Quaternary International xxx (2013) 1–25

Contents lists available at SciVerse ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Vegetation history, climate and human impact in the Spanish Central System over the last 9000 years

Q2 José Antonio López-Sáez [a,*], Daniel Abel-Schaad [a], Sebastián Pérez-Díaz [b], Antonio Blanco-González [c], Francisca Alba-Sánchez [d], Miriam Dorado [a], Blanca Ruiz-Zapata [e], María José Gil-García [e], Clemencia Gómez-González [e], Fátima Franco-Múgica [f]

[a] Archaeobiology Group, Institute of History, CCHS, CSIC, Albasanz 26-28, 28037 Madrid, Spain
[b] GEODE, UMR 5602 CNRS, Université Toulouse — Le Mirail, 31058 Toulouse, France
[c] Department of Archaeology, University of Durham, South Road, DH1 3LE Durham, United Kingdom
[d] Department of Botany, University of Granada, 18071 Granada, Spain
[e] Department of Geology, University of Alcalá de Henares, 28871 Alcalá de Henares, Spain
[f] Terrestrial Ecology Group, Department of Ecology, 'Autónoma' University, 28049 Madrid, Spain

ARTICLE INFO

Article history:
Available online xxx

ABSTRACT

In this paper we present a review of the available Holocene pollen records from the Spanish Central System (113 sites and 150 ^{14}C dates). Palynological data obtained from pollen analyses of peat-bogs, lakes and archaeological sites, as well as radiocarbon dating, were used to infer the human impact on vegetation and landscape during the last 9 millennia. The Neolithic contribution to the configuration of landscape is scarce, limited to the valleys, while Chalcolithic settlements and their related activities (agriculture and grazing) represent the first evidence of significant human impact on the high-mountains. The pollen record has allowed us to relate two cultural periods of changing, the Copper Age–Early Bronze Age and Late Bronze Age–Early Iron Age transitions, to abrupt climate disruptions, the so-called 4.2 and 2.8 ka cal BP events respectively. From the Iron Age to the Early Middle Ages, anthropic activities were still sporadic, mainly located in the lowlands, but from the Feudal Period onwards, when La Mesta transhumance system takes place, high-mountain landscapes changed dramatically. Late Modern Period brings a further intensification of human pressure, especially related to forestry, with widespread pinewood afforestation.

1. Introduction

Human disturbance has been suggested as the major driver of vegetation change in the Iberian Peninsula at least for the last ~7500 years (Riera et al., 2004; Pérez-Obiol et al., 2011). Nevertheless, direct evidence of anthropogenic transformations in later prehistoric times is not uniform in Spain, especially in mountainous areas (Carrión et al., 2010). In this sense, the improved linkage of archaeological and palaeoecological records is essential to understand the timing and extent of anthropogenic and/or climatic alterations on natural vegetation during the Holocene (Carrión et al., 2001a, 2007). Detailed investigations from Central Spain have demonstrated the suitability of palaeoecological analyses to provide environmental information comparable with archaeological and historical evidence (e.g. Blanco-González et al., 2009; López-Sáez et al., 2009b; Valbuena-Carabaña et al., 2010). By comparing pollen diagrams from several sites (bogs, lakes, archaeological sites) within a region, it is possible to obtain information on vegetation history, human impact and dynamics of agro-pastoral strategies on different spatial and temporal scales (López-Sáez et al., 2003a; Carrión et al., 2010; Gil-Romera et al., 2010). Along with archaeological data, palaeoecological information allows the reconstruction of interactions and/or adaptations of the past societies to Holocene climate changes during different historical periods (Carrión et al., 2000; Berglund, 2003; Gaillard, 2007; López-Sáez et al., 2009a).

The Spanish Central System acquires special interest for studies on this topic as its natural vegetation has been influenced by anthropogenic activity since at least 6000 years ago, starting with the introduction of Neolithic farming in the intramountain valleys,

* Corresponding author.
E-mail address: joseantonio.lopez@cchs.csic.es (J.A. López-Sáez).

1040-6182/$ — see front matter © 2013 Elsevier Ltd and INQUA.
http://dx.doi.org/10.1016/j.quaint.2013.06.034

and continuously increasing throughout several millennia of human occupation of these environments. The peculiar topography of Central Iberia, with two sub-plateaus surrounded by high-mountains ranges, has allowed humans to implement mobile pastoralism practices to exploit available pastures in every season. This mountain system has been traditionally considered as one of the main routes for prehistoric transhumance (Klein, 1990), but current data only allow to envisage short seasonal livestock movements at least since the Iron Age (Sánchez-Moreno, 1998; Álvarez-Sanchís, 1999; Sánchez-Moreno, 2001). This long history of human settlements and movements in the Spanish Central System has shaped a landscape with broad extensions of grasslands and shrublands, complemented with livestock resources located in the plains on either side of the mountain range. In this sense, fire and grazing pressure are considered the main modeling factors of the landscape in highland areas in southwestern Europe (e.g. Carrión et al., 2001b, 2007; Pausas and Keeley, 2009; López-Sáez et al., 2009b). Moreover, this mountainous massif shows a great biogeographical value, as it is located in a transition area between Eurosiberian and Mediterranean regions (Rivas-Martínez, 1963; Rivas-Martínez et al., 1987). It actually shelters a large number of endemic species (Peinado-Lorca and Rivas-Martínez, 1987) and has played an important role as refugia of forest species during glacial times (Ashcroft, 2010). These features allow its consideration as a biodiversity "hot spot" (Médail and Diadema, 2009).

Apart from the western sector of the Iberian Central System (Estrela Range), where the Lateglacial and the full Holocene are recorded in pollen sequences (e.g. van der Knaap and van Leeuwen, 1994, 1995, 1997), the Spanish Central System is scarce in Holocene records that extend back beyond the last 6000 years (Ruiz-Zapata et al., 1998). Most of them are short-term pollen records. In order to assess the degree of human impact in this region, a great number of investigations combining pollen analysis, archaeological studies, radiocarbon dating and information on past climate changes have been carried out by several researchers over a period of 30 years. These studies have focused on human–environment interactions, synchronism between environmental and cultural changes, and also on palaeo-phytogeographical issues (e.g. López-Sáez and López-García, 1994; López-García, 1997; Ruiz-Zapata et al., 1997, 1998; Pulido et al., 2007; Franco-Múgica, 2009; López-Sáez et al., 2009b, 2010a).

The main sources of information for this study are the palynological and archaeological data from the Spanish Central System. The presence of a large number of deposits susceptible of being analyzed (>100), have allowed the achievement of numerous palaeopalynological works (including 9 PhD theses) throughout the whole mountainous range and valleys. However, the absence in many cases of reliable dating hinders the establishment of any diachronic vegetation model and the proposal of any anthropogenic evolution during the Holocene. This paper provides a first comprehensive overview and addresses a critical evaluation of past vegetation changes in relation to human occupation and climate changes for the whole Spanish Central System.

2. Physical settings

The Iberian Central System is a mountain range of about 500 km long which divides the Duero and Tagus Basins (northern and southern Iberian plateaus respectively), so it has been considered as the "great Castilian borderline" (Pedraza and Carrasco, 1999), thanks to its WSW–ENE general layout (Rivas-Martínez et al., 1987; Ubanell, 1994). It consists of a series of mountainous ranges ("sierras") separated by depressions or troughs which represent natural corridors between the two sub-plateaus (De Vicente et al., 1994; Martín-Velázquez and Elorza, 2007). The ranges that make up this mountain chain are, from east to west (Fig. 1): Pela and Ayllón (~1400–1500 and 2000–2273 m asl respectively), Guadarrama (~1750–2428 m asl), Gredos (with the highest peak: Almanzor 2592 m asl), Béjar (with similar elevation), Francia and Gata (both below 1800 m asl), and finally Estrela in Portugal (where the altitude again reaches 2000 m asl close to the Atlantic coast).

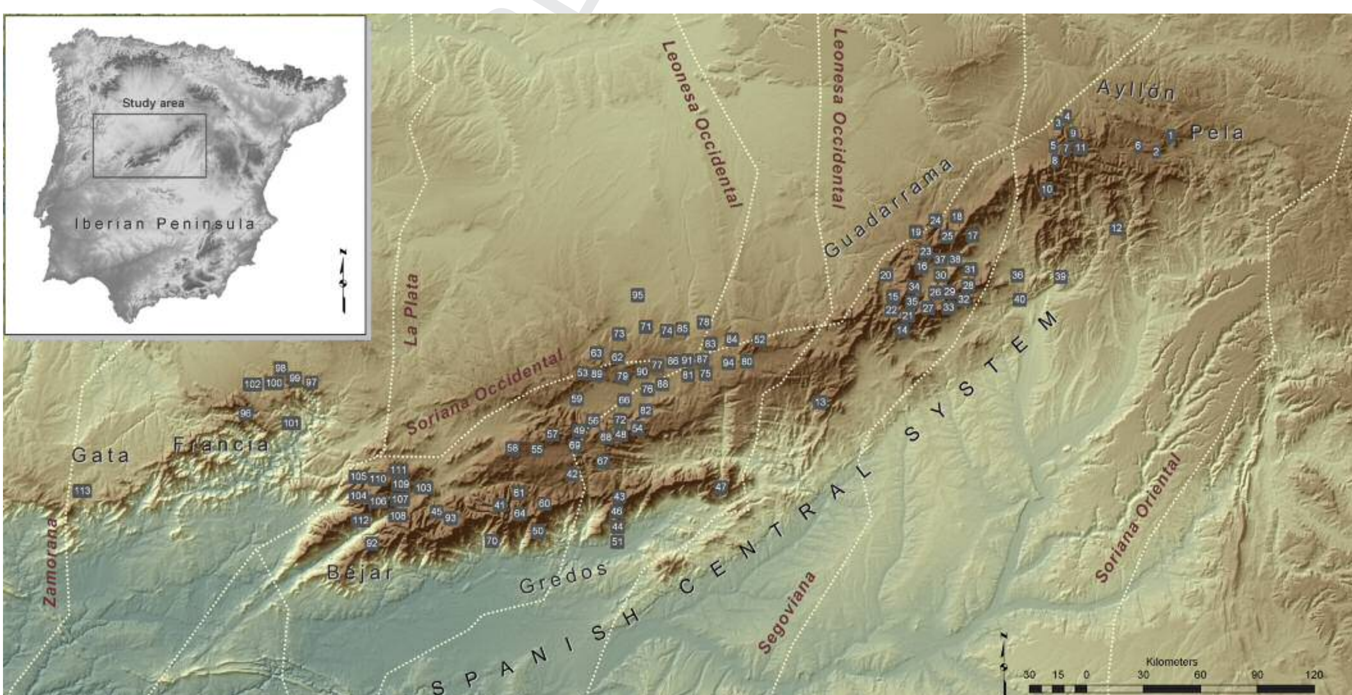

Fig. 1. Geographical position of the study area, location of the pollen sequences, and main livestock tracks crossing the Spanish Central System during La Mesta. The number of sites is reflected in Table 1.

Please cite this article in press as: López-Sáez, J.A., et al., Vegetation history, climate and human impact in the Spanish Central System over the last 9000 years, Quaternary International (2013), http://dx.doi.org/10.1016/j.quaint.2013.06.034

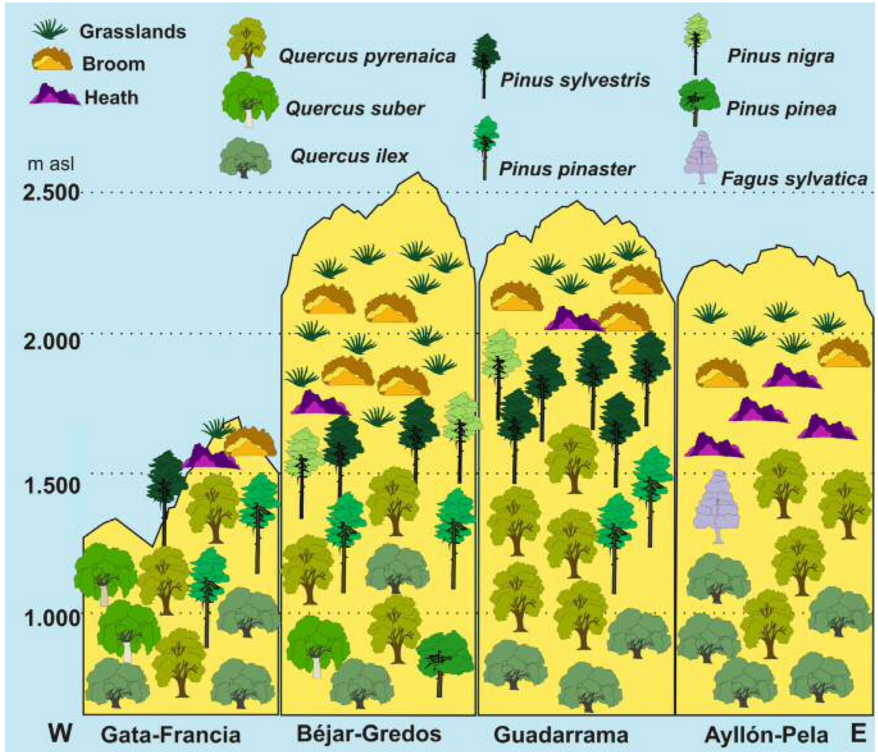

Fig. 2. Main vegetation types in Spanish Central System (redraw from Gómez-Manzaneque, 2009).

It is part of an ancient Hercynian and pre-Hercynian massif, swept along the Mesozoic and reactivated during the Paleogene, due to the Alpine Orogeny (Pedraza, 1989, 1994a; Ubanell, 1994). The result is a chain of sunken or elevated blocks (Pedraza, 1994b), which, according to the materials, granitic or metamorphic, is sorted out in different tectonic styles (De Vicente et al., 1994). In this sense, the central section has the characteristic structure of blocks, while at the edges it tends to be masked by the influence of the folded structure. These dynamics of blocks are responsible for the asymmetry between the northern and southern slopes of the mountainous chain, particularly in the western sector, because of the altitude of the northern plateau with respect to the deeply-set valleys in the Tagus Basin. Glacial morphologies developed throughout the Quaternary in the highest areas of the Iberian Central System, above 1900 m asl, so that only Francia and Gata Ranges remain outside their influence (Pedraza and Carrasco, 2006; Palacios et al., 2011). These processes and the subsequent periglacial phenomena, along with the fluvial shaping have essentially contributed to set the current relief.

The climate is of a Mediterranean type, characterized by a more or less broad summer drought period and more intense rainfall in autumn and winter (Devesa, 1995). However, there are large regional variations according to latitude, longitude, altitude and exposure (Gavilán et al., 1998). The asymmetry of the massif determines the regional climate: as for temperatures, there are more thermal conditions on the southern slopes, due to its lower elevation and greater sun exposure. Furthermore, there is a marked gradient of increasing maritime influence towards the Atlantic Ocean along the Iberian Central System, due to its predominant west–east alignment (Gavilán et al., 1998). Humidity tends to decrease from most western inlands areas along a west–east gradient. The predominance of southwest humid winds causes, similarly, a larger rainfall accumulation on southern slopes and a moisture gradient which, in this case, tends to fall inland. Differences in altitude offset in many cases the influence of these gradients. In this way, the climate would have been the main discriminant factor on vegetation distribution among the different massifs of this ridge (Rivas-Martínez et al., 1987; Gavilán et al., 1998).

Biogeographically, the Spanish Central System is located in the Mediterranean West Iberian province, at the boundary between Carpetano-Leonese and Luso-Extremaduran subprovinces. This bordering location denotes a great biological relevance, as a migratory route and a speciation center for orophilous and Atlantic elements (Peinado-Lorca and Rivas-Martínez, 1987; Costa-Tenorio et al., 1997).

Vegetation (Fig. 2) is dominated by oak forests of *Quercus pyrenaica*, especially in the western sector at mid altitudes (Amor et al., 1993; Devesa, 1995). Below them, holm oak (*Quercus ilex* subsp. *ballota*) and cork oak (*Quercus suber*) forests spread. Above them, different *Q. pyrenaica* communities develop according to rainfall ranges (Gavilán et al., 1998; Pulido et al., 2007). Eastwards, pine forests acquire greater prominence, especially in the Gredos and Guadarrama mountains, where *Pinus sylvestris* and *P. nigra* represent the timberline. Those altitudes over 1600 m asl are widely occupied by shrublands, where brooms such as *Cytisus oromediterraneus*, *Echinospartum ibericum*, *E. barnadesii* or, in more humid areas, heathlands, mostly composed by *Erica australis*, constitute the main features of the landscape (Rivas-Martínez et al., 1987; Sánchez-Mata, 1989; Fernández-González, 1991). Finally, grasslands are the dominant vegetation on the highest areas.

Also worth mentioning are the birch (*Betula alba*) and the beech (*Fagus sylvatica*) stands which are located in north-oriented headwaters. Especially widespread are the beech forests in the Ayllón Range (Hernández-Bermejo and Sainz-Ollero, 1984). Other tree species have found refuge close to these streams, associated with alder (*Alnus glutinosa*) groves, such as yew (*Taxus baccata*), rowan (*Sorbus aucuparia*), or holly (*Ilex aquifolium*). At lower altitudes, *Quercus robur*, *Prunus lusitanica*, *Ulmus glabra* or *Acer* *monspessulanum* also grow as part of these riparian woods (López-Sáez, 1995; Pulido et al., 2007).

3. Methods

The collected pollen dataset consists of 113 spots (69 peatlands, 7 lakes or lacustrine deposits, 4 paleosols, 33 archaeological sites) located in the Spanish Central System (Fig. 1, Table 1). The chronological setting of the study is established by 150 ^{14}C dates (Table 1), calibrated (2 sigma range) using CALIB 6.0 software (Stuiver and Reimer, 1993). Calibrated radiocarbon dates are given as cal BC or cal AD. The age-depth model in pollen diagrams has been obtained by linear interpolation between uncalibrated radiocarbon ages using the mean of the calibration interval following the original published data. When the authors present their own age-depth model it has been followed in the text. In those sites without radiocarbon dates, we have adopted the chronology given by their original authors. In the case of archaeological sites it may involve their available radiocarbon chronology or their wider cultural framework.

Table 1
Holocene pollen sequences in the Spanish Central System: A, archaeological; P, peatland; L, lacustrine; S, paleosoil

*N*er	Site	Nature	Latitude	Longitude	Altitude	^{14}C BP (calibrated ages 2σ)	References
Pela range							
1	Somolinos	L	4566415	30T 494572	1280	1385 ± 30 (AD 605–675) 1525 ± 30 (AD 503–604) 2190 ± 40 (383–164 BC) 2410 ± 40 (593–396 BC)	Currás et al. (2012)
Ayllón range							
2	Pelagallinas	P	4561802	30T 490419	1340	2400 ± 40 (768–393 BC) 3980 ± 90 (2861–2206 BC)	Franco-Múgica et al. (2001), Rubiales et al. (2012)
3	Hontanares	P	4570010	30T 463264	1430	–	Ruiz del Castillo (1993)
4	Martín Muñoz de Ayllón	P	4571853	30T 464952	1270	–	Ruiz del Castillo (1993)
5	San Benito	P	4563544	30T 460848	1440	–	Ruiz del Castillo (1993)
6	Galve de Sorbe	P	4563510	30T 485192	1370	–	Hernández-Vera and Ruiz-Zapata (1984)
7	Puerto de la Quesera	P	4564073	30T 464542	1400–1700	–	Gil-García (1992), Gil-García et al. (1995b, 1995d)
8	Pico del Lobo	P	4559204	30T 461333	2120–2130	1170 ± 80 (AD 683–1012)	Gil-García (1992), Gil-García et al. (1994c)
9	Buitrera	P	4566988	30T 466605	2038	–	Jiménez-Ballesta et al. (1985)
10	Hayedo de Montejo	P	4551002	30T 458221	1400	–	Gil-García (1992), Gil-García et al. (1993b, 1994c, 1995d), López-García (1997)
11	Tejera Negra	P	4566581	30T 467883	1400	–	Gil-García et al. (1995d)
12	Cueva de los Torrejones	A	4539924	30T 478197	1100	169.4 ± 0.5 pM (AD 1963–1967)[a] 150 ± 60 (AD 1663–1953) 250 ± 60 (AD 1468–1952)	Carrión et al. (2005)
Guadarrama range							
13	Arroyo de la Hoz	P	4489978	30T 393303	1020	4220 ± 70 (3008–2579 BC)	Franco-Múgica (1995), López-García (1997)
14	Navacerrada	P	4510620	30T 416767	1340	2380 ± 50 (751–380 BC)	Franco-Múgica (1995), López-García (1997)
15	Peñalara	P	4521353	30T 419418	1930 1940 2002 2100	80 ± 40 (AD 1682–1955) 275 ± 30 (AD 1499–1796) 340 ± 40 (AD 1462–1642) 730 ± 50 (AD 1209–1390) 755 ± 30 (AD 1221–1284) 1100 ± 60 (AD 778–1025) 1300 ± 30 (AD 661–772) 1680 ± 40 (AD 246–504) 2800 ± 50 (1112–831 BC) 4160 ± 70 (2899–2504 BC)	Alía et al. (1957), Jiménez-Ballesta et al. (1985), Ruiz-Zapata and García-Antón (1987), Ruiz-Zapata et al. (1988a, 1988b, 1988c), Bentley (1991), Vázquez (1992); Ruiz-Zapata et al. (1996c), López-García (1997), Gómez-González (2007), Gómez-González et al. (2007, 2009c), Ruiz-Zapata et al. (2009a)
16	Rascafría	P	4529020	30T 426685	1113	50 ± 40 (AD 1688–1955) 920 ± 50 (AD 1023–1213) 1000 ± 60 (AD 895–1172) 2455 ± 35 (755–411 BC) 7180 ± 70 (6220–5916 BC) 8410 ± 250 (8202–6768 BC)	Franco-Múgica and García-Antón (1994), Franco-Múgica (1995), López-García (1997), Franco-Múgica et al. (1998), Ruiz-Zapata et al. (2006a), Gómez-González (2007), Ruiz-Zapata et al. (2007c), Gómez-González et al. (2008), Ruiz-Zapata et al. (2008b), Franco-Múgica (2009), Gómez-González et al. (2009a, 2009b), Ruiz-Zapata et al. (2009b)
17	El Ventoso	P	4537760	30T 434087	1862	–	Vázquez (1992)
18	El Villar	P	4539122	30T 435333	1805	–	Vázquez (1992)
19	Hoyos de Pinilla	P	4535465	30T 427942	1840	1080 ± 60 (AD 778–1117)	Vázquez (1992)
20	Vaquerizas Bajas	P	4523227	30T 416277	1550	–	Vázquez (1992)
21	Guarramillas	P	4515155	30T 418436	2262	–	Jiménez-Ballesta et al. (1985)
22	Valdesquí	P	4516899	30T 418013	1830	–	Jiménez-Ballesta et al. (1985)

Table 1 (*continued*)

*N*er	Site	Nature	Latitude	Longitude	Altitude	^{14}C BP (calibrated ages 2σ)	References
23	Loma de Peñas Crecientes	P	4533195	30T 423874	1775	1830 ± 110 (88 BC–AD 504)	Vázquez (1992), Vázquez and Ruiz-Zapata (1992)
24	Lagunillas	P	4537008	30T 431097	1780	–	Ruiz del Castillo (1993)
25	Lozoya	P	4537567	30T 431653	1410	–	Ruiz del Castillo (1993)
26	Peña de la Morcuera	P	4521425	30T 430376	1740	1120 ± 60 (AD 775–1022) 1400 ± 60 (AD 541–770) 1770 ± 60 (AD 93–407) 2120 ± 60 (359–0 BC) 2520 ± 60 (800–416 BC)	Ruiz del Castillo (1993)
27	Monasterio del Paular	A	4526786	30T 425241	1100	–	Gil-García (2004)
28	Cachiporrilla	P	4526820	30T 432134	1640	–	Gil-García (1992), Gil-García and Ruiz-Zapata (1994), Gil-García et al. (1995a)
29	Cerro Genciana	P	4521662	30T 433149	1710	–	Gil-García (1992), Gil-García et al. (1995c)
30	El Espartal	P	4526339	30T 432007	1640	–	Gil-García (1992), Gil-García and Ruiz-Zapata (1994), Gil-García et al. (1995a)
31	Portachuelo	P	4528107	30T 433270	1500	–	Gil-García (1992), Gil-García and Ruiz-Zapata (1994), Gil-García et al. (1995a)
32	Puerto de Canencia	P	4521301	30T 434426	1000–1360 1450–1460	1170 ± 50 (AD 711–986) 2500 ± 80 (793–413 BC)	Gil-García et al. (1989), Gil-García (1992), Gil-García et al. (1993a, 1994a, 1994b), López-García (1997), Gil-García et al. (1996a)
33	Puerto de la Morcuera	P	4520043	30T 430121	1190–1200 1700–1720 1740–1750	640 ± 50 (AD 1279–1405) 1440 ± 110 (AD 661–1151) 1710 ± 90 (AD 94–543)	Gil-García et al. (1989), Gil-García and Ruiz-Zapata (1991), Gil-García (1992), Gil-García et al. (1993a, 1993c, 1994a), Andrade et al. (1994b), Gil-García et al. (1996b, 1996c), Ruiz-Zapata et al. (1996a, 1996b, 1996c), López-García (1997)
34	Pepe Hernando	P	4523098	30T 420231	2120	2060 ± 70 (352 BC–AD 80) 3350 ± 90 (1879–1450 BC)	Vázquez (1992)
35	Nicho de dos Hermanas	P	4521144	30T 419627	2100	–	Ruiz-Zapata et al. (1988a, 1988b, 1988c, 1996c)
36	Collado de El Berrueco	P	4526367	30T 449861	1040	530 ± 40 (AD 1312–1444) 680 ± 30 (AD 1270–1389) 2490 ± 49 (782–416 BC)	Ruiz-Zapata et al. (2006a, 2006b), Gómez-González (2007), Ruiz-Zapata et al. (2009c)
37	Cueva de la Buena Pinta	A	4530841	30T 431956	1114	1920 ± 40 (18 BC–AD 214) 4010 ± 40 (2832–2461 BC) 4940 ± 40 (3794–3647 BC)	Gómez-González (2007), Ruiz-Zapata et al. (2007a, 2007b, 2007d, 2008a, 2008b)
38	Abrigo de Navalmaíllo	A	4530859	30T 431956	1114	860 ± 40 (AD 1044–1261) 3690 ± 60 (2278–1913 BC) 3790 ± 40 (2401–2045 BC)	Gómez-González (2007), Ruiz-Zapata et al. (2007a, 2008b)
39	Dehesa de la Oliva	A	4525948	30T 462154	805–890	1565 ± 40 (AD 412–580) 1620 ± 40 (AD 344–541) 1640 ± 40 (AD 263–537) 1700 ± 30 (AD 256–412)	López-García (1997)
40	Laguna de Lirialón	L	4519425	30T 453641	750	–	López-García (1997)
Gredos range							
41	Hoyos del Espino	P	4462522	30T 311221	1450	1750 ± 70 (AD 87–428) 5960 ± 70 (5022–4690 BC)	Franco-Múgica (1995), Franco-Múgica (2009)
42	Navarredonda	P	4469346	30T 322254	1550	1090 ± 70 (AD 772–1150) 1770 ± 80 (AD 71–427)	Franco-Múgica (1995), Franco-Múgica et al. (1997), Franco-Múgica (2009)
43	Puerto de Serranillos	P	4462901	30T 335764	1700	522 ± 27 (AD 1326–1441) 1664 ± 35 (AD 257–530) 1895 ± 45 (AD 21–233) 1938 ± 35 (37 BC–AD 131)	López-Merino et al. (2009), López-Sáez et al. (2009b)
44	Lanzahíta	P	4454242	30T 335290	588	110.01 ± 0.3 pM (AD 1957–1997)[a] 780 ± 35 (AD 1118–1283) 1020 ± 35 (AD 899–1151) 1315 ± 29 (AD 654–771) 1907 ± 35 (AD 59–214) 2280 ± 55 (481–183 BC) 2387 ± 32 (727–393 BC)	López-Sáez et al. (2010a)
45	Navalguijo	P	4458578	30T 283957	1200	1920 ± 90 (162 BC–AD 325)	Franco-Múgica (1995)
46	San Esteban del Valle	P	4461427	30T 334950	1600	–	López-Sáez et al. (1997)
47	Puerto de Casillas	P	4465578	30T 368862	1250	–	López-Sáez et al. (1996, 1998)

(continued on next page)

Please cite this article in press as: López-Sáez, J.A., et al., Vegetation history, climate and human impact in the Spanish Central System over the last 9000 years, Quaternary International (2013), http://dx.doi.org/10.1016/j.quaint.2013.06.034

Table 1 *(continued)*

N^{er}	Site	Nature	Latitude	Longitude	Altitude	^{14}C BP (calibrated ages 2σ)	References
48	Pico Zapatero	P	4480674	30T 336193	1650	–	Andrade (1994)
49	La Serrota	P	4481841	30T 325723	1700	–	Andrade (1994)
50	Cuerda del Cervunal	P	4453062	30T 312393	1840	–	Ruiz-Zapata and Acaso (1981b, 1983, 1984, 1988), Ruiz-Zapata et al. (1996a, 1996b, 1996c)
51	Eliza	S	4452912	30T 335165	450	–	López-Sáez et al. (1999)
52	Ojos Albos	P	4507902	30T 375907	1483	101.7 ± 0.5 pM (AD 1953–1956)[a] 255 ± 35 (AD 1515–1951) 955 ± 40 (AD 999–1175) 1280 ± 40 (AD 658–861) 1555 ± 40 (AD 420–591) 1720 ± 40 (AD 237–412)	Blanco-González et al. (2009)
53	Puerto de las Fuentes	P	4498342	30T 327001	1580	940 ± 70 (AD 982–1251)	Dorado (1993)
54	Riatas	P	4490090	30T 342817	1120	–	Ruiz-Zapata et al. (1992), Dorado (1993), López-Sáez and Blanco-González (2005)
55	San Martín de la Vega del Alberche	P	4476376	30T 312120	1500	–	Andrade et al. (1990), Andrade (1994), Andrade et al. (1996)
56	Prado de las Zorras	P	4484377	30T 335043	1650	2040 ± 90 (358 BC–AD 133)	Andrade (1994), Andrade et al. (1994a, 1994b), Andrade and Ruiz-Zapata (1995), Andrade et al. (1996), Ruiz-Zapata et al. (1996a)
57	Puerto de Chía	P	4480768	30T 316528	1701	2250 ± 100 (736–40 BC) 2620 ± 60 (913–545 BC)	Andrade (1994), Andrade et al. (1996), Ruiz-Zapata et al. (1996a)
58	Puerto de la Peña Negra	P	4476828	30T 305112	1909	2465 ± 110 (826–265 BC)	Ruiz-Zapata et al. (1992), Andrade (1994), Andrade et al. (1996)
59	Puerto de Villatoro	P	4490926	30T 323517	1160	–	Dorado et al. (1990), Ruiz-Zapata et al. (1990), Dorado (1993), Andrade et al. (1994a)
60	Los Conventos	P	4460944	30T 314260	1680	–	Ruiz-Zapata and Acaso (1981a, 1984, 1988), Franco-Múgica (2009)
61	Garganta de las Pozas	P	4463960	30T 306984	1600	–	Ruiz-Zapata and Acaso (1985, 1988), Ruiz-Zapata et al. (1996a)
62	Narrillos del Rebollar	P	4502810	30T 335181	1560	2953 ± 68 (1387–980 BC)	Atienza et al. (1991), Dorado (1993), Andrade et al. (1994a), Ruiz-Zapata et al. (1996a, 1996c), López-García (1997), Dorado et al. (2001), López-Sáez and Blanco-González (2005), López-Sáez et al. (2009a)
63	Las Pozas-Amblés	P	4500370	30T 333589	1360	–	Dorado (1993)
64	Laguna Grande de Gredos	L	4458046	30T 307208	1960	–	Toro et al. (1992, 1993)
65	Las Lagunas	L	4489190	30T 338749	1160	–	Dorado et al. (1990), Dorado (1993)
66	Baterna	P	4490546	30T 337153	1140	5930 ± 100 (5444–5188 BC)	Dorado (1993), Ruiz-Zapata et al. (1996a, 1996b), López-Sáez et al. (2003b), López-Sáez and Blanco-González (2005), López-Sáez et al. (2009a)
67	Hoyocasero	S	4472990	30T 331042	1250	530 ± 80 (AD 1281–1616)	Andrade et al. (1992), Andrade (1994), Andrade and González-Jonte (2007)
68	Trío los Pingos	P	4479921	30T 332326	1550	–	Andrade (1994), Andrade et al. (1994b)
69	Garganta del Villar	S	4479000	30T 323000	1450	8030 ± 180 (7451–6514 BC)	This paper
70	El Raso	A	4450183	30T 299178	791	1840 ± 140 (165 BC–AD 533) 2010 ± 130 (376 BC–AD 252) 2090 ± 140 (405 BC–AD 232) 2190 ± 130 (733 BC–AD 81) 2190 ± 80 (395–51 BC)	López-García (1985, 1986), López-Sáez et al. (1991), López-Sáez and López-García (1994), López-Sáez et al. (2008)
71	Las Cogotas	A	4511604	30T 343393	1118–1156	–	López-Sáez et al. (2008)
72	Ulaca	A	4488255	30T 340301	1500	–	López-Sáez et al. (2008)
73	Mesa de Miranda	A	4509581	30T 335615	1154	–	López-Sáez et al. (2008)
74	Castillejos de Sanchorreja	A	4510436	30T 349371	1500	–	González-Tablas (1983), González-Tablas and Domínguez-Calvo (2002), López-Sáez and Blanco-González (2005)

Please cite this article in press as: López-Sáez, J.A., et al., Vegetation history, climate and human impact in the Spanish Central System over the last 9000 years, Quaternary International (2013), http://dx.doi.org/10.1016/j.quaint.2013.06.034

Table 1 (*continued*)

N^{er}	Site	Nature	Latitude	Longitude	Altitude	^{14}C BP (calibrated ages 2σ)	References
75	Aldeagordillo	A	4501800	30T 360400	1201	3510 ± 70 (2027–1668 BC) 3685 ± 25 (2189–1979 BC) 3690 ± 50 (2267–1938 BC) 4100 ± 80 (2879–2482 BC) 4115 ± 20 (2860–2580 BC) 4320 ± 70 (3325–2698 BC)	López-Sáez and Burjachs (2002-2003), López-Sáez et al. (2003b), Fabián (2006), Fabián et al. (2006), López-Sáez and López-Merino (2007)
76	Dehesa de Río Fortes	A	4493677	30T 345530	1100	3910 ± 100 (2836–2044 BC) 4970 ± 80 (3949–3641 BC)	López-Sáez (2002), Fabián (2006);
77	Fuente Lirio	A	4500536	30T 346560	1185	3910 ± 100 (2836–2044 BC) 4260 ± 60 (3076–2636 BC)	Burjachs and López-Sáez (2003), López-Sáez et al. (2003b), Fabián (2006), López-Sáez and López-Merino (2007)
78	Gravera de Puente Viejo	A	4512917	30T 359949	880	–	López-Sáez and Blanco-González (2004, 2005)
79	Los Itueros	A	4497417	30T 336598	1275	3850 ± 100 (2574–2028 BC) 3960 ± 90 (2857–2155 BC) 4120 ± 130 (3011–2299 BC)	López-Sáez and López-García (2003), López-Sáez et al. (2003b), Fabián (2006), López-Sáez and López-Merino (2007)
80	Los Tiesos	A	4505498	30T 368539	1110	–	López-Sáez et al. (2003b), López-Sáez and López-Merino (2007), López-Sáez (2011)
81	Valdeprados	A	4497800	30T 355450	1100	–	López-Sáez and Burjachs (2002), López-Sáez et al. (2003b), Fabián (2006), López-Sáez and López-Merino (2007)
82	El Picuezo-Sotalvo	A	4487578	30T 343312	1439	–	López-Sáez et al. (2005b), López-Sáez and Blanco-González (2005), Fabián et al. (2006)
83	Guaya	A	4505939	30T 366147	1110	2969 ± 40 (1370–1051 BC) 3068 ± 40 (1428–1216 BC)	Burjachs (2001), López-Sáez and Blanco-González (2005), Misiego et al. (2005), López-Sáez et al. (2009a)
84	La Viña	A	4507963	30T 367983	1070	–	López-Sáez and Blanco-González (2005), López-Sáez et al. (2009a)
85	Castillo de Cardeñosa	A	4511062	30T 353816	1104	–	Fabián et al. (2006)
86	Cerro de la Cabeza	A	4501716	30T 354324	1140	3820 ± 60 (2466–2059 BC) 3850 ± 60 (2472–2141 BC) 3970 ± 50 (2619–2299 BC) 4010 ± 50 (2839–2348 BC) 4020 ± 50 (2855–2369 BC)	Fabián (2006), López-Sáez and López-Merino (2007)
87	Cerro Hervero	A	4502233	30T 359507	1217	3924 ± 41 (2565–2289 BC)	Fabián (2006), López-Sáez and López-Merino (2007)
88	El Morcuero	A	4495179	30T 348120	1116	–	Fabián (2006), López-Sáez and López-Merino (2007)
89	El Picuezo-Guareña	A	4498039	30T 332993	1245	4180 ± 60 (2898–2584 BC)	Fabián (2006), López-Sáez and López-Merino (2007)
90	La Ladera	A	4498714	30T 344209	1170	–	Fabián (2006)
91	Tiro de Pichón	A	4501987	30T 358869	1120–1155	–	Fabián (2006), López-Sáez and López-Merino (2007)
92	La Panera	P	4449448	30T 264846	1648	235 ± 35 (AD 1630–1807)	Abel-Schaad et al. (2009b), Abel-Schaad (2012)
93	Garganta de los Caballeros	L	4456736	30T 287416	1365	1910 ± 30 (AD 21–210) 1965 ± 30 (41 BC–AD 116)	Ruiz-Zapata et al. (2011)
94	Laguna de los Casares	A	4502822	30T 366986	1150	–	Blanco-González et al. (2009)
95	El Vergel II	A	4520653	30T 340999	920	–	Blanco-González et al. (2009)
Francia range							
96	La Meseguera	P	4483677	29T 735596	900	102.81 ± 0.2 pM (AD 1954–1956)[a] 385 ± 30 (AD 1444–1631) 640 ± 30 (AD 1283–1396) 1270 ± 60 (AD 654–888)	Abel-Schaad (2012)
97	Castil de Cabras	A	4495576	30T 247484	1046	3530 ± 35 (1947–1752 BC) 3559 ± 32 (2016–1774 BC) 3580 ± 70 (2135–1746 BC)	López-Jiménez and López-Sáez (2005)
98	La Corona	A	4497595	29T 750081	1288	–	López-Jiménez and López-Sáez (2005)
99	Mata del Castillo	A	4494635	29T 748949	1149	1870 ± 45 (AD 30–244) 2028 ± 40 (163 BC–AD 59) 2068 ± 33 (176 BC–AD 2)	López-Jiménez and López-Sáez (2005)
100	Fuente de la Mora	A	4492846	29T 742241	1025	–	Ruiz del Árbol et al. (2003)
101	Herguijuela	S	4481693	29T 748004	750	–	Atienza (1996)

(*continued on next page*)

Table 1 (*continued*)

N^{er}	Site	Nature	Latitude	Longitude	Altitude	^{14}C BP (calibrated ages 2σ)	References
102	El Maíllo	P	4492050	29T 736094	1100	105.03 ± 0.2 pM (AD 1955–1957)[a] 1550 ± 40 (AD 423–594) 1990 ± 30 (48 BC–AD 72) 4790 ± 40 (3652–3384 BC) 5040 ± 30 (3951–3716 BC) 6900 ± 40 (5881–5716 BC) 7670 ± 40 (6594–6450 BC) 8970 ± 40 (8281–7974 BC) 9330 ± 50 (8745–8355 BC)	Morales-Molino et al. (2013)
Béjar range							
103	Garganta del Trampal	P	4466395	30T 272553	1440	5270 ± 90 (4333–3848 BC)	Ruiz-Zapata et al. (1989), Atieza et al. (1990, 1991), Atienza and Ruiz-Zapata (1992), Ruiz-Zapata et al. (1992), Atienza (1993), Atienza et al. (1996), Ruiz-Zapata et al. (1996a), Franco-Múgica (2009)
104	Dehesa de Navamuño	P	4467428	30T 264537	1480	4020 ± 70 (2864–2341 BC)	Atienza and Ruiz-Zapata (1992); Atienza (1993), Ruiz-Zapata et al. (1996a)
105	Peña Negra	P	4468662	30T 262814	1000	100 ± 80 (AD 1666–1955) 1140 ± 90 (AD 672–1033) 1538 ± 60 (AD 411–638) 1640 ± 30 (AD 337–534) 2490 ± 80 (789–412 BC) 2982 ± 43 (1320–1056 BC)	Pulido et al. (2007), Abel-Schaad (2012), Abel-Schaad and López-Sáez (2013)
106	Cuerpo de Hombre	L	4465844	30T 269423	2040	5160 ± 40 (4045–3807 BC)	Ruiz-Zapata et al. (2011)
107	Presa del Duque	L	4464949	30T 272077	1600	510 ± 95 (AD 1283–1632) 2380 ± 35 (729–390 BC) 6030 ± 40 (5033–4805 BC) 6830 ± 120 (5982–5535 BC) 7470 ± 150 (6598–6032 BC)	Ruiz-Zapata et al. (2011)
108	Garganta de la Solana	P	4466552	30T 271534	1620	–	Atienza and Ruiz-Zapata (1992), Atienza (1993)
109	Barrera de las Corzas	P	4466837	30T 272354	1600	–	Atienza (1993)
110	El Quemal-Candelario	P	4467925	30T 267582	1840	–	Atienza and Ruiz-Zapata (1992), Atienza (1993, 1995)
111	La Covatilla	P	4470514	30T 271640	1980	–	Atienza (1993, 1995), Atienza et al. (1996)
112	Jerte	P	4456089	30T 260785	1180	–	Atienza (1993)
Gata range							
113	Puerto de Santa Clara	P	4458271	29T 689552	1000	3560 ± 40 (2023–1772 BC)	Abel-Schaad et al. (2009a), Abel-Schaad (2012)

[a] These radiocarbon dates were calibrated using the CALIBomb program (http://calib.qub.ac.uk/CALIBomb) with the calibration dataset NH zone 1 (Hua and Barbetti, 2004).

With the aim of describing the mid-Holocene vegetation history, a new palynological record has been added, Garganta del Villar (Cepeda de la Mora, Ávila) in the Gredos Range, which chronology and sedimentary features have been already presented elsewhere (Díez et al., 1996). Three samples have been taken in an alluvial deposit (3 m depth) in the high-valley of the Alberche river at different depths within a level of black clay-rich organic matter dated ca. 7450–6515 cal BC (Fig. 3, Table 1). These samples have

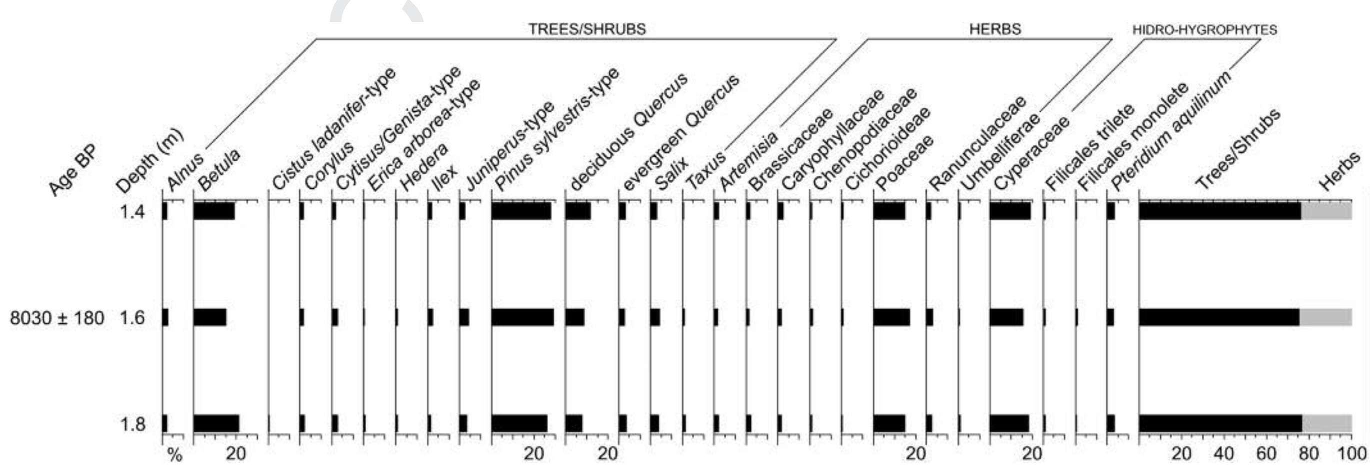

Fig. 3. Pollen diagram from Garganta del Villar (Gredos Range) (Points <2%).

been treated following the classic chemical methodology (Faegri and Iversen, 1989) with concentration in heavy liquid to obtain pollen and non-pollen palynomorphs.

4. Vegetation changes, climate changes and human activity in the Spanish Central System

The palynological evidence of anthropogenic vegetation changes is summarized and correlated for the different mountains in the Spanish Central System in Fig. 4. This summary is based on the palynological sequences considered in this paper (Fig. 1, Table 1). The development of natural landscapes is discussed in the context of the changing human occupation of the massif and the climate change events observed on a global scale.

4.1. Until the Early Neolithic (ca. 9000–4500 cal BC)

In western areas of the massif (Francia and Béjar Ranges), the pollen records of El Maíllo and Garganta del Trampal show that pre-Neolithic forests (ca. 8745–5500 cal BC) were dominated by birches (*Betula* ~40–80%) and pines (*Pinus* ~10–20%), with a certain presence of deciduous *Quercus* and other mesophytes between 1100 and 1440 m asl. *Carpinus betulus* is also documented sporadically at this time in Garganta del Trampal record. The relative abundance of mesophilous trees and hydro-hygrophytes (especially *Osmunda regalis*) could be associated with a humid climate. Temperate and humid climatic conditions at this time would have allowed the birch forest dominance not only in lowlands (El Maíllo, 1100 m asl) but also in highlands (Garganta del Trampal, 1440 m asl) (Fig. 4). However, the Presa del Duque pollen record (1600 m asl) shows a landscape ca. 6600–5535 cal BC dominated by Poaceae (~40%) with scattered occurrences of *Betula*, *Corylus* and deciduous *Quercus* while *Pinus* is almost absent. Sporadic presences of *Plantago*, *Rumex* and coprophilous fungi (*Sporormiella*, *Podospora*) could indicate some kind of pastoral pressure without ruling out that it could be also the result of wild animals. These data are very different from those above discussed, and, according to the authors, the two available radiocarbon dates for these levels appear to be inconsistent with the inferred vegetation. It seems to reflect cold and arid conditions more typical of the Younger Dryas or the 8.2 ka cal BP event. Anyway, the high-altitude of this site could explain these data: in fact, La Covatilla pollen record (1980 m asl) shows at this moment an open landscape (tree cover ~55%) dominated by birch, scattered pines and prostrate juniper (*Juniperus*-type).

In central and eastern areas of the Spanish Central System (Gredos and Guadarrama Ranges), the pollen records of Hoyos del Espino, Baterna and Riatas, Garganta del Villar (Fig. 3), Peñalara and Rascafría, show a well-developed pine forest (*Pinus* gr. *sylvestris/nigra* >50%) at higher altitudes, while towards the valleys deciduous and evergreen *Quercus*, *Betula*, *Fraxinus*, *Salix*, *Corylus*, *Ilex* and *Sambucus* prosper from ca. 8200 cal BC (Fig. 4). Colder and a more seasonal climate could explain these differences between central-eastern and western parts of the massif. The high percentages of birch pollen (~20%; unpublished data) in Garganta del Villar ca. 7450–6510 cal BC (Fig. 3) may be explained by the lowering of the forest treeline and by its pioneer and heliophilous character, as the sedimentological facies maps these samples to fill an abandoned channel that have suffered intense periglacial processes (Díez et al., 1996).

El Maíllo charcoal record shows that pine species which currently inhabits high-mountain areas of the Spanish Central System, grew during the early to mid-Holocene also at lower altitudes in western areas. In the Gredos Range pollen data from high-altitude sites (Hoyos del Espino, Garganta del Villar) demonstrate the existence of a pine forest ~1400 m asl. The presence of *P. sylvestris* in high-altitude areas (~1300–1850 m asl) since the mid-Holocene has also been reported in the Gredos Range by numerous radiocarbon-dated megafossils (Rubiales et al., 2007). However, in pollen sequences located below (~1100 m asl, Riatas and Rascafría), pine pollen percentages are unusually high (>50%) before 5500 cal BC, suggesting the presence of pines at lower altitudes. Studies on modern pollen rain in Gredos and Guadarrama Ranges support this view (Vázquez and Peinado, 1993; Dorado and Ruiz-Zapata, 1994; Andrade et al., 1994c; López-Sáez et al., 2010b).

In El Maíllo sequence two maxima in the charcoal concentration values are detected ca. 6100–6000 and 5500–5300 cal BC (Fig. 5) linked to episodes of grassland expansion. In the Rascafría pollen sequence the microcharcoal record showed a maximum value ca. 6200–6000 cal BC (Fig. 5) parallel to the decrease in *Pinus* values and the progress of herbaceous communities. Studies on the long-term occurrence of fire and the responses of vegetation are relatively common in Spain (Carrión et al., 2007; Gil-Romera et al., 2010), but they are fairly rare in the Iberian Central System (Franco-Múgica et al., 1998; López-Merino et al., 2009; López-Sáez et al., 2010a; Connor et al., 2012; Abel-Schaad and López-Sáez, 2013; Morales-Molino et al., 2013). Although fire is both a natural phenomenon and a human resource, used for example to clear and maintain open agro-pastoral areas by early farming communities (Tinner et al., 2005; López-Sáez et al., 2005a; Colombaroli et al., 2008), it seems difficult to understand human impact on fire regimes without placing it in the context of Holocene climatic and vegetation changes. Recent studies from the Alps, the Pyrenees and the Mediterranean area show that millennial variability in Holocene fire regimes is linked to climatic oscillations, particularly for the early to mid-Holocene ca. 9750–3000 cal BC (Vannière et al., 2011), but also fire regimes are human-driven during the last 4000 years (Tinner et al., 2005; Rius et al., 2009; Vannière et al., 2010; Rius et al., 2011, 2012). In fact, the charcoal record of El Maíllo shows the highest concentration values ca. 8250 and ca. 6550 cal BC linked to high tree pollen values (Fig. 5). This fire frequency is probably related to the dry climatic conditions and greatly benefited from the early Holocene biomass increase. The synchronicity of frequency curves ca. 6000–5500 cal BC between the charcoal records of El Maíllo, Rascafría and Charco da Candieira (Francia, Guadarrama and Estrela Ranges respectively) suggests a period of contrasted fire frequency with centennial oscillations and a millennial pattern similar to the regional Mediterranean fire activity (Connor et al., 2012; Morales-Molino et al., 2013). Therefore, climate control can be considered as the major forcing factor over fire occurrence during the mid-Holocene in the Iberian Central System at the millennial scale, but shorter variability may be accounted for by other factors such as human impact and/or fire-vegetation feedbacks (Carrión et al., 2010).

Some palynological records from the area come from high-altitudes (>1400 m asl: Garganta del Trampal, La Covatilla, Presa del Duque, Hoyos del Espino, Garganta del Villar), but in most cases they are placed about 1100 m asl (El Maíllo, Riatas, Baterna, Rascafría) in fertile valleys, hence in the main area of activity of the Neolithic population (Rojo et al., 2012). Although anthropogenic pollen indicators (e.g. *Aster*-type, Cichorioideae, *Echium vulgare*-type, *Plantago major/media*-type, *Rumex acetosa*-type, *Urtica dioica*-type) are scarce and discontinuous in these last pollen sequences from the Spanish Central System ca. 5500–4500 cal BC, we cannot rule out the possible influence of Early Neolithic communities, which appear precisely on this date in the whole of Central Iberia (Rojo et al., 2012). For instance, from ca. 5500 cal BC until ca. 3300 cal BC, grasslands start to show especially high values (Poaceae >40%) in El Maíllo record, although birches, pines and oaks maintain their presence in the area (Fig. 4). Instead, the Rascafría

Please cite this article in press as: López-Sáez, J.A., et al., Vegetation history, climate and human impact in the Spanish Central System over the last 9000 years, Quaternary International (2013), http://dx.doi.org/10.1016/j.quaint.2013.06.034

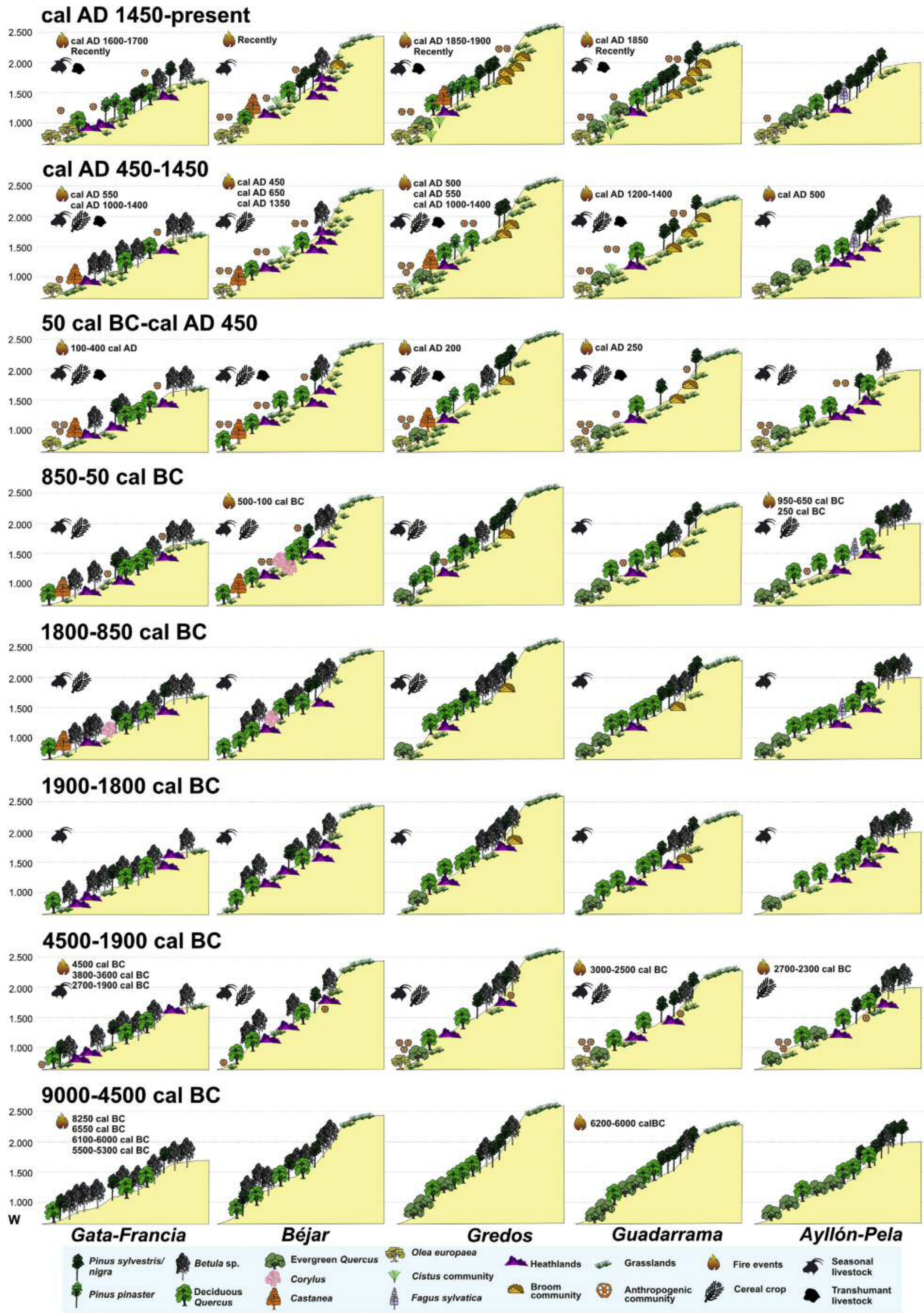

Fig. 4. Reconstruction of the palaeovegetation of the Spanish Central System since ca. 9000 cal BC.

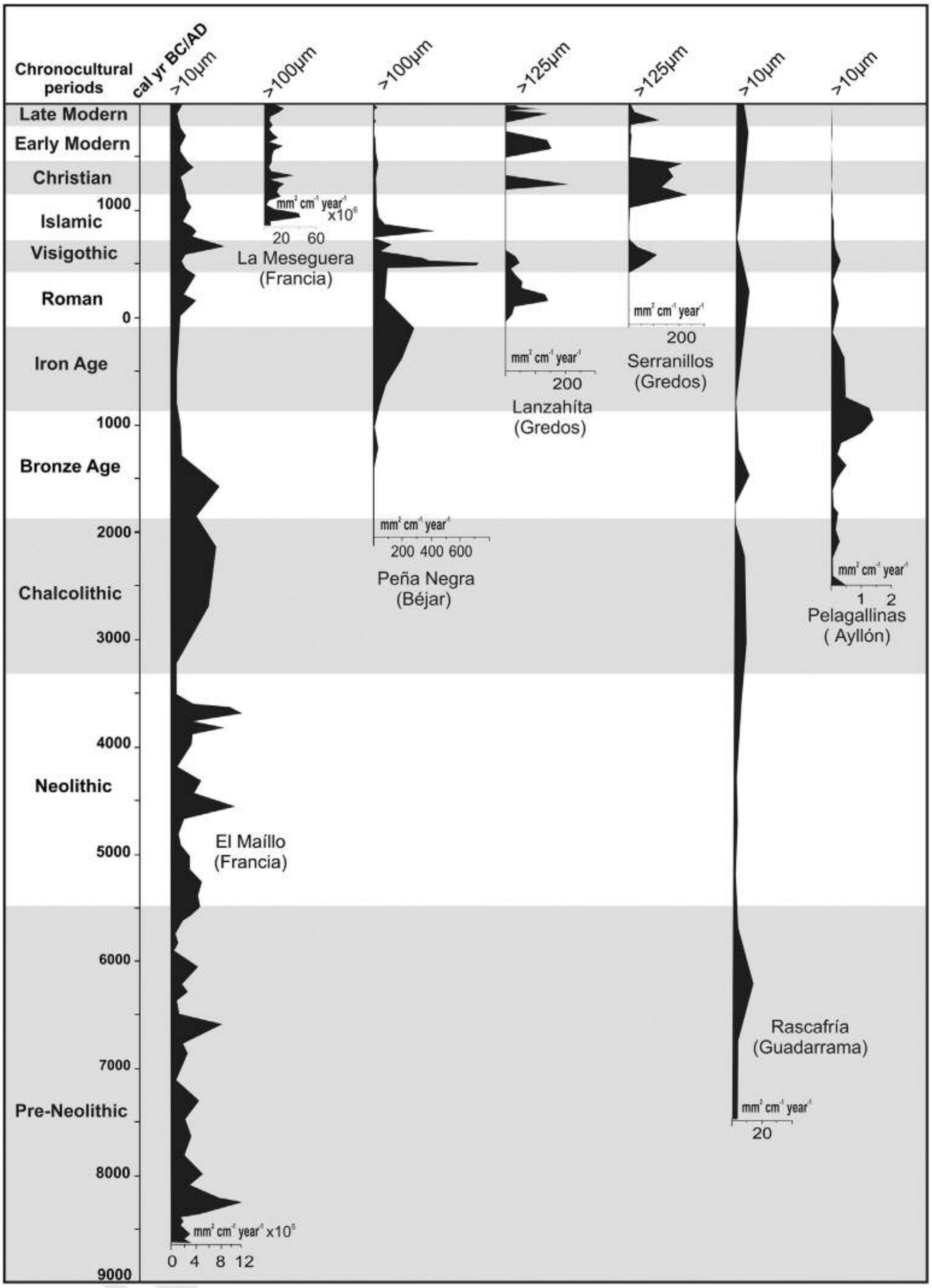

Fig. 5. Comparison among charcoal accumulation rates of several deposits during the Holocene in the Spanish Central System.

sequence shows no obvious change in its forests composition, neither anthropogenic pollen indicators, until ca. 3000–2500 cal BC, when a sharp fall in the pine cover is reported. Hypothetical grazing activities are documented in the Presa del Duque pollen record ca. 5500 cal BC at high-altitude (1600 m asl).

The adoption of the productive economy and its potential impact on the landscape is still an open question for debate throughout the Spanish Central System. Some Early Neolithic (ca. 5500–4500 cal BC) sites are known in the mountains of Béjar, Gredos, Guadarrama and Ayllón (Rojo et al., 2012), but unfortunately none of them have been studied from an archaeobotanical point of view. The most characteristic habitat of Early Neolithic sites in the Spanish Central System is the granitic outcrop shelter on rocky promontories, usually deployed at altitudes above 800–1300 m asl, except some open air sites on the southern slopes of the Gredos Range (La Vera valley) located about 500 m asl in relation to water availability. They would have possibly been semi-nomadic communities with a seasonal and a wandering lifeway depending upon a strong livestock husbandry vocation linked to the high-mountain pastures (Delibes and Fernández, 2000; Blanco-González, 2008). However, in both plateaus open air settlements near streams are more frequent in areas of high agricultural potential in the Duero and Tagus Basins (Muñoz, 2000; Jiménez, 2010). Archaeobotanical evidence for agriculture has been documented in the nearby areas of both the Duero and the Tagus Basins ca. 5300 cal BC (Estremera, 2003; López-Sáez et al., 2005a, 2007a).

4.2. Consolidation of the productive economy: Middle Neolithic to Copper Age (ca. 4500–1900 cal BC)

During the Middle and the Late Neolithic (ca. 4500–3300 cal BC) a *dehesa* landscape took form along both plateaus, as a result of farming and grazing activities into the oak forests (*Quercus ilex* and *Q. suber*), linked to new concepts of landscape organization represented by the first megalithic tombs (Jiménez, 2000; Bueno et al., 2002; López-Sáez et al., 2007b). Areas with greater agricultural aptitudes are increasingly populated from the Late Neolithic onwards, with small farmsteads located in the valley bottoms and the soft hills near streams; in short, these are the settings that will be colonised in the Chalcolithic period (Fabián, 2006; Blanco-González, 2008).

In the Amblés valley, within the lowlands of the Gredos Range, the pollen record from Dehesa de Río Fortes barrow shows a Late Neolithic landscape of meadows and ruderal communities which provides evidence of the increasing human pressure ca. 4000–3650 cal BC, mainly by grazing activities (high values of coprophilous fungi) without traces of crop cultivation. This is not strange due to the funerary nature of the deposit. These facts allow the interpretation of the monument, besides its sacred character, as a symbolic place of cattle transit (trasterminance). Pollen records from Baterna and Riatas peat-bogs reflect, at this time, an open evergreen oak forest (*Quercus ilex*-type) in the Amblés valley accompanied by a dense macchia of *Olea europaea* and nitrophilous and anthropozoogenous communities. Deciduous oaks (*Q. pyrenaica*) and ash tree (*Fraxinus*) would occupy alluvial soils and pines would be located at higher altitudes (Fig. 4). In the 3rd millennium cal BC, the landscape of the intramontane Amblés valley is still characterized by open evergreen oak forests between ca. 1200–1000 m asl. At this time, an increase in farming activity occurs, led by pastoralism. Pollen records from 9 archaeological sites of the Chalcolithic period (Aldeagordillo, Cerro de la Cabeza, Cerro Hervero, Los Itueros, Fuente Lirio, El Picuezo-Guareña, Tiro de Pichón, La Ladera and Valdeprados) and 2 peat-bogs (Baterna, Riatas) show the occurrence of *Cerealia*-type pollen (>3%), and high values of anthropozoogenous taxa, carbonicolous and coprophilous fungal ascospores, setting up an agropastoral landscape where the tree cover was low due to the use of fire to clear the original forest (López-Sáez et al., 2003b; López-Sáez and López-García, 2004, 2006; López-Sáez, 2007; López-Sáez and López-Merino, 2007). During the Copper Age (ca. 3300–1900 cal BC) crop farming seems to have played a major role in the activities near archaeological sites, especially in the valleys.

During the Late Neolithic only *Cercophora* and *Sordaria* were reported in the Dehesa de Río Fortes record, while the Chalcolithic palynological cores register both of them and also *Sporormiella*, *Chaetomium* and *Podospora*. The higher diversity of coprophilous fungal ascospores during the Copper Age could be the result of increasing grazing pressure from the Neolithic (López-Sáez and López-Merino, 2007). The identification of coprophilous fungi in the pollen record of two Chalcolithic barrows (Los Tiesos, El Morcuero) emphasises their symbolic character and their landscape prominence in the valley (Blanco-González and Fabián, 2010, 2011).

In the highlands of the Gredos Range, the pollen diagrams from Los Conventos (1680 m asl), Cuerda del Cervunal (1840 m asl), Hoyos del Espino (1450 m asl) and Narrillos del Rebollar (1560 m asl) show the first sporadic traces of human impact – expansion of heathlands and *Rumex*, increase of heliophilous taxa, such as birches, and pyrophilous taxa, such as *Asphodelus* – appearing during the Chalcolithic, ca. 2200–2000 cal BC, although pine forests still dominate the landscape (*P. sylvestris*-type ~50–80%) (Fig. 4). This is related to a more intensive Chalcolithic use of the highlands (seasonal livestock). Hence, the first clearly noticeable anthropogenic indicators in the high-altitude palynological record coincide with the increasing number of settlements in the lowlands (Fabián, 2006; Blanco-González, 2008).

One of the most important environmental changes for the Holocene is shown in El Maíllo record (Francia Range) ca. 3300–2000 cal BC, when *Betula–Pinus* forests declined and a rapid expansion of heathlands (*Erica arborea*-type >20%) took place, although this began ca. 4400 cal BC. It could be explained by different reasons: i) forest clearance by humans (although anthropogenic pollen indicators are scarce), ii) recurrent wildfires promoting fire-tolerant communities (high charcoal concentrations around 4500, 3800–3600 and between 2700 and 1900 cal BC, Fig. 5), iii) a climatic trend to drier conditions (decrease of sedimentation rate and hygrophilous grasslands) (Morales-Molino et al., 2013). A similar trend is documented in Peña Negra (1000 m asl, Béjar Range) ca. 2100 cal BC, where grasslands (Poaceae >30%) and heathlands (~10%) dominate this anthropogenic landscape including the presence of *Cerealia*-type pollen (~2%). In high-altitude sites from the Béjar Range (~1400–2000 m asl), the first evidence of anthropization ca. 2800–2300 cal BC is located in Garganta del Trampal, El Quemal-Candelario and La Covatilla pollen records, with grasslands, anthropogenic taxa and heathlands expansion, while a noticeable increase of birches is documented in Dehesa de Navamuño (Fig. 4). These clearances were probably performed for grazing activities as underlined by the slight increase of anthropozoogenous taxa and coprophilous fungi without *Cerealia*-type pollen until ca. 2000 cal BC. On the other hand, at an even higher altitude (2040 m asl), the Cuerpo de Hombre record shows no evidence of human impact since ca. 4050 cal BC.

Towards the eastern parts of the massif, in the Lozoya-Paular valley (~1100 m asl), the Rascafría record shows a sharp fall of high-mountain pine forests ca. 3000–2500 cal BC, associated with a significant rise in anthropogenic herbs (Asteraceae, *Asphodelus*, *Papaver*, *Plantago*) and a slight increase in shrub pollen taxa (heaths, *Cistus*), giving rise to an open woodlands landscape (Fig. 4). The decline of *P. sylvestris* forest is linked to human impact because it coincides with other features: i) local grazing (Sordariaceae), ii) the first appearance of *Cerealia*-type pollen, iii) a small peak in the charcoal record (Fig. 5). At this time, climate was dry as reflected by the disappearance of HdV-Type 128 (an indicator of open fresh water), a considerable increase of Zygnemataceae (characteristic of shallow, stagnant temperate waters), and the substantial presence of xerophytic taxa (*Helianthemum*, *Artemisia*). The timing of this opening of the forest canopy bears a close similarity to the woodland history of several other pollen records in the lowlands of the Guadarrama Range, such as Arroyo de la Hoz (1020 m asl) where *Cerealia*-type pollen is detected ca. 3000–2600 cal BC coinciding with a maximum peak of microcharcoals and grazing indicators; and Cueva de la Buena Pinta (1114 m asl) with high values of anthropogenic taxa and a decrease of the arboreal cover (*Quercus ilex*-type) ca. 3000–2500 cal BC. Even this similarity is confirmed in high-altitude pollen records such as Peñalara (~2000 m asl), where heliophilous taxa (*Betula*) and grazing indicators show noticeable values and *Olea* pollen is present ca. 2900–2500 cal BC. There is also a similar pattern in the Ayllón Range: the Pelagallinas record (1340 m asl) shows high values of anthropozoogenous taxa and *Cerealia*-type pollen ca. 2700–2300 cal BC (Fig. 4).

The existence of a *dehesa* landscape in lowlands and valleys of the Spanish Central System, from the Middle Neolithic to the end of the Copper Age (ca. 4500–1900 cal BC) was the outcome of a planned and rational management of the agroforestry resources, all of which required a lasting permanence in the area and therefore involved the progressive sedenterisation of the population, especially from the Copper Age (Delibes et al., 1995; Blanco-González, 2008). It is also important the fact that woodland-consuming copper production was practiced on a small scale in some mountainous areas of the massif (Blasco and Rovira, 1992-1993; Fabián, 1993, 1996; Delibes et al., 1996). Thus, the pollen record from Cerro de la Cabeza, a site probably related to metallurgical exploitation, is a good example (*Quercus ilex*-type values <2%). The vast majority of the known Chalcolithic settlements lie at ~1100–1300 m asl, so that it can be assumed that their location is related to having a visual control of (i) fertile alluvial soils where their agricultural fields are installed, (ii) immediate foothills where their cattle would breed and (iii) other localised and valuable resources, i.e. cupriferous ores or flint nodules (Fernández et al., 1997; López-Sáez et al., 2003b; Fabián, 2006; López-Sáez and López-García, 2006). It seems that the anthropogenic signal is rather of an extra-local character, as it is visible in all the palynological records considered, including those from the higher-mountains sites.

In summary, the Chalcolithic period was the climax of a process of demographic growth favoured by accumulation economy practiced during the Neolithic (Sherrat, 1981; Vicent, 1995, 1998). In the sedimentary contexts of both the Duero and the Tagus Basins, as well as in intramontane valleys in the Spanish Central System, a fully agrarian character of the landscapes has been demonstrated at least since the beginning of the 4th millennium cal BC. An increase in the number of prehistoric settlements is observed during the Chalcolithic (ca. 3300–1900 cal BC), indicating a substantial increase in the population. This demographic trend is combined with a more prolonged nature of the settlements and the investment of some surplus in agricultural infrastructure and strategies of political economy, denoted by the occurrence of prestige items and funerary constructions (Muñoz, 2000; Díaz del Río, 2001; Bueno et al., 2002, 2005; Fabián, 2006; Blasco et al., 2011).

4.3. A climatic change at the time of the Chalcolithic–Early Bronze Age transition (ca. 2350–1800 cal BC)

During the transition from the 3rd to the 2nd millennia cal BC, the study area was subjected to the effects of a short and abrupt climate change of extreme aridity, the so-called 4.2 ka cal BP event (ca. 2350–1850 cal BC) (Magny, 1993, 2004) or Bond event 3 (Bond et al., 2001), which has been recognized as a marked aridification phase in the Mediterranean Iberian region (Jalut et al., 2000, 2009; Carrión et al., 2010). According to Magny et al. (2009), this event is characterised in the western Mediterranean by a tripartite climatic oscillation: two phases with wetter conditions (ca. 2350–2150 and 2000–1900 cal BC) bracketed a phase of drier conditions at ca. 2150–2000 cal BC. Their consequences are clearly reflected in both the archaeological and palynological records during the transitional period between the end of the Chalcolithic and the onset of the Early Bronze Age in the Spanish Central System. The final result was the collapse of the Chalcolithic agrarian landscape ca. 1900 cal BC and the emergence of a more pastoralist oriented landscape with a major decline in the number of settlements in the Early Bronze Age (ca. 2200–1800 cal BC) (Fabián et al., 2006).

Although xerophytic taxa (*Artemisia*, *Olea*, Chenopodiaceae, *Helianthemum*-type) were abundant during the 3rd millennium cal BC in the pollen records of the above mentioned Chalcolithic sites from the Gredos Range, it is true that at the end of this period they considerably increased. This is clearly detected in the Late Chalcolithic levels of the Aldeagordillo pollen record, which lead to infer a maximum of aridity (~16% of xerophytic taxa *versus* ~9% in the Early Chalcolithic) ca. 2080 cal BC. In the time frame of this climate event the abandonment of the traditional Chalcolithic sites placed in the valley bottoms occurs while new settlements of the Early Bronze Age were created since ca. 2200 cal BC in highland settings (Delibes and Fernández, 2000; Fabián, 2006; Blanco-González, 2008). Pollen records from two Early Bronze Age sites located at high-altitudes (El Picuezo-Sotalvo and Castillo de Cardeñosa), reflect more humid climatic conditions, inferred by high values of hydro-hygrophilous taxa and the dominance of open oak forests (*Q. pyrenaica*-type) with *Pteridium aquilinum*, *Cistus ladanifer* and heaths, pointing to a readjustment towards forestry and livestock management strategies of the landscapes.

It is interesting to highlight the location chosen by these first communities of the Bronze Age, usually in mountainous domains, and concretely on granitic promontories of conical shape that are visual references in the landscape, always close to the presence of water (Jimeno, 1988; Fabián, 1995, 2006; Blanco-González, 2008). It is possible that these sites had some symbolic nature, as landmarks within landscapes of livestock vocation (Samaniego, 1999) occupied by small groups following seasonal cycles of trasterminance, i.e. short distance movements from valley to hilltop pastures (Blanco-González, 2008). Livestock, in these new settlements, seems to constitute the essential basis of subsistence (Harrison, 1994), as indicated by the abundance of anthropozoogenous taxa and coprophilous fungi, and the absence of cereal pollen grains, in the pollen records of the above mentioned sites. Paleodiet analyses have shown that the dietary pattern of Chalcolithic communities was based on a range of vegetables and meat options, while those of the Early Bronze Age exhibited a less varied trend more dependent on meat (Trancho et al., 1996).

Some evidence of the 4.2 ka cal BP event also seems to be found in the pollen records of Arroyo de la Hoz, Peñalara, Pepe Hernando, Abrigo de Navalmaíllo, Rascafría and Pelagallinas (Guadarrama and Ayllón Ranges), Hoyos del Espino, Baterna and Riatas (Gredos Range), Peña Negra, Garganta del Trampal, Cuerpo de Hombre and Dehesa de Navamuño (Béjar Range), and finally, Puerto de Santa Clara (Gata Range), usually indicated by increases in *Cytisus/Genista*-type and *Pinus* percentages and decreasing levels of *Betula* in high-altitude sites, while xerophytic taxa (*Helianthemum*-type, Chenopodiaceae, *Artemisia*), heaths and evergreen oaks extend at the expense of wet grasslands (Cyperaceae) at low-altitude sites (Fig. 4). The pollen records of Dehesa de Navamuño and Peña Negra, at high and low-altitudes respectively, are two very good examples of these facts. In all pollen records at both low and high-altitudes in the Spanish Central System, a very significant reduction in anthropogenic taxa (except a few weak peaks of secondary anthropogenic indicators such as *Plantago lanceolata*-type, *Polygonum aviculare*-type, Cichorioideae and *Urtica dioica*-type) occurred ca. 2000–1750 cal BC, as well as a general decrease in the charcoal concentration record (Fig. 5), when it is available.

4.4. A new way of life in the Late Bronze Age–Early Iron Age transition (ca. 1800–400 cal BC)

Middle and Late Bronze Age (ca. 1800–1150 cal BC) communities from Central Iberia would be characterized as small kinship groups living in ephemeral homesteads, concentrated in the same agrarian landscapes of preceding Neolithic groups with a clear preference for fertile soils in valleys and lowlands (~700–1000 m asl), and a dispersed settlement pattern with certain degree of seasonal mobility (Harrison, 1994; Fernández-Posse, 1998; Muñoz, 2000; Blanco-González, 2008, 2010). Only a few poorly understood sites were located above ~1200 m asl. The end of the Bronze Age in the Spanish Central System occurred at ca. 1150 cal BC. In the Gredos Range, the spread of Bronze Age settlements was influenced by a low phreatic level, in a semi-permanent lifestyle of small household communities practicing a cyclical agriculture and livestock husbandry (López-Sáez and Blanco-González, 2005). In western areas of the Spanish Central System, the pollen sequence from the Late Bronze Age site of Castil de Cabras (1046 m asl, Francia Range) indicates a well-preserved forested landscape with both evergreen and deciduous oaks, *Castanea*, *Pistacia terebinthus*, *Arbutus*, and *Viburnum*, low values of anthropogenic and grazing indicators, and *Cerealia*-type pollen (~3–4%) ca. 1300–1150 cal BC. A similar picture is found both in low and high-altitude sites from the Gata, Béjar and Francia Ranges, with birch and pine forests in the highlands (Cuerpo de Hombre, El Quemal-Candelario, La Covatilla, Dehesa de Navamuño, Garganta del Trampal), and oak, birch and hazel forests in lowlands (Puerto de Santa Clara, Jerte, Peña Negra, El Maíllo).

The vernacular and long-lasting ways of life characteristic of the Bronze Age societies collapsed in the last centuries of the 2nd millennium cal BC and the traditional patterns of occupation and exploitation of the environment were substituted by new schemes during a short transitory period known as the Bronze-to-Iron transition (ca. 1100–900 cal BC). Guaya and La Viña archaeological sites (Gredos Range) are dated to the Bronze-to-Iron transition, and their pollen records show a deforested landscape under warm and dry climatic conditions (high values of xerophytic taxa and absence of hygrophytes), evidence of agriculture (*Cerealia*-type >5%) and cattle raising (*Plantago lanceolata*-type, *Sordaria*). The Early Iron Age (ca. 850–400 cal BC) in the Spanish Central System is characterised by the concurrence of important demographical, technological, socio-political and environmental factors. Thus, the 1st millennium cal BC exhibits a sustained trend of rising population (Fernández-Posse, 1998; Blanco-González and Fabián, 2005; Blanco-González, 2010). This is shown by the increasing amount of settlements, the nature of the sites themselves, which are the outcome of processes of demographic aggregation. There is also evidence of clear expansive dynamics towards the highland regions in Central Iberia (Blanco-González, 2010).

From ca. 950 cal BC onwards it has been recognised a gradual process of economic intensification, due to the introduction of know-how and devices from the southern Iberian societies. These features represented a substantial improvement in the agricultural techniques among the local communities, such as the use of the light plough and the implementation of more sustainable strategies of cultivation, i.e. the fallow agriculture and the regeneration of soil nutrients with growing of legumes such as the bean (*Vicia faba*) (Álvarez-Sanchís, 1999, 2000). From the point of view of the social organization, the archaeological evidence for the Early Iron Age allows to acknowledge the emergence of the first nucleated and long-lasting permanent villages – very often on hilltop locations – along with the persistence of small isolated farmsteads in the more fertile lowlands. The inception of this phenomenon occurs in the first centuries of the 1st millennium cal BC and by ca. 700 cal BC it is widely spread and fully consolidated. The dispersed familiar homesteads archetypical of the Bronze Age societies are now replaced by stable, sedentary and self-sufficient villages formed by the aggregation of numerous families, occasionally with over 200 inhabitants. Some of these sites are surrounded by ditches and ramparts, and therefore they constitute the early hill forts in the region (Álvarez-Sanchís, 2000; Blanco-González, 2010).

The onset of the Iron Age in the region has been linked to the so-called 2.8 ka cal BP event (López-Sáez and Blanco-González, 2005; López-Sáez et al., 2009a), an abrupt and short climatic change on a global scale which occurred ca. 850–760 cal BC (van Geel et al., 1998; van Geel and Berglund, 2000). The rather humid period around ca. 850–760 cal BC, corresponding to Bond event 2 (Bond et al., 2001), was contemporary with the Late Bronze Age–Early Iron Age transition in the Spanish Central System, and represents the evolution from warm and dry conditions to wetter and colder ones. The new climatic conditions were responsible for a significant raise in the flow of the main rivers and also affect the subsoil water level, which had direct consequences on the agricultural practices (López-Sáez and Blanco-González, 2005). Pollen sequences from both high (Hoyos del Espino, Narrillos del Rebollar) and low-altitude peat-bogs (Baterna, Riatas) in the Gredos Range show how the increasing rainfall caused a higher environmental humidity ca. 900–850 cal BC, triggering the decline of high-mountain pine forests and increases of wetlands and anthropozoogenous taxa. In the lowlands there was a decrease of evergreen oak forests, wild olive, and xerophytic grasses, while deciduous oak forests and riparian taxa developed. High values of *Cerealia*-type pollen as well as grazing indicators have been documented in the Narrillos del Rebollar record (1560 m asl) at this time. Since ca. 850–700 cal BC, the pollen record from the Early Iron Age site of La Corona (1288 m asl; Francia Range), show a decrease of the arboreal cover and a rise of shrublands, anthropogenic indicators and coprophilous fungi, associated with a summer pastoral land use of high-mountain environments (Fig. 4). On the other hand, in the lowlands, *Corylus* increase its values in Peña Negra (Béjar Range) thanks to its pioneer role, indicating continuous deforestation and intensification of farming and human impact (*Cerealia*-type ~2% and first appearance of *Secale*). The wetter conditions of this period are characterized by increased values of Cyperaceae and by the drop in the percentages of *P. sylvestris*-type, a species better adapted to more continental climatic conditions. Ultimately, the Bronze Age–Iron Age transition did not occur abruptly, but there was a clear continuity in land use patterns.

The 2.8 ka cal BP event is poorly recorded in the Guadarrama Range, because a sedimentary hiatus is documented in most of the pollen sequences from high-altitude sites or many of them start later. In high-altitude pollen records, such as Peñalara or Pepe Hernando, ca. 900–800 cal BC birch-pine forests decreases and hazel levels increase. In the Lozoya-Paular valley, the Rascafría pollen record shows a decrease of pine values at this time and the rise of anthropogenic indicators including *Cerealia*-type. By contrast, the valleys of the Ayllón Range (900–1000 m asl) were relatively more densely inhabited than other areas of the massif during the Bronze Age, with a certain population stability around a series of settlements which seems to indicate a dominant trend to the population concentration (López-Ambite, 2003). However, the pollen record of Pelagallinas only shows a big maximum in the charcoal concentration curve ca. 950–650 cal BC (Fig. 5). Following this period of higher fire activity, *Pinus* is replaced by *Betula* ca. 550 cal BC and the pollen record does not show any increases in anthropogenic indicators (only small peaks from *Plantago lanceolata* and *Cirsium*) and heaths nor clear signs of deforestation around the site. Although these facts might be related to the first shepherds of the Early Iron Age in these mountains, the scarcity of anthropogenic indicators not allow these directly relate to fire activity.

4.5. The emergence of oppida and the Celtic society (ca. 400–50 cal BC)

By the time the Romans got to Central Iberia, different Celtic ethnic groups inhabited the Spanish Central System. The western part of this mountainous system was included in the *Vettonia* (Álvarez-Sanchís, 1999, 2000) whereas the eastern highlands constituted the *Carpetania* region (Abascal and González, 2007). There are several striking features which characterize a distinctive stage within the Iron Age in the study area up to the Roman conquest and effective administrative organisation of the region ca. 50 cal BC. The so-called Late Iron Age (ca. 400–50 cal BC) can thus be regarded as the subsequent culmination of the several processes inaugurated in the Early Iron Age (Álvarez-Sanchís, 2000, 2005). From ca. 400 cal BC onwards, we can state a series of significant trends, that precipitated in the last two centuries cal BC: i) a marked decrease in the number of settlements, with the disappearance of the open air farmsteads in lowland regions; ii) the strong nucleation of the populations within a few large hill forts, some of them transformed into proto-urban centres or *oppida* ca. 150–50 cal BC; iii) the spread of new funerary rituals, with the generalised adoption of the cremation of the dead; iv) the introduction of key technological improvements, such as the potter's wheel, the rotary quern, as well as the widespread use of iron implements, including tools and weapons, and, v) a marked social hierarchical organisation, with the emergence of an elite of warriors, the probable owners of the land – conspicuously delimited by zoomorphic sculptures acting as landmarks – (Fernández-Posse, 1998; Álvarez-Sanchís, 1999, 2000, 2005).

In the Gredos, Gata and Béjar Ranges, within the Vettonian region, pollen records from low (Lanzahíta, Peña Negra, Puerto de Santa Clara) and high-altitude (Puerto de Serranillos, Hoyos del Espino, Navarredonda, Narrillos del Rebollar, Cuerpo de Hombre, Presa del Duque, Garganta del Trampal) peat-bogs, show the presence of a well-developed pine or pine-birch forest in the highlands; and *Pinus pinaster* (Gredos Range), deciduous oaks-hazel (Béjar Range), or alder–birch (Gata Range) forests in the lowlands (Fig. 4). Despite the dominance of forests at this time, there is some evidence of anthropogenic activities linked to grazing and localized agriculture. By contrast, the pollen sequences from archaeological sites characterized as hill forts (El Raso, Las Cogotas, and Mesa de Miranda) or an *oppidum* (Ulaca), in the Gredos Range, document intense deforestation caused by human pressure. They all are located in mountain foothills (~1100 m asl), where the palynological data show the sparse presence of forest in the vicinity of the sites. Their pollen diagrams show the great extensions of grazing pastures, ruderal and anthropogenic taxa, as well as the identification of cereal pollen.

Within the Carpetanian region (Guadarrama and Ayllón ranges), both low (Arroyo de la Hoz) and high-altitude (Navacerrada, Peñalara, Puerto de la Morcuera, Peña de la Morcuera, Pepe Hernando, Puerto de Canencia, Pico del Lobo, Pelagallinas) pollen records show again a well-developed pine or pine-birch forest in the highlands and evergreen and deciduous oaks in the lowlands, with low percentages of anthropogenic pollen indicators (Fig. 4). However, in the Lozoya-Paular valley (Guadarrama Range), the pollen records from Rascafría and Collado del Berrueco demonstrate a relatively deforested landscape, with a low tree cover (<20%) and the proliferation of ruderal and anthropozoogenous taxa (*Aster*-type, Cichorioideae, *Plantago lanceolata*-type, *Urtica dioica*-type) as well as shrublands (*Erica*, *Cistus*). However, these pollen sequences do not demonstrate a high pastoral pressure, since coprophilous fungi are absent while cyanobacteria (*Rivularia*-type) and other indicators of oligotrophic conditions appear continuously (van Geel, 1978; López-Sáez et al., 1998; Ruiz-Zapata et al., 2006a; Gómez-González et al., 2008).

Easternmost pollen sequence from Somolinos (Pela Range) shows also the presence of a well-developed pine forest (~50%), accompanied by evergreen and deciduous oaks, with low representation of herbs and an increase in anthropogenic pollen indicators values since ca. 400 cal BC. The identification of *Cerealia*-type and *Secale* is an evidence of economic productive activities in this area, as well as coprophilous fungi ascospores (*Sporormiella*, *Sordaria*), indicating the presence of crops and some local grazing activities.

4.6. Landscape management during Roman rulership (ca. 50 cal BC–cal AD 450)

The first fights between the indigenous peoples and the Roman army started in 193 BC, with decisive advances during the wars of conquest (155–133 BC), but the hostilities remained till the campaigns of Caesar (61–60 BC) when the definitive pacification of the region was achieved. Only from 50 cal BC it is archaeologically evident the incorporation of the study area under the Roman rulership, as shown by facts such as the presence of later Republican imported commodities, coins or utensils in some of the later pre-Roman hill forts, i.e. El Raso, and in the earlier cities, i.e. *Avela* (modern-day Ávila). The main organization of the Roman countryside in the Lusitanian province was developed ca. 50 AD under the Flavian dynasty, and consisted in the agrarian colonization of the more fertile lands through a web of dispersed sites and the foundation of the earlier *villae* in these lowland landscapes (Blanco-González et al., 2009).

This period is characterized by increasing temperatures and three phases regarding to rainfall are reported by high-resolution pollen analyses of lakes both in south-east Iberia and the Pela Range (eastern Spanish Central System) (Martín-Puertas et al., 2008; Currás et al., 2012): i) a humid initial phase until 190 cal BC; ii) an arid interval from 190 cal BC to cal AD 150; and, iii) a humid phase parallel to the decline of the Roman Empire cal AD 150–350. Generally, the intensification of human pressure it is also distinctive, with the pre-eminence of agricultural activities against livestock farming (Álvarez-Sanchís, 1999), so a greater impact should be expected on lowlands than on montane areas (Sánchez-Palencia et al., 2003). The population gathers in urban centres and the development of a strong network permits livestock long-distance movements (Gómez-Pantoja, 2004). In the Late Roman Period (cal AD 250–450) a significant change occurs, resulting in an increasing drive of *villae*, which implies a further intensification of farming, especially in some montane areas (Blanco-González et al., 2009).

Pollen diagrams show this higher intensity of human pressure in low-altitude deposits around the western-central areas of the massif, such as Fuente de la Mora and El Maíllo on the northern slopes, or Jerte, Herguijuela, Lanzahíta, Puerto de Santa Clara and Peña Negra on the southern ones, some of them likely related to gold mining, especially in the western part (Sánchez-Palencia et al., 2003). Archaeological sites like Mata del Castillo, Laguna de los Casares and El Vergel II provide much evidence of cereal cropping and high grazing pressure in lowlands. It is noteworthy the wide cover of *Juglans* in Fuente de la Mora in the Francia Range. Arboreal pollen reaches its minimum values eastwards in Rascafría, Arroyo de la Hoz, Collado de El Berrueco and Cueva de la Buena Pinta (Guadarrama Range), Pelagallinas (Ayllón Range) and Somolinos (Pela Range) pollen records, pointing to pinewoods deforestation probably due to the use of timber for construction or as fuel, without ruling out mining activities at neighboring sites. It is also noteworthy the high levels of *Cerealia*-type and *Secale cereale* pollen in Somolinos, where can be highlighted the greatest human impact during this period in the whole of the Spanish Central System (Fig. 4). This is probably related to the existence of large urban centres such as Complutum or Duratón, or many small villages and farming communities that are especially abundant in the eastern massif (Guadarrama and Pela Ranges) but much rarer westwards (Gredos and Béjar Ranges). The pollen record from the Dehesa de la Oliva Roman site also provides evidence of a highly deforested landscape and cereal and olive cultivation.

In high-altitude deposits (~1400–2000 m asl) from the Béjar Range, pine pollen records its minimum values while grasslands and heathlands spread, as shown by the pollen sequences of Garganta del Trampal, Dehesa de Navamuño, Garganta de la Solana, Barreza de las Corzas, El Quemal-Candelario, La Covatilla, Cuerpo de Hombre and Presa del Duque, linked to livestock intensification and the extension of tree crops, without excluding the impact of mining activities in the lowlands. In contrast, in the Gredos Range the landscape appears scarcely altered by human activities in high-altitude deposits (~1400–1700 m asl) such as La Serrota, Prado

Please cite this article in press as: López-Sáez, J.A., et al., Vegetation history, climate and human impact in the Spanish Central System over the last 9000 years, Quaternary International (2013), http://dx.doi.org/10.1016/j.quaint.2013.06.034

de las Zorras, Puerto de Chía, Puerto de la Peña Negra, Hoyos del Espino, Navarredonda, Navalguijo, Puerto de Serranillos, Los Conventos, Garganta de las Pozas, Narrillos del Rebollar or Garganta de los Caballeros (Fig. 4). During this time, the Gredos Range was only an access route, and the area was a marginal territory sparsely populated due to its inhospitable character for the development of urban centres (Mariné, 1995).

The situation is completely different in some high-altitude pollen records from the Guadarrama Range such as Loma de Peñas Crecientes, Pepe Hernando and Peñalara, and even in the Ayllón Range (Pelagallinas), in which ca. 100 cal BC–cal AD 450 pine forests are highly deforested and anthropogenic pollen indicators show high values (Fig. 4). Other deposits, such as Navacerrada, Puerto de la Morcuera, Puerto de Canencia, Peña de la Morcuera and Lagunillas remain unaltered. Grazing pressure located only in some mountainous areas, related to the passage of the Roman road "XXIV" (Fuenfría pass) through the Guadarrama Range (Moreno et al., 2004), could explain such differences.

However, all of high-altitude pollen records show the mentioned farming intensification during Late Roman Period, resulting in a broader livestock pressure and a rise of pollen percentages of different crops. *Castanea* and *Olea* curves get continuous during this moment in almost all cases (Fig. 4), with a wider extent of sweet chestnut westwards and olive tree eastwards, likely related to climatic patterns (Janssen, 1994; Atienza, 1996; López-Sáez et al., 1996). Cereal levels also increase, but the long distance to the most suitable places for its cultivation prevents a stronger signal in most of these montane deposits.

Beyond the spread of grasslands to supply the increasing livestock density, the Spanish Central System acted as a passage area of herds through the communication network developed by Romans, who provide the first evidence of livestock long-distance movements (Gómez-Pantoja, 2004). In this sense, the Peña Negra pollen record shows clearly the transition from the land use during the early phases of the Roman Period, when the Béjar Range would have been a secondary cattle transfer zone, to a more intensive model during the Late Roman Period, with high values of coprophilous fungal spores, indicating a further development of livestock grazing. It is also noteworthy the light expansion of *Quercus ilex* and *Q. pyrenaica* forests favoured by the increasing temperatures and the repeated use of fire, and the increase of charcoal accumulation rates in most of the deposits (Fig. 5) during this period.

4.7. The deep transformation of high-mountain landscapes in the Middle Ages (cal AD 450–1450)

4.7.1. Early Middle Ages (cal AD 450–1100)

The Visigothic kingdom (cal AD 450–711) that evolved in Hispania after the Late Roman Empire was based on subsistence farming, and the fall of international trade eased the pressure on forest resources (Valbuena-Carabaña et al., 2010). However, climatic conditions changed strikingly with the onset of Early Medieval Cold Episode (cal AD 450–950), marked by lower temperatures and greater aridity (Desprat et al., 2003; Martín-Puertas et al., 2008). This climatic change clearly influenced the vegetation of the Spanish Central System in the Early Middle Ages, as evidenced in Somolinos pollen record which reports an arid phase extending from the final decades of the Late Roman Period until cal AD 700.

Birch forests increase their representation in almost all pollen records favoured by cold temperatures, possibly indicating a drop of treeline in high-altitude deposits (Fig. 4). However, also lower records located at the westernmost area of Spanish Central System display this spread, like Puerto de Santa Clara or El Maíllo. Eastwards, in the Presa del Duque record (Béjar Range) the drop of treeline is featured by pinewoods, which undergo a wide expansion. Forests also recover in the highest-altitude deposits of the Guadarrama Range such as Navacerrada and Peñalara, and Béjar Range such as Cuerpo de Hombre, Garganta del Trampal and Dehesa de Navamuño, these latter with new maxima of birch pollen.

Nevertheless, the Visigothic Period was a phase of large deforestation processes (López-Sáez et al., 2009b; Abel-Schaad, 2012), especially in montane areas, within a clear livestock-oriented pattern, although cropping keeps on. Forests were cleared to obtain new pastures and new lands were brought into cultivation, in a period of rural habitat proliferation and a land exploitation led by peasantry (Blanco-González et al., 2009). These forest clearances were mainly driven by means of fire (Fig. 5). This is reported in low-altitude deposits like El Maíllo, Lanzahíta, Peña Negra, Collado de El Berrueco, Rascafría and Arroyo de la Hoz, following the trend set by Romans, but more strongly in higher ones like Puerto de Serranillos, Nalvalguijo, Narrillos del Rebollar, Hoyos del Espino and Navarredonda (Gredos Range), Puerto de la Morcuera, Puerto de Canencia, Peña de la Morcuera and Lagunillas (Guadarrama Range), Pelagallinas (Ayllón Range) and Somolinos (Pela Range). This increase is likely related to grazing activities (high values of anthropozoogenous taxa and coprophilous fungi), in order to preserve upland pastures, but also to bring new lands into cultivation, in a new expansive dynamic of the farming strategies (Blanco-González et al., 2009). In this sense, both climatic conditions and the livestock intensification prevent a further expansion of crops in mountain areas. Nonetheless some extension of olive and sweet chestnut groves is detected, especially on southern slopes. The presence of cereal pollen declines as it would grew at a greater distance in areas with milder climatic conditions. However, rye (*S. cereale*), a cereal better adapted to low temperatures, appears in several sites during this period, like Ojos Albos or Peña Negra, pointing to the mentioned increasing human pressure on montane areas.

Until the effective political possession (the so-known Reconquest) and colonization of the Spanish Central System by the northern Christian kingdom ca. 1080 AD, this massif acted as a borderline between Muslim and Christian powers for several centuries (cal AD 711–1100) (Manzano, 1991). It is also a time of climatic transition, between the above mentioned Early Medieval Cold Episode and the Late Medieval Warm Episode (cal AD 950–1350), the latter characterized by similar temperatures to the current ones and moderate rainfall (Desprat et al., 2003), and a marked dry period from the 9th to 11th centuries cal AD (Martín-Puertas et al., 1998). Moreover, severe drought episodes are recorded at the end of the 9th century on the southern slopes of the Spanish Central System (García-Oliva, 2007).

At high-altitudes sites (>1400 m asl) in western areas of the massif (Béjar Range), an initial phase of forest recovery (birch, alder, deciduous oaks) is recorded cal AD 700–950 in the pollen records of Garganta del Trampal, Dehesa de Navamuño, Cuerpo de Hombre and Presa del Duque, as a result of a decline in livestock and farming activities. At this time, heathlands and grasslands decreased, as well as anthropozoogenous taxa, and there is no evidence of olive or sweet chestnut cultivation. Further west the same situation is documented on the southern slopes of the Gata Range (1000 m asl) in the Puerto de Santa Clara pollen sequence. Conversely, at low-altitude sites (~900–1100 m asl) of the Béjar Range (Peña Negra) grasslands spread again by means of fire (Fig. 5) in order to sustain the increasing livestock population. Differences between both slopes are evident in the Francia Range, where El Maíllo northern record shows the dominance of birch forests, while heathlands are widely spread on the southern slopes as recorded in La Meseguera deposit, where *Betula* pollen appears sporadically. The steeper slopes and greater rainfall would have enhanced erosion processes on this side, which would prevent forests to develop.

A similar picture is documented in the Gredos Range at high-altitude sites (>1400 m asl) such as Cuerda del Cervunal, Puerto de las Fuentes, Prado de las Zorras, Hoyos del Espino, Ojos Albos, Puerto de Chía, Puerto de la Peña Negra, Navarredonda and Puerto de Serranillos, and even in the Ayllón Range (Pico del Lobo) cal AD 680–1010, where high-mountain pine forests recover (*P. sylvestris*-type ~50–70%) thanks to cooler and drier climate. There is little evidence of anthropozoogenous taxa, coprophilous fungi, olive cultivation and low values of charcoal concentration (Fig. 5). In low-altitude (~450–600 m asl) pollen records of the southern slopes of the Gredos Range, such Lanzahíta and Eliza, by contrast, *P. pinaster* increase considerably (>60%), as well as *Cistus ladanifer*, while anthropogenic taxa, *Olea*, pyrophilous fungi (*Chaetomium*) and charcoal concentration levels (Figs. 4 and 5) decrease cal AD 710–1120.

By contrast, some high-altitude pollen records from the Guadarrama Range, such as Navacerrada or Puerto de la Morcuera, show the same recovery of pine and birch, while others, such as Peñalara, Peña de la Morcuera, Lagunillas, Loma de Peñas Crecientes, Hoyos de Pinilla and Pepe Hernando, show a very evident human impact by both the increase of anthropozoogenous taxa and the decreasing tree cover. In the Lozoya-Paular valley (Guadarrama Range), the Rascafría record shows a significant increase of *Plantago lanceolata*-type cal AD 800–1000 as well as a decline of tree cover (pines, deciduous and evergreen oak, ash tree) cal AD 895–1170.

The historical data about this period (cal AD 711–1100) fully corroborate the presented palynological data. They describe an economic model based on livestock grazing and small subsistence crops managed by relatively self-sufficient peasants, in central and western areas of the Spanish Central System, in a sparsely populated land (Franco-Moreno, 2005), more dense on mid-altitudes (~900–1110 m asl) than on valleys or high-altitudes (García-Oliva, 2007; Blanco-González et al., 2009). In the Guadarrama Range, in contrast, the settlements were mostly located in the river valleys, while in the mountain a very large number of watchmen were built in order to guard the mountain passes (Jiménez and Rollón, 1987).

After this initial phase of forest recovery, forest clearance is continuous around the above mentioned high-altitude deposits of the Gata, Béjar, Gredos and Guadarrama Ranges cal AD 950. This could be in relation to a seasonal exploitation of these areas, within a trasterminant-type model. Deposits located at lower altitudes show a different pattern. Livestock intensification does not involve a broad clearance of forested areas, neither the use of fire, but even a recovery of pinewoods and oak forests. This is possible thanks to pastures management, especially by means of irrigation, in previously deforested areas, like Peña Negra in the Béjar Range (Abel-Schaad and López-Sáez, 2013), Rascafría and Arroyo de la Hoz in the Guadarrama Range, or Pelagallinas in the Ayllón Range.

Fire and grazing indicators provide a bigger signal too, especially cal AD 1000–1100 (Fig. 5), pointing to a slightly more intense human pressure, in La Meseguera in the Francia Range, Range, probably related to the presence of northern Christian settlers. Crops slightly improve during this phase, helped by the milder climatic conditions of Late Medieval Warm Episode. Olive and, to a lesser extent, sweet chestnut groves grew in almost all sites and so did cereal crops, especially at the transition to the new millennium, as detected in the deposit of Ojos Albos where both *Cerealia*-type and *S. cereale* increase their percentages.

4.7.2. Feudal Period (cal AD 1100–1450)

From the political Re-conquest and demographic repopulation of the Spanish Central System by 1080 AD, some of the members of the urban councils directed a process of intensification of the rural economy (Monsalvo, 2003; Franco-Moreno, 2004). This trend was aimed at supplying the urban markets and was based on the intensification and specialization of livestock husbandry (with relatively long-distance movements between urban centres at both sides of the mountain range), cereal crops and olive and wine production. This period would last until the beginning of Early Modern Period, at the end of 15th century AD. Climate is still under the influence of the Late Medieval Warm Episode, a mild phase which ends with the onset of the Little Ice Age in the mid-14th century cal AD (cal AD 1350–1450) (Desprat et al., 2003). It is characterized by the intensification of farming activities, especially of livestock husbandry. Indeed, this is the ‘golden age’ of La Mesta, an organization founded in 1273 AD, which provided important privileges to large livestock owners (Klein, 1990; Anes and García, 1994). Large transhumant herds travelled through the livestock trails from wintering areas (Barceló, 1984), south of the Spanish Central System, to the northern summer ranges (Fig. 1). This system brought serious conflicts between local and foreign farmers, driving to the establishment of *dehesas* in a strict sense, as lands limited to local livestock use (Ezquerra and Gil, 2008).

Almost all pollen diagrams from high-altitude sites of the whole Spanish Central System show the maximum extent of grasslands and a clear rise in the levels of livestock indicators (anthropozoogenous taxa) (Fig. 4). These facts are in relation to the use of montane areas as summer pasturelands to complement the supply of herds that occupy lowlands the rest of the year, following the ancient trasterminant-type livestock model. Garganta del Trampal (Béjar Range), Hoyos del Espino (Gredos Range), Puerto de la Morcuera and Collado de El Berrueco (Guadarrama Range) pollen records, are good examples. However, some other pollen diagrams also indicate the passage of cattle through long-distance trail ports (Fig. 1), indicated by a lower presence of those livestock indicators, specifically ascospores of coprophilous fungi such as *Sordaria*, *Cercophora*, *Podospora*, *Sporormiella* or *Cercophora* (van Geel, 1978; van Geel et al., 2003; López-Sáez and López-Merino, 2007), within a wider frame of increasing human pressure. This could be the case of Puerto de Santa Clara in the Gata Range or Puerto de Serranillos in the Gredos Range. In addition, some pollen profiles display certain abandonment of livestock, which allows forest recovery, mainly of pinewoods (Fig. 1). This is the case of the pollen records from Navarredonda and Narrillos del Rebollar in the Gredos Range; Puerto de Canencia, Peñalara and Navacerrada in the Guadarrama Range; or Pico del Lobo and Hayedo de Montejo in the Ayllón Range.

The low-altitude deposit of Lanzahíta in the Gredos Range is a good example of an area with poor livestock interest. Pinewoods also recover in Arroyo de la Hoz, in the Guadarrama Range, and in Pelagallinas in the Ayllón Range, while grasslands and livestock indicators drop steadily. On the other hand, birch forests reach to their maximum extent in El Maíllo in the Francia Range. The low values of Poaceae, the minimum of *Erica* pollen and the absence of anthropogenic indicators in this pollen record suggest a continuous human depopulation.

The use of fire increases (Fig. 5), as shown, for instance, the maximum values in the Puerto de Serranillos record, becoming the main driver of landscape change. Previously deforested areas are also managed in order to allow this broad livestock intensification. In this context of overall landscape clearance, heathlands reach their maximum extent, especially on western sector. Eastwards, from the Béjar Range, broom communities with *C. oromediterraneus* and other shrub legumes start their spread to the Ayllón Range, where heathlands are again dominant. The consolidation of mountain settlements brings likewise crop intensification. Both a slight increase of *Castanea* pollen percentages and a more

Please cite this article in press as: López-Sáez, J.A., et al., Vegetation history, climate and human impact in the Spanish Central System over the last 9000 years, Quaternary International (2013), http://dx.doi.org/10.1016/j.quaint.2013.06.034

pronounced rise of *Olea* are detected throughout the mountain chain (Fig. 4). Cereal, after a significant initial drive, suffers a continuous decline in these montane areas.

4.8. The last five centuries of human impact in the Modern Period (cal AD 1450–present)

4.8.1. Early Modern Period (cal AD 1450–1800)

Climatic conditions at the beginning of Early Modern Period correspond to Little Ice Age (LIA), which would have started at the final stages of the Middle Ages, around cal AD 1350, and lasted until the mid-19th century cal AD (Desprat et al., 2003; Jalut et al., 2009). LIA was, in western Europe, a cold interval with an initial drier phase, until cal AD 1550, and a later and more humid one until the recent present (Bradley and Jones, 1993; Manrique and Fernández-Cancio, 2000). The Early Modern Period was a time of overall agricultural expansion, due to the continuous population growth. Cereal crops spread on the valleys and subsequently montane areas suffered a higher livestock density. This increasing livestock intensification weakens the impact of climatic variables at a palaeopalynological level. Olive groves gained great relevance, especially in the 18th century, while sweet chestnut suffered a serious decline because of a disease (Paniagua, 2004). In the late 18th century new regulations were established with the growing concern about the scarcity of forest resources (Ezquerra and Gil, 2008), which would have favoured the development of holm oak, pine or chestnut stands.

Virtually all pollen records show an increase of human pressure on the study area (Fig. 4). Clearance of forests goes on to obtain pastures, particularly by local farmers, who keep their herds by means of trasterminant movements. Only Puerto de Santa Clara (Gata Range), Navarredonda and Puerto de Serranillos (Gredos Range) and Pico del Lobo (Ayllón Range) remain as passages for transhumant livestock, while La Meseguera and El Maíllo (Francia Range), Peña Negra, Garganta del Trampal, Dehesa de Navamuño and Presa del Duque (Béjar Range), La Panera (Gredos Range), and Peñalara (Guadarrama Range), reveal the beginning of local pasturelands exploitation (Fig. 6). Cooler climatic conditions are only inferred by a slight rise of *Betula* pollen values, as shown in Puerto de Santa Clara deposit, or in high-altitude profiles of the Béjar Range. This increase is particularly high in the pollen records of Peñalara, Cerro Genciana, Puerto de la Morcuera, Puerto de Cancencia, Pepe Hernando, Loma de Peñas Crecientes, Hoyos de Pinilla, El Ventoso and El Villar in the Guadarrama Range.

Even those areas that in prior periods had stayed out of livestock activities, like Lanzahíta in the Gredos Range, Arroyo de la Hoz in the Guadarrama Range, or Pelagallinas in the Ayllon Range, suffered their consequences to a greater or lesser extent. Fire reduces the area occupied by pinewoods, especially in Lanzahíta, with maxima of livestock indicators. Likewise, dominant birch forests recorded in El Maíllo, in the Francia Range, start a sharp decline, in spite of climatic conditions, parallel to the spread of heathlands and grasslands, pointing to this overall increasing grazing pressure. The high levels of fire incidence (Fig. 5) favour again the spread of pyrophilous scrub, especially *Cytisus* or *Cistus* communities (Fig. 4). Pollen diagrams from this period are also characterized by alternating peaks of grasslands and heathlands mediated by the interaction between fire recurrences and stocking density, especially in western areas, like La Meseguera in the Francia Range, or eastern ones such as San Benito, Martín Muñoz de Ayllón, Hontanares and Galve de Sorbe in the Ayllón Range.

The establishment of new regulations to promote the spread and conservation of forests (Ezquerra and Gil, 2008) does not seem to be effective, as the species involved suffer generally bigger declines than the slight advances attributable to their plantation. Olive groves are the most developed crop in Early Modern period. All profiles detect rises in *Olea* pollen levels, mainly in the 18th century cal AD. Around this date, a disease affecting sweet chestnut caused the decline of its culture. However, some pollen records show an increase of *Castanea* pollen values – such as Garganta del Trampal and Dehesa de Navamuño in the Béjar Range, Herguijuela and La Meseguera in the Francia Range, Hoyos del Espino and Puerto de Casillas in the Gredos Range, Navacerrada in the Guadarrama Range, Pico del Lobo in the Ayllón Range – likely related to its cultivation in higher areas, where the impact of the disease could have been lower. Cereal pollen appears scarcely throughout pollen diagrams, but its increasing percentages are a new evidence of the mentioned anthropogenic intensification.

4.8.2. Late Modern Period (cal AD 1800–present)

The beginning of this period coincides with the final stages of Little Ice Age, which would have ended at cal AD 1850. From this date onwards, the average temperature has gradually increased up to the present, while rainfall has decreased (Desprat et al., 2003; Jalut et al., 2009). Major political changes in this period will have influenced on vegetation. The dissolution of La Mesta, after a steady decline, far from lightening the livestock pressure on montane areas, caused new clearances to obtain pastures for local farmers (Terés et al., 1995). The Confiscation Laws led to indiscriminate felling of oak forests in order to defray the costs of the purchase of farms (Llorente, 1992). Finally, several Afforestation Plans completed the landscape transformation with massive pine plantations, which contribute to a broad increase of tree cover, but also to a rise of the extension and effects of fires, with controversial results in view of current landscape.

Hence, the Late Modern Period could be considered as a new period of increasing human influence, not only with regard to agriculture, but also in relation to forestry. Despite this situation,

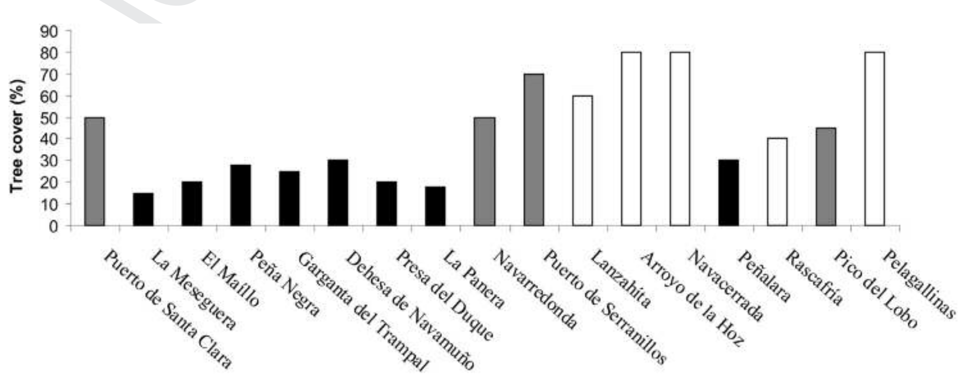

Fig. 6. Pollen percentages of tree cover from several records in the Spanish Central System, from west to east, at the end of the 18th century (cal AD 1750–1800). Low values (<30%) indicate summer grazing areas (black), while high values point to the passage of trashumant herds (gray) or to a poor livestock interest (white).

livestock continues to be the basis of the local economic system in most of the region. Pollen diagrams show maxima of coprophilous fungi and anthropozoogenous taxa and the largest extension of grasslands. By way of illustration, the deposit of El Maíllo registers the maximum extent of heathlands, grasslands and anthropogenic indicators in the uppermost samples, after more than 10 millennia of forest dominance. Only a few records indicate a change of exploitation towards forestry, such as La Meseguera, also in the Francia Range, where the intensive pine plantations prevented a further livestock development until recent decades, when large fires drove to a new spread of pastures ready for grazing (Fig. 5). Forestry has also become the main use in Navacerrada in the Guadarrama Range, a place where the area occupied by pinewoods has hardly changed over the last 3000 years, and in Pelagallinas in the Ayllón Range, which shows the maximum percentage of *Pinus* pollen in the uppermost samples.

All other records display a higher prevalence of livestock, although obviously forestry and cropping are also involved (Fig. 4). The deposit of Puerto de Santa Clara (Gata Range) has become a pastureland for local farmers, but pinewoods and olive groves acquire greater relevance than before. High-altitude sites of Gredos and Béjar Ranges remain and even grow as summer grasslands, also with a significant extent of pine plantations and, at lower altitudes, sweet chestnut and olive groves. Moreover, low-altitude sites in these ranges, like Peña Negra in the Béjar Range or Lanzahíta in the Gredos Range show a shared pattern of olive and chestnut cropping, livestock and forestry only altered by repeated fires. Opposite trends are recorded in Rascafría and Peñalara, both in the Guadarrama Range, the former with a greater livestock relevance in the valley and the latter with a wide expanse of pinewoods in the high-mountain.

Fire incidence reaches high levels, not only its frequency, but also its size (Fig. 5). Monospecific pine plantations favour large-scale fires and dramatic landscape changes. *Cytisus* and *Cistus* communities would have benefited from this situation, as they reach their largest expansion in almost all records. In this sense, the high values of *Cistus* pollen in coprolites collected in Los Torrejones' Cave are striking and illustrative. *Quercus ilex* and *Q. pyrenaica* oak forests also show a slighter advance, likely related to the felling of mature forests which prevent a further spread.

The impact on landscape caused by Afforestation Plans has been much higher in those areas where pinewoods never dominated. By contrast, their effects have been scarce where they were the main tree formation over time, especially on the southern slopes of the Gredos Range, because of a high fire incidence. This highlights the usefulness of long-term studies to design management strategies of plant cover.

5. Conclusions

Palynological evidence indicates that highland pines were dominant in central and eastern areas (Gredos and Guadarrama Ranges) of the Spanish Central System during the early Holocene ca. 9000 cal BC until ca. 3000–2500 cal BC, while western areas (Francia and Béjar Ranges) were dominated by mixed forests of birches and pines until ca. 3300 cal BC. The marked gradient of increasing continentality towards the east (or maritime influence towards the Atlantic Ocean) explains these facts (Franco-Múgica, 2009; Abel-Schaad, 2012).

Palynological and charcoal data records show that vegetation of the Spanish Central System was highly resilient to fire disturbances during the early and mid-Holocene. However, when the recurrence of fire crosses a certain threshold, forests are not able to completely recover and shrublands and grasslands become dominant (Carrión et al., 2010; Gil-Romera et al., 2010; Ruiz-Labourdette et al., 2011; Morales-Molino et al., 2013). In the whole massif this occurred approximately since 4500 cal BC. The establishment of "cultural landscapes" during the expansion of earlier metallurgical communities is clearly depicted in pollen diagrams, especially since the Copper Age, although some evidence of the anthropization process is already denoted from the Middle Neolithic period ca. 4500 cal BC, when a *dehesa* landscape took shape in lowlands and valleys. During the Chalcolithic (3300–1900 cal BC) grazing activities extended towards high-mountains zones, while signs of agriculture and human occupation are increasingly recorded on foothills and valleys.

Currently available data support that agriculture was practiced in the Spanish Central System at the end of the 4th millennium cal BC (ca. 3300–3000 cal BC) in the lowlands of Amblés and Lozoya valleys (Gredos and Guadarrama Ranges respectively). However, its impact on vegetation and landscape seems low until its final establishment towards the 3rd millennium cal BC with the Chalcolithic communities, when the first signs of large-scale deforestation and a more extensive land use are recorded, due both to a lasting permanence and the progressive sedenterisation of the population. From this time onwards, the clearance of forests and the development of cultivated fields, pastures, meadows and heathlands took place, with small differences in time and space depending on natural constraints such as topography, soil and climate, as well as cultural factors.

During the transition from the Late Chalcolithic to the onset of the Early Bronze Age (ca. 2350–1800 cal BC), coinciding with the 4.2 ka cal BP dry event, there are almost no traces of anthropogenic impact on vegetation (neither in charcoal nor in pollen records). The exceptions are a few weak peaks of anthropozoogenous taxa and coprophilous fungi, especially in high-altitude sites, pointing to pasture activities and suggesting subsistence relying on herding and the presence of fairly nomad groups. The convergence of diverse factors such as the progressive deforestation of low-altitude forests during the Middle–Late Bronze Age (ca. 1800–1150 cal BC), the likely demographic rise as shown by the increasing number and size of the Early Iron Age villages (ca. 850–400 cal BC), and the arrival of a climatic abrupt change towards wetter conditions ca. 850–760 cal BC (2.8 ka cal BP event), could have forced these last farming communities to leave the traditional strategies of exploiting the valley bottom and move to new territories, such high-mountain environments, from ca. 850 cal BC, where there were greater hunting opportunities and better forest potential which allowed small-scale agriculture. In any case, the effect of this climatic event in this cultural transition was not the same in each area.

At the time of the Late Iron Age (ca. 400–50 cal BC), anthropic dynamics had different impact on each considered mountain range. Within the Vettonian region (western and central areas of the Spanish Central System), forests are well-developed both in highlands and lowlands areas. Only in the vicinity of archaeological sites (hill forts) is documented an intense deforestation, showing a socioeconomic model deeply rooted in a combination of livestock and agriculture. A marked decrease in the number of settlements, mainly located in foothills (~1100 m asl), the strong nucleation of the population, and the disappearance of the open air farmsteads in lowland regions could explain these facts. Within the Carpetanian region (eastern areas of the massif), high-mountain forests are also well-developed, but lowlands, especially easternmost ones (Pela Range), demonstrate a phase of socio-cultural change with an increase in the number of settlements, territorial organization and new land use systems (Currás et al., 2012), resulting in a deforested landscape with evidence of both grazing and farming activities.

During Roman times (ca. 50 cal BC–cal AD 450), large-scale deforestations resulting in permanent open landscapes which characterize the lowlands areas of the Spanish Central System, as a consequence of the intensification of human activities like cropping, grazing, mining or forestry. However, anthropogenic dynamics in the highlands was different in each area of the massif and was in connection with mining (western areas) or greater settlements (eastern areas), while the Gredos Range (central area) was hardly altered due to its inaccessibility.

At the beginning of the Middle Ages (cal AD 450–1450), the intensity of human impact increased notably cal AD 450–700 after the collapse of the Roman system. This is documented by large deforestation processes at high-altitudes and by a rise of anthropogenic pollen indicators, within a clear livestock-oriented pattern, although new lands were brought into cultivation with the onset of the Early Medieval Cold Episode (cal AD 450–950). An initial phase of forest recovery (birch, alder and deciduous oaks in western areas; pine in central and eastern ones) is recorded in high-mountain environments since cal AD 700–950, as a result of a decline in livestock and farming activities, while agro-pastoral pressure increased in low altitudes. Then a new phase of forest clearance took place in the whole massif cal AD 950–1100, related to trasterminant movements and the milder weather conditions of the Late Medieval Warm Episode (cal AD 950–1350). In the lowlands livestock intensification did not involve a broad clearance of forested areas but some diversification in crops (rye, olive, sweet chestnut cultivation). After the Reconquest, the Feudal Period (cal AD 1100–1450) is the time when the current landscape of the high-mountain areas of the Spanish Central System originated: heathlands in western and eastern areas (Gata, Francia, Béjar and Ayllón Ranges) and broom communities in central ones (Gredos and Guadarrama Ranges). The intensification of farming activities and livestock husbandry, the creation of the La Mesta system with transhumant herds travelling through the livestock trails of these mountains, as well as the repeated use of fire, led to the extension of grasslands and a sharp deforestation of many high-mountain areas, mainly related to their use as summer pasturelands. A few mountainous areas where grazing is limited, however, recovered their forest cover, mainly consisting of pinewoods.

The Early Modern Period is marked by a further intensification of human pressure, not only related to cropping, with a noteworthy broad expansion of olive groves, but also to livestock husbandry, which undergoes an overall spread even in those areas with prior low densities. High fire recurrence is also characteristic in this period, inducing alternating peaks of grasslands and scrublands in pollen diagrams. This weakens the impact of climatic variables, despite this period corresponds to the Little Ice Age, indicated in the pollen records by slight rises of *Betula*. Finally, the Late Modern Period brought major political changes which did not lighten farming pressure on most montane areas. It could be considered as a new period of increasing human influence. Livestock continues to be the main use and the basis of the local economic system in most of the region, despite recent afforestation plans, mainly made with pines, have led some areas to forestry. The high fire incidence promoted growth of *Cistus* and broom communities throughout the ridge.

Acknowledgements

We are indebted to the CONSOLIDER-INGENIO 2010 Program (CSD2007-00058), EXCELENCIA 2011 Program (RNM-7033) and AGRIWESTMED (ERC-Advanced Grants, proposal n° 230561) for financial and technical support. We wish to thank to Fernando Pulido and Ana Valdeolmillos for valuable suggestions. SPD is currently supported by a post-doctoral research grant (Basque Government) at Toulouse-Le Mirail University.

References

Abascal, J.M., González, P., 2007. Carpetania: argumentos para una definición del territorio en época romana. Zona Arqueológica 10, 290–301.

Abel-Schaad, D., 2012. Evolución de la vegetación durante el Holoceno reciente en la vertiente extremeña del Sistema Central a partir del análisis palinológico (PhD dissertation). Universidad de Extremadura, Plasencia.

Abel-Schaad, D., López-Sáez, J.A., 2013. Vegetation changes in relation to fire history and human activities at the Peña Negra mire (Béjar Range, Iberian Central Mountain System, Spain) during the past 4.000 years. Vegetation History and Archaeobotany 22, 199–214.

Abel-Schaad, D., Hernández, A.M., López-Sáez, J.A., Pulido, F.J., López-Merino, L., Martínez-Cortizas, A., 2009a. Evolución de la vegetación en la Sierra de Gata (Cáceres-Salamanca, España) durante el Holoceno reciente. Implicaciones biogeográficas. Revista Española de Micropaleontología 41, 91–105.

Abel-Schaad, D., Hernández, A.M., López-Merino, L., Pulido, F.J., López-Sáez, J.A., 2009b. Cabras y quemorros: Tres siglos de cambios en el paisaje de la vertiente extremeña de la Sierra de Gredos. Revista de Estudios Extremeños 65, 449–478.

Alía, M., Menéndez-Amor, J., Vidal, C., 1957. Livre-Guide de l'excursion C3 et C4 Guadarrama, Massif Peñalara et variation El Escorial-Manzanares el Real. In: V Congres International INQUA. INQUA, Madrid, pp. 28–34.

Álvarez-Sanchís, J.R., 1999. Los Vettones. Real Academia de Historia, Madrid.

Álvarez-Sanchís, J.R., 2000. The Iron Age in Western Spain (800 BC–AD 50): an overview. Oxford Journal of Archaeology 19, 65–89.

Álvarez-Sanchís, J.R., 2005. Oppida and Celtic society in western Spain. Journal of Interdisciplinary Celtic Studies 6, 255–285.

Amor, A., Ladero, M., Valle, C.J., 1993. Flora y vegetación vascular de la comarca de La Vera y laderas meridionales de la Sierra de Tormantos (Cáceres, España). Studia Botanica 11, 11–207.

Andrade, A., 1994. Dinámica de la vegetación durante los últimos 3.000 BP en las Sierras de la Paramera, La Serrota y Villafranca (Ávila) a partir del análisis polínico (PhD dissertation). Universidad de Alcalá de Henares, Madrid.

Andrade, A., González-Jonte, R.H., 2007. El pinar de Hoyocasero (Ávila) ¿antigua repoblación o pinar natural conservado? Anales de Biología 29, 33–51.

Andrade, A., Ruiz-Zapata, M.B., 1995. Evolución de la vegetación en la vertiente septentrional de la Sierra de la Paramera (Ávila, España), durante los últimos 3000 BP, basada en análisis polínicos. In: III Reunião do Quaternario Ibérico. AEQUA, Coimbra, pp. 19–23.

Andrade, A., Martín, T., Ruiz-Zapata, M.B., 1990. Análisis palinológico de la cuenca alta del río Alberche (Ávila). Actas de Gredos 10, 15–18.

Andrade, A., Dorado, M., Ruiz-Zapata, M.B., Acaso, E., 1992. Análisis polínico de una zona de alto interés botánico: el Pinar de Hoyocasero. Actas de Gredos 12, 21–31.

Andrade, A., Dorado, M., Ruiz-Zapata, M.B., 1994a. Estudio comparativo de la evolución de la vegetación a partir del tránsito Subboreal-Subatlántico en las sierras abulenses (Ávila, Sistema Central, España). In: Mateu, I., Dupré, M., Güemes, J., Burgaz, M.E. (Eds.), Trabajos de Palinología Aplicada. Universitat de València, València, pp. 247–261.

Andrade, A., Martín, T., Ruiz-Zapata, M.B., 1994b. Estimaciones de la paleovegetación de la Sierra de la Paramera (Ávila), mediante estudios polínicos. In: La Serna Ramos, I. (Ed.), Polen y Esporas: contribución a su conocimiento. Universidad de La Laguna, Tenerife, pp. 333–342.

Andrade, A., Valdeolmillos, A., Ruiz-Zapata, M.B., 1994c. Modern spectra and contemporary vegetation in the Paramera Range (Ávila, Spain). Review of Palaeobotany and Palynology 82, 127–139.

Andrade, A., Ruiz-Zapata, M.B., Gil-García, M.J., Fombella, M.A., 1996. Acción antrópica y su impacto sobre la vegetación, desde el tránsito Subatlántico-Subboreal, en la vertiente norte de la Sierra de Gredos (Ávila, España). Estudio palinológico. In: Ruiz-Zapata, M.B. (Ed.), Estudios Palinológicos. Universidad Alcalá de Henares, Alcalá de Henares, pp. 7–12.

Anes, G., García, A. (Eds.), 1994. Mesta, trashumancia y vida pastoril. Junta de Castilla y León, Valladolid.

Ashcroft, M.B., 2010. Identifying refugia from climate change. Journal of Biogeography 37, 1407–1413.

Atienza, M., 1993. Evolución del paisaje vegetal en las Sierras de Béjar y Francia durante el Holoceno, a partir del análisis polínico (PhD dissertation). Universidad de Alcalá de Henares, Madrid.

Atienza, M., 1995. Estudio palinológico de los cambios en el límite superior del bosque durante el Holoceno en la Sierra de Béjar. Sistema Central Español. In: Aleixandre, T., Pérez, A. (Eds.), Reconstrucción de paleoambientes y cambios climáticos durante el Cuaternario. C.S.I.C., Madrid, pp. 329–338.

Atienza, M., 1996. Análisis polínico de un depósito próximo al haya de La Herguijuela. Sierra de Francia. Salamanca. In: Ruiz-Zapata, M.B. (Ed.), Estudios Palinológicos. Universidad Alcalá de Henares, Alcalá de Henares, pp. 13–17.

Atienza, M., Ruiz-Zapata, M.B., 1992. Estudio comparativo, desde el punto de vista polínico, de los datos procedentes de algunos depósitos de turba ubicados en las vertientes de Ávila y Salamanca, en la Sierra de Béjar. Actas de Gredos 12, 33–41.

Atienza, M., Gómez-Lobo, A., Ruiz-Zapata, M.B., 1990. Estudio polínico de un depósito localizado en la Garganta del Trampal (Sierra de Béjar, Ávila). Actas de Gredos 10, 19–23.

Atienza, M., Dorado, M., Ruiz-Zapata, M.B., 1991. La palinología en el estudio de la acción antrópica. Aplicación a dos depósitos localizados en la Sierra de Béjar y en la Sierra de Ávila (Ávila). Actas de Gredos 11, 31–38.

Atienza, M., Dorado, M., Gómez-Lobo, A., Ruiz-Zapata, M.B., 1996. Estudio polínico de un depósito situado en la vertiente norte de la Sierra de Béjar. Botánica Macaronésica 23, 201–209.

Barceló, J., 1984. Descripción de las Cañadas Reales. Editorial Museo Universal, Madrid.

Bentley, S., 1991. A Vegetational History of Peñalara in Central Spain. King College, London.

Berglund, B.E., 2003. Human impact and climate changes – synchronous events and a causal link? Quaternary International 105, 7–12.

Blanco-González, A., 2008. Tendencias del uso del suelo en el Valle Amblés (Ávila, España). Del Neolítico al Hierro inicial. Zephyrus 62, 101–123.

Blanco-González, A., 2010. 'Arqueología de la población' entre la Edad del Bronce y el Primer Hierro (1800-400 AC): sobre procesos migratorios y colonizadores en la Submeseta Norte. Arqueología Espacial 28, 361–379.

Blanco-González, A., Fabián, J.F., 2005. Los orígenes de las comunidades castreñas en el suroeste de la Meseta española: El proceso histórico Bronce Final-Segunda Edad del Hierro. Cadernos do Museu Municipal de Penafiel 11, 41–53.

Blanco-González, A., Fabián, J.F., 2010. Un hito de la memoria: el túmulo de El Morcuero (Gemuño, Ávila). Munibe (Antropologia-Arkeologia) 61, 183–212.

Blanco-González, A., Fabián, J.F., 2011. ¿Monumentos evocativos? Los túmulos de Los Tiesos (Mediana de Voltoya, Ávila) en su contexto prehistórico. Munibe (Antropologia-Arkeologia) 62, 251–282.

Blanco-González, A., López-Sáez, J.A., López-Merino, L., 2009. Ocupación y uso del territorio en el sector centromeridional de la cuenca del Duero entre la Antigüedad y la Alta Edad Media (siglos I-XI D.C.). Archivo Español de Arqueología 82, 275–300.

Blasco, C., Liesau, C., Ríos, P. (Eds.), 2011. Yacimientos calcolíticos con Campaniforme de la región de Madrid: Nuevos estudios. Universidad Autónoma, Madrid.

Blasco, M.C., Rovira, S., 1992-1993. La metalurgia del Cobre y del Bronce en la región de Madrid. Tabona 8, 379–415.

Bond, G., Kromer, B., Beer, J., Muscheler, R., Evans, M.N., Showers, W., Hoffmann, S., Lotti-Bond, R., Hajdas, I., Bonani, G., 2001. Persistent solar influence of North Atlantic climate during the Holocene. Science 294, 2130–2136.

Bradley, R.S., Jones, P.D., 1993. 'Little Ice Age' summer temperature variations: their nature and relevance to recent global warming trends. The Holocene 3-4, 367–376.

Bueno, P., Barroso, R., Balbín, R., Campo, M., Exteberría, F., González, A., Herrasti, L., Treserras, J.J., López García, P., López-Sáez, J.A., Matamala, J.C., Sánchez, B., 2002. Áreas habitacionales y funerarias en el Neolítico de la cuenca interior del Tajo: la provincia de Toledo. Trabajos de Prehistoria 59, 65–79.

Bueno, P., Barroso, R., Balbín, R., Campo, M., González, A., Etxebarría, F., Herrasti, L., Galván, V., Juan-Treserras, J., López-Sáez, J.A., López, P., Matamala, J.C., Millos, J., Robledo, B., Trancho, G., Sánchez, B., 2005. Alimentación y economía en contextos habitacionales y funerarios del Neolítico meseteño. In: Arias, P., Ontañón, R., García, C. (Eds.), III Congreso del Neolítico en la Península Ibérica. Universidad de Cantabria, Santander, pp. 83–92.

Burjachs, F., 2001. Análisis palinológico del yacimiento de Guaya, en Berrocalejo de Aragona (Ávila). In: Strato, S.L. (Ed.), Excavación arqueológica en el yacimiento de Guaya, en Berrocalejo de Aragona (Ávila) afectado por el trazado de la autopista de peaje de conexión A-6 (Villacastí n) a Ávila. Informe final, Análisis específicos, vol. II. Strato, Valladolid, pp. 21–32.

Burjachs, F., López-Sáez, J.A., 2003. Análisis paleopalinológico del yacimiento arqueológico de Fuente Lirio (Muñopepe, Ávila). Numantia 8, 51–54.

Carrión, J.S., Munuera, M., Navarro, C., Sáez, F., 2000. Paleoclimas e historia de la vegetación cuaternaria en España a través del análisis polínico. Viejas falacias y nuevos paradigmas. Complutum 11, 115–142.

Carrión, J.S., Andrade, A., Bennett, K.D., Navarro, C., Munuera, M., 2001a. Crossing forest thresholds: inertia and collapse in a Holocene sequence from south-central Spain. The Holocene 11, 635–653.

Carrión, J.S., Munuera, M., Dupré, M., Andrade, A., 2001b. Abrupt vegetation changes in the Segura mountains of southern Spain throughout the Holocene. Journal of Ecology 89, 783–797.

Carrión, J.S., Gil, G., Rodríguez, E., Fuentes, N., García-Antón, M., Arribas, A., 2005. Palynology of badger coprolites from Central Spain. Palaeogeography, Palaeoclimatology, Palaeoecology 226, 259–271.

Carrión, J.S., Fuentes, N., González-Sampériz, P., Sánchez, L., Finlayson, J.C., Fernández, S., Andrade, A., 2007. Holocene environmental change in a montane region of southern Europe with a long history of human settlement. Quaternary Science Reviews 26, 1455–1475.

Carrión, J.S., Fernández, S., González-Sampériz, P., Gil-Romera, G., Badal, E., Carrión-Marco, Y., López-Merino, L., López-Sáez, J.A., Fierro, E., Burjachs, F., 2010. Expected trends and surprises in the Lateglacial and Holocene vegetation history of the Iberian Peninsula and Balearic Islands. Review of Palaeobotany and Palynology 162, 458–475.

Colombaroli, D., Vannière, B., Chapron, E., Magny, M., Tinner, W., 2008. Fire-vegetation interactions during the Mesolithic-Neolithic transition at Lago dell'Accesa, Tuscana, Italy. The Holocene 18, 679–692.

Connor, S.E., Araújo, J., van der Knaap, W.O., van Leeuwen, J.F.N., 2012. A long-term perspective on biomass burning in the Serra da Estrela, Portugal. Quaternary Science Reviews 55, 114–124.

Costa-Tenorio, M., Morla, C., Sainz-Ollero, H. (Eds.), 1997. Los bosques ibéricos. Una interpretación geobotánica. Editorial Planeta, Barcelona.

Currás, A., Zamora, L., Reed, J.M., García-Soto, E., Ferrero, S., Armengol, X., Mezquita-Joanes, F., Marqués, M.A., Riera, S., Julià, R., 2012. Climate change and human impact in central Spain during Roman times: High-resolution multi-proxy analysis of a tufa lake record (Somolinos, 1280 m asl). Catena 89, 31–53.

Delibes, G., Fernández, J., 2000. La trayectoria cultural de la Prehistoria Reciente (6400–2500 BP) en la Submeseta Norte española: principales hitos de un proceso. In: Oliveira, V. (Ed.), Pré-historia recente da Península Ibérica, 3° Congresso de Arqueologia Peninsular. Adecap, Porto, pp. 95–122.

Delibes, G., Herrán, J.I., Santiago, J., Del Val, J., 1995. Evidence for social complexity in the Copper Age of the Northern Meseta? In: Lillios, K.T. (Ed.), The Origins of Complex Societies in Late Prehistoric Iberia, pp. 44–63. Ann Arbor, Michigan.

Delibes, G., Fabián, F.J., Fernández, J., Herrán, J.I., Santiago, J., Del Val, J., 1996. Los más antiguos testimonios del uso y producción de metal en el suroeste de la submeseta norte: consideraciones tipológicas. Humanitas 1, 163–202.

Desprat, S., Sánchez-Goñi, M.F., Loutre, M.F., 2003. Revealing climatic variability of the last three millennia in northwestern Iberia using pollen influx data. Earth and Planetary Science Letters 213, 63–78.

Devesa, J.A., 1995. Vegetación y Flora de Extremadura. Universitas Editorial, Badajoz.

De Vicente, G., González, J.M., Calvo, J.P., Muñoz, A., Giner, J., Rodríguez, M., 1994. Evolución y estructuras alpinas en la zona del centro peninsular. Cadernos do Laboratorio Xeolóxico de Laxe 19, 175–190.

Díaz del Río, P., 2001. La formación del paisaje agrario. Madrid en el III y II milenios BC. Comunidad de Madrid, Madrid.

Díez, A., Pedraza, J., Alonso-Azcárate, J., 1996. Evolución cenozoica de la fosa de Garganta del Villar (Sistema Central Español). In: Grandal d'Anglade, A., Pagés, J. (Eds.), IV Reunión de Geomorfología. Sociedad Española de Geomorfología, O Castro, pp. 59–77.

Dorado, M., 1993. Evolución de la vegetación durante el Holoceno en el Valle de Amblés (Ávila) (PhD dissertation). Universidad de Alcalá de Henares, Madrid.

Dorado, M., Ruiz-Zapata, M.B., 1994. Variabilidad de la lluvia polínica enlos transectos TP1 y TP2 del Valle de Amblés (Ávila). In: La Serna Ramos, I. (Ed.), Polen y Esporas: contribución a su conocimiento. Universidad de La Laguna, Tenerife, pp. 147–157.

Dorado, M., Martín, T., Gil-García, M.J., Ruiz Zapata, M.B., 1990. Estudio comparativo de los datos polínicos procedentes de dos depósitos de distinta naturaleza litológica (turba y material detrítico) localizados en el Valle de Amblés, Ávila. Actas de Gredos 10, 25–32.

Dorado, M., Valdeolmillos, A., Ruiz-Zapata, M.B., 2001. Actividad humana y dinámica de la vegetación en la Sierra de Ávila (Sistema Central Español) desde el Bronce Medio. Polen 11, 39–49.

Estremera, M.S., 2003. Primeros agricultores y ganaderos en la Meseta Norte: el Neolítico de la Cueva de la Vaquera (Torreiglesias, Segovia). Junta de Castilla y León, Zamora.

Ezquerra, F.J., Gil, L., 2008. La transformación histórica del paisaje forestal en Extremadura. In: Tercer Inventario Forestal Nacional 1997–2007. Ministerio de Medio Ambiente, Madrid.

Fabián, J.F., 1993. La secuencia cultural durante la Prehistoria reciente en el Sur de la Meseta Norte española. Trabalhos de Antropologia e Etnologia 33, 145–178.

Fabián, J.F., 1995. El aspecto funerario durante el Calcolítico y la Edad del Bronce en el Sur de la Meseta Norte. El enterramiento colectivo en fosa de El Tomillar (Bercial de Zapardiel, Ávila) en el marco cultural de la Prehistoria reciente del Sur de la Meseta Norte española. Universidad de Salamanca, Salamanca.

Fabián, J.F., 2006. El IV y III Milenio AC en el Valle Amblés (Ávila). Arqueología en Castilla y León, Series Monografías n° 5. Junta de Castilla y León, Salamanca.

Fabián, J., Blanco-González, A., López-Sáez, J.A., 2006. La transición Calcolítico-Bronce Antiguo desde una perspectiva arqueológica y ambiental: el Valle Amblés (Ávila) como referencia. Arqueología Espacial 26, 37–56.

Faegri, K., Iversen, J., 1989. Textbook of Pollen Analysis. Wiley, Chichester.

Fernández, J., Herrán, J.I., Orejas, A., Hernández, M., Paradinas, S., 1997. Minería y poblamiento Calcolítico en Ávila de Los Caballeros. In: Balbín, R., Bueno, P. (Eds.), II Congreso de Arqueología Peninsular: Neolítico, Calcolítico y Bronce. Fundación Rei Alfonso Henriques, Zamora, pp. 527–541.

Fernández-González, F., 1991. La vegetación del valle del Paular (Sierra de Guadarrama, Madrid), I. Lazaroa 12, 153–272.

Fernández-Posse, M.D., 1998. La investigación protohistórica en la Meseta y Galicia. Editorial Síntesis, Madrid.

Franco-Moreno, B., 2004. Territorio y poblamiento en la Kura de Mérida durante el emirato omeya (siglos VIII–X/II–IV). Espacio, Tiempo y Forma, Serie III, Historia Medieval 17, 167–184.

Franco-Moreno, B., 2005. Distribución y asentamiento de tribus bereberes (Imazighen) en el territorio emeritense en época emiral (s. VIII-X). Arqueología y Territorio Medieval 12, 39–50.

Franco-Múgica, F., 1995. Estudio palinológico de turberas holocenas en el Sistema Central: reconstrucción paisajística y acción antrópica (PhD dissertation). Universidad Autónoma, Madrid.

Franco-Múgica, F., 2009. El análisis polínico en la reconstrucción del paisaje vegetal. In: Génova, M., Gómez-Manzaneque, F., Morla-Juaristi, C. (Eds.), Los bosques de Gredos a través del tiempo. Junta de Castilla y León, Valladolid, pp. 89–117.

Franco-Múgica, F., García-Antón, M., 1994. Análisis polínico de una turbera en Rascafría (Madrid). In: La Serna Ramos, I. (Ed.), Polen y Esporas: contribución a su conocimiento. Universidad de La Laguna, Tenerife, pp. 361–369.

Franco-Múgica, F., García-Antón, M., Sainz-Ollero, H., 1997. Impacto antrópico y dinámica de la vegetación durante los últimos 2000 años BP en la vertiente septentrional de la Sierra de Gredos: Navarredonda (Ávila, España). Revue de Paléobiologie 16, 29–45.

Franco-Múgica, F., García-Antón, M., Sainz-Ollero, H., 1998. Vegetation dynamics and human impact in the Sierra de Guadarrama, Central System, Spain. The Holocene 8, 69–82.

Franco-Múgica, F., García-Antón, M., Maldonado, J., Morla, C., Sainz-Ollero, H., 2001. Evolución de la vegetación en el sector septentrional del Macizo de Ayllón (Sistema Central). Análisis polínico de la turbera de Pelagallinas. Anales del Jardín Botánico de Madrid 59, 113–124.

Gaillard, M.J., 2007. Pollen methods and studies: archaeological applications. In: Elias, S. (Ed.), Encyclopedia of Quaternary Science. Elsevier, Amsterdam, pp. 2571–2595.

García-Oliva, M.D., 2007. Un espacio sin poder: la Transierra extremeña durante la época musulmana. Studia Historica, Historia Medieval 25, 89–120.

Gavilán, R., Fernández-González, F., Blasi, C., 1998. Climatic classification and ordination of the Spanish Sistema Central: relationships with potential vegetation. Plant Ecology 139, 1–11.

Gil-García, M.J., 1992. Dinámica de la paleovegetación en el sector oriental del Sistema Central español durante el Holoceno, en base al análisis polínico. Implicaciones climáticas (PhD dissertation). Universidad de Alcalá de Henares, Madrid.

Gil-García, M.J., 2004. Estudio polínico de la huerta del Monasterio del Paular (Rascafría, Madrid). Universidad de Alcalá de Henares, Madrid.

Gil-García, M.J., Ruiz-Zapata, M.B., 1991. Vegetación y clima holocenos en el puerto de la Morcuera (Madrid) en base a datos polínicos. Geogaceta 9, 105–107.

Gil-García, M.J., Ruiz-Zapata, M.B., 1994. Resultados polínicos correspondientes al sector oriental del Sistema Central Español. In: La Serna Ramos, I. (Ed.), Polen y Esporas: contribución a su conocimiento. Universidad de La Laguna, Tenerife, pp. 381–391.

Gil-García, M.J., Ruiz-Zapata, M.B., Andrade, A., Vázquez, R., 1989. Datos palinológicos de una turbera localizada en el Puerto de Canencia (Madrid). Henares, Revista de Geología 3, 141–146.

Gil-García, M.J., Tomás Las Heras, R., Ruiz-Zapata, M.B., 1993a. Contribución al conocimiento de la dinámica de la vegetación en el sector oriental del Sistema Central español, en base al análisis polínico. Geogaceta 13, 46–48.

Gil-García, M.J., Tomás Las Heras, R., Ruiz-Zapata, M.B., 1993b. Acción antrópica y reconstrucción de la vegetación durante el Holoceno reciente en el Hayedo de Montejo (Madrid). Nova Acta Científica Compostelana 4, 49–57.

Gil-García, M.J., Tomás Las Heras, R., Ruiz-Zapata, M.B., 1993c. Paleovégétation pendand le Quaternaire récent dans le Puerto de Morcuera "Col de Morcuera" (Système Central, Espagne). Quaternaire 4, 31–37.

Gil-García, M.J., Martín, T., Tomás Las Heras, R., Ruiz-Zapata, M.B., 1994a. Evolución de los táxones arbóreos más relevantes en el sector oriental del Sistema Central Español. In: Mateu, I., Dupré, M., Güemes, J., Burgaz, M.E. (Eds.), Trabajos de Palinología Aplicada. Universitat de València, València, pp. 233–245.

Gil-García, M.J., Tomás Las Heras, R., Ruiz-Zapata, M.B., 1994b. Cambios climáticos y vegetación durante el Holoceno (2500 BP) en el Puerto de Canencia (Madrid-España). Revue de Paléobiologie 13, 381–389.

Gil-García, M.J., Tomás Las Heras, R., Ruiz-Zapata, M.B., 1994c. Evolución de los hayedos y dinámica de la vegetación en el Sistema Central Español en base a estudios polínicos. Revue de Paléobiologie 13, 399–409.

Gil-García, M.J., Tomás Las Heras, R., Ruiz-Zapata, M.B., 1995a. Degradación antropogénica de la vegetación, en base al análisis polínico, en la Sierra de Guadarrama: Altos de Hontanar (Madrid). Lazaroa 15, 151–163.

Gil-García, M.J., Tomás Las Heras, R., Ruiz-Zapata, M.B., 1995b. Influencia humana sobre el paisaje vegetal pasado en el Puerto de la Quesera. Nova Acta Científica Compostelana 5, 153–160.

Gil-García, M.J., Tomás Las Heras, R., Ruiz-Zapata, M.B., 1995c. Historia del paisaje vegetal y acción antrópica en el Cerro Genciana (Sierra de Guadarrama, Madrid) durante el Holoceno reciente. Polen 7, 32–39.

Gil-García, M.J., Martín, T., Tomás Las Heras, R., Ruiz-Zapata, M.B., 1995d. Reconstrucción del paleoambiente en el Macizo de Ayllón (Sistema Central Español) durante el Holoceno a través del análisis polínico. In: III Reunião do Quaternario Ibérico. AEQUA, Coimbra, pp. 49–54.

Gil-García, M.J., Martín, T., Tomás Las Heras, R., Ruiz-Zapata, M.B., 1996a. Dinámica de la vegetación durante el Holoceno en el Puerto de Canencia (Madrid): relación con el espectro polínico. Botánica Macaronésica 23, 221–232.

Gil-García, M.J., Tomás Las Heras, R., Ruiz-Zapata, M.B., 1996b. Degradación antropogénica de la vegetación en el Puerto de la Morcuera (Sierra de Guadarrama, España) durante los últimos 2.000 años, en base al análisis polínico. Boletín de la Real Sociedad Española de Historia Natural (Sección Biología) 92, 29–36.

Gil-García, M.J., Tomás Las Heras, R., Ruiz-Zapata, M.B., 1996c. Paleovegetation, climate and human action during the Upper Holocene at Morcuera Pass (Madrid, Spain). Revue de Paléobiologie 15, 469–478.

Gil-Romera, G., López-Merino, L., Carrión, J.S., González-Sampériz, P., Martín-Puertas, C., López-Sáez, J.A., Fernández, S., García-Antón, M., Stefanova, V., 2010. Interpreting resilience through long-term ecology: potential insights in Western Mediterranean landscapes. The Open Ecology Journal 3, 43–53.

Gómez-González, C., 2007. Actividad antrópica y vegetación en el valle del Lozoya (Madrid) durante el Holoceno reciente (PhD dissertation). Universidad de Alcalá de Henares, Madrid.

Gómez-González, C., Ruiz-Zapata, M.B., López-Sáez, J.A., Gil-García, M.J., Santiesteban, J., Mediavilla, R., Domínguez, F., 2007. El paisaje vegetal durante el Holoceno reciente en el Macizo de Peñalara (Sierra de Guadarrama, Madrid). In: XII Reunión Nacional de Cuaternario. AEQUA, Ávila, pp. 197–198.

Gómez-González, C., Ruiz-Zapata, M.B., López-Sáez, J.A., Gil-García, M.J., 2008. Uses of non pollen palynomorphs as a source of information of anthropic activities in the Rascafría site (Lozoya valley river, Madrid, Spain) during the last 2.500 BP. In: Maritan, M., Miola, A. (Eds.), 3rd International Workshop on Quaternary Non-pollen-palynomorphs. University of Padua and Regional Park of Euganean Hills, Padua, pp. 20–23.

Gómez-González, C., Ruiz-Zapata, B., López-Sáez, J.A., 2009a. Algunos palinomorfos polínicos y no polínicos como indicadores de antropización: un ejemplo. Ingeniería, Investigación y Desarrollo 8, 2–7.

Gómez-González, C., Ruiz-Zapata, M.B., López-Sáez, J.A., Gil-García, M.J., 2009b. Aportaciones de la palinología en la reconstrucción del impacto ganadero, en los alrededores de Rascafría (Madrid), durante el Holoceno reciente. In: Romero, A., Belmonte, F., Alonso, F., López, F. (Eds.), Advances in Studies on Desertification, Topic 5: Impact of Livestock and Agriculture in Terrestrial Ecosystems. Universidad de Murcia, Murcia, pp. 693–696.

Gómez-González, C., Ruiz-Zapata, B., Gil-García, M.J., López-Sáez, J.A., Santiesteban, J., Mediavilla, R., Domínguez, F., Vera, S., 2009c. Evolución del paisaje vegetal durante los últimos 1.680 años BP en el Macizo de Peñalara (Sierra de Guadarrama, Madrid). Revista Española de Micropaleontología 41, 75–89.

Gómez-Manzaneque, F., 2009. La cubierta vegetal y la flora. In: Génova, M., Gómez-Manzaneque, F., Morla-Juaristi, C. (Eds.), Los bosques de Gredos a través del tiempo. Junta de Castilla y León, Valladolid, pp. 43–85.

Gómez-Pantoja, J., 2004. Pecora consectari: transhumance in Roman Spain. In: Santillo-Frizell, B. (Ed.), Pecus: Man and Animal in Antiquity. The Swedish Institute in Rome, Rome, pp. 94–102.

González-Tablas, F.J., 1983. Los Castillejos de Sanchorreja y su influencia en las culturas del Bronce Final y de la Edad del Hierro de la Meseta Norte (PhD dissertation). Universidad de Salamanca, Salamanca.

González-Tablas, F.J., Domínguez-Calvo, A., 2002. Los Castillejos de Sanchorreja (Ávila): campañas de 1981, 1982 y 1985. Ediciones Universidad de Salamanca, Salamanca.

Harrison, R.J., 1994. The Bronze Age in Northern and Northeastern Spain 2000–800 BC. In: Mathers, C., Stoddart, S. (Eds.), Development and Decline in the Mediterranean Bronze Age. University of Sheffield, Sheffield, pp. 73–97.

Hernández-Bermejo, J.E., Sainz-Ollero, H., 1984. Ecología de los hayedos meridionales ibéricos: el macizo de Ayllón. M.A.P.A., Madrid.

Hernández-Vera, T., Ruiz-Zapata, M.B., 1984. Datos preliminares de los análisis polínicos de las tollas ubicadas en Galve de Sorbe (Guadalajara). Anales de la Asociación de Palinólogos de Lengua Española 1, 71–76.

Hua, Q., Barbetti, M., 2004. Review of tropospheric bomb ^{14}C data for carbon cycle modelling and age calibration purposes. Radiocarbon 46, 1273–1298.

Jalut, G., Esteban, A., Bonnet, L., Gauquelin, T., Fontugne, M., 2000. Holocene climatic changes in the western Mediterranean, from south-east France to south-east Spain. Palaeogeography, Palaeoclimatology, Palaeoecology 160, 255–290.

Jalut, G., Dedoubat, J.J., Fontugne, M., Otto, T., 2009. Holocene circum-Mediterranean vegetation changes: climate forcing and human impact. Quaternary International 200, 4–18.

Janssen, C., 1994. Palynological indications for the extent of the impact of man during Roman times in the western part of the Iberian Peninsula. In: Frenzel, B. (Ed.), Evaluation of Land Surfaces Cleared from Forest in the Mediterranean Region during the Time of the Roman Empire, Palaeoclimate Research. Gustav Fischer, Stuttgart, pp. 15–22.

Jiménez, J., 2000. Megalithic tombs and chalcolithic settlement in the Guadarrama mountains: following ancient roads, marking out territory. Journal of Iberian Archaeology 2, 99–109.

Jiménez, J., 2010. Cazadores y campesinos: la neolitización del interior de la Península Ibérica. Real Academia de Historia, Madrid.

Jiménez, J., Rollón, A., 1987. Guía de los castillos de Madrid. Editorial Tierra del Fuego, Madrid.

Jiménez-Ballesta, R., López, J., López-García, P., Ibáñez, J.J., 1985. Contribución al conocimiento de las formaciones superficiales turbosas en las Sierras de Guadarrama y Ayllón. Análisis polínicos. In: I Reunião do Quaternario Ibérico. AEQUA, Lisboa, pp. 213–224.

Jimeno, A., 1988. La investigación del Bronce Antiguo en la Meseta superior. Trabajos de Prehistoria 45, 103–121.

Klein, J., 1990. La Mesta: estudio de la historia económica española, 1273–1836. Alianza Editorial, Madrid.

Llorente, J.M., 1992. Identidad serrana, cultura silvícola y tradición forestal: La crisis de los aprovechamientos tradicionales en las tierras salmantinas y la opción forestal. Agricultura Y Sociedad 65, 217–252.

López-Ambite, F., 2003. El poblamiento de Cogotas I en el valle de los ríos Aguisejo y Riaza (Segovia). Complutum 14, 125–168.

López-García, P., 1985. Resultados de análisis polínicos del Holoceno en la Meseta española procedentes de yacimientos arqueológicos. Anales de la Asociación de Palinólogos de Lengua Española 2, 283–288.

López-García, P., 1986. Estudio palinológico del Holoceno español a través del análisis de yacimientos arqueológicos. Trabajos de Prehistoria 43, 143–158.

López-García, P., 1997. El Paisaje Vegetal de la Comunidad de Madrid durante el Holoceno Final. Comunidad de Madrid, Madrid.

López-Jiménez, O., López-Sáez, J.A., 2005. Paleoambiente y formación de los paisajes antiguos de la comarca de la Sierra de Francia (Salamanca, España): de la estructura social a la creación del paisaje. Conimbriga 44, 5–24.

López-Merino, L., López-Sáez, J.A., Alba-Sánchez, F., Pérez-Díaz, S., Carrión, J.S., 2009. 2000 years of pastoralism and fire shaping high-altitude vegetation of Sierra de Gredos in central Spain. Review of Palaeobotany and Palynology 158, 42–51.

López-Sáez, J.A., 1995. Las comunidades de *Prunus lusitanica* L. del Valle del Tiétar (Sierra de Gredos, Ávila). Anales de Biología 20, 111–113.

López-Sáez, J.A., 2002. Análisis paleopalinológico del yacimiento Dehesa de Río Fortes (Mironcillo, Ávila). Boletín del Seminario de Estudios de Arte y Arqueología 68, 42–48.

López-Sáez, J.A., 2007. El Valle Amblés en el III milenio cal BC. Acerca del origen antropozoógeno del paisaje. Cuadernos Abulenses 36, 211–221.

López-Sáez, J.A., 2011. Análisis palinológico del túmulo de Los Tiesos (Mediana de Voltoya, Ávila). Munibe (Antropologia-Arkeologia) 62, 283–288.

López-Sáez, J.A., Blanco-González, A., 2004. El paisaje de una comunidad agraria en el borde de la Cuenca del Duero: análisis paleopalinológico del yacimiento Protocogotas de la Gravera de Puente Viejo (Mingorría, Ávila, España). Zephyrus 57, 195–219.

López-Sáez, J.A., Blanco-González, A., 2005. La mutación Bronce Final/Primer Hierro en el suroeste de la Cuenca del Duero (provincia de Ávila): ¿cambio ecológico y social? In: Blanco, A., Cancelo, C., Esparza, A. (Eds.), Bronce Final y Edad del Hierro en la Península Ibérica. Universidad de Salamanca, Salamanca, pp. 229–250.

López-Sáez, J.A., Burjachs, F., 2002. Análisis palinológico de la Fosa de Valdeprados. Una contribución al conocimiento del paisaje calcolítico en el Valle Amblés (Ávila). Cuadernos Abulenses 31, 11–23.

López-Sáez, J.A., Burjachs, F., 2002-2003. El paisaje durante el Calcolítico en el Valle Amblés (Ávila). Análisis paleopalinológico del yacimiento de Aldeagordillo. Estudos Pré-históricos 10-11, 107–118.

López-Sáez, J.A., López-García, P., 1994. Contribution of the palaeoecological knowledge of Quaternary in the Tietar Valley (Sierra de Gredos, Ávila, Spain). Revista Española de Micropaleontología 26, 61–66.

López-Sáez, J.A., López-García, P., 2003. Análisis palinológico del poblado calcolítico de Los Itueros (Santa María del Arroyo, Valle Amblés, Ávila, España). Trabalhos de Antropologia e Etnologia 43, 171–180.

López-Sáez, J.A., López-García, P., 2004. La agricultura en el Valle Amblés (Ávila, España) durante el III milenio cal BC. Consideraciones arqueopalinológicas. Trabalhos de Antropologia e Etnologia 44, 169–180.

López-Sáez, J.A., López-García, P., 2006. Homme et milieu dans la Vallée Amblés (Massif Central, Ávila, Espagne) pendant le Chalcolithique. De la stratégie de peuplement à la paleoéconomie. In: Miras, Y., Surmely, F. (Eds.), Environnement et peuplement de la moyenne montagne du Tardiglaciaire à nos jours. Presses Universitaires de Franche-Comté, Besançon, pp. 145–155.

López-Sáez, J.A., López-Merino, L., 2007. Coprophilous fungi as a source of information of anthropic activities during the Prehistory in the Amblés Valley (Ávila, Spain): the archaeopalynological record. Revista Española de Micropaleontología 39, 103–116.

López-Sáez, J.A., López-García, P., Macías, R., 1991. Análisis polínico del yacimiento arqueológico de El Raso de Candeleda (Ávila). Actas de Gredos 11, 39–44.

López-Sáez, J.A., López-García, P., Gómez, C., Gil, P., 1996. Acerca del origen del castaño (*Castanea sativa*) en el Valle del Tiétar (Sierra de Gredos, Ávila). In: Ruiz-Zapata, M.B. (Ed.), Estudios Palinológicos. Universidad Alcalá de Henares, Alcalá de Henares, pp. 79–82.

López-Sáez, J.A., López-García, P., Macías, R., 1997. Acción antrópica y reconstrucción de la vegetación durante el Holoceno reciente en el valle del Tiétar, Sierra de Gredos (Ávila). Cuaternario y Geomorfología 11, 43–54.

López-Sáez, J.A., van Geel, B., Farbos-Texier, S., Diot, M.F., 1998. Remarques paléoécologiques à propos de quelques palynomorphes non-polliniques provenant de sédiments quaternaires en France. Revue de Paléobiologie 17, 445–459.

López-Sáez, J.A., Martín, M., López-García, P., 1999. Evolución del paisaje de Lanzahíta (Valle del Tiétar, Ávila) durante el Holoceno reciente: Una interpretación palinológica. Trasierra 4, 81–86.

López-Sáez, J.A., López-García, P., Burjachs, F., 2003a. Arqueopalinología: Síntesis Crítica. Polen 12, 5–35.

López-Sáez, J.A., Dorado, M., Burjachs, F., Ruiz-Zapata, B., López-García, P., Fabián, J.F., 2003b. Paleoambiente y paleoeconomía durante la Prehistoria en el Valle Amblés (Ávila). Polen 13, 129–141.

López-Sáez, J.A., López-García, P., López-Merino, L., Cerrillo, E., González, A., Prada, A., 2005a. Prehistoric landscapes in North Extremadura between the VIth and the IVth millenia cal. BC. Journal of Iberian Archaeology 7, 23–35.

López-Sáez, J.A., Rodríguez-Marcos, J.A., López-García, P., 2005b. Paisaje y economía durante el Bronce antiguo en la Meseta Norte desde una perspectiva paleoambiental: algunos casos de estudio. Boletín del Seminario de Estudios de Arte y Arqueología 71, 65–88.

López-Sáez, J.A., González, A., Cerrillo, E., 2007a. Paleoambiente y paleoeconomía durante el Neolítico antiguo y el Calcolítico en Extremadura: análisis arqueopalinológico del yacimiento del Cerro de la Horca (Plasenzuela, Cáceres, España). Zephyrus 60, 145–153.

López-Sáez, J.A., López-García, P., López-Merino, L., Cerrillo, E., González, A., Prada, A., 2007b. Origen prehistórico de la dehesa en Extremadura: Una perspectiva paleoambiental. Revista de Estudios Extremeños 63, 493–509.

López-Sáez, J.A., López-Merino, L., Pérez-Díaz, S., 2008. Los vettones y sus paisajes: paleoambiente y paleoeconomía de los castros de Ávila. In: Álvarez-Sanchís, J. (Ed.), Arqueología Vettona. La Meseta Occidental en la Edad de Hierro, Zona Arqueológica 12. Museo Arqueológico Regional, Alcalá de Henares, pp. 140–152.

López-Sáez, J.A., Blanco-González, A., López-Merino, L., Ruiz-Zapata, M.B., Dorado, M., Pérez-Díaz, S., Valdeolmillos, A., Burjachs, F., 2009a. Landscape and climatic changes during the end of the Late Prehistory in the Amblés Valley (Ávila, central Spain), from 1200 to 400 cal BC. Quaternary International 200, 90–101.

López-Sáez, J.A., López-Merino, L., Alba-Sánchez, F., Pérez-Díaz, S., 2009b. Contribución paleoambiental al estudio de la trashumancia en el sector abulense de la Sierra de Gredos. Hispania 69, 9–38.

López-Sáez, J.A., López-Merino, L., Alba-Sánchez, F., Pérez-Díaz, S., Abel-Schaad, D., Carrión, J.S., 2010a. Late Holocene ecological history of *Pinus pinaster* forests in the Sierra de Gredos of central Spain. Plant Ecology 206, 195–209.

López-Sáez, J.A., Alba, F., López-Merino, L., Pérez-Díaz, S., 2010b. Modern pollen analysis: a reliable tool for discriminating *Quercus rotundifolia* communities in Central Spain. Phytocoenologia 40, 57–72.

Magny, M., 1993. Solar influence on Holocene climatic changes illustrated by correlations between past lake-level fluctuations and the atmospheric ^{14}C record. Quaternary Research 40, 1–9.

Magny, M., 2004. Holocene climate variability as reflected by mid-European lake-level fluctuations and its probable impact on prehistoric human settlements. Quaternary International 113, 65–79.

Magny, M., Vannière, B., Zanchetta, G., Fouache, E., Touchais, G., Petrika, L., Coussot, C., Walter-Simonnet, A.V., Arnaud, F., 2009. Possible complexity of the climatic event around 4300–3800 cal. BP in the central and western Mediterranean. The Holocene 19, 823–833.

Manrique, E., Fernández-Cancio, A., 2000. Extreme climatic events in dendroclimatic reconstructions from Spain. Climatic Change 44, 123–138.

Manzano, E., 1991. La frontera de al-Andalus en la época de los Omeyas. CSIC, Madrid.

Mariné, M., 1995. El patrimonio arqueológico de la Sierra de Gredos. In: Trotitiño, M.A. (Ed.), Gredos: territorio, sociedad y cultura. Diputación de Ávila, Ávila, pp. 19–48.

Martín-Puertas, C., Valero-Garcés, B.L., Mata, M.P., González-Sampériz, P., Bao, R., Moreno, A., Stefanova, V., 2008. Arid and humid phases in southern Spain during the last 4000 years: The Zoñar Lake record, Córdoba. The Holocene 18, 907–921.

Martín-Velázquez, S., Elorza, F.J., 2007. Deformación cenozoica de la litosfera Ibérica: Sistema Central y cuencas del Duero y Tajo. Geogaceta 42, 11–14.

Médail, F., Diadema, K., 2009. Glacial refugia influence plant diversity in the Mediterranean Basin. Journal of Biogeography 36, 1333–1345.

Misiego, J.C., Marcos, G.J., Martín, M.A., Sanz, F.J., Villanueva, L.A., 2005. Guaya (Berrocalejo de Aragona, Ávila): reconstrucción de la vida y economía de un poblado en los albores de la Edad del Hierro. In: Blanco, A., Cancelo, C., Esparza, A. (Eds.), Bronce Final y Edad del Hierro en la Península Ibérica. Universidad de Salamanca, Salamanca, pp. 207–228.

Monsalvo, J.M., 2003. Frontera pionera, monarquía en expansión y formación de los concejos de villa y tierra. Relaciones de poder en el realengo concejil entre el Duero y el Tajo (c. 1072–c. 1222). Arqueología y Territorio Medieval 10, 45–126.

Morales-Molino, C., García-Antón, M., Postigo-Mijarra, J.M., Morla, C., 2013. Holocene vegetation, fire and climate interactions on the westernmost fringe of the Mediterranean Basin. Quaternary Science Reviews 59, 5–17.

Moreno, I., Rivas, J., Rodríguez, J., 2004. La vía romana del Puerto de la Fuenfría (desde Segovia a Galapagar). Estudios de Prehistoria y Arqueología Madrileñas 13, 117–174.

Muñoz, K., 2000. The Tagus Middle Basin (Iberian Peninsula) from the Neolithic to the Iron Age (V-I millenium cal. BC): the long way to social complexity. Oxford Journal of Archaeology 19, 241–272.

Palacios, D., Marcos, J., Vázquez-Selem, L., 2011. Last Glacial Maximum and deglaciation of Sierra de Gredos, central Iberian Peninsula. Quaternary International 233, 16–26.

Paniagua, J.A., 2004. Estudio etnográfico de Losar de la Vera. Revista de Estudios Extremeños 60, 475–514.

Pausas, J.G., Keeley, J.E., 2009. A burning story: the role of fire in the history of life. BioScience 59, 593–601.

Pedraza, J., 1989. La morfogénesis del Sistema Central y su relación con la morfología granítica. Cadernos do Laboratorio Xeolóxico de Laxe 13, 31–46.

Pedraza, J., 1994a. Los modelos genético-evolutivos del Sistema Central Español: Implicaciones morfotectónicas. Cadernos do Laboratorio Xeolóxico de Laxe 13, 91–118.

Pedraza, J., 1994b. Geomorfología del Sistema Central. In: Gutiérrez-Elorza, M. (Ed.), Geomorfología de España. Editorial Rueda, Madrid, pp. 63–100.

Pedraza, J., Carrasco, R.M., 1999. Morfotectónica del Sistema Central Español. Ideas actuales. Studia Geologica Salmanticensia 7, 51–71.

Pedraza, J., Carrasco, R.M., 2006. El glaciarismo Pleistoceno del Sistema Central. Revista de la Asociación Española para la Enseñanza de las Ciencias de la Tierra 13, 278–288.

Peinado-Lorca, M., Rivas-Martínez, S., 1987. La vegetación de España. Universidad de Alcalá de Henares, Madrid.

Pérez-Obiol, R., Jalut, G., Julià, R., Pèlachs, A., Iriarte, M.J., Otto, T., Hernández-Beloqui, B., 2011. Mid-Holocene vegetation and climatic history of the Iberian Peninsula. The Holocene 21, 75–93.

Pulido, F., Sanz, R., Abel-Schaad, D., Ezquerra, F.J., Gil, A., González, G., Hernández, A., Moreno, G., Pérez, J.J., Vázquez, F., 2007. Los bosques de Extremadura. Evolución, ecología y conservación. Junta de Extremadura, Mérida, p. 343.

Riera, S., López-Sáez, J.A., Argilagós, J.B., 2004. Premières traces d'anthropisation à l'est de la Péninsule Ibérique et les Îles Baléares. In: Richard, H. (Ed.), Néolithisation précoce. Premières traces d'anthropisation du couvert végétal à partir des données polliniques. Presses Universitaires Franc-Comtoises, Besançon, pp. 195–220.

Rius, D., Vannière, B., Galop, D., 2009. Fire frequency and landscape management in the north-western Pyrenean piedmont (France) since the early Neolithic (8000 cal. BP). The Holocene 19, 847–859.

Rius, D., Vannière, B., Galop, D., Richard, H., 2011. Holocene fire regime changes from multiple-site sedimentary charcoal analyses in the Lourdes Basin (Pyrenees, France). Quaternary Science Reviews 30, 1696–1709.

Rius, D., Vannière, B., Galop, D., 2012. Holocene history of fire, vegetation and land use from the central Pyrenees (France). Quaternary Research 77, 54–64.

Rivas-Martínez, S., 1963. Estudio de la vegetación y flora de las Sierras de Guadarrama y Gredos. Anales del Instituto Botánico A.J. Cavanilles 21, 5–325.

Rivas-Martínez, S., Belmonte, D., Cantó, P., Fernández-González, F., Fuente, V., Moreno, J.M., Sánchez-Mata, D., Sancho, L.G., 1987. Piornales, enebrales y pinares oromediterráneos (Pino-Cytision oromediterranei) en el Sistema Central. Lazaroa 7, 93–124.

Rojo, M.A., Garrido, R., García-Martínez, I. (Eds.), 2012. El Neolítico en la Península Ibérica y su contexto europeo. Ediciones Cátedra, Madrid.

Rubiales, J.M., García-Amorena, I., Génova, M., Gómez-Manzaneque, F., Morla, C., 2007. The Holocene history of highland pine forests in a submediterranean mountain: the case of Gredos mountain Range (Iberian Central Range). Quaternary Science Reviews 26, 1759–1770.

Rubiales, J.M., Morales-Molino, C., García, S., García-Antón, M., 2012. Negative responses of highland pines to anthropogenic activities in inland Spain: a palaeoecological perspective. Vegetation History and Archaeobotany 21, 397–412.

Ruiz del Árbol, M., Sánchez, J.F., López-Sáez, J.A., López-García, P., Macías, R., López-Jiménez, O., 2003. A geoarchaeological approach to the study of Roman terraces: landscape transformations in a mining area in the north-western Iberian Peninsula. In: Fouache, E. (Ed.), The Mediterranean World Environment and History. Elsevier SAS, Paris, pp. 331–339.

Ruiz del Castillo, J., 1993. Análisis palinológico de nueve perfiles turbosos cuaternarios en el sector oriental del Sistema Central Español (PhD dissertation). Universidad Complutense, Madrid.

Ruiz-Labourdette, D., Martínez, F., Martín-López, B., Montes, C., Pineda, F.D., 2011. Equilibrium of vegetation and climate at the European rear edge. A reference for climate change planning in mountainous Mediterranean regions. International Journal of Biometeorology 55, 285–301.

Ruiz-Zapata, M.B., Acaso, E., 1981a. Análisis polínico de una turbera localizada en el Glaciar de Los Conventos (Macizo Central de Gredos – Ávila). Botánica Macaronésica 8-9, 249–253.

Ruiz-Zapata, M.B., Acaso, E., 1981b. Contribución al estudio del cuadro vegetal y climático durante el Cuaternario reciente en el Macizo Central de Gredos (Ávila). Boletín de la Real Sociedad Española de Historia Natural (Sección Geología) 79, 299–307.

Ruiz-Zapata, M.B., Acaso, E., 1983. Análisis polínico de un depósito lacustre en el Macizo Central de Gredos (Ávila). In: Solé, N., Suárez, M. (Eds.), IV Simposio de Palinología A.P.L.E. Universidad de Barcelona, Barcelona, pp. 423–432.

Ruiz-Zapata, M.B., Acaso, E., 1984. Clima y vegetación durante el Cuaternario reciente en el Macizo Central de Gredos (Ávila). In: I Congreso Nacional de Geología. Colegio de Geólogos, Madrid, pp. 723–740.

Ruiz-Zapata, M.B., Acaso, E., 1985. Perfil polínico de un depósito glacio-lacustre, de posible edad Würm, en el Macizo Central de Gredos (Ávila). Anales de la Asociación de Palinólogos de Lengua Española 2, 255–261.

Ruiz-Zapata, M.B., Acaso, E., 1988. La investigación palinológica en la Sierra de Gredos: metodología y resultados. Actas de Gredos 7, 45–54.

Ruiz-Zapata, M.B., García-Antón, M., 1987. La palinología y su aplicación al estudio de la reconstrucción de la vegetación durante el Cuaternario (I): consideraciones generales. Henares, Revista de Geología 1, 77–84.

Ruiz-Zapata, M.B., García-Antón, M., Acaso, E., 1988a. Datos polínicos para el conocimiento de la vegetación en el Macizo de Peñalara (Sierra de Guadarrama). Acta Salmanticensia 65, 351–354.

Ruiz-Zapata, M.B., Acaso, E., Rebollo, L., 1988b. Aspectos geomorfológicos y paleoclimáticos del sector oriental de la Sierra de Guadarrama. Henares, Revista de Geología 2, 501–502.

Ruiz-Zapata, M.B., García-Antón, M., Vázquez, R., Gil-García, M.J., Andrade, A., 1988c. Análisis polínico de dos turberas localizadas en el Macizo de Peñalara (Sierra de Guadarrama, Madrid). In: II Congreso Geológico de España, pp. 321–332. Granada.

Ruiz-Zapata, M.B., Andrade, A., Atienza, M., Acaso, E., 1989. Contribución palinológica al conocimiento de la vegetación durante el Holoceno en la Sierra de Béjar. Actas de Gredos 9, 11–17.

Ruiz-Zapata, M.B., Vicente, R., Dorado, M., Martín, T., 1990. Datos polínicos e hidrológicos de un humedal localizado en el extremo occidental del Valle de Amblés (Ávila). In: Recio, J.M. (Ed.), Jornadas de Geografía Física y Análisis Medio Ambiental. Universidad de Córdoba, Córdoba, pp. 129–137.

Ruiz-Zapata, M.B., Gil-García, M.J., Dorado, M., Andrade, A., Atienza, M., Gómez, L., Martín, T., 1992. Evolución durante el Cuaternario reciente de los taxa arbóreos más representativos en el Sistema Central y Sistema Ibérico. In: III Congreso Geológico de España y VIII Congreso Latinoamericano de Geología. Universidad de Salamanca, Salamanca, pp. 554–559.

Ruiz-Zapata, M.B., Andrade, A., Gil-García, M.J., Dorado, M., Atienza, M., 1996a. Evolución de la vegetación en los últimos 6000 años en los sectores Central y Oriental del Sistema Central Español. Revista Española de Paleontología número extraordinario, 288–298.

Ruiz-Zapata, M.B., Dorado, M., Gil-García, M.J., Martín, T., Valdeolmillos, A., Andrade, A., 1996b. Reflexiones sobre la Palinología del Cuaternario y su aplicación en la reconstrucción paleoambiental y paleoclimática. II: Interpretación de los cambios de vegetación. Geogaceta 20, 221–224.

Ruiz-Zapata, M.B., Gil-García, M.J., Dorado, M., 1996c. Climatic changes in the Spanish Central zone during the last 3000 BP based on pollinic analysis. In: Diachronic Climatic Impacts on Water Resources with Emphasis on Mediterranean Region. Springer-Verlag, Berlin, pp. 9–23.

Ruiz-Zapata, M.B., Gil-García, M.J., Dorado, M., Andrade, A., Martín, T., Valdeolmillos, A., 1997. Vegetación y paleoambientes en el Sistema Central español. In: Rodríguez-Vidal, J. (Ed.), Cuaternario Ibérico. AEQUA, Huelva, pp. 248–260.

Ruiz-Zapata, M.B., Gil-García, M.J., Dorado, M., Valdeolmillos, A., Martín, T., Andrade, A., 1998. Vegetación y paleoambientes en el Sistema Central Español. Boletín de Noticias de la A.P.L.E. 1, 12–24.

Ruiz-Zapata, M.B., Gómez-González, C., López-Sáez, J.A., Gil-García, M.J., Santiesteban, J.I., Mediavilla, R., Dorado, M., Valdeolmillos, A., 2006a. Detección de la actividad antrópica durante el Holoceno reciente, a través de la asociación de palinomorfos polínicos y no polínicos en dos depósitos higroturbosos (El Berrueco y Rascafría) en la Sierra de Guadarrama, Madrid. Revista Española de Micropaleontología 38, 355–366.

Ruiz-Zapata, M.B., Gómez-González, C., López-Sáez, J.A., Dorado, M., Valdeolmillos, A., Gil-García, M.J., 2006b. Paleoambiente y usos del suelo durante el Holoceno reciente en la Tolla Collado de el Berrueco (Sierra de Guadarrama, Madrid). Geogaceta 40, 227–230.

Ruiz-Zapata, M.B., Gómez-González, C., Gil-García, M.J., Pérez-González, A., Baquedano, E., Arsuaga, J.L., López-Sáez, J.A., Bauz, S., Márquez, B., 2007a. Clima y vegetación durante el Holoceno reciente en El Calvero de la Higuera (Pinilla del Valle, Madrid): Nuevos datos polínicos. Revista Española de Micropaleontología 39, 215–226.

Ruiz-Zapata, M.B., Gómez-González, C., Gil-García, M.J., López-Sáez, J.A., Pérez-González, A., Baquedano, E., Arsuaga, J.L., 2007b. Evolución de la vegetación durante el Pleistoceno superior-Holoceno en los alrededores de la Cueva de la Buena Pinta (Pinilla del Valle, Madrid): primeros datos polínicos. In: Braga, J.C., Checa, A., Company, M. (Eds.), XXIII Jornadas de la Sociedad Española de Paleontología. I.G.M.E. – Universidad de Granada, Granada, pp. 210–211.

Ruiz-Zapata, M.B., Gómez-González, C., López-Sáez, J.A., Gil, M.J., Vera, M.S., Mediavilla, R., Domínguez, F., Santiesteban, J., 2007c. Cambios en la vegetación durante el Holoceno reciente en el Valle del Lozoya (Sierra de Guadarrama, Madrid). Revista Española de Paleontología 22, 95–102.

Ruiz-Zapata, M.B., Gómez-González, C., Gil-García, M.J., López-Sáez, J.A., Pérez-González, A., Baquedano, E., Arsuaga, J.L., 2007d. El paisaje vegetal holoceno en el Valle Alto del río Lozoya (Pinilla del Valle, Madrid). Revista Española de Paleontología 22, 89–94.

Ruiz-Zapata, M.B., Gómez-González, C., Gil-García, M.J., Pérez-González, A., López-Sáez, J.A., Arsuaga, J.L., Baquedano, E., 2008a. Evolución de la vegetación durante el Pleistoceno superior y el Holoceno en el valle alto del río Lozoya. Yacimiento arqueopaleontológico de la Cueva de la Buena Pinta (Pinilla del Valle. Sistema Central Español). Geogaceta 44, 83–86.

Ruiz-Zapata, M.B., Gómez-González, C., Gil-García, M.J., López-Sáez, J.A., Baquedano, E., Pérez-González, A., Arsuaga, J.L., 2008b. Comparación de las secuencias polínicas del Holoceno reciente del yacimiento arqueopaleontológico de El Calvero de la Higuera (Pinilla del Valle, Madrid) y de la turbera de Rascafría (Madrid). Geo-Temas 10, 1483–1486.

Ruiz-Zapata, M.B., Gómez-González, C., Gil-García, M.J., López-Sáez, J.A., Santiesteban, J.I., Mediavilla, R., Domínguez, F., Vera, M.S., 2009a. Reconstrucción de las condiciones paleoambientales del depósito Pñ (Macizo de Peñalara, Sierra de Guadarrama, Madrid) durante los últimos 2.000 años, a partir del contenido en microfósiles no polínicos (NPPs). Geogaceta 46, 135–138.

Ruiz-Zapata, M.B., Gómez-González, C., Santiesteban, J.I., Mediavilla, R., Domínguez, F., Gil-García, M.J., López-Sáez, J.A., Vera, M.S., 2009b. Reconstrucción paleoambiental y paleoclimática en el entorno del Valle del Lozoya: valoración del impacto humano. In: Sextas Jornadas Científicas del Parque Natural de Peñalara y del Valle de El Paular. C.A.M., Madrid, pp. 87–95.

Ruiz-Zapata, M.B., Gómez-González, C., López-Sáez, J.A., Dorado, M., Valdeolmillos, A., Gil-García, M.J., 2009c. Detección de la actividad antrópica durante el Holoceno reciente en la Tolla Collado de El Berrueco (Sierra de Guadarrama, Madrid, España) a través de la asociación de palinomorfos polínicos y no polínicos. Boletín de la Real Sociedad Española de Historia Natural (Sección Biología) 103, 121–129.

Ruiz-Zapata, M.B., Carrasco, R.M., Gil-García, M.J., Pedraza, J., Razola, L., Domínguez-Villar, D., Gallardo, J.L., 2011. Dinámica de la vegetación durante el Holoceno en la Sierra de Gredos (Sistema Central Español). Boletín de la Real Sociedad Española de Historia Natural (Sección Geología) 105, 109–123.

Samaniego, B., 1999. Espacios simbólicos en el Bronce Antiguo del Alto Duero. Complutum 10, 47–69.

Sánchez-Mata, D., 1989. Flora y vegetación del Macizo Oriental de la Sierra de Gredos (Ávila). Institución Gran Duque de Alba, Ávila.

Sánchez-Moreno, E., 1998. De ganados, movimientos y contactos. Revisando la cuestión trashumante en la Protohistoria hispana: la Meseta Occidental. Studia Historica. Historia Antigua 16, 53–84.

Sánchez-Moreno, E., 2001. Cross-cultural links in Ancient Iberia: socio-economic anatomy of hospitality. Oxford Journal of Archaeology 20, 391–414.

Sánchez-Palencia, F.J., Ruiz del Arbol, M., López-Jiménez, O., 2003. Tierra, Agua y Oro. Arqueología del Paisaje en la Sierra de Francia. Junta de Castilla y León, Salamanca.

Sherrat, A.G., 1981. Plough and pastoralism: aspects of the secondary products revolution. In: Hodder, I. (Ed.), Pattern of the Past. Cambridge University Press, Cambridge, pp. 261–305.

Stuiver, M., Reimer, P.J., 1993. Extended 14C database and revised CALIB radiocarbon calibration program. Radiocarbon 35, 215–230.

Terés, J., Valero, A., Pérez, C., 1995. Cuadernos de la Trashumancia n° 15-Extremadura. ICONA, Madrid.

Please cite this article in press as: López-Sáez, J.A., et al., Vegetation history, climate and human impact in the Spanish Central System over the last 9000 years, Quaternary International (2013), http://dx.doi.org/10.1016/j.quaint.2013.06.034

Tinner, W., Conedera, M., Ammann, B., Lotter, A., 2005. Fire ecology north and south of the Alps since the last ice age. The Holocene 15, 1214–1226.

Toro, M., Stevenson, A.C., Rose, N., Montes, C., 1992. Análisis paleoecológicos en sedimentos lacustres como testigos de la sensibilidad de los humedales de alta montaña en la Sierra de Gredos. Actas de Gredos 12, 11–19.

Toro, M., Flower, R.J., Rose, N., Stevenson, A.C., 1993. The sedimentary record of the recent history in a high mountain lake in central Spain. Verhandlungen des Internationalen Verein Limnologie 25, 1108–1112.

Trancho, G.J., Robledo, B., López-Bueis, I., Fabián, J.F., 1996. Reconstrucción del patrón alimenticio de dos poblaciones prehistóricas de la Meseta Norte. Complutum 7, 73–90.

Ubanell, A.G., 1994. Los modelos tectónicos del Sistema Central Español. Cadernos do Laboratorio Xeolóxico de Laxe 19, 249–260.

Valbuena-Carabaña, M., López de Heredia, U., Fuentes-Utrilla, P., González-Doncel, I., Gil, L., 2010. Historical and recent changes in the Spanish forests: a socio-economic process. Review of Palaeobotany and Palynology 162, 492–506.

van der Knaap, W.O., van Leeuwen, J.F.N., 1994. Holocene vegetation, human impact, and climatic change in Serra da Estrela, Portugal. Dissertationes Botanicae 234, 497–535.

van der Knaap, W.O., van Leeuwen, J.F.N., 1995. Holocene vegetation and degradation as responses to climatic change and human activity in the Serra da Estrela, Portugal. Review of Palaeobotany and Palynology 89, 153–211.

van der Knaap, W.O., van Leeuwen, J.F.N., 1997. Late Glacial and early Holocene vegetation succession, altitudinal vegetation zonation, and climatic change in the Serra da Estrela, Portugal. Review of Palaeobotany and Palynology 97, 239–285.

van Geel, B., 1978. A palaeoecological study of Holocene peat bog sections in Germany and the Netherlands, based on the analysis of pollen, spores and macro- and microscopic remains of fungi, algae, cormophytes and animals. Review of Palaeobotany and Palynology 25, 1–120.

van Geel, B., Berglund, B.E., 2000. A causal link between a climate deterioration around 850 cal BC as a subsequent rise in human population density in NW-Europe? Terra Nostra 7, 126–130.

van Geel, B., van der Plicht, J., Kilian, M.R., Klaver, E.R., Kouwenberg, J.H.M., Renssen, H., Reynaud-Farrera, L., Waterbolk, H.T., 1998. The sharp rise of $\Delta^{14}C$ ca. 800 cal BC: possible causes, related climatic teleconnections and the impact on human environments. Radiocarbon 40, 535–550.

van Geel, B., Buurman, J., Brinkkemper, O., Schelvis, J., Aptroot, A., van Reenen, G., Hakbijl, T., 2003. Environmental reconstruction of a Roman Period settlement site in Uitgeest (The Netherlands), with special reference to coprophilous fungi. Journal of Archaeological Science 30, 873–883.

Vannière, B., Colombaroli, D., Roberts, N., 2010. A fire paradox around the Mediterranean. PAGES Newsletters 18, 63–65.

Vannière, B., Power, M.J., Roberts, N., Tinner, W., Carrión, J., Magny, M., Bartlein, P., Colombaroli, D., Daniau, A.L., Finsinger, W., Gil-Romera, G., Kaltenrieder, P., Magri, D., Pini, R., Sadori, L., Turner, R., Valsecchi, V., Vescovi, E., 2011. Circum-Mediterranean fire activity and climate changes during the mid-Holocene environmental transition (8500–2500 cal. BP). The Holocene 21, 53–73.

Vázquez, R., 1992. Evolución del paisaje vegetal durante el Cuaternario reciente en la zona central y oriental de la Sierra de Guadarrama a partir del análisis palinológico (PhD dissertation). Universidad de Alcalá de Henares, Madrid.

Vázquez, R., Peinado, M., 1993. Relations between modern pollen rain and vegetation in the Sierra de Guadarrama (Madrid, Spain). Ecologia Mediterranea 19, 59–76.

Vázquez, R., Ruiz-Zapata, M.B., 1992. Contribución al conocimiento de la historia de la vegetación durante los últimos 2.000 años en la zona oriental de la Sierra de Guadarrama (Sistema Central Español), a través del análisis polínico. Boletín de la Real Sociedad Española de Historia Natural (Sección Biología) 88, 235–250.

Vicent, J.M., 1995. Early social complexity in Iberia: some theorical remarks. In: Lillios, K.T. (Ed.), The Origins of Complex Societies in Late Prehistoric Iberia, pp. 177–183. Ann Arbor, Michigan.

Vicent, J.M., 1998. La prehistoria del modo tributario de producción. Hispania 58, 823–839.

Please cite this article in press as: López-Sáez, J.A., et al., Vegetation history, climate and human impact in the Spanish Central System over the last 9000 years, Quaternary International (2013), http://dx.doi.org/10.1016/j.quaint.2013.06.034