Original Research Article

Combining conflicting, economic, and environmental pressures: Evaluation of the restored Lake Karla (Thessaly-Greece)

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ABSTRACT

In this paper, the restoration of Lake Karla's ecosystem is studied through the evaluation of its current status. Lake Karla was one of the most important wetlands of Greece with many benefits not only to biodiversity preservation, to water balance of the watershed, but also to local economy in terms of fisheries. Its drainage, in 1962, created a lot of environmental problems and led to the local economy shrinking. After its refilling, the newly re-established water body is considered a vital aquatic ecosystem since it is listed in the network of Natura 2000. The monitoring results, the pressures and their causes that affected the restoration effort are presented. The assessment of the water quality is achieved by evaluating the results of the monitoring and fieldwork programs that Management Body of Eco-development Area of Lake Karla has performed during the last four years funded by the European Union. The results indicate strong eutrophication along with threats to biodiversity. The delay of implementation of Lake Karla reconstruction project, the decline from the proposed Environmental Terms and the lack of environmental policy are the most important causes of pressures.

1. Introduction

The term *restoration* is used to describe various measures and actions, in order to improve, to rehabilitate or to enhance the structure and the function of the aquatic ecosystems (Dufour and Piegay, 2009; Kurth and Schirmer, 2014). The desire to restore freshwaters that have been degraded by land use change, agriculture, or other environmental stressors has primarily emerged over the last decades (NRC, 1992; Goldyn et al., 2014).

Among Mediterranean water bodies, shallow lakes and wetlands are the most threatened ecosystems and of particular importance, although they have received less scientific attention, regarding their values and services such as flood protection, water quality improvement, aquifer or groundwater storage and recharge (Alexakis et al., 2013). During the last years, there have been many re-assessments and changes of strategies concerning lakes' management (Millennium Ecosystem Assessment, 2005). National and transnational legislation, such as the European Water Framework Directive (European Communities, 2000), requires European fresh waters to be kept at, or restored to a *good* ecological status. However, Mediterranean lakes, like other ecosystems, are subject to multiple

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stressors (Beklioglu et al., 2007; Latinopoulos et al., 2016) arising from human activity and from inter-annual and long-term background changes in environmental conditions that can degrade ecological status. The emphasis in restoration and management studies on lakes has progressively shifted from specific water-quality problems, to dealing with environmental issues at a much broader level. Yet, the more sophisticated solutions are those where the entire catchment, the landscape variables and the variety of stressors of the water body to be restored, are taken into account. The relevance of those factors differs regionally (EEA, 2012): while in Northern Europe's cold temperate lakes, energy plants have affected lake's hydrology, morphology and connectivity, South Mediterranean catchments are impaired by scarcity, pollution and multi-pressures and services. In addition their response to pressures seems to be quite different from that of the cold temperate in Northern Europe (Beklioglu et al., 2007).

Lake Karla (Thessaly, Greece) was considered to be one of the most important shallow lakes in Greece until 1962, when complete drying of the lake took place – creating more agricultural land – and is now being re-constructed, establishing a 'new' reservoir. Prior to the 1960s Lake Karla was considered one of the most important ecosystems in the Mediterranean region as it served as a "hot-spot" of biodiversity, as a natural reservoir providing water storage and recharge to groundwater (Zalidis et al., 2004). The importance of restoring Lake Karla and reversing the environmental conditions caused by anthropogenic activities was considered of high importance by the European Union offering multi services, i.e. social, economic and ecological sustainable development to the region and not just creating a new reservoir.

In this paper we discuss the restoration effort of Lake Karla as well as the pressures and their causes that affect this restoration. This is achieved by evaluating the results of the monitoring and fieldwork programs that Management Body of the whole catchment (named as *Eco-development Area of Karla – Mavrovouni – Kefalovriso – Velestino*) has performed the last years funded by the European Union. Furthermore, this paper is an attempt to highlight the factors affecting the cascading effect of the restoring processes as a precursor to re-establish natural lake's structure and function.

2. Methods and materials

2.1. The study site – biogeographical context

Former Lake Karla occupied the lowest part of its natural basin and was considered as one of the most important wetlands in Greece until 1962 (Fig. 1). Surface runoff from the watershed and floodwaters of the Pinios River supplied the lake with large quantities of freshwater. Its surface area fluctuated between 40 km² and 180 km². In terms of biodiversity, the former Lake Karla endowed with a variety of habitats (pelagic, floating vegetation, shallow marshes with *Juncus* sp. and *Typha* sp., emergent vegetation and rocks), had the ability to support a rich fish and bird fauna (Jerrentrup, 1990).

The structure and function of Lake Karla was intimately linked with the Pinios River. The river occasionally overflowed, and floodwaters rich in oxygen and nutrients
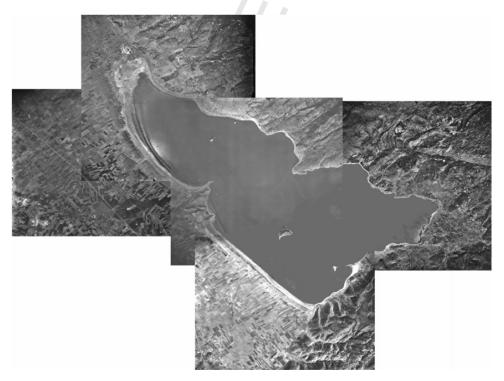

Fig. 1. Aerial photograph of Lake Karla in 1945.
After Ananiadis (1956).