Chapter 3
La Mancha

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Abstract The phytogeographic sector of La Mancha is located in central-eastern Spain and encompasses the vast plateau of La Mancha and the peripheral areas of transition to the surrounding mountain ranges. Sedimentary rocks (marls, limestone and gypsum) and base-rich soils are predominant. The climate is prevalently dry mesomediterranean with continental traits. The sector is divided in four watersheds: the Tagus and Guadiana basins drain water into the Atlantic Ocean, while the Júcar and Segura basins drain into the Mediterranean Sea. On well drained soils the main vegetation types are: (a) forests and sclerophyllous woodlands dominated by *Quercus rotundifolia*, *Quercus coccifera, Pinus halepensis*, *Juniperus phoenicea* and in a much lesser extent *Quercus faginea* or *Juniperus thurifera*, all of them currently very fragmented in their occurrence due to human deforestation, which has been particularly intense on the plateau; (b) a calcicole scrub often dominated by thorny or cushion like gorses, a gypsum scrub rich in gypsophytes, and yellow retama broom fields; (c) dry grasslands, including the tall steppic grasslands of *Macrochloa tenacissima* and in part *Lygeum spartum*, the short grasslands of *Brachypodium retusum*, the mesophilous grasslands dominated by *Brachypodium phoenicoides*, the heavily grazed pastures with *Poa bulbosa*, and the annual ephemeral pastures. Riparian ecosystems include elm, poplar, willow and tamarisk forests, in general poorly conserved, as well as some types of meadows. Instead, wetlands are abundant and varied (permanent lakes, some of them of karstic origin, fluvial floodplains, salt marshes and temporary ponds) due to the flat topography that favors the formation on endorheic basins and the large deposits of groundwater. Wetlands with fresh and subsaline water shelter large stands of reedbeds, fen-sedge beds and aquatic vegetation. Salt marshes are populated by many special communities: succulent annuals, salt scrub of woody succulents, salt steppes of *Lygeum spartum* and *Limonium* spp., saline rush meadows, aquatic halophytes, tamarisk woodlands, etc. Some comments about land use and conservation concerns are also given, highlighting the historically intense human pressure on the territory.

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3.1 Introduction

The Plateau of La Mancha and the *Manchego* Phytogeographic Sector The *meseta* of La Mancha is the largest plateau of the Iberian Peninsula. Its name derives from the Arab word *al-mansha*, meaning 'the dry land'; the old town of Almansa, located in the eastern edge of the plateau, has the same origin. This central Iberian upland originated as a tectonic depression of trapezoidal shape during the Alpine orogeny in the mid-Tertiary, which also raised the surrounding mountain ranges: the eastern and southern massifs of the Central and Iberian Systems to the north, the Sierra Morena and northern Betic mountains to the south, the Paleozoic shield of Montes de Toledo and Extremadura to the west, and the inner sierras of Valencia and Murcia to the east. The subsidence of the stepped bottom of the basin, composed of hard Paleozoic blocks in the west and sedimentary Mesozoic rocks in the east, created an inland sea that was filled with varied deposits during the Neogen: alluvial arkoses and gravels, lacustrine limestone and marls, and evaporitic gypsum marls. Once the basin was filled with sediments, a new fluvial system redistributed in part the surface materials and deposited new ones during the Quaternary. The moderate river incision has preserved largely the even geomorphology of the sedimentary layers, setting the vast plain dominated by perfectly flat horizon lines.

The plateau of La Mancha is the core area of the *Manchego* or La Mancha sector, but the geomorphological delimitation differs to a certain extent from the phytogeographical criteria. The environmental space of the plateau is defined by the predominance of base-rich soils and substrates, either calcareous or gypsiferous, and by a prevalent dry, mesomediterranean bioclimate with continental features. As these conditions are not limited to the plateau, the *Manchego* sector encompasses also a halo of peripheral areas that may be considered as transition zones between the true plateau and the surrounding mountains. In contrast, a narrow band of the plateau in its eastern edge has a warmer and maritime-influenced climate and holds floristic elements and vegetation units typical of the Valencian biogeographic subprovince, in which it must be included.

Thus defined, the *Manchego* or La Mancha biogeographical sector (Fig. 3.1) largely doubles the extent of the true plateau (ca. 48,000 km^2, 8% of the Iberian Peninsula), and has a more or less trialobed shape exceeding 300 km along its north-south and west-east main axes. It extends over large parts of the five provinces of the autonomous region of Castilla-La Mancha (Guadalajara, Cuenca, Toledo, Ciudad Real and Albacete) as well as the east and south of Madrid, the north and northwest of Murcia and small northern areas of the Andalusian provinces of Granada and Almería. Altitudes between 600–800 m are predominant in the plateau area, reaching up to 900–1000 m along the borders. The details of its delimitation are as follows. The western and southwestern boundaries are marked by the change to the siliceous lithologies of the Extremadura-Lusitanian subprovince (Montes of Toledo and Sierra Morena); in the northwest a similar lithological change establishes the limit with the Central System (Guadarrama sector) and the corresponding Iberian-Atlantic silicicolous vegetation series (Chaps. 13, in volume 1 and 2 in volume 2). The northern

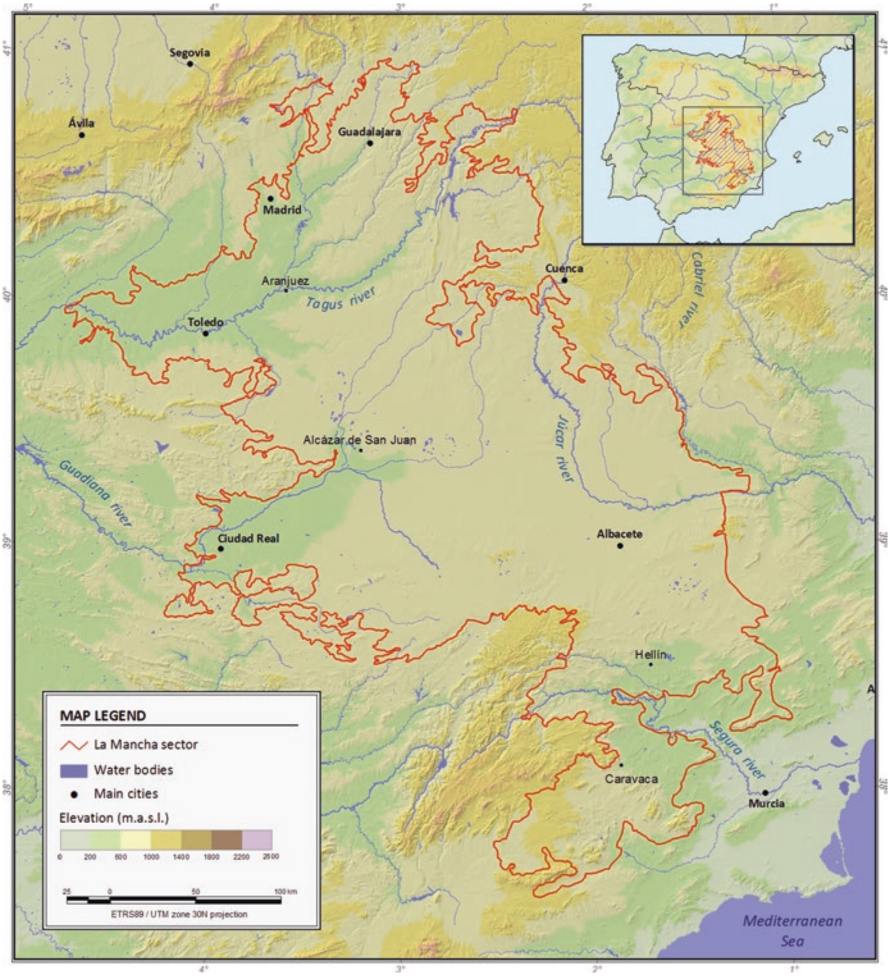

Fig. 3.1 Delimitation of the phytogeographic sector of La Mancha based on the map of vegetation series of Rivas-Martínez (1987) with later modifications by other authors (see the main text for references and Chap. 5, in volume 1). The main cities, rivers and water bodies are represented

boundary is adjusted to the transition to the supramediterranean bioclimates proper of the Celtiberia-Alcarria and Southern Oroiberian (Maestrazgo) sectors, a limit set by the altitude of 850–950 m which roughly matches the change from the Tertiary sediments dominant in the basin to the Secondary rocks (limestones, dolomites and sandstones) of the parameras and sierras of the Iberian System (Chap. 11, in volume 1). The eastern limit runs along the divides between the watersheds of the Júcar and Cabriel rivers, the latter holding the penetration of thermophilous Ibero-Levantine elements from the Valencian subprovince; and the eastern hills bordering the plateau (Sierra del Mugrón and Sierra de Oliva). The southeastern boundaries are more complex and controversial. They are clear with respect to the Prebetic massifs reaching the southwest of Albacete and northwest of Murcia (sierras of Alcaraz, Calar del Mundo, Las Cabras, Taibilla and Moratalla), which belong to the Subbetic sector, well characterized by its richness in endemic species diagnostic of the corresponding Betic vegetation series (see Chap. 4). But between these sierras and the easterly arid lands of the Murcia-Almería province (see Chap. 5) runs a stretch of hilly uplands in which the elements of the vegetation series of La Mancha are still recognizable, albeit floristically influenced in complex pathways by the surrounding biogeographical units (Subbetic to the west, Játiva and Murcia-Alicante sectors to the east). This stretch has been interpreted as a peculiar subsector (Murcia-La Mancha) or as two districts (Jumilla-Hellín and Sierra Espuña), about which more details are given later on (see also Chap. 5, in volume 1).

Climate The La Mancha sector is quite homogeneous with respect to climate. Almost all the land has an upper mesomediterranean thermoclimate, with mean temperatures ranging from 13–15 °C, cold winters (average minimum temperatures of the coldest month between −1.5 and 2 °C, absolute minima between −8 and −18 °C; down to −27 °C has been recorded in Albacete) and very hot summers, with maxima regularly exceeding 40 °C and extreme values reaching 48 °C. The continentality index (thermal amplitude) ranges between 18–22 °C. Only a handful of hills or small sierras scattered throughout the peripheral lands of the sector have enough altitude to recognize isolate spots of the supramediterranean belt, in particular in the southeastern corner of the sector, where there are also small representations of the lower mesomediterranean belt. Hence, average temperatures tend to rise moderately towards the south and the east of the sector.

Annual rainfall ranges between 350–600 mm, corresponding to a generalized dry ombroclimate. Only in some areas of the southeast of the sector the regime is clearly semiarid (300–350 mm). The precipitation increases moderately towards the north and the northwest of the sector, where some spots of a subhumid climate appear. Hence the rainfall patterns are influenced by a rain shadow effect of the north, west and south mountain ranges on the squalls coming from the Atlantic Ocean. Summers are very dry and still more so in the western half of the sector. Inter-annual variability in precipitation is high, dry years being more frequent than humid years; episodes of torrential rains are also frequent. More detailed bioclimatic maps of the region are in Fernández-González et al. (2009).

Hydrology The depression of La Mancha is warmer than the Duero basin but not as warm as the Ebro and Guadalquivir basins; it is also drier than the western basins. A further difference with these great basins flanking the Iberian Paleozoic shield lies in the fluvial system. Around two-thirds of the sector drain water into the Atlantic Ocean through the Tagus and Guadiana watersheds. Both rivers have dissected very moderately the plateau (Fig. 3.2) because their westward courses must traverse the rocky uplands of the Hercynian shield, weakening their erosive power. In fact, the boundaries between their respective basins and sub-basins are diffuse and include scattered small endorheic watersheds.

The eastern stretch of the plateau drains into the Mediterranean Sea through the Júcar river and its tributary the Cabriel river. The steep courses of both rivers and the

Fig. 3.2 Panorama of the La Mancha plateau from the windmills of Alcázar de San Juan, in the Guadiana basin. Cereal crops, vineyards and olive orchards dominate the flat landscape

soft sediments they traverse allowed the formation of deep, embedded valleys and even spectacular canyons (Fig. 3.3). Lastly, a small area in the southeastern end of the sector also drains into the Mediterranean Sea but through the Segura watershed, which rises in the Betic ranges (Sierra of Alcaraz) and collects water from its tributaries to the north (Mundo river) and south (Moratalla, Argos, Quípar, Mula and Guadalentín rivers).

While the Tagus tributaries from the right (Jarama, Guadarrama) show a permanent river flow and well developed fluvial valleys, its left tributaries and the whole river system of the Guadiana basin have poorly developed and often intermittent riverbeds. This is because in the La Mancha plateau the circulation of water runs mainly underground. Surface water infiltrates easily through the soft and permeable sediments into a complex system of aquifers which store and interchange the water between them, and feed the upwelling of subterranean water in many endorheic wetlands and along river courses. The most spectacular wellsprings (locally known as *ojos*, eyes) are those located in the confluence of the rivers Cigüela and Guadiana near the Tablas de Daimiel National Park. This hydrological functioning created the miracle of a myriad of wetlands of varied extent, water table permanence and salinity, emerging in a vast, dry, treeless, silent and dusty plain.

Fig. 3.3 The Júcar valley (Albacete) breaks abruptly the monotony of the La Mancha plateau. Aleppo pine forests, esparto grasslands (*Macrochloa tenacissima*) and calcicole scrub (Sideritido-Salvion lavandulifoliae) cover the slopes, while the bottom of the valley and the riverside are occupied by irrigated crops and poplar and willow riparian forests

Phytogeographic Division The patterns of floristic and vegetational diversity in the La Mancha sector are roughly related with river watersheds. Traditionally four subsectors or groups of districts (see Chap. 5, in volume 1) have been distinguished in the sector:

1. The Tagus watershed belonging to the La Mancha sector extends towards the north through the low *Alcarria* and the *Campiña del Henares* (west of Guadalajara and east of Madrid provinces), a transition area dominated by marl deposits (in part gypsiferous) crowned by Neogene limestone and variously dissected by the rivers Jarama, Tajuña, Henares and their tributaries. In the south of Madrid and the neighboring countryside of *La Sagra* in Toledo, the evaporitic deposits become dominant, conforming characteristic gypsum steppe landscapes. *La Sagra* extends eastwards until the *Mesa de Ocaña*, a typical tableland with gypsum marls on the slopes crowned by Miocene limestone; and westwards through the Tagus valley in a stretch dominated by carbonated arkoses and fluvial terraces up to the surroundings of the town of Talavera. In these erodible substrates the Tagus river has excavated spectacular landscapes like the Barrancas de Burujón, around the Castrejón dam (Fig. 3.4). South of the Tagus riverbed there is other interesting area included in the sector: *La Sisla* or the Crystalline Meseta,

Fig. 3.4 The Barrancas of Burujón or Castrejón, excavated by the Tagus river on the carbonated arkoses westwards from Toledo. Esparto grasslands (Arrhenathero-Stipetum tenacissimae) are the only vegetation able to protect the soil in these extremely erodible slopes

founded on carbonated magmatic rocks. Only the Algodor and Cedrón tributaries on the left side of the Tagus river are properly located in the La Mancha plateau; both have similar characteristics to the Guadiana fluvial system.

2. The Guadiana watershed occupies the largest part of the La Mancha plateau. The main rivers (Riansares, Cigüela (or Gigüela) and Záncara) rise in the reliefs of the Iberian System and join near Alcázar de San Juan. A few km to the south, the Cigüela joins with the upwelling groundwaters from the Western La Mancha aquifer in the *Ojos del Guadiana*, generating the remarkable landscape of the fluvial table of Las Tablas de Daimiel, nowadays a National Park. The Paleozoic bottom of the Guadiana basin is shallower than the bottom of the Tagus basin and in fact emerges in a set of quartzite hills holding impoverished representation of the silicicolous vegetation of the Extremadura-Lusitanian subprovince. Gypsum marls are less abundant as in the Tagus basin. The Guadiana basin encompasses two other remarkable areas along its southern border. The *Campo de Calatrava* is a land affected by an intense eruptive activity during the last 9 Ma (González Cárdenas et al. 2013), with an abundant production of volcanic materials and creating special geomorphologies like the *maares*, shallow lakes seated in old craters. The *Campo de Montiel* is a paramera of Mesozoic limestone and dolomite at 900–1100 m altitude, extended between Calatrava and the first buttresses

of the Sierra of Alcaraz. Besides patches of well-conserved vegetation, the karst of Montiel feeds a surprising wetland: the Lagunas de Ruidera Natural Park, a series of 16 lakes separated by travertine bars and spread over 25 km, the largest one reaching 103 ha in extent and a depth of 200 m.

3. The Júcar watershed extends across the eastern border of the La Mancha plateau in the provinces of Cuenca and Albacete. The deeply dissected valleys of this river and its tributary the Cabriel river break the monotony of the plateau (Fig. 3.3); the latter is taken as the eastern boundary of the sector because through it the thermophilous flora and vegetation of Valencian affinities (Valencia-Tarragona and Játiva sectors) penetrate the plateau until the Contreras dam, where the Cabriel headwater enters the Southern Oroiberian sector. Limestone is more abundant than in the western basins but there are also relevant areas of gypsum marls, as well as some spots of sandstones and sand deposits of eolian origin sheltering psammophilous and silicicolous flora. Lakes and wetlands become scarcer due to the lithologic and hydrological features, but there are still good examples like some karstic lakes in Cuenca or the salt marshes of the countryside of *Los Llanos* in Albacete.
4. The southeastern boundaries of the La Mancha sector are controversial and still need further clarification. The *Campo de Hellín* countryside and its surroundings still belong to the plateau but show an increasingly semiarid character with floristic influences from the neighboring Murcia-Almeria province. Salt lakes are present in the plains of Hellín and Tobarra with very characteristic floristic elements. Southwards the upper basin of the Segura river and its tributaries displays a more rugged landscape, in which the narrower bottom plains are broken by low or medium altitude sierras that are extensions or foothills of the Betic range. Across this stretch of land, the vegetation types of La Mancha extend southwards to the base of the eastern Betic massifs (Sierras of María and Estancias), just on the border with Andalusia (north of Almeria and Granada provinces). Along this stretch, in the lower valleys, the warm mesomediterranean climate favours the presence of a thermophilous flora of Ibero-Levantine affinities, as well as influences of the arid vegetation of the Murcia-Almeria province, in particular on xeric substrates like marls or gypsum. In the higher sierras, on the contrary, with summits up to 1500 m (Sierra Espuña, 1583 m), Betic influences are striking in the cushion-like scrub, rock vegetation, dolomite outcrops and even in the scarce forest remains.

Further readings about these biogeographical subjects are: Izco (1983), Rivas-Martínez (1982, 1987), Alcaraz et al. (1991a, b), Esteso (1992), Peinado et al. (1992, 2008), Sánchez-Gómez and Alcaraz (1993), Escudero et al. (1995), De la Torre et al. (1996), Rivas-Martínez et al. (1997, 2011), Rivas-Martínez and Loidi (1999), Navarro et al. (2001), Ríos et al. (2003), Valle (2003), Fernández-González et al. (2012).

Land Use and Vegetation History According to paleopalynological records (Carrión 2012) and historical chronicles, the main changes in vegetation and landscape during the Holocene were the following. Until the last glacial maximum (before 12,000 year BP) La Mancha was covered by juniper and pine woodlands of a relatively open structure, as concluded from the abundance of some scrub and grassland species. Pollen of oak species is minor but indicates that sclerophyllous forests were also present, probably supported on deeper soils or at favorable exposures. After the postglacial climate amelioration, perennial and deciduous oaks increased slowly in abundance at the expense of conifers, except for some drier episodes like the one between 9000 and 8000 year BP. The replacement seems more evident at lower altitudes and latitudes. Riparian forests also experienced an obvious recovery, with more tree species involved than nowadays. The humid Atlantic period (7000–5000 year BP) is reflected by an expansion of deciduous oaks. Later on, during the crisis of aridity of the Subboreal period (from 5000 to 4500 year BP onwards) perennial oaks became dominant besides many species of the Mediterranean shrublands and scrub. The high proportion of non-arboreal pollen during all postglacial periods suggests that the dominant forest structures were either relatively open or patchy. Evidence of agricultural uses of the landscape (crop and animal husbandry and burning) date back to at least 4500 years ago, but they were probably restricted to small areas around the human settlements. At this time (4200–3500 year ago) the so-called *Motillas* Culture flourished in the Guadiana basin (Mejías et al. 2015). The *Motillas* were prominent buildings functioning as defensive fortresses, housing, warehouses for agricultural products, and above all as a source of freshwater through wells deepening into the water table, which had lowered as a consequence of climatic dryness.

The first extensive agricultural transformation was carried out during the Roman period (second century BC to fourth century AD) and was based on the three main current crops: cereal, vineyard and olive. During the Visigoth and Moorish periods agriculture continued except in episodes of intensified military confrontation; Moors (eigth to eleventh centuries) improved the agricultural techniques and introduced some new crops, like saffron. La Mancha was reconquered by Christians during the eleventh to twelth centuries, then repopulated and agriculture relaunched until the end of sixteenth century, when the cropland area reached an extent similar to nowadays.

The actual landscape of La Mancha is dominated by agriculture. Crops occupy more than 80% of the land on the plateau, the Guadiana basin being the most extensively cultivated. Rain-fed crops account for 80% of the agricultural land, but irrigated crops increased fourfold in extent from 1970 to 1990. The three principal crops are cereals (45% of the agricultural land), vineyards (nearly 20%) and olive groves (around 7%). Cereals evoke the famous windmills immortalized in Cervantes' novel *Don Quixote*. The region of La Mancha is the world's leading producer of wine, with several designations of origin. Other crops include: sunflower, mainly in the northern and eastern areas of the sector; bulbs (saffron and garlic, both with protected designations of origin); legumes; almonds and other orchards; forage crops and corn (irrigated); and even some rice fields in *Campo de Hellín* and the Segura basin, which together with the Guadiana basin and the fertile valleys of the Tagus and Júcar rivers are the main areas of irrigated crops. The later decades, as from the 1960s, have seen changes in agricultural practices in the direction of intensification, due to the mechanization of husbandry and the expansion of irrigation, but also a progressive abandonment of the less productive fields that have been covered by grasslands and scrub or afforested under the prescriptions of the Common Agricultural Policy of the European Union.

The peripheral transition zones also have a high cultivation occupancy dominated by the three main crops, but the natural or seminatural vegetation is better represented on slopes, hard lithologies like limestone, or infertile substrates like gypsum. Mixed landscapes of crops, groves, woodlands, scrub and perennial grasslands are common.

Despite the dominant role of agriculture, animal husbandry was surprisingly important in the past and still is a noticeable activity. The plateau of La Mancha shelters an old cooperative livestock system (the 'cereal-sheep' system; Caballero et al. 2010; Pérez-Badia et al. 2011) based on feeding the livestock (mostly sheep) by grazing on the fallow fields, on the stubble after harvesting and before cereal seeding, on the available wetlands and on the wasteland or *eriales*, i.e. the small patches of uncultivated land strewn over the agricultural landscape. As the landowners are mostly husbandmen, they have to let the grazeable land to sheep owners according to an allotment system regulated by the municipalities. La Mancha still counts more than 3.5 million head of sheep, most of them of the *Manchega* breed, for the production of meat and especially of milk with which the *Manchego* cheese (a protected designation of origin that is world-wide commercialized) is made. Nevertheless, sheep herds are in decline because recent agricultural trends (mechanization, intensification, expansion of vineyards and irrigation) are leaving less land available for grazing, the net income of livestock products is low and the working conditions for shepherds is too harsh.

The La Mancha sector includes some large cities (e.g. most of the conurbation of Madrid) but presently is a sparsely populated area: more than three quarters of the municipalities have population densities of less than 25 persons/km^2 and around 95% of the sector fits the Eurostat definition of rural land. The main demographic trends were a population increase in the first half of twentieth century and a strong decrease from 1950 to 1990, followed by a relative stabilization that still stands today, although the small municipalities continue losing population in favor of the larger ones. The largest declines are in many municipalities of Cuenca, having today the same population as in 1900.

3.2 Oak and Conifer Woodlands and Shrublands

The plateau of La Mancha has been so largely deforested by the agricultural transformation that woody vegetation is reduced to small patches or even sparse trees among the crop fields (Fig. 3.5, see also Fig. 3.2). This transformation was less intense in the peripheral transition zones, which still conserve enough stands of the main vegetation units although variably altered and in many cases still in a phase of recovery (Fig. 3.6); reafforestation of important surfaces has been carried out in the

Fig. 3.5 In a few sites of La Mancha like here (Corral de Almaguer, Toledo), agriculture has respected holm oaks of the Asparago acutifolii-Quercetum rotundifoliae (Note that the trees growing in the cereal fields are older and bigger that the ones of the adjacent woodland, which probably were coppiced from centuries. The eastern foothills of the Montes de Toledo are perceptible in the horizon line)

Fig. 3.6 Typical transition landscape near the Júcar basin, composed by a mosaic of cultivated lands, kermes oak shrublands (Daphno-Quercetum cocciferae), calcicole scrub (Sideritido-Salvion lavandulifoliae) and perennial dry grasslands belonging to the vegetation series of the Asparago acutifolii-Quercetum rotundifoliae (Sisante, Cuenca)

last decades, mainly with pines (*Pinus halepensis, Pinus pinea* and *Pinus pinaster*). In any case the ecological homogeneity of the sector only allows a reduced diversity of woodland types, and the dry mesomediterranean climate with severe summers imposes evergreen sclerophyllous woodlands and thickets as the main forest vegetation, as well as some Mediterranean pine and juniper forests that are shortly described below.

Fig. 3.7 Wooded landscape in the northern border of the Mesa de Ocaña (Toledo), with holm oak (*Quercus rotundifolia,* dark green) and kermes oak (*Quercus coccifera,* light green) stands. Forest openings are filled with calcicole scrub (Lino-Salvietum lavandulifoliae) and dry grasslands (Arrhenathero-Stipetum tenacissimae). In this area Aleppo pines come mainly from plantations

Holm Oak (*Quercus rotundifolia*) Forests The mesomediterranean holm oak forests on base-rich soils of La Mancha belong to the association Asparago acutifolii-Quercetum rotundifoliae. Although this type of forests meets growth conditions almost everywhere in the sector, and in fact the holm oak is widely distributed in it except in the southeastern areas of *Campo de Hellín* and the Segura basin with a semiarid rainfall regime, deforestation and afforestation with other trees have drastically reduced the holm oak forests' cover, which nowadays is barely 2% of the territory. The scarce surviving patches are severely fragmented and relegated to the marginal lands less suitable for cultivation (Fig. 3.7). The holm oak is often the only tree species, but in many stands coexists with *Pinus halepensis, Juniperus oxycedrus* subsp. *lagunae, Quercus faginea* or *Juniperus thurifera*. As in other dry and continental sclerophyllous forests the floristic diversity of the understorey is low, in particular with respect to sclerophyllous shrubs (*Quercus coccifera, Rhamnus lycioides, Rhamnus alaternus, Daphne gnidium, Jasminum fruticans, Colutea hispanica, Juniperus oxycedrus* subsp. *oxycedrus*) and climbers (*Asparagus acutifolius, Rubia peregrina,* often accompanied by honeysuckles like *Lonicera implexa* or *Lonicera etrusca*). Common plants in the herb layer are *Teucrium chamaedrys, Carex hallerana, Bupleurum rigidum, Rhaponticum coniferum, Aristolochia pauci-*

nervis and *Silene mellifera,* besides other shrubland and grassland species able to survive under the often partially open canopies of the stands. This floristic composition resembles the holm oak forests of the Ebro basin inhabiting similar soils and climates.

The wide distribution of these forests allows the recognition of some floristic variants. Mixed forests with the marcescent oak *Quercus faginea* are more frequent in the north of the sector, and are transitional to the Cephalanthero rubrae-Quercetum fagineae forests*,* but they appear also along the Júcar and Guadiana basins and even in the Segura basin, on deeper, often clayey soils located in slope bottoms, hollows or on shady slopes. A variant enriched with thermophilous species (*Pistacia lentiscus, Arenaria montana* subsp. *intricata*) appears in the warm mesomediterranean enclaves of the southeast of the sector. Another edaphic variant may be recognized on gypsaceous soils, although most gypsophytes prefer open vegetation and avoid the shady forest understory. Gypsum outcrops, especially when massive and steep are hardly colonizable by holm oaks under dry rainfall regimes.

The *Manchego* sector includes some supramediterranean areas exceeding altitudes of 900–1000 m in the north or 1100–1200 m in the south, in which remains of the supramediterranean holm oak forest on base-rich soils can be recognized (Junipero thuriferae-Quercetum rotundifoliae). In the understory of these forests the more thermophilous climbers and sclerophyllous shrubs decline or disappear, while roses (*Rosa* spp.) or some cushion-like gorses become more frequent; often the tree layer incorporates the Spanish juniper (*Juniperus thurifera*)*,* which can grow also in the upper limits of the mesomediterranean belt. Conspicuous elements at the landscape scale also disappear, like the kermes oak thickets, the yellow retama shrublands, the dry esparto grasslands (*Macrochloa tenacissima*) or the olive groves. This holm oak-juniper forest type is mainly distributed in the north sectors of the Castilian subprovince and in the Oroiberian subprovince (Chap. 11, in volume 1), but it can be also recognized in the uplands of *Campo de Montiel*, albeit modified by Betic elements like the raspberry *Berberis hispanica* or the broom *Cytisus scoparius* subsp. *reverchonii;* some old stands dominated by the Spanish juniper are noticeable. The supramediterranean forest vegetation of the sierras of the Segura basin seems to be more related with those of the Subbetic sector (Chap. 4).

The insets of some siliceous foothills (quartzites, slates and gneisses) of the Montes de Toledo and Sierra Morena in La Mancha support marginal representations of the association Pyro bourgaeanae-Quercetum rotundifoliae*,* which encompasses the silicicolous holm oak forests of the Iberian south-west (Chap. 2). More information about the forests of this section can be found in Rivas-Goday et al. (1960), Alcaraz (1984), Izco (1984), Herranz (1988), Esteso (1992), De la Cruz and Peinado (1996), Costa Tenorio et al. (2001), Rodríguez-Rojo et al. (2009), Rodríguez-Rojo and Pérez-Badia (2009) and Rivas-Martínez et al. (2011).

Marcescent Oak (*Quercus faginea*) Forests Where rainfall increases to more than 500–550 mm, the holm oak forests growing on base-rich substrates can be replaced by marcescent oak forests of *Quercus faginea*. Stands dominated by this oak are scarce and fragmentary in the north of the Tagus and Guadiana basins but also in the Júcar basin, due to the few places fitting the moisture conditions necessary for their development. They belong to the association Cephalanthero rubrae-Quercetum fagineae, whose optimal conditions are in the supra-submediterranean climates of the uplands and mountains bordering the plateau northwards (La Alcarria and southern Iberian Range, Chap. 11, in volume 1). Its mesomediterranean representations in La Mancha are poorer in nemoral species of deciduous forests (*Brachypodium sylvaticum, Cephalanthera rubra, Cephalanthera longifolia, Viola alba*)*;* in the shrubby understory thorny and climber species proliferate (*Amelanchier ovalis, Crataegus monogyna*, *Buxus sempervirens, Rosa canina*, *Rosa micrantha, Lonicera etrusca* and *Lonicera periclymenum* subsp. *hispanica*)*,* accompanied by some differential elements of the holm oak forests (*Quercus coccifera, Daphne gnidium, Rhamnus lycioides, Jasminum fruticans, Carex hallerana*). Accompanying trees are few, aside from the holm oak; *Acer monspessulanum* is very rare and also *Acer opalus* subsp. *granatense* in the Júcar basin. More information about these forests can be found in Rivas-Goday et al. (1960), Casas et al. (1989), De la Cruz and Peinado (1996), Martín et al. (2004) and Valdés and Ruiz (2004).

Pine Forests (*Pinus halepensis* and *Pinus pinea*) Aleppo pine is a common tree throughout La Mancha where it tolerates all kinds of substrates, but the main natural or seminatural stands are restricted to the eastern part (Júcar basin, *Campo de Hellín* and Segura basin); most of the western stands in the Tagus and Guadiana basins come clearly from more or less recent afforestations and often show heavily managed structures. In the eastern natural stands (Querco cocciferae-Pinetum halepensis, Fig. 3.8) the tree layer may be more or less dense, often with holm oak as a secondary tree or arborescent shrub; thin canopies and openings favor the encroachment of a shrub layer similar in composition to that of holm oak forests or kermes oak shrublands, but often with more species typical of heliophilous scrub. The dynamic relationships between Aleppo pines, holm oaks and kermes oaks are complex in the eastern Iberia. Shortage in water availability favors pine and kermes oak, which tolerate semiarid rainfall regimes. A more humid climate, and a low recurrence of disturbances, like wildfires, favors holm oak, which is able to regenerate under shade conditions. High fire recurrence can suppress pines, as obligate seeders, favoring the dominance of resprout-regenerating oaks. But under intermediate climates and disturbance regimes, the coexistence of mosaics of both forest types and transitions between them is possible, the dynamics of each stand being dependent upon topographic conditions, fire events and management practices (Zavala et al. 2000). In any case, the Aleppo pine forests (or the kermes oak thickets, in absence of pine cover) play the role of potential vegetation in the semiarid areas of the southeast of the sector.

In the core area of La Mancha, between the provinces of Cuenca and Albacete, deep deposits of sands (in some places also of quartzitic pebbles) were accumulated by eolian and fluvial processes and at those sites not transformed by agriculture still sustain pine forests dominated by stone pine (*Pinus pinea,* Fig. 3.9), sometimes accompanied by *Pinus pinaster* or *Pinus halepensis*. Frequently, under this more or less open canopy the understory is composed of shrubby holm oaks, kermes oaks

Fig. 3.8 Aleppo pine forests (Querco cocciferae-Pinetum halepensis) in the limestone slopes and cliffs of the Júcar valley (Albacete)

and other woody species of the heliophilous shrublands: *Retama sphaerocarpa, Rosmarinus officinalis, Cistus salviifolius, Halimium umbellatum* subsp. *viscosum, Thymus vulgaris, Lavandula pedunculata,* etc. Annual pastures rich in psammophilous and silicicolous species develop in the glades. The root system of stone pines could help them to compete with holm oaks in this type of substrates submitted to intense water percolation. But man's impact on the current extent, structure and dynamics of these pine stands remains unraveled.

More information about these pine forests is in Valdés et al. (1992), Torres et al. (1999), Martínez and Marco (2006), Charco et al. (2008) and Molina et al. (2008).

Kermes Oak Shrubland (*Quercus coccifera*) Kermes oak shrublands on base-rich soils of the *Manchego* sector correspond to the endemic association Daphno gnidii-Quercetum cocciferae (Figs. 3.6 and 3.7). These are dense thickets, usually up to 2 m high, dominated by *Quercus coccifera* accompanied by other, mostly sclerophyllous, shrubs like *Rhamnus lycioides, Rhamnus alaternus, Jasminum fruticans, Juniperus oxycedrus* subsp. *oxycedrus, Daphne gnidium, Ephedra nebrodensis, Ephedra fragilis* (absent from most of the Guadiana basin), *Colutea hispanica* (Tagus and Guadiana basins), *Colutea brevialata* (Júcar basin), etc. *Pistacia lentiscus* and a few thermophilous elements penetrate in the warmer mesomediterranean areas, while boxwoods (*Buxus sempervirens*) can appear at more mesophytic places. The climbers *Rubia peregrina* and *Asparagus acutifolius* scale over these tangled

Fig. 3.9 Stands of stone pine (*Pinus pinea*) on deposits of sands and quartzite pebbles in the stretch between the provinces of Albacete and Cuenca, with holm oaks and sclerophyllous shrubs in the understory (Note also in the foreground the summer weed communities (Kickxio-Chrozophoretum tinctoriae) growing in the crop field)

thickets. The herb layer is poorly developed, with species like *Bupleurum rigidum, Brachypodium retusum* or *Carex hallerana*. From the dynamic point of view these shrublands behave as preforest stages of mesomediterranean holm oak, pine and marcescent oak woodlands, or locally as permanent vegetation of rugged slopes. More information about these shrublands is in Rivas Goday et al. (1960), Izco (1972), Peinado et al. (2008), Rodríguez-Rojo et al. (2009), Rodríguez-Rojo and Pérez-Badia (2009) and Rivas-Martínez et al. (2011).

In the scarce siliceous outcrops of western La Mancha the kermes oak thickets present some floristic modifications that allow their assignment to the southwestern Iberian association Hyacinthoido hispanicae-Quercetum cocciferae (Chap. 2).

Juniper Shrublands (*Juniperus phoenicea*) *Juniperus phoenicea* is not so abundant in La Mancha as in the Ebro basin, but dominates many stands on windy and rocky outcrops of limestone or dolomite along the eastern half of the sector (Júcar basin, *Campo de Montiel* and Segura basin). Other shrubs present in this association (Rhamno lycioidis-Juniperetum phoeniceae) are *Rhamnus lycioides, Rhamnus alaternus, Jasminum fruticans, Pistacia terebinthus* or, more occasionally, *Amelanchier ovalis*. In the south-east of the sector *Ephedra fragilis* and *Pistacia lentiscus* differentiate a warmer version of the association, which has an obvious character of permanent vegetation of crests, spurs and rocky ledges. Additional information is in López (1976), Esteso (1992), Sánchez-Gómez and Alcaraz (1993), Molina et al. (2008), Peinado et al. (2008).

3.3 Shrublands and Scrub

The shrubby vegetation types included in this section have the character of seral communities of the woodlands previously discussed. The main types of scrub in the La Mancha sector are closely related to lithological substrates: on base-rich, carbonated limestone and marls the matorrals mainly belong to the Sideritido incanae-Salvion lavandulifoliae alliance, while gypsum marls are the substrate for the matorrals of the Lepidion subulati and the sparse siliceous outcrops for the low maquis dominated by *Cistus* spp. These three types are scrub or shrublands dominated by chamaephytes and nanophanerophytes growing preferently on eroded, often stony soils, poor in organic matter. As they are rich in small woody plants, among which obligate seeders are predominant, many of them being endemics, a huge number of associations have been recognized. Although less abundant on the plateau due to the extensive agricultural land use, these matorrals occur widespread across all the peripheral transition zones. The last type corresponds to the broom shrublands dominated by yellow retama, typically poor in woody species and requiring more developed and deeper soils.

Calcicole Scrub (Sideritido-Salvion lavandulifoliae) The matorrals growing on limestones and calcareous marls have a varied set of dominant species like *Rosmarinus officinalis, Salvia lavandulifolia, Lavandula latifolia,* and several woody legumes (*Genista, Astragalus, Ononis, Erinacea anthyllis*). Other common species belong to different genera of the labiates (*Teucrium, Sideritis, Thymus, Satureja*) and rockrose families (*Helianthemum, Fumana* and some *Cistus* sp. pl.). The main associations of the alliance Sideritido incanae-Salvion lavandulifoliae represented in the La Mancha sector are the following (Fig. 3.10, see also Figs. 3.6 and 3.7). Lino differentis-Salvietum lavandulifoliae*:* meso- and supramediterranean scrub distributed mainly in the north of the sector (Tagus basin and north uplands of Júcar basin) and also in the Alcarria. Genisto scorpii-Ononidetum fruticosae: meso- and supramediterranean gorse shrubland located on marly soils mainly in the Júcar basin and often related dynamically to marcescent forests. Cisto clusii-Rosmarinetum officinalis: thermophilous mesomediterranean rosemary scrub characterized by *Cistus clusii,* common on sunny slopes, mainly in the eastern and southern parts of the sector. Salvio lavandulifoliae-Genistetum pumilae: cushion-like scrub of *Genista pumila* growing on limestone in the eastern and southeastern parts of the sector. Paronychio aretioidis-Astragaletum clusiani: hedgehog scrub of *Astragalus clusianus* (Fig. 3.11) growing on marly soils in the Guadiana and Segura basins. Teucrio gnaphalodis-Salvietum hegelmaieri: sage-scrub with rosemary growing on limestone in the *Campo de Montiel*. Scabioso turolensis-Erinaceetum anthyllidis: cushion-like supramediterranean scrub of *Erinacea anthyllis* from the sierras of the

Fig. 3.10 Calcicole scrub (Lino-Salvietum lavandulifoliae) in the Low Alcarria countryside (Guadalajara). *Linum suffruticosum* subsp. *loeflingii* and *Salvia lavandulifolia* are the main flowering species

Fig. 3.11 The hedgehog *Astragalus clusianus* is one of the cushion-like plants of the calcicole scrub (Paronychio-Astragaletum clusiani)

Segura basin. Other types of cushion-like scrub are locally scattered in upper meso- or supramediterranean spots close to the northern (Lino appressi-Genistetum rigidissimae) and eastern (Salvio lavandulifoliae-Erinaceetum anthyllidis) borders of the sector (see also Chap. 11, in volume 1).

Moreover, in the semiarid areas of the *Campo de Hellín* and the Segura basin the thyme-scrub belonging to the alliance Sideritidion bourgeanae are frequent, with species like *Anthyllis cytisoides, Anthyllis lagascana, Anthyllis onobrychioides, Sideritis bourgaeana, Sideritis serrata, Thymus antoninae, Thymus funkii*, etc. (more details in Chap. 5). The thyme scrub of *Hypericum ericoides* growing on limestone pavements in warm areas of the Segura basin is also worth of mention (Galio boissieriani-Hypericetum ericoidis).

The following are some of the many references about these communities: Rivas Goday and Rivas-Martínez (1969), Costa (1974), López (1976), Izco (1969, 1970), Alcaraz (1984), Izco and Molina (1988), Valdés and Herranz (1989), Esteso et al. (1991), Peinado et al. (1992), Sánchez-Gómez and Alcaraz (1993), Peris et al. (1993), Díez Garretas et al. (1998), Bartolomé et al. (2002), Rodríguez-Rojo et al. (2009).

Gypsum Scrub (Lepidion subulati) The matorrals growing on soils rich in calcium sulfate are very well represented in La Mancha due to the abundance of these substrates and the prevalent dry mesomediterranean climate. Although Miocene gypsum is predominant, there are also Triassic (Keuper), Cretacic and Paleogene gypsiferous sediments, all of low agricultural productivity. In total, almost 25% of the Spanish (and therefore European) gypsum scrub are in the sector of La Mancha (Mota et al. 2011). Gypsum scrub is characterized by a handful of gypsophytes endemic of the sector: *Centaurea hyssopifolia, Gypsophila bermejoi, Helianthemum marifolium* subsp. *conquense, Koeleria castellana, Teucrium pumilum, Thymus lacaitae* and *Vella pseudocytisus;* in addition, *Arenaria cavanillesiana, Arenaria favargeri* and *Brassica repanda* subsp. *gypsicola* are nearly endemics but not exclusive of gypsum substrates. Other basiphilous species of the calcicole scrub (Sideritido-Salvion lavandulifoliae or Sideritidion bourgaeanae in the southeast of the sector) contribute to the woody cover, but usually in a lower proportion; when they become dominant e.g. on soils that are wetter or poorer in gypsum content, the transitional communities are classified as subassociations of the calcicole matorral units. Typically, the gypsum scrub covers the gypsum outcrops forming patterned mosaics with esparto grasslands (*Macrochloa tenacissima*), short annual pastures (Sedo-Ctenopsion gypsophilae) and edaphic and bryo-lichenic crusts (Fig. 3.12), setting a characteristic steppe-like landscape (gypsum steppes, Fig. 3.13). Although these open landscapes are in part due to old human deforestation for harvesting, grazing, firewood or hunting, the fact is that colonization by trees or sclerophyllous shrubs is difficult, especially when gypsum outcrops are massive and rugged and still more under very dry or semiarid rainfall regimes; under more favorable conditions kermes oak, holm oak, pines and even marcescent oaks can develop on gypsiferous marls.

Fig. 3.12 Bryo-lichenic crusts on gypsaceous soils, with *Sedum gypsicola* (Sedo-Ctenopsion) as the main vascular plant colonizer

The main associations of gypsum scrub are the following. Gypsophilo struthium-Centaureetum hyssopifoliae (Fig. 3.14) is the core association in the vast gypsum steppes of the Tagus basin and in the more scattered ones of the Guadiana basin. Thymo lacaitae-Ononidetum tridentatae replaces the former to the east, in the Paleogene gypsum marls of the Guadiana headwater and the adjoining areas of the Tagus and Júcar basins; it is the only association entering also in the supramediterranean belt (Fig. 3.12). Herniario fruticosae-Teucrietum pumili is a very open and low scrub characterized by the endemic *Teucrium pumilum* (Fig. 3.15), which grows on soils dominated by crusts and on alabastrine gypsum in the Tagus basin and the Guadiana headwater. Gypsophilo struthium-Ononidetum edentulae assembles the scrub characterized by *Ononis tridentata* subsp. *angustifolia* distributed along the Júcar basin, mainly on Triassic gypsum. Helianthemo thibaudii-Teucrietum libanitidis corresponds to a scrub having its main distribution in north Murcia but entering also in the Campo de Hellín; it is well differentiated by *Teucrium libanitis* and *Thymus funkii*. Lepidio subulati-Teucrietum balthazaris corresponds to the scrub with *Teucrium balthazaris* and *Astragalus alopecuroides* subsp. *grosii* growing on Triassic and Miocene gypsum in the southern part of the Segura basin. The last two associations are floristically related to the original gypsum scrub of the Murcia-Almeria province (Chap. 5).

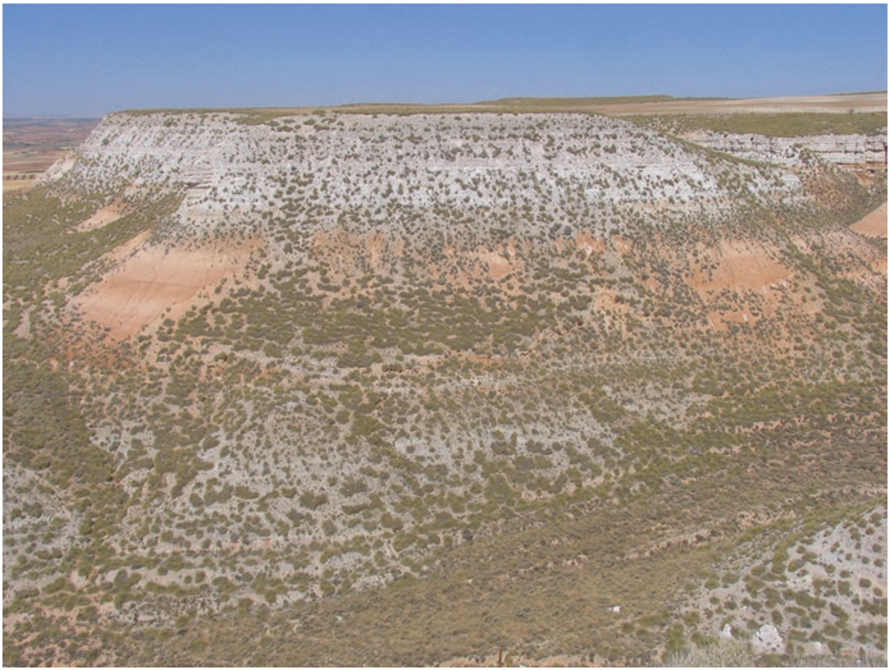

Fig. 3.13 Gypsum steppe landscape in the *Mesa de Ocaña* (Toledo). The upper plain of the mesa is cultivated and sits on a thin layer of limestone and calcareous sediments. The slope shows from top to bottom a sequence of white saccharoid gypsum, and reddish and grey gypsum marls, covered by a mosaic of esparto grasslands (Helianthemo squamati-Stipetum tenacissimae) and gypsum scrub (Lepidion subulati) distributed according to soil steepness and erodibility

More information on this vegetation, monographed by Mota et al. (2011), is in Chap. 6. Other local references are Rivas Goday et al. (1957), Rivas Goday and Rivas-Martínez (1969), Rivas-Martínez and Costa (1970), Costa (1974), López (1976), Izco (1984), Alcaraz (1984), Costa and Peris (1985), Laorga (1986), Valdés and Herranz (1989), Peinado et al. (1992), Díez Garretas et al. (1996, 1998), Loidi and Costa (1998), Bartolomé et al. (2002), Boira et al. (2002), Ferrandis et al. (2005), Mota et al. (2010).

Low Maquis of *Cistus* spp. In the sparse siliceous outcrops emerging in the surroundings of the Montes de Toledo and the Sierra Morena (quartzites) or the Serranía de Cuenca (sandstones), *Cistus*-shrublands, often dominated by *Cistus ladanifer* (more rarely by *Cistus albidus* or *Cistus monspeliensis*), are also represented, belonging respectively to the Ulici-Cistion ladaniferi and Cistion laurifolii alliances as seral vegetation of the corresponding silicicolous holm oak woodlands described in Chaps. 2 and 11, in volume 1. Still more impoverished silicicolous scrub are also found in some rocky outcrops of conglomerates of the Segura basin (Sánchez-Gómez and Alcaraz 1993), in sandy and pebble deposits of eolian or fluvial origin scattered in the central-eastern part of La Mancha (Valdés et al. 1992) or in the countryside of La Sagra (Costa 1972).

Fig. 3.14 Gypsum scrub (Gypsophilo struthium-Centaureetum hyssopifoliae) in the Tagus basin. *Helianthemum squamatum* (yellow flowers) and *Gypsophila struthium* (white flowers) are the most conspicuous species. Esparto grass (*Macrochloa tenacissima,* Helianthemo squamati-Stipetum tenacissimae) becomes dominant towards the upper, less steep part of the slope

Fig. 3.15 *Teucrium pumilum*, endemic of the Tagus and Guadiana basins, is one of the rarer plants of the gypsum scrub of La Mancha

Fig. 3.16 Colonization by yellow retama (Genisto scorpii-Retametum sphaerocarpae) of uncultivated lands (eriales)

Yellow Retama (*Retama sphaerocarpa*) Shrublands Yellow retama stands (Fig. 3.16) are tall broom shrublands dominated by *Retama sphaerocarpa* growing on more or less deep and well developed soils. Often they have an open structure, at least in their initial phases of colonization or when they are regularly grazed, but in wooded landscapes they may become encroached and richer in woody species from the neighboring scrub or sclerophyllous woodlands. The herbaceous layer mixes annuals and perennials and is commonly well developed, due to the clear canopies and the fertilization provided by the nitrogen-fixing bacteria contained in the retama root nodules. The dry mesomediterranean retama shrublands on base-rich soils belong to the association Genisto scorpii-Retametum sphaerocarpae, widely distributed across the sector but more abundant in the transitional peripheral areas than on the plateau. As retama is used for revegetation of marginal lands affected by transport infrastructures, its current distribution is probably becoming wider. Silicicolous retama shrublands with brooms (*Cytisus scoparius, Cytisus multiflorus*) belonging to the association Cytiso multiflori-Retametum sphaerocarpae are also present on the quartzitic outcrops of the western part of the sector. Fuente (1985), Laorga (1986), Esteso (1992), Molina et al. (2008) and Rivas-Martínez et al. (2011) provide more information.

3.4 Dry Grasslands

The dry grasslands constitute herbaceous seral stages favored by the degradation of woodlands promoted mainly by human deforestation and livestock management. La Mancha shelters a great diversity of grasslands. They can be classified by their dominant life-forms (perennial or annual grasslands), their soil chemistry and moisture status, and the way livestock is managed. As a consequence, the conservation of grassland habitats, which hold relevant components of biodiversity, requires in most cases to maintain a certain level of anthropozoogenic pressure. Specifically, the suitable conservation of many grassland types is favored by the traditional grazing systems with sheep, avoiding both livestock abandonment and the excesses of intensive farming.

Perennial Grasslands The grasslands covering lands devoid of woody vegetation are also important for soil retention against erosive agents like water and wind. Furthermore, those grasslands formed by tall and dense grass species with tenacious root systems contribute to the formation of soils with higher organic matter and moisture contents, in which late-succesional plants can establish. Among them, the esparto grasslands of *Macrochloa* (*Stipa*) *tenacissima* stand out in La Mancha for their soil protection abilities (Figs. 3.4 and 3.13), and at the same time they constitute a differential element in the landscape with respect to the Ebro and Duero basins. This species dominates three mesomediterranean associations in the sector: the Arrhenathero albi-Stipetum tenacissimae (Fig. 3.17) and Helictotricho

Fig. 3.17 Esparto grasslands of *Macrochloa tenacissima* (Arrhenathero albi-Stipetum tenacissimae) with scattered shrubby holm oaks (Sisante, Cuenca)

filifolii-Stipetum tenacissimae develop on limestone and calcareous marls, the former in the Tagus and Guadiana basins and the latter, differentiated by the grass of similar appearance *Helictotrichon filifolium*, in the Júcar and Segura basins and in the *Campo de Montiel*; while the Helianthemo squamati-Stipetum tenacissimae (Figs. 3.13 and 3.14) grows on gypsum marls, forming mosaics with gypsum crusts, annual pastures and gypsum scrub, from which it takes its main differential species. Still a fourth association (Lapiedro martinezii-Stipetum tenacissimae) can be recognized in the warmer mesomediterranean areas of the Segura basin. The composition of these esparto grasslands includes several grass species (*Arrhenatherum album*, *Avenula bromoides*, *Dactylis glomerata* subsp. *hispanica*, *Koeleria vallesiana*, *Melica magnolii*, *Stipa offneri*, *Stipa parviflora*, *Stipa juncea, Stipa barbata, Stipa pauneroana*), suffrutescent chamaephytes (*Phlomis lychnitis*, *Teucrium gnaphalodes*, *Teucrium pseudochamaepitys*, *Thymus zygis* subsp. *sylvestris*) and geophytes (*Dipcadi serotinum*, *Fritillaria lusitanica*, *Gladiolus illyricus, Crocus serotinus, Crocus nevadensis, Colchicum triphyllum, Sternbergia colchiciflora*)*; Koeleria castellana* and *Ferula loscosii* are also noteworthy on gypsum substrates. In the clayey gypsiferous soils of La Mancha subjected to spring episodes of hydromorphy also grows the other esparto grass or albardine (*Lygeum spartum*) that dominates the grasslands of the association Dactylido hispanicae-Lygeetum sparti, but as most of the *Lygeum* grasslands in La Mancha are related with peripheral saline soils of the salt marshes they will be discussed later. A fact about the importance of both esparto grass species is that their leaves are used in the region since at least 7000 years ago for making ropes, rugs, basketry, clothes, espadrilles, panniers and even paper, an industry nowadays in decline after the introduction of other fibers and plastics.
The dry pastures of *Brachypodium retusum* (Ruto angustifoliae-Brachypodietum retusi) are shorter grasslands growing on drier and shallower calcareous or clayey soils. Expanded mainly throughout the eastern and southern parts of the sector, they are usually somewhat richer in annual species. In contrast, the dense mesic grasslands of the Mediterranean tor-grass *Brachypodium phoenicoides* (Elytrigio campestris-Brachypodietum phoenicoidis) with couches (*Elymus hispidus, Elymus campestris*, also *Elymus curvifolius* on gypsum) prefer deep, clayey and moist soils, and therefore in La Mancha they appear mainly linked to bottom valleys and riparian systems.

More information on these grasslands can be found in Costa (1973), Alcaraz (1984), Laorga (1986), Costa et al. (1989), Cano et al. (1995), De la Cruz and Peinado (1997), De la Torre et al. (1997).

Annual Pastures The ephemeral annual pastures are formed by small pioneer herbs blooming in early spring and fructifying quickly before the desiccation of the poor and shallow soils they colonize in rock outcrops, recently degraded lands or gaps between the perennial vegetation. On limestone outcrops the main association of the sector is the Saxifrago tridactylitae-Hornungietum petraeae, characterized by *Saxifraga tridactylites* and *Hornungia petraea*. Other associations described are the Brachyapio dichotomi-Callipeltetum cucullaris (gravelly soils), Echinario capitatae-Wangenheimietum limae (carbonated granitoids) and Velezio rigidae-Asteriscetum aquatici (somewhat silty or clayey soils). These annual grasslands include a great diversity of plants like *Arenaria leptoclados, Arenaria modesta, Asterolinon linum-stellatum*, *Bombycilaena erecta*, *Brachypodium distachyon*, *Callipeltis cucullaris*, *Campanula erinus*, *Cerastium gracile*, *Cerastium pumilum*, *Desmazeria rigida*, *Echinaria capitata*, *Erophila verna*, *Galium parisiense*, *Linaria simplex*, *Minuartia hybrida*, *Stoibrax dichotomum, Valerianella coronata*, *Wangenheimia lima*, etc. On gypsum substrates the ephemeral pastures are poorer in species but incorporate small gypsophytes such as *Campanula fastigiata*, *Ctenopsis gypsophila*, *Linaria glauca, Sedum gypsicola* (Fig. 3.12)*, Chaenorhinum reyesii* and, in the southeast of the sector, *Chaenorhinum exile* and *Chaenorhinum grandiflorum* subsp. *carthagi-nense*. The association Chaenorhino reyesii-Campanuletum fastigiatae is common on gypsum crusts and in the gaps among the scrub or the esparto grass tussocks, it is replaced by the Campanulo fastigiatae-Chaenorhinetum exilis in the southeastern of the sector, while the Ctenopsio gypsophilae-Linarietum amethysteae grows on moderately gypsiferous soils.

A particular kind of annual pastures thrives on the deep deposits of sands accumulated by eolian or fluvial processes in some areas of the south of Cuenca and north of Albacete, the surroundings of the Tablas de Daimiel (Ciudad Real) or the arkoses of La Sagra (Toledo). On these poor and loose sandy soils a few silicicolous psammophytes like *Malcolmia triloba, Loeflingia hispanica, Linaria spartea, Silene portensis* and *Vulpia membranacea*, besides other basophilous annuals characterize communities of the Iberian inland alliance Corynephoro-Malcolmion patulae that are still imperfectly known.

Finally, under livestock pressure the sheepfold pastures of *Poa bulbosa* (Fig. 3.18) can develop on organic-rich soils subjected to trampling, manuring and intensive grazing mainly by sheep. This kind of pastures, more rich in geophytes and creeping hemicryptophytes, belong to the association Astragalo sesamei-Poetum bulbosae, which constitutes an important nutritional source for livestock, related to the proportion of legumes and other palatable species such as *Astragalus echinatus, Astragalus epiglottis, Astragalus sesameus*, *Astragalus stella*, *Medicago minima*, *Medicago rigidula, Medicago truncatula, Plantago albicans, Trifolium scabrum*, *Trigonella monspeliaca*, *Trigonella polyceratia,* etc.

More information on these grasslands can be found in Rivas Goday and Rivas-Martínez (1963), Rivas Goday and Ladero (1970), Izco (1973, 1974), Izco et al. (1986), Esteso and Peris (1991), Valdés et al. (1992), Galán de Mera et al. (2000), Cano et al. (2007), Rodríguez-Rojo et al. (2009), Rodríguez-Rojo and Pérez-Badia (2009), Mota et al. (2011), San Miguel et al. (2012).

As commented in previous sections, the siliceous outcrops scattered in La Mancha contain other types of acidophilous dry grasslands (Agrostio castellanae-Stipion giganteae, Agrostion castellanae, Tuberarietalia guttatae, Trifolio subterranei-Poion bulbosae, etc.; see Chap. 2).

Fig. 3.18 Sheepfold pastures of *Poa bulbosa* (*'*majadales', Astragalo sesamei-Poetum bulbosae) on limestone, with *Plantago albicans, Convolvulus lineatus, Medicago* spp., etc. *Poa bulbosa* is the dried grass at the time (early summer) in which the photo was taken

3.5 Rock Vegetation

Rocky habitats like cliffs and screes are poorly represented in La Mancha due to the predominance of soft lithologies and gentle reliefs; only in the peripheral transition areas some large outcrops of limestone or dolomite are found. Concerning the vegetation of genuine rock crevices, a community of small chamaephytes (*Teucrium thymifolium*, *Chaenorhinum crassifolium, Chiliadenus glutinosus*) extends over the Júcar and Segura basins and the *Campo de Montiel* (Jasonio glutinosae-Teucrietum thymifolii), while the communities of small ferns like *Cheilanthes acrostica*, *Asplenium petrarchae, Asplenium ruta-muraria* and *Ceterach officinarum* (Cheilantho acrosticae-Asplenietum petrarchae) are present although rare in the Tagus basin. The community dominated by *Sarcocapnos enneaphylla* (Chaenorhino crassifolii-Sarcocapnetum enneaphyllae) grows on overhanging rocks and slightly nitrified cliffs in the same areas. Marginal stands of other associations of rock crevices (Antirrhino pulverulenti-Rhamnetum pumilae) or of overhanging cliffs (Antirrhinetum microphylli, Antirrhinetum pulverulenti) with their optimum in the Alcarria and Oroiberian sectors (Chap. 11, in volume 1) are rare at the northern border of the *Manchego* sector, and the same occurs with several thermophilous associations with a southeast Iberian optimum (Chap. 5) in the Segura basin; in contrast, the supramediterranean belt of the higher sierras of this basin holds interesting disjunctions of Betic rocky and scree vegetation units (Alcaraz et al. 1991b).

Stonecrop communities growing on bare limestone surfaces (Sedetum albo-sediformis) are scattered in the same areas. Comophytic communities of ferns and mosses on shady, wide crevices and rocky ledges (Polypodietum cambrici) are rather rare in the sector. The vegetation of dripping rocks belonging to the Eucladio verticillati-Adiantetum capilli-veneris is also scarce; in the warmer southeastern areas this association is replaced by the Trachelio coerulei-Adiantetum. Scree vegetation is just represented by the communities of *Andryala ragusina* and *Scrophularia canina* (Andryaletum ragusinae) on river and stream shingle beds.

More information about this vegetation in La Mancha is available in Izco (1970), Alcaraz (1984), Fuente (1985), Figuerola and Mateo (1987), Loidi and Galán (1988), Escudero and Pajarón (1992), Esteso (1992), Sánchez-Gómez and Alcaraz (1993), Rivas-Martínez et al. (2002), Molina et al. (2008), Agulló et al. (2010).

3.6 Riparian Vegetation

The vegetation associated to running water is distributed in accordance with the water table conditions and the soil and water chemistry. Nevertheless the fluvial systems of La Mancha have been strongly modified by the construction of dams and reservoirs, the diversion of river flows for irrigation, the channelization and dredging of riverbeds, and the occupancy of the fertile soils of river floodplains by cropfields, meadows for livestock or even buildings. The induced changes in river dynamics in conjunction with water pollution and eutrophication suggest that the current riparian vegetation is far from its natural state.

Riparian Forests and Thickets The main riparian forest of La Mancha is nowadays the poplar forest dominated by *Populus alba* (Rubio tinctorum-Populetum albae) and growing on periodically flooded soils with a high water table (Figs. 3.3 and 3.19). The stands are often mixed with other riparian trees such as *Populus nigra, Fraxinus angustifolia*, *Ulmus minor, Celtis australis*, *Salix neotricha, Salix atrocinerea*, etc.; poplar cultivars like *Populus nigra 'Italica'* and *Populus* x *canadensis* have become widely naturalized. The understory is rich in climbers (*Rubia tinctorum, Cynanchum acutum, Calystegia sepium, Clematis vitalba, Bryonia dioica, Lonicera periclymenum* subsp. *hispanica*) but poor in nemoral herbs.
Where the river floods are important, arborescent willows can grow on the riverbeds contributing to the fixation of fluvial deposits; the Salicetum neotrichae is typical of the middle and low river courses, while the Salicetum discoloro-angustifoliae is distributed in the upper courses with faster water flow and mainly on limestone riverbeds. *Salix neotricha, Salix purpurea, Salix triandra* subsp. *discolor* and in the second association *Salix elaeagnos* subsp. *angustifolia* are the main species of these willow woodlands. In rivers and streams with saline water or large flow oscillations, arborescent tamarisks (*Tamarix canariensis*, *Tamarix africana*, *Tamarix gallica*) can replace willows and even poplars forming the first gallery of the riparian forest or secondary forests of disturbed riversides. The association Agrostio stoloniferae-

Fig. 3.19 Riparian vegetation in the Tagus river. Poplar forests (Rubio-Populetum albae) become dominant from the bend of the river, being replaced in the deforested stretch of the river by tamarisk woodlands (Tamaricetum gallicae) and reed beds of *Phragmites australis* and *Typha* sp. pl. (Note that the crop fields occupy almost the entire river plain, which would be the natural placement of the riparian elm forests (*Ulmus minor*). The photo was taken from a gypsum hill over the river)

Tamaricetum canariensis grows on salt-rich soils of salt marshes and streams crossing gypsum outcrops, while the Tamaricetum gallicae prefers subsaline conditions like those of most river systems (Fig. 3.19). Oleander galleries (*Nerium oleander*; Rubo ulmifolii-Nerietum oleandri) constitute the riparian vegetation on stony riverbeds of intermittent streams (*ramblas*) in the warmer mesomediterranean areas of the Segura basin.

The riparian forests farthest from the riverbed are those dominated by elms (*Ulmus minor*) that correspond to the association Opopanaco chironii-Ulmetum minoris. However, the agricultural use of their fertile soils and the recurrent outbreaks of elm disease have decimated elm forests during the last decades.

The natural hedges and shrubby seral stages of all these riparian forests (except on saline soils) are thorny deciduous thickets (Rosetum micrantho-agrestis) dominated by many prickly shrubs of the rose family: *Rubus ulmifolius*, *Crataegus monogyna*, *Prunus spinosa, Rosa agrestis*, *Rosa micrantha*, *Rosa canina*, etc. In the warmer mesomediterranean areas of the Segura basin *Coriaria myrtifolia* is involved in these hedges that belong to the association Rubo ulmifolii-Coriarietum myrtifoliae.

Riparian Meadows Grasslands and rush meadows growing on the riverbanks show a great diversification according to factors like the water table depth and anthropogenic pressures. The most extended rush community in La Mancha is dominated by *Scirpoides holoschoenus* (Holoschoenetum vulgaris) with moderate water requirements and a certain tolerance of summer drought. On wetter and more nitrified soils, rush communities of *Juncus inflexus* and mints (Mentho suaveolentis-Juncetum inflexi) develop with among other species *Mentha suaveolens*, *Mentha longifolia*, *Rumex crispus*, *Rumex conglomeratus,* etc. A high livestock pressure on the riverbanks leads to the transformation of rush meadows into more palatable grasslands dominated by *Cynodon dactylon* and clovers (Trifolio fragiferi-Cynodontetum dactyli) with *Trifolium fragiferum, Trifolium tomentosum, Trifolium pratense*, *Potentilla reptans*, *Ranunculus repens,* etc.; or dominated by mints (Mentho aquaticae-Teucrietum scordioidis) on moist soils with a more stable water table. Swards of ray-grass with *Lolium perenne*, *Plantago major*, *Poa pratensis*, etc. (Lolio perennis-Plantaginetum majoris) can also develop on wetter and trampled soils. On wet soils of intermittent streams of the Segura basin and in other wet and sandy soils of the southern Júcar and Guadiana basins, the tall cane-grasslands of *Saccharum ravennae* (Equiseto ramosissimi-Erianthetum ravennae) and *Imperata cylindrica* (Equiseto ramosissimi-Imperatetum cylindricae) are characteristic.

Riverbed Vegetation of Helophytes The tall helophytic vegetation most frequently rooting in the riverbeds are the reed, bulrush and club-rush communities of *Phragmites australis*, *Typha domingensis*, *Typha latifolia* and *Schoenoplectus lacustris* subsp. *glaucus* (Typho-Schoenoplectetum tabernaemontani, Fig. 3.19). Reeds are more tolerant to water table oscillations than fen-sedges (*Cladium mariscus*), which therefore are more common in lakes and ponds (Soncho maritimi-Cladietum marisci). The vegetation of smaller helophytes growing in backwaters, ditches or slow running shallow waters of the fluvial systems includes several associations: the Agrostio stoloniferae-Phalaridetum arundinaceae, Junco subnodulosi-Sparganietum neglecti, Veronico anagallidis-aquaticae-Juncetum fontanesii, Calliergonello cuspidatae-Eleocharitetum palustris and Apietum nodiflori, dominated respectively by *Phalaris arundinacea, Sparganium erectum* subsp. *neglectum, Juncus fontanesii, Eleocharis palustris* and *Apium nodiflorum*, accompanied by other species such as *Rorippa nasturtium-aquaticum*, *Veronica anagallis-aquatica, Glyceria notata, Juncus subnodulosus,* etc. Communities of small helophytes growing on calcareous springs and headwater brooks are proper of mountain areas but have marginal representations in the *Campo de Montiel* and in the Segura basin; they are dominated by *Cratoneuron filicinum* and other bryophytes together with delicate herbs like *Anagallis tenella* or *Samolus valerandi* (Cratoneuro filicini-Anagallidetum tenellae).

Aquatic Vegetation of Running Waters The submerged or floating aquatic vegetation from water courses also includes several associations and communities of alkaline waters, many of them also growing in standing waters of lakes and ponds: the Potamogetonetum colorati in deep, clean water on limestone riverbeds; the Myriophyllo verticillati-Potamogetonetum pectinati on deep mesotrophic waters; the Potamogetonetum denso-nodosi on clayey riverbeds and ditches with slow running waters; and the communities of batrachids (*Ranunculus peltatus, Ranunculus baudotii*, *Ranunculus trichophyllus*) and elodeids (*Zannichellia pedunculata, Zannichellia contorta*) growing in shallower backwaters or slow running waters and related to the association Ranunculetum baudotii.

More information on the riparian vegetation of La Mancha is in Laorga (1986), Mesón (1987), Alcaraz et al. (1991b), Esteso (1992), Sánchez-Gómez and Alcaraz (1993), Molina (1996), De la Cruz and Peinado (1996, 1997), Rivas-Martínez et al. (2002), Ríos et al. (2003), Molina et al. (2008).

3.7 Wetlands: Lakes, Ponds and Salt Marshes

The number and the ecological and biological diversity of wetlands in La Mancha are surprising, taking into account the climatic traits of the region. As said in the introduction, this fact results from the combination of several factors: a flat topography favoring endorheism, permeable and varied lithologies that foster water infiltration into a complex system of aquifers and furnish a varied set of anions and cations, which in turn may be selectively concentrated through the evaporation of water bodies enhanced by the dry and hot summers. The water supply of the wetlands is also varied: rainfall and runoff; karstic systems, like in Ruidera; river flows and floods, like in the floodplain of Daimiel; upwelling from aquifers, or mixed systems. The balance between water inputs and outputs determines the level and the permanence of the water table as well as the concentration patterns of mineral and organic nutrients, which condition the organisms living in the water body but are also influenced by them. The wetlands of La Mancha include permanent and seasonal water bodies, some of the latter being only occasional. Permanent and semi-permanent lakes show in general lower salt concentrations but most of them are predominantly subsaline (up to 2.5 g/L of salt concentration). Most seasonal wetlands are brackish, from hyposaline (up to 20 g/L) to hypersaline (above 40 g/L), with the exception of a few *maares* of the *Campo de Calatrava* that have subsaline or even fresh water. Sulfates and chlorides of sodium and magnesium are the more abundant ions in brackish water. Often the wetlands are composed of several water bodies differing in their hydrological characteristics.

Aquatic Vegetation Most of the submerged and floating plant communities mentioned for rivers are also present in fresh or subsaline standing waters: the Myriophyllo verticillati-Potamogetonetum pectinati is not rare in deep mesotrophic waters; the Potamogetonetum colorati appears in Ruidera and other karstic lakes of the *Campo de Montiel,* where there are also stands of the pondweed *Potamogeton lucens* (Potamogetonetum lucentis); the Potamogetonetum denso-nodosi covers sizeable patches in shallower ponds, channels or ditches; and the communities of batrachids (*Ranunculus trichophyllus, Ranunculus baudotii*, *Ranunculus peltatus*) in shallow and often temporary ponds, like in some *maares* of the *Campo de Calatrava* and other basins. The water lilies *Nymphaea alba* and *Nuphar luteum* became extinct in *Tablas de Daimiel* but the latter still keeps alive in at least one lake in the *Campo de Montiel* together with *Myriophyllum verticillatum* and *Polygonum amphibium* (Nymphaeo albae-Nupharetum lutei). *Ceratophyllum* (Potamo-Ceratophylletum submersi, Potamo-Ceratophylletum demersi) and *Utricularia australis* communities (Potamo-Utricularietum australis) grow submerged in the meso-eutrophic deep waters of the Tablas de Daimiel, the latter also in Ruidera. Non-rooted floating duckweed vegetation is nowadays only represented by eutrophic *Lemna gibba* communities (Lemnetum gibbae), but *Riccia fluitans* and *Hydrocharis morsus-ranae* were present in the past in the floodplain of Daimiel. Algal carpets of stoneworts (charophytes) are particularly important because of their role in feeding the aquatic fauna and their indicator value of water quality. The carbonated, oligo-mesotrophic deep and clear waters of the *Lagunas de Ruidera* shelter the more exuberant stonewort carpets with *Chara hispida var. major* (up to 1 m high and 15 m depth), *Nitella hyalina, Chara aspera*, etc. (Charion fragilis)*;* they are present also in other lagoons of the Campo de Montiel and Guadiana basin, as well as in Daimiel (Fig. 3.20) where they nevertheless have experienced recently a strong decline due to water eutrophication and turbidity. *Chara vulgaris, Chara connivens, Tolypella glomerata* and *Nitella confervacea* (Charion vulgaris) form smaller carpets on shallow waters and in temporary ponds scattered across the sector.

Aquatic communities look very different in saline waters, where life cycles are shortened to the spring flood period and macrophyte size is reduced. Stonewort carpets are dominated by species requiring salinity, like *Chara canescens, Chara galioides, Lamprothamnium pappulosum, Tolypella hispanica* and *Tolypella salina* (Charion canescentis); some of them tolerate hypersaline water. Extremely rare and special are the thin carpets of the bryophyte *Riella helicophylla*

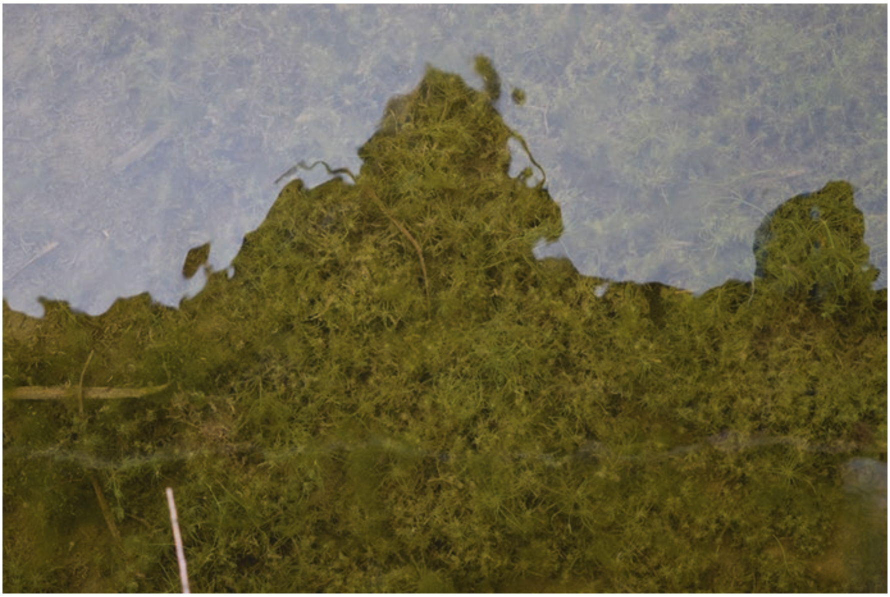

Fig. 3.20 Algal carpets of stoneworts (*Chara* spp.) in the wetlands of the Tablas de Daimiel National Park

(Rielletum helicophyllae) growing in very shallow saline water. Submerged elodeids are represented mainly by the communities of the Ruppietum drepanensis, with *Ruppia drepanensis* and more rarely *Ruppia maritima* or *Althenia orientalis*; and the Zannichellietum pedunculatae (*Zannichellia pedunculata, Zannichellia obtusifolia*) and Najadetum marinae (*Najas marina* subsp. *armata*) that prefer more stable, oligo-hyposaline waters.

Helophytic Vegetation and Travertine Fens The same associations of helophytes mentioned for river systems can be found in the fresh or subsaline standing waters of wetlands. In permanent lakes with carbonated or subsaline waters, fen-sedges (*Cladium mariscus,* Soncho maritimi-Cladietum marisci) may become the dominant circum-aquatic vegetation (Fig. 3.21), alternating with sedge communities (Cladio marisci-Caricetum hispidae) when the water table is shallower. So were the floodplains of Daimiel until the increase in flood level oscillations in recent decades has caused a strong decline of fen-sedge beds and the expansion of reedbeds. In more saline waters (Fig. 3.22) the dominant helophytes become the club-rushes *Bolboschoenus maritimus* or *Schoenoplectus litoralis* (Bolboschoeno compacti-Schoenoplectetum litoralis).

In some karstic lakes on limestone the travertine formations are very well developed and sustain particular communities (Molinio arundinaceae-Schoenetum nigricantis) dominated by black bog-rush (*Schoenus nigricans*) and purple moor-grass (*Molinia arundinacea*) that contribute actively to the biological production of tufa. *Dorycnium gracile* and *Carex distans* are other common plants in the association,

Fig. 3.21 Helophytic vegetation in the floodplains of the Tablas de Daimiel National Park: reed beds of Typho-Schoenoplectetum tabernaemontani with *Schoenoplectus litoralis,* and fen sedges (Soncho maritimi-Cladietum marisci) on deeper water tables. The riparian galleries of tamarisks (*Tamarix canariensis*) are perceptible in the background

well represented in the *Lagunas de Ruidera* and some wetlands of the *Campo de Montiel*. The black bog-rush also grows on oozing calcareous or marly slopes (Dittrichio viscosae-Schoenetum nigricantis) in other places of La Mancha.

Temporary Ponds The annual herb communities growing on clayey or loamy base-rich soils flooded in spring are scattered in the wetlands and correspond to the associations Heliotropio supini-Crypsietum schoenoidis, Lythro flexuosi-Crypsietum schoenoidis and Isolepido-Lythretum baetici, with species such as *Heliotropium supinum*, *Juncus sphaerocarpus, Lythrum flexuosum, Lythrum acutangulum, Lythrum junceum, Lythrum baeticum,* etc.; *Crypsis schoenoides* and especially *Crypsis aculeata* indicate more saline soils.

Salt Marshes and Salt Steppes Vegetation of salt marshes is typically distributed in concentric bands around the center of the endorheic depressions where soil moisture and salinity reach their maximum. After the evaporation of surface water these central areas are covered by a thick, whitish salt pan (Fig. 3.23) devoid of any plant cover, although biological activity of anaerobe bacteria is very intense in the wet soil under the crust. During summer and autumn at least the outer zone of the salt pan and the soil covered by thinner salt efflorescences are colonized by the succulent annual *Salicornia patula* (Suaedo braun-blanquetii-Salicornietum patulae, Fig. 3.24), often in monospecific populations. Behind the glasswort band, woody succulent chamaephytes can grow; the Puccinellio caespitosae-Suaedetum

Fig. 3.22 Helophytic vegetation in the salt lake of La Laguna (Cedrón river, La Guardia, Toledo): club-rush beds of *Bolboschoenus maritimus* (Bolboschoeno compacti-Schoenoplectetum litoralis) and saline rush meadows of *Juncus subulatus* (Aeluropodo-Juncetum subulati). On the other side of the lake reed beds of *Phragmites australis* (Typho-Schoenoplectetum tabernaemontani) become dominant on running water coming from the river. In the background, gypsum hills with gypsum steppes, Aleppo pine afforestations, olive orchards and cereal fields

braun-blanquetii, dominated by *Suaeda vera* subsp. *braun-blanquetii,* is the main association in the inland salt marshes of La Mancha (Fig. 3.25), while the three associations Puccinellio caespitosae-Sarcocornietum alpini (dominated by the endemic *Sarcocornia alpini* subsp. *carinata*), Puccinellio caespitosae-Arthrocnemetum macrostachyi (with *Arthrocnemum macrostachyum,* Fig. 3.26) and Arthrocnemo macrostachyi-Sarcocornietum hispanicae (with the southeastern Iberian endemic *Sarcocornia hispanica*) require somewhat longer flooding periods and are much rarer: the first two appear in several salt marshes of La Sagra, the central Guadiana basin and the *Campo de Hellín*; the third only in *Campo de Hellín*.

The outer band of vegetation of salt marshes corresponds to the genuine salt steppes thriving on soils with a high water table but only subjected to occasional flooding. The esparto-grass or albardine (*Lygeum spartum*) grasslands belonging to the association Senecioni castellani-Lygeetum sparti (Figs. 3.25 and 3.27) dominate the landscape of these saline steppes and shelter many of the protected plants of the salt marshes of La Mancha, like *Lepidium cardamines*, *Senecio auricula* subsp. *castellanus, Helianthemum polygonoides* and the diversified sea-lavenders (*Limonium costae*, *Limonium carpetanicum*, *Limonium cordovillense*, *Limonium dichotomum*, *Limonium erectum*, *Limonium latebracteatum*, *Limonium longebracteatum*, *Limonium mateoi*, *Limonium pinillense*, *Limonium soboliferum*, *Limonium*

Fig. 3.23 Salt pan in the hypersaline temporal lake *Laguna de Peñahueca* (Villacañas, Toledo)

Fig. 3.24 Halophytic glasswort communities of the succulent annual *Salicornia patula* (Suaedo-Salicornietum patulae) growing on salt pans (salt marsh of El Salobral, Toledo)

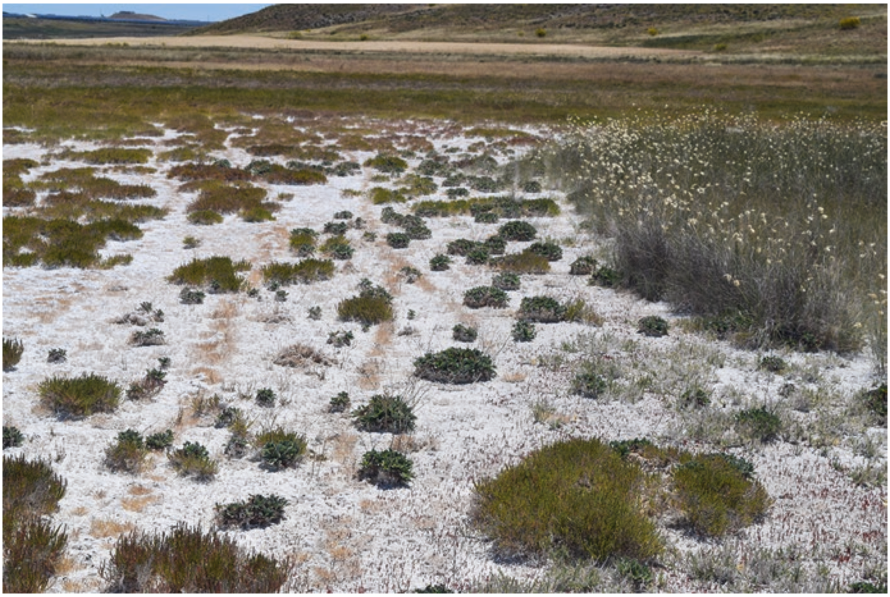

Fig. 3.25 Salt scrub with *Suaeda vera* subsp. *braun-blanquetii* (Puccinellio-Suaedetum braun-blanquetii), salt steppe of *Limonium costae* (Frankenio-Limonietum) and albardine salt steppe (Senecioni-Lygeetum sparti) (salt marsh of El Salobral, Toledo)

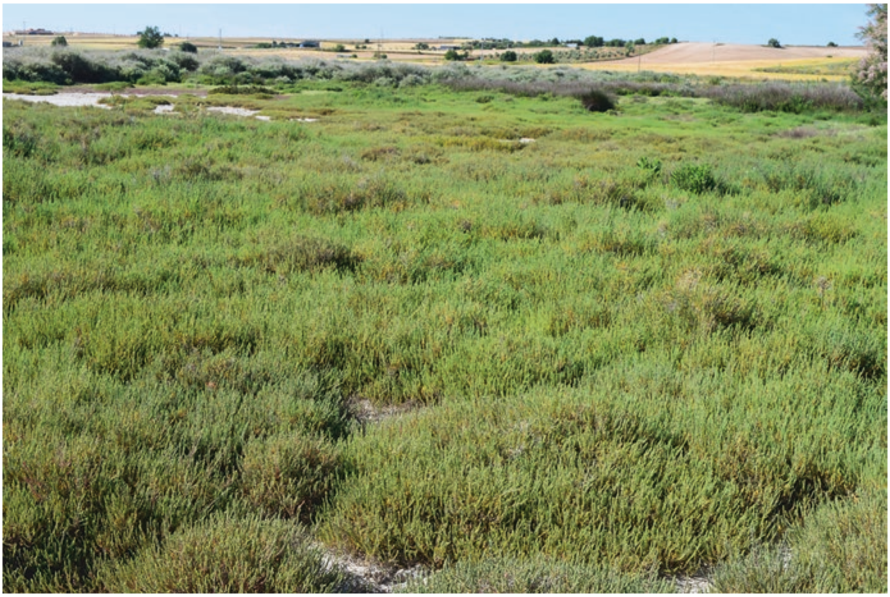

Fig. 3.26 Salt scrub with *Arthrocnemum macrostachyum* and *Suaeda vera* subsp. *braun-blanquetii* (Puccinellio-Arthrocnemetum macrostachyi) (Note the strip of halonitrophilous shrublands dominated by *Atriplex halimus* (Limonio dichotomi-Atriplicetum halimi) that surrounds the salt marsh (Huerta de Valdecarábanos, Toledo))

Fig. 3.27 Salt steppes: in the foreground, community dominated by *Limonium carpetanicum* (Frankenio-Limonietum); in the background, albardine grasslands (Senecioni castellani-Lygeetum sparti) (salt marsh of Peñahueca, Villacañas, Toledo)

squarrosum, *Limonium supinum*, *Limonium thiniense*, *Limonium toletanum*, *Limonium tournefortii*), most endemic to the sector and even some of them restricted to a unique salt marsh. Certain of these *Limonium* species can become dominant in the lower and more saline soils of the steppes (Frankenio thymifoliae-Limonietum latebracteati, Figs. 3.25 and 3.27) or on disturbed soils of ditches and bottoms of gypsum slopes (Gypsophilo tomentosae-Limonietum dichotomi, with *Gypsophila tomentosa*, *Limonium dichotomum, Limonium toletanum* and others). In addition to their floristic peculiarity, salt steppes moderate the runoff fluxes of sediments (and eventually fertilizers and pesticides) into the endorheic basins, thus playing an important role for the conservation of salt marshes. Unfortunately, large areas of saline steppes have been removed for agricultural uses, accelerating the processes of sediment filling, eutrophication and pollution in the marsh beds.

In the bands of glassworts and saline scrub other succulent annual species like seablites (*Suaeda spicata, Suaeda splendens*) and saltworts (*Salsola soda*) can thrive where soils are altered and enriched with organic matter. The main associations are the following, from less to more nitrophilous: the Suaedetum spicato-splendentis, Suaedo splendentis-Salsoletum sodae, and Cressetum villosae (with *Cressa cretica*). On somewhat drier soils a short, sparse pasture of annual halophytes like *Frankenia pulverulenta*, *Parapholis incurva*, *Sphenopus divaricatus, Spergularia diandra,* etc. (Parapholido incurvae-Frankenietum pulverulentae, Fig. 3.28) colonizes the gaps between patches of saline scrub and steppes. Denser annual pastures with a halo-nitrophilous character are dominated by *Hordeum*

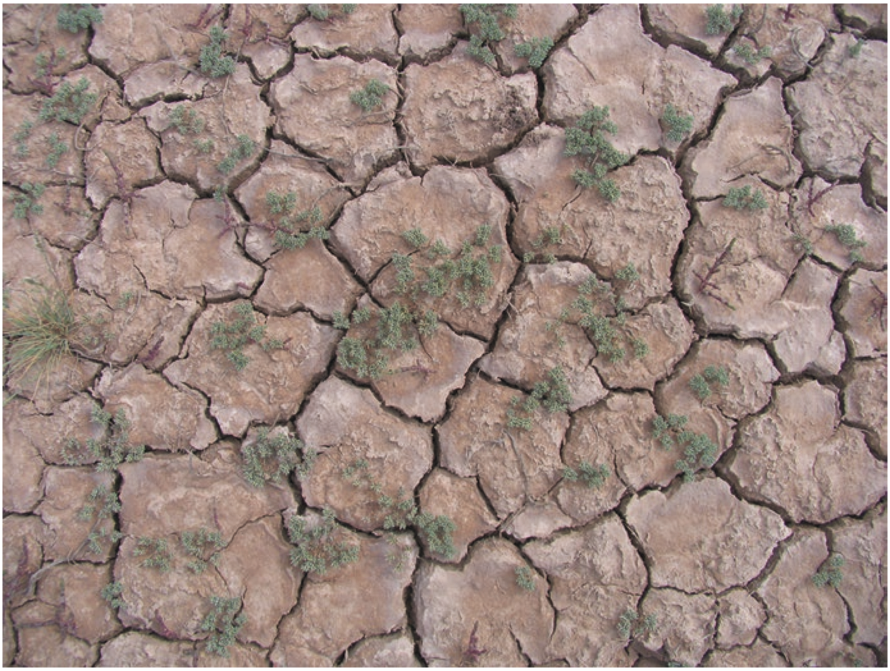

Fig. 3.28 Halophytic annual communities with *Frankenia pulverulenta* (Parapholido-Frankenietum pulverulentae) in the salt marshes of Huerta de Valdecarábanos (Toledo)

marinum and *Polypogon maritimus* (Polypogono maritimi-Hordeetum marini). Still another community dominated by the annual succulent *Microcnemum coralloides* (Microcnemetum coralloidis) thrives on microdepressions of saline steppes subjected to fleeting floods (Fig. 3.29).

In hollows, depressions and channels and around upwellings or streams where the water table is almost permanent or close to the soil surface, rush meadows and even some helophytes (reeds, club-rushes) complement the landscape of salt marshes. For the halophilous rush meadows several associations have been described which in the sequence of increasing hydromorphy are: short rush communities of *Juncus gerardi* (Bupleuro tenuissimi-Juncetum gerardii); saline tall rush meadows of *Juncus maritimus* (Elymo curvifolii-Juncetum maritimi), including a particular community with *Chamaeiris reichenbachiana* (Elymo curvifolii-Iridetum spuriae); and saline tall rush meadows of *Juncus subulatus* (Aeluropodo littoralis-Juncetum subulati, Fig. 3.22). Among the plants common in these rush meadows are: *Sonchus maritimus*, *Sonchus crassifolius, Elymus elongatus, Lactuca saligna, Linum maritimum, Oenanthe fistulosa, Oenanthe lachenalii,* etc. Another type of saline meadows favored by a certain cattle pressure on soils subjected to temporary flooding are those dominated by *Schoenus nigricans* and *Plantago maritima* subsp. *serpentina* (Schoeno nigricantis-Plantaginetum maritimae) or by the saltmarsh grasses

Fig. 3.29 Halophytic annual communities with *Microcnemum coralloides* and *Aeluropus littoralis* (Microcnemetum coralloidis) in the salt marsh of El Salobral (Toledo)

Puccinellia fasciculata, *Puccinellia caespitosa, Puccinellia festuciformis* subsp. *lagascana, Puccinellia hispanica* and *Aeluropus littoralis* (Puccinellietum lagascanae, Fig. 3.30).

The only arborescent vegetation thriving in salt marshes are the tamarisk woodlands of the association Agrostio stoloniferae-Tamaricetum canariensis, nowadays very fragmented except in the saline wetlands related to floodplains like the *Tablas de Daimiel* (Fig. 3.21). Some stands dominated by *Tamarix boveana* recently found in La Sagra (Tagus basin) can be assigned to the association Suaedo braunblanquetii-Tamaricetum boveanae.

The vegetation of the La Mancha wetlands has been illustrated in detail by Cirujano and Medina (2002); other sources of information are: Rivas Goday and Asensio (1945), Rivas Goday et al. (1957), Rivas-Martínez (1966, 1979a, 1983), Rivas Goday (1970), Izco and Cirujano (1975), Rivas-Martínez and Costa (1976, 1984), Castroviejo and Porta (1976), Castroviejo and Cirujano (1980), Cirujano (1980, 1981, 1982, 1989, 1990, 1995), Velayos (1981), Alcaraz (1984), Izco et al. (1984), Velayos et al. (1989), González Beserán et al. (1991), Valdés et al. (1993), Cirujano et al. (1993, 2007), Alonso (1999), García Fuentes et al. (2001), Rivas-Martínez et al. (2002), Alonso and de la Torre (2003), Peinado et al. (2008), Fuente et al. (2013).

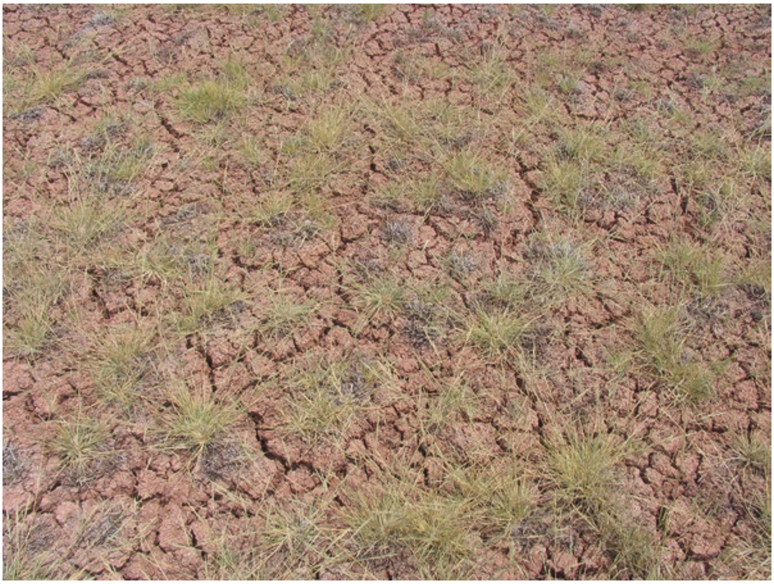

Fig. 3.30 Saline meadows of the saltmarsh grass *Puccinellia festuciformis* subsp. *lagascana* (Puccinellietum lagascanae) in Huerta de Valdecarábanos (Toledo)

3.8 Ruderal and Weed Vegetation

This section is addressed to plant communities requiring more or less altered soils in which moderate or high concentrations of nitrogen compounds and other nutrients are made available; disturbance contributes to nutrient release, and suppresses at the same time many competitive species. Human activities are by far the main agent of disturbance nowadays, in particular in regions like La Mancha that bear the traces of agricultural uses from millenia ago, and hence have spread and reshaped the ruderal vegetation from its originally restricted natural and seminatural stands.

Weed Vegetation Plant communities living in cropfields cover a large proportion of the La Mancha sector, becoming overwhelmingly dominant on the plateau. Although they constitute a typically species-poor vegetation, they also contain a handful of plants specialized in these particular habitats, many of them in serious decline due to tillage intensification and the overuse of herbicides and fertilizers. Nevertheless the patterns of floristic diversity of weed communities are also strongly influenced by landscape configuration and in particular by the maintenance of unplowed cropfield edges (Fig. 3.31) and of patches of fallow fields and uncultivated land that are the reservoirs of plant diversity in these extensive agricultural landscapes.

The classification of weed communities is related to crop type and management practices, which interact with phenology and soil and climate factors. The main association of weeds of the cereal or legume rain-fed crops dominant in La Mancha,

Fig. 3.31 An edge between two adjacent cereal fields showing the high species richness of these marginal habitats hosting annual subnitrophilous communities of the Hordeion leporini

Fig. 3.32 Weed vegetation (Roemerio hybridae-Hypecoetum penduli) dominated by poppies (*Papaver rhoeas*) growing on cereal crops (Villacañas, Toledo)

on base-rich, calcareous or gypsaceous soils, is the Roemerio hybridae-Hypecoetum penduli (Figs. 3.31 and 3.32), characterized by many poppies (*Hypecoum imberbe, Hypecoum pendulum, Papaver hybridum, Papaver pinnatifidum, Papaver rhoeas, Roemeria hybrida*) and other common weeds (*Agrostemma githago, Anchusa azurea, Galium tricornutum, Linaria hirta, Malcolmia africana, Turgenia latifolia, Vaccaria hispanica,* etc.) flowering in spring just before the harvest. During summer and early autumn other communites can thrive in the same cropfields (Fig. 3.9), but dominated by *Chrozophora tinctoria* (Kickxio lanigerae-Chrozophoretum tinctoriae), *Salsola kali* (Atriplici roseae-Salsoletum ruthenicae) or other goosefoots and amaranths (Chenopodio albi-Amaranthetum blitoidis)**.** In woody crops as vineyards and olive groves the communities of fumitories (with *Fumaria densiflora, Fumaria* *officinalis, Fumaria parviflora, Veronica persica, Veronica hederifolia;* Fumarietum densifloro-parviflorae) flower in early spring, being replaced later by communities of amaranths and *Diplotaxis erucoides* (Amarantho delilei-Diplotaxietum erucoidis). The weeds of irrigated crops and vegetable orchards include many neophytes with plants like *Digitaria sanguinalis, Echinochloa crus-galli, Setaria verticillata, Setaria viridis,* etc. (Setario verticillatae-Echinochloetum cruris-galli). Lastly, in the rice fields of *Campo de Hellín* and the Segura basin some weeds typical of this crop are also present, like *Ammania coccinea, Cyperus difformis, Echinochloa oryzicola* and *Echinochloa oryzoides* (Oryzo sativae-Echinochloetum cruris-galli).

Ruderal Annual Vegetation The cropfield edges, abandoned agricultural lands, roadsides and wastelands of the outskirts are covered on dry soils by a great variety of communities dominated by annual plants. The spring-flowering communities of mallows (*Malva parviflora, Malva nicaeensis, Malva sylvestris*), nettles (*Urtica urens*) and *Sisymbrium irio* (Sisymbrio irionis-Malvetum parviflorae), and the late summer-flowering communities of goosefoots (*Chenopodium murale, Chenopodium album, Chenopodium vulvaria, Chenopodium opulifolium*), amaranths, *Conyza bonariensis, Conyza sumatrensis,* etc. (several associations of the Chenopodienion muralis) thrive on the more disturbed and nitrogen-rich soils like waste dumps and stockyards. The spring communities of small barleys (Bromo scoparii-Hordeetum leporini, Asphodelo fistulosi-Hordeetum leporini in warmer areas) grow under more moderate conditions of nitrogen supply and soil stability, and are dominated by grasses (*Avena sterilis*, *Bromus diandrus*, *Bromus hordeaceus*, *Bromus tectorum*, *Hordeum murinum* subsp. *leporinum*, *Lolium rigidum*). With a similar aspect of grass pastures, the communities of wild-wheats (Medicagini rigidulae-Aegilopetum geniculatae, Bromo fasciculati-Aegilopetum geniculatae in the Segura basin) and of the needle-grass *Stipa capensis* (Medicagini littoralis-Stipetum capensis), grow under still more moderate disturbance pressures with species like *Aegilops geniculata*, *Aegilops triuncialis*, *Bromus rubens*, *Medicago minima*, *Medicago rigidula*, *Trigonella monspeliaca*, *Astragalus hamosus*, *Coronilla scorpioides*, etc. In soils frequently disturbed or recently tilled as well as on roadsides and cropfield verges (Fig. 3.31) several pioneer crucifers (*Diplotaxis virgata, Eruca vesicaria, Biscutella auriculata, Hirschfeldia incana, Moricandia moricandioides, Rapistrum rugosum, Sinapis alba* subsp. *mairei, Sisymbrium crassifolium, Sisymbrium austriacum* subsp. *hispanicum, Sisymbrium orientale,* etc) often become dominant, characterizing the associations Papaveri rhoeadis-Diplotaxietum virgatae (general on base-rich soils), Iondrabo auriculatae-Erucetum vesicariae (gypsaceous soils) and Rapistro rugosi-Sisymbrietum crassifolii (calcareous soils in the north of the sector). Some of these subnitrophilous crucifers are Iberian or Maghreb-Iberian endemics, like the endangered *Sisymbrium cavanillesianum* that grows in this kind of disturbed habitats on gypsaceous and subsaline soils.

A different type of nitrophilous vegetation with a more natural character is constituted by the annual communities growing mainly on the soils of forests and shrublands more or less cleared, often grazed, where they make use of the nutrients released by litter decomposition under semi-shade conditions. Common species are:

Anthriscus caucalis, Torilis nodosa, Scandix australis, Galium spurium, Myosotis ramosissima, Cardamine hirsuta, Geranium purpureum, Geranium rotundifolium, Geranium molle, etc. The association Galio aparinellae-Anthriscetum caucalidis is common in the understory of holm oak forests; the Hymenolobo procumbentis-Anthriscetum caucalidis grows on subsaline soils under the canopy of tamarisks or *Atriplex halimus*; and the Torilido nodosae-Scandicetum australis under gypsum scrub.

Ruderal Vegetation on Trampled Soils These communities are represented mainly by the associations Coronopodo squamati-Sclerochloetum durae on clayey soils, Spergulario rubrae-Matricarietum aureae on loose-textured soils, and Euphorbietum chamaesyco-prostratae on very trampled and often paved substrates, all of them being low cover communities dominated by prostrate annuals and some short-lived and creeping perennial herbs.

Ruderal Vegetation on Walls These are poorly represented by communities of *Parietaria judaica* (Parietarietum judaicae) or of *Cymbalaria muralis* (Cymbalarietum muralis), mainly in the walls of old buildings.

Thistle Vegetation Thistle communities thrive on soils frequently disturbed or recently tilled on roadsides, cropfield verges, abandoned croplands and wastelands, dynamically replacing the pioneer annual subnitrophilous vegetation. The main association on well drained and base-rich soils is the Onopordetum acantho-nervosi, dominated by *Onopordum nervosum* and also containing other tall or medium-sized, biennial or annual thistles like *Onopordum acanthium*, *Carthamus lanatus, Carduus pycnocephalus, Carduus tenuiflorus, Cirsium vulgare, Eryngium campestre*, *Lactuca serriola, Scolymus hispanicus,* etc. The thermophilous association Nicotiano glaucae-Onopordetum macracanthi reaches marginally the Segura basin. When the disturbed soils are rich in gypsum, as in the Tagus and north Guadiana basins, the endemic gypsophyte *Reseda suffruticosa* becomes dominant (Resedetum suffruticosae). On moister and strongly nitrified soils the dominant thistle usually is *Silybum marianum* (Carduo bourgeani-Silybetum mariani) accompanied by *Carduus bourgeanus*, *Cirsium arvense, Cichorium intybus,* etc. On heavy clayey, gypsaceous or subsaline soils, *Silybum eburneum* differentiates the scarce representations of the association Silybetum hispanici. Lastly, the association Dittrichio viscosae-Piptatheretum miliacei thrives in habitats (roadsides, outskirts) similar to those of thistle communities, but perennial herbs (*Piptatherum miliaceum, Foeniculum vulgare*) and even suffrutescent chamaephytes (*Dittrichia viscosa*) become dominant.

Mesophilous and Hygrophilous Ruderal Vegetation On the wet soils of riparian or wetland habitats the ruderal vegetation is dominated by tall forbs like *Conium maculatum* (Galio aparines-Conietum maculati) or *Sambucus ebulus* (Rubio tinctorum-Sambucetum ebuli), with climbers like *Galium aparine* or *Rubia tinctorum.* Still wetter soils are suitable for the lianoid communities of the Arundini donacis-Convolvuletum sepium, with *Calystegia sepium*, *Cynanchum acutum* or *Solanum dulcamara* climbing on riparian trees or on the canes *Arundo donax* and

Fig. 3.33 *Salsola vermiculata* scrub (Salsolo vermiculatae-Peganetum harmalae) on disturbed gypsaceous soils in the Monreal castle (Dosbarrios, Toledo)

Phragmites australis. Along streams and ditches of eutrophicated waters the forb communities of *Epilobium hirsutum* (Scrophulario lyratae-Epilobietum hirsuti) are common, with *Scrophularia lyrata, Lythrum salicaria, Cochlearia glastifolia, Rumex conglomeratus, Urtica dioica*, etc. The muddy sediments deposited by river floods are other substrates that abundantly release nitrogen compounds on which pioneer annual forbs like *Xanthium italicum, Polygonum lapathifolium* and *Polygonum persicaria* (Xanthio italici-Polygonetum persicariae) develop in late summer and autumn. The swards of *Paspalum dilatatum, Polypogon viridis* and *Polypogon monspeliensis* (Ranunculo scelerati-Paspaletum paspalodis) grow on the same fluvial sediments but towards the stream bed, exposed to temporary flooding.

Ruderal Scrub Under Mediterranean and other arid climates woody vegetation types growing in ruderal habitats are widespread. Some common species of the ruderal scrub in La Mancha are *Salsola vermiculata*, *Artemisia campestris* subsp. *glutinosa*, *Artemisia herba-alba*, *Helichrysum stoechas*, *Marrubium vulgare*, *Plantago sempervirens*, *Santolina* spp., *Peganum harmala*, etc.; many nitrophilous herbs grow between the scrub patches. The Salsolo vermiculatae-Peganetum harmalae (Fig. 3.33) is the most spread association, dominated by *Salsola vermiculata* and growing mainly on dry, marly soils and gypsum; it is replaced by the low scrub of *Santolina squarrosa* (Plantagini sempervirentis-Santolinetum squarrosae) in limestone substrates and also in cooler climates. In the arkoses and carbonated magmatic substrates of the western Tagus basin other low scrub of *Santolina rosmarinifolia* subsp. *castellana* (Artemisio herbae-albae-Santolinetum canescentis) occurs.

Fig. 3.34 Halo-nitrophilous scrub with *Frankenia thymifolia* (Artemisio-Frankenietum thymifoliae) in a disturbed patch of the albardine salt steppe (salt marsh of El Salobral, Toledo)

Communities dominated by *Artemisia herba-alba* (Salsolo vermiculatae-Artemisietum herbae-albae) are the pioneer scrub of abandoned cropfields and pastures. Other low scrub dominated by *Frankenia thymifolia* (Artemisio herbae-albae-Frankenietum thymifoliae) thrives on the bottoms of gypsum ravines and slopes (Fig. 3.34), with a halo-gypso-nitrophilous character; some sea-lavenders like *Limonium toletanum* or *Limonium dichotomum* may be common in this scrub. A scrub dominated by *Camphorosma monspeliaca* (Artemisio valentinae-Camphorosmetum monspeliacae) is much scarcer on eroded slopes of reddish gypsum marls subjected to episodic hydromorphy. The shrublands of *Atriplex halimus* (Limonio dichotomi-Atriplicetum halimi) also are halo-nitrophilous as they grow in the surroundings of salt marshes on disturbed saline or subsaline soils (Fig. 3.26). As *Atriplex halimus* is very much used for revegetation of marginal lands, its current distribution is becoming wider than the association mentioned. The tall hedges of *Lycium europaeum* or *Lycium barbarum* scattered along some roadsides and field edges (Ipomoeo purpureae-Lycietum europaei) are worth of mention here, although most of them seem to have been planted or at least handled by man.

More information about weed vegetation can be found in Rivas-Martínez and Rivas-Martínez (1970), Izco (1975, 1984), Alcaraz (1984), Laorga (1986), Nezadal (1989), Esteso (1992), Carretero (1995), De la Cruz et al. (1998), Pérez-Badia et al. (2011), Concepción et al. (2012). For the other types of ruderal vegetation, additional references are: Rivas-Martínez (1975, 1977, 1978a, b, 1979b), Rivas-Martínez and Izco (1977), Izco (1978a, b), Bartolomé (1987), Cirujano (1981), Peinado and Martínez Parras (1984), Peinado et al. (1985, 1988a, b), Carretero (1995), De la Cruz et al. (1998), Rivas-Martínez et al. (2002), Molina et al. (2008), Biurrun et al. (2008).

3.9 Nature Conservation Issues

Despite the age-old and extensive transformation of its landscapes, La Mancha still holds a lot of species and original habitat types with high conservation interest. Many people would agree that wetlands are the first conservation target, not only for the vegetation but also for the aquatic birds, fishes, amphibians and insects living in them. The wetlands of La Mancha suffered from many threats since long ago: draining, cultivation, water pollution by fertilizers, herbicides and sewage affecting also the soils and groundwater, overexploitation of aquifers, and the introduction of invasive species, in particular fishes and crustaceans (Cirujano and Medina 2002). The emblematic Tablas de Daimiel National Park holds the worst record regarding conservation concerns, since twice in recent years it has been at an extreme fire risk because of the spontaneous ignition of underground peat after severe drought episodes induced by aquifer depletion. Although the flood level seems to have been recovered during the last years, more than a dozen of aquatic plants became locally extinct and the strong decline of fen-sedge beds still persists (Álvarez Cobelas and Cirujano 1996, 2001). The newly emerging problems deal with water turbidity, invasive fishes and the severe decline of stonewort carpets (Laguna et al. 2016).

Similar stressors affect the fluvial systems, as mentioned above. The river flow has changed from permanent to intermittent or sporadic in many stream stretches of the Guadiana basin. A large part of the flow of the Tagus is diverted to the Segura river through a large hydraulic transfer built 35 years ago and, from its tributary the Jarama, the Tagus subsequently receives a great deal of polluted water from the conurbation of Madrid that cannot be diluted nor be naturally depurated by the fluvial system until more than 100 km further on. As a consequence, the complete stretch of the Tagus in La Mancha is among the most problematic river courses with regard to their conservation status. Occupancy of river banks by agriculture and flow regulation by dams also affect the Júcar and Segura basins.

But there are other conservation targets in La Mancha, like the gypsum steppes that are outstandingly represented here, even at European level. Agricultural occupancy, mining, infrastructures for transport or energy and in some cases wrong afforestations, have been the main pressures producing the current fragmentation of these special landscapes (Mota et al. 2011). Even the agricultural lands cultivated since millennia furnish the suitable habitat for many species of steppic birds declared as conservation targets by the European Union. For these birds the maintenance of extensive and low input farming, besides an agricultural landscape adequate for their habitat requirements are the main conservation concerns. Lastly, it should not be forgotten that the holm oak forests of La Mancha are among the most decimated Iberian forest types (Hernández and Romero 2012).

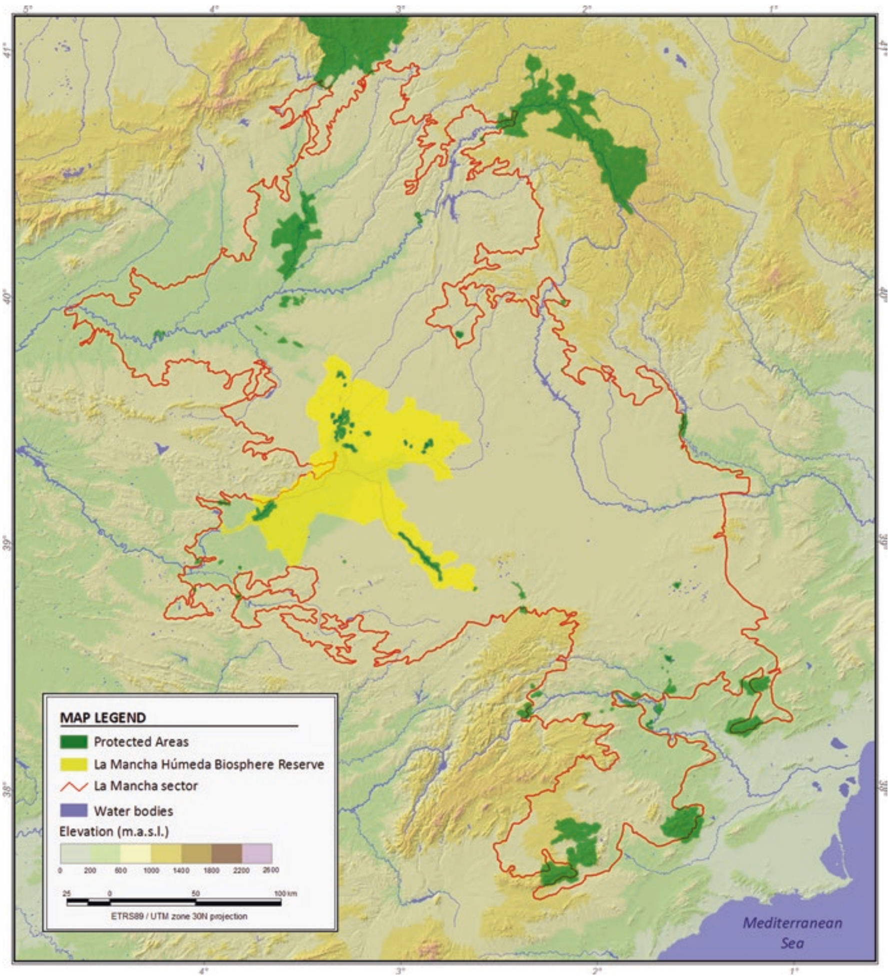

Fig. 3.35 Map of the currently protected areas (National Parks, Natural Parks, Nature Reserves, Fluvial Reserves, Natural Monuments, Microreserves) in La Mancha sector. The La Mancha Húmeda (La Mancha Wetlands) Biosphere Reserve is marked in *yellow*

For these conservation targets and other points of regional interest (Martín Herrero et al. 2003), an important proportion of the land of the sector has been preserved under different categories of protected areas. One national park, several natural parks and, in recent decades, more than thirty nature reserves were declared, mostly for the preservation of wetlands (Fig. 3.35). The European Natura 2000 network of protected sites has increased considerably the total protected area, encompassing most of the wetlands and salt marshes and large representations of gypsum steppes and areas of steppic birds (Ruiz and Serrano 2009; Fig. 3.36). To cope with the major problem of the overexploitation of groundwater in the upper Guadiana basin, an ambitious action plan was approved (Special Plan for the Upper Guadiana,

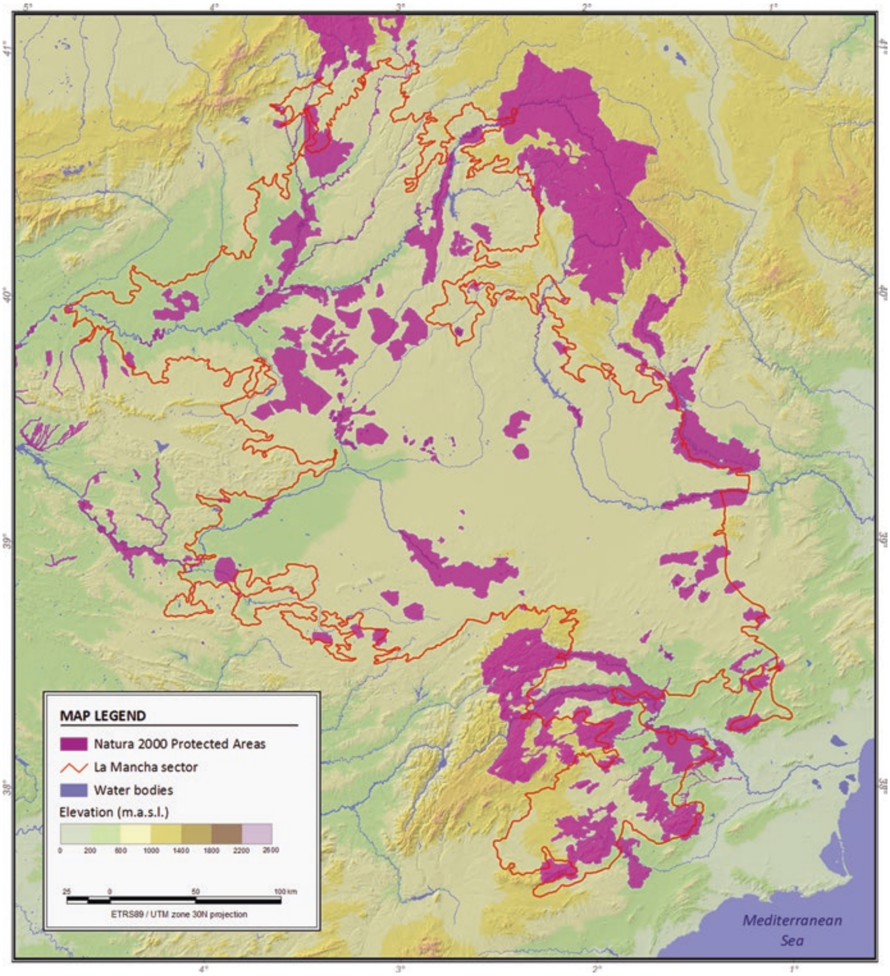

Fig. 3.36 Map of the sites included in the Natura 2000 European Network of Protected Areas in La Mancha sector

PEAG 2008), which however, could only partially be developed due to the rising economic crisis, but at least achieved the goal of recovering the levels of the main aquifers. Another initiative for the conservation of the Guadiana basin recently reactivated is the Biosphere Reserve of La Mancha Húmeda (La Mancha Wetlands), declared by UNESCO in 1981 and redefined in 2014 (Fig. 3.35) with a total extent of 418,000 ha of which 75,000 correspond to core and buffer areas including the protected wetlands, salt marshes and steppic bird areas (García del Castillo et al. 2011). Taking into account the magnitude of the problems outlined, La Mancha is an exciting field for conservation biology and sustainable agriculture, with more than 150 protected or threatened plant species and the challenge of reconciling the conservation of antagonistic systems like forests and steppes, or wetlands with and without water.

3.10 Vegetation Series and Geoseries

Table 3.1 summarizes the spatial and dynamic relationships among the main vegetation units discussed in the text and the vegetation series and geoseries (Rivas-Martínez et al. 2011) recognized in the sector of La Mancha. As in the main text, nomenclature

Table 3.1 Scheme of the main associations present in the area of each vegetation series and geoseries of La Mancha (see text). Red, inside or matching with the unit; yellow, marginal presence

Series and geoseries:	Series				Geoseries		
Associations:	**AQ**	**P-Q**	**JQ**	**CQ**	**RI**	**WL**	**SA**
Forests, woodlands and sclerophyllous shrublands							
Asparago acutifolii-Quercetum rotundifoliae	red						
Querco cocciferae-Pinetum halepensis		red					
Daphno gnidii-Quercetum cocciferae	red	red					
Junipero thuriferae-Quercetum rotundifoliae			red				
Rhamno lycioidis-Juniperetum phoeniceae	red	red	red				
Cephalanthero rubrae-Quercetum fagineae				red			
Opopanaco chironii-Ulmetum minoris					red	red	
Rubio tinctorum-Populetum albae					red	red	
Tamaricetum gallicae					red	red	
Salicetum discoloro-angustifoliae					red		
Salicetum neotrichae					red		
Rubo ulmifolii-Nerietum oleandri					yellow		
Agrostio stoloniferae-Tamaricetum canariensis							red
Suaedo braun-blanquetii-Tamaricetum boveanae							red
Shrublands and scrub							
Salvio lavandulifoliae-Genistetum pumilae	red	red	yellow				
Lino differentis-Salvietum lavandulifoliae	red		red	red			
Cisto clusii-Rosmarinetum officinalis	red	red					
Paronychio aretioidis-Astragaletum clusiani	red	red					
Teucrio gnaphalodis-Salvietum hegelmaieri	red		red				
Lino appressi-Genistetum rigidissimae			red				
Salvio lavandulifoliae-Erinaceetum anthyllidis			red				
Scabioso turolensis-Erinaceetum anthyllidis			red				
Genisto scorpii-Ononidetum fruticosae				red			
Gypsophilo struthium-Centaureetum hyssopifoliae	red						
Herniario fruticosae-Teucrietum pumili	red						
Gypsophilo struthium-Ononidetum edentulae	red	red					
Helianthemo thibaudii-Teucrietum libanitidis	red	red					
Lepidio subulati-Teucrietum balthazaris	red	red					
Thymo lacaitae-Ononidetum tridentatae	red			red			
Genisto scorpii-Retametum sphaerocarpae	red	red		yellow			
Rosetum micrantho-agrestis					red	red	
Rubo ulmifolii-Coriarietum myrtifoliae					red		
Grasslands and meadows							

(continued)

Table 3.1 (continued)

Series and geoseries:	Series				Geoseries		
Associations:	AQ	P-Q	JQ	CQ	RI	WL	SA
Arrhenathero albi-Stipetum tenacissimae	■						
Helianthemo squamati-Stipetum tenacissimae	■	■					
Helictotricho filifolii-Stipetum tenacissimae		■					
Dactylido hispanicae-Lygeetum sparti	■	■					
Astragalo sesamei-Poetum bulbosae	■	■	■	■			
Brachyapio dichotomi-Callipeltetum cucullaris	■	■					
Chaenorhino reyesii-Campanuletum fastigiatae	■						
Echinario capitatae-Wangenheimietum limae	■						
Ruto angustifoliae-Brachypodietum retusi	■	■	■	■			
Saxifrago tridactylitae-Hornungietum petraeae	■	■	■	■			
Mantisalco-Brachypodietum phoenicoidis	▣			■	■		
Elytrigio campestris-Brachypodietum phoenicoidis	▣			■	■		
Ranunculo scelerati-Paspaletum paspalodis					■		
Holoschoenetum vulgaris					■	■	
Mentho aquaticae-Teucrietum scordioidis					■	■	
Trifolio fragiferi-Cynodontetum dactyli					■	■	
Molinio arundinaceae-Schoenetum nigricantis					▣	■	
Aquatic and helophytic vegetation							
Apietum nodiflori					■	■	
Lemnetum gibbae					■	■	
Potametum denso-nodosi					▣	■	
Potametum lucentis					■	■	
Typho-Schoenoplectetum tabernaemontani					■	■	
Charion fragilis						■	
Charion vulgaris						■	
Cladio marisci-Caricetum hispidae						■	
Myriophyllo verticillati-Potametum pectinati						■	
Nymphaeo albae-Nupharetum lutei						■	
Potamo-Ceratophylletum demersi						■	
Potamo-Ceratophylletum submersi						■	
Potametum colorati						■	
Potamo-Utricularietum australis						■	
Soncho maritimi-Cladietum marisci						■	
Bolboschoeno compacti-Schoenoplectetum litoralis							■
Charion canescentis							■
Lamprothamnietum papulosi							■
Najadetum marinae							■
Rielletum helicophyllae							■
Ruppietum drepanensis							■
Zannichellietum pedunculatae							■
Halophytic vegetation							
Aeluropodo littoralis-Juncetum subulati							■
Arthrocnemo-Sarcocornietum hispanicae							■

(continued)

Table 3.1 (continued)

Series and geoseries:	Series				Geoseries		
Associations:	AQ	P-Q	JQ	CQ	RI	WL	SA
Bupleuro tenuissimi-Juncetum gerardi							■
Cressetum villosae							■
Elymo curvifolii-Juncetum maritimae							■
Frankenio thymifoliae-Limonietum latebracteati							■
Gypsophilo tomentosae-Limonietum dichotomi							■
Microcnemetum coralloidis							■
Parapholido incurvae-Frankenietum pulverulentae							■
Polypogono maritimi-Hordeetum marini							■
Puccinellietum lagascanae							■
Puccinellio-Arthrocnemetum macrostachyi							■
Puccinellio caespitosae-Sarcocornietum alpini							■
Puccinellio caespitosae-Suaedetum braun-blanquetii							■
Schoeno nigricantis-Plantaginetum maritimae							■
Senecioni castellani-Lygeetum sparti							■
Soncho crassifolii-Juncetum maritimi							■
Suaedetum spicato-splendentis							■
Suaedo braun-blanquetii-Salicornietum patulae							■
Suaedo splendentis-Salsoletum sodae							■
Ruderal and weed vegetation							
Artemisio herbae-albae-Frankenietum thymifoliae	■						■
Artemisio herbae-albae-Santolinetum canescentis	■						
Artemisio-Camphorosmetum monspeliacae	■						
Resedetum suffruticosae	■						
Roemerio hybridae-Hypecoetum penduli	■	■					
Salsolo vermiculatae-Peganetum harmalae	■	■					
Iondrabo auriculatae-Erucetum vesicariae	■	■					
Kickxio lanigerae-Chrozophoretum tinctoriae	■	■					
Papaveri rhoeadis-Diplotaxietum virgatae	■	■					
Dittrichio viscosae-Piptatheretum miliacei	■	■		■			
Onopordetum acantho-castellani	■	■		■			
Plantagini sempervirentis-Santolinetum squarrosae	■	■	■	■			
Bromo scoparii-Hordeetum leporini	■	■	■	■			
Medicagini rigidulae-Aegilopetum geniculatae	■	■	■	■			
Rapistro rugosi-Sisymbrietum crassifolii			■	■			
Scrophulario lyratae-Epilobietum hirsuti					■	■	
Xanthio italici-Polygonetum persicariae					■	■	
Rubio tinctorum-Sambucetum ebuli					■		
Limonio dichotomi-Atriplicetum halimi							■

of syntaxa follows the checklist of Rivas-Martínez et al. (2001, 2002, 2011). In a synthetic way the potential natural vegetation is organized in four climatophilous vegetation series and three geoseries linked to water tables (running water, standing water, and saline water and soils). They are:

AQ Vegetation series of the dry mesomediterranean holm oak forests of *Quercus rotundifolia* (Asparago acutifolii-Quercetum rotundifoliae)
P-Q Vegetation series of the mesomediterranean semiarid or dry Aleppo pine forests (Querco cocciferae-Pinetum halepensis) and the mesomediterranean semiarid kermes oak sclerophyllous shrublands (Daphno gnidii-Quercetum cocciferae)
JQ Vegetation series of the supramediterranean holm oak forests of *Quercus rotundifolia* with Spanish junipers (Junipero thuriferae-Quercetum rotundifoliae)
CQ Vegetation series of the meso-supramediterranean and submediterranean marcescent oak forests of *Quercus faginea* (Cephalanthero-Quercetum fagineae)
RI Geoseries of the riparian vegetation (rivers and streams) in La Mancha
WL Geoseries of the wetlands of La Mancha with fresh or subsaline standing water
SA Geoseries of the salt marshes of La Mancha

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