Peatlands of the Mediterranean Region

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Richard Payne

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Abstract

The generally arid climate of the Mediterranean region means that peatlands are typically small and scattered but these sites should not be overlooked. Peatlands are present in the vast majority of Mediterranean countries and make a disproportionately large contribution to regional biodiversity with endemic species recorded for several sites. These peatlands are often poorly documented and increasingly threatened by human activity, in particular the increasing need for agricultural land and water resources. The vast majority of sites are disturbed or destroyed but relatively natural sites do remain, particularly in mountainous regions. A greater focus on the important biodiversity and ecosystem service benefits of Mediterranean peatlands is needed, particularly in countries outside Europe.

Keywords

Agriculture · Europe · Levant · Mire · North Africa · Peatland · Wetland

R. Payne (✉)
Environment, University of York, Heslington, York, UK
e-mail: richard.payne@york.ac.uk

C. M. Finlayson et al. (eds.), *The Wetland Book*,
https://doi.org/10.1007/978-94-007-4001-3_111

Peatland Types, Occurrence, and Distribution

The Mediterranean drainage basin encompasses a large area of southern Europe, western Asia, and northern Africa. Climate in the region is variable but mostly warm and dry with mild, damp winters and hot dry summers. Cooler and wetter regions occur through the mountains of the Alps, Pyrenees, and Balkans and hotter drier regions across North Africa (Fig. 1). Despite this generally arid climate peatlands of some type are present in most countries of the region.

In the western European Mediterranean countries (France, Italy, Spain) there are many peatlands, although the majority are in areas which drain to the Atlantic rather than Mediterranean. Peatlands are present, and in some areas relatively abundant in the Pyrenees, Alps, Jura, and Apennine mountains (Table 1). In the Balkans peatlands are present but scattered, most are fens located particularly at high altitudes in upland regions although ombrotrophic bogs are recorded in at least Slovenia. Peatlands are present in Turkey including lowland and upland fens and one ombrotrophic bog. In the Levant, important sites include the extensive (drained/restored) Hula peatland in Israel and the Aammiq wetland in Lebanon (Table 2). There are extensive wetlands including areas referred to as peatlands (much now drained) in Egypt's Nile Delta. Through North Africa there are scattered peatlands, particularly in the mountains of Morocco, Algeria, and possibly Tunisia, although literature is extremely sparse. There are peatlands of various types on many of the larger Mediterranean islands including Corsica, Crete, and Cyprus (Tables 1 and 2).

The region is large and diverse; the peatlands are shaped by their local environment (physical, biogeographical, and human) which makes generalization difficult, particularly as most scientists can only be personally familiar with a small proportion of the area and the published literature is sparse. However, in general terms the peatlands can be grouped as:

(a) Intramontane basin fens. These peatlands are the largest in the region, often with very deep peats. Minerotrophic peats, often intercalating with lake sediments, have accumulated over long periods of time in basins which receive water supply from the surrounding land but have restricted, or no, outflow. Vegetation typically comprises reeds and sedges, often with extensive *Phragmites australis*. Examples are found in many countries, for instance, the Hula peatland in Israel (Fig. 2) or Philippi peatland in Greece. These sites are now generally damaged or destroyed with a large proportion drained for agriculture.
(b) Coastal peatlands. These peatlands are in low-lying coastal regions where peats have accumulated in estuaries or deltas, often with marine influence. Such sites are less frequent but sometimes extensive, for instance, in the Nile Delta. Vegetation generally comprises species such as *Phragmites australis, Typha domingensis*, and *Cyperus papyrus*. Many of these sites have been drained.
(c) Upland fens. These peatlands are in mountainous regions with water supply from springs or streams, often forming in areas with impeded drainage (Fig. 3). Such sites occur in all but the most arid mountain ranges and are perhaps the most

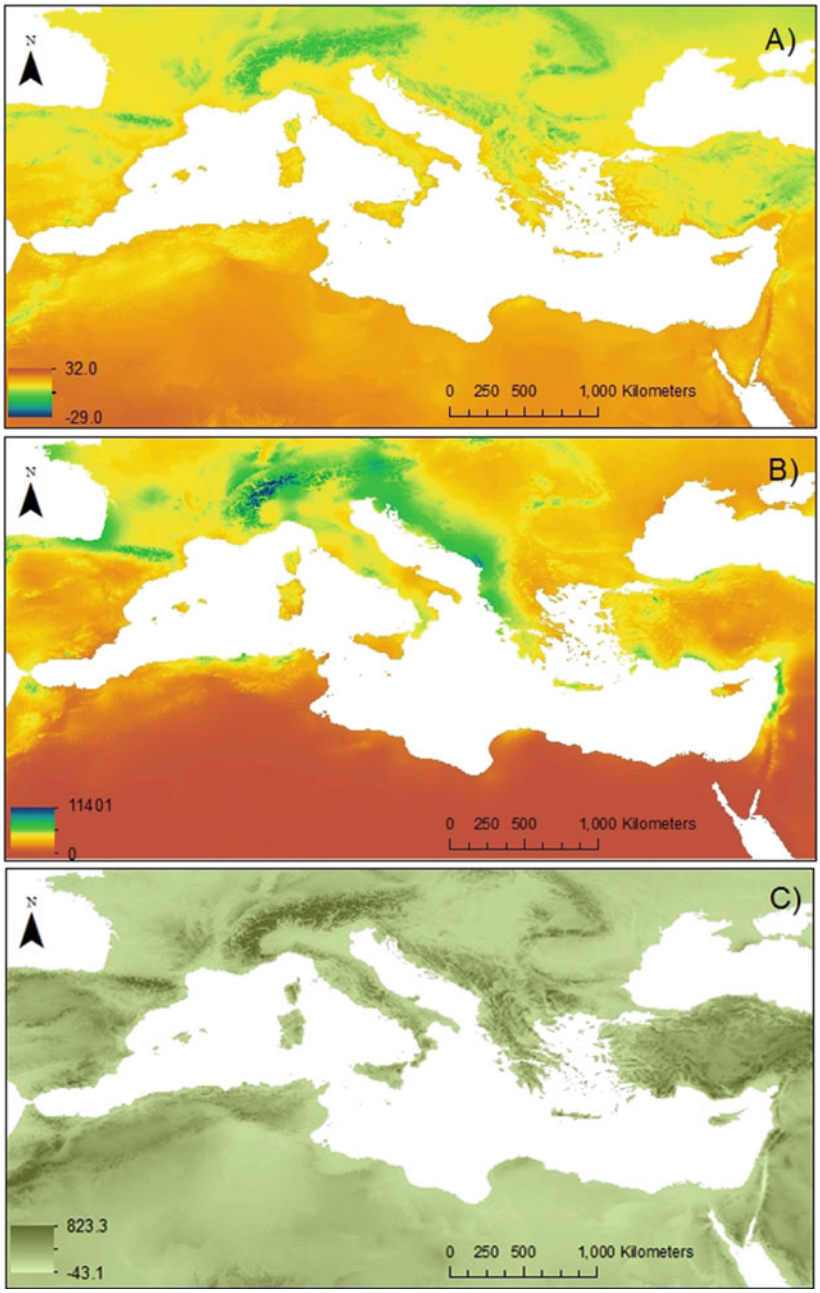

Fig. 1 Climate and physical geography of the Mediterranean basin – (**a**) temperature (°C), (**b**) Precipitation (mm), (**c**) Altitude (m). Interpolated data from the WorldClim database (Hijmans et al. 2005) produced by the author

Table 1 Peatlands in European countries directly bordering Mediterranean Sea (excluding Black Sea) (Turkey and Cyprus listed in Table 2)

Country/territory	Peatlands
Albania	European Soil Database peat area: 44 km^2, Map of organic C content, >25%: 0 km^2 (Montanarella et al. 2006) Fen plant communities recognized in national phytosociology (Dring et al. 2002) Peatland total area <100 km^2 including peatlands at Cukë, Xavë, and Malig (Lappalainen and Żurek 1996)
Bosnia and Herzegovina	European Soil Database peat area: 170 km^2, Map of organic C content, >25%: 32 km^2 (Montanarella et al. 2006) Peatland area 190 km^2 (Lappalainen and Żurek 1996) Minerotrophic peatlands in alpine and subalpine zones (Sulejman 2011)
Croatia	European Soil Database peat area: 41 km^2, Map of organic C content, >25%: 0 km^2 (Montanarella et al. 2006) Selected significant sites: Blatuša fen (1,000 ha), fen at Dubravica village, mires in the Gorski kotar region (Wetlands International 2006)
France	European Soil Database peat area: 3,157 km^2, Map of organic C content, >25%: 775 km^2 (Montanarella et al. 2006) National estimates of peatland area vary from 550 to 1,200 km^2 (Lappalainen and Żurek 1996) Peatlands are relatively widespread but much of the area is in northern France draining to the Atlantic not Mediterranean. Peatlands occur in the mountains of the Massif Central, Jura, Vosges, Pyrenees, and southern Alps (Francez et al. 1992; Muller, personal communication 2012). Fewer lowland peatlands such as Marais de Lavours in the Rhone Valley. Upland fens (Pozzine) occur in the mountains of Corsica (Gamisans and Marzocchi 1996). National mapping project currently underway
Gibraltar	None
Greece	European Soil Database peat area: 554 km^2, Map of organic C content, >25%: 0 km^2 (Montanarella et al. 2006) Peatland area 101 km^2 (Lappalainen and Żurek 1996) Peatlands mostly fens in intra-montane basins such as Phillipi, Koroni, Nissi, and Kalodiki (Botis et al. 1993), now mostly drained (Christanis 1996). Small transitional mires with *Sphagnum* occur near Bulgarian border (Papazisimou et al. 2002)
Italy	European Soil Database peat area: 292 km^2, Map of organic C content, >25%: 1 km^2 (Montanarella et al. 2006) Peatland area 300–1,200 km^2. Ombrotrophic peatlands including *Sphagnum* in upland areas, particularly in north (Lombardy, Piedmont, Veneto), valley, and coastal mires further south (Lappalainen and Żurek 1996)
Malta	None known (V. Gauci, personal communication 2012) European Soil Database peat area: 0 km^2, Map of organic C content, >25%: 0 km^2 (Montanarella et al. 2006)
Monaco	None European Soil Database peat area: 0 km^2, Map of organic C content, >25%: 0 km^2 (Montanarella et al. 2006)
Montenegro	European Soil Database peat area: 110 km^2, Map of organic C content, >25%: 0 km^2, figures for Yugoslavia as of 2006 including Montenegro, Kosovo, and Serbia (Montanarella et al. 2006)

(*continued*)

Table 1 (continued)

Country/territory	Peatlands
	Serbia and Montenegro: valley mires and lacustrine peatlands with herbs dominant, small montaine sloping mires, ombrotrophic *Sphagnum* peatlands rare (Wetlands International 2006) In all of the former Yugoslavia: 1,000 km^2, 300 Mt (Wetlands International 2006)
Slovenia	European Soil Database peat area: 78 km^2, Map of organic C content, >25%: 0 km^2 (Montanarella et al. 2006) Many peatlands in Julian Alps including ombrotrophic bogs, often forested, for instance, Pokljuka plateau (Kutnar and Martinčič 2003; Kutnar 2000) Bogs at Pohorje, fens at Bloška Planota (Beltram 2007)
Spain	European Soil Database peat area: 360 km^2, Map of organic C content, >25%: 184 km^2 (Montanarella et al. 2006) Peatland area 385 km^2 (Lappalainen and Żurek 1996) One important site is the Padul peatland (Granada) – a basin fen, which has a history of around 400 ka (Ortiz et al. 2004) Many blanket bogs and other peatlands occur in Galicia and northern Spain more generally (Martinez Cortizas and Garcia-Rodeja Gayoso 2001; Martinez Cortizas 2009a) but much of this area is in the Atlantic not the Mediterranean drainage basin. Transition mires and raised bogs occur in northern and central Spain (Martinez Cortizas 2009b, c). Small montane minerotrophic peatlands are found in the Sierra Nevada (Jiménez-Moreno and Anderson 2012). One coastal Ramsar Site includes peatland – Prat de Cabanes (Martinez Cortizas 2009d)

numerous type of peatlands in the region. Vegetation typically includes species of *Carex* and *Juncus;* in the most oligotrophic sites species of *Sphagnum* also occur. Examples include the Pozzines of Corsica and small mires in the Troodos Mountains of Cyprus (Christanis et al. 2008) and White Mountains of Crete (Atherden and Hall 1999). Such sites are often in less accessible areas and have consequently escaped human impacts to a greater extent than lowland fens.

(d) Ombrotrophic bogs. These sites are much the rarest type of peatland in the region. Sites are comparatively few and always situated at moderate to high altitude in regions with higher rainfall. Examples are found in the Alps, Pyrenees, and Soğanlı Dağ Mountains of northeast Turkey. Vegetation is *Sphagnum* dominated, and sites are in many ways similar to northern European bogs.

Biodiversity and Ecosystem Services

In contrast to other regions of the world, the peatlands of the Mediterranean are often small and frequently widely separated, essentially forming wetland islands in a generally arid landscape. Perhaps due to this disparate nature the sites include many endemic species. Some species only found in a single site include the grass *Poa asiae-minoris* in a Turkish mire (e.g., Scholz and Byfield 2000), the fish

Table 2 Details of peatlands in countries and territories of Africa and Asia bordering the Mediterranean Sea. Data is from the IMCG global peatlands database (Joosten 2004) with the exception of entries shown in italics. The literature referred to is often fragmentary, old, or secondary and for many regions should be treated with considerable caution

Country/ territory	Details of peatlands (and other wetlands and organic soils)
Algeria	290 km^2 freshwater marshes (Britton and Crivelli 1993) Peatlands in Atlas Mountains (Schokalskaja 1953) Peatlands may include Mekhada Marsh (Lappalainen and Żurek 1996) Possible peatlands in coastal regions (Schneider and Schneider 1990) No histosols. 193 km^2 gley soils (Van Engelen and Huting 2002)
Ceuta	None known
Cyprus	No histosols or gley soils (Van Engelen and Huting 2002) *Pashia Livadi and Almyrolivado* Juncus-*dominated small mires in Troodos Mountains* (Christanis et al. 2008) *Fassouri* Phragmites-*dominated wetland with saline peat*
Egypt	"Peatlands" in Nile Delta and adjacent to Red Sea (Markov et al. 1988) Manzala "peatland" 540 km^2, Burulus "peatland" 170 km^2 No histosols. 11,080 km^2 gley soils (Van Engelen and Huting 2002)
Gaza	None known No histosols or gley soils (Van Engelen and Huting 2002)
Israel	*Most significant peatland is the Hula wetland in northern Israel. Peatland drained in 1950s and now consists of oxidized drained peats, an area of mostly recently developed peats and a recent restoration project* (Payne and Gophen 2012 et seq.) Possible peatlands in Wadi Kubani, Wadi Faliq, Zevulun Valley, and Ain Arus *although some of these seem unlikely to still exist* 50 km^2 peatlands (Moore and Bellamy 1974) 48 km^2 wetlands (Lappalainen and Żurek 1996) No histosols. 93 km^2 gley soils (Van Engelen and Huting 2002)
Lebanon	*Most significant is Phragmites-dominated Aammiq wetland in the Bekaa Valley* (A Rocha 2012) *Possible montane peatlands* No histosols. 49 km^2 gley soils (Van Engelen and Huting 2002)
Libya	No peatlands known. Oasis wetlands
Melilla	None known
Morocco	Peatlands in High Atlas and Rif Mountains (Schokalskaja 1953) Peatlands may include Iriki swamp (now destroyed), Zima lake, and in the Middle Atlas (Howard-Williams and Thompson 1985) 2 km^2 freshwater marshes (Britton and Crivelli 1993) No histosols. 1140 km^2 gley soils (Van Engelen and Huting 2002) *Sedge fens. Sphagnum subnitens occurs in Krimada Fen (Larache region), Sphagnum auriculatum occurs in Rif Mountains* (Muller et al. 2011)
Syria	Formerly peatlands in the Ghab Valley (Niklewski and van Zeist 1970) No histosols. 1087 km^2 gley soils (Van Engelen and Huting 2002)
Tunisia	51 km^2 freshwater marshes (Britton and Crivelli 1993) Peatlands may include Ichkeul lakes and swamp and Sebka Kelbia Swamp (Howard-Williams and Thompson 1985) 8 km^2 wetlands (Lappalainen and Żurek 1996) No histosols. 93 km^2 gley soils (Van Engelen and Huting 2002)

(*continued*)

Table 2 (continued)

Country/ territory	Details of peatlands (and other wetlands and organic soils)
Turkey	Wetland area 561 km^2 (Őz 1996) Peatlands (>0.3 m depth) 130 km^2 *Most significant site is Sphagnum-dominated Ağaçbaşi peatland very like northern-European blanket mires. Vegetation includes endemic species* (Byfield and Őzhatay 1997) No histosols. 45,069 km^2 gley soils (Van Engelen and Huting 2002)

Fig. 2 The Hula peatland, Israel. This site is a drained and partially restored fen complex in the northern Afro-Syrian Rift. Photo shows the margins of the Hula Nature Reserve

Acanthobrama hulensis in an Israeli wetland (Crivelli 2006), and the fish *Aphanius sirhani* in a Jordanian wetland. In many more cases, a peatland may include the only examples of species occurring in a country or region. Mediterranean peatlands are important for migratory birds with many being important stopping points on routes between Europe, Asia, and Africa. Peatlands therefore contribute considerably to the diversity of this global biodiversity hotspot. Given the limited taxonomic survey work which has been conducted in these regions much unrecorded diversity, and possibly new species, remain to be discovered. This major contribution to regional biodiversity is one of the most important arguments for the conservation of these peatlands.

Ecosystem services provided by Mediterranean peatlands have been little considered and are almost entirely unquantified. In contrast to northern peatlands, the

Fig. 3 The Elatia Mires of northern Greece. These small fens occur in the Rhodope Mountains in an area with comparatively high rainfall. These mires are described by Papazisimou et al. (2002)

carbon sequestration function of Mediterranean peatlands is globally insignificant – although sometimes very deep, Mediterranean peatlands are scattered and small as a proportion of total area. Other functions are locally significant, particularly those of flood control and water purification.

Human Impacts

Very few peatlands in the region are in a pristine condition; most have been affected by human activity and many destroyed. Key threats include drainage, fire, grazing, eutrophication and, to a limited extent, peat cutting. Of these much the most serious impacts have been through drainage. Most of the large, low altitude fens have been partially or completely destroyed by drainage (e.g., Bouzinos et al. 1997); for instance, it is estimated that 87% of the peatlands in Turkey have been lost (Çayci et al. 1988; Byfield and Őzhatay 1997). Motivations for drainage include control of disease, water management, and particularly the provision of new agricultural land. Drainage schemes date back to prehistoric times (Christanis 1996) but increased in number and extent from the late nineteenth century and particularly into the first half of the twentieth century as mechanization made drainage easier. Most of these drained sites are now extensively degraded with extensive loss of peatland species and oxidation and erosion of peats. Many of these drainage schemes have not lived

up to initial expectations – agriculture has proved less productive than expected with large quantities of pesticides and fertilizers required, and there have been problems with subsidence due to peat oxidation and fire.

Some peatlands are affected by nutrient enrichment; for instance, the Ioannina peatland (Christanis 1996) adjacent to Lake Pamvotis in north-central Greece has been affected by sewage input into the lake from the city of Ioannina. Fire is an important agent of environmental change in Mediterranean ecosystems and a significant impact on some peatlands. Other peatlands, particularly in montane areas, are affected by grazing – in many cases the impacts of this grazing appear limited to minor trampling and nutrient enrichment but may be more serious in some sites. For instance, in the Asi Gonia peatland on Crete there is extensive trampling by sheep leading to considerable physical disturbance and some areas of bare peat. This site contains the most southerly *Sphagnum* in Europe and a unique palaeoecological archive (Atherden and Hall 1999) but does not appear to be in a favorable condition.

Peat-cutting is not widespread in the region. There is little culture of cutting and as peats are generally minerotrophic they produce poor quality fuel. Small-scale or experimental peat cutting has been carried out in several areas, for instance, the Yeniçağa fen in Turkey, the Phillipi peatland in northern Greece, and the Hula peatland in Israel. Particularly notable is peat cutting in the Sürmene Ağaçbaşı Yaylası peatland in north-eastern Turkey. This site is a remarkable ombrotrophic *Sphagnum*-dominated peatland which contains at least one endemic species and several more for which this is the only site known in Turkey (Byfield and Őzhatay 1997; Payne et al. 2007). Peat has been cut for at least 30 years with very extensive disturbance across the site. Peat has been removed by digging holes a few meters across down into the peat; fortunately, this pattern of cutting means that the hydrological impact has been less severe than might be expected.

Increasingly, the main pressure on peatlands may shift to water resources with rising human populations and climate change. An example is one of the most recent episodes of catastrophic drainage of an important wetland – the Azraq wetland in Jordan. From the 1980s the water table of the site dropped drastically with water abstraction, primarily to supply the growing city of Amman. By 1993 no surface water remained, and this unique and important site was all but destroyed. Climate change projections suggest rising temperatures and reduced precipitation in the Mediterranean basin (Giorgi and Lionello 2008). As many peatlands are at the climatic margins for peat formation and human usage of water is likely to increase the continued existence of many Mediterranean peatlands is in doubt.

Future Challenges

Peatlands in the region, particularly outside Europe, are highly under-researched. Unsurprisingly, in regions where peatlands are rare there is little expertise in peatland science and consequently little focussed study of the sites. Much basic inventory work is lacking, as can be seen from the overview of published literature presented in Tables 1 and 2. Only a minority of countries have comprehensive inventories of

peatlands. Basic biological data such as lists of plant taxa are available for only a very small minority of sites.

Peatland conservation across the Mediterranean is also variable. In Western Europe (France, Italy, Spain) there is often considerable protection for peatlands – many are managed by national, regional, or charitable conservation organizations and protected from disturbance. In other regions, particularly in the Middle East and North Africa there is frequently no protection at all. While some sites in developed countries are important destinations for ecotourism, particularly with respect to bird-watching, in many others there is little or no public recognition of the importance of peatlands. Much greater efforts are needed to catalog, conserve, and educate the public about the importance of Mediterranean peatlands before even more are lost.

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