

THE DEGRADATION AND RESTORATION OF LAKE HORNBOGA

By

Sven Björk

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## THE DEGRADATION AND RESTORATION OF LAKE HORNBERGA

Sven Björk

Institute of Limnology, University of Lund, Sweden

Due to water level lowerings, changes in hydrological regimes, removal of vegetation within catchment areas and increased supply of nutrients, sensitive wetland ecosystems are easily damaged. Among the many examples of wetland degradation caused by water level lowering, the developmental history of the Swedish Lake Hornborga (Swedish Hornborgasjön) will be described. This lake will also be used as a case study for illustrating the existing possibilities to restore degraded wetlands.

As so much wetland has been damaged, there is an urgent need for restoration methods. Every wetland area has its own unique character, but in spite of that the methods worked out within the Lake Hornborga project are applicable in many other restoration and management projects. This is the case in, for example, the Pahlavi Mordab in Iran (southwest of the Caspian Sea), where the accelerated aging through heavy overgrowth by macrophytes is caused by increased supply of silt from the deforested and overgrazed catchment area and nutrients from sewage etc. The Iranian Department of Environmental Conservation is now eager to restore and manage the important Pahlavi Mordab wetlands.

Due to rapid mobilization of investigations concerning the damage to the great Peace-Athabasca Delta in Canada caused by hydroelectric exploitation of the Peace River, the problems could be moderated by application of an ecologically designed hydrologic programme.

The damage due to overgrowing is very often so severe, that a simple raising of the water level is not enough to obtain longterm results. As a rule the damage can be looked upon as

irreversible and repairable only by technical measures. The difficulties of locomotion in wetlands with their mixture of open water and vegetation, soft bottoms, water level fluctuations etc. have long made wetland investigations difficult and active therapy and management impossible. During recent years the production of specially designed floating and amphibious working machines and transporters have opened up new possibilities, which the Lake Hornborga restoration project will demonstrate.

Lake Hornborga is situated in the Swedish county of Västergötland, between the great lakes Vänern and Vättern. Until man interfered with the well-organized system of components that functioned within this lake, it maintained a rather high degree of productivity without suffering from rapid aging. That is quite remarkable for a lake of this size (30 km<sup>2</sup>) and shallowness (3 m at the deepest point, with most of the lake much shallower). A constellation of such factors as rapid water renewal, well-situated inlets and outlets, strong water and ice movements prevented the lake from becoming overgrown and provided a good system for transporting matter from the lake.

Since 1802 the lake has been lowered five times in attempts to obtain arable land. The last two lowerings, carried out 1904-1911 and 1932-1933, have caused an almost complete overgrowth of emergent macrophyte vegetation (Fig. 1). The last big failure resulted in a bottom that was drained in the summer and consisted largely of calcareous mud. Since 1954 the lake area has been divided up into a partly water filled diked in portion, where the summer water depth is maximally 80 cm, and a summer dry part.

Since 1933 the lake has been completely canalized, but despite the fact that the inflowing water is led direct to the outlet, it has not been possible to cultivate the lake area. In the hydrotechnically short-circuited lake the accumulation of macrophyte detritus is very pronounced and at the same time

what was  
dredged  
1802

has through



the surrounding drained organogenic land is sinking. Thus a levelling process is taking place that gradually becomes more perceptible. Lake Hornborga has always been characterized by marked fluctuations in the water level - the easily drained catchment area is 616 km<sup>2</sup> - and therefore the filling in with detritus and the sinking of the surroundings will successively cause more serious inundations.

From a nature conservancy point of view the lake had a very high value before it was lowered and drained during this century, especially as a nesting site and resting place for waterfowl. The limnologic adaptations to the lowerings have resulted in a rapid decrease in the ornithologic value of the lake. The lowerings have also caused great losses from an economic point of view.

The Swedish Government made an investigation of the value of Lake Hornborga with respect to nature conservancy. It was found that "a restoration of Lake Hornborga is one of the most urgent conservancy projects at present in our country - at least as far as the safeguarding of a special nature conservancy subject is concerned". After being ordered by the Government to investigate the possibilities of restoring Lake Hornborga to the status of a waterfowl lake, the National Swedish Environment Protection Board organized a broad study of the complex of man-made problems within the wetland area.

One year of limnological studies made it quite clear - theoretically - that the lake could still be restored. Large-scale field experiments were begun in 1968 to work out practical methods of correcting the irreversible damage. This was made possible because of the cooperation between the National Environment Protection Board, the National Labour Market Board, the National Board of Forestry, Seiga Harvester Company in Copenhagen (manufacturer of amphibious machines), and the Institute of Limnology at the University of Lund. Thus the goal was to work out methods to solve the ecological problems in an economically favourable way. This has been done in an in-

spiring and fruitful cooperation among ornithologists, limnologists and limnotechnologists.

The restoration plan for Lake Hornborga includes a raising of the water level for a maximum depth of 2.4 m. It should take only one spring to fill the lake with water, as Hornborga Lake is flooded every year after snow melt. However, before the raising of the water level the irreversible damage caused by the lowerings must be treated.

Emergent vegetation has invaded the colonizable areas and the upper sediment layer has become interwoven by roots. With the two plant species Carex acuta (sedge) and Phragmites communis (reed) covering the main area of the southern and northern parts of the lake, respectively, the sedge has developed a thick, tough and resistant root felt. The sedge root felt poses a problem, as it is impossible to remove. The reed root felt can be cut, however, by amphibious rotor cultivators that were constructed for this project. The development of amphibious and pontoon-equipped machines for the restoration of lowered lakes is continuing, and rotor cultivators strong enough to cut the sedge root felt will be constructed.

The project goal for Hornborga Lake is to transform the reed areas to open water (about 11 km<sup>2</sup>) and to keep the sedge-covered part (about 18 km<sup>2</sup>) for emergent vegetation as a substitute for the originally marshy areas around the lake. When the water level has been raised, the sedge root felt will float to the water surface. This well-known phenomenon is caused by gas (mainly methane) that forms in and under the root felt, through which the gas bubbles cannot penetrate.

The floating root felt will rapidly be colonized by Phragmites, Schoenoplectus (bulrush) and Carex. By means of amphibious excavators it is possible to break up the monotony of the sedge-covered areas and to create a mosaic of open water and biotopes safe for nesting and attractive to birds. Even this work must be done before the raising of the water level.

Why?  
is the bottom  
different?  
Sediment  
removal  
after  
flooding?  
sedge?

Get the roots  
down to sedge



The procedure for achieving the change from production of emergent vegetation to production of submerged vegetation in the areas now covered by reed is as follows (Fig. 2).

In the winter the dry reed stems are cut by amphibious harvesters and burned on the ice. In the spring the stubble mats are shortened to about 40 cm by pontoon-equipped mowers. During the low water period in the summer and autumn, amphibious machines are again utilized, first for cutting the green shoots and then for rotor cultivating the stubble mats and root felts, the thickness of which are about 40 cm. The requisite time per hectare is 8-10 machine hours. Enormous masses of accumulated coarse detritus are loosened from the bottom and transported by the spring high water to the shores where they are burned in the summer. The exposed shores can regain to a considerable extent the characteristics of suitable biotopes for waders.

\* Canals and dikes are eliminated and a broad-front flow-through of water is ensured. Furthermore the ice movements will be re-established.

With the detritus out of the way, the consolidated mud again becomes the bottom and the reed monoculture is replaced by an underwater vegetation with a rich bottom fauna, microbenthos, and periphyton communities. The biotope changes during the experimental period have resulted in a very obvious improvement in the waterfowl fauna (Fig. 3).

The cost of the investigations on the possibilities of restoring Lake Hornborga amounted by 1974 to about 600,000 US \$. This sum includes all studies made by ornithologists, limnologists, technologists, economists and agriculturists. It also includes field experiments, purchase and construction of technical equipment etc. Within the near future the Swedish government will decide on the final restoration. The costs for the remaining limnological restoration of Lake Hornborga, i.e. the measures for directing the development of the vegetation etc., are estimated to another 600,000 US \$. The cost for the total project is of the order of magnitude of 4,000,000 US \$.

What is the  
discharge  
through the canal  
same as in 1904?  
What about  
spring flooding  
- canal could  
be used to  
control the lake  
levels & keep  
water in during  
the summer.  
what is the  
level of the  
canal - 1 m  
5 ft for  
2.4 m depth?

Finmark

In South Sweden the lakes are as a rule shallow. During the latter half of the 19th and the first decades of this century most lakes were lowered and some were completely drained. In southeast Sweden at least 90 % of the lakes are suffering from damage due to water level lowering and in other parts of Sweden as well as in Finland much harm has been done. Today there is a common wish to restore the lowered lakes for nature conservancy reasons, for water supply, esthetic purposes, fishing and other forms of recreation. Therefore, countywide investigations have been started in order to rank the lakes with respect to the need for restoration. For making realistic evaluations of the possibilities to restore lakes and wetlands and to estimate the costs, the results from the Lake Hornborga demonstration project are of great value.

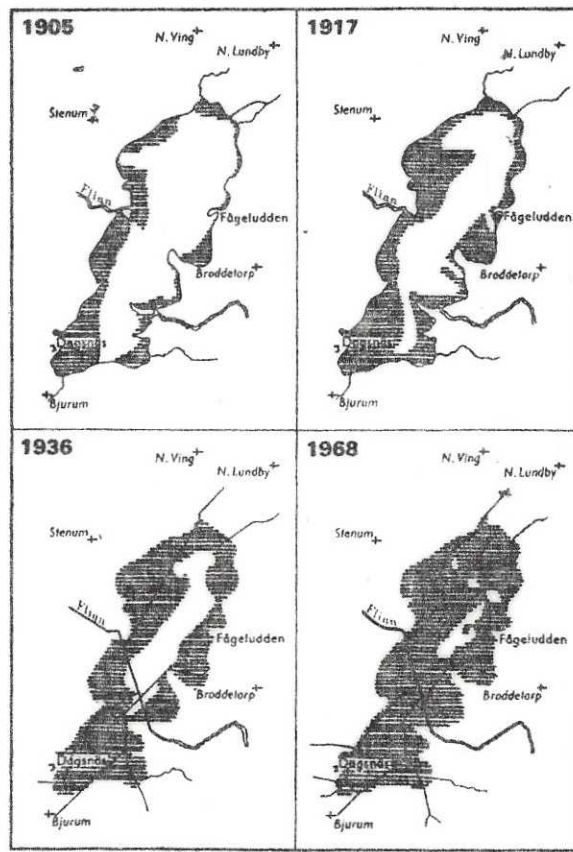


Fig. 1. Lake Hornborga. The last two water level lowerings (1904-1911 and 1932-1933) have caused an almost complete overgrowth by emergent macrophyte vegetation. At the beginning of the restoration investigation (1968) the emergent vegetation comprised stands of primarily common reed (about 12 km<sup>2</sup>) and sedge together with mixed stands with willow bushes. The small open waters were choked with charophytes.



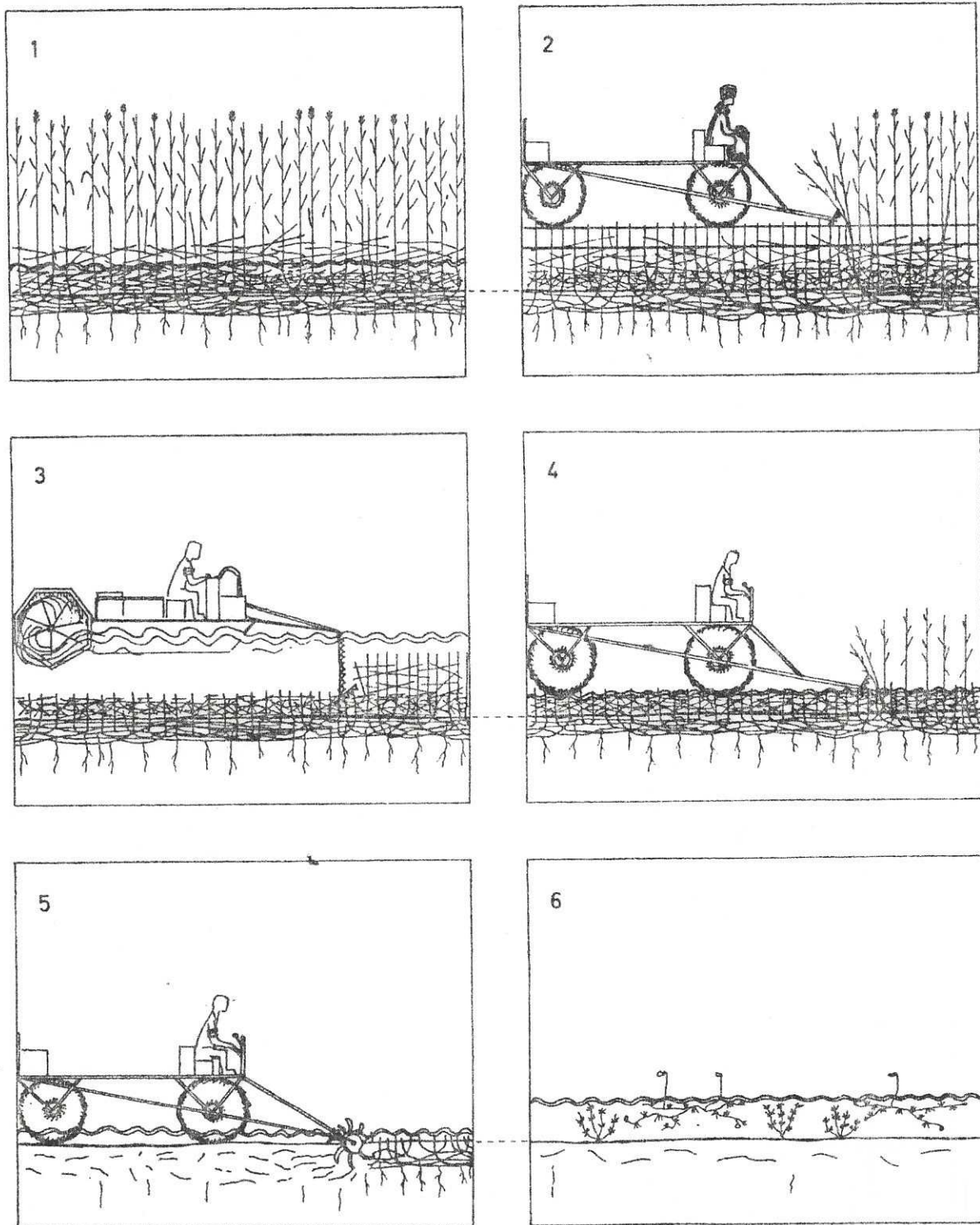
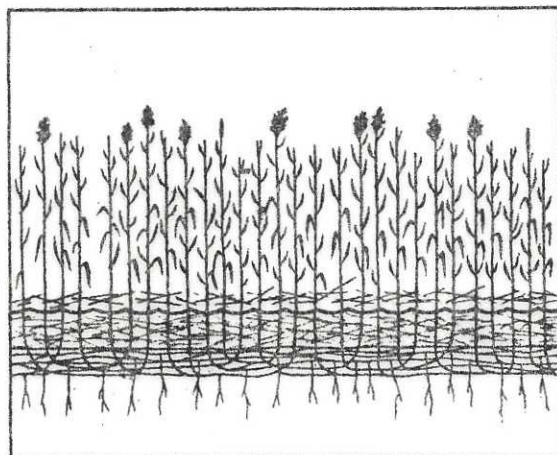
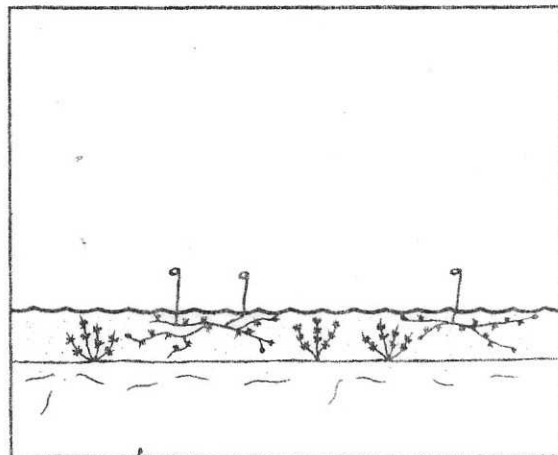


Fig. 2. The Lake Hornborga restoration project. 1. Initial state. The area overgrown by common reed, the consolidated mud covered by coarse detritus and a dense root felt developed in the top layer of the mud. 2. The work starts with cutting during the winter. Capacity 2 hectares per hour. The reed material is being burnt. 3. During the spring high water period pontoon-equipped mowing machines are used for shortening the stubble and clearing the bottom from the layer of horizontal reed stems. 4. At low water in the summer the green shoots are cut. 5. Final preparation of the bottom by a rotor cultivator. 6. Emergent vegetation is replaced by submerged plants, and bottom fauna communities rich in species and individuals are developed.



Area: Ca 11 km<sup>2</sup> covered by common reed until 1967



Area: Ca 1 km<sup>2</sup> finally prepared

**Macrophyte detritus:**

deposition ↓  
decomposition ← →

**Bottom fauna:**

Chironomidae ind/m<sup>2</sup> × 1200:

**Birds (pairs × 10):**

*Podiceps auritus*, Horned Grebe

*Aythya fuligula*, Tufted Duck

*Aythya ferina*, Pochard

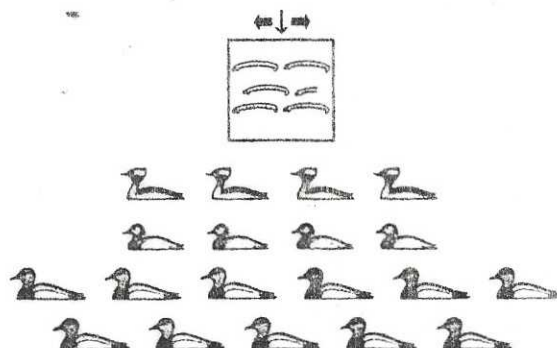
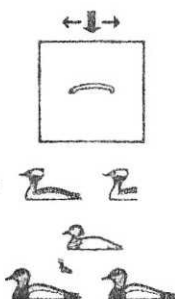


Fig. 3. Lake Hornborga before and after experiments for directing the primary production from emergent to submerged vegetation. Water level not yet raised. Comparison between conditions in 1965 and 1971. Data from H. Berggren and P.O. Swanberg.