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Mowing regime has different effects on reed stands in relation to habitat

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ABSTRACT

Reed (*Phragmites australis*) is widespread in aquatic habitats in Europe where it plays an important ecological role, especially as stabilizer of lake and river shores and as filter against pollutants. Reed is also abundant in ecotones towards terrestrial habitats, especially fen meadows, where its expansion can outcompete rare slowly-growing fen species. Therefore, defining appropriate guidelines for managing reed in wetlands has to consider differences in the ecological roles that reed plays in different wetland habitats. In a small pre-alpine lake in N Italy, we mowed reed stands in three plant communities located along a transect from the lake shore to the periphery. In each community, three areas were subjected to reed mowing in late winter, as traditionally done in the past. Three additional areas were subjected to mowing in winter and summer, while three areas served as un-treated controls. Summer mowing was carried out in August, when the nesting period of birds was concluded. Mowing in winter did not affect reed aboveground biomass (RAB) in any community but enhanced the efficiency of removing nutrients by reducing litter accumulation in the soil. Mowing in winter and summer only slightly decreased RAB in the riparian community, not at all in the intermediate community but significantly diminished RAB in fen meadows. Phosphorus deficiency and/or reduced competition with other species probably accounted for RAB reduction in fen meadows. In conclusion, winter mowing can be overall recommended for preventing eutrophication of littoral habitats while summer mowing is advisable for preventing reed expansion in fen meadows. However, the timing of summer mowing has to be defined considering all requirements needed for optimal management of each individual site.

1. Introduction

Defining appropriate guidelines for protection and/or restoration of wetland ecosystems represents an urgent need towards a sustainable management of wetlands, because of their ecological function and economic value (Erwin, 2009). *Phragmites australis* (Cav.) Trin. ex Steudel (common reed, henceforth called reed) is a vascular plant, with cosmopolitan distribution range, that forms extensive stands in several types of aquatic habitats, especially lake and river shores, marshes, coastal brackish swamps and lagoons (Engloner, 2009). The ecological importance of reed stands is widely acknowledged (Ostendorp, 1993). In particular, dense reed populations in aquatic habitats act an effective filter against pollutants, thus preserving water quality (Bonanno, 2011; Zhao et al., 2012). Furthermore, reed stands stabilize river and lake margins (Ostendorp, 1999; Lövstedt and Larson, 2010) and represent key habitats for wildlife, especially nesting birds (Poulin et al., 2002, 2010). For these reasons, researchers are paying much attention to investigate the causes of extensive reed die-back observed in reed-dominated freshwater ecosystems (Brix, 1999; Reale et al., 2012), but also in brackish coastal wetlands (Fogli et al., 2002).

Even if reed-dominated stands are typical of aquatic habitats, reed is also widespread in ecotones between aquatic and terrestrial habitats. In these ecosystems, increased nutrient load has often been found to enhance reed expansion in many regions outside Europe, from North America (Findlay et al., 2003; Kettenring et al., 2011), to East Asia (Karunaratne et al., 2004a) and South Africa (Russell and Kraaij, 2008). Eutrophication of European wetlands usually enhanced reed expansion into fen meadows (Van Duren and Pegtel, 2000; Güsewell, 2003). The main cause responsible for eutrophication of fen meadows consists in leaching of nutrients, especially nitrogen (N) but also phosphorus (P) and potassium from arable fields. Therefore, low productive ecosystems such as fen

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meadows can become more accessible to reed if nutrient levels increase (Brülisauer and Klötzli, 1998). Higher nutrient status enhances growth of reed much more than that of intrinsically slowly-growing fen species, which are thus out-competed by reed and can even disappear. This eventually implies habitat degradation, loss of rare species and lowered biodiversity in fen meadows (Ludwig et al., 2003), that are listed among priority habitats in the European legislation. Abandonment of the traditional practice of periodic mowing of the standing crop may further enhance reed expansion in European fen meadows. Several studies have reported reduced reed aboveground production in reed stands subjected to experimental mowing, although the amount of growth depression varied in relation to timing of the cuts (Mochnacka-Lawacz, 1974; Husák, 1978; Güsewell, 2003). An explanation of reed growth reduction after cutting the aboveground tissues resides in the removal of reserve carbohydrates before replenishing the rhizomes (Karunaratne et al., 2004b). The effects of mowing on reed aboveground production can, further, depend on water level. For example, Rolletschek et al. (2000) and Russell and Kraaij (2008) found stronger negative effects of mowing on reed growth in flooded areas probably because of impaired convective ventilation followed by hypoxia in the basal plant parts. Similarly, Próchnicki (2005) observed reduced growth rates in reed stands subjected to frequent flooding. Saltmarsh et al. (2006) reported reduced CO_2 assimilation rates in reed plants under permanent waterlogging.

The management of reed populations can have differing goals, essentially depending on if reed expansion is desired or not (Güsewell and Klötzli, 2000). This study was set up in order to investigate the effects of mowing on reed growth across a water-level gradient in a freshwater wetland in Northern Italy. We aimed to assess if reed mowing could be regarded as an appropriate management tool across the entire water-level gradient. We also aimed to evaluate the differential effect of the traditional winter cut on reed growth and nutrient removal versus a complementary cut treatment in summer. Our final goal was to define guidelines for managing reed populations for the sake of preserving reed stands in littoral areas and preventing reed invasion in the surrounding fen meadows.

2. Materials and methods

2.1. The study site

The study was conducted at Lago di Alserio (45° 47′ N 9° 13′ E; 260 m a.s.l.), a small shallow lake (1.23 km^2; maximum depth *c.* 8 m) in Northern Italy, close to the southern slopes of the Alps *c.* 35 km North of Milan. The lake, of glacial origin, is located in an inter-moraine basin on carbonate bedrock. The climate is temperate-humid, with mean annual temperature of *c.* 12 °C. The mean annual precipitation is *c.* 1400 mm, most of which is received in spring, summer and autumn.

A waterplant community, dominated by *Nuphar lutea* and *Nymphaea alba* (*Myriophyllo-Nupharetum*), is settled in the water body where the mean water depth ranges from *c.* 2 m to *c.* 0.5 m (Gerdol, 1987). The lake shore is covered by almost pure reed stands (*Phragmitetum australis*) in front of the free water and by reed stands rich in *Calamagrostis canescens* (*Peucedano-Calamagrostietum canescentis*) just behind. At greater distance from the shore the vegetation is mainly comprised of fen meadows, with two communities: the *Caricetum elatae* with *Carex elata* and the *Selino-Molinietum caeruleae* with *Molinia caerulea* as dominant species, respectively. Both communities are partly invaded by reed. Fragments of alluvial forests (*Alno-Fraxinetum oxycarpae*) and patches of ruderal vegetation rich in *Filipendula ulmaria* also occur in this area (Gerdol, 1987).

During the last decades the lake experienced a transition from mesotrophic to eutrophic conditions, because of intensive fertilization of the surrounding cropland and ineffective wastewater treatment. Nowadays, the water pH is alkaline and nutrient concentrations are high. In particular, concentrations of reactive P as high as 900 μg L^{-1} have been recorded during the summer months in the anoxic bottom layers of the water body (Rogora et al., 2002). The traditional practice of managing the littoral vegetation has been almost totally abandoned since about 30 years. Previously, reed stands were regularly harvested in winter in order to prevent fires. Reed was occasionally mown in late summer as well. Eutrophication and abandonment of traditional land-use practices caused a gradual expansion of reed into the fen meadows. This implied a significant reduction in the area covered by priority habitats and a strong decline, or even disappearance, of rare and endangered plant species such as *Drosera rotundifolia*, *Euphrasia marchesettii* and *Cicuta virosa* (Gerdol, 1987).

2.2. Experimental set-up

The experimental set-up was designed after a preliminary survey carried out in summer 1999. We initially planned to locate a number of small (1 × 1 m) experimental plots across a transect from the lake shore to the periphery. However, some assays showed that mowing brought about serious disturbance, especially at the edge of the mown areas. We, hence, decided to locate a smaller number of larger (10 × 10 m) areas in the most representative plant communities. In October 1999, three experimental areas were placed in each of the following three communities: the *Phragmitetum australis* (PA), the *Peucedano-Calamagrostietum canescentis* (PC) and the *Selino-Molinietum caeruleae* (SM). These areas were subjected to the following treatments during the period 2000–2002:

Un-treated control (C).

Winter mowing (W). All aboveground plant parts were manually mown and harvested in winter 2001 and winter 2002.

Winter + summer mowing (WS). All aboveground plant parts were manually mown in winter, as for the W treatment, and also in summer 2000 and summer 2001.

As a result, all treated plots experienced two cycles of W or WS cuts (Appendix). The winter cut was carried out in February, when the soil was frozen, as usually done in the past. The summer cut was carried out in early August when the nesting period of birds was concluded. In July 2000 three 1 × 1 m plots were set up in each of the nine experimental areas for measurements of reed aboveground biomass (RAB).

Water-table depth was measured manually, twice during the growing season 2002 (May and July, respectively), in a 50-cm long perforated pipe at each of the nine experimental areas.

In May 2002 twelve additional 1 × 1 m plots were set up in each of the nine experimental areas for subsequent samplings and measurements, according to the following protocol.

Three replicate soil samples in each area served for sampling soil. At each replicate plot, five soil cores were dug in July 2002 from the soil to a depth of *c.* 10 cm and bulked into a composite sample. The choice of the plots was subjective. However, all plots were located in homogeneous parts of the experimental areas with no apparent signs of damage to the vegetation. Three replicate plots in each area were used for sampling reed leaves. To this aim, the third leaf from ground was collected in July 2002 from five un-damaged reed culms and bulked into a composite sample. This material served for determining N and P concentrations. Three replicate plots in each area were used for sampling reed rhizomes. In July 2002 three 15-cm long parts were cut, just below the first branch, from 2 to 3 old healthy-looking horizontal rhizomes (Čížková and Bauer, 1998) for determining starch concentration. Three replicate plots in each area were used for measurements of RAB.