Journal of Archaeological Science: Reports 3 (2015) 144–159

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: http://ees.elsevier.com/jasrep

Best travel options: Modelling Roman and early-medieval routes in the Netherlands using a multi-proxy approach

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ARTICLE INFO

Article history:
Received 12 February 2015
Received in revised form 20 May 2015
Accepted 30 May 2015
Available online 15 June 2015

Keywords:
Early Middle Ages
Geographical Information Systems
Historical routes
Landscape archaeology
Network friction
Roman period

ABSTRACT

During the Roman and early-medieval period in the Netherlands, an extensive network of routes connected settlements on the local, regional and supraregional scale. The orientation of these route networks in part was determined by settlement locations, and in part by environmental factors (e.g. soil type, relief). Therefore these route networks provide a key in understanding the dynamic interplay between cultural and environmental factors.

This study focuses on modelling Roman and early-medieval routes using a multi-proxy approach. By combining network friction with archaeological data representing settlements, burial sites and shipping-related finds we wish to investigate the possibilities of using these large-scale datasets for modelling Roman and early-medieval route networks in the Netherlands. Data representing past infrastructure and isolated archaeological finds were used to validate the model output.

Results show that in geomorphologically diverse lowland regions, such as the Netherlands, network friction is extremely useful for modelling historical route networks. We found a clear relationship between environmental conditions, settlement locations and the spatial distribution of infrastructure. Using evidence-based modelling, we were able to correctly predict the location of 89% of the currently identified Roman infrastructure, and 85% of the known early-medieval infrastructure in the Netherlands within a 1000 m buffer. Additionally, despite only roughly covering a surface area of 13% in the Roman and 11% in the early-medieval period of the Netherlands, 82% and 72% of all known isolated finds were located within the same buffer.

1. Introduction

The Netherlands is a dynamic lowland region partially influenced by fluvial (e.g. Rhine, Meuse and Scheldt) and marine activity. The west and north of the country are low-lying regions which have been subjected to flooding throughout the Holocene (Stouthamer and Berendsen, 2000; Erkens, 2009; Vos et al., 2011; Cohen et al., 2012; Toonen, 2013; Vos and De Vries, 2013). The central, eastern and southern parts can be regarded as relatively stable landscapes largely consisting of somewhat higher Pleistocene soils (Steur and Heijink, 1991; De Vries et al., 2003; Koomen and Maas, 2004).

Recent research shows that major landscape changes (e.g. vegetation, flooding) occurred during the transition from the Roman period (12 BC–AD 450) to early-medieval period (AD 450–1050) (Stouthamer and Berendsen, 2000; Roymans and Gerritsen, 2002; Groenewoudt et al., 2007; Erkens, 2009; Groenewoudt, 2012; Jansma et al., 2014; Toonen, 2013). Archaeological evidence from these periods suggests simultaneous alterations in land use and settlement patterns as well as severe demographic decline (Cheyette, 2008). Historical route networks, which are the product of and influenced by both cultural and landscape dynamics, provide a key to understanding the nature of and interaction between these dynamics. Our own research on landscape prerequisites of potential Roman and early-medieval routes in the Netherlands shows clear differences in regional accessibility during these periods (Van Lanen et al., 2015). The western and northern parts would have been largely inaccessible by land and settlements in these regions must have been highly dependent on water transport. Additionally, in these regions landscape changes were most extreme from the Roman to early-medieval period as compared to other parts of the Netherlands (Van Lanen et al., 2015).

In recent years the reconstruction of historical roads, or more generally historical route networks, has been attempted frequently using *spatial modelling* and *Geographical Information Systems* (*GIS*) software (e.g. Gietl et al., 2008; Zakšek et al., 2008; Verhagen and Jeneson, 2012; White and Barber, 2012; Verhagen, 2013; Breier, 2013). Mostly focussing either on elevated regions where relief to a large extent

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http://dx.doi.org/10.1016/j.jasrep.2015.05.024

determines route orientation or on improving our theoretical understanding of how to model past routes, these papers mainly addressed the correct definition of tools such as friction layers, viewshed analyses and least-cost paths (Verhagen, 2013).

However, the usefulness of these approaches is limited when applied to lowland regions. In these areas, which are marked by small relief differences, other landscape characteristics equally determine route orientation (e.g. the presence of mires, natural peat bogs or rivers). Therefore a different approach is needed. This is why the present study uses a network-friction model (NFM) to combine data on past environments with archaeological data, in order to reconstruct Roman and early-medieval route networks. Network friction is the variable that determines potential regional accessibility based on the comparison of local and surrounding landscape factors (Van Lanen et al., 2015). The NFM for the Netherlands was developed by Van Lanen et al. in 2015 and combines numeral environmental datasets in order to calculate landscape prerequisites for Roman and early-medieval routes. Based on landscape factors, this model identifies and locates transport obstacles and movement corridors for the Roman period and Early Middle Ages. The central aim of this second study is to determine the extent to which movement corridors calculated by the NFM and data on settlement patterns can be integrated to model historical route networks in the Netherlands. The focus of the research is not on cultural interpretation but much more on methodology; specifically the potential of large-scale datasets and the benefits of an evidence-based, integrated approach.

2. Theoretical background

Routes are not roads, and route networks fundamentally differ from road networks. The evidence for the presence of actual roads in the Roman and early-medieval Netherlands is limited. Where roads can be regarded as fixed features connecting two places, routes are frequent-travel zones. Almost all Roman period and early-medieval roads were unpaved and not fixed to one location (e.g. Horsten, 2005). Seasonal (e.g. weather) or yearly (e.g. general wear) conditions could force travellers to shift to other adjacent lanes, creating a route zone. Therefore route networks are more spatially dynamic but in general orientation equal to road networks.

Landscape is constantly and inevitably changing through the influence of human and natural factors and the complex and dynamic interaction between them (Fairclough, 2007). Route networks are subjected to both these cultural and environmental factors and as such provide a key to better understand and study their dynamic interplay. The study of large-scale route networks requires a landscape-archaeological approach since these networks transcend the traditionally studied site level and require a focus on both cultural and environmental variables.

Landscape archaeology is best defined as the interdisciplinary investigation of the long-term relationship between people and their environment (Barker, 1986; Kluiving et al., 2012; Kluiving and Guttmann-Bond, 2012). The disciplines used in landscape archaeology have in common that the dynamics of past landscapes are investigated as that of one single, complex research entity. "Landscape" within this context is best defined at a basic level as: "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" (Council of Europe, 2000). In order to model past route networks and settlement patterns, both the natural (e.g. landscape dynamics, climate) and cultural (e.g. economy, politics) processes within these landscapes need to be sufficiently understood. Landscape archaeology is multi-disciplinary "by nature" and as such it is a perfect tool to study the interaction between physical and cultural processes.

Traditional GIS modelling of past routes has largely focussed on correctly defining cost-surface modules (Zakšek et al., 2008; Herzog and Posluschny, 2008; Murrieta-Flores, 2012; Herzog, 2013a,b,c; Verhagen, 2013; Herzog, 2014). In low-lying regions such as the Netherlands these approaches are less useful when modelling route networks. In these regions, other landscape factors greatly will have determined route networks and local translocation conditions (e.g. the presence of mires, peat bogs, rivers). Network friction calculates regional accessibility conditions based on environmental data and locates transport obstacles and corridors, and therefore can be used to model historical route networks (Van Lanen et al., 2015). Past route networks can be modelled and tested by combining network friction with archaeological data on e.g. settlements and infrastructure.

Due to cultural and environmental variables, settlements were never distributed equally throughout a region, which results in spatially variable settlement densities. Densely-settled areas can be expected to trade and communicate with nearby settlements and with other densely-settled areas a little further away and as such are expected to function as central hubs within dynamic systems.[1] Therefore these High-Density Settlement Clusters (HDSCs) are crucial for modelling route networks. HDSCs were determined based on the ratio of sites per square kilometres (s/km^2) in order to keep the NFM evidence based and to minimize archaeological-theoretical modelling. Settlements outside HDSCs (in this paper referred to as isolated settlements) are individual elements within the route network. Since either these settlements were founded near existing routes, or routes developed near existing settlements, they can be regarded as indicative of supra-regional route orientation.

In addition to following geographical transport corridors, people moving through the landscape preferably will have avoided uncultivated areas. The reason is that these regions most likely were less accessible because of soil and vegetation conditions (respectively e.g. mires and dense forests) and might also have been regarded as 'no-go areas' (Roymans, 1995; Spek, 2004; Kolen, 2005). If possible, travellers will have used settled areas (i.e. the settlement area including surrounding cultivated lands) as much as possible. This is why the settled areas of isolated settlements can be utilized for modelling route orientation.

3. Material

3.1. Network Friction Model (NFM)

Van Lanen et al. (2015) already determined geographical obstacles and corridors for possible translocation in ca. AD 100 and 800 (Fig. 1). The resulting NFM integrates palaeogeographical data from the Roman and early-medieval period (Bos, 2010; Vos et al., 2011; Cohen et al., 2012; Van Dinter, 2013; Vos and De Vries, 2013). Contemporary landscape data was added using the geomorphological and soil maps of the Netherlands. The geomorphological map (1:50,000) contains information on the relief, genesis and age of landscape elements (Koomen and Excaltus, 2003; Koomen and Maas, 2004). The soil map (1:50,000) provides an overview of current soil types and average groundwater levels (Steur and Heijink, 1991; De Vries et al., 2003; Van der Gaast et al., 2010). Landscape units postdating the Early Middle Ages were removed from both datasets. Elevation data for the Pleistocene soils was added through the Height Model of the Netherlands (AHN) (Brand et al., 2003; Swart, 2010; Van der Zon, 2013).

3.2. Archaeological data

Archaeological data representing settlements, burial sites, shipping (e.g. ships, canoes) and isolated finds were collected through the Archaeological Information System of the Netherlands (ARCHIS). This system contains a national overview of archaeological finds (Roorda and Wiemer, 1992; Wiemer, 2002).[2] In order to obtain maximum accuracy, the ARCHIS data were compared to the results of new research published in PhD theses, books and research reports (Miedema, 1983;

[1] The assumption of movement from these HDSCs is in line with the complex, dynamic interaction between people and landscape (e.g. Kolen, 1995; McGlade, 1999).

[2] ARCHIS is maintained by the Cultural Heritage Agency of the Netherlands (RCE) and was created in 1992. Website: http://archis2.archis.nl/.