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ABSTRACT

The Iberian Peninsula hosts a wide variety of inland saltscapes, from man-made solar evaporation salterns to hypersaline lakes and salt rivers, most of them unknown in other European countries. The present contribution deals with this diversity of saltscapes, briefly introduces their main features and locations, and presents a general overview of their conservation status. Some of their natural values are not even well understood by the scientists themselves, and therefore they are very rare and fragile and in need of protection. However, many of these natural saltscapes have been and are currently under threat, having been desiccated, used as waste dumps or polluted with irrigation runoff. With respect to artificial salinas, these have been halting their activity in the last decades. Generally, historically salt-making operations occurred where hypersaline environments already existed. These locations were converted into commercial operations. As these, too, are being phased out, the loss of production has negatively affected the halophilic plant and animal communities. These results are based on empirical field observations, and a comprehensive inventory and status report of Iberian saltscapes is needed to support the ideas presented here.

INTRODUCTION: IBERIAN SALTSCAPES

The presence of salts (especially common salt or sodium chloride, which will be referred to as "salt" hereonwards) in nature affects the behavior and physiology of individual species as well as the composition and diversity of plant and animal communities in many different ways. This effect does not only depend on extrinsic factors such as latitude, altitude, topography or climatic conditions of the site in which salt is present. Intrinsic factors such as the origin of the salt (brine sources, underground brine flows, rock salt, saline rivers, etc.), the dynamics of the salt delivery (seasonal, permanent), its concentration in water, soil or even air, etc. also affect all living beings at the site and often in different ways. Given the enormous amount of distinct landscape types that are associated to the presence of salt in nature and in fact define specific ecosystems (Montes & Martino 1987; Williams 1998), the Association of Friends of Inland Salinas (AFIS) has coined the term "saltscape" to define them as "any landscape type whose elements are strongly influenced by the presence of salt and forms a defined ecosystem". This definition is vague enough to include almost any type of saline habitat, regardless of salinity, seasonality or origin of the salt and also includes some cultural landscape types that exist due to the action of man in some of these saltscapes, in search of salt as a mineral resource. Some saltscapes have been artificially created almost from scratch, by pumping underground brine for salt production, which otherwise would have never reached the surface. This is the case of many inland solar evaporation salinas, which have also been defined by the Association of Friends of Inland Salinas as those "saltscapes dominated by solar evaporation salt making sites fed by evaporitic brine sources" (Hueso & Carrasco 2008c). This type of saltscape, inland salinas, is a typical Iberian phenomenon–even though it exists in many other regions of the world, but certainly in lesser amounts or concentrations–with remains of over 500 solar evaporation salt making sites away from the sea (Carrasco & Hueso 2008). However, many other types of inland saltscapes occur in Spain and Portugal, some examples of which are natural brine springs, hypersaline streams, salt meadows, salt/saline lakes, salt steppes, etc. Most of these saltcapes originate from the old Tethys Sea, which roughly covered the eastern half of the Iberian Peninsula 200 million years ago during the Triassic period (Figure 1) (Montes & Martino 1987; Comín & Alonso 1988). This sea evaporated and reinundated certain areas periodically, creating large evaporitic deposits in this region. Depending on later geological events (such as tectonic and karstic movements), these deposits have become more or less accessible for nature or man, in the form of layers, domes, diapirs, etc. Other saltscapes originate from the Miocene period, much later (5-10 million years ago), but with a similar geological evolution, and yet others are of endorheic origin, such as most saline lakes (Montes & Martino 1987; Comín & Alonso 1988). Some of these saltscapes include habitats protected by law, as will be seen below.

Although a proper inventory of saltscapes is pending, the regional authorities in Spain have started to conduct their own wetland inventories (M. Bernués, pers. comm.), including saline wetlands. The Association of Friends of Inland Salinas is now compiling this information in order to list all inland saline wetlands contained in the regional inventories and in other relevant references (Hueso & Carrasco, in preparation). Earlier work by Pardo (1948) resulted in a catalogue of the 2500 Spanish lakes existing at the time, in which he included 80 inland salt lakes. A later survey that focused only on continental Spain obtained a total of almost 5000 wetlands, of which 99 were inland saline wetlands and salterns (DGOH 1991). As can be seen from these figures, the Iberian Peninsula is not especially rich in inland wetlands. They barely cover 1% of its landmass, around 4000 square kilometers, of which 48 square kilometers correspond to saline lakes and half of that, to hypersaline lakes (Montes & Martino 1987; Casado & Montes 1991). Nevertheless, Spain has Europe's most diverse wetland types, and saline wetlands are one of its main characteristic features (Casado & Montes 1995, see below).

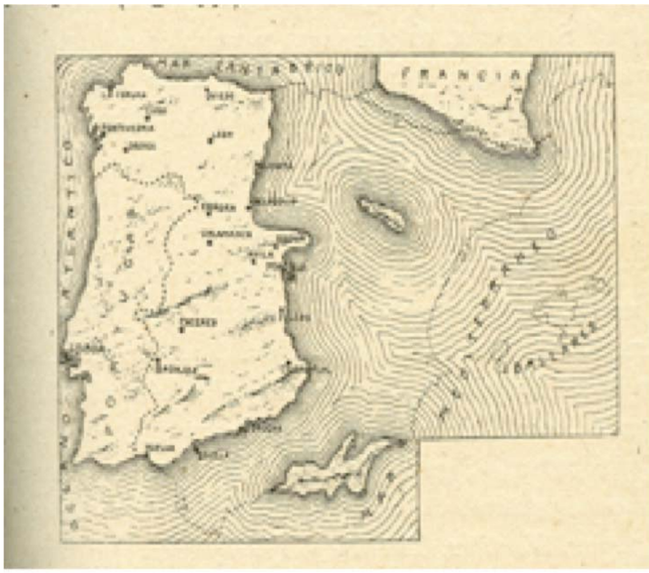

Figure 1–Map of the Iberian Peninsula 200 million years ago (Fábrega 1928).

Most Spanish saline lakes regularly undergo a dry period of between 3-10 months y^{-1} or dry up irregularly in periods of extreme drought, except Lake Chiprana (northeastern Spain), the only permanent and deep saline lake in Spain (Balsa et al. 1991; Guerrero et al. 1991). They are generally shallow, between 10-70 cm, although depth fluctuates greatly. Larger lakes such as Gallocanta (central Spain) and Fuentedepiedra (southern Spain) may reach 2 m and Lake Chiprana, up to 5 m depth (Montes & Martino 1987). Most authors distinguish four main salt lake districts in Spain (see also Montes & Martino 1987; Comín & Alonso 1988; Casado & Montes 1991; Guerrero & de Wit 1992):

- *Ebro river basin* (northeastern Spain): A Tertiary depression (alt. 150-410 m a.s.l.) refilled with evaporites. Semiarid conditions prevail and most lakes are ephemeral. It includes four endorheic subareas (Monegros, Lower Aragón, Ebro sources, Alavese Rioja).

- *Southern Castile tableland / La Mancha* (central Spain): About 30 lakes are found in a karstic area (alt. 640-690 m a.s.l.) with arid or semiarid conditions. Three subareas area are distinguished (Central Manchegan plateau, western Manchegan plateau, eastern Manchegan plateau).

- *Southern Spain / Guadalquivir basin*: Widely distributed saltponds (alt. 20-500 m a.s.l.), most of which are of endorheic origin. Most ponds are found in semiarid conditions. Two main areas are the Guadalquivir depression and Hoya de Antequera.

- *Northern Castile tableland* (northwestern Spain): Lakes are found in the endorheic areas (alt. 680-880 m a.s.l.) between the watersheds of two rivers. Semiarid conditions prevail. Due to the low salinity of the wetlands found here, not all authors agree to include this district (Montes & Martino 1987).

Other important saline wetlands mentioned by Comín & Alonso (1988) are Lake Gallocanta (alt. 1000 m a.s.l.) in central Spain and La Mata lagoon (at sea level) in southeastern Spain. Comín & Alonso (1988) also give details about the chemistry and biota of Spanish salt lakes, according to their ionic composition, salinity and seasonality. They conclude that the chemical composition of Spanish saline wetlands is rather diverse, with predominance of sodium chloride and magnesium sulfate rich lakes (see also Montes & Martino 1987; Guerrero & de Wit 1992). With respect to the species composition of Spanish saline lakes, relatively little is known. Macrophytes, crustaceans and birds are the best studied groups (Montes & Martino 1987). Nevertheless, it is generally agreed that the fauna of Spanish salt lakes is similar to that of other Mediterranean countries and Central Asia. In some cases that analysis included the *Anostraca*, *Cladocera*, and *Copepoda*, similarities have also been found with northern African saline wetlands (Alonso 1990). Also the brine shrimp *Artemia* sp. has been widely studied (Hontoria & Amat 1992), and research shows that Iberian inland salterns and hypersaline lakes are a reservoir for threatened *Artemia salina* (Amat et al. 2005, 2007; Green et al. 2005). Another interesting feature of the Iberian saline biota is the presence of microbial mats. In order to survive, these agglomerates of microorganisms require hypersaline environments (Guerrero & de Wit 1992). These mats are found in three of the four main saline lake districts (Ebro river basin, southern Castile tableland, southern Spain). Those in Lake Chiprana are especially interesting (Guerrero & de Wit 1992). Other researchers have focused on the genetics of halobacteria found in inland salterns and saline lakes (e.g. Martínez-Cánovas et al. 2004; Martínez-Checa et al. 2005). With respect to vegetation, most inland saltscapes are dominated by gradients of halophytes from extreme true halophiles to halotolerant species, in decreasing salinity order. These gradients are usually sharper than those found in coastal environments, as salinity quickly disappears on a short distance from its source (spring, stream, lake, etc.). Hypersaline sites are dominated by plant species typical of seashores and coastal salt marshes, but are rare and fragile when found far inland and at relatively high altitudes. Examples of these species are *Salicornia* sp., *Suaeda* sp., *Salsola* sp., *Arthrocnemum* sp., *Limonium* sp., *Glaux maritima*, etc. Waterplants such as *Ruppia maritima*, *Chara* sp., *Riella helicophylla*, etc. are also typical of hypersaline wetlands, and many are protected by European and regional laws (Montes & Martino 1987; Comín & Alonso 1988; Casado & Montes 1995; Sadoul et al. 1998; Cirujano & Medina 2002; Martín et al. 2003; Hueso & Carrasco 2008a).

Another particular type of saline wetland is represented by the hypersaline temporary streams or "ramblas" or "wadi complexes", which are found in the southeastern tip of the Iberian Peninsula. These streams are "wide, usually dry channels flowing only in flash flood events, although sometimes small permanent or temporary streams, springs and pools can be formed by groundwater seepage" (Vidal-Abarca et al. 1992; Moreno et al. 1996). Endemic to this type of habitat are a number of aquatic *Coleoptera* and *Heteroptera* (López-González 1997; Barahona et al. 2005; Velasco et al. 2006; Abellán et al. 2007; Sánchez-Fernández 2008).

In Portugal, hardly any scientific or policy literature can be found on local saltscapes. Most of these appear to be associated with estuarine or inland salterns (R. Neves, personal communication). However, it is worth noting that Portugal hosts an interesting example of a saline fen, located at the old Junqueira salt making site, a unique saltscape within the Iberian Peninsula (Dias 2005).

With respect to other types of saltscapes, little literature exists and even less an inventory of sites, except those that have been protected (see Table 1). Also pending is an inventory of cultural values associated with wetlands, which is especially needed in the case of saltscapes (Viñals et al. 2002, 2005).

Table 1–Habitat types recognized by the 1992 European Commission Habitats Directive that can be considered as saltscapes (European Commission 1999).

Annex 1[1] code nr.	Habitat type
13	**ATLANTIC AND CONTINENTAL SALT MARSHES AND SALT MEADOWS**
1310	*Salicornia* and other annuals colonizing mud and sand Formations composed mostly or predominantly of annuals, in particular *Chenopodiaceae* of the genus *Salicornia* or grasses, colonizing periodically inundated muds and sands of marine or interior salt marshes.
1340*	Inland salt meadows Non-coastal natural salt basins made up of different habitat types consisting of zones of seepage of saline water, running or stagnant saline water, with typical halophilous vegetation and of reed beds at the edge of brackish waters.
14	**MEDITERRANEAN AND THERMO-ATLANTIC SALT MARSHES AND SALT MEADOWS**
1410	Mediterranean salt meadows (*Juncetalia maritimi*) Various mediterranean communities and tall rush saltmarshes dominated by *Juncus maritimus* and/or *J. acutus*; short rush, sedge and clover saltmarshes and humid meadows behind the littoral, rich in annual plant species and in *Fabacea*, Mediterranean halo-psammophile meadows; Iberian salt meadows; halophilous marshes along the coast and the coastal lagoons; humid halophilous moors.
1420	Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*) Perennial vegetation of marine saline muds (schorre) mainly composed of scrubs, essentially with a Mediterranean-Atlantic distribution
1430	Halo-nitrophilous scrubs (*Pegano-Salsoletea*) Halo-nitrophilous scrubs (matorrals) belonging to the *Pegano-Salsoletea* class, typical of dry soils under arid climates, sometimes including taller, denser brushes.
15	**SALT AND GYPSUM INLAND STEPPES**
1510*	Mediterranean salt steppes (*Limonietalia*) Associations rich in perennial, rosette-forming *Limonium* spp. or esparto grass (*Lygeum spartum*), occupying, along Mediterranean coasts and on the fringes of Iberian salt basins, soils temporarily permeated (though not inundated) by saline water and subject to extreme summer drying, with formation of salt efflorescence.

The Protection of the Natural Heritage of Iberian Saltscapes

The protection of saltscapes has been a quite recent phenomenon and is still far from representative, as will be argued below. The first declarations of protected areas in the world, at the end of the 19th century, focused on romantic, scenic and wild mountainscapes. At that time, wetlands were considered a nuisance and even a threat to public health, as they hosted parasites and insects that could easily transmit infectious diseases. Decades later, attention was finally placed on wetlands, partially due to the 1972 Ramsar Convention on Wetlands (Mioduzewski 2006; O'Connell 2003). Again, many lesser–especially inland–wetlands were missed by Ramsar, as one of the main requisites to belong to the Convention was to host bird species or communities of international importance. Many small saline wetlands lack this feature, due to seasonality of the water table, fluctuating salinity, size of the wetland, distance to larger wetlands, off the main flyways of migrating birds, etc. (Casado & Montes 1991). Typical features of saltscapes such as habitat-specific plant species or communities, microbial diversity or rarity and/or fragility of halophilic organisms are just starting to be widely recognized by the scientific community. These features have also started to be acknowledged by policy makers and this has helped broaden the declaration criteria of Ramsar sites, allowing the declaration of smaller wetlands. In Spain and Portugal, 80 Ramsar sites have been declared to date (Ramsar 2008). Of them, over one third (30 sites; 38%) protect some sort of saltscape (see Table 3). It is worth noting that, in the case of Spain, more than half of the Ramsar sites devoted to the protection of saltscapes do protect inland saltscapes (15 of 25 sites or 60%), most of which are lakes and lagoons in central and eastern Spain. In Portugal, however, all five Ramsar sites protecting saltscapes are located at the mouth of important rivers, where coastal solar evaporation salinas exist.

On the other hand, the European Commission launched an ambitious project in order to efficiently protect the most representative species and habitats of the EU by creating the Natura 2000 (European Commission 2008) network. To this end, among other actions, a comprehensive catalogue of European habitats was prepared. Some of the habitats were considered in danger of disappearing and enjoy a special priority status when it comes to their protection. The final list of habitats contains six that could be considered as saltscapes (see Table 1), as these have been defined above.

Once this catalogue of habitats was made, each member state had the responsibility to designate areas to protect a representative part of them, by creating the so called "Sites of Community Interest" or SCIs. These sites may contain one or several habitats and form part of the Natura 2000 network, together with the so called, "Special Protection Areas" or SPAs, devoted to the protection of birds. Only recently have the member states designated both their SCIs as their SPAs. The next step is to educate both policy makers as the general public about the (legal) implications and opportunities of a certain area belonging to the Natura 2000 network, in order to be truly efficient. This is an ongoing process. But this would require a much deeper discussion that falls well beyond the scope of this paper.

Table 2–Number of designated SCIs per country and habitat type (European Commission classification system, see Table 1).

Country	Habitat type					
	1310	1340*	1410	1420	1430	1510*
Belgium	3					
Cyprus	1		1	1		
Denmark	34	6				
Estonia	2					
France	55	10	15	21		
Germany	13	49				
Greece	7		9	8		1
Ireland	23		35	2		
Italy	49		53	45	7	41
Latvia	3					
Malta			1	3		
Netherlands	21					
Poland		1				
Portugal	9		8	8	7	2
Slovenia		2				
Spain	79		73	124	55	68
Sweden	33					
United Kingdom	18	1		5		
Total SCIs	350	69	195	217	69	112

A brief look at the number of designated SCIs per country and per habitat type quickly shows that the Mediterranean countries in general and Spain in particular are leading in the number of designated saltscapes (Table 2). Portugal, however more modestly, also hosts most of the saltscape habitats. An exception to this is habitat type 1340* (inland salt meadows), which belongs to the continental biogeographic region, not represented in most Mediterranean countries and not at all in Spain or Portugal. Of all other saltscapes represented by these habitat types, Spain and Portugal host 46% of all of the protected designated SCIs in the EU.

These figures give an idea of the importance and representativeness of these saltscapes in the Iberian context. However, Table 2 only gives an estimate of *protected* saltscapes in the EU. It is rather difficult to estimate the total number of valuable saltscapes in a certain region, as many of them are seasonal, intermittent or artificially created by soil erosion, salt water intrusion or excessive irrigation (Williams 1998). It has to be assumed that the number of saltscapes protected within the Natura 2000 network in the different EU countries is only representative of their total number. Also, bearing in mind that hardly any inland solar evaporation salt making facilities exist outside Iberia, and that Spain and Portugal host (the remains of) 500 such sites (Carrasco & Hueso 2008), the Iberian peninsula may be considered as the European reservoir of saltscapes both from a qualitative as well as a quantitative point of view and as such they should be protected (González Bernáldez 1987; Montes & Martino 1987; Casado & Montes 1991; Guerrero & de Wit 1992).

A completely different way to look at the protection of saltscapes is their conservation as cultural heritage. The Spanish legislation may designate historic buildings, sites, or other tangible heritage as “Good of Cultural Interest” (GCI), which confers them with a protection status and enforces their owners and the local and regional authorities, to protect and maintain them. Most GCIs are churches, monasteries, castles and fortifications. However, more recently, other more modest sites have started to be declared as GCI. Among the relatively new designated sites are a number of salt making sites. Of the almost 1.6×10^4 declared GCIs, 17 are salt making sites, of which 35% (6 sites) are inland (Table 3). The declaration of a site as a GCI normally only affects the man-made structures (buildings, engines, infrastructures) found in it and not its surrounding landscape or natural values. In fact, only in two cases (Salinas de Añana, in the Basque Country, and Salinas de Saelices de la Sal, in Castile–La Mancha) do two protection statuses overlap (SCI and GCI).

Some regional governments in Spain are starting to understand cultural heritage as part of a geographic context and refer to it as “cultural landscapes” or “territories” (i.e. Castile and León, Aragón). Several non-governmental organizations devoted to the protection of industrial, archaeological and mining heritage are using the concept for the protection of whole mining districts (International Committee for the Conservation of the Industrial Heritage/TICCIH, Spanish Society for the Defense of Geological and Mining Heritage/SEDPGYM, Industrial Archaeology Association/INCUNA, Spanish Society for History of Archaeology/SEHA, etc.), including also their natural (mainly geological, but not only) heritage. This trend may be useful for saltscapes too, especially in those sites where salt has been obtained by man, as both the cultural and material values are tightly interwoven.

Table 3–Number of protected saltscapes in Spain according to different protection categories and type of saltscape.

Type	SCI[1]	Ramsar[2]	GCI[3]
Coastal salinas	4	7	11
Inland salinas	8	1	6
Other saltscapes	173	17	0
Total saltscapes	185	25	17

[1]SCI: Site of Community Importance: Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (EUNIS 2008).
[2]Ramsar: Ramsar Convention on Wetlands, 1972 (Ramsar 2008).
[3]GCI: Good of Cultural Interest: Law 16/1985 of Spanish Historic Heritage (historic sites, monuments, etc.) (Ministerio de Cultura 2008).

Threats and Challenges to Iberian Saltscapes

Despite their importance and value, wetlands are being threatened globally, for different reasons: drainage, overpopulation, eutrophication, intensification of agriculture, overexploitation, pollution, alteration of ecological conditions, etc. Many of these actions are related to each other and create synergic effects: since 1900, more than half of the world’s wetlands have disappeared (Casado & Montes 1991, 1995; Barbier 1993; Pearce & Crivelli 1994; Schuyt & Brander 2004). Saltscapes in general and saline wetlands are no different in this respect; they have been under threat almost everywhere around the world and predictably will be in the next decades (Williams 1986, 1993, 1998, 2002; Jellison 2003). Many of them continue to be destroyed or irreparably damaged (Williams 1986, 1993). A team of researchers from the ecology departments of the three universities of Madrid, Spain has estimated a loss of between 40 and 70% of the total wetland area in Spain since the 18th century. In the Upper Guadiana watershed, 90% of the wetlands disappeared between 1953 and 1973, as a result of agricultural land reclamation and hygienic measures against malaria (Álvarez 2007). In the case of saline wetlands, this loss has been reduced to 30%, mainly due to the conservation of large salt lakes such as Gallocanta and Fuentedepiedra. A larger percentage of smaller saline wetlands has disappeared (16%) or is highly altered (35%) (Casado & Montes 1991). One of them is La Janda Lagoon, in southern Spain, the southernmost saline lake in Europe (Montes & Martino 1987). As will be seen in the discussion below, saltscapes in general and saline wetlands in particular suffer threats that are common to other wetlands in general, but others are specific to them:

Ignorance

One of the most important threats to saltscapes is, in fact, ignorance of their existence and therefore their natural, cultural and even economic values. Scientists such as Williams (1981, 1986, 1998) or Margalef (1983, 1994) have repeatedly defended the study of saline inland water while limnology has typically restricted itself to fresh water. Policy makers, however, seem not to value fresh and saline water to the same extent. To illustrate this, the Association of Friends of Inland Salinas has repeatedly and fruitlessly tried to include an event related to saline wetlands within the NGO forum of the Universal Expo on Water that was celebrated during the spring and summer of 2008 in Zaragoza (Spain). The little attention that has been paid to Iberian wetlands has directly been related to their bird diversity and abundance (i.e. Doñana), but Spain contains large numbers of small wetlands, too small to host interesting bird communities, but with more hidden natural values. This is especially so in the case of Iberian inland saline wetlands, as they are unique within Europe (see above) and host specific ecological functions and values not found in other types of wetland (Casado & Montes 1991).

Abandonment

The abandonment of inland saltscapes in Spain is tightly related to the so called rural exodus that had its peak during the second half of the 20th century, but in fact had started decades earlier. Traditional activities such as extensive agriculture, animal husbandry, and handicrafts were quickly abandoned at the prospect of a better life in the then fast growing cities. This is also the case for inland traditional salinas. In artificial saltscapes such as inland salterns, the abandonment of traditional salt making has resulted in the disappearance of valuable halophilic communities, which are being replaced by generalist or opportunist plant or animal species as soon as salinity decreases. As a result, these saltscapes are abandoned and follow an uncontrolled ecological succession towards degradation (Carrasco & Hueso 2006; Hueso & Carrasco 2008b, 2008c).

Agriculture and Irrigation Runoff

In the second half of the 20th century, agriculture in Spain underwent an important transformation process, from extensive, low impact, to intensive practices, with comprehensive land reclamations and irrigation projects in large, arid areas (Casado & Montes 1991). One of the affected areas, the Monegros desert, located in one of the salt lake districts in northeastern Spain, has since lost 50% of its wetlands and 30% of the remaining ones have been invaded by non-native vegetation (Castañeda & Herrero 2007). Another associated effect of agricultural intensification is, depending on the quantity of water used, eutrophication of saline wetlands or further salinization of water bodies and/or soil (Guerrero & de Wit 1992).

Infrastructures and Water Reservoirs

Previously, authorities did not hesitate to destroy wetlands to build infrastructures, but today they must search for alternative locations, as present environmental impact assessment legislation requires. Water reservoirs have been built on saline wetlands such as Mar de Ontígola, El Atance, Estanca de Alcañiz (cental Spain) or Sariñena (northeastern Spain) (Montes & Martino 1987; personal observation) and roads have covered the remains of traditional salt making sites as Tordelrábano (central Spain) (personal observation).

Wild Recreation and Vandalism

Even though overpopulation is not an issue in inland rural Spain, certain human activities are highly damaging to wetlands. Especially fragile are saline wetlands, as they are usually dry during the summer months, a period in which outdoor activities are more popular and people have more leisure time. A lack of public awareness and enforcement of nature protection laws causes many people to practice uncontrolled outdoor activities such as motor racing, mountain biking, or even 4x4 wheel driving on dry wetland beds that offer large, flat, isolated areas for these purposes. Such activities severely damage these fragile habitats (personal observation). Another issue is sheer vandalism, which is practiced mainly upon the cultural heritage of saltscapes because most of its buildings are abandoned and have become an easy prey for collectors of tools, machinery, etc. or for people wishing to renovate their home with “authentic” pieces of wood, stone, tile, etc. (Carrasco & Hueso 2006; personal observation).

Drainage*, *Desiccation and Waste (Water) Dumping

Although not currently a common practice, in the past many wetlands have been drained or desiccated for health purposes. In fact, an important part of early limnological studies in Spain was focused on wetland drainage and desiccation (Álvarez 2007). A few decades ago, they were considered the source of infectious diseases, especially malaria. Later, wetlands were often used as wastewater dumps which therefore reinforced the image of unhealthy sites (Comín & Alonso 1988; Casado & Montes 1991; Álvarez 2007; personal observation). Montes & Martino (1987) cite a number of saline wetlands used as waste dumps: Las Eras and Camino de Villafranca (central Spain) and Laguna del Gobierno (southern Spain).

Climate Change

A recent evaluation of the threat of climate change on Spanish wetlands concludes that seasonal saline wetlands of endorheic origin may disappear altogether. This is especially the case for the smaller ones. Other possible consequences of climate change may be the alteration of ionic composition, eutrophication, and hypersalinization (Álvarez et al. 2005).

The future management of saltscapes faces numerous challenges in Iberia (Montes & Martino 1987; Comín et al. 1999; Álvarez et al. 2005; Hueso & Carrasco 2008c). Wetlands in general and saline lakes in particular host a number of values (natural, cultural, intangible) and functions (regulation of natural processes; production of commodities and raw materials such as salt, cosmetics, edible plants, microorganisms for biotechnological and industrial applications, etc.; economic activities such as agriculture, husbandry, tourism, recreation, health care, etc.; and education through research, interpretation, etc.) that make them complex habitats that require complex and site-specific approaches (Hammer 1986; Skinner & Zalewski 1995; Viñals et al. 2002; Schuyt & Brander 2004; Hueso & Carrasco 2008c). However, an attempt is made here to classify the most important challenges ahead of saltscape managers.

Raise Awareness of Stakeholders

Ignorance of the values of saltscapes is widespread. Therefore an important task for saltscape managers is to raise awareness of them at different levels (local community, visitors, owners, policy makers, general public, etc.). Saltscapes, thanks to their unique combination of natural and cultural values along with their diversity, offer excellent grounds for educational and interpretation activities from a multidisciplinary perspective (Hueso & Carrasco 2008c).

Saltscapes as Systems

Conservation measures should not only be designed at the wetland level but also at the much larger watershed level. This is especially important for Spanish wetlands in general, which have a very high ratio watershed to wetland surface. This is not always taken into account when designing management plans (Álvarez 2007). The same can be said about the socioeconomic aspects of wetland management, in which many levels of stakeholders are involved (local community, policy makers, owners, non-government organizations, and even non-users, who simply value their existence) (Schuyt & Brander 2004). Therefore, management measures should be planned in a broader context and in a longer term than is usually the case, and involve the coordination of multidisciplinary teams (Hueso & Carrasco 2008c).

Increase (Applied) Research on Inland Saline Wetland Values

Basic research on saltscapes is still needed. Several authors have suggested a number of issues of interest, such as diversity and dynamics and halophilic microorganisms, long term limnological processes, ecological modeling of saline ecosystems, biogeochemistry of saltscapes, cultural tangible and intangible values of saltscapes, etc. (Guerrero & de Wit 1992; Viñals et al. 2002, 2005; Álvarez 2007). Applied research towards the optimal use of saltscape resources (i.e. for biotechnology, electronics, pharmaceutical uses, etc.) may also help them to recover in a sound and even profitable way (Hueso & Carrasco 2008c).

Invest in Sound (Socio-Economic) Recovery Projects

In the case of inland saltscapes, and especially, in traditional salt making sites, preference should be given to projects that recover wetland functions through the restoration of the cultural and natural heritage, increase conservation awareness, recognize the spiritual values of wetlands for the local communities and value cultural traditions for the benefit of everyone (Viñals et al. 2002, 2005). An interesting example of a coordinated recovery project of cultural, socioeconomic and natural values of a saltscape is the Master Plan for the Salinas de Añana salt inland salt making site Basque country (Lasagabaster et al. 2003).

CONCLUSION

Spain hosts a great diversity and abundance of saltscapes, both at the European and at the global level. Although protection efforts have been implemented in the last decades, knowledge of the cultural and natural values of these saltscapes is still patchy as compared to other landscapes and wetlands. Saltscapes still need to be properly catalogued, studied, and the information disseminated in order to reach efficient levels of protection and sound use, optimizing their values and functions in a sustainable way.

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