TITLE: To see or to be seen… is that the question? An evaluation of Palaeolithic sites' *visual presence* and their role in social organization.

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ABSTRACT: Visibility is one of the most common features considered when analyzing site location; visual control of a territory is usually considered to be a desirable characteristic for a prehistoric settlement. However, the role that visibility could have played in the perception of sites, as a significant element of Palaeolithic landscapes, has been rarely evaluated. Sites can act not only as settlements but as places for population aggregations, social interactions and symbolic activities; in this context, the relevance presence of a site within the landscape could have been an influencing factor in site location preferences. This paper focuses on the visual presence of a set of sites from Late Palaeolithic Cantabria (Northern Iberian Peninsula), and evaluates how the way they were perceived could have been related to their role in the social organization of foraging communities.

KEYWORDS: visibility, settlement, site location preferences, GIS, Late Palaeolithic, social organization, symbolism, Cantabria

1. Introduction: visibility analyses in archaeology

The analysis of visual properties of archaeological sites and monuments have long become a typical issue in archaeology, in parallel with the evolution of the theoretical basis of the discipline, from positivistic economy-based approaches to cognitive and phenomenological ones (Giles, 2007; Wheatley and Gillings, 2000). Moreover, the generalization of visibility analyses has been boosted by the development of some computer applications like GIS, which make it possible to carry out visibility analyses in a quantitative, precise and easy manner. In this sense, the real goal of visibility analyses have evolved from viewshed analyses focused on how much physical surface area can be seen from any given place or set of places, to cognitive approaches, in which the landscape is socially constructed and, consequently, must be perceived and interpreted by human agents living in and within it (Llobera, 2006). This evolution has led to a dichotomy between two mutually exclusive approaches; on the one hand, a technical approach, based on technological innovations, such as GIS applications; on the other hand, an experimental one, based on phenomenology (Gillings, 2009; Lake, 2007).

However, the influence of perception-based visibility analyses has been more widely important for some specific archaeological issues, like the interpretation of Megalithic monuments (Earl and Wheatley, 2002; Fontijn, 2007; García-Sanjuán et al., 2006) or the study of fortified settlements (Mitcham, 2002; Sakaguchi, et al., 2010), but in contrast these kind of perception-based studies have rarely focused on prehistoric hunter - gatherer societies, usually applied to post-palaeolithic hunter-gatherers (Fairén, 2002-2003; Garcia Atienzar, 2011) or native American foraging communities (Jones, 2006). The construction of social landscapes has been thus usually addressed for food producing societies, through the evaluation of the symbolic importance of both artificial and/or natural geographical features, and their role in the relationship between human communities and land, such as the appropriation of a particular territory (Bongers, et al., 2012; García-Sanjuán, et al., 2006; Gillings, 2009; Llobera, 2007).

Regarding foraging societies' settlement patterns, visibility analysis usually tend to explain the relationship between the monitoring of resources and site location preferences (Jones, 2010; Maschner, 1996), rather than the way in which landscape is socially constructed and perceived, although some recent works has focused on the symbolism ("sanctification") of some geographical features, as in the case of North American native communities (Diggs, et al., 2012). Moreover, Fontjin (2007) pointed out the importance that several "archaologically invisible" places, as marshes or peatlands, could play in the construction of social and symbolic landscapes for both foraging or food producing societies.

In the case of the Cantabrian Palaeolithic, visibility analyses have never been conducted, and visual characteristics of sites have merely been mentioned in a vague and ambiguous way, such as "strategic location" or "great visibility", usually related to the visual control of the territory and/or the monitoring of specific resources; however, visual characteristics of sites have never been quantified, or subjected to rigorous and systematic analysis.

Site location preferences depend on a broad range of factors, such as availability, habitability conditions, accessibility, resource monitoring or proximity to specific resources (García-Moreno and Fano-Martínez, 2011), but other non-economic factors may be involved in site location preferences, such as the symbolic meaning given to specific places (Tilley, 1994); in this sense, the presence of Palaeolithic rock wall paintings in some caves can be related to some kind of site symbolism. Moreover, settlements constitute not only places for dwelling or carrying out domestic activities, but places for social interactions and group aggregations (Conkey, 1980; Utrilla, 1994), and consequently they play a role in social organization as a significant locus within a socially constructed landscape.

This role in social organization, as well as the symbolic conception of some sites, can be expected to change through time as subsistence and land use strategies change (González-Morales, 1997). In other words, changes in site location preferences, even those derived from changes in resource catchment strategies and settlement patterns, would imply the abandonment or, at least, a less intensive use of some places, and consequently the social organization role of such places will also change.

In order to evaluate how the changes in site location preferences could have been related to the social role and symbolism of hunter - gatherer settlements, visibility from several Cantabrian Late Palaeolithic sites is analyzed, considering not only the surface viewed from sites, but how those sites could have acted as landmarks. Using a GIS, visual patterns from a set of Palaeolithic sites are analyzed, taking into account not only the size of each site's viewshed, but the directional dispersion of this viewshed and the altitude of each site from the valley floors. Results from these visibility analyses are interpreted from the perspective of the site's symbolic value, which is considered to be related to the perceptibility of each site as a relevant feature within the landscape, which I defined as the visual presence of the sites. Finally, evolution in visual presence is linked to economic and social changes taking place at that period.

2. Materials and Methods

2.1. Geographical and archaeological background

Iberian Cantabria is characterized by a steep relief, defined by parallel, river basins perpendicular to the coast, separated from each other by mountain ranges (Fig. 1). The region is a narrow strip of about 30 km wide, ranging from the modern shoreline to the Cantabrian Cordillera, which marks the division between the north-facing Atlantic coast, and the Castilian plateau with its Mediterranean climate. During the Würm Glaciation, climate conditions in this region were considerably dryer and colder than at present, with landscapes dominated by pine forests and open grasslands, together with deciduous forest in climate refugia (García-Moreno, 2010a; Ramil et al., 1998). The sea level descended up to 100-120 meters at its lowest level (Cearreta et al., 1992), although because of the steep relief of the continental shore, the Pleistocene coast would be located about 5-7 kilometers away from its modern position (García-Moreno, 2010b).

FIGURE 1

The Late Palaeolithic record from this region shows a clear shift in subsistence strategies from preceding periods, which can be generalized in the adoption of a broad spectrum economy including intensification in the exploitation of several resources marginally exploited hitherto, such as mollusks or forest ungulates (González-Sainz and González-Urquijo, 2004; Gutiérrez, 2011). These transformations are accompanied by a change in settlement patterns, with the appearance of a larger set of small, specialized logistical sites, broadly distributed, which implies the exploitation of new spaces (García-Moreno, 2010b, 2012; Terradas et al., 2007), and probably a different distribution of population and changes in group demography and social organization (García-Moreno, *in press*). Social and cultural changes of any kind are evident because of the disappearance of Palaeolithic art by this time (González-Sainz, 2005).

One of the changes outlined with regard to settlement patterns is a shift in site location preferences, since most of Late Magdalenian – Azilian sites were located on valley floors and foot-of-slope, in contrast with the previous situation when sites were usually located mid-slope, as proposed for the Asón river basin (Straus et al., 2002; Straus et al., 2006). The spread of the number of sites and the changes in site location preferences have been linked to the logistical function of new sites and the increasing exploitation of local resources (García-Moreno, 2010b, 2012; Terradas et al., 2007), as well as to an increase in population density (González-Sainz, 1995). However, even been a consequence of changes in subsistence strategies or land use patterns, no evaluation has ever been applied to the possible impact of those changes in site location preferences on the social role, or the symbolic value of the settlements themselves. In this sense, the analysis of site visual characteristics would help in the understanding of the role this factor could have played within site location preferences, as well as in how changes in settlement patterns could have affected the symbolic value of sites themselves.

2.2. Methodology

The visibility analysis was carried out on a set of 28 archaeological sites (Fig. 1), dating from the Early Magdalenian (without harpoons, dated between about 17,000 – 14,000 cal BP) and/or the Late Magdalenian and Azilian (with harpoons, from 14,000 cal BP to 10,700 cal BP), from the western half of the Cantabrian coast; most of them are located in caves, as usual within this region, with only two sites located in rockshelters. The main criteria for site selection was the existence of direct datings, mainly by radiocarbon, as well as the presence of harpoons, a clear indicator of Late Magdalenian or Azilian chronology (González-Sainz and Utrilla, 2005). Since the main settlement pattern changes seem to occur between the Early and Late Magdalenian, sites were classified into two different groups: Group A includes all sites which were inhabited during both the Early and Late Magdalenian (N=9), while Group B comprises sites occupied from the Late Magdalenian or Azilian (N=19).

The site visibility study was based on three different, complementary analyses. First, sites were classified according to their altitude from the valley floors, differentiating two categories: VF sites (sites located on valley floors or foot-of-slope) in contrast with MS sites (mid-slope sites). As a general assumption, sites located at mid-slope were considered to be more visible than the ones located on valley floors.

Second, the viewshed of each site was calculated using ArcGIS 9. In order to do so, a Digital Elevation Model (DEM) was created from the digital topographic cartography published by the *Instituto Geográfico Nacional* (Spanish National Geographic Institute), 1:25000 series. Altitude curves and points from this cartography were interpolated using the Inverse Distance Weight method to create an altitude matrix with a resolution of 25 meters per cell. With a Mean Square Error of 2.27 and a maximum error of 3.24, the DEM proved to be accurate enough, according to the quality levels established by the US Geological Survey.

Once the Digital Elevation Model was created, the relationship between each cell in the model and the spot marking the location of each site (or more precisely, each cave mouth) was calculated, by creating a virtual line between them; when no topographical features intersect this line, cells were assumed to be visible from the origin point (Wheatley and Gillings, 2002). Viewshed analysis was restricted to a radius of 10 km around the observation point, so that the visibility analysis represents the distance limit of the human eye to identify and understand what is observed.

Since the aim of this work was to evaluate how the sites were visible within the landscape and the visual characteristics of sites, rather than to calculate the reciprocal viewshed relationships between two precise points, the observation point was considered to be placed at the entrance of each cavity, discarding alternative nearby observation points which would simulate viewer movements around sites. Therefore no viewer height was considered in these calculations, since it was not the goal of these analyses to calculate the visibility of each site from a specific point of view, but to evaluate the overall site visibility within a given territory. On the other hand, due to changes in the landscape from the Late Pleistocene to the present, as well as to the lack of artificial structures which would improve or make viewshed difficult, such as towers or walls documented in historical periods (Mitcham, 2002), the application of viewer height was considered not to be relevant for this calculation.

Placing the observation point at cave mouths posed another problem, due to the fact that viewshed analyses are not reciprocal, because of differences in viewer height, illumination, relevance of higher places, presence of fire lights or smoke, etc. (Gillings and Wheatley, 2001). However, the inclusions of site location (mid-slope vs. valley floor), as well as disregarding the viewer height and specific viewing points across the landscape, make viewshed reciprocity an acceptable assumption (Wheatley and Gillings, 2000). Another critical assumption to be made concerns vegetation, since the presence and density of forests will affect visibility. Moreover, due to climate changes during the Late Glacial, the forest cover changed significantly along this period (García-

Moreno, 2010a; Ramil et al., 1998). The use of predictive models allows approaching the potential distribution of forests (García-Moreno, 2007), but the low accuracy of such models, together with the difficulty of calculating the density of vegetation, prevents its use in visibility analyses.

On the other hand, in order to avoid anomalies that occur in the visible range of a single point (binary viewshed), a *Cumulative Viewshed Analysis* (CVA) was done for every site (Wheatley, 1995). To calculate the CVA, three observation points were added to caves mouths: two of them were placed 100 meters at the same level that the original observation point, while a third point was placed 100 meters uphill the original one. Using CVA offers a more realistic approach to how people perceive landscapes; it assumes that people don’t need to see a specific, singular point, but a broader area around cave mouths (Fig. 2).

FIGURE 2

Finally, the dominant direction of each site’s viewshed was calculated. Once viewsheds were calculated, eight azimuth sectors (north, northeast, east, etc.) around each site were defined, counting the number of visible cells included in each sector. Hence the dominant direction of sites viewshed could be derived by calculating in which direction the largest surface area could be viewed from each site, as well the longest distance from which the cave mouths could be watched.

The comparison of these three factors (altitude, viewshed and dominant distance) allowed us to evaluate the visual characteristics of Late Palaeolithic sites, including the perceptibility of each cave mouth, which could have had an effect on the role played by settlements in hunter - gatherer social organization.

3. Results

As previously stated, a larger number of sites are located on valley floors or foot-of-slope than mid-slope (Fig. 3); when considering the relationship between location and site chronology, a clear difference between the two site groups can be perceived, since all nine sites in Group A are situated mid-slope, while ten (52.6%) Group B sites are located on valley floors. When checking the relationship between location and chronology, a $\chi 2$ analysis (6.283, p=0.012) confirms that the mid-slope concentration of Group A sites versus the varied location of Group B sites is significant at 0.05 level, and is not by chance; it probably reflects an evident preference for foot-of-slope and valley floor locations from the Late Magdalenian onward, in contrast with previous site location preferences.

FIGURE 3

Regarding viewshed (Table 1), average visibility of all sites is 6.01% of the surface area within a 10 km radius around each location, although the standard deviation of 10.85% indicates the great variability of the sample; hence we can see in 6 cases (21.4% of the sample) the visible surface area from sites is 1% or less, while in four of them (14.2%) it is about 20% or more (with a maximum of 47.21%). The wide dispersion completely precludes any interpretation based on the sample average (Fig. 4).

TABLE 1

FIGURE 4

However, the sample is biased by the presence of four outliers, with more than 20% of their 10 km territories visible: one from Group A (Lumentxa) and three from Group B (La Fragua, El Perro and Santa Catalina). The fact that these four sites are placed along the modern shoreline could mean that during the first part of the Late Glacial period, settlements on the coastal plain could also have had a high visibility, but they disappeared due to the sea level rise.

If we exclude these four sites, the remaining set is much more homogeneous, since the average visibility becomes 2.04%, with a standard deviation of 1.61%. A cluster analysis based on each site's viewshed differentiates two main site groups (Fig. 5): on the one hand, sites with a viewshed of about 4% of their 10 km territory, i.e. the sites at El Otero, La Chora, El Miron, El Castillo, Morin, Santimamiñe, La Garma and Cullalvera. On the other hand, sites with a more limited viewshed, between 1% and 2%, as with Cubera, Abbitaga, Ermittia, Rascaño, El Horno, Ekain, El Valle, Arenaza and Atxeta, or less than 1% like Piélago II, Erralla, El Pendo, Laminak II, Goikolau and Urtiaga.

FIGURE 5

According to their chronology, 50% of sites included in the first cluster (N = 8) can be grouped into Group A; if we include in this group the four cases with higher values, the percentage of sites already occupied from the Early Magdalenian is reduced to 41.6%. In contrast, we found that only 25% of cases from the second cluster (N = 16) are Group A sites. The different number of cases included in both chronological groups makes it impossible to establish a significant relationship between viewshed and settlement chronology, as indicated by a χ^2 value of 0.873 (p=0.350). However, despite the lack of statistical significance, a certain pattern in visual presence as a function of the period can be inferred, i.e. a greater proportion of settlements with lower visibility from the Late Magdalenian onward. Moreover, it must be noted that sites from Group A with high visibility (about 4%) such as El Castillo, La Garma, Santimamiñe, Lumentxa and to a lesser extent, El Miron, are located on characteristic, highly remarkable conical hills, which can be easily recognized in the landscape (Fig. 6).

FIGURE 6

When considering the *Cumulative Viewshed Analysis* (CVA), it can be observed that the surface viewed from most sites (and in consequence places where sites can be seen viewed from) increases. In some cases, the difference between binary viewshed (from one point) and CVA is irrelevant, as in El Castillo (Fig. 7a), El Otero, Cubera or Urtiega, but in other cases it increases from 6% (El Mirón, Fig. 7c) to 10% (El Perro, La Fragua, El Horno or Santimamiñe). In most of the sites, differences between binary viewshed and CVA range between 1 to 3% (Fig. 7b). CVA shows that, particularly for some specific cases, a site can be highly perceived if we assume that people look for a feature on the landscape rather than for a single place, although a high correlation can be observed between both variables (Pearson correlation=0.971; p=0.000).

FIGURE 7

Thus, in spite of the reduced sample, it would still appear that during the Early Magdalenian there is greater interest in locations with a wide viewshed, especially if we consider the possibility that there were more sites with high visibility on the coastal plain, which were submerged by the rising sea level at the end of the Pleistocene. In contrast, from the Late Magdalenian onward it seems that visibility is not a determining factor when choosing new places of occupation, possibly as a result of sacrificing a wide visual control for other variables.

This impression is reinforced when considering the dominant direction of visibility (Table 2). A total of ten sites show a visibility sharply facing a particular direction, since more than half of their viewshed corresponds to a single azimuthal sector (Fig. 8); representing 35.7% of the sample (N = 28), this the case for Morin, La Garma, El Valle, Cullalvera, El Horno, Atxeta, Goikolau, Urtiaga, Ekain and Erralla. The El Mirón cave could also be included within this set since, despite not exceeding 50% in any sector, over 90% of the viewshed is facing the west and northwest. Of these eleven locations, five were occupied during the Early Magdalenian (45%) while six of them were inhabited after this period (55%).

By contrast, the seventeen remaining sites had a wider visibility, since their viewshed can be divided between at least three directions with more than 10% each, while no direction encompasses more than 50% (Fig. 8). In most cases the calculated viewshed describes a wide range of view, since the azimuthal sectors with more than 10% of viewshed are adjacent, accumulating up to 90% of the visible territory on many occasions. This group includes the sites of El Castillo, El Pendo, El Piélago, El Rascaño, El Salitre, El Otero, La Chora, El Perro, La Fragua, Cubera, Arenaza, Santimamiñe, Lumentxa, Santa Catalina, Abbitaga, Laminak II and Ermittia (Table 2). A typical example of this type of settlement would be Santa Catalina, where 89% of its viewshed covers an angle of 180° from east to west, dominating the emerged coastal plain during the Late Glacial period (Fig. 9). According to their chronology, 76.4% of settlements in this group have evidence of Late Magdalenian occupations but not of Early Magdalenian ones, which may indicate an increasing interest during the second half of the Late Glacial period by sites with a wider visual range.

TABLE 2

FIGURE 8

FIGURE 9

Table 3 shows the relationship between viewshed size and dominant direction. On the one hand, *Cluster 1* includes the sites with greater viewshed (i.e., the four outliers with the greatest viewsheds, and eight from which more than 4% of their territory can be seen), while *Cluster 2* refers to those with less than 2% of their 10 km territory visible. On the other hand, *Cluster A* refers to settlements in which viewshed is focused in one direction (more than 50% of viewshed included in one azimuth sector), while *Cluster B* designates those which have a wider visibility.

Sites included in 1A are Morin, La Garma, El Miron and Cullalvera, while group 2A includes El Valle, El Horno, Atxeta, Goikolau, Urtiaga, Ekain and Erralla. Group 1B comprises El Castillo, La Fragua, El Perro, El Otero, La Hora, Lumentxa, Santa Catalina and Santimamiñe. Finally, group 2B is formed by El Pendo, El Piélago II, El Rascaño, El Salitre, Cubera, Arenaza, Abbitaga, Ermittia and Laminak II.

TABLE 3

Observation of this table suggests some issues. First, it seems that a direct relationship between viewshed size and direction of visibility cannot be established; a larger viewshed does not always mean a viewshed focused in one direction. Despite the number of sites in group 1A (large viewshed focused in one direction) being less than half that of the opposing group 2B (wide viewshed with short range), the high number of sites in groups 1B and 2A shows the heterogeneity of the cases.

Second, the proportion of sites with Early Magdalenian occupations compared to sites inhabited from the Late Magdalenian onward is similar in groups 1A, 1B and 2A, while it is much higher for the latter in Group 2B. This could be interpreted as an increasing interest from the Late Magdalenian onward for locations which sacrifice the extent of their viewshed for obtaining a broader picture, or, in other words, despite the small sample size, it would still appear that from Late Magdalenian onward there is an increasing interest in settlements with a better visual control of their immediate environment compared to locations preferred in the previous period, with greater control of a larger territory. But, what does this mean with regard to visual presence and site perception?

4. Discussion

As previously stated, it could be suggested that from the Late Magdalenian onward settlements are located preferentially on valley floors and foothills, and in consequence in places where a better viewshed of the closer environment can be obtained than caves which offer a wider viewshed. These new preferences are probably linked to changes in subsistence strategies taking place during this period, and more precisely with an increasing interest in the monitoring of and easier access to local resources, as a part of a process of economic diversification in which local resources are more intensively exploited (García-Moreno, 2013; González-Sainz and González-Urquijo, 2004).

Anyway, whatever the factors involved in the new site location preferences, the preferential location of sites on valley floors and less visible from their surroundings, to the detriment of places with a greater visual presence in the landscape (Fig. 10), might have had some consequences for the role played by these settlements in social organization, as well as for their symbolic meaning. Settlements are not only shelters, but places where human groups can meet together, paint and practice rituals or bury their ancestors (Arias, 2009; Conkey, 1980; Utrilla, 1994), and consequently they play a major role in hunter - gatherer social organization, moreover their function as shelter or activity *locus*; this role would bring some settlements with a special value, turning them into significant landmarks through a socially constructed landscape. The decrease in the intensity of use of these meaningful places, due to changes in subsistence strategies and settlement patterns, would entail a less close relationship of human communities with them, and consequently a change in the way these places were perceived, as well as in their social and ritual role (González-Morales, 1997).

FIGURE 10

It is difficult to discriminate the degree of intensity with which Paleolithic sites were occupied, and therefore to identify a decrease in the intensity of occupation between the Early and Late Magdalenian. A good example of that process can be found at El Mirón Cave, in the Asón river valley. The thickness and artifact assemblage richness and diversity of Early Magdalenian occupation deposits point to major residential occupations of the cave at this period (Straus, 2006), while the presence of a burial also suggests some symbolic importance of this large settlement (Straus, et al., 2011). By contrast, Late Magdalenian and Azilian levels present a much lower density of remains, suggesting that the occupation of the cave, even if it acted as a residential settlement, was less intense (González-Morales and Straus, 2012), while new valley-floors located sites appear (García-Moreno and Fano-Martínez, 2011). Thus, the less intensive occupation of El Mirón at the end of the Palaeolithic probably involved some loss of its symbolic importance as a landmark. Same situation can be observed in El Castillo cave, where Early Magdalenian layer (Obermaier's Magdaleniense Beta) is archaeologically richer than Late Magdalenian (Magdaleniense Alfa) and Azilian layers (Cabrera, 1984).

However, other sites could adopt a role as large residential sites or as aggregation sites from the Late Magdalenian onward, mainly in Eastern Cantabria, probably due to an increasing intensity of human occupation of this area during the Late Glacial (González-Sainz, 2007; González-Sainz and González-Urquijo, 2004). This is apparently the case of Santimamiñe cave (Utrilla, 1994) and could be the case of other Basque sites as Lumentxa or Urtiaga (González-Sainz, 1989; Utrilla, 1977).

In any case, in spite of the existence of residential or aggregation sites during the Late Magdalenian - Azilian, the higher proportion of small and less intensely occupied logistical sites, preferentially located on valley floors (García-Moreno, 2013; Terradas, et al., 2007; Straus et al., 2002), suggests a loss of the importance of large residential sites.

Changes in subsistence strategies also involve changes in land use, mobility strategies and group demographic organization; from the Late Magdalenian onward, Cantabrian spaces seem to be occupied in a more extensive way, with an increasing number of small, logistical sites distributed within all basin sections, and some areas inhabited for the first time (Arribas, 2005-2006; Ibáñez and González, 1997; Terradas et al., 2007). This kind of land use strategy would have probably required a greater disaggregation of forager communities than in previous periods, when mobility and resource catchment seem to have been based on residential movements (García-Moreno, *in press*; González-Morales and Straus, 2012). Large residential settlements and aggregation sites, as per Conkey (1980), which were essential during the Early Magdalenian, played an essential role in hunter - gatherer society social organization and inter-group relationships, and consequently, the possibility of being seen from a large distance would be a desirable factor when selecting a place for dwelling, since this place would act as a significant landmark in the landscape where forager groups moved to.

In contrast, the development of a logistical, extensive settlement pattern from the Early Magdalenian and Azilian would have supposed a reduction in the importance of residential and aggregation sites; as stated before, the archaeological evidence usually shows a critical decrease in large residential sites’ occupation intensity after the Old Magdalenian, as in the case of El Mirón (Straus, 2006); monitoring and easy access to local resources would become more preferable factors, while having a good visual presence would be less important, since settlements would have acquired a more practical role than previously, no longer serving as aggregation sites.

In short, despite the small sample size, a relationship between the role played by settlements in the social organization of forager communities and site visibility can be proposed. The reduction of long distance contacts observed in the Final Magdalenian and Azilian, together with the change in settlement patterns due to an increasing intensification in the exploitation of local resources (Arribas, 2004; Terradas et al., 2007), would have resulted in a reduction of inter-group interactions, and consequently aggregation sites acting as landmarks would became unnecessary or, at least, not so important as previously. In this context, the visual presence of settlements also became unnecessary and, consequently, visibility seems to have become an insignificant factor in site location preferences.

5. Conclusions

The analysis of Late Palaeolithic site visual characteristics, such as viewshed size, dominant viewshed direction and site position, showed a change in site location preferences between both periods, from sites located mid-slope with a large viewshed to valley floor sites, whereby the visual presence was considerably reduced. Even if it is evident that economic factors related to subsistence strategies as well as mobility strategies are key in the selection of dwelling places, this change in site location preferences implies a less intensive occupation of settlements with a high visual presence.

The relegation of viewshed into the background when considering locations for new settlements might represent a decreasing importance of the role played by sites in social organization and, consequently, in how settlements were perceived as significant landmarks within the landscape. This hypothesis is consistent with the archaeological evidence, which suggests changes in forager group size and composition, as well as in land use and population dispersion, a context where large aggregation sites with high visual presence were no longer relevant.

Future work on this kind of approaches should focus on the improvement of the methodology used, for example by including more variables on the calculation of sites viewshed, as well as on trying to overcome some of the limitations of visibility analysis, such as those related with past vegetation, by gathering better paleovegetation data or improving predictive models. However, despite these limitations, the study of the visual characteristics of Palaeolithic archaeological sites through the application of a specific methodology can provide useful information for a better understanding of land use strategies, settlement dynamics and social organization of foraging societies.

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Table(s)

Table 1. Classification of sites considered in this work according to their chronology (GROUP), relative altitude (*VF*: valley floor; *MS*: mid-slope), and results of viewshed analysis, considering the proportion of surface viewed from each site within a 10km radius (VIEWSHED), the surface viewed measured in km^2 (SURFACE), and the proportion of surface viewed according to the *Cumulative Viewshed Analysis* (CVA).

SITE	GROUP	ALT. CATEGORY	VIEWSHED %	SURFACE km^2	CVA %
El Castillo	A	MS	4.54	14.26	5.16
Morín	B	MS	4.54	14.26	7.66
El Pendo	B	VF	0.09	0.29	1.14
La Garma A	A	MS	4.23	13.28	5.90
El Piélago II	B	MS	0.38	1.18	2.11
Rascaño	A	MS	1.03	3.24	2.75
El Salitre	B	MS	2.07	6.50	4.19
El Otero	B	VF	4.02	12.62	3.94
La Chora	B	VF	3.89	12.20	6.38
El Perro	B	MS	23.11	72.61	32.85
La Fragua	B	MS	18.73	58.83	26.97
El Valle	B	VF	1.80	5.66	3.81
Cullalvera	B	VF	3.26	10.25	4.32
El Mirón	A	MS	3.75	11.80	9.76
El Horno	B	VF	1.46	4.59	11.54
Cubera	B	VF	1.20	3.76	1.53
Arenaza	B	MS	1.74	5.48	7.08
Atxeta	B	VF	2.54	7.99	5.58
Santimamiñe	A	MS	4.39	13.78	13.68
Lumentxa	A	MS	30.36	95.37	34.14
Santa Catalina	B	MS	47.21	148.31	50.47

Abbitaga	B	MS	1.20	3.76	2.34
Goikolau	B	MS	0.14	0.45	5.40
Laminak II	B	VF	0.04	0.14	0.92
Ermittia	B	MS	1.21	3.81	2.29
Urtiaga	A	MS	0.25	0.79	0.56
Ekain	A	MS	0.85	2.66	1.71
Erralla	A	MS	0.46	1.44	1.68

Table 2. Viewshed dominant direction. Percentage indicates the proportion of visible cells included into each azimuth sector within a 10km radius from each site.

SITE	VIEWSHED%	N%	NE%	E%	SE%	S%	SW%	W%	NW%
El Castillo	4,54	17,75	16,60	13,91	48,49	0,02	0,05	0,02	3,15
Morín	4,54	2,54	9,77	17,78	51,57	7,91	2,32	6,22	1,88
El Pendo	0,09	3,06	3,93	10,70	41,92	32,97	1,97	2,62	2,62
La Garma A	4,23	0,02	0,01	0,50	17,75	5,96	66,82	8,79	0,15
El Piélago II	0,38	34,92	1,96	1,85	1,01	8,11	29,25	17,22	5,62
Rascaño	1,03	5,31	0,25	0,10	0,06	14,74	11,63	45,22	22,68
El Salitre	2,07	6,94	0,00	0,00	0,00	0,02	47,03	17,34	28,66
El Otero	4,02	7,58	9,63	32,95	3,86	1,72	12,70	19,28	12,27
La Chora	3,89	0,11	1,50	10,47	10,10	32,53	9,34	17,61	18,34
El Perro	23,11	0,00	2,33	41,89	15,56	23,13	17,07	0,00	0,00
La Fragua	18,73	0,00	0,01	42,70	23,10	32,23	1,95	0,00	0,00
El Valle	1,80	17,94	2,18	0,08	0,07	0,11	2,24	53,95	23,42
Cullalvera	3,26	4,04	0,02	0,02	0,02	0,04	16,26	59,21	20,39
El Mirón	3,75	0,04	0,04	0,02	0,02	2,25	6,93	42,12	48,59
El Horno	1,46	0,07	0,04	0,03	0,08	16,59	13,20	69,71	0,26
Cubera	1,20	44,85	14,85	3,60	17,03	16,30	0,63	1,71	1,01
Arenaza	1,74	0,05	0,07	0,15	12,20	31,63	14,75	4,82	36,32
Atxeta	2,54	1,13	7,42	69,18	19,10	3,08	0,02	0,02	0,04
Santimamiñe	4,39	0,05	0,06	1,35	29,20	20,63	38,66	10,01	0,04
Lumentxa	30,36	37,22	39,66	16,15	0,00	0,00	0,96	2,25	3,67
Santa Catalina	47,21	21,94	24,44	24,34	6,57	0,00	0,08	3,74	18,65
Abbitaga	1,20	0,05	3,52	18,66	7,65	45,29	24,69	0,05	0,07
Goikolau	0,14	2,08	19,00	58,11	15,67	4,16	0,42	0,28	0,14
Laminak II	0,04	6,85	0,91	11,42	40,18	11,87	5,94	6,85	15,53
Ermittia	1,21	15,96	3,05	0,41	0,03	0,03	12,14	43,30	25,06
Urtiaga	0,25	0,24	0,32	0,79	7,10	26,28	57,06	6,16	1,97

Ekain	0,85	4,45	6,10	53,65	3,13	28,98	0,07	0,02	3,58
Erralla	0,46	26,78	10,77	7,23	50,80	0,87	0,17	0,52	2,81

Table 3. Relation between viewshed size and its dominant direction, considering the number and chronology of sites within each group (Old Magdalenian / Recent Magdalenian).

		Viewshed	
		Cluster 1	**Cluster 2**
Direction	**Cluster A**	2 / 2	3 / 4
	Cluster B	3 / 5	1 / 8

Figure 1

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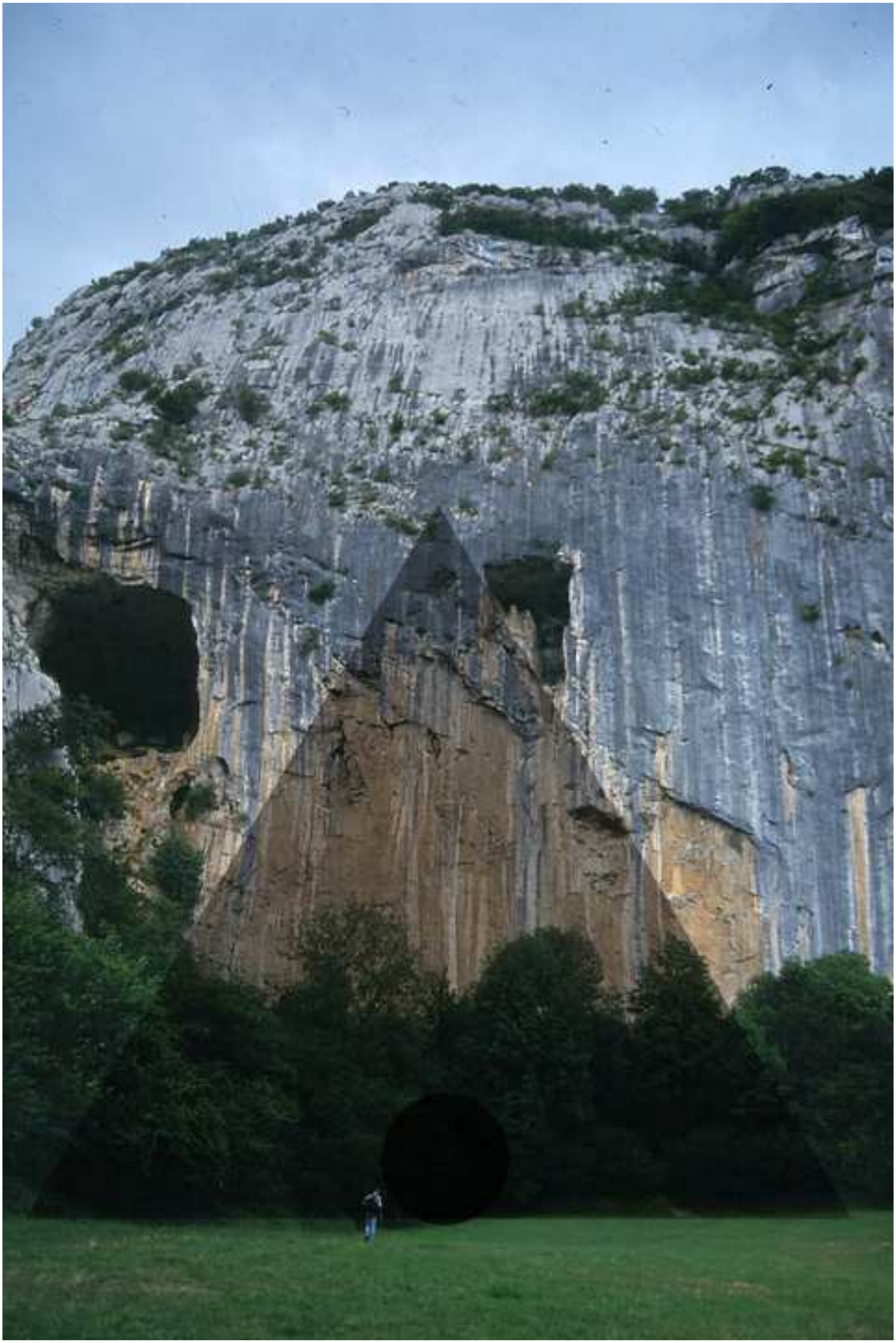

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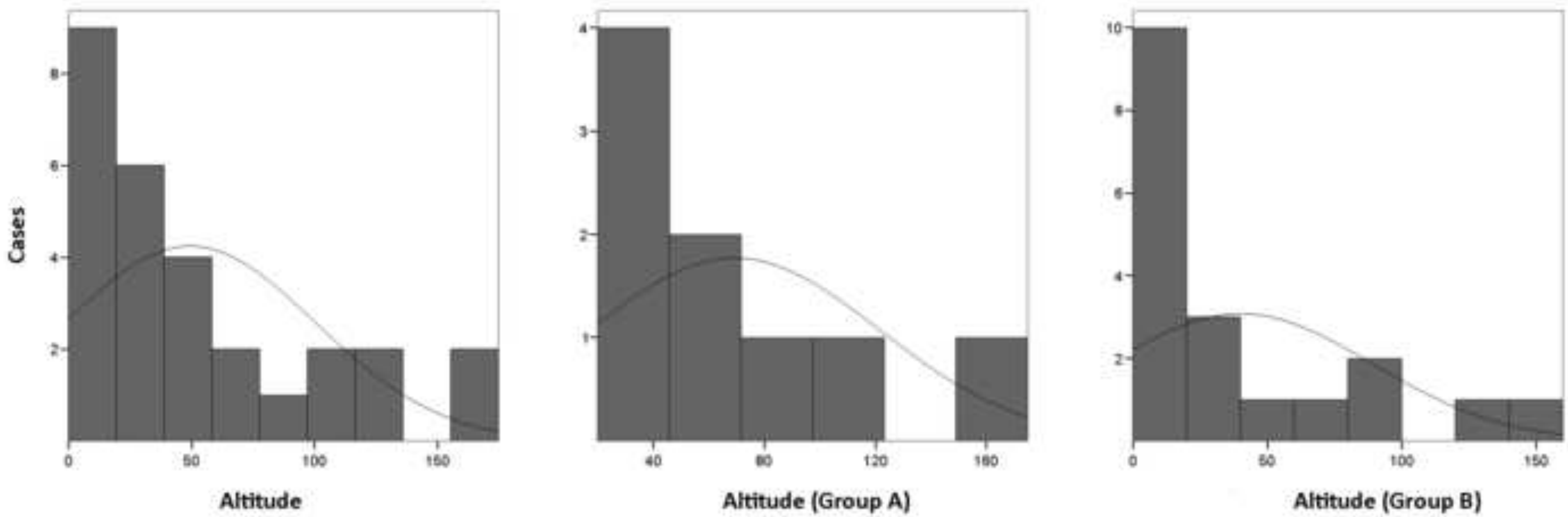

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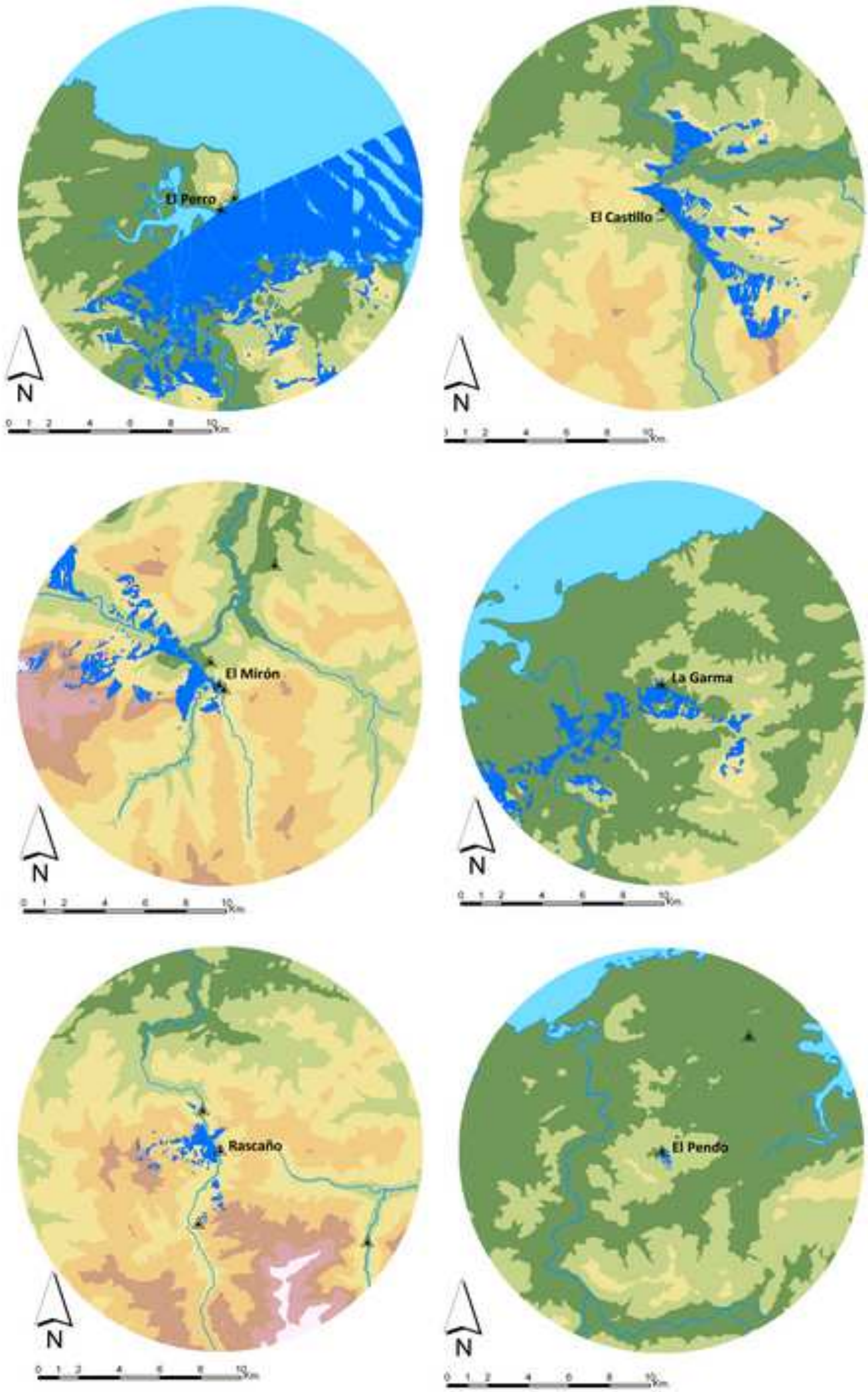

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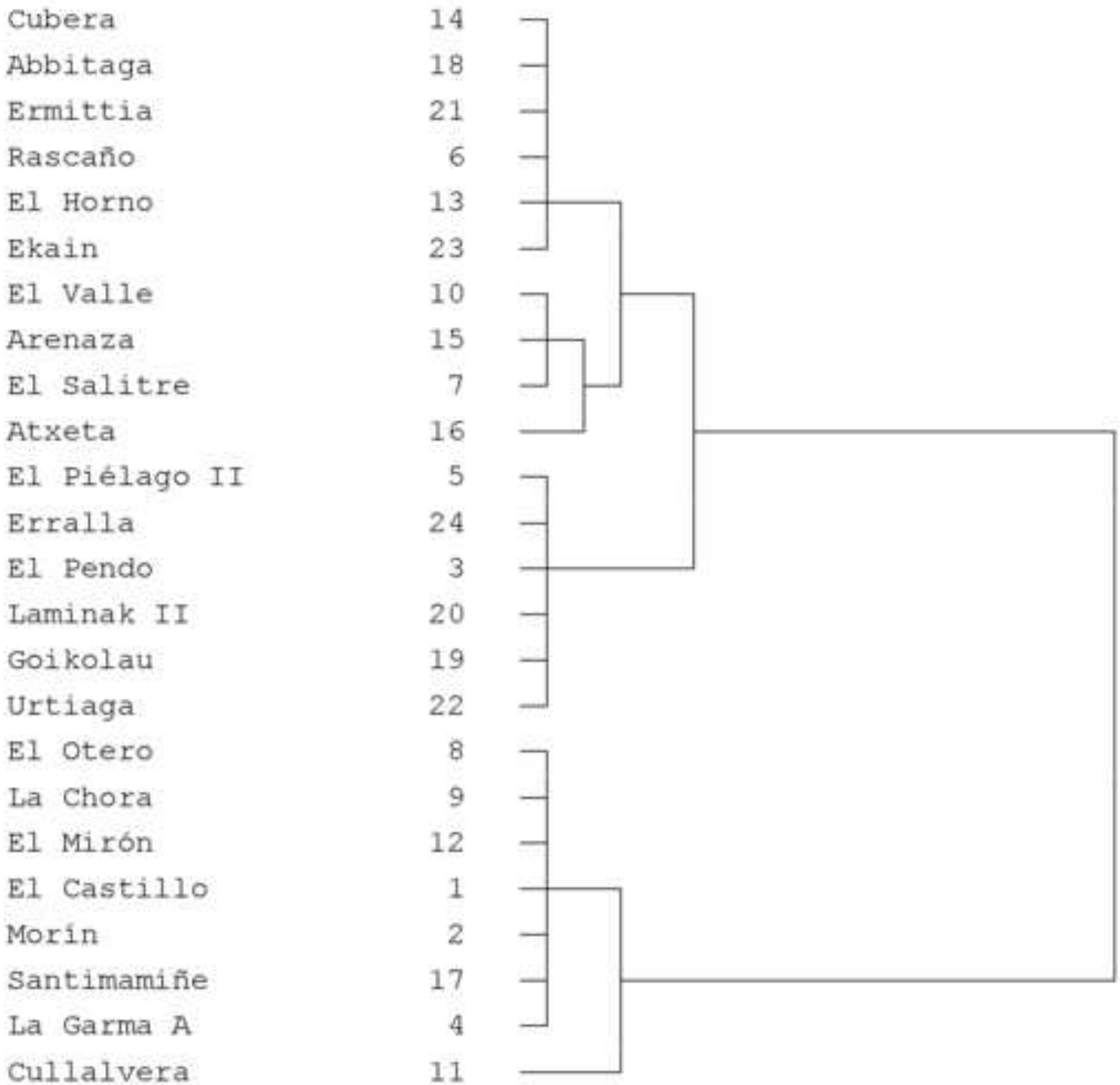

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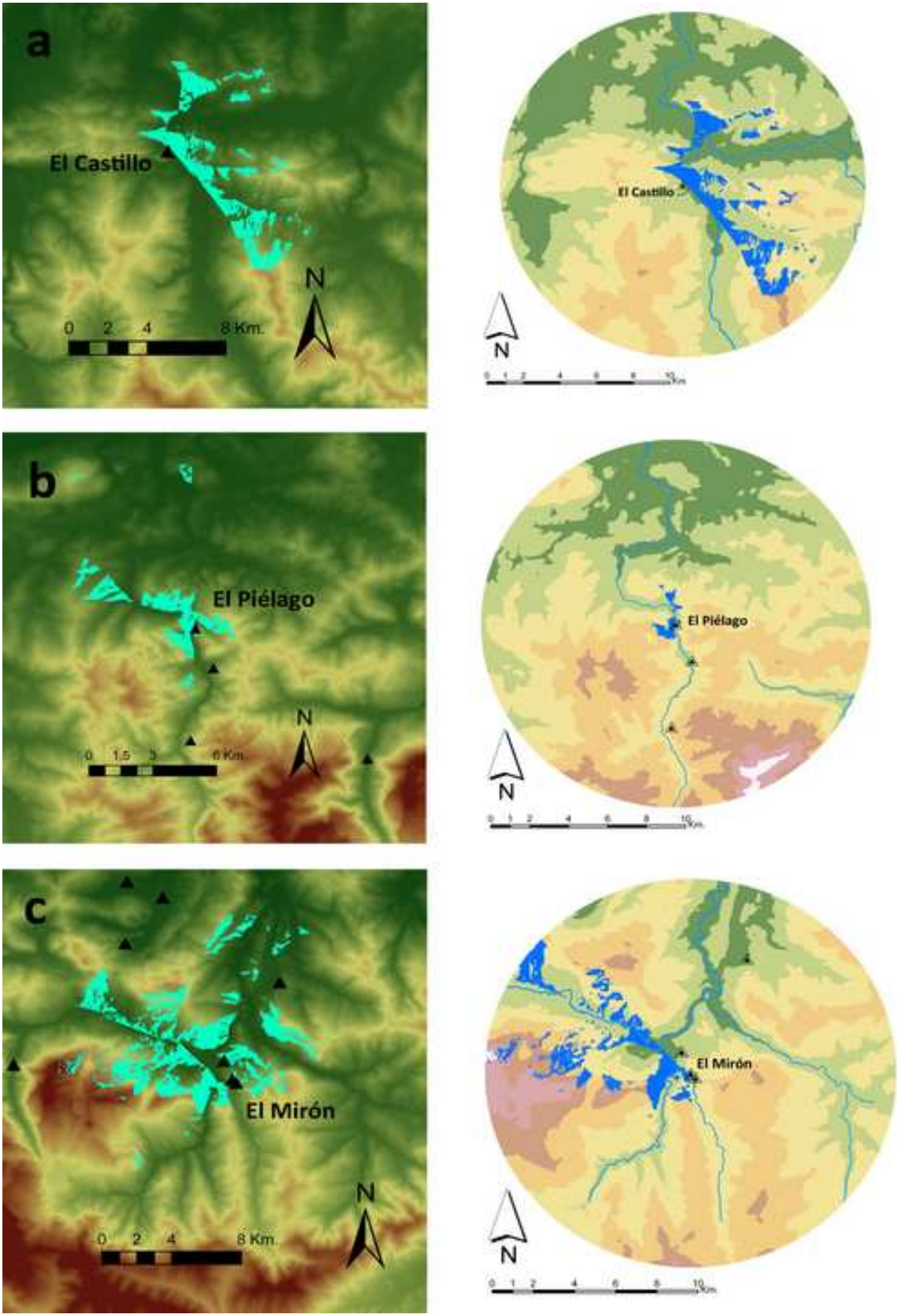

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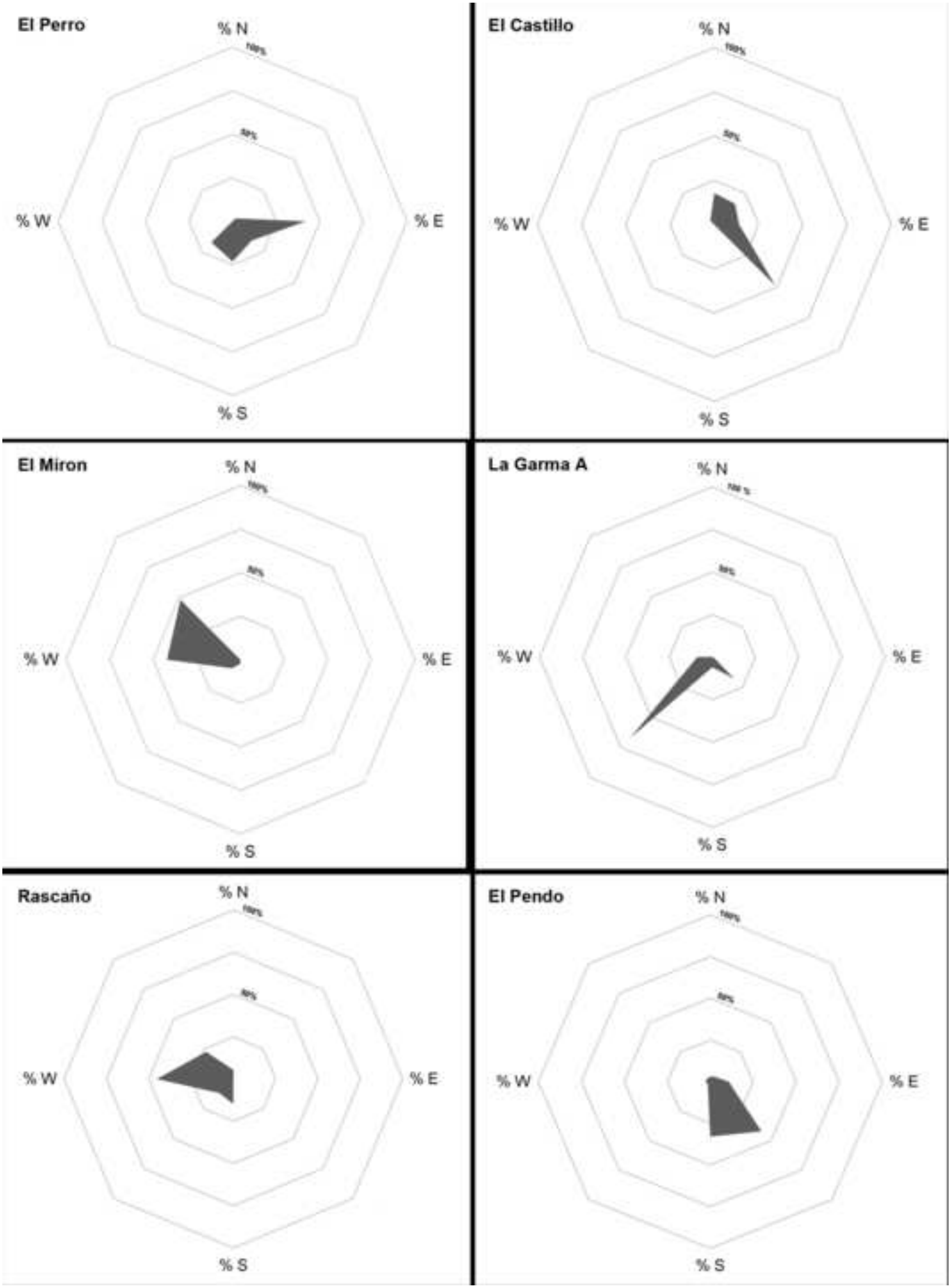

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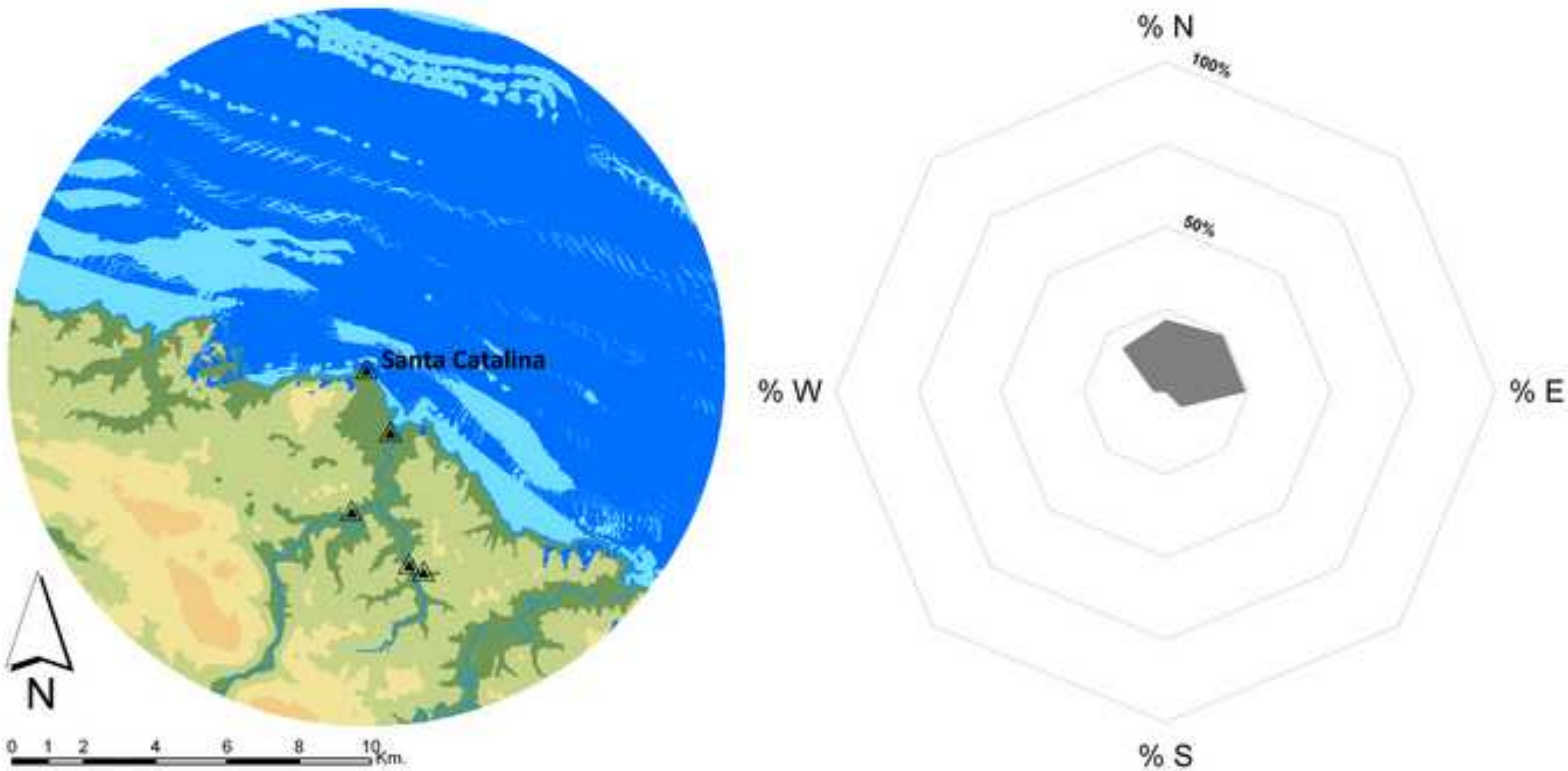

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