



Combining vulnerability analysis and perceptions of ecosystem services in sensitive landscapes: A case from western Moroccan temporary wetlands



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ABSTRACT

Given that people are an inseparable part of their environment through their dependence on ecosystems and the services they provide, it is essential to understand the human influences that impact the environment and in turn determine the effects they will have on the existing ecosystem services. This relationship was explored by coupling a habitat vulnerability study with an ecosystem service perception evaluation. A biological survey and a socio-economic study were implemented in western Morocco (Benslimane Province) to identify the vulnerability of different temporary pools and to determine the perceived ecosystem services obtained by local stakeholders. A total of 101 temporary pools were studied and in person interviews were conducted with 110 randomly selected households. For each pool, vulnerability to various land uses, pressures and threats were analyzed. Temporary pools located in forested areas were under less threat than those located in agricultural lands. The nuisances associated with temporary pools were indicated by local stakeholders, increasing the pools' vulnerability. Provisioning and cultural ecosystem services were also perceived, increasing acceptance for conservation measures. The results of this study highlight the need to account for natural science and social sciences to inform future management. This methodology can further be tested and applied in other fragile ecosystems to better target conservation strategies.

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1. Introduction

In the last five decades, our planet has rapidly changed due to human activities, and these changes are expected to accelerate during the next decades (Vitousek, Mooney, Lubchenco, & Melillo, 1997; MEA, 2005). Intense anthropogenic activities are responsible for the loss of many natural habitats (Lambin et al., 2001; Yan, Wu, Dorji, & Jia, 2005) and their biodiversity (Angermeier & Karr, 1994; MEA, 2005). It has been argued that ecosystems are declining worldwide, largely due to ignorance of their value to humans and

inadequate social and economic mechanisms to encourage individuals to invest in maintaining them (Cork, 2001). The concept of ecosystem services has been introduced to demonstrate the services that ecosystems provide to humans and the values (monetary and non-monetary) of these services (De Groot, Alkemade, Braat, Hein, & Willemen, 2010; Seppelt, Dormann, Eppink, Lautenbach, & Schmidt, 2011). Ecosystem services are often divided into three categories: provisioning, regulating and cultural services (Carpenter et al., 2009). These three value categories attributed to ecosystem services can play a critical role in identifying management goals and setting the context for environmental decision making and biodiversity conservation (Bengston & Xu, 1992; Paavola & Klaus, 2013). Environmental decision making is often guided by values that provide the greatest economic return (Brown, 2004); however, the incorporation of cultural values and perceptions allows for the consideration of social values in management (Brown, 2004).

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Given that people are an inseparable part of their environment through their dependence on ecosystems and the services they provide (Robards, Schoon, Meek, & Engle, 2011), it is essential to understand the human influences that impact the environment and in turn determine the effects they will have on the existing ecosystem services. The chain of causal links has been introduced into environmental assessment to identify the driving causes of change, determine the pressures of these driving forces, and to identify the effects of the pressures on the current and future states of the ecosystems (Kristensen, 2004). The chain of causal links highlights the factors that influence the state of the ecosystem and thus determine the vulnerability of the system. Vulnerability is the likelihood or imminence of destruction or alteration of habitats (Pressey, 2001). In this study, we define vulnerability in such a way to include both the traditional elements of an impact assessment (i.e. potential impacts of a system to exposures) and adaptive capacity to cope with the potential impacts of global change (Metzger, Rounsevell, Acosta-Michlik, Leemans, & Schröter, 2006). A habitat vulnerability assessment can provide responses where conservation needs are greatest (Rodrigues et al., 2004); however, research demonstrates that a purely natural science approach can have catastrophic consequences for local people (Scott, 1998). Coupling a habitat vulnerability study with an ecosystem service perception evaluation can be used to determine which actions must be taken to prevent threatening events from happening (prevention) or to alleviate their effects (adaptation) (Schröter, Metzger, Cramer, & Leemans, 2004). By understanding both the perceptions of the local population and the vulnerability of the habitats, decision makers can make more educated decision about which actions to undertake (Berkes & Folke, 1998; Robertson & McGee, 2003). Hence, understanding the perceptions and the needs of diverse stakeholders is crucial for efficient conservation policy and has become an agenda for improving environmental management around the world.

Wetlands are among the most valuable and productive ecosystems on earth (Ramsar, 2008; Castañeda & Herrero, 2008); however, they are being destroyed and degraded around the world and particularly in the Mediterranean region (Perennou, Beltrame, Guelmami, Tomas Vives, & Caessteker, 2012). The principle factors attributed to Mediterranean wetland loss and degradation are anthropogenic due to land use changes (Zorrilla-Miras et al., 2014), water pollution, invasive species, sectoral and non-sustainable water management, climate change (leading towards decreased water input), and the over-exploitation of certain resources (UNEP/MAP-Plan Bleu, 2009). Salafsky, Margoluis, Redford, and Robinson (2002), Salafsky et al. (2008) have developed a threat taxonomy based on direct and indirect threats to ecosystems. Direct threats can be grouped into ecosystem elimination, ecosystem degradation and species decline and elimination. Indirect threats are factors with a negative effect that contribute to the direct threats. Public perception of wetlands being wastelands and sources of nuisance are indirect threats, further driving the direct threats causing wetland loss (Barbier, Acreman, & Knowler, 1997). Negative views toward wetlands potentially result from a lack of understanding of the value and services provided by these sensitive habitats (Xie, Xu, & Yan, 2010), leading to their conversion to agricultural, industrial or residential lands (Barbier et al., 1997). Past studies have demonstrated that the local perception of Mediterranean wetland values are driven by multiple motivations rooted in the social nature of shared ecological knowledge. There are some differences in the values attributed to these habitats by the local population compared to those of the scientific community (Franco & Luiselli, 2014).

The present study focuses on Mediterranean temporary pools in the province of Benslimane (North-west region of Morocco). Mediterranean temporary pools are defined as endoreic depressions that fill with water during the rainy season (winter) and most

frequently dry out during the summer months. They have been identified as important habitats for biodiversity in the Mediterranean region (Grillas, Gauthier, Yavercovski, & Perennou, 2004). In northern Africa (Grillas et al., 2004), they are under high anthropogenic pressure, leading to continued conversion or complete destruction (Saber, 2006; Rhazi et al., 2012).

A previous study conducted within Benslimane province (North-west region of Morocco) highlighted a large decline in the number of pools during the last 50 years from 871 in 1955 to 670 in 2001, representing a total loss of 23% (Saber, 2006; Rhazi et al., 2012). Our research combined a socio-economic study and a biological survey in the same area to identify the threats associated with temporary-flooded wetlands and the local stakeholders' perceptions of ecosystem services provided by the temporary wetlands. The objectives of this study were to identify the wetlands that were under the greatest threats and determine the sensibility of the local population to their future conservation.

2. Materials and methods

2.1. Study site

The study area is located in the province of Benslimane, on the Moroccan Atlantic coast between the cities of Rabat and Casablanca (Fig. 1). The studied region harbors numerous temporary pools, covering 2% of the total surface area of the province with varying shapes, sizes, depths, locations and uses (Rhazi, Rhazi, Grillas, & El Khyari, 2006). A study area of 7300 ha was selected, covering three municipalities where the concentration of temporary pools was high (Ain Tizgha, Mwaline El Ghaba and Ouled Yahia Louta). In 2004, the population density within Benslimane province was 83 people/km², lower than the average rural population in Morocco (147.75 people/km²) (<http://perspective.usherbrooke.ca>). The illiteracy rate is 42.4% in Benslimane Province, with a labor force comprising 80.1% men and 19.1% women, essentially in agricultural activities (Anonymous, 2009).

2.2. Vulnerability, pressure and threat on temporary pools

Within the study area, 101 pools were randomly selected (approx. 50% of all pools) and information concerning each pool (geographic coordinates, size, nature of the surrounding environment, ownership, land uses, proximity to roads/tracks, distance to habitats and distance to the town of Benslimane) was collected in 2008. For each pool, vulnerability to various land uses, pressures and threats were assessed as follows:

2.2.1. Vulnerability assessment

Vulnerability was assessed using the different threat categories as identified by Salafsky et al. (2002). We particularly focused on the direct threats of ecosystem elimination (urbanization, conversion to agricultural land), ecosystem degradation (over grazing, sports facilities and water extraction) and species decline and elimination (harvesting of medicinal plants). The assessment aimed to identify, quantify, rank and map the human-induced threats occurring in the study area (Battisti, Luiselli, & Teofili, 2009). A vulnerability index was estimated for each pool and each land use, according to judgments based on a consensus between experts. Expert opinion has gained acceptance in recent years for decision making concerning natural resources (Schmoldt & Peterson, 1997, 2000; O'Connor & Kuyler, 2009). We adopted this approach through conducting key-informant interviews with recognized experts in ecology and socio-economy of natural habitats (see authors and acknowledgments). In order to better define the indices, we took into account data dealing with the influences of human activities (grazing, recreation, drainage, cultivation and urbanization) on the

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