Peatlands in the Toledo Mountains (central Spain): characterisation and conservation status

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SUMMARY

We have limited knowledge about the biodiversity and vulnerability of peatlands in the lower-altitude mountains of the Iberian Peninsula, largely because peatlands have not been routinely differentiated from other habitat types in Spain. Understanding is now developing about the ecology of peatlands in central Spain, but they are already under severe threat of conversion and degradation. In this article we describe the results of a field survey and literature review study to characterise and describe the current condition of peatlands in the Toledo Mountains in terms of their typology, the representation of habitat types protected by European (EU) designations, threats, endangered plant species, and conservation status. Our results suggest that the principal threats are overgrazing by domestic animals and ungulates (red deer and wild boar), fire, expansion of cereal crops, drying-out and erosion. Disturbance is most severe in areas that are not protected by nature conservation designations, where peatlands are especially vulnerable to damage arising from human activities.

KEY WORDS: bonales; peatland conservation; peatland vegetation; threats

INTRODUCTION

Peatlands (bogs and fens) comprise about 50 % of the world's wetlands (Mitsch & Gosselink 2000, Joosten & Clarke 2002). They are rare in Mediterranean areas such as most of the Iberian Peninsula, where they are often threatened by human development, mainly for agriculture and grazing (Guerrero & Polo 1990). Consequently they are of high regional importance and require good management. The main challenges to achieving this are poor understanding of their palaeoecological value (Martínez-Cortizas 2001), of their ecological functions, and of their locations and extent in some regions. They are recognised as important and endangered biodiversity reservoirs, and many of the resident species have legal protection (Rydin & Jeglum 2006). In Mediterranean Iberia they are located primarily in high-altitude mountain environments (namely the Iberian, Central and Baetic ranges), although extensive peat deposits also occur sporadically in coastal wetlands in the south-west (Doñana) and farther inland. Peatlands can also occur in the floodplains of large rivers (Tablas de Daimiel, central Spain) (Martínez-Cortizas *et al*. 2000). However, much less is known about lower-altitude (up to ~1000 m a.s.l.) mires in Mediterranean mountains.

In this article we make a first attempt to assess the representation of threatened plant species in the peatlands of the Montes de Toledo (Toledo Mountains) in central Spain. Despite their importance, relatively little is known about these peatlands (particularly outside literature in the Spanish language) because there has been little effort to distinguish them floristically from other habitat types. There have been relatively few investigations of either vascular or non-vascular peatland plants, and no studies that examine ecological interactions and compare communities across different areas and peatland types. As a result, the biodiversity of the peatlands is poorly understood even though they are such distinctive parts of the landscape.

In this article we provide a preliminary characterisation of the peatlands of the Toledo Mountains, based on literature evidence and initial field survey. The primary focus is on peatland habitats and species of conservation interest, the threats they face, and knowledge gaps requiring further work.

STUDY AREA

The Montes de Toledo cover an area of almost 3,800 km^2 in central Spain, between Toledo and Ciudad Real Provinces in the region of Castilla-La Mancha (Figure 1). Geologically, they represent the western half of the Iberian Hercynian Massif, which

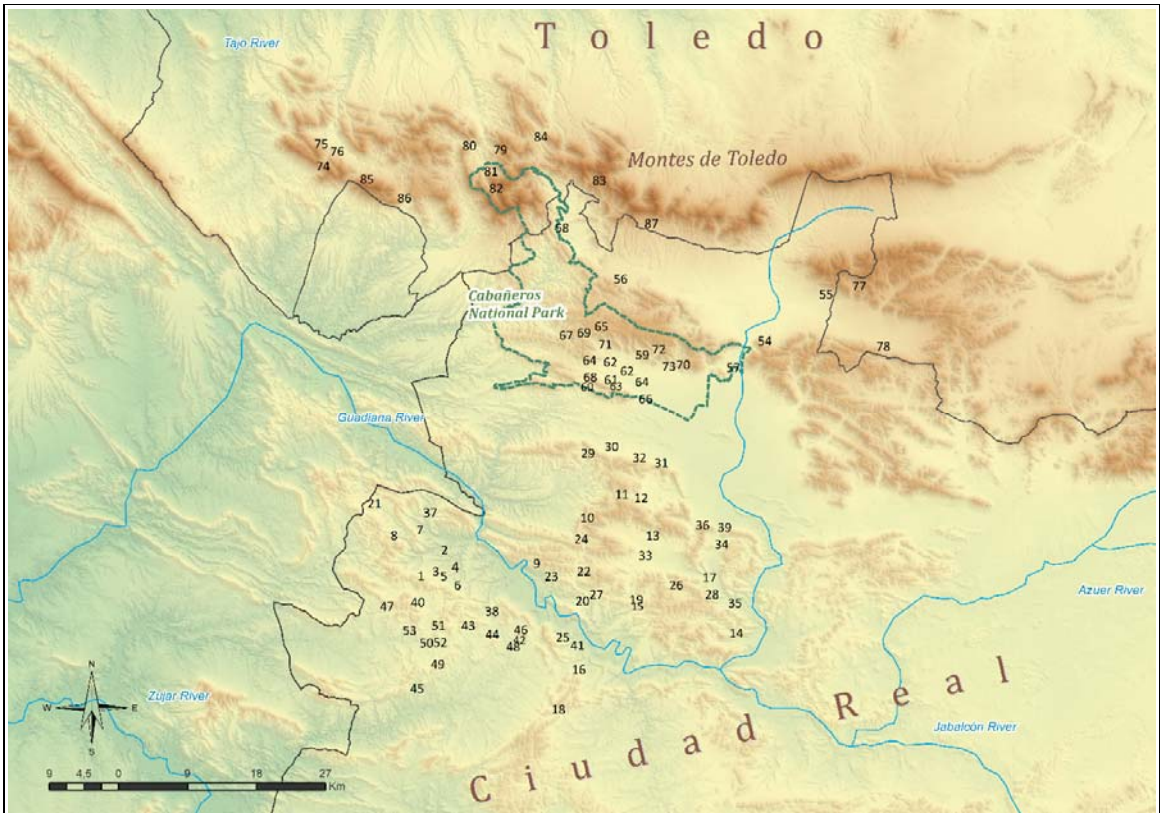

Figure 1. Distribution of peatlands in the Toledo Mountains (central Spain). The numbers indicate the locations of the 87 study peatlands listed in Table A1 (see Appendix). The small map (right) shows the location of the study area within Spain.

is the oldest geological formation of the Iberian Peninsula. It consists of granitic rocks, mica-schists, slates, quartzites and limestones. At the end of the Hercynian orogeny this basement was fractured and divided into a series of blocks which were later uplifted or lowered by the Alpine orogeny. In the centre of the peninsula, two great horsts (Central System and Toledo Mountains), and a tectonic graben (Tagus basin) separating them, were formed (Molina *et al.* 1991). The Toledo Mountains structure was rejuvenated by the Alpine orogeny but, unlike the Central System, it does not have raised and sunken blocks, but an Appalachian relief uncovered after intense erosion. Thus, the mountains are uniform quartzite outcrops, around 1400 m a.s.l., which have not been affected by glacial erosion. From the middle Miocene to the lower Pleistocene, the deep Hercynian basement was locally buried under an alluvial sedimentary layer termed “rañas” (Vicente *et al.* 1991, 1997). Since then, present-day rivers and streams have eroded this alluvial cover.

The climate of the Toledo Mountains has been classified as temperate Mediterranean with dry summers and an oceanic tendency in the west (Muñoz 1976). Mean annual rainfall is roughly 800 mm, ranging from 400–600 mm in inter-mountain basins and valleys to 700–1000 mm in the westernmost mountain areas. Mean annual temperatures range from 17 ºC at low altitudes to 10 ºC at the highest summits.

The most representative plant communities are the holm oak (*Quercus ilex*) and cork oak (*Q. suber*) woodlands of the meso-mediterranean foothills (*Pyro bourgaeanae-Quercetum rotundifoliae* and *Poterio agrimonioidis-Quercetum suberis* communities respectively), the first associated with mesothermophilous taxa (*Arbutus unedo*, *Phillyrea angustifolia*, *Pistacia terebinthus*, *P. lentiscus*, *Pyrus* *bourgaeana*, *Rosmarinus officinalis*, *Genista hirsuta*, *Lonicera implexa*, *Paeonia broteroi*, *Lavandula stoechas* and *Olea europaea*) and the second with deciduous trees (*Quercus faginea* subsp. *broteroi*, *Q. pyrenaica*, *Acer monspessulanum*). In wetter areas and shady valleys evergreen oak forests with *Quercus faginea* subsp. *broteroi* (subas. *quercetosum fagineae*) extend to high altitude. Deciduous oak forests of *Quercus pyrenaica* (*Sorbo torminalis-Quercetum pyrenaicae*) occupy the supra-mediterranean bioclimatic belt (> 900 m a.s.l.). Chorologically, the study area is included in the Mediterranean region, Western Mediterranean subregion, Mediterranean West Iberian province, Luso-Extremadurenian subprovince and Toledano-Tagano sector (Perea & Perea 2008).

In the Toledo Mountains, peatlands (known locally as "trampales" or "bonales") provide the primary habitats for a variety of plants and animals, some of which are endangered species. These singular ecosystems have undergone substantial biotic impoverishment as a result of human activities. They are also threatened by climate change, due to the fragility and vulnerability of their marginal and relict flora (Martín-Herrero *et al.* 2003a, Herranz *et al.* 2009, Ruiz & Serrano 2009, Herranz 2010).

FIELD SURVEY

Field assessments were carried out between 1990 and 2013 at a total of 87 peatland sites (Figure 1). Peatland sites were defined as areas with a peat layer more than 30 cm thick and include both peatlands and mires *sensu* usage of the terms in south-western Europe (Joosten & Clarke 2002). In this article we shall consider only peatlands of area > 0.02 ha. For each site we recorded peatland name, municipality and province, geographical co-ordinates, altitude (metres a.s.l.), extent (ha) and protection status (Table A1 in Appendix).

Each peatland was classified (Table A1) according to its location, the source of nutrients and water regime following the hydrogeomorphological approaches of Martínez-Cortizas (2001). Each peatland site was characterised on the basis of its floristic characteristics and habitat types following the methodology and protocols commonly used in phytosociology. Plot size was fixed at 100 m^2 except when the areas covered by single plant communities were smaller than this. Nomenclature follows Bouso *et al*. (2012) for vascular plant species and Cezón & Muñoz (2013) for bryophytes. Finally, the general characteristics of each site were noted and, particularly, any signs of disturbance and related threats were recorded.

CHARACTERISATION AND TYPOLOGY OF PEATLANDS

To date, environmental managers and scientists have identified about 130 peatlands in the Toledo Mountains. Of these, around 110 are in Ciudad Real Province (including 32 in Cabañeros National Park) and the other 20 are in Toledo Province (García-Río 2000, Martín-Herrero *et al.* 2003b, Vaquero 2010, Bouso *et al.* 2012). Their occurrence is scattered. The areas of only 12 (13.8 %) of the 87 peatlands studied here exceed 10 ha. Indeed, they are characterised by small surface area (average 4.5 ha), ranging from 0.02 ha (8 sites) to 113.6 ha (Arroyo de Valdelapedriza, Site 15) (Table A1). The remainder present smaller surface areas, most of them 1 ha or less (63.2 %), 1–5 ha (14.9 %) and 5–10 ha (8.1 %). The altitudes of these peatlands range from 560 to 1025 m a.s.l. (Table A1). However, 51 of them are located in a few areas in north-western Ciudad Real Province that lie below 700 m a.s.l. (Figure 1).

The Toledo Mountains peatlands were formed by terrestrialisation in waterlogged zones (García-Río 2001, Martín-Herrero *et al.* 2003b). They are located in "rañas" (continental detritic formations which appear always to be associated with quartzitic mountain ranges) or small valley bottoms, either in the contact area between the bedrock and the raña (26 sites, 29.9 %) or in ravines carved into the latter (12 sites, 13.8 %). Others occur in catchment heads with low gradients (26 sites, 29.9 %) or as localised soil deposits associated with (groundwater) springs in valley bottoms flanked by hills and Palaeozoic mountains (23 sites, 26.4 %) (Table A1).

In terms of their hydrological regimes most of these peatlands are minerogenous (geogenous) because some of their water supply enters the peatland from the surrounding mineral soil. They are generally minerotrophic and often nutrient-rich, reflecting the predominance of surface and groundwater sources (Table A1). They are further divided into two major hydrological types, namely: i) topogenous peatlands with essentially flat water tables located in terrain basins with both inlets and outlets; and ii) sloping soligenous peatlands with directional water flow through the peat or on the surface. There is evidence of only four peatlands with at least partially domed surfaces (known locally as "vejigas" or "chichones") that are isolated from groundwater influenced by mineral soil and receive water only as precipitation (ombrogenous). These are: Raña Maleta (Site 2), which has a peat dome ~3 m high and ~8 m diameter (Infante & Heras 2012); together with Brezoso (Figure 2a), Peral east and Peral west (Sites 70, 72 and 73), which have domes ~2 m high (Vaquero 2010).

Figure 2. Peatlands in the Toledo Mountains: (a) the ombrogenous site of Brezoso; (b) birch forest on La Ventilla peatland; (c) perimeter fence of the Bermú site; (d) Canalejas peatland; (e) Valdeyernos peatland; (f) open habitat on Fuente de la China peatland, which is influenced by periodic disturbance and hosts a large population of *Rhynchospora alba*.

CONSERVATION STATUS AND HABITAT TYPES

The Toledo Mountains peatlands are included in the Natura 2000 network of Protected Natural Areas of Castilla-La Mancha SCI ES4250005 (Table A1). Of the 87 peatlands studied, 47 are not protected in any way, and 40 are protected as "habitats of special protection" in three different categories (Martín-Herrero *et al*. 2003a, Ruiz & Serrano 2009, Rubio 2010). In Toledo Province, only six peatlands are legally protected; four (Valdeyernos and Las Lanchas 1, 2 and 3) at regional level as 'microreserves' (small natural areas containing rare habitats or threatened species of flora and fauna), and the other two (Arroyo del Chorro 1 and 2) at national level following the expansion of Cabañeros National Park. In Ciudad Real Province, 16 peatlands are protected as microreserves, 17 within Cabañeros National Park, and one (Arroyo de Valdelapedriza) as a 'river reserve' (natural spaces of linear nature with seasonal or permanent water regime dependent ecosystems). Most of these peatlands are also amongst the areas considered 'sensitive' by the European Union (EU) as "Sites of Community Importance" (SCI) (Table A1). Eleven of the habitat types recorded on peatlands in the Toledo Mountains are included in Annex I of the EU Habitats Directive (92/43/EEC), which thus places some priority on their conservation. Brief general descriptions of these habitat types are given in Table 1, and their distribution amongst the 87 studied peatlands is summarised in Table 2. An overview of their presentation at our sites follows.

- Transition mires or "tremedales" (Habitat 7140). This highly complex habitat is the most abundant type recorded in the Toledo Mountains study area (present at 54 sites). The most characteristic species are *Anagallis tenella*, *Carum verticillatum*, *Dactylorhiza elata* subsp. *sesquipedalis*, *Drosera rotundifolia*, *Eleocharis multicaulis*, *Galium palustre*, *Holcus lanatus*, *Hypericum elodes*, *H. undulatum*, *Lobelia urens*, *Lotus uliginosus*, *Myrica gale*, *Pinguicula lusitanica*, *Scutellaria minor* and *Wahlenbergia hederacea*.

- Depressions on peat substrates of the *Rhynchosporion* (Habitat 7150). In our study area this habitat occurs in fragmentary stands on nine sites, as a microhabitat within other more extensive habitats (e.g. Habitat 7140 above). Additional characteristic species in the Toledo Mountains are *Anagallis tenella*, *Juncus bulbosus*, *J. acutiflorus*, *Carex binervis* and *C. flacca*. The bryophyte layer is always thin and a few *Sphagnum* species (including *S. denticulatum*) can develop sparsely but always in mixtures.

- Active raised bogs (Habitat 7110). Present as a nano- and micro-habitat in four peatlands (Sites 2, 70, 72 and 73). The mire surface typically displays distinctive microtopography, with patterns of hummocks and hollows rich in *Sphagnum denticulatum* and other peat-forming species. Around bog pools there may sometimes be patches of *Rhynchosporion* communities.

- Temperate Atlantic wet heaths with *Erica tetralix* (Habitat 4020). This habitat occurs on the drier parts of peatlands in the Toledo Mountains (66 sites).

- Temperate Atlantic dry heaths (Habitat 4030). Especially abundant around the margins of Toledo Mountains peatlands, as well as in areas that are subject to human and pastoral pressure.

- *Molinia caerulea* meadows on peaty soils (Habitat 6410). Known regionally as "pajonales" or "mansiegares". This habitat is found on the margins of peatlands, encroaching onto them where the conditions favour communities that are less demanding of soil moisture, and completely invading the most degraded peatlands. Tall herbs such as *Fuirena pubescens*, *Potentilla erecta* and *Genista tinctoria* are sometimes present, and the *Sibthorpio europeae*-*Pinguiculetum lusitanicae* association appears in areas with oozing water.

- Oligotrophic waters containing very few minerals of sandy plains (Habitat 3110). This habitat is represented in our study area by the amphibious communities *Hyperico eloidis*-*Scirpetum fluitantis*, *Hyperico eloidis*-*Potametum oblongi* and *Ludwigio palustris*-*Potametum polygonifolii*.

- Natural eutrophic ephemeral lakes with *Magnopotamion* or *Hydrocharition*-type vegetation (Habitat 3150). The most characteristic species are *Potamogeton* spp., *Callitriche* spp., *Nuphar luteum* and *Utricularia vulgaris*.

- Amphibious communities in seasonal oligo-mesotrophic wetlands (Habitat 3170). Represented by the *Hyperico humifusi*-*Cicendietum filiformis* and *Pulicario paludosae*-*Agrostietum pourretii* associations. *Isoetes histrix* and *Ophioglossum azoricum* are notable species.

Table 1. Habitat types found in the Toledo Mountains peatlands that are listed in Annex I of the European Union (EU) Habitats Directive.

Habitat	**Description**
7140	Transition mires or "tremedales": peat-forming communities developed at oligotrophic to mesotrophic water surfaces, with characteristics intermediate between soligenous and ombrogenous types. This habitat is always found on slopes or valley bottoms fed by water circulation, and never appears in bog hollows or confined areas (Martínez-Cortizas *et al*. 2009b). It presents a large and diverse range of minerotrophic vegetation influenced by base-rich groundwater or surface water, which mixes with acidic, oliogotrophic precipitation. The vegetation includes sedge-lands (Cyperaceae, Juncaceae); and floating (quaking) carpets of *Sphagnum* mosses (*Sphagnum papillosum*, *S. palustre*, *S. denticulatum*, *S. subnitens*, etc.), usually accompanied by aquatic and amphibious communities with *Potamogeton polygonifolius*. It also hosts common heathland species and other bryophyte taxa (*Aulacomnium palustre*, *Cephalozia connivens*, *Cephaloziella divaricata*, *Philonotis capillaris*, *P. fontana*, *Riccardia multifida*).
7150	Depressions on peat substrates of the *Rhynchosporion*. Pioneer and helophilous communities of humid exposed peat or acid sand, with *Rhynchospora alba*, *Eleocharis multicaulis* and *Carex echinata* (*Eleocharito multicaulis*-*Rhynchosporetum albae*). This habitat type is found on cutover areas of transition mires; on naturally seepage-eroded areas of wet heaths and mires; and in the fluctuation zones of oligotrophic pools with sandy, slightly peaty substrata. It is always present in very waterlogged soils with little vegetation, where water moves slowly but steadily, and whose chemical composition is different from nearby habitats, being charged with mineral compounds (Martínez-Cortizas *et al.* 2009a).
7110	Active raised bogs. Lowland raised bogs form raised domes of peat, accumulated over thousands of years, that are isolated from the influence of groundwater and irrigated solely by rainfall. They typically overlie earlier minerotrophic peat. Such rainwater-fed ecosystems are very acid and poor in plant nutrients and typically support a restricted range of species (Martínez-Cortizas *et al.* 2009c) including *Sphagnum* spp., *Erica tetralix*, *Calluna vulgaris*, *Molinia caerulea* and *Drosera rotundifolia*.
4020	Temperate Atlantic wet heaths with *Erica tetralix*. Hygrophilous heathlands containing *Erica tetralix*, *Calluna vulgaris*, *Genista anglica* and sometimes *Myrica gale* founded on acid and oligotrophic wet peaty soils with slightly impeded drainage, although they also extend onto dry soils (*Genisto anglicae*-*Ericetum tetralicis* and *Erico tetralix*-*Myricaetum galeae*). Often they form mosaics with other mire communities (habitats 7140 and 7150) and even with dry heaths with *Erica lusitanica*, *E. scoparia* and *E. umbellata* (habitat 4030).
4030	Temperate Atlantic dry heaths. Xerophilous heathlands on acid soils, with *Erica lusitanica*, *E. scoparia* and rarely *Cistus psilosepalus* (*Genisto anglicae*-*Ericetum scopariae*).
6410	*Molinia caerulea* meadows on peaty soils. These oligotrophic communities (*Molinio caeruleae*-*Lotetum pedunculati*), with swards reaching up to two metres in height, usually occur as components of wet pastures and often form mosaics with dry grassland, heath, peatland and scrub communities. *Molinia caerulea* is accompanied by a wide range of associated species, including rushes (*Juncus squarrosus*, *J. acutiflorus*, *J. effusus*, *J. subnodulosus*, *J. conglomeratus*), sedges (*Carex paniculata* subsp. *lusitanica*, *C. echinata*, *C. binermis*), and the grass *Danthonia decumbens*.
3110	Oligotrophic waters containing very few minerals of sandy plains. The most significant species are *Potamogeton polygonifolius*, *Hypericum elodes*, *Eleocharis palustris*, *Ludwigia palustris*, *Scirpus fluitans*, *Callitriche stagnalis*, *Juncus heterophyllus* and *Utricularia vulgaris*.
3150	Natural eutrophic ephemeral lakes with *Magnopotamion* or *Hydrocharition*-type vegetation.
3170	Amphibious communities in seasonal oligo-mesotrophic wetlands.
92A0	Riparian forests dominated by *Salix atrocinerea.*
92B0	Alluvial forests with *Betula pendula* subsp. *fontqueri* var. *parvibracteata.*

Table 2. Distribution of EU Habitats Directive Annex 1 habitat types amongst the Toledo Mountains peatland sites. The habitat types are described in Table 1.

No.	Peatland	7140	7150	7110	4020	4030	6410	3110	3150	3170	92A0	92B0
1	Raña del Aulagar	x				x	x		x			
2	Raña Maleta	x	x	x		x	x	x	x			
3	Horcajillas de los Baturros	x	x			x	x		x			
4	Fuente del Tío Chasco	x				x	x		x			
5	Los Jareros	x				x	x		x			
6	Raña de los Terreros	x	x			x	x		x			
7	Barranco del Remilladero	x			x		x				x	x
8	Barranco de los Membrillos	x	x		x		x		x			x
9	Barranco del Chorro	x			x	x	x	x			x	x
10	Sierra del Hontanar		x		x	x	x	x				
11	Cerro de los Barranquillos	x	x		x	x	x	x			x	x
12	El Alcornocal	x			x		x		x			
13	Morro de la Parrilla				x	x	x		x		x	
14	Arroyo de Valdelamadera	x			x		x	x	x		x	
15	Arroyo de Valdelapedriza	x			x	x	x		x		x	x
16	Barranco de Riofrío	x			x		x		x		x	x
17	Barranco de Zalzalagorda	x			x		x		x			
18	Sierra de la Virgencita				x		x					
19	Sierra Larga	x			x		x	x				x
20	Sierra de Puerto Quemado					x	x				x	x
21	Cerro de los Polvos						x					
22	Sierra de la Podadilla						x					
23	Collado del Pocito						x					
24	Raso del Portijuelo				x			x				
25	Monte Castilnegro				x		x					
26	Valle de la Viuda				x		x					
27	Los Casuchones				x	x	x	x				
28	Arroyo del Gargantón	x				x	x	x				
29	Arroyo del Puerto				x		x	x				
30	Mechocamino	x			x			x				
31	Raña de Navalajarrilla				x		x					
32	La Canaleja	x			x		x	x				
33	Raña del Reguero de la Manca						x					
34	Cerro Montón de Trigo					x	x					
35	Casas de El Gargantón						x					
36	Boca del Camellar											
37	Barranco de El Espinar											
38	Sierra Gorda				x		x					
39	Boca de los Carriles				x	x						
40	El Perro											
41	Vallejo Huertas Viejas				x		x					
42	Fuente de las Saceas				x	x						
43	La Chaparrera				x	x	x					
44	Fuente de la Chaparrera				x	x	x					
45	Santorrostrillo	x			x	x	x	x				
46	Arroyo del Caballo						x					
47	Sierra de la Media Luna	x			x	x	x	x				
48	Tejoneras				x	x	x					
49	Cerro del Oso 1	x			x	x	x					
50	Cerro del Oso 2	x			x	x	x					

No.	Peatland	7140	7150	7110	4020	4030	6410	3110	3150	3170	92A0	92B0
51	Cerro del Oso 3	x			x	x	x					
52	Valle de los Ricos	x					x					
53	Barranco de la Teja						x					
54	Torre de Abraham				x		x					
55	Bermú				x		x					
56	Raña del Carrizal	x	x		x		x	x				
57	La Ventilla	x			x		x				x	
58	Fuente de la China	x	x		x		x	x		x		
59	Canalejas	x			x	x	x	x				
60	Casa del Labradillo	x			x	x	x	x		x		
61	Fuente del Labradillo	x			x	x	x	x		x		
62	Mateo	x			x	x	x	x		x		
63	Zauz	x			x	x	x	x		x		
64	El Redondo	x			x	x	x	x		x		
65	Trinchapanetes				x	x	x					
66	El Rostro	x			x	x	x	x		x		
67	Los Canarios				x	x						
68	El Estrecho	x			x	x	x	x		x		
69	Viñuelas				x	x	x	x		x		
70	Brezoso	x		x	x	x	x	x		x		
71	Cuesta del Diablo	x			x	x	x	x		x		
72	Peral east	x	x	x	x	x	x	x		x		
73	Peral west	x		x	x	x	x	x		x		
74	Las Lanchas 1	x			x	x	x					
75	Las Lanchas 2	x			x	x	x					x
76	Las Lanchas 3	x			x	x	x					x
77	Valdeyernos	x			x	x	x					x
78	Arroyo de la Peña	x			x	x	x					
79	Patateros	x			x		x					
80	La Botija	x			x		x					
81	Arroyo del Chorro 1	x			x		x					
82	Arroyo del Chorro 2	x			x		x					x
83	Cuevas del Milano	x			x	x	x					
84	Casa de Vaquerizo	x			x		x					
85	Garganta del Pusijo	x										
86	Piedraescrita	x			x		x					
87	Cabrahigos	x			x	x	x					

- Riparian forests dominated by *Salix atrocinerea* (Habitat 92A0). In the Toledo Mountains this habitat is associated with streams and ravines where some peatlands are located. The most frequent species in these communities (*Viti viniferae-Salicetum atrocinereae* and *Frangulo alni-Myricetum gale*) are *Salix atrocinerea*, *S. salviifolia*, *Frangula alnus* and *Myrica gale*.

- Alluvial forest with *Betula pendula* subsp. *fontqueri* var. *parvibracteata* (Habitat 92B0). Birch forests on floodplains and peatland environments on acid soils subject to periodic inundation (Figure 2b), often accompanied by *Arbutus unedo*, *Ilex aquifolium*, *Taxus baccata*, *Myrica gale*, *Frangula alnus*, *Phillyrea angustifolia* and *Calluna vulgaris* (Ladero & Velasco 1978).

About 150 vascular and 120 non-vascular plants have been recorded from the peatlands of the Toledo Mountains (Rivas-Goday *et al.* 1954, 1968; Velasco 1978, 1980; Peinado *et al.* 1983; Velasco *et al.* 1986; Gómez-Manzaneque 1987, 1988; Marcos-Samaniego & Matute 1989; Marcos-Samaniego *et al.* 1989; Vaquero 1991, 1993a, 1993b; Vaquero & Costa 1992; Marcos-Samaniego & Navarro 1993; Vaquero *et al.* 1994; Martín 1996; Fuertes 1998;

Martín & Carrasco 1998; García-Río 2000; Rodríguez-Marzal & Pérez-Carral 2000; Medina *et al*. 2002; Sanz-Elorza 2006; Perea & Perea 2008; Cezón & Muñoz 2013). Forty-four species occurring in the Toledo Mountains peatlands are included in the Regional Catalogue of Protected Species of Castilla-La Mancha (García-Río 2002, Martín-Herrero *et al.* 2003a, Sanz-Elorza 2006, Ruiz & Serrano 2009) (Table A2). Five of them (*Betula pendula*, *Prunus lusitanica*, *Taxus baccata*, *Rhynchospora alba*, *Utricularia australis*) are protected as 'Vulnerable' and the rest within the category 'Species of Special Concern' (D.O.C.M. 1998, 2001).

THREATS

Despite their unique status, the Toledo Mountains peatlands remain under threat for several reasons (Table 3) including afforestation and logging of upland and lowland areas, alterations to hydrological regime (drainage, drying, erosion), overgrazing by domestic animals and ungulates, repeated burning, dumping of waste (including agrochemicals) and related development of infrastructure. In consequence, the area of peatlands has declined throughout historical times and the rate of loss has increased in recent decades (García-Río 2000). Future climate change scenarios are not favourable for peatland ecosystems in the Toledo Mountains because of their intrinsic dependence on the water regime (Fernández-González *et al.* 2009).

The main conservation problems of peatlands in the Toledo Mountains are related to livestock and agricultural uses, which have intensified in recent years (García-Río 2001). Livestock rearing and expansion of cereal crops have altered and reduced peatland ecosystems, and even caused them to practically disappear in the cases of Sierra de la Virgencita, Sierra de la Podadilla, Raso del Portijuelo, Barranco de El Espinar, Boca de los Carriles, Santorrostrillo, Tejoneras and Barranco de la Teja (Sites 18, 22, 24, 37, 39, 45, 48 and 53). When Rivas-Goday *et al.* (1954) visited the Valle de la Viuda peatland (Site 26) they inventoried the hygrophytic vegetation of the valley bottom, documenting all peatland habitats typical of the Toledo Mountains including *Myrica gale* communities. They concluded that this site was an 'island' of Atlantic vegetation within a territory dominated by Mediterranean flora. However, this peatland has now been almost completely converted to poplar and eucalyptus cropland. As in many other cases, the main impact has been intentional drainage of the peatland in order to grow cereal crops. Another case of extreme modification is presented by El Perro (Site 40), where the peatland must have occupied an area of about 315.6 ha in the past but is now reduced to three fragments, without peatland vegetation, whose total area is 3.7 ha.

Most peatlands in the Toledo Mountains have been subjected to excessive grazing by both domestic stock and wild ungulates, so in some cases perimeter fences have been installed to protect them. This is the case for Barranco del Remilladero, Bermú, Viñuelas and Brezoso (Sites 7, 55, 69 and 70) where grazing and browsing are currently in balance with the long-term conservation of plant cover (Figure 2c). For Canalejas (Site 59) the fencing is allowing recovery of one of the largest peatlands in Cabañeros National Park (Figure 2d). The vegetation is now becoming much more uniform, but it seems that certain threatened species (notably *Sphagnum subnitens*, *S. palustre*, *Carex echinata*, *Drosera rotundifolia* and *Sibthorpia europaea*) that were formerly present had already disappeared before the fence was installed. In the case of Barranco de los Membrillos (Site 8), moderate grazing (albeit with signs of burning) has produced one of the best-preserved peatlands in the north of Ciudad Real Province. Torre de Abraham (Site 54) is protected on account of a nature trail.

Generally, people cut and clear heath and *Molinia caerulea* meadows, usually employing sustained fire, to promote access to water for both domestic livestock and wild ungulates. This leads inevitably to drying-out of these ecosystems. Trinchapanetes and Los Canarios (Sites 65 and 67; in Cabañeros National Park) are effectively dead peatlands because of a fierce fire in 1993 and are currently covered by dense heathland, thickets and brambles. In fact, *Molinia* meadows have mostly evolved under extensive management and late mowing regimes (for bedding). The opening-up of *Erica tetralix* wet heath by overgrazing or loss of moisture causes the intrusion of dry heath species and *Molinia caerulea* (Sites 1–6, 28, 31, 45, 52, 60, 70, 71). However, if the pastoral pressure is very high *Molinia* cover is lost (Sites 23, 37, 68, 72), peat is exposed on the surface and dries out, then slowly disappears by erosion. Most particularly, intensified use of peatlands for grazing leads to the disappearance not only of *Molinia* but also of *Myrica gale*, which is a protected species. This is the case at Sierra de Puerto Quemado (Site 20), where numerous dead specimens of *Myrica* can be found within a peatland that has gradually been colonised by *Pteridium aquilinum*. High pressure from ungulates threatens the survival of *Myrica* in the peatlands of Cabañeros National Park (i.e. Brezoso, Site 70) where many specimens have only male inflorescences, which means that the species must reproduce almost entirely by vegetative means (Vaquero 2010).

Table 3. Threats to the peatlands of the Toledo Mountains.

No.	Peatland	DRYING	EROSION	DRAINAGE	OVERGRAZING	UNGULATES	RECREATIONAL USES	AFFORESTATION (EXOTIC TREES)	LOGGING	ANTHROPIC SOIL DISTURBANCE	SOIL DISTURBED BY WILD BOAR	FIRE	AGROCHEMICALS	DUMPING	NEARBY INFRASTRUCTURE
1	Raña del Aulagar	x	x		x				x	x			x		x
2	Raña Maleta		x		x				x	x			x		x
3	Horcajillas de los Baturros		x		x				x	x			x		x
4	Fuente del Tío Chasco	x	x	x	x				x	x			x		x
5	Los Jareros	x	x	x	x				x	x	x	x	x		x
6	Raña de los Terreros	x	x	x	x				x	x			x		x
7	Barranco del Remilladero				x	x		x	x			x	x		x
8	Barranco de los Membrillos	x							x			x			x
9	Barranco del Chorro	x							x						x
10	Sierra del Hontanar	x	x	x				x	x	x			x		
11	Cerro de los Barranquillos	x		x	x	x			x	x	x	x	x	x	x
12	El Alcornocal	x	x	x	x	x			x	x			x		x
13	Morro de la Parrilla	x	x		x	x			x	x	x		x		x
14	Arroyo de Valdelamadera						x	x	x				x		x
15	Arroyo de Valdelapedriza		x					x							x
16	Barranco de Riofrío								x						
17	Barranco de Zalzalagorda		x						x	x	x		x		x
18	Sierra de la Virgencita	x	x	x	x			x	x	x	x	x	x		x
19	Sierra Larga										x				x
20	Sierra de Puerto Quemado	x	x		x	x		x		x	x		x		x
21	Cerro de los Polvos	x	x		x								x	x	x
22	Sierra de la Podadilla	x	x	x	x	x				x					
23	Collado del Pocito	x	x	x	x	x	x		x	x	x				x
24	Raso del Portijuelo	x	x	x	x		x		x	x	x	x	x	x	x
25	Monte Castilnegro	x	x	x	x	x		x	x	x	x			x	x
26	Valle de la Viuda	x	x		x	x		x	x	x	x	x	x	x	x
27	Los Casuchones	x				x		x			x				
28	Arroyo del Gargantón	x			x	x									
29	Arroyo del Puerto		x		x	x	x		x		x				x
30	Mechocamino	x	x	x	x			x	x	x		x	x	x	x
31	Raña de Navalajarrilla	x	x	x	x			x	x	x		x	x	x	x
32	La Canaleja	x	x	x	x			x	x	x			x	x	
33	Raña del Reguero de la Manca	x		x				x				x	x		
34	Cerro Montón de Trigo							x		x			x		x
35	Casas de El Gargantón				x	x			x	x			x		x
36	Boca del Camellar	x	x	x	x				x	x			x		x
37	Barranco de El Espinar		x		x	x					x	x	x		
38	Sierra Gorda				x	x		x					x		x
39	Boca de los Carriles			x	x			x	x	x			x	x	x
40	El Perro	x	x	x	x	x	x		x	x	x	x	x	x	
41	Vallejo Huertas Viejas	x	x	x	x			x	x	x	x				
42	Fuente de las Saceas	x	x	x	x				x	x			x	x	x
43	La Chaparrera	x	x	x	x					x			x		x
44	Fuente de la Chaparrera	x	x	x	x					x			x		x
45	Santorrostrillo	x	x	x	x					x	x	x	x		x
46	Arroyo del Caballo	x		x				x	x	x	x		x	x	x
47	Sierra de la Media Luna	x		x	x								x	x	x
48	Tejoneras	x		x	x			x	x	x	x		x	x	x
49	Cerro del Oso 1	x	x		x					x	x		x		
50	Cerro del Oso 2	x	x		x					x	x		x		
51	Cerro del Oso 3	x	x		x					x	x		x		
52	Valle de los Ricos			x	x			x							
53	Barranco de la Teja	x	x	x	x		x			x			x	x	x
54	Torre de Abraham						x								x
55	Bermú				x	x		x			x				
56	Raña del Carrizal	x		x	x					x				x	
57	La Ventilla					x			x						
58	Fuente de la China	x	x		x	x					x				x

No.	Peatland	DRYING	EROSION	DRAINAGE	OVERGRAZING	UNGULATES	RECREATIONAL USES	AFFORESTATION (EXOTIC TREES)	LOGGING	ANTHROPIC SOIL DISTURBANCE	SOIL DISTURBED BY WILD BOAR	FIRE	AGROCHEMICALS	DUMPING	NEARBY INFRASTRUCTURE
59	Canalejas	x	x	x					x			x			
60	Casa del Labradillo		x			x					x				
61	Fuente del Labradillo		x			x					x				
62	Mateo		x			x					x				
63	Zauz		x			x					x				
64	El Redondo		x			x					x				
65	Trinchapanetes	x	x			x					x	x			
66	El Rostro														
67	Los Canarios	x	x			x					x	x			
68	El Estrecho	x	x			x					x				
69	Viñuelas		x			x					x				
70	Brezoso	x	x			x					x				x
71	Cuesta del Diablo		x			x					x				
72	Peral east		x			x					x				
73	Peral west		x			x					x				
74	Las Lanchas 1						x	x	x		x				x
75	Las Lanchas 2		x				x	x	x	x					x
76	Las Lanchas 3		x				x	x	x						x
77	Valdeyernos	x	x		x	x					x				
78	Arroyo de la Peña				x	x					x				
79	Patateros				x	x	x	x	x		x	x			
80	La Botija		x		x		x		x	x	x	x			x
81	Arroyo del Chorro 1					x	x				x				
82	Arroyo del Chorro 2		x				x			x					
83	Cuevas del Milano		x		x	x					x				
84	Casa de Vaquerizo		x		x		x	x	x	x					x
85	Garganta del Pusijo		x		x	x	x								
86	Piedraescrita		x	x	x		x		x	x			x		x
87	Cabrahigos				x	x			x						x

During the 20th century there has been a sharp increase in the abundance of ungulate (especially red deer, *Cervus elaphus*) populations in the Mediterranean woodland habitats of central Spain (Acevedo *et al*. 2008). The impacts of ungulates on peatland ecosystem function may be dramatic, but have been poorly quantified in the Toledo Mountains. In fact, ungulate browsing has become one of the main factors constraining seedling performance in many ecosystems (Perea & Gil 2014). Several recent studies have documented negative effects of high densities of ungulates on the abundance and diversity of peatland plants in Cabañeros National Park. This is a 408 km^2 protected area shared by Toledo and Ciudad Real Provinces in south-central Spain, where hunting is not allowed. It has only wild ruminants, domestic ruminants being confined within the surrounding estates (Vaquero 2010). It has been argued that high ungulate densities mediate an impoverishment of habitat quality, decreasing shrub cover and increasing the exposure of peatland ecosystems to further alteration by other mammals. In Cabañeros National Park the densities of red deer are high in both forests and *dehesas* (traditionally managed rangeland) which are precisely the areas where many peatlands are located. Wild boar (*Sus scrofa*) and roe deer (*Capreolus capreolus*) can also be found in the National Park, but at lower densities (Muñoz *et al.* 2009). Most damage by ungulates occurs in summer, when the animals even sleep in peatlands, whereas both red deer and wild boar avoid these ecosystems during the colder weather of autumn, winter and spring. Red deer mainly affect the aerial parts of the peatland plants whereas wild boar disturb the hydrological system by digging into the peatland to access the water table.

Although most studies have neglected other types of ungulate damage such as trampling and rooting, these are the greatest threats posed by the activities of wild boar to peatlands in the Toledo Mountains. This is especially evidenced by the limited distributions of *Pinguicula lusitanica*, *Drosera rotundifolia* and *Narcissus hispanicus*. At Valdeyernos (Site 77, Figure 2e), the status of the first of these species became critical due to habitat alteration by ungulates (trampling, overgrazing) and droughts (Rodríguez-Marzal & Pérez-Carral 2000). Fortunately, its final disappearance was prevented by designation of the area as a microreserve in 2003, and the peatland ecosystem has been gradually recovering since that time. The same reasons can be offered to explain the disappearance of *Myrica gale* from Valdeyernos and Arroyo de la Peña (Site 78), where this species was present in the past but could not be actually located by Caparrós *et al.* (2010), and for the imminent extinction of the same species at Los Casuchones (Site 27).

A case that is particularly worthy of note is that of *Rhynchospora alba*, a hemicryptophyte species of circumboreal distribution which is very rare in the Mediterranean region. In the centre of its worldwide distribution, population sizes are often copious and it may be the dominant species in some acidic bogs. However, its occurrences in the Iberian Peninsula are scattered in the north and north-west and sparse in the Central System, always with very small populations vulnerable to inbreeding and genetic drift (Barrett & Kohn 1991). Its southernmost location is on the Raña Maleta peatland in the province of Ciudad Real (Ladero *et al.* 1997). Interestingly, the areas it can occupy have restricted distribution because it is a shade-intolerant species typical of open areas subject to periodic disturbance. In Cabañeros National Park it occurs on the Fuente de la China peatland (Site 58, over 4000 plants, Figure 2f), where periodic disturbance by wild boar and cattle grazing maintains an open habitat with small herbaceous species that do not compete with *Rhynchospora* (Jiménez 2005). It is also present at Raña del Carrizal (Site 56) but seems to be disappearing (only 80 plants) here. It has been recorded as present since 2010 at Peral east (Site 72), where it was probably not detected in 2009 due to harvesting processes undertaken to promote the growth of two other species, namely *Parnassia palustris* and *Fuirena pubescens*, for which this is the only site within the Cabañeros National Park (Vaquero 2010). *Rhynchospora* was documented at Brezoso (Site 70) in 1993 but not subsequently, and has now been re-introduced. This species occurs on other peatlands in the Toledo Mountains (Table A2), provided that a grazing regime is maintained. A key question is why it is absent from some peatlands in the study area that could be subject to grazing by wild ungulates. The answer probably lies in the historical uses of these wetlands, as the species is present today only on sites that have been constantly grazed by domestic livestock.

Rhynchosporion communities (Habitat 7150) have experienced severe contraction and deterioration of habitat quality during recent decades, and this can be linked to the abandonment of traditional farming activities. Consequently, to ensure the persistence of suitable ecological conditions, the management of these communities has to be considered at two different levels, namely the maintenance of a complex of peaty habitats (mires or wet heaths), and the maintenance of pioneer stands within these habitats. Needless to say, the occurrence *Rhynchospora* is often linked to human land use, and it is quickly replaced by more competitive species such as *Sphagnum* spp., *Erica tetralix* or *Molinia caerulea* in the absence of disturbance. In most cases, communities of the *Rhynchosporion* do not persist for more than ten years in the face of succession processes. The conservation programme for this species carried out in Cabañeros National Park (Jiménez 2005) recommends that seed should be gathered in order to build up a reserve of genetic material, as well as to secure a means for artificial conservation of the species. Furthermore, the propagation of plants *ex situ* will permit the reinforcement of populations.

In some peatlands, large areas of bare peat devoid of vegetation appear, probably due to the activities of ungulates such as wild boar (Sites 1–6, 20, 22, 25, 60, 68, 70, 72) or fire (Sites 24, 33, 37, 65, 67). Sierra del Hontanar (Site 10), Morro de la Parrilla (Site 13), Sierra de la Podadilla (Site 22), Raña del Reguero de la Manca (Site 33) and Boca del Camellar (Site 36) are good examples of peatlands where Habitat 7140 has completely disappeared as a result of drought and factors associated with agricultural drainage. Further examples of degradation can be seen at El Alcornocal and Santorrostrillo (Sites 12 and 45), which are located in a plain and surrounded by fields of cereal crops. These peatlands are frequently used as watering holes by both domestic and wild cattle, and are currently undergoing mineralisation through the transformation of organic nitrogen to inorganic forms (NH_4^+ or NH_3), probably enhanced by agrochemical pollution. Cerro de los Barranquillos and Raña de Navalajarrilla (Sites 11 and 31) provide good examples of the harmful effects of agrochemicals, overgrazing and agricultural drainage resulting in progressive reduction of the peatland area and loss of floristic diversity.

Dehydration causes loss of the *Sphagnum* cover and some species such as *Eleocharis multicaulis*, and increased abundance of other species (*Molinia caerulea*, *Pteridium aquilinum*, *Rubus ulmifolius*, *Erica scoparia*, *E. umbellata*, *Halimium ocymoides*, *Adenocarpus complicatus*). However, the main effect of drying is the reduction of the areas of peatland ecosystems. This is the case for El Alcornocal and Morro de la Parrilla (Sites 12 and 13), whose extent appears to have been reduced to less than half of the original area through the development of peripheral flats of peat mixed with mineral material derived from the surroundings, which lack vegetation (Florín 2012). More damaging is the artificial drainage of some of these ecosystems (Table 3), which can bring about their final demise by converting peatland vegetation to *Agrostis castellana* grassland with *Trifolium repens*, *T. pratense*, *Prunella vulgaris*, *Pteridium aquilinum* and *Parentucellia viscosa*, among other species. Arroyo del Caballo (Site 46), for instance, has been completely desiccated by water abstraction from wells. In some cases (Sites 12, 18, 20, 44, 45, 47, 52), small ponds have been excavated in peatlands to serve as watering holes for livestock; and the consequent soil removal, euthrophication and drying have caused the disappearance of protected species such as *Scirpus fluitans* (Site 43). In Vallejo Huertas Viejas (Site 41) such effects have led to the partial death of willow forest, the replacement of wet heath (except for a single bush of *Erica tetralix*) by *Molinia* meadow, and the complete disappearance of *Sphagnum*. When these threats become severe, the peatland vegetation disappears altogether, as at Boca del Camellar (Site 36).

The disposal of waste, rubbish, carcasses and manure is rare but evident in some peatlands (Table 3), where it alters the chemical regime towards more eutrophic conditions by nitrification (García-Río 2001). The development of infrastructure (paved roads, forest roads, buildings, *etc*.) sometimes causes erosion in peatlands, especially when it involves local deforestation. Disturbance of soil by human activities such as earthworks, rock and peat extraction has also been documented. Afforestation with exotic trees can be very damaging, especially when pine forest invades peatlands and causes severe dehydration, as at Monte Castilnegro and Vallejo Huertas Viejas (Sites 25 and 41). Timber deposited in the peatlands when these forests are felled causes further degradation.

In summary, 36.8% of peatlands in the Toledo Mountains (32 sites, marked with asterisks "*" in Table A1) have been modified by man to a point where they are no longer accumulating peat and are actively decomposing. Unless urgent conservation measures are adopted they are likely to disappear in the near future. Only three of them (Sites 4, 12 and 13) are legally protected as microreserves. Others have already disappeared completely (we were able to confirm at least five cases) and have not been mentioned here.

As expected, the peatlands that are subject to fewest threats (i.e. Sites 8, 9, 16 and 19) are richest in species, especially protected ones. These are the best preserved peatlands of the Toledo Mountains, probably due to their inaccessibility; although, because they are situated on steep slopes, climate change is now causing progressive drying, reducing the cover of *Sphagnum* moss. For example, Barranco de Riofrío (Site 16) hosts one of largest *Myrica gale* populations in the Iberian Peninsula. Barranco del Remilladero (Site 7) could be similar, but had reached a delicate situation in which it came close to disappearing due to a combination of ungulate pressure, agriculture, logging and planting of exotic trees. It has now been fenced, is regenerating well, and has already regained substantial floristic richness.

In short, although nature protection activities in the Cabañeros National Park have ensured the preservation of its peatlands, these ecosystems are still subject to high risks from ungulate pressure and climate change.

CONCLUSIONS

Mediterranean ecosystems are among the 25 biodiversity hotspots of the world (Myers *et al.* 2000). Mediterraean peatlands are protected under the EU Habitats Directive because they maintain high levels of plant and animal diversity and examples of many Annex I habitats. Despite the relatively small surface area they occupy in the western Mediterranean basin, the Toledo Mountains peatlands host a significant part of the region's endangered flora. However, the conservation of these mid-altitude mountain peatlands is not sustainable in the long term due to the chronic lack of regeneration in vegetation that is heavily disturbed by agriculture and overgrazing.

Among the peatlands studied here we should highlight Raña Maleta, which is the southernmost ombrotrophic peatland in Europe, with the added interest of its low altitude. Such ecosystems are typical of areas with high rainfall and low evaporation in the north of the Iberian Peninsula, but in central Spain they have a relict edge-of-range character. Unfortunately, like many other habitats in the territory and despite its protection as a microreserve, the current management of this unique ecosystem means that it is subject to strong pressure from livestock which is incompatible with its long-term conservation.

We are just beginning to gain an understanding of plant biodiversity in the peatlands of the Toledo Mountains. Our peatland characterisation forms a solid foundation for the incorporation of data from much-needed inventories and biodiversity assessments, and resource managers will use these data in their day-to-day work of developing management priorities and conservation programmes. However, biodiversity conservation must not depend solely on protected natural areas. In the Toledo Mountains, some agricultural, grazing and forestry activities have not been regulated or banned because they support the livelihoods of people. A key requirement for the protection of peatlands is that sustainable development of these areas should be viewed in a broad and complex context; meaning that we must consider its social, economic, environmental, cultural, institutional and governmental dimensions, as well as their interactions. In fact, traditionally managed agricultural and farming systems and forests are keystones for peatland conservation outside natural protected areas.

Many studies have suggested that the factors determining the diversity of peatlands vary according to their different landscape contexts and environmental histories. The next step in our research will be a multi-proxy palaeoenvironmental study of these peatland ecosystems, in order to assess the roles of anthropic factors and climate dynamics in the evolution of their vegetation. So far, only two of the Toledo Mountains peatlands (Valdeyernos and Patateros) have been studied from a palynological viewpoint (Dorado-Valiño *et al.* 2014a, 2014b).

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Appendix

Table A1. Some key characteristics of the study sites. **Province**: CR= Ciudad Real; TO = Toledo. Type by **Location**: R = associated with the contact between bedrock and *raña* (alluvium); B = located in ravines carved into the *raña*; S = hillsides of Palaeozoic mountains), V = valley bottoms of Palaeozoic mountains. Type by predominant perceived **Nutrients** source: M = minerotrophic; O = ombrotrophic. **Hydrological system**: S = soligenous; T = topogenous. **Protection**: NP = National Park; MR= Microreserve; RR = River reserve. **SCI** = Site of Community Importance. An asterisk (*) after the name of the peatland indicates that it is no longer accumulating peat.

No.	Peatland	Municipality	Province	UTM X-east	UTM Y-north	Altitude (m a.s.l.)	Area (ha)	Location	Nutrients	Hydrology	Protection	Year	SCI
1	Raña del Aulagar	Puebla de Don Rodrigo	CR	351159	4328593	625	15.34	R	M	T	MR	2002	Yes
2	Raña Maleta	Puebla de Don Rodrigo	CR	351726	4328594	613	14.46	R	M - O	T	MR	2002	Yes
3	Horcajillas de los Baturros	Puebla de Don Rodrigo	CR	352015	4328194	623	8.88	R	M	T	MR	2002	Yes
4	Fuente del Tío Chasco*	Puebla de Don Rodrigo	CR	353146	4328236	588	2.37	B	M	S	MR	2002	Yes
5	Los Jareros	Puebla de Don Rodrigo	CR	353067	4327598	627	11.92	R	M	T	MR	2002	Yes
6	Raña de los Terreros	Puebla de Don Rodrigo	CR	353759	4327605	617	10.62	B	M	T	MR	2002	Yes
7	Barranco del Remilladero	Puebla de Don Rodrigo	CR	348842	4334860	597	31.58	B	M	S	MR	2003	Yes
8	Barranco de los Membrillos	Puebla de Don Rodrigo	CR	345483	4334083	661	6.89	B	M	S	MR	2003	Yes
9	Barranco del Chorro	Puebla de Don Rodrigo	CR	364080	4330426	688	17.63	S	M	S	MR	2002	Yes
10	Sierra del Hontanar	Arroba de los Montes	CR	370212	4336383	672	5.61	S	M	S	MR	2003	Yes
11	Cerro de los Barranquillos	Fontanarejo	CR	374724	4339457	730	10.46	S	M	S	MR	2002	Yes
12	El Alcornocal*	Piedrabuena	CR	377239	4338956	714	13.04	R	M	T	MR	2003	Yes
13	Morro de la Parrilla*	Piedrabuena	CR	378742	4334048	699	5.11	R	M	S	MR	2002	Yes
14	Arroyo de Valdelamadera	Piedrabuena	CR	389672	4321370	608	22.32	V	M	S	MR	2002	Yes
15	Arroyo de Valdelapedriza	Piedrabuena	CR	377123	4324707	620	113.56	V	M	S	RR	2003	Yes
16	Barranco de Riofrío	Saceruela	CR	369112	4316614	631	16.77	V	M	S	MR	2003	Yes
17	Barranco de Zalzalagorda	Piedrabuena	CR	386157	4327732	627	9.12	V	M	S	MR	2003	No
18	Sierra de la Virgencita*	Saceruela	CR	366465	4311397	680	1.11	V	M	S	–	–	No
19	Sierra Larga	Piedrabuena	CR	376602	4325693	640	0.42	S	M	S	–	–	No
20	Sierra de Puerto Quemado*	Puebla de Don Rodrigo	CR	370683	4326739	630	0.27	S	M	S	–	–	No
21	Cerro de los Polvos*	Puebla de Don Rodrigo	CR	342448	4338238	680	0.56	S	M	S	–	–	No
22	Sierra de la Podadilla*	Puebla de Don Rodrigo	CR	369762	4329401	650	0.63	S	M	S	–	–	No
23	Collado del Pocito*	Puebla de Don Rodrigo	CR	365525	4328774	580	0.02	S	M	S	–	–	No

No.	Peatland	Municipality	Province	UTM X-east	UTM Y-north	Altitude (m a.s.l.)	Area (ha)	Location	Nutrients	Hydrology	Protection	Year	SCI
24	Raso del Portijuelo*	Arroba de los Montes	CR	369445	4333599	670	0.45	S	M	S	–	–	No
25	Monte Castilnegro*	Puebla de Don Rodrigo	CR	369029	4319609	560	0.91	S	M	S	–	–	No
26	Valle de la Viuda*	Piedrabuena	CR	381803	4327616	650	0.02	V	M	S	–	–	No
27	Los Casuchones*	Puebla de Don Rodrigo	CR	371408	4326394	620	0.90	V	M	S	–	–	No
28	Arroyo del Gargantón*	Piedrabuena	CR	388488	4325208	620	0.02	V	M	S	–	–	No
29	Arroyo del Puerto	Fontanarejo	CR	370290	4344777	680	0.05	V	M	S	–	–	No
30	Mechocamino*	Alcoba	CR	375406	4344479	677	3.78	R	M	S	–	–	No
31	Raña de Navalajarrilla*	Alcoba	CR	379860	4343542	656	0.18	R	M	S	–	–	No
32	La Canaleja*	Alcoba	CR	377022	4344225	668	0.69	R	M	S	–	–	No
33	Raña del Reguero de la Manca*	Piedrabuena	CR	377786	4331473	667	4.07	R	M	S	–	–	No
34	Cerro Montón de Trigo	Piedrabuena	CR	387720	4332957	628	0.36	R	M	S	–	–	No
35	Casas de El Gargantón*	Piedrabuena	CR	389476	4325262	600	0.21	R	M	S	–	–	No
36	Boca del Camellar*	El Robledo	CR	385232	4335421	651	0.81	R	M	S	–	–	No
37	Barranco de El Espinar*	Puebla de Don Rodrigo	CR	349725	4336290	576	2.47	B	M	S	–	–	No
38	Sierra Gorda	Valdemanco de Esteras	CR	357789	4324218	580	1.93	R	M	S	–	–	No
39	Boca de los Carriles*	El Robledo	CR	388102	4335131	590	0.31	R	M	S	–	–	No
40	El Perro*	Puebla de Don Rodrigo	CR	348110	4325379	690	3.74	B	M	S	–	–	No
41	Vallejo Huertas Viejas*	Saceruela	CR	368941	4319759	580	0.09	V	M	S	–	–	No
42	Fuente de las Saceas*	Saceruela	CR	360120	4320294	590	0.33	R	M	S	–	–	No
43	La Chaparrera*	Saceruela	CR	358588	4321880	630	7.21	R	M	T	–	–	No
44	Fuente de la Chaparrera*	Saceruela	CR	357850	4321191	620	0.44	R	M	T	–	–	No
45	Santorrostrillo*	Valdemanco de Esteras	CR	348025	4314112	590	1.97	R	M	T	–	–	No
46	Arroyo del Caballo*	Saceruela	CR	361561	4321576	624	0.41	R	M	S	–	–	No
47	Sierra de la Media Luna*	Agudo	CR	344098	4324836	655	0.78	R	M	T	–	–	No
48	Tejoneras*	Saceruela	CR	360556	4319600	599	0.67	R	M	S	–	–	No
49	Cerro del Oso 1	Agudo	CR	351278	4321096	624	1.21	V	M	S	–	–	No
50	Cerro del Oso 2	Agudo	CR	351027	4321291	613	0.98	V	M	S	–	–	No
51	Cerro del Oso 3	Agudo	CR	350793	4321684	615	2.31	V	M	S	–	–	No
52	Valle de los Ricos*	Agudo	CR	351044	4320147	597	0.41	V	M	S	–	–	No
53	Barranco de la Teja*	Agudo	CR	347047	4321709	600	0.22	B	M	S	–	–	No
54	Torre de Abraham	Retuerta del Bullaque	CR	393382	4359506	800	0.02	V	M	S	–	–	No
55	Bermú	Retuerta del Bullaque	CR	401372	4365576	783	0.05	R	M	T	–	–	No

No.	Peatland	Municipality	Province	UTM X-east	UTM Y-north	Altitude (m a.s.l.)	Area (ha)	Location	Nutrients	Hydrology	Protection	Year	SCI
56	Raña del Carrizal	Retuerta del Bullaque	CR	374554	4367593	790	0.22	R	M	T	–	–	No
57	La Ventilla	Retuerta del Bullaque	CR	389254	4356028	655	0.68	V	M	T	NP	2005	Yes
58	Fuente de la China	Navas de Estena	CR	366935	4374257	656	0.55	V	M	S	NP	2005	Yes
59	Canalejas	Alcoba de los Montes	CR	377385	4357699	785	0.91	S	M	S	NP	2005	Yes
60	Casa del Labradillo	Alcoba de los Montes	CR	372183	4356016	706	0.39	B	M	S	NP	2005	Yes
61	Fuente del Labradillo	Alcoba de los Montes	CR	371684	435609	719	0.27	B	M	S	NP	2005	Yes
62	Mateo	Alcoba de los Montes	CR	373217	4356725	707	0.07	S	M	S	NP	2005	Yes
63	Zauz	Alcoba de los Montes	CR	373589	4357321	712	0.25	S	M	S	NP	2005	Yes
64	El Redondo	Alcoba de los Montes	CR	372539	4358122	736	0.78	S	M	S	NP	2005	Yes
65	Trinchapanetes	Alcoba de los Montes	CR	371664	4360224	798	0.22	V	M	S	NP	2005	Yes
66	El Rostro	Alcoba de los Montes	CR	377805	4352033	642	0.46	R	M	S	NP	2005	Yes
67	Los Canarios	Alcoba de los Montes	CR	370493	4360331	813	0.02	V	M	S	NP	2005	Yes
68	El Estrecho	Alcoba de los Montes	CR	370597	4354780	727	0.03	R	M	S	NP	2005	Yes
69	Viñuelas	Alcoba de los Montes	CR	371800	4359387	761	0.02	V	M	S	NP	2005	Yes
70	Brezoso	Alcoba de los Montes	CR	382723	4356399	733	10.62	B	M - O	S	NP	2005	Yes
71	Cuesta del Diablo	Alcoba de los Montes	CR	372555	4359043	756	0.07	S	M	S	NP	2005	Yes
72	Peral east	Alcoba de los Montes	CR	381105	4356346	749	7.31	B	M - O	S	NP	2005	Yes
73	Peral west	Alcoba de los Montes	CR	380855	4356320	745	3.47	B	M - O	S	NP	2005	Yes
74	Las Lanchas 1	Robledo del Mazo	TO	337325	4383497	800	0.18	S	M	S	MR	2003	Yes
75	Las Lanchas 2	Robledo del Mazo	TO	337526	4383997	774	0.07	S	M	S	MR	2003	Yes
76	Las Lanchas 3	Robledo del Mazo	TO	337589	4384229	766	0.02	S	M	S	MR	2003	Yes
77	Valdeyernos	Los Yébenes	TO	405685	4366696	929	3.93	V	M	S	MR	2003	Yes
78	Arroyo de la Peña	Los Yébenes	TO	408825	4358798	808	0.14	V	M	S	–	–	No
79	Patateros	Los Navalucillos	TO	358877	4384433	782	0.15	V	M	S	–	–	No
80	La Botija	Los Navalucillos	TO	354832	4384969	755	0.07	S	M	S	–	–	No
81	Arroyo del Chorro 1	Los Navalucillos	TO	357669	4381351	772	0.08	S	M	S	NP	2005	Yes
82	Arroyo del Chorro 2	Los Navalucillos	TO	358344	4379424	872	0.10	S	M	S	NP	2005	Yes
83	Cuevas del Milano	Hontanar	TO	371799	4380435	1025	2.78	S	M	S	–	–	No
84	Casa de Vaquerizo	Los Navalucillos	TO	364160	4386126	858	0.21	S	M	S	–	–	No
85	Garganta del Pusijo	Robledo del Mazo	TO	341477	4380611	915	0.08	S	M	S	–	–	No
86	Piedraescrita	Robledo del Mazo	TO	346346	4378137	885	0.02	S	M	S	–	–	No
87	Cabrahigos	San Pablo de los Montes	TO	378576	4374826	949	0.65	S	M	S	–	–	No

Table A2. Endangered plant species of Toledo Mountains peatlands included in the Regional Catalogue of Protected Species of Castilla-La Mancha: Am (*Acer monspessulanum*), Ag (*Alnus glutinosa*), Af (*Athyrium felix-femina*), Bp (*Betula pendula*), Ce (*Carex echinata*), Cp (*Cistus psilosepalus*), De (*Dactylorhiza elata* subsp. *sesquipedalis*), Dr (*Drosera rotundifolia*), Em (*Eleocharis multicaulis*), El (*Erica lusitanica*), Et (*Erica tetralix*), Fp (*Fuirena pubescens*), Ga (*Genista anglica*), Gt (*Genista tinctoria*), He (*Hypericum elodes*), Ia (*Ilex aquifolium*), Ih (*Isoetes histrix*), Lu (*Lobelia urens*), Mg (*Myrica gale*), Nh (*Narcissus hispanicus*), Nl (*Nuphar luteum*), Oa (*Ophioglossum azoricum*), Or (*Osmunda regalis*), Pp (*Parnassia palustris*), Pl (*Pinguicula lusitanica*), Pt (*Prunus lusitanica*), Pc (*Pyrus communis*), Ra (*Rhynchospora alba*), Sr (*Scilla ramburei*), Sf (*Scirpus fluitans*), Se (*Sibthorpia europaea*), Sc (*Serapias cordigera*), Sa (*Sorbus aria*), Sd (*Sorbus domestica*), Spc (*Sphagnum capillifolium*), Spd (*Sphagnum denticulatum*), Spn (*Sphagnum nemoreum*), Spp (*Sphagnum palustre*), Spl (*Sphagnum papillosum*), Sps (*Sphagnum subnitens*), Spu (*Sphagnum subsecundum*), Ss (*Spiranthes aestivalis*), Tb (*Taxus baccata*), Ua (*Utricularia australis*).

No.	**Peatland**	*Am*	*Ag*	*Af*	*Bp*	*Ce*	*Cp*	*De*	*Dr*	*Em*	*El*	*Et*	*Fp*	*Ga*	*Gt*	*He*	*Ia*	*Ih*	*Lu*	*Mg*	*Nh*	*Nl*	*Oz*	*Or*	*Pp*	*Pl*	*Pt*	*Pc*	*Ra*	*Sr*	*Sf*	*Se*	*Sc*	*Sa*	*Sd*	*Spc*	*Spd*	*Spn*	*Spp*	*Spl*	*Sps*	*Spu*	*Ss*	*Tb*	*Ua*
1	Raña del Aulagar								x	x																											x								
2	Raña Maleta					x		x	x	x		x		x		x		x	x	x			x			x			x	x	x		x			x	x	x	x	x	x				
3	Horcajillas de los Baturros								x	x																			x								x								
4	Fuente del Tío Chasco								x	x																											x								
5	Los Jareros					x			x	x																			x								x								
6	Raña de los Terreros								x	x																			x								x								
7	Barranco del Remilladero				x				x			x		x																							x	x	x						
8	Barranco de los Membrillos				x	x		x	x	x	x	x		x					x							x			x								x	x	x						
9	Barranco del Chorro				x			x	x	x	x	x		x					x	x				x		x							x				x	x	x						
10	Sierra del Hontanar					x				x		x		x		x			x							x			x			x					x				x				
11	Cerro de los Barranquillos				x	x		x	x	x	x	x		x					x	x						x			x								x		x						
12	El Alcornocal					x		x	x	x		x		x	x	x			x							x				x							x								
13	Morro de la Parrilla											x		x																															
14	Arroyo de Valdelamadera								x		x	x		x		x			x	x	x																x	x	x	x					
15	Arroyo de Valdelapedriza				x	x			x	x	x	x		x		x			x	x	x																x	x	x	x	x				
16	Barranco de Riofrío				x			x		x		x		x		x			x	x	x											x				x	x	x			x				
17	Barranco de Zalzalagorda					x			x		x	x		x					x	x						x										x	x	x			x				
18	Sierra de la Virgencita									x		x		x					x																		x								
19	Sierra Larga				x				x			x				x				x																	x								
20	Sierra de Puerto Quemado				x	x					x	x				x				x												x					x								
21	Cerro de los Polvos									x									x							x			x								x								
22	Sierra de la Podadilla										x																																		
23	Collado del Pocito											x				x																													
24	Raso del Portijuelo									x		x		x		x			x																										

No.	**Peatland**	*Am*	*Ag*	*Af*	*Bp*	*Ce*	*Cp*	*De*	*Dr*	*Em*	*El*	*Et*	*Fp*	*Ga*	*Gt*	*He*	*Ia*	*Ih*	*Lu*	*Mg*	*Nh*	*Nl*	*Oz*	*Or*	*Pp*	*Pl*	*Pt*	*Pc*	*Ra*	*Sr*	*Sf*	*Se*	*Sc*	*Sa*	*Sd*	*Spc*	*Spd*	*Spn*	*Spp*	*Spl*	*Sps*	*Spu*	*Ss*	*Tb*	*Ua*
25	Monte Castilnegro											x																																	
26	Valle de la Viuda											x								x									x								x								
27	Los Casuchones										x	x				x				x												x													
28	Arroyo del Gargantón					x				x						x			x													x													
29	Arroyo del Puerto											x				x																													
30	Mechocamino								x	x	x	x				x			x																		x								
31	Raña de Navalajarrilla							x											x																										
32	La Canaleja					x				x		x		x		x																					x								
33	Raña del Reguero de la Manca													x																							x								
34	Cerro Montón de Trigo											x		x																															
35	Casas de El Gargantón							x			x	x		x																															
36	Boca del Camellar																																												
37	Barranco de El Espinar											x		x		x																					x								
38	Sierra Gorda									x		x		x		x			x	x																	x								
39	Boca de los Carriles							x				x		x																		x					x								
40	El Perro																																												
41	Vallejo Huertas Viejas										x	x																																	
42	Fuente de las Saceas					x			x	x		x		x					x																		x								
43	La Chaparrera							x		x		x		x	x															x															
44	Fuente de la Chaparrera											x		x																							x								
45	Santorrostrillo									x		x		x	x	x								x								x													
46	Arroyo del Caballo											x		x		x								x																					
47	Sierra de la Media Luna							x		x		x		x							x					x							x				x								
48	Tejoneras									x		x				x										x																			
49	Cerro del Oso 1							x	x	x		x		x												x							x				x								
50	Cerro del Oso 2							x	x	x		x		x												x							x				x								
51	Cerro del Oso 3							x	x	x		x		x												x							x				x								
52	Valle de los Ricos											x		x		x															x						x								
53	Barranco de la Teja											x		x																															
54	Torre de Abraham					x	x		x			x		x	x				x	x	x					x						x					x					x			
55	Bermú							x	x			x							x																		x								
56	Raña del Carrizal									x		x		x		x			x										x								x		x						

No.	**Peatland**	*Am*	*Ag*	*Af*	*Bp*	*Ce*	*Cp*	*De*	*Dr*	*Em*	*El*	*Et*	*Fp*	*Ga*	*Gt*	*He*	*Ia*	*Ih*	*Lu*	*Mg*	*Nh*	*Nl*	*Oz*	*Or*	*Pp*	*Pl*	*Pt*	*Pc*	*Ra*	*Sr*	*Sf*	*Se*	*Sc*	*Sa*	*Sd*	*Spc*	*Spd*	*Spn*	*Spp*	*Spl*	*Sps*	*Spu*	*Ss*	*Tb*	*Ua*
57	La Ventilla			x					x		x	x					x						x															x	x	x						
58	Fuente de la China					x		x	x	x	x	x		x		x			x											x	x									x		x	x	x			
59	Canalejas									x		x		x						x					x				x									x								
60	Casa del Labradillo									x		x		x	x	x																x							x		x		x			
61	Fuente del Labradillo					x		x	x	x	x	x		x		x													x		x							x		x	x	x			
62	Mateo					x			x	x	x	x		x		x																x							x		x	x				
63	Zauz					x		x		x		x																			x							x		x	x	x			
64	El Redondo					x				x		x		x																			x							x		x		x			
65	Trinchapanetes											x																			x							x		x					
66	El Rostro							x	x	x	x	x		x		x																x							x		x	x	x			
67	Los Canarios											x																											x					
68	El Estrecho					x				x		x				x													x		x							x		x	x				
69	Viñuelas					x						x																			x							x		x					
70	Brezoso					x		x	x	x	x	x		x	x	x			x	x	x					x			x			x					x		x	x	x				x
71	Cuesta del Diablo					x				x		x				x													x		x							x		x		x			
72	Peral east					x		x	x	x		x	x	x		x				x						x	x			x			x				x	x		x		x			
73	Peral west							x	x	x		x		x		x			x							x						x							x		x		x			
74	Las Lanchas 1	x						x	x		x	x		x					x					x		x						x							x		x		x			
75	Las Lanchas 2				x				x		x	x					x		x					x			x					x			x		x				x			x	
76	Las Lanchas 3	x			x			x	x		x	x					x		x					x		x	x					x							x				x			
77	Valdeyernos				x				x			x		x					x							x						x							x						x		
78	Arroyo de la Peña								x			x		x					x													x							x							
79	Patateros								x			x		x					x							x						x							x		x					
80	La Botija							x	x			x		x					x							x															x					
81	Arroyo del Chorro 1		x	x	x				x			x		x			x		x	x				x		x				x		x		x	x			x	x					x	
82	Arroyo del Chorro 2			x	x			x	x		x	x		x			x		x				x		x				x		x						x							x	
83	Cuevas del Milano							x	x		x	x		x					x							x											x								
84	Casa de Vaquerizo								x			x		x					x							x											x								
85	Garganta del Pusijo							x	x			x		x					x							x																	x			
86	Piedraescrita								x			x		x					x							x						x							x								
87	Cabrahigos							x	x			x		x					x																			x								