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DYNAMICS OF EMERGENT MACROPHYTES OVERGROWTH IN LAKE ENGURES

Abstract
Expansion of emergent plants is one of the most important problems of Lake Engures, a Ramsar site. The aim of the study was an assessment of dynamics and patterns of emergent plant overgrowth. Visual interpretation of historical aerial photography and orthophoto maps was used to detect changes in patterns of emergent plant occurrence from 1956 to 2007. The area covered by emergent macrophytes has increased from 2190 ha to 2971 ha in 2007, while open water territory has decreased from 3072 ha in 1956 to 2291 ha in 2007. The expansion of emergent macrophytes in the period 1972 to 2007 showed to be approximately half of that which occurred in the period 1956 to 1972. Emergent plant distribution has been limited to the aquatorium, where the depth exceeds 0.5 m. The dynamics of emergent plant expansion has been different in various parts of the lake. Some parts have experienced a dramatic increase of emergent macrophytes, while others have experienced very little change or no expansion at all. The spring maximum water level appears to be a major factor, which influences the occurrence of emergent macrophytes.

Key words: historical aero photography, visual interpretation, shallow lakes, phragmites australis

Introduction

Latvia is rich in beautiful lakes; some of them have originated as lagoons of previous stages of the Baltic Sea. Lake Engures is the largest lake of such origin in Latvia. Eutrophication has been a major problem for lake ecosystems over the last century in the world. It is believed that eutrophication in Lake Engures is reflected in an increase of macrophyte biomass (Springe et al., 2000), particularly reed biomass. Thus increase of reed covered area is a consequence of eutrophication of Lake Engures.

Remote sensing has been used as a tool to study retrospective dynamics of aquatic vegetation (Wilcox et al., 2003; Fredriksen et al., 2004; Dekker et al., 2005; Liira et al., 2010) to note few of many examples.

The objective of this study was to detect patterns in the dynamics of emergent macrophytes in Lake Engures over the last half century. Tasks were: georeferencing of historical aerial photography and visual interpretation of remote sensing data; to detect changes in the area covered by emergent macrophytes in Lake Engures; to identify major factors which control emergent macrophytes in Lake Engures; to determine how the dynamics of emergent macrophytes differs from one aquatorium to another.

Materials and Methods

Study site

Lake Engures is part of the NATURA 2000 territory, Ramsar convention site and nature park, thus it is protected at national, European and global level. The biological diversity of the park

is remarkable, with 844 plant species (Gavrilova & Baronina, 2000) and 186 nesting bird species (Viksne, 1997) observed either on the lake or its surroundings.

Lake Engures is a large coastal lake, the area of which before the lowering of the water level in 1842 by 1.2 to 1.7 m (Eberhards and Saltupe, 2000) was about 90 km^2. This occurrence has dramatically changed the lake and has transformed it into a vast, extremely shallow wetland. Nowadays the area of the lake is 35 to 45 km^2. Average depth is 0.4 to 1 m, while the maximum depth is about 2.1 m (Viksne, 1997). A significant area of Lake Engures has been covered by emergent macrophytes, with the most dominant species being *Phragmites australis*. It is reported that the area of the lake outside the reed belt is only about 17 km^2 (Aunins, 2000). Submerged vegetation, primarily chara species, dominates that area (Viksne, 1997).

Materials

Historical aerial photography was used as a raw data source. Images were taken in the end of June or beginning of July in 1956, 1972, and 1981. Orthophoto maps of 1994, 2004 and 2007 were also used and these were acquired in the end of June, middle of October and beginning of June respectively. The orthophoto maps covered the entire study area. Data for a negligible area was missing for 1956 and 1981, while data for about 30% of the Lake was missing for 1972. This data was extrapolated from 1981 data. Water level measurements obtained by the Ornithology Laboratory of the Institute of Biology were used. Finally lake bathymetry was derived from topographical maps (scale 1:10 000).

Methods

Historical aerial photography was georeferenced using ESRI ArcGIS ArcView 9.2. 8 to 34 ground control points were used to georeference images to the orthophoto maps. 2nd order polynomial transformations were employed to calculate new coordinates. Ground control points were objects, which were distinguishable in the image and in the map mostly by their shape and associations. However a sufficient number of such points were not always available. Therefore there were some cases when stands of *Scirpus lacustris* were used.

Visual interpretation is used in most cases where historical aerial photography is used, which often has poor quality (Lehmann & Lachavanne, 1998). This is especially true for the earliest, year 1956, aerial photography. Technique which is suitable for lowest quality materials was used to determine aquatic vegetation coverage. Interpretation was performed to obtain two classes: first, emergent vegetation, and second, open water, which included submerged and floating leaf vegetation.

Results

Lake Engures has experienced an immense increase of area covered by emergent macrophytes. Most of the increase should be attributed to the time period from 1956 to 1972, when the area increased from 2190 to 2691 ha. A rather slow increase of emergent macrophytes cover occurred from 1972 to 1994; while from 1994 to 2007 a faster increase has been recorded, see figure 1. Open water territory decrease by the same area has consequently been recorded. Thus the area of Lake Engures outside the reed belt was 2291 ha in 2007.

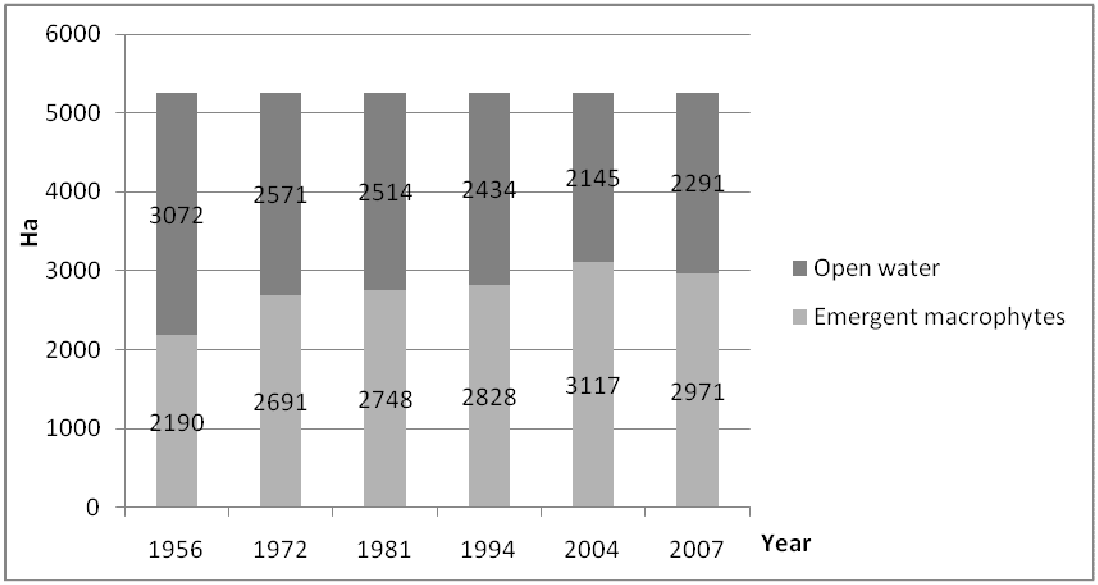

Figure 1. Dynamics of the Lake Engures emergent macrophytes and open water (calculated by author).

In 2004 the area of the emergent macrophytes was greater than in any other year, but the season when remote sensing data was acquired should be considered. In all other cases information was gathered in early summer, while in 2004 information was gathered in autumn.

The annual increase of emergent macrophytes from 1956 to 1972 was 1.32%, while from 1972 to 1994 it is only 0.22%, but from 1994 to 2007 it is 0.38%.

In places where the depth exceeds 0.5 m the area of emergent macrophytes was 5 ha in 1956, 15 ha in 1994 and 21 ha in 2007.While the total area exceeding such depth is 1279 ha.

It is characteristic that all aquatoriums experienced the largest increase of emergent macrophytes from 1956 to 1972, however in aquatoriums 11 and 1 the increase is not that pronounced. The strongest increase of emergent macrophytes took place in aquatorium 2 from 1956 to 1981, while from 1981 to 1994 decrease of emergent macrophytes was observed. Increase of emergent macrophytes has been slower or equal in most aquatoriums from 1994 to 2007 than from 1981 to 1994 except in aquatorium 7. Aquatorium 9 has experienced slower

increase than any other aquatorium or even decrease of emergent macrophytes in all study periods.

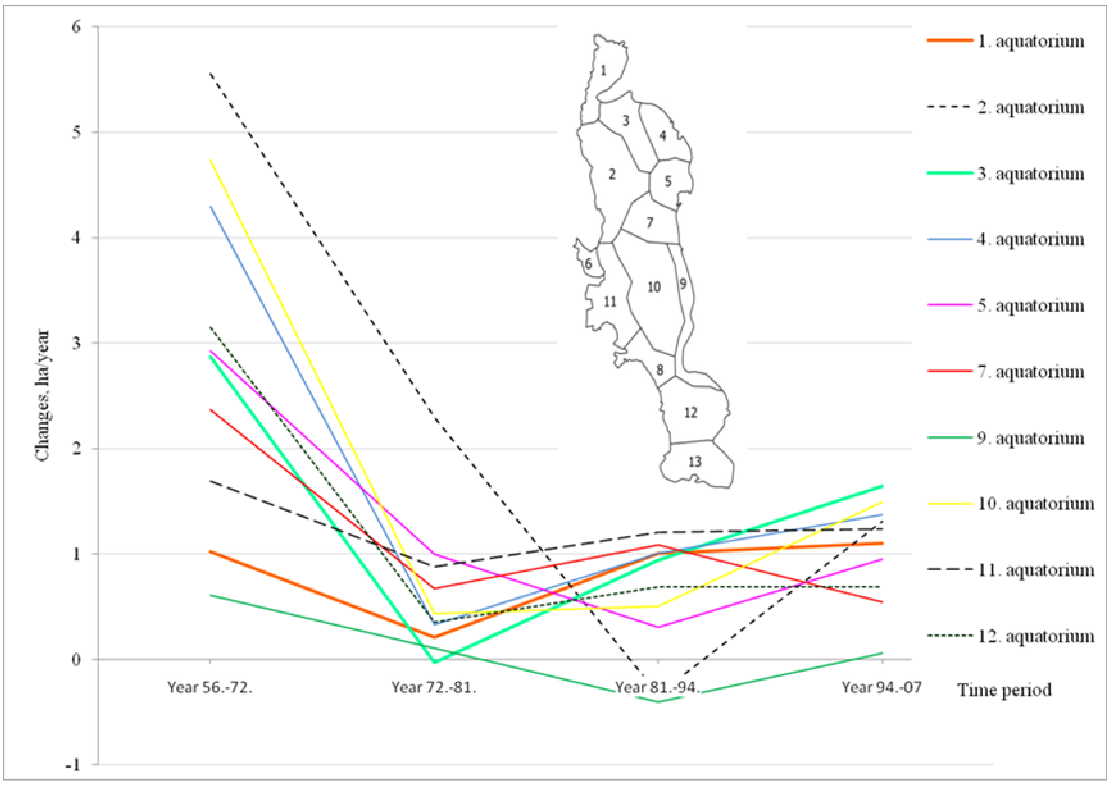

Figure 2. Dynamics of emergent macrophytes in aquatoriums of the Lake Engures (calculated by author).

Discussion

In this study open water was considered as territory with no emergent vegetation, when comparing to results of Lake Engures vegetation mapping in 1997 as open water should be considered territories with no vegetation or with submerged vegetation. The area of such mapping classes was 16.5 km^2 in late August of 1997 (Auniņš et al., 2000), while this study showed that it is considerably larger, in 2007 it was 22.9 km^2. Considering seasonal variations of emergent macrophytes i.e. comparing 2004 October data (21.4 km^2) there is still considerable difference. One should note that the open water territory showed a tendency to decrease, thus in 2004 open water area should be smaller than in 1997. Such differences might be attributed to the differences of the open water definition. One might map territory as covered by emergent macrophytes when only sparse stands are present, while others might request dense stands. Another source of differences might be differences in resolution. Landsat TM image pixel size is 900 m^2, while orthophoto map pixel size is 1 or 0.25 m^2. Fine structure vegetation and water mosaic might draw errors when medium resolution satellite images are used.

Changes in the cover of emergent macrophytes might be attributed to changes in the northern part of the lake. Water flow has been disturbed to the 1st aquatorium from rest of the lake.

There are no water level measurements before 1970; however I believe it might be lower before than after.

During 1956 to 1972 there was no expansion of emergent macrophytes in places with a depth greater than 0.5 m. A small increase is recorded since 1972. However it has been observed that emergent macrophytes may grow even in 2 m deep water (Anderson, 2001). Thus almost the entire area of Lake Engures is suitable for emergent macrophyte development.

The increase of water level from 1972 to 1994 matches with the slower expansion of emergent macrophytes while the decrease of water level from 1994 to 2007 matches with the faster expansion.

There is still considerable variance observed when water depth factor is excluded. You may see several aquatoriums, where macrophyte cover is generally lower than in others.

Conclusions

The area covered by emergent macrophytes in Lake Engures has increased by 781 ha from 1956 to 2007.

The greatest expansion of emergent macrophytes was observed between 1956 and 1972.

Emergent macrophytes expanded at approximately double the rate between 1994 and 2007 (0.38%) than between 1972 to 1994 (0.22%).

Aerial photography should be taken at the same season to have valid results.

Very few places deeper than 0.5 m were affected by expansion of emergent macrophytes.

Different areas of Lake Engures have experienced distinctively different dynamics of emergent macrophyte growth.

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