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Vegetation on expansive clays from Madrid and La Sagra region (Madrid-Toledo, Spain)

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Abstract. Soils rich in expansive clays (i.e., smectite and montmorillonite, and, to a lesser extent, soft clays such as sepiolite and palygorskite) are found in a broad stretch running NNE-SSW from the east of Madrid to the Tagus River surroundings in the province of Toledo. These clays tend to give rise to a specific type of soil, known as "vertisols" or related argillic soils with vertic behaviour, varied chemical and sedimentological composition, and occasionally siliceous or dolomitic clasts. In these soils, where there is an absence of woody vegetation, the colonising nitrophilous vegetation becomes of particular interest through the usage and alteration of the land. These argillic soil plant communities are incredibly diverse, with flora suited to the unique hydrogeochemical conditions of these settings. The variety of these plant communities is determined by factors such as land use, lithology, terrain, and the level of humidity they can withstand. In the present work, we identified the primary plant community on the Madrid-Toledo expansive clays, as well as provide a preliminary approach to the different varieties and transitions to other related plant communities. The main dynamic and catena links are established, and a floristically summarised table is provided, along with a descriptive examination of the community's behaviour and variability. Lastly, its conservation status and the high degree of threat to which it is subjected are assessed.

Keywords: argillic flora, La Sagra, *in situ* conservation, endangered flora, land-use.

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Introduction

At first glance, the vegetation of the clayey areas in the northwest corner of the southern Spanish sub-plateau —which are dominated by large cereal fields— is difficult to tell apart from that of the gypsum- and arkose-dominated areas to the southeast and northwest, respectively. However, a more detailed observation reveals big differences in the vegetation, which make this clayey area different from the neighbouring gypsum and arkose vegetation.

Soils in the area studied with a high content of expansive clays (i.e., smectites, mostly saponite-stevensite and montmorillonites, and to a lesser extent sepiolite-palygorskite) have distinct chemical properties, such as the abundance of magnesium (García-Rivas, 2018); but, most importantly, they are characterised by their harsh physical conditions, like the way the soil breaks apart into deep cracks in the dry season, and how it fills up with water and pools on the surface in the wet season, giving way to the formation of mudslides (IUSS-WRB, 2015). Because of the depth and size of the cracks produced in these soils, the alternate expansions and contractions promote horizon mixing, root breaking, and rapid drying of the edaphic profile; a mechanical behaviour that acts as a selective pressure for plant colonisation and establishment.

Although these clays produce vertic soils, they do not appear on soil maps as 'Vertisols' (Data CAM, 1990), but rather as 'Cambisols' and 'Luvisols' with vertic characteristics, with the latter aspect rarely highlighted by soil cartography (Data CAM, 1990). When interspersed hard materials such as dolomites or flint appear, they are referred to as 'Regosols' (Monturiol & Alcalá, 1990). These clays are in contact with sepiolite levels, which are present in almost all mineralogical studies of clay soils. In the study area, sepiolite levels can achieve high purity, which is extremely important because they represent the world's largest exploitation reserves. In these areas, agriculture and urbanisation are primarily responsible for the extinction of plant communities and species endemic to the peninsula's clayey soils, but

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industrial exploitation of these sepiolite, ceramic, and brick-making clays is also a significant factor.

To better define the peculiar soil type that sustains the flora that will be identified and described in this study, we have settled on the term “expanding magnesium clays.” Herbaceous plant communities are found in the argillic ecosystems of the examined territory. Soil chemistry (i.e., the predominance of dolomites, magnesium, silicates, carbonates, or gypsum) and sedimentology (i.e., clayeyness, sandiness, or stoniness) and, most importantly, soil management practises that involve varying degrees of alteration and nitrification, all contribute to the diversity within these plant communities. There is no evidence of arboreal vegetation. However, when hard materials arise scattered between these mostly clayey soils, some broom shrubs (*Retama sphaerocarpa*), asparagus (*Asparagus acutifolius*), gorse (*Genista scorpius*), almond trees from abandoned crops, and a few holm oaks (*Quercus rotundifolia*) appear. Due to the hard conditions imposed on the colonising plants, which tend to support the maintenance of the soils’ vertic nature, a distinct grassland has emerged in association with these expansive clays (green, grey, or maroon).

Nearly two decades of direct observation, tracking, discussion, results, locality selection, and classification led to its endangered conservation designation. Over the past few decades, reckless land management changes and aggressive urbanisation have eliminated some important plant localities and species in Madrid (Martínez Labarga, 2009; 2013b,c). Twenty years of diligent observation of individual sites (see Martínez Labarga, 2009, 2010) resulted in the addition of new sites and the terrible loss of many others to development, infrastructure, or transformed into urban gardens (Martínez Labarga, 2013a). Due to their unique plant species, we’ve been interested in the characterisation and conservation of these areas. Our goals are to (1) characterise the argillic flora of these localities, and (2) make an approximate comparison with other, comparable communities in the region and their geotopographic catena. We identified the species that ‘should be’ and noted the remarkable floristic similarity due to resemblance between geographically distant areas, confirming a high floristic concordance.

Location and geological context

The studied territory is located within the Bajomatritense and Bajotoledano-Sagrense districts of the Manchego sector of the Castilian subprovince of the Central Iberian Mediterranean region (Rivas-Martínez *et al*., 2017). Its climate corresponds to the oceanic pluviseasonal Mediterranean bioclimate. Using the values from the nearest climatic stations (i.e., Toledo (Castile and La Mancha Region) and Getafe (Madrid)) for the period 1980–2010, we obtain a simple continentality index (Ic = 20.4–20.0; marked semi-continental oceanic, bordering on continental), a dry ombroclimate with 342–365 mm per year, and a thermic index of It=267–286, putting this territory in the upper horizon of the mesomediterranean bioclimatic floor (Rivas-Martínez, 1983).

The presence of these argillic soils is owing to the unusual meeting of two massive, very different geological zones: the Central System and the Madrid basin. Due to their mutual interactions, with mineral substitutions, neoformations, or various chemical alterations, the lithological range in this intermediate stretch between the siliceous mountainous materials and the limestone-gypsum in the basin’s centre is broad. Consequently, clayey, sandy, dolomite, and flint materials predominate on a lower gypsum layer, which also interstratifies (Domínguez *et al*., 1997; Lomoschitz *et al*., 1985). The plant groups and species of interest in this study can be found across the entire intermediate zone (Figure 1).

IGME Magna 50 series maps 559 Madrid, 560 Alcalá de Henares, 582 Getafe, 604 Villaluenga de La Sagra, and 605 Aranjuez show a heterogeneous lithological composition. As a result, we can find green-greyish magnesium clays (thanks to saponite) and pink clays (due to stevensite), sometimes pure but often mixed with micaceous sand, non-magnesium, and non-expansive lamellar clays (primarily illite, which gives brown clays a different shade). Modulated magnesium clays, such as sepiolite, limestone-dolomitic concretions, and gypsum and flint intercalations are present (Domínguez *et al*., 1997). Dolomites and flint outcrops southeast of this formation create uneven morphologies. The huge gypsum in the basin’s core and the mountain granite arkoses to the northwest interconnect in both lithological contact regions (García Romero, 2004).

This contact area is located in the immediate vicinity of Madrid and follows the layout of the Cañada Real Galiana, an ancient livestock route (Villalvilla *et al*., 1994) running from Paracuellos del Jarama in the NNE towards La Sagra in Toledo in the SSW, passing through the municipalities of San Fernando de Henares, Torres de la Alameda, Loeches, Coslada, Vicálvaro, Rivas Vaciamadrid, Vallecas, Carabanchel, Getafe, Pinto, Valdemoro, Leganés, Torrejón de Velasco in Madrid and, in Toledo, Illescas and almost all the municipalities of La Sagra Baja, from the Extremadura highway (A5) to the Andalusian highway (A4). Given the importance of the area as a classic locality for botanists, visited by renowned botanists since the 18th century, and as a tribute to Madrid’s Cerro Negro, we gathered the plants cited in the bibliography that we consider to be characteristics of these clays and added another column to the table of inventories (without assuming abundances) to demonstrate the remarkable floristic coincidences among the various locations where we find these expansive magnesium clays.

Status of the territory

This entire region was, until recently, Madrid’s agricultural pantry, having been heavily populated since Neolithic times due to the economic mining of flint (Consuegra *et al*., 2004). They are currently marginal peri-urban areas with a range of large infrastructures (e.g., AVE-high speed train, radial highways, ring roads,

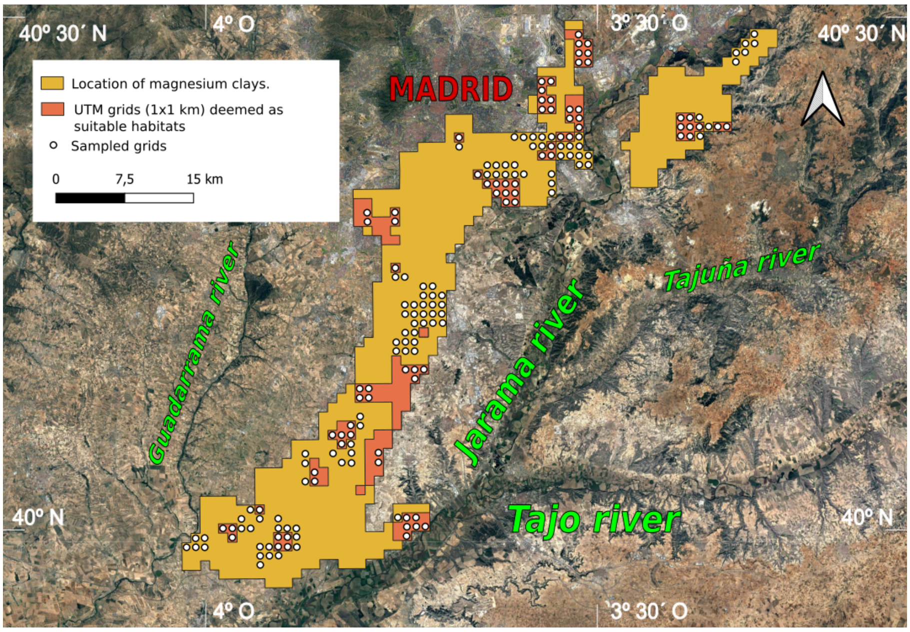

Figure 1. Approach to the argillic area located between the arkose areas from the Sistema Central range and the Madrid basin. This estimated argillic area represents the plausible distribution of *the Klaseo flavescentis-Cynaretum tournefortii* in Madrid and Toledo, excluding western areas of the Guadarrama river.

railway lines, and high voltage lines) and significant remnants of industrial and mining operations (brick clays and sepiolite) from the last two decades as a result of unrestrained urban expansion (de Pablo *et al*., 2017).

The few surviving natural areas have been reduced to lots, undeveloped properties, or marginal regions between urban infrastructures. Contrary to popular belief, this has advocated for the preservation of the only surviving remnants of this type of vegetation (Isabel *et al*., 2023). When you compare these lands and empty fields to the rest of the land in Madrid and Toledo that is used for agriculture, the former statement is easy to illustrate. Given the high aggressiveness of modern agricultural techniques, the use of biosafety products and the increasing absence of fallows and burdocks have led to the disappearance of traditional weed species in the vast majority of agricultural fields.

Materials and Methods

We analysed existing geological-edaphic studies (Consuegra *et al*., 2004; Domínguez *et al*., 1997; García-Rivas, 2018; Lomoschitz *et al*., 1985; Magna 50) to more precisely correlate lithologies and plant communities. To create a bibliographic compilation of the zone's geology and identify clay-rich areas, all existing literature on the classic sites of Madrid's immediate urban environs was examined. Furthermore, we expanded this search and identification to neighbouring areas (Hernández *et al*., 1990; Saldaña & Gallardo, 1992), such as the volcanic area of Campo de Calatrava (García Camacho *et al*., 2004; Horra *et al*., 2008), and the Triassic clays in the Alcázar de San Juan (Luengo, 2020). We used a geographic information system (QGIS 3.24.0) to plot the location of the magnesium clays and, within that area, where we could still discover some of the associated flora and fauna in the form of surviving vegetation patches (Figure 1).

Once the locations with a high clay incidence and low vegetation were identified, transects were drawn to carry out itineraries to catalogue the vegetation (transects referenced in Datum ETRS89). Magnesium clays are expected to cover an area of 786 UTM grids (1x1 km), with the Guadarrama River serving as the western boundary and the Tajuña River serving as the eastern boundary of the area examined (Figure 1). Natural herbaceous vegetation covers 108 km^2 of this region. In total, 181 (23%) grids were visited in all the transects in this study. Seventy-eight of these 181 grids were located on what we deemed to be suitable habitat for the existence of the indicated plant community (~72%). More than one trip was made to most of the grids, with floral inventories being taken at each visit.

We were able to locate and categorise the flora in these isolated areas with the use of a number of inventories and other personal or bibliographic approaches. After verifying the existence of these minor variations in the surrounding Iberian interior, this investigation will be broadened to explore the more systemic vicariants.

Except for particular references, we followed the work of Castroviejo (1986–2021), Tutin *et al.* (1964–1980), and Aizpuru *et al.* (1999), the Anthos project (Anthos 2011–2021), and GBIF (2021) for species nomenclature. To investigate the floristic community, we also consulted the work of Cavanilles, (1791–1801), Cutanda (1861), Colmeiro & Penido (1885–1889), López (2007), Grijalbo (2010), and the available flora lists for the Madrid Autonomous Community (Abajo *et al*., 1982; Cebolla & Rivas, 1994; Grijalbo, 2012, 2016; López, 2007; Morales, 2003; Martínez Labarga, 2014), paying special attention to the information available in Meliá (2009).

Figure 2. *Carduncellus matritensis* specimen in its habitat in La Sagra (province of Toledo, Spain).

Results

Flora and Vegetation

Overall, the vegetation in the area is comprised of lush and diverse grasslands, as well as thistle-dominated areas as a result of the abandonment of grazing and agricultural practices, or due to a high level of human alteration. Poor agricultural exploitation is found in the remaining areas, particularly on the slopes along the major valleys (Jarama, Henares, Manzanares, Guatén) and in the areas where the topography retains some witness hills (Almodóvar, Telégrafo, Batallones, Cerro Magán, etc.). Thus, it allows for the formation of outcrops of the original flora, featuring fewer holm oaks and more almond trees from abandoned fields, with a few broom-gorse and thyme bush-like vegetation. The clay-rich area sits between the two altitudinal levels (hills and main valleys) and is mostly flat, or virtually flat, like the lower elevations closer to the Tagus River, but with a salty tendency. Southeast, clay-associated vegetation becomes gypsum-associated. This floristic transition stands out from the 'aljezar's' Gypsophiletalia.

The most distinctive grassland of the Madrid-La Sagra region is highly diverse, with a floristic catalogue including up to 500 species, depending on the period lapsed since agricultural abandonment. Among the perennial species we have *Anchusa azurea*, *Astragalus alopecuroides*, *Cynara cardunculus* subsp. *flavescens*, *C. tournefortii, Ecballium elaterium*, *Echium asperrimum*, *Eryngium campestre*, *Klasea flavescens*, *Lavatera triloba*, *Linum austriacum* subsp. *collinum*, *Malvella sherardiana, Matthiola fruticulosa*, *Ononis spinosa*, *Ornithogalum narbonense*, *Phlomis herba-venti*, *Salvia aethiopis*, *S. argentea*, *Taraxacum obovatum* or *Thapsia dissecta* (Arán & Mateo, 2002). Among the most important annual herbs are species such as *Acinos rotundifolius*, *Adonis microcarpa*, *Astragalus scorpioides*, *A. sesameus*, *A. hamosus*, *Bromus lanceolatus*, *Euphorbia sulcata*, *Geropogon hybridus, Papaver dubium*, *Podospermum laciniatum*, *Scorzonera angustifolia*, *Thrincia hispida*, *Tragopogon porrifolius*, *T. dubius*, *Turgenia latifolia*, *Silene muscipula*, or *S. nocturna*; with the following species being characteristic and locally abundant in these grasslands: *Anagallis arvensis, Carlina corymbosa* subsp. *hispanica*, *Convolvulus arvensis*, *Coronilla scorpioides*, *Crepis alpina*, *C. pulchra*, *C. taraxacifolia, Crupina crupinastrum*, *C. vulgaris*, *Echinops strigosus*, *Linum strictum*, *Lomelosia simplex*, *L. stellata*, *Medicago minima*, *M. sativa, M. truncatula*, *Ononis biflora*, *Polygonum aviculare*, *P. bellardii* and *Scandix australis.*

Graminoids are hardly abundant, except for *Avena sterilis*, with *Aegilops geniculata*, *A. triuncialis*, *Brachypodium distachyon*, *Bromus lanceolatus*, *B. matritensis*, *B. rubens*, *B. scoparius*, *Dactylis glomerata* subsp. *hispanica*, *Echinaria capitata*, *Lolium rigidum*, *Phalaris minor* or *Rostraria cristata*; and in thyme-dominated or somewhat stony areas *Avenula bromoides*, *Koeleria castellana*, *Stipa* spp. or *Wangenheimia lima. Triticum boeoticum* can also be found with a difficult biogeographic explanation, given that its presence in Europe is only recorded west of the continent (Ruiz *et al*., 2012, Martínez Labarga, 2013a; Meliá, 2009; Grijalbo, 2012).

This argillic vegetation highlights species that are rare in the inner peninsula or are on the verge of extinction on a local, regional, or even global scale. This is the case for *Aizoon hispanicum* (Molina & Sanz, 2002), *Allium cyrilli, Anchusa puechii, Astragalus scorpioides, Carduncellus matritensis*, *Chamaeiris reichenbachiana*, *Colchicum triphyllum*, *Conringia orientalis*, *Convolvulus humilis*, *Cynara tournefortii*, *Geropogon hybridus*, *Gladiolus italicus*, *Hohenackeria polyodon*, *Malvella sherardiana*, *Nepeta hispanica*, *Onosma tricerosperma, Scolymus maculatus, Teucrium spinosum*, or *Triticum boeoticum*.

Others very rare, but with less risk, like *Acinos rotundifolius*, *Astragalus alopecuroides*, *Bupleurum rotundifolium*, *Ceratocephala falcata*, *Convolvulus meonanthus*, *Crepis alpina*, *Crucianella patula*, *Echinops strigosus*, *Klasea flavescens*, *Linaria caesia*, *Linum austriacum* subsp. *collinum*, *Minuartia hamata*, *Ononis pubescens*, *Ridolfia segetum*, *Rochelia disperma*, *Silene muscipula*, *Sternbergia colchiciflora* or *Vicia narbonensis* (Table 1).

The location of two important species was discovered during the characterization of this plant community: *Allium cyrilli* Ten., a novelty for the Iberian Peninsula that was previously identified as *A. nigrum*, and not found in Madrid since the early XX Century (Jiménez Box *et al.,* 2022), where three populations had been identified; with only the one in Rivas-Vaciamadrid remains today, while the two in Vallecas have recently vanished due to the urbanisation of Madrid's Southeast Developments). The other species, *Carduncellus matritensis* Pau (Luengo *et al*., 2022, 2023; Figure 2), was identified near Monte Magán in La Sagra (Toledo) and was considered to be extinct in its sole known location, Cerro Negro (Madrid; Bañares *et al*., 2004).

Anchusa puechii, *Convolvulus humilis*, *Gladiolus italicus*, *Onosma tricerosperma*, *Saponaria glutinosa*, and *Teucrium spinosum* are other species threatened in Madrid and Castile-La Mancha (Table 1). After extensive and futile search efforts, we believe *Hohenackeria polyodon* has vanished from Madrid. The latter, as it has not been spotted since 2003 near its known location, the Santa Catalina station (Revilla, 2003).

Table 1. Endangered or very rare species from the community proper of expansive clays from Madrid-Toledo (La Sagra) classified according to UICN (2012). The cited sources provide in-depth information on the local or regional ecology and status of the specified species. Our proposed additions to the protected red lists are indicated with an asterisc (*). Threat level, danger of extinction; Clay affinity, degree of affinity to expansive clays (+5 to 0). Red list categories: CR, critical; EN, endangered; VU, vulnerable.

Species	Threat level	Clay affinity	Red list category	Observations
Acinos rotundifolius	3	4		
Aizoon hispanicum	3	3	*	Disjunction/Salt
Allium cyrilli	5	4	CR C2 a(i,ii)b (see Jiménez *et al.*, 2022)	New for Spain.
Anchusa puechii	5	5	*	Southern vertisols
Astragalus alopecuroides	3	4	*	Gypsum influence
Astragalus scorpioides	4	4	*	
Carduncellus matritensis	5	5	CR B1ab(i,ii,iii) B2ab(i,ii,iii) (see Luengo *et al.*, 2023)	Rediscovered
Ceratocephala falcata	3	3		
Chamaeiris reichenbachiana	4	3	*	Humidity/Salt
Colchicum triphyllum	3	3	*	
Conringia orientalis	4	4		Weed species
Convolvulus humilis	5	5	*	Northernmost
Convolvulus meonanthus	4	5	*	Almost northernmost
Cynara tournefortii	4	5	CR B2ab(iii,iv,v) (see Moreno, 2008)	Northernmost
Geropogon hybridus	3	4	*	Innermost location
Gladiolus italicus	4	4	*	Weed species
Hohenackeria polyodon	5	5	VU B2ab(i,ii,iii); C2a(i)b (see Moreno, 2008)	Probably Extinct
Klasea flavescens	3	4		Innermost location
Linaria caesia	3	4		
Malvella sherardiana	4	5	VU B2ac(iii,iv); C2a(i) (UICN, 2012) (see Bañares *et al.*, 2004)	Almost northernmost
Nepeta hispanica	4	3	VU B2ab(i,iv)c(iv); D2 (see Moreno, 2008)	Gypsum influence
Ononis pubescens	5	3		Almost northernmost
Onosma tricerosperma	5	4	*	
Rochelia disperma	4	4		Gypsum influence
Saponaria glutinosa	4	4	*	Supramediterranean
Scolymus maculatus	3	5		Weed species
Silene muscipula	3	5		
Sternbergia colchiciflora	3	3		With flynt or stones
Teucrium spinosum	4	5	*	Almost northernmost
Triticum boeoticum	5	4	*	Humidity
Turgenia latifolia	2	5		
Vicia narbonensis	2	4		Humidity

Syntaxonomic remarks

The vegetation on clayey magnesium soils, the main focus of this study, is a rare mesophilic, dry-semiarid association in the argillic mesomediterranean soils of the Manchego Sector of the Castellan subprovince. It is a new plant community which has to be called *Klaseo flavescentis-Cynaretum tournefortii* (Table 2, see below). Other communities related to clay richness depend on edaphic variations (e.g., sedimentology, humidity, presence of gypsum, sands, stones, etc.) or the topographic position. As a result of the soil's vertic behaviour, several species, such as thistles and others that have adapted to the shifting substratum, have taken on a nearly nitrophilous character. *Artemisietea* plants share these characteristics, therefore they can thrive here, both in their native environment as well as in a dynamic one, brought on by human activity. Consequently, the main vegetation consists primarily of a grassland, with an incomplete cover, and a total richness flora of close to 500 species, around 40–50 representative and, from these, approximately 30 rare or critically endangered species.

When succession is complete, *Cynara tournefortii,* which has disappeared from most of its historical locations, is the dominant species in this community, with presence in the seed bank. The community is identified by the large size and abundance of this artichoke growing at ground level (Figure 3), but its congener *C. cardunculus* subsp. *flavescens* may be more common in the Toledo area. During our field campaigns, we were able to collect oral records of its abundance in many locations around Madrid and even in Guadalajara (Quer, 1762–1764), suggesting a past abundance far from its current status and presumed absence.

Klasea flavescens was chosen as the representative species since it is common in these soils. It can also be found in croplands or thyme-dominated Miocene clayey soils in eastern Ciudad Real, whereas other subspecies of *K. flavescens* can be found to the south and southeast of the Iberian Peninsula (Cantó, 2012). Due to its casualness, resemblance, and synergy, we initially thought *Carduncellus matritensis* was the representative species of these sites. However, its presence is so rare that it fails the bare criteria of representativeness. *Astragalus alopecuroides* was another candidate, but it is more prevalent in the xerophyte or gypsum transition than these clays.

Figure 3. Type locality for *Klaseo flavescentis-Cynaretum tournefortii*, Quintana del Jarama (San Fernando de Henares, Spain).

Table 2
Klaseo flavescentis-Cynaretum tournefortii Luengo, de Pablo, Sánchez Mata & Mart. Labarga *ass. nova*
(*Onopordion castellani*, *Carthametalia lanati*, *Artemisietea vulgaris*)

Altitude	594	587	586	618	618	615	686	620	637	624	590	558	580	580	550	573	615
Number of taxa	60	22	43	43	28	21	41	34	25	38	33	48	44	59	21	37	.
Relevé Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Characteristics																	
Cynara tournefortii	3	4	1	1	1	.	.	.	.	.	.	1	3	2	2	.	x
Klasea flavescens	1	+	.	+	2	.	1	2	.	.	2	.	.	1	1	1	x
Astragalus alopecuroides	1	.		1	+	.	3	.	.	.	1	.	1	.	.	.	x
Phlomis herba-venti	1	+	1	1	2	1	1	.	.	+	1	.	+	1	2	2	x
Thapsia dissecta	+	.	1	1	+	.	+	+	1	1	1	1	.	+	1	+	x
Salvia argentea	+	1	.	1	+	.	.	.	1	+	1	.	.	+	.	2	x
Ononis spinosa	1	1	.	+	1	1	.	2	1	+	.	+	.	+	.	.	x
Malvella sherardiana	1	.	.	.	1	1	.	2	.	.	.	1	2	1	.	.	x
Echinops strigosus	2	1	2	1	1	1	1	2	.	1	.	1	1	3	1	.	x
Valerianella discoidea	1	1	+	1	.	1	.	1	1	.	.	1	2	1	.	1	x
Crepis alpina	1	.	2	1	.	.	1	3	1	1	1	2	3	3	.	.	.
Coronilla scorpioides	1	1	.	.	.	.	.	1	.	2	1	1	1	1	.	.	x
Euphorbia sulcata	2	1	.	.	1	.	.	.	.	1	.	.	3	1	1	.	x
Silene muscipula	2	.	.	+	+	.	+	.	.	.	.	.	.	+	+	+	.
Carduus bourgeanus	.	.	+	+	+	.	+	1	.	1	.	1	1	.	.	.	.
Rapistrum rugosum	.	.	1	+	.	.	.	1	.	.	.	+	1	1	.	1	.
Bromus lanceolatus	2	.	.	1	.	.	1	1	.	.	1	+	.	.	.	.	x
Scolymus maculatus	+	.	+	.	.	.	.	.	.	.	.	.	+	2	1	.	x
Geropogon hybridus	1	.	.	+	.	1	.	.	.	.	.	.	+	+	.	.	x
Anagallis arvensis	1	.	+	.	.	.	.	1	.	.	.	2	+	1	.	.	.
Scandix australis	.	.	.	1	.	+	.	.	.	.	1	.	.	.	.	1	x
Nigella gallica	.	.	.	.	.	.	+	.	.	.	.	+	.	+	.	1	x
Turgenia latifolia	.	.	.	1	.	+	.	.	.	.	.	.	.	+	.	+	x
Acinos rotundifolius	.	.	.	+	.	+	.	+	.	.	.	.	1	1	.	.	.
Kickxia lanigera	+	.	1	.	.	.	.	+	.	.	.	.	+	+	.	.	.
Carduncellus matritensis	.	.	.	.	.	.	.	.	.	.	.	1	2	.	1	.	x
Ononis biflora	.	.	.	.	.	.	.	.	1	1	.	1	.	.	.	.	x
Mantisalca spinulosa	1	.	1	.	.	.	.	.	.	.	.	+	.	.	.	.	x
Ornithogalum narbonense	1	+	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.
Lavatera triloba	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.
Sisymbrium austriacum subsp. *contortum*	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	+	.
Teucrium spinosum	2	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	x
Vicia monantha subsp. *calcarata*	.	+	.	+	.	.	.	.	.	.	.	.	+	.	.	.	x
Androsace maxima	.	+	.	.	.	.	.	.	.	+	.	+	.	.	.	.	x
Salvia aethiopis	.	.	.	.	+	.	.	+	.	.	+	.	.	.	.	.	.
Sisymbrium crassifolium	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	x
Allium pallens	.	.	+	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Linaria caesia	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	x
Onobrychis matritensis	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	x
Convolvulus meonanthus	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	x
Convolvulus humilis	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x
Althaea hirsuta	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Cynara cardunculus subsp. *flavescens*	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.
Ammi visnaga	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.
Scabiosa galianoi	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.

Nonea vesicaria	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.
Linum austriacum subsp. *collinum*	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.
Allium cyrilli	.	.	.	.	.	.	.	.	1	2	.	.	.	.	.	.	.
Triticum boeoticum	.	.	.	.	1	3	.	.	.	.	.	.	.	.	.	.	.
Adonis microcarpa	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Crucianella patula	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Ranunculus arvensis	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Other species																	
Eryngium campestre	+	1	1	+	1	+	1	+	1	2	1	+	1	1	.	2	.
Thrincia hispida	2	.	1	+	1	1	1	1	1	1	.	1	1	1	1	1	.
Avena sterilis	1	.	1	1	3	.	2	.	3	1	1	1	+	1	.	1	.
Bromus matritensis	+	.	+	.	+	.	1	.	1	1	1	1	2	1	1	1	.
Centaurea melitensis	.	+	1	+	.	.	.	1	.	1	1	1	1	3	2	1	.
Bromus rubens	+	.	+	+	.	+	.	.	+	+	1	+	1	.	1	+	.
Euphorbia serrata	.	.	1	1	1	+	1	1	.	1	+	+	+	1	.	.	.
Crepis taraxacifolia	2	.	1	1	1	.	2	.	1	1	+	1	1	1	.	.	.
Aegilops geniculata	.	+	1	1	2	.	1	.	1	.	1	.	.	1	.	1	.
Carlina corymbosa subsp. *hispanica*	.	1	+	.	1	.	1	.	.	+	1	+	.	1	.	+	.
Filago pyramidata	1	.	1	.	.	.	+	1	.	2	1	+	1	1	.	.	.
Sonchus asper subsp. *glaucescens*	1	.	.	.	.	.	1	1	1	.	.	.	2	2	1	+	.
Asteriscus aquaticus	1	.	1	.	.	.	1	.	.	.	1	1	.	1	2	1	.
Ecballium elaterium	+	.	.	.	.	.	+	2	.	+	.	+	1	1	+	+	.
Linum strictum	+	.	.	.	1	.	1	1	.	.	2	.	+	1	.	1	.
Neatostema apulum	.	1	.	+	.	.	1	1	.	.	1	.	1	1	2	.	.
Bartsia trixago	+	.	1	1	.	.	1	.	.	2	.	1	1	1	.	.	.
Lomelosia simplex	.	.	.	+	2	.	+	.	1	1	2	.	.	.	.	1	.
Centranthus calcitrapae	.	.	+	+	.	.	.	1	.	.	1	1	3	2	.	.	.
Galium parisiense	+	.	+	1	.	.	1	1	.	.	.	.	1	1	.	.	.
Tragopogon porrifolius	.	.	1	+	+	+	.	.	1	+	+	.	.	.	.	.	.
Eruca vesicaria	.	.	+	+	.	.	.	1	+	1	1	+	.	.	.	.	.
Medicago minima	.	.	1	1	+	.	.	.	.	1	.	.	+	.	.	1	.
Anchusa azurea	.	.	.	.	.	+		1	.	.	.	+	+	1	.	+	.
Sanguisorba verrucosa	1	.	.	.	1	.		.	.	.	+	+	+	1	.	.	.
Crupina vulgaris	.	.	+	2	3	+	.	.	.	2	.	.	+	1	.	.	.
Hedypnois cretica	.	+	.	+	.	.	1	.	.	.	.	.	+	.	.	+	.
Scolymus hispanicus	.	.	+	.	.	.	+	.	.	+	.	.	.	+	.	+	.
Carthamus lanatus	+	.	1	.	.	+	.	.	.	.	.	+	.	.	.	2	.
Biscutella auriculata	.	.	+	+	.	.	.	.	1	1	.	.	.	.	.	+	.
Echium vulgare	.	.	.	.	.	.	.	1	.	.	+	+	.	1	1	.	.
Papaver rhoeas	2	.	1	.	.	.	.	.	.	.	.	+	1	2	.	.	.
Convolvulus arvensis	+	.	.	.	1	.	.	1	.	.	.	.	+	1	.	.	.
Echinaria capitata	+	.	.	1	.	+	.	.	.	1	.	+	.	.	.	.	.
Lomelosia stellata	+	.	1	.	.	.	1	.	+	.	+	.	.	.	.	.	.
Bombycilaena discolor	1	.	.	.	.	.	1	.	.	.	.	.	.	1	.	+	.
Diplotaxis virgata	.	.	+	.	.	.	.	1	.	.	.	+	.	.	.	1	.
Melica ciliata subsp. *magnolii*	+	.	2	.	.	.	.	.	.	+	.	.	.	.	.	1	.
Papaver dubium	1	.	.	+	.	.	.	.	.	.	.	+	.	+	.	.	.
Ononis viscosa	1	+	.	.	.	.	2	.	.	.	.	.	.	+	.	.	.
Crepis pulchra	+	.	+	.	+	.	.	.	.	.	.	.	.	+	.	.	.
Brachypodium distachyon	2	.	.	1	.	.	1	.	.	.	.	1	.	.	.	.	.
Phlomis lychnitis	.	.	.	+	.	.	1	.	.	+	1	.	.	.	.	.	.
Podospermum laciniatum	.	.	+	.	.	+	.	.	2	1	.	.	.	.	.	.	.

Cichorium intybus	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	+	.
Dactylis hispanica	1	.	.	.	.	.	.	.	.	.	1	.	.	+	.	1	.
Lolium rigidum	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.
Campanula erinus	.	+	.	.	.	.	.	1	.	.	.	.	.	.	.	+	.
Silene nocturna	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.
Retama sphaerocarpa	+	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.
Rostraria cristata	.	.	.	.	.	.	1	.	.	.	.	.	+	1	.	.	.
Reseda lutea	.	.	.	.	.	.	.	+	.	+	+	.	.	.	.	.	.
Polygala monspeliaca	.	.	.	.	.	.	1	.	.	2	1	.	.	.	.	.	.
Taraxacum obovatum	.	.	1	.	.	.	.	.	.	1	2	.	.	.	.	.	.
Tragopogon dubius	+	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.
Centaurea solstitialis	.	.	+	1	.	.	.	.	.	+	.	.	.	.	.	.	.
Echium asperrimum	.	.	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.
Matthiola fruticulosa	.	+	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.
Medicago sativa	+	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.
Salvia verbenaca	.	.	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.
Silene vulgaris	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	+	.
Delphinium gracile	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Cleonia lusitanica	.	.	.	.	.	.	2	.	.	.	.	.	.	.	3	.	.
Carduus tenuiflorus	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	.
Taeniatherum caput-medusae	.	.	.	.	.	.	1	.	.	.	+	.	.	.	.	.	.
Thymelaea passerina	1	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Thymus zygis subsp. *sylvestris*	2	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Polygonum aviculare	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Other species: Characteristics: *Onosma tricerosperma* 1 in 1; *Gladiolus italicus* and *Bupleurum rotundifolium* + in 3; *Astragalus scorpioides* + in 12; *Ridolfia segetum* + in 13; *Hohenackeria polyodon* + in 17. Other species: *Genista scorpius*, *Crucianella angustifolia*, *Raphanus raphanistrum* and *Torilis arvensis* 1; *Sideritis incana*, *Teucrium capitatum*, *Helianthemum asperum* and *Stipa barbata* + in 1; *Asterolinum linum-stellatum* 1, *Prunus dulcis*, *Bassia prostrata*, *Astragalus incanus*, *Helianthemum ledifolium*, *Atractylis cancellata* + in 2; *Melilotus sulcatus* 1 in 3; *Erodium cicutarium* + in 4; *Picnomon acarna* + in 5; *Medicago truncatula* + in 6; *Bassia prostrata*, *Dorycnium pentaphyllum*, *Helianthemum hirtum* and *Bromus hordeaceus* 1, *Quercus coccifera*, *Salsola vermiculata*, *Helichrysum stoechas* and *Iberis pectinata* + in 7; *Lamium amplexicaule* 1, *Astragalus stella* + in 8; *Cardaria draba* 3, *Erodium botrys* 2, *Geranium molle*, *Sisymbrium runcinatum*, *Hypecoum imberbe*, *Astragalus sesameus*, and *Cirsium arvense* 1, *Euphorbia exigua* + in 9; *Aristolochia pistolochia*, *Xeranthemum inapertum*, *Anacyclus clavatus*, *Reseda phyteuma*, *Lathyrus clymenum* and *Hordeum murinum* 1, *Muscari comosum* + in 10; *Plantago albicans* and *Silene colorata* 1, *Hippocrepis commutata* + in 11; *Silybum marianum* 1, *Amaranthus blitoides*, *Chenopodium vulvaria*, *Chrozophora tinctorea*, and *Mantisalca duriaei* + in 12; *Olea europea*, *Nonea echioides*, *Lactuca serriola*, and *Papaver somniferum* + in 13; *Pinus halepensis* 1 and *Olea europea* + in 14; *Plantago lagopus* 2, *Daucus carota* and *Mantisalca salmantica* 1, *Hirschfeldia incana* + in 16; *Trigonella gladiata*, and *Rochelia disperma* + in 17.

Localities: 1: Madrid, San Fernando de Henares, Quintana del Jarama. Green clays with scarce sepiolite. N 40.468-W -3.5184, 80% cover, 200 m^2 [reg. May 2010], *holotypus ass*; 2: Madrid, Paracuellos del Jarama, Berrocales, patch towards NNW close to the pine forest and the high-tension tower, N 40.472-W -3.5247, SE-N faces, 80% cover, 100 m^2, W [reg. May 2016]; 3: Madrid, San Fernando de Henares, Quintana del Jarama, m,in trough, almost below; more humidity, N 40.468-W -3.5204, 95% cover, 5% slope, 100 m^2. WSW [reg. May 2019]; 4: Madrid, old plot, prior to the disappearance at CTC Coslada, green clays, N 40.437-W -3.5634, 90% cover, 100 m^2 [reg. May 2013]; 5: Madrid, remnants CTC Coslada. grasslands angle tracks, green clays, N 40.4379-W -3.5663, 85% cover, 200 m^2, E [reg. May 2019]; 6: Madrid, remnants CTC Coslada, grasslands with *Triticum boeoticum*. green clays, N 40.4379-W -3.5714, 90% cover, 200 m^2 [reg. May 2014]; 7: Madrid, Torres de la Alameda, brown clays, N 40.3965-W -3.3405, 80 % cover, 100 m^2, WNW [reg. May 2021]; 8: Madrid, Vicálvaro, Arroyo de Los Migueles, hillsides/slopes next to the AVE bridge stream, green clays with flint and sandblasted sepiolite, N40.3731-W-3.5610, 85% cover, 100 m^2, ENE [reg. May 2019]; 9: Madrid, Rivas-Vaciamadrid, Barrio de la Luna, sandlot close to M-45 highway, green clays with flint, N 40.3811-W -3.5413, 95% cover, 200 m^{2,} WSW [reg. April 2017]; 10: Madrid, Vallecas, north of M-50 highway, grey clays with flint; N 40.3449-W -3.6046, 75% cover, 200 m^2, W [reg. April 2018]; 11: Madrid, Valdemingómez, not far from Manzanares River, hilltop, grey clays with clasts of flint and dolomite, N 40.3266-W -3.6233, 100 m^2 [reg. June 2016); 12: Toledo, Numancia de La Sagra, close to the unfinished Borox highway, grey clays between crops and thistle-dominated area, N 40.0894-W -3.8262, 95% cover, 50 m^2 [reg. June 2022]; 13: Toledo, Villaluenga de La Sagra, grey clays with added clasts, N 40.0919-W -3.8348, 65 % cover, 100 m^2 [reg. May 2021]; 14: Toledo, Villaluenga de La Sagra, edge of pine forest. grey clays with added clasts, N 40.0920-W -3.8349, 80 % cover, 300 m^2 [reg. June 2021]; 15: Toledo, Magán, Magán Hill, base of the hill, grey clays, N 39.9868-W -3.9099, 5º, SSW, 75% cover, 100 m^2 [reg. June 2021]; 16: Toledo, Borox, Valdelayegua, plain on grey clays near gypsum soils, N 40.0605-W -3.7873, 10º, NNW, 100 m^2 [reg. June 2018]; 17: Madrid. Cerro Negro, taken from historical data in the CSIC Botanical Garden's herbarium via Advanced Search. (Real Jardín Botánico-CSIC: Collections 2021), N 40.3813-W -3.6760, only presence/absence data is included.

Discussion

Prior circumstances

Despite the region's rich cultural past, which includes a large agricultural and cattle-raising background, this type of vegetation was only recently constrained by aggressive urban development (Martínez Labarga 2010, 2013a,b,c). The latter has resulted in the extinction of some historic sites and their distinctive plant species, as well as the widespread botanical belief that such sites are "too altered," cultivated, or anthropized to be considered natural and deserving of study. Therefore, until recently (see Luengo *et al*., 2017), these plant communities were mostly ignored, leading to their near extinction. However, this was not always the case, as botanical studies in the nineteenth and early twentieth centuries focused on defining and cataloguing the species found in these clayey soils in the south and southeast of Madrid (e.g., Delicias train station, Cerro Negro, Vallecas, Vicalvaro; López, 2007, Ibáñez *et al*., 2009). Nevertheless, these studies did not consider the relationship between the type of substrate on which these communities exist and other ecological conditionings.

Since prehistoric times, fertile grasslands have evolved on these lush, clayey soils, allowing for high grazing and agriculture. These fertile grasslands formed the "Cañada Real Galiana," an ecological corridor connecting the northern Iberian regions with those in the south Manchego and Andalusia (Martínez Labarga, 2014). Species from the south, including *Convolvolus humilis*, *Cynara tournefortii*, *Echinops strigosus, Geropogon hybridus*, *Gladiolus italicus*, *Scolymus maculatus* or *Teucrium spinosum,* may have followed this migration path, as many have their northernmost inland Iberian locations in eastern Madrid (Martínez Labarga, 2013b).

Floristic Variability

Plant species such as *Allium cyrilli*, *Amaranthus blitoides*, *Anagallis arvensis*, *Anchusa azurea*, *Astragalus hamosus*, *Bupleurum rotundifolium*, *Carduus bourgeanus*, *Caucalis platycarpos*, *Chondrilla juncea*, *Chrozophora tinctorea*, *Cichorium intybus*, *Convolvulus arvensis*, *Coronilla scorpioides*, *Echinops strigosus*, *Kickxia lanigera*, *Lactuca serriola*, *Lamium amplexicaule*, *Lolium rigidum*, *Lomelosia simplex*, *Medicago sativa*, *Ononis spinosa* subsp. *spinosa*, *Ornithogalum narbonense*, *Polygonum aviculare*, *P. bellardii*, *Ranunculus arvensis*, *Scolymus maculatus*, *Silene muscipula*, *Sonchus asper* subsp. *glaucescens*, *Turgenia latifolia*, *Teucrium spinosum* or *Vaccaria hispanica*, will be among the most weedy and associated with agricultural tillage (as long as extensive pesticide usage and resting intervals are applied).

Thyme-dominated areas (always *Thymus zygis*) appear when boulders or harder strata are intercalated with clays. We find some species of the *Lino-Salvietum* association, as well as some that are uncommon and unique to these clays, such as *Acinos rotundifolius*, *Allium pallens* (sensu Pastor & Valdés, 1983), *Alyssum simplex*, *A. fastigiatum*, *A. serpyllifolium*, *Androsace maxima*, *Aristolochia pistolochia*, *Asparagus acutifolius*, *Astragalus alopecuroides*, *A. incanus*, *Atractylis cancellata*, *A. humilis*, *Asperula aristata* subsp. *scabra*, *Avenula bromoides*, *Brachypodium distachyon*, *Cleonia lusitanica*, *Colchycum triphyllum*, *Coris monspeliensis*, *Crucianella patula*, *Dianthus pungens* subsp. *hispanicus*, *Echinaria capitata*, *Echinops ritro*, *Euphorbia falcata*, *E. serrata*, *Fumana procumbens*, *F. thymifolia*, *Helianthemum angustatum*, *H. asperum*, *Hippocrepis commutata*, *Limonium echioides*, *Linum austriacum* subsp. *collinum*, *L. strictum*, *Minuartia hamata*, *Neatostema apulum*, *Onobrychis matritensis*, *Ononis pusilla*, *O. viscosa* subsp. *brachycarpa*, *Paronychia capitata*, *Scrophularia canina*, *Silene colorata*, *Stipa barbata*, *S. iberica*, *S. lagascae*, *S. parviflora*, *Teucrium gnaphalodes*, *Thymus zygis* or *Thapsia dissecta.*

We see the introduction or increased abundance of species such as *Asteriscus aquaticus*, *Atractylis cancellata*, *A. humilis*, *Centaurea melitensis*, *Cleonia lusitanica*, *Colchicum triphyllum*, *Convolvulus lineatus*, *Crucianella angustifolia*, *C. patula*, *Echium asperrimum*, *E. vulgare*, *Filago pyramidata*, *Gypsophila struthium* subsp. *struthium*, *Haplophyllum linifolium*, *Helianthemum ledifolium*, *H. salicifolium*, *Iberis pectinata*, *Koeleria castellana*, *Launaea fragilis*, *Limonium dichotomum*, *L. echioides*, *Malva aegyptia*, *Muscari baeticum*, *Neatostema apulum*, *Nepeta hispanica*, *Plantago albicans*, *Rochelia disperma*, *Salsola vermiculata*, *Sideritis hirsuta*, *S. montana*, *Sternbergia colchiciflora*, *Thapsia villosa* or *Teucrium capitatum* in the transition zone to gypsum, which is territorially extensive and gradual, with laminated gypsum plasters intercalated with clays before the appearance of massive gypsums.

The sandiest grassland loses cover due to the presence of micaceous sands or arkose intercalations. Here, we find species such as *Andryala integrifolia*, *A. ragusina*, *Centaurea ornata*, *C. solstitialis*, *Chondrilla juncea*, *Ononis biflora*, *Pallenis spinosa* and occasionally *Rumex induratus* or *Thymus mastichina*, as well as the presence of clovers, which are good markers of these conditions. Micaceous sands are more common and less acidic, with fewer clovers. In these sands the *Rumex* is *R. roseum* and can be found on the slopes of the numerous communication routes (Luengo *et al*., 2017).

The slopes are home to a rather consistent population across all of its communities, with the exception of a few highly modified regions. We can highlight species such as: *Astragalus scorpioides* (Rivas Goday & Borja Carbonell, 1958), *Coronilla scorpioides*, *Echinops strigosus*, *Echium vulgare*, *Euphorbia sulcata*, *Glaucium corniculatum*, *Linaria caesia*, *Malvella sherardiana*, *Moricandia moricandioides*, *Rumex roseus*, *Turgenia latifolia*, etc. In areas with higher alteration, we find *Caucalis platycarpos*, *Gypsophila pilosa*, *Moricandia arvensis*, *Papaver rhoeas*, *P. somniferum*, *Scrophularia canina*, thistles, etc.

The extremely nitrophile vegetation in clays described above includes all of the standard mixture of opportunistic species, with a distinguishing feature being the high biomass of some thistles such as *Carduus bourgeanus*, *Cichorium intybus*, *Cynara tournefortii*, *Ecballium elaterium*, *Onopordon nervosum*, *Scolymus maculatus* or *Sonchus asper* subsp. *glaucescens*; with increasing alteration, we find *Cardaria draba*, *Cirsium arvense*, *Crepis alpina*, *Diplotaxis virgata*, *Echium italicum*, *E. vulgare*, *Papaver spp.* or *Silybum marianum.* Furthermore, we found specimens of *Kickxia lanigera, Vicia narbonensis* and *Teucrium spinosum* in areas with higher humidity.

Since clays make up a large portion of these soils, their water-holding capacity is very high, making it difficult to distinguish between a mesophilic grassland and a more humid grassland where we might find more abundant species like *Allium ampeloprassum*, *Ammi visnaga*, *Bartsia trixago*, *Crepis pulchra*, *Cynodon dactylon*, *Gladiolus italicus*, *Phalaris minor* or *Triticum boeoticum.* A clearly hygrophilous grassland would have other species like *Carex divisa*, *Chamaeiris reichenbachiana*, *Phalaris aquatica* or *Scirpoides holoschoenus* and, in case of temporary waterlogging, *Lythrum tribracteatum* and nano-rushes.

There is a type of hygrophilous-halophile flora being studied in the valley bottoms and flooded borders of streams in the southeast of Madrid and La Sagra, even south of the Tagus River, and we are still unclear of how important the presence of these clays is for their establishment. Rushes of *Juncus acutus* rich in water lilies (*Chamaeiris reichenbachiana*) and even *Camphorosma monspeliaca* grow in these communities (Laorga, 1982; Velasco & Marcos, 1986). The rare *Aizoon hispanicum* or *Ceratocephala falcata* can be found in areas where the substrate combines these clays with Tagus boulders and a saline influence.

Vegetation catena

The topographically superior and inferior parts are connected by a distinct vegetation catena. Ridged areas are created by harder strata such as dolomites or flint, resulting in minor cornices and slopes with traces of clays or sepiolitic gravels and the presence of thyme and the broom-gorse association. When the proportion of finer materials (i.e., clay, sepiolitic gravels) rises with humidity, a generalist, mesophilic, argillic grassland develops, which can transition into a hygrophilous grassland in the valley bottoms. Despite the limited number of areas where we can see the complete vegetation catena, we provide an illustration of the optimal dynamic scheme in Figure 4.

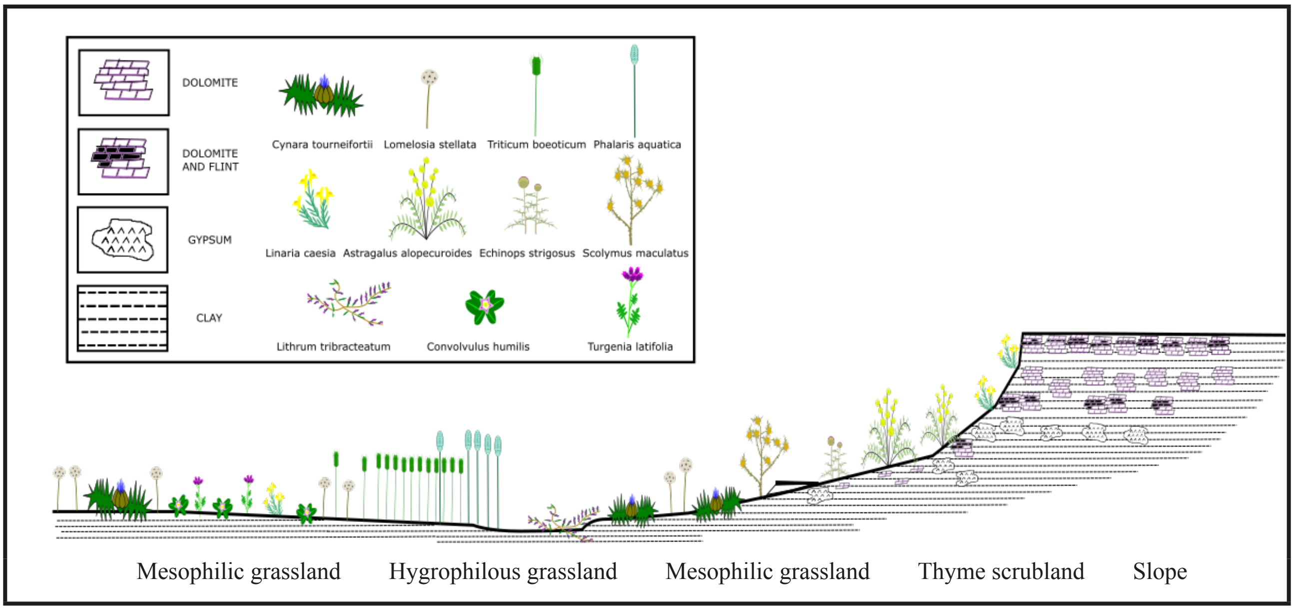

Figure 4. Optimal vegetation catena in the expansive clays of the Madrid-La Sagra region.

Vegetation responses to anthropogenic disturbances

The vegetation undergoes a radical transition if the region has been altered; however, the influence of these clays remains significant. In general, the alteration leads to thistle-dominated areas, that are characterised by the presence of *Cynara tournefortii*, as well as the abundance of *Carduus bourgeanus*, *Cichorium intybus*, *Crepis alpina*, *Cynara tournefortii*, *Ecballium elaterium*, *Lomelosia simplex*, *Onopordon nervosum*, *Scolymus maculatus* or *Sonchus asper* subsp. *glaucescens* which are common on the slopes. And, as alteration increases, we see the presence of *Cardaria draba*, *Cirsium arvense*, *Crepis alpina*, *Diplotaxis virgata*, *Echium italicum*, *E. vulgare*, *Papaver spp.* or *Silybum marianum.* Furthermore, at higher humidity levels, *Kickxia lanigera*, *Vicia narbonensis* and *Teucrium spinosum* appear.

Weed vegetation has become the most prevalent type as a result of agricultural tillage. As consequence, some species vanish from the mesophilic, argillic grassland, and there is an increased proportion of species such as *Lomelosia simplex*, *Centaurea solstitialis*, *Papaver rhoeas*, *Pallenis spinosa*, thistles from the genus *Carduus* and *Onopordum*, and species such as *Diplotaxis virgata*, *Carduus bourgeanus*, *Carthamus lanatus*, *Papaver rhoeas* or *Silybum marianum.* Aside from thistles, in gypsum-influenced areas we observe a rise in the abundance of *Astragalus alopecuroides*, *Centaurea melitensis*, but mostly of *Dittrichia viscosa*, *D. graveolens*, *Salsola vermiculata* and *S. kali*. The dominance of *Echinops strigosus*, *Euphorbia sulcata*, *Glaucium corniculatum*, *Moricandia arvensis*, *Papaver rhoeas*, *P. somniferum*, *Platycapnos spicata* or *Sisymbrium runcinatum* is evident on altered slopes.

The substrate's edaphic instability is also nitrifying allowing the admission of opportunistic nitrophilous species (*Cardaria draba*, *Carduus spp*., *Centaurea spp*., *Cirsium arvense*, *Echium spp*., *Diplotaxis virgata*, *Ecballium elaterium*, *Onopordon spp*., *Papaver spp*., *Sonchus spp*., *Silybum marianum*, etc.). This nitrophilic trait reaches some of its characteristic species, including *Astragalus alopecuroides*, *Crepis alpina*, *Cynara tournefortii*, *Echinops strigosus*, *Lavatera triloba*, *Linaria caesia*, *Malvella sherardiana*, *Sonchus asper* subsp. *glaucescens*, *Teucrium spinosum* or *Vicia narbonensis*.

Many of the distinctive species, such as *Astragalus alopecuroides*, *A. scorpioides*, *Crepis alpina*, *Glaucium corniculatum*, *Matthiola fruticulosa*, *Linaria caesia*, *Lomelosia simplex*, *Melilotus spicatus*, *M. sulcatus*, *Moricandia arvensis*, *M. moricandioides*, the numerous *Ononis* (*O. biflora*, *O. pusilla*, *O. spinosa*, *O. viscosa* subsp. *brachycarpa*), *Scrophularia canina* or *Rumex roseus*, have an early-colonizer nature due to this same adaptation to instability.

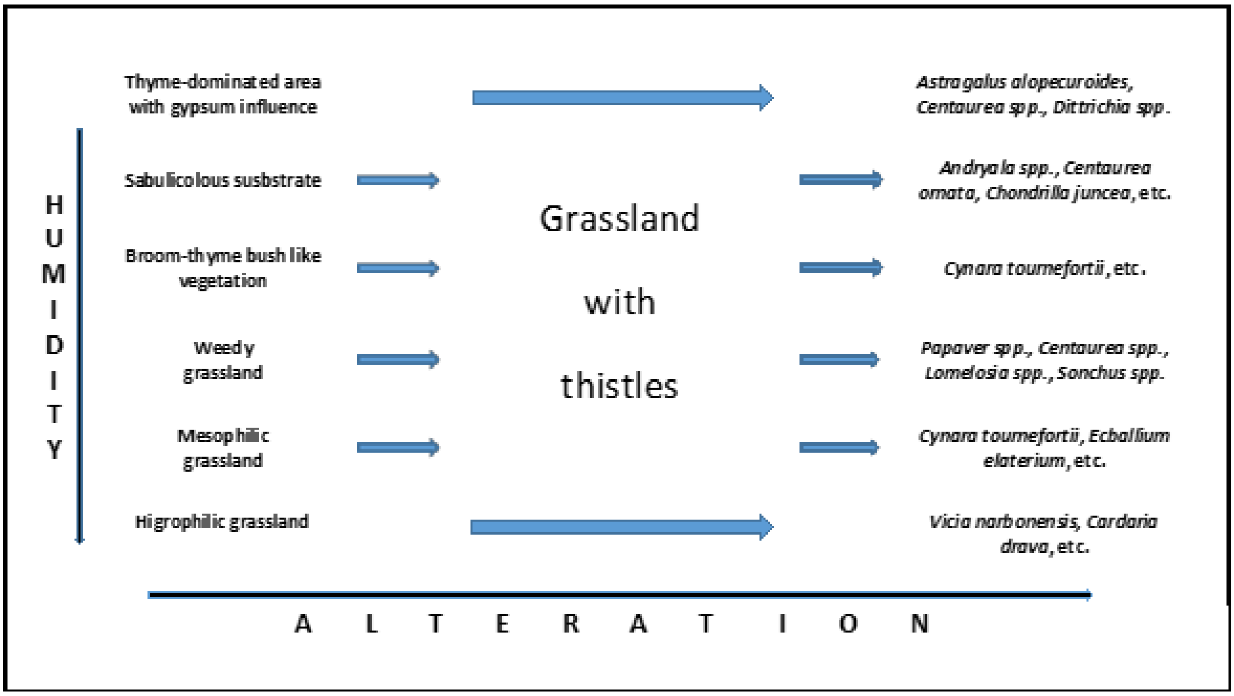

Figure 5. Dynamic relationships of land alteration in the magnesium clays from the Madrid-La Sagra region.

Conclusions

Clays are a type of rock and sedimentology that, if a particular quantity threshold or proportion in the soil is exceeded, results in the mechanical behaviour described above. As illustrated in our study, clays' particular chemistry acts as a selection mechanism for the flora (Domínguez *et al*., 1997), where a varied range of plants associate with particular subsurface chemical components in clayey soils.

Laminar, modular, or fibrous magnesium clays with a large volumetric transition from dry to humid circumstances predominated in this investigation. The Madrid-La Sagra's expansive clays differ from those in the south and southeast of the Iberian Peninsula due to high magnesium cation concentration and calcium cation imbalance. In warmer areas with high seasonal humidity, such as Tierra de Barros in Extremadura (Saldaña & Gallardo, 1992) or the Guadalquivir Valley black soils (called "bujeo" soils in Spanish) these are classified as vertisols (Hernández *et al*., 1990). The Madrid-La Sagra expansive clays may have nutritional inadequacies due to magnesium-calcium-potassium cationic competition (Domínguez *et al*., 1997). Our study sites' cationic competition may resemble volcanic rocks' magnesium clays of Campo de Calatrava in Ciudad Real (Horra *et al*., 2008).

Ongoing observations and comparative studies in neighbouring regions have confirmed significant floristic coincidences with clayey areas in Ciudad Real (García-Camacho *et al*., 2004) and the more difficult coincidence of characteristic species in common in the volcanic region of Campo de Calatrava (*Allium nigrum*, *Echinops strigosus*, *Geropogon hybridus*, *Gladiolus italicus*, *Onosma triceropserma*, *Scolymus maculatus*, *Teucrium spinosum*, etc.). These similarities may also apply to Triassic clays east of Ciudad Real (Luengo, 2020), although with more contrasts. This study's vegetation differs from the limestone decalcified clays despite floristic similarities.

This work uncovered and partially filled a knowledge gap in the botanical literature by identifying many species we encounter as argillic edaphisms. The latter makes characterization and identification difficult. We are convinced that a varied spectrum of argillic vegetation has yet to be defined, extending to an unknown phytosociologic range that we cannot estimate. Since clays are prevalent in most soil types, many argillic species are thought to be common and found in almost any substrate, but their settling is driven by clay quantity and chemical composition. Clay-rich soil foster species like *Anchusa azurea*, *Coronilla scorpioides*, *Ononis spinosa*, *Phlomis herba-venti*, *Salvia argentea*, and *Thapsia dissecta*.

The floristic composition of these argillic grasslands is influenced by variables such as 1) land use and conservation status, which affect the degree of modification and nitrification; 2) the edaphic physical conditions established by the amount of clays, their type, and sedimentology combination (presence of sand, clasts, etc.), as well as topographic factors; 3) its chemical composition, particularly the proportion of magnesium, carbonates, gypsum, and salts; and 4) the range of humidity, from dry grasses or thyme on the rare stony strata of dolomites, flint, sand, or sepiolite to halophytic reed meadows.

The edaphic aspect is limited by an abundance of clays, which have an aggressive mechanical behaviour that supports root hypoxia due to excess water during rainy periods or wide vertical fissures while drying, which can slash plant roots. The substrate's mobility and fragility diminish plant cover or form gilgai-type superficial micro-reliefs (IUSS-WRB, 2015). Deep vertical cracks rapidly dry the edaphic system, causing persistent drought. We confirmed the late spring rainfall reliance during vegetative, blooming, and fructification. We also assume that some species use parasol-shaped leaves at ground level (e.g., *Cynara tournefortii*, *C. cardunculus* subsp. *flavescens*, *Carduncellus matritensis*, or *Malvella sherardiana*) or deep vertical roots to retain moisture. The abrupt end of the growing season may have resulted in a substantial thermophilic feature in the flora due to its adaptation to surface soil breakdown and disaggregation caused by cyclic and early-season structural dryness.

The peninsula's interior basins have comparable soils due to this type of lithological contact between the mountain range and the basin. When extensive orographies with limestone-gypsum basins emerge, this type of soil and similar or vicariant plant communities arise for the same climatic or biogeographical reasons. We are verifying this in regions of the northern Castilian plateau, Cuenca, Extremadura, and the Andalusian basins, where several species with features can be discovered.

At least within the alliance, argillic associations may be part of higher phytosociological rank units and occur at different geographic scales. We have no bibliographical information as we are convinced that this intention has yet to be realized, but there must be plant communities adapted to argillic soils worldwide, at least where there is a high content of expansive clays and a distinct wet and dry season.

Perspectives for protection and restoration

Recent disappearances of important locations, like the Coslada Transport Centre in 2013 (Martínez Labarga, 2013a,b,c), despite warnings (Martínez Labarga, 2010; Moreno *et al*., 2011), and the clear indifference or inability of the different administrations to deal with this problem (Navarro, 2000), call for strict conservation measures. The designation of the few remaining localities as micro-reserves (Laguna, 1995, 1996) or the translocation of characteristic species is necessary to prevent the extinction of this plant community.

Cerro Negro has disappeared, with the wild area of the Coslada Transport Centre reduced to its bare minimum (Martínez Labarga, 2013b,c) and parts of Valdemingómez and Vallecas adorned with artificial hills and intensive agricultural exploitation monopolizing these fertile lands, leaving only a few remnants of this type of vegetation, now recognized and defined, in many places in Madrid-Toledo. The following are the most vulnerable areas, almost none of which are devoid of speculative projects (Martínez Labarga, 2009; de Pablo *et al*., 2017; Luengo *et al*., 2017):

- Quintana del Jarama farm and surroundings, situated between San Fernando de Henares and Paracuellos del Jarama, Madrid.
- Wastelands encircling the Puerto Seco Ambroz Transport Center railway line in Madrid's San Blas-Canillejas district, Madrid.
- Vallecas meadows in Madrid (Valdecarros, La Gavia stream, Atalayuela, Valdemingómez, and Salmedina), Madrid.
- Cereal fields in San Fernando de Henares, Madrid, stretching from Soto Baezuela to Cerro del Viso, Madrid.
- Cerro Almodóvar in Vicálvaro-Santa Eugenia and its extension to the southeast, for certain plots still extant in the urban development of Los Berrocales (with one of the largest Iberian populations of *Malvella sherardiana*), as well as open areas in Rivas Vaciamadrid's neighbourhood of La Luna, Madrid.
- Cerro Batallones bases, as well as fallows in the vicinity of the Guatén stream and Los Estragales, between Valdemoro, Pinto, and Torrejón de la Calzada, Madrid.
- La Sagra. Abandoned agricultural areas or in the vicinity of old clay quarries in Illescas and infrastructure borders in Illescas, Yeles, and Numancia de La Sagra, Toledo.
- La Sagra. Cerro Magán and surroundings of Cabañas de La Sagra. Localities with *Carduncellus matritensis* and other locations will be restored thanks to Lafarge-Holcim's assistance (Figure 6), Toledo.

The micro-reserve figure could protect some of these remnants (Laguna, 1995, 1996), which is already enforced in Castile-La Mancha and could be easily transposed to the regulations of the Autonomous Community of Madrid. In these ecosystems, "environmental fallow land" (MAPA, 2021) would promote sustainable farming without harming natural flora.

An effective "environmental-fallow field" approach following legislative instructions is needed to promote responsible agricultural exploitation compatible with these rare species.

Figure 6. Monte Magán, Magán (Toledo). Area that must be protected with numerous similarities to the now-gone Cerro Negro de Madrid, the type location of *Carduncellus matritensis.*

Despite the evidence, we refuse to declare *Hohenackeria polyodon* extinct in Madrid. Other endangered species, such as *Allium cyrilli*, *Carduncellus matritensis*, *Colchycum triphyllum*, *Convolvolus humilis*, *C. meonanthus*, *Cynara tournefortii*, *Geropogon hybridus*, *Gladiolus italicus*, *Malvella sherardiana*, *Onosma triceropserma*, and *Teucrium spinosum*, are also in danger of extinction in the studied region (Table 1). Even though some of the mentioned species are already listed in the Red Lists (Moreno, 2008, 2010), none of them have guaranteed protection because the plant community ensures their viability, and preserving this plant community is necessary to understand and recover the ancestral Castilian landscape of expansive clays. To sustain the community's ecological gradients and floristic diversity, and avoid extinction, these species must be included in regional catalogues of Madrid (Anon., 1992b), Castile-La Mancha (Anon., 1998), and national catalogues of endangered flora, based on current Spanish legislation (Anon., 2007, 2011). However, the community itself is the most important element, and it would be ideal to achieve its certification as a Priority Habitat at the European level (Anon., 1992a) by meeting the relevant standard.

Syntaxonomical scheme

ARTEMISIETEA VULGARIS Lohmeyer, Preising & Tüxen ex von Rochow 1951

Carthametalia lanati Brullo in Brullo & Marcenò 1985

Onopordion castellani Br.-Bl. & O. Bolòs 1958

Klaseo flavescentis-Cynaretum tournefortii Luengo, de Pablo, Sánchez Mata & Mart. Labarga ass. nova

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Authorship

DSM, EL: Conceptualization, Methodology; EL, DSM, JML: Formal analysis; EL, JML, RMU, RPS, DSM: Research; EL, RMU: Writing; EL, DSM: Supervising.

Conflict of interest

None.

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