To see or not To see. Archaeological data and surface visibility as seen by an AIS (Archaeological Information System) approach

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ABSTRACT

The main goal of this paper is to check if a surface visibility analysis carried out using a GIS approach could provide useful results to estimate the possibility of discovering archaeological evidence in relationship to the modern territory. The main interest in this work is the opportunity to confirm or not the results of a GIS analysis through the superimposition of a detailed geographical distribution of a large number of already known archaeological sites on the same area. Final data allow authors to suggest that a Geographical Information System definition seems to be inadequate when a GIS approach is carried out in order to be applied to Archaeology. Therefore, they propose the definition "Archaeological Information System" (AIS) to be applied when a GIS approach is carried on in archaeological research.

INTRODUCTION

Surface visibility could be considered one of the most intriguing and interesting challenges in a GIS approach. Since its first appearance in the 80's, surface visibility has represented a powerful tool which provides a better understanding of the meaning and the significance of the archaeological data in a given geographical area (Lloyd *et al.*, 1985; Bintliff & Snodgrass, 1985; Gallant, 1986; Shiffer, 1987; Cherry *et al.*, 1991; Voorrips *et al.*, 1991; see also Gaffney *et al.*, 1991). Technical and methodological procedures became more definite in the 90's (see among others Cambi & Terrenato, 1992). As stated by Terrenato & Ammerman, the methodological issue was "... intended as a contribution to the development of the recovery theory (in the sense of Clarke, 1973) as it relates to the archaeological survey" (1996: 91).

Currently, all the approaches (but see Bintliff, 1988) have been directed towards the creation of a tool to see how surface visibility limitations can affect the survey data and, if possible, to correct this view with statistical models (van Dalen, 1999; Terrenato, 2000; Cambi, 2000; Bintliff, 2000).

In this work, the authors aim to contribute to this topic by presenting a case-study, represented by the large territory (6208 Km^2) of Trentino Province, North-eastern Italy, which is characterised by a great variety of environmental, geological, and geomorphological features. The same territory has been intensively investigated by archaeologists over the last few decades (Bagolini, 1971; Bagolini *et al.*, 1984, Broglio, 1971, 1972, 1982, 1995; Broglio and Lanzinger, 1990, 1996; Dalmeri *et al.*, 2001). Published information, such as topography, deposit formation processes, paleoenvironmental and archaeological data, is abundant and useful to understand human population patterns in mountain areas following the last Ice Age.

The main goal of this paper is to check if a surface visibility analysis carried out using a GIS approach could provide useful results to estimate the possibility of discovering archaeological evidence in relationship to the modern territory. The main interest in this work is the opportunity to confirm or not the results of a GIS analysis through the superimposition of a detailed geographical distribution of a large number of already known archaeological sites on the same area.

Today, more than 400 archaeological sites, attributed to the late Upper Palaeolithic/Mesolithic, are known in north-eastern Italy (Dalmeri and Pedrotti, 1995). We limited our research to the archaeological sites located in Trentino Province (172 sites). Archaeological data were collected on the basis of literary sources and come from different field research such as excavations in well stratified deposits as well as occasional surface finds that have occurred over several decades (Fig. 1).

THE DATABASE

A database was created using Access software. It is divided into nine tables: 1 – Sites; 2 – ^{14}C dates; 3 – Artefacts; 4 – Typology; 5 – Microburins; 6 – Blade Technology; 7 – Flake Technology; 8 – Retouch; 9 – Core. The tables are linked together by ID codes. In this work we are particularly interested in the "sites" table. The records are described here in 53 fields, while the last two fields are reserved for the person who fills the form. GIS Cartography.

FIELD	DESCRIPTION
Site number	Site number
Site	Site name
Locality	Locality where the site is found
Municipality	Municipality where the site is found
Province	Province where the site is found
EST Gauss-Boaga	Gauss-Boaga East
NORD Gauss-Boaga	Gauss-Boaga Nord
Altitude	Meters above sea level of the site location
Typology	Site typology (rock shelter, cave, open air, wet area, …)
Culture 1	Main cultural attribution of the site
Culture 2	Other cultural attribution of the site (if different from the previous one)
No culture	Indeterminate cultural attribution of the site
Burial	Presence of burial/s at the site
^{14}C	Radiometric date of the site
Cultural periods1	Other cultural attributions of the site not relevant for the study of the site
Cultural periods2	Other cultural attributions of the site not relevant for the purpose of the research (Neolithic, Bronze age, …):
Localisation	Current position of the site in a valley (Fig. 12) (valley floor, medium altitude, high altitude)
Palaeolocalisation	Ancient position of the site in a valley
Natural data	Analyses carried on in the site (pollen, charcoal, …)
Geology 1	Sediment nature of the site (clay, sand, …)
Geology 2	Sediment nature of the layer covering the site
Geomorphology 1	Current geomorphology of the site (alluvial plain, slope, …)
Geomorphology 2	Ancient geomorphology of the site
Palaeoenvironment	Palaeoenvironmental reconstruction
Raw material	Presence of raw lithic material
Quartz	Presence of hyalin quartz
Charcoal	Presence of charcoal.
Antler	Presence of antler/horn.
Bone	Presence of animal bones
Macrofauna (4 fields)	The first four most abundant mammal species
Ichtyiofauna (2 fields)	The first two most abundant fish species
Avifauna (2 fields)	The first two most abundant bird species
Fauna (2 fields)	Other information concerning fauna
Malacofauna	Presence of shells
Hearths	Presence of hearths
Postholes	Presence of post holes
Referencies	Site references
Explored area (mq)	Excavated surface
Excavation	Nature of the excavation (emergency, annual, …)
Occasional excavation	Occasional findings in excavation activity
Survey	Occasional findings in survey activity
Post deposition proces 1	Presence of post depositional process
Post deposition proces 2 (2 fields)	Nature of the post depositional process (erosion, …)
Observations	Any other observation

The creation of the GIS project in ArcInfo 9 required the insertion of raster cartography and themes in a vectorial format, which facilitated this research.
In this work we used:

- Technical Provincial 1:10,000 scale maps (CTP).
- Themes regarding physical data and modern anthropization: hydrography, use of the soil, hydrographic basins, footpaths, mountain refuges, road network, population centres, toponymy.
- 1:100,000 scale map of the main geological formations.
- Coloured and black and white ortho-rectified photos.
- Elevation points

We must emphasise that the greatest obstacle to our research was the lack of geomorphologic maps of the area under examination.
The three-dimensional models were created using contour lines with 10 metre steps and elevation points to create two TINs (Triangulated Irregular Network) with differing accuracies. The data was processed in Surfer 7 as it provides the possibility of choosing the most suitable interpolation algorithm for the data available (more or less numerous and/or distributed differently). Using simple overlay operations they were superimposed, according to the requirements, vectorial themes, raster cartographic themes or ortho-rectified photos. The database with the 172 sites was then inserted into the GIS project. The sites were geo-referenced on the CTP maps (1:10,000).

VISIBILITY ANALYSIS AND NATURAL TERRITORY

We chose three environmental features which *a priori* may be considered as the ones most representative of the extreme natural variability in Trentino:

a) Inclination degree of the slopes.
b) The distribution of sediments, such as detritic, alluvial, and morenic deposits (DAM), which could represent an obstacle to surface visibility or to the preservation of archaeological deposits.
c) The soil use.

The inclination degree of the slopes was calculated by defining three different groups:

a) 0°-15° degrees
b) 15°-35° degrees
c) 35°-90° degrees

The three groups are considered representative of "High", "Medium", and "Low" Surface Visibility Level (SVL), respectively. We gave importance to the 35° degree limit because this is the physical limit after which stones and other non-rounded items may roll down the slope. As we will see below, this feature plays a very important role in potentially destructive post depositional processes. The logical reason is that a slope with less than 35° degree of inclination will cause less damage to an ancient deposit (if this exists). According to this feature, the Trentino Province area is mainly characterized by Low SVL (3698.828 Km^2) and High SVL (1730.707 Km^2); Medium SVL is present on a surface area of 778.9153 Km^2.
If we turn our attention to the presence/absence of DAM sediments, Trentino is divided into two areas, called High and Low. We considered as the "Low" (1089.111 Km^2) area, the land where DAM sediments are observed.
Finally, the territory was also defined by means of the soil map. "Low" SVL (3368.781 Km^2) is represented by the territory covered by Dense forest and Glaciers; "Medium" SVL (715.757 Km^2) is represented by the territory covered by urban areas, sparse forest, rivers and lakes, wet areas; "High" SVL (2155.228 Km^2) is represented by the territory covered by open uncultivated/unused land, open or wooded pastureland meadows and agricultural cultivation.

VISIBILITY RESULTS AND ARCHAEOLOGICAL DATA

If the general distribution of late Upper Palaeolithic and early Mesolithic sites is observed, some very interesting considerations may be put forward. If we assume that all the already known sites represent the hypothetical total of the sites existing in the region, the inclination degree of the slopes represents the natural feature most suitable to explain the archaeological site distribution (Fig. 2).
In fact, 51% (88) of the sites are found in High SVL, 44% (76) in Medium SVL, and only 5% (8 sites) are found in Low SVL. Therefore, if the area characterized by slopes with an inclination of more than 35 degrees (i.e. about 12% of the whole of Trentino) is excluded from the map, it is possible to find the 95% of the archaeological sites in the remaining 88% of the Trentino area. The 35 degree limit seems to play a very important role in the preservation (or visibility) of archaeological sites.
A dramatic decreasing trend from Low to High SVL is observed when density data are considered. If a very low density of sites could be reasonable under Low SVL, a strong difference between Medium and Low SVL seems to become an interesting feature when a survey project is planned. In fact, a very relevant density (one site found in less than 20 Km^2)

characterizes the High SVL area which represents less than one third of the study area. This leads to the conclusion that, according to the inclination degree of the slopes, the best probability of discovering a larger number of sites is to be found in areas with slopes with a 0-15 inclination degree.

Inclination degree	SVL	Area (Km^2)	Area (%)	Number of sites	Sites (%)	Density (Km^2/Site)
0°-15°	High	1730.7	27.9	88	51	19.6
15°-35°	Medium	3698.8	59.6	76	44	48.6
35°-90°	Low	778.9	12.5	8	5	97.3

Some geological formations seem act as remarkable diagnostic natural features (Fig. 3).
About 88% (152) of the archaeological sites have been found in areas where DAM sediments are not present. The few archaeological cases associated with DAM sediments are mainly represented by caves and rock shelters (such as for instance those in the Adige valley, near Trento) which were covered by thick slope deposits during the early Holocene. They were discovered because of industrial quarrying activity carried out in modern times.

DAM sediments	SVL	Area (Km^2)	Area (%)	Number of sites	Sites (%)	Density (Km^2/Site)
Not present	High	5119.3	82.4	152	88	33.6
Present	Low	1089.1	17.5	20	12	54.4

If we join together the first two natural features (inclination degree of the slopes and the presence/absence of DAM sediments), it becomes evident just how significant the suitability of these features is in order to define an area where archaeological evidence may be found. About three-fourths of Trentino may be excluded if a survey project should be implemented. On the contrary it would be worthwhile starting a survey project in the areas characterized by the absence of DAM sediments and inclination degrees of the slopes comprised between 0° and 15°. Here, about the 80% of the sites is characterized by a very high density value.

Presence/absence of DAM sediments + Inclination degree	SVL	Area (Km^2)	Area (%)	Number of sites	Site (%)	Density (Km^2/Site)
Absence of DAM + 0°-15°	High	1730.7	23.8	134	77.9	13.5
Absence of DAM + 15°-35°	Medium	3698.8	51	10	5.8	369.8
Presence of DAM + 35°-90°	Low	1819.5	25.1	28	16.2	61.8

Finally, quite surprisingly, the relationship between the soil use and the distribution of the sites does not appear as significant as the previous ones (Fig. 4). 59% of the sites are found in High SVL, 34% in Low SVL, and only 6% are found in Medium SVL. Therefore, we can state that soil use is not a real diagnostic feature in order to implement a GIS approach aimed at defining potential archaeological areas in a given territory (in a mountain area, at least). Interestingly, density value shows a remarkable difference between High SVL (one site in 22 Km^2) and Medium and Low SVL (one site in 65 and 58 Km^2, respectively). This means that areas, where soil use allows a High SVL, may not be really significant in terms of planning survey activity but, at the same time, these areas provide the best chance of finding a site in a limited territory. It is also worth mentioning that the observed density value is quite similar to that observed in High SVL inclination degree.

Soil use	SVL	Area (Km^2)	Area (%)	Number of sites	Sites (%)	Density (Km^2/Site)
open uncultivated land, open or wooded pastureland meadows and agricultural cultivation	High	2255.2	35.7	101	58.7	22.3
Urban areas, sparse forest, Rivers and lakes, Wet areas	Medium	715.7	11.2	11	6.4	65
Dense forest and Glaciers	Low	3368.7	53.1	58	33.7	58
Undetermined				2	1.1	

CONCLUSIONS

As previously stated, we tried to check whether a surface visibility analysis carried out by a GIS approach could provide useful results to estimate the possibility of discovering archaeological evidence in relationship to a modern territory. The main interest in this work was represented by the opportunity to confirm or not the results of a GIS analysis through the superimposition of a detailed geographical distribution of a large number of already known archaeological sites on the same area. We would like to conclude by making the following statements:

1) From an archaeological perspective, we have seen that some natural features, such as the inclination degree of the slopes, the presence/absence of specific geological sediments, and soil use, should be treated differently and evaluated in a GIS approach. The mountain environment of Trentino was a very suitable test case in this respect. The more differentiated the territory (in terms of natural and geological variability) the more attention should be paid to the interrelations occurring between these (and several other) features. This is leading us to the conclusion that the striking difference in the distribution of sites in Trentino – i.e. abundant presence of Upper Palaeolithic/ Mesolithic archaeological evidence in the eastern region and, on the contrary, absence of this evidence in the western part – may be explained only through the differences in the intensity of the research carried out over the last few decades and not to any behavioural changes that may have occurred in prehistoric times.
2) From a methodological perspective, we have seen that the evaluation of several natural features has been demonstrated only by the huge presence of already known archaeological evidence. Without this evidence, the method and the results we discussed before would only be useful through a "possibilistic/probabilistic" approach. As a first step, we used a "reductionist" strategy leading us to progressively decrease the territory extension where archaeological evidence may be found. By excluding from the map those areas that could be seen as characterized by "not-preserving-archaeological-evidence" feature/s (such as steep slopes and/or disturbed deposits), we geographically defined the areas where the possibility of finding archaeological evidence is absent. In other words, we obtained a more and more limited area where the possibility of finding this evidence is present. The second step of the approach was that of only analysing these "possibilistic" areas where the probability of finding a site was quite high. In this respect, we used other features that, even if they were not really diagnostic during the previous possibilistic step (in our case, the soil use), revealed themselves to be more suitable during this probabilistic step.
3) Finally, we would like to conclude our work by suggesting that, in accordance with the previous statements, a Geographical Information System definition seems to be inadequate when a GIS approach is carried out in order to be applied to Archaeology. Therefore, we are pleased to propose the definition "Archaeological Information System" (AIS) to be applied when a GIS approach is carried on in archaeological research. We really hope scholars and colleagues will agree with us.

REFERENCES

BAGOLINI B. (1971) – Ricerche sulla tipometria litica dei complessi epipaleolitici della Valle dell'Adige. *Preistoria alpina* 7, p. 243-276.

BAGOLINI, B.; BROGLIO, A.; LUNZ, R. (1984) – Le Mésolithique des Dolomites. *Preistoria Alpina*, 19, p. 15-36.

BINTLIFF, J. L. (1988) – Site patterning: separating environmental, cultural and preservation factors. In: J. L. Bintliff, A. D., Davidson, E. G. Grant (eds.) – *Conceptual issues in environmental archaeology*. Edinburgh: University Press, p. 129-144.

BINTLIFF, J. L. (2000) – The concept of "site" and "offsite" archaeology in surface artefact survey. In: M. Pasquinucci, F. Trément (eds.) – *Non-Destructive Techniques Applied to Landscape Archaeology*. Oxford: Oxbow Books, p. 200-215.

BINTLIFF, J. L.; SNODGRASS, A. (1985) – The Cambridge /Bradford boeotia expedition: the first four years. *Journal of Field Archaeology*, 12, p. 123-161.

BROGLIO, A. (1971) – Risultati preliminari delle ricerche sui complessi epipaleolitici della Valle dell'Adige. *Preistoria alpina*, 7, p. 135-241.

BROGLIO, A. (1972) – I più antichi abitatori della Valle dell'Adige. *Preistoria alpina*, 8, p. 157-176.

BROGLIO, A. (1982) – Culture e ambienti della fine del Paleolitico e del Mesolitico nell'Italia nord-orientale. *Preistoria alpina*, 16, p. 7-29.

BROGLIO, A. (1995) – Mountain sites in the context of the nort-east Italian Upper Palaeolithic and Mesolithic. *Preistoria Alpina*, 28, 1, p. 293-310.

BROGLIO, A.; LANZINGER, M. (1990) – Considerazioni sulla distribuzione dei siti tra la fine del Paleolitico superiore e l'inizio del Neolitico nell'Italia nord-orientale. *Natura Bresciana*, 13, p. 53-69.

BROGLIO, A.; LANZINGER, M. (1996) – The human population of the southern slopes of the eastern Alps in the Wurm Late Glacial and early Postglacial. *Il Quaternario*, 9, 2, p. 499-508.

CAMBI, F. (2000) – Quando i campi hanno pochi significati da estrarre: visibilità archeologica, storia istituzionale, multi-stage work. In: R. Francovich, H. Patterson, G. Barker (eds.) – *Extracting meaning from ploughsoil assemblages*. Oxford: Oxbow Books, p. 72-76.

CAMBI, F.; TERRENATO, N. (1992) – Introduzione all'archeologia dei paesaggi. Nuova Italia Scientifica Ed.

CHERRY, J. F.; DAVIS, J. L.; MANTZOURANI, E. (1991) – Landscape Archaeology as long-term history: Northern Keos in the Cycladic Islands from earliest settlement until modern times. *Monumenta Archaeologica*, Institute of Archaeology, University of California, Los Angeles 16. Los Angeles: UCLA Institute of Archaeology.

CLARKE, D. (1973) – Archaeology: the loss of innocence. *Antiquity*, 47, p. 6-18.

DALMERI, G.; PEDROTTI, A. (1995) – Distribuzione topografica dei siti del Paleolitico superiore finale e Mesolitico in Trentino. *Preistoria alpina*, 28, 2, p. 247-267.

DALMERI, G.; GRIMALDI, S.; LANZINGER, M. (2001) – Il Paleolitico e il Mesolitico. In: Lanzinger M., Marzatico F., Pedrotti A. (eds.) – *La preistoria e protostoria*, "Storia del Trentino", volume I, p. 15-118. Istituto Trentino di Cultura, Trento (Italia).

GAFFNEY, V. L.; BINTLIFF, J. L.; SLAPSAK, B. (1991) – Site formation processes and the Hvar Survey Project, Yugoslavia. In: A. J. Schofield (ed.) – *Interpreting artefact scatters. Contributions to ploughzone archaeology*. Oxbow Monographs 4. Oxford: Oxbow, p. 59-77.

GALLANT, T. W. (1986) – Background noise and site definition: a contribution to survey methodology. *Journal of Field Archaeology*, 13, p. 403-418.

LLOYD, J. A.; OWENS, E. J.; ROY, J. (1985) – The megalopolis survey in Arcadia: problems of strategy and tactics. In: S. Macready, F. H. Thompson (eds.) – *Archaeological field survey in Britain and abroad*. Occasional Paper 6. London: Society of Antiquaries, p. 217-224.

SHIFFER, M.B. (1987) – *Formation processes of the archaeological record*. Albuquerque: University of New Mexico Press.

TERRENATO, N. (2000) – The Visibility of sites and the interpretation of field survey results: towards an analysis of incomplete distributions. In: R. Francovich, H. Patterson, G. Barker (eds.) – *Extracting meaning from ploughsoil assemblages*. Oxford: Oxbow Books, p. 60-71.

TERRENATO, N.; AMMERMAN, A. J. (1996) – Visibility and site recovery in the Cecina Valley Survey, Italy. *Journal of Field Archaeology*, 23, p. 91-109.

VOORRIPS, A.; GAFFNEY, V. L.; REYNOLDS, P. R. (1991) – *The Agro Pontino Survey Project*. Amsterdam: University Press.

VAN DALEN, J. (1999) – Probability Modelling: A Bayesian and a Geometric Example. In: M. Gillings, D. Mattingly, J. van Dalen (eds.) – *Geographical Information Systems and Landscape Archaeology*. Oxford: Oxbow Books, p. 117-124.

FIGURES

Fig. 1 – Distribution map of Upper Palaeolithic and Mesolithic sites in Trentino (172 sites).

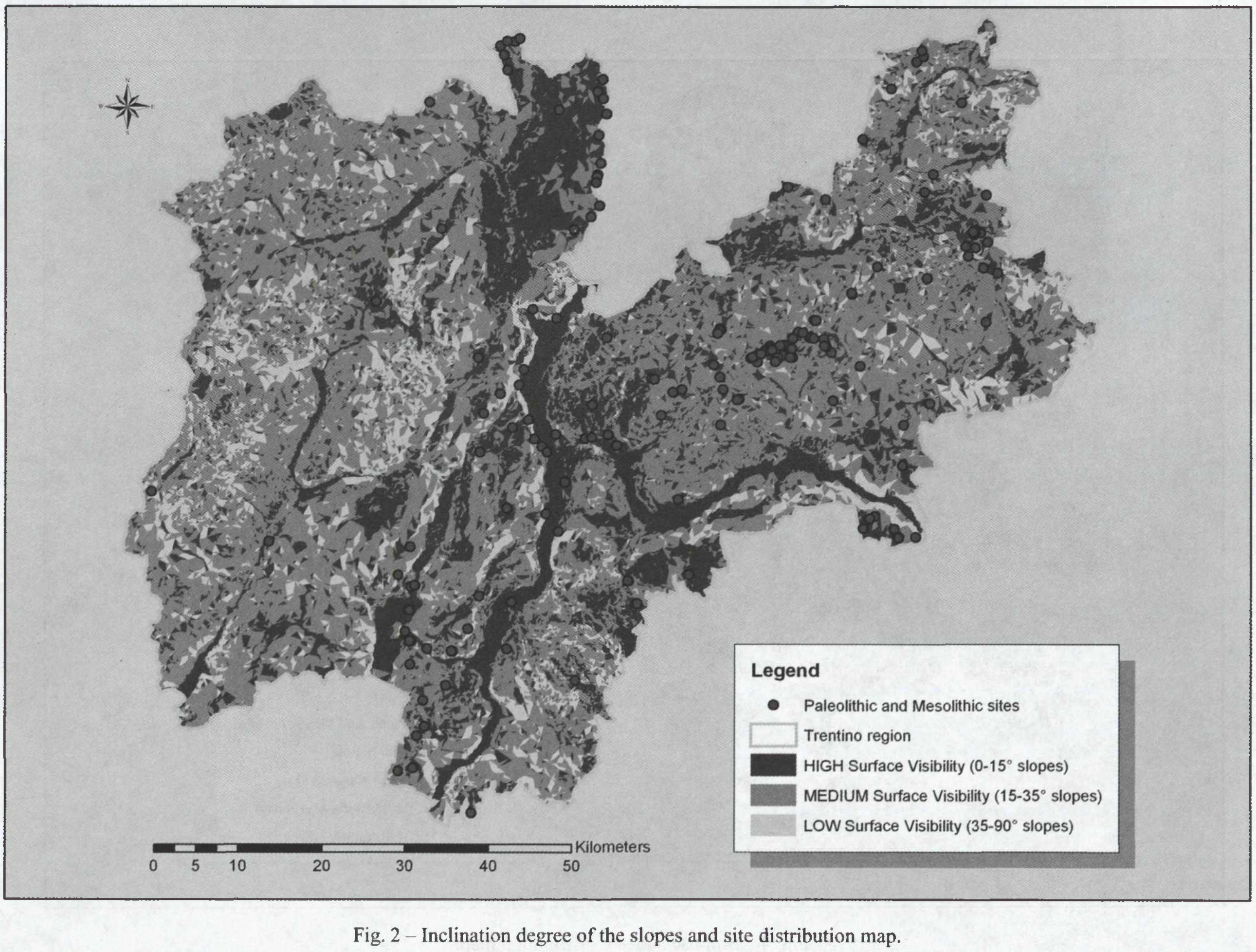

Fig. 2 – Inclination degree of the slopes and site distribution map.

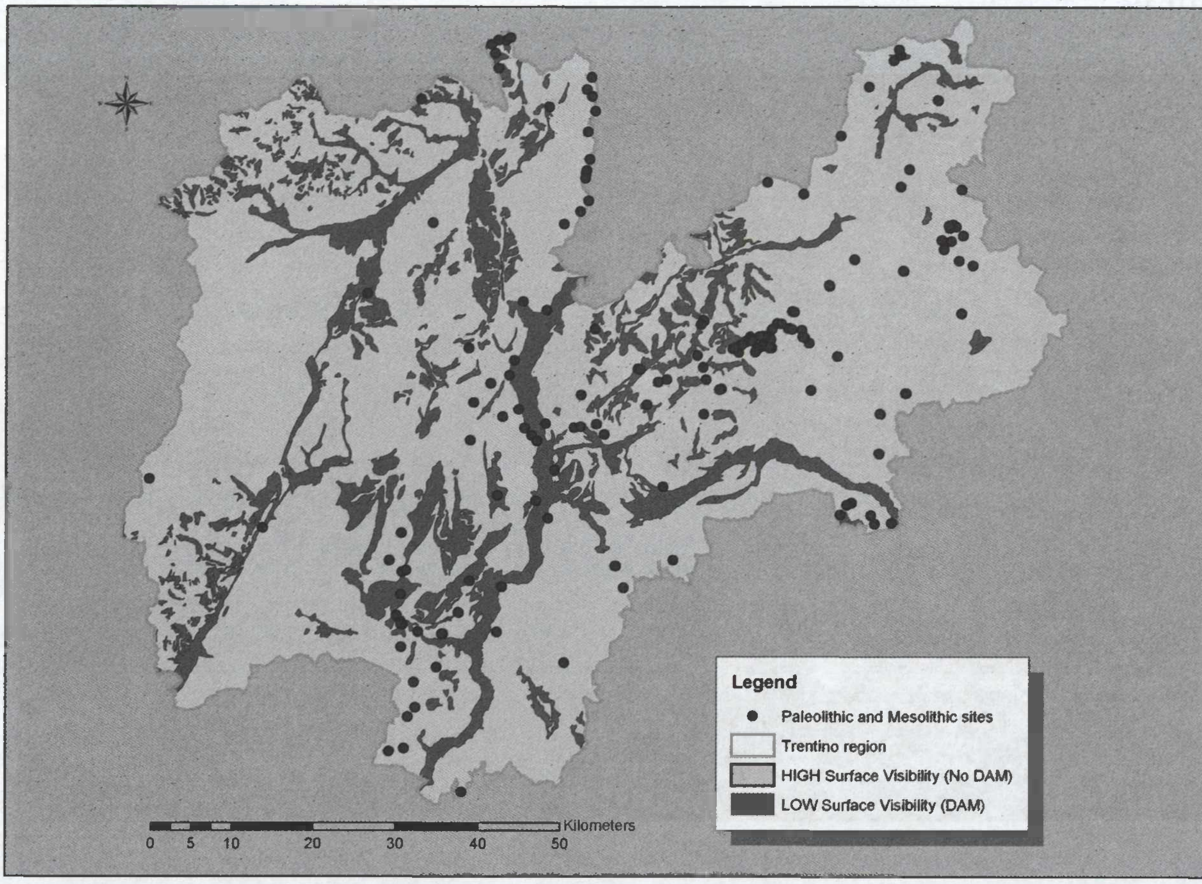

Fig. 3 – DAM sediments and site distribution map.

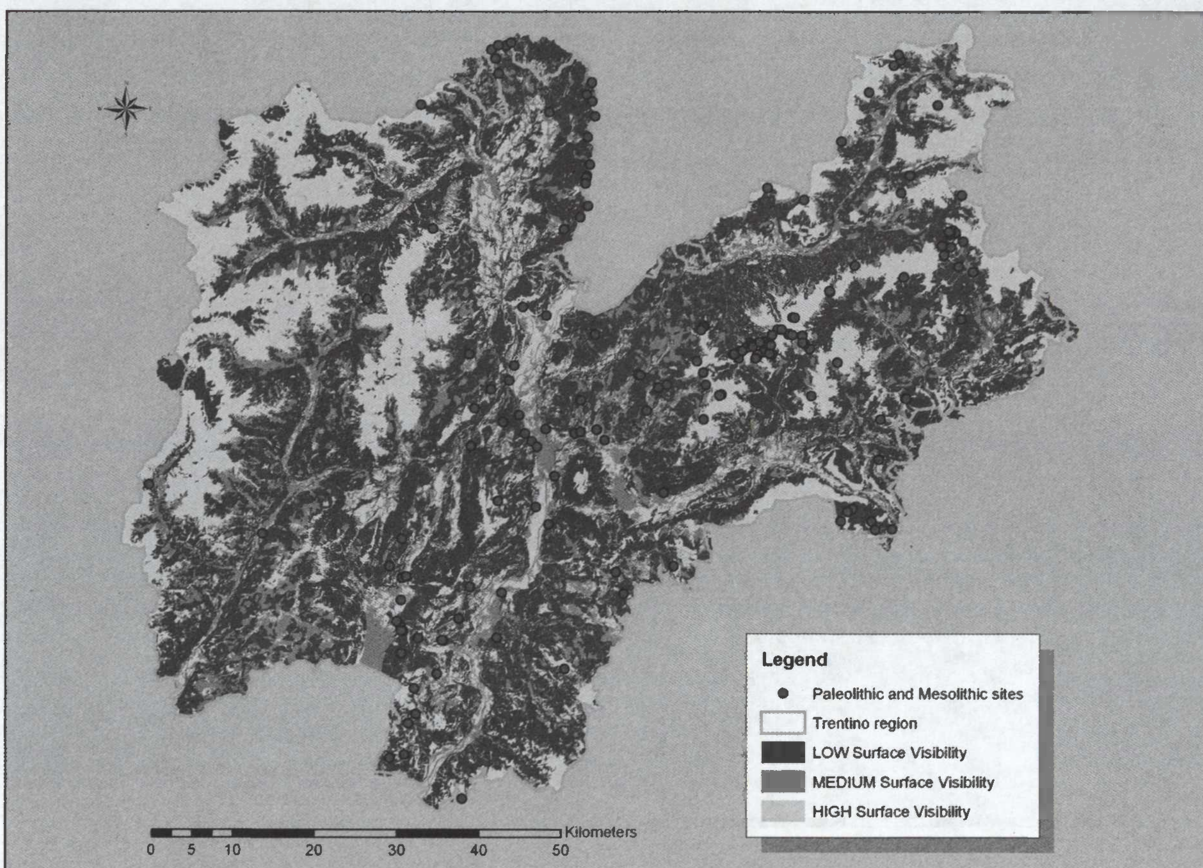

Fig. 4 – Soil use and site distribution map.