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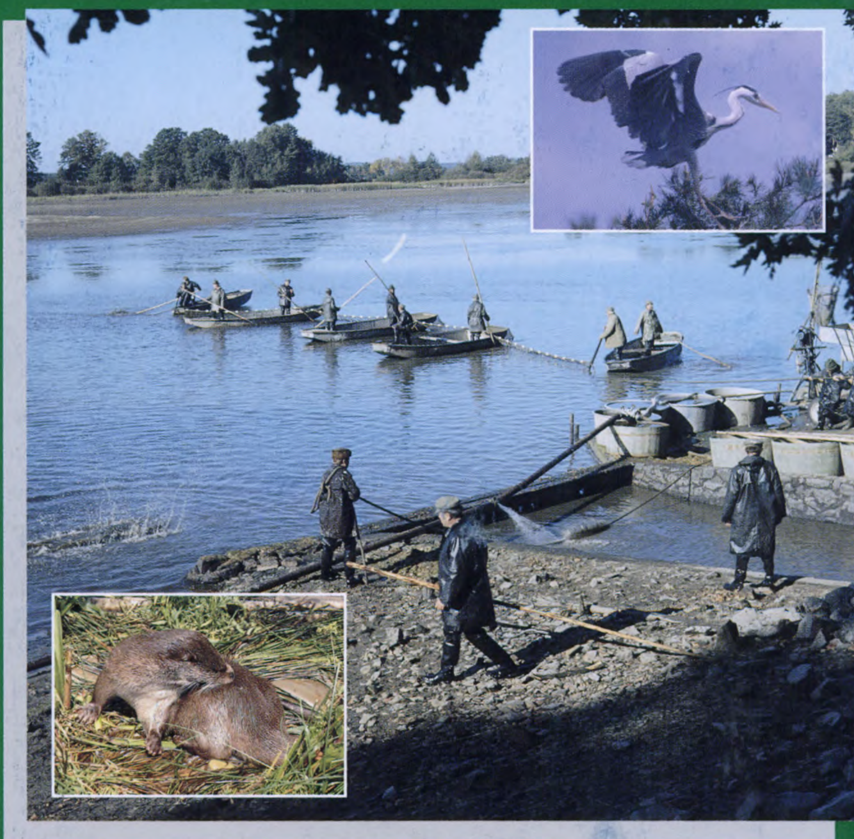
IUCN European Programme

The Ecology and Economics of
Fishponds in Central Europe

Fishing for a Living



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IUCN European Programme

Fishing for a Living

The Ecology and Economics of Fishponds in Central Europe

1997	Environmental Research Series	11

This One

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Contents

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Tables

Figures

Maps

Digitized by Google

Introduction

Conserving the rich natural heritage of Central and Eastern Europe is of prime importance. The recent political, economic and social changes in the region simultaneously present unique possibilities and serious threats for the environment. Many areas of Central and Eastern Europe have, so far, escaped the environmentally damaging processes that accompanied economic development in the west. The European Programme of IUCN is striving to prevent such damage occurring during the current process of change in these countries by encouraging research, information exchange and development of best practice in the conservation and sustainable use of natural resources.

This report presents the results of the project "Environmental/economic appraisal of commercial fish pond operations in four Central European countries (Czech Republic, Hungary, Poland and Slovakia)". The economic and conservation importance of fishponds in these countries is much greater than would be suggested by the surface area which they cover. Some of them were established as long ago as the 13th and 14th centuries, but they are now faced with changes in ownership and management which could potentially have a significant impact upon the conservation status of these areas.

Hence the assessment of the natural and economic values of the fishponds presented here is both timely and necessary for the proper consideration of the conservation and commercial regimes required to maintain the productive capacities and natural services which they provide. In order to ensure that both interest groups were represented, the groups of experts set up to carry out this project in each country included an economist as well as biologists and ecologists, a novel experience for all concerned.

An overall survey of fishponds was done in all four countries and then more detailed work carried out on a smaller number of sites significant for their biodiversity. Each country has published a full account of this research (with considerable quantities of data) together with the ensuing recommendations in their own languages. The reports contained in this volume are summaries of these publications.

It is hoped that the work of the many contributors to this project will play its part in the establishment of a common nature conservation policy for the four countries involved and thus to the sustainable, equitable and wise use of natural resources in the region.

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Acknowledgements

The compilation of this report required the coordination of a large number of experts, a task admirably carried out by the heads of the four IUCN Country Offices involved: Jan Plesník (Czech Republic), Ferenc Nemeth (Hungary), Zenon Tederko (Poland) and Peter Sabo (Slovakia).

The reports were sub-edited by A. Hoskins, R. Hoskins, the Nature Conservation Bureau Limited and T. Rajamets.

Zbigniew Karpowicz and Tiina Rajamets of the IUCN European Programme were responsible for overall coordination and production.

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Obituary – Jiří Janda

On 8 May 1994 Dr Jiří Janda died in hospital following a severe traffic accident, while undertaking a conservation work, at the early age of 36. From 1985 Jiří Janda headed the Třeboňsko Protected Landscape Area and Biosphere Reserve Administration based in the centre of the unique southern Bohemian mosaic of natural and man-made habitats. In his short life, Jiří accomplished an enormous amount of work in developing the Administration as a modern conservation office. As well as being an expert in wetland ecology, Jiří Janda became a distinguished person in international nature conservation. In addition to his long service on the International Waterfowl and Wetlands Research Bureau (now Wetlands International) Executive Council, in his capacity as Czech Ramsar Committee Honorary Secretary he carried out many activities related to the application of this important international conservation convention in the Czech Republic.

Due to his rich experience in wetland research and management, Jiří Janda was a Czech representative in the IUCN Pan-European Wetland Expert Group. He headed the expert team for the IUCN European Programme project on fishponds, of which this publication is one result. Jiří Janda was a very talented, hard working and dedicated person, respected by all who knew him. He is deeply missed.

All that has been done within this project is to his memory.

Jan Plesník

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The Czech Republic

1.1. Introduction

The IUCN European Programme project "Environmental and economic appraisal of commercial fishpond operations in Central Europe" has been carried out in the Czech Republic by the IUCN Country Office in Prague. It is also a part of the preparatory work for the European Ecological Network (EECONET). The Institute of Botany, Academy of Sciences of the Czech Republic at Třeboň, in cooperation with ENVI Ltd Třeboň and with the Třeboňsko Protected Landscape Area (PLA) and Biosphere Reserve (BR) Administration Třeboň has produced material which includes information about the present state of fishponds in Třeboň region. The material covers aspects of legislation (ownership, protective regimes) and also focuses on the biological functions of ponds in the region (detailed evaluation of long-term trends in chemical development, plankton communities, littoral and bird fauna) in connection with the impact of the present management scheme.

The results of the project were presented at a National Seminar at Třeboň on 20 April 1994, where colleagues from the Slovak Republic also participated, and at the IUCN European Programme International Seminar which took place at Třeboň on 25–27 October 1994. At the event the work of the national project's participants (the Czech Republic, Hungary, Poland and Slovakia) was presented. In addition to this summary, the full output of the project has been presented as a National Report (in Czech).

1.2. The importance of fishponds in the Czech Republic for national and international nature conservation

In contrast to the other Central European countries in which the present project was undertaken (i.e. Hungary, Poland and Slovakia) it was not possible to evaluate the importance for biodiversity and landscape diversity and stability of all the Czech fishponds, because of the high number of ponds: 20,000 in 1995 (mostly artificial water reservoirs, with a natural bottom, provided with equipment for controlling water levels, i.e. for draining and filling with water). (For a more detailed definition of the fishpond, see Mitsch and Gosselink 1993 and Whigham *et al.* 1993.) Therefore, the evaluation of fishponds or fishpond systems in the Czech Republic is mostly based on the recently published study of the Czech Ramsar Committee, which summarises results of an extensive national inventory of wetlands (Hudec *et al.* 1993, 1995).

Wetland biotopes were divided into four categories according to their importance:
(a) listed wetlands of international importance (Ramsar sites);
(b) wetlands of supraregional (national and Central European) importance;

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1.3. Třeboňsko Protected Landscape Area and Biosphere Reserve – a basic characterisation

1.3.1. Review of the natural history of the Třeboň area

The Třeboň region is a flat basin with an average altitude of 410–450m above sea level, situated in South Bohemia (Map 1). The area is bordered by moderately undulating hills. The axis of this region is the river Lužnice, running from the Austrian border to Veselí nad Lužnicí. The region near Třeboň has been intensively cultivated since the Middle Ages. More than 500 ponds of different sizes, connected by a network of ditches, canals and water streams (Nová řeka, Zlatá stoka), were constructed during a unique period of landscape and water management that started in the 14th century and finished during the 16th century. Extensive littoral vegetation can be found in the ponds, and there are remains of wet meadows in the flood areas. The other large wetlands are located in the Lužnice and Nová řeka valleys. Plentiful peat bogs, with growth of *Pinus rotundata* and *Ledum palustre*, are among the most valuable ecosystems of the Třeboň region. These areas vary in size from tens to hundreds of hectares (Červené blato, Žofinka, Široké blato) and also include smaller peat bogs near ponds without forests. Approximately half of the territory is covered by pine and spruce forests with a particular cultural character. There are also remains of floodplain riverine forests. Lines of old oaks on pond dikes are significant elements of the country. Intrinsic to the natural values are the typical villages and country buildings, and also the Třeboň town area.

The rivers Lužnice and Nežárka partially drain the basin, but the whole hydrological regime of ponds is based on an artificial system of ditches. These artificial ditches use water from the rivers and partially also from their tributaries coming from the forests. The water level in the water bodies can be regulated. Water in these reservoirs is eutrophicated due to human activity. Water in smaller reservoirs is of mesotrophic character.

The climate is mild. Annual average temperature is about 7.5°C and annual average rainfall about 600–650mm. There are 40–50 summer days, 110–120 frosty days and 30–40 icy days. Ponds are covered by ice from the end of December to the middle of March.

The flora of the Třeboň region is highly valued due to the various types of still and running waters, which used to be mostly dystrophic and oligotrophic in the past, but today tend to be more mesotrophic and eutrophic. *Nuphar pumila*, which has declined greatly, is one of the rarest species in the region. *Nymphaea candida* has already disappeared from most of its localities as a result of the eutrophication of waters. *Nuphar lutea* is also becoming increasingly rare due to the deterioration of many natural biotopes. Numerous populations of *Potamogeton alpinus*, *P. lucens* and *P. gramineus* can be found. In Třeboň waters species of carnivorous plants – *Utricularia neglecta, U. minor, U. intermedia* and *U. ochroleuca* – occur in parts of the present protected area. *Tillaea aquatica* is very rare, while *Myriophyllum spicatum, Ceratophyllum demersum* and *C. submersum* still survive

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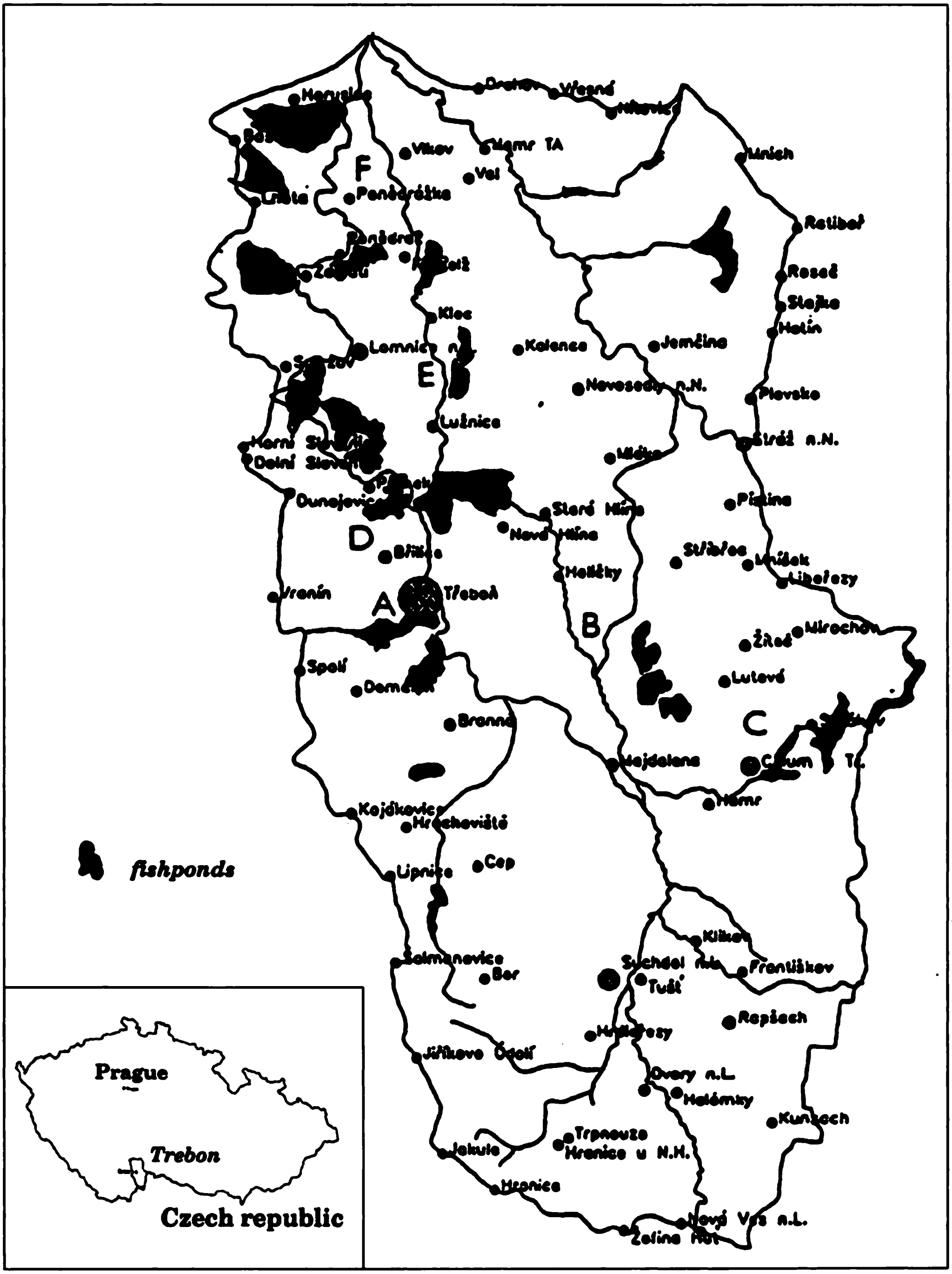
Map 1. Fishponds in the Třeboň area, Czech Republic



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in some localities. Besides *Phragmites communis, Typha latifolia* and *T. angustifolia*, which are somewhat infrequent, *Sparganium simplex, S. ramosum* and exceptionally large numbers of Cyperaceae grow in the more extensive reedbed areas. The increasing level of surface water eutrophication also has a quantitative and qualitative influence on the aquatic and littoral flora.

A number of plant species in the Třeboň region appear on pond beds which are periodically drained. Sand banks are also suitable habitats for some unique species. The most frequent are: *Spergularia echinosperma, Pilularia globulifera, Coleanthus subtilis, Illecebrum verticillatum, Radiola linoides, Limosella aquatica, Litorella uniflora, Lindernia pyxidaria, Dichostylis micheliana, Juncus tenageia* and others. Most of the species growing in pond beds are endangered by loss of their preferred habitats. Some of these have now become extinct in the Třeboň region.

The enormous diversity of biotopes is the reason for the high species richness of fauna in the Třeboň region. Within an area of several tens of square kilometres, there may be, close to each other, habitats similar to northern tundra, various types of coniferous and deciduous forests, cultural landscapes, wet meadows, rivers and pond and littoral habitats. The diversity of fauna mainly manifests itself in the representation of invertebrate communities, since these depend on particular microclimatic, vegetational and soil conditions more than vertebrates. The importance of vertebrate fauna is in a number of species which depend on various types of wetlands and forest biotopes. Important invertebrate communities live at various types of wetland ecosystems, including valleys and ponds, in the region. Even though these ecosystems include a lot of valuable species, their importance, first of all, is in a number of species which are disappearing in the surrounding country. There are different species of Odonata, Plecoptera, Megaloptera, Trichoptera and also some species of Mollusca, Crustacea and Araneae.

More than 150 bird species nest in the region. In addition, for many more bird species the region is a wintering ground or a regular stopping-off place during migration. Birds of the forests or mountainous regions can be found in the region, although the most typical birds are associated with water or wetland habitats. The enormous number of ponds, canals, ditches, swamps and wetlands makes the Třeboň region one of the most important localities for waterfowl in Central Europe. The number of migrating birds connected with water reaches 10,000–20,000 individuals during the autumn. Typical of the region are birds of the order Ciconiiformes. The colony of 400 pairs of grey heron *Ardea cinerea* is among the largest in Central Europe. Ten to twenty pairs of white storks *Ciconia ciconia* nest on constructions or buildings in villages nearby. Recently, about ten pairs of black stork *Ciconia nigra* reared offspring in the Třeboň Basin. Other species include bittern *Botaurus stellaris*, little bittern *Ixobrychus minutus*, purple heron *Ardea purpurea* (here at the northern limit of its breeding range) and night heron *Nycticorax nycticorax*; all are sharply declining in numbers. The colony of cormorants *Phalacrocorax carbo* consists of about 50 pairs and numbers are kept at this level with regulatory measures.

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Another characteristic bird group living in the wetlands are the Anseriformes (ducks and geese). About 200 pairs of greylag goose *Anser anser* nest there. From August to November 2,500–5,000 individuals from other nesting areas gather in the Třeboň area. Among the interesting duck species are ten nesting pairs of red-crested pochard *Netta rufina* and 20–50 nesting pairs of goldeneye *Bucephala clangula* (Třeboň is the southern limit of their breeding range). Common duck species such as mallard *Anas platyrhynchos* and tufted duck *Aythya fuligula* number several thousand individuals.

The white-tailed eagle *Haliaeetus albicilla* is a typical bird of prey in this region. Five pairs of this globally threatened raptor have nested here since 1984, after a gap of 150 years. The Třeboň region is also an important wintering ground for white-tailed eagles coming from the north. The population of another species, marsh harrier *Circus aeruginosus* includes 120 individuals. Except for these typical wetland species there are also another eleven species of birds of prey in the Třeboň region.

Among the most valuable passerines in this wetland area are *Locustella luscinoides* and reed warblers *Acrocephalus* spp. It is interesting that white-spotted bluethroat *Luscinia svecica cyanecula* has gradually spread here. It was first recorded in the 1970s and its numbers are still increasing. Current estimates suggest several tens of breeding pairs.

Fifty mammalian species have been recorded in the Třeboň area, the majority of which are more or less common on the territory of the Czech Republic. The quality and especially quantity of mammals found in the area, particularly of bigger species, is partly a result of the low density of settlement and relative quiet and the extensive area of forests, marshes and wetlands. Among mammals in the Třeboň Protected Landscape Area and Biosphere Reserve, two species should be mentioned in more detail. The European otter *Lutra lutra* is at present a relatively common carnivore and its local population is probably one of the most numerous and stable in Central Europe. Snow tracking census of otters in the area (undertaken in January 1995 and February 1996) suggests that at least 101–130 specimens live in the Třeboňsko PLA and BR (Šimek pers. comm.). The Třeboň Otter Foundation, funded by the Luxembourg Ministry of Foreign Affairs through the Secretariat of the Bern Convention, has aimed at preparing a complex management plan to improve the population status of this carnivore and its habitats in the Třeboň area (Dulfer 1994).

Having migrated from Poland the elk *Alces alces*, also threatened at the pan-European level, has regularly occurred in the region since the early 1970s. There is a small population of ten individuals in the north-eastern part of the region and in nearby forests. The Elk regularly breeds here (Hora, Kaňuch *et al.* 1992, Květ 1992, Janda 1994).

1.3.2. National and international protection of fishponds in the Třeboňsko PLA and BR – current status

The model area, for which the management plan has been prepared, consists of ponds in the Třeboň PLA and BR. Under the name of "Třeboňské rybníky" (Třeboň ponds) they

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Table 3. Basic data on fishponds listed as "Ramsar Core Sites" in the Třeboňsko PLA and BR

Number	Name	Area (ha)	Conservation status
RS2.02	Horusický rybník fishpond	438	–
RS2.03	Kaňov fishpond	162	–
RS2.04	Rod fishpond	40	NR
RS2.05	Rožmberk fishpond	700	–
RS2.08	Staré Jezero fishpond	128	P
RS2.09	Velký a Malý fishponds	706	NNR

NNR: National Nature Reserve, NR: Nature Reserve, P: proposed for protection, –: site without protection

Table 4. Fishponds which need, at least partially, special attention and management

Kaňov	Černičný
Podsedek	Švarcenberk
Tobolky	Pohořelec
Koclířov	St. Vdovec
Potěšil	Skutek
Bošilecký	Ptačí Blato
Ponědražský	Nové jezero

make up approximately 70% (total water surface 5,289ha) of the ponds listed as Wetlands of International Importance according to the Ramsar Convention (see Frazier 1996). The whole area of the wetland, including transitional zones, is 10,165ha.

The whole of the Ramsar site is situated within the Třeboňsko PLA and BR. Table 3 shows the basic data on the most important fishponds listed as sub-sites of the Ramsar site ("Ramsar Core Sites"). Under the Czech National Council Act No. 114/1992 and the Czech Ministry of the Environment Decree No. 395/1992 the most valuable sites are included in the network of Specially Protected Areas, in which destruction of littoral vegetation and waterfowl hunting are forbidden. A conservation plan has been drawn up for these sites. The other sites are under standard management. The PLA and BR Administration can, however, intervene in all sediment dredging activities (which involve destruction of littoral stands), in application of chemicals, and so on. A list of fishponds

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(or parts of fishponds) which need special nature conservation attention, including appropriate management schemes, is given in Table 4.

The wetland consists of shallow basins of various sizes (1–490ha) which are connected by ditches and canals. They were constructed on a flat area which is drained by the river Lužnice. The original communities – forests – became limited to one third of their former area. A lot of ponds have meandering banks with well-developed littoral communities. There are 159 ponds and biotopes of international importance surrounding them which are included in the wetland area.

Ponds in the Třeboň region form 16 water management systems which belong to the rivers Lužnice and Nežárka basins (for a complete list of Třeboň fishponds see IUCN 1996). The volume of flooded areas connecting to the rivers Lužnice and Nežárka is approximately 390 million cubic metres. This volume can be increased by an additional 50 million cubic metres of retention water.

In spite of the fact that the ponds in the Třeboň area have been constructed by man, the considerable age of most ponds has enabled the establishment of biotopes and communities of a more or less natural character.

The intensive farming system of the last 50 years has contributed to the destruction and loss of many of these semi-natural habitats. Although the changes in intensification of fishpond management have affected the ponds in many ways, the simple fact that some fishponds have been relatively well preserved is remarkable. However, there is still a need to preserve the ponds and prevent damage to the littoral zone and pond banks.

The most valuable ponds (or parts of ponds) should receive special treatment when new management systems are being applied, because they are part of a landscape that is increasingly being seen as worthy of protection.

1.3.3. Main contemporary problems of the Třeboň region in nature conservation and environmental protection

Farming, forestry and fishery are the main economic activities in the Třeboň region. One of the most serious problems for land protection is the wholesale eutrophication of the environment, which is caused by the system of agricultural production in the region. The high concentration of pigs being fattened is a particular problem, because the question of how to treat the resulting manure has not been successfully resolved. The application of manure to fields and ponds causes an enormous overload of organic nutrients.

Fisheries management produces a negative influence from excessive fish stocks, unsuitable harvesting times (i.e. April to June, during the bird breeding season) and the depletion of littoral plants. Forestry, with its strong pressure towards economic activities, has caused extensive devastation. The huge areas without forests and the condition of forests is a cause for concern. The excavation of gravel has also contributed to negative influences in the region.

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1.3.4. Legislation

The most valuable part of the Třeboň region has been a Protected Landscape Area since 1980. The area of this region is about 700km². It extends from Veselí nad Lužnicí on the north to Halámky and Nová Ves nad Lužnicí on the south. Stráž nad Nežárkou is the eastern limit and Dunajovice and Spolí are the western limit of the protected area. More than 33,000ha of the protected area are covered by forests, and arable land forms 20,000ha. There are 25,000 inhabitants within the protected area, including the largest town, Třeboň, with 9,000 inhabitants.

The unique biological importance of the Třeboň Protected Landscape Area has also been internationally evaluated. The Třeboň area has been a UNESCO Biosphere Reserve (in the framework of the UNESCO "Man and the Biosphere" project) since 1977. In 1990, after Czechoslovakia signed up to the Ramsar Convention, a significant number of ponds and wetland habitats nearby were registered as Wetlands of International Importance (Třeboň fishponds – see section 1.3.2 above). In 1993 the most valuable peat-bogs were also registered as being of international importance (Třeboň peat-bogs – area 1,080ha).

Thanks to the large number of bird species which nest or migrate to the Třeboň region, the area has been included in "Important Bird Areas in Europe" (Grimmett and Jones 1989, Hora, Kaňuch *et al.* 1992).

A practical approach to the protection of the area and also to the realisation of international commitments is possible due to the consistent application of available legislative measures. The most important of them is the Czech National Council Act No. 114/1992. The Act clarifies the basic conditions (§ 26) for protection and clearly defines the scope of human activities in the protected area (§ 78, Bureš 1995).

1.4. Historical development of fishponds in the Třeboň area

1.4.1. General conditions for development of fishponds in the Třeboň area

Fish farming in the region has maintained its traditions for centuries. The region's landscape contributed to the development of a unique pond system. The construction of ponds had a large impact on the previously homogeneous landscape of peat-bogs and lakes in the Třeboň region. The primary goal of pond construction was to drain the area and to gain more arable land here. The prospect of profits from fish culture was also a reason for the construction of ponds.

The beginning of the transformation to a cultural or semi-natural landscape with peat-bog refuges dates back to the 13th century. During the process of forming the cultural landscape, several types of pond construction for different kinds of marshes were carried out.

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Step by step ponds became an organic part of the landscape and they replaced primary lakes, marshes and wetlands. Over the centuries they were inhabited by various communities of water and wetland species.

The construction of a wetland landscape without water flow and drainage has no analogy in Central Europe. Work was slowly but deliberately focused on:

- drainage and the creation of a new landscape from swamps
- construction of new water bodies.

Not only artificial water installations but also a network of canals and ditches were constructed, unlike anything previously seen in the country.

At first the changes were very slow and there were several stages over time. First of all it is necessary to stress that new biocorridors were emerging due to the construction of pond dams which were filled with soil rather than constructed with big stones on the water-face side. The resulting new habitats had a decisive impact on the biological variety of the new landscape, which comprised quite unique communities of macrophytes, new types of wetlands, communities of dams, forests and also newly emerging communities of preserve parks.

The first colonists, the Slavs, under the noble family of Landstein from Central Bohemia or the German Knights Templars who were supported by the Lords in Hradec, had to overcome great obstacles in the Třeboň region. The inaccessible and vast forest complexes of peat-bogs, swamps and beech and spruce forests were unfavourable for settlement. Deforestation caused the extension of swamps because there were fewer large trees to facilitate evaporation of the water surplus. It was here that the achievements of the architects of the water management system began – man-made canals, mill races, dams and shallow installations. These installations were favourable for freshwater fish culture, and are proof of the skill, art and steady work of many generations. Fish was used for feasts in monasteries and later on by country landlords. The land was not used for agriculture to begin with, and pollen samples from the Třeboň peat-bogs do not include the pollen of cereals and weeds for a long time.

1.4.2. History of fish farming

Fish farming has a long and rich tradition in the Třeboň region. Ponds in shallow valleys on small water streams (tributaries of the rivers Lužnice and Nežárka in the flat Třeboň basin) can keep a surplus of water during floods. The Zlatá stoka (Golden Canal) enables the supply of ponds with water during times of rainfall deficit.

Exact data about ponds as man-made water reservoirs suitable for fish farming and other purposes can be traced from the 12th century in Central Europe. In Bohemia the first pond is mentioned in 1115 in the archives of Kladruby monastery.

The most intense period of pond construction was at the end of the 15th century and at the beginning of the 16th century. The period is connected with the work of Štěpánek

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Netolický. He was the first man to develop a pond construction system. On the basis of his principles a lot of large ponds were constructed or extended in the Třeboň area. Zlatá stoka, a man made 46km-long canal was built by Štěpánek Netolický between 1506 and 1520.

The next significant constructor of ponds in the Třeboň area was Jakub Krčín. His activities included the reconstruction of existing ponds, as well as the construction of new ponds. He improved the basin of the brook Spolský and the river Lužnice, and, after construction of the Vdovec, Potěšil and Krčín ponds, he dammed the river Lužnice and started the construction of the pond Rožmberk in 1584. He wanted to protect the land against floods and therefore he connected the rivers Nežárka and Lužnice by a man-made canal named Nová řeka (New River). The pond of Rožmberk was finished in 1590.

The last significant period of fishpond construction was during the lifetime of Josef Šusta (1835–1914), when 36 ponds were constructed. The total water area of these ponds is 413ha. The largest of them is the pond Ženich.

The water area of the Třeboň ponds was 6,370ha in 1908. The water area today is nearly the same as it was then, and covers 11.4% of the Třeboň PLA and BR.

Information about species used for fish farming in ponds is not complete. At first ponds were probably used for fish storage and fish could spawn and propagate there. Knowledge of how to keep fish was brought by immigrants from south and west Europe to the Třeboň region.

The first data concerning carp *Cyprinus carpio* cultivation in the Třeboň area are from 1450. Brood fish were stocked into a pond, they spawned there and after six or even more years the pond was cleared. The biggest fish were sold and smaller ones were stocked in other ponds.

This method of fish culture is called the cumulative method and it was replaced by a method of separate cultivation, in which fingerling, stocking material and marketable fish are cultivated separately, according to the recommendation of Jan Dubravius in his book *O rybnících* [About Ponds] from 1547 (Dubravius 1547). Ponds were divided into three categories: spawning ponds for the spawning of fish and fry cultivation, fingerling ponds for fish stock, and main or carp production ponds for bigger fish which were caught for market. The book also describes methods of overwintering fish, whereby they are kept in deeper ponds during winter.

Carp was the only fish species involved in that type of cultivation. The pike *Esox lucinus* was introduced to the ponds Záblatský and Velký Tisý in 1515–1516.

A new method focused on carp culture was elaborated in 1568. Main ponds were divided into three equal groups. A pond was cleared each third year. The result was that it was possible to supply the market regularly. Fingerling ponds were harvested each year. Spawning ponds were harvested once in a three year period. As in main ponds, they were divided into three equal groups. During the first year they were drained in the summer. In the other two years ponds were full of water and a mixture

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of one-year- and two-year-old carp was harvested. If spawning ponds were overstocked with broodstock material along with their offspring from two spawning seasons the fish would not have enough food.

The new type of fish culture aimed to increase total fish production. About 200 tonnes of marketable fish were harvested each year from Třeboň ponds at the end of the 16th century. Carp was the prevailing species but pike, tench *Tinca tinca*, perch *Perca fluviatilis* and bream *Abramis brama* were also harvested. The weight of six-year-old carp ranged from 2.5–3kg.

The harvest of 1607 is entered in the archives in detail. It proves that 219 tonnes of fish were harvested in that year. In the following years, the Thirty Years War had an unfavourable influence on the fishery. A gradual decline in harvests followed, culminating in the lowest harvest recorded, 48 tonnes of fish, in 1626. Pike was overstocked, and the summer draining of ponds was not carried out which also contributed to the decline of natural pond productivity.

The recovery of fishpond culture started from 1677, but with a shortage of both fishermen and managers development of the industry was slow. A common situation was that breeding and growing ponds were overstocked and the live weight of fish was insufficient due to lack of food.

The next important changes in fish culture began from 1784. The practice of overstocking the ponds was overcome, and the principles for keeping fish stock in growing and main ponds were settled. The introduction of the proper method of fish culture in fingerling ponds was not successful as yet. A three year period was still practised so that the fingerlings were in a bad condition and undernourished and there were considerable losses of fish during overwintering, as well as during production seasons.

The summer draining (or "drying") of fishponds, instead of fingerling ones, was introduced into fish culture practice during the 18th century. There is also evidence for spring harvests at main ponds in those days, when previously ponds were only harvested in the autumn. A harvest of 260 tonnes of marketable fish, which was extremely high, was achieved in 1751. In addition, 20 tonnes of fish were harvested during the spring season. There are no details on which fish species were harvested that year.

During that time, other fish species such as pike, tench and burbot *Lota lota* were introduced into the main ponds. Subsequently, burbot was not farmed but since 1784 the pike-perch *Stizostedion lucioperca* has been kept in ponds. Six pike-perches coming from the river Nežárka were stocked in the pond of Rožmberk. Offspring of those fish represent the pike-perch culture of today.

Entries from the second half of the 18th century show the use of manure for fertilisation of pondbeds. It means that this type of improvement was incorporated into the summer draining system in fish culture. It was also observed that better results were achieved if ponds were surrounded by fields and meadows rather than forests. This was due to better

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fertilisation of ponds by nutrients from agricultural activity. Special fertilisation was not applied, but nevertheless the grazing of cattle around pond edges was permitted.

Low fish prices caused arable farm land rather than fish farming to be of more interest from the beginning of 19th century. Although fisheries declined a little in the Třeboň area, the change in emphasis had relatively little effect, unlike the region near the river Labe. The change of attitude is noticeable from the mid-19th century. A revision of fish culture methods began in 1871 and this was introduced into practice from 1874. The summer draining system was extended and some ponds were used for arable farming to produce cereals or other plants in a one or two year cycle. Fish handling was also improved and fishery practice became more professional.

The export of fish started, with 18 tonnes of fish, mainly carp, exported in 1883. During this time, mirror carp was introduced.

The 17th to 19th centuries can be described as a period of trial and error. Results fluctuated, with successful years often followed by less successful ones. It was only exceptionally that levels of fish production equalled those commonly achieved in the 16th century, e.g. in 1751 and in 1879 when 206 tonnes of market fish was harvested. More usually total production of fish was about 150 tonnes per year.

Because elementary information about fish biology was not known, especially knowledge concerning food demands, it was not possible to provide appropriate methods for better fish culture. The basis of new knowledge was empirical, e.g. a new pond provided better production of fish: that is why the summer draining system had been applied.

Fish and hydrobiology research brought about a change in farming practices from the last decades of the 19th century, especially with the work of Josef Šusta. He recognised how to improve fish output, which was important because the rising incomes from arable farming resulted in the reduction of pond water. His work helped to develop a better understanding of water organisms as food for carp and to understand the role of these organisms to enhance pond production. Summer draining of ponds, the use of lime and additional food were the first measures to improve fish culture (Šusta 1884, 1898).

Carp was recognised as a good fish for successful fishpond farming because it can utilise both natural food and supplemented food. Šusta also introduced other fish species to fishponds, e.g. the freshwater houting *Coregonus maraena*, and focused his work on the balance between fish stocks and the amount of natural food. He also stressed the poor results from overstocking of fishponds, which cannot be improved even by a higher amount of additional food.

Other followers of Šusta implemented his recommendations and working methods so the production of fish from 1900 was nearly unchanged till 1945.

The next extensive change in fishpond production was implemented in the second half of the 20th century in connection with agricultural intensification. In the 1930s the natural production was quite low: 50–100kg of fish per hectare. Numerous ponds contained acid

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water and fish stocks were lower than today, although they were rich in fish species. The water was cleaner (more transparent), ponds were overgrown by macrovegetation and there was a broad variety of benthos and also a broad biodiversity of nature in general.

During the next years the life-cycle of carp was shortened, so that the harvest of marketable fish was 1,000 tonnes in 1952. Due to intensification measures in fisheries during the 1950s, including the use of fertilisers, the more intensive use of lime, and lately the use of additional food and the increasing of fish stock, the change in the chemical properties of water also brought about a loss of water organism diversity. This was accompanied by the gradual eutrophication of water due to the supply of nutrients from the catchment area.

Farming of ducks began in 1952 and production reached 1,000 tonnes in 1980. In places the water and the pond banks were very frequently overmanured by the system of duck production on a limited area.

The negative consequences of such development were not visible at first. A slight improvement in the state of pond water from the viewpoint of eutrophication also led to the increased occurrence of water birds. Regular lime application increased water pH and contributed to the gradual extinction of calcifuge organisms. At the global level the gradual increasing of zooplankton and zoobenthos biomass without any significant decrease in the number of animal species present was common. Although such a phenomenon would be considered unusual today, it can be simply explained by fish feeding extensively on water fleas (Cladocera). This caused a reduction in the period when water transparency was high and an increase in the amount of smaller phytoplankton, which, after sinking to a low nutritive pond bottom, helped in enriching the availability of higher food supply for zoobenthos.

More important changes appeared with the implementation of fish feed mixtures which enabled the increase of fish stock many times over. It quickly caused the reduction of biomass and zoobenthos species. The size structure of zoobenthos was changed in favour of smaller zoobenthos species. The species structure of phytoplankton was also simplified, chlorococcal algae caused long term turbidity and reduced the transparency of the water to only a few decimetres. All this caused serious damage to submerged macrovegetation species.

Increasing carp stock (more than 1,000kg per hectare) led to a diminishing of littoral vegetation including its fauna. The introduction of the grass carp *Ctenoparyngodon idella* in the mid-1960s, and its influence in polycultural stock, contributed to these damages.

With the use of heavy machinery, pond littoral zones were limited by the practice of removing pond mud to the bank area. This diminishing of a suitable biotope area limited the nesting possibilities for numerous water birds, which needed pond areas because natural wetlands had been more or less destroyed in the country. The spectrum of fish species in ponds was also poorer. Species which were not restocked nearly disappeared. These were the consequences of deteriorating conditions for natural fish spawning, the

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Table 5. Fish production of State Fisheries in former Czechoslovakia

indicator	1930	1938	1950	1960	1970	1980	1985	1988
pond area (ha)	10,858	12,328	34,419	41,911	43,093	41,627	41,843	41,910
increase in weight/ha (kg)	86	97	135	182	251	320	400	
Fish harvest (t)	937		4,200	7,322	10,736	11,789	15,019	16,057
Carp	856				9,999	10,688	13,588	14,437
Tench	58				275	323	267	354
Predatory fish	19				32	51	38	77
Herbivorous fish				?	?	39	564	425
Consumption of feed-stuffs (t)	2,094			8,600	17,353	15,527	29,618	32,138
Consumption of fertilisers (t)	1,560			10,200	100,100	126,210	141,460	156,700

eating of their eggs by predatory Copepoda and also their direct eating by carp in overstocked ponds.

A particular problem was the existence of botulism in ponds which, in some cases, led to the death of water birds and which had a negative influence on duck-keeping on ponds. A high level of eutrophication of ponds resulted from fertilisation and the additional feeding of fish, and more importantly from an increase in intensive manuring, increased amounts of duck excrement, and also the influence of waste communal waters. This set the conditions for a massive outbreak of botulism from the mid-1970s in ponds with a prevailing anaerobic status in the upper strata of sediment. Botulism caused a large and long-term decrease in the numbers of some water birds, especially diving ducks.

The harvest of marketable fish was 1,752 tonnes in 1970. Today it is about 3,000 tonnes in the Třeboň region. New fish species have been introduced to fish culture. They are the grass carp, silver carp *Hypophthalmichthys molitrix* and another non-native species bighead carp *Aristichthys nobilis*. Table 5 gives basic information on fish production by the State Fisheries in former Czechoslovakia (Baruš, Oliva *et al.* 1995).

1.4.3. Current fish-farming practice

Třeboň Fishery (Rybářství Třeboň), a joint stock company, was founded on 1 May 1992 by privatising the previous State Fishery Enterprise Třeboň, following the

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implementation of the Privatisation Act No. 92/1991. The State Fishery Enterprise managed 7,500ha of water area which comprised 480 ponds. Now, after restitution and privatisation the Třeboň Fishery owns 6,850 ha of water area comprising 320 ponds. Besides that the Třeboň Fishery manages another 200–400ha of water area, nearly 30 ponds, which are privately owned by individuals or local authorities. The size of ponds ranges from 0.1ha (pond Emílek) to 711ha (cadastral area of pond Rožmberk). Most of the Třeboň ponds are relatively large, with approximately 66% of ponds being 50ha or more. From the point of view of the three-year production cycle this size structure is not so favourable because there are not enough smaller ponds (5–20ha) suitable for younger fish stock.

The carp is the main fish species cultivated and bred after a long tradition not only in the Třeboň region but in other pond regions in the Czech Republic (see Table 6). The Třeboň Fishery owns shoals of scaled carp, 2,500 brood fish and 2,200 mirror carp. The brood fish are kept in particular ponds and their stock number is controlled under a strict selection programme. The so-called "Třeboň scaled carp" is cultivated as a commercial fish. Also the Ròpšín hybrid (originating from Bielarus) and the Tataj hybrid are kept. Most of the mirror carp which are now produced originated from the mirror form of Hungarian carp. A part of the mirror carp population partly descends from former East Germany and partly from the Blatná mirror carp form.

Successful carp culture depends on high quality fingerlings, 98% of which come from artificial spawning which is carried out at Mokřiny hatchery. Nearly 70 million carp fry are produced there each year. Each production year, up to 60 million carp fry are required. Only a small part of the carp fry is produced by natural propagation (Dubravius method) in 100m^2 spawning ponds. The stocking density of fry ranges from 40,000 to 200,000 individuals per hectare. The suitable fry ponds take up about 8% of all pond area. Such a pond ranges from 1 to 5 ha of water area. Good water quality (pH, alkalinity, dissolved

Table 6. Proportion of fish species in total commercial production at the Třeboň Fishery (in 1995)

species		proportion (%)
Carp	*Cyprinus carpio*	93.8
Tench	*Tinca tinca*	1.5
Grass Carp	*Ctenopharyngodon idella*	1.5
Silver Carp	*Hypophtalmichthys molitrix*	1.4
Pike	*Esox lucius*	0.4
Perch Pike	*Stizostedion lucioperca*	0.4
others		1.0

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oxygen) is essential for the proper development of carp embryos. In connection with that there is a necessity for proper plankton structure which should include minute zooplankton (rotifers and minute species of water fleas). These represent the most suitable food for early stages of carp embryos. In autumn the developed carp fry are fished out and transferred to a wintering pond. During spring the fry are transferred to rearing ponds. It is also possible, in many cases, to keep carp fry in one pond during winter and stocked at the same place for the second year. The weight of this fish stock ranges from 0.03 to 0.10kg per individual. Weight is a decisive factor in the length of the carp farming cycle. The production of marketable fish is organised in one or two summer seasons which means that it can be described as a three or four year production cycle. The three year production cycle gives an individual weight of carp which ranges from 1.2 to 1.8kg. The four year cycle can provide carp above 2.0kg.

The advantage of the two summer production cycle is that it minimises the need for water manipulation (this point is mainly important in larger ponds during dry seasons). Pond drainage once every two years means a reduced loss of dissolved nutrients which are washed up as effluent. Less extensive fish handling also reduces the possibility of injuries during fish transport and reduces stress from sudden changes in the environment. The other advantage of the two summer production cycle is that lighter fish stock is sufficient for further cultivation. The disadvantage of this production type is the difficulty of checking fish stocks during the second year and the risks connected with the reduced amount of fish stock per ha of water area during the first year. In addition, the natural production of the pond is not fully exploited. This can be compensated for by a lower water amount which creates a better relation between fish biomass and water area. Fish harvesting during the second season or additional fish supply are other measures. During winter the fish are in main ponds or in deeper wintering ponds with a sufficient amount of fresh water inlet. Wintering of fish requires 70% of the total pond area. The remainder of the ponds are without water during winter and they are filled in spring before the rearing season.

The numbers of fish stocked in the main ponds varies according to the natural production, level of production intensity, size of marketable fish and other criteria such as recreation purposes and the needs of nature protection. Ponds with lower production intensity (Ministry of Agriculture Decree No. 1716/88-110/1988) keep 1,000–3,000 individuals of one-year-old carp or 500–1,000 individuals of two- or three-year-old carp. In ponds with higher production intensity, fish stock of 10,000 individuals of one-year-old carp and 2,000 individuals of two-year-old carp per ha are placed. Stocks of other fish species differ substantially. The most common fish species are tench, silver carp, bighead carp, grass carp, pike and pike-perch.

Each year Třeboň Fishery produces 2.5 million of two-year-old fish stock, and 800,000 individuals of three-year-old carp. Production (weight gain in kg per ha) on average reaches 600kg per ha, but the maximum production rate in some ponds can reach

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Table 7. Commercial production of fish by the Třeboň Fishery (tonnes)

year	1989	1990	1991	1992	1993	1994	1995
carp	2.508	2.607	2.563	2.699	3.019	2.890	2.460
other fish	0.201	0.207	0.228	0.154	0.161	0.174	0.192

more than 1,000kg per ha. The basic principle of carp production is the maximal use of a pond's natural production and use of natural food (plankton and benthos). Above that, effective carp production needs supplementary feeding. Only in the most intensive method of carp production do feed mixtures represent a substantial part of food intake. The most effective method of fish culture today is to optimise fish stock together with the growing season by a partial harvest or additional fish stocking which can optimise natural food and feed mixture consumption.

The total amount of marketed fish harvest during 1989–1995 by the Třeboň Fishery is shown in Table 7. It can be seen there that fish production is relatively stable during those years.

Fertilisation supports the natural production of ponds. Manure is applied for that purpose today. Most of the manure is applied during spring. Of the main nutrients, the supply of nitrogen ranges from 10 to 140kg per ha, and the supply of phosphorus ranges from 2 to 40kg per ha. Although the dose of fertilisers is not increasing, the trophic level is still very high. In part this is due to run-offs and effluents from agricultural activity near ponds. The liming of ponds is the other important measure assuring fish production, aimed at securing this biogenetic element, stabilising pH levels and maintaining a proper balance between organic carbon (from manure) and calcium. Liming is also important as a disinfectant. It is usually carried out immediately after harvest or before filling the pond.

The economic results of the Třeboň Fishery are regarded as very good. There is an increasing level of earnings from the trade in fish. The company also ensures the processing of fish into different products. Fish can be marketed all year round due to the farming of carp in full ponds during May to September. It represents 33% of earnings from the whole budget realised in 1994. 78% of marketable fish was exported. For the first time in 1994, the price of live fish for export and for domestic market was similar, and this influenced results in a positive way. The processing unit at Třeboň plays a highly important role in enriching the fish market. During the years 1989–1995 there was a considerable decrease in duck farming in the Třeboň Fishery. Now it seems that the decrease has stopped and the level of duck production has stabilised at the level of 20% compared with 1990. Economic results give an optimistic forecast for successful management in the future.

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1.4.4. Importance of fish production in the Czech Republic

Fish culture has a long tradition in the Czech Republic. Nowadays fish farming is the only branch of agriculture which has increased production since the transformation of 1989 – commercial fish production has increased by 8%.

There are 51,000ha of ponds in the Czech Republic in 1995, of which 30,000ha are managed by members of the Fishery Association. More than 70% of this water area is in South Bohemia. The common carp is the prevailing fish species, representing 88% of total fish production (Table 8). Specialised fish producers produce the main part (79.8%), sport fishing anglers produce 17.9% and pond owners with extensive farming only 2.3% of the total fish production.

Table 8. Commercial production of fish in the Czech Republic (in 1994)

species/group		proportion (%)
Carp	*Cyprinus carpio*	88.0
Grass carp	*Ctenopharyngodon idella*	4.5
Silver carp	*Hypophthalmichthys molitrix*	
Rainbow trout	*Salmo gairdneri*	3.0
Tench	*Tinca tinca*	1.5
Whitefish	*Coregonus* spp.	1.0
Pike	*Esox lucius*	1.0
Perch pike	*Stizostedion lucioperca*	
Wels or European catfish	*Silurus glanis*	
others		1.0

Fish exports from the Czech Republic have tripled since 1989. Carp is the main species exported. In 1994, 2,084 tonnes of carp were exported to the Federal Republic of Germany alone. Fish exports from the Czech Republic during 1990–1995 are shown in Table 9.

Fish consumption is only 4.5kg per capita per year in the Czech Republic, of which only 1kg is consumption of freshwater fish; the world average for fish consumption is about 13kg per capita per year. Most live fish is sold at Christmas and Easter time. Fish farmers are able to supply the market during the whole year, although there is still further progress to be made in changing consumers' habits and developing trade relations. In 1989 fish consumption, evaluated as low, was 6kg per capita per year. This also included fish caught by anglers. It means that fish consumption in the Czech Republic is far behind that of other European countries (Table 10).

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Table 9. Fish exports from the Czech Republic (in thousand tonnes)

year	1990	1991	1992	1993	1994	1995
export (thousand tonnes)	2.7	4.6	5.6	9.3	7.5	7.4
percentage of total production	14.2	26.3	28.7	56.3	39.5	39.0

Table 10. Average consumption of fish in some European countries in 1994 (in kg/person/year)

country	consumption
Norway	41.0
Russian Federation	32.0
France	31.0
Sweden	27.0
United Kingdom	19.0
Federal Republic of Germany	12.0
Austria	8.0
Czech Republic	4.5

1.5. Impact of fishery management on the trophic level of fishpond waters

Fishponds have an important role in the hydrological system of the Třeboň region and generally they represent the most common type of still water biotope in the Czech Republic. Most of the fishponds are several hundred years old, and have therefore lost their artificial character and become an integral part of the countryside. Despite the fact that they now look like shallow lakes, in many respects the fishponds differ from natural lakes. These originally artificial lakes represent a managed aquatic ecosystem in which the most important factors for their functioning – water level, fish stock and to some extent also nutrient input – are under human control. However, from the Middle Ages to the end of the 19th century, the development of the fishpond ecosystems was a more or less natural process and not too affected by human activity. In these fishponds a part of the original plant and animal communities was preserved when their original localities were destroyed after the drying and cultivation of the adjacent swamps and pools.

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Modern methods of breeding fish began at the end of the last century, but the period of direct intensification of fish production dates back to the 1930s, when liming and fertilisation of the fishponds became common. Since the 1930s fish production has increased from about 50kg/ha to more than 500kg/ha on average. Larger fish stocks in the last 40 years have led to the use of artificial food (grain, fish pellets). The changes in management practice may be considered as a long-term and large-scale "unplanned ecosystem experiment", because similar fish stocking and fertilising have been used in the most important Czech fishpond regions during the last four decades. The new practices of fish farming have thus had an impact on both the structure and dynamics of the whole ecosystem. The eutrophication of the ponds has been both intentional and artificial and changes have been made at both ends of the food chain with higher concentrations of nutrients and higher fish stocks. Our data, collected over several decades from a number of localities, allow us to evaluate mechanisms responsible for the observed changes in water chemistry, biodiversity and ecological status of the fishponds.

The management trend towards higher fishstock densities and nutrient loadings results in increasing trophic level up to a state of hypertrophy. The main symptoms of this state are massive development of phytoplankton and cyanobacterial water blooms, great fluctuation in the concentration of oxygen, pH, and an excess of some products of degradation of the organic matter (e.g., ammonia).

Long-term development of eutrophication of the Czech fishponds is shown in Table 11. 'Load' means the input of fertilisers (expressed as N and P) applied per ha per year. A

Table 11. Long-term development of N and P supply per year and fish stocking in some Czech fishponds (data represent average values)

period	load N (kg ha^{-1})	load P (kg ha^{-1})	N:P	fish stock (ind ha^{-1})	fish harvest (kg ha^{-1})
1930s	0.1	0.3	0.3	100	200
1951–1960	4.6	12.0	0.4	260	350
1961–1970	11.8	8.2	1.4	510	650
1971–1980	26.0	6.7	3.9	790	720
1981–1990	30.0	8.0	4.9	980	880
1991–1993	46.3	9.7	4.7	880	810

1930s data from Jirovec and Jírovcová (1938)
1951–1960 data from State Fishery Blatná (about 12 fishponds)
1961–1990 data from State Fisheries Blatná and Třeboň (about 300 fishponds)
1991–1993 data from Fishery Třeboň (about 40 selected and monitored fishponds)

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Table 12. Long-term changes in TN, TP, transparency and chlorophyll (data represent average values)

period	TN ($mg\ l^{-1}$)	TP ($mg\ l^{-1}$)	TN:TP	Transparency (m)	Chlorophyll ($\mu g\ l^{-1}$)
1954–1958	1.00	0.20	5.0	1.70	35
1973–1984	1.48	0.12	12.3	1.04	64
1990–1993	2.51	0.25	10.0	0.50	102

1954–1958: 9 fishponds in Blatná area sampled 6–8 times a season

1973–1984: 12 fishponds in Blatná and Třeboň area sampled 10–12 times a season

1990–1993: 40 fishponds in Třeboň area sampled three times a season, 91 fishponds in Třeboň area sampled five times in 1992 for transparency and chlorophyll

lower amount of P in the 1960s and 1970s reflects a decreased application of mineral fertilisers (superphosphate). In the 1980s, mineral fertilisation was replaced by application of large doses of organic fertilisers, especially swine and bovine manure. Similarly, the average fish density and catch of fish show an increase in the range up to ten times the previous magnitude (Pokorný *et al.* 1993, 1994; Pechar 1995).

Table 12 shows the responses of the main trophic parameters (average seasonal concentrations of total phosphorus and total nitrogen, water transparency and chlorophyll concentration) to an increase in nutrient input and fish stocks. The total nitrogen amount increased about 2.5 times from the 1950s to the 1990s (Pechar 1995).

The changes in the concentration of total phosphorus correspond to the above-mentioned decrease of mineral fertilisers applied in the 1960s and 1970s. The rise of total phosphorus in the 1990s results from a higher load of organic fertilisers. The considerable decrease of transparency and a corresponding increase of chlorophyll concentration illustrate well the high level of eutrophication.

The long-term development of plankton species composition which has been observed is closely related to changes in fishery management.

At the beginning of this century the fish stock was low and nutrients were present at low concentrations. The pH was around 6.5 and species of *Chrysophyta* and *Dinophyta* were dominant in the low biomass of phytoplankton.

During the 1930s and 1950s the fishponds were limed and heavily enriched by artificial fertilisers, i.e. superphosphate, urea and saltpetre (NH_4NO_3). These intensification measures resulted in a significant increase of production of the whole fishpond ecosystem. But with fish stocks still relatively low the low feeding pressure from fish could not control the development of zooplankton (mainly *Daphnia pulicaria*), which increased in numbers and individual size. In such a situation, the period of clear water with high

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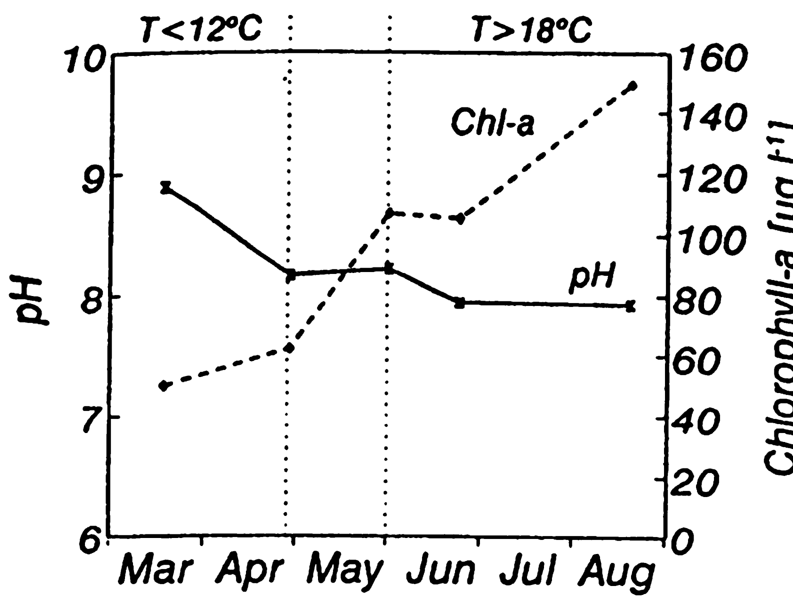
transparency in spring and the water bloom of *Aphanizomenon flos-aquae* represented in the summer the most common type of seasonal plankton development.

The fish stock increased considerably from 1960 to the mid-1980s. At the same time fertilisation by artificial (mineral) fertilisers was replaced by the application of high doses of manure. The high fish stock regulated the zooplankton in favour of small-size zooplankton. The higher TN:TP ratio (total nitrogen : total phosphorus), as a result of manuring, and the fact that zooplankton were no longer regulating the phytoplankton, resulted in an increase of different genera of chlorococcal algae and small-size blue-green algae.

The eutrophication of fishponds in the Třeboň region reached even higher levels during the 1980s. The enormous amount of organic fertilisers and the dense fish stock resulted in a very small zooplankton population. The dense blooms of phytoplankton elevated the pH and decreased the TN:TP ratio. New species of blue-green algae typical of hypertrophic waters, such as *Planktothrix agardhii* and *Limnothrix redikei*, became common in fishponds.

The current seasonal changes in the main trophic parameters (nutrients and phytoplankton expressed as chlorophyll concentration) can be described from the average data from 91 fishponds (Figure 1). Seasonal changes in pH and chlorophyll show the

Figure 1. Seasonal trends in pH and chlorophyll-a concentration (mean data from 91 fishponds in 1992)



(T = average water temperature)

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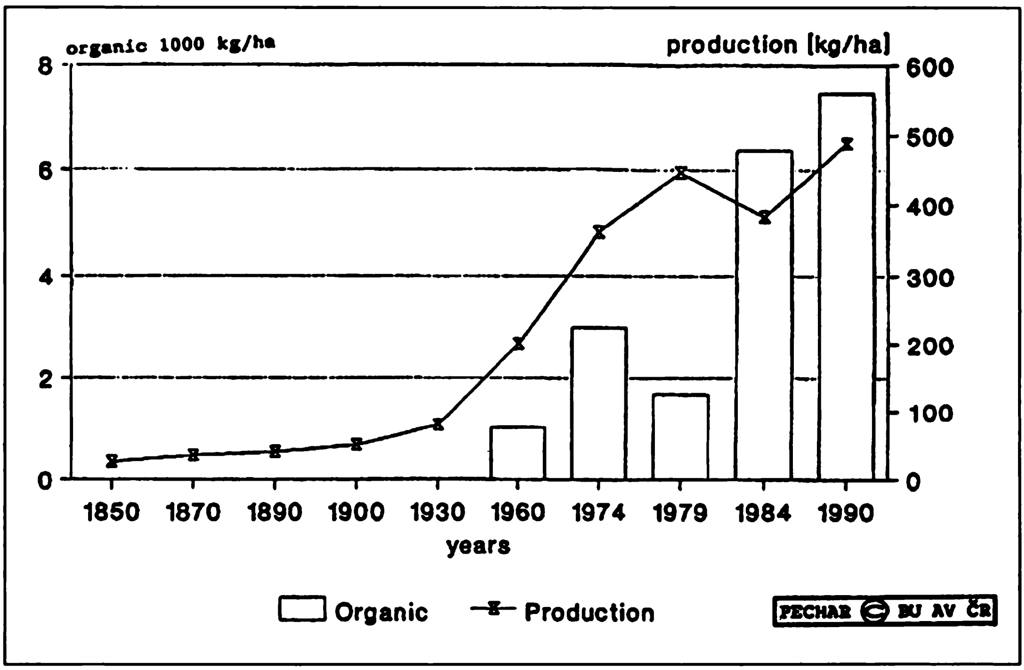
highest pH in spring when chlorophyll concentration is relatively low. The high pH values are caused by photosynthesis, which is less inhibited by low temperature than is respiration. High pH can bring about fish deaths, particularly in late spring when higher concentrations of NH_4 occur. The pH value falls slightly from spring to late summer, while the chlorophyll concentrations, on the other hand, rise from March (50µg/l) to August (150µg/l). This discrepancy between increasing concentration of chlorophyll and decreasing values of pH may be explained by higher microbial (respiration) activity in warmer water and sediments in summer and by the different temperature dependence of photosynthesis and respiration: the rate of respiration increases with temperature more than photosynthesis. For more detailed information on the hydrobiology of the Třeboň fishponds see IUCN (1996).

The change, and in recent years intensification, in fish farming methods has had an impact on the water quality. A particular problem is that oxygen deficiency can arise as a result of two different situations. The first is the absence of phytoplankton due to the high feeding pressure of zooplankton in understocked fishponds (e.g. after a winter fish harvest). The high rate of consumption of oxygen through the decomposing processes in the bottom sediments and the respiratory activity of huge populations of zooplankton is not compensated for by photosynthesis and concentrations of dissolved oxygen can fall below 1mg/l. Similarly in summer over several warm and calm days oxygen drops to a

Figure 2. Relationship between use of organic fertilisers and fish production for the Třeboň basin fishponds from 1850 to 1990



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low level. The high biomass of phytoplankton and self-shading effects lead to a strong light gradient. In such conditions only a small part of the phytoplankton occurs in the zone of greatest light, and most of the plankton community contributes to the respiration.

In spite of the high trophic level of fishponds, the fishery management can be regarded as semi-intensive. There are still great differences at certain localities and the present situation includes a large spectrum of various ecological conditions. This ecological mosaic in the Třeboň fishpond region offers some hopeful possibilities for nature protection.

A marked correlation was found between fish production and the amount of fertilisers and food used over the period 1930–1965, but not for the period 1969–1990 (Figure 2). These results support the opinion that the former oligotrophic and mesotrophic conditions in ponds were changed by intensive management and increased run-off etc. into eutrophic and hypertrophic systems (Pokorný *et al.* 1993, Janda *et al.* 1994). In 1992, 40% of the fishponds have a cyanobacterial water bloom (*Cyanophyta*) layer on the surface (Pechar unpublished). There is also the change in the ratio between nitrogen and phosphorus despite their seasonal dynamics.

1.6. Development and formation of macrophytic vegetation

The origin of fishpond vegetation can be traced to the vegetation of wetlands, temporary alluvial waters, pools and running waters. Aquatic and wetland macrophytic vegetation is characterised by great adaptability to fluctuations of the water table, to sediment exposure and to a large amplitude of nutrient availability. These parameters change markedly and frequently in fishponds owing to fishpond management practices. The intensity of management, which underwent substantial changes during several hundred years of fishpond history, markedly modifies the natural development of aquatic vegetation, which is well described for lake shores.

In fishponds subject to a low management intensity, the communities of littoral macrovegetation pass through similar successional stages as in shallow lakes. In intensively managed fishponds, by contrast, the vegetation undergoes a specific development, largely determined by management practices (e.g. the vegetation of exposed pond beds during the summer draw-down, and changes in the composition of submerged vegetation in response to fish stock). Generally, the littoral zone of managed fishponds shows a high degree of instability in comparison to that of lakes.

It is well documented (Šusta 1898) that the influence of management was fairly weak in the 19th century. The formation of macrophytic communities was largely determined by natural processes, similar to those in shallow lakes and pools. The intensification of fishpond management, characteristic especially of the second half of the 20th century, has brought about changes in the periodicity and dynamics of the water regime, an increase in

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water level fluctuations, and a changed frequency of pond bed exposure (winter and summer draw-downs). The whole fishpond ecosystem has been subjected to much larger inputs of mineral nutrients (through supplies of lime and manure). As a result, the chemistry of fishpond waters has shifted towards the calcium-bicarbonate type, and to a higher trophic status. The increasing size of the fish stock has started determining both the submerged vegetation and phytoplankton structure (which in turn reduces water transparency). Last but not least, herbivorous fish have been introduced.

1.6.1. General factors determining the structure and species composition of macrovegetation

The influence of natural factors (height of the water table, light, substrate and nutrients) on the aquatic vegetation can nowadays hardly be separated from the human impact. The vegetation of any site is an integral result of a whole range of modifying effects. Below, the most important trends in the development of fishpond vegetation are related to major environmental factors.

Water column and light conditions
Wetland ecosystems in general, and fishponds in particular, have a great degree of adaptability to water table fluctuations. The fishpond reservoirs are regularly emptied, also determining their vegetation. The draw-downs take place during the fish harvest, before summer draining and during repairs of hydrotechnical equipment. In addition, the water level drops in dry years as a result of insufficient water supply. All these situations are reflected by characteristic changes in macrophytic vegetation. The formation and occurrence of macrophytic communities is also determined by light conditions, i.e. water transparency and depth. Submerged plants are limited by the access of solar radiation to submerged leaves. Light becomes a limiting factor under high fish stocks, combined with a high input of manure and fish feed.

The controlled water regime and the diversity of management practices result in rapid changes in macrophytic communities over the whole reservoir system. Expanding synanthropic species can invade the zonation of native littoral and aquatic plant communities.

Morphology of fishpond shores and beds
The development of macrophytic vegetation is largely determined by the morphology of fishpond shores and beds. The following zones can be distinguished within the fishpond reservoir (Hejný 1990, Hejný and Husák 1978, Hejný and Květ 1978; plant community classification follows the Zürich-Montpellier school):

The sedimentation zone occupies the fishpond bed. It is formed by peloid, i.e. fine, sediment. When the pond bed is exposed, the peloid particles shrink and the bottom surface cracks into small polygonal fields. During summer draw-downs, this zone is

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colonised by communities of the foederatios *Bidention* and *Oenanthion*. Communities of the foederatio *Nymphaeion* are formed when the reservoir is filled up.

The erosion zone covers the fishpond sublittoral zone. The sediment consists of sand and gravel, which are mixed with peat humolites in the Třeboň area. The sedimentation and erosion zones cover similar areas in large Třeboň fishponds, but in small fishponds the erosion zone may be much narrower than the sedimentation zone. When the fishpond is filled up, the erosion zone is occupied by communities of the foederatios *Littorelion*, *Eleocharition ovatae* and *Radiolion*. Communities dominated by *Epilobium* species, especially by the neophytic *E. ciliatum*, have recently expanded into this zone.

The transitional zone occurs on the contact between the sedimentation and erosion zones. It is formed by a layer of organic deposits of varying thickness, superimposed on sediment of the erosion zone. Communities of the foederatio *Eleocharition ovatae* predominate in this zone.

The 'reed peat' zone is situated on the lakeward edge of reed belts (*Phragmitetea*) or tall sedge communities (*Magnocariceta*), i.e. along the outward edge of the erosion zone. It is formed on the litter layer, originating from decayed leaves and stems of reed and tall sedges. When the fishponds are filled up, this zone hosts characteristic communities, e.g. *Potametum obtusifolii*. Characteristic communities of the foederatio *Bidention* are found there during summer draw-downs.

1.6.2. Succession

Fishponds are shallow water bodies, and can become overgrown with vegetation in the absence of regular suitable management and control of plant communities. The ponds then lose the character of water bodies and change through succession into marshes, alder carrs or other similar types of wetlands.

Choking and terrestrialisation

Choking is understood as the filling of the water body with biomass of both submerged and floating-leaved aquatic plants, including free-floating plants and tree leaves (e.g. from alder *Alnus glutinosa*). Terrestrialisation is a fairly long-lasting process, including the whole succession from macrophytic communities to terrestrial communities of trees and shrubs. Both processes are associated with reservoir aging. They are typical for alluvial still waters and lakes. The aging of fishponds is slowed down by draining, especially winter or summer draining. Choking and terrestrialisation depend on the reservoir size, its water regime, and on the composition of submerged and emergent plant

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species. The natural choking of fishponds has almost completely ceased since dredging and frequent winter draining were introduced. On the other hand, mineral sediments from field run-off nowadays contribute significantly to fishpond choking; this can be ascribed to the reduced retention capacities of ploughed-up meadows and the narrower littoral zones after dredging.

Mineral nutrients

Nutrient status, including water alkalinity and pH, is one of the major factors determining development of aquatic macrophytes. In the first half of the 20th century the trophic status of fishponds (and the resulting vegetation) differed according to the fishpond origin. Mesotrophic vegetation prevailed in fishponds constructed from marshes, oligotrophic fishponds originated from lakes and dystrophic fishponds were based on peat bog vegetation.

Current fishpond management practices assume the necessity of supplying water with sufficient amounts of mineral nutrients, in order to support the food chain serving as fish food (Kubů *et al.* 1994). Since the 1950s, wastes from animal production have also been discharged into fishponds and fishpond littoral zones. This practice was associated with an intentional eutrophication, again with the aim of increasing fish production. The process was, however, purely empirical, without sufficient pre-knowledge of the system response. Fishponds of the Třeboň region represent a striking example of this 'unplanned experiment' and its consequences. The manure from a pig farm was applied to reedbeds, sedge marshes and even on the waterward side of the dams over several decades. This caused a rapid invasion of anthropocoenoses, e.g. large stands of *Urtica dioica* with *Artemisia vulgaris*.

This intensive fishpond management brought about an enormous increase in the levels of mineral nutrients both in water and in sediments (Pokorný *et al.* 1994). The fishpond sediments usually contain much higher concentrations of mineral nutrients than fishpond water. The average values (as a percentage of dry mass) are: N=1%, P=0.01%, K=0.02%, Ca=0.2%. This means that a layer of fishpond sediment 1–2mm thick contains the same amount of mineral nutrients as a 1m high water column.

According to Dykyjová (1992), the littoral zone of the Opatovický fishpond (Třeboň), with an area of 21.4ha, supports reed stands which yield a total annual above-ground production of 205 metric tonnes. This biomass contains 3,070kg nitrogen, 420kg phosphorus, 3,300kg potassium, 560kg calcium and 250kg magnesium. Following the autumnal die-back of reed shoots and their decomposition, these mineral nutrients return to the aquatic environment and bottom sediments, which further contributes to fishpond eutrophication. On the other hand, if the biomass is not completely mineralised, it retains part of the mineral nutrients and, in addition, becomes one of the few systems accumulating organic carbon. Run-off from adjacent fields has become another source of accelerated nutrient input into fishponds (Koutníková unpublished).

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1.6.3. Management and its consequences

Management practices, such as intense manuring, dredging, summer draining and changes in fish stock densities, have caused marked changes in the composition of both aquatic and wetland plant communities. Management practices in the surrounding land affect the fishpond vegetation indirectly, through the water quality of the tributaries, field run-off, reduced retention capacity of ploughed meadows, and waste disposal near fishponds. These factors accelerate fishpond eutrophication and contribute to changes on fishpond peripheries, (shores, dams etc.), which are invaded by synanthropic plant communities. The consequences of eutrophication include changes in the species composition of macrophytic communities as well as in community structure, frequently leading to the destruction of native littoral vegetation, or its degradation followed by the formation of new vegetation types.

The changes in plant species composition in fishpond littoral zones have been caused mainly by the following management practices:

- The feeding of fish and ducks (including the importing of the feed) has caused the immigration of new species whose occurrence can be ephemeral, temporary or permanent, the species being incorporated in the vegetation as a neophyte.
- Manuring (producing an increase in levels of mineral nutrients and a resulting decrease in water transparency) usually reduces species richness of macrophytic vegetation.
- Dredging and duck farms cause large-scale and often permanent changes in the vegetation, the native fishpond vegetation being replaced by ruderal types.
- Winter and summer draining (periods of reduced or absent water column) cause the development of specific forms of vegetation. The development of vegetation of exposed pond beds is modified by increased nutrient levels in the sediment, bringing about a reduction of species richness and changes of species composition.

1.6.4. Current status of fishpond vegetation

A global evaluation of the current status of fishpond vegetation for all 22 fishpond systems of the Třeboň region is feasible at the level of plant communities.

A fairly high number of macrophytic plant communities (80) has been recorded from the Třeboň region. Of this number, a fairly low proportion has become extinct (1.25%) or in danger of extinction (8.75%). A considerable number of communities, however, are retreating (43.75%). The number of stabilised communities (21.25%) is similar to the number of expanding or invasive communities (27.50%). Considering the total proportion of extinct, endangered and retreating communities, the overall outlook is rather bleak.

Both the area and species richness have decreased for hard reed vegetation, represented by stands of the common reed (*Phragmitetea*) and tall sedges (*Magnocariceta*). Some types of soft littoral vegetation (*Glyceria maxima*), which can make use of the high nutrient levels, have expanded.

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White and yellow water-lilies (*Nymphaea alba* and *Nuphar lutea*) have disappeared from most fishponds. On the other hand, new types of vegetation have appeared which overgrow the open water area in a fast and uncontrollable manner.

The community dominated by *Lemna minor* (*Lemnetum minoris*) has retreated. The associations *Lemno-Spirodeletum* and *Lemnetum gibbae* are invasive. The associations of *Ricciocarpetum natantis* and *Utricularietum australis* became temporarily invasive upon the destruction of reed stands. *Ceratophyllum demersi* shows signs of an invasive character.

The prospect for floating-leaved communities is generally bad. *Potamogetoneto natantis - Nymphaetum candidae* and *Nupharetum pumili* are almost extinct. The former suffers from frequent winter draining and liming, the latter is suppressed by mass growths of filamentous algae promoted by field run-off. Most of the other communities of aquatic macrophytes are retreating. The only exception of an expanding plant community with an anti-erosion effect is the community dominated by *Polygonum amphibium*.

Of the foederatio *Potamion lucentis*, the community with *Potamogeton lucens* is retreating. Stands of *Elodea canadensis* have an invasive character.

Communities of *Parvopotamion* are in a more or less stabilised condition. An invasive community of small *Potamogeton* species with *Zanichellia palustris* has responded quickly to the enhanced supply of mineral fertiliser. This community, which was rare in the Třeboň region at the beginning of the 1960s, has since suppressed most of the other communities of small *Potamogeton* species. The expansion status of the locally neophytic association *Naiadetum marinae* (occurring in fishponds Velký Dubovec, Malý Dubovec and Černičný) is still unclear.

Of *Batrachium* dominated communities, only *Hottonietum palustris* and *Batrachio fluitantis - Callitrichetum hamulatae* (occurring in the Zlatá stoka) are retreating, while a calciphilous type, *Batrachietum circinati*, formerly absent from the Třeboň region, has become invasive to a similar extent to the *Ceratophyllum demersi* dominated community.

Marked changes have occurred in the sublittoral zone. *Pilularietum globuliferae* became extinct as early as in the 1950s. *Litorello - Eleocharitetum acicularis* and *Ranunculo flammulae - Juncetum bulbosi* have retreated owing to intense manuring and liming. The invasive character of *Eleocharis acicularis* dominated communities is a general phenomenon all over South Bohemia. Eutrophication has also negatively affected communities of peat bog *Utricularia* species (*Sphagno-Utricularion*). These communities were well-developed in fishponds of the Lutová system until intensive management was introduced.

The communities of exposed pondbeds were unique in Europe both for the number of associations and for their species diversity. The great diversity of these communities was due to:

- the large area of the Třeboň region
- the great concentration of reservoirs
- the continuous supply of diaspores
- the contrasting properties of oligotrophic and dystrophic waters.

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Table 13. Establishment of alien plant species in Třeboň fishpond system during the last 50 years

species	permanent establishment	temporary establishment
Acorus calamus	+	–
Cerastium dubium	–	+
Ceratophyllum submersum	–	+
Elodea canadensis	+	–
Epilobium ciliatum	+	–
Epilobium hirsutum	+	–
Erechthites hiersciifolia	–	+
Echinochloa grus-gali	+	–
Chenopodium serotinum	+	–
Bidens frondosa	+	–
Impatiens glandulifera	+	–
Impatiens parviflora	+	–
Juncus tenuis	+	–
Lemna gibba	+	–
Lythrum hyssopifolium	–	+
Kickxia spuria	–	+
Najas marina	–	+
?*Heracleum mantegazzuanum*	–	–
?*Typha lamanni*	–	–

19 species in total: 11 permanently established, 6 temporarily established, 2 uncertain

Table 14. Changes in macrophyte communities during eutrophication

higher vegetation unit	oligotrophy/ mesotrophy	weak eutrophy	eutrophy/ hypertrophy
Lemnetea	*Lemnetum minoris* *Riccietum fluitantis*	*Spirodeo-lemneteum*	*Lemneteum gibbae*
Potametea	*Potameto natantis-Nymphaetum candidae* *Potametum acutifolii*	*Elodeetum canadensis* *Potametum crispi*	*Parvopotameto-Zannichellietum*

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Table 14. (continued)

higher vegetation unit	oligotrophy/ mesotrophy	weak eutrophy	eutrophy/ hypertrophy
Litorelletea	*Pilullarietum globuliferae* *Ranunculus flammulae Juncetum bulbosi*	*Littorelo-eleocharitetum acicularis*	*Eleocharis acicularis com.*
Isoeto-nanojunceta	*Junco tenaegeiae-Radioletum linoidis* *Centuncuso-antholeretum punctati*	*Eleocharito ovatae-Caricetum bohemicae* *Gypsophyllo muralis-Juncetum buffonii*	*Peplido-eleocharitetum ovatae* *Cypero fusci-Juncetum buffonii* *Juncus buffonius-com.*
Bidentetea	*Bidentetum cernui*	*Rumicetum maritimi*	*Bidentetum tripartiti* *Epilobietum hirsuti* *Bidens frondosa-com.*
Phragmitetalia	*Equisetetum fluviatilis* *Phragmitetum australis*	*Typhetum angustifoliae* *Phragmitètum australis* *Glycerietum maximae* *Phalaridetum arundinacae*	*Typhetum angustifoliae* *Typhetum latifoliae* *Phragmitetum australis* *Glycerietum maximae* *Sparganietum erecti* *Phalaridetum arundinacae*
Magnocari-cetalia	*Callaetum palustris* *Caricetum elatae* *Peudano-Caricetum lasiocarpae* *Caricetum rostratae*	*Cicuto-Caricetum pseudocyperi* *Caricerum elatae* *Pseudano-Caricetum lasiocarpae* *Caricetum gracilis* *Caricetum rostratae* *Caricetum vulpinae*	*Caricetum gracilis,* *Caricetum vesicariae* *Calamagrostis canescens-com.*

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Of the total number (12), four associations are endangered with extinction, seven are retreating, while only one is fairly stable.

The status of the nitrophilous foederatio *Bidention*, colonising the sedimentation zone, is different. All four associations are invasive. The neophytic *Bidentetum frondosae* deserves closer attention.

Tall littoral communities are of great value for their bank stabilisation function. The reed communities have been affected by all factors associated with the enormous management impact. Of the total number of eight associations, four are retreating (*Phragmitetum communis, Scirpetum lacustris, Equisetum fluviatilis, Acoretum calami*), while the other four have become invasive (*Glycerietum aquaticae, Sparganietum ramosi, Typhetum angustifoliae, T. latifoliae*). The latter type has a periodic occurrence, quickly filling empty niches in fishpond littoral zones.

Communities associated with fluctuating water levels (*Oenanthion aquaticae*) are endangered principally by farms which raise domesticated wild ducks. These birds soon destroy the vegetation. Of five associations, three are retreating and only two are relatively stable (*Glycerio fluitantis - Oenanthetum aquaticae* and *Eleocharietum palustri*). Quagmire associations of *Carici - Rumicion hydrolapati* are in danger of extinction.

Tall sedge communities used to occupy even larger areas in the Třeboň region than reed stands. Of the total number of nine communities, five are retreating and only three are expanding. *Caricetum vesicariae* responds positively to littoral zone dredging. *Phalaris arundinacea* quickly invades niches formerly occupied by *Caricetum gracilis*.

The eutrophicated habitats may be successfully invaded by communities whose species are able to reproduce several generations during one year. Such species include: *Oenanthe aquatica, Glyceria fluitans, Alisma plantago-aquatica, Epilobium ciliatum, Rumex maritimus, Rorippa palustris, Typha latifolia, Ranunculus sceleratus, Fila gynella uliginosa* and *Eleocharis acicularis*. Most of them are nitrophilous species or species well adapted to high loads of organic or inorganic fertiliser.

Liming, together with winter draining, has resulted in the retreat of *Nymphaea alba* from most Třeboň fishponds. This also applies to most *Potamogeton* species. By contrast, *Polygonum amphibium* and *Batrachium* species are fairly resistant. The intense manuring is tolerated by only a few aquatic species: *Spirodella polyrrhiza, Lemna gibba* and *Zanichellia palustris*. The number of expanding reed species is equally small: *Glyceria aquatica* and *Typha latifolia*. This limited number of species forms monotonous dense communities, which invade destroyed niches of less tolerant species.

Of the great number of associations of pondbeds, only one has an invasive character: communities of the foederatio *Bidention tripartitae*. The latter overgrows the existing communities of the foederatios *Eleocharis ovatae* and *Radiolion linoides*. Of the latter, two associations are in danger of extinction and five are retreating.

Table 13 shows the alien plant species which have become established in the Třeboň fishpond systems during the last 50 years. Table 14 shows changes in macrophytic

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communities during the above-mentioned process of eutrophication, which is a common feature for many fishponds, not only in the Třeboň basin.

1.7. Factors influencing the bird fauna of the Třeboň basin fishponds

1.7.1. Population size of breeding bird species and their habitat selection

An annual census of breeding water and wetland birds was carried out in the Czech Republic on 182 fishponds in the Třeboňsko PLA and BR during 1988–1995 (Musil 1995). On all ponds in this study two checks were carried out during each breeding season, one in the second half of May, and the other in late June. At each check, all adult birds of the species under study were counted around each pond. Numbers of all species of Gaviiformes, Podicipediformes, Pelecaniformes, Ciconiiformes, Anseriformes, Ralliformes, Charadriiformes and Lariformes were assessed, as well as *Alcedo atthis* and those species of raptors and passerines which occur in aquatic and marsh habitats.

In total, 127,646 individuals of 78 species dependent on wetland habitats were recorded in the study area in 1988–1995. Among the species found, gadwall *Anas strepera* was recorded from the greatest number of fishponds, while black-headed gull *Larus ridibundus* was the most abundant species.

For bird species whose breeding could be considered to be confirmed in the Třeboň area since 1990 and which prefer fishponds and their close vicinity, breeding population sizes and their changes were estimated (Table 15).

1.7.2. Changes in breeding populations and possible causes related to management of fishponds and their vicinity

Table 16 shows changes in breeding population numbers of target bird species, comparing their status in 1945 and in 1980.

In the 1988–1995 census, mentioned above, a significant decrease in abundance was recorded for great reed-warbler *Acrocephalus arundinaceus*, marsh warbler *Acrocephalus palustris*, mallard *Anas platyrhynchos*, great-crested grebe *Podiceps cristatus*, coot *Fulica atra*, snipe *Gallinago gallinago* and grey wagtail *Motacilla cinerea*. On the contrary a significant increase in numbers was found in red-crested pochard *Netta rufina*, marsh harrier *Circus aeruginosus*, bluethroat *Luscinia svecica*, gadwall and sedge warbler *Acrocephalus schoenobaenus*.

A significant correlation between trends in breeding population recorded in the Třeboňsko PLA and BR and trends in the whole Czech Republic was found in 47 species (i.e. 58.7%).

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Table 15. Population sizes and habitat relations of breeding water and wetland birds in Třeboňsko PLA and BR

species	population	LF	SF	RB	VS	LT	SH	PL	DF	IS	WE	ME	FS	WT	OL	note
Tachybaptus ruficollis	130–300		+					+					-	+		
Podiceps cristatus	300–450	+						-								
Podiceps grisegena	0–2		+										-	+		
Podiceps nigricollis	80–200															1
Phalacrocorax carbo	70–100	+						-	-	+			-		-	2
Nycticorax nycticorax	20–30						+			+						
Ardea cinerea	about 400	+						-							-	
Ardea purpurea	0–2	+		+				+		+					+	
Ciconia nigra	10–15														-	
Ciconia ciconia	[???]														+	
Cygnus olor	40–60	+														
Anser anser	120–150	+		+					-	+						
Anas strepera	500–800								+	+					+	
Anas crecca	2–10				+	+					+	+			-	
Anas platyrhynchos	1,000–1,500															
Anas querquedula	5–10				+	+					+	+			+	
Anas clypeata	1–10				+	+					+	+			+	
Netta rufina	20–30									+					+	
Aythya ferina	1,000–1500				+					+						
Aythya nyroca	0–1															
Aythya fuligula	1,300–2,000									+			-	+		
Bucephala clangula	40–70	+											-	+	-	
Haliaeetus albicilla	5–6															
Circus aeruginosus	40–60	+		+				+							+	

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Table 15. (continued)

species	population	LF	SF	RB	VS	LT	SH	PL	DF	IS	WE	ME	FS	WT	OL	note
Rallus aquaticus	50–70	+		+			+	+								
Porzana porzana	2–10	+		+	+			+								
Crex crex	0–2				+	+					+	+				
Gallinula chloropus	50–100			+	+		+	+								
Fulica atra	1,500–2,000															
Recurvirostra avosetta	2 (1993)								+						+	
Charadrius dubius	60–100								+							
Vanellus vanellus	80–150								+		+	+			+	
Gallinago gallinago	10–20				+	+					+	+				
Limosa limosa	0–2								+		+	+			+	
Tringa totanus	1–2				+	+			+		+	+			+	
Tringa ochropus	20–30								+						-	
Larus ridibundus	6,000–12,000									+						
Sterna hirundo	100–150									+						
Chlidonias niger	10–20					+				+						
Alcedo atthis	5–10													+		3
Anthus pratensis	10–20					+					+	+				
Motacilla flava	10–15					+					+	+				
Motacilla cinerea	10–20															4
Motacilla alba	???								+							
Luscinia svecica	60–80								+							
Saxicola rubetra	10–20										+	+			+	
Locustella naevia	20–30					+					+	+				
Locustella fluviatilis	20–30					+	+				+	+				

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Table 15. (continued)

species	population	LF	SF	RB	VS	LT	SH	PL	DF	IS	WE	ME	FS	WT	OL	note
Locustella luscinioides	10–15	+		+				+	-						+	
Acrocephalus paludicola	0–1				+	+										
Acrocephalus schoenobaenus	1,000–1,500				+	+			-		+					
Acrocephalus palustris	500–800					+	+		-		+	+				
Acrocephalus scirpaceus	2,000–3,000			+					+							
Acrocephalus arundinaceus	30–80	+		+				+	-							
Panurus biarmicus	2–5	+		+				+							+	
Remiz pendulinus	100–200						+									
Emberiza schoeniclus	600–900	+		+		+		+			+	+	+		+	

LF: larger fishponds (>10ha)
SF: smaller fishponds (<1ha)
RB: reedbeds
VS: vegetation dominated by sedges Carex *spp.*
LT: low littoral vegetation
SH: shrub bank and islet vegetation
PL: fishponds with extensive littoral growths
DF: drained or partially drained fishponds
IS: islets on fishponds
WE: wetlands close to fishponds
ME: meadows close to fishponds
FS: high fish stock density
WT: high water transparency
OL: open landscape in the vicinity of fishponds
-: negative relation with habitat
+: positive relation with habitat
***notes:** a few species prefer very specific nesting habitats, as follows:*
1: fishponds with nesting colonies of black-headed gull
2: fishponds with fish 10–20cm in length
3: fishponds and streams with bare shores
4: rapidly flowing streams (brooks or creeks)

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Table 16. Water and wetland bird population trends and their causes, Třeboňsko PLA and BR

species	1945	1980	causes +	causes -
Tachybaptus ruficollis		-		FST, FF, FLU
Podiceps cristatus	fl	fl	FST	FF, FLU
Podiceps grisegena	fl	fl		
Podiceps nigricollis	-	--		FST, FF, LIT
Phalacrocorax carbo		since 1983 *+	FST, PRO	REG
Nycticorax nycticorax	fl	fl	ART, FST	FLU, LIT, OVG
Ardea cinerea	+	+	FST	
Ardea purpurea	after 1950 -	-		LIT, FLU
Ciconia nigra	since 1930s +	+		
Ciconia ciconia	+			REC
Cygnus olor	+	+		
Anser anser	+	-	ART, PRO	OVG, LIT, FLU
Anas strepera	+	fl	ART	OVG, FLU, FF, FST
Anas crecca	--	-	LOW	LIT, FF, FST, REC
Anas platyrhynchos	by late 1970s +	--	ART	OVG, FLU, FF, FST
Anas querquedula	-	-	LOW	LIT, FF, FST, REC
Anas clypeata	-	-	LOW	LIT, FF, FST, REC
Netta rufina	since 1950s +	fl	ART	OVG, FLU
Aythya ferina	+	--	ART	OVG, FLU, FF, FST
Aythya nyroca	-	*-		
Aythya fuligula	+	--	ART	OVG, FLU, FF, FST
Bucephala clangula	+	--	NB	PRED, FF, FST
Haliaeetus albicilla		*+	PRO, IN	
Circus aeruginosus	+	+	PRO	
Rallus aquaticus	fl	fl		LIT, FLU
Porzana porzana	-	-		LIT, FLU
Crex crex	-	o+		LIT, REC
Gallinula chloropus	-	-		LIT, FLU
Fulica atra	since 1960s +	--		FLU, LIT
Recurvirostra avosetta		# *+	FLU	FLU
Charadrius dubius	fl		FLU	FLU
Vanellus vanellus	-	+	FLU	AGR, FLU, MF, REC, GRO
Gallinago gallinago	-	-		REC, MF, GRO

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Table 16. (continued)

species	1945	1980	causes +	causes -
Limosa limosa	-fl	*-	FLU	REC, MF, LIT, GRO
Tringa totanus	-	-		LIT, MF, REC, GRO
Tringa ochropus	*+	+	FLU	
Larus ridibundus	by late 1970s +	--		FF, AGR
Sterna hirundo	fl	+	ART	FLU
Chlidonias niger	fl	fl		FLU, LIT
Alcedo atthis	fl			
Anthus pratensis	-		REC	LIT
Motacilla flava	-		REC	LIT
Motacilla alba				FLU
Luscinia svecica		+	FLU	
Saxicola rubetra	-	+	REC	
Locustella naevia		+		LIT, REC
Locustella fluviatilis				LIT, REC
Locustella luscinioides		-		LIT, FLU
Acrocephalus schoenobaenus	fl	+		LIT
Acrocephalus palustris	o-	-	MF, AGR	LIT, REC
Acrocephalus scirpaceus		-	FLU	LIT
Acrocephalus arundinaceus		fl-		FLU, LIT
Panurus biarmicus	fl	fl		
Remiz pendulinus	+	fl	GRO	
Emberiza schoeniclus	fl	+		LIT

fl: *fluctuations in population size*
+*:* *increase in numbers*
+*: *establishment of a population and increase in its numbers*
-*:* *decrease in numbers*
--*:* *deep decline in numbers*
o-: *less pronounced decrease in numbers*
-:* *extinction of breeding population*
#*:* *sporadic breeding in 1993.*

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Table 16. (continued)

Among factors influencing or affecting the bird numbers, these were identified:

AGR: changes in agricultural measures
ART: building of artificial islets and mud deposits
FF: over-fertilisation of fishponds
FLU: water level fluctuations during the spring
FST: high fish stock density
GRO: intensive development of bank shrub and wood growths
IN: introduction (reintroduction, re-stocking)
LIT: reduction in area of littoral and bank vegetation on fishponds filled with water in the late season
LOW: development of low littoral vegetation on fishponds filled with water late in the season
MF: over-fertilisation of meadows
NB: erection of nest-boxes
OVG: shrub and woody overgrowth of artificial islets and mud deposits
PRED: high predation rate by pine martens
PRO: effective protection on a pan-European scale
REC: reclamation of meadows and wetlands in the vicinity of fishponds
REG: regulation of bird reproductive success

1.7.3. Influence of individual factors on water and wetland birds on fishponds

Changes in agricultural measures (AGR)
The loss of dispersed greenery or scattered green patches in the landscape, the overloading of agricultural lands by fertilisation and the application of pesticides in everyday agricultural practices are among the most important changes in agricultural landscape management. These changes have resulted in a reduction in shelter and nest-site availability and in an increase in natural food availability in marginal parts of fishponds and particularly next to them.

Reclamation of meadows and wetlands in the vicinity of fishponds (REC)
The loss and destruction of meadows and wetlands in the vicinity of fishponds causes the loss of some species which prefer this nesting habitat and the migration of species to arable land or littoral and bank growths on fishponds.

Over-fertilisation of meadows (MF)
The fertilisation of meadows negatively affects the structure of meadow plant communities and, consequently, insect communities on grassland habitats. The process is accompanied

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by the formation of more dense meadow vegetation which causes difficulties for birds incubating clutches of eggs, especially waders and passerines.

Over-fertilisation of fishponds (FF)

The overloading of fishponds by fertilisation results immediately in an increase of nutrients, supporting the development of phytoplankton and plants. This means that water transparency decreases so that food is less available for diving waterfowl. On the other hand, the development of littoral, floating and submerged vegetation is beneficial for water and wetland birds because of the greater availability and access to nest-sites and shelters.

High fish stock density (FST)

In recent decades, an extensive increase in fish stock density has resulted in stronger competition between fish and birds. Extremely high carp stock density destroys food resources for many waterfowl species. At the same time, fish cause a decrease in water transparency (by preying on zooplankton which can then allow an extensive development of phytoplankton) or stimulate the reduction of littoral growths.

Water level fluctuations during the spring (FLU)

The manipulation of water levels in fishponds very often does not take into account the needs of nesting birds. Although the water level is generally kept high, the increasing practice of fish-harvesting in the spring (by draining the ponds) negatively affects the breeding of waterfowl. Numbers of grebes Podicipitidae, mute swan *Cygnus olor*, greylag goose *Anser anser*, ducks Anatinae, rails and crakes Rallidae, gulls Laridae or passerines Passeriformes have decreased as a result of this. On the other hand, partial summer draining often provides suitable nesting sites for some wader species. However, water level fluctuations can also have a negative effect on the nesting of many birds including the total destruction of their nests.

Reduction in area of littoral and bank (coastal) growths (LIT)

A reduction or even complete loss of littoral and bank or coastal growths, whether direct (due to the excavation of pond mud and vegetation including reeds and their placing in very high mounds with sheer sides) or indirect (resulting from the water level manipulations or from the increase of fish stock density) can significantly limit shelter and nest-site availability for most birds. Fortunately, this negative trend can be compensated for by building artificial islets which can be a by-product of pond mud excavation.

Development of low littoral vegetation on fishponds filled with water in the late season (LOW)

Due to low water levels in the late spring and summer, low littoral vegetation stands are temporarily or even permanently formed on the fishponds which are drained in the spring.

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Thus, these growths are used as nest sites or shelter by a lot of water and wetland bird species.

Building of artificial islets and mud deposits (ART)
The destruction of littoral growths can positively influence nest-site availability by creating mud deposits and artificial islets, both longitudinal and transversal: these are very often used for nesting by ducks. From the point of view of bird bionomics, mud deposits which are connected with a fishpond bank or shore are most suitable. However, when dredging or moving mud around fishponds, care must be taken not to damage the natural transition zone from the pond bed to the surrounding land; there should be a gradual slope to the shoreline.

Shrub and woody overgrowth of artificial islets and mud deposits (OVG)
In the course of the research carried out on fishponds in the Třeboňsko PLA and BR it was found that the importance of artificial islets and mud deposits (especially transversal ones) is at its greatest during the first 10 to 20 years after their creation. Nevertheless, due to natural succession these habitats are overgrown by both herb and shrub/woody growths, the latter making waterfowl nests more vulnerable, particularly to predation by other birds.

Intensive development of bank shrub and wood growths (GRO)
As a result of stopping grazing in the vicinity of fishponds, destroying littoral vegetation and building of peripheral mud deposits, the transition zone between the fishpond and the adjacent landscape has been gradually overgrown by shrubs and trees. Therefore, most fishponds have become "forest" water reservoirs. A lot of bird species avoid these potential nest sites, probably because they do not feel themselves to be safe.

Effective protection on a pan-European scale (PRO)
More effective bird protection at passage sites during their migration as well as on wintering grounds has positively influenced population trends in a lot of bird species.

Introduction (reintroduction, re-stocking) (IN)
The release of young birds successfully reared in captivity to re-stock or re-establish a population nesting in the wild has been carried out for the white-tailed eagle. In recent decades, captive-bred mallard have very often been released into the wild by gamekeepers and hunters at numerous sites, although this measure only slightly influences the size of the nesting population. Most ducks of this origin are not able to survive for a long period in the wild since they cannot take shelter from predators.

Erection of nest-boxes (NB)
The installation of suitable wooden nest-boxes was a key positive factor in the establishment and following increase of a population of goldeneye in the Třeboň area from the 1960s to

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the 1980s. In the 1980s, these artificial nesting hollows have had to be erected at sites totally surrounded by water since those installed on trees suffered from heavy predation from pine martens.

Although similar nest-boxes were installed for the mallard at various sites, a significant effect on nesting populations of this game species has not yet been confirmed.

High predation pressure by pine martens (PRED)

The growth of the goldeneye population breeding in the Třeboň PLA and BR in nest-boxes brought about food specialisation for pine martens. Since the predation ratio on nests of the duck species in relatively vulnerable nest-boxes erected on trees, especially on the pond dikes, was really very high, the boxes have been installed at sites totally surrounded by water during the last decade.

Regulation of bird reproduction success (REG)

Since 1988, reproduction output has been controlled only for the cormorant which is considered to be the most important bird species causing damage to fish-farming.

1.7.4. Key factors influencing fishpond ecosystems – appraisal of effects on waterfowl

The key factor influencing both numbers and species composition of bird communities on fishponds in the Třeboň area is fishpond management, which includes both density, age and species composition of fish stocks, and the technical measures deployed on these artificial water reservoirs. In an effort to maximise profits, the whole area of each fishpond is utilised for fish-farming. Therefore pond mud and vegetation, including reeds, is excavated. The mud removal is usually accomplished with bulldozers and the mud from the pond beds is placed in very high mounds with sheer sides or on artificial islets or peninsulas. In addition, changes in agricultural techniques on farmland in the vicinity of fishponds, succession, changes in littoral growths and some locally significant human activities (e.g. hunting, recreation and tourism) should be mentioned as significant from this point of view.

The density of fish stocks is a factor which has a crucial influence on the whole fishpond system and especially the waterfowl, or at least on their chicks which feed on water invertebrates. Since the density of fish stock in ponds has increased since the 1970s (see Table 11, page 22), food resources (large zooplankton and bottom-dwelling, free-swimming and littoral fauna) have dramatically declined because of predation by carp or as a result of low water transparency.

The most sharply pronounced decline in waterfowl numbers has been the 30%–70% decline in ducks, reported from the Třeboň PLA and BR in the late 1970s and the early 1980s. As a result of this, some local organisations of gamekeepers and hunters started to raise mallard in captivity and then to release them onto some fishponds in the wild. For this purpose, some fenced rearing facilities were built where ducks were additionally fed by

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humans and only released onto fishponds during the summer. There are various negative effects of this measure – a part of the shoreline is destroyed, the biota being permanently disturbed. In addition, native gene resources of the original autochthonous mallards can be genetically polluted by hybridisation with the individuals which originated from hybrids between the mallard and domestic duck.

The decline in numbers coincided with the most intensive period of fish-farming in the area (the increasing use of fertilisers, the run-off from agricultural lands and the decrease in absorption, and in soil capacity). At the end of the 1980s and in the 1990s the general decline in waterfowl numbers in the Třeboň area came to a halt and the abundance of individual populations stabilised although at much lower densities than in the early 1970s.

The relationship between the density (or biomass) of fish stocks and numbers of ducks and coot on fishponds was confirmed using data from about 200 South Bohemian fishponds collected in the early 1990s (Pykal 1995, Pykal and Janda 1994). The higher the fish biomass was in the fishpond, the lower the density of diving ducks of the genus *Aythya* was in July. The dense stock of carp causes extremely high pressure on available food (large zooplankton, bottom-dwelling and littoral fauna).

When comparing fishponds with various age classes of the carp, a significantly higher density of ducks in the breeding season was found on the fishponds where one-year old carp were released or on fry ponds in which the biomass is low in the spring, allowing a rich development of ducks feeding on natural food.

An even more pronounced preference for fry ponds was found in some waterfowl broods, since their chicks almost exclusively prefer animal food and are negatively affected by competition for food from dense fish stocks. These waterfowl species include pochard *Aythya ferina*, tufted duck and goldeneye. On the other hand, the highest density of the fish-eating great crested grebe broods was reported from fishponds with one-year old carp.

Predation pressure of fish stock not only reduces food resources in individual fishponds but also affects some parameters of the water environment, such as transparency. Breeding diving ducks generally prefer fishponds with a high water transparency. For the great crested grebe, however, the highest density of broods was found on fishponds with a low water transparency, since one-year old carp dominate there.

Therefore, one possibility for improving conditions for breeding waterfowl on fishponds in Nature Reserves and other specially protected areas is to manipulate fish stock. Average seasonal fish biomass in ponds should be lower than 400kg per ha. The highest numbers of breeding waterfowl were found on fishponds with mixed fish stock without carp (i.e. with tench, small cyprinid fishes and pike), where the mass of fish is low (about 50kg per ha in the first year of the cycle) and the feeding pressure of fish is consequently low. This system of fishpond management is highly recommended.

In the autumn a high proportion of mallard and greylag goose populations is present in South Bohemian fishpond reserves (usually more than 80% of all individuals) and on the

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most extensive fishponds where hunting is more difficult. These species forage on fields in the vicinity of fishponds, and only roost on the ponds during daytime. The most important aim in this period is to restrict disturbance at the site, and especially to prevent shooting.

1.8. Proposed guidelines for wise management of the Třeboň area fishponds

Fishpond systems in the Třeboň basin are unique systems of man-made water reservoirs which have become integrated components of the landscape. Wise management is necessary for their further existence. Fish farming and fish culture is the priority use, and the Třeboň Fishery joint stock company aims at economically profitable fish production. Nevertheless, the importance of the Třeboň fishponds should be appraised with more general approaches and in broader terms. The fishpond systems crucially determine hydrological patterns of the surface waters in the Třeboň basin and significantly contribute to the local climatic conditions. In the landscape, the fishponds provide a rich mosaic of habitats and types of the environment for a wide range of plant and animal species whose communities have preserved to a large extent their relatively natural features. The maintenance of their multi-purpose function with respect to conservation of some natural values as well as to landscape stability is undoubtedly a very important social and economic goal (Plesník *et al.* 1995). Because the town of Třeboň is an important recreation and spa centre it is important to keep in mind aesthetic and recreational values. This can only be achieved by seeking some kind of compromise which respects specific conditions at each site.

The necessary precondition for achieving such compromises is a more general approach, which includes the effort to find appropriate solutions over a more extensive area, i.e. at more sites. It is clearly evident that every fishpond, however extensive, cannot be used for water management purposes, for recreation and leisure time and, at the same time, for intensive fish-farming operations.

Secondly, when assessing economic aims, nature conservation interests and the recreational capacity of fishponds, the assessment should be aimed at maintaining the "healthy functioning" of the fishpond ecosystems. Obviously, this requirement must go further than simply the achievement of some levels in water quality, or the occurrence of some target plant and animal species.

1.8.1. Recommendations

General recommendations

Obviously, the Třeboň basin fishponds cannot be returned to their original state with almost oligotrophic conditions. At the same time it is unacceptable to increase the trophic level in the future. Water quality deterioration resulting from continuous eutrophication will be a limiting factor in fish-farming in the very near future.

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Therefore, at present fish-farming practices cannot be substantially changed since they are determined by a long-term tendency for intensifying fish-farming, and by more recent economic conditions during the transition period. However, some measures to improve the present state and simultaneously allow for more effective fish-farming can be found.

A decrease in the total amount of fertilisers is considered to be a key measure:

- Application of fertilisers should be controlled on the basis of nutrient conditions in a fishpond. The fertiliser load should be more evenly distributed throughout the season. The spring food provision, i.e. the application of huge single loads in fishponds, should be reduced. In addition, natural production differences among individual localities should be respected.
- Similarly, liming of fishponds should be gradually reduced and stabilised at the level which is necessary for covering losses.
- Application of fertilisers and liming should not be carried out at important littoral sites.
- The trophic level and effective application of nutrients should be controlled by the size of the introduced fish stock to achieve medium-sized zooplankton and water transparency ranging between 40 and 60cm. With respect to the type of fishpond or the course of the season, either water level management or feeding (to control predation of fish on zooplankton) could be introduced where necessary.
- At many sites, sediments from the fishpond bottoms should be removed: in some cases, degraded muddy littoral vegetation can also be excavated. In addition to a reduction in the level of nutrients in a fishpond, botulism sources may be eliminated. Nevertheless, mud removal needs environmentally sensitive technology. During these measures, the importance of reedbeds should be respected and sediments should be placed outside the fishpond area.
- In individual fishpond systems, management schemes allowing the establishment of a broader range of environmental conditions (e.g. water transparency, size of zooplankton) should also be introduced.

Recommendations for macrophytic conservation in particular types of fishponds

1. Fishponds classed as gene pool reserves.
   1a. Fishponds of intermediate size, with a complete representation of successional stages, developed in zones according to water depth.
   1b. Large fishponds of lake type, where vegetation has developed in the form of patches (colonies) and there is sufficient open water for the development of pelagic communities (microcoenoses).

The conservation regime should exclude the disposal of sewage, manuring along shores, and liming. Specific management is needed to maintain the macrophyte stands.

2. Fishponds of small to intermediate size with a developed profile of peat (fen) along the shores, found especially in the south western part of the Třeboň Basin. These fishponds

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require a complete protection of the littoral zone, with the exclusion of dredging, liming, duck farms and other forms of intensive management.

3. Fishponds of small to intermediate size, with protection required for particular plant communities. Partial changes in management should be made while the fishpond continues to be used for other purposes.

In fishponds where the complex of plant communities is largely destroyed management should aim at the regeneration of littoral plant communities.

Protection of littoral communities is closely related to the problem of mud mounds which have been created in the last decades. Therefore, improving the old mud deposits, especially removing undesirable trees and ruderal vegetation, is highly recommended. Similarly, external edges of littoral growths should be managed. Marginal parts of fishponds separated by the deposits should be considered as potential refuges for wetland communities which have disappeared from these habitats.

Where suitable and appropriate, fishponds may be used for cultivation of selected types of utility plants (*Acorus calamus, Caltha palustris, Phragmites communis* etc.), which occur in fishpond habitats of the area.

Recommendations from the viewpoint of bird population management

With respect to water and wetland birds a management plan for the Třeboňsko PLA and BR should include these measures:

- To decrease fish stock density in some selected fishponds (at least in Specially Protected Areas, i.e. in small-size protected areas). The effort should aim at supporting the development of natural food (large zooplankton, bottom-dwelling and littoral fauna). Consequently, water transparency will be improved and development of submerged vegetation will be encouraged. The latter is a suitable habitat for many invertebrate species. At the same time, littoral growths will be restored so nest-site availability for some bird species will be improved.
- Nutrient inputs to some selected fishponds should also be decreased or effectively controlled by stopping pond liming, fertilisation and application of manure in these fishponds. At some sites catchment areas should be sensitively restored and revitalised.
- Reedbeds should be periodically cut (in a 10-year cycle) to stop undesirable succession changes in these growths, e.g. terrestrialisation and overgrowth by trees. As with the above-mentioned steps, this measure should also be carried out only at selected sites.
- At sites where suitable conditions for breeding grassland waders (Charadriiformes) have been preserved, the original shoreline as a gradual zone should be restored. This can be done by cutting trees on the periphery of the littoral stands, depositing mud that has been removed outside the fishpond area and forming a gradually sloped shoreline.

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- Both duck-farming and releasing of mallard bred in captivity should be strictly prohibited on selected valuable fishponds.
- A network of refuges for ducks Anatinae and geese Anserinae should be created. It should include fishponds where waterfowl are not hunted. These water reservoirs have to be extensive enough since they will play a significant role as gathering sites for the above-mentioned birds; an area of at least 100ha is recommended. Islets or shallow waters will support roosting birds during the daytime, improving their role as shelters against potential predators.

1.9. Conclusions

The present state of fishponds in the Třeboňsko PLA and BR has resulted from long-term fish-farming management as well as from agricultural production in the vicinity. Both approaches have tried to maximalise profits for a long time. That is why we are seeking to understand natural processes in the new situation in which the fishponds now exist.

Proposals described in this chapter are based on our knowledge of what has happened in fish-farming and what the consequences have been. Many arguments indicate that the capacity of regeneration in the fishpond ecosystems is still high. However, there is a total lack of well-researched examples, i.e. long-term complex experiments examining what happens with a lower application of nutrients and contaminants. More detailed economic appraisal of these operations has to be included into such a study.

These problems should be studied in the near future:

- Contamination of bottom sediments in the fishponds by heavy metals and organic compounds (PCBs, PAUs etc.), especially sediments in the Rožmberk fishpond.
- Influence of draining a fishpond before the fish-harvest on water quality in streams and their total contamination.
- Experimental evidence for the influence of the reduction of pond fertilisation on fish stock and consequently, on the main parameters of water quality. The research should also include monitoring of dissolving of nutrients from sediments in a water reservoir. The consequences should be appraised from the environmental and economic viewpoint.
- Key parameters should be monitored (Janda and Květ 1993, Janda *et al.* 1994, Pechar 1995). These include water quality, status of important communities at key sites such as Specially Protected Areas or heavy polluted localities.

As outputs of the monitoring and research, real limits for assessment of the trophic state of a fishpond with respect to the biota, adapted to nature conservation aims, should be proposed. The results should be a good basis for changes in legislation which should take account of the current situation, i.e. nutrient level and the above-mentioned limits.

Features of the Třeboň area landscape were substantially modified by humans even in the Middle Ages. New landscape elements have been formed for centuries and the balance

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and stability of the man-made landscape has been developed. When assessing all human activities in the unique Třeboň area both biodiversity and stability should be kept in mind.

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2. Hungary

2.1. The present status of commercial fishponds in Hungary

2.1.1. History and traditions of fish farming

Fisheries have been of great significance in Hungary since the Conquest in 896. Despite this, fish farming became a common activity only at the beginning of the 20th century, when it was already well-known in other parts of Europe.

About one quarter of the country was temporarily or permanently flooded before the river regulation and drainage works of the mid-nineteenth century. Fishponds created naturally or artificially from oxbow lakes were an important element of traditional floodplain farming and contributed to the systematic and manifold utilisation of soil, water, even floods.

The basis of traditional water management was the maintenance of so-called 'eyes' together with the runlets and channel systems connected to them (see Map 1). When the rivers flooded, low-lying areas next to the main river channels would fill with water, which would then drain back into the main channel through narrow ditches or runlets. 'Eyes' were gates or sluices inserted into the runlets to hold the flood water back. As the waters began to recede after flooding the eyes were dammed by barrages, creating ponds from which fish could be harvested, or by nets which caught bigger fishes and released smaller ones – prey for future years – into the main river channel.

Fish farming using eyes developed from various local forms of ancient moor fishing, which involved blocking the smaller channels to catch fish as they passed through. Eye fishing became the most important part of traditional floodplain farming. The only management tasks were the regular filling and draining of oxbows and other water bodies along rivers – these waters are the best spawning and fishing areas. The right to establish an eye fishery together with the property rights to the land used for this purpose was endowed in the same way as, for example, 'mill-places' had been (Károlyi and Nemes 1975).

Traditional eye fishing prospered between the ninth and sixteenth centuries, and was then replaced by more primitive types of fishing (e.g. loaching) as a result of Turkish rule. Fishponds were actually built later in the Middle Ages for supplying monasteries and the royal court of Hungary, but sophisticated fish farming methods were unknown at that time. A memorial, more interesting than characteristic, of that era is the Öreg-tó at Tata, which is a Ramsar site today.

The river regulation and flood protection works of the nineteenth century initiated by industrial development and capitalist land use significantly decreased the importance of fishing in natural waters. Rivers that were canalised had a higher discharge and fewer

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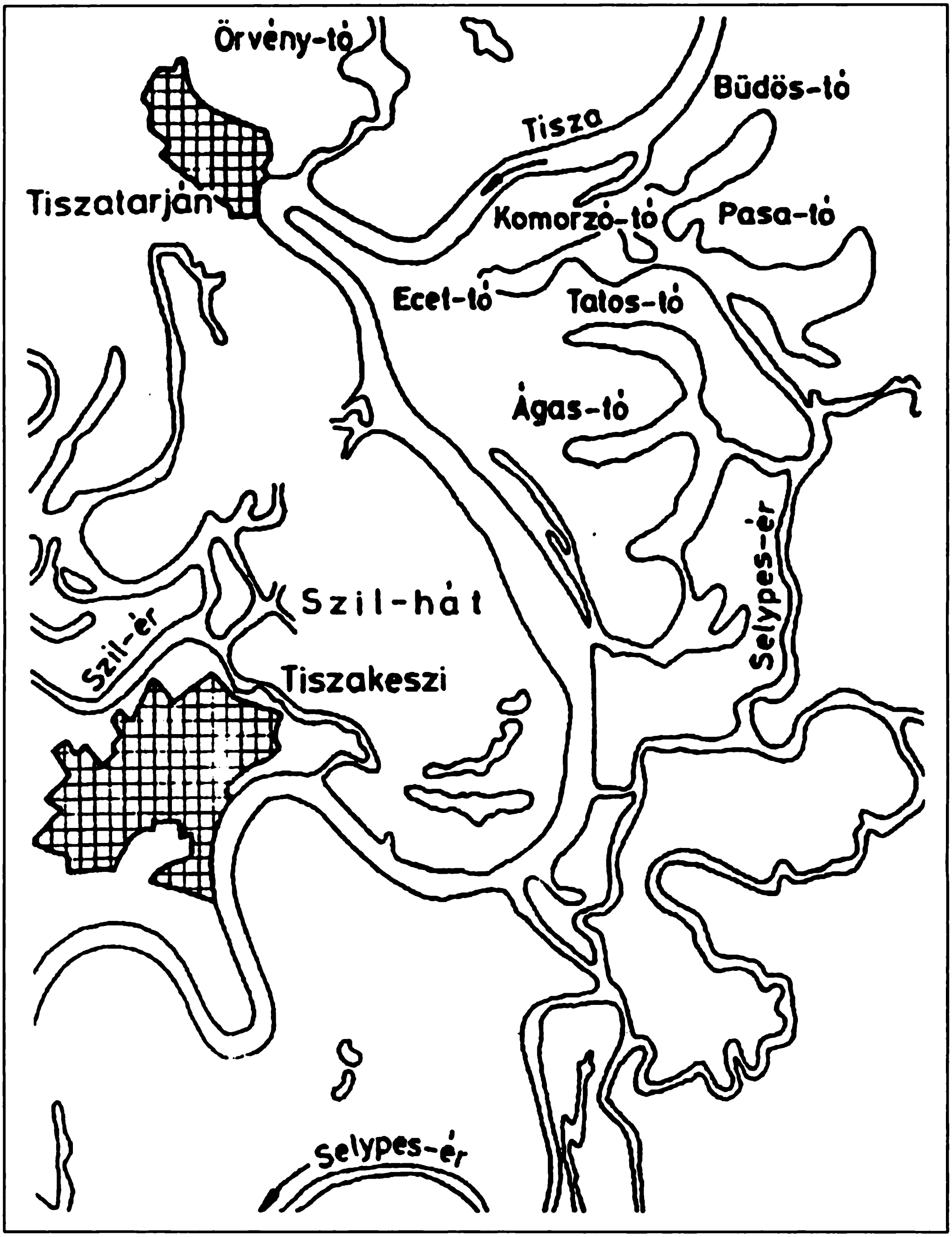
Map 1. Flood plains of the Middle Tisza area, showing inhabited areas (cross-hatched), fish-ponds and other water bodies



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areas suitable for spawning (that is, shallow and easily warmed water bodies and wetlands), and fish species lost their former habitats. The mythical fish abundance of the past decreased to a hundredth of its former status. The famous Hungarian polymath Ottó Herman recommended the establishment of fishpond systems to compensate for this decrease in fish stock at the end of last century.

The artificial fish hatchery techniques, based mainly on the experiences and partly on the cultivated varieties of Bohemian and Moravian fishponds, only became common among Hungarian fish farmers at the beginning of this century. (The first improved carp were imported to Hungary by Ferenc Walasek, who ordered breeding stock from Třeboň.) Later some local varieties were selected in some fish farming areas.

The first period of fishpond building was from the turn of the century up to the second world war. The most important fishpond systems – such as the Hortobágy Great Fishpond, the Biharugra pond system, a part of the Fehér-tó at Szeged, as well as many of the barrage-dammed fishponds of the Transdanubia – were created at that time. It was primarily the great estate owners, church estates, groups of capitalists (in the case of Biharugra), or rich country towns of the Great Plain (Szeged, Debrecen) that established fishponds, so fish farming on fishponds may be considered a capitalistic agricultural activity. The great producers founded a common market within the framework of the Hungarian Fish Farms Co. in the twenties. This Corporation had an extended trade network, wagon park for rail transport and fish stocking capacity.

The creation of fishponds gathered new impetus with the establishment of large-scale agriculture after the Second World War. An extremely high increase in pond surface area was observed in the fifties. Their area covered more than 26,000ha in the late 1980s, after which no significant increase took place, due to the restrictive economic policy rather than because of a lack of suitable areas.

2.1.2. Economic importance of commercial fishpond operations

Fisheries are a small but specialist sector of agriculture. About 3,000 people, 0.54% of all agricultural employees, make their living from it. The value of the fish yield is about US$23 million per year, contributing about 2% to the total agricultural production. The economic importance of fisheries is not the absolute value of their gross income but the fact that they very effectively utilise areas with no other agricultural potential (i.e. they have relatively low input needs).

There are about 140,000ha of natural waters and 27,100ha of fishponds that provide areas for fish farming in Hungary. Fishponds cover only 0.3% of the total land, while water surfaces useful for fishery cover 1.4%.

About 30% of the total fish yield comes from natural lakes and about 3% from rivers. The remaining 67% comes from fish farms, which are mass producers able to supply fish in autumn and winter. Fresh fish from late spring to autumn come from natural waters.

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There has been a gradual increase in angling: for example 24% of all fishes of market size came from this source in 1992 (Váradi and Jeney 1993).

Fish production has been between 20,000 and 30,000 tonnes annually since the mid-1960s. Area expansion in the 1950s and intensification, together with the introduction of polycultural fish farming (i.e. using several fish species to make efficient use of food resources) between the 1960s and 1980s, resulted in a slight increase in fishpond yields. A short period of stagnation followed by a sharp decline due to the failing economy occurred after the mid-1980s.

Fish farming serves both internal supply and export in Hungary. Fish consumption is low, almost the lowest in Europe: 2–2.5kg per year per capita. Although this figure for fish consumption is roughly equivalent to the annual fish production total of 30,000 tonnes, several factors force the fishpond management to export fish.

One of these factors is that seasonal internal demand is at its highest for religious feast days (Christmas and Easter), while the autumn production peak is usually higher than the market demand. Unfortunately the stocking capacities of fish farms are restricted. Another factor is that Hungarian consumers do not prefer the plant-eating species of the Far East which are inevitably important in polycultural communities. There is a high level of competition in fish importing. Fish production is more expensive in Hungary than in its neighbouring countries (Czech Republic, Slovak Republic, Croatia, Romania) because of the higher social costs, higher taxation and higher costs of resources (water, land, energy, food, chemicals). About 2,000 tonnes of fish (carp primarily) were imported from these countries in 1992, which equals the yield of about 1,000–3,000ha of fishponds of Hungary.

Sea fish – pre-processed or not – also competes with fish farm production. It is easy to prepare sea fish for the table, and usually cheaper than carp, so people are happy to buy sea fish.

The main export products are carp and predatory species. The main market is west Europe, and in particular Germany, which is the main market for Czech and Croatian fish as well. Competition is increasing; for example the members of the Association of Fish Producers exported 75% less carp in 1992 than in 1991. The cheap plant-eating fishes were exported to the Near and Middle East, primarily to Iraq, but these countries are no longer able to afford such imports.

In spite of market difficulties, fish could be profitable because of the low input requirements during production. Maintaining or even developing fish production in fishponds is important for the national economy in a country which needs to increase its foreign currency income.

2.1.3. Ownership

Decisive changes have happened in the past decade concerning ownership of fishponds (Table 1). In 1984, State farms had management rights over 65% of fish farms, agricultural

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Table 1. Proprietorship of Hungarian fishponds in 1984 and 1994 (data of the Ministry of Agriculture)

	1984	1994
state farms	15,908ha	3,000ha
agricultural cooperatives	4,382ha	4,000ha
fishery cooperatives	2,589ha	2,000ha
National Angling Society	300ha	1,000ha
private fisheries	–	9,700ha
nature conservation NGOs	–	2,500ha
nature conservation authorities	–	800ha
total	**23,179ha**	**23,000ha**

cooperatives over about 20%, fishery cooperatives 10%, and the remaining area belonged to the National Angling Society of Hungary. In 1994, 13,000 of the total 23,000ha of active fishponds were managed by private producers or producer companies. State ownership decreased to 13%, while agricultural cooperatives remained at 20% (although this latter figure includes a significant uncertainty owing to the land re-privatisation processes*).

Re-privatisation of fishponds began in the 1980s, in order to create more favourable incentives and to transfer the risk of production leasing and management to self-regulatory units independent of state farms and cooperatives.

2.1.4. Factors affecting the profitability of fish production

The factors affecting productivity of fish farming are manifold, and they vary according to specific fish farms (Figure 1 and Table 2). Nevertheless, some general statements regarding the future of this sector can be formulated.

One of the most serious problems on the input side (expenditure) is water resources. Costs and resource use contributions for water have increased tenfold since the end of the 1980s and are particularly high in fishpond systems which require a significant amount of pumping. These costs now endanger the existence of fish farms.

On top of the water cost, there has been a long-lasting drought in Hungary for more than ten years now. There is no natural inflow, and water recycled over years is high in

* Data refer only to property rights and not to land use, since the majority of state-owned fishponds are managed by leaseholders.

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pollutants. The purpose of the 1 HUF/m^3 (in 1993) and the 0.5 HUF/m^3 (in 1994) additional water fee support from the Ministry of Agriculture was to help fish farmers in this transition period.

Increasing fertiliser and foodstuff prices have led towards the evolution of new technologies and a corresponding decrease in the quantity used in fishponds (Figure 2).

Changing property relations have also contributed to increasing fish food prices. Before the political changes, fish farms were usually part of a major economic unit (e.g. state farm or agricultural concern), and thus could buy feed at cost price. Fish farms have become independent after re-privatisation and lost areas of croplands for fish food at the same time. For example, in the case of Biharugra – one of the largest fishpond systems in

Figure 1. Economic costs and benefits for Hungarian fishponds

Costs

fish stock
water
fishfood
fertiliser
manpower
tools and machines
reconstruction

Benefits

fish yield
secondary activities:
reed cutting
hunting
ecotourism
angling
etc.

Table 2. Fish productivity in different types of fishponds (Ruttkay 1992)

production intensity	productivity (tonnes/hectares/year)
natural	0.02–0.03
intensive fishponds	1.0–3.0
very intensive waters	10–30
semi-industrial 'lakes'	100–300

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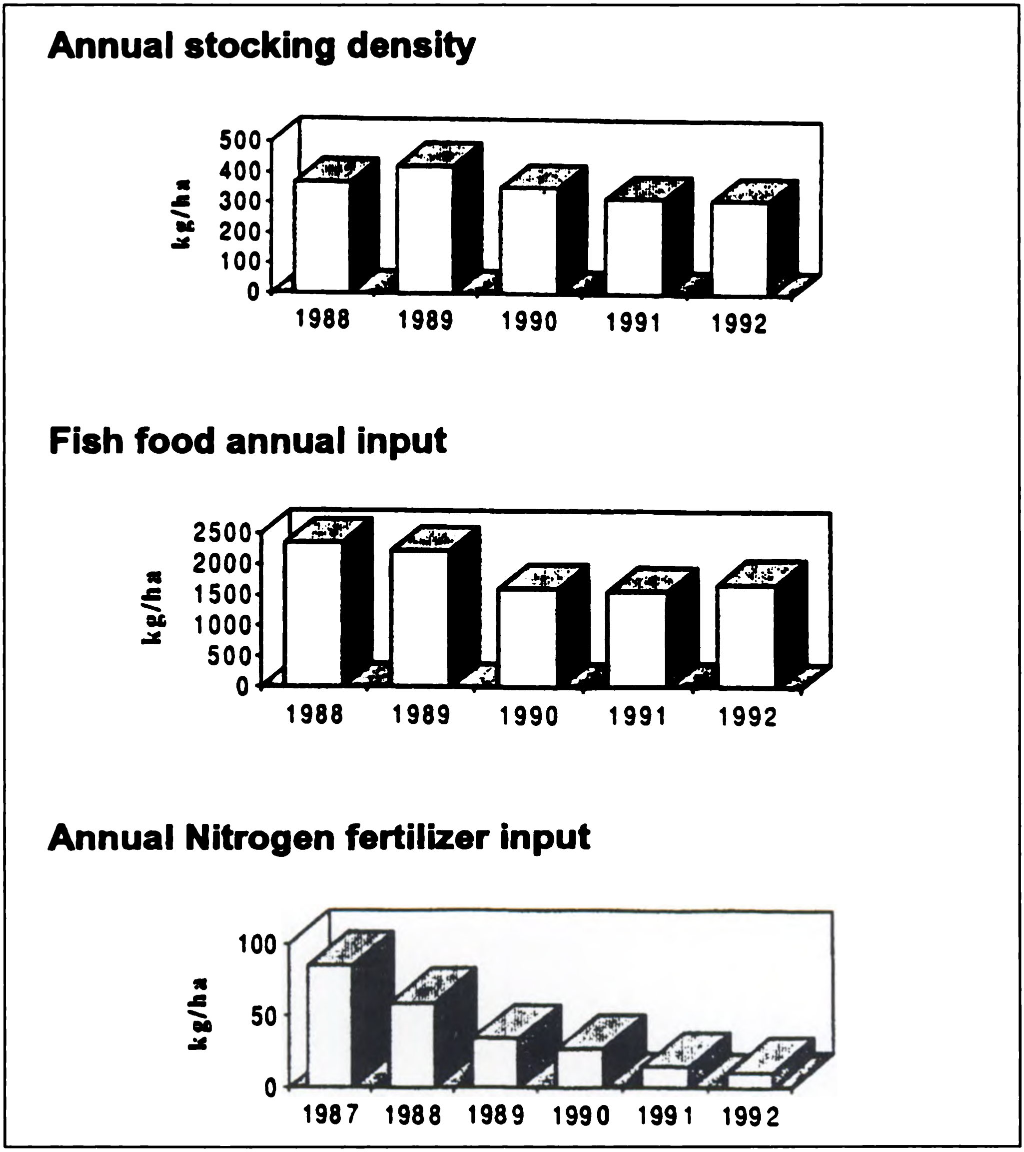
the country – this has meant that instead of the 1,000ha land needed for fish food production, the new owners were offered only 520ha tenure at the beginning of privatisation, and after satisfying all local citizens' compensation entitlements, the fish farm was left with only 280ha of arable land.

Figure 2. Stocking density and inputs for the Association of Fish Producers during 1988–1992 (after Váradi and Jeney 1993)



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Another negative effect of the economy is that new owners are having difficulties repaying the loans they got for buying their ponds, consequently the disinvestment from the sector is continuous. Today even the price of breeding stock is more than owners can afford. Not surprisingly natural spawning in fishponds has become more frequent. The status of highly developed farms is also worsening because of decreasing fish demand. Spawning in ponds counteracts the nature conservation interest of protecting breeding birds on lakes, and also increases damage to fish stocks caused by birds.

The profits produced by fish farms (with inflation rising from 15% to 30% a year) is only enough to ensure the following year's fish production but not enough for renewing ponds, maintaining infrastructures or building new ponds. Production conditions are worsening: fish harvesting is more expensive and productivity is decreasing because of erosion of dams and a higher rate of leakages (due to the lack of upkeep).

All the circumstances described above contribute to lowering the income capacity of fishpond economies and the year-to-year decrease in fishpond area.

2.2. Characteristics of artificial fishponds

2.2.1. Abiotic features

There are 277 fishpond systems in Hungary according to the water management registers (Table 3). Artificial fishponds were built mainly in the lowland and hilly regions of the country, the most numerous in Somogy and Baranya counties. There are less ponds on the plains (e.g. in Hajdú-Bihar, Jász-Nagykun-Szolnok, Békés, Csongrád and Fejér counties) but their surface area is much larger.

Hungarian fishponds are generally 10–100ha in area. Only ten fishpond systems are larger than 500ha, those of Rétszilas, Biharugra, Begécs, Virágoskút, Elep, Csécs,

Table 3. Number and total area of licensed fishponds classed by size (data from Water Management Directorates)

size (hectares)	number	total area (hectares)
0–10	41	175.7
10–100	156	6,090.4
100–500	70	14,028.5
500–1,000	5	3,105.0
>1,000	5	6,738.0
total	**277**	**30,137.6**

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Hortobágy-Nagy Halastó, Csaj, Szeged-Fertő and Szeged-Fehértó. All of these are situated in the Great Plain.

Two main types of fishponds exist in Hungary:

- Fishponds with circular embankments (diked ponds); these are more typical on the plains in the vicinity of larger rivers or channels.
- Barrage-dammed fishpond systems; these are usually smaller and are more widespread in hilly areas (mainly in the counties of Somogy, Tolna, Baranya and Veszprém).

Sometimes oxbow lakes are also used for fish production, but these are of low importance, and a detailed description will only be given of the two main types.

Diked fishponds of the plains

Artificial fishponds with circular embankments are typical for plains areas not suitable for arable land – often on places of former marshes, alkaline lakes or dry grasslands. Areas which previously grew rice but were of low productivity were transformed into fishponds in several cases (e.g. Tamáshát fishpond at Kőtelek). Diked fishponds usually have a lower fish yield than the barrage-dammed ponds of Dunántúl region because of disadvantageous environmental circumstances (e.g. unfavourable soil conditions).

The fishpond dikes rise above the surrounding land, and usually their water level is higher than the ground level. In order to stop surrounding areas from becoming water-logged the fishponds are ringed by seepage canals.

Since constructed fishponds with circular embankments are not faced with relief constraints, they are usually greater in surface area than barrage-dammed ponds. Mechanisation can be significant in these extended fishponds, and local narrow-gauge railway or common outside-dike fishbed systems were introduced in many places.

Barrage-dammed fishponds of the hilly areas

The majority of Hungarian fishponds are barrage-dammed reservoirs on larger or smaller rivers or creeks. As they were formed by damming valleys, their shape and size depend on relief features.

In the simplest case, the valley sides are the lake shore, thus the inflowing water fills the parts of the pond-system one after another and fish are harvested from the lowest pond first, and upstream afterwards. To mitigate restricted management possibilities of this type of fishpond, so called longitudinal dammed pond systems are constructed. Incoming water flows into an outside supply channel at the side of the ponds and fills the ponds through short connecting channels.

Water bodies are filled by gravity in any type of barrage-dammed fishpond, consequently all technological steps of management (filling up, supplementing during summer and draining) are determined by discharge which depends on climatic and relief conditions. Management technologies have to be adapted to the precipitation predicted for the total catchment area which limits the water available for filling the ponds.

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The long term survival of fishponds in hilly areas is seriously jeopardised by changing climatic conditions (longer dry periods and less precipitation). This process may destroy pond or wetland habitats as, for example, Hajmáslap-pond of Boronka Protected Landscape Area of Somogy county, where the pond could not be filled for four years because of the low discharge.

The chance of chemical pollution (fertiliser and other uses in the catchment area) causing eutrophication and sedimentation is also higher in barrage-dammed ponds than in artificial ponds of plains areas. This conflict may be solved by a higher level of acknowledgement of, and support for, environmentally friendly agriculture and by restricting industrial and communal activities near the inflowing waters.

2.2.2. Cultivated fish species

Conditions in Hungarian fishponds make it possible to produce only certain fish species. Polycultural production dominated by carp *Cyprinus carpio* is the most typical production method in Hungary. The main stages of commercial carp production are:

- spawning and raising offspring in the first year
- production of young in the second year
- sale of fish to the market with a mean weight of 1.5kg in the third year.

This fish production period can be reduced to 2–2.5 years with more intensive offspring raising and feeding.

Thus fish production is based on carp breeding in Hungary, with this species providing more than 70% of the yield in fisheries in 1992 (Figure 3). The most important food types for carp are crustaceans *Malacostraca*, worms living in the mud and insect larvae living on vegetation.

Other important species of polycultural production are herbivorous fish species of Far Eastern origin, such as silver carp *Hypophthalmichthys molitrix*, bighead carp *Aristichthys nobilis* and grass carp *Ctenopharyngodon idella*. In Hungary polycultural production is a widespread method, and thus herbivorous fish species represent the second largest part of fish production beyond carp. The role of silver and bighead carp is to filter out food from the plankton while grass carp feed on plants found on the pondbed and shores. By fertilising ponds and populating them with silver carp, fish production can be greatly increased. These species introduced into Hungarian waters 30 years ago have populated almost all natural and artificial waters, causing serious problems to their food webs.

On certain ponds with deep mud and dense reed-grasses the breeding of tench *Tinca tinca* can play an important role in the production of predatory fish species.

For more effective utilisation of the food supply in fishponds (such as 'rubbish' fishes, insect larvae and tadpoles) the breeding of predatory species such as catfish *Silurus glanis* and pike perch *Stizostedion lucioperca* can play a role in polycultural production.

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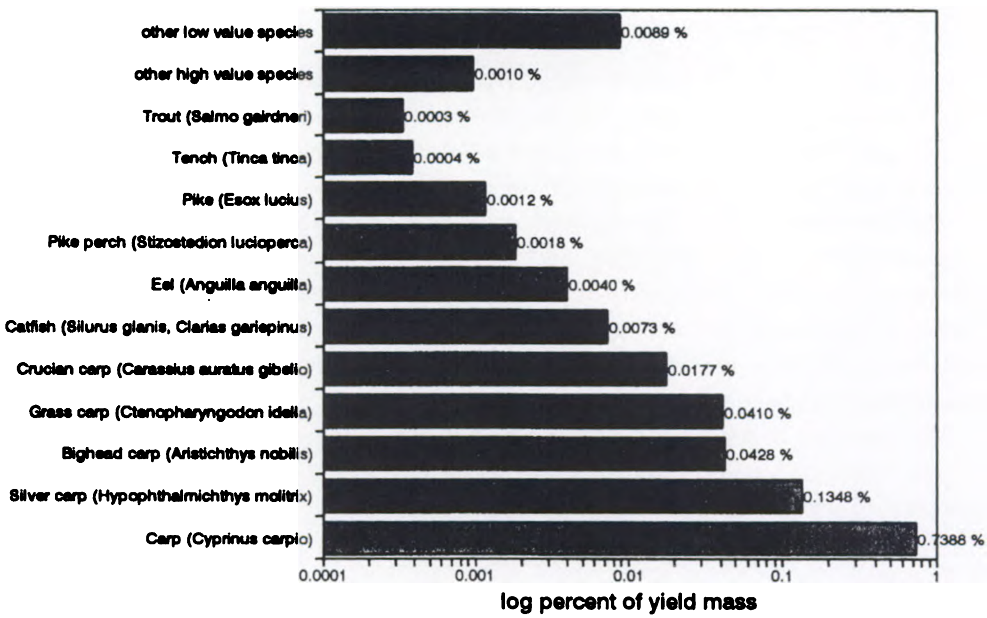
Figure 3. Yield of fish species based on catching data for Hungarian fishponds in 1992 (after Váradi and Jeney 1993)



Breeding trout *Salmo* spp., which live in cold and clean brooks, are restricted to only a few places in Hungary. Trout production is far below market demand.

2.3. Nature conservation importance of fishponds

In Hungary the basic nature conservation importance of fishponds is that they provide habitats for species that are wetland or water related. These species are endangered all over the world and especially in Hungary because of the large-scale decrease in all kinds of wetland areas (temporary flooded areas, marshes, open water tables etc.) caused by human and natural factors. Habitat dependence of aquatic creatures is much stronger than that of terrestrial ones. Thus the species composition of fishponds and their immediate surroundings differs to a large extent from that of the surrounding areas, and includes many specialist species.

Species composition and species richness of fishponds is essentially determined by the trophic level of ponds and the regular ecological perturbation (draining, filling up) according to the type of management. Consequently their flora and fauna fluctuate greatly

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and have no relict values. At the same time their outstanding characteristics are species richness and the abundance of certain species of nature conservation value.

2.3.1. Botanical values

In fishponds, because of the regular and sudden ecological changes only plant communities of low level stability can develop. The life of plant species is largely dependent on applied technologies, introduced fish species and intensity of pond mowing. In spite of this, valuable plant communities and species can survive on fishponds and their surroundings.

As in any other aquatic plant community, succession of particular zone communities is characteristic. Their complexity and stability depend considerably on the natural characteristics of the pond, quality of water, introduced fish species and age of pond. First of all reed-grass and reed communities should be mentioned. Terrestrial vegetation is much more affected by human activities (mowing, treading, plantation etc.), thus its classification and connection to fishponds is more difficult.

As a function of local characteristics of soil, water supply and phytogeographically different types of forests (mainly willow, aspen or alder plantations), wet meadows or even alkaline grasses are also related to fishponds.

Plant communities

a) Reed-grass communities

The opportunities for developing reed-grass communities are restricted because of fishpond management activities. In fishponds populated by *Cyprinus carpio* considerable reed-grass cannot develop because carp limit its establishment by foraging. Also, fish-farmers try to restrict reed-grass because it fixes many nutrients in its biomass and reduces space for fish. Moreover, because of overshadowing, floating reed-grasses limit photosynthesis on the area below. However thin reed-grass communities do develop sometimes on certain fishponds. These are mostly natural communities and ought to be protected.

b) Reeds

Almost all fishponds except newly-constructed ones have natural reed (*Phragmites*) associations. The area of reeds extends as the ponds age. Keeping a lake-basin dry or water level low and giving up fish management often results in a reedy lake-basin.

Flora

Usually weeds adapt the best to the rapidly changing circumstances in fishponds. Consequently they are the characteristic species of dams and pond beds. However some protected plant species or species listed in the Hungarian Red Data Book and the IUCN European Red List occur on the Hungarian fishponds (Table 4). Among these *Nymphoides peltata* and saligot or water-chestnut *Trapa natans* can be quite abundant in some places.

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Table 4. Botanical values of Hungarian fishponds (a: communities, b: species)

a. Plant communities of fishponds and their nature conservation value (after Simon 1992)

Lemno-Utricularietum	N
Salvinio-Spirodeletum	V
Hydrochari-Stratiotetum	N
Hottonietum palustris	V
Elodeetum	A
Myriophyllo-Potamogetonetum	N
Potomogetum natantis	N
Nymphaeetum albo-luteae	N
Nymphoidetum peltatae	V
Trapetum natantis	R
Scirpo-Phragmitetum	V
Bolboschoenetum maritimi	N
Caricetum acutiformis-ripariae	N

R: relict community
V: community of high value, protected or to be protected
N: natural or semi-natural community
A: communities dominated by adventive species

b. Protected and endangered plant species of fishponds

Hottonia palustris
Marsilea quadrifolia
Salvinia natans
Trapa natans
Lindernia procumbens
Armocaria macrocarpa
Nymphoides peltata
Nymphaea alba
Nymphaea lutea

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2.3.2. Zoological values

Invertebrates

Assessing the richness of invertebrate species in fishponds is difficult because of a lack c relevant studies. Studies carried out on Petesmalmi fishpond near Lábod village, Somog county, showed the presence of 34 dragonfly species, a considerable number on a nationa level. Reeds provide good habitat for several Lepidoptera species, too. In the future mor detailed studies on invertebrate fauna of fishponds need to be carried out.

Fishes

The primary purpose of fishponds is to provide good conditions for cultivated fis species. Fishponds with continuously changing conditions do not provide optimal habita for protected or endangered fish species; however, these species can occasionally fin their way into certain ponds through supply streams.

In older fishponds on the Great Plain (Hortobágy, Biharugra), where there are regularl water surfaces that cannot be drained, *Misgurnus fossilis* and even *Umbra crameri* ofte occur in great numbers.

Amphibians and reptiles

Fishponds provide good habitat for amphibians and reptiles. The following species ar found in almost every pond: grass snake *Natrix natrix*, marsh frog *Rana ridibunda*, poc frog *R. lessone* and edible frog *R. esculenta*. The presence of other species is mainl determined by the quality of surrounding areas. The European pond terrapin *Emy orbicularis* occurs on older ponds in greater numbers. The fire-bellied toad *Bombin bombina* is a characteristic species of ditches and channels of shallow water related t fishponds. The common tree frog *Hyla arborea* is abundant on the vegetation (reed an trees) of shores. Fishponds are important as breeding places for moor frog *Rana arvali* common spadefoot *Pelobates fuscus*, green toad *Bufo viridis*, common toad *Bufo bufo* an smooth newt *Triturus vulgaris*.

Birds

Waterfowl constitute one of the most important natural values of fishponds in Hungary because of their great abundance and species richness. This is the reason that studying th relationship between fish management and birds has a considerable role in recent nationa ornithological literature (Horváth 1954, Csigó 1954, Sterbetz 1963, Bodnár 1982, Kovác 1984, Csizmazia 1986, Nagy 1989, Szabó and Polyák 1994). Factors determining specie composition and abundance of waterfowl on fishponds are:

- geographical localisation
- extension
- vegetation cover

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- food availability
- physical condition of ponds
- disturbance.

Several endangered species occur on fishponds during the breeding season and as migrants (Table 5).

Breeding birds

(1) Reed-grass nesters

Floating reed-grass tables provide good breeding places for several bird species, such as whiskered tern *Chlidonias hybrida*, common tern *Sterna hirundo*, red-necked grebe *Podiceps griseigena* and black-necked grebe *P. nigricollis*.

(2) Reed nesters

Reeds provide nesting sites for the greatest number of birds. Coot *Fulica atra*, great crested grebe *Podiceps cristatus*, little grebe *Tachybabtus ruficollis* and black-necked grebe are the most abundant species. Black tern *Chlidonias niger*, black-headed gull *Larus ridibundus*, greylag goose *Anser anser*, common pochard *Aythya ferina* and moorhen *Gallinula chloropus* are characteristic species too. Purple heron *Ardea purpurea*, bittern *Botaurus stellaris* and little bittern *Ixobrychus minutus* breed alone or in small colonies, while great white egret *Egretta alba* and spoonbill *Platalea leucorodia* breed in large colonies. Other related species are often associated with these colonies, such as grey heron *Ardea cinerea*, little egret *Egretta garzetta*, squacco heron *Ardeola ralloides,* night heron *Nycticorax nycticorax* and glossy ibis *Plegadis falcinellus*. For the protection of these heron colonies on fishponds (which make up 21%–53% of all heron colonies of the country) it is important to preserve old reeds on the one hand and to reduce the fluctuation in water level during the breeding season on the other, because many of these birds (e.g. *P. leucorodia* and *I. minutus*) make nests a few decimetres above water level.

The most abundant passerine species are sedge warbler *Acrocephalus schoenobaenus*, reed warbler *A. scirpaceus*, great reed warbler *A. arundinacea* and Savi's warbler *Locustella naevia*. Moustached warbler *Acrocephalus melanopogon* and bluethroat *Luscinia svecica* are rare breeding species.

(3) Tree and bush nesters

The penduline tit *Remiz pendulinus* is one of the characteristic breeding species in old willow plantations. Trees standing in ponds provide good nesting sites for cormorants *Phalacrocorax carbo*. Sometimes endangered species such as pygmy cormorant *P. pygmeus* may breed in these colonies.

(4) Ground nesting birds

(4a) Pondbed nesting birds

A part of drained pondbed always contains some water in spring on one hand and some dry areas as well. In this state fishponds are very similar to alkaline lakes, and consequently characteristic breeding species of alkaline lakes regularly occur on fishponds too. These

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Table 5. Endangered bird species of fishponds in Hungary

species	breeding status	conservation status	
Anser erythropus	nb	G	RL
Ardea purpurea	b	E	
Ardeola ralloides	b	E	RL
Aythya nyroca	b	E	
Chlidonias hybrida	b	E	RL
Ciconia ciconia	nb	E	RL
Ciconia nigra	nb	E	RL
Circus aeruginosus	b	E	
Egretta alba	b	E	RL
Egretta garzetta	b	E	RL
Grus grus	nb	E	RL
Haliaeetus albicilla	b	G	RL
Larus melanocephalus	b	E	RL
Limosa limosa	nb	E	
Luscinia svecica	b	E	RL
Lusciniola melanopogon	b	E	
Numenius arquata	nb	E	RL
Numenius tenuirostris	nb	G	RL
Pandion haliaetus	nb	E	RL
Phalacrocorax pygmaeus	b	G	RL
Platalea leucorodia	b	E	RL
Plegadis falcinellus	b	E	RL
Podiceps griseigena	b	E	RL
Porzana porzana	b	E	
Recurvirostra avosetta	b	E	RL
Sterna hirundo	b	E	
Tringa stagnatilis	nb	E	RL

b: *breeding species*
nb: *non-breeding species*
E : *vulnerable or endangered species with small or decreasing populations in Europe*
G: *globally threatened species*
RL: *species listed in the Hungarian Red Data Book*

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include avocet *Recurvirostra avosetta*, lapwing *Vanellus vanellus* and little ringed plover *Charadrius dubius*. Occasionally Kentish plover *Charadrius alexandrinus* breeds on fishponds too (Széll 1986).

If the pondbed is harvested in autumn and becomes grassy till spring then redshank *Tringa totanus* and black-tailed godwit *Limosa limosa* can breed too. Unfortunately breeding attempts of pondbed nesting birds often fail because the ponds fill up with water.

(4b) Island breeders

In some fishponds there are smaller islands where characteristic bird communities can occur depending on vegetation. On barren islands the characteristic breeding species is the common tern. The black-headed gull is a less sensitive bird and may breed on naked concrete blocks or on islands covered with high weed vegetation and often creates huge colonies. Sometimes rare species such as the Mediterranean gull *Larus melanocephalus* can occur in these colonies too.

(4c) Birds breeding on shores

The most characteristic species on shores are ducks, namely mallard *Anas platyrhynchos*, garganey *A. querquedula* and shoveler *A. clypeata*. Species considered internationally endangered breed in small numbers on several islands, e.g. ferruginous duck *Aythya nyroca* and gadwall *Anas strepera*.

Migrant birds

During the migration season waterfowl occur on fishponds in large numbers. Among these species are the globally endangered lesser white-fronted goose *Anser erythropus* and slender-billed curlew *Numenius tenuirostris*. In Hungary the most important habitats for these birds are fishponds. Thus the draining and filling up periods of these fishponds are controlled by Hungarian nature conservation bodies (Box 1).

Wintering birds

Of the migratory species in autumn, cranes, geese and ducks stay on the fishponds till they freeze. However, the bird fauna of frozen fishponds is far poorer. On fishponds the estimated wintering number of white-tailed eagle *Haliaeetus albicilla* is about 100–150. The most important wintering places of this species are situated along river Tisza (Hortobágy, Tiszasüly, Szeged) and in Inner-Somogy (Table 6). Wintering of this species is promoted by providing extra food (see also Box 1).

Mammals

Among mammals occurring on fishponds the most important species is the otter *(Lutra lutra)*. This mammal lives in largest densities in Southern Dunántúl where most of the fishponds are situated. Because of its predation on fish the otter is illegally hunted in spite of being a strictly protected species.

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Box 1. Examples of habitat management for endangered birds on fishponds in Hungary

Protection and restoration of lesser white-fronted goose Anser erythropus *and slender-billed curlew* Numenius tenuirostris *habitats*

Both species are globally threatened and prefer drained fishponds for short or longer term stops during migration. The lesser white-fronted goose has been a regular autumn (September–November) and occasional spring migrant on the drained fishponds of Hortobágy since 1987, when they found new suitable habitat (watery surfaces, together with low level and young, or even pioneer vegetation, e.g. *Polygonum, Echinocloa*). A maximum of 130–450 birds are recorded annually on the ponds nowadays, and birds will stay on a pond for several weeks if the habitat is quiet and suitable. The slender-billed curlew also appears on drained fishponds. Beside these two species, the ponds are overnight sites for about 30,000 cranes *Grus grus*, and for many geese, ducks and shorebirds.

Creating a resting area for the above migrating species, especially lesser white-fronted goose, fishponds have to be drained on about 20 August every year. Geese will find optimum habitat on pond beds at 15–18 September, which is when they usually arrive. If a second group of ponds is drained around that time, and then every six weeks until the end of October, geese will remain on the area even after the vegetation of the first ponds grows higher than they need. The overgrown ponds may be filled up immediately after the geese leave for another pond. If there are not enough ponds for the above rotation, than the drained ponds can be filled up and drained again for vegetation maintenance.

Protection of overwintering white-tailed eagles Haliaeetus albicilla *in the Hortobágy National Park*

The overwintering of this species depends on the supply of dead fish found around the ponds and on waterfowl wounded or killed and left by hunters. The Greater Pond of the Hortobágy National Park is a Ramsar site, consequently hunting is forbidden, and this traditional wintering area is lacking food for eagles. The park rangers have started to feed the eagles with fish and sometimes with sheep and meat on the empty fishpond beds. As this species is highly sensitive to disturbance, even ornithologists are prohibited from approaching the feeding area, but observation towers are built for their interest.

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Table 6. Number of white-tailed eagles *Haliaeetus albicilla* wintering annually on Hungarian fishponds

Hortobágy Greater Fishpond	30
Csécs-pond	27
Biharugra Fishponds	14
Virágoskút-pond	10
Szeged Fehér-tó	10
Homor Fishpond	9
Elep Fishpond	8
Horvátpuszta-pond	7
Sumony Fishponds	6
Kónya-pond	5
Pacsmag Fishpond	5
Alexandrapuszta Fishpond	5
Lábod, Petesmalom Fishpond	5

In fishponds another characteristic species of aquatic mammal is the muskrat *Ondrata zibethicus*, which causes a problem to fish farmers by burrowing into dams.

Reeds situated along fishponds provide good habitat for other protected mammal species such as the harvest mouse *Micromys minutus* and ermine *Mustela erminea*.

2.3.3. Nature conservation appraisal of fishponds

A nature conservation appraisal of fishponds can be undertaken partly based on nature conservation value and abundance of occurring species. Methods developed by BirdLife International and Wetlands International (formerly IWRB) are useful for determining the international importance of fishponds from an ornithological point of view (see Grimmett and Jones 1989, Frazier 1996).

Protected fishponds in Hungary are: Szilvásvárad-Pisztrángos in Bükk National Park, Hortobágy-Nagy-Halastó in Hortobágy National Park, Fehértó and the part of Fertő at Szeged, Csaj lake in Pusztaszer Landscape Protected Area, Biharugra and Begécs in Biharugra Landscape Protected Area, Boronka, Hajmáslap and Mesztegnyő in Boronka Landscape Protected Area, Péteri lake and Pacsmag as Nature Conservation Areas of national importance and Öreg-tó at Tata as Nature Conservation Area of local importance. Four of these fishponds (Hortobágy-Nagy-Halastó, Fehértó fishpond at Szeged, Csaj lake, Öreg-tó at Tata) are listed in the register of wetlands of international importance. Six other fishpond systems (Biharugra and Begécs fishponds, Péteri lake, Rétszilas, Sumony and Pacsmag fishponds) are proposed for designation under the Ramsar Convention.

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Hungarian fishponds of international importance

In Hungary within the framework of the IUCN project all the pond systems were studied from an ornithological point of view. Based on these results it can be determined which ponds fulfil Ramsar site criteria. Beside those fishponds which can be designated as Ramsar sites, ponds which meet the criteria of Important Bird Areas in Europe have to be considered as ponds of international importance (Table 7). Of the ponds listed in Table 7, the following satisfy the criteria of the Ramsar Convention: ponds at Csécs, Virágoskút, Elep, Horvátpuszta, Irmapuszta, Fonyód, Soponya.

The role of fishponds in EECONET

There are close interactions between fishponds and their narrower or wider environment. Consequently the conservation policy of fishponds has to be drawn into a wider nature conservation policy as a part of the European Ecological Network (EECONET; see Box 2). Fishponds can be classified in the EECONET as ecological corridors or areas of rehabilitation.

Table 7. Fishponds of international importance in Hungary

name	important bird species
Hortobágy Greater Pond	*Phalacrocorax pygmeus, Egretta alba, Platalea leucorodia, Anser erythropus, Branta ruficollis, Anser albifrons, Anser fabalis, Anser anser, Anas platyrhynchos, Anas crecca, Bucephala clangula, Haliaeetus albicilla, Numenius tenuirostris, Philomachus pugnax*
Csécs Fishponds	*Phalacrocorax pygmeus, Egretta alba, Platalea leucorodia, Anser erythropus, Branta ruficollis, Anser albifrons, Anser anser, Bucephala clangula, Haliaeetus albicilla*
Virágoskút Fishpond	*Phalacrocorax pygmeus, Egretta alba, Platalea leucorodia, Anser erythropus, Branta ruficollis, Anser albifrons, Anser anser, Haliaeetus albicilla*
Elep Fishpond	*Egretta alba, Platalea leucorodia, Branta ruficollis, Anser albifrons, Anser anser, Haliaeetus albicilla*
Biharugra Fishpond System	*Egretta alba, Platalea leucorodia, Anser fabalis, Anser anser, Anser albifrons, Anser erythropus, Anas platyrhynchos, Haliaeetus albicilla*
Horvátpuszta Fishpond	*Egretta alba, Platalea leucorodia, Anas platyrhynchos*

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Ponds are connected to the upper sections of their catchment area, to rivers, reservoirs or even to each other by streams. Thus fishponds have many connections with other habitats. The dispersal stages of certain species (e.g. seeds, eggs) can be transported by these streams.

Vegetation situated along the streams provides habitat for the spread of some species (e.g. food-specialised butterflies, passerine birds and small mammals). In an arid environment fishponds ensure the existence, spreading and migration of species which are temporarily related to water.

Due to the geographical characteristics of the Carpathian Basin, bird migration routes (mainly waterfowl) cross Hungary. There is a large overlap of Eastern Atlantic and Mediterranean migration routes in Hungary.

The most important natural water bodies and corridors for bird migration are the big rivers: the Danube and Tisza with their tributaries connecting to the surrounding fishponds and grasslands. Previously the chain of alkaline ponds in Kiskunság was also an important

Table 7. (continued)

name	important bird species
Szeged Fehér Lake	*Phalacrocorax pygmeus, Platalea leucorodia, Branta ruficollis, Anser fabalis, Anser albifrons, Anser anser*
Szeged-Fertő	*Phalacrocorax pygmeus, Platalea leucorodia, Branta ruficollis, Anser albifrons, Anser anser*
Csaj-Lake	*Phalacrocorax pygmeus, Egretta alba, Platalea leucorodia, Anser fabalis, Anser albifrons, Anser anser*
Péteri-Lake	*Egretta alba, Platalea leucorodia*
Tatai Öreg-tó (lake)	*Anser fabalis*
Pacsmag Fishpond	*Egretta alba, Anser fabalis, Aythya nyroca*
Irmapuszta Fishpond	*Anser anser, Bucephala clangula*
Fonyód Fishpond	*Anser anser*
Soponya	*Egretta alba, Anser anser, Anser fabalis, Anser albifrons, Anser anser, Anas platyrhynchus*
Sumony	*Egretta alba, Anser fabalis, Anser anser, Haliaeetus albicilla*
Rétszilas	*Egretta alba, Platalea leucorodia, Anser anser, Anser fabalis*

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Box 2. The European Ecological Network (EECONET)

The aim of EECONET is to identify species and habitats of European importance and to develop measures that conserve the integrity of the natural systems upon which they depend. This concept would provide a framework for protected areas policy in Europe, as well as for conserving nature in the countryside as a whole. It recognises that protecting individual species or sites is not enough. A shift is needed in conservation policy from species to habitats, from sites to ecosystems, and from national to international measures.

It aims to protect not only the most important sites (core areas) but also to designate areas of habitat restoration, and to establish (continuous or 'stepping stone') corridors between them, or even between corridors. All kinds of areas or corridors may have buffer zones, preferably as rehabilitation areas (e.g. valuable agricultural systems which do not counteract nature conservation activities). This network and approach would lead to a more dynamic and flexible protection policy, hopefully at local, national and European level also.

A Dutch initiated programme (Bennett 1991) was accepted as a basis for a common environmental policy by the environmental ministers of the European Union in Maastricht in 1993. IUCN – The World Conservation Union is working on the designation and evaluation of national ecological networks in four European countries, namely in the Czech Republic, in Poland, in Slovakia and in Hungary.

Box 3. Goose and crane migration through Hungary

The breeding area of the Central European greylag goose *Anser anser* extends from the Baltic to eastern Austria and Slovakia (Ogilvie 1974). Before the severe frost period starts greylags assemble at various Pannonian sites, primarily on the Hungarian and Austrian shores of Lake Fertő and at the Kis-Balaton (Small Balaton), but some fishponds are also preferred by them. Later they move further to North Africa, mainly Tunisia and eastern parts of Algeria (Ogilvie 1974).

The bean goose *Anser fabalis* is common mainly in the Dunántúl (Transdanubia). Their most important gathering places are Lake Fertő and the Szigetköz and the Solt section of the Danube, the Tata Öreg-tó (Old Lake) area, the Velencei-tó (Lake), the fishponds of the Sárvíz valley (Soponya, Rétszilas), the lower section

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Box 3. (continued)

of the Danube (between Dunaföldvár and Mohács), Kelemenszék, and the Small Balaton, the Lake Balaton, the river Dráva and the Sumony Fishponds. The Hungarian gathering places are connected to the Yugoslavian places (Vajdaság areas: Palics-Lake, Kopácsi-meadow), and geese follow the Danube to the Danube Delta (Ogilvie 1974). Ringing data provides evidence that migration connects with the Austrian gathering places and further that the geese follow the Danube and Rhine rivers (as do some ducks as well, Sterbetz 1972).

The white-fronted goose *Anser albifrons* breeding in Northern Russia migrates to the Tiszántúl (Trans-Tisza) area, which together with the Western Romanian areas provides them with a wintering place (Owen 1980). The Hortobágy, the Szeged Fehér tó, the Csaj-tó and Biharugra (all of them around fishponds) are the most important gathering places for the species. They migrate further in the direction of Otomani and Banat in Romania, Belo Blato and the Kopácsi-meadow in Yugoslavia, and also towards the Skodra Lake.

According to Owen (1980) the lesser white-fronted geese *Anser erythropus* which cross the Carpathian Basin are from the northern European breeding population. Sterbetz (1982) argues that not only northern European but also Russian-born birds winter in Hungary, because there is a characteristic double peak in its migration. The most significant resting areas for this species are the Hortobágy and its fishponds (150–240 geese) and the Biharugra Fishpond System. The Kardoskút Fehér tó lost its importance after it dried out. There are connections with Yugoslavia (Belo Blato), Greece (Evros-mouth) and Bulgaria (Burgas).

The Baltic-East European route of cranes *Grus grus* crosses Hungary towards breeding areas in Finland (Karelia, Kola Peninsula) and Russia (Petersburg). Cranes gather in the eastern part of the Baltic sea and cross east Poland and the Carpathians (around Uzsok-pass and Tarca valley) in autumn. They enter Hungary at the Bereg Plain or through the Bodrog and Hernád valleys. The most important gathering place is the Hortobágy, from where they follow the rivers of Hortobágy and Berettyó towards Kardoskút-Pitvaros. Biharugra was also an important resting area for cranes, but nowadays the hunting disturbance is so high that birds almost totally avoid the area. There is an increasing number of sightings around Szeged (Szeged Fehér-tó, Büdösszék (Széll 1990)). The migration route divides into two below Szeged: one route crosses the Égei sea towards the valley of the Nil, the other, the more important, goes south-west through Bosnia, follows the Drina valley until Skadar Lake, then follows the Albanian coast to Valona where cranes cross the Adriatic Sea, reaching Sicily and arriving in Tunisia (Béczy *et al.* 1974).

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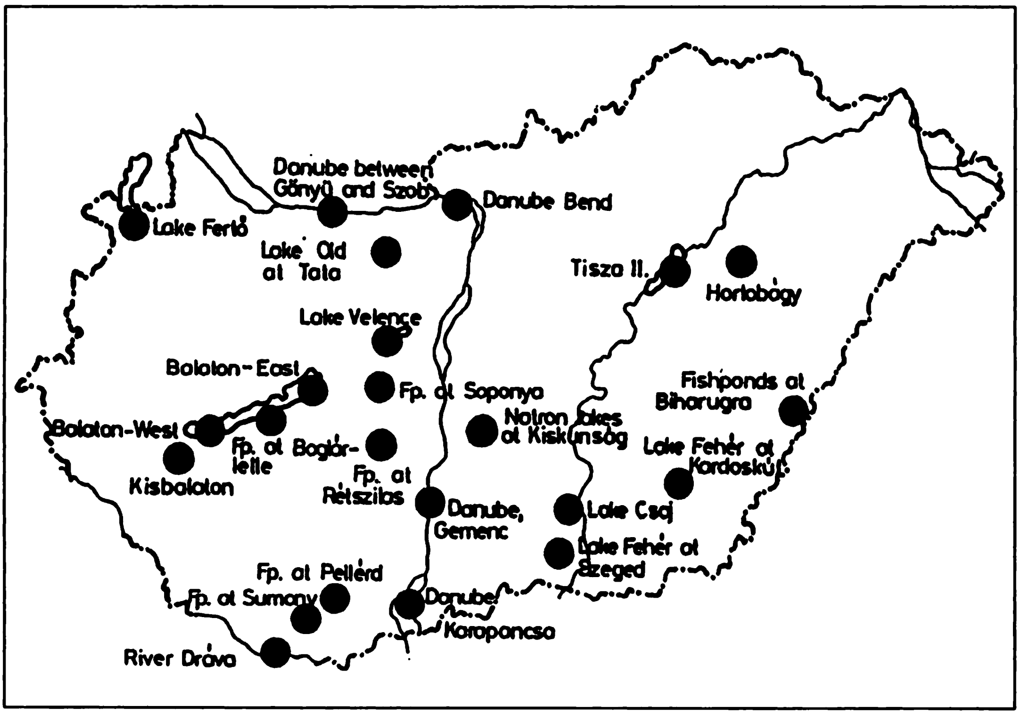
part of this system. However, these ponds have almost disappeared because of problems of water management and the more than ten-year-long drought. Thus the last representatives of wetlands in Kiskunság are fishponds (e.g. Szakmár, Harka and Péteri fishponds).

The majority of birds (primarily shorebirds) migrating through fishponds follow the continental side of the Eastern Atlantic migration route. The remainder, including spotted redshank *Tringa erythropus* and greenshank *T. nebularia*, arrive in Hungary from northern Europe and northern Russia. Migration of these species is closely connected with the migration route running along the Baltic sea from where the birds enter the Carpathian basin through tributaries of the river Tisza (Bodrog, Hernád) and Danube (Vág, Ipoly) after following the big rivers (Oder, Vistula, Elbe). Some of these birds, such as the crane *Grus grus*, migrate further to Italy, Tunisia and Algeria (Box 3). The others migrate to southern France, Spain and Morocco. The Mediterranean migration routes which cross Hungary finish in the Danube delta and the Near East.

The Pannonian region is a traditionally important wintering site, mainly for wild geese (Box 3, Map 2).

It is clear that fishponds can play a multiple role in the European Ecological Network. Fishponds of international importance have a special role in European bird migration. In

Map 2. Roosting and wintering sites for wild geese



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Hungary fishponds meet the Ramsar site criteria (reaching the one per cent limit) only in the case of wild geese. However, as part of an extended system fishponds have great importance for migrating ducks, shorebirds and herons, too. Consequently almost all fishponds have corridor or rehabilitation functions in the national ecological network.

2.4. Relationships between economic and recreational activities, the environment and nature conservation

Economic activities in fishponds are getting more and more complex due to the decreasing profitability of fish management. The more common additional activities are reed management and hunting of waterfowl. Other practices which occur but are not widespread include the combination of fish management with rice production, crop cultivation or keeping ducks or more rarely geese for meat production. Angling on fishponds is becoming more and more widespread as a partial or exclusive activity.

A new activity has appeared after privatisation – recreation. This has resulted in the division of areas surrounding fishponds into parcels for water sports (e.g. wind surfing) or ecotourism. Thus the importance and possible conflicts of economic activities in fishponds can be discussed only by considering all these activities.

2.4.1. Fishing

Fisheries provide good conditions for certain natural values. The main reasons are:

- There are water and mud surfaces providing security and optimal foraging conditions for waterfowl.
- Fish management activities (filling up, fish harvesting) and pondbed configurations mean that parts of the fishponds allow birds to forage.
- The high food input (fertilisation, foodstuff) and the breeding fish mean that the food supply (plankton, weed plants, worms, molluscs, aquatic insects, fishes, amphibians) for birds is high.
- There are optimal nesting sites for birds (floating reed-grass, reeds, shore trees, dry pondbed).

Due to these characteristics fishponds are essential for waterfowl because there is very little other optimal habitat in Hungary's arid environment.

The commercial exploitation of fisheries is important both for fish farmers and nature conservationists. Fish production is the source of livelihood for fish farmers. From the nature conservation point of view sustaining fish production is a management method which can secure the existence of habitats by restraining succession and siltation processes. Thus sustaining water quality suitable for fish production and moreover protecting fishponds and the surrounding areas from pollution is a common interest of both groups.

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Introducing fertiliser and food into fishponds is not necessarily a damaging activity from a nature conservation point of view because besides increasing fish production, an improved food supply is secured for waterfowl, too.

Conflicts between fishing and nature conservation can be divided into two groups:

- the negative impacts of birds on fishponds
- nature conservation problems caused by fish farming.

The negative impacts of birds on fishponds

Factors adversely affecting fish production are:

- competition for food between fishes and birds
- fish predation by birds
- transmission of parasites.

In Hungary there have not been any full assessments of these negative impacts which take all factors into consideration.

Birds eating food intended for fishes

In Hungary most of the avian fish-food consumption can be attributed to two non-protected bird species: coot and mallard. These birds follow the boats and catch fish-food, competing with the fish. On fishponds their breeding population size is usually small but they assemble in ever increasing numbers on large undisturbed ponds from the end of the breeding season till the beginning of autumn.

From August one method of prevention is hunting, which disperses the large duck flocks. This method is not only against nature conservation regulations but it cannot solve the problem, because fish are most intensively fed outside the hunting season, from July to August. Two alternative methods are installing self-feeding equipment or wire-netting above feeding places. The disadvantage of both these methods is that investment is required. Moreover, self-feeding equipment requires extra work, while applying wire-netting obstructs the checking of food consumption.

Fish predation by birds

One of the basic conflicts between fish management and nature conservation is fish predation by birds. Food composition of birds feeding on fishponds (mainly cormorants, herons, gulls, grebes and ducks) and their effects on fish management were studied by Hungarian researchers. In spite of their results, the fish farmers' opinion is that all birds are enemies of fish management. Fish predation by birds is estimated as being between 3% and 10% of the gross yield (Box 4).

Most of the fish are predated by cormorant, grey heron, black-headed gull and herring gull *Larus argentatus*. Among these species the cormorant and the herring gull are not protected, while the grey heron and the black-headed gull are protected except on fishponds where these species can be hunted as well. Fish consumption by other protected

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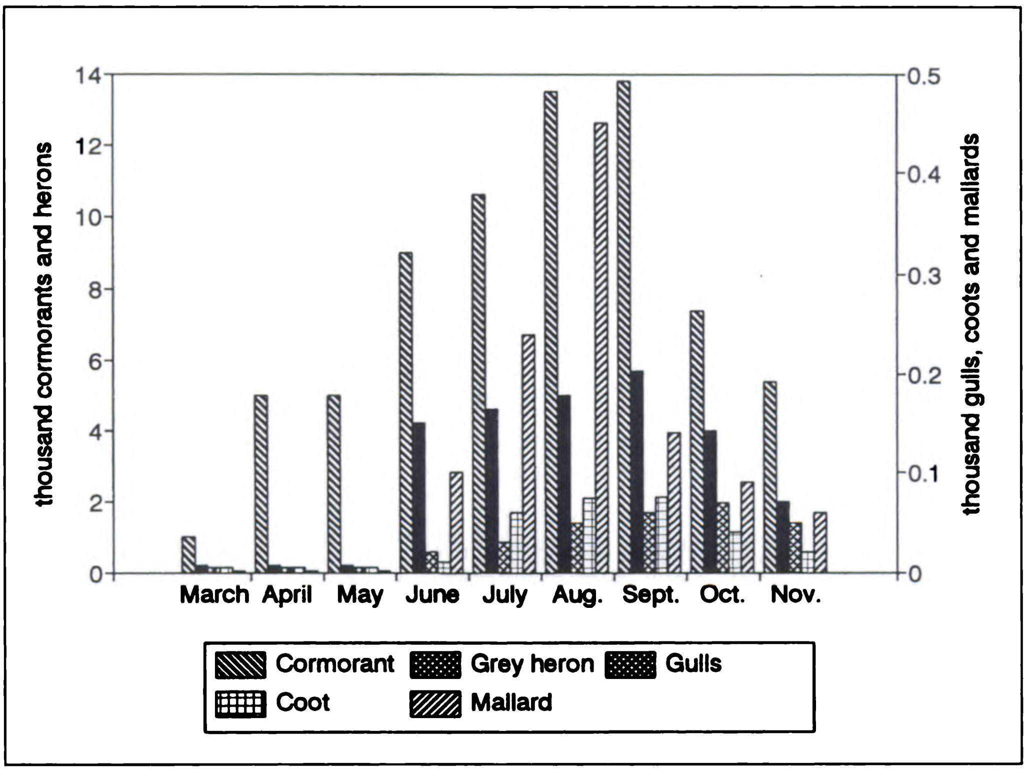
Box 4. Bird damage on fishponds of state farms in 1985

Birds were estimated to consume 1,663.7 tonnes of fish and 1,932 tonnes of fish food in 1985 over the 14,855ha of the 13 large state-owned fishpond systems. This equates to 106 million Hungarian forints (at 1985 value), and to 10% of the annual yield.

bird species is insignificant. Serious problems arise mainly on those protected ponds where hunting and disturbing non-protected species is prohibited. As with fish-food eating birds, the presence of fish-eating birds is not constant and the damage caused by them varies through the year (Figure 4).

Cormorants feed on fish from yearlings to adult carp weighing 0.5kg. Optimal feeding conditions are available for them mainly on ponds that are full or are still at an early stage of draining. Their numbers vary in different ponds during the year. On certain ponds the

Figure 4. Annual changes in numbers of birds which eat fish or fish-food



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number of cormorants can increase to more than 1,000 specimens, with young fledglings and adults arriving from other countries of Europe. The most serious problems arise on fishponds at Hortobágy, Biharugra and the southern part of the Great Plain.

Grey herons feed on waste and young fishes. They occur in great numbers during fish-harvesting, when they eat fish crowded into the fishbed. Fish consumption and numbers of this species are low in other periods.

Black-headed gulls feed on smaller sized fish, so catch mainly young and waste fish. They occur in thousands, causing damage during fish-harvesting at the end of summer and autumn. Beside fish consumption they wound many fish too.

Herring gulls feed on smaller and medium sized fish but at fish-harvesting they catch full (market) sized fish as well, and often forage on fish carrion. Preventing damage caused by birds is a central problem for fish farmers and nature conservationists. In Hungary recently the most widespread methods for alarming birds have been the use of guns and carbide cannon. Hunters shoot not only the harmful species but often the protected ones. The effectiveness of this method is questionable because birds are kept off for a few days only. Due to the optimal feeding conditions fish-eating birds assemble on fishponds from a wide area.

Technical methods (e.g. applying wire-nettings above hatcheries) are rarely used for preventing damage caused by birds. Adoption of these methods is avoided because of financial considerations (requiring high investment), in spite of the existing high costs of lost fish, foodstuffs and employing fish guards.

At the same time there are several 'ecological' methods which fit in well with management without extra expense. Such methods include sustaining pond water level at an adequate depth to prevent fish predation by shorebirds. Another possibility is stocking different age groups in different types of pond. This means that small-sized and young fish – preferred by birds – ought to be raised in smaller and safer rearing ponds. However the common practice is that offspring are released into large ponds with dense reeds. Defending these ponds from birds is difficult and draining is a time-consuming process, so that fish spend longer on the unsafe and overcrowded pond bed during draining.

Damage caused by birds on fishponds has been the central source of conflict between nature conservation and fish management for a long time. Optimal foraging conditions on fishponds and protection of birds has contributed to increased population sizes for certain birds, such as cormorant, grey heron and black-headed gull. Nowadays the way that Hungarian nature conservation policy handles the negative impacts of birds – namely to permit hunting and disturbance of fish-eating birds – is not enough to solve this problem. Moreover non-protected fish-eating birds breed together with endangered species. Consequently an overall approach should be taken by nature conservation to solve such problems. The following problems arise from the unresolved situation:

- cooperation over other issues between fish farmers and nature conservationists becomes more difficult

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- some fish farmers use illegal methods to limit damage caused by fish-eating birds
- hunting and disturbance of non-protected birds endangers the protected species also.

One of the basic principles of the new approach has to be that sustaining the optimal population size of all species should be achieved, in accordance with international agreements. At the same time coordination is needed on a national and international level to regulate the number of bird species which cause problems from an economic and/or ecological point of view. Long-term monitoring of populations of these species is required. Necessary artificial regulation of population sizes should be made only under strict control, cooperating actively with nature conservation authorities. The responsibility and activity of nature conservation authorities extends to these problems because the nesting places of birds causing damage are usually situated in protected areas.

Nature conservation problems caused by fish farming

Beside the advantages for nature conservation resulting from fish farming problems arise as well. The primary aim of fisheries is to increase profits or at least to cover their expenses, often pushing into the background the interests of nature conservation. The following problems can arise:

- transformation of valuable natural habitats (e.g. marshes, alkaline lands, wet meadows)
- destruction of reed belt habitat
- damage to species-rich habitats because of reed and reed-grass mowing
- drainage and flooding at unfavourable times from a nature conservation point of view
- extinction of certain species or whole aquatic communities because of eutrophication
- disturbance
- killing of protected bird species.

Habitat transformation

In Hungary most fishponds were constructed in areas which were not suitable for other agricultural activity. Consequently natural conditions were almost unchanged, preserving important natural values in these areas. However, during the construction of fishponds, species of special environmental requirements can lose their habitat. On the other hand, in the case of certain barrage-dammed fishponds the rate of flow of lower sections can decrease drastically.

To avoid such problems an environmental impact study should be made before the construction of certain fishponds, looking at the natural values of the construction area and the expected impacts of the planned fishpond on the environment. Unfortunately, coordinating the interests of management and nature conservation becomes more and more difficult because of privatisation. Privatisation results in plots of land of some ten or hundred hectares only. Construction of profitable and optimal sized fishponds which are advantageous from a nature conservation point of view is hardly imaginable on these small plots.

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Destruction of reed belt habitat

The aim of fishpond owners is to produce as many fish as possible. This requires restricting reed belts because reeds occupy productive parts of the water surface. They try to restrict the expansion of reeds by mowing, burning and introducing herbivorous fish species. These activities endanger bird species nesting in reeds.

Sustaining and protecting reeds is in the interest of fishpond owners too, because reeds protect dams against erosion much better than other technical solutions. Moreover, valuable products can be produced from reeds.

Reed management is an important activity for fishpond owners. Siltation of ponds can be controlled by regular cutting of reeds, and harmful materials fixed in the reed tissue can be removed too.

Damage to reed and reed-grass habitat due to mowing

The reasons for mowing reed and reed-grass areas during fish management are similar to those which prompt destruction of this habitat. This activity destroys floating reed-grass and higher vegetation which could serve as important nesting sites for terns and grebes. Species of floating reed-grass (*Nymphoides peltata, Nymphaea alba*) are protected and occur in only a few fishponds. Higher vegetation which could grow up because of draining of ponds disappears without any regulation after one or two years. If mowing is required this should only be started after the end of the breeding season. In connection with mowing most problems arise on the ponds used for large-scale spawning, because this method is applied on drained ponds with dense vegetation which are filled up during spring. Then urgent mowing is needed to provide optimal habitat for the plankton which is the most important food for young fish.

Drainage and flooding

Successful breeding of heron species is endangered by unfavourable water level regulation (draining or filling up of ponds during the breeding season). This usually happens during fish-harvesting in summer. Ducks, terns and grebes nesting on floating reed-grass are also sensitive to draining during the breeding season.

Site fidelity of herons, greylag geese and species nesting on reed-grass is strong and they will breed on the same pond year after year. Due to this behaviour, pond drainage or flooding causes fewer problems, and it is possible to adapt management methods to their life cycle and requirements. To restrict conflicts permitted draining and re-filling periods ought to be included in management plans of protected fishponds.

In the case of species such as avocet that nest on pondbeds, the situation is more difficult. The optimal habitat is developed for them where ponds are filled up in late spring only. Because these ponds were created for spawning and offspring raising (which both start in early spring) the fish farmers are simply not able to compromise over the time at which they fill the ponds (Box 5).

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Box 5. Habitat management for the avocet *Recurvirostra avosetta* on fishponds

The avocet, although strictly protected, has a breeding success of only 50% on fishponds in Hungary because of the inappropriate water level changes (filling up of ponds) and pond-bed management of fisheries (Boros and Szimuly 1993). Habitat management to benefit avocets is also a suitable method for pond reconstruction, and allows ponds to be given a 'resting' or fallow period. Such management should be implemented on any ponds where avocets regularly appear, and especially in the case of Pusztaszer, Hortobágy and Biharugra ponds.

Habitat management for avocets should take into account the following:

1. Where ponds are filled up in autumn this will prevent avocets from settling. In this case nature conservation management should provide suitable, maybe artificial, habitat for the birds elsewhere in the vicinity.
2. Fast re-filling of the pond can be the solution if spring draining is really unavoidable for economic reasons. In this case re-filling should take place before the mud dries, which means that only fishponds of less than 50ha, with a properly working drainage system, may apply this method. Again, this management does not support avocet breeding, and outside artificial breeding sites have to be provided.
3. In cases where ponds are drained in the spring and fast re-filling is impossible or unnecessary the pond bed will dry. If avocets then breed on the pond bed it should remain unfilled until the chicks hatch (in July). Because of the late re-filling, only preformed fish can be used for stocking. Pond bed maintenance should be avoided, except for large ponds where a buffer zone can be left around the nests. Liming is forbidden because it destroys the food of avocet.
4. Avocets frequently attempt to breed in fish-breeding ponds that have a month-long dry period for fishery management. In these cases the ponds need to remain dry for an extra 2–3 week period to allow the chicks to hatch. If such an extra dry period is not tolerable by the fishery then the only options are to prevent avocets nesting in the first place by disturbing the birds or to raise the height of the nests and re-fill the pond to a low level only.

Eutrophication

Fish farmers make efforts to increase the production capacity of fishponds. They introduce organic and artificial fertilisers into fishponds, reaching a hundred fold density compared to natural waters, and the process of eutrophication is initiated. The chlorophyll content increases, water transparency decreases and certain species sensitive to nitrogen or

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phosphorus will die. High densities of blue algae may cause fish and bird deaths. In summer fish death may occur because of anoxia in ponds at high population density (yields above 1,000kg/ha). During decomposition of organic materials hydrogen sulphide and ammonia are released causing serious toxicity. However, in many cases problems caused by eutrophication can be prevented with controlled management.

Disturbance

Activities (e.g. fertilising) connected with fishing may disturb the birds. Certain species (such as cormorants, herons and gulls) become habituated to regular disturbance of management. Others (such as wild geese) are very sensitive to disturbance and usually leave their roosting sites.

Killing of protected animals

Fish farmers try to decrease damage caused by birds with disturbance techniques and shooting (see page 82). In many cases protected bird species and otters are killed as well. Appropriate actions have to be taken both by fish farmers and nature conservationists to prevent such events.

2.4.2. Reed management

On smaller fishponds there is no real reed management. A common practice is the burning of reeds and regular reed harvesting is only carried out on some ponds. However reed management is a significant complementary activity of fish farms, with considerable profits on larger and older fishpond systems (Hortobágy, Biharugra etc.).

Reed cutting may be a useful activity from the nature conservation point of view by arresting succession in fishponds. However, reed cutting causes many problems for nature conservation as well:

- in many cases nesting sites for herons are destroyed because of clear cutting
- in winters when it does not freeze the continuing reed cutting disturbs greylag geese and other early breeding species which are preparing for nesting
- in Hungary machines used for reed cutting damage the rhizomes and reduce reed regeneration
- environmental pollution (oil, plastic ropes) is often caused by these machines
- storage sites and transport routes often damage valuable areas.

In spite of these problems the interests of reed management and nature conservation can usually be harmonised. The following actions are recommended:

- reed management should be stopped in those areas which are important breeding sites for herons
- reed cutting should finish by 28 February, and the thin, inner parts of reeds should be saved for securing the nesting of greylag geese

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- burning of reeds – which is otherwise prohibited – should be finished by 28 February
- Storage sites should be located in areas which are already damaged, transport routes should not cross areas (especially flooded areas) sensitive to compaction, and timing of transport activity should be outside the breeding season of birds nesting in the reeds.

2.4.3. Other agricultural activities

Because of reconstruction works, lack of funds or unprofitable fish production cultivation of crops has developed on some drained ponds. Plants such as maize and sunflower, with late sowing-time and high food requirements, are most frequently cultivated. One serious problem is that weeds which are difficult to eradicate (e.g. *Xhantium* spp.) also become numerous on these ponds. Another danger is that waterfowl may lose their habitat.

The Fish Culture Research Institute at Szarvas has been dealing with the integrated breeding of fish and duck for 30 years. Fishponds provide food supply (plankton) and bathing, roosting and hiding places among the shore vegetation for ducks, while the droppings of ducks fertilise the pond, improving feeding conditions for the fish.

A special method was developed at Szarvas. Integrated fish/duck breeding over a period of 4–5 years is followed by lucerne growing on the pondbed for two years then rice production for 2–3 years. This system has not become widespread in spite of favourable results because such complex utilisation requires preparation, broad knowledge of the different types of land-use/production methods and several sets of machinery.

On certain fishponds – mainly in Hortobágy – poultry (e.g. domestic goose) breeding occurs. It may cause degradation or even extinction of shore vegetation. Moreover vaccinated birds present a danger of infection for wild birds.

Rice production causes transformation in the characteristics of the area but cannot be considered as entirely unfavourable from a nature conservation point of view because good feeding conditions are provided for shorebirds during spring, for herons (mainly little egret, squacco heron and night heron) during the breeding season and for ducks at the end of summer and in autumn.

2.4.4. Recreational activities

The possibilities for recreational utilisation of fishponds are as follows:

- hunting
- angling
- ecotourism.

Hunting

Hunting of waterfowl has a special importance on fishponds. The economic importance of hunting is equal to that of fish and reed management. However, hunting does not

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assist in maintaining habitats and causes great disturbance. In spite of the bad reputation of hunting with many nature conservationists, the long-term existence of this activity has to be taken into consideration on fishponds because of the high profitability of hunting by foreign hunters. Since privatisation, hunting has become the primary activity on several fishponds.

The common interest of nature conservation and hunting is to sustain the populations of game birds and this must be used to establish cooperation between them.

General trends of waterfowl hunting in Hungary

Until recently, waterfowl that could be hunted in Hungary included bean goose *Anser fabalis*, white-fronted goose, mallard, garganey, wigeon *Anas penelope* and pochard. Since 1993 the Ministry for Agriculture has strictly limited waterfowl hunting as follows:

- hunting of white-fronted goose and wigeon is prohibited or restricted
- in certain important areas hunting is prohibited
- bag size is limited (four geese, eight ducks and eight coots are permitted daily)
- hunting is permitted in daylight only
- use of decoy birds, calls and motor-boats are prohibited.

Nowadays the Hungarian regulation of waterfowl hunting is the most comprehensive in Europe.

Goose hunting

In Hungary among the wild geese only the bean goose and with strict limitation the white-fronted goose may be hunted. Greylag goose has been protected since 1954 and lesser white-fronted goose since 1982.

In Hungary the number of wild geese shot were 5,000–6,000 during the second half of the 1980s and the beginning of 1990s, which was 2.8%–7.1% of the maximum observed number (in November).

On the Dunántúl region mainly the bean goose can be shot. During the above mentioned period the bag size of this species was 2.6%–6.2% of the maximum observed number. Thus the bag size changed parallel with changes in population size of the species. Unfortunately the main problem is that a large part of the bag was shot in a few places only (at Tata, Soponya, Fertő, Danube region) of which the first two are fishponds.

White-fronted geese mainly migrate through the Great Plain. During the same period as for the bean goose their observed number decreased to one fifth while the bag size decreased by 25% only. The number of shot birds increased to 8.2%–13.9% of their maximum observed number. Most of the birds were shot at Hortobágy, which is the region richest in fishponds.

These reasons made it necessary for the Ministry for Agriculture to enact restrictions.

Duck hunting

Recently the bag size is stable with 100,000–110,000 specimens. Most of the ducks are shot in the Great Plain and certain Dunántúl regions (Győr-Sopron, Komárom,

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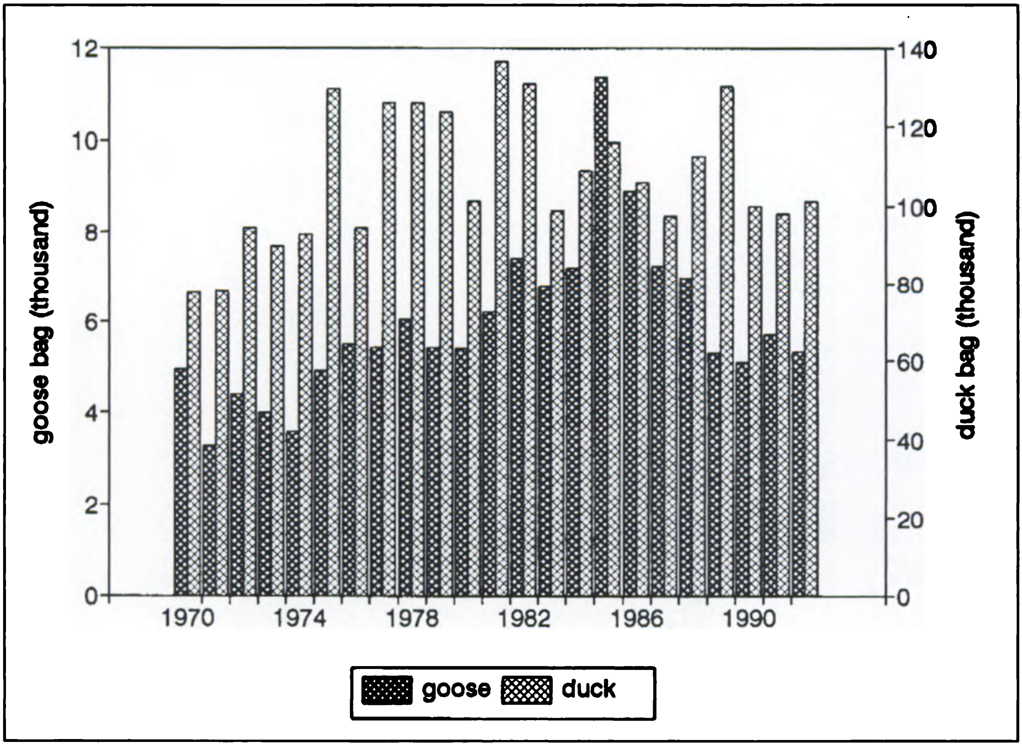
Figure 5. Goose and duck bag in Hungary between 1970 and 1992



Fejér counties). In both regions there are large fishponds. The bag consisted mainly of mallard (Faragó 1988). Each year bag sizes corresponded proportionally to the number of ducks observed during synchronous counting in November (Figures 5 and 6).

The effects of hunting on and around fishponds

The distribution of ducks is rather uniform as they occur in almost every adequate habitat due to their behaviour and ecological requirements. However, roosting-site fidelity of wild geese is strong and they occur permanently only in some places. While ducks are sensitive to disturbance only to a certain extent geese may even change their migrating routes and wintering areas because of continuous disturbance.

In Hungary traditional roosting-sites and wintering areas of geese are mainly situated in fishponds of the Great Plain (Hortobágy, Biharugra and Fehértó fishpond at Szeged). At the Dunántúl region the most important areas in this respect are the Soponya, Rétszilas, Fonyód and Öreg-tó fishponds. Because these fishponds are the only representatives of wetlands in a grassland environment their maintenance and hunting utilisation are of international importance.

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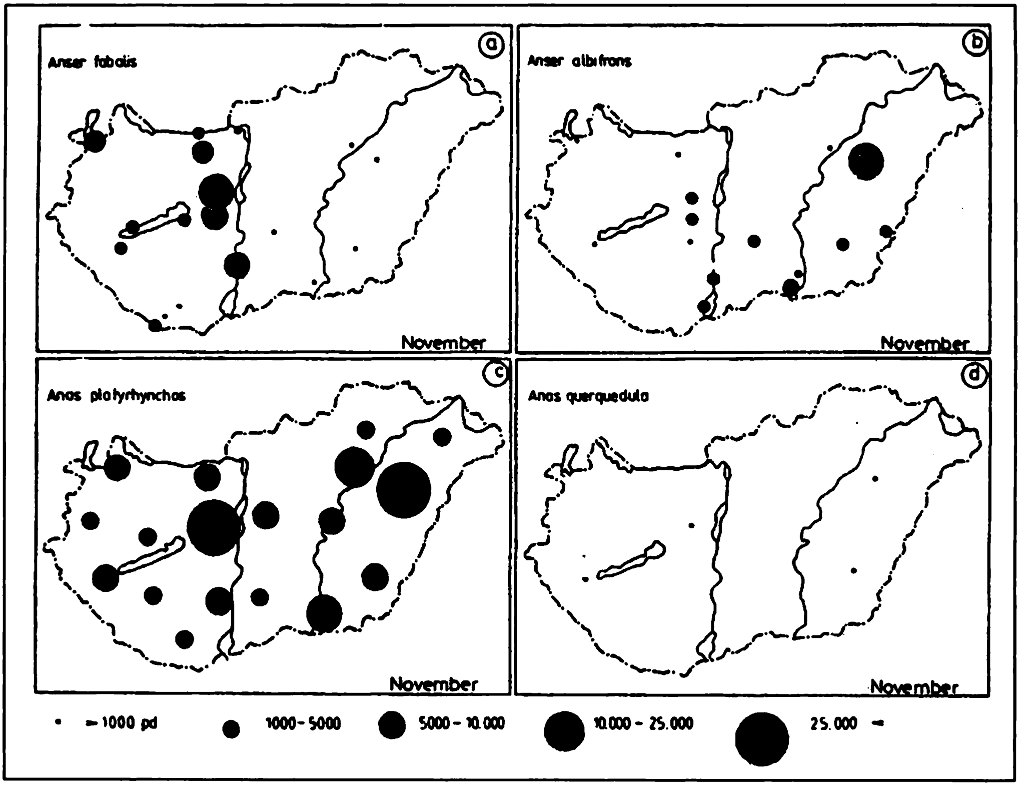
Figure 6. Synchronous counts of waterfowl in Hungary



On fishponds of international importance nature conservation must have priority. This is the reason that on and around the following ponds, waterfowl hunting is prohibited:

- Biharugra and Begécs fishponds
- Hortobágy Greater Fishpond
- Fehértó at Szeged and Csaj lake at Tömörkény
- fishponds at Rétszilas.

Problems may arise after privatisation because fishpond owners will have exclusive rights if hunting is linked with ownership. To prevent conflicts it would be recommended to take as many fishponds as possible under the management of nature conservation bodies. Previous experiences show that leaseholders are forced into encouraging intensive hunting (mainly inviting foreign hunters) because of financial constraints.

Appropriate hunting methods on fishponds

Temporal restrictions

The simplest means of restriction is by permitting hunting only on certain days of the week usually on Saturday or Sunday. The number of hunting days can be further decreased if the open season is shortened e.g. to August–September or October only.

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Spatial restrictions
This method can be applied on larger ponds and pond systems. Areas where hunting is forbidden are established, to which waterfowl can retire on hunting days. Hunting days should be followed by undisturbed days to let the birds move back over the entire area of the ponds.

Complex regulation
a) Two year rotation
The pond system is divided into two parts with similar conditions for hunting. In year one hunting can take place on one part, in year two on the other part. Because the two parts are close to each other, birds can easily fly over to the undisturbed one. Hunting can be organised more easily as well. However, non-disturbance of the closed unit has to be strictly enforced for this system to work effectively.

b) Three year rotation
Three areas are formed on the fishpond. At any one time two are always closed while hunting is performed on the third one. Each area stays closed for two years and is then used for hunting for only one year during the three year cycle. If weekly restrictions are applied then birds will stay at the ponds and good hunting conditions are provided at the same time as well.

Goose hunting regulations
Hunting is prohibited on the most important fishponds excluding fishponds at Soponya, Tác and Sumony.

In Hungary hunting should be prohibited on all areas used for roosting by geese. It should be declared that geese may be shot in flight or on the foraging sites only. This is in the basic interest of hunting as well.

Angling

There is no tradition of angling on fishponds. However there are a few examples of the transformation of smaller fishponds (e.g. at Kadarcs, Gödöllő) into angling ponds. Around these ponds angling stages and bungalows were built gradually. This practice did not become widespread during the time of large-scale fish farming. Angling on fishponds became more and more common with the extension of leasing and accelerated with privatisation because new landowners wanted to increase their incomes by selling daily tickets as well.

Previously more or less closed areas became more popular and consequently more frequently disturbed.

Ecotourism

In Hungary organised ecotourism is not widespread on fishponds. This kind of habitat is visited mainly by bird watchers and nature photographers because of rarities, species richness and great abundance of certain species. These visits are mainly based

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on personal contacts and do not constitute a part of management. However, there are examples of ecotourism as a profit-oriented activity bringing in foreign students and friends of nature.

Ecotourism on fishponds should be allowed when the necessary infrastructure (bird hides and other watching sites, information centres etc.) has been developed.

Other sports

Other recreational activities such as water sports (wind surfing, water skiing) have appeared on larger fishponds of the Great Plain (e.g. at Borsós fishpond). Mass tourism should only be permitted on ponds of no nature conservation value.

2.5. Possibilities for protecting fishponds

Due to economic and political changes previous mechanisms for coordinating the various interests have been radically transformed in Central and Eastern Europe. During the socialist regime the only way to enforce interests was by legal regulation.

Recently the importance of legal regulation has not decreased but its effectiveness has significantly declined. The extension of private ownership throws into question the enforcement of previous regulations. Nowadays to restrict the rights of proprietors without any compensation is not acceptable. However, the requirements of environment-friendly fish management are often incompatible with the short-term economic interests of proprietors. Consequently the new nature conservation policy concerning fish management has to guarantee the maintenance of natural values of fishponds. The solution is to integrate nature conservation, sectoral and economic interests as well (see Appendix 1, page 98).

2.5.1. Obtaining property rights

The most effective way of protecting fishponds would be to place them under the ownership of nature conservation organisations (both governmental and non-governmental). This would ensure the coordination of interests of management and protection at the highest level. Unfortunately the privatisation of fishponds has been more or less finished without establishing the protection of the most important ponds.

The transitional law of cooperatives prohibited privatisation of protected fishponds only used by cooperatives. These ponds should have passed into management of nature conservation as with state property, but this has not happened yet. Csaj and Péteri lakes are in this category while the fishpond at Csanytelek has been privatised under unclear circumstances.

Concerning the protected state ponds no law has been accepted by parliament so far. Fishponds were privatised as animal keeping farms. The government intends to retain

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only certain ponds of the Balaton Fish Farm, the Warm Water Fish Hatchery at Százhalombatta and the Fish Culture Research Institute at Szarvas. The other pond systems are set under the control of the State Property Agency (ÁVÜ) and State Property Share Company (ÁVRt) with the properties of state farms, and most of them have already been privatised. During privatisation, respecting nature conservation regulations was only required from buyers of protected ponds. However, contracts have been written without any guarantee and management specification.

Among the protected ponds, Lake Fertő and a large part of Lake Fehér at Szeged have already been privatised. Most of the fishponds of Hortobágy Fish Farm (including the Hortobágy Greater Fishpond) and the Pacsmag fishpond have not yet been privatised.

Only the third, tenth and eleventh units of Lake Fehér at Szeged and sixth and seventh units of Hortobágy Greater Fishpond, with a total area of 800ha, had become the property of nature conservation organisations by 31 October 1994.

Non-governmental organisations have bought about 2,500ha of fishponds. Fishponds (at Csokonyavisonta, Lábod-Petesmalom, Mike and Soponya) previously belonging to the Balaton Fish Farm were bought by the Provincial Association for Nature Conservation Somogy, which bought Boronka fishponds too. A major part of the fishpond system at Biharugra has been bought by the Hungarian Ornithological and Nature Conservation Society (MME).

Consequently there are a few possibilities to acquire ownership of the most valuable fishponds by the nature conservation organisations.

2.5.2. Declaring protection

Under existing regulations nature conservation authorities can only intervene in the management of fishponds if they are protected. Declaring the most important fishponds protected would make it possible to coordinate the interests of fish farming and nature conservation through the development of management plans. Management plans for fishponds must include recommendations for the solution of problems such as those described in sections 2.3 and 2.4 above. Within the frame of the IUCN project experts have worked out management plans for three model areas, namely for Biharugra-Begécs fishpond system, at Hortobágy, and Lábod and Petesmalom fishponds. These plans formulate management techniques taking into account the interests of nature conservation and considering the characteristics of the respective pond systems (see Appendix 1, page 98).

Based on surveys made by the MME the following fishponds ought to be protected: Csécs, Ohat, Gyökérkút, Derzs, Fényes, Akadémia, Kúngyörgy, Elep, Virágoskút, Kengyel, Telekhalom, Tata (should be re-classified to national importance), Soponya, Tác, Rétszilas, Örspuszta, Sumony.

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2.5.3. Measures in water resource use

Water is essential for the life of waterfowl. Drained fishponds do not provide good habitats for these bird species for long. Thus maintaining non-intensive fish farming and management on ponds is in the fundamental interest of nature conservation.

From 1992 the Ministry for Agriculture has subsidised water-charges as a compensation for drought damage for fish farms. Unfortunately the system includes a lot of restrictions:

- compensation is awarded because of drought, thus it is not available for fish farmers at the beginning of the year
- compensation is independent of nature damaging or protecting management methods, and thus does nothing to stimulate better management
- compensation does not address the conflicts arising between fish management and nature conservation.

A lot of endangered waterfowl species – such as lesser white-fronted goose, slender-billed curlew, crane, great white egret, spoonbill and terns – require special use of water which means extra expense for fish farmers. In these reasonable cases extra expenditure ought to be compensated by nature conservation. Thus filling up of ponds would be far cheaper on those ponds where it serves the interests of nature conservation. Based on surveys made by the MME the following ponds are concerned in this respect:

- 6th and 7th units of Hortobágy-Nagy-Halastó and Kondás at Hortobágy
- 3rd, 11th, 13th and 14th units of Fehér lake at Szeged
- 3rd and 4th units of Csaj lake
- Biharugra: Nagyszik lake and Nagy-Csík lake.

In the case of the most important pond systems a wide-ranging compensatory system ought to be introduced because maintaining habitats on fishponds requires the management of the entire pond system coordinated with nature conservation interests. Thus nature conservation would undertake the payment of water-charges via the Environment Protection Fund, securing the ecological water resource use of the pond systems concerned. At the same time management would be carried out following a nature conservation management plan, in which disturbance to waterfowl would be prohibited and there would not be compensation for damages caused by birds. This compensatory system ought to be applied for ponds of international importance where hunting for waterfowl is prohibited, namely:

- Hortobágy-Nagy-Halastó
- Fehér-tó at Szeged
- Csaj lake
- Biharugra and Begécs ponds
- Rétszilas fishponds
- Öreg-tó at Tata.

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2.5.4. Environmentally Sensitive Ponds – introducing the ESA system to fishpond areas

Instead of a systematically supported water resource use an alternative way of support could be the compensation system of the zonation programme of the European Union. Introducing the system is partly motivated by the obligations undertaken in the articles of a partnership made with the EU. Background regulations to introduce the system are included in the draft version of the nature conservation law (under the title "Environmentally Sensitive Areas"). According to studies made by the MME and the WWF, beside grasslands and extensive arable lands, fishponds are areas where introducing such a system ought to be required in Hungary. This is because a great number of endangered species live there whose existence fundamentally depends on management of these habitats.

Application of the system is made difficult by the much more complex management methods of fishponds compared to other agricultural systems. To fit the regulation of EU no. 2078/92 the ESA systems applied on fishponds would have to include such specifications which restrict or decrease the intensity of production. Regulating the periods of draining, filling up and reed mowing could be a fundamental part of these specifications.

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Appendix 1. Examples of model management plans for Hungarian fishponds

Biharugra-Begécs Fishpond system

The site is one of the best places for evaluating a model management plan in Hungary, because there exists traditional fishery management which takes natural values into account, it is owned partly by a nature conservation NGO, two relevant research institutes are close to it, cooperation between local authorities is much better than in other parts of the country, and it lies far from parts of the country which have a polluted environment or have to cope with (mass) tourism. The owners are forced to exploit the economic potential of the pond system not only because they wish to maintain the traditional fishery-connected natural values, but because they are left with a large debt after buying the land. The managers are able to test several other methods as well on the diverse fishpond system where a great variety of habitats and human experience have developed in the past decades.

Site
The pond systems are on the Biharugra Landscape Protected Area (No. 217/TK/90) in Békés county (46°58'N, 21°35'E). It has also been a proposed Ramsar site since 1991, and is listed in the Important Bird Areas of Europe (IBA 036).

name	date created	area
Biharugra Fishponds	1909–1911	752ha
Begécs Fishponds	1960–1963	1,175ha
total:		1,927ha

Biharugra Pond is a diked artificial water body, Begécs is a diked and flooded marsh. Together they contain 30 pond units (more than 100 water bodies) of 1–150ha. The ponds are close to the national border, and a road crosses the area connecting the neighbouring village to a duck farm (soldiers and farmers cross the area regularly). There are several farm buildings, stock houses and even observation towers in the vicinity of the ponds. The ponds form an ecological unit with the Cséfa Pond System in Romania (IBA 018).

Data for the area
Local history and fishery data can be found in Biharugra, while natural history data are stored in the Faunistical Register and at the Hungarian Wild Goose Group of the Hungarian Ornithological and Nature Conservation Society (MME).

Tenure
Upon privatisation the Fishery of Hidashát State Farm fishponds became the property of Mercurius Ltd. (owned by MME, former leaders of the Fishery, and some individual

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members of MME). The property rights cover utilisation of pond bed and canals. Owners lease 280ha of ploughed land for growing crops for fish food. Forestry management and hunting rights belong to the DALERD Co. Tempó Ltd is contracted for five years for reed mowing.

Regulations

The nature conservation authority is the Kőrös-Maros Nature Conservation Directorate. There is one major ranger on this area. Beside the general regulations of nature conservation there is a Management Prescription (KVM TVF-293/89) for the area and a Management Plan from the former nature conservation authority (Kiskunság NP, Oct. 1991). Regulations in effect are:

- Reed mowing is allowed between 1 November and 28 February without licence.
- Water level changes are allowed between 15 July and 1 April. Outside this period the manager should consult with the nature conservation authority over any water level adjustment, except in the case of hatcheries.
- The area has been closed to waterfowl hunting since 15 August 1993 (8/1993. Min. Agric.).
- The nature conservation authority licenses disturbance of birds.
- Times for reed mowing should be agreed in advance by the area manager.

Land use

Fishery: fish breeding and fish rearing.

Recreation: wild boar and pheasant are hunted (time of shooting is agreed in advance with the nature conservation authority). Angling is forbidden. Visits to the area are made regularly by local bird watchers and occasionally by foreign researchers. Previous initiatives to create accommodation for ecotourism on the neighbouring farms have stopped.

Management

There are detailed temporal and spatial prescriptions for water level regulation, reed management, pond bed and fish rearing pond maintenance, wild boar hunting, reed grass mowing, reed burning, transportation, forestry and landscape management, fish stocking and forest plantation species composition, and fertilisation and liming. All of these take into account nature conservation values (e.g. egret, avocet, tern and goose nesting success, waterfowl resting areas and behaviour and landscape of high value) and economic interests (e.g. fish breeding and fish yield, reed mowing and hunting). All damaging activities (e.g. reed burning, bird disturbance and egg collecting) are described and well-known, so they can be managed and problems can be prevented.

Factors lacking in this long-term management plan include infrastructure, financial support, maintenance of good quality water input, effective methods for cormorant population regulation, a compensation fund (e.g. for damage to neighbouring crop lands by geese), a

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zonation based visitor regulation, acknowledgement on national and international level, and even human capacities (e.g. educating local people, employing guards against theft).

Hortobágy fishponds

The Hortobágy fishpond system surrounded by the famous puszta habitats is the largest in Hungary, covering about 20% of all fishponds. The Hortobágy Greater Lake is the largest fishpond in Hungary, with an area of 1,850ha. The species and habitat diversity of the area is outstanding even by international standards. More than 80% of all recorded Hungarian bird species occur here. Owing to the age of the ponds, they have a high landscape value as well. The area is one of the most important gathering places in Europe for crane *Grus grus*. The globally threatened lesser white-fronted goose *Anser erythropus* and slender-billed curlew *Numenius tenuirostris* also appear regularly. The many rarities include *Platalea leucorodia* and *Chlidonias hybrida* breeding in colonies, and the largest number of *Haliaeetus albicilla* wintering in Hungary. These species are sensitive to changes in land use and to any kind of disturbance.

The manifold and sometimes conflicting interests of fishery, reed management, hunting, tourism and nature conservation make any kind of cooperation difficult. Although a detailed conservation management plan has been elaborated concerning water, pond bed and reed management, hunting, farming and tourism, the only solution in this case could be the protection of the whole fish-pond system. At the very least fishponds meeting the criteria for Ramsar sites (Virágoskút, Elep and Csécs) should be protected.

Site

The pond systems are in the Hortobágy National Park, the most visited tourist site in Hungary. Two of the 15 ponds are protected. The Greater Lake is a Ramsar site. The ponds are diked artificial water bodies of different ages.

Data for the area

Local history, natural history, hunting records and fishery data can be found in the National Park Directorate. The ecosystem of the area is well studied, and Dr G. Kovács and M. Bodnár investigated the connections between fishery and bird populations.

Tenure

Ownership rights belong to the Hortobágy Fishery for the majority of the ponds. The Fishery is under privatisation, and many of the ponds are managed by leaseholders. Some of them are managed by the National Park or by the Water Management Directorate.

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Regulations
The nature conservation authority is the Hortobágy National Park Directorate. Beside the general regulations of nature conservation waterfowl (even cormorant) hunting and disturbance is prohibited on the Greater Lake. The tenancy agreement specifies the nature conservation regulations in the case of outer ponds.

Land use
Fishery and reed management are not well coordinated between entrepreneurs and nature conservation. There are domestic goose farms in the Ohat, Derzs, Gyökérkút, Kónya and Akadémia ponds. Because of recent economic constraints, many of the fishponds are now drained and used as farm land.

Recreation
Waterfowl are hunted on all ponds except the Ramsar site Greater Lake. Hunting is not affected by nature conservation interests. Angling is significant on the Csécs Pond and on its channels, and on the Kadarcs and Borsós Ponds. The Greater Lake is a tourist attraction.

Conflicts and management
Detailed temporal and spatial prescriptions exist only for the Hortobágy Greater Lake. The prescriptions are: draining cannot take place during the breeding period of herons; bird disturbance is prohibited (and in 1991 *Phalacrocorax pygmeus* and *Plegadis falcinellus* established breeding colonies here); at least one basin of the pond should be 25%–30% filled by water to support cranes resting in the area until the end of November; reed-grass mowing is prohibited in breeding season; reed can be mowed only between 1 December and 28 February, but reeds with heron colony sites should be left and a buffer strip should remain around them; old reeds and other vegetation should never be burned; hunting is prohibited everywhere in the National Park area.

There is no nature conservation management on other ponds, but they are regularly visited by rangers and researchers of the National Park. If a threatened protected species is found, the general nature conservation rules should be applied, which are usually sufficient to protect nests and individuals, but not to control water or reed management or tourism. The fishery management exploits many ponds ruthlessly. Birds are disturbed by guns and aircraft. Water level changing (both draining and re-filling) is usual in the breeding season. Vegetation is burned in spring or mowed in the breeding season and channels are maintained in summer. Clear cutting of reeds, even in March and April, and burning of old reeds is also usual. The use of large-scale machinery pollutes and destroys water and soil. Reed is processed on the pond sides and thus pollutes the water. Goose farms overpopulate some ponds. Night hunting and Italian style shooting disturb all wildlife. The main target destination for 'green' tourism (namely birding) in Hungary is the Greater Lake. Fisheries and reed management could also be of interest to tourists if better conditions and a less

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depressing environment were ensured. Tourist firms should collaborate with the National Park to put forward common projects for development.

Somogy Wetland Programme

The Somogy Wetland Programme is based on the historically almost continuous wetlands and 1,500km² of marshes in the area between Lake Balaton and the river Dráva. The Somogy Provincial Association for Nature Conservation planned to protect and reconstruct at least a part of this interesting habitat. Their principles are the same as for the EECONET project although they started this programme more than seven years ago. This is the only example in Europe where a green corridor system has been established on areas owned by nature conservation NGOs. The core areas are the protected natural and semi-natural places of the region, and the channels, smaller wetlands and even fishponds (e.g. at Mike, Lábod, Petesmalom and Csokonyavisonta) of the valleys serve as corridors. The fishponds of the valleys are habitats for the largest Hungarian populations of otters, white-tailed eagles and black storks. The Somogy Association own five fishpond systems (of which only one is protected), and they have developed a management plan for the Petesmalom Fishponds.

The barrage-dammed ponds were built at the beginning of this century. The 111ha owned by the Association covers 71ha of ponds and 40ha of farm land, reed and meadow. In spite of this small area, a great diversity of habitats and species can be seen here. The long-established fishery activities resulted in a landscape of scattered ponds with wide reed belts and forested hillsides. Fishponds are managed extensively, so they maintain wildlife and natural processes, and have produced a suitable place for environmental education and 'green' tourism. Education trails, camp sites and an otter rehabilitation presentation were created at the ponds, and summer international camps are regularly organised. The cooperation between the Society and local people is fairly good because many visitors stay in the houses of neighbouring settlements. Traditional fishery, agricultural work and natural values are introduced to the visitors. The programme is so successful that the full season (3.5 months) is reserved before summer. The Association together with the Pannon Agricultural University continues technological studies and experiments for elaborating an environment-friendly fishpond management system.

Proprietorship

Balaton Fishery was the area manager until privatisation in 1992. The Somogy Association and the Somogy Forestry bought the ponds as private owners.

Regulations

Only the general nature conservation regulations are effective on ponds. On ponds managed by the Association hunting is prohibited on a contractual basis. As a compensation, hunters may fish on one of the ponds.

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Land use

Owing to the high value of the deer population and large flocks of ducks on neighbouring sites, hunting played a significant part in the economy of the fisheries. The area is a recreation site for people from south-west Hungarian towns, as well as for foreign visitors.

Conflicts and management

The quality of inflowing water is worsening, and consequently there is a great danger of habitat and species loss. Hunting, angling and tourism disturb wildlife (e.g. transport disturbs egg-laying tortoises). Besides the common conflict points mentioned at Hortobágy (e.g. reed burning, timing of water level adjustment) inappropriate fishpond management, namely abandoned ponds and bad stocking (species composition and age of fish), is the most important threat here. Abandonment hastens succession, leading to the ponds gradually drying out, and bad stocking degrades or changes the vegetation of ponds.

The detailed management plan deals with all avoidable types of damage and all activities for the long-term survival of this small ecological unit. The protection of the above mentioned pasture of high botanical value should be chosen as the first conservation priority, and the northern degraded pastures may act as a buffer zone for the pond system after applying habitat restoration measures.

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Appendix 2. Recommendations of the Fishing and Nature Conservation Conference held at the Fish Culture Research Institute, Szarvas, 13 December 1994

The area of habitat suitable for water related plant and animal species is continuously decreasing. Fishponds are becoming increasingly important wetland habitats. The basic interest of both fisheries and nature conservation is in sustaining the area and its ecological potential.

The participants of the Conference on Fishing and Nature Conservation, 13 December 1994, accepted the following proposals:

1. For ecological and economic reasons a constant and safe water table level for fishponds has to be ensured.
2. A water price has to be differentiated according to the nature conservation values of the different fishpond systems.
3. Water resource use for ecological purposes should be free on fishponds rich in natural values.
4. After the drought of the last decade it is necessary to retain the maximum possible amount of water in our region, so that water inflow (by gravitation) should be free of charge out of the breeding season.
5. If a fishpond has better quality outflowing than inflowing water than it should be handled and supported as a biological sewage cleaning system.
6. A monitoring activity should be continued on fishponds for studying the role of fish-eating animals.
7. Technical methods of damage appraisal should be elaborated as the basis of future compensation.

Organisers of the Conference: Hungarian Ornithological and Nature Conservation Society, IUCN-Hungarian Foundation, National Alliance of Fish Producers, Fish Culture Research Institute, WWF-Hungarian Office.

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3. Poland

3.1. Fishponds in Poland

A pond is a shallow, natural or artificial, flow-limited water reservoir. This study deals with artificial water bodies. As ponds are not as deep as lakes, their thermal and chemical vertical differentiation, as well as the bottom differentiation, are insignificant (Mikulski 1974, Starmach *et al.* 1978). Fishponds have been built in Central Europe since the Middle Ages (Inglot and Nyrek 1960, Berka 1985). At the end of the 12th century carp *Cyprinus carpio* was brought to Poland from Bohemia and Moravia by Cistercian monks and became the main species bred in the fishponds. Ponds also performed many other important functions. Water-mills, saw-mills and fulling-mills (mills for cleansing cloth) were built on a system of races supplying water to the ponds. Weirs and mill-races reduced water runoff from the catchment area, increased water retention and regulated the groundwater level in the area. Ponds situated in palace parks and properties constituted a significant component of the cultural landscape of the Polish countryside.

In 1985 there were 699 systems of fishponds registered in Poland, covering an area of about 48,600ha. From 1985 to 1993 the number of ponds first declined and then increased again. Pond area has declined to 45,600ha (Table 1). The number of large ponds (51–200ha) has particularly declined. At the moment small ponds (below 50ha) are the most numerous. They make up 63.4% of all groups. Ponds over 500ha make up only about 1.0% (see Table 2).

The distribution of ponds is very uneven across Poland. Most are situated in central and southern Poland. There are three main areas: south-west Poland (provinces Legnica and Wrocław), south Poland (provinces Bielsko and Katowice) and south-east Poland (provinces Tarnobrzeg, Lublin and Chełm). The areas with the least numerous ponds are the Baltic coast, the lake districts Mazurskie and Pomorskie and most of the mountain districts. A large percentage of the total surface area of ponds in Poland (33.3%) is found in the following provinces: Wrocław, Bielsk, Tarnobrzeg and Katowice. Management for

Table 1. Changes in number and water area of ponds from 1985 to 1993 (modified from GUS 1994)

	1980	1985	1990	1992	1993
Water area (1,000ha)	45.6	48.6	46.8	44.8	45.6
Number of ponds (systems)	636	699	686	680	709

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Table 2. Fishponds in size order (modified from GUS 1994)

	1985		1993	
area in ha	**number**	**proportion (%)**	**number**	**proportion (%)**
10–25	223	31.9	250	35.3
26–50	179	25.6	197	27.8
51–75	103	14.7	98	13.8
76–100	63	9.0	43	6.1
101–150	68	9.7	64	9.0
151–200	29	4.1	24	3.4
201–500	27	3.9	25	3.5
> 500	7	1.0	8	1.1

fishing hardly exists in the provinces Nowy Sącz, Suwałki, Krosno and Wałbrzych (Figure 1).

The distribution of ponds among landscape types in Poland is fairly uniform, ranging from 116,000ha of ponds in agricultural landscapes to 147,000ha in woodland. Ponds situated in meadow areas make up 142,000ha. Pond holding sizes and the average pond area are more varied. The largest holdings are situated in the areas with a predominance of meadows (on average approximately 72ha), the smallest ones in agricultural regions with a predominance of ploughed land (approximately 35ha). Woodland holdings take the middle position (approximately 54ha). The average pond size ranges from about 7ha in the agricultural landscape to about 12ha in meadow landscapes. The average size of pond areas in woodland is about 8ha (Table 3). The distribution of ponds among landscape types in provinces does not indicate any geographical pattern. The predominance of ponds in agricultural landscapes was recorded in nine provinces, in meadows in ten provinces and in woodland in 14 provinces. Ponds in inhabited areas were recorded in 16 provinces. Their contribution to the total pond area was the largest in the province of Warsaw (approximately 34%). In the rest of the provinces it ranged from 1% to 15% of the total pond area.

At the moment there are three kinds of ownership of fishponds in Poland: state, cooperative and private. Ponds which are owned by the state cover an area of 40,232ha (usable area), making up almost 78% of the total pond area in Poland. Groups of ponds which are cooperatively or privately owned make up a small percentage of the total area. The Agencja Własności Rolnej Skarbu Państwa (the Agriculture Agency of the State Treasury, established in 1991) has taken possession of all ponds which were owned by the Ministry of Agriculture properties and included them in the Zasób Własności Rolnej

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Figure 1. The percentage of total fishpond area for each province in Poland (vertical solid line: average province value, dotted line: standard deviation)

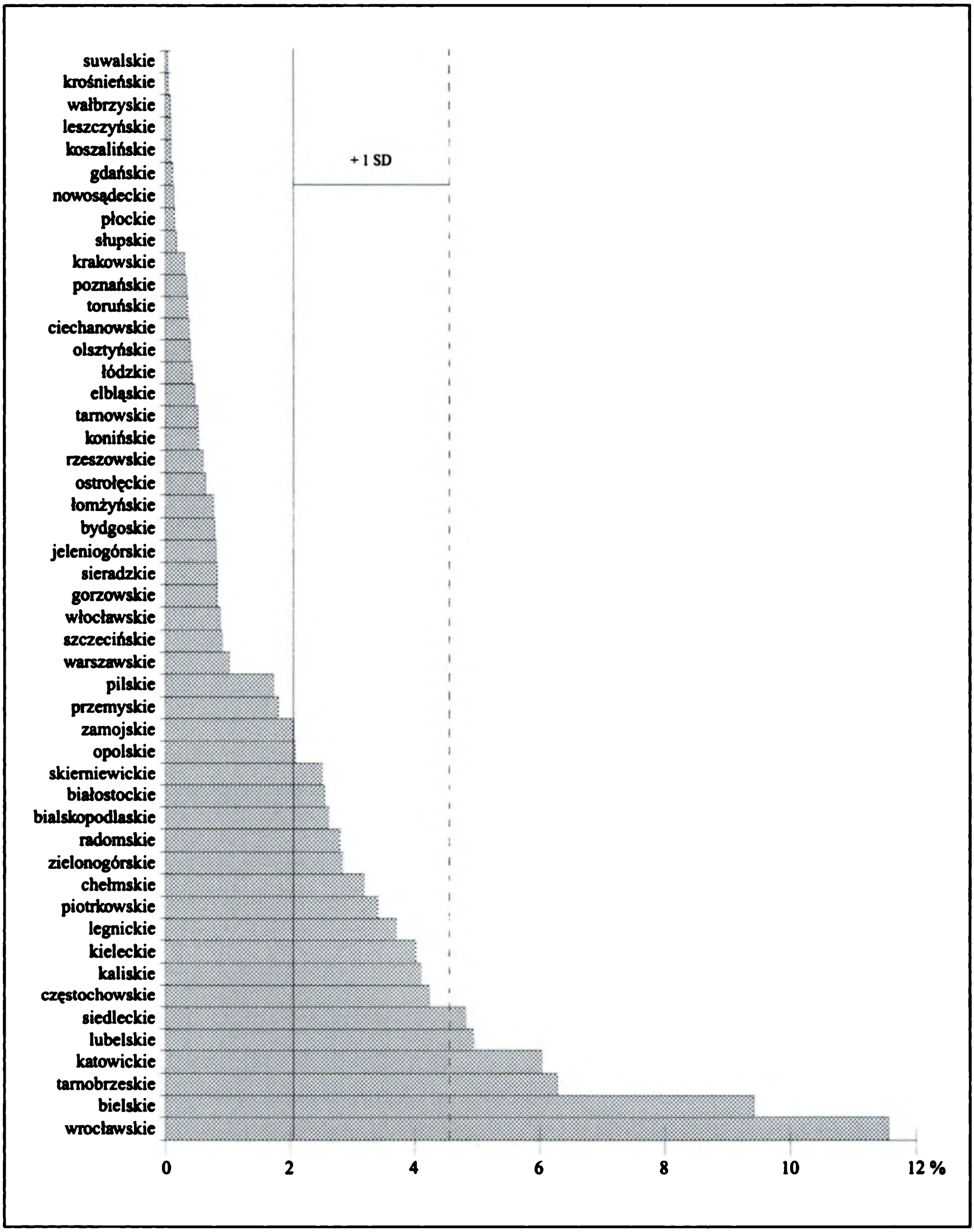

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Table 3. Environmental distribution of fishponds in Poland

province	land use around ponds																				
	fields			mostly fields			meadows			mostly meadows			woodland			mostly woodland			mostly built up		
	area (ha)	no. of systems	no. of ponds	area (ha)	no. of systems	no. of ponds	area (ha)	no. of systems	no. of ponds	area (ha)	no. of systems	no. of ponds	area (ha)	no. of systems	no. of ponds	area (ha)	no. of systems	no. of ponds	area (ha)	no. of systems	no. of ponds
Bialskopodlaskie	100	3	26	–	–	–	155	4	17	375	3	14	–	–	–	470	2	11	–	–	–
Białostockie	235	4	30	20	1	5	10	1	1	646	3	16	–	–	–	165	2	11	–	–	–
Bielskie	450	14	70	1,690	20	177	35	2	3	1,060	3	35	10	1	10	10	1	1	580	4	55
Bydgoskie	45	2	10	10	1	5	24	3	23	10	1	4	15	1	12	35	2	21	–	–	–
Chełmskie	105	2	8	280	3	19	20	2	5	350	4	47	346	3	26	155	1	15	90	1	10
Ciechanowskie	25	2	7	–	–	–	55	3	28	60	1	10	20	2	10	–	–	–	–	–	–
Częstochowskie	75	3	11	80	4	13	65	1	4	380	7	30	505	11	49	645	17	80	35	1	2
Elbląskie	90	4	21	–	–	–	–	–	–	40	2	6	10	1	1	60	1	1	–	–	–
Gdańskie	–	–	–	50	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Gorzowskie	–	–	–	–	–	–	75	3	27	10	1	1	215	5	19	55	3	19	–	–	–
Jeleniogórskie	–	–	–	35	2	2	105	3	19	50	1	13	450	3	36	–	–	–	–	–	–
Kaliskie	55	3	12	95	6	28	70	1	6	280	3	11	265	11	34	920	8	63	10	1	3
Katowickie	490	13	125	700	15	106	40	3	8	940	10	43	95	6	23	330	8	37	70	4	12
Kieleckie	385	10	69	385	10	50	–	–	–	615	8	66	175	6	25	260	8	44	–	–	–
Konińskie	80	2	16	10	1	1	35	2	6	10	1	2	10	1	2	80	3	14	–	–	–
Koszalińskie	–	–	–	10	1	6	–	–	–	–	–	–	30	2	10	–	–	–	–	–	–
Krakowskie	25	1	2	75	3	12	–	–	–	–	–	–	20	2	17	–	–	–	10	1	2
Krośnieńskie	–	–	–	20	2	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Legnickie	30	2	2	220	2	4	860	5	56	295	6	44	100	3	16	–	–	–	55	2	4
Leszczyńskie	20	1	4	–	–	–	10	1	7	–	–	–	10	1	4	–	–	–	–	–	–
Lubelskie	545	10	37	335	7	44	30	2	10	490	11	47	235	6	34	370	6	33	125	7	22
Łomżyńskie	60	3	8	65	1	3	–	–	–	–	–	–	–	–	–	200	2	26	–	–	–
Łódzkie	35	2	10	85	1	8	–	–	–	–	–	–	20	1	4	40	1	6	–	–	–
Nowosądeckie	30	3	10	–	–	–	–	–	–	25	1	5	–	–	–	–	–	–	–	–	–
Olsztyńskie	105	5	10	65	3	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

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Opolskie	215	10	35	145	3	19	10	1	1	45	3	19	605	10	56	150	4	15	80	6	15
Ostrołęckie	50	2	9	–	–	–	170	2	18	–	–	–	50	2	10	–	–	–	–	–	–
Pilskie	–	–	–	160	2	13	400	2	29	–	–	–	45	2	13	125	1	9	–	–	–
Piotrkowskie	150	6	14	60	2	16	30	2	5	280	9	45	575	11	45	345	5	29	–	–	–
Płockie	15	1	6	–	–	–	15	1	1	35	1	7	–	–	–	–	–	–	–	–	–
Poznańskie	25	1	7	145	2	28	10	1	2	–	–	–	–	–	–	55	3	16	10	1	3
Przemyskie	20	2	2	–	–	–	–	–	–	355	2	15	220	8	46	170	3	17	–	–	–
Radomskie	140	7	27	330	7	45	105	2	8	210	3	20	100	5	22	240	6	25	70	2	2
Rzeszowskie	15	1	2	70	2	11	40	1	6	–	–	–	30	1	3	100	2	20	–	–	–
Siedleckie	420	14	57	420	9	35	195	4	21	630	11	55	45	2	4	430	5	23	–	–	–
Sieradzkie	15	1	4	25	1	7	20	1	3	200	5	20	75	4	23	–	–	–	30	2	4
Skierniewickie	275	9	31	75	2	12	50	1	4	695	7	37	–	–	–	105	1	6	–	–	–
Słupskie	15	1	2	–	–	–	20	2	11	–	–	–	20	2	4	20	2	12	–	–	–
Suwalskie	15	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Szczecińskie	135	6	23	80	4	8	100	3	18	–	–	–	15	1	5	40	3	19	25	2	6
Tarnobrzeskie	55	2	5	325	7	51	150	1	12	70	1	3	1,320	6	157	550	4	47	–	–	–
Tarnowskie	85	6	16	25	1	2	–	–	–	–	–	–	100	2	6	10	1	1	–	–	–
Toruńskie	20	1	3	15	1	1	–	–	–	–	–	–	20	1	1	–	–	–	–	–	–
Wałbrzyskie	25	2	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	1	7
Warszawskie	115	4	20	–	–	–	15	1	3	60	2	5	–	–	–	95	1	7	145	3	15
Włocławskie	105	4	35	–	–	–	–	–	–	225	1	8	40	2	8	–	–	–	–	–	–
Wrocławskie	130	10	28	20	2	6	70	1	37	2,755	7	62	500	9	48	1,360	12	78	45	2	6
Zamojskie	395	11	57	215	6	24	–	–	–	230	2	16	30	2	8	–	–	–	–	–	–
Zielonogórskie	55	5	14	20	2	8	25	2	7	85	2	17	605	15	87	410	7	91	–	–	–
total	5,475	196	896	6,360	137	791	3,014	64	406	11,511	122	723	6,926	151	878	8,000	125	797	1,390	40	168
%	12.8	23.5	19.2	14.9	16.4	17.0	7.1	7.7	8.7	27.0	14.6	15.5	16.2	18.1	18.8	18.7	15.0	17.1	3.3	4.8	3.6
average pond size (ha)	6.11			8.04			7.42			15.92			7.89			10.04			8.27		
	7.02						12.87						8.91								
average pond complex size (ha)	27.93			46.42			47.09			94.35			45.87			64.00			34.75		
	35.54						78.09						54.08								

– : does not occur in province

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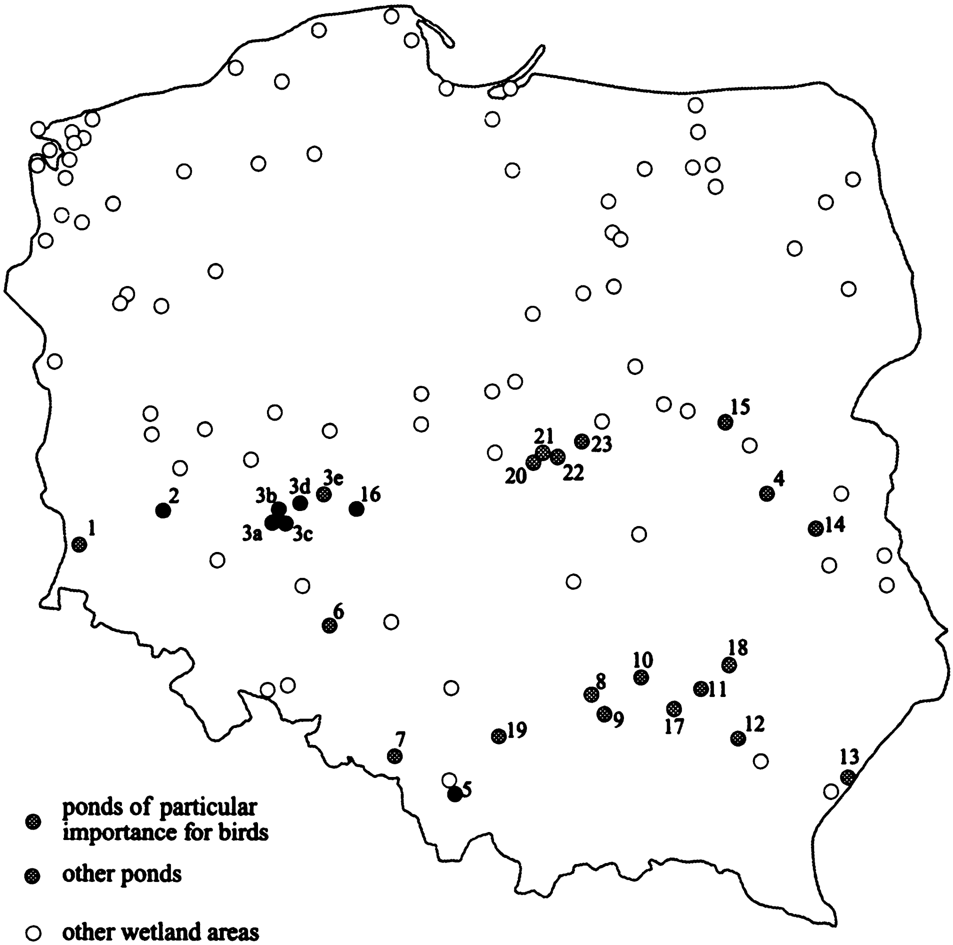
Figure 2. Distribution of wetiands of international importance for birds in Poland (according to ICBP and IWRB classifications; modified from Grimmett and Jones 1989)



1: Parowa. 2: Przemków. 3: Milicz (3a: Jamnik, 3b: Radziądz, 3c: Ruda Sułowska, 3d: Sławno, 3e: Potasznia). 4: Siemień. 5: Ligota. 6: Niemodlin. 7: Łężczak. 8: Młodzawy. 9: Górki. 10: Grobla. 11: Buda Stalowska. 12: Poręby. 13: Starowa. 14: Sosnowica. 15: Kotuń. 16: Stare Przygodzice. 17. Osieczyska. 18: Lipa. 19: Przeręb. 20: Mysłaków. 21: Okręt i Rydwan. 22: Walewice. 23: Psary.

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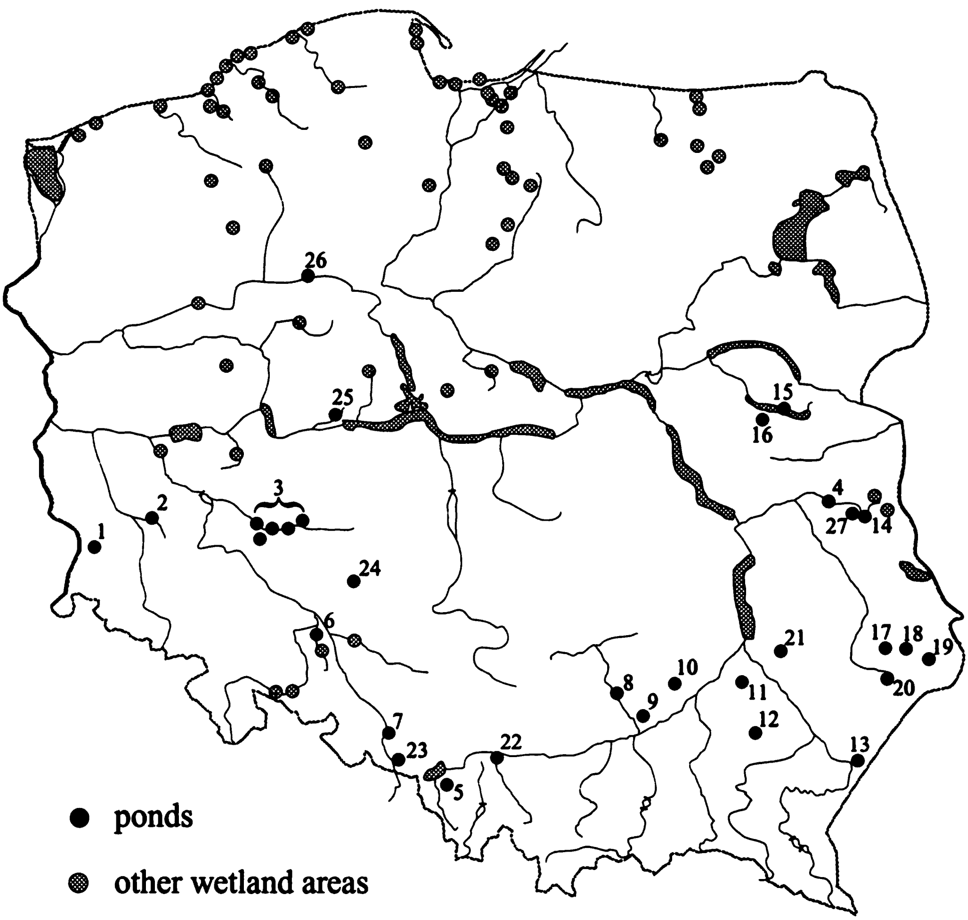
Figure 3. Important refuge areas for waterfowl (modified from Winiecki and Wesołowski 1987)



1: Parowa. 2: Przemków. 3: Milicz. 4: Siemień. 5: Ligota. 6: Niemodlin. 7: Łężczak. 8: Młodzawy. 9: Górki. 10: Grobla. 11: Buda Stalowska. 12: Poręby. 13: Starowa. 14: Sosnowica. 15: Kotuń. 16: Broszków. 17: Łabuńki. 18: Duba. 19: Huczwa. 20: Tarnawatka. 21: Imielity Ług. 22: Zator. 23: Wielikąt. 24: Krystyna. 25: Miłosław. 26: Ostrówek. 27: Białka Lubiszów.

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Skarbu Państwa (Agricultural Properties Fund of State Treasury). The next step in the change of ownership is the sale or leasing of all these ponds. The process of privatising the first two fish holdings (Mała Rasowa and Niedźwiedzice in Legnica province) began in November 1993.

Systems of fishponds as well as other wetlands can perform an important function as a habitat for birds. The first step towards wetland classification (including ponds) in terms of their biological importance was cataloguing the areas of special importance for bird conservation, supervised by the International Council for Bird Preservation (ICBP, now BirdLife International) and the International Waterfowl and Wetlands Research Bureau (IWRB, now Wetlands International). The main task was locating the most significant areas for bird conservation in Europe (Grimmett and Jones 1989). In Poland 126 such areas have been located (78 of special importance for waterfowl). Of these, 27 are systems of fishponds (that is, 35% of all important wetlands). The distribution of these systems against the background of all valuable wetlands in Poland is shown in Figure 2. They are mostly situated in Upper Silesia and Lower Silesia and also in the provinces of Tarnobrzeg and Katowice. Using the criteria of the Ramsar Convention (with regard to numbers and density of each species) the present authors found six groups of fishponds to be particularly important for the conservation of waterfowl breeding sites and migration routes in Europe. They are as follows: Ligota (Katowice province), Przygodzice (Kalisz), Milicz (Wrocław), Parowa (Jelenia Góra), Przemków (Legnica) and Siemień (Bielsk Podlaski). Only two of them, Milicz ponds and Przemków ponds, are actually protected as nature reserves.

Besides wetlands of international significance, those of national significance have also been catalogued. They are so-called refuges for waterfowl (Dyrcz 1985, 1989, Winiecki and Wesołowski 1987, Wesołowski and Winiecki 1988). Among 119 wetlands of this kind there are 27 groups of fish ponds (Figure 3). Some of them are also of international significance. Of the pond systems 26 out of 27 are notable for their variety of species. Only four of the appointed areas are actually under protection: Milicz ponds (five systems), Przemków ponds, Broszków Ponds and Łężczak. One group, Imielity Ług, is actually within a landscape park. Ponds near the villages Młodzawy and Górki are within a landscape protection zone. Generally the law protects only 26% of all pond systems (14.8% are included in natural reserves and 11.1% are within the range of landscape parks or protected landscape zones).

3.2 Economic importance of fishponds

The general purpose of fishpond management is to reach as high a level of efficiency of production as possible. It is measured by the annual (seasonal) increase in fish population, which depends on the type of management. The process of increasing the fish population

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also depends on biotic and abiotic factors (Starmach *et al.* 1978). One approach to pond management development is intensive breeding of high productivity species with low maintenance costs as well as efficient manufacture and marketing. The alternative way is complex (integrated) management – many different species with different requirements but also relating pond management to other sorts of management (Wojda 1981a, b). Traditional, extensive fish production methods are limited by the amount of natural food, so production is not as efficient (Szumiec 1985a, b). If fishponds are properly restored, the traditional carp breeding may increase to optimum density and a proper balance can be achieved between natural and artificial food. Production can reach a maximum of 2,500kg/ha with a density of 2,000–2,500 two-year-old carp or 10,000 one-year-olds per hectare (Szumiec and Szumiec 1993). The process is also conditioned by increasing the frequency of feeding and the amount of feed, which depends on the species and age of the fish as well as temperature and oxygen content in the water. If the carp breeding is accompanied by other species (silver carp, grass carp) production may increase by approximately 30% (Opuszyński 1989).

In Poland extensive management is most common, involving shallow ponds no bigger than 50ha with a thick layer of sediment. It is affected by weather conditions, exploitation of obsolete types of ponds, high modernisation costs, and low quality or shortage of water (Kruger 1985). In Poland there are more than 10,000ha of unexploited or hardly exploited old ponds and areas which used to be ponds. Pond production is limited by climate conditions as well as by consumers' habits. Only two species of fish, carp and trout, are involved. At the moment the dominant species in fish management is carp (over 95% of all production). Most carp ponds are situated in the following provinces: Wrocław (6,991ha), Bielsko (5,339ha) and Tarnobrzeg (4,035ha) (Szczerbowski 1993). The success of this type of management depends on climate and the methods employed. Efficiency of carp production ranges from 200kg/ha to 3,200kg/ha. The most efficient production has been recorded in Wrocław region and Łódź region, the least efficient in Mazury district and Lublin region. The reasons for low efficiency production in the Lublin region are unsuitable climate and, chiefly, use of obsolete pond types (ponds in cascade systems).

In 1988 total fish production in state ponds was 21,172 tonnes (mostly carp), which makes up 82% of all pond production in Poland. Cooperative and private pond systems make only a small contribution to the total fish production in Poland (see Table 4). Among other species of breeding fish only trout is of economic interest. Trout holdings are concentrated in north Poland (Pomorze) and south Poland (Karpaty and Sudety). The important advantage of trout management is the possibility of high production in a comparatively small area. However, trout require a lot of well-oxygenated water and a small temperature range. In 1992 trout holdings reached a total production of 41,526 tonnes, 60.6% from state pond holdings, 36% from individual holdings and 3.4% from experimental cooperative and state holdings.

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Table 4. Productive area of ponds belonging to different owners (from Szczerbowskí 1993)

pond owners	area (ha)	productivity (tonnes)
State Fishing Holdings	31,276	16,835
Other units of State Agriculture sector	5,201	2,690
Fishing holdings of State Forests	3,452	994
Fishing holdings of non-agricultural sectors	303	653
Cooperative fishing holdings	2,048	964
Polish Fishing Club	1,502	101
Private holdings	7,939	3,382
total	**51,721**	**25,619**

3.3. Environmental importance of fishponds

In spite of the fact that ponds are usually exploited as nursery ponds for fish, they also perform many other functions. Their environmental function depends on size, situation and type of management. Fishponds can considerably improve hydrological conditions in an area. They may regulate the groundwater level and they serve as additional reservoirs during dry weather (Fic and Macioszczyk 1985). In Poland the total content of water in ponds is approximately 500 million cubic metres (Augustyn *et al.* 1994). Another important function is the removal of organic substances from the inflowing water by using them for primary production (e.g. plant growth) (Augustyn *et al.* 1994). Pond complexes situated near reservoirs prevent marsh formation in the shallow upper part of these reservoirs and, with competent management, can also prevent biogenic water contamination. Ponds which are situated in river catchment basins influence water quality in a similar way (Bointe 1977, Polak 1985). The elimination of nutrients in fishponds depends not only on biological absorption, but also on the chemical and physical conditions of the pond water in comparison with river water. In ponds, denitrification occurs in the bottom layers of the water due to the low concentration of dissolved oxygen. Phosphates are precipitated when the water is intensely alkaline. The emergent flora of the pond ecosystem plays an important role in accumulating biogenic substances. The excess of nutrients in ponds can then be removed by cutting out reeds, which can be used as fertiliser elsewhere.

Fishponds are an important landscape element, especially if there is no other water in an area. The eutrophication commonly found in ponds produces rich vegetation growth and consequently provides a habitat for a great number of animal species. Ponds are a potential biotope for many plant and animal species which are in danger of extinction due

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to the destruction of their natural habitat. For example, waterfowl have always been an important component of pond ecosystems. Fishponds are a substitute for their natural biotope. Some pond systems are actually protected to conserve their biological value. So far there are nine pond systems with this conservation status: Nowokuźnicki pond and Smolnik pond (Opole province) – flora reserves; Wydymacz ponds (Kalisz) – landscape reserve; Milicz ponds (Wrocław), Przemków ponds (Legnica), Łężczak pond (Katowice), Broszków pond (Siedlce), Raszyn ponds (Warsaw) and Stawinoga pond complex (Ostrołęka v.) – fauna reserves.

3.4. Importance of fishponds for waterfowl

In a study of 59 fishponds, 127 species of waterfowl have been recorded (see appendices, pages 134 and 136). Dense rush beds usually ensure suitable habitat for nesting birds (bittern *Botaurus stellaris*, little bittern *Ixobrychus minutus*, coot *Fulica atra*, all species of grebes *Podiceps* spp., moorhen *Gallinula chloropus*, reed bunting *Emberiza schoeniclus*, sedge warbler *Acrocephalus schoenobaenus*, great reed warbler *A. arundinaceus* and reed warbler *A. scirpaceus*). Partial cutting of rushes, if done before the nesting period, can supply waterfowl with plenty of nesting materials as well as securing a large feeding ground. However, over-cutting of the rushes reduces the number of nesting places and encourages predation (Goc 1993).

The most important factors influencing the number and variety of breeding birds on the pond are islands, sand dykes and overgrown dykes. The more the shores, dykes and islands are varied, the larger the variety of bird species. Islands are important breeding sites for ducks and gulls (*Anas* spp., *Aythya* spp. and *Larus ridibundus*). Grass or sand dykes are good for waders (Charadrii). The great diversity of vegetation (plankton, vascular plants) as well as animals (zooplankton, fry, molluscs, larval and adult insects) for feeding provides opportunities for many types of birds (Dobrowolski 1969, Jakubiec 1978, Borowiec and Grabiński 1982). Feeding fish with additional food causes biotope enrichment and consequently attracts a great many birds, especially those such as ducks that feed on the bottom of the pond and coots and swans *Cygnus* spp. which are plant feeders. It has been claimed (Dyrcz 1989) that fishponds in Poland provide the most crucial breeding places for bittern, little bittern and ferruginous duck *Aythya nycora* (33%–58% of the total country population). Fishponds are also important for little crake *Porzana parva* and spotted crake *P. porzana*. Many species use ponds as a feeding ground, including birds of prey (Accipitridae), cormorant *Phalacrocorax carbo*, grey heron *Ardea cinerea*, white stork *Ciconia ciconia*, and black stork *C. nigra*. Fishponds are very important nesting areas for some species that are very rare or in danger of extinction and that appear in the Polish Red Data Book (Głowaciński 1992). Pond systems of particular significance for rare water birds are shown in Table 5.

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Table 5. Pond systems with nesting rare and endangered bird species (from Głowaciński 1992, for ponds with at least three endangered or one rare species)

name of system	number of species	
	in danger of extinction	rare
Milicz	7	3
Przygodzice	5	2
Zator	5	1
Starzawa	3	3
Okręt i Rydwan	3	1
Gutocha	3	1
Niemodlin	2	1
Stawinoga	2	1
Przemków	1	2
Łężczaki Ligotniak	1	1
Żabokliki	3	–
Raszyn	3	–
Siemień	3	–

Nesting sites of night heron *Nycticorax nycticorax* and purple heron *Ardea purpurea* coincide with pond systems in southern and south-west Poland (the only two colonies of night heron are on ponds in Katowice province and Bielsko province). Nesting sites of whiskered tern *Chlidonias hybrida* can be found on large pond systems in eastern and south-east Poland. In general 72 nesting species have been recorded on the 59 fishponds under analysis. Some fishponds are moulting places for Lamellirostres (Anseriformes; *Cygnus olor, Anser anser, Anas platyrhynchos, Anas querquedula* and *Aythya ferina*) (Winiecki and Wesołowski 1987), e.g. Przygodzice ponds near Ostrów Wielkopolski, where about 250 mute swans *Cygnus olor* are recorded each year after the nesting period (Wiatr 1970, Dolata 1993) or Siemień ponds – the largest moulting places for mute swans in the Lublin province, with about 200 individuals (Buczek and Buczek 1988). Some large pond systems are important areas for birds during migration. In this case the timing of filling and draining the ponds is crucial. On an empty pond area there are suitable feeding places for waders, but these birds will carry on without stopping at the ponds if the water is drained too late in the year. If the water is drained too early the area becomes unattractive for Lamellirostres. Among 18 pond systems under analysis, there are five of special significance in the migration period: Starzaw, Przygodzice, Przemków, Siemień and Zator. Altogether, 111 species have been recorded on the pond systems under analysis during

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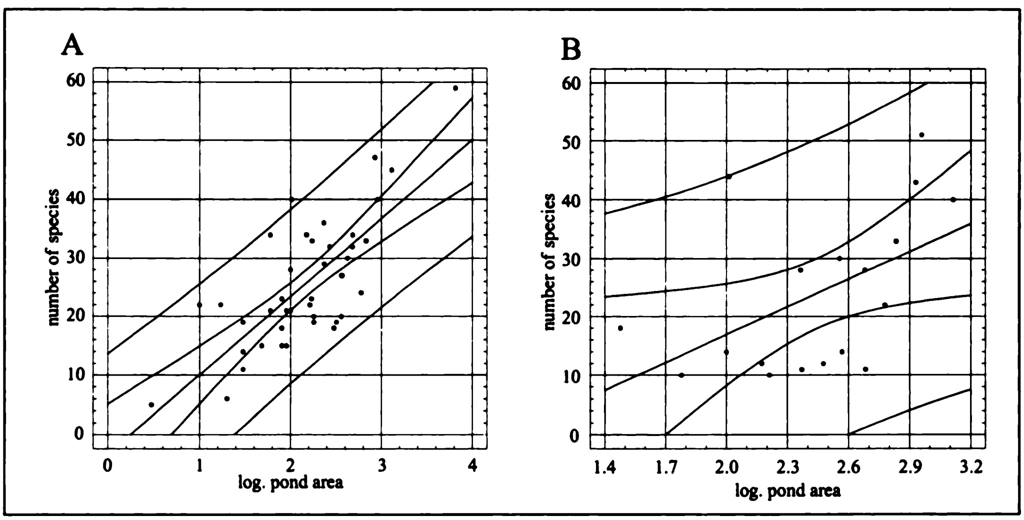
migration (see appendices, pages 134 and 136). In winter, ponds are of little importance for waterfowl. The majority of ponds are empty or are usually covered with ice. In the middle and lower Vistula basin, on ten pond systems in winter 1983/84, only ten species were recorded, which was only 26% of all bird species recorded as wintering in this area. In terms of numbers they were 0.7% (1,112 individuals) of all waterfowl wintering in the Vistula basin (Dombrowski et al. 1985). Similar results for Silesia, Mazovia and Podlasie ponds were recorded in the winter of 1984/85 (Kot *et al.* 1987).

3.5. Conditions affecting waterfowl on fishponds

Considerable differences in the number of waterfowl breeding species have been discovered, depending on the surface area of the pond system (analysis of variance (ANOVA), $F=15.01$, $df=4.36$, $p<0.01$) (Figure 4a). Small pond systems (surface area below 50ha) had fewer breeding bird species (4–19 species, average 13.3±6.47) than pond systems with surface areas over 100ha (averages 26.4–43.3 species). Numbers of breeding bird species on pond systems with a surface area of 51–100ha were not significantly different to numbers of breeding bird species on pond systems of surface area 50ha or less ($t=2.62$, $df=14$, $p>0.05$). The largest numbers of breeding bird species occurred on pond systems with a surface area of over 500ha: Zator, Spytkowice, Przeręb systems (45 species), Przemków ponds (40 species), Przygodzice ponds

Figure 4. Relationship between number of bird species and pond surface area – A: breeding species, B: migratory species



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influences are falling groundwater levels, chemical contamination of pond water and eutrophication. Other influences are closely related to fishpond management regimes (particularly intensive ones) which may impoverish the ecosystem. These include the remodelling of ponds to raise the water level, cutting and burning reeds, remodelling and strengthening of dykes, hunting, and excessive development nearby.

3.7. Effects of waterfowl on fishponds

Because of the fact that waterfowl find either plenty of natural food and fish in the ponds or take advantage of fish feed, there often exists a rivalry between fishermen and waterfowl. The greatest problems are caused by fish-eating birds such as cormorant, grey heron and great crested grebe *Podiceps cristatus*. Other species are not so destructive, either because of rarity (white-tailed eagle, osprey *Pandion haliaetus*), low food intake (terns) or low fish content in feed (black tern *Chlidonias niger*, black-headed gull and other species of grebes) and they do not cause any fish management losses. According to fishermen, waterfowl also cause stress to the fish and consequently fish have no appetite for food, they grow more slowly and the risk of disease increases (Carss and Marquiss 1992). Cormorants are particularly harmful to fish management. The daily intake of an individual cormorant ranges from 425 to 750g of fish. It can eat fish 7–60cm long (average 10–20cm). One cormorant eats about 89–147kg of fish a season (7 months). In Poland the problem arose in the mid-1980s when cormorant numbers increased; existing colonies grew larger, new colonies came into being and the range of occurrence expanded. At the moment the regions suffering the most conflict are the provinces of Olsztyn, Zielona Góra and Bielsko (Dobrowolski and Dejtrowski 1995).

Another species which causes conflict, though not to such a degree, is the grey heron. Its diet is more varied: besides fish, which is its most common food, it also preys on amphibians and small mammals (Cramp and Simmons 1983). One grey heron needs 300–550g of food a day. It usually hunts by wading along shores in shallow water. The size of fish it catches ranges from 3 to 55cm. One grey heron usually eats 69–105kg of fish a season (7 months). The most popular feeding grounds are shallow ponds situated close to heron nesting places. The areas subjected to most damage are fry ponds at the close of the season and during water draining. Often grebes are accused of preying on fish. The food needs of the great crested grebe range from 200 to 350g of food a day. About 80% of their food consists of fish, but they also eat insects and some plants. Fish eaten range in size from 5 to 20cm (usually 10cm or less), and they are usually bleak, roach, perch and rudd. Less common in the grebe diet are dace, pike, tench, stickleback, eel, gudgeon, crucian carp, bream, trout, chubb, *Blicca bjoercna* and ruff. One grebe's food needs range from 31.5 to 52.5kg of fish a season (7 months). Great crested grebes breed only in small numbers, at a density of from 0.4 pairs per 10ha to 2.4 pairs per 10ha (Dyrcz *et al.* 1991,

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Walasz and Mielczarek 1992), so they do not greatly influence the stock of fish. Cieślak and Jankowski (1992) estimated losses caused by cormorants and herons on Przemków ponds. It appears that those two species ate about 7%–8% of healthy carp and about 10% of all fish (both healthy and unhealthy).

Another problem with waterfowl on ponds is that birds eat the fish feed. These losses are not of such importance as is generally assumed. Research in Milicz (Krajewski 1972, Dobrowolski and Halba 1982) showed that birds eat approximately 2%–7.5% of fish feed a year (including coot, which ate 0.7%). Birds can also be vectors for trematodes and tapeworms which parasitise fish (Dunajewski 1943, Cieślak and Jankowski 1992).

While considering the losses which can be caused by waterfowl on fish farms one should also emphasise their positive function in pond ecosystems. Birds are an important part of the biocoenosis, influencing its diversity by participating in the food chain. Ducks, swans and waders prevent ponds becoming overgrown, by reducing algae and some plant growth. Grey heron, bittern, little bittern, grebes, gulls and terns feed on predatory invertebrates (dragonfly larvae, water beetles, heteropteran bugs) which feed on fry (Sakowicz 1952, Ferens and Wasilewski 1977). Predatory insects make up 30% of the black-headed gull's diet (Ferens and Wasilewski 1977). Grey herons eat diving beetle (Dytiscidae) larvae, which feed on fry (Bocheński 1960). According to Gwiazda (1994) great crested grebe eat plankton-feeding fish, thereby reducing fish predation on zooplankton, allowing the zooplankton to consume phytoplankton more efficiently and thus limiting the development of algal bloom. Birds feeding on fish usually chose sick and weak individuals, which improves the health of the overall population (Cieślak and Jankowski 1992). Black kites *Milvus migrans* also feed on weak and dead fish, which during epidemics make up 70% of their diet (Sakowicz 1952). Gulls and terns feeding close to the water surface catch so-called fish-weeds or, in the case of gulls, also sick and dead individuals (Ferens and Wasilewski 1977). Dobrowolski (1973) has emphasised another important characteristic of waterfowl, which influences their function in water ecosystems, namely their mobility. Some birds feed at the ponds but nest away from them, others do the opposite. Consequently birds are one of the elements in the circulation of organic matter in the pond ecosystem: they take away organic matter from the pond and at the same time supply it with mineral components. Bird excrement accumulated in ponds is an efficient fertiliser, which increases the vegetation growth and consequently enriches the natural fish feed. Taking into consideration all the functions performed by birds in the pond environment, it is necessary to take a middle line and reconcile the fish farms economic profits with the free existence of waterfowl, which are indispensable to the natural value of the ecosystem.

3.7.1. Reducing damage from waterfowl

Efforts to bring about a reduction in, or prevention of, fish losses in ponds have recently intensified. New ponds are to be built far from migration routes and bird roosts (Salmon

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and Conte 1982). Pond design can also help prevent fish loss: cages, channels and small water basins can be protected more efficiently than large ground ponds. Ponds deeper than 1m with steep sides and the vegetation removed are relatively unattractive for waterfowl. At the moment the main methods of reducing the pressure of bird populations on existing ponds are either removing birds from the area or reducing the likelihood of fish being preyed upon. In the past the only way was shooting birds recognised as pests (Dombeck *et al.* 1984). At the moment most waterfowl are under protection, so this method is used only exceptionally. Another way is protecting ponds by nets and ropes to keep birds out. Ropes are stretched crosswise or parallel, with the distance between them depending on the bird species. This method is rather expensive and inconvenient for pond workers, so it cannot be used on large areas. The next method of reducing losses is the so-called buffer fish population. Birds are allowed to prey on small, young and easy-to-catch fish which are not of economic importance (Barlow and Bock 1984). Changes in fish breeding methods can also help, e.g. reducing fish density and postponing fry transfer into open ponds (Barlow and Bock 1984, Moerbeek *et al.* 1987). Keeping ponds clean and tidy (removing dead fish) as well as attaching importance to the state of ponds and to maintaining the protection installations may help to minimise losses. The presence of people seems to keep cormorants away. They usually keep away from ponds which are situated near the road or human dwellings (Cramp and Simmons 1977, Moerbeek *et al.* 1987), and recreational use of ponds may help keep these birds away.

The Stawinoga fishpond complex provides suitable habitat for a variety of wetland species, including rare tree frogs.

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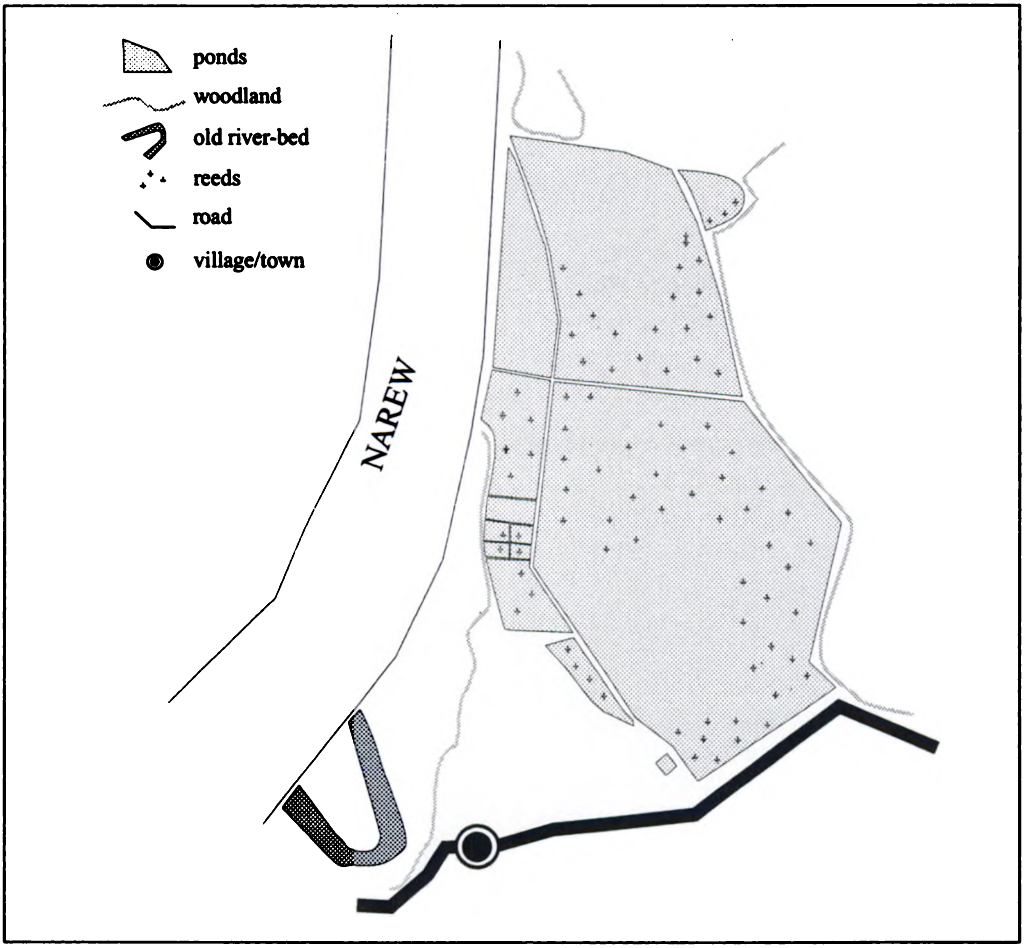
Figure 6. The Stawinoga fishpond complex



3.8. The Stawinoga fishpond complex

Besides carrying out a literature review, the present authors have tried to define the variety of functions of an individual pond system. Stawinoga ponds in the Ostrołęka province was chosen for this study. This pond system belongs to the Polish Fishing Club. The ponds were created in the 1920s, and comprise two large ponds (about 20 and 35ha) and four small ones (Figure 6). The total pond area (within dykes) amounts to 74ha. The area of open water is limited to 37ha because of encroaching reeds. The Stawinoga ponds structure is partly under protection and consequently intensive fish breeding is limited. During the breeding process only natural feed is used: chiefly wheat grain, but also rye, maize and lupin. From mid-March to mid-October 1994, 51 tonnes of feed were used. The main production of

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Table 6. Plant communities in Stawinoga preserve (in descending order of area covered)

reed communities – Klasa *Phragmitetea*

1. *Phragmitetum communis* Schmale 1939
2. *Typhetum latifoliae* Soo 1927
3. *Typhetum angustifoliae* Soo 1927
4. *Acoretum calami* Kobendza 1948
5. *Phalaridetum arundinacea* Libb. 1931
6. *Iridetum pseudoacori* Eggler 1933
   6.a. variant with *Alnus glutinosa*
   6.b. variant with *Eupatorium cannabinum*
7. *Cicuto - Caricetum pseudocyperii* de Boer 1942

hay meadow communities – Klasa *Molinio - Arrhenatheretea*

8. *Cirsio - Polygonetum* Tx 1951
   8.a. variant with *Alnus glutinosa*
   8.b. type community
   8.c. variant with *Carex gracilis*
9. *Epilobio - Juncetum effusii* Oberd. 1957
10. *Junco - Molinetum* Prsg. 1951

forest and scrub communities

11. *Salici - Populetum* Drees 1936
12. *Salicetum triandro - viminalis* Lohm 1952
13. *Ribo - nigri - Alnetum* Sol.-Górn. 1975
14. *Circaeo - Alnetum* Oberd. 1953

Stawinoga is carp fry (85%), crucian carp, pike and tench. This year fish production reached 26 tonnes, an output of about 700kg/ha. Protection of Stawinoga causes some problems. The main ones are bans on reed cutting and bird disturbance. Reeds make up almost 50% of the pond areas, which considerably reduces production possibilities. To prevent further overgrowth of reeds the Stawinoga manager decided to change the production profile from fry to trade carp, in order to limit reed overgrowth by disturbing the bottom of banks by fish. According to pond workers, this year losses caused by waterfowl reached 400kg of fish (i.e. 1.5%). Losses are also caused by otters and numerous mink.

Botanical research was carried out in 1994 (summer season) on the macrophyte community in the major basin of the reserve and the synanthrophic vegetation communities, which grow on the nearby dykes of small seasonally dry ponds (see Table 6). Willow-poplar carr associated with the marshy meadows of large river valleys was the most

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Table 7. Bird species recorded on Stawinoga fishponds in 1961–1962, 1964–1965 and 1994

	species	observation period		
		1961–1962	1964–1965	15.ii.1994–15.x.1994
1.	*Gavia arctica*			+
2.	*Podiceps cristatus*	+	+	+
3.	*Podiceps griseigena*	+	+	+
4.	*Podiceps nigricollis*	+	+	+
5.	*Tachybabtus ruficollis*	+	+	+
6.	*Phalacrocorax carbo*			+
7.	*Botaurus stellaris*			+
8.	*Ixobrychus minutus*	+		+
9.	*Ardea cinerea*	+	+	+
10.	*Ciconia ciconia*	+	+	+
11.	*Ciconia nigra*		+	+
12.	*Cygnus olor*	+	+	+
13.	*Anser fabalis*			+
14.	*Anser albifrons*			+
15.	*Anser anser*			+
16.	*Anas penelope*	+		+
17.	*Anas strepera*	+	+	+
18.	*Anas crecca*	+		+
19.	*Anas platyrhynchos*	+	+	+
20.	*Anas acuta*	+		+
21.	*Anas querquedula*	+	+	+
22.	*Anas clypeata*		+	+
23.	*Aythya ferina*	+	+	+
24.	*Aythya nyroca*	+	+	+
25.	*Aythya fuligula*	+	+	+
26.	*Bucephala clangula*			+
27.	*Mergus albellus*			+
28.	*Mergus merganser*	+		+
29.	*Milvus migrans*	+	+	+
30.	*Milvus milvus*			+
31.	*Haliaetus albicilla*			+
32.	*Circus aeruginosus*	+	+	+

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Table 7. (continued)

	species	observation period		
		1961–1962	**1964–1965**	**15.ii.1994–15.x.1994**
33.	*Circus pygargus*			+
34.	*Accipiter gentilis*	+		+
35.	*Accipiter nisus*	+		+
36.	*Buteo buteo*	+		+
37.	*Pandion heliaetus*	+		+
38.	*Falco tinnunculus*	+	+	+
39.	*Falco vespertinus*		+	
40.	*Falco subbuteo*	+	+	+
41.	*Perdix perdix*		+	+
42.	*Phasianus colchicus*		+	+
43.	*Rallus aquaticus*			+
44.	*Porzana porzana*	+	+	+
45.	*Crex crex*			+
46.	*Gallinula chloropus*	+	+	+
47.	*Fulica atra*	+	+	+
48.	*Grus grus*			+
49.	*Charadrius dubius*	+	+	+
50.	*Charadirus hiaticula*			+
51.	*Pluvialis apricaria*	+		
52.	*Vanellus vanellus*	+	+	+
53.	*Calidris alpina*			+
54.	*Philomachus pugnax*	+	+	+
55.	*Gallinago gallinago*	+	+	+
56.	*Scopolax rusticola*		+	+
57.	*Limosa limosa*	+	+	+
58.	*Numenius arquata*			+
59.	*Tringa erythropus*		+	+
60.	*Tringa totanus*	+	+	+
61.	*Tringa nebularia*	+	+	+
62.	*Tringa ochropus*	+	+	+
63.	*Tringa glareola*	+	+	+
64.	*Actitis hypoleucos*	+	+	+
65.	*Larus minutus*			+

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Table 7. (continued)

	species	observation period		
		1961–1962	1964–1965	15.ii.1994– 15.x.1994
66.	*Larus ridibundus*	+	+	+
67.	*Larus canus*			+
68.	*Larus marinus*			+
69.	*Larus fuscus*			+
70.	*Larus argentatus*			+
71.	*Sterna hirundo*	+	+	+
72.	*Sterna albifrons*		+	
73.	*Chlidonias niger*	+	+	+
74.	*Columba palumbus*		+	+
75.	*Streptopelia decaocto*		+	+
76.	*Streptopelia turtur*	+	+	+
77.	*Cuculus canorus*	+	+	+
78.	*Strix aluco*			+
79.	*Asio otus*			+
80.	*Caprimulgus europaeus*			+
81.	*Apus apus*	+		+
82.	*Alcedo atthis*	+		+
83.	*Coracias garrulus*	+		
84.	*Upupa epops*	+	+	+
85.	*Picus viridis*			+
86.	*Dryocopus martius*			+
87.	*Dendrocopos major*			+
88.	*Dendrocopos medius*			+
89.	*Dendrocopos minor*	+		+
90.	*Lullula arborea*			+
91.	*Alauda arvensis*		+	+
92.	*Riparia riparia*	+		
93.	*Hirundo rustica*	+	+	+
94.	*Delichon urbica*	+	+	+
95.	*Anthus trivialis*			+
96.	*Anthus pratensis*			+
97.	*Motacilla flava*	+	+	+
98.	*Motacilla alba*	+	+	+

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Table 7. (continued)

	species	observation period		
		1961–1962	1964–1965	15.ii.1994–15.x.1994
99.	*Troglodytes troglodytes*		+	+
100.	*Prunella modularis*			+
101.	*Erithacus rubecula*	+	+	+
102.	*Luscinia luscinia*			+
103.	*Luscinia svecica*	+	+	+
104.	*Saxicola rubetra*	+	+	+
105.	*Saxicola torquata*		+	
106.	*Turdus merula*			+
107.	*Turdus philomelos*			+
108.	*Turdus iliacus*			+
109.	*Turdus viscivorus*			+
110.	*Locustella naevia*	+		+
111.	*Locustella fluviatilis*			+
112.	*Locustella luscinioides*	+		+
113.	*Acrocephalus schoenobaenus*	+	+	+
114.	*Acrocephalus palustris*	+	+	+
115.	*Acrocephalus scirpaceus*	+	+	+
116.	*Acrocephalus arundinaceus*	+	+	+
117.	*Hippolais icterina*			+
118.	*Sylvia curruca*			+
119.	*Sylvia communis*	+	+	+
120.	*Sylvia borin*	+		+
121.	*Sylvia atricapilla*	+		+
122.	*Phylloscopus sibilatrix*			+
123.	*Phylloscopus collybita*		+	+
124.	*Phylloscopus trochilus*			+
125.	*Muscicapa striata*			+
126.	*Ficedula albicollis*			+
127.	*Panurus biarmicus*			+
128.	*Aegithalos caudatos*			+
129.	*Parus palustris*			+
130.	*Parus montanus*			+

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Table 7. (continued)

	species	observation period		
		1961–1962	1964–1965	15.ii.1994–15.x.1994
131.	*Parus cristatus*			+
132.	*Parus ater*			+
133.	*Parus caeruleus*	+		+
134.	*Parus major*	+		+
135.	*Sitta europaea*			+
136.	*Certhia brachydactyla*			+
137.	*Remiz pendulinus*	+	+	+
138.	*Oriolus oriolus*			+
139.	*Lanius collurio*	+	+	+
140.	*Lanius excubitor*			+
141.	*Garrulus glandarius*		+	+
142.	*Pica pica*	+	+	+
143.	*Corvus monedula*	+	+	+
144.	*Corvus frugilegus*			+
145.	*Corvus corone cornix*	+	+	
146.	*Corvus corax*	+		+
147.	*Sturnus vulgaris*	+	+	+
148.	*Passer domesticus*			+
149.	*Passer montanus*	+		+
150.	*Fringilla coelebs*		+	+
151.	*Serinus serinus*		+	+
152.	*Carduelis chloris*	+		+
153.	*Carduelis carduelis*			+
154.	*Carduelis spinus*			+
155.	*Carduelis cannabina*	+	+	+
156.	*Carpodacus erythrinus*	+		+
157.	*Pyrrhula pyrrhula*	+		+
158.	*Coccothraustes coccothraustes*			+
159.	*Emberiza citrinella*	+	+	+
160.	*Emberiza schoeniclus*	+	+	+
	total	83	74	153

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Table 8. Numbers of breeding birds on Stawinoga pond system

species	no. of pairs	species	no. of pairs
great crested grebe	2–4	spotted crake	2
red-necked grebe	1	coot	5–10
black-necked grebe	1	redshank	+
little grebe	4–6	lapwing	+
little bittern	+	black tern	+
bittern	2	kingfisher	1
mallard	10	penduline tit	5–7
garganey	1	bearded tit	+
gadwall	+	bluethroat	4
shoveler	+	river warbler	+
tufted duck	?	savi's warbler	2–3
pochard	1–2	grasshopper warbler	+
greylag goose	1	great reed warbler	4–5
mute swan	4	reed warbler	8–10
marsh harrier	1–2	sedge warbler	18–22
water rail	3–4	scarlet grosbeak	18–20
moorhen	8	reed bunting	14–18

+: breeding species, but exact numbers unknown

common plant association found. Less common was elm-poplar carr growing on less moist chernozems and alder carr on waterlogged low bogs. Single, old willows (*Salix alba, S. purpurea, S. fragilis*), black poplars (*Populus nigra*) and groups of alders (*Alnus glutinosa*) are remnants of the forest biotope.

The first steps in ornithological research on Stawinoga ponds were taken at the time of the building of the Zegrze reservoir (Zalew Zegrzyński) before it was filled (1961–1962) and afterwards (1963–1965) (Nowicki 1974). The filling of the Zegrze reservoir has not influenced the bird species variety in Stawinoga very much. In both research seasons the most numerous species were waterfowl belonging to bottom-feeding and plant-feeding categories (see appendices, pages 134 and 136). Bird counts in the Stawinoga ponds area were undertaken in 1994. Between 15 March and 15 October 1994 nine censuses were carried out. In all 161 species have been recorded (Table 7), of which 152 species were recorded in 1994. That makes up over 37% of all species recorded in Poland. Thirty-four species were considered as breeding ones (Table 8), which is over 15% of all breeding species in Poland and 46% of breeding waterfowl in the country. During migration periods the species variety in Stawinoga ponds is also very great. Large groups of ducks (up to 500

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individuals) were noted, of which the most numerous were mallard, goldeneye and goosander *Mergus merganser*. In the autumn season flocks of geese (up to 100) were staying on the ponds, including greylag goose, white-fronted goose *Anser albifrons* and bean goose *Anser fabalis*. The research has proved the great variety of species in this area, justifying its status as a nature reserve.

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Appendix 1. Bird species recorded on Polish ponds

Species marked with an asterisk (*) are breeding species.

Gavia arctica
Gavia stellata
Tachybabtus rufficollis (*)
Podiceps cristatus (*)
Podiceps griseigena (*)
Podiceps auritus
Podiceps nigricollis (*)
Phalacrocorax carbo (*)
Pelecanus onocrotalus
Botaurus stellaris (*)
Ixobrychus minutus (*)
Nycticorax nycticorax (*)
Ardea cinerea (*)
Ardea purpurea (*)
Egretta alba
Egretta garzetta
Ciconia ciconia (*)
Ciconia nigra (*)
Platalea leucorodia
Cygnus olor (*)
Cygnus cygnus
Cygnus columbianus
Anser anser (*)
Anser albifrons
Anser erythropus
Anser fabalis
Branta canadensis
Tadorna tadorna
Casarca ferruginea
Anas platyrchynchos (*)
Anas strepera (*)
Anas penelope
Anas crecca (*)
Anas querquedula (*)
Anas acuta (*)
Anas clypeata (*)
Netta rufina (*)
Aythya ferina (*)
Aythya nyroca (*)
Aythya fuligula (*)
Aythya marila
Somateria mollisima
Clangula hyemalis
Melanitta fusca
Bucephala clangula (*)
Mergus merganser
Mergus serrator
Mergus albellus
Oxyura leucocephala
Milvus milvus (*)
Milvus migrans (*)
Haliaetus albicilla (*)
Circus aeruginosus (*)
Circus cyaneus (*)
Circus pygargus (*)
Aquila pomarina (*)
Pandion haliaetus (*)
Rallus aquaticus (*)
Porzana porzana (*)
Porzana parva (*)
Crex crex (*)
Gallinula chloropus (*)
Fulica atra (*)
Grus grus (*)
Haematopus ostralegus
Himantopus himantopus
Recurvirostra avosseta
Glareola pranticola
Charadrius hiaticula (*)
Charadrius dubius (*)
Pluvialis apricaria
Squatarola squatarola
Vanellus vanellus (*)
Calidris ferruginea
Calidris canutus
Calidris minuta
Calidris temminckii
Calidris alpina
Crocethia (Calidris) alba
Limicola falcinellus
Philomachus pugnax (*)
Lymnocryptes minimus
Gallinago gallinago (*)
Gallinago media
Limosa limosa (*)
Limosa lapponica
Numenius arquata (*)
Numenius phaeopus
Tringa erythropus (*)
Tringa totanus (*)
Tringa nebularia
Tringa stagnatilis
Tringa ochropus (*)
Tringa glareola
Actitis hypoleucos (*)
Arenaria interpres
Phalaropus lobatus
Larus marinus
Larus fuscus
Larus argentatus
Larus cachinnans (*)
Larus canus
Larus melanocephalus
Larus minutus
Larus ridibundus (*)
Rissa tridactyla
Sterna hirundo (*)
Sterna albifrons (*)

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Hydroprogne caspia (*H. tschegrava*)
Chlidonias niger (*)
Chlidonias leucopterus
Chlidonias hybrida (*)
Alcedo atthis (*)
Riparia riparia (*)
Luscinia svecica (*)
Locustella fluviatilis (*)
Locustella luscinioides (*)
Locustella naevia (*)
Acrocephalus schoenobaenus (*)
Acrocephalus paludicola (*)
Acrocephalus arundinaceus (*)
Acrocephalus scirpaceus (*)
Acrocephalus palustris (*)
Panurus biarmicus (*)
Remiz pendulinus (*)
Carpodacus erythrinus (*)
Emberiza schoeniclus (*)

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Appendix 2. Number of bird species on ponds in Poland

name of pond system	area (ha)	number of species: breeding	number of species: regular migrants	source
Przeciszów	30	11	–	Harmata (1981)
Gołysz	163	22	10	Bocheński (1960), Gwiazda (1994a)
Zator	1,300	45	40	Wasilewski (1966, 1973)
Siemień	680	33	33	Buczek i Buczek (1988)
Ślesin	180	19	–	Nowysz i Wesołowski (1973)
Samostrzel	48	15	–	Nowysz i Wesołowski (1973)
Ostrówek	318	19	–	Nowysz i Wesołowski (1973)
Smogulec	180	20	–	Nowysz i Wesołowski (1973)
Okołowice	–	27	–	Markowski (1982)
Chrząstów	–	22	–	Markowski (1982)
Szczekociny	–	23	–	Markowski (1982)
Pukarzów	–	25	–	Markowski (1982)
Gostomin	–	22	–	Markowski (1982)
Maluszyn	–	24	–	Markowski (1982)
Tarnawatka	482	34	11	Riabinin (1963)
Starzawa	850	47	43	Kunysz i Hordowski (1992), Kunysz (1993)
Wielikąt	370.5	27	14	Cempulik (1985)
Łagów	60	21	10	Stawarczyk (1981)
Krogulno	300	18	12	Janowski (1965)
Staw Nowokuźnicki	30	19	18	Michalak (1963), Witkowski (1965)
Niemodlin	360	27	30	Borowiec i Grabiński (1982)
Łężczak i Ligotniak	479	32	28	Harmata (1963), Krotoski (1987)
Krośnice	425	30	–	Ranoszek (1987)
Żeleźniki	172	33	–	Ranoszek (1987)
Stawy przemkowskie	910	40	51	Cieślak i in. (1991)
Stawy Podgórzyńskie	235	29	11	Gramsz (1991)
Stawy Przygodzickie	600	24	22	Wiatr (1970), Dolata (1993)
Żabokliki	232	36	28	Kot (1986)
Gutocha	150	34	12	Bukaciński i in. (1989)
Bytów	–	16	–	Górski i in. (1991)

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Appendix 2. (continued)

name of pond system	area (ha)	number of species: breeding	number of species: regular migrants	source
Polchów	–	12	–	Górski i in. (1991)
Lutków	–	7	–	Górski i in. (1991)
Raszyn	103	40	44	Bukacińska i Bukaciński (1991)
Stawy w Lesie Piwnickiem	–	4	–	Goc (1977)
Kąśna Dolna	–	6	–	Tomek (1973)
Bogoniowice	–	4	–	Tomek (1973)
Okręt i Rydwan	270	32	–	Markowski i in. (1974)
Białka	80	15	–	Dyrcz i in. (1973)
Brus	170	23	–	Dyrcz i in. (1973)
Komarne	80	18	–	Dyrcz i in. (1973)
Krasne	90	21	–	Dyrcz i in. (1973)
Libiszów	90	15	–	Dyrcz i in. (1973)
Pieszowola	90	21	–	Dyrcz i in. (1973)
Sosnowica	360	20	–	Dyrcz i in. (1973)
Tyśmienica	100	21	–	Dyrcz i in. (1973)
Uścinów	17	22	–	Dyrcz i in. 1973)
Milicz	6,521	59	–	Mrugasiewicz i Witkowski (1962)
Ułęż	100	28	14	Piotrowska (1976)
Stawy przy ul. ks. J. Poniatowskiego	3	5	–	Bocheński i Harmata (1962)
Mydlniki	20	6	–	Bocheński i Harmata (1962)
Lubliniec	–	28	–	Horodowski (1991)
Ruda Różaniecka	80	23	–	Horodowski (1991)
Chotylubie	10	22	–	Horodowski (1991)
Dobra	–	15	–	Horodowski (1991)
Surmaczówka	–	12	–	Horodowski (1991)
Hamernia	30	14	–	Horodowski (1991)
Stawinoga	60	34	–	personal observation (1994)
Stawy koło Robczyska	–	13	–	Kuźniak (1992)

–: no data

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4. Slovakia

4.1 Introduction

This project has considered a large number of fishponds of interest for their biodiversity. Whether they are used strictly commercially or for sport fishing, it is important to take account of their nature conservation value. Fishpond management must be multifunctional in order to guarantee water management and commercial and recreational use of the fishponds, as well as their unique role as refuges for rare, endangered and protected species (especially aquatic and littoral organisms) and as ecostabilising elements in the landscape.

The priority is the integration of nature conservation and economic use of fishponds. It is a basic principle of sustainable use of these ecosystems to seek common ground between the extremes of the traditional economic attitude (characterised by insufficient evaluation of the complex functions and services of ecosystems) and the traditional scientific conservation attitude of strict protection and prohibition of use. It is now clear that there is a close link between the support of economic functions of fishponds and the conservation of their natural values.

4.2. Overview of fishponds in Slovakia

4.2.1. Evaluation methodology and criteria for fishpond classification

Information was gathered about the distribution and state of Slovakia's fishponds during summer and autumn 1993 and spring 1994. Their importance for nature conservation was evaluated, as well as the composition of the biotopes closely surrounding the water bodies.

A number of criteria were chosen to evaluate the nature conservation significance of each fishpond: the natural value of the fishpond (its ecological significance), its position, its size and the structure of biotopes surrounding the water body. Fishponds significant for nature conservation were classified into the following groups:

I – fishponds of international significance
II – fishponds of national significance
III – fishponds of regional significance
IV – fishponds of local significance.

To estimate the natural value of a fishpond the following measures were combined: the state of preservation of the fishpond (i.e. of its natural ecosystems and those of its close surroundings), the current state of vegetation (with emphasis on the presence of

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wetland vegetation), and the occurrence of protected and endangered species, especially birds. The presence of artificial elements, since they usually negatively correlate with the level of habitat preservation, was taken into account as well.

Four levels of fishpond ecological significance were defined:

1. Original natural depressions currently functioning as fishponds or fishponds developed by altering terrain (deepening, building dikes) while preserving their natural character (i.e. these have well-preserved natural vegetation). The value of vegetation was not determined according to presence of rare and endangered species but with regard to conditions for nesting, food, etc.
2. Fishponds with relatively well-preserved vegetation, with occurrence of protected and endangered species, and with a minimum of artificial technical components.
3. Fishponds with little growth or less well-preserved vegetation, with lower occurrence of protected and endangered species and with evident presence of artificial technical elements.
4. Fishponds with extensive technical interventions and without any original vegetation or with existing vegetation largely reduced.

To help to define the ecological significance of fishponds the composition of the biotopes surrounding the water body was assessed and expressed as a percentage.

Reservoirs of over 400ha have not been included in this report since their primary function is quite different (drinking water reservoirs, energy production, recreation). Fish production is only of secondary importance there and fish biodiversity has mostly a bioregulative function.

4.2.2. Overview of the evaluated fishponds

Slovakia does not have a long tradition of fishponds. Only a few original natural depressions persist today. Practically all of the reservoirs, fishponds, or wetlands are affected by some technical intervention and elements related to water management. Dozens of small fishponds have disappeared as a result of urbanisation or of the decline in farming waterfowl. A small number of new fishponds has been created by deepening some area or damming a valley, only partially substituting for the role of the ponds which have been destroyed.

Information was gathered for 147 fishponds and natural water bodies of fishpond type significant for nature conservation, but because of limited resources, systematic studies and inventories of all the fishponds in Slovakia were not carried out. Therefore, this report should be accepted as the first attempt to map fishponds in Slovakia.

The 147 fishponds surveyed were classified as follows:

I – five sites of international significance (including Ramsar sites)
II – 13 sites of national significance
III – 46 sites of regional significance
IV – 83 sites of local significance.

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Significant fishponds and natural water bodies of fishpond type
Table 1 lists Slovak fishponds of international and national significance. A similar analysis of the 46 fishponds of regional significance and 83 fishponds of local significance is available in the Slovak version of this report (IUCN 1995).

Table 1. Significant fishponds and similar waterbodies in Slovakia

locality	protected status	size (ha)	ecological significance	% composition of nearest habitats
I. International significance (5 sites, including 4 Ramsar sites)				
1. Čičovské mŕtve rameno	NNR	80	1	F=80, W=20
2. Hrhovské rybníky		251.2	1+2	W=25, A=40, M=15, U=20
3. Iňačovce-Senné	NNR	211.3	2	M=75, W=20, U=5
4. Parížske močiare	PNA	57.2	1	W=100
5. Šúr	NNR	10	1	W=25, T=75
II. National significance (13 sites)				
6. Centnus		60	1+2	F=30, A=50, U=20
7. Dolný les		12	2	F=100
8. Chýmske rybníky		110	1+2	A=85, T=5, U=10
9. Glabušovce		14	1+2	W=40, M=30, A=20, U=10
10. Kechnec		28	1	A=80, U=20
11. Kvetnianske rybníky		60	2+3	A=100
12. Lepňa		16	1+2	M=100
13. Plavečské štrkoviská		24	1	W=10, A=60, M=30
14. Pohrebište		80	1+2	A=95, U=5
15. Raudazi		13	1+2	M=70, F=30
16. Revištský rybník	NM	21	2	A=50, W=20, T=30
17. Šrek		15	1+2	M=100
18. Veľké Blahovo		70	1+2	A=100

Protected status: NNR – national nature reserve; NR – nature reserve; PNA – protected natural area; NM – natural monument

Ecological significance: 1 – absent or very low level of human intrusion; 2 – low level of human intrusion; 3 – medium level of human intrusion (see page 139 for further information on these categories)

Habitat types: A – arable land; F – forests; M – meadows and pastures; T – non-forest tree and shrub vegetation; U – urbanised or otherwise degraded area; W – wetlands

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4.2.3. Summary of general observations from the fishponds field survey

Summarising knowledge from the field observations of fishponds and other water bodies of the fishponds type we can state the following.

1. Several sites significant for biodiversity conservation occur in each district of Slovakia, usually covering from ten to several hundred hectares.
2. These sites are well-situated for nature conservation, as they are in side valleys and are mostly isolated from human settlements and busy roads.
3. The sites studied are used for:
   - intensive fish and/or fry production
   - water sources for irrigation where intensive fish production is only a secondary activity
   - sport fishing and recreation, unsuitable for intensive fish production.
4. Fishponds and water reservoirs are purposeful constructions, developed for the production of market and/or fry fish. At the same time they play other roles in the landscape, and are:
   - important components of surface waters, which greatly affect the water regime of the landscape
   - water sources for agricultural crop irrigation
   - important anti-erosion elements, as the amount of turbid matter transported has been increasing in recent decades
   - important gene pools for aquatic and littoral plant and animal species
   - significant landscape elements used for recreation.
5. Important natural and semi-natural habitats (gravel pits, isolated river meanders, etc.) utilised or potentially utilisable for fish production activities are also included among the fishponds described in this report. Such water areas cannot be emptied, so the biota develops there in a more or less natural way.
6. The multifunctionality of fishponds and other water bodies used for fish production has several negative impacts upon naturally concentrated water and wetland communities. These are:
   - water pollution caused by percolation from nearby settlements, farms etc.
   - technical barriers built close to fishponds (fences, electric posts, communications) inhibiting natural migration of animals and often endangering their lives
   - destruction of reed growth to produce the largest possible volume of water for fish farming.

4.2.4. General characteristics of the most significant fishponds

The list of fishpond and fishpond type sites of the highest significance for nature conservation includes important natural water areas of fishpond type, such as isolated

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meanders (Čičovské mŕtve rameno), swamps (Parížske močiare), and the fishponds Šúr, Hrhovské, and Senné-Iňačovce.

The first three of these sites represent relics of original wetland habitats with a stable water level. Their nature conservation status demonstrates that even in the past they were much appreciated ecologically. The site Senné-Iňačovce also represents an original water-filled habitat. Parts of its territory were excluded from economic activities and a nature reserve (211.3ha) was established there. The remaining part of the water body (over 500ha) is still utilised for intensive fish production.

Hrhov fishponds originally consisted of low moorland with a stable water level. They were converted into productive fishponds and several changes aimed at improvement of their economic utilisation (such as deepening) have been made. Currently there are two intensively utilised carp fishponds. The system is quite large so it also significantly affects the character of the landscape.

Choice of demonstration site: Hrhov fishponds

Hrhov fishponds are the oldest fishponds in eastern Slovakia. They are unique as they are situated at the base of the slopes of the largest karst territory in Slovakia, with specific climatic, hydrogeological, chemical, and biological conditions. These fishponds belong to the buffer zone of Slovenský kras karst Biosphere reserve, included in the UNESCO Man and the Biosphere (MAB) programme. The fishponds were established in the 1960s, and since then large and extremely valuable wetland herb communities have developed. Avifauna and some larger mammals which utilise the ponds' surroundings make the area even more valuable.

Hrhov fishponds represent a refuge of original landscape and at the same time represent one of the largest commercially utilised fishponds in Slovakia. As the last big water area among limestone plateaux they significantly improve the Slovenský kras karst biodiversity. Thanks to their location on the Juhoslovenský kras karst foot, as well as their direct contact with the lowland of Veľká uhorská nížina through the Turňa river basin, they are a meeting point of many flora and fauna elements.

As today's technologies are aimed at the highest economic profit, there exists a singular example of conflict of interest between business and nature conservation in the area. Further deterioration is caused by several pipelines and communication corridors already built or planned near these fishponds. The proposal of optimal integration of such interests could be a good model for the solution of similar problems in other localities.

4.2.5. Brief description of waterfowl migration routes including the Slovak fishponds

Wetlands, fishponds and water reservoirs with a stable water level are used by migratory birds as resting and/or feeding places. There are two basic bird migration routes in the Carpathian region: south-west and south-east. Some weather-assisted passage species fly

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over the Carpathian Mountains from north to south but then change to the south-west or south-east routes in the basin.

The river valleys play the role of navigation lines. The main corridor of western Slovakia runs along the Váh and Orava river valleys. The valleys of the Nitra, Hron and Turiec rivers are considered as wildlife corridors. They are linked to the Orava river valley. The important bird migration routes of eastern Slovakia are determined by a system of parallel river valleys including the Laborec, Ondava, and Topľa and the chain of Hornád, Torysa and Poprad river valleys. Hrhov fishponds occur on a biocorridor and with the fishponds situated close to Perín-Chým village they represent an important resting place for migratory birds.

Only one of the localities on the eastern Slovakian corridors has a character similar to the original state of the area (Senianska depression). It is the site Senné-Iňačovce. In the past, wetland habitats and flood areas created a belt spreading from the confluence of the Tisa and Danube rivers to the foot of the Vihorlat mountains (about 115,000ha). Only Šírava (a reservoir, 3,290ha), Domaša (a dam built on the Ondava river), Beša (a dry reservoir built for regulation of extreme floods in watersheds, 1,600ha) and the Senné-Iňačovce fishpond system remain after recent river regulation and arable land improvement.

Proposal for fishponds to be included in the ECONET

The results of the Slovak fishponds survey imply that all shallow water bodies of at least 100ha area should be included in the Slovak ecological network (ECONET) as core areas of national significance. This is a sufficiently large area to attract waterfowl, amphibians, reptiles and even game in a relatively short time. At the same time, parts of the water body are changing to wetland as part of the succession process. Similarly, we strongly recommend the inclusion of all the areas covering more than 200ha in the European ecological network (EECONET) as core areas of international significance.

4.3. The Hrhov fishponds site

4.3.1. Geography and character of the area

The system of fishponds is situated 50km west from Košice, the main city of eastern Slovakia and 500m south of Hrhov village. The name Veľké jazero Hrhov (Large Hrhov Lake) originally denoted a constant water body filling the original depression of the Turnianska kotlina basin. The construction of a dike later divided the lake into two parts: Veľké jazero (Large lake) and Malé jazero (Small lake). Today these are known as Veľký hrhovský rybník (large Hrhov fishpond) and Malý hrhovský rybník (small Hrhov fishpond), and are generally abbreviated to LHF and SHF respectively in the following text.

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The depression forming the lakes is situated around the Turňa river and Fej stream confluence, reaching 192.5m above sea level, between the state road I/50 and the Turniansky potok stream. The Turnianska kotlina basin divides the plateaux of the Slovenský kras karst into two parts: Horný vrch, situated 2,000m north of the fishponds (reaching 801m above sea level), and Dolný vrch, situated 1,500m south of the fishponds (reaching 533m above sea level). The width of the Turnianska kotlina basin is 2,500m at the foot of the plateau (250m above sea level) but the distance between the plateau peaks is 4,500m. The valley runs from east to west.

Geomorphology
According to the geomorphological system of Slovakia, the Hrhov fishponds belong to the Vnútorné Západné Karpaty (inner west Carpathians) subprovince, Slovenské rudohorie mountains region, Slovenský kras area and Turnianska kotlina basin division.

Phytogeography
The area is a part of the Pannonicum region, the Eupannonicum area, and Košická kotlina basin district.

Zoogeography
From the zoogeographic perspective the area is incorporated into the incarpathian habitat province, Pannonian region, south Slovak area, and Košice district.

4.3.2. Geology and soils

Turnianska kotlina basin is a westward spur of the Košice gravel formation. The basin mostly lays on lower Triassic slate of Kampil age, and/or on Meliatska formation. The material which fills the basin is formed by gravel-clay sediments, freshwater limestones and jacks or lignil of Pliocene age. Erosion during the lower Pliocene caused Werfenian schist cores of narrow anticlinale belts to be disclosed from the once flat karst surface. Raising and inclination of karst platforms increased the erosive dynamic of the water flows, which had begun to form the present day contours of the Turnianska kotlina basin. Drainage slowed and finally flooded habitats appeared. Cliffs in the basin were formed from more resistant rocks of the Meliatska group of Silický nape.

Floodplain soils are represented by fluvisols, with a characteristic 100cm deep, dark-grey humic horizon. These were formed from mineral-rich limestone sediments under the influence of highly mineralised ground waters in an alluvial habitat. A subtype of fluvisol – peaty gley soil – developed in the area of Hrhov fishponds. This was created on the organic fossil substrates of former peatbog. The Hrhov region is considered to be an important example of peat areas in Slovakia.

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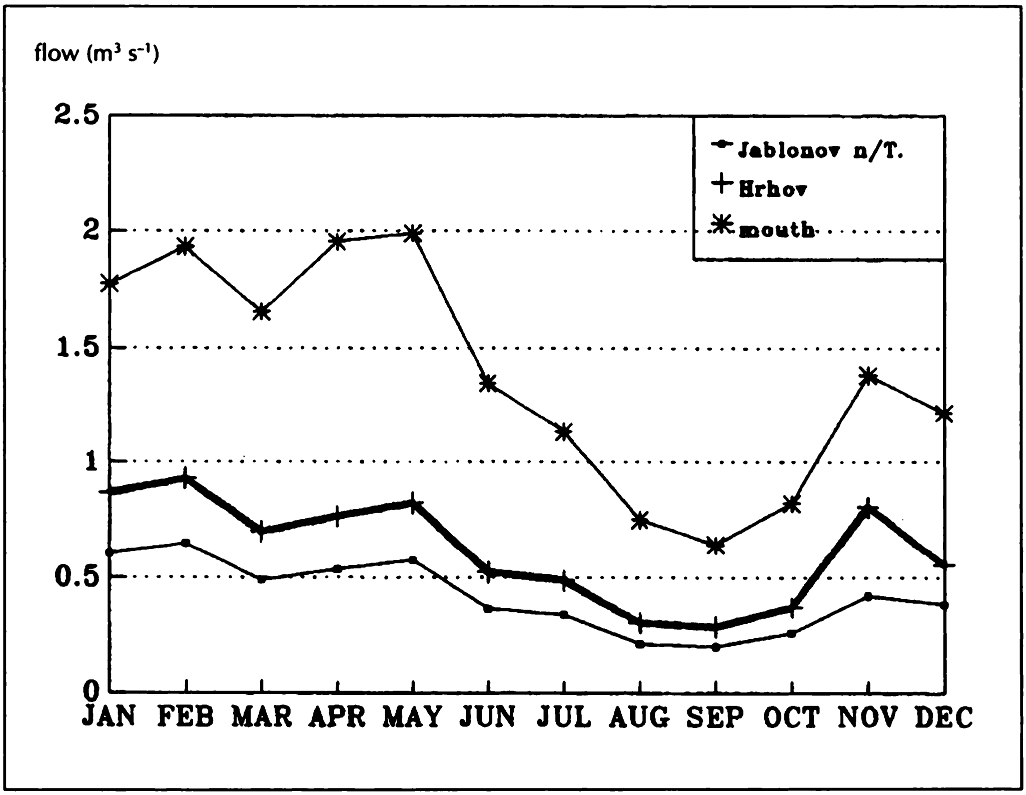
4.3.3. Hydrology

Hrhov fishponds belong to the Bodva river basin and the Turňa stream basin. General characteristics of the Turňa stream are: length 28.80km; stream-basin area 188.82km²; mean inclination of the stream-basin 12.20%; mean inclination within the basin 3.30%.

Table 2. Characteristics of the Turňa stream in several profiles

profile	river (km)	area (km²)	precipitation (mm)	precipitation flow (mm)	specific flow (l s⁻¹ km²)	flow (m³ s⁻¹)
Jablonov n/T	15.6	93.99	854	141	4.47	0.420
Hrhov	9.7	120.87	847	157	4.96	0.606
Ústie do Bodvy	0.3	188.20	836	2,066	47.00	1.380

Figure 1. Mean monthly flow of the Turňa stream



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There is a precipitation discharge of 21% from the Turňa stream-basin. The basin belongs to the snow-rain or rain discharge regime with maximum discharge in April and May and minimum in August and September. The long-term mean discharges are listed in Table 2 and the mean monthly flow is illustrated in Figure 1.

Only mean data calculated from long-term studies are listed in Table 2, and there could be large differences in any individual year. Generally, the summer months (July–September) are unfavourable for fish production. A moisture deficit is typical for karst territories at that time. The maximal and minimal flows of Veľká hlava spring (the main source of water for Hrhov fishponds) illustrate this. Because of this, the Bodva river waters had to be diverted to them, but this channel has fallen out of use.

Kullman and Chalupka (1995) drew attention to a significant decrease of rainfall as well as stream water levels in southern parts of the eastern Slovakia region. They state that the levels of streams on the south slopes of the South Slovak Karst fell by about 42.9% during the period 1989–1994. Szolgay *et al.* (1995) point also to the risk of water deficit caused by predicted continental warming in Central Europe.

4.3.4. Climate, temperature and precipitation

The Turnianska kotlina basin represents a temperate-cool climate geographical type of basin with frequent inversions and high humidity. The mean January temperature ranges from –3.5 to 6°C. The mean July temperature reaches 16–17°C. Annual rainfall is 600–850mm. The climatic conditions are illustrated in Mazúr *et al.* (1980).

4.4. Evaluation of biotic elements of the Hrhov fishponds site

4.4.1. Water quality

Both fishponds are supplied by the same water source. They belong to the same owner and they are utilised in the same way. Mean values of all the studied chemical parameters are given in Table 3. Chemical parameters of the water were analysed at two week intervals and were evaluated according to former Czechoslovak standards for surface waters. Chlorophyll-a was extracted using acetone.

LHF was emptied in 1994, and mean values were calculated for the same period in the same way as for SHF. LHF is now intensively overgrown with water macrophytes (about 50% of the area). SHF is overgrown with macrophytes only along its borders (about 10%).

Chlorophyll-a

Significant differences were found in the average as well as in absolute (Figure 2) concentrations of chlorophyll-a in both fishponds. We assume that the ten-times greater

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Table 3. Mean values of some chemical parameters for the Hrhov fishponds, from April to September 1994

Elements	(units)	Mean values LHF	SHF
pH	(–)	7.5	7.2
Ca^{2+}	(mg l^{-1})	76.5	48.4
Mg^{2+}	(mg l^{-1})	5.0	3.6
Cl^-	(mg l^{-1})	11.48	15.9
NO_3^-	(mg l^{-1})	0.81	1.98
NO_2^-	(mg l^{-1})	0.045	0.111
NH_4^+	(mg.l^{-1})	0.77	1.66
PO_4^{3-}	(mg l^{-1})	0.26	0.352
chl-a	(µg l^{-1})	26.86	363.59

LHF: large Hrhov fishpond
SHF: small Hrhov fishpond

concentration of chlorophyll-a in SHF (compared to LHF) is caused by differences in macrophyte growth.

A great leap in concentration of chlorophyll-a in SHF was recorded on 31 July (Figure 3) – 675.5µg l^{-1}. This is 3.5 times higher than the average value up to that date (198.4µg l^{-1}). Such concentration of chlorophyll-a could cause unnatural fish deaths. A similar leap was recorded in LHF two weeks later. The maximal value of chlorophyll-a concentration there was only 42.09µg l^{-1}, but this was still 3.5 times higher than the average to 17 July. However, at LHF even the maximal concentration of chlorophyll-a is too low for effective fish production. The average concentration of chlorophyll-a (15.57 µg l^{-1}) is not sufficient for ponds utilised for fish production.

We assume that the significant increase in chlorophyll-a concentration in both fishponds at the end of July related to a long period of high temperatures in June, July, and August. Morning temperatures in the upper levels of surface water exceeded 25°C during this period.

Values for pH and concentrations of magnesium and calcium

The values for pH, magnesium and calcium recorded in the LHF as well as in the SHF during the period of our study are shown in Figure 3. The pH values were more or less similar, oscillating around 8.0. A slight increase was recorded on 31 July, related to the chlorophyll-a increase in both fishponds at that time.

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Figure 2. Values for chlorophyll-a and zooplankton, Hrhov fishponds (1994)

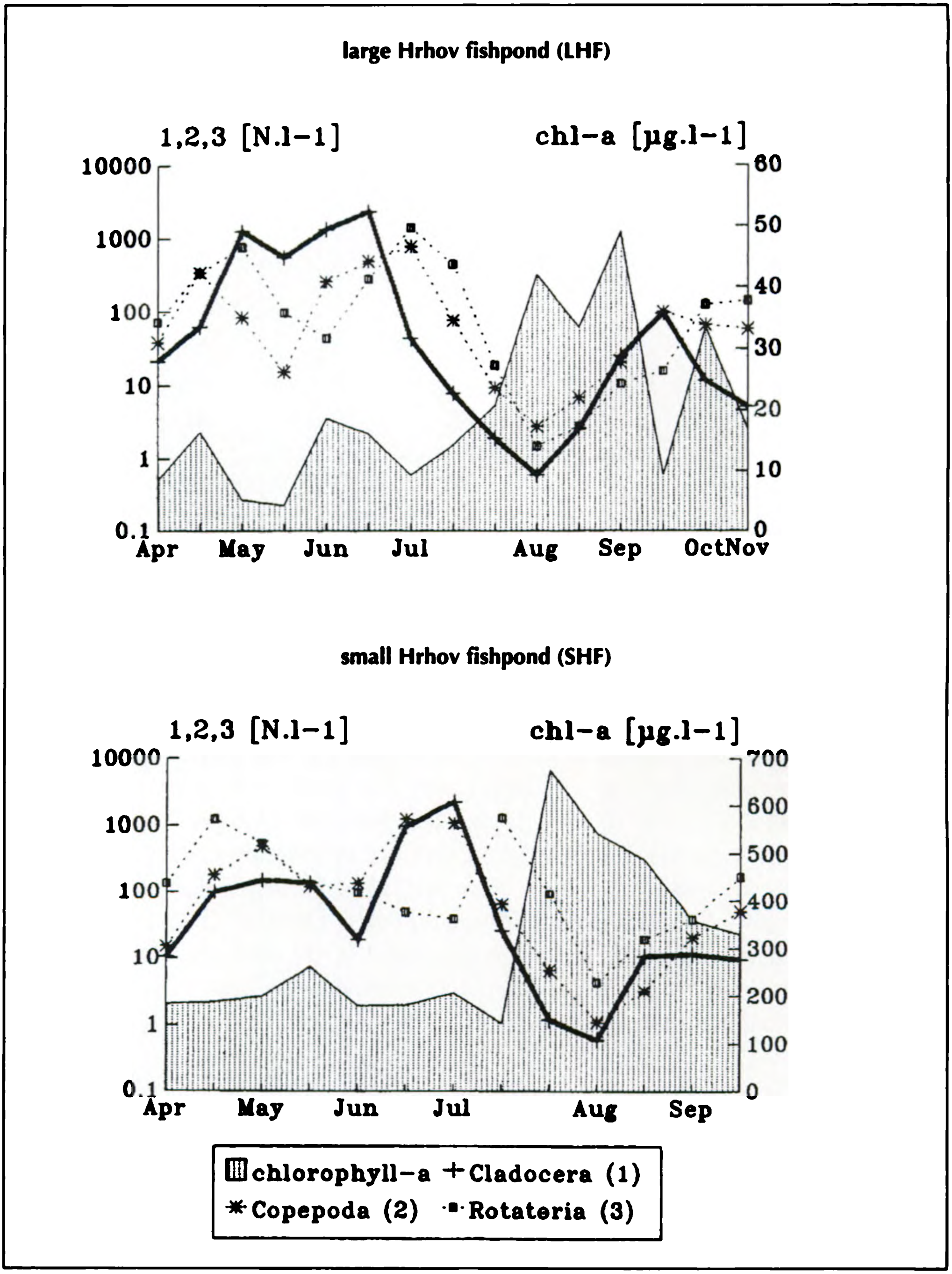

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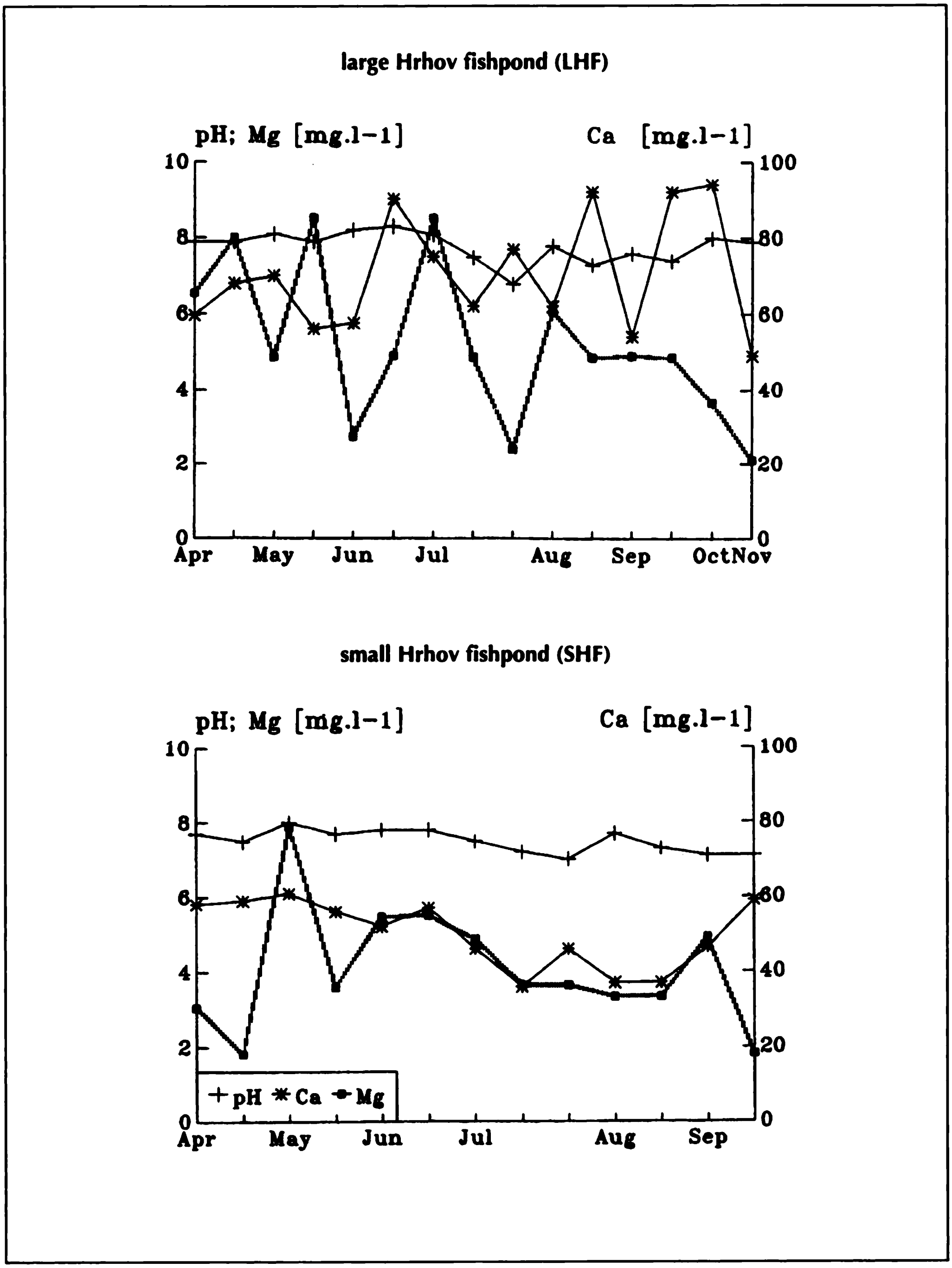
Figure 3. Values for pH, calcium (Ca) and magnesium (Mg), Hrhov fishponds



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comparison to Iňačovské fishponds the Hrhov fishponds are not located on as important a bird migration route, and do not have so many different wetland habitats associated with them.

Introduction and distribution of non-native species

Since there is no purpose-built breeding equipment for fish fry production, the unintentional introduction of other species to the fishpond habitat can be expected. This is probably the cause of the colonisation of both Hrhov fishponds by the water flea *Daphnia parvula* (a North American species) in 1994. We presume that all fishponds managed in the same way may be inhabited by this and other non-native species and that they may become distribution centres for new non-native aggressive species to surrounding habitats. This situation carries a high risk of disease introduction into the fishponds. Because of this it would be good to consider examining new fish stock as well as the water in which such stock is transported.

There are great differences in the species and class abundance in both fishponds. In the large Hrhov fishpond (LHF), with well grown macrovegetation, 50% more species of water fleas and rotifers have been determined compared to the small Hrhov fishpond (SHF) with its rather low macrovegetation cover. This is very important for biodiversity. We may assume that fishpond biodiversity is positively influenced by macrovegetation and negatively by existing fish production management.

Zooplankton dynamics

The development of zooplankton quantity is demonstrated in Figure 3. A gradual increase of zooplankton mass was recorded in both fishponds. A maximum was reached at the end of June in SHF and in mid-June in LHF. The notable decrease of zooplankton in July correlated with its summer minimum, typical for fishpond ecosystems of the moderate climatic zone (Korínek *et al.* 1987). Unexpectedly low values of all groups of zooplankton around 15 August were probably caused by long-term high temperatures in the region.

Large cladocerans were found in the LHF zooplankton until about 20 April. After consolidation of the fish population only small species, mainly *Bosmina longirostris* and *Chydorus sphaericus*, were found.

4.4.3. Botanical characteristics of the area

The Hrhov fishpond system is representative of the fishpond habitat, with a wide range of plant communities. Especially significant from the landscape, ecological and aesthetic viewpoints are littoral communities (including reed, bulrush and tall sedges) and open water body communities. The largest growths are formed by *Phragmites australis, Typha angustifolia* and *Typha latifolia*. The ratio of open water to reed and bulrush is optimal in

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the SHF. The largest growth of the lesser bulrush *Typha angustifolia* is in the south and south-east part of the LHF. Field research in 1993 and 1994 recorded the following plant communities for the Hrhov fishponds.

Lemnetum minoris (EGGLER 1993) Th. MULLER et GORS 1960
A simple community predominantly formed by the species *Lemna minor*, which occurs in small areas and alongside littoral communities belonging to the alliance *Phragmition*. In the studied areas it occurs on the surface of stagnant or slow flowing waters of various depths, especially near leeward banks, and also penetrates into reed and sedge growth.

Lemno - Utricularietosum vulgaris (SOÓ 1971)
Community adjoining growths of *Phragmites australis, Typha angustifolia* and *Glyceria maxima*. Continuous and ecologically balanced vegetation growth has developed, especially in the south and south-east part of LHF.

As well as *Utricularia vulgaris*, in the water there are pondweed species belonging to the association ***Potamogetum natantis*** (SOÓ 1927), with *Potamogeton natans* dominant in the open water areas of LHF. Also in the water of LHF there is a fragment of the association ***Potamogetum obtusifolii*** (SAUER 1937; CARSTENSEN 1955), containing *Potamogeton obtusifolius*.

Phalaridetum arundinaceae (LIBBERT 1931)
Phalaroides arundinacea prevails in the composition of the community. Two subassociations have been identified:
- ***phragmitetosum*** (T. 1954) KOPECKÝ 1960, with dominant *Phragmites australis* and *Scirpus sylvaticus;*
- ***filipendulosum*** (PASSAGE 1955) KOPECKÝ 1960, characterised by the presence of *Cirsium oleraceum, Filipendula ulmaria* and *Lythrum salicaria*. The community also contains *Solanum dulcamara, Calystegia sepium* and others. This community connects to species of the alliance *Glycerio-Sparganion* and where soil is forming (i.e. where succession has started) it overlaps with species of the alliance *Caricion gracilis*; another overlap is with *Deschampsia caespitosa* and *Bidens frondosa.*

Scirpetum lacustris (ALLORGE 1922) CHOUARD 1924
This community has low diversity, with dominant *Schoenoplectus lacustris*, small island-growths of which penetrate into the sublittoral with higher water levels, especially in LHF.

Scirpetum silvatici MALOCH 1935
The dominant species is *Scirpus sylvaticus*, which penetrates into alliances *Phragmition communis* and *Caricion gracilis*.

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Equisetum fluviatilis STEFFEN 1931
Community of areas which are drying out through succession, with dominant occurrence of *Equisetum fluviatile*, together with *Alisma-plantago aquatica, Sparganium erectum* and *Potamogeton natans*.

Glycerietum maximae (NOWINSKI 1928) HUECK 1931
Community with a significant dominance of *Glyceria maxima*. In the lower layers species of the order *Phragmitetalia* and *Magnocaricetalia* also occur irregularly. The community overlaps with reed growths in the open water area. It is adaptable to water level changes. Due to recent extreme climatic conditions the water level has dropped and new species, such as *Bidens tripartitus, Persicaria hydropiper, Rorippa islandica, Alopecurus aequalis,* and *Ranunculus sceleratus* have occurred. These grow on bare fishpond substrates and thus the community is the most frequent in areas drying out through succession. Thinner growths also contain *Utricularia vulgaris, Iris pseudacorus, Lysimachia vulgaris, Rorippa amphibia, Rumex hydrolaphatum* and others.

Phragmitetum australis (GAMS 1927) SCHMALE 1939
Community characterised by dominant *Phragmites australis*. Continuous growths of reeds are botanically poor and rather uniform. They have their function in the soil-forming belt, creating conditions for the succession of other species. *Urtica dioica* also occurs as a result of the impact of nitrification from agriculture, fishery and other activities. The inner borders of reeds are fringed by *Alisma plantago-aquatica, Glyceria maxima* and *Sparganium erectum*. *Phragmitetum australis* represents one of the most common littoral vegetation communities in both fishpond areas.

Typhetum angustifoliae PIGNATTI 1953
The growths of *Typha angustifolia* are confined to areas with stable water level. They are linked to the reeds and also overlap with communities of the open water area. The largest continuous growth of lesser bulrush (*Typha angustifolia*) is in the south and south-eastern part of LHF. Large growths are also found in SHF.

Typhetum latifoliae (LANG 1973)
Notable for its structural features, this community is simply organised, with dominant *Typha latifolia*. It also colonises barren, eutrophic substrates and littorals. In the lower layers of both bulrush associations species of the alliance *Lemnion minoris* and *Phragmition australis* occur.

Typhetum laxmanii (NEDELCU 1968)
A community with dominant *Typha laxmanii* linked to the growths of reed and bulrush. The community is optimally developed on the western side of LHF. Smaller groups have

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also been recorded on the eastern side of SHF and in the tributary channels in the southern part of the study area.

Rorippo amphibiae - Oenathetum aquaticae (SOÓ 1928) LOHMEYER 1950
The community structure is determined by *Rorippa amphibia* and *Phellandrium aquaticum*.

Caricetum gracilis ALMQUIST 1929
This community of high sedges is dominated by *Carex gracilis*. It is linked to the growths of reed on the western bank of LHF and partially also on the northern and north-eastern bank of SHF. In the border parts it overlaps with communities including *Calamagrostis epigeios* and consequently passes to *Molinietum*. The community occupies relatively large areas in the studied fishpond sites.

Alopecuretum aequalis BURRICHTER 1960
The structure is determined by *Alopecurus aequalis*. The species composition is also influenced by plants from the alliance *Bidention tripartii*, recorded on the eastern side of LHF.

In total, 16 plant communities were recorded in LHF and 8 in SHF. The most valuable localities are those with communities containing *Utricularia vulgaris, Typha laxmanii, T. angustifolia, Potamogeton obtusifolius, Ceratophyllum demesum* and *Bidens cernua*.

Protected, rare and endangered species
The total number of protected, rare and endangered plant species recorded in the study area is 16. According to Maglocký and Feráková (1993), these species are classified as:

- E, R (critically endangered and rare species) – 1 species: *Symphytum bohemicum* (LHF littoral)
- V (vulnerable) – 6 species: *Butomus umbellatus* (LHF littoral), *Centaurium pulchellum* (wet meadows on south and south-east side of LHF), *Cicuta virosa* (LHF and SHF littoral), *Nuphar lutea* (tributary channel of LHF and the Turňa stream), *Thalictrum flavum* (LHF and SHF littoral), *Utricularia vulgaris* (open water area on south and south-east side of LHF)
- I (indeterminate) – 9 species found in the littoral zone of both fishponds: *Alchemilla* sp., *Lythrum hyssopifolium, Pseudolysimachion longifolium, Rosa* sp., *Rubus* sp., *Scrophularia umbrosa, Thymus* sp., *Typha laxmanii, Veronica anagalloides*.

Tree and shrub growth
Along the dikes there is a dense and continuous growth of the poplar *Populus canadensis*. The fishpond margins are overgrown with various kinds of shrubs, which do not form distinctive communities.

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Tree and shrub growth around the water and on the slopes of dikes is formed by: *Salix alba, S. caprea, S. cinerea, S. fragilis, S. purpurea, S. viminalis, Alnus glutinosa, Sambucus nigra, Swida sanguinea, Rosa* sp., *Rubus caesius* and *Viburnum opulus*. Shrub willows of *Salicion triandre* with dominant *Salix triandra* mostly border the Turňa stream banks.

Evaluation of the state of vegetation

The broken tree growth surrounding the fishponds is ready to harvest as timber and is disappearing from the landscape. The large areas of macrophyte growth are an important part of the ecological value of the fishponds. In the SHF such growth forms a border (occupying 15% of the water area) on the north and west, passing continuously from water to vegetation belt.

The growths of macrophytes in the northern part of the LHF have the character of littoral vegetation. In the eastern half of the fishpond they also grow inside the water area in compact belts. Only in some places does water penetrate into these growths. We estimate that macrophytes occupy 35%–50% of the real fishpond area and that from the viewpoint of fish production they are not distributed in an optimal way.

By means of methodology based on the vegetation composition, its continuous growth, multifunctional significance and species diversity, we have determined its qualitative value – its significance in the landscape. According to this analysis we have obtained the five basic categories shown in Figure 5. The current vegetation distribution for the study area is depicted in Map 1.

Floodplain willow-poplar forests were typical for the original wetland field depression below Hrhov. These have become scarce due to regulation, agricultural activity and drainage. Only traces remain in the northern and western parts of the SHF.

4.4.4. Mollusc fauna of the Hrhov fishponds

By sampling part of the alluvial sediments from the banks, an almost complete picture of the mollusc species composition of the fishponds has emerged, not just today, but also in the recent past. Twenty-three species of molluscs have been found in SHF, 26 species in LHF and 21 species in the fishpond surroundings. Of 49 species identified in Hrhov fishponds and in their surroundings, 28 are aquatic species. However, today almost all the water species have been exterminated here. We have confirmed only *Sadleriana pannonica* (Frfld.) in the LHF tributary and *Lymnaea auricularia* (L.).

The following recorded species are listed in the Red List of molluscs of Slovakia (Šteffek 1994).

- Critically endangered: *Anisus vorticulus* (SHF), *Cochlicopa nitens*.
- Endangered: *Valvata pulchella, Anisus septemgyratus, Planorbis carinatus* (SHF).
- Rare: *Bithynia leachi, Sadleriana pannonica, Bathyomphalus contortus, Gyraulus laevis*.

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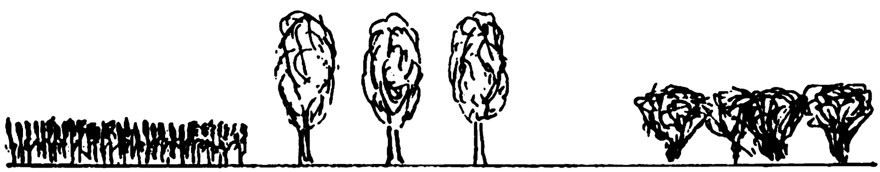
Figure 5. Ecological values of categories of vegetation cover

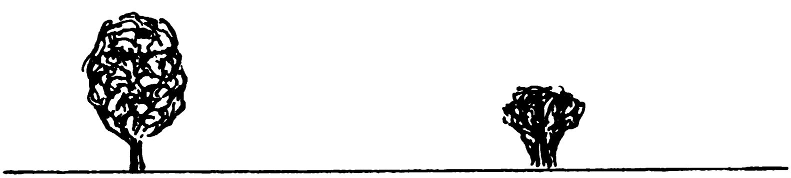
1. Category of the highest ecological value – copses of trees with dense bushy and herbaceous undergrowth.

2. Category of higher ecological value – a) trees with bushy undergrowth; b) trees with undergrowth of macrophytes; c) bushes with undergrowth of macrophytes.

3. Category of medium ecological value – a) copses of macrophytes; b) clumps of trees; c) clumps of bushes.



4. Category of low ecological value – a) solitary trees; b) solitary bushes.



5. Category of the lowest ecological value – herbaceous growth without trees and bushes.

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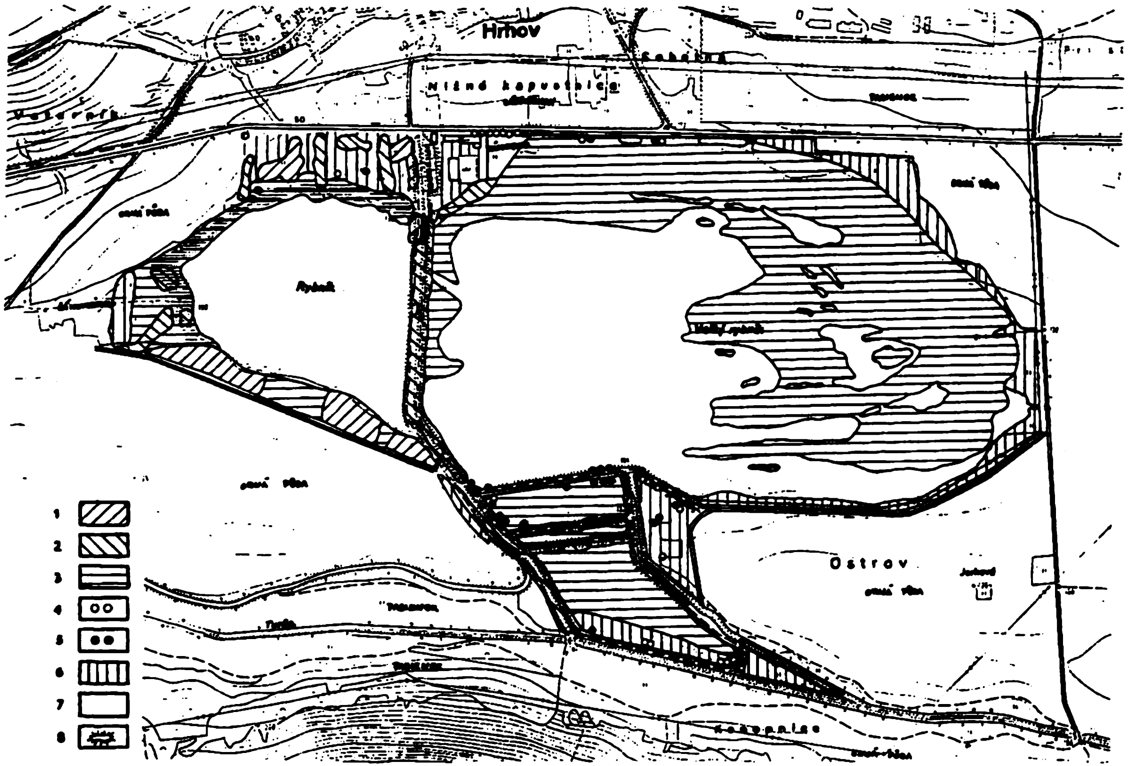
Map 1. Current vegetation cover for the Hrhov fishponds

Key:

Present state of the vegetation cover of area

1. Vegetation cover of the highest ecological value, category 1.
2. Vegetation cover of higher ecological value, category 2.
3. Vegetation cover of medium ecological value, category 3 (copses of *Phragmites* and *Typha*).
4. Vegetation cover of lower ecological value, category 4 (solitary trees).
5. Vegetation cover of lower ecological value, category 4 (solitary bushes).
6. Vegetation cover of the lowest ecological value, category 5 (besides *Phragmites* and *Typha*).
7. Water area.
8. Deposits of the material from the fishpond bed.



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- Indeterminate, requiring attention: *Helix lutescens.*

In addition, the following species were included in IUCN's list of endangered species in Europe (Šteffek 1994): *Anisus spirorbis, Vertigo angustior, Segmentina nitida, S. nitida distinguenda.*

4.4.5. Dragonflies of the Hrhov fishponds

Research on dragonflies was carried out during the summer of 1994. Due to their requirements for food and breeding sites and position in the trophic chain, dragonflies are strictly linked to the water environment and water vegetation. Dragonflies can act as indicators for the state of this environment, as they react quickly to environmental changes. The Large Hrhovský Fishpond provides good conditions for the existence of dragonfly communities, which are stable here.

The 1994 research confirmed the occurrence of 14 species of dragonflies, including five species which are on the Red List of dragonflies of Slovakia (Škapec 1992).

- Critically endangered: *Coenagrion scitulum*
- Rare: *Ischnura pumilio, Erythroma viridulum, Aeshna affinis* (*mixta*)
- Migrant: *Crocothemis erythraea*

The following dragonfly communities were identified at Hrhov fishponds.

1. Still water communities: *Lestes-Sympetrum-Aeshna mixta* (*affinis*) *sensu* Jacob (1969), David (1992b). Constant species of the community are *Lestes sponsa, L. barbatus, Sympetrum sanguineum, S. vulgatum, S. striolatum*, and the species already listed from the genus *Aeshna*. Accompanying species are *Enallagma cyathigerum, Ischnura elegans, I. pumilio* and species of the genus *Coenagrion.*
2. Flowing water communities: *Gomphus* (*vulgatissimus*)*-Calopteryx splendens.* Usually *Platycnemis pennipes* occurs in this community.

Species of the suborder Anisoptera hunt further from the water bodies. Conditions influencing the presence of dragonflies include: distribution of macrovegetation, state of succession, chemistry of the water environment, and economic use of the water area. In the case of Hrhov fishponds grazing of cattle and sheep, and consequent trampling of the water fringes in the littoral area, also have an influence.

4.4.6. Vertebrate fauna of the Hrhov fishponds

Qualitative and quantitative research on the vertebrate fauna of the Hrhov fishponds was carried out in 1993 and during the nesting period in 1994.

For birds, singing males, nest-building, feeding of young, and secondary attributes of nesting (such as egg shells and feathers) were recorded to determine the breeding species. Additional information was provided by a specific search for nests in the reeds (heron, birds of prey) and by netting and ringing the birds. Mammals were recorded by trapping

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(for small mammals) and by analysis of tracks, droppings and other accompanying features.

Recorded vertebrate species

Table 4 presents the species of vertebrate fauna determined in the study area during the years 1993–1994 (excluding fish species, which are described on page 167), with details of their status.

Evaluation of vertebrates at Hrhov fishponds

Nineteen species of birds were recorded among the macrophyte growth, on open water and adjacent to the open water. The most significant group were *Porzana porzana, P. parva, Botaurus stellaris, Ixobrychus minutus* and *Crex crex*. It was surprising to find six nests of the heron *Ardea cinerea* nesting on the ground, among the macrophytes. Similarly, *A. purpurea* also nests here. The wet meadows on the eastern and northern fringe between the road and the fishpond are the nesting place of *Gallinago gallinago, Porzana porzana* and *P. parva*. *Crex crex* was heard from south of the fishponds, in an area used for agricultural purposes. Fifty-one bird species nest in the dispersed littoral growth, directly in the macrophytes or on the banks of the fishponds.

Four species of woodpecker (three nesting) and *Jynx torquilla* were recorded in the old dying poplars, but were not frequent. Poplar growth in the southern fringe has the character of a forest biotope, and attracts forest species such as *Anthus trivialis, Coccothraustes coccothraustes, Fringilla coelebs* and *Phylloscopus collybita*. Steppe communities of herbs and shrubs on the southern fringe are occupied by species such as *Saxicola rubetra, S. torquata, Miliaria calandra, Emberiza citrinella, Lanius collurio, Sylvia nisoria* and others.

The reed and bulrush communities surrounding open water areas and wet herb and shrub communities in the former fishpond chambers are occupied by species of the genus *Locustella* and *Acrocephalus*, also by *Motacilla flava* and *Sylvia communis*. The littoral growth along the tributary canal is occupied by *Luscinia megarhynchos, Sylvia atricapilla, Remiz pendulinus* and others. In recent years, *Panurus biarmicus* has become a resident species of the reed growth.

Larger numbers of migrating birds, such as ducks, geese, cranes and waders, occur during spring and autumn migration, but do not stay long. *Pandion haliaetus* was also observed during migration.

To conclude, six species of amphibians, three species of reptiles, 110 species of birds and 20 species of mammals have been recorded at Hrhov fishponds. Of these, 112 species are protected according to the Nature and Landscape Conservation Act No. 287/1994. According to the Red Book of the former Czechoslovakia six species are Endangered (E), 33 are Vulnerable (V), eight are Rare (R), two are endangered migrants (M) and 11 species are of indeterminate status (I) requiring

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Table 4. Vertebrates recorded from the Hrhov fishponds, 1993–1994

AMPHIBIA (amphibians) species	**status in Slovakia**
1. *Bombina bombina* (L.)	
2. *Bufo bufo* (L.)	CH
3. *Hyla arborea* (L.)	V, CH
4. *Pelobates fuscus* (LAUR.)	V, CH
5. *Rana kl. esculenta* L.	V
6. *Rana ridibunda* PALL.	E

REPTILIA (reptiles) species	**status in Slovakia**
1. *Lacerta agilis* L.	CH
2. *Natrix natrix* (L.)	V
3. *Natrix tessellata* (LAUR.)	V

AVES (birds) species	**category**	**status in Slovakia**	**ICBP status**
1. *Podiceps cristatus* (L.)	N		
2. *Tachybaptus ruficollis* (PALL.)	N		
3. *Podiceps griseigena* (BODD.)	N	R, CH	
4. *Podiceps nigricollis* (BREHM)	N	I	
5. *Ardea cinerea* L.	N	V, CH	
6. *Ardea purpurea* L.	N	E, CH	+
7. *Egretta alba* (L.)	M	R, CH	+
8. *Ixobrychus minutus* (L.)	N	V, CH	+
9. *Botaurus stellaris* (L.)	N	E, CH	+
10. *Ciconia ciconia* (L.)	T	I, CH	+
11. *Ciconia nigra* (L.)	T	V, CH	+
12. *Anser fabalis* (LATH.)	M		
13. *Anas platyrhynchos* L.	N		
14. *Anas querquedula* L.	N	V	
15. *Anas crecca* L.	M	V	
16. *Spatula clypeata* (L.)	M	V, CH	

.../continued

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Table 4. (continued)

species	category	status in Slovakia	ICBP status
17. *Aythya ferina* (L.)	M	M, CH	
18. *Aythya fuligula* (L.)	N		
19. *Buteo buteo* (L.)	T		
20. *Aquila heliaca* SAV.	T		
21. *Aquila pomarina* BREHM	T		
22. *Circus cyaneus* (L.)	M		
23. *Circus aeruginosus* (L.)	T	I, CH	+
24. *Falco tinnunculus* L.	T	CH	
25. *Pandion haliaetus* (L.)	M	M, CH	+
26. *Coturnix coturnix* (L.)	T	V, CH	
27. *Phasianus colchicus* L.	N		
28. *Grus grus* (L.)	M	M, CH	+
29. *Rallus aquaticus* L.	N	V	
30. *Porzana porzana* L.	N	V, CH	+
31. *Porzana parva* (SCOP.)	N	V, CH	+
32. *Gallinula chloropus* (L.)	N		
33. *Fulica atra* L.	N		
34. *Vanellus vanellus* (L.)	N	CH	
35. *Charadrius dubius* SCOP.	N	CH	
36. *Philomachus pugnax* (L.)	M	CH	+
37. *Actitis hypoleucos* (L.)	M	V	
38. *Tringa erythropus* (L.)	M	CH	
39. *Tringa nebularia* (L.)	M	CH	
40. *Tringa glareola* L.	M	CH	+
41. *Tringa ochropus* L.	M	R, CH	
42. *Tringa totanus* (L.)	M	V, CH	
43. *Gallinago gallinago* (L.)	N	V	
44. *Limnocryptes minimus* (BRUNN.)	M	CH	
45. *Larus ridibundus* L.	M	CH	
46. *Chlidonias niger* (L.)	M	V, CH	+
47. *Columba palumbus* L.	N		
48. *Columba oenas* L.	T	V, CH	
49. *Streptopelia turtur* (L.)	N		

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Table 4. (continued)

species	category	status in Slovakia	ICBP status
50. *Streptopelia decaocto* (FRIV.)	T		
51. *Cuculus canorus* L.	N		
52. *Apus apus* (L.)	T	CH	
53. *Alcedo atthis* (L.)	N	V, CH	+
54. *Jynx torquilla* L.	N	V, CH	
55. *Picus canus* GM.	T	CH	+
56. *Dendrocopos major* (L.)	N	CH	
57. *Dendrocopos syriacus* (HEM. & EHRN.)	N	I, CH	+
58. *Dendrocopos medius* (L.)	T	I, CH	+
59. *Dendrocopos minor* (L.)	N	CH	
60. *Galerida cristata* (L.)	N	V, CH	
61. *Alauda arvensis* L.	N	CH	
62. *Hirundo rustica* L.	T	I, CH	
63. *Delichon urbica* (L.)	T	CH	
64. *Anthus pratensis* (L.)	M	CH	
65. *Anthus trivialis* (L.)	N	CH	
66. *Anthus spinopletta* (L.)	T	R, CH	
67. *Motacilla flava* L.	N	V, CH	
68. *Motacilla cinerea* TUNST.	T	CH	
69. *Motacilla alba* L.	N	CH	
70. *Troglodytes troglodytes* (L.)	N	CH	
71. *Erithacus rubecula* (L.)	N	CH	
72. *Luscinia megarhynchos* BREHM	N	I, CH	
73. *Phoenicurus ochruros* (GM.)	N	CH	
74. *Saxicola rubetra* (L.)	N	V, CH	
75. *Saxicola torquata* (L.)	N	V, CH	
76. *Turdus merula* L.	N	CH	
77. *Turdus pilaris* L.	N	CH	
78. *Turdus philomelos* BREHM	T	CH	
79. *Locustella fluviatilis* (WOLF)	N	CH	
80. *Locustella luscinioides* (SAVI)	N	R, CH	
81. *Acrocephalus schoenobaenus* (L.)	N	CH	
82. *Acrocephalus palustris* (BECHST.)	N	CH	

.../continued

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Table 4. (continued)

species	category	status in Slovakia	ICBP status
83. *Acrocephalus scirpaceus* (HERM.)	N	CH	
84. *Acrocephalus arundinaceus* (L.)	N	CH	
85. *Sylvia nisoria* (BECHST.)	N	I, CH	+
86. *Sylvia communis* LATH.	N	CH	
87. *Sylvia borin* (BODD.)	N	CH	
88. *Sylvia atricapilla* (L.)	N	CH	
89. *Phylloscopus collybita* (VIEILL.)	N	CH	
90. *Panurus biarmicus* (L.)	N	R, CH	
91. *Parus caeruleus* L.	N	CH	
92. *Parus major* L.	N	CH	
93. *Sitta europaea* L.	N	CH	
94. *Oriolus oriolus* (L.)	N	CH	
95. *Lanius collurio* L.	N	V, CH	+
96. *Lanius excubitor* L.	T	CH	
97. *Pica pica* (L.)	N		
98. *Corvus corone cornix* L.	T		
99. *Corvus corax* L.	T	I, CH	
100. *Sturnus vulgaris* L.	N		
101. *Passer domesticus* (L.)	N		
102. *Passer montanus* (L.)	N		
103. *Fringilla coelebs* L.	N	CH	
104. *Carduelis chloris* (L.)	N	CH	
105. *Carduelis carduelis* (L.)	N	CH	
106. *Carduelis cannabina* (L.)	N	CH	
107. *Coccothraustes coccothraustes* (L.)	N	CH	
108. *Emberiza citrinella* L.	N	CH	
109. *Emberiza schoeniclus* (L.)	N	CH	
110. *Miliaria calandra* (L.)	N	V, CH	

MAMMALIA (mammals)

species	status in Slovakia
1. *Erinaceus concolor* MARTIN	V, CH

.../continued

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Table 7. (continued)

species	status in Slovakia
2. *Talpa europaea* L.	
3. *Sorex araneus* L.	CH
4. *Neomys anomalus* CABRERA	R, CH
5. *Crocidura suaveolens* (PALL.)	CH
6. *Myotis blythi* (TOMES)	V, CH
7. *Myotis daubentoni* (KUHL)	I, CH
8. *Rhinolophus ferrumequinum* (SCHREB.)	E, CH
9. *Rhinolophus hipposideros* (BECHST.)	E, CH
10. *Lepus europaeus* PALL.	
11. *Mus musculus* L.	
12. *Ondatra zibethica* (L.)	
13. *Microtus arvalis* (PALL.)	
14. *Vulpes vulpes* L.	
15. *Mustela erminea* L.	
16. *Putorius putorius* L.	V
17. *Lutra lutra* (L.)	E, CH
18. *Sus scrofa* L.	
19. *Cervus elaphus* L.	
20. *Capreolus capreolus* (L.)	

Status in Slovakia

E, V, R, M, I: status according to the Red Book (Sedláček 1988)

E: critically endangered

V: vulnerable

R: rare

M: endangered migrant

I: indeterminate, requiring further research

CH: species protected in Slovakia

Category (birds only)

N: nesting

T: transmigrant

M: migrant

ICBP status (birds only)

+: listed as a European Threatened Species in Grimmett and Jones 1989 (Appendix 3)

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further research. Of the bird species, 71 are nesting species, 20 are transmigrants and 20 migrants.

4.5. Economic activities at the Hrhov fishponds

4.5.1. History of the origin and operation of Hrhov fishponds

A lowland wetland with several deeper depressions developed in the Turnianska basin. In one of the depressions, south of the village Hrhov, a fishpond with an area of 280ha was built in 1950–1953. Later the regional water management service initiated a project of further Hrhov fishpond development. The Small Hrhov fishpond (SHF) is in the west, with an area of 42.79ha and an average depth of 1.3m. It was filled with water in 1954 and is permanently used for fish production. The Large Hrhov fishpond (LHF) is in the east, with an area of 187.47ha. It was filled with water in 1958.

Peat was extracted from SHF by the Slovenské rašelinové závody (Slovak peat enterprises) in 1974–1986. At the same time they deepened the fishpond to 3.5m. State fisheries Stupava improved the banks and supplied pumping equipment to renew fish production after the peat was extracted. Building two chalets near the outlet and connecting them to 22kV electrical power was also part of the project. In the northern fringe of the fishpond a duck production farm was also in operation until 1991.

In 1994, 50% of the fishpond area was used for commercial fish production. State fisheries in Stupava designed the project improving the Turňa stream (length 1,379km), the Fej stream (length 1,800km) and building a canal from the Turňa stream (length 3,280km). The space between the southern dike of the LHF and Turňa stream has been adjusted into three production chambers: a southern chamber (13ha), middle chamber (1.82ha) and northern chamber (6.14ha). The chambers have not been used since 1987. Currently the fishponds are under the administration of the Východoslovenský rybársky podnik (East Slovakian Fish Farming Enterprise).

4.5.2. General principles of the economic activities at the fishponds

Fishponds are purposeful enterprises, aimed at the production of market and fry species, eventually utilised for sport fishing. The effort to achieve the highest profit is based on artificial 'improvement' of the natural biological processes.

To maintain this process at a high level over the long term, with the exclusion of natural biological elements, is demanding both economically and ecologically. From the ecological viewpoint, the artificial fishpond ecosystem is unstable and vulnerable. However, the idea of a long-term stability of fishpond biota, without interference of man, is unrealistic. It is necessary to know, define and characterise the largest possible set of

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factors affecting the process, as well as their impacts on the environment, and also their mutual relations, to foresee their impacts on the optimisation of fish production.

Despite the given basic description of fishponds in Slovakia, no two are identical, and it is not always possible to transfer knowledge of one fishpond directly to the fish production process in another. The selected demonstration site has been characterised in as much detail as possible to enable comparison of both positive and negative parallels in economy and operation, ecological conditions and nature conservation possibilities in the area.

These descriptions form the basis for our general conclusions, emphasising the differences between nature conservation aims and effective fish production in one fishpond ecosystem. We have concentrated on those areas of conflict which can be solved (both from the viewpoint of nature conservation and fish production) when there is good will. The selected sets of problems may provide a model for other fishponds.

State of the water

The critical water resource is the Fej stream. Other smaller water sources were not included in the calculations. The Turňa stream, despite the specially-built supply canal, is not used to supply fishponds anymore, due to its low water flow volume (see Figure 1 and Table 2) and the overall drop in water flow in recent years. The cement works at Turňa also depend on the water flow volume. Due to this a compromise in water use has been reached.

The fishponds can be filled with water for two years at a time. Currently the LHF is in its second productive year and is up to 70% full. We cannot exclude the possibility that the lower water level is caused by infiltration into the bedrock, due to the extracted peat and uncovered gravel bedrock.

Composition of fishpond species

According to the owner, the composition of fishpond species is 70% carp *Cyprinus carpio* and 30% supplementary species, mostly grass carp *Ctenopharyngodon idella* and both species of the silver carp: *Aristichthys nobilis* and *Hypophthalmichthys molitrix*. These have been put into fishponds as part of the efforts to eliminate macrophyte growths. Among other species of this group are chub *Leuciscus cephalus*, roach *Rutilus rutilus*, perch *Perca fluviatilis*, *Chondrostoma nasus*, crucian carp *Carassius carassius*, goldfish *Carassius auratus*, European eel *Anguilla anguilla* and pike *Esox lucius*.

Optimal fish production requires a minimum of 1,000 fish to 1ha of the managed water area. The expected growth is 0.2–0.3kg per fish in the first year, 0.5kg in the second year and 1–2kg in the third year. The most important fish production species is carp *Cyprinus carpio*, achieving 2kg on average, in approximately 3 years.

Economics of fish production

A production fishpond can be compared to a fish meat producing factory, and as such aims to be efficient. Technological interventions are combined to provide the highest

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economic yields. This means the fish is intensively supplied with food, the fishponds are manured, etc. It is clear that intensive eutrophication is common in fishponds, followed by succession. All this considerably influences fauna bound to the fishpond biotopes. It is, for example. generally known that crayfish populations are weakened and ultimately perish in intensively utilised fishponds (this is also the case in the Hrhov fishponds).

Similarly, the composition of other components of plankton is influenced by fish production. Phytoplankton develops intensively (especially in SHF – see Figure 2); for example see the average value of chlorophyll-a in Table 2. Zooplankton is reduced both in its diversity (section 4.4.2) and in its quantity.

In the Hrhov fishpond system a three-year production cycle is used (partly due to the inadequate water level). The destocking of fishponds is carried out alternately, e.g. SHF was discharged in the autumn 1994 and destocking of LHF is planned in 1995. However, the parallel use of both fishponds for economic purposes takes into account neither the requirements of sustainable development, nor the implications of global climate change (with temperatures of over 30°C recorded for 35 days during 1995 such changes may already be occurring).

Only just over 50% of the fishponds (about 90ha) in LHF are used for economic production, due to the large areas of macrophytes. Attempts to reduce macrophyte growth by aerial herbicide spraying were stopped after 1989 as this technique did not bring the expected effect.

LHF was reconstructed recently, as the advanced stage of succession was inhibiting its use for fish production. Large peat moor remnants have been preserved only on its northern and north-eastern part. The SHF does not have large macrophyte growths at this time.

Up to now, manure has only been applied once a year, during winter, on the ice. LHF has not been manured recently due to a lack of financial resources. This practice has been partly substituted by dung-water and liquid-manure discharging into the eastern part of the fishpond. On the surface of SHF 4,000m^3 of manure (100m^3/1ha) was applied. Liming of the fishponds has not been performed due to the existing chemical properties of the inflowing water (which has a naturally high content of $Ca(HCO_3)_2$, as described above).

It has been calculated that, in order to increase fish weight by 1kg, 2.5kg of feed is needed. The feed, however, is not completely used up and it accumulates on the bottom. This was confirmed by the samples of molluscs from the bottom of the fishpond. Monitoring of phytoplankton and zooplankton development is controlled routinely, visually, by the manager, and feeding is interrupted if there are signs of a serious decline.

Another important factor which could influence fishpond production is an insufficient knowledge of the basic trophic relationships, briefly outlined below.

Trophic relationships between the selected vertebrate species in the fishponds

Amphibians use the shallow margins of fishponds for their reproduction. The tadpoles and small frogs are much favoured as food by those species of fish which feed in the

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vegetation (carp). The adult frogs feed on bugs, snails, tadpoles and fish. Water animals represent 20% of their food.

Reptiles use the water environment for hunting, especially for amphibians, but also insects and small fish.

Diving birds are able to feed on insects and their larvae, worms, snails, tadpoles and small fish. The cormorant feeds especially on fish up to 20–25cm, followed by molluscs and water insects. Herons also feed on fish, as well as frogs, molluscs and aquatic insects.

Storks, although consuming a considerable percentage of small fish, can adapt to changes in their food. Of the Anseriformes, only ducks compete with carp for food. Ducks mostly eat plants, i.e. parts floating on or under the surface, as well as the young parts of water plants. They also eat fish food from the pond bottom.

Regarding predators, harriers are the most significant in the fishpond ecosystem, taking the eggs and the young of waterfowl (herons), but also adult nesting females (ducks, gulls). A similar role is played by kites nesting near the water bodies. Under favourable weather conditions ospreys are the primary fish hunters. When the weather is bad, they hunt for coots, ducks and divers and fulfil the role of waterfowl predator.

On fishponds rails are mostly represented by coot and moorhen. Their diet predominantly includes the larvae, pupae and adults of water insects, spiders, snails and butterflies, but they also eat seeds of plants such as *Scirpus, Potamogeton, Lemna*, etc. Gulls consume a variety of food, mainly insects, occasionally fish and small mammals. They also hunt in the fields. Of the remaining species, redshanks and terns are noteworthy, with insects and snails predominating in their diet. Kingfishers feed predominantly on small fish.

The only mammal dependent on fish as its prey is the otter. Water shrews *Neomys* spp. may also take small fish. Other carnivorous mammals in the fishpond ecosystem act mainly as predators of nesting birds, and only secondarily as predators of living and dead fish.

4.5.3. Further significant stress-factors and potential pollution sources

Significant stress factors

Road transport: the I/50 state-route Rožňava–Košice passes along the northern boundary of the fishponds. The traffic intensity in 1990 was 3,700 vehicles a day, 38% of them heavy vehicles; the trend is for road transport to increase. On the eastern verge of LHF, in a north-easterly direction, an asphalt road crosses the I/50, passing up to the Turňa stream. The communication route on the side of SHF is faced by concrete panels.

Railway transport: north of the ponds the southern branch of the Zvolen–Košice railway line passes (at about 700m distance). It is expected that this line will be electrified by 2010.

Noise: traffic on the I/50 state road reaches a noise level of 70.9dB(A). At a distance of 13m from the road it decreases to 65dB(A). However, 50dB(A) was still recorded at 190m from the road. The noise level on work-days is higher. This is related to the

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activity of the Včeláre surface mining operation and to the passage of trains in the vicinity of the Hrhov fishponds.

Electricity grids: southwards, behind the Turňa stream, there is a 110kV double electricity mast, Jablonov–Moldava (with a 15m buffer zone). Northwards from the ponds, between Hrhov village and the I/50 road, pass Rimavská Sobota–Moldava 400kV grid (25m buffer zone) and Rožňava–Turňa 110kV grid (15m buffer zone). Along the eastern and southern verge of LHF there is a 22kV grid on 28 concrete poles, which leads to the cabins on the dike. The grid buffer zone is 10m.

Pipelines: in the east–west direction, south from the Turňa stream, there are four transit gas pipelines, with a 200m buffer zone. Parallel to this is the Bratstvo pipeline. Between Hrhov village and the road, there are two oil pipelines, with the capacity of 9 million tonnes of oil per year. There is a 100m buffer zone, increasing to 300m near water sources.

Potential pollution sources

Community waste dumps: in depressions left by the original bed of the Turňa stream and in the mining pits, uncontrolled dumps of household waste have appeared over an area of 1ha. Their surface is currently covered by soil and partly by vegetation. The original dump is separated from the ponds by the Turňa river.

Sewage pollution: due to the extensive growth of macrophytes, pollution by household sewage is not obvious in the ponds. Parts of the agricultural land are isolated from the ponds by several drainage canals. The northern verge of SHF is isolated from the state road by a pit, leading to vegetation growths at the northern verge of the pond.

Accidental spillage: accidents occurring during the transport of dangerous chemical loads by railway and car are a potential threat and may exceed the retention capacity of the road cuttings.

Airborne pollution: when an eastern air current is active (this occurs during about 6% of the year) there is a possibility of dust falling on the ponds from surface limestone mining in the Včeláre quarry and its processing in the Turňa cement works. Aerial spray application to agricultural crops in close vicinity is also a potential threat. Taking into account the road traffic and air-currents, higher concentrations of exhaust gases and heavy metals, especially lead, can be expected in the fishponds.

Economic and recreation activities in the littoral zone

Recreation: in summer the LHF dike between the outflow and the cabins, with the adjacent water body, serves as a beach for several dozens of bathers and rowers. They travel to LHF by car, motorcycle, bicycle, and on foot.

Hunting and poaching: the fishponds are part of a hunting area. In the autumn, there is a duck hunt. In winter, there is also hunting for boar and deer dwelling in the macrophytes. The chalets on the dike are the property of the hunting association. On the eastern

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verge of LHF a high shooting stand is installed. There has also been illegal fishing, taking eggs from nests and catching the young.

Grazing and watering of cattle: cattle from the agricultural cooperative farm are grazed across the eastern verge of LHF. Another herd of cattle is led to the area of the fish stock, and their eastern part. Besides the fact that most of the herd is attacked by the parasite *Fasciola hepatica*, the passage of the herd over the narrow littoral zone causes heavy trampling, destroying bird nests and ground-dwelling invertebrates and introducing ruderal plant species.

Burning: burning is used to control reed growth and enlarge the area of open water. There are also instances of uncontrolled spring burning along road cuttings and drainage canals.

4.6. Ecological evaluation of the Hrhov fishponds

4.6.1. Landscape and ecological characteristics

The fishponds at Hrhov lie on spring and autumn bird migration routes. It is a significant roosting site for migrating waterfowl in Slovakia. With about 100ha of macrophyte growth, the area is particularly attractive to birds, and together with the constant water surface (about 130ha), it contributes significantly to the ecological stability of the landscape. After the landscape changes and agricultural developments in the area, the Hrhov fishponds form one of the few remnants of the original landscape structure.

The ecological value of the territory of the Hrhov village is derived from the spatial structure of the landscape forming elements (areas with constant grass growth, marshes, bush and tree copses, arable land, fishponds, built-up areas etc.). Their ecological significance according to the Rožňava district Regional terrestrial system of ecological stability (RÚSES), on the scale 0.1–1.0, ranges from 0.6 to 0.7, indicating a favourable ecological state. This means that forested areas, pasture land on the verges of karst plains and the fishponds are the most important part of the local landscape for their ecosystems and for their species diversity.

The Hrhov area forms a moderately warm, basin landscape set in a varied hill landscape with cultivated steppe areas. The territory represents the village type of settled landscape, with the majority of population involved in agriculture, industry and services.

4.6.2. Nature conservation

In 1972–1973 the Hrhov fishponds were classified as ecologically significant areas, valuable for their biology and landscape. Since 1973, by the decree no. 110 Zb. of the

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Ministry of Culture of SSR, the territory of the fishponds has become part of the buffer zone of the Biosphere Reserve Slovenský kras karst Protected Landscape Area. The area around the source of the Fej stream, which feeds the system of fishponds, has the status of Protected Area 1.

4.6.3. Outline of the basic trophic relations at the site

The basic producers of the trophic pyramid are the algae, blue algae and eutrophic bacteria (phytoplankton). A smaller group of producers includes freely floating or rooted water plants (macrophytes).

The second grade of the trophic pyramid includes the primary consumers (water-fleas, insect larvae, fish and other vertebrates). The third group completing the cycle of substances in the water environment are the decomposers (bacteria, protozoans and fungi). Complete

Yellow iris *Iris pseudacorus* growing in the Hrhov fishponds

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decomposition only takes place in the presence of oxygen. In its absence, fats, cellulose, lignin etc. accumulate on the pond bottom.

For fish farming the cycle of substances is influenced greatly by the volume of fish stock in the commercial fishponds. The direct supply of food to fish stock shows little respect for the biological balance between the producers, consumers and decomposers. This disequilibrium impairs the oxygen balance in the water, which is detrimental to carp (*Cyprinus carpio*), for example. The ecological processes in the fishpond, however, can be influenced by biological methods. For instance, the presence of ducks (both domestic and wild) increases the trophic value of the pond by 80%–120%. The ducks remove undesirable vegetation, destroy sick fish and fertilise the ponds with their excrement.

The pressure of herbivorous fish on the macrophyte growths in LHF is insignificant, as the macrophytes form a continuous growth from the fishpond verges on the northern side towards the open water body.

4.6.4. The present state of the Hrhov fishponds

The supply of basic components for phytoplankton creation in the Hrhov fishponds system has been disturbed over recent years by lack of finances for organic manure purchase. The liquidation of the former duck farm reduced a further source of nitrates. At present, this supply has been substituted by dung-water discharging on the eastern verge of the LHF and from sewage in the main tributary. The secondary production of zooplankton reflects the water level and its average temperature. The presence of a large amount of macrophytes in this environment contributes to the balance of the phytoplankton and zooplankton production in the LHF.

A different situation exists in the SHF. A detailed comparison of the water chemistry, and especially the trend in chlorophyll development, shows clear differences between the two ponds. The ecosystem of SHF under changing conditions appears to be relatively unstable, and increased phytoplankton (as chlorophyll) reproduction in a hot summer can mean high economic losses, connected with a strong overpopulation of blue algae.

Very low values of chlorophyll in SHF, at the same time, suggest a direction by which the present management could be changed. The growth of a larger area of macrophytes in the fishponds, exceeding 10%, would reduce the area for fish production, but would be more likely to maintain production under conditions of higher temperatures.

4.6.5. Relationship between fish production and nature conservation in the Hrhov fishponds

At present all technological processes are proposed and carried out with the aim of maximising fish production, thus negatively influencing the fishpond fauna and, at the same time, preventing stable fish production in future.

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At present both Hrhov fishponds are intensively managed, so it is necessary to understand them as open living systems into which a substantial part of the input of food, manure etc. should be supplied intentionally from external resources to achieve the highest possible yields.

This type of management is also necessary from the point of view of nature conservation, as eutrophication and subsequent soil-forming successional processes take place in the fishponds much more quickly than in natural ecosystems. This is demonstrated by the huge area of wetland vegetation in the LHF. In general, the processes of change in the fishponds are unusually quick without active management and can be compared to final processes of secondary eutrophication, ending up in terrestrial successional stages.

4.7. Proposed management plan

It is evident that the primary function of the fishponds cannot be entirely suppressed at the expense of nature conservation. Without fish production, the majority of the fishponds would gradually disappear, as a consequence of successional development, resulting in the loss of many valuable habitats for water and wetland species (including protected, rare and threatened species). From the point of view of nature conservation, the fishponds will be a valuable biotope for rare and threatened water and wetland plants and animals when the requirements of nature conservation are taken into account in their commercial management.

4.7.1. General recommendations for integrating fish management and nature conservation

Recommended basic principles for ecologically sustainable management of the fishponds

- Planning of the technological processes, especially manuring, feeding, removing the mud or reduction of reeds, has to be based on knowledge of the ecological relations and processes. It is necessary to ensure that these interventions do not significantly impair the fishpond ecosystem and that the rare and protected species or their habitats are not threatened, and at the same time that no preconditions arise for destabilisation of fishpond production. This requires regular inventories of the fishponds and the development of a precise, ecologically optimal scheme of manuring, feeding, removing the mud and cutting, reflecting at the same time the economic requirements.
- The reed-growths are one of the most essential components of the fishpond ecosystem, for water purity, presence of the rare plant species, and provision of food and nesting sites for many protected and threatened species of birds, insects etc. Their reduction should, therefore, never be automatic, and should not cover the whole area of their

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growth. Reed-cutting should be carried out over a longer period of time (3–4 years), and should not take place during nesting periods.

- Improvement of the fishpond banks and their vegetation cover (including the reed growths) should respect (in accordance with the new Nature and Landscape Conservation Act, valid from 1 January 1995) the requirements for the biotopes of water and wetland species, i.e. the necessity to create banks with moderate inclination, to plant preferably native species, and to take into consideration the necessity of conservation and creation of new suitable nesting possibilities.
- In planning fishpond management, it is necessary to take into account on-going global warming and to carry out planning in the wider context of the water-basin, with the aim of solving questions of water supply and reduction of its pollution. For example, draining of ponds and reed-cutting should be planned so that during the nesting, migration or hibernation periods the biotopes necessary for survival and reproduction of protected and threatened species remain, at least over part of the area.

Recommended basic legislative measures

- It is necessary to elaborate an amendment or a new fishing law. The obsolete law no. 102 Zb. does not take into account nature conservation and does not solve the current ownership relations. It is equally important to apply the new Nature and Landscape Conservation Act, especially with respect to protection of rare and threatened species, as well as penalising the introduction of invasive non-native species.
- We recommend the designation of all fishponds of international and national significance as protected areas (the internationally significant in the category of national nature reserve, the nationally significant ones either in the category of nature reserve or in the category of protected area 1). They should be included in European, national or regional ecological networks, and/or terrestrial systems of ecological stability.
- In cooperation with local communities, village councils and environment bureaux, for all the ecologically important fishponds it is necessary to deal with the issues of ecological carrying capacity for recreational and sports use. This should be fully in accordance with the law on environment impact assessment, as well as in accordance with the new Nature and Landscape Conservation Act no. 287/1995.
- Using the Nature and Landscape Conservation Act no. 287/1994 it is necessary to solve legislatively and economically the issue of compensation. This applies to owners of property on territory where economically restrictive conservation measures are applied, with the aim of conserving a rare species or biotope.

Basic economic and property measures

- Nature conservation organisations should become the users and/or joint-owners of areas of international and national conservation significance.

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- Tax concessions should be applied to such fishponds regardless of who uses them. The state should provide financial support to processes aimed at the recovery and strengthening of natural ecological relations.
- It is necessary to safeguard fish fry in the fishponds, the quality of the fish embryos, early stages, and breeding stages. State policy on subsidies for breeders of these stages must be finalised, as must the inevitable hygienic measures.
- We recommend the introduction of a series of economic measures, rewarding ecologically favourable fishpond economies and penalising other practices. At the same time, support should be provided for investment enabling reduction of fish production losses caused by birds without threatening species or their biotopes.

Basic planning and institutional measures

- Prior to the building of the fishponds, it is necessary to consider the possibilities and consequences of pollution from their environment. Existing fishponds should be regularly monitored for water quality and also for the introduction of toxic substances into the trophic chain.
- For all fishponds of I and II category of ecological significance, it is necessary to prepare binding and ecologically acceptable (i.e. ecologically sustainable) management plans as soon as possible. In the fishponds of III and IV category of ecological significance, we recommend solving nature conservation issues by written agreements between the state administration and/or NGO and the owner and/or user of the fishpond.
- By means of long-term management plans, an integrated approach has to be safeguarded, respecting both the economic functions and ecological potential of fishponds and reflecting their multifunctionality. In this case the resulting impact is usually smaller than when a single function – the economic one – is maximised. It is necessary regularly to evaluate environmental impacts of economic activities.
- As fishpond ecosystems and the ecosystems immediately linked to them have a specific function in the country, we recommend their inclusion in a wider wetland conservation programme. A specific Fishpond Supervision Office should be created to fulfil the requirements of fishpond economy and nature conservation in ecologically significant fishponds in Slovakia.

Basic research and educational measures

- It is necessary to carry out systematic inventories of the most significant fishponds. Subsequently, it is necessary to include them in a wider natural and socioeconomic context and to outline the possibilities of their economic use (including the basic limits of ecological carrying capacity of fishpond ecosystems).
- It is necessary to focus applied ecological research on issues of biological control of fishpond economic pests and on solving the conflict of interests between fish

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farming and optimal biotope conditions for waterfowl. It is necessary to safeguard systematic monitoring of biotic components, including game, of the most important fishponds.

- Education in the natural values of fishponds is important for university students of natural history, employees of state nature protection in the sphere of natural resources management, voluntary nature conservationists and state administration managers as well as commercial and sport fishermen.
- Public awareness of fishpond conservation should be enhanced by educational seminars, publication of information materials and building nature ecotourism excursion trails (where it is possible and suitable).

4.7.2. Specific sustainable management plan for the Hrhov fishponds

On the basis of the above-mentioned analysis of the biotic state and economic activities on the fishpond and its immediate surroundings, we suggest that the following measures should be undertaken.

Proposal for zonation of LHF

As a basis for an ecologically sustainable fish economy on Hrhov fishponds, we propose zonation of the large pond (LHF) into three zones: production, transition (buffer), and protected.

- Production zone: focused fully on production management, the size of this area would represent 50%–60% of the total fishpond area. Production of fish would have priority, but basic (minimal) nature conservation requirements should be respected.
- Transition zone: this is the buffer zone surrounding the protected zone. Its size should represent 20%–25% of the fishpond area. In this zone nature conservation measures and production interests should both be taken into account. The measures mentioned below would be realised in a mosaic way. Part of the transition zone would be used for fish breeding and this area would be counted in the production zone area for the determination of fish fry and further production procedures. The island and peninsular areas of vegetation in this zone would be counted both in the production and conservation zone areas. It seems suitable to divide the transition zone into five or six sections which would be altered cyclically to form part of the production fishpond area.
- Protected zone: the most valuable for nature conservation, the core-zone of the LHF, with the largest representation of macrophytes. Its size should not be more than 25% of the total fishpond area. This zone should be very effectively protected, although sensitive management will still be necessary. A management plan for this zone would include removal of part of the dry macrovegetation (by cutting), but any interventions in this zone should only take place during the winter months (December and January).

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The individual zones should have ecologically sustainable management with differentiated measures. Prior to the agreement of the user (owner) of Hrhov fishponds with the nature conservation authorities about the proposed demarcation of the fishpond into the respective zones, we consider it necessary to realise minimal measures at the site, presented in more detail below.

Proposed measures for safeguarding the quality of the water environment

- For the optimisation of input dosages, we recommend chemical analyses of water, providing indicators important for fish breeding management.
- From the beginning of April until the end of August, monitoring of chlorophyll levels should be done at two week intervals (important for predicting phytoplankton overgrowth and potential subsequent loss of fish).
- As a complementary indicator of the state and activity of the fish fry in the same period, we recommend evaluation of zooplankton at least once a month.
- From the beginning of April to the end of August, we recommend increasing the flow of water into the fishpond to improve overall water quality in the system.

Proposed measures for conservation and improvement of the vegetation cover

- To create ecostabilising landscape structural components, we recommend planting vegetation to protect against emissions, wind and noise along the I/50 state route, leaving an open space for waterfowl flying in to the water surface.
- Clearance of poplars along the access roads and canal between SHF and LHF should not be agreed unless they are replaced by multiple planting of willow, elm, alder, maple and ash trees, thus gradually creating a multifunctional biocorridor.
- In the LHF we suggest reduction of macrophytes to the level of 25%–30% of the area and, at the same time, ensuring a more optimal spatial arrangement of this vegetation (see Map 2).
- We recommend elimination of reed growth to below 30% of the area by cutting during winter months.

Proposed measures for plant and animal species protection

- Macrophytes should not be burnt during the spring months; reed reduction should be exclusively by cutting during the winter months.
- Grazing and watering of cattle should not be allowed directly on the bank and in the immediate vicinity of the LHF water area, in order to avoid damage to the south-eastern banks of LHF.
- Artificial islands should be created, from the material obtained by scraping-out the fishpond bottom, to provide compensatory nesting sites for further bird species.
- Trees should be planted parallel with the 22kV powerline to create a barrier to protect birds from colliding with the powerline.

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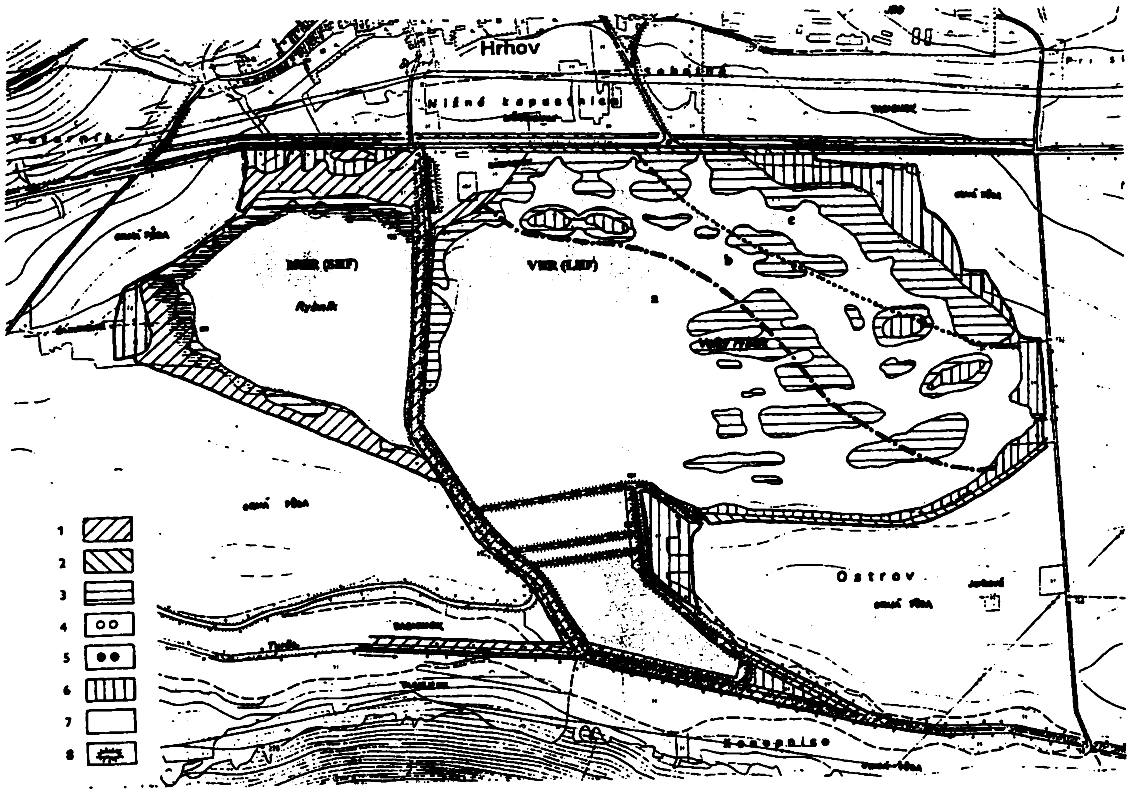
Map 2. Proposed changes and improvement for vegetation of the Hrhov fishponds

Key:

1. Vegetation cover of the highest ecological value, 1st category
2. Vegetation cover of higher ecological value, 2nd category
3. Vegetation cover of medium ecological value, 3rd category (growths of *Phragmites* and *Typha*)
4. Vegetation cover of lower ecological value, 4th category (solitary trees)
5. Vegetation cover of lower ecological value, 4th category (solitary bushes)
6. Vegetation cover of the lowest ecological value, 5th category (besides *Phragmites* and *Typha*)
7. Water area
8. Deposits of the material from the fishpond bed
   a) Production zone
   b) Buffer zone
   c) Protected zone



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- An underpass for frogs should be constructed in the kilometre 399–400 of the I/50 state road to prevent mass deaths of frogs during spring migrations.
- Undergrowth on the north-east and east of LHF should be cut to prevent succession and to maintain nesting habitat for waders such as plovers.
- In the nesting period, during the months May to August, it is necessary to avoid disturbing the site (and to prevent entrance into the macrophyte growths, with the exception of essential fishpond management activities).
- The continuous macrophyte growth in the LHF area should be preserved (see Map 2).
- The built fish chambers in the southern part of LHF should be filled with water.
- The core zone of the site (zone 'c' on Map 2), and possibly also the buffer zone, should be declared a National Nature Reserve, within the framework of a supraregional biocentre.

Proposed economic measures

- Tax relief: the Hrhov fishponds, due to their European significance (for biodiversity conservation) should be completely exempt from real estate tax; or the tax should be payable only for the area included in the LHF production zone.
- Use of the reeds: in accordance with the need for the regular reduction of macrophytes in the LHF, we recommend their regulated commercial use for industrial and artistic purposes.
- Use of mud from dredging: as in every fishpond, regulated removal of the mud is necessary to prevent accumulation of soil due to successional processes. We recommend considering regular removal of mud, which can be sold for use in gardens. The proceeds could partly cover the expenses necessary to conduct conservation measures.
- The development of ecotourism: we recommend regulated use of the Hrhov fishpond area for this purpose, building a simple wooden roofed observation tower on the Fej stream bank (and a roofed wooden passage leading to it) for use by visitors birdwatching in the area.

4.8. Conclusion

The fishponds and the water bodies used as fishponds represent anthropogenic, but often very significant, water and wetland ecosystems. Their importance for nature conservation in the last decades has increased since a number of original wetland biotopes of water, marshland and wetland organisms in the country have disappeared. Economic interests connected with the production functions of the fishponds frequently conflict with nature conservation interests. In practice there are no specific methods which would help responsible officers (administrators) of fishery and nature conservation to solve problematic situations.

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The task of this project is, at least partially, to fill this gap. The example of Hrhov fishponds offers a model of multifunctional and sustainable use of a water body. At the same time, it represents a search for modern nature conservation measures without strict exclusion of all socioeconomic activities. In addition to an immediate use of the results of this project by the users (owners) of Hrhov fishponds and by the local state authorities, the outcomes of the project can serve as a model for the elaboration of similar action management plans for other fishpond ecosystems in Slovakia.

A valuable outcome of the project is also the basic survey of the fishponds in Slovakia and their ecological evaluation. The results of the project are thus directly useful for setting up proposals for European and national ecological networks, as well as local ones.

The possibilities for project realisation depend on the active participation of the representatives of the fishpond economy (fishpond administrators), local authorities and others involved in preparation and approval of the management plan. An important role in this process is that of the nature conservation NGOs. Their members in this project have shown a high level of expertise, e.g. the wetland mapping project, initiated by the Slovak Union of Nature and Landscape Conservationists, was a valuable resource.

The realisation of several proposals of the management programme for the Hrhov fishpond locality requires a certain amount of investment (which can be partly covered by further economic activities in the fishpond, such as appropriate and regulated ecotourism). Possible financial resources for revitalisation work and measures for recovery and preservation of the Hrhov fishponds biodiversity may include the State Fund for the Environment of Slovak Republic. Further resources could include the State Budget of Slovak Republic, which can be used by the Slovak Union of Fishers, administrators of waters and NGOs. Another important source may be the grants provided by various foundations.

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