# WET MEADOW RESTORATION AT LAKE MIKRI PRESPA, GREECE: RESULTS OF VEGETATION MONITORING (2002-2007)

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**Abstract:** Restoration of wet meadows at Lake Mikri Prespa, in NW Greece, is very important for endangered birds such as Dalmatian pelicans and Pygmy cormorants. To improve the conservation status for these species and enlarge fish spawning grounds, littoral vegetation management aiming at controlling high emergent vegetation on seasonally flooded areas was implemented by applying three treatments, namely water buffalo grazing and summer cutting with and without aftermath grazing. Their effects were monitored along transects crossing the littoral zone where cover and species composition was recorded in mid July of the years 2002-2007. We found that the cover of the high emergent helophytes, mainly of *Phragmites australis*, was reduced by all three treatments, especially by the ones involving grazing. In 2007, cover values were significantly lower in the two treatments (5.9% and 7.8% with only buffalo grazing and summer cutting with grazing respectively) than in the one involving only summer cutting (22.9%). On the contrary, the cover of wet meadow species such as *Carex pseudocyperus* was increased, but did not differ significantly among the three treatments in 2007 (60.9%, 70.5% and 68.8% respectively). Litter cover was significantly increased in the two treatments that included grazing while bare soil was significantly increased only in the treatment of buffalo grazing (14.7% in 2007). It is concluded that despite their differences in the effectiveness of controlling high emergent helophytes, all three treatments should be combined in an integrated management scheme for wet meadow restoration and maintenance in the littoral zone of Lake Mikri Prespa.

**Keywords:** wet grasslands, reedbeds, land use change, restoration of grazing and other traditional management techniques

## Introduction

Lake Mikri Prespa is a Wetland of International Importance (Ramsar Convention) covering a surface area of 47.4 $Km^2$ shared by Greece (~90% of its total surface area) and Albania (~10%). The lake and its surrounding catchment basin form the southern part of the Trans-boundary Prespa Park that consists of the whole of the Prespa basin in the three neighbouring countries including Lake Megali Prespa (253.6 $Km^2$) and the part belonging to the FYR of Macedonia. Reedbeds of *Phragmites australis* and *Typha angustifolia* are the dominant habitat type on the littoral zone of Lake Mikri Prespa and host the world's largest breeding colony of Dalmatian Pelicans (*Pelecanus crispus*, ~1000 pairs in 2007) and one of the most important colonies of Pygmy cormorants (*Phalacrocorax pygmeus*, ~500 pairs in 2007) in the European Union (SPP 2007). However, these bird species, as well as many other aquatic organisms including fish, depend on the existence of wet meadows located on seasonally flooded zones between the reedbeds and terrestrial habitats. Since 2002, systematic management of the littoral vegetation is practiced by means of grazing and mechanical summer cutting on a total surface area of 70 ha aiming at the restoration and maintenance of wet meadows on sites previously dominated by reedbeds due to the abandonment of traditional management techniques. Parallel to that, active conservation measures have been taken to efficiently regulate the water level of the lake in order to flood wet meadows during the critical spring-early summer season (Malakou et al. 2007). The evolution of vegetation

characteristics at the managed sites is monitored every year and results of the 2002-2007 period are presented in the current paper.

**Materials and methods**

Three treatments were applied for the management of the vegetation at ten littoral sites: a) intensive water buffalo (*Bubalus bubalis*) grazing (at one site/ grazed since 2001), b) summer cutting with aftermath grazing by cattle and/or buffaloes (at six sites), and c) summer cutting without aftermath grazing (at three sites). When the mown vegetation is of good quality, summer cutting is followed by the removal of the mown biomass (baling). At most of these sites, 3-6 fixed line transects, 25-140m long each, were set up in 2002-2003 crossing the lakeshore vertically, that is from the upper and drier parts to the reedbed. Sampling took place every summer by mid July when reed-like macrophytes had reached their maximum growth and access to the lower parts of the managed sites was relatively easy. It included plant species records every 1 m (all plants touching the needle/thin spear) and measurements of structural parameters of reed and reedmace within 0.5m X 0.5m quadrats every 5 m along each transect. Data presented here on vegetation cover are derived from four of the above sites (1/ grazed by water buffalo, 2/ with summer cutting and aftermath grazing, and 3-4/ with summer cutting solely). Plant species were categorized in four functional groups: a) high emergent helophytes (HEH), b) wet meadow species (WMS), c) Hydrophytes, and d) prairie species (those usually found on drier grasslands). Group cover was calculated by taking into account only the first contacts of the needle along each transect, while litter and bare soil were also included as separate cover categories. Mean cover values (± st. error) were calculated per site using the number of transects as replicates. Cover scores for 2007 (sites 3 and 4 put together as one treatment) were subjected to the Levine test and analysis of variance (ANOVA) and differences between means were determined by the Duncan test. Prior to statistical analyses, cover percentages were transformed to angles of equal information in degrees; their means were converted again to percentages after analyses for comprehensive presentation (Steel & Torrie 1980).

**Results and discussion**

At site 1, located on the western lakeshore, the pre-management condition of the vegetation (as expressed by the 2002 values in most other sites) was not measured as the water buffalo had been grazing the site continuously since 2001. However, buffalo grazing at a mean stocking density of 3,8 Large Animal Units per ha caused substantial decrease of HEH cover from 2002 to 2007 (17.9% to 5.9±3.3%), while in the same period the cover of WMS increased from 48.7% to 60.9±3.6%. Other important effects of water buffalo grazing on the site included the increased proportions of litter and bare soil throughout the same period (their total value varying from 23.1% to 42.5%) (Figure 1). The openings caused by buffalo trampling in the ex reedbed were largely covered by hydrophytes (10.3±3.4% in 2006), such as *Hydrocharis morsus-ranae*, *Salvinia natans*, *Myriophyllum* spp. and *Nymphoides peltata*. All these effects, in combination with the fact that the site was flooded for a large part of the year, created very favourable conditions for wet meadow-dependent wildlife species, such as feeding *Plegadis falcinellus* and spawning *Cyprinus carpio*.

At site 2(northern shore), management was done by summer cutting followed by cattle and buffalo grazing on a total surface of 16 ha (the largest project site) mainly covered by a dense mixed reed-reedmace bed. HEH cover decreased from 30.4±8.6% in 2002 (relatively low value because of the extremely dry conditions of that year) and 51.7±16.0% in 2003 to 7.8±1.3% in 2007. WMS cover increased substantially in the same period from 49.6±0.4% in 2002 to 70.5±6.0% in 2007, thus indicating the positive effects of summer cutting and aftermath large herbivore grazing. Hydrophyte cover was relatively high in 2005 and 2006 (5.5±1.9% and 11.2±3.8% respectively), favoured by the reduction of reed and reedmace and the beneficial flooding regime.
At sites 3 (north-western shore) and 4 (western shore, Table 1, Figure 2), management of the vegetation caused substantial reductions in the HEH cover values, especially after three years of applying the summer cutting treatment without aftermath grazing. HEH cover at site 3 decreased from 39.2±2.8% in 2002 to 13.2±2.8% in 2007, while WMS cover increased from 57.7±2.9% to 74.0±4.9% in the same period, while similar progresses were observed at site 4 (Table 1). The appearance of hydrophytes at site 3 in 2006 (2.9±1.7%) and the increased proportion of litter cover in 2004-2007 (10.1±4.0% to 7.9±3.3% respectively) indicate the improvement of vegetation characteristics to a more open habitat type.

*Table 1*. Group cover (%) at site 4 (managed by summer cutting without aftermath grazing) in 2003-2007

| Cover groups (%) | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| High emergent helophytes | 94.1±4.6 | 95.4±4.6 | 60.0±6.7 | 66.3±7.8 | 32.5±3.9 |
| Wet meadow species | 5.9±4.6 | 4.6±4.6 | 30.8±5.6 | 29.0±6.6 | 63.6±3.3 |
| Hydrophytes | 0.0 | 0.0 | 0.0 | 0.5±0.5 | 0.0 |
| Prairie species | 0.0 | 0.0 | 0.0 | 0.0 | 0.4±0.4 |
| Litter | 0.0 | 0.0 | 3.0±1.6 | 2.9±0.9 | 3.6±0.5 |
| Bare soil | 0.0 | 0.0 | 6.1±0.4 | 1.3±0.7 | 0.0 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

After five years of systematic implementation of the management regime, grazing (either as buffalo grazing solely or in combination with summer cutting) caused a significant decrease in HEH cover compared to the summer cutting treatment (Table 2).

*Table 2*. Mean cover (%) in the three treatments in 2007

| | Treatments | | |
|---|---|---|---|
| Cover groups (%) | (1) Buffalo grazing | (2) Summer cutting with aftermath grazing | (3) Summer cutting without aftermath grazing |
| High emergent helophytes | 5.9 b | 7.8 b | 22.9 a |
| Wet meadow species | 60.9 a | 70.5 a | 68.8 a |
| Hydrophytes | 0.0 a | 0.0 a | 0.0 a |
| Prairie species | 3.9 a | 3.6 a | 2.1 a |
| Litter | 14.5 a | 17.8 a | 5.7 b |
| Bare soil | 14.7 a | 0.4 b | 0.5 b |

*Values in the same row followed by the same letter are not significantly different at the 0.05 level (treatment 1: n=4, treatment 2: n=3, treatment 3: n=6)*

However, all three treatments were effective in promoting the establishment of wet meadow species, as no statistically significant differences appeared for WMS cover values between the three treatments in 2007 (Table 2). Similar results were found for hydrophytes and prairie species, although the former depend to a great extent on the flooding regime and 2007 was a year of fairly low water levels. Litter cover was found significantly higher at the grazing-including treatments, a fact attributed to trampling, whereas mechanical cutting and piling of the vegetation also contributed to the accumulation of litter rows, especially at locations where the mown biomass was not removed by baling or winter burning. Finally, bare soil cover was found significantly increased in the buffalo grazing treatment and this was mainly due to the intense grazing pressure applied at site 1 compared to the other treatments and managed sites.

*Figure 1*. The buffalo grazed site in late March 2005 (Y. Chardaloupas/ SPP)

*Figure 2*. Summer reed cutting at site 4 (Y. Kazoglou/ SPP)

## Conclusions

Restoration of wet meadows at Lake Mikri Prespa was achieved by grazing and summer cutting, solely or combined, at specific sites of the littoral zone during 2002-2007. Vegetation management at these sites, complemented by efficient water level regulation and continuation of monitoring activities, should be continued in an integrated management scheme that will include all three treatments for the maintenance and further improvement of wet meadow habitats.

## Acknowledgements

The present work took place in the framework of the LIFE-Nature project (LIFE2002 NAT/GR/8494) “Conservation of priority bird species in Lake Mikri Prespa” and the project of the Society for the Protection of Prespa on the restoration of wet meadows, both co-funded by WWF-Greece. The authors wish to thank all project staff and members of its scientific committee, as well as Dr K. Mantzanas and Dr M. Vrahnakis for their assistance in statistical analyses.

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