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Delineation and functional status monitoring in small saline wetlands of NE Spain

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Abstract

The small playa-lakes and other saline wetlands of Monegros, scattered over a dry area with winter cereal monoculture, are threatened by the settlement of new irrigation districts and other kinds of human pressure. Enforcing the protection rules of European Union in these valuable habitats requires, first, their delimitation and monitoring. This article shows how these tasks can be undertaken using remote sensing in conjunction with field observations. A series of Landsat images covering different seasons provided a comprehensive view of these wetlands encompassing their changing facies, hydrologic regime, state of conservation, and functional status. Remotely-sensed data were the primary, and in most cases the only available, source of consistent information. Our approach can help planning and surveying for the implementation of saline wetland protection measures in harmony with the conterminous agricultural areas.

Keywords: Conservation status; Inland wetlands; Halophytes; Landsat; Playa-lake; Monegros

1. Introduction

Wetlands are priority sites in environmental policies. National and international agencies consider wetland degradation or loss a matter of great environmental concern in terms of biodiversity and hydrological function. Many of the world's most spectacular wetlands are in arid zones of Australia, India, South America, South Africa and Arabia. Arid zone wetlands exhibit a high variability. They range from perennial to temporary, from freshwater to hypersaline, and in size from small pans of less than 0.1 km^2, like some Spanish playa-lakes, to large intermittent lakes of more than 9000 km^2, like Lake Eyre. At present, our understanding of arid zone wetlands is relatively poor, in spite of their conservation importance (Ramsar Convention Secretariat, 2004). Characterized by highly variable interannual and seasonal rainfall, arid zone wetlands host plants and animals adapted to live in very extreme conditions.

Inland saline wetlands around the world, i.e., closed lakes, dry lakes, salt pans, inland sabkhas and playa-lakes, have been studied using the classical approaches of sedimentology, limnology, or geochemistry (Castañeda and Herrero, 2005). Detailed description of these environments requires specific diagnostic tools and indicators. As barren lands, often located in desert and remote areas, their mapping has been overlooked, and their study has been marginal and often conducted for scientific purposes only. Environmental concern, especially with regard to increasing urban or agricultural development, is changing the way the society looks at saline wetlands.

Castañeda et al. (2005a) reviewed the application of remote sensing to inland wetlands, finding that study had been restricted to playa-lakes or inland sabkhas covering thousands of hectares (Epema, 1992; Harris, 1994; Bryant, 1999). The techniques used in these studies are not well suited to small saline wetlands due to problems with the spatial resolution of sensors or the image treatment procedures used. The saline wetlands of the Monegros desert require approaches adapted

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to their average size with a median of 7 ha, to their irregular and rapid change in appearance, and to the lack of *in situ* data. For this purpose, we defined (Castañeda et al., 2005a) the term facies encompassing the soil surface cover, vegetation or other, and soil intrinsic features like cracking patterns, efflorescences, salt pans, ponding, etc.

The aim of this work is to understand the Monegros saline wetland behavior and to establish a baseline chiefly focused on inventory and characterization, hydrological regime, and conservation status.

2. Study site

The Monegros Desert (Fig. 1) includes an arheic area of 36,000 ha with scattered saline wetlands that currently occupy 2% of the whole area (Figs. 1–3). It is one of Europe's most arid zones (Herrero and Snyder, 1997), with an annual mean rainfall of 388 mm and a mean annual ET_0 of 1255 mm. Soils are shallow and stony, calcareous or gypseous, with low organic matter contents, in agreement with the water deficit of the area and the parent materials. In addition, the soils are saline towards the borders of the wetlands, surpassing thresholds for crop production in agricultural fields surrounding the playas. Barley, the most suitable crop, produces 1050 kg/ha on average, though some years production is zero (McAneney and Arrúe, 1993). Subsidies provide crucial support for farmers' income. This agricultural environment differs from the profitable farming areas surrounding other playa-lakes in developed countries, such as the High Plains in U.S. (Haukos and Smith, 1994).

The natural vegetation in the area, 825 ha, is limited to the borders and escarpments of playa-lakes and to the bottoms of the closed depressions. Of the vegetation surface area, 45% corresponds to habitats protected by the 97/62/CEE Directive. The perennial halophytes *Suaeda vera* and *Arthrocnemum macrostachyum* account for 99% of the flora.

The Monegros saline wetlands, locally named "saladas", range from <2 ha to >200 ha in size. Some of them are playa-lakes and others are closed saline depressions of high scientific and environmental values as natural habitats of endemic microbes (Casamayor et al., 2005), plants (Domínguez et al., 2006) and animals (Melic and Blasco, 1999). These saladas differ from other inland playa-lakes in that they are saline groundwater discharge areas (Samper and García-Vera, 1998). The shallow brine, spread over the bottom by the prevailing NW wind, hardly reaches more than 50 cm in depth. The presence of the brine in a few weeks per year depends on the groundwater dynamics (Castañeda and García-Vera, 2008) and the accumulated previous rainfall (Castañeda and Herrero, 2005). The occurrence and the extent of the transitory water body determine the distribution of the vegetation and the wet surface (Fig. 2). The saladas usually appear in stark contrast to the rest of the landscape as a flat surface covered with water and/or salt efflorescence, dark soil, and halophytes.

This landscape is undergoing agricultural intensification. Land consolidation and intensive plowing have destroyed most of the native vegetation and have changed the shape of the fields, which before were more adapted to the landforms. The installation of irrigation was blocked by European Union for 10 years and led to the total exclusion of some areas. Irrigation advance, clearly visible in the satellite images of Fig. 3, is the main threat to playa-lakes. Irrigation will modify the

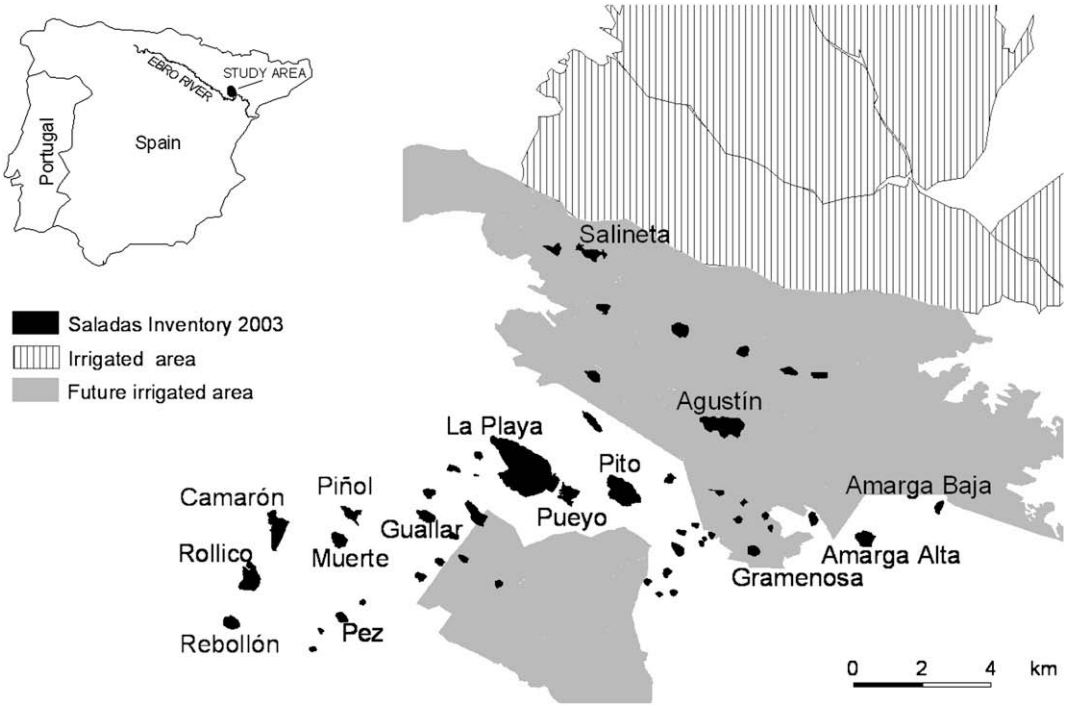

Fig. 1. Location of the Monegros wetlands.