

# Recommendations and guidelines for the management of the reedbeds of Lake Lesser Prespa

Report within the framework of LIFE Project “Prespa Waterbirds” LIFE15 NAT/GR/000936



Arles, 2019



**Proposed citation: Grillas P., Sakellarakis F.-N., Catsadorakis G., Kastritis Th., & I. Koutseri 2019. Recommendations and guidelines for the management of the reedbeds of Lake Lesser Prespa. Report within the LIFE15 NAT/GR/000936 Bird conservation in Lesser Prespa: benefiting local communities and building a climate change resilient ecosystem. 17 pp.**

## Contents

Preamble .....	4
1. Introduction.....	4
2. <i>Phragmites</i> versus <i>Typha</i> : does it matter for biodiversity? .....	6
3. Reedbed management issues / objectives.....	7
3.1. Reedbed expansion/ reduction of wet meadows.....	8
3.2. Dominant species and biodiversity of reedbeds .....	9
3.3. Fire management.....	10
4. Recommendations.....	13
References .....	16

## Preamble

This report collates recommendations and guidelines in a concise and applicable way, which stem out of the work carried out in the preparatory stages of the project, i.e. the assessment of wetland vegetation dynamics (Action A1). Recommendations and guidelines on wetland vegetation management have been discussed at various stages of the project, such as the Wetland Vegetation Management Advisory Group meetings (in 2016 and 2017) and the Project Management Group (PMG) meetings (2016 and 2018). This report is the final result following presentations and meaningful discussions during the last PMG meeting on the 7<sup>th</sup> of May 2018 at the SPP offices, Lemos, Greece.

## 1. Introduction

Reedbeds are key ecosystems with important functions and services in the landscape. Located at the interface between aquatic and terrestrial ecosystems they have an important role in nutrient cycling (Hocking 1989); they tend to reduce the nutrient inflow from terrestrial habitats (e.g. agriculture) and thus prevent eutrophication of lakes and more generally aquatic habitats. Additionally, they can also prevent shore erosion through buffering wave action and they are core habitat for important species, notably plant, arthropods and birds. Furthermore, reedbeds are used for various socio-economic activities such as reed harvest, fishing, hunting, bird watching, etc.

The management of reedbeds is multifaceted. The conservation and restoration of reedbeds is an issue in Europe, notably in northern countries, where a strong decline of their surface area reaching up to 80% (*Phragmites* die-back effect) has been experienced. The “dieback” phenomenon was first observed in Central and Northern Europe (Ostendorp 1989, Boar et al. 1989, Sukopp & Markstein 1989, Ostendorp et al. 1995, Rea 1996, Armstrong et al. 1996a, Armstrong et al. 1996b,) and more recently in Southern Europe (Gigante et al. 2014). Several factors have been identified as potential causes of this decline, i.e.: stabilization of water level, eutrophication, over-exploitation of reed biomass, anoxia, wave actions (sometimes generated by boat traffic) or a combination of the above mentioned. The dieback results in large openings or total disappearance of reedbeds. In the reedbeds of Prespa National Park signs that can be attributed to the die-back phenomenon have not been observed (Grillas et al., 2018).

Conversely, the expansion of tall helophytes including *Phragmites australis* in wet meadows is a wide spread phenomenon notably in Europe and in the Balkans where it is a concern for the conservation of biodiversity (e.g. Güsewell & Edwards 1999, Prach 2008, Joyce 2014,). Wet meadows play an important role for the conservation of biodiversity including plants, invertebrates, amphibians, fish and birds (Pyrovetsi & Crivelli 1988, Benayas & Scheiner 1993, Kazoglou et al. 2004, Morón et al. 2008). Wet meadows are highly threatened because of direct conversion to agricultural land and the lack of appropriate management (van Diggelen et al. 2006, Duncan & D’Herbès 1981). Abandonment is a particular concern in Europe,

especially in central European and Baltic countries (Joyce 2014). Waterlevel fluctuations generate optimal conditions for *Phragmites* encroachment along lakeshores (Coops & Van Der Velde 1996, Coops et al. 2004). In traditional management grazing reduced the dominance of *Phragmites* allowing the development of wet meadows (e.g. Vulink et al. 2000). Reed encroachment results in a loss of biodiversity (e.g. Duncan & D'Herbès 1981, Esselink et al. 2000, Burnside et al. 2007).

Mowing is often used as a substitute to traditional grazing practice after abandonment in order to maintain habitat (Buttler 1992, Berg & Gustafson 2007, Kołos & Banaszuk P. 2013). The date and frequency of mowing may have significant impact on biodiversity including nesting water birds and invertebrates (Cattin et al. 2003, Berg & Gustafson 2007). Common cattle are successful at keeping reeds when grazing pressure is high (Vulink et al. 2000). Alternative species such as the water buffaloes which penetrate deep into the shore zone can be more efficient in opening wide areas of reedbeds (Catsadorakis & Malakou 1997; Kazoglou et al., 2004a, Sweers et al. 2013). However, high grazing pressure may threaten the nesting success of waterbirds (Müller et al. 2007) and grazing pressure should be limited by nature conservation restrictions (Oppermann & Luick 1999).

Although significant scientific literature exists on reedbed ecology and management (e.g. Tyler et al. 1998, Ostendorp 1999, Sinassamy & Mauchamp 2001, White et al. 2004, Mathevet et al. 2007, Valkama et al. 2008, Fogli et al. 2014, Deák et al. 2015), the relationships between environmental factors, the dynamics, as well as the structure of reedbeds remain insufficiently understood to produce standardized recommendations. The phenotypic plasticity of the dominant species in combination with their great tolerance to environment stress and the delayed occurrence of the post-stress effects makes difficult to produce locally precise predictions on vegetation dynamics. Local studies are always needed to better adapt the general existing knowledge on the ecology of confined reedbed ecosystems, in order to produce locally adapted recommendations.

Recent studies on the reedbeds ecology of the study area includes the use of water-buffalo grazing as a tool for wet meadow restoration (Kazoglou et al., 2004a; Kazoglou et al., 2004b, Kazoglou 2007) study of nutrients in Prespa lake, and the analysis of the ecological niches of *Phragmites australis* and *Typha angustifolia* (Grillas et al., 2018a; Grillas et al., 2018b) as well as the effects of reed cutting/fire on its regeneration in the absence or presence of subsequent submergence (Sakellarakis & Grillas, 2019).

Additionally, thorough research has been carried out on the ecology of animal and plant species directly or indirectly related to the reedbeds of Lesser Prespa. Pavlides (1985) and Babalonas & Pavlides (1989) gave an insight on the syntaxonomy of the reedbed communities and wet meadows. Vrachnakis et al. (2011) provided a description and mapping of the habitat types as these have been classified according to the 92/43/ECC for the Natura 2000 network. Fotiadis (2017) studied the vegetation patterns and the plant richness in reedbed and related ecosystems. Strid et al. (2017) provided several new plant species records related to aquatic

and wet meadow vegetation. Theodoropoulos (2017a, 2017b) offered a good overview on the ecology of the otter (*Lutra lutra*) and on the small mammals that occur in reedbed while Sotiropoulos et al. (2017) on the ecology and species richness of amphibians. Several studies have provided useful information on the relationship of reedbeds and bird species (Catsadorakis 1997; Catsadorakis et al. 1998; Catsadorakis & Crivelli 2001, Bounas 2017) as well as for fish species (Crivelli et al. 1997).

## 2. *Phragmites* versus *Typha*: does it matter for biodiversity?

Reedbeds in a broad sense include helophyte stands dominated by various species such as *Phragmites australis*, *Typha angustifolia*, *T. latifolia*, *Cladium mariscus* and *Schoenoplectus lacustris*. In Prespa all except *Cladium mariscus* can be found but *P. australis* and *T. angustifolia* are more widespread and tend to create extensive monospecific stands. The structure of the vegetation between the two species is very different (Grillas et al. 2018a); in general *P. australis* tends to be denser and taller than *T. angustifolia* and the latter produces a dense layer of dead leaves from previous year.

Even though the ecology of both species is well understood, few studies have compared the biodiversity of *P. australis* versus *T. angustifolia* dominated reedbeds. From a floristic point of view Meyerson et al. (2000) found richer plant communities in *T. angustifolia* in comparison with *P. australis* stands, an observation that comes in agreement with our results from Prespa (Sakellarakis & Grillas, unpublished). This could be explained by higher light attenuation by *Phragmites* than by *Typha* (Meyerson et al. 2000).

No differences were found in benthic macroinvertebrates communities, an important element of reedbeds food-web, between *T. angustifolia* and *P. australis* stands (Osgood et al. 2006, Yozzo & Osgood 2013). Similarly, Theodoropoulos (2017) found no indication of preference by the otter (*Lutra lutra*) in the use of *Typha* versus *Phragmites* for the construction of their open couches (Theodoropoulos 2017). Direct or indirect evidence suggest though that reedbeds that are composed mainly by *P. australis* are more favorable than that of *T. angustifolia* for colonial breeding herons, even though the bittern (*Botaurus stellaris*) can use both types of reedbeds for breeding (Sinnassamy & Mauchamp 2000). The Dalmatian pelican *Pelecanus crispus* Bruch, 1832 and the Great white pelican *Pelecanus onocrotalus* Linnaeus, 1758 are known to create their nests only on *P. australis* stands in PNP (Catsadorakis & Crivelli, 2001) even though nests have been observed on *Typha angustifolia* in other Greek wetlands (e.g. Lake Chimaditis; SPP unpublished data). Both species are included in Annex I of the 2009/147/EC Directive and are listed as Vulnerable in the Greek Red Data book (Catsadorakis et al., 2009a, Catsadorakis et al., 2009b).

**Table 1.** Importance of the dominant plant species for the 9 targets waterbird Annex I species, which breed regularly in Lake Lesser Prespa (X= less important, XX= medium importance, XXX= very important):

Target species	<i>Phragmites</i>	<i>Typha</i>
Dalmatian Pelican ( <i>Pelecanus crispus</i> )	XXX	X
Great White Pelican ( <i>Pelecanus onocrotalus</i> )	XXX	X
Pygmy Cormorant ( <i>Microcarbo pygmeus</i> )	XXX	X
Ferruginous Duck ( <i>Aythya nyroca</i> )	XX	XX
Glossy Ibis ( <i>Plegadis falcinellus</i> )	X	
Great White Egret ( <i>Ardea alba</i> )	XXX	X
Little Egret ( <i>Egretta garzetta</i> )	XXX	X
Night Heron ( <i>Nycticorax nycticorax</i> )	XXX	X
Squacco Heron ( <i>Ardeola ralloides</i> )	XXX	X

Additionally, *Aldrovanda vesiculosa*, a rare - Appendix I (92/43/ECC) - aquatic carnivorous plant species, the occurrence of which in Greece, North Macedonia and Albania is restricted to Prespa Transboundary Park, can be found in both *P. australis* or *T. angustifolia* dominated stands (Jovanovska et al., 2017; Grillas et al., 2018a) while floating individuals can be found across the lake (Strid et al., 2017). Knowledge of the ecology of this rare species remains weak, however considering its conservation importance, attention should be paid to the impact of management of reedbeds on its populations.



Figure 1. *Aldrovanda vesiculosa* confirmed localities in the reedbeds of Prespa National Park.

### 3. Reedbed management issues / objectives

In former times reedbeds were important resource for the people of Prespa. Common reed used to be collected from the locals as a building material and livestock fodder for the winter. Additionally, reedbeds were under management (cutting, burning) from fishermen as a way to increase the spawn areas. Moreover, animal grazing – mostly by cattle and buffalos - maintained the open wet meadow vegetation. With the transformation of the rural society

during the early '80s, when the intensive monoculture of beans occurred, reedbeds started to expand against wet meadows. Current management of reedbeds at Lake Lesser Prespa needs to take into consideration a multitude of contrasting issues related to:

- **Wet meadow expansion:** restore wet meadows for biodiversity, and socio-economic purposes. Wet meadows decreased almost by 100 ha within the period 1945-2000 as a result of lack of traditional management, such as grazing and cutting for fodder (Kazoglou et al., 2004b and references therein). Although recent efforts (2002 – 2012) have restored wet meadows, today it is considered important to extend these restoration efforts for two main reasons: (a) the gradual reduction of management in the littoral zone since 2012 which has led anew to an expansion of the reedbed at the expense of wet meadows and (b) the increasingly reduced water level of Lake Lesser Prespa (observed and projected) in spring, which renders the creation of wet meadows through reed cutting in deeper parts of the littoral zone necessary (National Observatory of Athens 2017, Malakou et. al. 2018), in order to have an adequate surface area of flooded meadows in spring at all water level scenarios. Wet meadows are key habitats for spawning fish, amphibians, and feeding waterbirds, while they also hold socio-economic importance related to fish populations (carp) and grazing.
- **The dominant plant species:** restore the dominance of *P. australis* versus *T. angustifolia* (see Importance of Prespa reedbeds). During the last 25 years, narrowleaf cattail (*T. angustifolia*) has encroached to areas formerly occupied by common reed in large patches of the marshlands at the northern part of the Lake Lesser Prespa creating monospecific communities (Grillas et al., 2018a; Sakellarakis et al., 2018). If continued, the expansion of cattail communities will threaten to greatly reduce the proper nesting substrate of all colonial waterbirds nesting in the wetlands of the lake.
- **Prevent wildfire risk** (Catsadorakis & Malakou 1997) that can have severe consequences to the whole lakes' biota and more specifically to nesting colonies of the Dalmatian and Great white pelican and other water bird colonies or nests.

### 3.1. Reedbed expansion/ reduction of wet meadows

The expansion of reedbed is mainly driven by the dynamics and the management of vegetation at the shore of the lake. If not controlled, tall helophytes (*P. australis*, *T. angustifolia*, *Schoenoplectus lacustris* and related taxa) tend to expand on drier substrates excluding less competitive species. In shallower sites, grazing by cattle or water buffaloes reduces the dominance of these tall helophytes and allows the development of wet meadow vegetation (Kazoglou et al. 2004a, 2004b). These meadows are characterized by species-rich plant communities and constitute an important habitat for fish (for spawning), amphibians (for reproduction), invertebrates and waterbirds (feeding habitat).



Extensive experience exists at Prespa on grazing management for the restoration and maintenance of wet meadows (Catsadorakis & Malakou 1997; Kazoglou et al., 2004a; Kazoglou et al., 2004b, Malakou et al., 2007). However, the current socio-economic conditions limit the implementation of grazing activities on the shore of the lake. Alternative methods for the management of wet meadows is cutting (Buttler 1992, Berg & Gustafson 2007, Kotos & Banaszuk 2013). Burning, as a management tool for controlling reed expansion, was forbidden in the study area from 1971 (Kazoglou 2017) even though large-scale fire events still take place (Sakellarakis et al., 2018) almost annually (Malakou et al. 2018). Cutting alone in winter period has limited impact on the structure of the reedbed and thus does not contribute to the creation or restoration of wet meadows (see section 3.3). However, cutting in combination with water level manipulation can eliminate *P. australis* or *Typha angustifolia* cover (Baule 1979; Motivans & Apfelbaum 1987; Russell & Kraaij 2008; Rolletschek et al. 2000; Sakellarakis & Grillas, 2019), and thus can contribute in the reestablishment of wet meadow plant communities. However, only one cutting can be insufficient in reducing the dominance of tall helophytes (Beule 1976, Sakellarakis & Grillas 2019) and repeated cutting might be needed for achieving a complete elimination and maintenance. Combining summer cutting with hydrological management can provide better control of *P. australis* and contribute to the restoration of wet meadows (Russell & Kraaij 2008). Cutting in late spring – early summer, when carbohydrate reserves in the rhizomes of the plants are at their minimum would be the best strategy to weaken *Phragmites* (Granéli et al. 1992, Sinnassamy & Mauchamp 2001, Güsewell S. 2003) while autumn cutting has more limited effects on the structure of the reedbed (Hazelton et al. 2014). The effects of autumn harvest can however lead to severe reduction of the density and height of *Phragmites australis* when followed by a long flooding of the remaining culms.

Furthermore, late spring-early summer cutting would have dramatic consequences on biodiversity, notably on breeding birds. Hence, for the restoration of wet meadow at Prespa National Park, cutting in summer (after the end of the breeding season) or autumn when the water level reach its annual minimum and, should be the best compromise and provide good results. In the case of insufficient decrease of reedbed cover that might occur locally, a second cut in mid-autumn when the above ground of *Phragmites* or *Typha* are dead and before the rise of the water level of the lake could be tested in favourable years, in terms of water level regime, which should severely impact the density and height of *Phragmites* (Sakellarakis & Grillas 2019).

### **3.2. Dominant species and biodiversity of reedbeds**

Once established, thanks to their clonal growth form, helophytes species are resilient to ecological change and can encroach in neighboring habitats (Hara, van Der Toorn & Mook, 1993, Amsberry et al. 2000, Luo et al. 2014). The dominant species is generally related to environmental factors such as water depth and nutrient levels (Grace & Wetzel 1981, Wilson

& Keddy 1985, Weisner 1993). The replacement of one helophyte species by another is usually explained by ecological change (notably change in hydrology, anoxia and eutrophication), disturbance or encroachment of invasive species (e.g. Boar et al. 1989, Coops et al. 1999, Boers & Zedler 2008, Uddin & Robinson 2018).

However, the recent encroachment of *Typha angustifolia* in *Phragmites* dominated reedbeds could not be related to soil characteristics, trophic levels or to water depth (Grillas et al. 2018). Therefore, the remaining hypothesis to explain the observed encroachment is a major disturbance event which may have killed large areas of *P. australis* (Grillas et al. 2018b) and allowed *T. angustifolia* to establish itself. The severe drought experienced by the lake in 1989 – 1990 could be such an event. The high water level observed the following year (the highest ever recorded in Lesser Prespa since data exist) could further explain *T. angustifolia* establishment: this species produces many more seeds (Vaccaro 2005) than *P. australis* and their seedlings are more tolerant to flooding. Once established, *T. angustifolia* can prevent the germination of *P. australis*. However, the latter is expected to be more competitive than *T. angustifolia* and should have recolonized the lost area by lateral (vegetative growth). The frequency of fires might also be a factor stopping and reversing this succession, i.e. not allowing the recolonization by *Phragmites australis*.

A management experiment run in 2017-2018 supported the hypothesis of strong decline of *Phragmites australis* stands when flooded after harvest (Sakellarakis & Grillas, 2019), which is also supported by the scientific literature related to the oxygen demand from below ground parts of the plants and the role of emerging culms (e.g. Armstrong et al. 1999b). However, this field experiment could not test the facilitated establishment of *T. angustifolia* because the germination of the tiny seeds of that species requires conditions that cannot be controlled (lake water level).

The replacement of *Phragmites australis* by *Typha angustifolia* on large areas of the northern part of Lake Lesser Prespa is not yet fully understood. However, it is suspected that fire and hydrology are key drivers of this change. To reverse the expansion of *Typha* against *Phragmites*, it is thus recommended to try to reduce the frequency and extent of fires (see below chapter 3.3.).

### 3.3. Fire management

Cutting in winter and burning have similar effects on reedbeds if the fire does not reach the soil (wet or flooded conditions) (Middleton et al. 2006). The effects of fire are hardly comparable with those of summer harvest as the first probably cannot occur or is very rare when reed is still growing and with high water content. The effects of summer harvesting are best compared with those of grazing and usually not used to maintain reedbed structure but conversely to transform them in wet meadows (see section 3.1).

There is a vast literature on the impacts of winter harvesting and burning on the effects of fire on reedbeds and their biodiversity (e.g. Dithlago et al. 1992, Sinassamy & Mauchamp 2000,

Valkama 2008, White et al. 2014). The effects of management depend on the type of management, the temporal frequency, spatial extent and the local intensity of manipulations (Mérö et al. 2018). Winter harvest has limited impact on the structure of the reedbed unless combined with flooding (Rolletschek et al. 2000; Smith 2005; Russell & Kraaij 2008; Hazelton et al. 2014; Sakellarakis & Grillas 2019). Mowing underwater or mowing followed by flooding has similar impact by preventing oxygenation of underground parts (Rolletschek et al., 2000; Ausden 2007).

Contrasted results have been reported on the impact of reed management of invertebrates (Ditlhogo et al., 1992; Cowie et al., 1992; Schmidt et al., 2005; Poulin & Lefebvre, 2002). Valakama et al. (2008) on a meta-analysis of 17 published articles found an overall negative effect of reed management on invertebrate community especially when management is implemented for long period (on the short term impact is more variable). Species overwintering within the plant shoots (e.g. moths) are the most exposed to harvesting or fire impact. Since management has a cumulative effect on *Phragmites* and invertebrates are dependent on reedbed structure, the effects of management increased with time (Schmidt et al., 2005). However, phytophagous species might benefit from the better nutritional value of re-growing reeds after harvest and their higher density (Schmidt et al., 2005).

The abundance of reed-specialist passerines decreases in mowed, grazed, and burned parts of reedbeds, and some warblers of the genus *Acrocephalus* avoid mowed areas entirely (Graveland 1999, Mérö et al. 2018). Valkama et al. (2008) found that reed management had a strong negative effect on passerine birds (60% reduction) probably associated with food limitations. However, the effects can differ according to the reproduction phenology of the birds (Poulin & Lefebvre 2002): the reedbed has already started to grow and provide suitable breeding habitat for late migrating birds. Reed regrowth is stronger in burned areas than in unmanaged or grazed areas (Mester et al. 2015) and can eventually support higher food resources for passerines (Poulin and Lefebvre 2002). Therefore, rotation in harvesting plots can constitute a compromise between socio-economic use of the reedbed and the biodiversity, but may not apply when the objective is to shift the ecosystem towards wet meadows.

The structure of the reedbed is important for supporting the large nest of ardeids, depending also on their phenology. In Mediterranean France, the purple heron (*Ardea purpurea*) nests in old reedbeds with standing water (Barbraud et al 2002), whereas the great bittern (*Botaurus stellaris*) was found most abundant in harvested reedbeds (Poulin et al. 2002).

The effects of the management (harvested/ non-harvested) depend partly on the size of the patches. Relatively small patches in non-harvested reedbeds can be sufficient for the establishment of bird nests and this is particularly important for colonial waterbirds (e.g. herons). Similarly, increasing the diversity of aquatic habitats within reedbed systems will benefit amphibians and other species (Hardman et al. 2011, Mérö et al. 2015, Mester et al. 2015).

No evidence could be found on the impact of reed management on amphibian populations (Smith & Sutherland 2014). More recently Mester et al. (2015) found that the number of amphibian species and individuals decreased with mean reed cover and old reed density, and increased with variability in reed cover. Correspondingly, amphibian richness and counts were greatest in newly burned areas the next spring but this effect lasts only one year. Combining fire and grazing management creates a mosaic of different habitats favorable to amphibians (Mester et al. 2015) and probably other species.

The general strategy for Lesser Prespa reedbeds could be to reduce (1) the risk of wildfire, (2) the expansion of wildfires across the reedbed and (3) the duration of flooding of the remaining culms. In that perspective the best option seems to establish fire breaks notably at the mouth of the drainage canals and within Vromolimni in order to halt fire expansion if ever one starts.

## 4. Recommendations

The management of Prespa reedbeds can be discerned in three main objectives:

- (1) Reducing the cover and dominance of tall helophytes in the margins of the reedbed so **to increase the total cover of wet meadow vegetation.**
- (2) **Protecting important bird colonies** from wildfires.
- (3) **Re-establishing *P. australis* dominance** in areas currently dominated by *T. angustifolia* and preventing the further expansion of the latter species.

An additional objective, on a secondary level, is to utilize the biomass of reedbeds as a by-product of the management, which can serve as fodder or soil improvement for farmers of the area.

In order to propose management recommendations, two main limitations to management should be considered: (a) cutting in spring and early summer (i.e. June) must be avoided for reasons related to the breeding of fauna species and (b) the water level regime, which allows the inundation of large littoral areas for the benefit of biodiversity, but at the same time creates technical difficulties for the application of management (e.g. cutting in waterlogged areas).

Therefore, and taking into consideration the above mentioned objectives and limitations, the following can be recommended:

### Objective 1: Increase surface area of wet meadows

- The creation of wet meadows involves cutting at the terrestrial shore of the reedbed and should ideally be followed by grazing in order to prevent regrowth.
- For the restoration and maintenance of wet meadows, cutting should be implemented on green vegetation, from mid-summer (after the end of the breeding season, i.e. after July) to autumn, in a similar pattern as was implemented in previous years (2002-2012). Cutting in summer (after July) is well adapted to the local conditions, as at that time the water level is gradually receding and allows cutting to be implemented by appropriate tools and machinery (Kazoglou, 2007, Malakou, et. al. 2018). Implemented on an annual basis, it will limit the regrowth of reed and favor the establishment of wet meadow vegetation.
- Cutting can also be implemented until late autumn when the water level is low and the above ground organs of both *Phragmites* and *Typha* are dead. After late cutting, i.e. from October, the plants will not have time to regrow and winter flooding will strongly impact their survival and regrowth the following season. It has been established that cutting as late as November when followed by flooding of the remaining culms, limits the regrowth of *Phragmites*, more effectively than summer cutting (Sakellarakis & Grillas 2019).
- A second cutting date could be considered on sites where the first cutting was early and regrowth abundant. It could be an opportunistic cut, depending on the need and feasibility (e.g. low water level).

## Objective 2: Creation of firebreaks

- Cutting aiming at the creation of firebreaks should be implemented at different locations for (a) protecting important sites (e.g. colonial water birds' colonies and more particularly pelicans colonies), (b) at the mouth of the drainage canals to prevent the expansion of fires at one of the main starting points and (c) at specific sites and intervals across the reedbed (from the edge to the deep lake), in order to prevent fire propagation.
- Firebreaks should be at least 10m wide to minimize the risk of firebrands transport.
- In order to create firebreaks, two strategies may be employed:
  - (a) The creation of permanent firebreaks, i.e. the creation of areas/zones within the reedbed where helophyte regrowth needs to be suppressed in order to stop its regrowth permanently. This may be achieved by cutting vegetation underwater in summer or autumn (Kazoglou, 2007, Malakou et al. 2007). Because of some remaining regrowth from the cut plants and of the lateral growth of uncut plants, this cutting should be repeated regularly until the desirable situation is achieved. Permanent firebreaks may be created around the most frequently-used long-term colonies (two main sites in Lake Lesser Prespa) to ensure permanent protection.
  - (b) The creation of non-permanent firebreaks, could be achieved by cutting above water in winter (e.g. January). Winter cutting tends to revitalize the reedbed, creating only temporary open areas (Hawke & Jose 1996, Malakou et. al. 2007). However, the sites will be free of dry reed biomass in the season of fire outbreaks, thus preventing the spread of fires. Non-permanent firebreaks can be used in areas where it is considered important to retain the reedbed intact, but only for a limited time or in cases where a disruption of the reedbed is necessary for not allowing the spread of fires. In any case this strategy is not preferred, as conditions at this time of the year (e.g. frozen lake) may not allow for interventions.
- The choice of any of the two strategies, depends on the several factors and both can be employed alternatively, adapting to local annual water level and reedbed conditions.

## Objective 3: Re-establishing *P. australis* dominance

The replacement of *P. australis* by *T. angustifolia* is most probably the result of a combination of disturbance, the succession of severe drought and probable extensive wildfires followed by extremely high water levels. This large scale severe disturbance gave an opportunity for *T. angustifolia* to colonize this open area. Alternative hypotheses exist for the mid-term dynamics of the reedbed after *Typha* encroachment:

- (a) *P. australis* will recolonize progressively *Typha* dominated stands by competition
- (b) The availability of seeds of *P. australis* and/or the niche regeneration for their germination and successful establishment are not met for recolonization
- (c) Recurrent fires prevent *Phragmites* recolonization (i.e. *T. angustifolia* is more resilient to fires)

- (d) The dominance of *T. angustifolia* and *P. australis* corresponds to alternative stable states (Schröder et al. 2005; Fukami & Nakajima 2011).

The on-going field monitoring and management experiments should help sorting the most relevant hypotheses.

- Transects have been established at the interface between *Phragmites*-*Typha* dominated stands allowing to assess the competitive output, i.e. if *P. australis* encroach into *T. angustifolia* dominated stands. These transects could show different results depending on their environmental conditions and the disturbance regime they are exposed to (if different between sites) (hypotheses a & c).
- The monitoring of the autumn cutting experiment (2017-2018) will provide information on the recovery of the reedbed after the sharp decline in density and height of *P. australis*.
- The monitoring of the transplantation experiment of *P. australis* inside *Typha* dominated stands will provide answer on the propagule limitation (hypothesis b)
- The monitoring of the effects of the management (cutting) on *Phragmites* and *Typha* dominated stands will inform on the resilience of both species to disturbance. The diversity of situations will provide insight on the driving environmental factors (water depth, grazing, etc.) - (hypotheses c & d).

## References

- Amsberry L., Baker M.A., Ewanchuk P.J., Bertness M.D. 2000. Clonal Integration and the Expansion of *Phragmites australis*. *Ecological Applications*, 10:1110–1118.
- Armstrong J., Afreen-Zobayed F., Armstrong W. 1996b. *Phragmites* die-back: sulfide- and acetic acid induced bud and root death, lignifications, and blockages within aeration and vascular systems. *New Phytologist*, 134: 105–113.
- Armstrong J., Armstrong W., Van der Putten W. 1996a. *Phragmites* die-back: bud and root death blockages within the aeration and vascular systems. *New Phytologist*, 133:339–414.
- Ausden M. 2007. *Habitat Management for Conservation: A Handbook of Techniques*. Oxford University Press, Oxford, 387p, ISBN: 9780198568728.
- Babalonas, D. & Pavlides G. 1989. Contribution to the vegetation of aquatic plants of lake Mikri Prespa [In Greek with English abstract]. – Bios (Thessaloniki), 19-29 pp.
- Barbraud C., Lepley M., Mathevet R., Mauchamp A. 2002. Reedbed selection and colony size of breeding Purple Herons *Ardea purpurea* in southern France. *Ibis*, 144:227–235. doi: [10.1046/j.1474-919X.2002.00047.x](https://doi.org/10.1046/j.1474-919X.2002.00047.x)
- Benayas J.M.R., Scheiner S.M. 1993. *Diversity patterns of wet meadows along geochemical gradients in central Spain*. *Journal of Vegetation Science* 4:103–108. doi: [10.2307/3235737](https://doi.org/10.2307/3235737)
- Berg Å., Gustafson T. 2007. *Meadow management and occurrence of corncrake *Crex crex**. *Agriculture, Ecosystems & Environment* 120:139–144. doi: [10.1016/j.agee.2006.08.009](https://doi.org/10.1016/j.agee.2006.08.009)
- Beule, J. D. 1979. Control and management of cattails in southeastern Wisconsin wetlands. Wisconsin Department Natural Resources Tech. Bulletin 112, Madison. 41 pp.
- Boar R.R, Crook C e., Moss B. 1989. Regression of *Phragmites australis* reedswamps and recent changes of water chemistry in the Norfolk Broadland, England. *Aquatic Botany*, 35(1):41-55. doi: [10.1016/0304-3770\(89\)90065-X](https://doi.org/10.1016/0304-3770(89)90065-X)
- Boers A.M., Zedler J.B. 2008. *Stabilized Water Levels and Typha Invasiveness*. *Wetlands*, 28:676–685. doi: [10.1672/07-223.1](https://doi.org/10.1672/07-223.1)
- Bounas T. 2017. Census of passerine birds in the reedbeds of Lake Mikri Prespa. Report under the framework of LIFE Project “Prespa Waterbirds” LIFE 15 NAT/GR/000936.
- Burnside, N.G., Joyce, C.B., Puurmann, E. & Scott, D.M. (2007) Use of vegetation classification and plant indicators to assess grazing abandonment in Estonian coastal wetlands. *Journal of Vegetation Science*, 18(5), 645–654.
- Buttler A. 1992. *Permanent plot research in wet meadows and cutting experiment*. *Vegetatio* 103:113–124. doi: [10.1007/BF00047697](https://doi.org/10.1007/BF00047697)
- Catsadorakis G., & A. J. Crivelli. 2001. Nesting habitat characteristics and breeding performance of Dalmatian Pelicans in Lake Mikri Prespa, NW Greece. *Waterbirds*. 24:386–393.



- Catsadorakis G, Malakou M. 1997. Conservation and management issues of Prespa National Park. In: Crivelli AJ, Catsadorakis G (Editors), Lake Prespa, Northwestern Greece: A Unique Balkan Wetland. Dordrecht: Springer Netherlands; pp: 175-96. [https://doi.org/10.1007/978-94-011-5180-1\\_13](https://doi.org/10.1007/978-94-011-5180-1_13)
- Catsadorakis G. 1997. The importance of Prespa National Park for breeding and wintering birds. *Hydrobiologia*. 351: 157-174
- Cattin M.-F., Blandenier G., Banašek-Richter C., Bersier L.-F. 2003. *The impact of mowing as a management strategy for wet meadows on spider (Araneae) communities*. *Biological Conservation* 113:179–188. doi: [10.1016/S0006-3207\(02\)00297-5](https://doi.org/10.1016/S0006-3207(02)00297-5)
- Coops H., Geilen N., Van Der Velde G. 1999. Helophyte zonation in two regulated estuarine areas in the Netherlands: Vegetation analysis and relationships with hydrological factors. *Estuaries*, 22:657–668. doi: [10.2307/1353053](https://doi.org/10.2307/1353053)
- Coops H., Van Der Velde G. 1996. *Impact of hydrodynamic changes on the zonation of helophytes*. *Netherlands Journal of Aquatic Ecology* 30:165–173. doi: [10.1007/BF02272236](https://doi.org/10.1007/BF02272236)
- Coops H., Vulink J.T., van Nes E.H. 2004. *Managed water levels and the expansion of emergent vegetation along a lakeshore*. *Limnologica* 34:57–64. doi: [10.1016/S0075-9511\(04\)80022-7](https://doi.org/10.1016/S0075-9511(04)80022-7)
- Cowie N.R., Sutherland W.J., Dithlago M.K.M., James R. 1992. The Effects of Conservation Management of Reed Beds. II. The Flora and Litter Disappearance. *Journal of Applied Ecology*, 29:277–284. <https://doi.org/10.2307/2404496>
- Crivelli, A. J., D. Hatzilacou, and G. Catsadorakis. 1998. The breeding biology of the Dalmatian Pelican *Pelecanus crispus*. *Ibis*, 140:472–481.
- Crivelli, A. J., G. Catsadorakis, M. Malakou & E. Rosecchi, 1997. Fish and fisheries of the Prespa lakes. *Hydrobiologia*, 351: 107–125.
- Deák B., Valkó O., Török P., Kelemen A., Tóth K., Miglécz T., Tóthmérész B. 2015. Reed cut, habitat diversity and productivity in wetlands. *Ecological Complexity*, 22:121–125. <https://doi.org/10.1016/j.ecocom.2015.02.010>
- Diggelen R. van, Middleton B., Bakker J., Grootjans A., Wassen M. 2006. *Fens and floodplains of the temperate zone: Present status, threats, conservation and restoration*. *Applied Vegetation Science* 9:157–162. doi: [10.1111/j.1654-109X.2006.tb00664.x](https://doi.org/10.1111/j.1654-109X.2006.tb00664.x)
- Dithlago M.K.M., James R., Laurence B.R., Sutherland W.J. 1992. The Effects of Conservation Management of Reed Beds. I. The Invertebrates. *Journal of Applied Ecology*, 29:265–276. <https://doi.org/10.2307/2404495>
- Duncan, P. & D'Herbes, J.M. (1982) The use of domestic herbivores in the management of wetlands for waterbirds in the Camargue. In: Scott, D.A. (ed.) *Managing Wetlands and Their Birds*, International Waterfowl Bureau, Münster, 51–67.

- Esselink, P., Zijlstra, W., Dijkema, K.S. & van Diggelen, R. (2000) The effects of decreased management on plant-species distribution patterns in a salt marsh nature reserve in the Wadden Sea. *Biological Conservation*, 93(1), 61–76
- Fogli S., Brancaloni L., Lambertini C., Gerdol R. 2014. Mowing regime has different effects on reed stands in relation to habitat. *Journal of Environmental Management*, 134:56–62. <https://doi.org/10.1016/j.jenvman.2014.01.001>
- Fotiadis G. 2017. Survey on the floristic diversity of Lesser Prespa Lake. Report within the program «LIFE Prespa Waterbirds» (LIFE15 NAT/GR/000936). Society for the Protection of Prespa (In Greek).
- Fukami T., Nakajima M. 2011. *Community assembly: alternative stable states or alternative transient states?* *Ecology Letters* 14:973–984. doi: [10.1111/j.1461-0248.2011.01663.x](https://doi.org/10.1111/j.1461-0248.2011.01663.x)
- Gigante D., Angiolini C., Landucci F., Maneli F., Nisi B., Vaselli O., Venanzoni R., Lastrucci L. 2014. New occurrence of reed bed decline in southern Europe: Do permanent flooding and chemical parameters play a role? *Comptes Rendus Biologies*, 337(7):487-98. doi: [10.1016/j.crv.2014.05.005](https://doi.org/10.1016/j.crv.2014.05.005)
- Granéli W., Weisner S.E.B., Sytsma M.D. 1992. Rhizome dynamics and resource storage in *Phragmites australis*. *Wetlands Ecology and Management*, 1:239–247. doi: [10.1007/BF00244929](https://doi.org/10.1007/BF00244929)
- Graveland J. 1999. Effects of reed cutting on density and breeding success of reed warbler *Acrocephalus scirpaceus* and sedge warbler *A. schoenobaenus*. *Journal of Avian Biology*, 30: 469-482.
- Grillas P., Sakellarakis F.-N., Maliaka V., Smolder F. 2018. Identification of the ecological niches of *Typha angustifolia* and *Phragmites australis*. Report within the LIFE15 NAT/GR/000936 Bird conservation in Lesser Prespa: benefiting local communities and building a climate change resilient ecosystem. 37 pp.
- Güsewell S. 2003. Management of *Phragmites australis* in Swiss fen meadows by mowing in early summer. *Wetlands Ecology and Management* 11:433–445. doi: 10.1023/B:WETL.00000007197.85070.58
- Güsewell S., Edwards P. 1999. *Shading by Phragmites australis: a threat for species-rich fen meadows?* *Applied Vegetation Science* 2:61–70. doi: [10.2307/1478882](https://doi.org/10.2307/1478882).
- Hara T., van Der Toorn J., Mook J.H. 1993. Growth Dynamics and Size Structure of Shoots of *Phragmites australis*, a Clonal Plant. *Journal of Ecology*, 81:47–60. doi: [10.2307/2261223](https://doi.org/10.2307/2261223).
- Hardman C.J., Mackley E.K., Harris D.B. 2011. Bringing Reedbeds to Life Project Wildlife surveys, CHAPTER 9: Amphibian Surveys, 31pp. <https://www.rspb.org.uk/globalassets/downloads/documents/conservation-projects/bringing-reedbeds-back-to-life/technical-report-c9-amphibians.pdf>
- Hawke, C. J. & P.V. José. 1996. Reedbed Management for Commercial and Wildlife Interests. Royal Society for the Protection of Birds.

- Hazelton E.L.G., Mozdzer T.J., Burdick D.M., Kettenring K.M., Whigham D.F. 2014. *Phragmites australis* management in the United States: 40 years of methods and outcomes. *AoB Plants*, 6:1-19; [cited 2018 Mar 11]. doi: [10.1093/aobpla/plu001](https://doi.org/10.1093/aobpla/plu001)
- Hocking, P.J. 1989. Seasonal dynamics of production, and nutrient accumulation and cycling by *Phragmites australis* (Cav.) Trin. ex Steudel in nutrient-enriched swamp in inland Australia. I. Whole plants. *Aust. J. Freshwater Res.*, 40:421-444.
- Jovanovska D., Mladenova M., Minova E., Melovska N., Melovski Ljupco. 2017. Rediscovery of *Aldrovanda vesiculosa* L. and new data on its distribution in the Republic of Macedonia. *Acta Musei Macedonici Scientiarum Naturalium*, 20:31–40.
- Joyce C.B. 2014. *Ecological consequences and restoration potential of abandoned wet grasslands*. *Ecological Engineering* 66:91–102. doi: [10.1016/j.ecoleng.2013.05.008](https://doi.org/10.1016/j.ecoleng.2013.05.008)
- Kazoglou Y., Koutseri I., Malakou M. 2004a. Conservation management of wet meadows at the Greek part of Lake Mikri Prespa. *Balwois* 10 pp.
- Kazoglou Y., Mesléard F. & Papanastasis V.P. 2004b. Water buffalo (*Bubalus bubalis*) grazing and summer cutting as methods of restoring wet meadows at Lake Mikri Prespa, Greece. In Lüscher A. (Ed.) *Land Use Systems in Grassland Dominated Regions*,: Proceedings of the 20th General Meeting of the European Grassland Federation, Luzern, Switzerland, vdf Hochschulverlag AG, pp: 225-227.
- Kołos A, Banaszuk P. 2013. Mowing as a tool for wet meadows restoration: Effect of long-term management on species richness and composition of sedge-dominated wetland. *Ecological Engineering*, 55:23-88.
- Kołos A., Banaszuk P. 2013. *Mowing as a tool for wet meadows restoration: Effect of long-term management on species richness and composition of sedge-dominated wetland*. *Ecological Engineering* 55:23–28. doi: [10.1016/j.ecoleng.2013.02.008](https://doi.org/10.1016/j.ecoleng.2013.02.008)
- Luo F.-L., Chen Y., Huang L., Wang A., Zhang M.-X., Yu F.-H. 2014. *Shifting effects of physiological integration on performance of a clonal plant during submergence and de-submergence*. *Annals of Botany*, 113:1265–1274. doi: [10.1093/aob/mcu057](https://doi.org/10.1093/aob/mcu057)
- Malakou, M. [ed.]. 2018. Guidelines for wetland vegetation management in Lake Lesser Prespa: Review of vegetation management in the littoral zone of Lake Lesser Prespa in 2008 – 2017 and management proposals for 2018. Produced within the project LIFE15 NAT/GR/000936 “Bird conservation in Lesser Prespa: benefiting local communities and building a climate change resilient ecosystem”. 46 pp.
- Malakou, M., Kazoglou, Y., Koutseri, I., Parisopoulos, G., Rigas, A., Ziankas, G., Athanasiadou, E. & E. Mertziou. 2007. Guideline document for the restoration and management of wet meadows in Lake Lesser Prespa (2007-2012). LIFE2002NAT/GR/8494. Society for the Protection of Prespa
- Mathevet R., Le Page C., Etienne M., Lefebvre G., Poulin B., Gigot G., Proréol S., Mauchamp A. 2007. BUTORSTAR: A role-playing game for collective awareness of wise reedbed use. *Simulation & Gaming*, 38:233–262. <https://doi.org/10.1177/1046878107300665>
- Mérő T.O., Žuljević A., Varga K., Lengyel S. 2018. Reed management influences philopatry to reed habitats in the Great Reed Warbler (*Acrocephalus arundinaceus*). *The Condor*, 120:94–105. doi: [10.1650/CONDOR-17-114.1](https://doi.org/10.1650/CONDOR-17-114.1)

- Mérő, T. O., Lontay L., Lengyel S. 2015. Habitat management varying in space and time: The effects of grazing and fire management on marshland birds. *Journal of Ornithology*, 156:579–590.
- Mester B., Szalai M., Mérő T.O., Puky M., Lengyel S. 2015. spatiotemporally variable management by grazing and burning increases marsh diversity and benefits amphibians: A field experiment. *Biological Conservation*, 192:237–246
- Meyerson L.A., Saltonstall K., Windham L., Kiviat E., Findlay S. 2000. A comparison of *Phragmites australis* in freshwater and brackish marsh environments in North America. *Wetlands Ecology and Management*, 8:89–103. doi: [10.1023/A:1008432200133](https://doi.org/10.1023/A:1008432200133)
- Middleton BA, Holsten B, Diggelen R van. 2006. Biodiversity management of fens and fen meadows by grazing, cutting and burning. *Applied Vegetation Science*, 9(2):307–16.
- Moroń D., Szentgyörgyi H., Wantuch M., Celary W., Westphal C., Settele J., Woyciechowski M. 2008. *Diversity of wild bees in wet meadows: Implications for conservation*. *Wetlands* 28:975. doi: [10.1672/08-83.1](https://doi.org/10.1672/08-83.1)
- Motivans, K. & Apfelbaum, S. 1987. Element stewardship abstract for *Typha* spp., North American cattails. The Nature Conservancy
- Müller, J., Kayser, M. & Isselstein, J. (2007) The effect of stocking rate on nesting success of meadow birds. In: De Vliegheer, A. & Carlier, L. (eds.) Permanent and Temporary Grassland. Plant, Environment and Economy. European Grassland Federation, Gent, 72–73.
- National Observatory of Athens. 2017. Final report of the assessment of habitat vulnerability to climate change. Report within the LIFE15 NAT/GR/000936 Bird conservation in Lesser Prespa: benefiting local communities and building a climate change resilient ecosystem. 82 pp.
- Osgood D.T., D.J. Yozzo D.J., R.M. Chambers R.M., S. Pianka S., C. LePag S.,e and J. Lewis J. 2006. Patterns of habitat utilization by resident nekton in *Phragmites* and *Typha* marshes on the Hudson River Estuary, New York. In Hudson River fishes and their environment, eds. J.Waldman, K. Limburg and D. Strayer. American Fisheries Society Symposium, 51:151–173.
- Ostendorp W. 1989. Die-back of reeds in Europe, a critical review of literature. *Aquatic Botany*, 35: 5–26.
- Ostendorp W. 1999. Management Impacts on Stand Structure of Lakeshore *Phragmites* Reeds. *International Review of Hydrobiology*, 84:33–47. <https://doi.org/10.1002/iroh.199900006>
- Ostendorp W., Iseli C., Krauss M., Krumscheid-Plankert P., Moret J., Rollier M., and Schanz F. 1995. Lake shore deterioration, reed management and bank restoration in some Central European lakes. *Ecological Engineering*, 5:51–75.
- Pavlidis, G. 1985. Geobotanical study of the national park of lakes Prespa (NW Greece). Part A'. Ecology, flora, phytogeography, vegetation. – Thessaloniki: xi + 308 pp. + 1 map (In Greek with English summary).

- Poulin B., Lefebvre G. 2002. Effect of winter cutting on the passerine breeding assemblage in French Mediterranean reedbeds. *Biodiversity and Conservation*, 11:1567–1581. doi: [10.1023/A:1016866116220](https://doi.org/10.1023/A:1016866116220)
- Poulin B., Lefebvre G., Mauchamp A. 2002. Habitat requirements of passerines and reedbed management in southern France. *Biological Conservation*, 107:315–325. doi: [10.1016/S0006-3207\(02\)00070-8](https://doi.org/10.1016/S0006-3207(02)00070-8)
- Prach K. 2008. *Vegetation Changes in a Wet Meadow Complex during the Past Half-Century*. *Folia Geobot* 43:119–130. doi: [10.1007/s12224-008-9011-z](https://doi.org/10.1007/s12224-008-9011-z)
- Pyrovetsi M., Crivelli A. 1988. *Habitat use by water-birds in Prespa National Park, Greece*. *Biological Conservation* 45:135–153. doi: [10.1016/0006-3207\(88\)90044-4](https://doi.org/10.1016/0006-3207(88)90044-4)
- Rea N. 1996. Water levels and *Phragmites*: Decline from lack of regeneration or dieback from shoot death. *Folia Geobotanica*, 31:85–90. doi: 10.1007/BF02803997
- Rolletschek, H., Rolletschek, A., Hartzendorf, T., Kohl, J.-G., 2000. Physiological consequences of mowing and burning of *Phragmites australis* stands for rhizome ventilation and amino acid metabolism. *Wetlands Ecology and Management* 8,425–433.
- Russell I.A. & Kraaij T. 2008. Effects of cutting *Phragmites australis* along an inundation gradient, with implications for managing reed encroachment in a South African estuarine lake system. *Wetlands Ecology and Management*, 16(5):383-93, doi: 10.1007/s11273-007-9075-1.
- Sakellarakis F.-N. & Grillas P. 2019. Effects of cutting and flooding on *P. australis* reedbeds – Results of a field experiment. Report within the LIFE15 NAT/GR/000936 Bird conservation in Lesser Prespa: benefiting local communities and building a climate change resilient ecosystem. 21 p. + Appendix.
- Sakellarakis F.-N., Merle C., Lefebvre G., Guelmami A., Sandoz A., Grillas P. 2018. Mapping Prespa reedbeds and recent changes. Report within the LIFE15 NAT/GR/000936 Bird conservation in Lesser Prespa: benefiting local communities and building a climate change resilient ecosystem. 27 pp. + Appendix I & II.
- Schmidt M.H., Lefebvre G., Poulin B., Tschardt T. 2005. Reed cutting affects arthropod communities, potentially reducing food for passerine birds. *Biological Conservation*, 121:157–166. doi: [10.1016/j.biocon.2004.03.032](https://doi.org/10.1016/j.biocon.2004.03.032)
- Schröder A., Persson L., Roos A.M.D. 2005. *Direct experimental evidence for alternative stable states: a review*. *Oikos* 110:3–19. doi: [10.1111/j.0030-1299.2005.13962.x](https://doi.org/10.1111/j.0030-1299.2005.13962.x)
- Sinnassamy J.-M. & Mauchamp A. 2001. Roselières - gestion fonctionnelle et patrimoniale, Cahiers Techniques. ATEN, Montpellier.
- Smith S.M. 2005. Manual Control of *Phragmites australis* on Pondshores of Cape Cod National Seashore, Massachusetts, USA. *Journal of Aquatic Plant Management*, 43:50–53.
- Smith, R.K. and Sutherland, W.J. 2014. *Amphibian conservation: Global evidence for the effects of interventions*. Exeter, Pelagic Publishing.
- Sotiropoulos K., Bounas T., Papadaki Ch., Sergiadou D., Siarampi S., Toli E.A., 2017. Assessment of the diversity of amphibians in reedbeds of Mikri and Megali Prespa. Report within the

- program «LIFE Prespa Waterbirds» (LIFE15 NAT/GR/000936). Laboratory of Molecular Ecology & Conservation Genetics, Department of Biological Applications & Technology, University of Ioannina. Society for the Protection of Prespa (In Greek).
- Strid A., Bergmeier E., Sakellarakis F.-N., Kazoglou Y., Vrahnakis M. & Fotiadis G. 2017. Additions to the flora of the Prespa National Park, Greece. *Phytologia Balcanica* 23 (2): 207–269.
- Sukopp H. and Markstein B. 1989. Changes of the reedbeds along the Berlin Havel, 1962–1987. *Aquatic Botany*, 35:27–39.
- Sweers W., Horn S., Grenzdörffer G. & Müller J. 2013. Regulation of reed (*Phragmites australis*) by water buffalo grazing: use in coastal conservation. In *Mires and Peat*, Volume 13, Article 03, 1–10. International Mire Conservation Group and International Peat Society Editor, <http://www.mires-and-peat.net/>, ISSN 1819-754X.
- Theodoropoulos Y. 2017. A study on the presence of the otter (*Lutra lutra*) in Lesser Prespa Lake. Report within the framework of LIFE Project “Prespa Waterbirds” (LIFE15 NAT/GR/000936), 35 pp. Society for the Protection of Prespa.
- Theodoropoulos, Y., 2017b. A baseline survey of small terrestrial mammals along the reedbeds of Lesser Prespa Lake. Report within the framework of the project “LIFE Prespa Waterbirds” (LIFE15 NAT/GR/000936). Society for the Protection of Prespa.
- Tyler G.A., Smith K.W., Burges D.J. 1998. Reedbed management and breeding bitterns *Botaurus stellaris* in the UK. *Biological Conservation*, 86,: 257–266. [https://doi.org/10.1016/S0006-3207\(97\)00174-2](https://doi.org/10.1016/S0006-3207(97)00174-2)
- Uddin M.N., Robinson R.W. 2018. *Can nutrient enrichment influence the invasion of Phragmites australis?* *Science of The Total Environment* 613–614:1449–1459. doi: [10.1016/j.scitotenv.2017.06.131](https://doi.org/10.1016/j.scitotenv.2017.06.131)
- Vaccaro L. 2005. Patterns, mechanisms and ecological implications of cattail (*Typha* spp.) dominance in Great Lakes wetlands. M.S. Thesis. Cornell University, Ithaca, NY.
- Valkama E., Lyytinen S., Koricheva J. 2008. The impact of reed management on wildlife: A meta-analytical review of European studies. *Biological Conservation*, 141,: 364–374. <https://doi.org/10.1016/j.biocon.2007.11.006>
- Vrahnakis, M., Fotiadis, G. & Kazoglou, Y. 2011. Habitat types of Prespa National Park, Record, Evaluation and Geographical Presentation 2011. Society for the Protection of Prespa – TEI Larisas, 104 pp. (+ Annexes) [in Greek].
- Vulink, J.T., Drost, H.J. & Jans, L. 2000. The influence of different grazing regimes on *Phragmites* and shrub vegetation in the well-drained zone of a eutrophic wetland. *Applied Vegetation Science*, 3(1), 73–80.
- Weiner S.E.B. 1993. Long-term competitive displacement of *Typha latifolia* by *Typha angustifolia* in a eutrophic lake. *Oecologia*, 94:451–456. doi: [10.1007/BF00317123](https://doi.org/10.1007/BF00317123)
- White G., Self M. & Blyth S., 2014. Bringing Reedbeds to Life: creating and managing reedbeds for wildlife. RSPB report, 64 pp. <https://www.rspb.org.uk/globalassets/downloads/documents/conservation-projects/bringing-reedbeds-back-to-life/bringing-reed-beds-to-life-report.pdf>

- Wilson S.D. & Keddy P.A. 1985. Plant Zonation on a Shoreline Gradient: Physiological Response Curves of Component Species. *Journal of Ecology*, 73:851–860. doi: 10.2307/2260152
- Yozzo D.J., Osgood D.T. 2013. Invertebrate Communities of Low-Salinity Wetlands: Overview and Comparison between *Phragmites* and *Typha* Marshes Within the Hudson River Estuary. *Estuaries and Coasts*, 36:575–584. doi: [10.1007/s12237-012-9543-6](https://doi.org/10.1007/s12237-012-9543-6)