Mediterranean wetland soil classes and its relationship with vegetation and land-uses types

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Abstract
This study performs a wetland soils mapping approach of the 'El Hondo' Natural Park in southeastern Spain by using aerial photographs and geographical information systems (GIS). Vegetation types and land-uses were also mapped to assess their relationship with the soil types. Calcisols, Gleysols and Histosols were identified. Agricultural uses and associated vegetation were closely related to the Calcisols. The saltmarshes on abandoned farmland were also closely related to the Calcisols. Gleysols and Histosols were associated to the presence of vegetation in marshes and saltmarshes in the reservoirs, ponds and floodplains of the Natural Park.

Key Words
Soil mapping, vegetation, land-use, GIS.

Introduction

Wetlands provide enormous beneficial services to people in the form of water supply, the maintenance of fisheries, the support of agriculture (through the maintenance of water tables and nutrient retention in floodplains), timber production, energy resources, wildlife resources, transportation routes, and recreation and tourism opportunities (RAMSAR 2007). The basic characteristic that defines a wetland is the permanent or seasonal presence of water. Wetland soils function as sinks and as transformers of nutrients, toxic metals and organics (Reddy *et al*. 2000). The task of mapping wetlands is difficult because these habitats are relatively poorly known (due to limited access) and vary seasonally (due to water fluctuations) (Novo and Shimabukuro 1997). Studies of marsh loss and degradation are usually based on field site investigations or aerial photographic analysis (Rogers and Kearney 2004). The combined employment of remote sensing (aerial or satellite) and geographical informations systems (GIS) provides a powerful tool to model and monitor environmental and socio-economic processes and phenomena. Remote sensing offers the capability of rapid and synoptical monitoring of large areas (Andrew and Ustin 2008). The objective of this study was the mapping of soil classes for a Mediterranean wetland according with the World Reference Base for Soil Resources (IUSS Working Group WRB 2006). Soil classes were identified by visual inspection of aerial photographies combined with field observations. The relationship among soil classes and, vegetation and land-uses was assessed.

Material and methods

The 'El Hondo' Natural Park is located in a coastal zone of south-east Spain, near the town of Elche (province of Alicante, Spain). The topography is very flat and altitudes range from sea level to several meters above sea level. The Natural Park comprises a series of human-made dams and ponds built on top of a lagoon that was dried a few centuries ago. The climate in this Spanish coastal region is semiarid Mediterranean, with a mean annual rainfall of less than 300 mm and a mean annual temperature of 17ºC. The climate is considered arid or semiarid according to the aridity index of Martonne (De Martonne 1926) and the aridity index of UNEP (1997) respectively. The 'El Hondo' Natural Park is included in the RAMSAR list of wetlands of global importance and in the NATURE-2000 network of the European Union. The park accommodates a wide range of migratory and nesting bird species some of which are critically endangered, for instance, the marbled teal *(Marmaronetta angustirostris)*. Open water bodies, reed communities, saltmarshes and irrigated agricultural fields are the dominant land-cover types within and around the Natural Park. The water cycle in the park is controlled by the need for water extraction for agricultural irrigation and wildlife conservation. A mosaic of colour aerial photographies acquired in summer of 2007 (1m of spatial resolution) was used for soil classes delineation. Aerial photographies were georreferenced in a GIS and soil classes were digitised by visual inspection of the images and field observations. A vector cartography of soil classes was obtained. Vegetation and land-uses maps were also obtained with the same procedure. In order to

assess the relationship among soil types and vegetation and land-uses classes, vector cartography was converted to raster format and a cross-tabulation analysis was performed with the resulting raster maps.

Results and discussion

Major soil classes of the study area were Calcisols, Gleysols and Histosols (Figure 1). Gleysols and Histosol were located around permanently inundated areas (in years with no extreme droughts). Soil sealing areas correspond with roads, buildings and recreational areas. Calcisols were preferentially located in the perimeter of the Natural Park area were soil saturation by is less frequent. The network of channels and paths that cross the wetland area defines some soil classes limits resulting in a map with some linear inter-soil boundaries suggesting the great influence of human activities on the soil. Histosols are located in the northern of the Natural Park and corresponds with an area of stable marsh since more than fifty years ago.

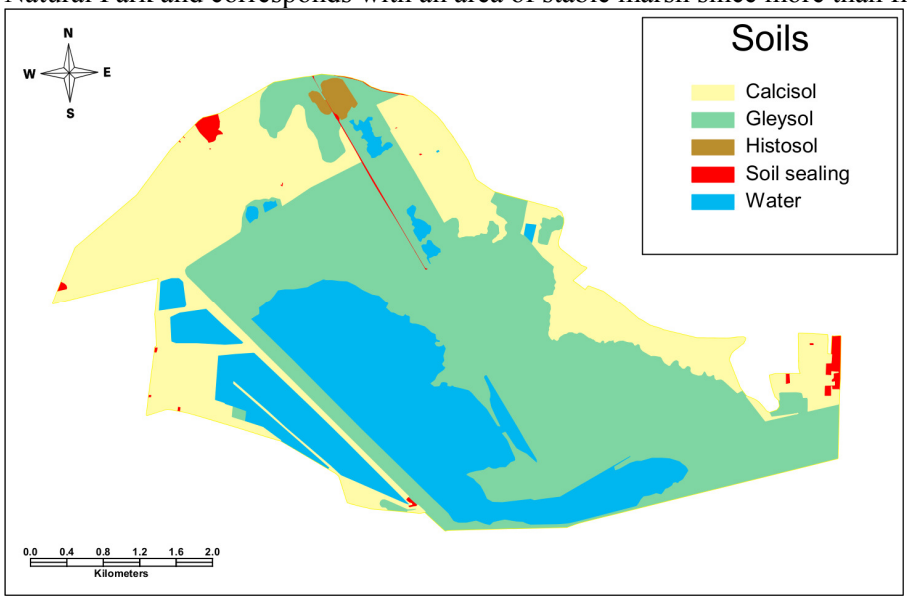

Figure 1. Major soil classes map for the 'El Hondo' Natural Park.

Marshes (dominated by *Phragmites sp*. stands) and saltmarshes (e.g. *Salicornia sp., Suaeda sp., Arthrocnemum sp.*) were the most abundant vegetation types (Figure 2) and are preferentially located in and around water bodies. Some bare soil areas with no vegetation result form the reduction of the water table in summer. Palm tree (*Phoenix sp*.), fodder crops and citrus tree agriculture areas were located in the perimeter of the Natural Park were soil are less saline. Artificial areas correspond with roads, buildings and recreational areas (soil sealing).

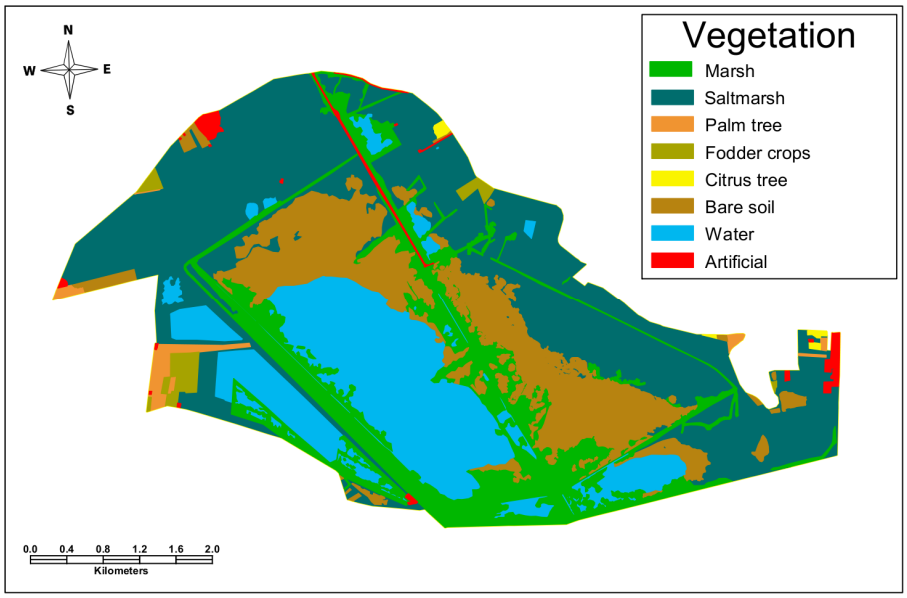

Figure 2. Vegetation types map for the 'El Hondo' Natural Park.

The current configuration of 'El Hondo' Natural Park is based on the existence of two large reservoirs of water for agricultural use in surrounding agriculture areas and a set of ponds employed for hunting (Figure 3). Marshes are located on the reservoirs, pond and flooded areas. Saltmarshes occupy abandoned farmland areas. Two classes of abandoned farmland areas were identified: 1) abandoned farmland class which corresponds with agriculture fields that were abandoned many years ago and nowadays salthmarshes are highly developed and the boundary between ancient fields has virtually disappeared under the vegetation canopy; and 2) recently abandoned farmland class were saltmarshes are in the process of colonisation of agriculture fields that were abandoned only a few decades ago. Artificial areas correspond with roads, buildings and recreational areas (soil sealing).

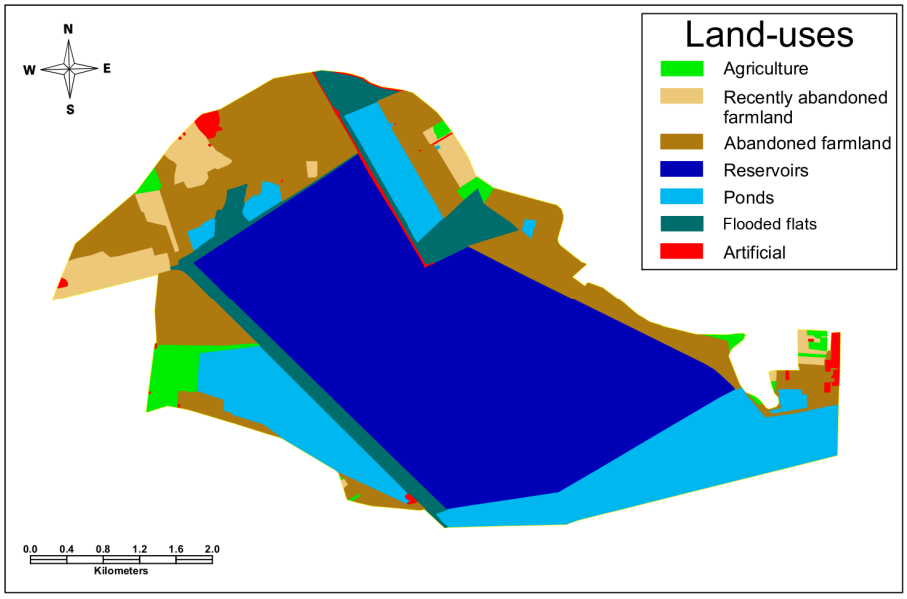

Figure 3. Land-use classes map for the El Hondo Natural Park.

The relationship between soils and vegetation was assessed with a cross tabulation matrix and their relative presence in each soil class was estimated (Figure 4).

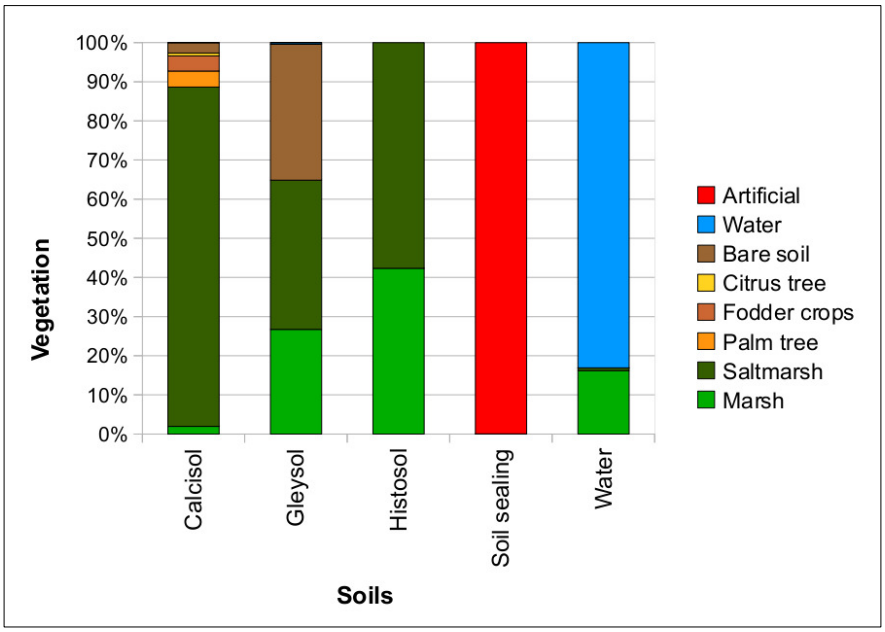

Figure 4. Relative presence of vegetation classes in each soil class.

Vegetation types related with agriculture (palm tree, citrus tree and fodder crops) were exclusively on Calcisols. Saltmarsh was the dominant vegetation on Calcisols. Gleysols were occupied by saltmarsh and marsh vegetation classes and some areas were bare soil. Such areas correspond with floodplains that were dry at the time of acquisition of the aerial photography. Undisturbed since more than fifty years ago marshes

and saltmarshes were developed on the Histosols which are very scarce in the Natural Park. Soil sealing class corresponds with artificial areas while water class is occupied by open water tables and some inundated marshes. Finally, the relationship between soils and land-uses was assessed with a cross tabulation matrix and their relative presence in each soil class was estimated (Figure 5). Land-uses developed on Calcisols were agriculture, the two types of abandoned farmlands, some human made ponds and a small portion of the reservoirs. Gleysols were occupied by reservoir, pond, flooded flats and abandoned farmland land-uses. Gleysols were the most characteristic soil type of the wetland while the scarce Histosols were only developed on floodplains and agriculture fields abandoned many years ago. Soil sealing class corresponds with artificial areas. Reservoir, ponds, flooded flats and abandoned farmland were the land-uses classes of the permanent water class.

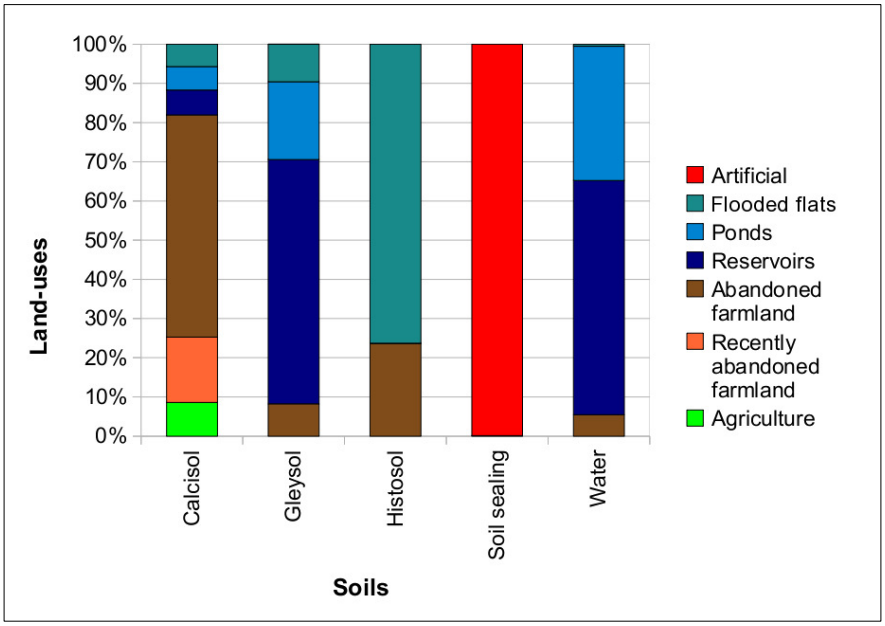

Figure 5. Relative presence of land-uses classes in each soil class.

Conclusion

Soils mapping plays an important role in soil science, providing valuable information for land management. This study served to make a first approach to mapping the soils of the 'El Hondo' Natural Park with an accuracy hitherto unrealised. The study showed the interdependence between vegetation types and land uses that are present in the Natural Park and the soils on which they are developed. Future studies should serve to improve the mapping and increase their use in wetland management

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