# Existing areas and past changes of wetland extent in the Mediterranean region: an overview

## *État actuel et changements passés de l'étendue des zones humides en région méditerranéenne : un bilan*

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**Abstract**

*We quantified the amount of existing wetlands in the Mediterranean region as well as their losses in the past century. An estimated 18.5 ±3.5 million ha of wetlands existed in c. 2000, one quarter of them consisting of artificial wetlands, including primarily reservoirs and rice-fields. Past losses were estimated to represent c. 50% over the 20th century. Land-cover maps derived from the CORINE Land-Cover system were also used to test whether they could monitor total surface areas, surfaces by wetland types, or wetland losses, at the required scale.*

**Résumé**

*Nous avons quantifié la surface de zones humides existant en Méditerranée, ainsi que leurs pertes au cours du siècle passé. Environ 18,5 millions d'hectares (± 3,5 millions) existaient vers l'an 2000, dont environ un quart de zones humides artificielles, principalement des réservoirs et des rizières. Les pertes sont estimées à environ 50 % au cours du XXe siècle. Les cartes d'occupation du sol tirées de CORINE Land-Cover ont aussi été utilisées, afin de tester si elles permettraient de suivre, à l'échelle requise, la surface totale, la surface par type de zones humides, et la perte de ces milieux.*

**Keywords:** Mediterranean wetlands, Wetland surface, Wetland loss, Habitat trends, CORINE Land-Cover, Artificial wetlands.

## Introduction

Although wetlands are one of the richest ecosystems in terms of biodiversity, and one that contributes most to human well-being, they are also the ecosystem most threatened by human activities (Millennium Ecosystem Assessment 2005). Worldwide, many people depend on wetlands for their basic needs, especially for water supply. The international community has acknowledged their importance: wetlands are the only ecosystem that benefits from a specific international convention. The Ramsar Convention on Wetlands of International Importance was signed in 1971 in order to ensure their protection and wise use. But since then and despite conservation actions implemented by governments and Non-Governemental Organisations, wetlands have continued to disappear more rapidly than other ecosystems (Finlayson *et al.* 1992). Wetlands are well represented in the Mediterranean region, which is itself a biodiversity hotspot (Mittermeier *et al.* 2005; CEPF 2010) due to a combination of high biodiversity and high level of threats, especially in coastal areas (Plan Bleu 2009). Regionally, these threats are particularly acute, both because of the rarity and irregularity of freshwater resources, and because of growing human pressures affecting them directly or indirectly

(*e.g.* Plan Bleu 2009; Mediterranean Wetlands Observatory 2012). Mediterranean wetlands are therefore particularly rich but vulnerable ecosystems.

Despite their importance, Mediterranean wetlands (surface area and losses) have never been reviewed on a regional scale. Quantifying the wetland surface area and trends is important because this can be a direct measure to analyse the degree of threat to the ecosystem (Walpole *et al.* 2009). In the absence of better, quantitative data, wetland area can also be a proxy for wetland ecosystem services (UNEP-WCMC 2011), as there could be a direct relationship between wetland decline and reduction in the services that they provide.

For these reasons, the trend in wetland area is a major indicator of the Convention for Biological Diversity (CBD) (CBD 2006; Walpole *et al* 2009). It is also used to measure the success of regional strategies for biodiversity, aimed at implementing the CBD, such as the European initiative "Streamlining European Biodiversity Indicators 2010" (EEA 2009a). The same indicator has been proposed or used at national (*e.g.* FOEN 2009) or local levels (*e.g.* Popy 2010). Finally, it was recently adopted as a Priority Indicator by the Mediterranean Wetlands Observatory, a recent initiative to monitor the state and evolution of wetlands in the entire Mediterranean basin (Mediterranean Wetlands Observatory 2012).

Although the issue has received increasing attention in recent decades, adequate monitoring data for this indicator, with consistent and repeated measures, are still not available in the Mediterranean Basin. At best, only one-off situations are described, usually in the form of wetland inventories. These inventories were promoted in the region by MedWet, an initiative under the aegis of the Ramsar Convention that aims at conserving and sustainably managing Mediterranean wetlands, and which gathers 27 countries. Since its inception in 1992, this initiative has assisted the development of methodologies, tools and frameworks for wetland inventories (*e.g.* Costa *et al.* 1996). Between 1994 and 2009 comprehensive national inventories were produced for Albania, Bulgaria, Croatia, Greece, Macedonia, Portugal, Slovenia and Tunisia. In addition, preliminary inventories or surveys were launched in Algeria, Cyprus, Libya, Morocco, Serbia and Turkey, as well as regional/provincial inventories in France and Italy. Most of these have also attempted to quantify past losses. But despite this wealth of national and regional information, a full, pan-Mediterranean overview had yet to be produced. The closest attempt so far was by Caessteker (2007). Following Hecker & Tomas-Vives (1996), he reviewed information on all Mediterranean countries, but summarized quantitative information only for the 16 best-known ones (out of 27). It was shown that collectively, the 16 countries harboured at least 4.5 million hectares of wetlands. However, this result was hampered by the fact that figures were not available for several countries known for their huge wetlands (*e.g.* Algeria, Egypt, Libya…), whilst for others the figures proposed were clearly under-estimates (*e.g.* France). As a result, the Mediterranean picture was still very incomplete.

Beyond inventories, monitoring the surface area of wetlands is even less developed at the Mediterranean scale, although good attempts exist at local scale. Despite improved methods and tools for remote sensing, and an ever-increasing quality and availability of satellite images, translating their results into meaningful and reliable metrics of change for wetland habitats – and other ecosystem types – has proved challenging to date at regional scale (Walpole *et al.* 2009).

In this paper, we assess the existing wetlands in the 27 Mediterranean countries around the year 2000. We measure it in terms of surface area and number of wetlands. We also try to identify the relative importance of artificial *vs.* natural wetlands. Whenever possible, we both update the figures for the 16 countries covered by Caessteker (2007), and bridge the gaps for the remaining 11 countries – which had not yet been completed. Secondly, we evaluate the changes in wetland extent over the 20th century. Finally we evaluate the possible advantage of using CORINE Land-Cover information for monitoring wetland extent in the future.

## Material and methods

### Area studied

This study was performed for the 27 Mediterranean countries (Figure 1) corresponding to the MedWet members, *i.e.* all 21 countries that have a Mediterranean coastline plus Bulgaria, Jordan, Macedonia, Palestine, Portugal and Serbia/Kosovo. Some large ones, *e.g.* Algeria, France, Turkey or Libya have a large part of their territory lying outside the bioclimatic Mediterranean region. Wetlands from these areas are nevertheless incorporated into all the statistics.

### Definition of wetlands

"Wetlands" were understood in the broadest, Ramsar sense, *i.e.* encompassing virtually every aquatic ecosystem except the sea deeper than 6 meters (Ramsar Secretariat 2008). This definition therefore includes rivers, large lakes, reservoirs, ricefields, flooded meadows, etc. However, we reviewed only figures for continental, surface wetlands. This excluded de facto karstic systems and shallow, marine habitats (outside estuaries), although both are considered as wetlands in the Ramsar definition.

Artificial (or human-made) wetlands are included as one of the three principle types of wetlands in the Ramsar definition. Artificial wetlands encompass irrigated or seasonally flooded agricultural land, saltpans, water storage areas, aquaculture ponds, oases, etc. We used this classification to distinguish between "artificial" and "natural" wetlands. However, it is well understood that in the Mediterranean, due to the long history of human influence, even the wetlands called "natural" have virtually all undergone some degree of human-induced changes.

### Data

A review of published and grey literature and Internet pages was performed, largely focussing on bridging the gaps in knowledge that remained after earlier reviews of existing Mediterranean (Hecker & Tomas-Vives 1996; Caessteker 2007) or European (Nivet & Fra-

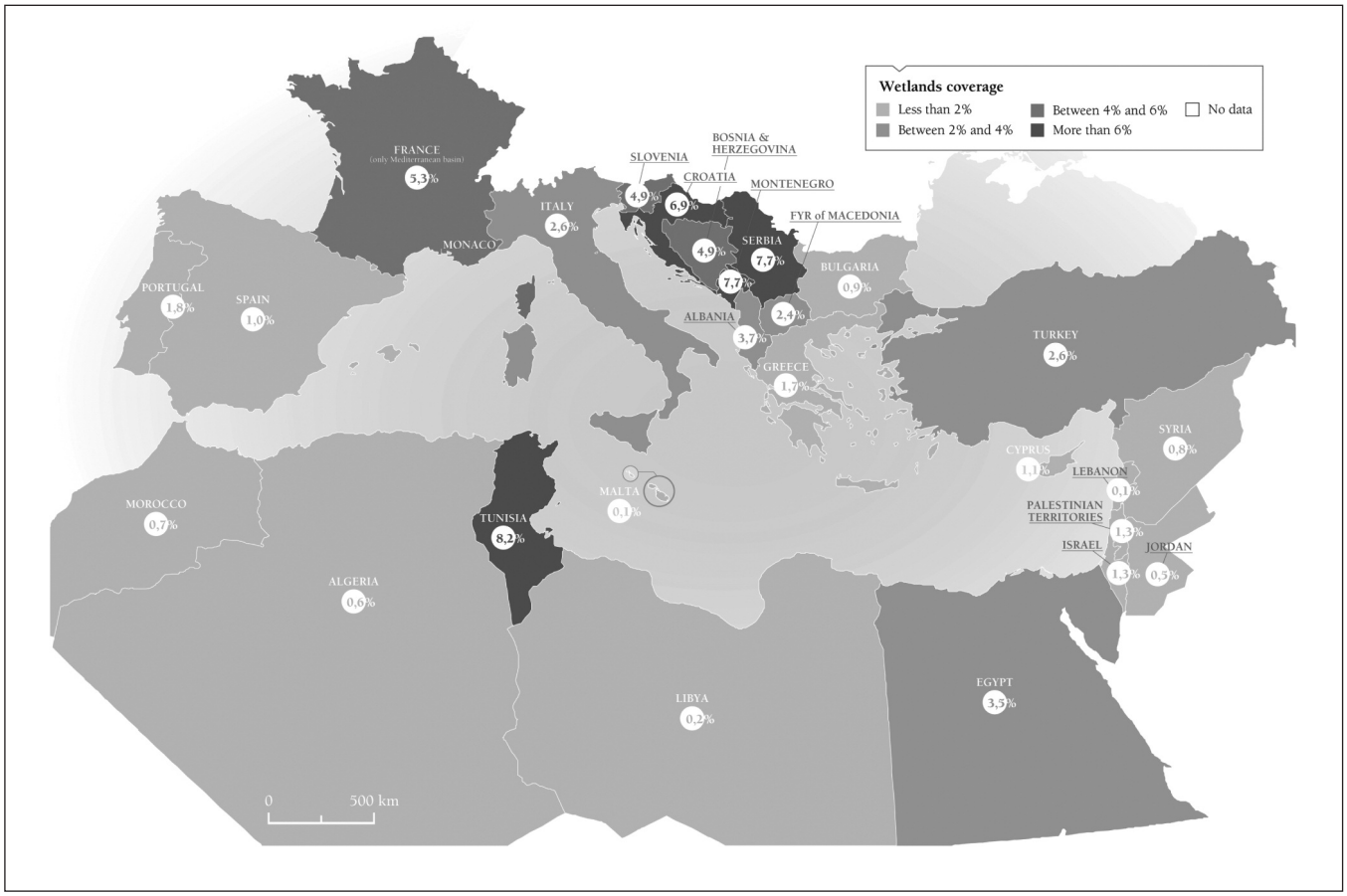


***Figure 1 – Proportion of wetland coverage, in relation to total country surface area, for Mediterranean countries. Serbia and Kosovo are presented together, as the latest information available dates back to years when they were united.***
*Sources: see Table 1.*

***Table 1 – Existing surfaces of wetlands in Mediterranean countries by year 2000 (±10 yr); 1a Europe; 1b North Africa, Middle East and overall totals.*** *Countries with an existing, comprehensive wetland inventory (or assessment) are indicated with **; countries with only a preliminary or partial/regional inventory(ies) with a *; national totals in North Africa/Middle East exclude oases, which are estimated separately.*

| **1a** | **Wetland surface (ha)** | | **Minimum n° of wetlands** | **Sources & method used for figures/ ranges proposed** *(additional useful sources within brackets, italics)* | **CORINE-LC 2006 surface areas (ha)** | |
|---|---|---|---|---|---|---|
| | **Estimate** (or lower range limit) | **Upper range limit** | | | **Total wetlands** (excl. wet meadows) | **Total wetlands + all meadows** |
| Albania ** | 101,132 | | 792 | Mima *et al.* 2003 updated by Kapanidis (2008) | 63,655 | 106,548 |
| Bosnia-Herzegovina | 250,000 | 500,000 | ? | Nivet & Frazier 2004[1] ; range reinterpreted based on their sources | 37,810 | 443,028 |
| Bulgaria ** | 104,750 | 109,509 | 6781 | Michev & Stoyneva 2007 | 120,147 | 529,512 |
| Croatia ** | 390,885 | | 3883 | MEPPP 2003 (in Caessteker 2007) | 73,753 | 371,657 |
| Cyprus* | 10,000 | 20,000 | 7 | This study; minimum calculated from Heath & Evans 2000 | 4047 | 5215 |
| France * | 2,200,000 | 3,000,000 | 58,475[2] | Cizel 2010 (surface) ; Perennou *et al.* 2012 (n° of wetlands) | 635,012 | 9,331,177 |
| Greece ** | 216,032 | | 410 | Zalidis & Mantzavelas 1994, updated by Kapanidis 2008 | - | - |
| Italy* | 765,000 | 1,500,000 | 1515 | This study; calculated after N.Baccetti & B. Amadesi (*pers. comm*. July 2010), D'Antoni *et al.* 2011 and FAO-STAT 2012 *(De Maria 1992)* | 670,821 | 1,096,472 |
| Kosovo | *(see Serbia)* | | | - | 2336 | 20,109 |
| Macedonia ** | 60,000 | 80,000 | 44 | This study; derived using Micevski 2002 & FAO-STAT 2012 | 60,935 | 263,629 |
| Malta ** | 24 | | 24 | MEPA 2006 (in Caessteker 2007) | 25 | 25 |
| Monaco ** | 10 | | 1 | Caessteker 2007 | | |
| Montenegro | *(see Serbia)* | | | - | 38,424 | 59,017 |
| Portugal ** | 162,462 | | 816 | Farinha & Trindade 1994; Farinha & Fonseca 2006 (in Caessteker 2007) | 167,167 | 209,032 |
| Serbia * | 677,200[3] | | 499 | Yugoslav Federal Republic 1998 (in Nivet & Frazier 2004) | 108,154 | 266,997 |
| Slovenia ** | 35,409[4] | 98,759[4] | 3525 | Water Management Institute 2000 | 11,023 | 127,230 |
| Spain* | 500,000 | 1,000,000 | 1379 | This study; calculated using Casado & Montes 1995, Nivet & Frazier 2004 and FAO-STAT 2012 | 562,584 | 1,210,163 |
| Turkey * | 2,062,527 | 3,000,000 | 135 | This study; derived using Magnin & Yarar 1997, Ministry of Environment and Forestry 2007, Karadeniz *et al.* 2009, M.Ataol /DogaDernegi *comm. pers.* 2010 | 1,784,932 | 3,263,785 |
| ***Sub-Total Europe*** | **7,535,431** | ***10,856,013*** | **79,286** | | **4,340,825 (Greece excl.)** | **17,303,593 (Greece excl.)** |

1. "The Statistical Yearbook of Bosnia-Herzegovina (1983) gives 400,000 ha (*i.e.* 11% of the country area) as the total surface area covered by wetlands in the country. No precision is given on how this estimate was made" (Nivet & Frazier 2004).
2. Under-estimated minimum: data only available for the Rhone watershed, *i.e.* one-quarter of the country. Wetland extent (in ha.) is for the full country.
3. Includes Montenegro and Kosovo, still united at the time the estimate was produced.
4. Highest figure includes floodplains; lowest figure only strict wetlands outside floodplains.

| **1b** | **Wetland surface (ha)[1]** | | **Minimum n° of wetlands** | **Source or method used for figures (or range) proposed** *additional useful sources within brackets, italics* |
|---|---|---|---|---|
| | **Estimate** (or lower range limit) | **Upper range limit** | | |
| Morocco * | 298,700 | | 185 | Kapanidis 2008 *(Dakki & El Hamzaoui 1997)* |
| Algeria | 1,500,000 | 3,000,000 | 1475 | This study; based on Ramsar site list and DGF 1999, 2001, 2002, 2004 |
| Tunisia ** | 1,269,031 | | 254 | Hughes *et al.* 1994, 1997 |
| Libya | 400,000 | 1,000,000 | 66 | This study; derived using Defos du Rau *et al.* 2003, Azafzaf *et al.* 2005, 2006, Etayed *et al.* 2007 *(also Anonymous 2012)* |
| Egypt | 3,500,000 | 4,500,000 | 13 | This study ; derived using Hughes & Hughes (1992) |
| Israel & Palestine | 35,000 | 100,000 | 13 | This study; derived using Evans 1994, Scott 1995, and recent IBA data online (http://www.birdlife.org/datazone/site/search#) |
| Jordan | 50,000 | 200,000 | 14 | |
| Lebanon | 1500 | 4000 | 8 | |
| Syria | 200,000 | 400,000 | 25 | This study; derived using Evans 1994, Scott 1995, Murdoch *et al.* 2004 and recent IBA data online (http://www.birdlife.org/datazone/site/search#) |
| **Sub-Total N Africa + Middle-East** | **7,254,231** | **10,771,731** | **2013** | |
| **TOTAL** without oases | **14,789,662** | **21,627,744** | **81,299** | |
| **TOTAL** incl. oases | **15,101,412** | **21,939,494** | | |

1. Oases are excluded from national totals in Table 1B, as their coverage in national inventories was very heterogeneous between countries. They are accounted for separately in the grand total using Toutain *et al.* (1989).

zier 2004) wetland inventories. The review collected systematically, whenever available, national data on:

- current surface areas of wetlands in Mediterranean countries;
- the relative importance of natural *vs.* artificial wetlands;
- absolute losses (or rates of loss) of natural wetlands over the 20th century, or part of it, or since the late 19th century, depending on availability.

The reference period was the year 2000 ±10 years, *i.e.* inventory data covering 1990-2010 was used. In a few cases when no other data was available, a few older data were used. The review covered national and international wetland inventories, previous compilations and online databases (Table 1), as well as specific syntheses or official statistics on some wetland types: oases (Toutain *et al.* 1989), ricefields (FAO-STAT 2012), dams (Margat & Treyer 2004) (Table 2). The MedWet Web Information System (MedWet-WIS; www.wetlandwis.net), a database designed to help update wetland inventories, was also consulted; its contents were summarized by Kapanidis (2008).

The sources used for each country are provided in Table 1. Ten countries had comprehensive national inventories (or lists), which provided precise wetland numbers and surface areas. Seven countries had preliminary or regional inventories, which helped build reliable ranges for surface areas. For the remaining eleven countries, basic data was derived from several non-comprehensive sources. For this, we combined data from continental inventories that cover only the most important sites in each country (*e.g.* Hughes & Hughes 1992 for Africa; Scott 1995 for the Middle East), with data from constantly updated, online lists of both Ramsar sites (www.ramsar.org) and IBAs (Important Bird Areas: Heath & Evans 2000; Evans 1994; www.birdlife.org). Data from specific surveys (*e.g.* Murdoch *et al.* 2004 for Syria) were also integrated.

## Calculations

### Wetland surface area per country

We used the figures from comprehensive national inventories with reliable totals when they were available. When this information did not exist, simple calculations were performed in order to produce estimated ranges. Figures from the non-comprehensive sources described above were first corrected for the inclusion of sometimes large percentages of non-wetland habitats in the registered sites, based on published or online site descriptions. For instance, the Ramsar sites in Algeria, when corrected using the Department of Forestry (DGF) figures from 1999, 2001, 2002 and 2004, gave an actual wetland surface area of only 30% of the indicated total surface area.

In a second step, and taking the sum of these corrected surfaces as a national minimum, ranges were then proposed for each country. For this, we first assessed from qualitative information provided in the sources the likely degree of completeness of these partial lists, before assigning a conservative range (*e.g.* [m, 2m], [m, 3m], [m, m+1 million ha]; where m represents the minimum surface area calculated from the non-exhaustive sources). Ranges rather than figures were also proposed in a few other cases, when several figures from independent sources existed for one country, or when published figures were obviously underestimates (*e.g.* when some wetland types were explicitly omitted). In the pan-Mediterranean compilation, these ranges were used in conjunction with the precise figures existing from well-inventoried countries.

Finally, even in a few relatively well inventoried countries (Spain, Italy, Macedonia) some wetland types were largely omitted, notably most ricefields. Figures were thus corrected by adding surfaces for this artificial habitat, obtained from other sources (FAO-STAT 2012).

### Artificial vs. natural wetlands

To assess their relative importance, and as comprehensive data does not exist for all 27 countries, we used a two-step approach. First, for all the countries (*i.e.* 12) where there was sufficiently detailed information on surface areas for each of these main wetland types, we calculated the ratio "Artificial wetlands surface/Total wetland surface", for each country separately and overall (Table 3). Secondly, in order to check whether this overall ratio – valid for 12 countries – would be a correct order of magnitude for the whole Mediterranean, we cross-checked it with separate, independent sources of data. We used specific statistics that exist for the whole basin for some of the main artificial wetland types

***Table 2 – Minimum surfaces and number of some artificial wetland types in the Mediterranean.***

| | Surface of Oases (ha) | Surface of ricefields (ha) | Minimum n° of reservoirs | Minimum surface of reservoirs (ha) |
|---|---|---|---|---|
| Albania | - | | 507 | 17,875 |
| Bosnia-Herzegovina | - | | 29 | ? |
| Bulgaria | - | 6808 | 2530 | 39,500 |
| Croatia | - | | 24 | 5966 |
| Cyprus | - | | 29 | 320 |
| France *( Medit. Watershed only)* | - | 19,933 | 155 | 15,000 |
| Greece | - | 27,653 | 25 | 35,824 |
| Italy | - | 232,165 | 145 | ? |
| Macedonia | - | 2874 | 19 | 6391 |
| Portugal | - | 26,356 | 9 | 33,969 |
| Slovenia | - | | 72 | 2700 |
| Spain | 150 | 110,858 | 1024 | 250,000 |
| Turkey | - | 95,467 | 500+ | 380,000 |
| Serbia-Montenegro-Kosovo | - | | ? | ? |
| Morocco | 80,000 | 6233 | 90 | 80,000 |
| Algeria | 93,000 | 184 | 44 | ? |
| Tunisia | 36,000 | | 21 | 28,479 |
| Libya | 63,000 | | 16 | 800 |
| Egypt | 50,000 | 627,985 | 10 | 581,000 |
| Israel & Palestine | 600 *for the "Middle East"* | | 1 | ? |
| Jordan | | | | 400 |
| Lebanon | | | 2 | 1000 |
| Syria | | | 142 | 82,000 |
| **Minimum Total** | **311,750** | **1,156,516** | **5397** | **1,561,224** |

*Sources: national and continental wetland inventories, as listed in Tables 1 and 3, as well as Margat & Treyer 2004 for reservoirs, Toutain* et al. *1989 for oases and FAO-STAT 2012 for ricefields (average for 2005-2010).*

***Table 3 – Proportion of artificial wetlands in 12 Mediterranean countries.*** *The figures in the 2nd column represent the surface over which data on the relative share of natural/artificial wetlands is available; note that it is not necessarily equal to the total surface of wetlands in the country as provided in Table 1.*

| | Wetland surface (ha) | Surface artificial wetlands (ha) | % artificial wetland | Sources |
|---|---|---|---|---|
| Albania | 96,803 | 19,449 | 20% | Mima *et al.* 2003 |
| Bulgaria | 104,750 | 40,197 | 38% | Michev & Profirov 2003; Michev & Stoyneva 2007 |
| Croatia | 390,885 | 20,050 | 5% | MEPPP 2003 |
| Cyprus | 9913 | 320 | 3% | Derived from Heath & Evans 2000 |
| France *( 4 départements only : Var, Gard, Herault and Bouches du Rhone)* | 174,439 | 72,033 | 41% | Gomila & Peyre 2004; Bousquet & Willm 2001; Anonymous 2006; Biotope 2004 |
| Greece | 202,618 | 58,236 | 29% | Zalidis & Mantzavelas 1995 and FAO-STAT 2012 |
| Macedonia | 59,291 | 8429 | 14% | Micevski 2002; FAO-STAT 2012 |
| Portugal | 130,943 | 36,569 | 28% | Farinha & Trindade 1994 |
| Slovenia | 35,409 | 22,239 | 63% | Water Management Institute 2000 |
| Spain | 491,900 | 377,900 | 77% | Casado & Montes 1995; Nivet & Frazier 2004; FAO-STAT 2012 |
| Turkey | 2,062,000 | 493,000 | 24% | Ministry of Environment and Forestry 2007; M.Ataol/ DogaDernegi 2011, *pers. comm.* |
| Tunisia | 1,269,031 | 28,479 | 2.2% | Hughes *et al.* 1994, 1997 |
| **TOTAL** | 5,027,982 | 1,176,901 | 23.4% | |

(Table 2): for salinas, Sadoul *et al.* (1998) corrected for printing errors (N. Sadoul, *pers. comm.* 2010); for oases, Toutain *et al.* (1989); and for ricefields the Food and Agriculture Organisation (FAO) statistics (*e.g.* FAO-STAT 2012). Similar comprehensive data on national surfaces of artificial reservoirs could not be found for all 27 Mediterranean countries (only for 20), as national and pan-Mediterranean statistics usually focus on their storage capacity instead (*e.g.* Margat & Treyer 2004). The total for all these artificial wetland types was then compared to the expected artificial wetland area, then the precise ratio calculated for 12 countries was extrapolated to the whole Mediterranean basin (27 countries).

### Change of extent of natural wetlands over the 20th century

Recorded changes per country were compared (in relative terms) to the area of existing wetlands. When computing losses, we took into account the conversion of natural wetlands to artificial types (*e.g.* ricefields, dams…) since, despite being of some ecological value, especially for waterbirds, these artificial habitats do not fully compensate the loss of natural wetlands (*e.g.* Green *et al.* 2002).

## Cross-checking with land-cover GIS data: CORINE Land-Cover

We used land-cover data for the northern part of the Mediterranean region, as a way to cross-check the information derived from the literature and Internet survey. The European Environment Agency (EEA) has been monitoring land-cover since 1990 through the interpretation of satellite images, from which maps are derived using the CORINE Land-Cover (CLC) system. We extracted land-use data from the online database (http://sia.eionet.europa.eu/CLC2006). Data were available for 16 countries for 2006, *i.e.* the whole area north of the Mediterranean (including Turkey) except Greece and Monaco. We considered as "wetlands" the CLC categories 4 ("Wetlands") and 5 ("Water bodies", excluding subcategory 523 "Open sea and oceans"), as well as 213 "Ricefields".

# Results

## Surface and number of existing Mediterranean wetlands

### Surface

At the turn of the 21st century (year 2000 ± 10 years), the Mediterranean hosted a minimum of 81,000 wetlands, covering between 15 and 22 million hectares (Table 1). This represents 1.7 to 2.4% of the total area of the 27 countries. This percentage varies between countries, from <0.5% in Lebanon and Malta, to 8.2% in Tunisia (Figure 1). About half the surface area of wetlands was found in the Northern Mediterranean (incl. Turkey) and the other half was in North Africa and the Middle East.

### Number

The alternative of using either the number or the total surface area of wetlands for comparing countries leads to contrasted results (Table 1). For instance Egypt, which likely has the largest wetland area of all Mediterranean countries (over 3.5 million ha) would appear to have only 13 wetlands, whereas *e.g.* Slovenia has over 3,500 wetlands, but they cover less than 100,000 ha. Similarly, France, where the results of many local, detailed inventories (down to the level of individual small pools) were aggregated, apparently harbours the majority of Mediterranean wetlands (>58,000 out of 81,000).

### Weight of the largest Mediterranean wetlands

Based upon existing inventories, the largest known wetlands (>100,000 ha) are mainly deltas and large, temporary chotts and sebkhas of North Africa, as well as some lakes and reservoirs.

The Nile delta is the largest wetland in the region, with *c.* 2.3 million ha (10-14% of all Mediterranean wetlands). Other large deltas include the much smaller Guadalquivir (Spain: 165,500 ha), Po-Adige (Italy: 150,000 ha) and Rhone delta (France: 145,000 ha). The largest chott in North Africa is Chott El Jerid in Tunisia, which jointly with Chott el Fedjadj (very close and often listed together) covers 495,000 ha. In Algeria, Chott Melghir/Chott Merrouane similarly cover together 275,000 ha, and Chott Ech Chergui *c.* 150,000 ha. These chotts seldom fill up completely, so most of these surfaces remain dry in most years. In Egypt, the Qattara depression covers 300,000 ha and the Tawargha sebkha in Libya *c.* 230,000 ha. Other very large wetlands include the huge reservoir of Lake Nasser (Egypt: Aswan dam) with 581,000 ha, and in Turkey the lakes Van (375,500 ha) and Tuz Gölü, the largest salt lake in central Anatolia (*c.* 160,000 ha).

Collectively, these 14 wetlands cover 5.3 million ha, or 25 to 36% of the 15-22 million ha of wetlands found in the Mediterranean basin.

### Artificial vs. natural wetlands

The 12 countries (or parts of countries) with sufficient data to assess the relative importance of artificial vs. natural wetlands represent over 5 million ha of wetlands in total, *i.e.* one quarter of the regional total (Table 3). Depending on countries, artificial wetlands represent between 2 and 77% of national totals. For these 12 countries taken jointly, *c.* 23% of their existing wetlands are artificial. Extrapolating this ratio with caution to the whole Mediterranean basin, with its 15-22 million ha of wetlands, would suggest the existence of 3.5 to 5.1 million ha of artificial wetlands.

Separately, pan-Mediterranean statistics for the main artificial wetland types (Table 2) identify *c.* 75,000 ha of saltpans active in the Mediterranean in the mid 1990's (Sadoul *et al.* 1998; N. Sadoul, *pers. comm.*); over 1.1 million ha of ricefields (FAO-STAT 2012); at least 1.5 million ha of reservoirs (Margat & Treyer 2004 and national sources cited in Table 1 – incomplete data[1]), and *c.* 312,000 ha of oases (Toutain *et al.* 1989). The combined total, *c.* 3.1 million ha, is clearly an underestimate due to the lack of statistics on reservoirs for 7 countries, and of pan-Mediterranean data for all other artificial habitats (*e.g.* fish-ponds, sand or gravel pits, waste water treatment ponds, industrial lakes…). It is therefore fully compatible with the results that an extrapolation from a sample of 12 countries would suggest, *i.e.* 3.5 to 5.1 million ha of artificial wetlands. This convergence suggests that approximately one quarter (*c.* 23%) of the wetlands in the Mediterranean basin are artificial wetlands.

1. Data cover only 20 of 27 Mediterranean countries, and one of them only partly.

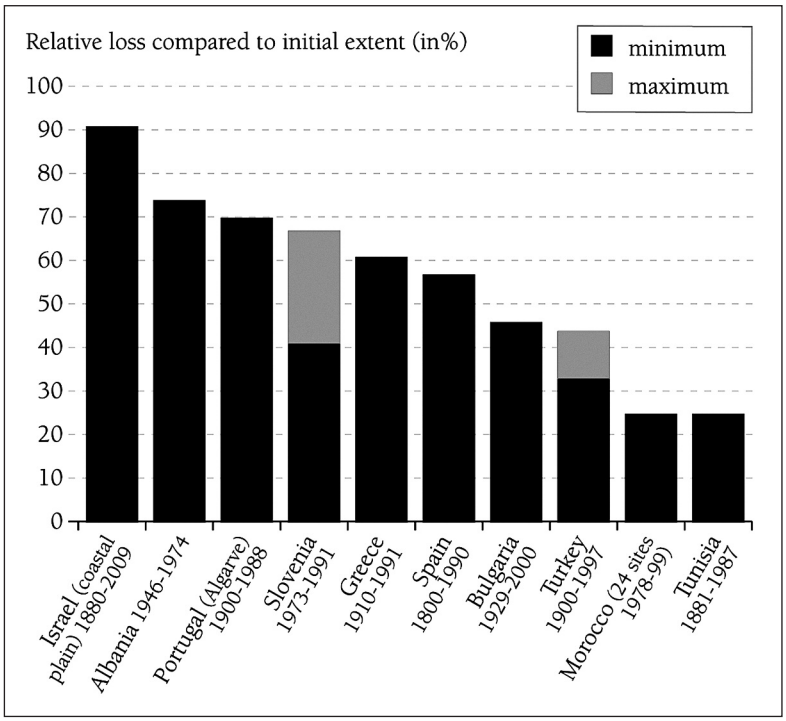


***Figure 2 – Loss of natural wetland area in selected Mediterranean countries/provinces in (mainly) the 20th century.***
*Sources as in Table 1, plus Pullan (1988) and Psilovikos (1992). Note that (1) some of these losses include conversion from natural to artificial wetlands,* e.g. *ricefields, reservoirs…; and (2) although figures for Spain span almost 200 years, the original source highlights that the great majority were lost in the 20th century.*

## Changes in existing wetlands

At national scale, recorded changes involved only wetland losses. Figures for such losses were produced over different periods in different countries (Figure 2), which prevents the calculation of an overall percentage or total figure of loss over a given period. In some countries the "minimum losses" registered included the conversion of natural to artificial wetlands, *e.g.* in Bulgaria the loss includes 23,713 ha of "net loss" in addition to 35,000 ha of losses due to conversions, largely to reservoirs (Michev & Stoyneva 2007). However; wetland loss was not specified in most countries.

Wetland loss is not affecting all types of wetlands equally. For instance in Spain, there was 60% overall wetland loss between 1800 and 1990, but this ranged from small loss for mountain and karstic wetlands, to larger losses for inland saline, coastal, inland freshwater and floodplain wetlands (23%, 60%, 68% and 80% respectively) (Casado & Montes 1995).

## Cross-checking with CORINE Land-Cover data

CLC data can be compared with other, national sources (Table 1a). Overall, CLC produced a wetland area of 4.3-17.3 million ha for the 16 countries encompassed, depending on the inclusion of meadows or not. This range is much larger than – but compatible with – the range derived from the literature review (7.3-10.6 million ha) for the same countries. In countries like France that have very large extents of meadows, the resulting range in wetland surface using CLC is very broad: between 0.6 and 9.3 million ha. Conversely, some national ranges produced by both methods are highly consistent, *e.g.* in Spain, Turkey, Albania, Malta, and to a lesser extent Italy. Still in other countries, where good inventories exist, CLC ranges (without/with meadows) do not overlap the estimated ranges or figures we produced. Depending on countries, CLC either over-estimates the extent of wetlands (*e.g.* Bulgaria and possibly Portugal), or under-estimates them (*e.g.* Croatia, Cyprus). The bias is therefore not systematic.

The CLC maps also allow an estimation of the main habitat types present in the 16 countries covered in 2006 (±1 yr) (Figure 3). In addition, "Meadows" cover an extra 13 million ha, but the relative proportion of "Wet meadows" (which are wetlands) and "Dry meadows" (which are not) among this total is unknown, as CLC does not separate them. Thus, wet meadows are potentially one of the most abundant wetland types in Euro-Mediterranean countries. "Water bodies", *i.e.* freshwater lakes and reservoirs, appear as the second most prominent wetland type (2.1 million ha) followed by ricefields (0.8 million ha), water courses and inland marshes (almost 0.5 million ha each). Lagoons, estuaries, salinas etc. cover smaller extents. CLC figures can be compared with independent, official statistics for ricefield surfaces, which are specifically monitored by the Food and Agricultural Organisation (FAOSTAT 2012). Based upon this source, average ricefield cultivated area in 2005-07 was 5164 ha (Bulgaria), 17,418 ha (France), 227,531 ha (Italy), 2471 ha (Macedonia), 24,746 ha (Portugal), 109,083 ha (Spain) and 92,633 ha (Turkey). Conversely, CLC produced totals for the same period that were systematically higher than national statistics, by factors of 2.8, 2.1, 1.3, 2.1, 2.1, 1.3 and 2.7, respectively. These results were statistically significant (Sign test; N=7 countries; p=0.02).

## Discussion

### Mediterranean wetlands: 1.5% of a global resource

Using the worldwide estimates of wetland surface area from Finlayson & Davidson (1999) that range from 748-778 million ha (excluding salt marshes, coastal flats, seagrass meadows, karsts, caves and reservoirs) to 1.2-1.3 billion ha, the Mediterranean basin hosts approximately 1.5% of the global wetlands (18.5 ± 3.5 million ha). The total surface area is approximately 4 times higher than the 4.5 million ha of wetlands recorded by Caessteker (2007) in his review of the 16 best-known countries. Wetlands are under-represented in the Mediterranean region, compared to global averages: the 27 countries represent 6.6% of all emerged lands on Earth outside Antarctica, but only 1.5% of the wetlands. This is partly due to various Mediterranean countries (North Africa, Middle-East) lying mainly in desert or semi-desert bioclimates.

Approaches for estimating wetland surfaces in the Mediterranean are still very crude, especially for countries that do not have a detailed national inventory. Even among countries which have detailed inventories, methods are not yet rigorously comparable between countries, especially in terms of what is included in the "wetland" definition. Some inventories focus on "natural" wetlands only, and exclude large lakes, reservoirs and ricefields, while others include them systematically. In other cases only wetlands or ornithological importance are included. For this reason, it was important to cross-check, or to complete if necessary, data from national inventories with other sources (for example ricefield surface areas or reservoirs). Despite the variety of methodologies that exist, we considered it possible to draw a preliminary, overall picture, using conservative ranges where no detailed inventories existed. In order to reduce these biases, it is likely that future attempts at monitoring wetland surface area in the Mediterranean region will increasingly use results from satellite image analysis, as was recently done at global scale (Prigent *et al.* 2012).

The apparent discrepancy between the pictures provided by either the number or the surface area of wetlands results from two causes. The first one is the degree of completeness of inventories: still basic and preliminary, covering only the largest sites in various countries, *e.g.* Egypt, but very detailed in others, *e.g.* Slovenia. The second reason is a highly heterogeneous treatment between countries of what is counted as "one wetland" in wetland inventories. For instance the huge Nile delta is treated as a single wetland in the African wetland inventory used for Egypt (Hughes & Hughes 1992), whereas the Rhone delta (Camargue, France), although 15 times smaller, has been subdivided into at least 27 wetland units in the detailed regional inventories of southern France, therefore counting as "27 wetlands". In conclusion, comparing countries on the basis of the total number of wetlands can be misleading due to potentially strong biases. We suggest that the total surface area, which appears more robust, be used instead for comparisons.

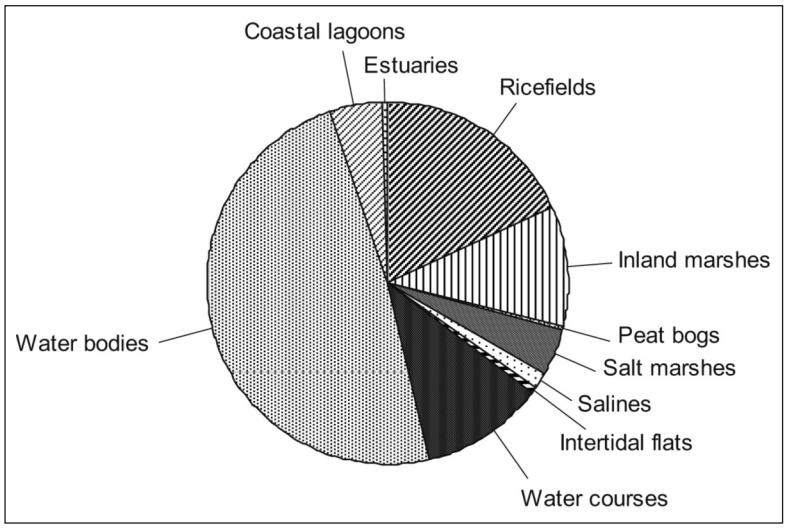


***Figure 3 – Main wetland types in 16 Euro-Mediterranean countries in 2006 (± 1 yr), calculated from CORINE Land-Cover data.***
*(N = 4.3 million ha; source: http://sia.eionet.europa.eu/CLC2006), excluding meadows (see text).*

### Continuous wetland loss during the last century

National inventories and other studies attempted to quantify past wetland losses over different time periods in different countries, with a variety of methods. It is therefore not yet possible to pool national results into a reliable, synthetic figure that encompasses all losses in the Mediterranean region. However, existing national or sub-national datasets (Figure 2) suggest that the region has probably lost *c.* 50% of its wetlands during the 20th century. The Mediterranean basin seems to have followed the global trend, since world-

wide loss over the same period has also been estimated at 50% (Finlayson & Davidson 1999). Part of these losses includes an unspecified percentage of conversion to artificial wetland types (reservoirs, ricefields…).

The loss of some wetland types may be hard to detect, which may lead to under-estimating true losses. In the arid areas of North Africa and the Middle East, large inland temporary wetlands (*e.g.* chotts, sebkhas…) do not flood every year. Even in the absence of any human impact, they may remain naturally dry for 10-20 years over most of their surface area. A reduction in flooding intensity and/or frequency may occur, *e.g.* through water diversion schemes in the watershed, without land-use or vegetation changes occuring within the wetland. So, although parts of the chott/sebkha may be functionally lost as a "wetland" through persistent lack of flooding, this may go undetected for decades. Given the increasing human pressures on water resources in the southern and eastern parts of the Mediterranean (Plan Bleu 2009; Margat & Treyer 2004), combined with climate change (Giorgi & Lionello 2008), there is a potential for the very large wetlands lying in the arid part of the basin to be particularly affected. Careful evaluation and quantification would be required in relevant countries.

Losses of natural wetlands have not been assessed comprehensively in all countries. Published figures (or percentages) often refer only to known losses: the real surfaces lost are therefore higher. Turkey is likely to be one of the countries which has lost the most wetlands in the 20th century, *i.e.* at least 1.3 million ha (Magnin & Yarar 1997; Karadeniz *et al.* 2009). However, similar assessments are lacking in other large countries (*e.g.* Egypt, France) where large extents of natural wetlands were also lost. For instance in the Nile delta, apart from the largest lagoons connected to the sea, virtually all natural wetlands have been turned into agriculture land (Hughes & Hughes 1992). Similarly in the Maghreb, large wetland areas were lost during colonial times (1850-1930) (*e.g.* in the Gharb in Morocco; in the Mitidja plains in Algeria: Sergent & Sergent 1947; DGF 1999), but remain undocumented in terms of precise surface area. Because of their size, small wetlands such as temporary pools are often neglected in basic wetland inventories and studies of wetland losses. But where data exist, their loss has been very high, often in the order of 60-90% (*e.g.* Saber 2006 and Saber *et al.* 2008 for Morocco, and Levin *et al.* 2009 for Israel).

Two main causes drive the disappearance of Mediterranean wetlands, often acting together: the human needs for land and for water. In the first case, wetlands are intentionally reclaimed for agricultural, residential or industrial land conversions or for transportation infrastructures. Numerous examples come from Spain (Casado & Montes 1995), Greece (Handrinos 1992), Lebanon (Scott 1995), Israel (Hambright & Zohary 1998), Turkey (Karadeniz *et al.* 2009). The second driver, *i.e.* the need for water, causes over-abstraction upstream of wetlands or from the underlying water-table, which leads to their gradual drying-up. Again, numerous cases come from Jordan (Al Zu'bi 1996), Turkey (Dadaser-Celik *et al.* 2008), Spain (Cirujano 1996) etc. In the past, sanitary reasons were also an important driver, *e.g.* for the eradication of diseases (*e.g.* Sergent & Sergent 1947; Hambright & Zohary 1998; Handrinos 1992). Climate change is likely to become increasingly important driver as it may reduce the total amount of rainfall and affect its distribution in space and time (IPCC 2007, Giorgi & Lionello 2008; Plan Bleu 2009; EEA 2009b).

There are quantitative evidences that wetland losses continue. A recent study on a sample of 24 wetlands in Morocco showed a decrease in their area of 25% in 21 years, at the end of 20th century (Green *et al.* 2002). In Turkey the Sultansazligi marshes, despite being designated as a Ramsar site, have virtually dried out in recent decades, following water abstraction upstream (Dadaser-Celik *et al.* 2008), as have other large wetlands in central Anatolia (Gramond 2002). In Libya recent studies have shown a loss of 4647 ha (3% of the existing total) of wetlands of ornithological importance in just 5 years, between 2005 and 2010 (Anonymous 2012). Wetland loss is therefore not a phenomenon restricted to the distant past: it continues even in the recent past decades, as also demonstrated at global scale (Prigent *et al.* 2012).

## Importance of artificial wetlands in the Mediterranean

Over the 20th century, the creation of many artificial wetlands took place, partly over former natural wetlands. These wetlands are

treated differently in each country, with some countries listing all artificial wetlands (*e.g.* Slovenia, Albania) while others largely omit them (*e.g.* Spain; Casado & Montes 1995). However, this could be circum-vented thanks to existing, independent statistics on these man-made habitats. With a necessary caution due to a European bias in existing data, artificial wetlands now represent about one quarter of the total surface area of Mediterranean wetlands. They are principally made of reservoirs and ricefields. In some countries (*e.g.* Slovenia, Spain) artificial wetlands may now represent up to 2/3 or 3/4 of the total wetland area. For instance, in the Ebro Delta (Spain), 210 $km^2$ of the 320 $km^2$ total wetland surface area are now ricefields. This is a huge conversion compared to the 300 $km^2$ that were natural habitats in 1860 (Martinez-Vilalta 1996).

Therefore, when assessing the extent of wetlands in a given country, one should carefully watch for the proportion of these special wetland types, which may bias the picture. Some are of high ecological value, especially for waterbirds (*e.g.* Sadoul *et al.* 1998; Tourenq 2000; Tourenq *et al.* 2001), but others have destroyed irreplaceable natural marshes, floodplains, pools, etc.

### CORINE Land-Cover data: still too limited for monitoring wetlands

Land-cover maps derived from satellite images are often seen as a promising way to monitor the existing wetlands. This has been done successfully on large wetland sites that have suffered important and rapid losses (*e.g.* Gramond 2002; Dadaser-Celik *et al.* 2008; Ernoul *et al.* 2012). However, our comparisons between national inventories for Euro-Mediterranean countries and CLC maps highlight that the application of the method at larger scale is still not well established, as can be illustrated with 3 wetland habitats.

Probably the main limitation of CLC is that it does not distinguish yet between wet and dry meadows. In countries like France that have large extents of both, and where partial data suggest that wet meadows may actually be the dominant wetland type (Cizel 2010), the resulting range in wetland surface area is extremely broad (by a factor 15; Table 1) because of an unknown percentage of wet meadows within the CLC category "Meadows". Other wetland types are clearly under or over-estimated by CLC, too. For instance, France has between 60,000 and 100,000 ha of peat-bogs (Pôle Relais Tourbières 2011), rather than the 6,800 ha detected by CLC. This may be due to the fact that CLC only maps land-cover patches of a size superior to 25 ha (*e.g.* SoES 2011): most peat-bogs are too small to be detected, and/or occur under tree cover. On the other hand, CLC tends to over-estimate the areas covered by other wetland types like ricefields.

Based upon these examples, CLC figures should be taken cautiously when assessing, for a given country or the whole northern Mediterranean region, the main wetland types and their relative importance. They may provide a first approximation when no other data is available, but detailed comparisons within a few well-inventoried countries would be required to identify the cause for the variable and unsystematic discrepancies that exist between countries (see Table 1). These differences may lay either in CLC or in the heterogeneity of national inventories.

## Conclusion

A first, conservative range for the extent of wetlands in the pan-Mediterranean region is now available, synthetising the information from both well-inventoried countries and areas without a wetland inventory. Future improvements will require launching or publishing wetland inventories in areas with limited data available such as Algeria, Bosnia-Herzegovina, Cyprus, Egypt, Israel, Jordan, Kosovo, Lebanon, Libya, Montenegro, Morocco, Palestine, Serbia, Syria and Turkey. In some countries local/regional inventories exist (*e.g.* in France, Italy, Spain) but a full national synthesis, bridging the remaining gaps and/or the methodological variability, is still awaited.

Wetland losses are even less well-known than existing wetlands. Nevertheless, data for a sample of countries suggests that around half of the wetlands have been lost in the course of the 20th century. Quantifying these past losses by using old maps has not been attempted on a large scale (but see an example in Levin *et al.* 2009). This would probably prove very valuable for areas like North Africa, which lost large areas of wetlands 80-150 years ago. Wetland loss continues nowa-

days and conservation actions are still deeply needed. National programmes to monitor trends in wetland surface area are required in all countries, even where good national inventories exist. This would provide the necessary information to confirm whether wetland loss has slowed or eventually stopped following conservation actions.

Large-scale land-cover maps such as CLC do not yet fulfil their promises for monitoring national wetland areas. But other approaches combining satellite images over a large sample of wetlands with other sources of information, such as digital elevation models, are starting to provide potential tools for monitoring wetland areas at pan-Mediterranean scale (Hüttich *et al.* 2012). An alternative that remains to be tested regionally would be to monitor the extent of flooded areas – as a proxy to wetland extent –, as recently undertaken by Prigent *et al.* (2012) at global scale.

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## References

Anonymous, 2006. *Inventaire départemental des zones humides de l'Hérault.* Montpellier, France, Aquascop/Écologistes de l'Euzière, 113 p.

Anonymous, 2012. *Atlas of wintering waterbirds of Libya.* Tunis, EGA-RAC/SPA, 306 p.

Azafzaf H., Baccetti N., Defos du Rau P., Dlensi H., Essghaier M.F., Etayed K., Hamza A. & Smart M., 2005. *Report on an Ornithological Survey in Libya from 3 to 17 January 2005.* Tunis, UNEP-RAC/SPA, 90 p.

Azafzaf H., Baccetti N., Defos du Rau P., Dlensi H., Essghaier M.F., Etayed K., Hamza A. & Smart M., 2006. *Report on an Ornithological Survey in Libya from 19 to 31 January 2006.* Tunis, UNEP-RAC/SPA, 32 p.

Biotope, 2004. *Inventaire des zones humides du département du Gard*. Nîmes, France, Conseil général du Gard, 48 p.

Bousquet C. & Willm L., 2001. *Inventaire préliminaire des zones humides des Bouches-du-Rhône.* Arles, France, Tour du Valat, 79 p.

Caessteker P., 2007. *Synthèse du statut des inventaires de zones humides dans la région méditerranéenne*. Marseille, France, Tour du Valat/MedWet/Université de Provence, 245 p.

Casado S. & Montes C., 1995. *Guia de los lagos y humedales de Espana*. Madrid, Reyero J.M., 243 p.

CBD, 2006. *Framework for monitoring implementation of the achievement of the 2010 target and integration of targets into the thematic programmes of work.* (Decision VIII/15, COP 8, 2006); available at www.cbd.int/decisions/

CEPF, 2010. *CEPF Ecosystem profile of the Mediterranean Basin Biodiversity Hotspot*. Washington, Conservation International, 251 p.

Cirujano S., 1996. Las Tablas de Daimiel, Spain. *In:* Morillo C. & Gonzalez J.L. (eds), *Management of Mediterranean Wetlands*. Vol. II. Madrid, MedWet/Ministerio de Medio Ambiente: 295-310.

Cizel O., 2010. *Protection et gestion des espaces humides et aquatiques. Guide juridique d'accompagnement des bassins de Rhône-Méditerranée et de Corse.* Lyon, France, Agence de l'eau RM&C/Pôle-relais Lagunes, 600 p. (available online at: http://www.pole-lagunes.org/web/view_section.php?id_section=674&anchorName=2).

Costa L.T., Farinha J.C., Hecker N. & Tomàs-Vives P., 1996. *Mediterranean wetland inventory: a reference manual.* Lisbon, MedWet/ICN/Wetlands International, 111 p.

D'Antoni S., Battisti C., Cenni M. & Rossi G.L., 2011. *Contributi per la tutela della biodiversità delle zone umide.* Roma, Ispra report 153/11, 461 p.

Dadaser-Celik F., Bauer M.E., Brezonik P.L. & Stefan H.G., 2008. Changes in the Sultan Marshes Ecosystem (Turkey) in Satellite Images 1980-2003. *Wetlands* 28: 852-865.

Dakki M. & El Hamzaoui M., 1997. *Rapport national sur les zones humides, Maroc*. Rabat, Institut scientifique, 33 p.

De Maria G. (ed.), 1992. *Inventario delle zone umide del territorio italiano.* Roma, Ministerio dell'Ambiente, Servizio Conservazione della Natura, 263 p.

Defos du Rau P., Essghaier M.F. & Etayed K., 2003. Inventaire préliminaire des zones humides de Libye. *Faune Sauvage* 259 : 44-48.

DGF (Direction générale des forêts d'Algérie), 1999. *Atlas des zones humides algériennes.* Alger, Direction générale des forêts/MedWet, 45 p.

DGF (Direction générale des forêts d'Algérie), 2001. *Les zones humides – un univers à découvrir*. Alger, Direction générale des forêts/MedWet, 49 p.

DGF (Direction générale des forêts d'Algérie), 2002. *Atlas des 26 zones humides algériennes d'importance internationale.* Alger, Direction générale des forêts, 89 p.

DGF (Direction générale des forêts d'Algérie), 2004. *Atlas [IV] des zones humides algériennes d'importance internationale.* Alger, Ministère de l'Agriculture et du Développement rural/Direction générale des forêts, 107 p.

EEA, 2009a. *Progress towards the European 2010 biodiversity target.* Copenhagen, European Environment Agency Report nº4/2009, 52 p.

EEA, 2009b. *Water resources accross Europe – confronting water scarcity and drought.* Copenhagen, European Environment Agency nº2/2009, 55 p.

Ernoul L., Sandoz A. & Fellague A., 2012. The evolution of two great Mediterranean Deltas: Remote sensing to visualize the evolution of habitats and land use in the Gediz and Rhone Deltas. *Ocean & Coastal Management* 69: 111-117.

Etayed K., Essghaier M.F., Hamza A., Smart M., Azafzaf H., Defos du Rau P. & Dlensi H., 2007. *Report on an ornithological survey in Libya from 3 to 15 February 2007.* Tunis, UNEP-RAC/SPA, 40 p.

Evans M.I., 1994. *Important Bird Areas in the Middle East.* Cambridge, UK, Birdlife International Conservation Series nº 2, 410 p.

FAO-STAT, 2012. *World rice statistics.* Extracted from the public database http://faostat3.fao.org/home/index.html#DOWNLOAD/on 30 July 2012.

Farinha J.C. & Trindade A., 1994. *Contribuição para o inventário e caracterização de zonas húmidas em Portugal continental.* Lisboa, Instituto da Conservação da Natureza/MedWet, 211 p.

Finlayson C.M., Hollis T. & Davis T. (eds), 1992. *Proceedings of the Symposium on* "*Managing Mediterranean wetlands and their birds*", Grado, Italy, 6-9 February 1991. IWRB Special Publication nº20, 285 p.

Finlayson C.M. & Davidson N.C., 1999 (2nd Edition). *Global review of wetland resources and priorities for wetland inventory. Summary Report*. Darwin, Australia, Environmental Research Institute of the Supervising Scientist/Wetlands International. http://www.wetlands.org/RSIS/WKBASE/GRoWI/welcome.html

FOEN, 2009. *The state of biodiversity in Switzerland. Overview of the findings of Biodiversity Monitoring Switzerland as of May 2009.* Bern, Federal Office for the Environment, 28 p.

Giorgi F. & Lionello P., 2008. Climate change projections for the Mediterranean region. *Global Planet Change* 63: 90-104.

Gomila H. & Peyre O., 2004. *Inventaire des zones humides du Var*. Toulon, France, Sémaphores /Mediaterre, 79 p.

Gramond D., 2002. *Dynamique de l'occupation du sol et variation des usages de l'eau en Anatolie centrale (Turquie) au cours du XXe siècle.* Ph.D. Thesis. Paris, La Sorbonne University, 359 p. + annexes.

Green A.J., El Hamzaoui M., El Agbani M.A. & Franchimont J., 2002. The conservation status of Moroccan wetlands with particular reference to waterbirds and to changes since 1978. *Biol. Cons.* 104: 71-82.

Hambright K.D. & Zohary T., 1998. Lakes Hula and Agmon: destruction and creation of wetland ecosystems in northern Israel. *Wetlands Ecol. & Manag.* 6: 83-89.

Handrinos G., 1992. Wetland loss and wintering waterfowl in Greece during the 20th century: a first approach. *In:* Finlayson C.M., Hollis T. & Davis T. (eds), *Proceedings of the Symposium on* "*Managing Mediterranean wetlands and their birds*", Grado, Italy, 6-9 February 1991. IWRB Special Publication nº 20: 183-187.

Heath M.F. & Evans M.I. (eds), 2000. *Important Bird Areas in Europe: Priority sites for conservation.* Cambridge, UK, BirdLife International Conservation Series No. 8, 866 p. + 791 p. (2 vol.).

Hecker N. & Tomàs Vives P. (eds), 1995. *The status of wetland inventories in the Mediterranean region.* Slimbridge, UK, IWRB Publication nº 38, 146 p.

Hughes J.M.R., Maamouri F., Hollis G.E. & Avis C., 1994. *A preliminary inventory of Tunisian Wetlands.* London, University College, Department of Geography, Wetland Research Unit., 453 p. + 126 maps.

Hughes J.M.R., Ayache F., Hollis G.E., Maamouri F., Avis C., Giansante C. & Thompson J., 1997. *A preliminary inventory of Tunisian Wetlands.* London, University College, Department of Geography, 473 p.

Hughes R.H. & Hughes J.S., 1992. *A Directory of African Wetlands.* IUCN, Gland, 820 p.

Hüttich C., Reschke J., Keil M., Dech S., Weise K., Beltrame C., Fitoka E. & Paganini M., 2012. *Using the Landsat Archive for the Monitoring of Mediterranean Coastal Wetlands: Examples from the Glob-Wetland-II Project.* Earthzine. http://www.earthzine.org/2011/12/20/using-the-landsat-archive-for-the-monitoring-of-mediterranean-coastal-wetlands-examples-from-the-globwetland-ii-project/

IPCC, 2007. *Climate Change 2007: Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Geneva, IPCC, 104 p.

Kapanidis Y., 2008. *Statistics on wetlands stored in the MedWet Web Information System* http://www.wetlandwis.net/ Thessaloniki, Greece, EKBY/MedWet/INTERREG IIIC, 5 p.

Karadeniz N., Tiril A. & Baylan E., 2009. Wetland management in Turkey: problems, achievements and perspectives. *Afr. J. Agr. Res.* 4: 1106-1119. (Available online at http://www.academicjournals.org/ajar).

Levin N., Elron E. & Gasith A., 2009. Decline of wetland ecosystems in the coastal plain of Israel during the 20th century: Implications for wetland conservation and management. *Landscape and Urban Planning* 92: 220-232.

Magnin G. & Yarar M., 1997. *Important bird areas in Turkey.* Istanbul, Society for the Protection of Nature, 313 p.

Margat J. & Treyer S., 2004. *L'eau des Méditerranéens : situation et perspectives.* Athens, UNEP/MAP, Technical Report Series nº 158, 366 p.

Martinez-Vilalta A., 1996. The rice fields of the Ebro Delta. *In:* Morillo C. & Gonzalez J.L. (eds), *Management of Mediterranean Wetlands*. Vol. II, Madrid, MedWet/Ministerio de Medio Ambiente: 173-197.

Mediterranean Wetlands Observatory, 2012. *Mediterranean Wetlands Outlook 2012 – Technical report.* Arles, France, Tour du Valat Publ., 126 p.

Micevski B., 2002. *Inventory of Macedonian wetlands as natural resources.* Skopje, Bird Study and Protection Society of Macedonia, 72 p.

Michev T.M. & Profirov L., 2003. *Mid-winter numbers of waterbirds in Bulgaria (1977-2001).* Sofia-Moscow, Pensoft Publ., 160 p.

Michev T.M. & Stoyneva M.P., 2007. *Inventory of Bulgarian wetlands and their biodiversity. Part 1: Nonlotic wetlands.* Sofia, Elsi-M Publ., 364 p. + CD supplement.

Millennium Ecosystem Assessment, 2005. *Ecosystems and human well-being: wetlands and water – Synthesis*. Washington D.C., World Resources Institute, 68 p.

Mima M., Fitoka E.N. & Bego F., 2003. *Inventory of Albanian wetlands.* Tirana, Albania, Environmental Center for Administration and Technology (ECAT) & Thessaloniki, Greece, Greek Biotope & Wetlands Centre (EKBY), 414 p.

Ministry of Environment and Forestry [of Turkey], 2007. *The state of Turkey's Environment* http://www.cedgm.gov.tr/CED/AnaSayfa/webUygulama/turkiyeCevreDurumRaporu.aspx?sflang=tr

Mittermeier R.A., Gil P.R., Hoffman M., Pilgrim J., Brooks T., Goettsch Mittermeier C., Lamoreux J. & da Fonseca G.A.B., 2005. *Hotspots Revisited: Earth's Biologically Richest and Most Threatened Terrestrial Ecoregions.* Conservation International, University of Chicago Press, 392 p.

Murdoch D.A., Vos R., Abdallah A., Abdallah M., Andrews I., Al-Asaad A., Van Beusekom R., Hofland R., Roth T., Saveyn B., Serra G. & Wells C., 2004. *A Winter survey of Syrian wetlands (Final Report of the Syrian Wetland Expedition, January-February 2004).* London, privately published, 135 p.

Nivet C. & Frazier S., 2004. *A Review of European Wetland Inventory Information.* Wageningen, The Netherlands, Wetlands International, 262 p.

Perennou C., Ardouin A., Bettinelli L., Girardin S., Guelmami A., Isenmann M., Porteret J. & Quelin L., 2012. *Premier bilan sur les zones humides existant dans le bassin Rmc.* Lyon, Agence de l'eau/RhoMeO, 6 p. (http://rhomeo.espaces-naturels.fr/axeb).

Plan Bleu, 2009. *State of the Environment and Development in the Mediterranean.* Athens, UNEP-MAP Plan Bleu, 200 p.

Pôle-Relais Tourbières, 2011. *Où trouve-t-on des tourbières en France ?* Web pages http://www.pole-tourbieres.org/repartition%20.htm, extracted on 30 July 2012.

Popy S., 2010. *Bases de réflexion pour la constitution d'un jeu d'indicateurs pour l'Observatoire régional de la biodiversité en Languedoc-Roussillon. Rapport final.* Montpellier, France, Cemagref, 379 p.

Prigent C., Papa F., Aires F., Jimenez C., Rossow W.B. & Matthews E., 2012. Changes in land surface water dynamics since the 1990's and relation to population pressure. *Geophys. Res. Letters* 39, L08403, doi: 10.1029/2012GL051276

Psilovikos A., 1992. Prospects for wetlands and waterfowl in Greece. *In:* Finlayson C.M., Hollis T. & Davis T. (eds), *Proceedings of the Symposium on* "*Managing Mediterranean wetlands and their birds*", Grado, Italy, 6-9 February 1991. IWRB Special Publication nº 20: 53-55.

Pullan R.A., 1988. *A survey of the past and present wetlands of the Western Algarve. Portugal*. University of Liverpool, Liverpool Papers in Geography nº 2, 100 p.

Ramsar Secretariat, 2008. *Strategic Framework and guidelines for the future development of the List of Wetlands of International Importance of the Convention on Wetlands (Ramsar, Iran, 1971).* Online document http://www.ramsar.org/cda/ramsar/display/main/main.jsp?zn=ramsar&cp=1-31-105^20823_4000_0__#B, extracted on 30 July 2012.

Saber E., 2006. *Approche de la dynamique spatio-temporelle des géosystèmes de la province de Benslimane, Maroc.* Ph.D. Thesis. University of Provence/Aix-Marseille II.

Saber E., Rhazi M., Rhazi L., & Baillais J.L., 2008. Inventaire des mares temporaires du Maroc occidental par télédétection : une première en Afrique du Nord. *Au fil des mares* 6-7 : 11.

Sadoul N., Walmsley J. & Charpentier B., 1998. *Salinas and nature conservation.* Arles, France, Tour du Valat/MedWet Conservation Series nº 9, 95 p.

Scott D.A., 1995. *A directory of wetlands In the Middle East*. Gland (CH) & Slimbridge (UK), IUCN & IWRB, 560 p.

Sergent E. & Sergent E., 1947. *Histoire d'un marais algérien.* Alger, Institut Pasteur d'Algérie, 293 p.

SOeS, 2011. *CORINE Land Cover. Méthode de production de la base de données.* Downloadable from: http://www.statistiques.developpement-durable.gouv.fr/donnees-ligne/t/methode-production-base-donnees.html?tx_ttnews%5Btt_news%5D=11268&cHash=88595af0806f46f2c8901fd438ea809f; accessed 30 July 2012.

Toutain G., Dollé V. & Ferray M., 1989. Situation des systèmes oasiens en régions chaudes. *Options méditerranéennes* 11 : 7-18.

Tourenq C., 2000. *Valeurs et fonctions des rizières pour les communautés d'oiseaux d'eau en Camargue*. Ph.D. Thesis. Montpellier II University, 258 p. (+ annexes).

Tourenq C., Bennetts R.E., Kowalski H., Vialet E., Lucchesi J.L., Kayser Y. & Isenmann P., 2001. Are ricefields a good alternative to natural marshes for waterbird communities in the Camargue, southern France? *Biol. Conserv.* 100: 335-343.

UNEP-WCMC, 2011. *Developing ecosystem service indicators: experiences and lessons learned from sub-global assessments and other initiatives.* Montreal, Secretariat of the Convention on Biological Diversity, Technical Series nº 58, 159 p.

Walpole M., Almond R.E.A., Besançon C., Butchart S.H.M., Campbell-Lendrum D., Carr G.M., Collen B., Collette L., Davidson N.C., Dulloo E., Fazel A.M., Galloway J.N., Gill M., Goverse T., Hockings M., Leaman D.J., Morgan D. H. W., Revenga C., Rickwood C.J., Schutyser F., Simons S., Stattersfield A.J., Tyrrell T.D., Vié J.-C. & Zimsky M., 2009. Tracking Progress Toward the 2010 Biodiversity Target and Beyond. *Science* 325: 1503-1504.

Water Management Institute [of Slovenia], 2000. *Inventory of wetlands in Slovenia*. Ljubljana, Ministry of Environment and Physical Planning, 40 p. (+ annexes).

Zalidis G.C. & Mantzavelas A.L., 1994. *Inventory of Greek wetlands as natural resources*. Thessaloniki, Greek Biotope/Wetland Centre (EKBY), xvi + 448 p.