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Vegetation/land cover of a UTM-Hectad in Utande (La Alcarria, Central Spain)

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ABSTRACT

In this paper, we present a map of the current state of vegetation and land use in a UTM square measuring 10 × 10 km in Utande (La Alcarria, Central Spain) at a semi-detailed scale of 1:20,000. The map presented here offers an example of how to carry out a series of maps of the plant landscape, using regular grid squares of 100 km^2 (hectads). The map was drawn up using a cartographic method scaled in levels, which can be updated in line with advances in territorial tracking, and enabled us to group together synthetic categories adapted to the biogeographical idiosyncrasy of territory. We recommend combining this phytocoenotic study with another focusing on the flora and the chorology in the same space. A map was obtained with 35 categories, which offers a large-scale image of the biophysical land covers. This will be useful for territorial planning and biodiversity protection.

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1. Introduction

In today's world of technical and scientific progress, traditional phytogeographical studies receive strong support from the advances in geographical information technologies (GIT). Together with the necessary direct reconnaissance of the real situation of the vegetation in the field, these technological advances enable us to implement proposals and initiatives that can contribute, with greater consistency and detail, to a better knowledge of plant systems and their integration into the landscape.

Phytogeographic research has been closely associated with the different ways of representing vegetation. Much of the debate has centred on how to conceptualize an entity or unit of vegetation in a way that, despite involving a degree of abstraction, can successfully express the reality of plant life, as verifiable on the ground (Bohn et al., 2005; Braun-Blanquet, 1979; Franklin, 2013; Gaussen, 1961; Panareda, 1996; Pedrotti, 2013; Whittaker, 1978). The representation of potential vegetation, normally executed at small and medium scale (1:200,000 and smaller), has opted for solutions based on more general and/or abstract notions related with bioclimate, altitude, soil conditions, vegetation series and the most important azonal types of vegetation (Bohn et al., 2000–03; Rivas-Martínez, 1987).

However, when Cartography displaying the current state of vegetation reflects the real situation more reliably. This requires an increase in the scale and a readjustment of some ideas, concepts (see also Géhu & Rivas-Martínez, 1981; Mucina et al., 2016; Peet & Roberts, 2013; Whittaker, 1962) and, specially, of the nomenclature of vegetation types, adapted to the phytogeographical idiosincrasy of territories. Typically, these ideas have been linked together via their integration into natural systems, landscape elements and direct human action on vegetation (Bertrand, 1966; Costa & Blanco, 2000; Géhu, 1988; Guerra, 2001; Khoroshev & Dyakonov, 2020; Rivas-Martínez, 2005; Terradas, 2001). This question is crucial, as was recently pointed out by Beato Bergua et al. (2021). And, in addition, all these approaches have aimed to be viable in terms of their practical use for vegetation mapping: to enable us to find out more about the formations, identify them in the field, represent their distribution and use the results for applied purposes.

In Spain, the experience acquired after decades of institutional mapping campaigns at a national level has opened various methodological paths regarding vegetation cartography. They were conducted at a scale of 1:50,000, either directly in the Atlas of Habitats-Natura 2000 Network (MITECO, 2005), some of whose vegetation types exactly has coincided with our cartographic units (Section 4), and the Forestry

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Map of Spain (MAGRAMA, 2006), or indirectly within land-use mapping in the Map of Crops and Uses (MAPAMA, 2010) and, at a scale of 1:25,000, the Spanish Land Cover Information System (SIOSE, 2018). The last two are not strictly vegetation maps, but they do provide some useful information on this question. In addition, other institutions or projects have produced maps at a regional or local level. In general, these maps used the same scale of 1:50,000 or they increased it to semi-detailed (up to 1:10,000) or detailed (more than 1:10,000) (Beato Bergua et al., 2021; Benito, 2018; Carrillo & Ninot, 1997; Del Arco, 2006; Ferré et al., 2010; Gobierno Vasco, 1990–92; Ignacio et al., 2010; Marino Alfonso et al., 2020; Olmedo, 2012; Panareda et al., 2000, 2003; Serrano Giné, 2010; Vigo & Masalles, 1996; etc.).

One of these proposals (García-Abad & Panareda, 2010; Pintó & Panareda, 1995) suggested combining a large-scale, two-pronged (autoecological and phytocoenotic) analysis for the same unit of territory with chorological maps of taxa plus a map of plant formations. In both types of maps, fieldwork is essential, in order to cover small areas and obtain results having the 1 km^2 units (UTM grid) as the base of environmental information. In an earlier phase of our research, we produced chorological maps in a territory measuring 100 km^2 (García-Abad, 2015, 2016). The objective of this paper is therefore to complete and complement the earlier research by presenting this last map at a semi-detailed scale (1:20,000).

This kind of floristic survey with a resolution of 1 km^2 is being carried out in some European countries (Floron, 2022; French, 2020; Trueman et al., 2013, etc.) and is being extended to surveillance and monitoring data of biodiversity and habitats (BDM, 2022; Bunce et al., 2006; CS, 2022, etc.). The idea of integrating geospatial data using standard spatial units can be a promising way to facilitate the implementation of links between Spatial Data Infrastructures across different territories (Ronzhin et al., 2019). This would allow the comprehensive tracing of 1 × 1 km units to generate floristic and vegetation maps by systematic geographic surveys that can be synthesized progressively to larger nested spatial units (4, 25 and 100 km^2).

2. Study area

The study area is defined by a UTM cartographic square of 10 × 10 km size (Datum ED50, Zone 30N, reference 30TWL02). We refer to it as Utande (UTM-Hectad of Utande), its main municipality (hereinafter referred to as Utande-Hectad). Situated in the centre of the Iberian Peninsula, it is 82 km north-east of Madrid and belongs to the province of Guadalajara (Spain). The western side of the hectad coincides exactly with the 3°W Meridian and its central point has a latitude of 40°52′31′′N (Figure 1).

It covers a stage of the interfluve between the Henares and the Badiel Rivers situated to the north of the sedimentary Tajo basin, which consists of different kinds of Neogene deposits. It also falls within the natural region of La Alcarria, an upland with calcareous tabular plateaus, interspersed with valleys (gravel, sands, silts and river clays). There are elevation differences of up to 250 m between the high areas (known as ‘alcarrias’) and the low parts (flood valley bottoms or ‘vegas’). These are connected by steep slopes with varying orientations and outcrops of sands, clays, marls, sandstones, gypsum and other carbonated levels (Asensio et al., 1991; Calonge & Rodríguez, 2008). These plateaus, which are as high as 1045 m a.s.l., are separated by the Henares (lowest altitude 765 m), Badiel and other smaller river valleys. The area is dominated by alkaline soils, except in part of the west-northwest where they are acid (gravel and quartzite-slate sands), and in the gentle depressions of the plateau caused by decarbonation.

The climate is Mediterranean with a slightly continental influence. According to the Spanish State Meteorology Agency (Chazarra et al., 2018), the Köppen climate is Csa (temperate with dry or hot summer), near the limit with Csb (temperate with dry or temperate summer); with an average annual temperature from 12°C to 13°C; annual average precipitation from 450 to 550 mm. In autumn and winter, inversion layers are formed in the deep valleys. The topographical factor and the orientation of the valleys, which are quite steep and narrow, tend to intensify this phenomenon and heighten the temperature contrasts between sunny and shaded areas. According to the system proposed by Rivas-Martínez, the hectad is located at the border and/or transition between two bioclimates. It has an oceanic, pluviseasonal, Mediterranean bioclimate, but lies near the border with the sub-Mediterranean oceanic template. The values and diagnoses are presented in Table 1.

In biogeographical terms, this area is also one of transition. According to the units into which the Iberian Peninsula was divided in previous research (Rivas-Martínez et al., 2007, 2011b, 2014), the Utande-Hectad falls within the Central Iberian Mediterranean Province and within that in the Castilian Subprovince. The Subprovince is divided into various sectors. Our hectad falls within two of these sectors: the dominant Celtiberia and Alcarria sector (High Alcarria District), and the Mancha sector (Low Madrid District), covering just the low-lying areas in the northwest. We also detected slight introgression by the West Iberian Mediterranean Province (Guadarrama Sierra Sector, Ayllón Sierra District) in hectads in the west-northwest. This is manifested by the dominant presence of *Cistus ladanifer*, *C. laurifolius*, *Cytisus scoparius* and *Retama sphaerocarpa* together with a notable concentration of another acidophile taxa.

Figure 1. Location of the study area. Digital databases from the CNIG-Spain (Instituto Geográfico Nacional).

There are seven vegetation series in the Utande-Hectad (Fernández-González et al., 2017; Peinado et al., 2008, 2017; Rivas-Martínez, 2011b). The climatophile series of interfluve forests are *Cephalanthero rubrae-Querco fagineae* S. (meso-supramediterranean neutro-basophile and basophile), *Junipero thuriferae-Querco rotundifoliae* S. (supramediterranean basophile), *Junipero lagunae-Querco rotundifoliae* S. (meso-supramediterranean siliceous) and *Asparago acutifolii-Quercetum rotundifoliae* S. (mesomediterranean basophile). The first is dominant and alternates with the second on the plateaus and slopes, while

Table 1. Values for the Rivas-Martínez Worldwide bioclimatic system in the Utande-Hectad (the bioclimates marked with an asterisk* occupy very little space within the hectad).

Parameters	Geographic scope	Diagnosis	Values 1	Values 2, when necessary
Bioclimate	Worldwide	Temperate oceanic (*)	Ic 11–21	Io > 3.6
	Worldwide	Mediterranean pluviseasonal oceanic	Ic ≤ 21	Io > 2.0
	Utande-Hectad	Both	Ic = 18.5–19.5	Io = 3.0–3.8
Continentality	Worldwide	Strong oceanic semicontinental (*)	Ic 19–21	–
	Worldwide	Weak oceanic semicontinental	Ic 17–19	–
	Utande-Hectad	Both	Ic = 18.5–19.5	–
Thermotypes	Worldwide	Upper Mesomediterranean (*)	Itc 220–285	Tp 1500–1800
	Worldwide	Lower Supramediterránean	Itc 150–220	Tp 1200–1500
	Utande-Hectad	Both	Itc = 197.5–225	Tp = 1420–1555
Ombrotypes	Worldwide	Lower subhumid (*)	Io 3.6–4.8	–
	Worldwide	Upper dry	Io 2.8–3.6	–
	Utande-Hectad	Both	Io = 3.0–3.8	–

Notes: Ic: Simple continentality index, Io: Annual ombrothermic index, Itc: Compensated thermicity index, Tp: Positive annual temperature. Based on Rivas-Martínez et al. (2011a, 2011b, 2017) and Chazarra et al. (2018).

the third (acidophile introgression) and fourth (northwest and some shaded areas in the South) are less frequent. The edaphohygrophile series on the river banks consists of *Rubio tinctorum-Populo albae* S. (riverbanks with high phreatic levels), *Opopanaco chironii-Ulmo minoris* S. (with low levels) and *Salici neotrichae* S. (areas close to the riverbeds).

The Utande-Hectad has been farmed for centuries. In the last six decades, it has suffered a severe demographic slump due to the rural exodus. According to the 2011 Census, the population living within the populated areas of the hectad declined from 481 inhabitants in 2001 to 429 in 2011 (Spanish National Statistics Institute). Much of the land covered by semi-natural vegetation is used for hunting purposes. Forestry uses are evident in the form of a few plantations. There is very little livestock farming, but agriculture remains important. The configuration of the vegetation is strongly influenced by ancient and current land uses such that the semi-natural plant formations (45.1% of the hectad) alternate with spontaneous 'weeds' in cultivated areas, areas with artificial covers or with very low plant cover (54.9%).

3. Materials and methods

Our knowledge of the flora and of the vegetation in the hectad is based on the information gathered during our own fieldwork and that gleaned from the documentation for the Iberian Peninsula as a whole (Blanco et al., 1997; García-Mijangos et al., 2015; Rivas-Martínez et al., 2002, 2011b), for the centre of the Peninsula and La Alcarria (Bellot et al., 1979; Fernández-González et al., 2017; Izco, 1984; Peinado et al., 2008, 2017; Ron, 1970; Ruiz de la Torre, 1995-96; Varela, 1996), and other studies in the hectad or its neighbouring area (Bartolomé, 1987; Cruz, 1994; García-Abad, 2015, 2016; García-Abad et al., 2009).

Between 2005 and 2012, we performed the survey of the chorological maps in Utande-Hectad with a resolution of 1 km^2 (García-Abad, 2015, 2016). After this phase, we continued with another survey of the vegetation in the form of the map presented here. The fieldwork lasted five years (between 2011 and 2015, plus reviews in 2021 to solving some boundaries, identifications, etc.). We used the method for mapping vegetation and land uses tested in a small sector of NE Spain (Panareda, 1996–97; Panareda et al., 2003), with a scaled legend system. It contained a legend which is structured in scales of up to seven hierarchical levels from the general level (Level 1) to the most detailed level (Level 7). It enables the information (number of categories in the legend) to be enlarged and updated as more territories are studied.

The information was gathered by direct observation in the field by transects that covered all the biotopes, kilometre by kilometre, and with on the ground support from aerial photos with an approximate scale of 1:6000 (PNOA, the Spanish Aerial Orthophotography National Plan taken in 2010; http://www.ign.es). This interpretation was digitized *in situ* onto the aerial photos. The types of vegetation and land uses were assessed on the ground. The following three criteria were combined (syncretic and synchronic approach): (a) physiognomy (stratification) and dynamics of vegetation (Meaza, 2000; Panareda et al., 2003), (b) phytosociological method (Braun-Blanquet, 1979), and (c) CORINE-Land Cover (Heymann et al., 1994) for the anthropogenic biophysical covers.

We then created rough draft maps at a scale of 1:10,000 with a minimum mapping area of 0.16 ha (minimum width of 4 m), which were digitalized on the topographic base from the CNIG and aerial photography from PNOA (IGN, Spanish National Geographic Institute; http://www.ign.es), using the screen and the digital resources provided by the *ArcGIS* (10.3) software. This GIS was also used to group the many highly detailed categories together into other more synthetic categories, so enabling us to draw up a harmonized map with a scale of reference of 1:20,000. After this process, we reached a synthesis with 35 definitive categories (Main Map). Specialized manuals were consulted (Cauvin et al., 2010; Gaussen, 1961; Küchler, 1967; Pedrotti, 2013) in relation to the application of the principles of basic map drafting (design, generalization, drafting) and thematic maps (use of visual variables, etc.).

Finally, the map was drawn up with ArcMAP 10.7.1. Combining the vegetation map on a raster from the topographic model of the relief (resolution 2×2 m, generated from a Digital Elevation Model of the IGN) enabled us to apply hillshade (hypothetical lighting, neutral colour ramp and transparency of 40%) to the thematic layer. This helped contextualize the vegetation and land-cover with altitudes, gradients and physiographic units.

4. Cartographic units of vegetation and land cover

The map displays above all the physiognomy (stratification) and the dynamics of the vegetation, it also highlights the dominant flora composition, especially in scrub areas. Table 2 shows the general correspondence between the semi-natural vegetation formations and their affinities with the phytosociological, syntaxonomical units and vegetation complexes. For the land covers of clear human origin or those with a very low level of vegetation cover (<20%), Table 3 also identifies the syntaxa that coexist with them and/or are spontaneously linked to them. Each category, identified in brackets with a number, is classified in turn into eight groups (following sections).

Table 2. Correspondence between categories of semi-natural vegetation (1–21) and phytosociological units (1).

Id	Vegetation and land cover	Main phytosociological adscriptions (1)
1	Castilian holm oak woodland	*Junipero thuriferae-Quercetum rotundifoliae*
		Junipero lagunae-Quercetum rotundifolia
2	Gall oak woodland	*Cephalanthero rubrae-Quercetum fagineae*
3 and 5	Holm-Gall oak mixed woodland and Arborescent microwood/scrubland	*Junipero thuriferae-Quercetum rotundifoliae*
		Cephalanthero rubrae-Quercetum fagineae
4	Montpelier maple woodland	*Cephalanthero rubrae-Quercetum fagineae*
6	Poplar woodland	*Rubio tinctorum-Populetum albae*
		Salicetum neotrichae (*)
7	Elm and other riparian woodlands	*Opopanaco chironii-Ulmetum minoris*
8	Kermes oak scrubland	*Daphno gnidii-Quercetum cocciferae*
9 and 10	Dwarf scrubs to arborescent scrubland and Basophile dwarf scrubland	*Lino differentis-Salvietum lavandulifoliae*
		Lino appressi-Genistetum rigidissimae
11	Rosemary and grey-leaved 'Cistus' scrubland	*Cisto clusii-Rosmarinetum officinalis*
		Rosmarino-Cistetum ladaniferi
		Lino-Salvietum subas. *cistetosum albidi*
12	*Genista scorpius* scrubland	*Lino differentis-Salvietum lavandulifoliae*
13	Acidophile scrubland	*Rosmarino-Cistetum ladaniferi*
		Cytiso scoparii-Retametum sphaerocarpae
		Genisto scorpii-Cistetum laurifolii
14	Spanish sage scrubland	*Lino-Salvietum* subas. *salvietosum lavandulifoliae*
15	Bearberry scrubland	*Lino-Salvietum* s. *arctostaphylletosum crassifoliae*
16	Snowy mespilus scrubland	*Amelanchiero-Buxenion*
17	'Rosaceae'-dominated prickly scrubland	*Rosetum micrantho-agrestis*
18	Grassland with dwarf shrubs	*Irido chamaeirido-Brachypodietum retusi*
		Lino differentis-Salvietum lavandulifoliae (*)
		Lino appressi-Genistetum rigidissimae (*)
		Taeniathero-Aegylopion geniculatae
		Brachypodion phoenicoidis
		Hordeion leporini
		Silybo-Urticion
19	Ramose false brome perennial grassland	*Irido chamaeirido-Brachypodietum retusi*
		Lino differentis-Salvietum lavandulifoliae (*)
		Lino appressi-Genistetum rigidissimae (*)
20	Semi-natural therophyte grassland	*Brachypodion distachyi*
21	Mesophile and higrophile grasslands	*Phragmition communis*
		Brachypodion phoenicoidis
		Molinio-Holoschoenion vulgaris
		Populion albae (*)
		Pruno-Rubion ulmifolii (*)
		Mentho-Juncion inflexi
		Nasturtio-Glycerietalia
		Senecionion fluvatilis
		Trifolio fragiferi-Cynodontion
		Conio maculati-Sambucion ebuli (*)
		Balloto foetidae-Conion maculati (*)

Notes: Based on Izco (1984), Cruz (1994), Peinado et al. (2008, 2017), Rivas-Martínez et al. (2011b) and Fernández-González et al. (2017). (Id) Identification number of the category in the text. (1) if there is more than one adscription, they appear in decreasing order of size or relevance. (*) Syntaxa that are not strictly characteristic, constituting vegetation complexes, accompanying crops, plantations, very degraded or marginal areas.

4.1. Interfluvial woodlands and microwood/shrublands (1–5)

Castilian holm oak woodland (1) is dominated by *Quercus ilex* subsp. *ballota* (Figure 2). These woodlands tolerate both acid and alkaline soils and are dominated by arboreal (>7 m) and arborescent (3–7 m) strata. These are accompanied by other trees, small trees and high bushes (*C. laurifolius*, *Colutea hispanica*, *Crataegus monogyna*, *Juniperus* spp., *Lonicera etrusca*, *Rhamnus* spp., *Rosa* spp. and *Sorbus aria*).

The gall oak woodland (2) is dominated by *Quercus faginea* subsp. *faginea*. It is less resistant to the summer drought and prefers alkaline soils, although it has some tolerance for acidic ones (Figure 3). It shares with the holm oak woodland the aforementioned features in terms of habit and floral composition, but it also includes other trees and tall bushes (*Acer monspessulanum*, *Cornus sanguinea*, *Fraxinus angustifolia*, *Sorbus domestica*, *S. torminalis*, *Ligustrum vulgare* and *Viburnum lantana*). Holm-gall oak mixed woodland (3) may also appear for various reasons such as the bioclimatic and biogeographical transition, changes in forestry management, and in the relative influence of farming. In the west-northwest, there are a few small surviving Montpelier maple woodlands (4) (*Acer monspessulanum*), which stand in corridors in narrow, boxed-in valleys where they are protected from the sunlight and the summer drought.

The arborescent microwood/scrubland (5) consists of tall shrub formations or short trees dominated by specimens that are shorter than normal, with a mixture of *Quercus ilex*, *Q. faginea*, *Q. coccifera*, *Pinus halepensis*, *Juniperus oxycedrus*, together with some of the tall bushes mentioned earlier, as well as *Daphne gnidium* and *Jasminum fruticans* and short bushes (Figure 3). It is dominated by the arborescent and arbustive strata (0.5–3 m). This formation is a dynamic phase prior to the regeneration of the holm oak or gall oak.

Table 3. Phytosociological units that coexist in categories 22–35, heavily influenced by humans and/or very low vegetation cover.

Id	Vegetation and land cover	Main phytosociological adscriptions (1)
22	Weed and ruderal herbaceous formations	*Taeniathero-Aegylopion geniculatae* *Hordeion leporini* *Roemerion hybridae* *Silybo-Urticion* *Polygono-Chenopodion polyspermi* *Diplotaxion erucoidis*
23 and 27	Olive groves and other woody crops and crops with remains of vegetation areas	*Roemerio hybridae* (*) *Diplotaxion erucoidis* (*) *Taeniathero-Aegylopion geniculatae* (*) *Hordeion leporini* (*)
24 and 25	Vegetable patches and Irrigated corn crops	*Polygono-Chenopodion polyspermi* (*) *Silybo-Urticion* (*)
26	Non-irrigated herbaceous crops	*Roemerion hybridae* (*)
28	Planted pine woodland	*Lino differentis-Salvietum lavandulifoliae* (*) *Irido chamaeirido-Brachypodietum retusi* (*)
29	Planted poplar woodland	*Brachypodion phoenicoidis* (*) *Molinio-Holoschoenion vulgaris* (*) *Pruno-Rubion ulmifolii* (*) *Mentho-Juncion inflexi* (*) *Trifolio fragiferi-Cynodontion* (*)
30, 33 and 35	Urban fabric and other construction sites, Irrigation reservoirs and Anthropic bare ground and rock outcrop	Irrelevant
31	Road and rail networks	*Taeniathero-Aegylopion geniculatae* (*) *Hordeion leporini* (*)
32	Mineral extraction and dump sites	*Silybo-Urticion* (*) *Onopordion castellani* (*)
34	Natural rock outcrop	*Alysso-Sedetalia* *Galeopsio angustifoliaa-Ptychotidetum saxifragae* *Lino differentis-Salvietum lavandulifoliae* (*) *Irido chamaeirido-Brachypodietum retusi* (*) *Parietarietalia* (*) *Potentilletalia caulescentis* (*) *Brachypodion distachyi* (*)

Notes: Based on Izco (1984), Cruz (1994), Peinado et al. (2008, 2017), Rivas-Martínez et al. (2011b) and Fernández-González et al. (2017). (Id) Identification number of the category in the text. (1) if there is more than one adscription, they appear in decreasing order of size or relevance. (*) Syntaxa that are not strictly characteristic, constituting vegetation complexes, accompanying crops, plantations, very degraded or marginal areas.

4.2. Riparian woodlands (6 and 7)

Poplar woods (6), elm woods and other riparian woodland (7) are made up of deciduous trees which grow in the flood valleys. These woodlands have been shaped by human activities and in many places have been replaced by vegetable patches and 'vega' crops. In the wider valleys, poplar woods dominate. The most common are *Populus alba*, *P. nigra*, as well as hybrids of *P.* × *canadensis* and *P.* × *canescens*, which were originally planted as crops but now grow wild. These are mixed with *Fraxinus angustifolia* and *Ulmus minor*, and a narrow strip of *Salix* spp., *Tamarix gallica* and *Alnus glutinosa* near the river bed (Figure 3).

The elm and other riparian woodlands (habitat 82A041 of the Natura 2000 network) are typically found in the narrower valley bottoms with a lower

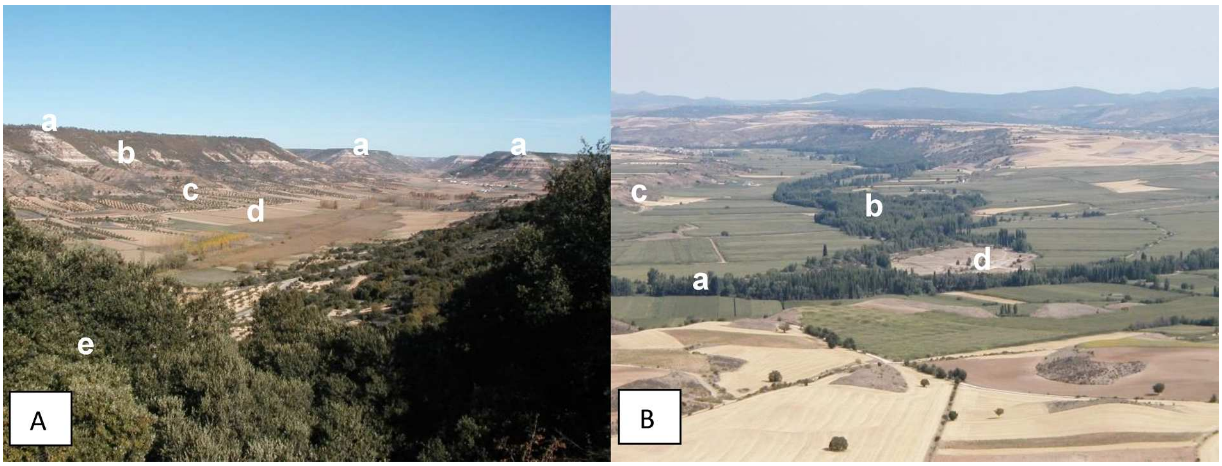

Figure 2. (A) Valley of the River Badiel (south): (a) Plateaus ('alcarrias'); (b) Steep slopes; (c) Foothills; (d) Valley bottom ('vegas'); (e) Castilian holm oak woodland; (B) Bornova and Henares river valleys (northwest): (a) Banks of the River Henares; (b) Banks of the River Bornova; (c) Fluvial Terrace; (d) Gravel pit.

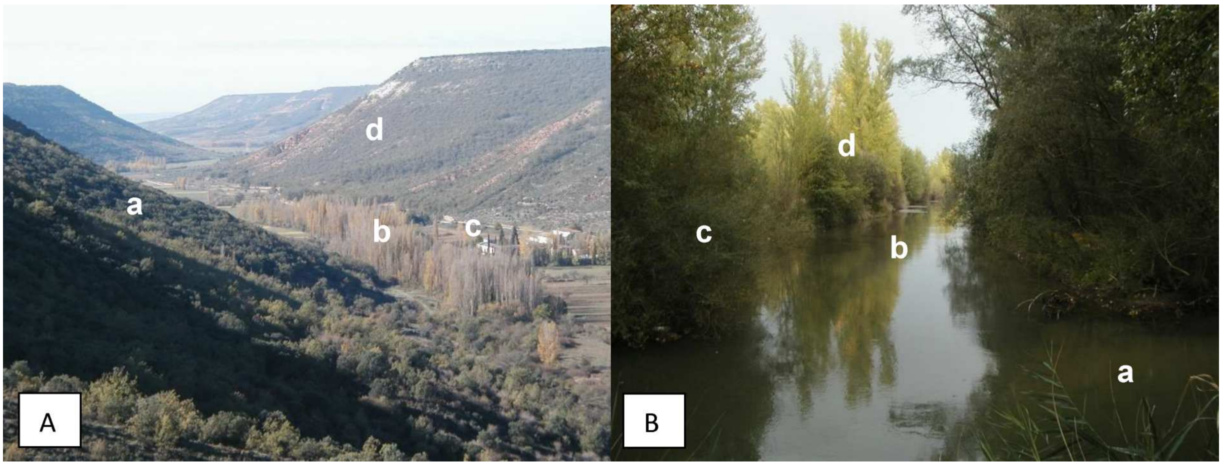

Figure 3. (A) Badiel River valley (east-southeast): (a) Gall oak woodland; (b) Poplar woodland; (c) Vegetable patches; (d) Arborescent microwood. (B) Confluence of main rivers (northwest) (a) River Henares; (b) River Bornova; (c) Willows (*Salici neotrichae* S.); (d) Poplars (*Rubio tinctorum-Populo albae* S.).

water flowrate, as well as in gullies at the foot of the hillsides and in the occasional karstic spring. They are dominated by *Ulmus minor*. On occasions, it is mixed with *Quercus faginea* in contact areas between the two formations.

4.3. Scrublands (8–17)

They are dominated by both tall and short bushes, in which there are few or no trees. They are a successional stage after the degradation (due to livestock farming, ploughing and fires) of woodlands and many of them have a great phytosociological affinity (*Sideritido incanae-Salvion lavandulifoliae*). Their main differentiating features are having a particularly dominant taxon and/or a particular degree of variation in the stratification. The kermes oak scrubland (8) is dominated by *Quercus coccifera* (habitat 421014), a tall bush (2–3 m). It is similar to formation 5, although the arborescent stratum is either very limited or non-existent, it has less biodiversity and is more stable.

A successional transition formation can be classified as dwarf scrubs towards arborescent scrubland (9). This is a progressive dynamic stage towards formations with high strata of *Quercus* spp. It is calcicole and is dominated by suffrutescent chamaephytes (strata from 0.05 to 0.5 m) and medium-sized bushes (0.5–2 m). Tall bushes and short trees can also be found in small but significant numbers (arborescent stratum). These scrublands are dominated by thyme (*Thymus* spp.) and other small bushes (*Fumana* spp., *Globularia vulgaris*, *Helianthemum* spp., *Lavandula latifolia*, *Linum suffruticosum*, *Salvia lavandulifolia*, *Satureja intricata*, *Sideritis incana*) and bushes (*Dorycnium pentaphyllum*, *Genista scorpius*, *G. pumila* subsp. *rigidissima*, *Rosmarinus officinalis*).

When the scrubland has either a very poor arborescent stratum or none at all, its dynamic nature is less evident. It maintains a mixed composition with no clearly dominant taxon. It can be categorized as basophile dwarf scrubland (10) (Figure 4). This form of scrubland is a preliminary successional stage after

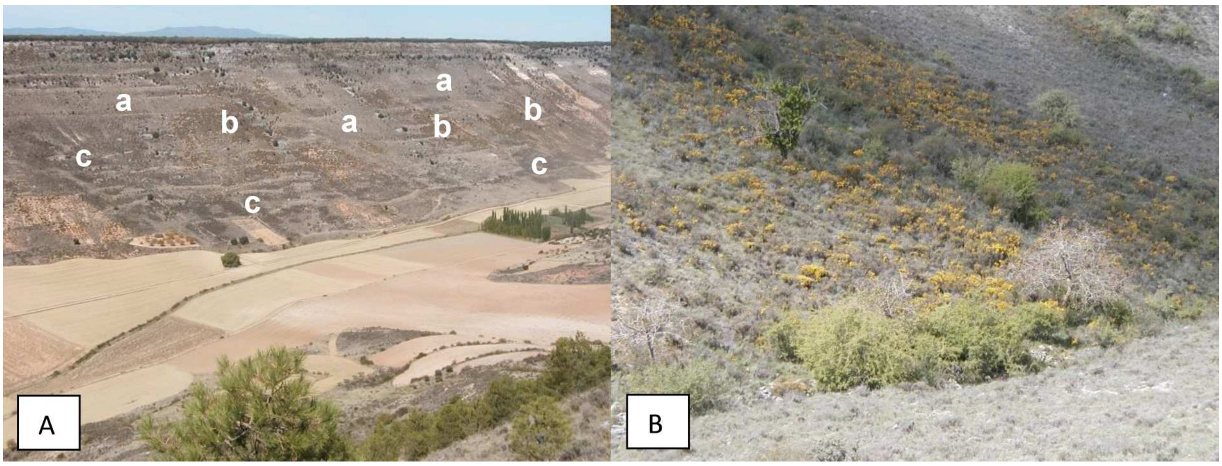

Figure 4. (A) Valley of the Valdeiruega stream (centre-east): (a) Basophile dwarf scrubland; (b) Rosemary scrubland; (c) *Genista scorpius* scrubland. (B) Flowering *Genista scorpius* scrubland.

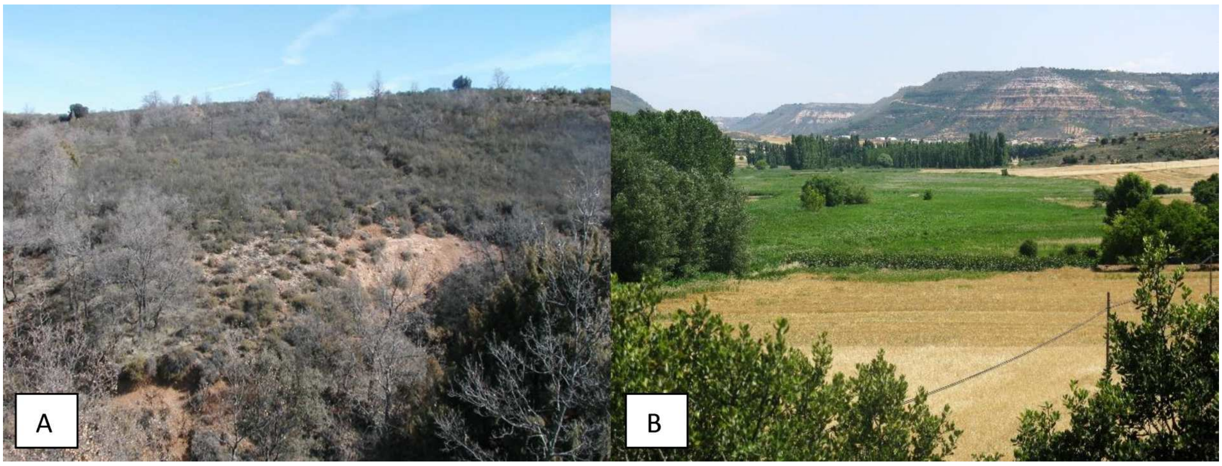

Figure 5. (A) Municipality of Casas de San Galindo (west-northwest): Acidophile scrubland of *Cistus ladanifer* with scattered gall oaks. (B) Municipality of Muduex (south): reed beds of *Phragmites australis*.

the degradation of woodlands over various centuries. They are dominated by the woody stratum <0.5 m.

This flora and stratification base gives rise to slight variants depending on whether there are facies with a single dominant taxon. When the scrubland is dominated by heliophile taxa such as Rosemary (*Rosmarinus officinalis*) and grey-leaved 'Cistus' (*Cistus albidus*), they are grouped together as a separate category (11). The former also grows in acidic soils. On slightly concave hillsides, the scrubs are slightly sheltered from the sunlight, and facies dominated by *Genista scorpius* (12) appear (Figure 4). In the introgression of the Sierra de Guadarrama Sector, the scrubs are acidophile (13, Figure 5). The basophile facies of Spanish sage (14) is dominated by *Salvia lavandulifolia*. The bearberry scrublands (15), dominated by *Arctostaphylos uva-ursi*, are located on the plateaus. These plants have a creeping habit (<0.25 m). The snowy mespilus scrubland (16), dominated by *Amelanchier ovalis*, occupies small stands in the NE quadrant, in shaded hillsides with a tall bush habit (2–3 m).

The 'Rosaceae'-dominated prickly scrublands (17) areas are dominated by bushes from the Rosaceae family, such as *Crataegus monogyna*, *Rubus ulmifolius*, *Prunus spinosa*, and above all, wild rose bushes, consisting of *Rosa* spp. (habitat 411544). Lianas and other tall bushes can also be found. These scrublands occupy pre-forest borders, enclaves with natural springs, abandoned vegetable fields and some riverbeds.

4.4. Grasslands and herbaceous vegetation (18–22)

These herbaceous formations may have a limited (medium-low to nil) presence of short woody plants (<0.5 m). Grasslands with dwarf shrubs (18) can be found when the dominant herbaceous taxa combine with other mixed woody taxa (mixed formations) or in mosaics. In ecological terms, they are the product of natural, ecotone and above all anthropozoogenic dynamics (grazing, anthropogenic interference). Xeric, semi-natural taxa dominate, but they can also be mesophile, subnitrophile and nitrophile. The ramose false brome perennial grassland (19) is dominated by *Brachypodium retusum*. This facies marks the slow recovery of scrublands which in the past were often affected by fires started by shepherds to preserve the grazing land for their livestock.

The semi-natural therophyte grassland (20) areas are dominated by nanotherophytes that grow in dry, thin and very poor soils. They are ephemeral and fill the clearings in perennial formations. They are in scattered sites largely unaffected by human activity. The mesophile and higrophile grasslands (21) occupy low-lying areas where fresh water accumulates and/or flows, as well as in other enclaves where the soils become humid at certain times of the year. They may be basophile to neutrophile and sometimes show nitrophile tendencies. They appear above all on riverbanks, watercourses, riverbeds dry to wet, agricultural drainage channels, springs on hillsides and occasional depressions in the plateaus (Figures 5 and 6). There are facies with riverbank trees and prickly rosaceae bushes.

The weed and ruderal herbaceous formations (22) include patches in which during field visits we identified nitrophile and subnitrophile species of *Artemisietea vulgaris* and *Stellarietea mediae*, typically found in currently functioning or abandoned crop fields, agricultural or drovers' paths, drainage channels, roadsides, dumps and edges (Table 3). They cover plateaus, plains, foothills and some slopes.

4.5. Agricultural crops (23–27)

In addition to the crops themselves, these areas also host communities of weeds in fallow and stubble fields, together with associated pioneer nitrophile

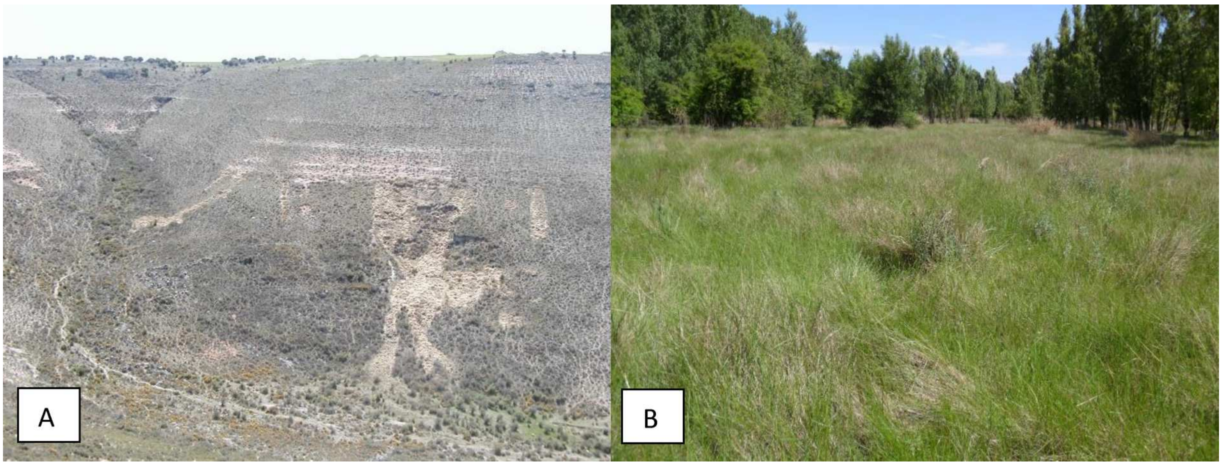

Figure 6. (A) La Calleja, on the border between the municipalities of Ledanca and Utande (centre-east): oozing spills from meso-hydrophile formations of purple moor-grass of *Molinia caerulea* in springs. (B) El Sargal, in the municipality of Jadraque (north-west): tall grass pastures of *Brachypodium phoenicoides*.

grasslands. Olive trees and other woody crops (23) are clearly dominated by *Olea europaea* L. Most of the olive groves are located at the foot of hillsides in the southern half of the hectad, in areas yesteryear occupied by holm oak woods of the *Asparago acutifolii-Quercetum rotundifoliae* S. series. Other much less frequent crops include *Prunus dulcis* and *Juglans regia*.

Vegetable patches (24) were a much more widespread land cover in the past, but today they are concentrated almost entirely in the bottom of river plains near populated areas. The irrigated corn crops (25) are located exclusively in the northwest quadrant at the bottom of valleys and adjacent gullies, which would potentially be a habitat for the *Opopanaco chironii-Ulmo minoris* S. series. The Non-irrigated herbaceous crops (26) dominate almost all the plateaus, where it has replaced woodlands. It can also be found in less broad valley bottoms, flatter parts of hillsides and gentle slopes and terraces. The most common crop is barley, and wheat and sunflowers are also widespread. We have also distinguished on the map a category called crops with remains of vegetation areas (27).

4.6. Planted woodlands (28 and 29)

The forestry sector has two types of planted woodland: Planted pine and planted poplar woodlands. The former (28) are dominated by *Pinus halepensis*, used above all for the purposes of conserving shaded hillsides that have been damaged by erosion. They have also been planted in marginal shaded areas where at the highest altitudes *Pinus nigra* and *P. sylvestris* can also be found. For their part, the poplar woodlands (29) are dominated by *Populus × canadensis* and *P. nigra*. They are mainly grown for timber production. They are planted predominantly in areas previously covered by mesophile grasses and prickly borders of rosaceae.

4.7. Artificial areas (30–33)

Area covered by populated sites, farm buildings, industries, abandoned or ruined buildings, road networks, dumps, etc. It is worth highlighting the presence of woodland paths, farm tracks, abandoned quarries, a railway line and two main roads with their corresponding service areas.

4.8. Rocky areas or no significant vegetation cover (34 and 35)

Lastly, we come to rocky outcrops where the vegetation cover is very low or non-existent (<20%). In the part covered by natural rock outcrops (34), human intervention ranges from non-existent to very indirect or only in ancient times. They include prominent geoforms, slopes that normally consist of gullies and a few screes. These areas sometimes host extremely open scrub and grasslands. Natural communities of rupicole, chasmophytes and scree plants occur only very rarely. However, given their rarity and singularity, the following taxa are worthy of note: *Antirhinum graniticum*, *Chiliadenus glutinosus*, *Galeopsis ladanum*, *Melica ciliata*, *Sedum acre*, *S. dasyphyllum* and *Umbilicus rupestris*. Anthropic bare ground and rock outcrops (35) includes other rocky surfaces that outcrop due to the fact that the land has been laid bare by human activities with direct, recent effect. These include areas hollowed out by continuous agricultural, livestock and/or forestry uses.

5. Conclusions

This paper highlights the technical and methodological value of using U.T.M.-hectads in studies of plant landscape at a local level, as regular units that enable the systematic comparison of areas of the same shape and size. Within one such hectad (Utande), we conducted combined, detailed analyses of the flora (autoecological approach) and the vegetation (phytocoenotic), interwoven with a study of the land covers. The results show that this is a robust, effective method that produced a great deal of information at a high level of detail, which could be applied in territorial planning for protection and conservation purposes.

The semi-detailed scale and the incorporation of the physiognomic criterion (stratification), together with the floristic criterion enabled us to identify varied categories of scrublands, which were marked off in large formations across the study area. This enabled us to detect a wide diversity of plant landscape. The study has covered a representative area of the landscape of central Spain, which is not mountainous but could be classified as a highland region. This is an area of bioclimatic and biogeographical transition, in which most of the semi-natural environments are confined to the hillsides, marginal spaces for anything but subsistence agriculture. In these areas, we observed a generalized pattern of progressive vegetation succession, together with the reforestation with plantations of pine trees. Agriculture and forestry are concentrated on the plateaus and in the valleys and for now at least there is no space for extending the autochthonous forest.

Software

The vegetation map was produced using Esri ArcGIS 10.7.1 software. This facilitated tasks such as shading, based on the IGN digital model of the 5 m terrain, or the digitization of the tiles and their representation via thematic symbology.

Disclosure statement

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Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials (Main Map).

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