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Roebroeks, Wil; Kamermans, Hans; Mol, Joanne; Turq, Alain; Kolfschoten, Thijs van et al.; Bakels, Corrie; Kamermans, Hans

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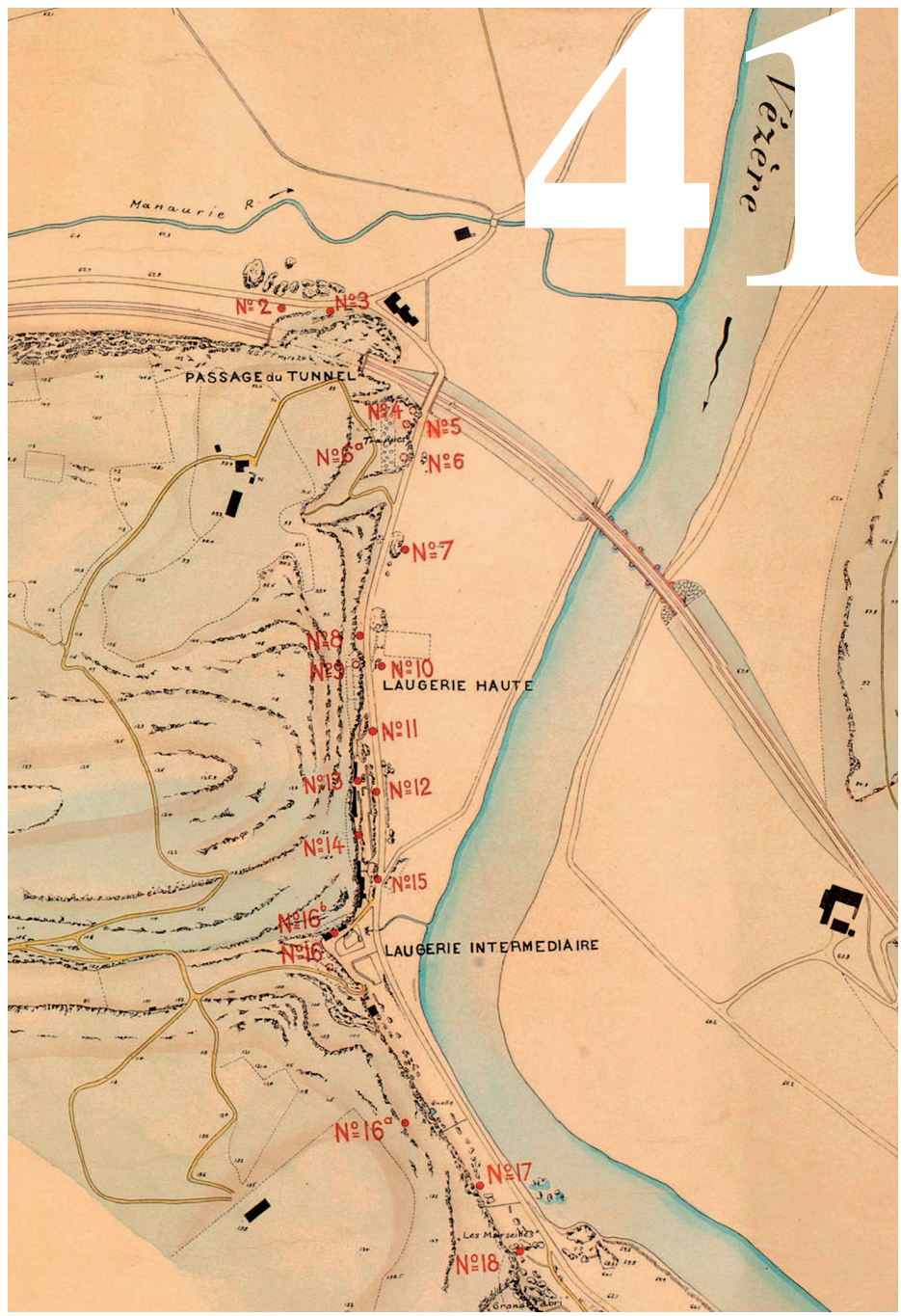

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Patterns of Middle and Upper Palaeolithic land use in Central Lazio (Italy)

Hans Kamermans and Jan Sevink

The Italian Agro Pontino and surroundings are well known for their archaeological and palaeo-environmental research. This paper presents the results of interdisciplinary research in that area that started in the 1970's and continued into this century. After a description of the geology and soils of the Agro Pontino and the Monti Lepini, this data is used in a predictive model for land use during the Middle and Upper Palaeolithic. The model predicts that Middle and Upper Palaeolithic inhabitants of the area exploited only the Agro Pontino and not the surrounding mountains. They did this as generalist hunter-gatherers practising residential mobility.

1 Introduction

The difference in land use between Middle Palaeolithic and Upper Palaeolithic hunter-gatherers is a well-studied research topic (e.g. Mellars and Stringer 1989). One of the more rarely used tools to analyse this difference is predictive modelling (Kamermans 2006). To apply predictive modelling to archaeology, a number of conditions must be met, in particular, adequate data on the archaeology and the palaeo-environment.

Predictive modelling is a technique used in archaeology to predict, in a region, locations of material evidence of past human behaviour on the basis of observed patterns of archaeological and environmental material or on assumptions about human behaviour. The goal is either to predict archaeological site locations to guide future spatial developments in the modern landscape – an archaeological heritage management application – or to gain insight into former human behaviour in the landscape – an academic research application. We use the technique here for the latter purpose.

The Agro Pontino is a coastal plain along the Tyrrhenian Sea approximately 80 km southeast of Rome (fig. 1), in the North and East bordered by the Monti Lepini and the Monti Ausoni, which largely consist of limestones. The geology is well known. In the past decades, geologists, physical geographers, and palynologists studied the area intensively (Segre 1957; Sevink *et al*. 1982; 1984; 1991; Kamermans 1991). Half of the Agro Pontino consists of a low-lying graben filled with peat and fine-grained sediments; a complex of marine terraces forms the other half.

The archaeology of the region is also well known and most of it is collected in a controlled way by field surveys. Field surveying has for a very long time been a well-respected method to gather archaeological data for regional studies. The archaeological data used in this study has been collected through various surveys in the Agro Pontino in the 1980s (Holstrom *et al*. 2004) and through recent surveys in the Monti Lepini (van Leusen, forthcoming).

In archaeology, one of the problems with regional studies is the delimitation of the region. How big should the region be to allow for viable conclusions regarding archaeological cultures? Of course this depends, among other things, on the economic system in the past. For example, the size of an area exploited by hunter-gatherers differs from one exploited by pastoralists or agriculturalists. In this study we try to establish whether during Middle and Late Palaeolithic times the coastal plain of the Agro Pontino could support permanent habitation by hunter-gatherers or whether these hunter-gatherers also had to exploit the surrounding mountains. The results could be of wider importance since this question of scale is a general archaeological problem.

2 Previous work

2.1 Archaeological survey

Surveys are a cheap and non-destructive method way to collect archaeological data from a large area. Most surveys only visit a sample of the study area. Field walking is the most common way of doing a survey. A group of people usually crosses a field at a certain distance from each other and collects or registers all the archaeological material. Both projects described below used this technique.

2.1.1 Surveys in the Agro Pontino

There is a long tradition of Dutch research in the Agro Pontino and its surroundings. Between 1966 and 1984 the Laboratory for Physical Geography and Soil Science of the University of Amsterdam (the Netherlands) had a research project in Southern Lazio and adjacent Campania (Sevink *et al*. 1984). During a soil survey in 1978 in the Agro Pontino archaeological material was encountered (Sevink *et al*. 1982), and in 1979 the Instituut voor Pre- en Protohistorische

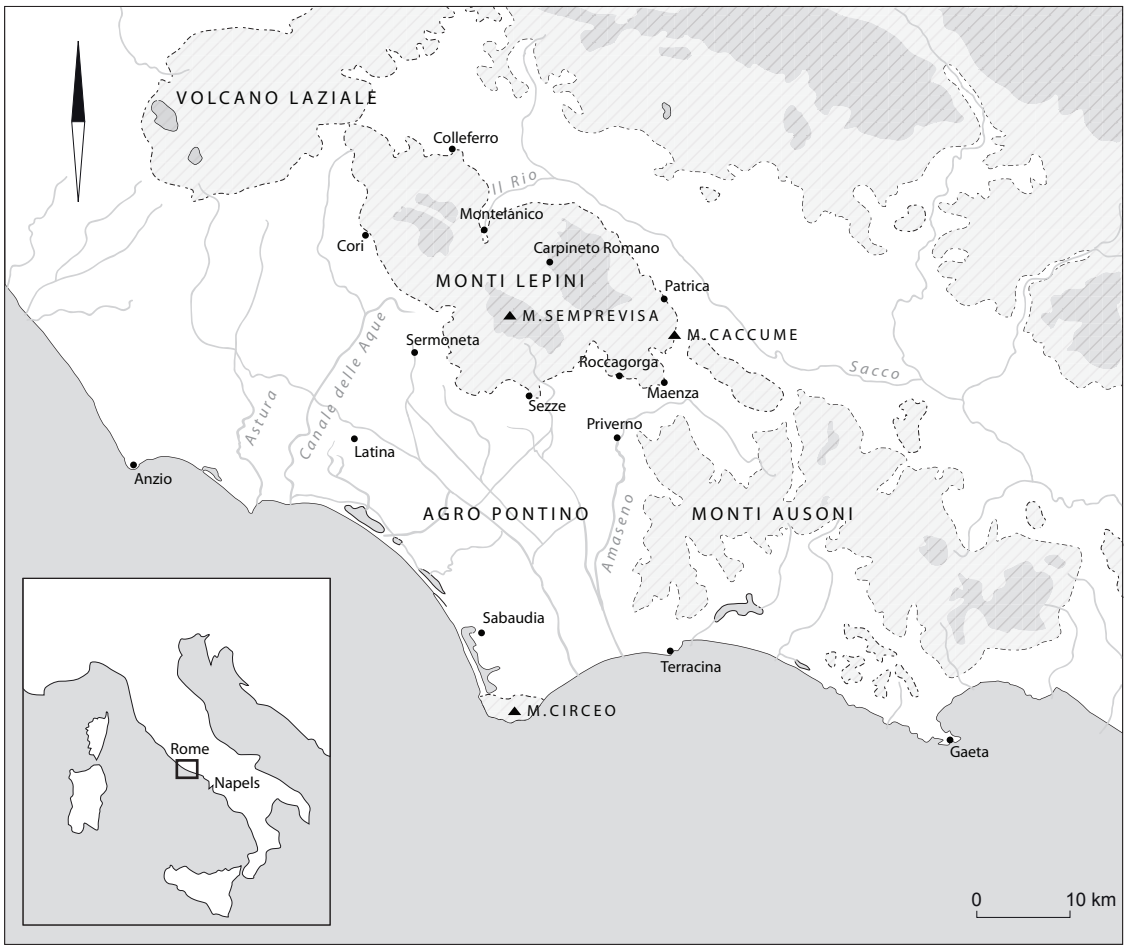

Figure 1 The study area in Central Lazio (Italy).

Archeologie Albert Egges van Giffen (IPP) of the University of Amsterdam started a study project in the Agro Pontino directed by Susan Holstrom Loving, Albertus Voorrips and Hans Kamermans (Voorrips *et al*. 1983; 1991; Holstrom *et al*. 2004). The two main research themes of the project were the transition from the Middle to the Upper Palaeolithic (Holstrom Loving 1996; Loving *et al*. 1990/91; 1992; Loving 1996) and the application of land evaluation in archaeology (Kamermans *et al*. 1985; 1990; Kamermans 1993; 1996; 2000; 2006).

Since it was not possible to survey the entire Agro Pontino, a sampling programme was required. It was decided to use a systematic unaligned transect sample, with transects crossing the area width-wise, from the southwest coast to the mountains. The sampling unit would be the agricultural field. After estimating that a single transect would cross about 150 fields and calculating that the minimum number of fields needed to answer the project's archaeological questions ranged up to 670, it was decided to draw five transects. The area was subdivided into 5 equally wide blocks and the location of the transect within each block was selected using a random method. An additional 727 fields were surveyed outside the transects.

Between 1979 and 1989 the project carried out seven surveys, three small ones with two to four people (1979, 1980, and 1989) and four larger ones with a crew of up to twenty scholars and students (1982, 1984, 1986, and 1988). In 1986 the Archaeology department of the University of Leiden joined the project. In 1980 and 1981 material for palynological research was collected. Methods used and results were published in Voorrips *et al*. (1991) and various other publications (Holstrom Loving 1996; Kamermans 1993; 1995; 1996; 2000; 2003; 2006; Kamermans *et al*. 1985; 1990; Kamermans and Voorrips 1986; Loving 1996;

Loving *et al*. 1990/91; Voorrips *et al*. 1986; 1989). In 2004 an annotated and illustrated catalogue of all the data collected was published on a CD (Holstrom *et al*. 2004).

The University of Groningen started the Pontine Region Project in 1987 with the objective to gain insight into the developments and changes in the organisation of the Pontine region during the first millennium BC (Attema 1993, Attema and van Leusen 2004, Attema *et al*. forthcoming). Various environmental and archaeological field surveys were carried out. The University of Groningen's archaeological research is still continuing. Relevant details are described in the next section.

2.1.2 Surveys in the Monti Lepini

As an offspring of its research, the University of Groningen developed a project named 'hidden landscapes' aiming at a full survey of the adjacent mountains and the border of the Agro Pontino plain, and paying particular attention to the development of the landscape over time and the interaction with human land use. Systematic surveys, in which all archaeological material was collected, were executed as part of the project (for an extensive description of the methodology employed, see van Leusen 2005; forthcoming). As to the Palaeolithic material, specific surveys were executed in 2005 and 2006. The soil map produced by Sevink *et al*. (1984) was used to establish the areas with surfaces that potentially have remained stable since the Middle Palaeolithic and to identify possible sources of flint or flint-like material in the mountains. A small team of physical geographers and archaeologists using the same techniques as for the Agro Pontino survey surveyed these areas. Fields were only surveyed when the visibility was sufficient (little or no vegetation, recent rain, etc.).

Additionally, prior to the survey, Palaeolithic materials that had been found in earlier studies by professionals as well as amateurs were evaluated for their technique and the nature of the lithic material. Furthermore, we tried to assess all sites where Palaeolithic material has been reported and visited these to check their occurrence and the origin of the lithic material.

2.2 Land evaluation as predictive modelling

One of the first definitions of predictive modelling is by Kohler and Parker: "Predictive locational models attempt to predict, at a minimum, the location of archaeological sites or materials in a region, based either on a sample of that region or on fundamental notions concerning human behaviour" (Kohler and Parker 1986, 400). The most common distinction in predictive modelling is a methodological one between inductive and deductive methods. The inductive method is dominant, but many methods and techniques are available. With the inductive approach a model is constructed based on the correlation between known archaeological sites and attributes from (mostly) the current physical landscape. On the basis of correlation, causality is assumed, and the model is then used to predict site location. These predictions in turn can be used for planning purposes. Often external expert knowledge is used to evaluate and adjust the models. With the, more rarely used, deductive approach the model is constructed on basis of *a priori* knowledge (social, mainly anthropological, historical and archaeological knowledge) and the known sites are then used to evaluate the model.

Land evaluation is a technique developed by soil scientists to generate different models for land use, as defined by the socio-economic context, on the basis of environmental and ecological information. In archaeology, land evaluation can be used as a deductive form of predictive modelling. After an initial inventory of the palaeo-environment, socio-economic models are constructed using ethnographical, historical, and archaeological data. Land units are ranked according to their suitability for a certain type of land use, and finally an expected form of land use is compared with the archaeological record.

Kamermans (2000; 2006) published the results of previous predictive modelling studies for the Agro Pontino. His conclusion was that land evaluation as predictive modelling could be a useful tool for research into land use for palaeotechnic peasant ecotypes but did not work for hunter-gatherer societies. Between the defined land units for the Palaeolithic, no differentiation in find spot density was found. Significant variations in find spot density between the defined land units is a condition for the proper application of predictive modelling, even for deductive predictive modelling. The study area must be large enough to have this variation. It could be that hunter-gatherers, in this particular case, operated on a different scale than palaeotechnic peasants and did not only exploit the Agro Pontino plain but also the adjacent mountains (Monti Lepini and Monti Ausoni).

3 DATA

3.1 Geology and soils

3.1.1 Agro Pontino

The area consists of an inner, low-lying graben filled with peat and other fine-textured sediments, and an adjacent complex of stable marine terraces, which date from the Middle to Late Pleistocene (Segre 1957; Sevink *et al*. 1982; 1984; 1991; Kamermans 1991). A full summary of the extensive available information on the geology and soils of the Agro Pontino has been given in Voorrips *et al*. (1991). Recently Van Joolen (2003) and Smith (2007) studied the Late Quaternary history of the graben. Results conform with those from the earlier studies by Sevink *et al*. (1984) and Kamermans (1991).

Soil maps of the Agro Pontino generally have a scale 1:100.000 (Sevink *et al*. 1984) with some areas being

mapped in more detail (e.g. De Wit *et al.* 1987). Related information on the genesis and properties of the soils served as a basis for the prehistoric land evaluation carried out by Kamermans (1993) and Van Joolen (2003).

3.1.2 The Mountains

Whereas quite a few geological studies exist on the Mesozoic to early Tertiary rocks, detailed studies on its Quaternary geology and its soils are largely limited to those by Sevink *et al.* (1984, with soil map with a scale of 1:100.000) and Arnoldus-Huyzendveld *et al.* (1985, with detailed soil maps of some basins). Also the scarce archaeological literature barely provides information on the geology and soils of these mountains, for which reason an extensive summary is given here.

Geology

The Monti Lepini are a topographically clearly delimited mountain range, consisting of predominantly NW-SE oriented chains and valleys, and divided into two parts by the large synclinal valley of Montelanico-Carpineto Romano (fig. 1 and 2). A large limestone massif forms the NE part, resembling a dissected plateau with altitudes generally over 1000 m. In the SW part limestones also dominate, constituting a large mountainous range with pronounced relief that culminates in the Monte Semprevisa (altitude up to about 1600 m). In the SW and S, this range is flanked by a series of less elevated limestone plateaus and hills. Drainage is largely subterranean, the area having pronounced karst features and lacking permanent rivers.

In the SE and E, the intermontane Priverno and Amaseno basins with a thick infill of Quaternary deposits separate the Monti Lepini from the Monti Ausoni. The latter consists of ridges and irregular plateaus, marked by a well-developed karst relief, with elevations generally between 500 and 850 m. To the SW and NE the Monti Lepini are abruptly bordered by the Agro Pontino and Valle Latina, respectively, with more or less linear, very steep slopes resulting from major faulting. In the NE, later volcanic deposits from the Volcano Laziale mask these major faults, but even here the boundary between the limestones of the Monti Lepini and the volcanic rocks stands out sharply. In the mountains, drainage is largely subterranean and karst features abound. In the low-lying intermontane basins, however, larger rivers carry water throughout the year, most notably the Amaseno River.

Major rock types distinguished in the Monti Lepini and Ausoni are: a) Mesozoic to Palaeocene carbonate rocks; b) Syn- and tardi-orogenic Tertiary rocks, and c) Quaternary rocks. The description of the first two groups is largely based on Parotto and Praturlon (1975), and that of the Quaternary rocks on Sevink *et al.* (1984).

a: The carbonate rocks comprise limestones and dolomites in shelf facies, ranging in age from Upper Trias to Palaeocene. They are dense, fine-grained, and coarsely bedded rocks, very low in terrigenous material. Other types, however, also occur such as for example detrital breccia and conglomerates. Limestones containing chert or related silicified material are of very subordinate importance.

b: The syn- and tardi-orogenic Tertiary rocks predominantly comprise flyschoid deposits of Miocene age, rocks such as olistostromes, nappes and olistoliths of the Sicilide complex, and finally a number of deposits of presumed Pliocene age.

Flyschoid deposits are relatively common in the Montelanico-Carpineto Romano valley and predominantly consist of calcarenites of which the habitus ranges from hard and dense coarse-bedded limestone to soft highly schistose marly limestone that is frequently interbedded with calcareous shales.

Rocks of the Sicilide complex are scarce and largely limited to the Monte Caccume area (a 'Klippe') and the Amaseno basin. They comprise a range of sedimentary rocks (shales to limestone). Contents of chert ('diaspri') tend to be very low or nil and ophiolitic material (serpentine/gabbro) lacks.

Sediments dated with more or less certainty to the Pliocene occur mostly transgressive on the Flysch succession, but locally also as isolated bodies. They comprise two marine formations (Catenacci and Molinari, 1965): an older, presumably Early Pliocene conglomerate and a younger rock type, presumably Pliocene s.l., consisting of clay with fragments of hard older strata and strongly resembling the clayey Flysch. The older conglomerates have some intercalations of finer textured beds and consist of limestone pebbles and very subordinate pebbles of Miocene sandstone and acid crystalline rocks. It is these older conglomerates, notably in the vicinity of Roccagorga, that contain some chert-like material in the form of angular strongly silicified limestone fragments.

c: Quaternary rocks can be subdivided into 4 groups: limestone weathering residues ('terra rossa'), rocks of volcanic origin, fluvial deposits (mostly alluvial fan deposits), and marine-lacustrine-aeolian deposits. The latter two types are largely limited to the lower parts of the Monti Lepini.

Terra rossa abounds in the dolines and related karst depressions. Often the upper layers are largely volcanic in origin, being composed of a mixture of weathered volcanic ashes and limestone weathering residue. In some places, intercalated volcanic ash layers can be distinguished, but generally the superficial deposits are clearly colluvial in origin, the ashes and terra rossa being intimately mixed. It is only extremely occasional that the terra rossa contains gravel

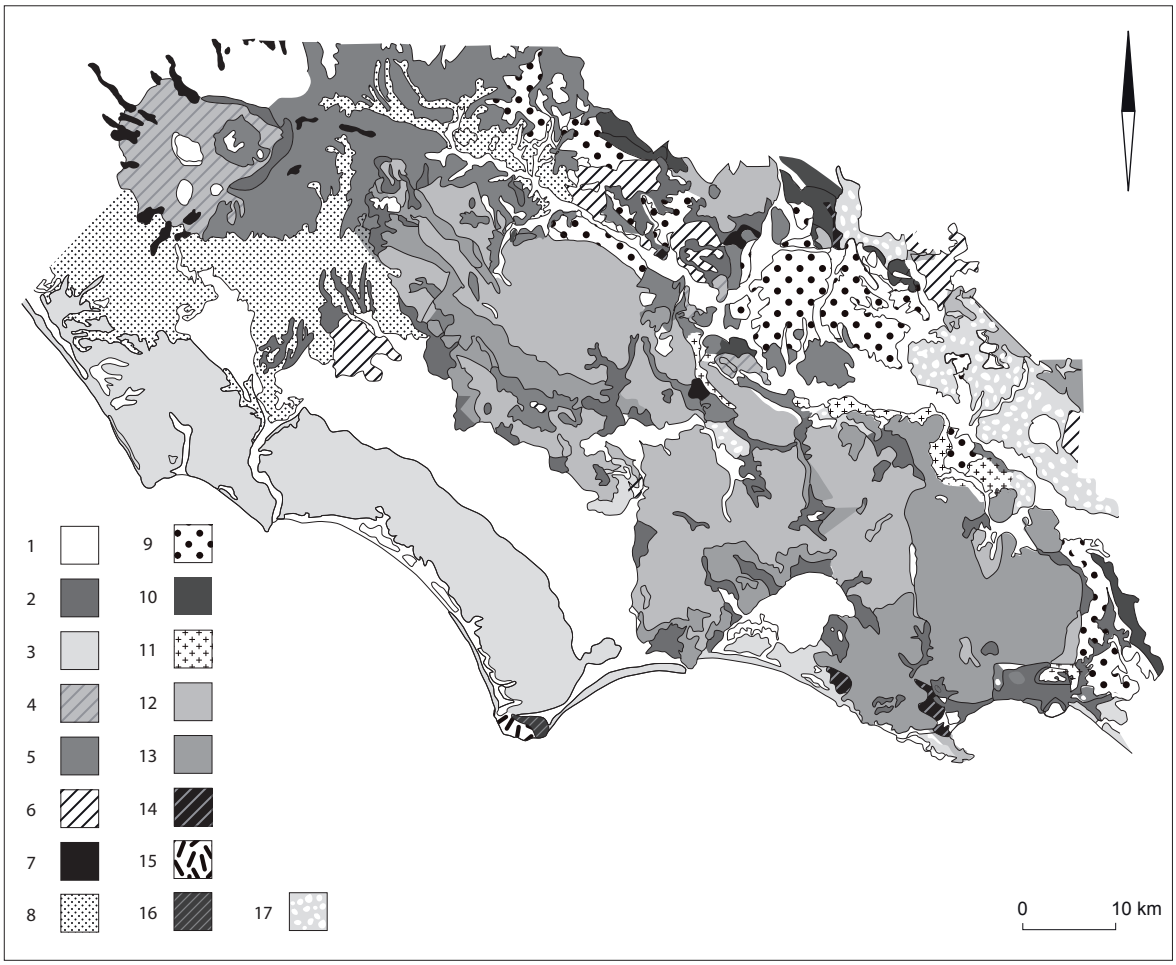

Figure 2 Geological map of Central Lazio (Italy) (after Bigi, Cosentino and Parotto 1988).

1 Holocene fluvio-lacustrine deposits and alluvial valley fills.
2 Holocene/Pleistocene slope deposits, alluvial fans and limestone weathering residues (terra rossa).
3 Holocene/Pleistocene beach ridges and dunes.
4 Upper Pleistocene phreatomagmatic pyroclastics
5 Middle to Upper Pleistocene pyroclastics
6 Travertines
7 Middle Pleistocene tephritic to leucitic lava flows
8 Middle Pleistocene pyroclastic flows.
9 Tortonian-Serravallian clayey-sandy turbidites.
10 Serravallian-Langhian bryozoae and litotamnae limestones
11 Eocene-Upper Cretaceous chaotic complex, variegated clays
12 Paleocene-Upper Cretaceous shallow marine limestones
13 Lower Cretaceous-Jurassic shallow marine limestones
14 Lower Liassic limestones and dolomitic limestones
15 Aquitanian sandstones of the Monte Circeo
16 Lower Liassic limestones and dolomitic limestones of the Monte Circeo.
17 Middle and Upper Pleistocene lacustrine deposits.

sized or coarser, mostly angular residual silicified limestone fragments, while residual chert was not observed.

Rocks of volcanic origin largely comprise air-born volcanic ashes from the Colli Albani, which in the western part of the Monti Lepini on relatively flat surfaces (e.g. near Sezze) may reach considerable thicknesses (several tens of metres) and in that case can be described as clearly stratified volcanic ashes with abundant intercalated palaeosols, largely dating from the Tuscolano-Artemisio phase (0.6-0.3 MY ago). Moreover, pyroclastic flows from the Colli Albani locally reached the lower river valleys in the northern Monti Lepini, where they formed thick, largely unstratified pozzolano-type deposits ("Pozzolane nere") as e.g. North of Montelanico.

At larger distances from the Volcano Laziale, thicknesses of these ashes decline. However, in the East, near the Amaseno basin and around Maenza, local eruptions have in places led to major volcanic ash deposits such as in this basin and its tributary valleys and, incidentally, to small lava-dominated volcanoes (Giuliano di Roma), and to lithoid tuff layers (e.g. Eastern Priverno basin). In the SE of the Monti Lepini and adjacent Monti Ausoni volcanic rocks are scarce, being limited to some air-born ash mixture in topsoils. All of these volcanic rocks are of Mid-Pleistocene age.

Fluvial deposits largely comprise coarse gravelly alluvial fan deposits, notably in the large valley between Roccagorga and Maenza where several phases can be identified of which the older have intercalated volcanic ashes and are locally strongly cemented. Similar cemented fan deposits are also encountered in the Amaseno basin and in the hills to the W of the Priverno basin. More recent fan deposits abound in the border zone of the Monti Lepini, such as the fans near Cori, Sermoneta, Sezze and Fossanova in the SW, and the series of fans along the NE border between Colleferro and Patrica. Truly fluvial deposits are largely restricted to the riverbeds of the Amaseno and Il Rio and these are largely matrix-supported gravels. In all deposits, the coarser fragments (gravel and coarser) consist dominantly of limestone and, very subordinate, sandstone. Fragments of silicified limestone or chert are extremely rare.

Marine-lacustrine-aeolian deposits are restricted to the Priverno area, where a complex of quartzitic aeolian sands rests on presumably lagoonal/lacustrine finer textured deposits with some thin volcanic ash intercalations. Deposits largely date to the Middle Pleistocene. Fine textured lagoonal/lacustrine deposits of Mid Pleistocene age are also encountered in the eastern part of the Priverno basin, with intercalated lithoid tuff, and in the adjacent Amaseno basin. It is only in the latter basin that these deposits contain some gravel-size material. This is partly composed of chert and silicified limestone (e.g. near Amaseno) that apparently are derived from the older Argille Scagliose in that basin.

Soils

Regarding soils, the following observations are relevant. Soils on relatively steep slopes have commonly suffered from accelerated soil erosion resulting from deforestation and long continued agriculture, and completely lost their top soil, while on lower slope sections and in depressions this eroded soil material accumulated in the form of poorly sorted largely colluvial deposits. Thus most of the steeper limestone slopes are severely eroded and lower sections of alluvial fans often consist of (sub-) recent sediments, burying older surfaces that upslope crop out. Thus, large tracts of the Priverno basin have been filled in during Post-Roman times with at least several metres of recent colluvium and similar phenomena occur in the outer zone (e.g. the fan near Sezze).

Less steep slopes and relatively stable, permeable soils often suffered far less from this human induced erosion. Thus deep, old soils are well preserved on the relatively stable, rather undulating surfaces of the aeolian/lacustrine complex of Priverno, in the larger karst depressions and on relatively gentle lower slopes in limestone (as for example in the Montelanico-Carpineto-Romano valley), in the larger volcanic ash complexes as e.g. encountered near Sezze, and in the older alluvial fans, both within and in the outer zone of the Monti Lepini.

3.2 Sources of lithic material

In the Agro Pontino, relevant sources of lithic material are gravels in the beach ridges to the W of Latina, notably the Eemian beach ridge and adjacent outcrops of its lagoonal deposits, underlain by gravels. During cold phases of the Last Glacial they probably were also extensively exposed on the now flooded parts of the plain. These gravels largely consist of well-rounded chert pebbles, which may be up to 10 cm in diameter, and gave rise to the Pontinian type lithic culture (Blanc 1937; 1939). Ansuini *et al*. (1990/91, 485), Kuhn (1995, 44), Holstrom Loving (1996, 507) and Riel-Salvatore and Negrino (2009, 220-221) give an extensive description of this material and its sources. But still the original source of the flint is not truly known.

In the mountains, chert and related rocks are extremely rare. They occur in small quantities near Roccagorga as minor component of some rare and small outcrops of presumably Early Pliocene deposits and as a very minor component of some lacustrine/lagoonal deposits in the Amaseno Basin, where they are probably derived from the Argille Scagliose.

3.3 Archaeology

The Agro Pontino is an archaeologically well-studied area. The earliest traces of human activity date from the Middle Palaeolithic. The area has been inhabited ever since. In this paper, we will focus on the Palaeolithic period. Research in

Palaeolithic archaeology in the Agro Pontino started before the Second World War. The region is famous for its Neandertal finds from the caves of Monte Circeo (e.g. Blanc 1957; Ascenzi 1990/91). Later excavations in other caves in Monte Circeo and in the Monti Ausoni yielded a wealth of archaeological and palaeontological material (see for an overview Mussi 2001). In more recent years, this material has been reanalysed by American researchers (Stiner 1994; Kuhn 1995). During the 1980s a team of Dutch, American and Italian scholars and students studied the archaeology and past environment of the Agro Pontino (Voorrips *et al*. 1983; 1991). This project was called the Agro Pontino Survey. The two main research themes were the transition from the Middle to the Upper Palaeolithic (Holstrom Loving 1996; Loving *et al*. 1990/91; 1992; Loving 1996) and the application of land evaluation in archaeology as predictive modelling (Kamermans *et al*. 1985; 1990; Kamermans 1993; 1996; 2000; 2006). The complete results of the survey of the Agro Pontino are published in Holstrom *et al*. (2004).

Many open-air sites dating from the Palaeolithic are known from the plain (Zampetti and Mussi 1988). Some were even excavated (Bietti 1984). This evidence, together with the data collected by the Agro Pontino Survey, showed clearly that humans intensively exploited the plain, from Middle Palaeolithic times onwards.

One of the main conclusions of all earlier research in the Agro Pontino is that there is a clear distinction in many aspects of human behaviour between the Middle and Early Upper Palaeolithic inhabitants of the plain. The most striking difference is the toolkit. There are two Early Upper Palaeolithic industries: the Uluzzian and the Aurignacian. Both differ in technology and typology from the Middle Palaeolithic Mousterian. The Uluzzian industry is seen as a continuation of the Mousterian and is commonly connected with Neandertals. In the same view the Aurignacian industry belongs to anatomically modern man (Mussi 2001).

For the adjacent mountains no systematic survey or reconnaissance had been carried out so far, finds being very much site-based and rather scattered over the area, lacking a systematic description. A first attempt at a more systematic survey has been started by the Hidden Landscapes project of the University of Groningen. This research started in 2005 and makes use of a geo-archaeological evaluation of the area, based on the earlier studies on the soils and geomorphology described above. The project concentrates on historical archaeological periods. No Palaeolithic open-air sites were discovered during these surveys.

The first attempt to locate Palaeolithic artefacts in the Monti Lepini was made in July 2005. Several areas were visited but without success. In 2006 a number of geologically speaking 'stable' areas were visited in the Monti Lepini. In January one site with flint and two sites with flint-like material (chert) were discovered. No tools were present. In the area of Roccagorga a natural outcrop of chert-like material was prospected. In July 2006 other areas were visited, but again without success. In almost none of the fields surveyed in the Monti Lepini was any lithic material found, while the material from later periods was often abundant. Discussions with local archaeologists and amateur archaeologists, and the study of local literature (Casto and Zarlenga 1997; Casto 2005) revealed that no confirmed Palaeolithic sites are known in the Monti Lepini.

4 Analyses

The research question is whether there was a difference in land use between the Middle and Upper Palaeolithic inhabitants of the Agro Pontino and adjacent mountains. To answer this question a deductive form of predictive modelling, land evaluation, has been used. The following analysis is similar to the one published by Kamermans in 2006. The data used comes from the Agro Pontino and the SW part of the Monti Lepini.

4.1 Deductive predictive modelling

For the analysis, two socio-economic models were constructed: the generalist practising residential mobility and the specialist practising logistic mobility. A semi-quantitative land classification was formulated for these two models.

The characteristics of a generalist are: hunting various species of animals in an area with a great variability in land units and a high residential mobility. In order to be able to identify the generalist, land units are grouped together in order to construct units with a great variability. The smaller marine terraces along the coast are grouped together, as are the younger inland lagoonal deposits, and the volcanic and travertine deposits. The Terracina level and the more recent alluvial/colluvial deposits are left out of the analysis since they did not exist during the Palaeolithic. The only areas with stable surfaces in the Monti Lepini are the relatively flat parts covered with volcanic material. These are the only areas with potentially Palaeolithic material on the surface. The rest of the mountains had to be left out of the analysis.

Land unit	Predicted Rank
Coastal terraces	1
Small lagoonal	2
Volcanic & travertine	3
Latina lagoonal	4
Aeolian	5
Monti Lepini	6

Table 1 Semi-quantitative land classification for the generalist hunter-gatherer during the Palaeolithic (see also figure 3).

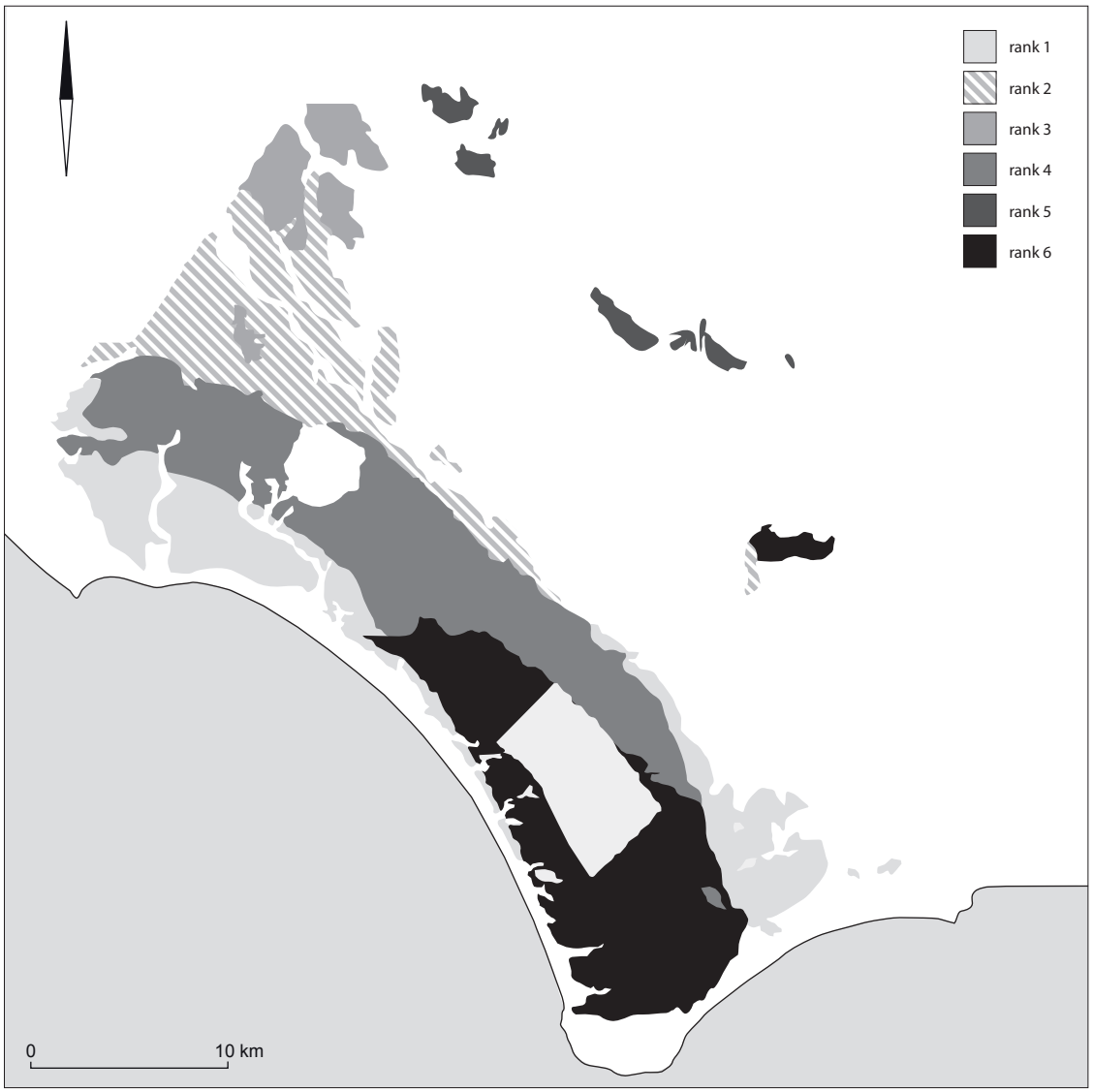

Figure 3 Semi-quantitative land classification for the generalist hunter-gatherer during the Palaeolithic. Predicted rank. (see also table 1).

Figure 3 and table 1 give the semi-quantitative land classification for the generalist hunter-gatherer during the Palaeolithic. The most suitable area would seem to be a combination of the younger marine terraces characterized by a diverse environment, i.e. sandy ridges alternating with clayey plains. Also the more inland lagoonal areas would be suitable for the general hunter-gatherer, followed by the volcanic and travertine deposits and the large lagoonal and aeolian units. The isolated areas in the Monti Lepini are considered the least suitable for generalist hunter-gatherers.

The characteristics of a specialist hunter-gatherer are: high logistic mobility, foraging in large land units. The environment in the land units should be less diverse than for the generalist hunter-gatherer. In this case, the smaller marine terraces along the coast, the younger inland lagoonal deposits and the volcanic and travertine deposits are not grouped together. Table 2 shows that the large Latina lagoonal deposit would be the most suitable land unit for the specialist hunter-gatherers during the Palaeolithic and the Monti Lepini the least suitable (fig. 4).

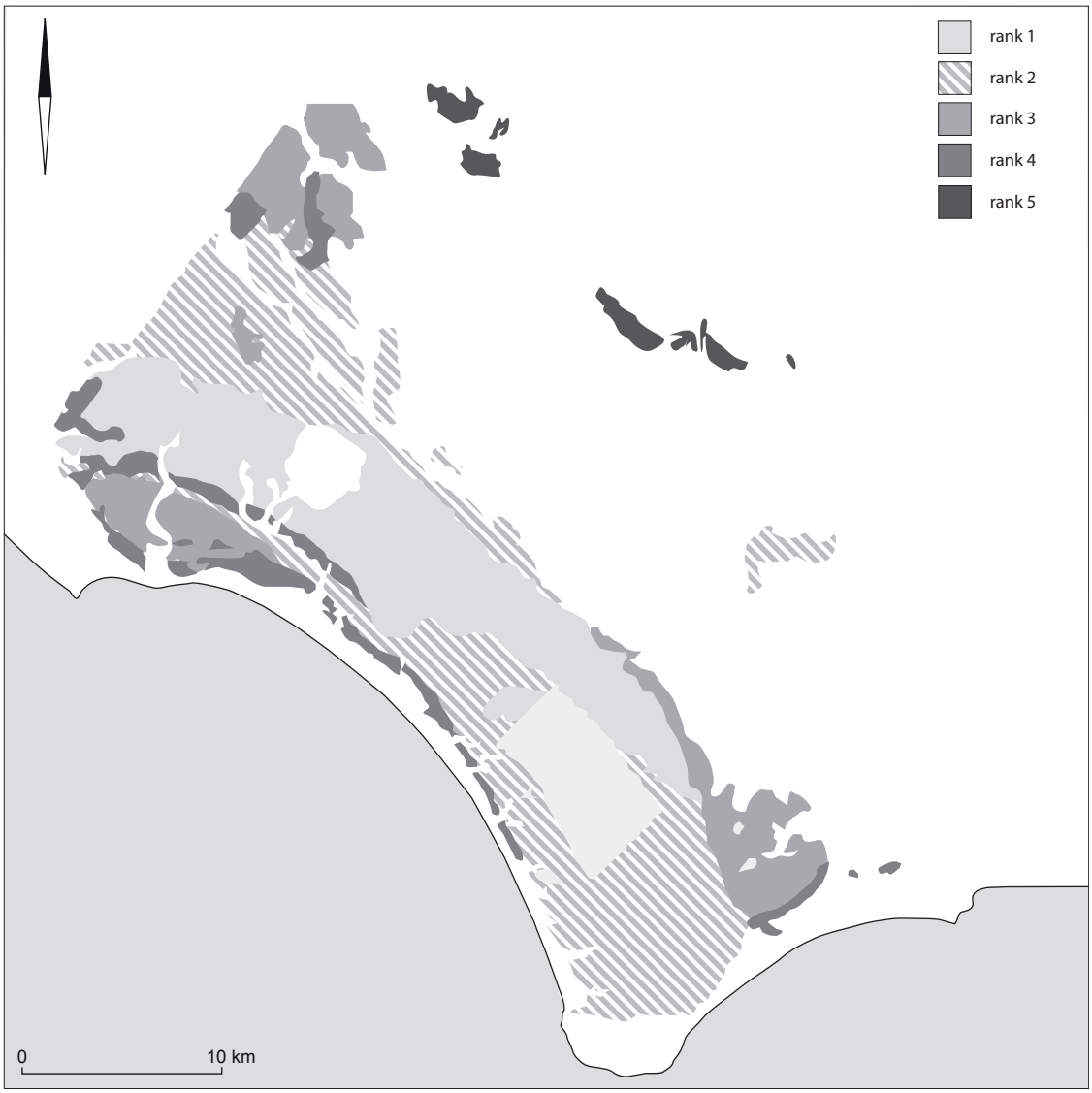

Figure 4 Semi-quantitative land classification for the specialist hunter-gatherer for the Palaeolithic. Predicted rank. (see also table 2).

Land unit	Predicted Rank
Latina lagoonal	1
Borgo Ermada inland lagoonal	3
Minturno beachridge	3
Aeolian	3
Borgo Ermada lagoonal	6
Volcanic	6
Travertine	6
Borgo Ermada beachridge	9.5
Minturno lagoonal	9.5
Minturno inland lagoonal	9.5
Monti Lepini	11

Table 2 Semi-quantitative land classification for the specialist hunter-gatherer for the Palaeolithic (see also figure 4).

The rank order of the different land units, based on data on find spot density collected during the survey, was compared with the expected rank order of the land units for the

Land unit	Predicted rank	Observed Middle Palaeolithic	Observed Upper Palaeolithic
Coastal terraces	1	4	4
Small lagoonal	2	2	1
Volcanic & travertine	3	3	3
Latina lagoonal	4	1	2
Aeolian	5	5	5
Monti Lepini	6	6	6

Table 3 Comparison of predicted and observed preferences for general hunter-gatherers during the Middle and Upper Palaeolithic.

Period	Spearman test			Kendall's test		
	R	t(3)	signif.	Tau-c	ASE1	t
Middle Palaeolithic	.486	1.111	.329	.333	.407	.818
Upper Palaeolithic	.600	1.500	.208	.467	.361	1.292

Table 4 Spearman's and Kendall's test for the data in table 3.

different models. In addition, a test was carried out to see whether there was significant difference in find spot density between the different land units for every separate time period.

Table 3 gives the expected and observed rank order for the generalist hunter-gatherer during the Middle and Upper Palaeolithic. Both the Spearman test and Kendall's test were used to test the rank order (table 4).

With an α of 0.1 none of the rankings was significant which means that none of the observed rankings correspond to the predicted ranking for general hunter-gatherers.

Table 5 gives the expected and observed rank order for the specialist hunter-gatherer during the Middle and Upper Palaeolithic. Table 6 gives both the Spearman test and Kendall's test to test the rank order.

Land unit	Predicted Rank	Observed Middle Palaeolithic	Observed Upper Palaeolithic
Latina lagoonal	1	2	4
Borgo Ermada inland lagoonal	3	3	3
Minturno beachridge	3	6	5
Aeolian	3	10	8
Borgo Ermada lagoonal	6	8	7
Volcanic	6	4	9
Travertine	6	9	2
Borgo Ermada beachridge	9.5	5	6
Minturno lagoonal	9.5	7	10
Minturno inland lagoonal	9.5	1	1
Monti Lepini	11	11	11

Table 5 Comparison of predicted and observed preferences for specialised hunter-gatherers during the Middle and Upper Palaeolithic.

Period	Spearman test			Kendall's test		
	R	T(8)	signif.	Tau-c	ASE1	t
Middle Palaeolithic	.161	.490	.636	.154	.316	.487
Upper Palaeolithic	.285	.891	.396	.242	.282	.859

Table 6 Spearman's and Kendall's test for the data in table 5.

Again, with an α of 0.1 none of the rankings was significant which means that none of the observed rankings corresponds to the predicted ranking for specialised hunter-gatherers.

For the Middle and Upper Palaeolithic none of the expected rank orders for either the generalist or the specialist fits with the observed rank order.

4.2 Inductive predictive modelling

In order to explain the failure of land evaluation to detect differences in land use in the Agro Pontino and Monti Lepini between the Middle and the Upper Palaeolithic, an inductive approach is used to see whether there is a correlation between find spot density and land units.

The archaeological hypothesis for the Middle Palaeolithic is that hunter-gatherers had no preference for any of the constructed land units. The null hypothesis is that there is no difference in find spot density between the defined land units.

The Attwell-Fletcher test was used to test this hypothesis. This test (Attwell and Fletcher 1985; 1987) is designed to test the existence of a significant association between a point pattern distribution and categories of an environmental variable. It compares an observed pattern with a simulated random pattern. Two sets of hypotheses are tested. The null hypothesis for the first set is no association, the alternative hypothesis is that at least one category is favoured. In the other case the null hypothesis is of course the same but the alternative hypothesis is that at least one category is avoided.

Table 7 shows that two land units, the Latina lagoonal and the Small lagoonal, have a category weight similar or higher than the 95th percentile. This means that the density of find spots is higher than can be expected on the basis of chance. One land unit, the areas in the Monti Lepini covered with volcanic material, has a value below the 5th percentile such that the null hypothesis of no association is rejected, i.e. there is an association. This means that there are fewer than expected find spots in the area. This is hardly a surprise since no Palaeolithic find spots have been found in the Monti Lepini.

Land unit	number of find spots	expected proportion	observed proportion	category weight
Coastal terraces	13	0.2492	0.23	0.16
Small lagoonal	12	0.1273	0.21	0.30
Latina lagoonal	23	0.2376	0.40	0.31
Aeolian	2	0.1210	0.04	0.05
Volcanic & travertine	7	0.1231	0.12	0.18
Monti Lepini	0	0.1418	0.00	0.00

Table 7 Attwell-Fletcher test to compare the find spot density and geomorphological land units for hunter-gatherers during the Middle Palaeolithic in the Agro Pontino. Number of find spots = 57, number of categories = 5, number of simulations = 1000. 95th percentile = 0,30 ± 0,005, 5th percentile = 0,04 ± 0,006.

For the Upper Palaeolithic the hypotheses are the same. The archaeological hypothesis is that hunter-gatherers had no preference for any of the constructed land units. The null hypothesis is that there is no difference in find spot density between the land units. Table 8 shows that for the Upper Palaeolithic no category weight is above the 95th percentile and the category weight of the land unit in the Monti Lepini is, again, below the 5th percentile.

Land unit	number of find spots	expected proportion	observed proportion	category weight
Coastal terraces	7	0.2492	0.22	0.15
Small lagoonal	7	0.1273	0.22	0.30
Latina lagoonal	12	0.2376	0.38	0.28
Aeolian	2	0.1210	0.06	0.09
Volcanic & travertine	4	0.1231	0.13	0.18
Monti Lepini	0	0.1418	0.00	0.00

Table 8 Attwell-Fletcher test to compare the find spot density and geomorphological land units for hunter-gatherers during the Upper Palaeolithic in the Agro Pontino. Number of find spots = 32, number of categories = 5, number of simulations = 1000. 95th percentile = 0,35 ± 0,015, 5th percentile = 0,03 ± 0,013.

5 Discussion

The Agro Pontino has a high density in Palaeolithic find spots. The finds consist almost exclusively of material made from flint beach pebbles. If we analyse the distribution of find spots in the Agro Pontino without the adjacent mountains, the outcome is that these sites are distributed randomly over the area (Kamermans 2006); there is no difference in both Middle and Upper Palaeolithic site densities between the distinguished land units. If we include the Monti Lepini, then the outcome for the Middle Palaeolithic is different. In the coastal lagoonal areas the density of find spots is higher than expected and the land units in the mountains have a lower density (table 7). However, neither the ranking for the model for general hunter-gatherers nor for specialised hunter-gatherer fits the encountered rank order. For the Upper Palaeolithic period there is only significant difference in find spot density for the land units in the mountains, there are fewer find spots than expected. Again, none of the rank order predicted by the models fits the observed order.

The interpretation of these results is not easy. First we have to deal with the assumption that find density is an indication of human activity in a particular area. This general assumption among archaeologists stems from the observation that human activity in the landscape produces a spatial pattern of material culture. So patterning is taken to be evidence for behaviour. The spatial arrangement of archaeological material in a region reflects the utilization of space in the past (e.g. Hodder 1978). There are not many ethnographic studies devoted to this topic that we could use for comparison. A study on the discard of stone tools in Papua New Guinea Highlands shows that most of the tools were discarded around houses and a small proportion in gardens, along tracks, in rock shelters and other locations (White and Modjeska 1978). So in general the tools are discarded in the areas where the activities take place.

We may assume that the density of find spots with flint material in the Agro Pontino and the adjacent mountains is an indication of the intensity of the exploitation of that area. Given the number of find spots, it looks as if the plain has been used intensively during both Middle and Upper Palaeolithic times. The spatial pattern of the find spots, however, gives no indication for a difference in land use (Kamermans 2006). If we change the scale of our research and include the adjacent mountains, our results only change slightly. There are no known Palaeolithic find spots in the mountains. Is this a consequence of human behaviour or of taphonomic processes?

If we consider the information we have from our own survey in the stable areas and from other sources that there are no sites in the mountains as a good indication of the use that Palaeolithic men made of the mountains, we can conclude that this use was not very intensive. The sources of flint are all in the coastal area of the Agro Pontino. In the mountains there are no flint sources at all, and only a few places where poor quality chert can be found. The availability of water sources in the mountains is low. Water is only available in the intermontane basins. The conditions for food and shelter in the mountains during the end of the Pleistocene were often poor.

On the other hand the areas on both sides of the mountains, the Agro Pontino in the south and the Valle Latina in the north had very favourable conditions. The conclusion must be that Palaeolithic men living in the Agro Pontino and the Valle Latina had no need to exploit the Monti Lepini. The resources (including flint material) were in both quality and quantity sufficient for habitation.

However other researchers made other observations in the same area. During the late 1980s two American scholars studied, respectively, the faunal and the lithic material from the cave sites of Monte Circeo. Both Stiner and Kuhn (Kuhn 1991; 1995; Stiner 1990; 1991; 1994; Stiner and Kuhn 1992) see a major change in subsistence during the Middle Palaeolithic in Latium. Before 55,000 BP scavenging was the main activity for subsistence, while after 55,000 BP hunting was. They base their conclusions mainly on the fact that head parts of medium-sized ungulates dominate the pre-55,000 collections. The range of formal tool types in the Mousterian sample stays the same across the 55,000 year boundary, but the reduction technique changes. Mussi (1999) expressed surprise that scavenging continued until that late a date in the Agro Pontino and ascribes the differences in notably the faunal material to differences in excavation techniques. Indeed, all the sites dated before 55,000 BP were largely excavated before the Second World War, the later sites after the war.

One of Steven Kuhn's observations (1995) is that the percentage of tools made of non-local flint is higher in the Upper Palaeolithic layers than in the Mousterian layers. Combined with the evidence of Mary Stiner (1994), he concludes that Middle Palaeolithic inhabitants of the Agro Pontino had a tendency towards very frequent residential moves, while the Upper Palaeolithic population may have had a highly differentiated pattern of seasonal movement (Kuhn 1995, 178). The Mousterian population apparently lived and foraged exclusively along the coast and the coastal plain. The Upper Palaeolithic populations made trips more inland to other sources of flint than the flint pebbles found along the coast.

6 Conclusions

Kuhn (1995) assumes that his Middle Palaeolithic toolmakers practised residential mobility and Upper Palaeolithic foragers had a very high mobility. We find indeed a higher than expected density of find spots for the Middle Palaeolithic in

the coastal area. This agrees with Kuhn's hypothesis that the Mousterian population lived and foraged exclusively along the coast and in the coastal plain. There is, however, no evidence of exploitation of the Monti Lepini during the Palaeolithic, which means no support for the theory of Upper Palaeolithic seasonal transhumance. The Agro Pontino formed during the Palaeolithic a more densely exploited 'autarchic area'. On the question of difference in land use between the Middle and Upper Palaeolithic, we must come to a slightly different conclusion than the earlier conclusion by Kamermans (2006). We agree with Stiner and Kuhn that the Middle Palaeolithic inhabitants practised frequent residential moves, but we do not see any evidence for the highly differentiated pattern of seasonal movement for the Upper Palaeolithic. We think that both the Middle Palaeolithic Ancients and the Upper Palaeolithic Moderns considered the whole of the Agro Pontino as one land unit and used the same way of exploiting the area: as generalist hunter-gatherers practising residential mobility.

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Hans Kamermans
Faculty of Archaeology
Leiden University
Reuvensplaats 3
2311 BE Leiden
The Netherlands
e-mail: h.kamermans@arch.leidenuniv.nl

Jan Sevink
University of Amsterdam,
Institute for Biodiversity and Ecosystem Dynamics,
Sciencepark 904,
1098 XH Amsterdam,
The Netherlands
e-mail: j.sevink@uva.nl