but it is above all the characteristics (type of indicators) of the find spot as they relate to prospection that determine whether an application is appropriate in terms of method, technique and strategy.

Over the past few years important steps have been taken to improve the application of field evaluation methods. Guidelines have been published for prospective borehole surveys and trial trench surveys as part of the Dutch Archaeology Quality Standard.[6] These two sets of guidelines allow the choice of method, technique and strategy to be more firmly underpinned. The English Heritage report 'Geophysical Survey in Archaeological Field Evaluation' was also adopted as a guideline in 2013.[7]

3 Examples include: Graafstal, Hoegen & Van der Roest 2009; Kattenberg *et al.* 2008; Kortlang *et al.* 2014; Van den Oever 2013; Van der Rijst 2008; Visser, Gaffney & Hessing 2011; Wilbers 2007; Verhagen & Borsboom 2009; Willemse 2013. For the PhD theses, see Kattenberg 2008; Oonk 2009.
4 Rensink *et al.* 2016a.
5 Stichting Infrastructuur Kwaliteitsborging Bodembeheer 2013.
6 Borsboom & Verhagen 2009; Tol *et al.* 2004.
7 English Heritage 2008; Kattenberg & Hessing 2013.

6.3 The Prospection Best Practice project

Over the past few years the Cultural Heritage Agency has also launched initiatives designed to provide more insight into the subject of prospection. In 2010, it launched a project designed to generate new knowledge of archaeological field evaluation, in collaboration with the Stichting Infrastructuur Kwaliteitsborging Bodembeheer (SIKB) network.[8] The project was to deliver products and results that could be used directly to update existing guidelines. The initiative formed the basis of the Agency's Archaeological Prospection project that was completed in 2012 with a critical evaluation of the standard of archaeological desk-based assessment in the Netherlands.[9]

The Prospection Best Practice project, part of the Archaeology Knowledge Kit programme, builds on this knowledge and experience. One important request made by the State Secretary for Education, Culture and Science in 2012 was that the Agency should 'provide insight into the most suitable methods and techniques for detecting archaeological remains in a certain region, given the landscape and the remains likely to be encountered'.[10]

Four years were spent gathering, analysing and providing online access to data on archaeological prospection. There was much discussion of terms and concepts. The term 'prospection' encompasses archaeological field evaluations for both survey (mapping phase) and value assessment (valuating phase) purposes.[11] A survey is a systematic investigation of a particular area to detect the presence of archaeological finds and/or features. If one or more find spots are present, a value assessment will be performed in order to gather additional information on aspects such as their nature, size, date and physical quality. To understand these two types of archaeological field evaluation correctly, it is important that we distinguish between methods, techniques and strategy. These have been defined as follows:

- method: action designed to locate and investigate archaeological remains (finds and features) in the field and to identify their landscape context. This can be achieved by destructive methods, such as excavation and borehole survey, or non-destructive methods, such as field-walking and geophysical survey;
- technique: further specification of the method of locating and investigating archaeological remains (finds and features) in the field and identifying their geographical context. Examples include excavation techniques (manual or machine; type of gouge [auger or Edelman gouge] and diameter of drilling head) and geophysical survey techniques (electrical resistivity, electromagnetic, ground penetrating radar etc.);
- strategy: the way in which an archaeological technique is applied in the field in terms of the position and orientation of research units, such as excavation pits, trial trenches, boreholes and transects.

Given the time available, it was decided that the nationwide digital information system Prospection Made-to-Measure should focus on the first level (method). The system does not yet provide advice on the use of specific techniques or strategies needed to adequately locate and assess certain types of archaeological remains. Analysis and presentation of methods designed to detect archaeological remains under water (the maritime heritage in underwater sediments) was also beyond the scope of the project. This is part of the Agency's Maritime Programme.[12]

6.4 Prospection methods

6.4.1 Introduction

As explained in section 6.2, numerous prospection methods are used in the Netherlands. Eight archaeological field evaluation methods were distinguished for the Prospection Made-to-Measure digital information system, and categorised into destructive and non-destructive methods.

6.4.2 Non-destructive prospection methods

Visual inspection, field-walking and geophysical survey are all non-destructive prospection methods (Fig. 2). The feature they all have in common is that they do not disturb the soil or any archaeological remains present. A visual

8 Stichting Infrastructuur Kwaliteitsborging Bodembeheer 2010. This project was part of the Agency's 'What is Heritage?' research programme.
9 Rensink 2012.
10 Lauwerier 2017: this volume chapter 1.
11 RCE 2013.
12 See www. rijksdienstvoorhetcultureelerfgoed.nl/dossiers/maritieme-archeologie/maritiem-programma (In Dutch).

a

b

Figure 2 Non-destructive methods of prospection: a. field-walking; b. geophysical survey.

inspection involves inspecting the area in question with the naked eye, taking note of things like the characteristics of the terrain (differences in relief) and other features visible at the surface that might indicate the presence of an archaeological find spot. Field-walking involves collecting finds from the surface by walking across fallow fields or inspecting the sides of ditches that have been cleared of vegetation. Geophysical survey includes various techniques that can detect and map archaeological remains or geological features. Analysis of the results using a computer allows any features and structures in the soil to be visualised.

6.4.3 Destructive prospection methods

Methods that disturb the soil are known as destructive prospection methods. Borehole surveys, test pits combined with sieving and trial trench surveys, are all destructive methods, as is metal detecting, albeit to a lesser extent (Fig. 3). The borehole survey is the most commonly used method in the Netherlands, partly as a result of research tradition. The borehole survey method was developed by physical geographers for the study of low-lying areas of the western Netherlands, whose evolution is characterised by successive layering of sand, clay and/or peat with a complex stratigraphy. The borehole method can be used with or without sieving. In the latter case, boreholes are made with a 3 cm auger or 7 cm Edelman gouge. Such investigations focus on identifying an archaeological layer, with little or no intention of gathering finds. In a borehole survey combined with sieving, a larger drilling head is used (e.g. 12 or 15 cm), and the sediment in the core is sieved with the aim of gathering archaeological remains such as pieces of worked flint, fragments of pottery and carbonised bone from the sieved residue. Test pit surveys can also be performed in combination with sieving, whereby the sediment dug out of the pit, or from 50 x 50 cm sections of 5 cm thickness, for example, is sieved. Since the units from which material is gathered are larger than in the case of borehole surveys, the likelihood of encountering finds is greater. Test pits measure no more than 1 x 2 m, and are generally dug by hand. The units excavated in trial trench surveys are larger, the length of a trench ranging from 10 metres to several hundred metres, and they are generally dug by machine. This method is particularly suitable for detecting find spots with features that are not covered by a thick layer of sediment. Trial trench surveys are less useful for detecting find spots that lie more than 2 metres below the surface. It is not possible to dig trial trenches this deep, particularly in the Holocene part of the Netherlands, where the water table is high. One possible solution is well point dewatering, though they are used more as an exception than as a rule in the archaeological field evaluation phase due to the high costs. Metal detection is a form of geophysical survey, but it is regarded as a separate method in this project, as it is distinct from other methods of geophysical survey in the sense that the results of the measurements are not visualised. Furthermore, metal detection is object-oriented, and generally also involves recovery of the detected object.

Besides the methods of prospection outlined above, the concept of ‘custom-made fieldwork’ has also been defined. The term applies to find spots that are visible at the surface, such as dolmens (*hunebedden*), barrows, dwelling mounds (*terps*) or fortifications. The find spot as such does not need to be found. Given the great diversity among find spots visible at the surface in terms of site type, relief characteristics, size and date, a customised approach must be taken to value assessment. This requires a well-considered, tailored approach to collecting the field data needed to further test the specified archaeological prediction.

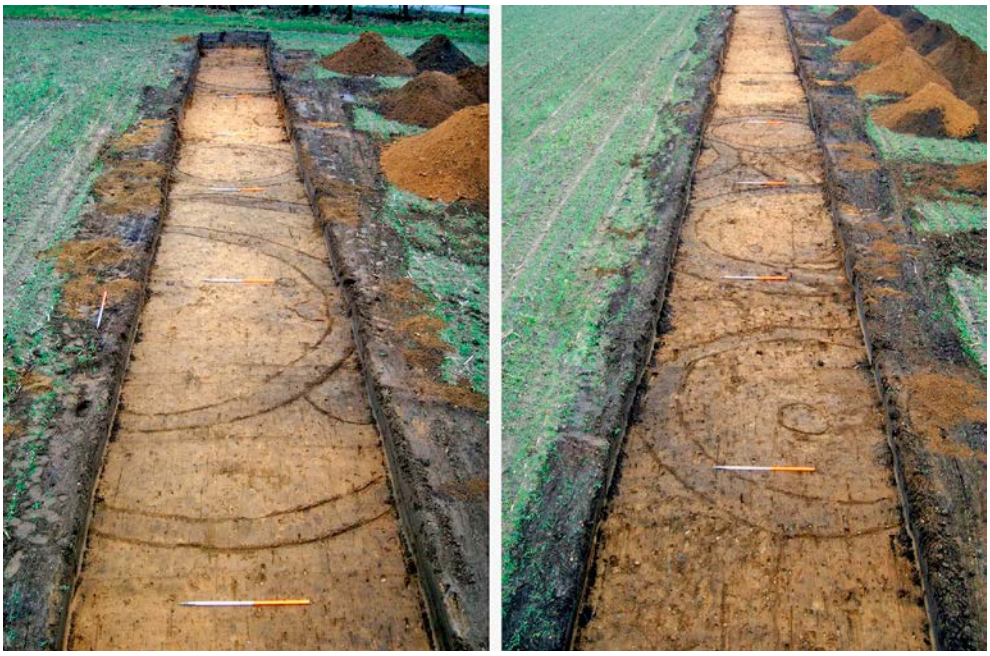
6.4.4 Research modules

Besides the application of individual methods, methods sometimes have to be used in combination. Such ‘research modules’ consist of a minimum of two and a maximum of four methods, e.g. field-walking and geophysical survey, or field-walking combined with a trial trench survey and metal detection. The principle is that the methods should complement and reinforce each other, and that the simultaneous or phased application of two or more methods produces a better and more reliable result in archaeological terms.

6.5 Prospection characteristics of find spots

A thorough knowledge of the workings of prospection methods, as they relate to the properties of the soil in which the features and finds are embedded for example, is crucial for correct application and a reliable result. But good knowledge and understanding of the properties of the subsurface archaeology itself are also important for good prospection. These archaeological characteristics (type of indicators) result first and foremost from the way humans

a



b

Figure 3 Destructive methods of prospection: a. borehole survey (Edelman gouge, 12 cm); b. trial trench survey. Excavation by Archol (Meurkens 2009).

used a location in the past, as a place to live (settlement), for example, or for burying their dead (cemetery). The natural and anthropogenic processes that affect the physical quality and the original spatial context of archaeological remains at various times (depositional and post-depositional) are at least equally important. Examples include the complete decay of organic archaeological remains and the fading of soil features, as a result of which they are not recognisable as such during archaeological field evaluation. These processes determine the nature of and way in which the archaeological remains manifest themselves in the soil.

In recent years, several publications in the Netherlands have focused on the characteristics of different types of find spots and their implications for the efficient use of prospection methods.[13] The Dutch Archaeology Quality Standard also mentions several of these characteristics in its Desk-based Assessment protocol, and as part of the specified archaeological prediction. Based partly on this, nine characteristics of find spots that are relevant to prospection have been selected for the Prospection Made-to-Measure application:[14]

- Date (by main period): In the Archaeology Knowledge Kit programme the detailed periodisation used in the national archaeological information system Archis has been grouped into four main periods in order to simplify analysis at a national scale so that it can be performed more clearly and efficiently. The four-period system of archaeology developed for the programme has been used to attribute the dates of known or predicted find spots to main periods.[15] The following four period have been used: hunter-gatherers and early farmers (300,000-3400 BC), early farming societies (3400-1500 BC), late farming societies (1500 BC to AD 900) and state societies (AD 900 to 1950).
- Site type (by main theme): For the same reason, the hundred or more archaeological concepts (site types) used in Archis[16] were combined and grouped into five main themes: settlement, burials, economy, infrastructure and ritual practices.[17] Unlike in other parts of the Archaeology Knowledge Kit programme, economy has been separated from infrastructure here because of the major differences between the two in terms of characteristics relevant to prospection. The economy is reflected above all in point locations or layers, while infrastructure mainly takes the form of linear features.
- Depth: Depth refers to the position of archaeological remains (features and finds) relative to the current surface. This allows partially visible find spots at the surface to be distinguished from find spots that are covered by for instance a plaggen soil or a layer of clay. Four possibilities have been distinguished: at the surface and visible; at the surface and not visible; covered and less than 2 m deep; covered and deeper than 2 m.
- Find visibility at surface: Land use and vegetation and other coverage have implications for the detection of find spots at the surface. Find visibility refers to the extent to which archaeological remains (finds) can be seen (recognised) at the surface. There are two categories: good and poor find visibility.
- Find density and feature density: The project team has estimated the find density and feature density of different site types, using classes of find and feature density published in the literature.[18] There is considerable variability in find and feature density between find spots, largely because they often consist of different site types. Site types grouped into the same main theme can, for example, have either high or low feature density. Where this was the case, the average find density and feature density of the find spots in question were estimated.
- Archaeological layer: The presence of a well-developed and clearly recognisable archaeological layer is important for the detection of find spots covered by sediments. This is a layer that is distinct from the layers above and below it as a result of the presence of artefacts, or of remains of potential archaeological importance (such as charcoal), and as a result of differences in colour and/or texture. Dutch archaeologists use various synonyms: cultural layer, find layer, find level, occupation level, waste layer. A distinction has been drawn between find spots with and without such a layer.
- Monumental character: A further distinction has been drawn between site types with a monumental character, and those without. This depends on the presence of certain features. Site types with a monumental character have deep or wide features such as ditches, canals or

13 Examples include Sueur 2006; Wilbers 2007; Willemse, Verhelst & Scholte Lubberink 2010; Willemse, Verhelst & Van Oosterhout 2014.
14 The term 'characteristics' is used here in accordance with the Dutch Archaeology Quality Standard (SIKB 2013). It is synonymous with the properties of find spots.
15 Groenewoudt & Smit 2014; 2017: this volume 2.2.
16 De Wit & Sloos 2008.
17 Rensink & Van Doesburg 2015; 2017: this volume 2.3.
18 For find density see Tol *et al*. 2004; Verhagen *et al*. 2011. For feature density see Borsboom & Verhagen 2009.

the remains of walls, stone or brick foundations or traces of their location (e.g. robber trenches), stone paving and cobbles.

- Specific metal objects: The presence or absence of specific metal objects is important for detecting certain types of find spot from the late farming societies and state societies periods. Such objects can be found using a metal detector if they are located on or just below the surface. They include weapons, parts of armour and projectiles associated with battlefields, and metal slags, lumps of molten metal and scrap metal that provide evidence of metalworking. A distinction has been drawn between find spots with and without specific metal objects.

6.6 From find spot properties to prospection best practice

6.6.1 Introduction

During the project, a great deal of attention was focused on the relationship between methods of prospection and the properties of find spots. Analysis of this relationship was used to define a number of general principles which were then used to identify the most suitable method(s) of prospection for detecting archaeological find spots and verifying the specified archaeological prediction that resulted from the desk-based assessment. This section examines these principles for various categories of find spot.

6.6.2 General principles

Find spots visible at the surface
These find spots are visible due to differences in relief at the surface (e.g. barrows, dwelling mounds (*terpen/wierden*), fortifications). In many cases, they can be located by analysing the Digital Elevation Map of the Netherlands (AHN),[19] historical maps or aerial photographs, followed by visual inspection in the field. No other prospection methods are needed to detect such find spots. The walls of ruins, boulders belonging to dolmens (*hunebedden*) and other small elements that are not visible on the detailed relief images of the AHN can – if visible at the surface – be traced by visual inspection. A customised approach will generally be needed to verify the specified archaeological prediction.

Surface find spots
Find spots where archaeological remains (finds) lie on the surface, and where find visibility is good and find density high, can be located by means of field-walking. Reducing the distance between the lines walked by two surveyors from 5 to 2 metres, for example, can provide additional data on the date, size and nature of a find spot. If no finds are encountered during field-walking, and there are doubts as to the reliability of the outcome – due to poor find visibility for example – it is advisable to use another method of prospection.

Find spots with an archaeological layer
Find spots with a well-developed archaeological layer that is clearly recognisable in a core can generally be located by means of a borehole survey (using a 3 cm auger or 7 cm Edelman gouge Fig. 4). A trial trench survey will generally be needed to verify the specified archaeological prediction, e.g. in order to determine the nature and date of the find spot.

Find spots with low find density or no soil features
A trial trench survey is not a suitable method for detecting this category of find spot. A good alternative for locating and gathering archaeological finds would be a borehole survey and/or a test pit survey combined with sieving.

Find spots with soil features
A trial trench survey is generally the most suitable way of locating find spots with soil features and verifying the specified archaeological prediction.

Find spots covered by sediment
In the absence of an archaeological layer, or in connection with the position of the water table, tracing find spots at a depth of more than 2 m below the surface is possible only by means of a borehole survey combined with sieving.

Find spots with a monumental character
Geophysical survey is the appropriate method for locating find spots with a monumental character at or close to the surface (where the covering layer is less than 2 m thick).

[19] Examples of applications in the Netherlands include: De Boer *et al.* 2008; Van Zijverden & Laan 2005; Waldus & Van der Velde (eds.) 2006.

Figure 4 Two well-developed archaeological layers at Zwaagdijk in de province of Noord-Holland, the Netherlands. Both layers are divided by a thin, less dark coloured layer. The top layer dates to the Early Bronze Age and the lowermost layer to the Late Neolithic. Excavation by Archol (Knippenberg 2014, 14).

6.6.3 Prospection in historic urban centres

Historic urban centres are considered separately. Detailed historical sources, including maps, generally exist for town centres, in particular. Archives often also contain information about the use of a location in the past. Find spots in historic urban centres (date: Middle Ages and Early Modern period) do not therefore need to be located by means of archaeological field evaluation. Historic urban centres might also contain find spots older than the village or town. Such predictions are generally based on the extrapolation of landscape and archaeological data from outside the built-up area. Possible disturbance of archaeological remains due to subsequent human activity must however be taken into account. Verification of the archaeological prediction is usually possible only by means of a trial trench survey. It is often impossible to use geophysical survey and field walking because of the presence of rubble, buildings and paving. The same applies to borehole surveys. However, mechanical boreholes can provide information on the stratigraphy and the presence and depth of recent disturbances in the soil profile. The most suitable method for verifying the specified archaeological prediction is the trial trench survey.

6.7 Prospection Made-to-Measure digital information system

The principles set out in the previous section provide the basis for the Prospection Made-to-Measure digital information system. The user starts with the specified prediction resulting from the desk-based assessment of the area in question. After the user has clicked a number of characteristics relevant for prospection from several different options, the system recommends a method or research module for the archaeological find spots that are to be located, and the verification of the specified archaeological prediction. An example based on the selected options shown in Box 1 is given by way of illustration (Fig. 5).

Box 1: Output from Made-to-Measure application with selected options.

User action: select one of the following options:
- ☐ hunter-gatherers and early farmers
- ☐ early farming societies
- √ late farming societies
- ☐ state societies

Characteristic: main theme
User action: select one of the following options:
- √ settlement
- ☐ burial
- ☐ ritual
- ☐ economy
- ☐ infrastructure

Characteristic: depth
User action: select one of the following options:
- ☐ at surface, visible
- ☐ at surface
- √ below surface, less than 2 metres deep
- ☐ below surface, more than 2 metres deep

Characteristic: find visibility at surface
User action: select one of the following options:
- ☐ good
- ☐ poor

No option need to be selected here, as the prediction is for one or more covered find spots (less than 2 m below the surface).

Characteristic: monumental
User action: select one of the following options:
- √ yes
- ☐ no

Characteristic: archaeological layer
User action: select one of the following options:
- ☐ yes
- √ no

Characteristic: specific metal objects
User action: select one of the following options:
- ☐ yes
- √ no

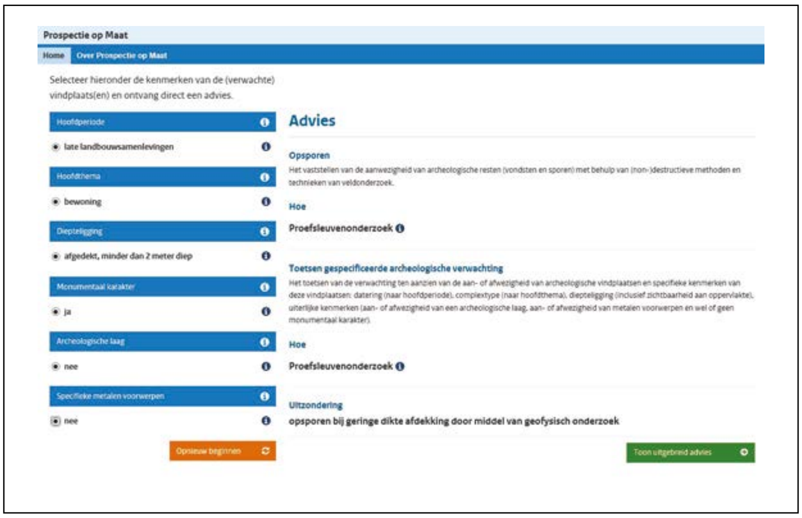


Figure 5 Screenshot of Application and options in Prospection Made-to-Measure information system.

The Prospection Made-to-Measure system uses the selected options to recommend the best way to locate find spots (in this example a trial trench survey) and verify the specified archaeological prediction (also a trial trench survey). Users have the option of clicking a 'show detailed recommendation' button for more details, including a brief explanation of the proposed method or combination of methods (research module) and points to consider ('nuances'). The detailed recommendation also includes references to the Dutch Archaeology Quality Standard and practical examples in the form of standard reports of archaeological field evaluations. These reports have been supplied by professional archaeologists and are intended to serve as an example and as a source of inspiration. Together, the recommended method(s) and the practical examples constitute best practice in archaeological prospection.

To get the most out of the Prospection Made-to-Measure digital information system and the customised advice , it is important that predictions concerning date (by main period), site type (by main theme) and archaeological characteristics (type of indicators) of find spots are specified as far as possible for individual landscape zones. Such a specification is vital if the area in question consists of two or more landscape zones (e.g. a coversand ridge and a stream valley bottom). In this case, the options for archaeological find spots and their properties must be entered for each landscape zone separately.[20]

Finally, another point to consider. The system can recommend two or more methods of prospection as a research module. In such cases, no order of preference is given as regards application of the individual methods. Users must decide for themselves, possibly in consultation with an archaeological specialist or consultant, which method is used first. Generally speaking, use of one or more non-destructive methods would generally be the first choice. If used in the correct way, these methods are relatively quick and effective, and often provide a reliable outcome, depending on the characteristics of the predicted archaeological find spots. If no find spots are located using non-destructive methods, and there are doubts as to the reliability of this outcome, destructive methods may be used in the first mapping phase of archaeological field evaluation, such as a borehole survey (perhaps combined with a test pit survey) or trial trench survey.

6.8 Considerations for the future

Since September 2016 the Prospection Made-to-Measure application has been providing online recommendations of the most suitable method(s) of archaeological field evaluation. The plan is to expand and improve the system over the coming years, and for it eventually to recommend techniques and strategies. If we take borehole surveys as an example, this would include recommendations as to the type of bore and the diameter of the drilling head (= technique) and the number of boreholes and distance between them (= strategy).

Which techniques and strategies of prospection are the most applicable depends partly on the properties of the soil in which the archaeological remains lie. Certain geophysical survey techniques work well in some types of soil, while in others they work less well, or produce unreliable results. By cataloguing, analysing and assessing the properties of the soil in association with region-specific prospection characteristics of find spots, as well as with the potential and limitations of specific techniques of archaeological prospection, a new dataset of useful prospection surveys can be created. Such a dataset could then serve as a basis for recommendations down to the level of technique and strategy, taking account of the position (landscape characteristics) of the development area or survey area in the Netherlands. The Archaeological Landscapes Map of the Netherlands would provide an excellent framework for such an inventory, analysis and assessment at national level. The most important aspect would be a description of the soil and prospection characteristics of find spots in relation to 26 landscapes featured on the map.[21]

Whether and how such 'nuances' could be translated into a practical application in the Prospection Made-to-Measure system is a matter for future consideration. For the time being, it is important that the use of Prospection Made-to-Measure is monitored and evaluated, and that adjustments are made where necessary, in such a way that the system helps to improve the application of the various prospection methods in Dutch archaeological practice, and helps the correct choices be made on the basis of the results.

20 At a national scale, information on landscape and landscape zones can be obtained from the Archaeological Landscapes Map of the Netherlands and the associated land-use images (see Smit & Feiken 2017: this volume 3.5). This information can be accessed via the www.archeologieinnederland.nl portal, in the Land Use in Layers web application.

21 Rensink *et al.* 2016b; 2017: this volume 2.4.

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7 Answers to questions. The new National Archaeological Research Agenda of the Netherlands

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Abstract
Research requires focus. Most Dutch archaeologists would agree. More than ten years after publication of the first edition, the new version of the National Archaeological Research Agenda was launched in April 2016. The National Archaeological Research Agenda 2.0, like its predecessor, is a joint product of the entire archaeological community in the Netherlands, and is designed to feed and guide development-led archaeology, providing topical and relevant research questions. This is essential in order to maximise the benefits – both to science and to society – of archaeological research. This chapter explores the background to and creation of this updated, user-friendly digital edition of the National Archaeological Research Agenda. It centres on 117 specific research questions that highlight the most pressing issues of the day. Practical guidelines associated with each question will make it easier to address them in the field, bringing us closer to answers. The National Archaeological Research Agenda 2.0 is more tailored to its users, and ready for the future.

Keywords: development-led archaeology, research agenda, research framework, research questions, online search engine

7.1 Introduction

Dutch archaeology has changed dramatically since the European Convention on the Protection of the Archaeological Heritage (Valletta Convention) was signed in 1992. One key change was the advent in 2001 of private agencies to perform excavations. This not only introduced market forces into archaeology, but also new forms of societal involvement, reflected in a quality management system devised by the archaeological sector itself (self-regulation) and new forms of government supervision.[2] The quality management system not only stipulates technical standards for research (in the field and otherwise) and standards for excavating parties and individual archaeologists, it also defines the goals that the archaeological system should be ideally be working towards. One of the initiatives undertaken was the development of a National Archaeological Research Agenda, the first version of which was published in 2005, in three substantial volumes. It was intended to stimulate the development of new knowledge by presenting and explaining the most important archaeological research questions so that they could guide development-led archaeological fieldwork. The first version of the research agenda (1.0) did not fully achieve this goal, so a new, thoroughly revised version has been produced. The National Archaeological Research Agenda 2.0 – an online search engine – was launched in April 2016 (www.NOaA.nl).[3]

This chapter explores the background to, aims and creation of the new National Archaeological Research Agenda. We start by looking at how the first version came about, and then consider the phenomenon of national research agendas in more general terms, focusing on two important aspects: the need to make choices, and the question-driven approach. We close with a systematic description of the creation of the National Archaeological Research Agenda 2.0, in the hope that this might help others draw up their own research agendas.

7.2 A brief history of the National Archaeological Research Agenda

The growing awareness that a more question-driven approach to development-led excavation is vital both for scientific gain and for public support led the Netherlands to draft its first National Archaeological Research Agenda between 2005 and 2008. The initiative had been launched around 2001. In the five years prior to this, archaeological fieldwork had been a mix of rescue excavations and the occasional project conducted 'in the spirit of Malta', such as the investigations along the route of the Betuwe freight rail link.[4] This fieldwork was question-driven to some extent, because the objectives of the investigations were generally clearly worded, though the research questions were not often explicitly defined. To enhance the scientific benefit of archaeological research, it was decided that the mandatory project outline should be amended by including a section entitled 'Research questions'. Fieldwork was designed to address these more local questions.

1 Corresponding author: b.groenewoudt@cultureelerfgoed.nl.
2 Bazelmans 2006.
3 Also accessible via the portal www.archeologieinnederland.nl.
4 E.g. Goudswaard 2001.

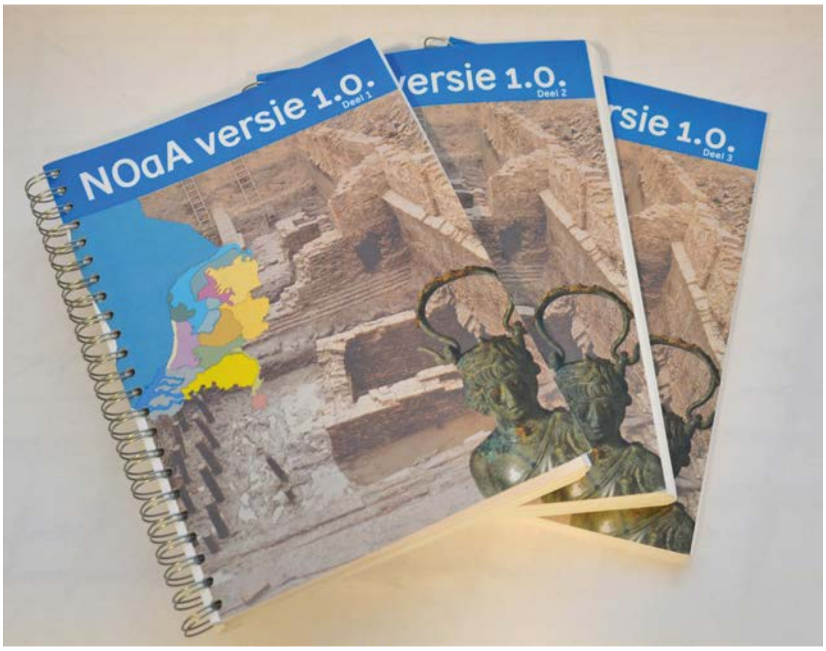


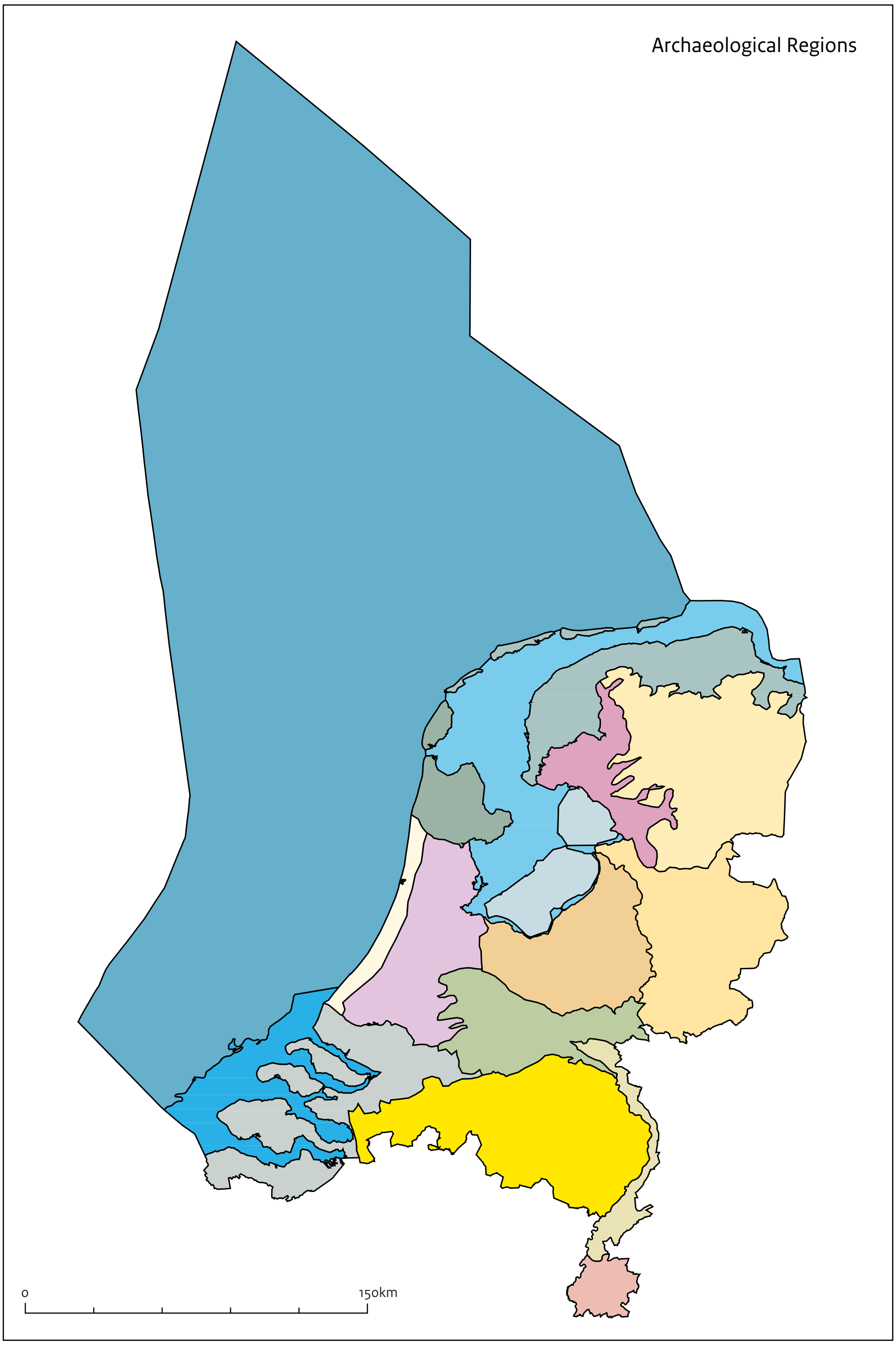
Figure 1 The old print version of the National Archaeological Research Agenda 1.0 (three volumes, approx. 1000 pages).

There was also a desire to define and explain research themes from a national perspective. And so the idea of an agenda developed into a plan of action on which the entire archaeological community in the Netherlands worked for several years. Archaeologists from universities, archaeological agencies, local authority and regional archaeological services, and the Cultural Heritage Agency of the Netherlands (RCE) collaborated in a number of writer groups, explaining research themes and essential questions from a national perspective.[5] The idea was that those research questions – included in the project outline – would then be able to steer development-led archaeological fieldwork. In this way, the agenda would work both as an aid to selection and as a guide.

That first version of the National Archaeological Research Agenda was published in three thick volumes with 24 chapters totalling around a thousand pages (Fig. 1). Many of those pages were devoted to descriptions of the current state of knowledge and detailed explanations of the research themes. The research agenda was therefore clearly intended as an inspiring reference work. Fourteen of the chapters focused on a combination of a specific archaeological region (Fig. 2)[6] and a specific period. There were also ten thematic chapters on subjects like urban archaeology, archaeological prospection, archaeobotany, archaeozoology and absolute dating methods such as dendrochronology, ^{14}C analysis and luminescence dating.

Looking back after some ten years, it is clear that the National Archaeological Research Agenda was far from ideal as a tool for selection and source of inspiration for more scientifically relevant archaeological fieldwork. Though project outlines in the Netherlands always contain research questions, they are often fairly standard. The aim of providing building blocks for answers to national research questions has not been entirely successful and, more importantly, neither have attempts to translate them into targeted fieldwork (operationalisation). This became clear in the first evaluation and later user meetings.[7] Users put forward a number of complaints at these meetings. The research agenda contained no fewer than 1508 research questions, and was not therefore selective. The abundance of questions made it difficult to search through the agenda, making it opaque and almost impossible to distil any relevant research questions. The level of abstraction also varied sharply: some questions were too complex, too theoretical, while others were fairly general or indeed too detailed. One important gap was the absence of maritime archaeology. Given the fact that the research agenda was drawn up over ten years ago, the

5 Fokkens, Groenewoudt & Jungerius 2001.
6 Groenewoudt 1994, slightly adapted in; Van Dockum, Lauwerier & Zoetbrood 2006.
7 Bekkering-Vermeulen 2009.



Clay regions
- Clay area Noord-Holland
- Clay area Friesland and Groningen
- Clay area Zeeland
- Clay area Flevoland

Sandy regions
- Sandy area Utrecht and Gelderland
- Sandy area Limburg
- Sandy area Overijssel and Gelderland
- Sandy area Brabant
- Sandy area Drenthe
- Holland dune area

Peat regions
- Peat area Friesland
- Holland peat and clay area

River clay regions
- Utrecht and Gelderland river area

Loess regions
- Loess area Limburg

Marine regions
- Wadden Sea / IJsselmeer-Markermeer
- Voordelta (front delta) / Streams Zeeland
- Continental shelf

Figure 2 The geographical framework of the National Archaeological Research Agenda 2.0: 'archaeological regions' (Groenewoudt 1994, slightly adapted 2002: Van Dockum *et al.* 2006).

content of some chapters was now somewhat dated. Finally, one chief drawback of the National Archaeological Research Agenda lay in its disconnection from practice, because there were no suggestions as to how questions should be translated into fieldwork (operationalisation). These shortcomings, which users repeatedly highlighted, were the reason not merely to update the National Archaeological Research Agenda, but to radically overhaul it.

7.3 Research agendas in archaeology at home and abroad

In the run-up to the overhaul of the National Archaeological Research Agenda, a survey of archaeological research agendas in the Netherlands and abroad was conducted. Though it was far from comprehensive, some features can be distilled from the sample obtained. It is clear that use of research agendas is not common practice in archaeology. Nor is there any precise definition of what an archaeological research agenda is. The envisaged function and status of such documents also varies widely.

Such documents are referred to by various names, including 'resource assessment' and 'research framework'. Most are not really agendas in the sense that – as one would expect – a (very) limited number of matters are listed for consideration, but are in fact more a survey of the current state of archaeological knowledge. The terminology used is also rarely suitable for the purpose; there is rarely any clear division or clear structure, as proposed by Oliver.[8] Oliver sees a (regional) research framework as comprising: 1) Resource Assessment: an overview of the current state of the potential of the resource; 2) Research Agenda: recognition of the gaps in our knowledge and an unprioritised list of research topics; 3) Research Strategy: a prioritised list of research objectives (seen as flexible over time), furthered by implementing specific Research Projects.

Usually promising research topics are presented, or lists of points requiring attention, and sometimes 'opportunities' are identified (e.g. current research programmes). Some are restricted to broad outlines,[9] while others are highly detailed, like the first version of the National Archaeological Research Agenda in the Netherlands. Agenda-like documents by no means always contain specifically defined research questions.

Most research agendas can be accessed online in pdf format. The authors are generally archaeological specialists, but heritage agencies or public authorities often take the lead. In such situations, the content of the agenda is based primarily on academic considerations, and there is an obvious possibility that personal or institutional interests will have an influence. Non-academic interests also play a role, however. In the Netherlands, it appears that some agendas – particularly regional agendas – are influenced by current policy on heritage, landscape and economic development (or by 'regional branding'). In situations like this, it is difficult to determine when the context of and reasons behind the choices made shifts from archaeological and academic to strategic and policy-driven. Nevertheless, choices are made.

As far as we have been able to ascertain, agenda-type documents have been produced in only a limited number of countries.[10] National archaeological agendas are rare. However, we should note that archaeology may be integrated into agendas covering the entire heritage, as in Australia.[11] A 'Flanders Archaeological Resource Assessment' was drawn up at the instigation of Flanders Heritage (Agentschap Onroerend Erfgoed; formerly 'Instituut voor het Roerend Erfgoed', VIOE).[12] In addition to this, Flanders is working on a theoretical framework for defining specific research questions.[13] In Scandinavian archaeology it has been common practice in recent decades to set out 'research programmes' for rescue/preventive archaeology for the coming five to ten years.[14]

Britain clearly leads the field when it comes to drafting agendas.[15] Both regional[16] and period-specific[17] agendas are used there, and there are also separate agendas for Wales[18] and Scotland (ScARF).[19] Historic England (previously known as English Heritage) has drawn up a national agenda covering the entire heritage.[20] There are also research agendas relating to the World Heritage sites of Stonehenge and Avebury.[21] In some cases, research agendas have been drawn up within the context of a particular spatial development or economic activity with potentially major implications for the archaeological heritage. One example is the research agenda for the aggregate-producing landscapes of Worcestershire, England (Severn and Avon Valleys).[22]

8 Oliver 1997.
9 English Heritage 2005.
10 The European Archaeological Council (EAC) is conducting a survey. The EAC 15th annual symposium (2014) resulted in a new strategic agenda, the Amersfoort Agenda, aimed at 'setting the agenda for the future of archaeological heritage management in Europe and better embedding archaeology in society: moving from "Valletta to Faro"'. In 2015 an Action Plan for the implementation of the EAC Amersfoort Agenda was drafted. This action plan includes the subject of 'decision-making' (theme 2), one of the three key themes ('Dare to choose') of the Amersfoort Agenda.
11 DECC 2006.
12 https://onderzoeksbalans.onroerenderfgoed.be/onderzoeksbalans/archeologie (in Dutch).
13 Ervynck, Martens & Ribbens 2016.
14 E.g. Riksantikvarieambetet 1999; Martens 2004.
15 For a summary, see: Pye-Tait Consulting/English Heritage 2014.
16 http://www.citizan.org.uk/resources/archaeological-research-frameworks/ http://www.archaeoleg.org.uk/other.html
17 E.g. Prehistoric Society/English Heritage 2008.
18 http://www.archaeoleg.org.uk/intro.html
19 http://www.scottishheritagehub.com/
20 E.g. English Heritage 2005.
21 Darvill 2007. http://www.wessexarch.co.uk/projects/wiltshire/stonehenge-avebury-rrf/new-combined-research-agenda-june-2012
22 Jackson & Dalwood 2007.

The number of agendas is impressive. However, the fact that they are not connected and that it has proven very difficult to update or keep them current is regarded as a problem. Historic England has therefore devised a plan to create a national online platform where all the agendas can be accessed and managed regionally by enabling cross-searching etc.[23]

The practice of producing regional research frameworks originated in Britain, as part of the Regional Research Frameworks (RRF) initiative, which was promoted in 1997 by English Heritage in collaboration with local authorities, and was designed to produce an effective, yet flexible, structure for decision-making in relation to archaeological research.[24]

The first edition of the Netherlands' archaeological research agenda closely resembled a Regional Research Framework. It included features of all three elements distinguished by Oliver (Resource Assessment, Resource Potential, Research Agenda)[25], though most chapters do not contain suggestions for specific research projects. The resource assessment element was particularly detailed in the National Archaeological Research Agenda 1.0. Many pages were devoted to the current state of knowledge at the time (2005), because the agenda was clearly intended as an inspiring work of reference.

The survey has taught us that in Europe, and particularly in Britain, archaeological research agendas are in use on different geographical scales, with boundaries determined by current administrative units: nation, region (or province), municipality. Such units are not uniform in terms of size, of course. The national level in the Netherlands is for example comparable to the regional (state) level in Germany. Besides great variations in scale, we can also conclude that the number of agendas is on the increase. In this respect, it is good to note that there are initiatives at European level designed to achieve a certain degree of streamlining when it comes to choices that impact on archaeological research.[26]

The Netherlands has a national research agenda, and also three provincial, two regional and 20 municipal agendas (Fig. 3). These local agendas have been produced both by small local authorities that do not have their own archaeologist (such as Best, Hardenberg and Sluis) and by a number of large local authorities in the western conurbation that have had their own archaeological service for many years (such as Alkmaar, Haarlem, Leiden and The Hague). Uniquely, Leiden's heritage agenda covers both archaeology and the built heritage.[27]
A research framework for archaeological research has also been drawn up in connection with certain large, long-term infrastructural projects, such as the Maaswerken river widening project, which involved a lot of soil excavation.[28]
Such examples also exist at a much smaller scale, such as the research framework published prior to the archaeological investigation in Cuijk municipality.[29]

7.4 The need to make choices

Opinions differ widely as to whether it is acceptable or even desirable to make choices. The fact is, however, that choices are inevitable. This applies on various geographical scales, and also at certain moments in the archaeological process.

If we restrict ourselves to archaeological excavations (choosing between archaeological sites), the hard reality is that there are simply not enough resources to excavate 'everything'. But what, then, should we excavate? Archaeological sites have both scientific and broader social significance. The latter is most evident in the case of archaeological phenomena that are visible as striking elements in the landscape, or are associated with stories or events that appeal to the public. Most countries have relatively few such places, and most archaeological sites are primarily sources of information. In this sense, of course, all archaeological sites have social significance, as a source of information about our collective past.[30]

As a source of knowledge, archaeological excavations are significant at two levels. Individual excavations can answer questions at site level. At the same time, excavations provide building blocks which, in the long run, allow more comprehensive questions to be addressed, thus allowing the accepted narrative of our history to be supplemented and corrected. What is more, they allow new research questions to be defined.[31]
To make this possible, those building blocks (datasets) must be analysed in context. Excavations are not an end in themselves; they must serve a purpose, and this must be made

23 https://historicengland.org.uk/research/support-and-collaboration/research-resources/research-frameworks/; Miles 2015.
24 Olivier 1997, 4-6.
25 Oliver 1997.
26 The 15th annual symposium (2014) of the European Archaeological Council (EAC) resulted in a strategic agenda for the future of archaeological heritage management (AHM) in Europe and better embedding of archaeology in society. In 2016 a working group was set up on the theme of 'Informed, transparent and participative archaeological heritage management.' The Strategic Research Agenda (SRA) of the European Commission Joint Programming Initiative (JPI) on Cultural Heritage and Global Change (JPI CH) is another example. The JHEP 2 programme was launched in 2016 to put this into practice ('to develop effective and efficient governance of the alignment of the national research and innovation programmes': http://www.jpi-culturalheritage.eu/ec-projects/jhep2/. See also: European Commission 2014.)
27 Brandenburgh & Orsel 2013.
28 Stoepker, Rensink & Drenth 2004.
29 Rensink 2004.
30 Lipe 1974; Darvill 1987.
31 E.g. Darvill 2007.

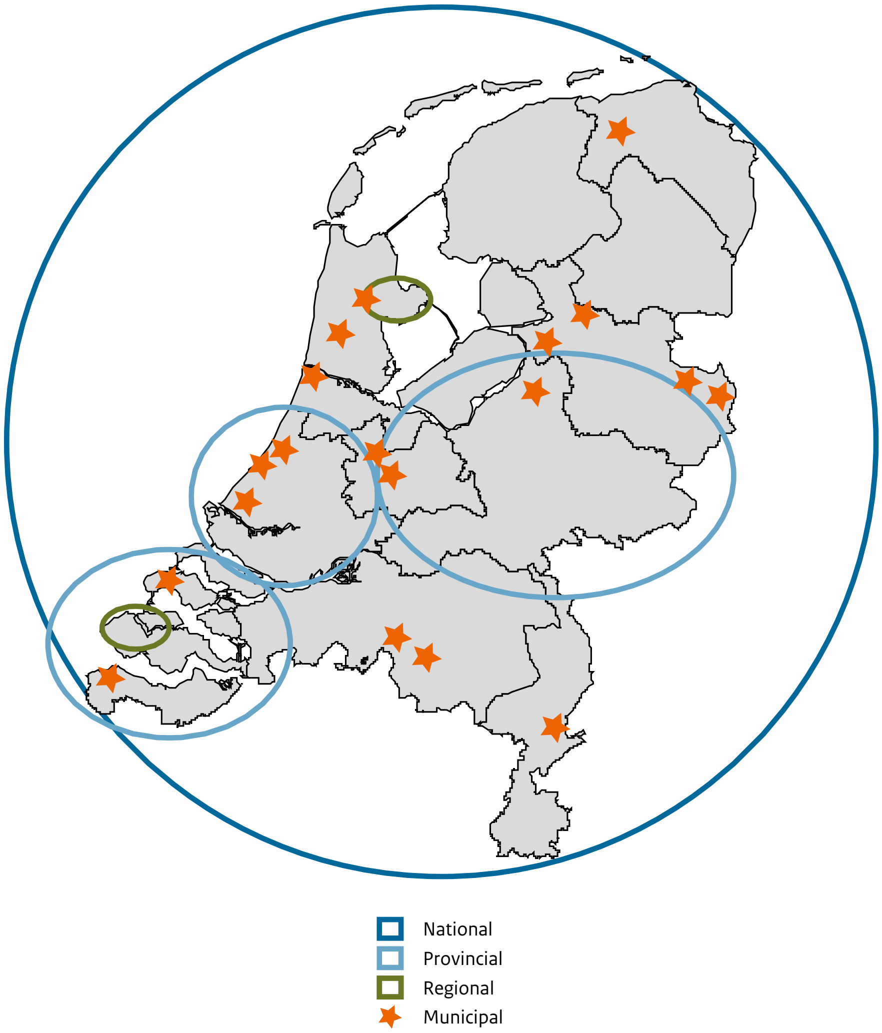


Figure 3 Instruments used to guide archaeological research in the Netherlands: national research agenda, provincial research agendas (Zeeland, Zuid-Holland and Gelderland), regional research agendas (Walcheren and West-Friesland), and municipal research agendas (approx. 20).

convincingly and transparently clear. The public have a right to this.[32] The question is therefore: which essential research questions (gaps in knowledge) will the excavation of a certain archaeological site help to address? And furthermore, what is this prediction based on? How unique, rare and potentially informative are various types of site? In other words: what archaeological resources do we have?[33] How can our goals be achieved? Do the benefits weigh up against the likely costs? Clearly, making explicit choices is also important when it comes to public support for archaeology. There is no justification for the view that everything should be excavated, everywhere and at all times – and at any price.[34]

7.5 Question-driven archaeology

There is also the issue of the choices made during an excavation. It is an illusion to think that it is possible to identify all potential sources of information, and to explore them all thoroughly. So every excavation destroys some information potential. And nor does excavating a large area guarantee a maximum result. Making explicit choices is the only way to maximise contributions to our knowledge of the past.[35] Only then can we achieve the optimum results in cost-benefit terms. So we need to

32 Deeben *et al.* 1999.
33 Olivier 1997; Deeben *et al.* 2006.
34 Groenewoudt & Bloemers 1997.
35 Groenewoudt 2015.

focus – but how? By taking explicit research questions as the focal point. For why excavate? In scientific terms, excavations are useful only if they help answer questions about our past. So, what exactly do we want to know? And is it important? More specifically: what are the most topical and meaningful research questions in a given situation? And where is it possible to answer specific questions (and where is this not possible)? Do we already have unprocessed excavation data 'on the shelf' that could be used to answer those questions? And if so, why excavate more? If not, can we address certain questions better and more cheaply elsewhere? And finally: how can we best translate research questions into targeted fieldwork, in order to guarantee an optimum contribution to efforts to address those questions?[36] Without effective operationalisation, there is no point setting out research questions. This is useful only if a reasonably detailed picture of the nature and potential of the archaeological site in question is available. This information must therefore be available in good time (archaeological site evaluation). One frequently heard objection to question-driven archaeological fieldwork is that 'you never know what you will find'. Of course one's idea of a site can change during an excavation, and this can be a reason to alter the question and the excavation strategy, but it must not be used as an argument to excavate unscientifically and without defining questions beforehand. The fact that the subsurface archaeological resource is to a certain extent unpredictable means it is sensible to use a flexible strategy when excavating, and to perform a post-excavation evaluation. Reasons continually arise for making new choices, adopting new approaches that are likely to maximise the yield in terms of addressing essential questions. A research agenda can help in the making of such choices, playing a guiding and selecting role in the practical implementation of research.

7.6 National Archaeological Research Agenda 2.0: the general principles

In the drafting of the National Archaeological Research Agenda 2.0, the main focus was on the wishes of the parties responsible for making choices in the context of archaeological heritage management. For several years now, much of the decision-making has been conducted at local authority level, rather than central government level. As with the first edition, responsibility for drawing up the National Archaeological Research Agenda 2.0 lay with the Cultural Heritage Agency. The National Archaeological Research Agenda 2.0 was created on a project basis, with the end product, preconditions, procedure, powers and planning (in terms of both time and money) precisely defined and agreed beforehand. This was important in order to keep the process on track.

The National Archaeological Research Agenda 2.0 provides a current overview of only the most important national (supraregional) archaeological questions, focusing specifically on development-led (Malta) archaeology. On the choices that local authorities, aided by archaeological advisers and specialists, must make. The National Archaeological Research Agenda was deliberately compiled independently of the current (but changing) research ambitions of universities and other research institutions. The goal was to produce a broad-ranging and balanced set of research questions. This seemed to be the best way to serve the management of the archaeological heritage as a source of knowledge of our collective past now and, above all, in the longer term.

The new agenda is intended to highlight the national (supraregional) perspective in terms of archaeological research questions more explicitly than the first version, and above all to put forward specific suggestions as to how the questions might be translated into day-to-day practice in the field.[37] At the same time, the National Archaeological Research Agenda 2.0 is intended as a basis for regional and local initiatives, to update regional or local research agendas, for example, or to assist with the study design for an archaeological investigation. However, a research agenda enhances scientific quality only if it is actually used, and if decision-makers are concerned with quality as well as with costs.

Principles

A number of principles were set out on the basis of the shortcomings identified in the National Archaeological Research Agenda 1.0, and the

[36] Eerden *et al.* 2017: this volume chapter 8.
[37] Theunissen *et al.* 2015.

goal and ambition defined for the second version. One important basic principle was that the new research agenda should be concise, user-friendly and accessible. Non-specialists should be able to use it to a certain extent, for example in their role as clients or as active and well-informed citizens. The search process should therefore be quick and efficient. These prerequisites – concise, user-friendly, accessible, fast search process – could only really be met by a digital structure, because this would make the system easy to update and improve.

It was also important that the focus be on specific research questions and that there should be no detailed descriptions of the current state of knowledge. The research questions would also have to meet certain requirements.

The questions are archaeological ('cultural heritage'), essential in the sense that they address main issues, from a national and international perspective. The archaeological region is the smallest geographical unit in the agenda. An essential question must strike a balance between national significance and scientific ambition on the one hand, and practical operationalisation on the other. National Archaeological Research Agenda 2.0 questions had to be seen as relevant, challenging and useful by archaeologists in the field; they must be questions they can actually use, if only as an inspiring point of departure. The potential for translation into practical investigation – for operationalisation, in other words – was therefore an important selection criterion. Research questions had to be supplied with practical guidance for use in the field, explaining how the question can be translated into actual fieldwork. This translation into methods and techniques was also regarded as essential for consolidating the position of specialist knowledge and skills in the field of archaeology.

7.7 National Archaeological Research Agenda 2.0: the process of drafting the agenda

At an early stage, in the initial preparatory phase, a broad-based group of representatives from the most important future user groups were consulted on a regular basis. Particularly note was taken of the views of local authority representatives, both archaeologists and staff of the spatial planning department. They, after all, are the ones who take decisions on the archaeological heritage, local archaeology policy and municipal research agendas. Staff of provincial and regional authorities were also consulted, as they also draft provincial and regional research agendas (Fig. 3).

Archaeological agencies were consulted, as the parties that actually perform archaeological fieldwork, and also because they often provide specialist input to underpin local authority policy. Archaeologists working for agencies are also often the ones who actually formulate questions for archaeological fieldwork, as part of the project outline.

After this consultation phase it soon became clear how the National Archaeological Research Agenda 1.0 was perceived, and what objections existed. It was therefore obvious that the new version would take the form not of several weighty tomes or a downloadable pdf file, but of a web-based information system. Creating this system involved a number of practical steps. First, all archaeological (cultural heritage) research questions were systematically extracted from the National Archaeological Research Agenda 1.0. Then the most prominent questions were identified – questions that are frequently and explicitly raised.[38] The next matter that had to be addressed was which research questions had already been answered, either in part or in full. To ascertain this, the knowledge gained since the completion of the National Archaeological Research Agenda 1.0 was identified by systematically analysing synthesising publications such as PhD theses and scientific papers.[39] Fully or partially answered questions were removed or reworded (to make them more specific). The results of this exercise were discussed with the archaeological community at an open discussion meeting. This resulted in an initial draft list of National Archaeological Research Agenda 2.0 questions, which was then screened by staff of the Cultural Heritage Agency's Archaeology Department to produce a second draft version, which was again presented to the archaeological community. Proposed changes were collected and tested against the agreed principles concerning the ambition level, form and size of the National Archaeological Research Agenda 2.0. This gave

38 Habermehl 2015.
39 Theunissen & Feiken 2014.

rise to a third draft, which was again discussed at an open meeting. The discussion focused on remaining scientific issues. The final list of research questions was then adopted.

All National Archaeological Research Agenda 2.0 questions were then entered in a digital environment, and four different types of textual additions were made to each. First, metadata was added to each question. In other words, the question was defined in terms of its geographical, chronological and thematic scope, and its applicability to certain types of site. Second, short explanations were added, to make the context of the question clear. Third, references to a small number of key publications were added and, finally, brief guidelines were added to help with the operationalisation of the question, in the form of practical tips. Links to relevant guidelines, best practice and other research agendas will be added to these tips wherever possible in the near future.

This modular web-based National Archaeological Research Agenda came about via a democratic process, in the sense that every archaeologist in the Netherlands had the opportunity to contribute. Over a hundred archaeologists eventually made a contribution. One thing that was not up for discussion in this phase was the essence of the commission awarded to the Cultural Heritage Agency to improve the National Archaeological Research Agenda (making it more selective, encompassing only key matters of 'national' importance, and also more accessible, more user-friendly and more up-to-date).[40] Another matter that was not open to discussion was the form, as designed following consultations with the primary user groups and laid down in the project plan.

7.8 National Archaeological Research Agenda 2.0: defining the research questions

One of the biggest challenges when drafting the new research agenda lay in carefully formulating the essential research questions at national level. The old research agenda had no fewer than 1508 questions, and was not therefore selective. The new agenda was to include no more than 150 questions. This called for questions to be worded at a certain level of abstraction; the basic tenor of the question is the most important thing. A good question strikes a balance between national significance and scientific ambition, on the one hand, and practicability on the other. It was therefore decided that 'middle-range' questions should be formulated. These are questions that fall somewhere between highly abstract and too basic. Middle-range questions cannot generally be answered (at least not fully) in an individual excavation, though useful building blocks (datasets and insights) can be gathered. This search for the correct middle-range questions, perfectly balanced between national significance and the potential for practical incorporation into the design of an excavation, was an essential element of the development of the new research agenda. A number of guidelines proved useful in the process.

For example, all research questions were associated with broader research fields (research topics, Table 1). These 23 research fields constitute an entire body of 1) important transitions, pivots in the cultural history of the Netherlands; 2) important but poorly understood cultural heritage phenomena; and 3) geographical gaps in knowledge, larger areas on which no comprehensive archaeological information is available, not even at a basic level, making it difficult to make evidence-based choices at regional and local level.

Besides this list of research fields, various principles were applied that allowed the research questions to be defined. The following basic principles were used when selecting and defining questions:

- the questions concern essential archaeological gaps in knowledge and promising directions for research, from a national and international perspective;
- only archaeological (cultural heritage) questions have been included. Given that a lot of human activity impacts on the landscape, attention was focused on the historical cultural landscape, in both a biotic and an abiotic sense, and in terms of anthropogenic influence;
- questions on maritime archaeology have been included;
- the questions reflect scientific ambitions, but also take account of focal points and gaps in current Dutch field archaeology. For example, current field practice rarely focuses on early

[40] See Lauwerier 2017: this volume chapter 1.

prehistory, yet a substantial number of questions relate to this period;
- the questions were worded as specifically as possible (avoiding abstraction to the greatest possible degree);
- the questions involve a high degree of empiricism, making it easier to operationalise them in the context of day-to-day excavation practice;
- the questions are in principle unrelated to particular theories. In other words, they are as independent as possible of theoretical views or principles;
- no individual 'specialist' questions (relating to bioarchaeology, physical geography, micromorphology, absolute dating etc.) have been included. Specialisms relevant to archaeology play an instrumental role, and thus relate largely to the operationalisation of the cultural heritage research questions. The idea is that this will firmly associate such input with good-quality archaeological fieldwork, making it less easy to omit it for budgetary or other reasons;
- no local/detailed questions have been included. Questions must be important at the archaeological region level (Fig. 2) at least;
- no 'why' questions are included. Answering such questions, identifying causes and analysing change processes, for example, generally requires synthesising research. This is beyond the potential of the research agenda, and is not the purpose of individual development-led excavations.

At the time of the launch of the new research agenda, 23 research fields were included (for further information (Table 1).

Table 1 National Archaeological Research Agenda of the Netherlands: research fields.

No	Research field
1	areas where little is known of the archaeology
2	the dynamics of the Netherlands' cultural landscape
3	use of water
4	occupation and adaptation in the rivers area and along the coast
5	social differentiation
6	emigration and immigration
7	the archaeology of ritual
8	conflict archaeology
9	funerary practice and grave monuments
10	the earliest occupation in the Netherlands
11	Late-Palaeolithic – Early Mesolithic transition
12	neolithisation process
13	consolidation of farming
14	the role of natural food sources after the introduction of farming
15	the Roman limes: structure and interaction
16	Roman period – Early Middle Ages transition
17	incorporation into the Frankish Empire and Christianisation
18	formation of villages
19	development of towns
20	relationship between town and country
21	dynamics of land use
22	human-material culture relationships
23	networks and infrastructure

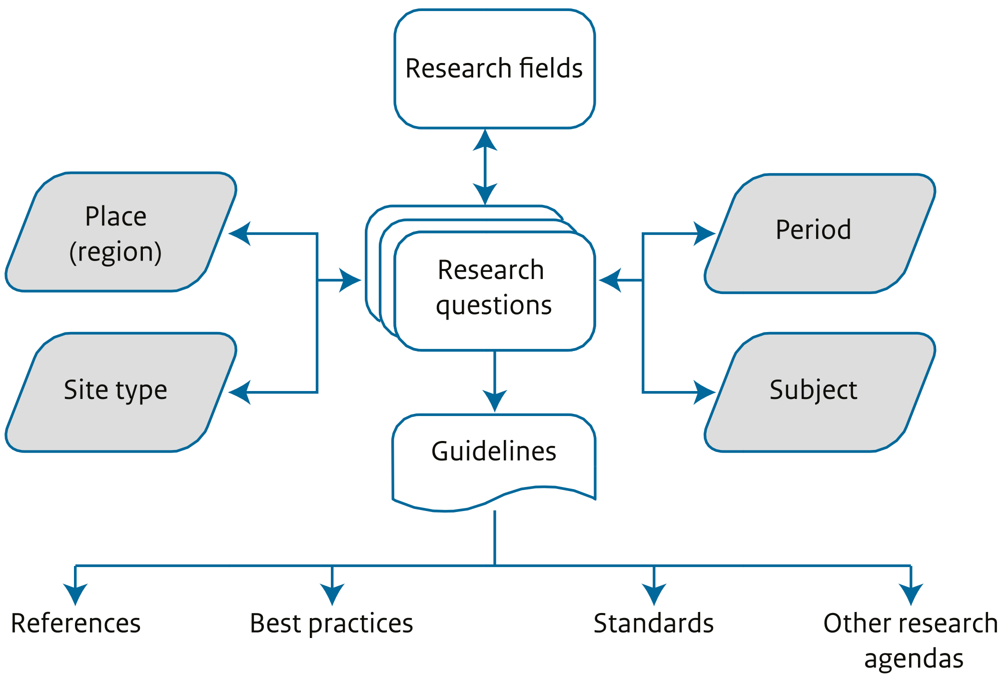


Figure 4 The structure of the new National Archaeological Research Agenda 2.0.

7.9 How does the National Archaeological Research Agenda 2.0 work?

Taking these principles as a guide, it was decided that the National Archaeological Research Agenda 2.0 should take the form of an online search engine with a modular structure (Fig 4). The system has two layers: a Research fields (research topics) layer and a Research questions layer. The research questions are the modules. They are in fact blocks of text containing research questions (100-150); context information: research fields (20-25); and guidelines for translating questions into fieldwork (100-150). Each research question includes a number of references, sources that relate to the underlying theory or can serve as inspiring practical examples and methods. In due course, references to best practice, standards and other research agendas will also be included. The research questions can be accessed via four search filters: place (archaeological region, Fig. 2), period, subject (Appendix 1) and site type.[41] Searching on 'place' provides responses for the archaeological region where the place is situated.

Users start by going to www.NOAA.nl. The homepage briefly describes the purpose of the National Archaeological Research Agenda 2.0 and how to use it. There is also a link to a background document for those seeking more information. The button 'Find your research question' gives access to the search engine. The search options are listed on the left, and the results – research questions categorised by research field – are shown on the right. The search options appear in the following order from top to bottom: archaeological region (or place name), period, site type, subject. When the information button by each option is clicked, information appears on the screen. The more search options are used, the more specific (shorter) the results of the search. Clicking on a selected research question causes information such as that shown in box 1 to appear on the screen: the question, with extra information and references. There are two options at the top of the screen: on the right the option to access context information (information on the research field in question) and on the left the option to return to the search option. Each search result can be copied and printed (option at bottom of page), and it is also possible to cut and paste from the result. The 'back to top' option at the bottom of the page takes the user back to the beginning of the search screen. An example of a search result is shown in Figure 5.

41 The Dutch basic archaeological register (ABR) has been used to classify period, subject and site type. The ABR also forms the basis of the national archaeological information system ARCHIS. Since archaeological predictions are rarely very specific prior to an investigation, the National Archaeological Research Agenda 2.0 search options also have only a limited level of detail.

Box 1 One of the 117 NOaA 2.0 research questions, with extra information (explanation and suggestions for field work) and references.

What role did 'urban farming' play in urban society and in the spatial organisation of towns? (NOaA 2.0, question 88)
The study of towns focuses mainly on the 'urban', on urban functions and characteristics, on what makes a town a town. But in terms of the way they functioned and the way they looked, almost all towns also had some degree of agricultural activity, and we know much less about this. This rural dimension was reflected in specific agricultural activities such as horticulture, fruit cultivation, stock breeding, and all kinds of associated activities (urban farming). At times of economic decline the importance of agricultural activities generally grew, both within and outside the town walls ('ruralisation'). The role that urban farming played, how that role changed, and what activities were located where undoubtedly depend on several factors. It is clear that towns where land within the walls remained vacant had the space. Many smaller rural towns, in particular, were also farming villages, where most of the residents were farmers (either full-time or part-time). This applies even more to 'failed towns', which in economic terms were in fact villages, or soon reverted to this status. The mix of urban and rural activities led to certain types of houses (*Ackerbürgerhäuser*) and small towns (*Ackerbürgerstädte*) in the east of the country.

Context (research field 19). The development of towns. *Towns are larger, not (primarily) agricultural and often fortified settlements that function as economic, administrative, social and religious centres. They have not always existed. Apart from the founding of a number of towns during the Roman period, and from specialised Early Medieval trade settlements (emporia) like Dorestad, towns did not develop in the Netherlands until approx. the ninth and tenth centuries. From then on, however, developments proceeded quickly, and by the Late Middle Ages the area that is now the Netherlands was one of the most urbanised regions of Europe. There is a large degree of regional and context-specific variation as regards the date of, background to and form that town formation took, and in how function and rural setting are reflected in the form and structure of towns.*

Guidelines
Take specific note of rural aspects of the urban economy, and urban influences on urban buildings and the urban landscape. Local horticulture, fruit orchards and stock breeding can (in principle) be demonstrated bioarchaeologically. Spaces in the town that have never been built on are promising locations, as is the zone just outside Medieval town walls. Storage facilities may have been located there, as well as fences and animal stalls. Plant holes may indicate the presence of orchards. Houses may have included animal stalls (e.g. for cows, pigs, goats, chickens). Structural characteristics and dung layers (within the floor plan of the house) or a dung heap in the back yard may indicate this. Animals may also have been housed in outbuildings. Pigs were probably kept on a large scale in towns. Most cattle will have been grazed outside the town. Indications of local stock breeding: buried foetal animals and skeletal elements from the entire body. Historical sources (including images) also provide indications. Date precisely, as the urban economy sometimes changed dramatically. Be aware of, survey and analyse urban 'black earth'.

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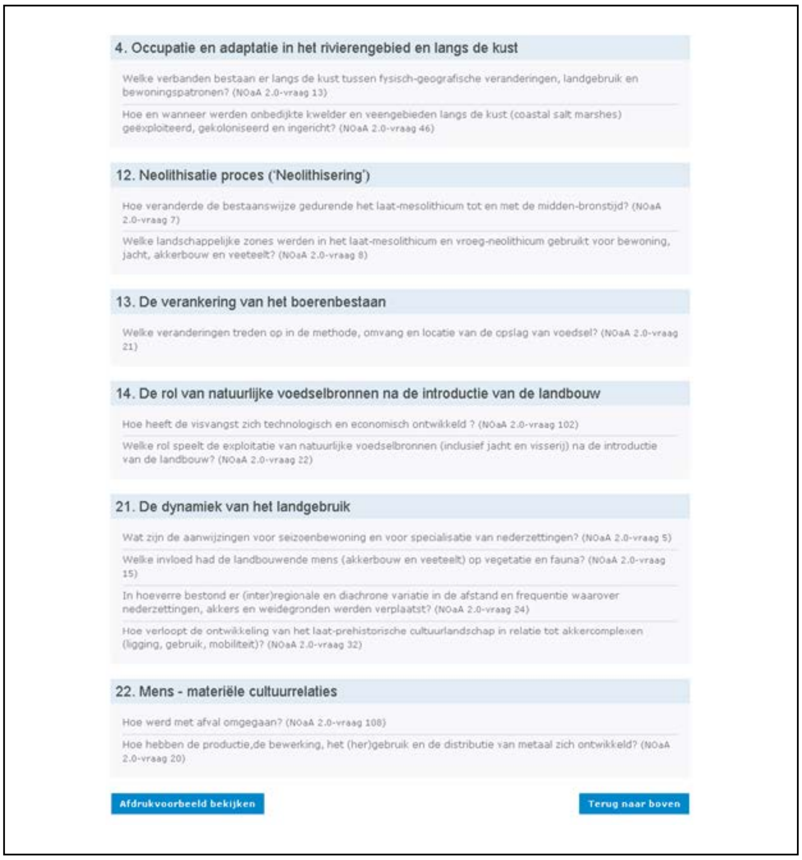

4. Occupatie en adaptatie in het rivierengebied en langs de kust

Welke verbanden bestaan er langs de kust tussen fysisch-geografische veranderingen, landgebruik en bewoningspatronen? (NOaA 2.0-vraag 13)

Hoe en wanneer werden onbedijkte kwelder en veengebieden langs de kust (coastal salt marshes) geëxploiteerd, gekoloniseerd en ingericht? (NOaA 2.0-vraag 46)

12. Neolithisatie proces ('Neolithisering')

Hoe veranderde de bestaanswijze gedurende het laat-mesolithicum tot en met de midden-bronstijd? (NOaA 2.0-vraag 7)

Welke landschappelijke zones werden in het laat-mesolithicum en vroeg-neolithicum gebruikt voor bewoning, jacht, akkerbouw en veeteelt? (NOaA 2.0-vraag 8)

13. De verankering van het boerenbestaan

Welke veranderingen treden op in de methode, omvang en locatie van de opslag van voedsel? (NOaA 2.0-vraag 21)

14. De rol van natuurlijke voedselbronnen na de introductie van de landbouw

Hoe heeft de visvangst zich technologisch en economisch ontwikkeld ? (NOaA 2.0-vraag 102)

Welke rol speelt de exploitatie van natuurlijke voedselbronnen (inclusief jacht en visserij) na de introductie van de landbouw? (NOaA 2.0-vraag 22)

21. De dynamiek van het landgebruik

Wat zijn de aanwijzingen voor seizoenbewoning en voor specialisatie van nederzettingen? (NOaA 2.0-vraag 5)

Welke invloed had de landbouwende mens (akkerbouw en veeteelt) op vegetatie en fauna? (NOaA 2.0-vraag 15)

In hoeverre bestond er (inter)regionale en diachrone variatie in de afstand en frequentie waarover nederzettingen, akkers en weidegronden werden verplaatst? (NOaA 2.0-vraag 24)

Hoe verloopt de ontwikkeling van het laat-prehistorische cultuurlandschap in relatie tot akkercomplexen (ligging, gebruik, mobiliteit)? (NOaA 2.0-vraag 32)

22. Mens - materiële cultuurrelaties

Hoe werd met afval omgegaan? (NOaA 2.0-vraag 108)

Hoe hebben de productie,de bewerking, het (her)gebruik en de distributie van metaal zich ontwikkeld? (NOaA 2.0-vraag 20)

Afdrukvoorbeeld bekijken

Terug naar boven

Figure 5 Screenshot of a NOaA 2.0 search result, based on the following selection:
- place name: **'Hoogwoud'** (situated in the *Noordhollands kleigebied* archaeological region)
- archaeological period: **'neolithicum'** (Neolithic period)
- site type: **'bewoning'** (settlement)
- subject: **'economie'** (economy).

7.10 Concluding remarks

We close this chapter with a cautious look to the future. The initial response to the National Archaeological Research Agenda 2.0 has been largely positive. Users are pleased with the user-friendliness of the system and the relevance of the questions. This should encourage the formulation of specific, challenging research questions in project outlines. Here and there we see National Archaeological Research Agenda questions guiding archaeological research, and being discussed and honed at specialist meetings.[42] In fact, the research questions and use of the agenda will be critically examined every year; the database of questions etc. that forms the basis of the National Archaeological Research Agenda system is easy to alter. Users may report shortcomings and suggest improvements.

In another hopeful development, one of the criteria for access to a recently established national archaeology fund for exceptional finds is that the investigation must help to address National Archaeological Research Agenda 2.0 questions. Archaeological project managers regard the additional guidance in helping to translate research questions into actual fieldwork as useful. Some users have noted that certain questions are too general, too unspecific for the local situation. It must be underlined that National Archaeological Research Agenda questions are intended to be translated (specified) to the local situation; locally relevant

[42] Such as the National Archaeological Research Agenda 2.0 questions in research field 4: Occupation and adaptation in the rivers area and along the coast, at a conference on the archaeology of water management in the Netherlands in the Middle Ages (Hoorn, the Netherlands, 24 June 2016).

questions may also be added. It therefore looks like the new version of the National Archaeological Research Agenda is working better than its predecessor. But what ultimately determines the success of a research agenda or research framework? The benchmark is the degree to which instruments such as these contribute to good, useful archaeological investigations. But what does that depend on? Organisational context, embedding in policy and usability appear to be important factors at any rate. If we look at the relatively small number of countries that use these instruments, we can conclude that the organisation of archaeological heritage management in those countries ranges from centralised to fully devolved. The degree to which private parties are involved in the practice of archaeology also varies. One important determining factor appears to be how archaeological heritage management is organised on a project basis. If the process has been formalised and there are clear phases with transparent monitoring and selection, research agendas/frameworks will probably be more productive than where this is not the case (and they will probably only come about in such circumstances). In such situations, research agendas play a vital role in substantiating and legitimising choices, and therefore in public accountability. Experiences in the Netherlands suggest it makes little difference whether use is mandatory or not. It is more important that the instrument is authoritative, up-to-date and easy to use. It is these factors that determine whether the instrument is used merely out of duty and routinely, or in the manner in which it is intended.

Finally, we would like to address two pressing questions. Firstly: will national (overarching) research agendas become obsolete in places where the power of decision is devolved to regional or local authorities, and local research agendas emerge? Absolutely not. Local research, whether guided by local agendas or not, provides detailed, but local, information, for the focus is generally on the local. The sum of in-depth 'scientific particularism' does not automatically contribute significantly to efforts to address supralocal questions, or generate supralocal theories.[43] Secondly: is it possible to produce a single national research agenda that pleases all parties in archaeology? An agenda that both reflects the scientific ambitions of the academic world (at various levels) and is regarded as locally relevant and useful (community archaeology)?[44] This is no easy task. Differences in level of abstraction and the degree of 'theory' inherent in questions are likely to form a significant obstacle. It is basically a matter of connecting big academic research themes (and preferences) as well as possible with local research preferences, and sometimes highly specific questions. What is needed is open discussion, not necessarily led by universities. They can play a facilitating role, ranking and fine-tuning questions, providing a theoretical framework, and advising and assisting with operationalisation. Finally, we would like to extend a hand to the universities, and invite them to join us in inspiring debates, combining academic paradigms and local narratives to generate new questions.

Acknowledgements
We would like to thank Jes Martens (University of Oslo) and Daniel Miles (Historic England) for providing information on archaeological research agenda-like initiatives in Scandinavia and the United Kingdom respectively.

43 Cf. Johnson 2006.
44 This is a particular challenge in countries where local community archaeology plays an important role, including in support for the practice of archaeology in general terms (Pye-Tait/English Heritage 2014).

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8 Synthesising data from development-led archaeological research

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Abstract
This chapter focuses on the synthesising of archaeological knowledge over the past ten years in the Netherlands and, more specifically, on the Valletta Harvest project.

The goal of Valletta Harvest is to synthesise the results of development-led archaeological research to produce new knowledge about the history of the Netherlands. These new insights will allow more accurate archaeological predictions to be made, on which archaeology policy can be based. Apart from providing new knowledge of the past, such syntheses also provide input for new questions in the archaeological research agenda.

We examined which areas, themes and archaeological periods were the subject of the most reports. We then selected questions from the national archaeological research agenda that could potentially be answered on the basis of those reports. These are referred to as 'knowledge opportunities'. Two methods, described here, were used to define these knowledge opportunities (bottom-up and top-down). Finally, we took provisional stock on the basis of the results of the first synthesising research reports and discussions with fellow archaeologists, assessing what we have learnt so far about the scientific synthesis of development-led research reports, and defining recommendations to improve excavation practice and reporting.

Keywords: synthesising research, development-led archaeology, archaeological heritage management, knowledge opportunities, Valletta Convention

8.1 Introduction

The Netherlands signed the European Convention on the Protection of the Archaeological Heritage, also known as the Valletta Convention or the Treaty of Malta, in 1992. The aim of the convention is to improve protection of the archaeological heritage as a source of the collective memory and as an instrument for scientific study.[2] The goal is to protect archaeological find spots *in situ*, incorporate them into spatial developments and provide funding for archaeological research. It has placed archaeology – which used to be primarily an academic discipline – firmly in the world of spatial planning, contracting and public decision-making.[3] The convention was implemented in the Netherlands in the form of the 2007 Archaeological Heritage Management Act (*Wet op de archeologische monumentenzorg*), under which the 'rescue archaeology system' made way for a 'development-led archaeology system'. The obligation to handle archaeology with due care in spatial plans by instigating timely archaeological investigations, and the 'developer pays' principle led among other things to a sharp increase in the amount of archaeological research being performed.[4]

In order for all interests to be properly considered in archaeological heritage management, it is crucial that the knowledge gained from development-led archaeological research ('Malta archaeology') leads to new insights into the past. These new insights allow more accurate archaeological predictions to be made, on which archaeology policy can then be based. The evaluation of Dutch archaeology legislation in 2011 revealed that there had been insufficient interpretation and scientific synthesis of development-led archaeological research, and that such research was therefore not producing enough new insights into the past.[5] The archaeological heritage management cycle was grinding to a halt at the point of 'interpretation and synthesis' (Fig. 1). To get things moving again, the minister asked the Cultural Heritage Agency to take steps to stimulate synthesising research.[6] To this end, the Valletta Harvest project was launched in 2012, with the aim of developing new knowledge and new ideas about the past by synthesising the results of development-led archaeological research throughout the Netherlands. The new knowledge thus generated has been made accessible both to the archaeological profession and to the public.

This chapter focuses on the synthesis of archaeological knowledge over the past ten years, and more specifically on the Valletta Harvest project, taking stock of the benefits so far.

The project also involves making the results of the synthesising research available to the public. Since there was no online overview of the archaeology of the Netherlands designed for the general public, the possibility of producing such

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[2] http://wetten.overheid.nl/BWBV0002031/2007-12-12/0/informatie
[3] Willems 2008.
[4] http://erfgoedmonitor.nl/indicatoren/archeologisch-onderzoek-aantal-onderzoeksmeldingen.
[5] Van der Reijden, Keers & Van Rossum 2011; Lauwerier 2017: this volume 1.
[6] Letter from the minister to the House of Representatives, 7 February 2012.

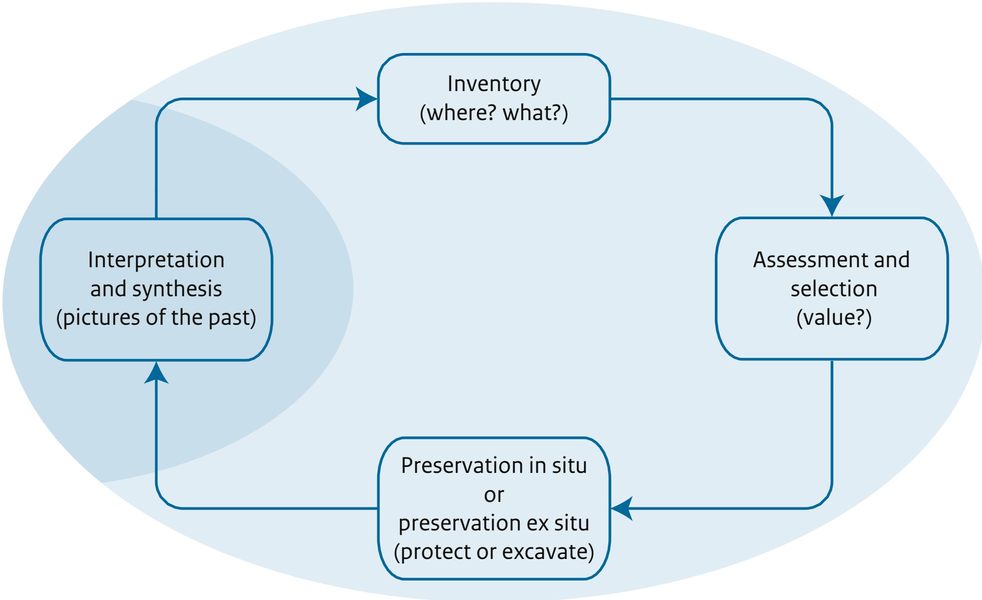


Figure 1 Schematic representation of the archaeological heritage management cycle.

an overview and incorporating the individual results was explored. The National Museum of Antiquities has made the new knowledge available to the public in collaboration with the Cultural Heritage Agency in the form of a website presenting Dutch archaeology from a national perspective.[7] This public website is not further considered here.

8.2 Synthesising research before and after the Valletta Convention

Before the Malta era, archaeological research was performed mainly by a limited number of organisations that held an excavation licence: universities, the State Service for Archaeological Investigations (ROB; now known as the Cultural Heritage Agency), the National Museum of Antiquities and a handful of local authorities. Given the limited capacity and the financial constraints, fieldwork largely remained unrecorded in the form of basic reports, and few syntheses were produced.

After the introduction of development-led archaeology the number of archaeological investigations increased sharply. They were increasingly performed by commercial agencies, whose numbers were growing. By contrast, academic archaeology was dwindling.[8] This led to a huge backlog of synthesising studies on the steadily growing stacks of archaeological reports. The recording of excavation results in the form of basic reports, by contrast, was safeguarded under the terms of the Archaeological Heritage Management Act.

Several incentive programmes have boosted synthesising studies of archaeological research over the past ten years:

- ‘Malta Harvest’ (2003-2009) was the first programme for the scientific synthesis of archaeological research. It was an initiative of the Netherlands Organisation for Scientific Research (NWO) and the Ministry of Education, Culture and Science. In open competitions, universities were awarded commissions to run four research programmes on broad themes, which they tied in with their own university research agendas.
- ‘Odyssey’ (2008-2014) was the second incentive programme, an initiative of the NWO, the Ministry and *Erfgoed Nederland* (‘Dutch Heritage’). The focus of this programme was the analysis and synthesis of field research from the pre-Malta era. It resulted in 32 projects performed by universities, commercial agencies, local authorities and the Cultural Heritage Agency.

7 https://www.archeologieopdekaart.nl/
8 KNAW 2007; Groenewoudt 2015.

The programme helped reduce the huge backlog in the publication of archaeological research.

- 'Valletta Harvest' (2012-2016), the third incentive programme, is an initiative of the Ministry. It has been implemented by the Cultural Heritage Agency in collaboration with agencies, universities and local authorities. The focus is on the synthesis of Malta reports published since 1997. The motivation behind the programme is to improve archaeological heritage management practice so that more precisely targeted choices can be made.

There is no overview of the latest situation as regards the synthesis of development-led archaeological research in all European countries that signed the Valletta Convention. However, Van den Dries, in her 2016 paper 'Is Everybody Happy?',[9] noted that a lack of synthesising studies was an issue in several countries, and that some governments felt responsible and were therefore initiating and/or facilitating programmes to stimulate synthesis. Examples are the Irish National Strategic Archaeological Research (INSTAR) programme and the above-mentioned programmes in the Netherlands. The results of a synthesis project in the UK on late prehistory in northwestern Europe and based on development-led fieldwork were recently published. This was a collaborative project involving universities and the Leverhulme Trust.[10]

8.3 Valletta Harvest synthesising research

Valletta Harvest aims to develop new knowledge, new ideas about the past, by synthesising the results of development-led archaeological research (Fig. 2). Research commissions have been devised and put out to tender by the Cultural Heritage Agency. They are related to evident knowledge gaps concerning the nature, dating and distribution of buried archaeological phenomena in the Netherlands. In concrete terms, the project has produced a number of synthesising publications in the *Nederlandse Archeologische Rapporten* (NAR, Dutch Archaeological Reports) series. The research results have also provided input for the updating of the National Archaeological Research Agenda.[11]

A number of principles were set out for the contracting out of Valletta Harvest synthesising research:

- 'knowledge opportunities' have been identified and selected to provide a basis for sound choices. A knowledge opportunity concerns a period, region and/or theme as set out in the National Archaeological Research Agenda which constitutes a considerable gap in our knowledge that can potentially be filled by a synthesising analysis of a substantial number of reports of archaeological research performed in a 'Malta' context (basic archaeological reports);
- a synthesising analysis is a comprehensive scientific analysis of a large quantity of data from basic archaeological reports designed to answer scientific questions or fill geographical gaps in knowledge;
- the basic archaeological reports referred to here are reports of excavations and, to a lesser extent, of assessments performed on a substantial scale since 1996;
- knowledge opportunities that allow better choices to be made within the context of archaeological heritage management have priority. Geographical gaps in knowledge (Fig. 3) are important in this regard. These are relatively large areas about which little archaeological information (and certainly no comprehensive overview) was available until the introduction of development-led archaeology.[12] Even basic syntheses represent a significant step forward from the perspective of archaeological heritage management in these cases.

8.4 Identification of knowledge opportunities and phase 1 selection

Given that an analysis of all development-led research reports (bottom-up approach) would have been too complex and time-consuming in view of the urgent need to contract out some of the synthesising research in 2013, a top-down approach was adopted in phase 1.[13] Major, undisputed opportunities for synthesising research were identified and compiled into a longlist of potential knowledge opportunities.

9 Van den Dries 2016.
10 Bradley *et al.* 2016.
11 Groenewoudt *et al.* 2017: this volume 7.
12 Groenewoudt & Lauwerier 1997; Groenewoudt & Bloemers 1997.
13 De Groot & Groenewoudt 2013.

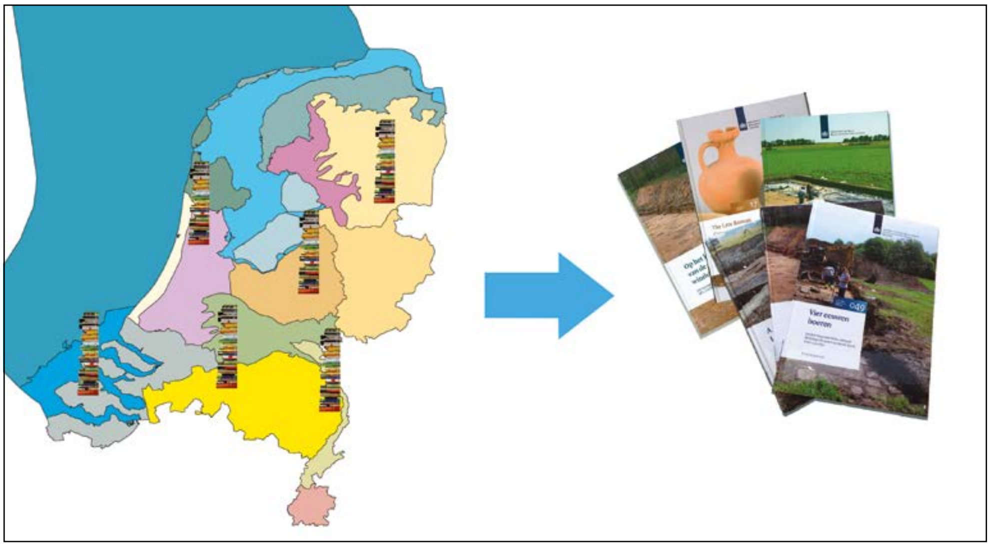
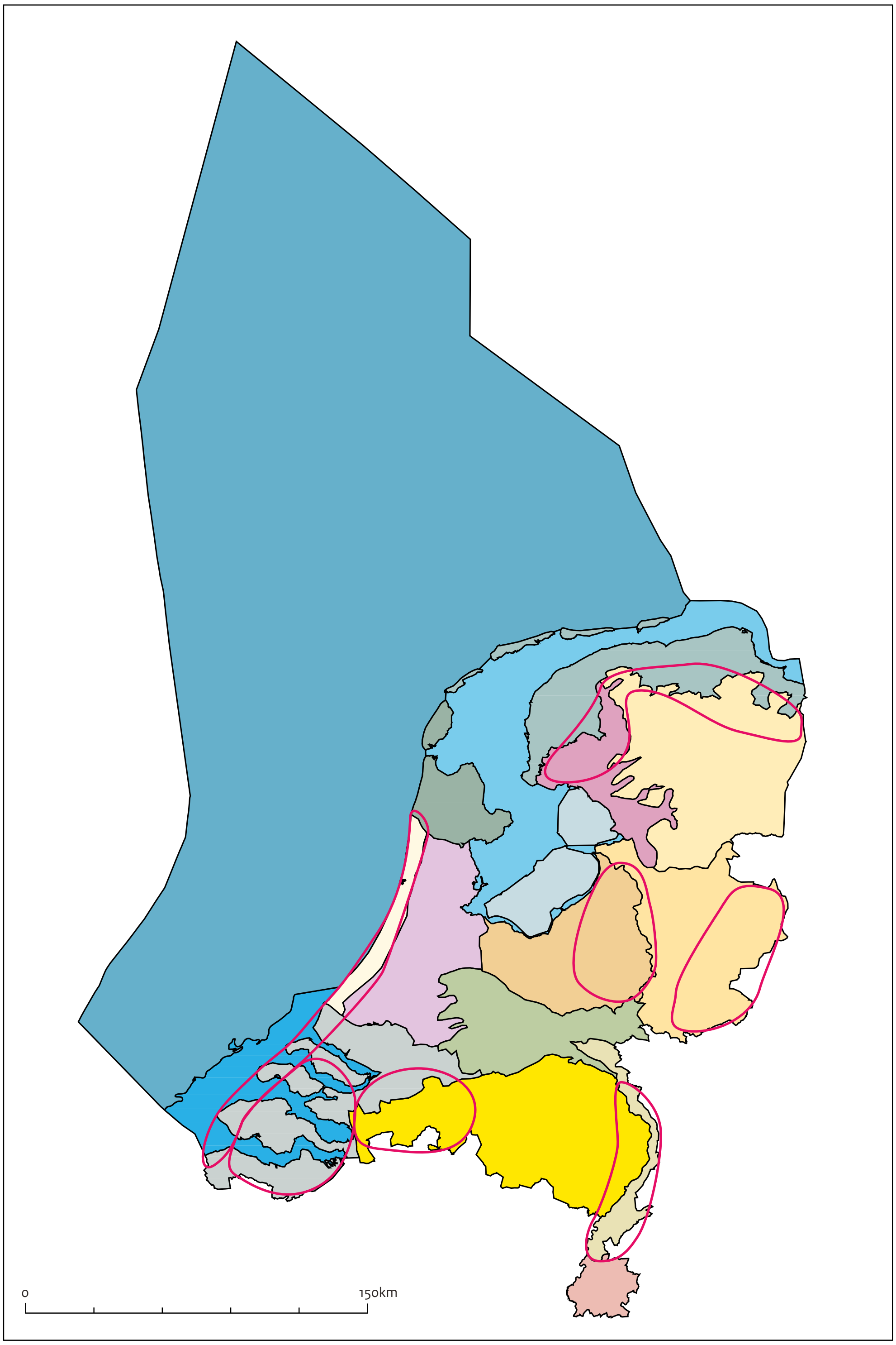


Figure 2 Harvesting new knowledge from piles of reports on development-led archaeological research. Knowledge is gained not only on regions, but also on specific periods and themes.

Any that had already been taken up by universities or in other contexts were removed from the longlist. The most promising were then selected from the longlist on the basis of expert judgment. These were defined more precisely and contracted out in 2013/2014 (Table 1).

Archaeologists from the Cultural Heritage Agency identified and selected the geographical, chronological and thematic knowledge opportunities. Five studies were performed by agencies, one by a local authority and one by a university in this phase.



- Area with knowledge gap

Clay regions
- Clay area Noord-Holland
- Clay area Friesland and Groningen
- Clay area Zeeland
- Clay area Flevoland

Sandy regions
- Sandy area Utrecht and Gelderland
- Sandy area Limburg
- Sandy area Overijssel and Gelderland
- Sandy area Brabant
- Sandy area Drenthe
- Holland dune area

Peat regions
- Peat area Friesland
- Holland peat and clay area

River clay regions
- Utrecht and Gelderland river area

Loess regions
- Loess area Limburg

Marine regions
- Wadden Sea / IJsselmeer-Markermeer
- Voordelta (front delta) / Streams Zeeland
- Continental shelf

Figure 3 National 'geographical gaps in knowledge' projected onto the archaeological regions (Lauwerier & Lotte 2002).

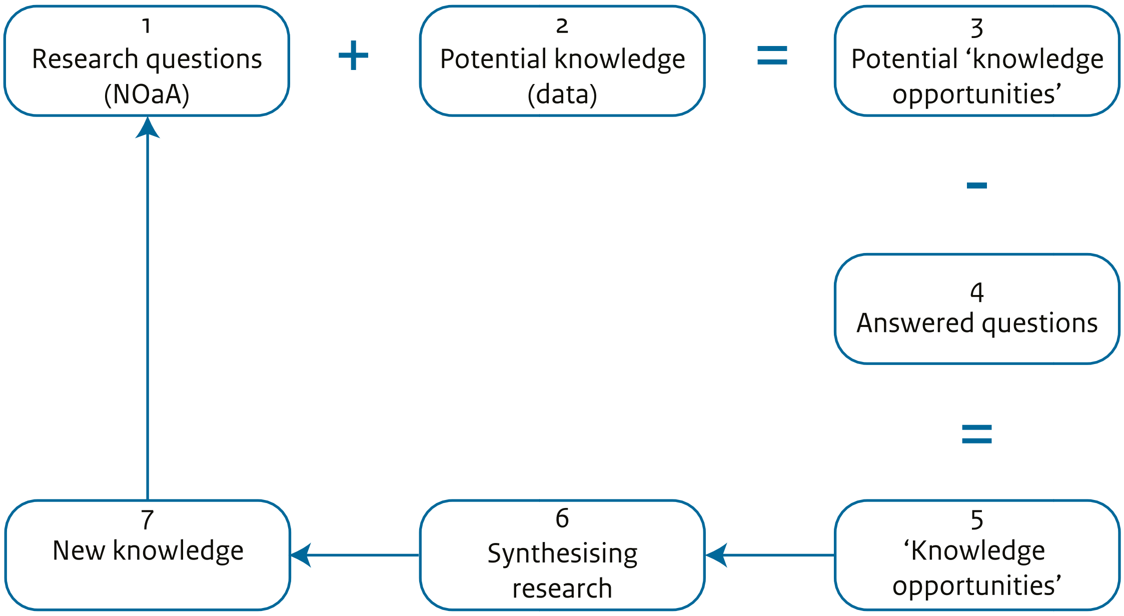


Figure 4 Bottom-up method of identifying knowledge opportunities and creating new knowledge and questions.

8.5 Identification of knowledge opportunities and phase 2 selection

In phase 2 of Valletta Harvest, from 2014, knowledge opportunities were identified in accordance with a bottom-up approach.[14] In other words, a systematic analysis was performed to identify the most promising opportunities for gaining knowledge on the basis of basic archaeological reports. Knowledge opportunities are identified and substantiated in a five-stage process (Fig. 4):

1. Which research questions? What are the big questions and the most important gaps in knowledge, according to the National Archaeological Research Agenda (NOaA)?
2. Which data (potential knowledge)? What data do the basic archaeological reports contain? Where do data clusters exist?
3. Potential knowledge opportunities: situations where data clusters appear to provide an opportunity to answer 'big questions' (overlap between steps 1 and 2).
4. Answered questions: those questions that have been answered since the National Archaeological Research Agenda 1.0 was published in 2007.[15] If it turns out that questions in the first version of the research agenda have already been fully or partially answered, or will be answered in other research contexts, synthesis of basic archaeological reports to answer those questions will no longer be necessary, or will be a less urgent priority.
5. Result: well-founded and verified knowledge opportunities.

Step 1: Which research questions?
The National Archaeological Research Agenda 2.0, which has been available online since 1 April 2016,[16] contains a number of overarching research fields based on gaps and questions set out in the first version of the agenda.[17] These research fields and the questions associated with them were taken as the basic principle for the definition of knowledge opportunities (Table 2).

Step 2: Which data (potential knowledge)?
The dataset comprised all excavation reports published in the context of 'Malta' and all reports of watching briefs performed in accordance with the excavation protocol. A selection was also made on the basis of time period, and metadata was added to reports from 1 January 2007 to October 2013. The Archaeological Heritage Management Act took effect on 1 September 2007, but because work was already being performed 'in the spirit of

14 De Groot & Groenewoudt 2014.
15 Projectgroep NOaA 2007.
16 www.noaa.nl; this volume 7.
17 Groenewoudt , De Groot & Eerden 2014.

Table 1 Subjects of Valletta Harvest syntheses and the number of reports selected and screened in each synthesis.

Subject of synthesis	Reports screened (n)
Phase 1 selection	
Geographical knowledge opportunities	
• Regional occupation history of western North Brabant from prehistory to the Late Middle Ages	477
• Regional landscape and occupation history of the Gelderse Vallei region with an emphasis on the Iron Age/Early Roman period and Middle Ages	100
• Regional occupation history of the Holland dune region from prehistory to the Early Modern period	398
Chronological knowledge opportunities	
• Occupation history of the Netherlands from the Late Neolithic to the Middle Bronze Age A	44
• Occupation history of the southern Netherlands from the Late Roman period – Early Middle Ages transition	127
Thematic knowledge opportunities	
• Archaeological characteristics of farms and farmsteads between c. 1250 and 1650	180
• Location choice and occupation dynamics in late prehistory, the Roman period and the Middle Ages in eastern North Brabant	850
Phase 2 selection	
Geographical knowledge opportunity	
• Occupation and land use history of the Maas Vallei in the provinces Limburg and North Brabant	380
Chronological knowledge opportunity	
• Occupation and use of landscape in early prehistory in the Netherlands	130
Thematic knowledge opportunities	
• Land division and emergence of stone buildings in urban areas in the Late Middle Ages-Early Modern period	474
• Formation of villages in the Netherlands in the Middle Ages, c. 800-1600	200
• Wooden objects	286

Malta' prior to that date, all reports from 1 January 2007 onwards were included. This date also ties in with the publication of the National Archaeological Research Agenda 1.0. Eventually, metadata were added to 812 excavation reports published between 2007 and October 2013; their contents can now be searched.[18] The following metadata were added:

- Date
- Archaeological region (Fig. 3)[19]
- Type of investigation
- Site type
- National Archaeological Research Agenda 2.0 research fields
- Geographical data
- Investigation notification number
- Keywords

Terminology for 'date' and 'site type' was derived from the Basic Archaeological Register[20], and a list was drawn up from which keywords could be selected. The reports were then entered into a database complete with metadata.

Analysis produced data clusters, first on the basis of variables such as the number of reports per archaeological region or period, and then on the basis of links between variables. The most notable results included a large number of reports on the Late Middle Ages and the Early Modern period, particularly on settlements with an urban character, and a large number of reports on the *Brabants Zandgebied* (Brabant sandy area) archaeological region (Figs. 5, 6 and 7). The data are publicly accessible via the Cultural Heritage Agency's library system,

18 Eerden & Lobbes 2014.
19 Archaeological regions are areas in which there is an overall link between the landscape and occupation history, and between landscape-forming processes and the creation of archaeological find spots and subsurface archaeology in general (Groenewoudt 1994).
20 Brandt *et al.* 1992

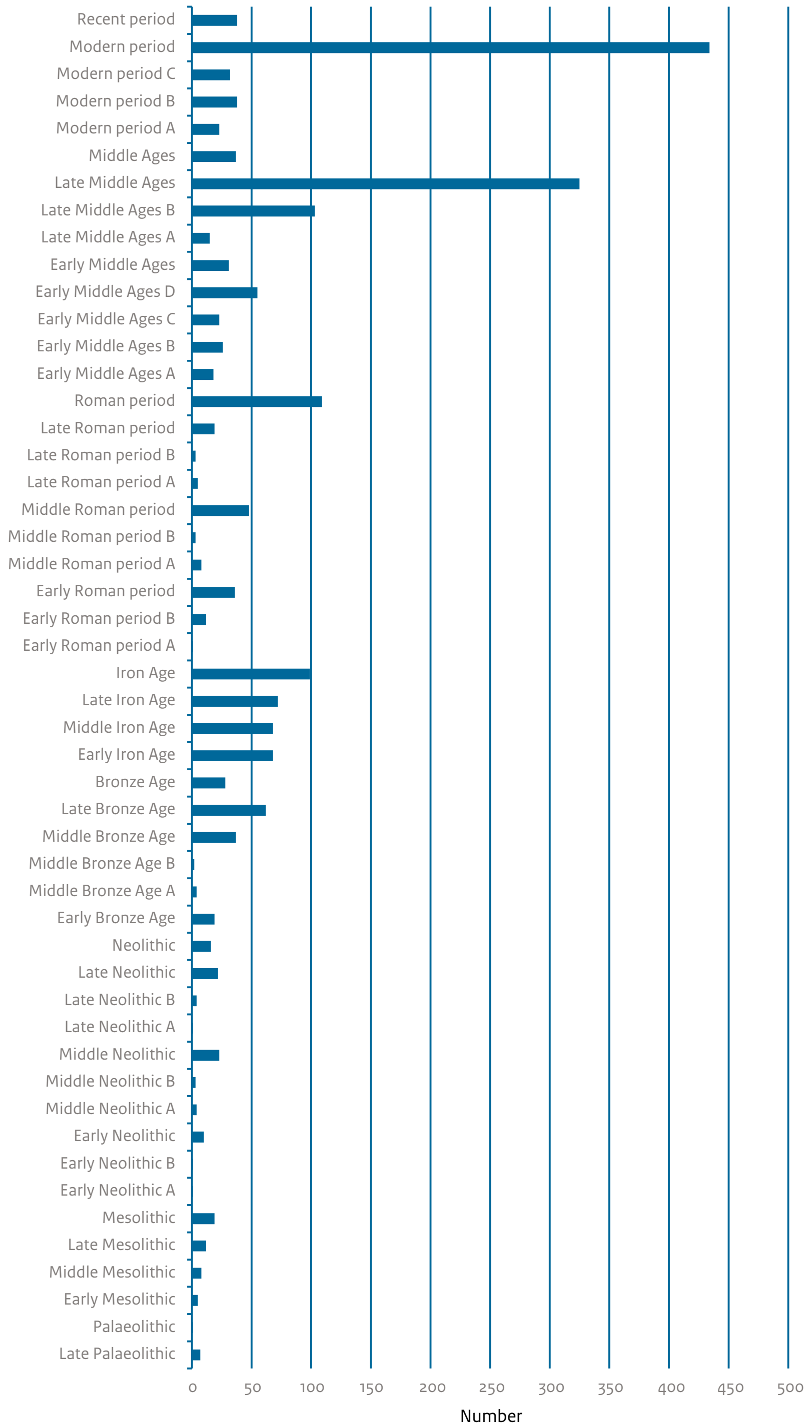


Figure 5 Overview of frequency with which a certain period was addressed in archaeological reports over the period 2007-2013.

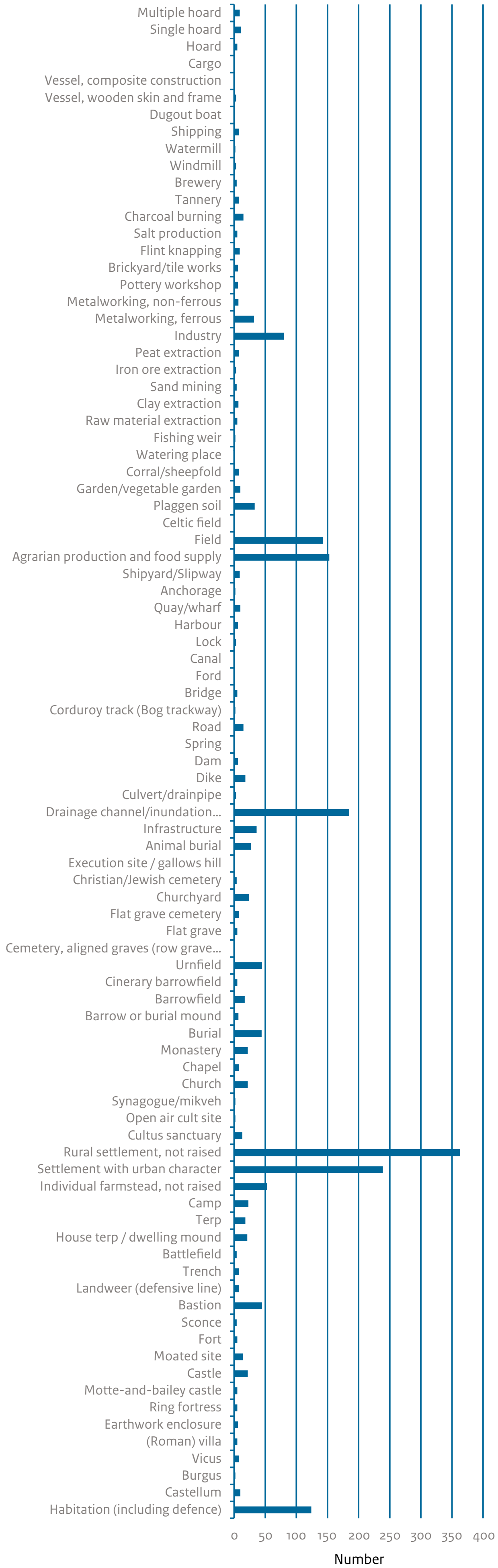


Figure 6 Overview of frequency with which a certain site type was addressed in archaeological reports over the period 2007-2013.

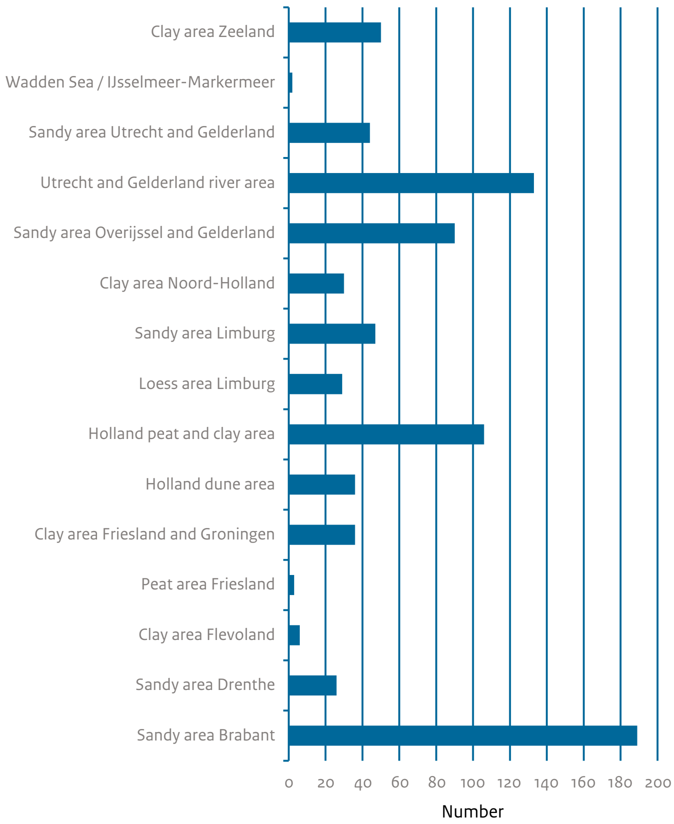


Figure 7 Overview of frequency with which a certain archaeological region was addressed in archaeological reports over the period 2007-2013.

through which anyone can select excavation reports relevant to a particular investigation.

Step 3: Potential knowledge opportunities

The matches obtained by comparing the data clusters (from step 2) with the research questions (step 1) are known as ' potential knowledge opportunities'. To define final knowledge opportunities, insight into the knowledge gained since the introduction of the National Archaeological Research Agenda 1.0 was needed.

Step 4: Answered questions

It was important to ascertain which national research agenda questions had been answered since the publication of the first version, not only in order to update it and publish a second version, but also to define knowledge opportunities. After all, if certain questions have been answered (either fully or partially) since the agenda was first published, or are likely to be answered in other research frameworks, synthesising research will no longer be necessary, or will have lower priority.

A database was established to help identify the themes, periods and archaeological regions on which knowledge has been gained over the past few years.[21] Information on synthesising works such as PhD theses, books and academic papers was entered into the database, building on the survey conducted for the *Erfgoedbalans* (Heritage Review)[22] and the '*Vragen over Malta*' ('Questions about Malta') report.[23] Websites and annual reports of universities and the NWO were systematically consulted, as well as a large range of academic journals. A number of internal and external experts on the Late Middle Ages were also consulted. The survey was based on the principle that the publications must have a clear synthesising character and concern a subject relevant to archaeology. The subject must focus on reconstructing life in the past. 'Synthesising character' means that the research on which the

21 Theunissen & Feiken 2014.
22 De Boer 2009.
23 Lauwerier *et al.* 2011.

publication is based encompasses more than one site and that the research results can be placed in a broader context.

The Knowledge Harvest (*Kennisoogst*) database contains 229 publications (60 PhD theses, 120 papers and 49 books). Metadata was added to each, detailing the type of publication, research theme, archaeological region, period and site type, and entered into an Access database. This is a relatively small collection in which the output of a single individual, the omission of one journal or the addition of a new research project can have a visible effect. NWO programmes like Settlement and Landscape in Archaeology, Conservation and Development of a Soil Archive, Malta Harvest and Odyssey have had an unmistakable impact on the output; the Odyssey programme is responsible for a peak in output in 2012, for example.

Using the database, the numbers of synthesising publications (knowledge gained) per period and theme were identified and then divided on a more detailed level, e.g. theme, by archaeological region and period.[24] Despite the fact that the introduction of the Archaeological Heritage Management Act has meant that excavations are now more evenly spread across the country (even outside areas that were previously the focus of university archaeological research), there are still archaeological regions about which a great deal (e.g. the sandy area of Brabant), or indeed very little is written (e.g. the Frisian peat lands). The traditional research themes of 'settlement' and 'burial' are the subject of many publications, particularly when it comes to the Neolithic and the Roman period. The high numbers are due partly to the products of the NWO 'Malta Harvest' incentive programme (2003-2009) and Groningen

Table 2 National Archaeological Research Agenda of the Netherlands: research fields.

No	Research field
1	areas where little is known of the archaeology
2	the dynamics of the Netherlands' cultural landscape
3	use of water
4	occupation and adaptation in the rivers area and along the coast
5	social differentiation
6	emigration and immigration
7	the archaeology of ritual
8	conflict archaeology
9	funerary practice and grave monuments
10	the earliest occupation in the Netherlands
11	Late-Palaeolithic – Early Mesolithic transition
12	neolithisation process
13	consolidation of farming
14	the role of natural food sources after the introduction of farming
15	the Roman limes: structure and interaction
16	Roman period – Early Middle Ages transition
17	incorporation into the Frankish Empire and Christianisation
18	formation of villages
19	development of towns
20	relationship between town and country
21	dynamics of land use
22	human-material culture relationships
23	networks and infrastructure

[24] Theunissen & Feiken 2014.

University's Swifterbant project. The main conclusion, in light of the potential knowledge opportunities, is that very little knowledge has been gained on the Late Middle Ages – Early Modern period, despite the fact that these are the periods on which the largest number of Malta reports have been published.

Step 5: Result – well-founded and verified knowledge opportunities

By comparing potential knowledge opportunities with the knowledge gained over the past few years, we were able to compile a final list of actual knowledge opportunities. These knowledge opportunities refer to a period, region and/or theme which – from a national perspective, as set out in the National Archaeological Research Agenda – represent a considerable gap in knowledge which is likely to be filled by a synthesising analysis of a substantial number of basic archaeological reports. Archaeologists from the Cultural Heritage Agency actually identified and selected the knowledge opportunities. The selected subjects were worked into research commissions which were then put out to tender (Table 1) and the work performed by commercial agencies, universities and one local authority.

The assumption is that synthesising research yields new knowledge. This new knowledge allows the questions in the national research agenda to be more precisely defined (Fig. 4), and better choices to be made in archaeological heritage management.

8.6 Conclusions

Drawing conclusions from the process to date, we can now take provisional stock of the situation. In the context of Valletta Harvest, since autumn 2013 twelve synthesising studies have been initiated to generate new knowledge of the history of the Netherlands. The first have now been published and this is a good moment to consider what we can learn from the process of synthesising basic archaeological reports.

Most important conclusion is that synthesising development-led archaeological research reports yields new knowledge about our past in terms of filling period-specific, thematic and geographical gaps in knowledge. In addition it has resulted in recommendations to develop further the archaeological work practice.

Three managers of Valletta Harvest projects shared their experiences with fellow archaeologists at the annual conference of archaeologists (*Reuvensdagen*) at the end of 2015. Once the other nine projects have been completed in late 2016 and early 2017, experiences from these projects can be included, and final stock taken of the project.

The experiences and recommendations of these three project managers and participants in the discussion concerned the suitability of Malta reports, questions as a driver of research, the level of knowledge of researchers, specialist analysis, the national archaeological database Archis as a source for synthesising research and the storage of research data.[25] A number of experiences and recommendations are given below.

Suitability of Malta reports for scientific synthesis

The suitability of Malta reports depends entirely on the quality and reliability of the data they contain, and the level of detail. There are major differences, which seem to depend on the researchers rather than the institution where they work. Research may be of a high standard, with input from specialists, but if the results are not presented in a comprehensive and verifiable manner (in a report that includes tables, graphs etc.), they cannot be used for synthesis and the primary sources have to be consulted (drawings, find lists, databases, photos, daily reports etc.).

It takes a lot of time to trace all these basic archaeological reports as there is no central access. Researchers have concluded from experience of synthesising pre-Malta research (e.g. Odyssey) and Valletta Harvest research that the storage of research data and reports in the DANS or Archis databases has improved as a result of the 2007 Archaeological Heritage Manangement Act. There is still room for further improvement, however, as some datasets at regional and local authority level are still inaccessible, and are still 'grey'. This is caused by several factors, including backlogs in processing, writing or publication.

Despite the variation in quality and the difficulty of finding some reports, the synthesis of Malta reports certainly delivers a gain in knowledge in terms of filling period-specific, thematic and geographical gaps in knowledge.

25 Eerden *et al.* 2016.

A large quantity of literature (some of it grey) has now been cross-referenced and made accessible.

Questions as driver
One important challenge for the future is to improve question-driven archaeological fieldwork. Archaeology is a science, which implies that archaeological research must be driven by questions. Research questions must be fit-for-purpose, related to the expected archaeological finds, and translated into specific fieldwork goals.

All too often, questions in the National Archaeological Research Agenda 1.0, and also in project outlines, focus on 'dating' and 'characteristics'. This produces little new knowledge. Every question in a project outline should come with details of why the information is needed, and what methods can be used to answer the question. Region- and period-specific knowledge is required for this, and this is not always available.

Insufficient use is made of the potential of small-scale research (borehole surveys and small trial trenches) because it does not generally include questions on landscape. Palaeogeographical information allows palaeogeographical reconstructions to be made, which can be used as a basis for improving predictive models.

The more recent periods receive little attention, though these are precisely the periods that attract the most public interest and support.

Knowledge and skills of researchers
Continuity in a group of researchers with region-specific knowledge, who are active in a region over a long period, has great benefits in terms of knowledge formation.

Variable report quality is caused partly by the outdated knowledge of many field archaeologists. For example: settlements and homesteads are often excavated, but many archaeologists know little about the various above-ground structures used to construct houses and how to find evidence of them in archaeological features.

Use of specialist analysis
Specialist analysis represents both a great strength and a great weakness of Malta research. It can have major added value in many situations, providing insight into health, subsistence base and diet, for example. The reports of large excavations, in particular, often contain extensive contributions from specialists, but they tend not to be integrated or properly considered in the analysis and answers to the research questions. This might be because of a lack of knowledge about specialist analysis on the part of the project manager (who writes the report), or too little interaction between archaeologist and specialist. On the other hand, specialists often look no further than their own specific expertise, which does not foster integration. Spending on specialist analysis seems to be on the decline. This is not a positive development. The question is whether this is a result of the fall in the number of large projects or of increased competition, which has led to sharp price decreases.

The Ministry of Education, Culture and Science acknowledges the need to synthesise the results of archaeological research performed in the context of 'Malta', and wishes to make it structural, to keep the heritage management cycle moving and prevent it from repeatedly stagnating, prompting a need for further one-off programmes.

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List of products

This appendix provides an overview of the output produced by the Archaeology Knowledge Kit programme.

1 General

Website
- 'Archeologie in Nederland' (Archaeology in the Netherlands). Knowledge portal that gives access to most of the products resulting from the Archaeology Knowledge Kit programme, and also to maps, guidelines etc. developed in other contexts; www.archeologieinnederland.nl or www.archeologieinnl.nl

Maps
- 'Archeologische Landschappenkaart' (Archaeological Landscapes Map): pdf and interactive version. A map of the Netherlands distinguishing 26 landscapes, and numerous landscape zones within each of them presenting archaeologically relevant units; www.archeologieinnederland.nl/bronnen-en-kaarten/ and www.landschapinnederland.nl/bronnen-en-kaarten/.
- 'Archeologische Landschappenkaart' (Archaeological Landscapes Map): GIS-files (MapInfo-format and shapefile) available via DANS EASY; www.easy.dans.knaw.nl.
- 'Archeologische Landschappenkaarten' (Archaeological Landscapes Maps): 26 separate landscape maps (pdf); www.archeologieinnederland.nl/bronnen-en-kaarten/ and www.landschapinnederland.nl.

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- Rensink, E. & J. van Doesburg 2017: Grouping archaeological assemblage types by main theme, in: R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers & J. van Doesburg (eds.), *Knowledge for Informed Choices. Tools for more effective and efficient selection of valuable archaeology in the Netherlands*, Amersfoort (Nederlandse Archeologische Rapporten 55), 32-35.
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Netherlands, Amersfoort (Nederlandse Archeologische Rapporten 55), 36-47.

Brochure and newsletters
- 'Archeologische kennisbronnen voor gemeenten' (2016). Brochure on municipal archaeology maps, National Archaeological Research Agenda, disturbances by agricultural activities, palaeogeographical maps, etcetera.
- 7 newsletters 'Verbeteracties Archeologie' (Improvement Actions Archaeology). Newsletters containing items about activities of the programme.

2 Predictions

Digital application
- 'Landgebruik in lagen' (Land Use in Layers). Web application with information about land use in different periods for the landscape units of the (in depth) archaeological landscape maps of the Netherlands; www.archeologieinnederland.nl/bronnen-en-kaarten/.
- Map viewer on five in-depth archaeological landscape maps of the Netherlands; www.archeologieinnederland.nl/bronnen-en-kaarten/

Maps
- 12 palaeogeographical maps of the Netherlands (pdf and GIS): Pleistocene, 9000 BC, 5500 BC, 3850 BC, 2750 BC, 1500 BC, 500 BC, AD 100, AD 800, AD 1500, AD 1850, AD 2000 (revised versions, made by P. Vos, Deltares); www.archeologieinnederland.nl.
- 5 palaeo-vegetation maps of the Twente region (pdf): 10,000 BC, 4000 BC, 1500 BC, AD 200, AD 1500 (made by University of Leiden and ADC ArcheoProjecten; grant RCE); www.archeologieinnederland.nl.
- 5 time depth profiles (GIS): province of Friesland, Groningen, Noord-Holland, Zuid-Holland, Zeeland (made by P.Vos, Deltares); www.archeologieinnederland.nl.
- 3 in-depth archaeological landscape maps (made by TNO, Deltares and University of Utrecht); www.archeologieinnederland.nl.

Documentation and publications

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- Bouwmeester, H.M.P., 2017: Modelling the 16th-century urban countryside. A zone of influence and interaction, in: R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers & J. van Doesburg (eds.), *Knowledge for Informed Choices. Tools for more effective and efficient selection of valuable archaeology in the Netherlands*, Amersfoort (Nederlandse Archeologische Rapporten 55), 108-120.
- Cohen K.M. & J. Schokker 2014: *Geïntegreerd Plan van Aanpak: RCE-10A: Vervaardiging digitale paleo-hoogtemodellen voor de top van het Pleistoceen en tijdsnede 1, 2 en 3; RCE-10B: Landschapskartering van archeologisch relevante landschapseenheden, naar periode en diepte*, Utrecht.
- Cohen, K.M. 2017: *Beschrijving gebiedsindeling en legenda kaartlaag T0123, begraven landschappen en landschapszones*, Utrecht (Deltares rapport 1210450-000-BGS0014).
- Cohen, K.M., R. Dambrink, R. de Bruijn, V.C. Marges, G. Erkens, H.J. Pierik, K. Koster, J. Stafleu, J. Schokker & M.P. Hijma 2017: Mapping buried Holocene landscapes. Past lowland environments, palaeoDEMs and preservation in GIS, in: R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers & J. van Doesburg (eds.), *Knowledge for Informed Choices. Tools for more effective and efficient selection of valuable archaeology in the Netherlands*, Amersfoort (Nederlandse Archeologische Rapporten 55), 73-93.
- Cohen, K.M., R. Dambrink, R. de Bruijn, J. Schokker & M.P. Hijma, M.P. 2017: *Vervaardiging van hoogtemodellen en landschapskaarten naar periode en diepte voor archeologisch gebruik in Holoceen-afgedekte delen van Nederland*. Deltares i.s.m. TNO Geologische Dienst Nederland en Universiteit Utrecht (Deltares rapport 1210450-000-BGS-0012 /TNO rapport 2015 R10685-XXX).
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Kenniskaart-portaal, Utrecht (Deltares rapport 1210450-000-BGS-0013).
- Dambrink, R., J. Stafleu, J. Schokker, K. Cohen & K. Koster, 2015: *Vervaardiging digitale paleo-hoogtemodellen*, Utrecht (TNO-rapport 2015 R10685).
- Smit, B.I. & H. Feiken 2017: Land Use in Layers. A digital insight into the complex occupation history of the Netherlands, in: R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers & J. van Doesburg (eds.), *Knowledge for Informed Choices. Tools for more effective and efficient selection of valuable archaeology in the Netherlands*, Amersfoort (Nederlandse Archeologische Rapporten 55), 94-107.
- Van Beek, R., M.T.I.J. Gouw-Bouman & J.A.A. Bos 2015: Mapping regional vegetation developments in Twente (the Netherlands) since the Late Glacial and evaluating contemporary settlement patterns, *Netherlands Journal of Geosciences* 94-3, 229-255.
- Van Beek, R., M.T.I.J. Gouw-Bouman, J.A.A. Bos & M.H. Kriek 2017: A glimpse into the past. Mapping regional vegetation development since the Late Glacial in Twente (the Netherlands), in: R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers & J. van Doesburg (eds.), *Knowledge for Informed Choices. Tools for more effective and efficient selection of valuable archaeology in the Netherlands*, Amersfoort (Nederlandse Archeologische Rapporten 55), 64-72.
- Vos, P., 2015: Compilation of the Holocene palaeogeographical maps of the Netherlands, Chapter 2 in: P. Vos, *Origin of the Dutch coastal landscape Long-term landscape evolution of the Netherlands during the Holocene, described and visualized in national, regional and local palaeographical map series*, Utrecht, 50-81.
- Vos, P.C. & S. de Vries 2017: Applied palaeolandscape research as a tool in archaeological heritage management. Modelling the Holocene coastal evolution of the Netherlands, in: R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers & J. van Doesburg (eds.), *Knowledge for Informed Choices. Tools for more effective and efficient selection of valuable archaeology in the Netherlands*, Amersfoort (Nederlandse Archeologische Rapporten 55), 50-63.

3 Disturbances

Digital application
- 'Verstoringsbronnen in kaart' (Sources of Disturbance Map). Map viewer with information about the access and quality of national and regional datasets on soil disturbances in the Netherlands; www.archeologieinnederland.nl/bronnen-en-kaarten/

Documentation and publications

- Bouwmeester, H.M.P., J.-E. Abrahamse & A.M. Blom 2017: Mapping disturbances. Potential disturbance of archaeological remains in built-up areas, in: R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers & J. van Doesburg (eds.), *Knowledge for Informed Choices. Tools for more effective and efficient selection of valuable archaeology in the Netherlands*, Amersfoort (Nederlandse Archeologische Rapporten 55), 143-153.
- De Kort, J.W. & M.A. Lascaris 2017 (in prep.): *Vergelijking van de doelmatigheid van verschillende veldwerkmethoden voor het vaststellen van de mate van bodemverstoring in de gemeenten Sudwest Fryslan (prov. Friesland) en Reusel de Mierden (prov. Noord-Brabant).*
- De Vries, F., F. Brouwer, A.H. Heidema & G. Maas 2016: *Kans op bodemverstoring in beeld, Methode voor het bepalen van de kans op verstoring in drie pilotgebieden in de gemeente Ede*, Wageningen (Alterra-rapport 2710).
- De Vries, F. & G.J. Maas 2017: Mapping sources of soil disturbance information relevant to archaeology, in: R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers & J. van Doesburg (eds.), *Knowledge for Informed Choices. Tools for more effective and efficient selection of valuable archaeology in the Netherlands*, Amersfoort (Nederlandse Archeologische Rapporten 55), 128-132.
- Lascaris, M., 2014: *Analyse LTO-pilot "Mag het een onsje minder zijn"*, Amersfoort (report Cultural Heritage Agency).
- Lascaris, M.A., F. Brounen, B.J.H. van Os, D.J. Huisman, G. Mauro, J. Bouwmeester & M. van der Heiden (eds.), 2017 (in prep.): *Verstoringen in Kaart. Methoden voor het in kaart brengen van*

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- Lascaris, M.A. & D.J. Huisman 2017: Towards a predictive model for agricultural disturbances caused by agricultural land use, in: R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers & J. van Doesburg (eds.), *Knowledge for Informed Choices. Tools for more effective and efficient selection of valuable archaeology in the Netherlands*, Amersfoort (Nederlandse Archeologische Rapporten 55), 133-142.
- Maas, G.J., F. de Vries, F. Brouwer & A.H. Heidema 2016: *Inventarisatie GIS-bestanden met informatie over bodemverstoring*, Wageningen (Environmental Research Rapport 2751).
- Peekel, A., M van der Schoot, D. Beekmans & P. van Hout, 2016: *Methodeonderzoek voor het opstellen van een verwachtingsmodel ten aanzien van bodemverstoringen door agrarische grondroerende activiteiten*, 's-Hertogenbosch (report ZLTO).
- Van Reuler, H., 2017: Disturbance of soil and of archaeological remains resulting from soil tillage in the Dutch agricultural and horticultural sector, in: R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers & J. van Doesburg (eds.), *Knowledge for Informed Choices. Tools for more effective and efficient selection of valuable archaeology in the Netherlands*, Amersfoort (Nederlandse Archeologische Rapporten 55), 121-127.
- Van Reuler, H., G.D. Vermeulen, J. Spruijt, D.J.M. van Balen, M.P.M. Derkx, G. Heijerman, A.H.M.C. Baltissen & J.J. de Haan 2015: *Inventarisatie van reguliere teelthandelingen in de landbouw in Nederland, de invloed ervan op de bodem in verband met de consequenties voor de archeologische resten*, Wageningen (Rapport Stichting Dienst Landbouwkundig Onderzoek (DLO), Praktijkonderzoek Plant & Omgeving).
- Willemse, N.W., L.J. Keunen, S. van der Veen, E.H. Boshoven & H.W. Veenstra 2016: *Naar een verwachtingsmodel voor agrarische bodemverstoringen Een methode-onderzoek binnen de pilotgemeente Súdwest-Fryslân*, Weesp (RAAP-rapport 3082 RAAP Archeologisch Adviesbureau).

4 Archaeological heritage maps

Digital application
- 'Overzicht gemeentelijke archeologische kaarten' (Survey Municipal Archaeology Maps). Map viewer with information about the availability and access of municipal (digital) information and maps on archaeology and cultural history in the Netherlands; www.archeologieinnederland.nl/bronnen-en-kaarten/

Maps
- Map of the Netherlands showing municipalities with maps on known archaeology (pdf); www. archeologieinnederland.nl.
- Map of the Netherlands showing municipalities with maps on archaeological predictions (pdf); www. archeologieinnederland.nl.
- Map of the Netherlands showing municipalities with maps combining archaeology and other cultural heritage features (pdf); www. archeologieinnederland.nl.

Documentation and publications
- Boshoven, E.H., 2015: *Waardenkaarten in veelvoud. Een landelijke inventarisatie van gemeentelijke archeologische en cultuurhistorische waardenkaarten*, Weesp (RAAP-Notitie 5019.
- Brinkkemper, O., 2014: *Kwaliteitsverbetering gegevens Archis*, Amersfoort (report Cultural Heritage Agency).
- Van Doesburg, J., 2015: Archeologische kaarten. Van bonte lappendeken naar uniform dekbed, *Tijdschrift van de Rijksdienst voor het Cultureelerfgoed* 2015-1, 15.
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- Van Doesburg, J., O. Brinkkemper, F.T.S. Brounen, I.M.M. van der Jagt, B.J.M. Janssen, M.A. Lascaris, E. Romeijn, M. Snoek & B.P. Speleers 2017: Mapping the past for the future. Local authority predictive maps and archaeological heritage management, in R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers & J. van Doesburg (eds.), *Knowledge for Informed Choices. Tools for more effective and efficient selection of valuable archaeology in the Netherlands*, Amersfoort (Nederlandse Archeologische Rapporten 55), 155-164.

Other products
- 1500 mutations made in Archis, the national archaeological database, to improve the quality of data on excavations of the National Heritage Agency and its predecessors (ROB, RACM, RCE).
- 1600 municipal archaeology maps collected.

5 Prospection

Digital application
- 'Prospectie op Maat' (Prospection-Made-to-Measure) Web application which recommends a suitable prospection method based on the archaeology likely to be present and the local circumstances; www.archeologieinnederland.nl/bronnen-en-kaarten/

Documentation and publications
- Rensink, E., 2012: *Hooggespannen verwachtingen. Een verkenning van de kwaliteit van de gespecificeerde archeologische verwachting in standaardrapporten van bureauonderzoek*, Amersfoort (Rapportage Archeologische Monumentenzorg 212).
- Rensink, E., J.W. de Kort, J. van Doesburg, L. Theunissen & J. Bouwmeester 2016: *Digitaal informatiesysteem Prospectie op Maat. Werkwijze en verantwoording. Eindversie (juli 2016)*, Amersfoort (report Cultural Heritage Agency).
- Rensink, E., J.W. de Kort, J. van Doesburg, E.M. Theunissen & H.M.P. Bouwmeester 2017: Prospection Made-to-Measure. A digital information system for archaeological prospection methods, in: R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers & J. van Doesburg (eds.), *Knowledge for Informed Choices. Tools for more effective and efficient selection of valuable archaeology in the Netherlands*, Amersfoort (Nederlandse Archeologische Rapporten 55), 165-178.
- Verhagen, Ph., E. Rensink, M. Bats & Ph. Crombé 2013: Establishing discovering probabilities of lithic artefacts in Palaeolithic and Mesolithic sites with core sampling, *Journal of Archaeological Science* 40, 240-247.

6 Research questions

Digital application
- 'Nationale Onderzoeksagenda Archeologie 2.0' (National Archaeological Research Agenda). Web application focused exclusively on national and international archaeological research questions; www.archeologieinnederland.nl/bronnen-en-kaarten/

Documentation and publications
- Eerden, M. & M. Lobbes 2014: *Rapporten Malta-opgravingen 2007-2013 beter ontsloten*, Amersfoort (report Cultural Heritage Agency).
- Groenewoudt, B. 2014: Valletta Harvest: value for money. Dutch initiatives to make 'Malta' excavation results relevant to heritage management, science and society, in: *Proceedings of the International Conference Amersfoort, The Netherlands, 20-22 March 2014* (EAC Occasional Paper 10), 91-98.
- Groenewoudt, B., T. de Groot & M. Eerden 2014: *Naar een nieuwe Nationale Onderzoeksagenda Archeologie*, Amersfoort (report Cultural Heritage Agency).
- Groenewoudt, B., T. de Groot, L. Theunissen & M. Eerden 2015: *Voltooiing NOaA 2.0*, Amersfoort (report Cultural Heritage Agency).
- Groenewoudt, B.J., M.C. Eerden, T. de Groot & E.M. Theunissen 2017: Answers to questions. The new National Archaeological Research Agenda of the Netherlands, in: R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers & J. van Doesburg (eds.), *Knowledge for Informed Choices. Tools for more effective and efficient selection of valuable archaeology in the Netherlands*, Amersfoort (Nederlandse Archeologische Rapporten 55), 179-194.

- Theunissen, L. & T. de Groot 2015: *Denk mee met de Nieuwe NOaA (NOaA 2.0)*, Amersfoort (report Cultural Heritage Agency).
- Theunissen, L., B. Groenewoudt, T. de Groot & M. Eerden 2015: Wat willen we weten over het verleden? Naar een Nationale Onderzoeksagenda Archeologie 2.0, *Archeobrief* 19-2, 7-13.

Other products
- 812 reports of development-led research from the period 2007-2013 were provided with key words and made accessible via the library system of the Cultural heritage Agency.

7 Syntheses

Website
- 'Archeologie op de kaart' (Archeology on the Map). This website present a general impression of Dutch archaeology (made by the National Museum of Antiquities [RMO] in cooperation with the Cultural Heritage Agency); www.archeologieOpDeKaart.nl.

Syntheses
- Regional occupation history of western North Brabant from prehistory to the Late Middle Ages (study conducted by BAAC in cooperation with Vestigia): Ball, E.A.G. & R.M. van Heeringen (red.) 2016: *Westelijk Noord-Brabant in het Malta-tijdperk. Synthetiserend onderzoek naar de bewoningsgeschiedenis van het westelijk deel van het Brabants zandgebied*, Amersfoort (Nederlandse Archeologische Rapporten 51).
- Regional landscape and occupation history of the Gelderse Vallei region with an emphasis on the Iron Age/Early Roman period and Middle Ages (study conducted by RAAP): Utrechts-Gelders zandgebied: Scholte Lubberink, H.B.G., L.J. Keunen & N.W. Willemse 2015: *Op het kruispunt van de vier windstreken. Synthese Oogst voor Malta onderzoek de Gelderse Vallei (Utrechts-Gelders zandgebied)*, Amersfoort (Nederlandse Archeologische Rapporten 48).
- Regional occupation history of the Holland dune region from prehistory to the Early Modern period (study conducted by ADC): Heeringen, R.M.van & H.M. van der Veld (red.) 2017: Struinen door de duinen, Synthetiserend onderzoek naar de bewoningsgeschiedenis van het Hollands duingebied op basis van gegevens verzameld in het Malta-tijdperk, Amersfoort (Nederlandse Archeologische Rapporten 52).
- Occupation history of the Netherlands from the Late Neolithic to the Middle Bronze Age A (study conducted by Universiteit Leiden): Fokkens, H., B.J.W. Steffens & S.F.M. van As 2017: *Farmers, fishers, fowlers, hunters. Knowledge generated by development-led archaeology about the Late Neolithic, the Early Bronze Age and the start of the Middle Bronze Age (2850 - 1500 cal BC) in the Netherlands*, Amersfoort (Nederlandse Archeologische Rapporten 53).
- Occupation history of the southern Netherlands from the Late Roman period – Early Middle Ages transition (study conducted by Archaeological Service of the Municipality of Nijmegen): Van Enckevort, H. & J. Hendriks (in prep.): *Nieuw licht op donkere eeuwen. De overgang van de laat-Romeinse tijd naar de vroege middeleeuwen in Zuid-Nederland. Synthese Oogst voor Malta onderzoek*, Amersfoort (Nederlandse Archeologische Rapporten).
- Archaeological characteristics of farms and farmsteads between c. 1250 and 1650 (study conducted by RAAP): Schabbink, M. (red.) 2016: *Vier eeuwen boeren; Synthese Oogst voor Malta onderzoek: Archeologische sporen van boerderijen en erven 1250-1650*, Amersfoort (Nederlandse Archeologische Rapporten 49).
- Location choice and occupation dynamics in late prehistory, the Roman period and the Middle Ages in eastern North Brabant (study conducted by BAAC): Ball, E.A.G. & R. Jansen (red.) Drieduizend jaar bewoningsgeschiedenis van oostelijk Noord-Brabant; Synthetiserend onderzoek naar locatiekeuze en bewoningsdynamiek tussen 1500 v.Chr. en 1500 n.Chr. op basis van archeologisch onderzoek in het Malta-tijdperk, Amersfoort (Nederlandse Archeologische Rapporten).
- Land division and emergence of stone buildings in urban areas in the Late Middle Ages-Early Modern period (study conducted by BAAC): Cleijne, I.J., A.M.J.H Huijbers, A.D. Brand & R.J.W.M. Gruben 2017: Huizenbouw en percelering in de late middeleeuwen en nieuwe tijd in tien steden, Amersfoort (Nederlandse Archeologische Rapporten 57).

- Formation of villages in the Netherlands in the Middle Ages, c. 800-1600 (study conducted by Universiteit van Amsterdam): Verspay, J.P.W. , A.M.J.H. Huijbers, H. van Londen, J. Renes, J. Symonds 2017: *Village Formation in the Netherlands during the Middle Ages (800 – 1600). An assessment of recent excavations and a path to progress*, Amersfoort (Nederlandse Archeologische Rapporten 56).
- Occupation and use of landscape in early prehistory in the Netherlands (study conducted by Rijksuniversiteit Groningen): Peeters, J.H.M., D.C.M. Raemaekers, I. Devriendt, P. Hoebe, M. Niekus, G. Nobles & M. Schepers 2017 (in prep.): *Paradise Lost? Insights into the Early Prehistory of the Netherlands from 15 years of development-led archaeology*, Amersfoort (Nederlandse Archeologische Rapporten).
- Wooden objects (study conducted by De Steekproef BV in cooperation with Biax): Lange, S., L.I. Kooistra & J. Jelsma (red.) 2017: *Uit het juiste hout gesneden. Houten gebruiksvoorwerpen uit archeologische context tot 1300 n.Chr.*, Amersfoort (Nederlandse Archeologische Rapporten 54).
- Occupation and land use history of the Maas Vallei in the provinces Limburg and North Brabant region in Limburg, and the adjacent area in Brabant (study conducted by BAAC): Ball, E.A.G., L.A. Tebbens & C.M. van der Linde (red.) 2017 (in prep.): De bewonings- en gebruiksgeschiedenis van het Maasdal in Limburg en het aangrenzende Brabantse deel; Synthetiserend onderzoek op basis van archeologisch onderzoek tussen Eijsden en Mook in het Malta-tijdperk, Amersfoort (Nederlandse Archeologische Rapporten).

Other publications and documentation

- De Groot, T. & B. Groenewoudt 2013: '*Kenniskansen' voor AMZ-relevant synthetiserend onderzoek op basis van Malta-rapportages*, Amersfoort (report Cultural Heritage Agency).
- De Groot, T. & B. Groenewoudt 2014: *Kenniskansen voor AMZ-relevant synthetiserend onderzoek op basis van Malta-rapportages* 2, Amersfoort (report Cultural Heritage Agency).
- Eerden, M. & M. Lobbes 2014: *Rapporten Malta-opgravingen 2007-2013 beter ontsloten*, Amersfoort (report Cultural Heritage Agency).
- Eerden, M., B.J. Groenwoudt, H. van der Velde, M. Schabbink & H. Fokkens 2016: Oogsten uit maltarapportages, *Archeobrief* 2016-2, 28-33.
- Eerden, M.C., B.J. Groenewoudt, T. de Groot, E.M. Theunissen & R. Feiken 2017: Synthesising data from development-led archaeological research, in: R.C.G.M. Lauwerier, M.C. Eerden, B.J. Groenewoudt, M.A. Lascaris, E. Rensink, B.I. Smit, B.P. Speleers & J. van Doesburg (eds.), *Knowledge for Informed Choices. Tools for more effective and efficient selection of valuable archaeology in the Netherlands*, Amersfoort (Nederlandse Archeologische Rapporten 55), 195-209.
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With the aim of providing ‘knowledge for informed choices’, a series of tools have been developed for archaeological heritage management in the Netherlands. They include maps, datasets, methods, guidelines, best practice and web-based applications to facilitate the effective and efficient selection of valuable archaeological remains. The products relate to predictive models, disturbances by agriculture and other activities, archaeological heritage maps, methods of prospection, research questions and scientific syntheses to close the archaeological heritage management cycle.

This scientific report is intended for archaeologists and for other professionals and amateur enthusiasts involved in archaeology.

The Cultural Heritage Agency of the Netherlands provides knowledge and advice to give the future a past.