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Global spatial distribution of wetlands

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Summary

We reviewed currently available data bases of wetlands including peatlands, their spatial resolution, and the time period when the data was assembled. We found six global datasets that use information from various data sources. The database with the greatest spatial detail (0.5 arcminutes, c. 1 km at the equator) and finest classification is the Global Land and Wetland Database (Lehner & Döll 2004). It reflects the situation before 1992 and is also the most recent map.

Introduction

The soils of wetlands and peatlands store an enormous amount of carbon because decomposition is restricted by the availability of oxygen. Draining of wetlands often greatly increases the decomposition of dead plant material and release of carbon dioxide into the atmosphere. This process can significantly affect the global carbon budget when it happens at a large extent. The global distribution of wetlands, however, is not well characterized because there is no specialized global remote sensing product. This prevents also the timely detection of changes in the extent of wetlands and peatlands.

We reviewed currently available data bases of wetlands and peatlands, their spatial resolution, and the time period when the data was assembled.

Review

Global maps

Existing maps of wetlands have been reviewed earlier by Sanderson (2001). The review compared five maps using the wetlands databases of Matthews & Fung (Fig. 1, 1987, 1° × 1° resolution) and Aselmann & Crutzen (Aselmann and Crutzen 1989, 2.5 × 5.0°). The M&F map is derived from the Soil map of the world (FAO 1971-1981) combined with a vegetation classification data base (Matthews 1983) and Operational Navigation Charts. The A&C map cites (Gore 1983) and 'various maps' as sources. Sanderson recommends using the map by Stillwell-Soller et al. (1995, 1° × 1°) interpolated from Aselmann & Crutzen (Aselmann and Crutzen 1989) and additional data in the global circulation model STOCHEM because the map was derived from more direct information about wetlands.

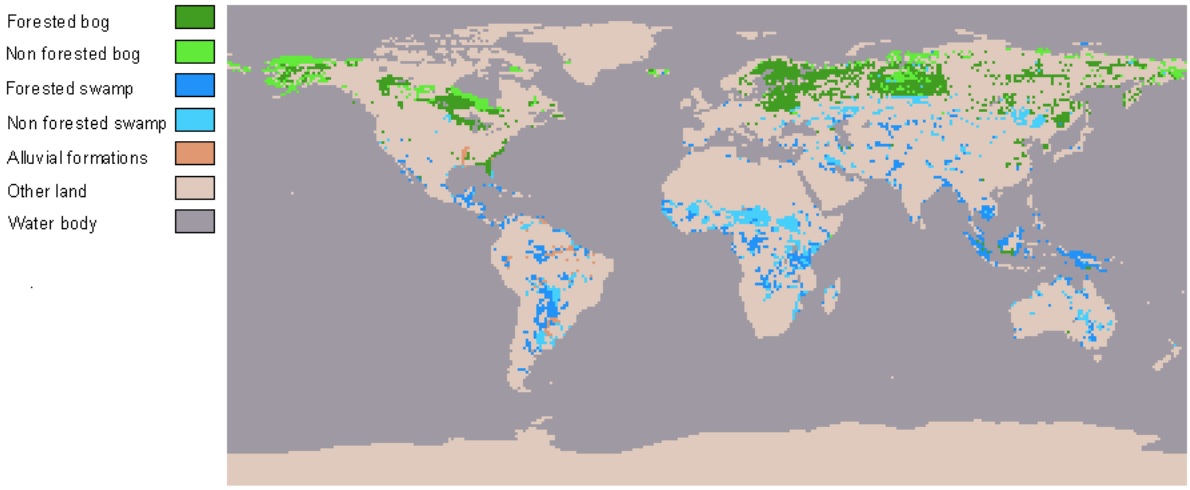

Fig. 1. Database of Matthews & Fung (1987) as shown in Mitra et al. (2005).

Another wetlands map (Fig. 2, Reich 1997, 2' × 2') has been compiled by the United States of America Department of Agriculture (USDA) from a reclassified FAO-UNESCO Soil map of the world (FAO 1971) combined with a USDA Soil climate map.

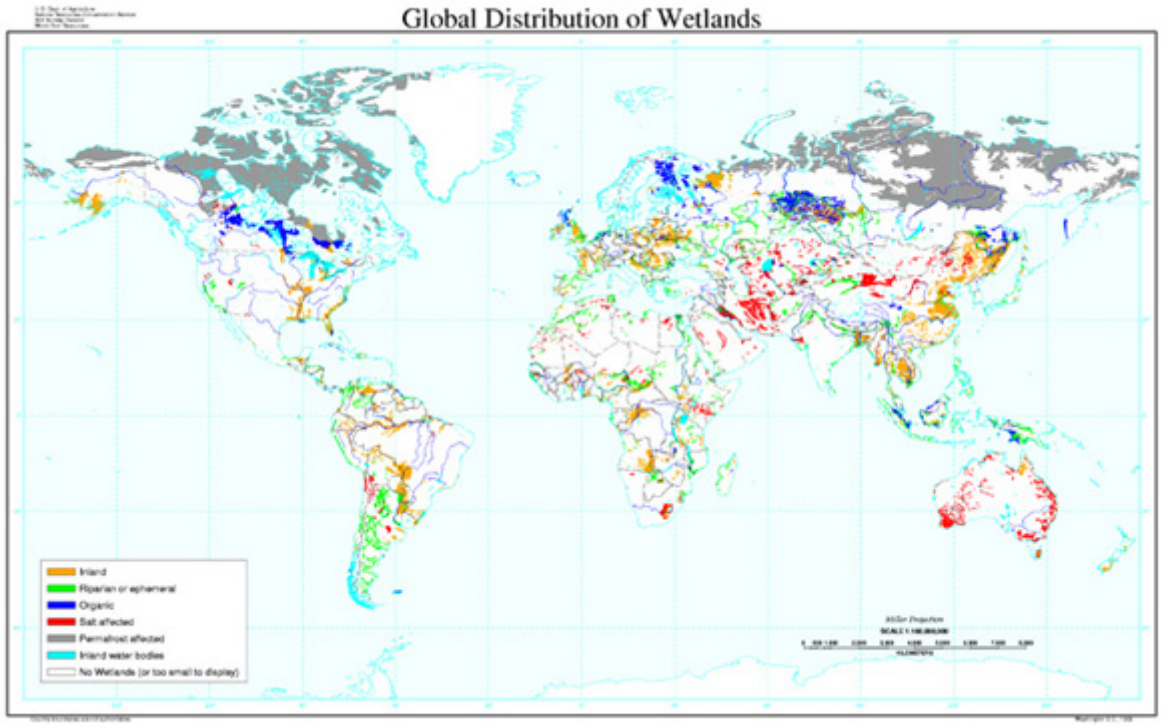

Fig. 2. Wetlands map compiled by the USDA (Reich 1997).

Mitra et al. (2003, Mitra et al. 2005) compared the Matthews & Fung map with land cover maps from the International Satellite Land Surface Climatology Project (ISLSCP, http://badc.nerc.ac.uk/data/islscp/) and the International Geosphere-Biosphere Programme/Data Information System (DISCover). The ISLSCP map is based on hydrological maps (Darras et al. 1999 in Mitra et al. 2003). The map, however, seems to be no longer accessible. The DISCover map is based on remote

sensing with AVHRR (Loveland and Belward 1997). The M&F and ISLSCP maps matched only 57% although their global estimates of wetland area was very similar. The match among M&F and ISLSCP with DISCover, however, was even lower. The original remote sensing data of the DISCover map is now provided in much finer resolution as the Global Land Cover Characteristics Data Base based on AVHRR remote sensing (Fig. 3, Loveland et al. 2000).

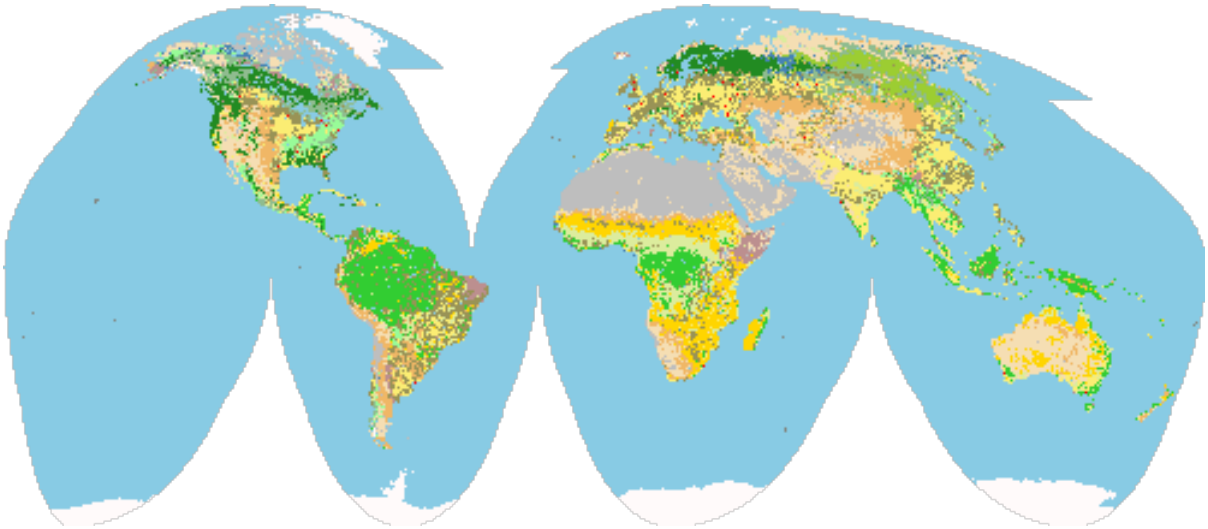

Fig. 3. Global ecosystems extracted from the Global Land Cover Characteristics Data Base 2.0 (Loveland et al. 2000), http://edc2.usgs.gov/glcc/globe_int.php.

The most recent conventional map (Fig. 4) provided by the Global Lakes and Wetlands Database (GLWD) uses mostly information from the Digital Wetlands Data set (World Conservation Monitoring Centre 1993, Lehner and Döll 2004). It is available online (http://www.worldwildlife.org/science/data/item1877.html). The most detailed map layer distinguishes nine types of wetlands and has a resolution of 30 arcseconds. Lehner & Döll (Lehner and Döll 2004) also provide a contemporary overview of existing global and regional data sets of lakes, reservoirs, and wetlands. The authors also compare the latitudinal and longitudinal distribution of wetlands with several older wetland maps.

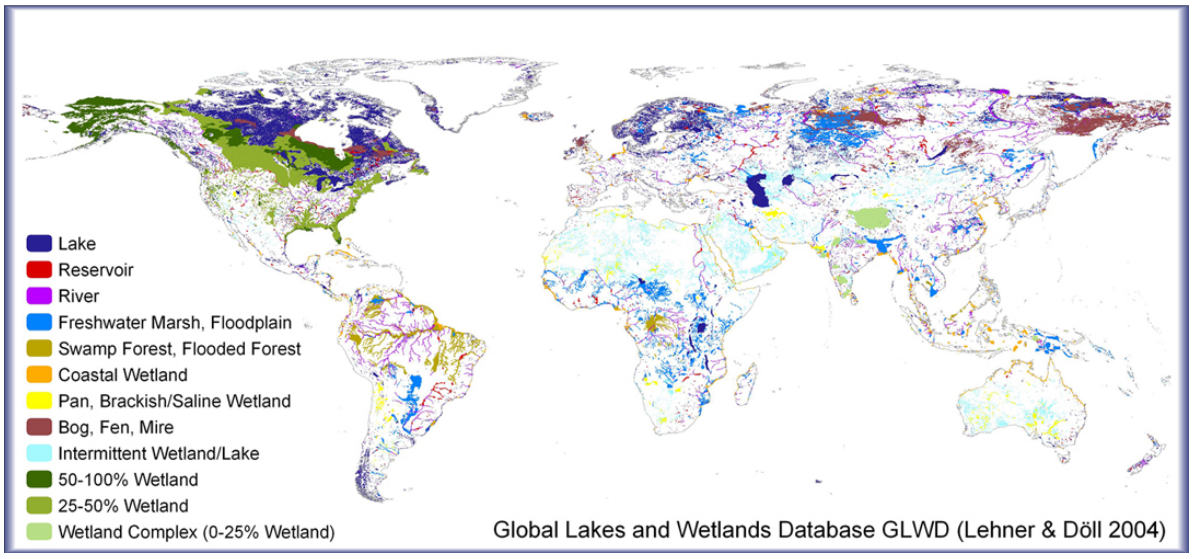

Fig. 4. Global lakes and wetlands database (Lehner and Döll 2004).

Table 1. Overview of global wetland maps.

Reference or Title	wetland categories	spatial resolution	reflected time
Matthews & Fung 1987	5[1], percentage of cell area covered by wetlands	1° × 1°	1970s
Aselmann & Crutzen 1989	6[2]	2.5 × 5.0°	<1983
ISLSCP	6[2]	1° × 1°	<1988
DISCover	percentage of cell area covered by wetlands	1° × 1°	1992/1993
Global Land Cover Characteristics Data Base 2.0	1–6 (Global Ecosystems legend[3])	1 km × 1 km or 30" × 30"	1992/1993
GLWD (level 3), Lehner & Döll 2004	3+9[4]	30" × 30"	<1993

Global inventories

The International Union for Conservation of Nature carried out inventories of wetlands between 1985 and 1995. The reports have recently been made accessible via the WWW (http://www.iwmi.cgiar.org/wetlands/WetlandDir.asp). Information on each site can be accessed through a map server (http://webmap.iwmi.org/). It is provided by the Global Wetland Initiative of the International Water Management Institute.

Another global inventory of wetlands was commissioned by the Bureau of the RAMSAR Wetlands Convention (Finlayson and Spiers 1999). It was based on literature research, government documents, polling of organizations, and personal communication in 1998. The final report pointed out the large inconsistency in information among countries due to access to data and differences in definitions. This was reiterated in a review of global and continental figures by Mitra et al. (2003).

[1] forested bog, nonforested bog, forested swamp, nonforested swamp, alluvial formation

[2] bog, fen, swamp, marsh, floodplain, shallow lake

[3] 'Wooded Wet Swamp', 'Rice Paddy and Field', 'Inland Water', 'Mangrove', 'Mire, Bog, Fen', 'Marsh Wetland'; the classes 'Coastal Wetland' with subclasses, 'Water and Island Fringe', 'Land, Water, and Shore', and 'land and Water, River' have zero area.

[4] 'Lake', 'Reservoir', 'River'; 'Freshwater Marsh, Floodplain', 'Swamp Forest, Flooded Forest', 'Coastal Wetland', 'Pan, Brackish/Saline Wetland', 'Bog, Fen, Mire', 'Intermittent Wetland/Lake', '50-100% Wetland', '25-50% Wetland', 'Wetland Complex (0-25% Wetland)'

The RAMSAR Wetlands Convention adopted an "Integrated Framework for wetland inventory, assessment and monitoring" (2005). It identifies core biophysical features for wetland description:

- *Site name (official name of site and catchment)*
- *Area and boundary (size and variation, range and average values) **
- *Location (projection system, map coordinates, map centroid, elevation) **
- *Geomorphic setting (where it occurs within the landscape, linkage with other aquatic habitat, biogeographical region) **
- *General description (shape, cross-section and plan view)*
- *Climate - zone and major features*
- *Soil (structure and colour)*
- *Water regime (periodicity, extent of flooding and depth, source of surface water and links with groundwater)*
- *Water chemistry (salinity, pH, colour, transparency, nutrients)*
- *Biota (vegetation zones and structure, animal populations and distribution, special features including rare/endangered species)*

Quoted from *The Ramsar Convention Manual, 4th ed.*

What are wetlands?

Wetlands are areas where water is the primary factor controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of the land, or where the land is covered by shallow water.

The Ramsar Convention takes a broad approach in determining the wetlands that come under its aegis. Under the text of the Convention (Article 1.1), wetlands are defined as:

"*areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres*".

In addition, for the purpose of protecting coherent sites, the Article 2.1 provides that wetlands to be included in the Ramsar List of internationally important wetlands:

"*may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands*".

Five major wetland types are generally recognized:

- *marine* (coastal wetlands including coastal lagoons, rocky shores, and coral reefs);
- *estuarine* (including deltas, tidal marshes, and mangrove swamps);
- *lacustrine* (wetlands associated with lakes);
- *riverine* (wetlands along rivers and streams); and
- *palustrine* (meaning "marshy" - marshes, swamps and bogs).

In addition, there are *human-made wetlands* such as fish and shrimp ponds, farm ponds, irrigated agricultural land, salt pans, reservoirs, gravel pits, sewage farms and canals. The Ramsar Convention has adopted a Ramsar Classification of Wetland Type which includes 42 types, grouped into three categories: Marine and Coastal Wetlands, Inland Wetlands, and Human- made Wetlands.

According to the text of the Convention, marine wetlands are considered to be wetlands up to a depth of six meters at low tide (the figure is thought to come from the maximum depth to which sea ducks can dive whilst feeding), but the treaty also provides for waters deeper than six meters, as well as islands, to be included within the boundaries of protected wetlands. It is also worth noting that lakes and rivers are understood to be covered by the Ramsar definition of wetlands in their entirety, regardless of their depth.

Wetlands occur everywhere, from the tundra to the tropics. How much of the earth's surface is presently composed of wetlands is not known exactly. The UNEP-World Conservation Monitoring Centre has suggested an estimate of about 570 million hectares (5.7 million km2) – roughly 6% of the Earth's land surface – of which 2% are lakes, 30% bogs, 26% fens, 20% swamps, and 15% floodplains. Mitsch and Gosselink, in their standard textbook Wetlands, 3d ed. (2000), suggest 4 to 6% of the Earth's land surface. Mangroves cover some 240,000 km2 of coastal area, and an estimated 600,000km2 of coral reefs remain worldwide. Nevertheless, a global review of wetland resources prepared for Ramsar COP7 in 1999, while affirming that "it is not possible to provide an acceptable figure of the areal extent of wetlands at a global scale", indicated a 'best' minimum global estimate at between 748 and 778 million hectares. The same report indicated that this "minimum" could be increased to a total of between 999 and 4,462 million hectares when other sources of information were taken into account.

Peatlands

Peatlands are an important class of wetlands because of their high carbon content. The importance of peatlands for biodiversity and climate change have been recently reviewed (Parish et al. 2008). The review contains a map of mires (Fig. 5) as percent of land area after Lappalainen (1996) and a map of percentage of peatland area per country after van Engelen & Huting (2002). H. Joosten maintains the comprehensive Global Peatland Database (www.imcg.net/gpd/gpd.htm) of the International Mire Conservation Group. The GPD is an ongoing critical evaluation of the literature. The data is being summarized for Wetlands International (Joosten 2010).

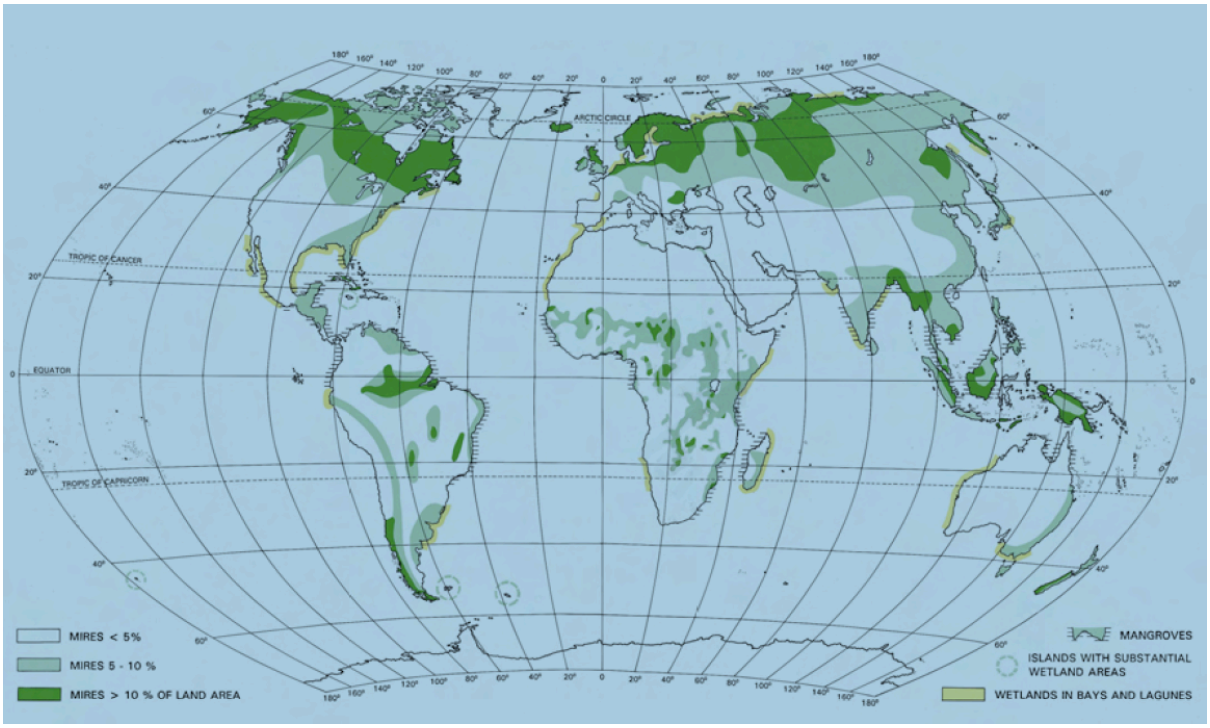

Fig. 5. Global peatlands according to Lappalainen (1996) as shown in Parish et al. (2008).

Conclusions

Our review shows the limited data base for monitoring wetlands, especially peatlands. Wetlands are usually charted by a combination of soil types, vegetation classes and possibly inundation. The success of remote sensing products is still not much better than conventional methods (Mitra et al. 2005) but is important for continued monitoring. Remote sensing methods are developed further on regional scales, e.g. the GlobWetland project (http://www.globwetland.org, see also the special issue in Journal of Environmental Management 90(7)) or the Wetland Map of China (http://www.slrss.cn) (Niu et al. 2009).

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