

# Engineering the restoration of a coastal freshwater wetland: a sluice-and-canal scheme in Rodia Swamp, Amvrakikos, Greece.

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## ABSTRACT

This paper presents a summary of the approach and the technical infrastructure developed to restore freshwater input into a degraded riverine wetland area in Greece. Ecological restoration is an important aspect of sustainable development within protected natural areas and this form of conservation management is often essential where water resources have suffered from overexploitation or where natural habitats have been degraded due to poorly planned development. Emphasis is given here on the need to promote water management for restoration with primary regard for the use of water for aquatic and semi-aquatic habitats and their wildlife. Finally, wetland restoration is an important tool for the wise-use and conservation of water resources as promoted by the EU Water Framework Directive 2000/60/EC.

## INTRODUCTION

The EU Water Framework Directive 2000/60/EC promotes a new approach for water protection and management and incorporates restoration as a procedure for protecting degraded ecosystems. The strict timeframe imposed by the Directive includes that member states must “protect, enhance and restore” all bodies of surface water with the aim of achieving good surface water status by the year 2015 (Kallis & Butler, 2001). Most Greek wetlands, including many lowland rivers suffer from environmental degradation (Zalidis & Mantzavelas, 1996). One of the most widespread conservation problems concerns the deterioration of lowland riverine freshwater ecosystems due to poorly-planned water exploitation, river regulation works, wetland drainage and agricultural intensification.

This presentation describes the establishment of one of the largest riverine wetland restoration infrastructures in Greece, within a proposed National Park. Particular mention is given to the local circumstances of this restoration project in view the need to appraise the proximate and ultimate benefits of such a project within a protected natural area.

## Study Area

Amvrakikos, in western Greece, is one of the country's largest wetlands of International Importance; one of Greece's 11 Ramsar Wetland sites. This wetland area was primarily created by the deposits of the Louros and Arachthos rivers that flow into the semi-enclosed Amvrakikos Gulf. One of the most significant parts of this coastal wetland in terms of its biodiversity is the Louros river floodplain and the Rodia Swamp (27 km<sup>2</sup> in size); the largest reed-dominated swamp in Greece. This freshwater wetland has progressively been deteriorating since the 1960's when efforts were made to embank the entire stretch of the Louros river for flood control and agricultural development. Due to the increasing influence of brackish water from the adjacent saline lagoon, Rodia Swamp's vegetation begun to change quickly after the river embankment construction completely disrupted natural river flooding of the swamp. Since the '70s the swamp's varied reed communities died-back, water salinities increased with declines in biodiversity and biological productivity (Szijj, 1981; Lawrie, 2002; Economou et al., 2004).

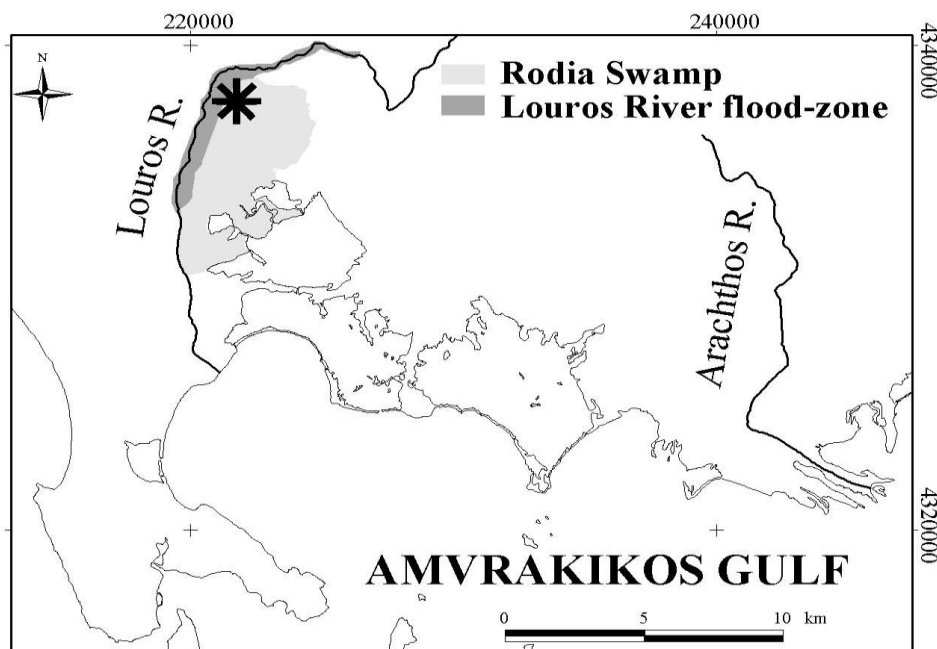
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**Fig. 1.** Study area. Location of the Rodia Swamp restoration project is shown with an asterisk. Source: Economou et.al. (2004)

## METHODS

### Restoration rationale

Although it is certain the current environmental state of the Rodia Swamp has deteriorated only very limited hydrological data exists. Proposals to restore the connection between the Louros and Rodia Swamp have been presented in several studies (Szijj, 1981; Skoulos et al., 1994; Grieve & Zogaris, 2001). Finally, this specific action was undertaken within the framework of a EU Life-Nature project entitled “Conservation management of Amvrakikos Wetlands” (B4-3200/99/006475) and the local communities’ supported the vision to restore the wetland.

Ecological restoration focused on re-establishing a regulated freshwater input from the Louros river to the riverine-deltaic Rodia Swamp. Since the area of the restoration project is under statutory protection, it was very important to secure specific government permits and have a scientific basis for the restoration scheme. It is important to note the potential risk of environmental damage and degradation if a so-called restoration action is poorly thought-out and not carefully planned and executed. Although it may be impossible to restore natural hydrological regimes in such a large regulated wetland area, restorative efforts must ultimately provide specific benefits to the ecological integrity of the ecosystem. The approach chosen for restoration at the Louros-Rodia wetland area is founded on habitat rehabilitation of particular freshwater aquatic and semi-aquatic wetlands which are scarce and threatened within the Amvrakikos National Park and its surrounding area. Priority is given to the conservation of biodiversity and the restoration of natural structure and functioning; prime aspects of ecological integrity (Angermier & Karr, 1994). Ecological restoration should aim towards creating self-sufficient and naturally functioning systems (White & Walker, 1997); and, at Amvrakikos it should accommodate many local community needs as well (for example: small-scale fisheries in the adjacent lagoons and deltaic wetlands). Finally the restoration project and associated scientific monitoring is also viewed as a means to increase

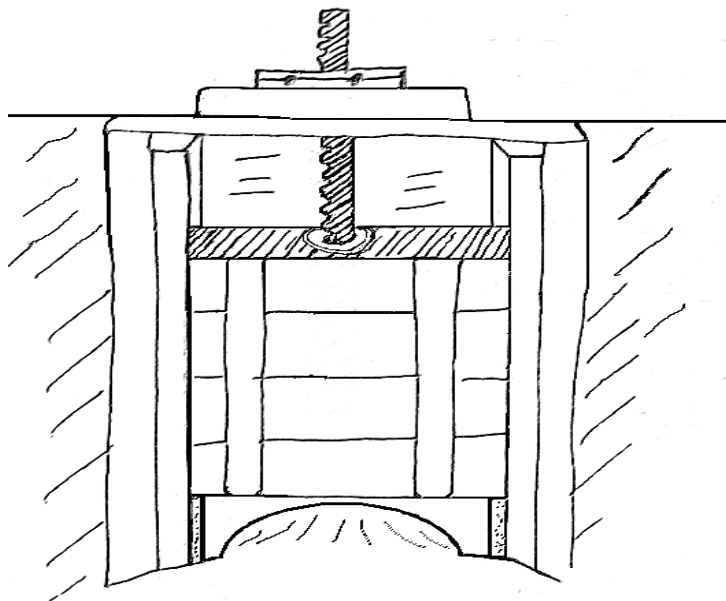
an understanding of the large and complex river-wetland ecosystem and its appropriate management.

The restoration work is based primarily on freshwater wetland biodiversity rehabilitation, with the following specific aims: 1) to restore freshwater flood pulses from the Louros River into Rodia Swamp, without negative impacts to the river, its flood-zone or the coastal lagoons which are adjacent to Rodia Swamp; 2) to enable control of water pulses with sluice gates; 3) to enable an implementation of a freshwater flooding regime which will re-establish natural plant communities and support freshwater-dependent species including threatened waterbird species; 4) to provide the potential ability to manage water resources for other rehabilitation regimes in the future and also for local fishery needs in the adjacent coastal lagoons.

This restoration approach obviously has a bias towards protecting natural biodiversity and ecosystem functioning because it is within a strictly-protected area; but, this special interest is also in line with demands for scarce habitat and species protection promoted in the Birds Directive (79/409/EC) and the Habitats Directive (92/43/EC), as well as the special reference given to protected areas in the Water Framework Directive and its guidance documents.

## THE PROJECT

In 1999 a Life-Nature project “Conservation and Management of Amvrakikos Wetlands” (LIFE 99 NAT/ GR/ 006475) initiated a suite of conservation works and studies that included an action to restore the connection between the river Louros and Rodia Swamp in order to enhance habitats for threatened birds and the freshwater biota. After two studies and biodiversity monitoring at the site the project was begun in October 2002 (Oikos LTD, 2003).



**Fig. 2.** Typical sluice gate proposed for construction on the Louros river embankment. The sluice gate is lifted by a spiral mechanism and allows river water to enter the artificial canals.

Source: Grieve & Zogaris, 2001.

The project was completed on July 1<sup>st</sup> 2003, and included: two sluices and water transport ditches (from the river to the sluices); and, two 1000 m. long canals in the swamp. The ditches transport water from the river to the swamp without disturbing intervening floodplain water meadow habitats. The water meadow habitats are part of a unique flood-zone between the two artificial embankments of the Louros and have a very high biodiversity value (see Fig 1).

### Infrastructure development details

A simple sluice-canal system was constructed in the heart of the floodplain-swamp wetlands, 13 Km upstream from the Louros river's outlet to the sea. The main infrastructure consists of two large sluices and two canals through the swamp, each 1000 meters long (6 m. wide, 1,5 m. deep), which can transport water directly from the river to the swamp without draining the river's flood-zone. The canals go through the swamp as fairly strait linear features (although the northern canal is crooked). It was decided to have strait canals (i.e. not meandering) in order to promote the free movement of water away from the embankment and towards the upper centre of the swamp (older former distributaries in the swamp are also linear-like features – no complex meandering is evident). The canals were constructed with the use of an IHC Beaver 300 cutter dredger. Dredged material (14.600 m<sup>3</sup>) was piled into islet-like heaps next the canals. These heaps of dredged soil were spread about so they do not artificially protrude more than 1.5 m above the canal's water surface. The line of dredged heaps is broken at very frequent intervals to allow water to pass through, and to create an islet-like feature suitable for wildlife cover. The two large sluice gates at the river's embankment work with a simple spiral mechanism (see Fig. 2); above the sluice gates are concrete bridges on the embankment.

The restoration works cost € 210.000.00 in total (€ 97.000.00 for dredging works and € 113.000.00 for sluices, concrete ditches, embankment bridges, and other infrastructures). Infrastructure work took about 9 months to complete because works were stalled due to winter flooding and difficulties in dredging the swamp.

Even during low summer flows river water drains from the river to the swamp canals in the lower elevation Rodia Swamp basin, through gravitational movement (without the use of pumps). The sluice gates were opened in July and August 2003 and large quantities of river water entered the Rodia Swamp during the summer for the first time in more than 30 years.

### RESULTS

After the sluices were opened on July 1<sup>st</sup> 2003, rapid changes in the hydrology and even in the biodiversity of the swamp were observed. The quantities of water entering the Rodia Swamp were remarkable, and the swamp's water level began to rise within a week of the flow of water into the swamp.

Proximate results of the project's success are evident upon a rapid assessment immediately after works were completed: A) The canals can transport approximately 134000 m<sup>3</sup>/day of water from the river to the swamp. This maximum amount (maintained with both sluices wide-open) represents 13.2% of the rivers discharge during its lowest summer flows and proved that it can effectively increase water levels in nearly all parts of the swamp basin, as it did in July 2003. B) Vegetation regeneration of the canals with freshwater helophytes and aquatic plants was rapid and certain freshwater-dependent species have expanded into former seasonally brackish reed-swamp; C) Large numbers of birds, including freshwater-specialized species used the canals immediately after their construction. This includes species considered freshwater specialists such as the threatened Ferruginous Duck (*Aythya nyroca*). At least 9 species of fish were recorded in the new canals, including rheophilic cyprinids presumably from the river's floodplain (Economou et al. 2004). The spread of some species of aquatic invertebrates was also presumably quite rapid. For example the Medicinal Leach *Hirudo medicinalis* (Gnathobdellae: Hirudinidae) was found near Strogili Village where residents had over 30 years to see leaches since the swamp had been degraded by salinization. These preliminary indications, provide evidence that the restoration infrastructure can be an important tool for rehabilitation if it is employed in appropriate water management. It is not yet possible to assess the ultimate success of the project or the functioning of the infrastructure since monitoring has not taken place. Due to a lack of funding immediately

after the end of the Life-Nature project in September 2003, a water regulation and a water management plan have not been completed.

## DISCUSSION

The Water Framework Directive emphasizes the imperative actions needed to enhance and restore degraded water bodies (Kallis & Butler, 2001). It also appreciates the needs wetland habitats have for adequate surface and ground water. In Greece and other Mediterranean countries there is very little experience with the practice of restoring riverine wetlands. Rarely are experiences from conservation projects published in the scientific literature; therefore it is important to describe even the basic infrastructure created by some of these projects, as case-studies.

Conservation and ecological restoration projects should target elements and features of the landscape that are scarce, threatened and have declined or deteriorated due to human pressures. Freshwater marshes, riparian woods and water meadows are the most threatened wetland habitats at the Amvrakikos and the region's biodiversity and ecological integrity have suffered from their loss and degradation (Zogaris et al., 2003). Furthermore, the need to focus on the restoration of peripheral freshwater habitats is critical due to their threatened status and scarcity, both at a local and national level.

The loss of freshwater wetlands has been extensive, rapid and relatively recent at Amvrakikos. Through air-photo analysis, it is evident that 63% of the wetlands of the Louros-Arachthos deltaic plain have been drained since 1945; and at least 80% of these consisted of inland freshwater wetlands. Most freshwater wetlands were replaced primarily by cultivated land, whose areal cover has increased by 59% since 1945 (Zogaris et al., in prep.). The remaining coastal wetlands have suffered from salinization which has also been proved to be a reason for degradation of reed-swamp structure in Rodia Swamp (Lawrie, 2002; Oikos, LTD 2003). Recent high dam developments (Pournari I Dam 1981, Pournari II Dam 1999) have severely disrupted the natural hydrological regime on the Arachthos river and plans are underway for more surface water abstraction adjacent to the Louros (Oikos LTD, 2003).

It is important to note here that an understanding of the loss of wetlands and the obvious need for freshwater input into hydrographic basins such as a riverine deltaic swamp is not enough for restoration to be ultimately successful. It is critical that the restoration infrastructure be placed within the framework of a water management plan targeting ecological restoration. In order to develop this plan, careful research and monitoring of an array of hydrogeological, wildlife, habitat and socio-economic elements must be completed. It must be reiterated that the simple opening of a sluice gate to increase water levels in a swamp is obviously not ecological restoration. In order to restore semi-natural hydrological regimes and to enhance natural habitat and biodiversity care is needed to define specific future desired states; and specifically, the quantities and timing of flooding. For this reason the constructed infrastructure remains out-of-use until a proper restoration water management plan and monitoring can be funded.

## CONCLUSION

Wetland restoration infrastructure in Greece and Mediterranean Europe is rarely described in the scientific literature and much information is restricted to technical reports and other "gray literature". This article documents a restoration infrastructure development in Western Greece, presents a summary of targets and construction details. Appropriate infrastructure has been developed at the Amvrakikos' Louros Floodplain and Rodia Swamp in order to promote the implementation of a large wetland restoration project. The initial positive results of the restoration

infrastructure should encourage carefully-planned restoration works in other Mediterranean wetlands.

Wetland restoration in order to benefit ecological integrity, biodiversity and threatened species is a vital part of managing internationally important wetlands that have undergone anthropogenic degradation. The restoration of desired conditions and resources for biodiversity may require long-term planning and research and can be an expensive undertaking. It is important to study the development of such engineering projects since they will soon be needed in many degraded inland water bodies of the Mediterranean due to the implementation of the EU Water Framework Directive.

## ACKNOWLEDGEMENTS

ETANAM SA was responsible for the management of this project; funded by EU Life-Nature '99 (Life-Nature B4-3200/99/006475). We wish to thank Mr. Kostas Arvanitis for all assistance; Dimitris Papandropoulos who assisted us in overseeing the engineering project; and Efi Vrettou, Kostantinos Bizas, and Vassilis Hatzirvassanis - the environmental impact study team of Oikos-Nature Management-LTD, who worked on the design and development of the project. V. Kapsimalis (HCMR -Institute of Oceanography) provided mapping assistance. A. Grieve (RSPB) provided assistance in the initial stages of preparation of the infrastructure; and A.N. Economou (HCMR – Institute of Inland Waters) provided important help with a hydrobiological study. VISTONIS SA was responsible for waterworks dredging.

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