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A comparative study of macrophyte species richness in differently managed shore stretches of Lake Peipsi

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ABSTRACT

We have compared the floristic composition of managed (M) and wild (W) shore areas in the northwestern, eutrophic part of Lake Peipsi (3555 km^2, with unregulated water levels). Management techniques include uprooting or cutting of reeds and willows, building a terraced area between the dunes and the water edge and frequent mowing. In 2006 and 2008, macrophyte species richness was registered summarily for different shore stretches; in 2009–2010, a study on 12 transects, each with 10–15 quadrats of 0.5 m × 0.5 m, was carried out in the same area. In parallel to this, the vegetation in an overgrown inlet near the lake was studied. The aims were: (1) to estimate species richness on managed and wild shore areas and to determine the suitability of managed areas for maintaining declining species and (2) to study the impact of terrace building and duration of management on the vegetation.

In total, 116 herbaceous species were found during the study period. Xero-, meso- and hygrophilous apophytes were characteristic for M (managed) stretches and hydrophilous apophytes for W (wild) stretches. Small threatened amphibious plants and hygrophytes such as *Alisma gramineum*, *Ranunculus reptans*, *Sagina nodosa*, *Cyperus fuscus*, *Eleocharis* spp., *Juncus* spp. were characteristic for the M stretches. The number of species was the highest (average per quadrat 11) in the mowed intermediate zone between the terrace and open water. In the inlet area the number of protected plants was highest in the first study year (2006) and then declined from 5 to 2. The highest total number of species was found in areas under ownership with diverse M and W habitats. Jaccard's similarity coefficients (JSCs) for the whole study area between the years were 0.30–0.50. The calculation of 462 JSCs among all ownerships and transects for the study period yielded floristic similarities of 0–0.59. The year along with style of management seemed to have strongest relationship with higher JSCs, and the yearly changing water levels the most obvious reason for the changes. This study has revealed the contribution of active management towards the support of persistent species richness in conditions of changing water levels, but probably not supporting richness at the more stable water edge.

Introduction

Fresh water makes up only 0.01% of the world's water, but this tiny fraction of global water supports at least 100,000 species (Dudgeon et al. 2006). Declines in biodiversity appear to be far greater in fresh waters than in most affected terrestrial ecosystems (Sala et al. 2000). The decrease in species richness of wetlands is a worldwide concern, so to survey present and possible future changes are of fundamental importance. How biodiversity-ecosystem functioning in multispecies systems responds to stressors is still far from clear (Woodward 2009). Shores of the water bodies with remarkably changing water level are permanently affected by intermediate disturbance. This kind of disturbance maintains highest level of diversity (Connell 1978). Some stressors may be mediated by natural factors. In boreal areas increasing trophic levels of shallow water bodies may enhance the dominance of cosmopolitan species with large genetic variabilities, *e.g.*, helophytes, and at the transition from oligo-mesotrophic to eutrophic conditions, there is often an expansion of the common reed *Phragmites australis* (Cav.) Trin. ex Steud. subsp. *australis* (Mäemets and Freiberg 2004; Čížková and Kvet 2009; Liira et al. 2010). During the last few decades, a significant decline in the frequency of several macrophyte species has been observed in the large, shallow eutrophic Lake Peipsi in Estonia, and the most probable reason for this decrease is the expansion of thick reed areas occupying suitable eulittoral habitats (Mäemets et al. 2010). The factors favouring the success of the reed are the presence of non-regulated, highly changeable water levels and transitions from mesotrophic to eutrophic conditions, such as have taken place in the large northern part of Lake Peipsi. Such conditions are favourable for the reed expansion, within a general background of reed declines in numerous highly eutrophic and regulated

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waterbodies in Europe (summarized by Čížková and Kvet 2009). Among the protected and other declining taxa of L. Peipsi are small-sized amphibious plants and hygrophytes such as *Alisma gramineum* Lej., *Ranunculus reptans* L., *Sagina nodosa* (L.) Fenzl, *Cyperus fuscus* L., *Eleocharis uniglumis* (Link) Schult. *Juncus articulatus* L., *J. gerardii* Loisel., *J. nodulosus* Wahlenb., and *Potamogeton gramineus* L.; however, there are also decreases in medium-sized helophytes such as *Eleocharis palustris* (L.) Roem. et Schult. and submerged plants such as *Chara contraria* A. Braun and *Potamogeton perfoliatus* L. (Mäemets et al. 2010). Some studies have documented the negative effects of reed cutting on wildlife, including macrophytes, invertebrate communities and passerine birds (Farnsworth and Meyerson 1999; Valkama et al. 2008). On the other hand, Cowie et al. (1992) found that cutting of reeds positively affected floristic diversity in the undergrowth of wetlands. Reed bed management can slow down or even reverse succession, so that a balance of different habitat types can be maintained (Hawke and Jose 1996). All these studies reveal that a moderate level of human impact (intermediate disturbance discussed by Connell 1978) can have positive effects on biodiversity.

Local people and holidaymakers near Lake Peipsi are interested in having open shores without reed beds. The aim of the lakeshore management has been to prevent any undesired spread of tall and thick reed stands. Unfortunately, this kind of activity was planned and organized by local residents who have little knowledge about possible effects on other macrophytes growing in this environment. Only a limited amount of information is available about the consequences of reed removal on changing the real floristic composition in managed, as compared with unmanaged, shore stretches. In this study we have compared species richness on managed and unmanaged shore areas over several years, and also compared species diversity on differently managed shore stretches. The specific objectives of the study were to: (1) reveal species richness and composition on managed and wild shore areas and the suitability of managed areas for species in decline and (2) study the impact of terrace building and duration of management to the vegetation.

Table 1
Selected water characteristics: dissolved inorganic nitrogen (DIN), total nitrogen (TN), phosphate (PO_4^{3-}), total phosphorus (TP), bicarbonate (HCO_3^-), pH and Secchi depth of Lake Peipsi s.s. in 1997–2010, presented as geometric mean values with 95% tolerance limits for the open water period (Julian days 100–310 for each year). Data were obtained from the database of the State Monitoring of Lake Peipsi.

Parameter	Number of measurements	Mean	95% tolerance limits	
DIN ($mg\,N\,m^{-3}$)	544	118.2	31.4	445.0
TN ($mg\,N\,m^{-3}$)	543	729.9	392.6	1356.9
PO_4^{3-} ($mg\,P\,m^{-3}$)	542	8.0	1.2	52.9
TP ($mg\,P\,m^{-3}$)	543	47.5	15.8	143.3
HCO_3^- ($mg\,l^{-1}$)	543	151.8	120.4	191.5
pH	481	8.4	7.7	9.0
Secchi depth (m)	558	1.6	0.3	2.8

Materials and methods

Site description

Lake Peipsi on the border between Estonia and Russia is one of the largest lakes in Europe. Its total area is 3555 km^2, mean depth 7.1 m and maximum depth 15.3 m. Main inflows are the Velikaya River in the south and the Emajõgi River in the west. The water level is unregulated; average annual fluctuation of the water level during the period 1890–2005 was 1.5 m and its absolute range was 3 m (Jaani et al. 2008). Mean values for the chemical composition of the surface water are presented in Table 1. As in many shallow lakes in Europe, eutrophication is the most serious problem for Lake Peipsi (Kangur and Möls 2008). The ecological state of the lake is also strongly influenced by natural processes, among which periodic fluctuations in water level and temperature are the most important (Kangur et al. 2003).

Our study area is situated in the northwestern part of Lake Peipsi at Vilusi village (Fig. 1). Species composition was studied in August 2006 at extremely low water levels, in September 2008 with rising water levels, and at high water in the July-August period in 2009

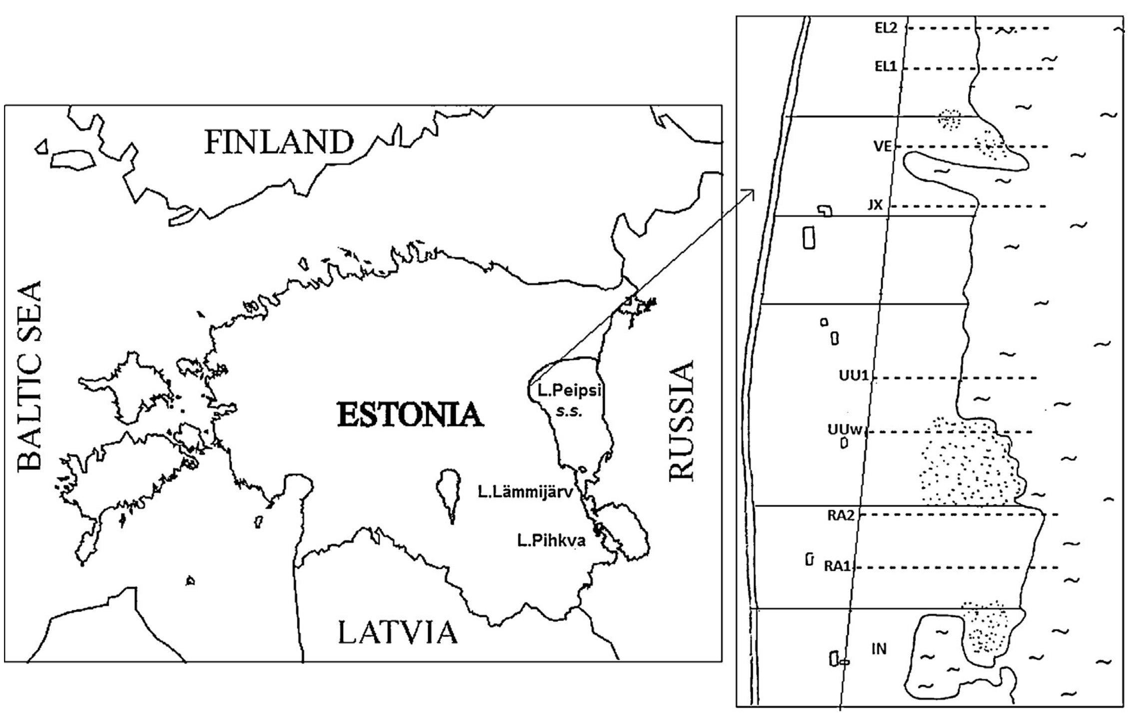

Fig. 1. Location of Lake Peipsi with a schematic drawing of the northern portion of the transects used and the inlet (IN). Abbreviations represent the owners of different transects measured. Conventional signs: ═ – road; □ – buildings; :::: – reed and willows; ~ – water; – – property boundaries.