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Establishing discovery probabilities of lithic artefacts in Palaeolithic and Mesolithic sites with core sampling

Philip Verhagen [a,*], Eelco Rensink [b], Machteld Bats [c], Philippe Crombé [c]

[a] Research Institute for the Heritage and History of the Cultural Landscape and Urban Environment (CLUE), Faculty of Arts, VU University, De Boelelaan 1105, 1081 HV, Amsterdam, The Netherlands
[b] Cultural Heritage Agency (RCE), Amersfoort, The Netherlands
[c] Department of Archaeology, Ghent University, Ghent, Belgium

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ABSTRACT

This paper reports the results of a study into the effectiveness of core sampling for discovering Palaeolithic and Mesolithic hunter-gatherer sites in the Netherlands and northwestern Belgium. Earlier work established optimal sampling strategies for use in archaeological heritage management survey in the Netherlands. However, the statistical model used for this was based on a limited amount of data on the distribution of lithic artefacts in Palaeolithic and Mesolithic sites. For the current study we have analyzed the distribution of artefacts in a selected number of excavated sites, and estimated discovery probabilities of these sites through simulation. The simulation results indicate that discovery probabilities are lower than expected due to the effect of clustering of finds. Furthermore, the density of flints in Palaeolithic and Mesolithic sites is generally lower than the estimates that were used for setting up the optimal sampling strategies, and a substantial number of sites is very small. This means that, in order to discover Palaeolithic and Mesolithic sites with sufficient reliability, we will have to apply more intensive survey strategies than have been recommended up to now.

1. Introduction

Over the past ten years, procedures for fieldwork in archaeological heritage management (AHM) in the Netherlands have become codified in a system of regulations set up by the archaeological sector itself. This set of quality norms (the Quality Norm for Dutch Archaeology or KNA version 3.2; SIKB, 2010) describes the procedures to be followed in AHM research, moving from desk-based assessment through survey to excavation. The quality norms specify *what* needs to be done, but do not prescribe *how* things should be done. However, in some cases, it was felt that additional guidance was needed on the 'how' as well. One of these issues is the establishment of the most effective and efficient strategies for detecting archaeological sites. Accompanying guidelines have therefore been developed concerning the use of core sampling (Tol et al., 2006) and trial trenching (Borsboom and Verhagen, 2009) – these being the most frequently used survey methods in the Netherlands. The guidelines are based on theoretical statistical models that specify the probability of detecting archaeological sites of a certain dimension and find density (see Tol et al., 2004; Verhagen, 2005; Verhagen and Borsboom, 2009). They are used to help design survey project briefs and to evaluate survey results. The guidelines provide preferred survey strategies that will result in a 75% chance of discovery of archaeological sites that are classified according to such prospection characteristics as size and artefact density (Table 1). However, it is still difficult to assess the actual effectiveness of these strategies, since the prospection characteristics of many archaeological site types are only known in general terms. More empirical data are needed to compare the situation in the field to the theoretical assumptions used for the guidelines. Unfortunately, this type of data is still in small supply, and no mechanisms are available in Dutch AHM that would enable us to increase our knowledge on these aspects. The excavation of sites is usually considered to be the closing chapter of AHM, and is not systematically used to collect information on, for example, the spatial distribution and density of artefacts or features that can be of use in the earlier phases of fieldwork in the future. This paper reports the results of an investigation that has tried to do just that. We have used excavation data of Stone Age sites, especially from the Late Palaeolithic (ca. 13,000–8700 cal BC) and Mesolithic (ca.

* Corresponding author. Tel.: +31 20 5982848.
E-mail addresses: j.w.h.p.verhagen@vu.nl (P. Verhagen), e.rensink@cultureelerfgoed.nl (E. Rensink), machteld.bats@ugent.be (M. Bats), philippe.crombe@ugent.be (P. Crombé).

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Table 1
Overview of standard strategies for core sampling survey in the Netherlands for different site types.

Site type	Lithology	Grid spacing	Core diameter	Sieving mesh	Grid spacing	Core diameter	Sieving mesh
Stone Age	**Flint scatter**				**Cultural layer**		
Medium size, 200–1000 m^2	Sand	20 × 25 m	15 cm	3 mm	20 × 25 m	3 cm	–
Base camp	Clay/loess	17 × 20 m	12 cm	3 mm			
House plan	Clay/loess	13 × 15 m	12 cm	–			
Large size, >2000 m^2	Sand	40 × 50 m	15 cm	3 mm	40 × 50 m	3 cm	–
Large base camp	Clay/loess	30 × 35 m	12 cm	3 mm			
Aggregated settlement	Clay/loess	20 × 25 m	12 cm	–			
Multiple house plans							
Bronze Age – Middle Ages	**Ceramic scatter**				**Cultural layer**		
House plan(s), 500–2000 m^2	Sand	30 × 35 m	15 cm	4 mm	30 × 35 m	3 cm	–
	Clay/loess	20 × 25 m	12 cm	4 mm			
	Clay/loess	17 × 20 m	12 cm	–			
'Village', >8000 m^2	Sand	80 × 90 m	15 cm	4 mm	80 × 90 m	3 cm	–
	Clay/loess	60 × 70 m	12 cm	4 mm			
	Clay/loess	40 × 50 m	12 cm	–			
Unspecified							
	Sand	20 × 25 m	15 cm	4 mm			
	Clay/loess	13 × 15 m	12 cm	–			

Flint and ceramic scatters can only be effectively detected when artefact densities are >80 per m^2, for lower densities core sampling is not recommended. Sieving is used to increase the detection probability of artefacts. In clay or loess soils however, sieving may be too difficult, and an alternative strategy is given using a larger number of samples. Cultural layers are distinct lithostratigraphical units that can be recognized directly as archaeological relics, and hence have a detection probability of 1. Source: Tol et al., 2006: p. 38.

Table 2
Example of calculating discovery probabilities from core samples using the binomial distribution. Given a detection probability of artefacts ranging from 0.1 to 0.9, the probability of discovering the site is given when 5 cores are placed inside the site. For example, when the detection probability is 0.1, there is a probability of 0.59 that no cores will recover an artefact; a probability of 0.33 that 1 core will recover an artefact, 0.07 that 2 cores will recover one, and 0.01 that 3 cores will. The discovery probability is then 0.41.

Number of hits	Detection probability								
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	0.59	0.33	0.17	0.08	0.03	0.01	0.00	0.00	0.00
1	0.33	0.41	0.36	0.26	0.16	0.08	0.03	0.01	0.00
2	0.07	0.20	0.31	0.35	0.31	0.23	0.13	0.05	0.01
3	0.01	0.05	0.13	0.23	0.31	0.35	0.31	0.20	0.07
4	0.00	0.01	0.03	0.08	0.16	0.26	0.36	0.41	0.33
5	0.00	0.00	0.00	0.01	0.03	0.08	0.17	0.33	0.59
Discovery probability	**0.41**	**0.67**	**0.83**	**0.92**	**0.97**	**0.99**	**1.00**	**1.00**	**1.00**

8700–4500/4000 cal BC) in the Netherlands and northwestern Belgium (Flanders) to better understand and describe their prospection characteristics. This is especially relevant since many of these sites are difficult to discover by means of core sampling because of their relatively small size, low density of artefacts and often deep stratigraphic position.

2. Background: core sampling and site detection

The Netherlands and northwestern Belgium are located in the highly dynamic Rhine-Meuse-Scheldt delta, where fluvial and marine sedimentation as well as erosion have had a substantial effect on the three-dimensional distribution of archaeological sites. In many places, the archaeological remains found at the surface only form a small portion of the actual archaeological record, and subsurface survey methods are needed to detect archaeological sites. From the late 1980s on, core sampling has been an important

Table 3
List of analyzed excavations.

Site name	Code	Landscape setting	Period	Excavated area	Grid size	Sieving strategy
Eyserheide	EY	Loess	Late Palaeolithic (Magdalenian)	158 m^2	1 × 1 m	4 mm wet and dry (only in centre of the site)
Geldrop-Aalsterhut	GA	Aeolian sand	Late Palaeolithic (Ahrensburg culture)	305 m^2	2 × 2 m	2 mm wet
Hardinxveld-De Bruin	HA	River dune covered with fluvial clay	Late Mesolithic/Early Neolithic	345 m^2	50 × 50 cm	4 mm wet (only sandy soil)
Hempens	HE	Aeolian sand covered with marine clay	Late Mesolithic/Early Neolithic	443 m^2	50 × 50 cm	3 mm wet
A27-Hoge Vaart	HV	Aeolian sand covered with marine clay	Late Mesolithic/Early Neolithic	1342.75 m^2	50 × 50 cm	2 mm wet, only counted in selected transects
Keinsmerbrug	KB	Tidal marsh deposits covered with marine clay	Neolithic (Single Grave culture)	432 m^2	1 × 1 m; some squares 2 × 1 and 2 × 2 m	Unknown
Oudenaarde-Donk	OD	Point bar deposits covered with fluvial clay	Early Mesolithic	145 m^2	50 × 50 cm	1 mm wet
Stroe	ST	Valley side covered with aeolian sand	Late Palaeolithic (Hamburg cultuur)	29.5 m^2	50 × 50 cm	1 mm wet
Sweikhuizen-Groene Paal	SW	Loess	Late Palaeolithic (Magdalenian)	625 m^2	2 × 2 m	3 mm wet
Verrebroek-Aven Ackers (2 sites)	VA	Aeolian sand covered with peat and fluvial clay	Early, Middle and Late Mesolithic	321.5 (2007) + 43.75 m^2 (2006)	50 × 50 cm	2 mm wet
Verrebroek-Dok	VD	Aeolian sand covered with peat and fluvial clay	Early Mesolithic	2091 m^2	50 × 50 cm	2 mm wet
Zutphen-Ooijerhoek	ZO	Aeolian sand	Early Mesolithic	294.75 m^2	50 × 50 cm	3 mm wet