Integrating objectives for the restoration of wetlands in intensively irrigated territories

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Abstract: Ecosystem restoration relies on a number of criteria and indicators corresponding to different scales of integration. A multipurpose approach was used in the intensively irrigated territory of Monegros (NE Spain) to establish a protocol for the restoration of wetland habitats and bird populations. Water, soil, vegetation, birds, and landscape characteristics were measured in eighteen wetlands. Water analysis showed that a wetland must have a minimum area of 0.5 ha to improve efficiently water quality (50% nitrogen retention, organic matter accumulation) as water flows through it. Amoeboid or elongated wetlands of area not lower than 0.05 with a heterogeneous plant cover favor a rich and diverse bird community. At territory scale, at least 3-6% of the land must be used for wetlands in order to remove nitrogen and major dissolved salts (the key components for water quality) from water outflowing irrigated fields. Following these results, a protocol to restore wetlands in intensively irrigated agricultural zones is proposed which proceeds through dichotomy steps in order to select one or multipurpose restoration objectives. The larger the target area is, the more possibilities for wetland restoration arise. At wetland and sub-watershed scale, restoration can easily achieve one objective. At territory scale (a land made of different sub-watersheds and watersheds in the same biogeographic area) wetland restoration can achieve different objectives integrated at ecosystem scale. The application of these results to Monegros zone shows an array of possibilities to restore wetlands at territory scale and the accomplishment of different objectives related to habitat, biodiversity and landscape improvements.

Keywords: wetlands, Mediterranean, temporary, water quality, biodiversity, landscape, fragmentation, agricultural policy.

Introduction

Wetland loss has reached up to 50% in Europe and North America specially in the last century basically as consequence of agricultural transformations, infrastructures development, water withdrawal, overexploitation and introduction of alien species (MEA, 2005). While wetlands play multiple roles and at different scales (Mitsch & Gosselink 2000), their restoration should be addressed to accompllished most of these. This can be achieved by planning site restoration with multiple objectives and by integrating different objectives while restoring wetlands in the landscape (Comín *et al.* 2000)

In semiarid zones intensively transformed for agriculture purposes landscape homogenization, habitat loss and water quality degradation as a consequence of run-off of salts and nutrients from irrigated lands has been a common place (Hansson *et al.* 2005). The aim of this study is to provide feasible guidance on how to restore or create wetlands with multiple objectives in catchments degraded by intensive agricultural uses under Mediterranean semiarid conditions.

Materials and methods

Monegros is a 2,764 km^2 semiarid territory in the River EBro Basin (NE Spain) intensively used for irrigated agriculture development. In this territory 9 experimental

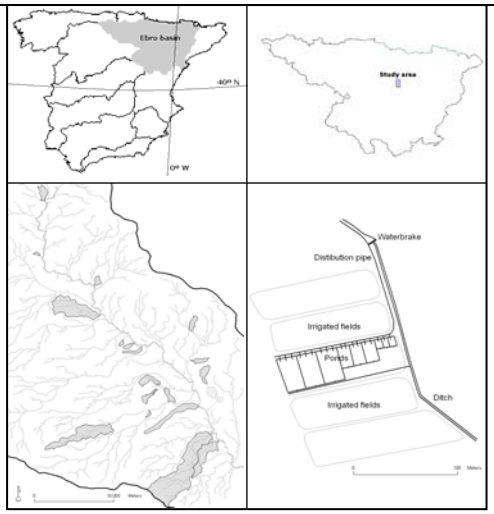

Fig. 1. Study area in the Ebro River Basin (NE Spain)

surface flow wetlands and 19 small natural wetlñands (0.3-1.5 ha) located in subcatchments distributed in an area of 1,564 km^2 were sampled to estimate their nitrogen retention potential several times during the year (Fig. 1). Birds visiting these natural wetlands were counted as indicators of biodiversity using direct observation and their songs. Their morphometric characteristics and plant coverage together land features were used to define major landscape patterns and propose a protocol for planning wetland restoration across spatial scales in this territory. Details of the study area and methods are included in Moreno *et al.* (2007).

Results and discussion

Restored wetlands of 500 m^2 can remove 50% of the nitrogen discharged from irrigated fields after 2-4 years of operation. Over this size the nitrogen removal efficiency did not increase significantly. This efficiency can improve with time after plant coverage estabilizes and size adjusted water flow is achieved. It may also increase cafter surface and subsurface water flow is combined.

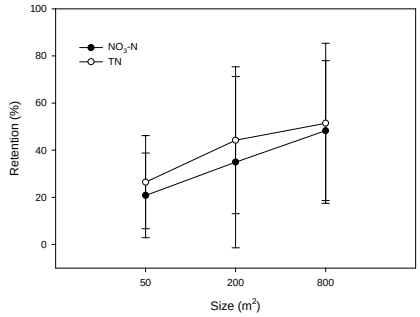

Fig. 2. Percentage of inflow nitrogen removed in constructed wetlands related to their area in Monegros.

Bird community richness, abundance and diversity are directly related with the presence of vegetation and its heterogeneity in the wetland, wetland area and distance between wetlands. It is clear that wetlands providing a variety of habitats will host a more divese community, while size is important to host large numbers of birds. Otherwise, food resources must be obtained from other sites. In this case, the closer the wetlands are to

each other the higher the frequency of observations of the birds in the wetlands. So, open zones with permanent water facilitates an habitat required by full aquatic brids. Heterogeneous plant cover fosters a diverse and rich community. However, a dominant tall vegetation (higher than 2,30 cm) contributes to dominance of a few specialized bird species. Consequently, a mosaic of different types of wetlands distributed in this territory would contribute to enhance a rich, diverse and abundant bird community.

The area of every wetland in the study zone is 2.8±2.7 percent of the subcatchment area where they are located. A larger area should be occupied by wetlands in order to increase their efficiency to remove nitrogen, according to our results and others (Hammer 1992). Design of wetlands should take into accout the total area to be covered by wetlands in the territory and in the wetland catchment. Related to this, the relationships between landscape and wetland metrics indicate that the number of wetlands, size and portion of the catchment covered by wetlands are key variables determining landscape characteristics. Many small wetlands distributed in the territory contribute to a higher landscape diversity while offer more possibilities for non-point wastewater treatment (Chen *et al.* 2002, Moreno *et al*. in press). Detailed studies will contribute to know also the processes involved in water quality improvement as wetlands originated by seepage through permeable soils in footslopes in Monegros are important both for water quality and landscape improvement (Blackwell *et al*. 1999).

In order to integrate these multiple objectives in land use planning and restoration a protocol may consider a hierarchy of objectives and the spatial scale at which they are suitable (Table 1).

Table 1. Suitability of objectives in relation with the different spatial scale of wetland restoration

Scale / Objective	Wetland	Catchment	Basin	Territory	Articles
Water quality improvement	●	●	●	•	Mitsch & Gosselink. 2000
Biodiversity strengthening	•	●	●	●	Hansson et al. 2005
Landscape heterogeneity		●	●	●	Comín et al. 2001
Landscape integration		●	•		Moreno et al. 2007
Carbon sequestration	•	●	●	●	Zedler 2005

In semiarid territories intensively transformed for agricultural purposes, land use and irrigation planning could incorporate wetland restoration and creation to achieve multiple objectives. At landscape scale wetlands of different form and habitat coverage distributed in their subcatchments will cotribute to establish a diverse and complex landscape. Wetlands of different size incorporating at least one relatively large wetland at affordable distance from the others will host a rich and abundant bird community. Providing wetlands with a variety of habitats will enhance communitiy diversity. Furthermore, in addition to the general role that wetlands distributed in the territory will play to remove nitrogen from agricultural sewage, designing specific sized and structured wetlands for nitrogen removal will require a wetland area of 5% of the subcatchment area and a minimum size of 0.05 ha. for each wetland.

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