WETLANDS IN AGRICULTURAL AREAS

Complementary measures to reduce nutrient transport to inland and coastal waters

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FINAL REPORT

Front page: Wetland in the watershed of Kävlinge river (1999).

Photographs: All photographs have been taken by Ekologgruppen, except figure No 10 and 11(right) which were taken by Olle Nordell

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In this report the term "wetland" comprises traditional wetlands (shallow, more or less permanent waters) as well as ponds.

Summary

A project based on a regional co-operation with ten municipalities involved to improve water quality, reduce nutrient transport and increase biodiversity in intensively cultivated farmland, is presented. Establishment of wetlands and buffer-strips which improve the nutrient-reducing capacity of the landscape, are used as a complement to efforts within sewage treatment and agriculture. The measures are implemented in full scale within the watersheds of the Höje and Kävlinge rivers in the Southwest part of Sweden with a total drainage area of about 1500 km². The project was carried out from July 1996 to Oktober 1999 and was financed by the municipalities, the European commission by the Life-fund and a regional environmental fund. The support from the LIFE-fund (27% of the total costs) has enabled a realisation of the project in a full scale an given the project a national and international recognition.

Politicians from all municipalities are involved in the steering committee of the project while environmental officers manage the practical work through a working group. A consultant is responsible for the implementation of the project.

During the project period 74 hectares wetlands (n=65) have been constructed. Regarding location of the wetlands, priority has been given to areas with a high nutrient concentration in the water and with impoverished biological diversity. The size of the constructions range between 0.2 and 6.1 hectares with an average size of 1.1 ha. Different types of wetlands are presented and prerequisites of wetlands localisation as well as practical problems during and after construction are discussed. Buffer-strips have been established and prepared along 59 km (36 hectares) of the streams. Buffer-strips have priority where the risk of erosion and surface run-off is great, along streams with intensively used farmland in close connection to open water and along stretches with a need of recreational areas.

Studies of nutrient retention in four of the wetlands indicate that wetlands are effective nutrient traps. Depending on nutrient load the reduction capacity of the four wetlands ranges between 400 and 4 000 kg N(nitrogen)/ hectare*yr, with a mean of 1 700 kg N/ hectare*yr. The relative retention in terms of nitrogen ranges between 5-50 %. The reduction of phosphorus varies between 20 and 80 kg per hectare which corresponds to 10 – 45 % of the incoming nutrient. As phosphorus often appears bound to particles the retention correlates well to that of suspended matter.

Biological studies illustrate the positive effect of newly created wetlands in the intensively cultivated agricultural areas. Already during the first year after construction the invertebrate fauna comprises a large number of species and individuals. Plant colonisation shows the same pattern and on average 32 wetland plants were found per wetland. Consequently bird life shows a quick response to the constructed habitats and more than 25 breeding species have been observed in the studied wetlands. A total number of 19 threatened species of animals and plants from the Swedish red list was recorded in the studies.

Within the Life project a total area of about 110 hectares of arable land has been transformed into areas available for recreation.

Throughout the project period experiences from the project have been disseminated through a number of different activities. Publications of lasting value, available to the public and other interested are:

Video - *Wetlands in agricultural areas*.
Posters - *Implementation of wetlands in agricultural areas – organisation and results.*
- *Benefits of constructed ponds in intensively used farmland areas in south of Sweden.*
Home page -*http://www.ekologgruppen.com/wetnet.htm*
Brochures and leaflets – mostly directed to landowners
Layman's version of Final report - *Wetlands in agricultural areas- experiences from a Life project*

The costs included in the Life project amounts to 25 millions SEK. The rent of land converted to wetlands and buffer-strips is not included in the Life budget.

The total costs of large scale implementation of measures in the agricultural landscape are dominated by the investment in wetlands 63 %, while 16 % of the costs have been used for planning and projecting the wetlands and buffer-strips and 3 % to administration of the project. Around 3 % of the costs have been used for follow up studies and dissemination respectively, while rent of land and compensation of crops amounts to 9 % of the costs (not included in Life).

The mean construction costs of wetlands implemented within the project amount to 260 000 SEK/ hectare excluding projecting costs and rent of land.

With an assumed nitrogen capacity of 1000 kg N/hectare*yr, an interest rate of 6% and a writing off period of 30 years, the average cost of nitrogen retention amounts to 24 SEK/ kg N in the wetland project including planning, projecting, construction, compensation for crop losses and rent of land. In addition to the value of nutrient retention the environmental benefits of the wetlands are significant concerning biological variation and increased recreational area, other major aims of the project. Thus, the cost effectiveness of nutrient retention supports the conclusion that wetland creation in agricultural areas gives great value for money.

1. INTRODUCTION

Background

In ponds, wetlands and streams nutrients can be retained by natural processes. This is one of the main facts on which this project is founded. In addition, wetlands represent a key habitat, important for many animal and plant species. Both these qualities make ponds and wetlands an important feature in the agricultural landscape.

The load of nutrients on streams, lakes and coastal waters has increased dramatically since the 1940ies, mainly due to intensification of agricultural methods but also due to sewage outlets and urban runoff. Moreover, the agricultural landscape has been subject to a dramatic change during the last 200 years, when canalisation of streams and drainage of wetlands have decreased the length of open watercourses by 50% and the wetland area by 90% in the region. In addition to eutrophication of waters, these changes have caused a reduction in biological diversity.

Phosphorus is considered the limiting nutrient in most freshwater systems and phosphorus reduction through sewage treatment was initiated in the sixties and has been intensified since then. In contrast, since nitrogen seldom causes overgrowth in streams and lakes, the efforts to reduce nitrogen leakage from farmland, sewage plants and household waste have been minimal up to recently. Nitrogen may be crucial for the occurrence of nuisance algal blooms in coastal waters, as it is frequently the limiting nutrient for phytoplankton growth in the sea. Although the importance of nitrogen versus phosphorus in the eutrophication of coastal waters is debated, most scientists now agree that transport of both nutrients should be limited. Political decisions in Sweden aim at decreasing the anthropogenic nitrogen emission by 50%. So far the efforts have been directed mainly towards upgrading of sewage treatment and changed agricultural practises, but until now the reduction goal is far from achieved. Complementary measures are needed and measures in the landscape are one possible approach.

In this project construction of wetlands and establishment of buffer-strips in the intensively used farmland is promoted. The measures provide a complement to improvements of sewage plants and agricultural practises. Moreover, ponds, wetlands and buffer-strips will function as refuges for many animals and plants. Additional benefits are the improved conditions for recreation and outdoor life, since a large part of the wetlands and buffer strips will be created on agricultural land with limited previous recreational value.

Incentives

The project aim at reduction of nutrients is a problem, which normally doesn´t belong to municipality responsibility. Decisions to reduce eutrophication are ratified on a number of political levels nationally and regionally, but the responsibility for the fulfilment of sufficient measures is not clearly expressed. In the densely populated region of Skåne, eutrophication is significant and the motivation to tackle the problem is high. Moreover, the public accessibility to nature, especially water, is low compared to the rest of Sweden. The ten local authorities have decided to translate words into deeds and try to fulfil the national goal for nutrient reduction. Responsibility for the environment is perceived as the most important motive for local politicians to engage themselves in this project, especially the objective to reduce the nutrient load to the sea. The need for recreational land to the general public is an additional motive for municipalities to initiate the implementation of the project. The background survey and documents on which this project is founded was initiated through the existing co-operation on water conservation and the broad political support facilitated the following implementation of the project.

Aim

The aim of this project, as written in the application, is:

- Long-term reduction, without external energy input, of nitrogen and phosphorus transport to inland and coastal waters.
- Improvement of the conditions for animals and plants in the agricultural landscape, that is, an increase in the biological diversity.
- Increase in areas available for recreation in a landscape dominated by farmland.
- Develop a new method for sustainable development through co-operation between local and regional authorities and farmers.

Presentation of the working area

The working area of the Life-project includes the two adjoining rivers Kävlinge river and Höje river, situated in the west part of the province of Skåne in the south of Sweden.

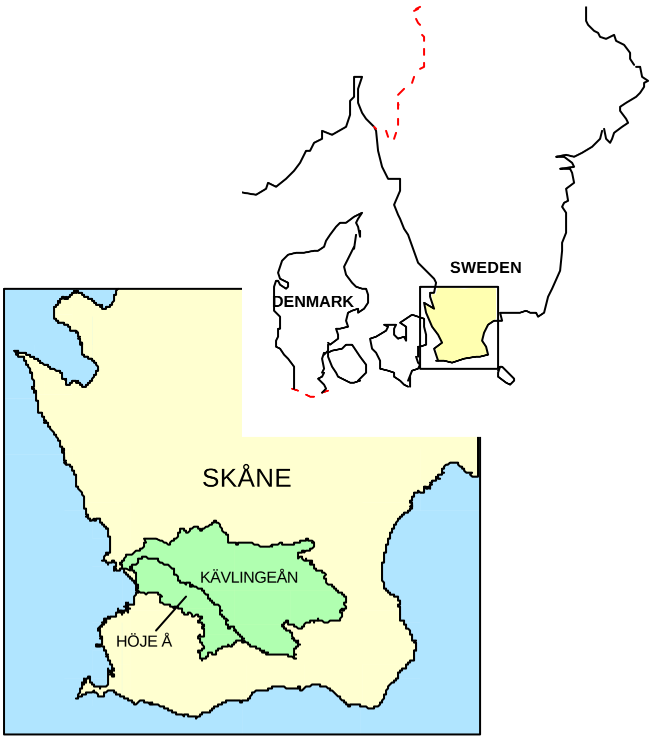


Figure 1. *The working area of the Life project.*

Their total drainage area is about 1500 km^2. The area is relatively densely populated and holds many villages and towns. The land-use is dominated by farming. A number of lakes are situated in the area. Vombsjön is the largest with an area of 13 km^2.

Table 1. *Facts about the two watersheds in the working area of the Life project.*

	Kävlinge river	Höje river
Size of watershed	1200 km²	320 km²
Arable land	61 %	58 %
Grazing land	9 %	4 %
Forest	15%	24 %
Municipality	4 %	12 %
Lakes	2 %	0,5 %
Other landuse	9 %	1,5 %
Mean concentration (1989-1997) in the main stream – nitrogen	5.4 mg/l	8.7 mg/l
Mean concentration (1989-1997) in the main stream – phosphorus	0.07 mg/l	0.15 mg/l
Example of maximum nitrogen concentration in a tributary stream from arable land	16 mg/l	21 mg/l
Example of maximum phosphorus concentration in a tributary stream from arable land	0.8 mg/l	0.7 mg/l
Annual mean temperature in the air (Lund 1961-1990)	7.9 ° C	7.9 ° C
Annual mean precipitation (Lund 1961-1990)	655 mm	655 mm
Annual runoff	8-12 l/s *km²	8-10 l/s *km²

The measures have largely been carried out in areas with arable land (see map, fig. 2) where the concentrations of nutrients in the river system are high. In the project plans, each municipality was provided a quota of wetland area to be implemented.

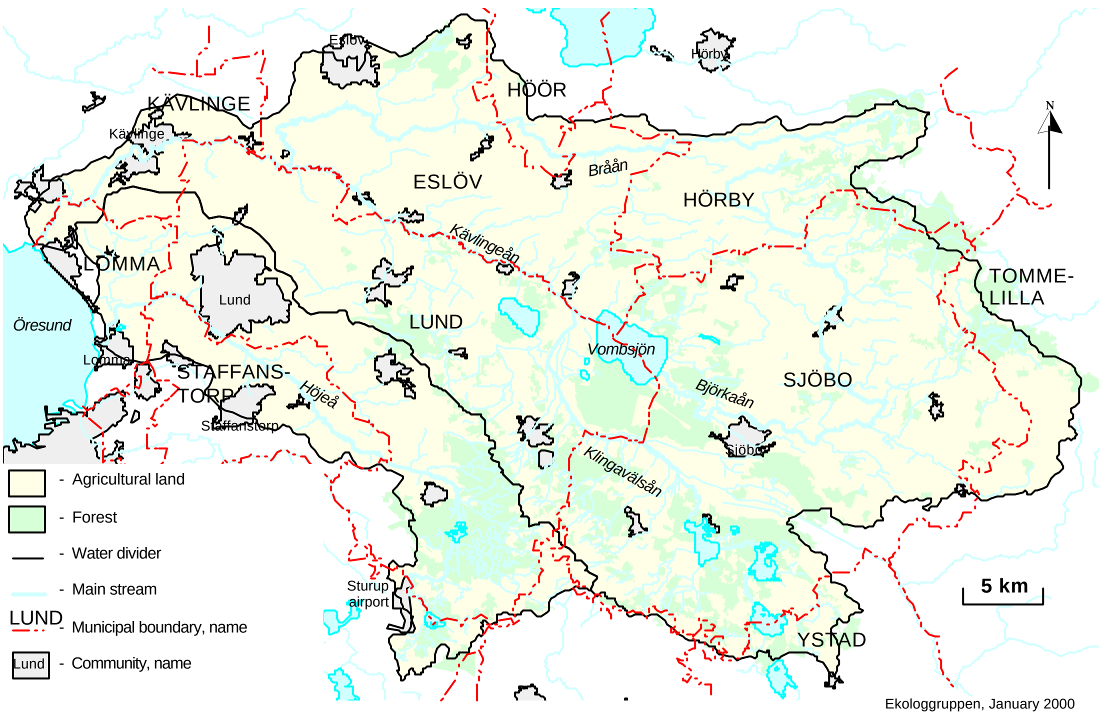


Figure 2. *The watersheds of the Kävlinge river and the Höje river with administrative (municipality) borders.*

2. PROJECT MANAGEMENT AND MAIN TASKS

Project management

The project is a co-operation between the ten municipalities through which the watersheds of the two rivers Kävlinge and Höje extend. The policy making body of the organisation is political while municipality employees through a consultant handle the accomplishment. Implementation is managed through separate organisations for each river[1] (fig. 3) while economy and administration is common and managed by environmental officers in two of the municipalities together with the consultant involved.

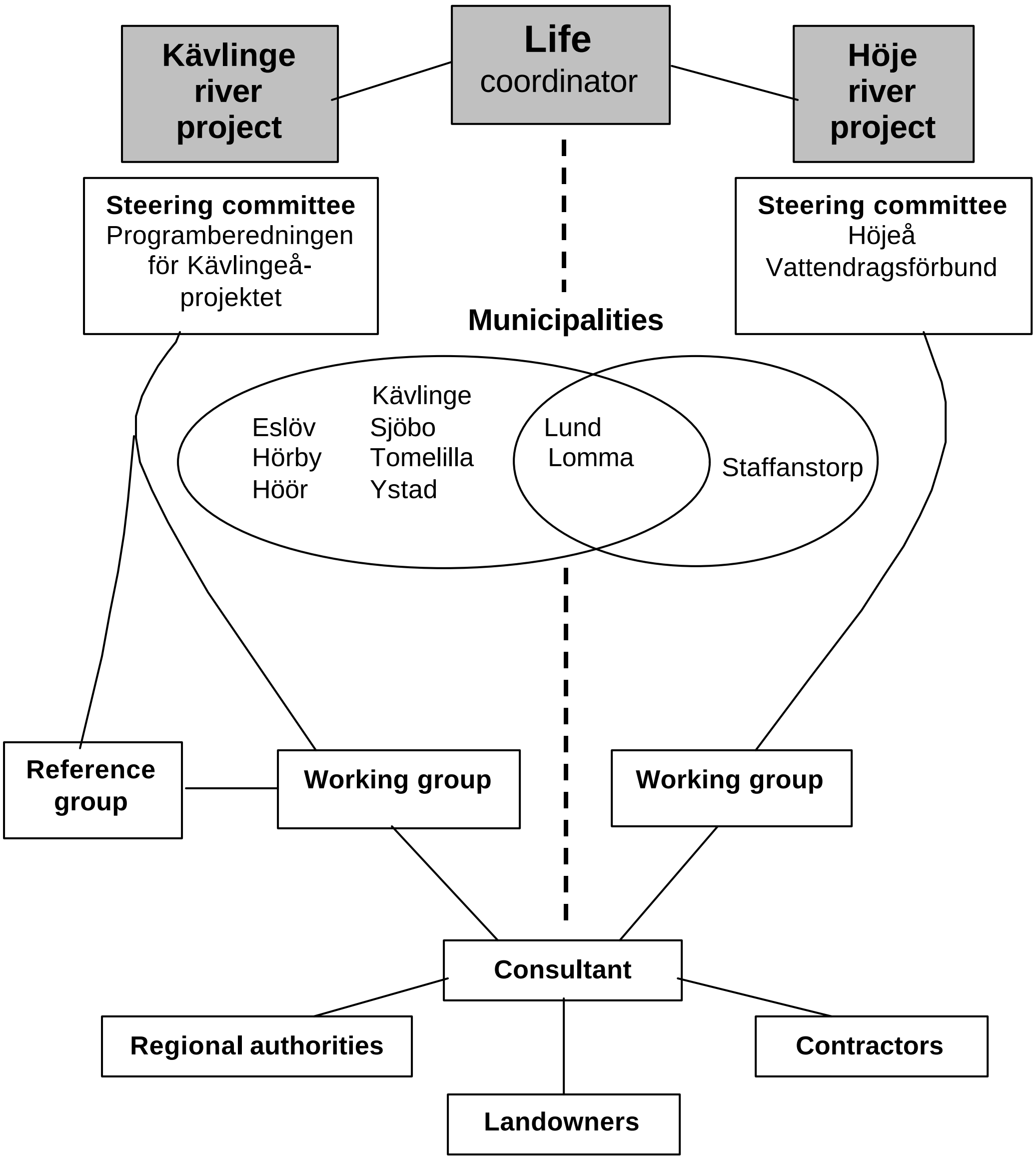


Figure 3. *Organisation of the project*

[1] By historical reasons the implementation of the measures are separated between the rivers. As project-plans initially were taken by existing Water Protection Associations the most cost-effective way to continue was to keep this organisation.

Organisation

The size of this project and the number of actors require a good and/or a well-established organisation. The project organisation has its nucleus in the Water Protection Associations with a tradition of co-operation on water-related issues. The ten municipalities are all represented in the project organisation, on the political level in the steering committees and on the administrative level in the working groups. Thus each municipality has the same deal of influence in the project, independently of size and location within the watershed. The administration is large and involves the consultant and employees from two of the municipalities. Routines are circumstantial although well established.

Implementation of measures, follow up studies and dissemination is managed through **working groups**, which also prepare material for decisions in the steering committees. The working groups include environmental officers from all involved municipalities. The chairman, co-ordinator of the Life project, is common for both rivers. The consultant, responsible for planning and implementation, is involved in both working groups, farmers are represented in the Höje river working group only. The working groups meet 4-5 times per year.

The policymaking / decisional organs are the **steering committees** which include politicians from all involved municipalities in each river respectively and employees from the environmental county administration. Additional members in the Höje river steering committee are environmental officers from each municipality and the regional office of the Swedish agricultural board. The steering committees generally meet 4-5 times every year.

In the Kävlinge part of the project additional members constitute a **reference group**, including representatives from interest groups such as farmers, nature protection and fishing as well as scientists from the University of Lund ,employees from regional authorities and Kävlinge river federation. The reference group gather twice every year and get informed about the progress of the project. They may have input and give advice on the accomplishment of the project.

The **consultant,** dominated by ecologists, has the responsibility for the implementation of measures including all steps, from planning and information / negotiation with landowners to location of measures, projecting and design of wetlands. The consultant also arranges permissions from authorities and interest groups, purchase and supervision of construction work, preparation of contracts between the municipality and the landowners as well as follow up studies, evaluation and preparation of reports. The consultant informs to environmental officers about the progress, practical problems or uncertainties in each municipality respectively. The economical tasks of the consultant include attestation of invoices as well as the economical overview (together with the co-ordinator).

The consultant purchases assistance for e.g. hydrological calculations, levelling and geological surveys, construction works and most of the plantation work.

Finances

The basic economy of the project relies on municipal tax money (67%). During the *Life* support period 27% of the costs are covered by *Life*. A regional environmental fund has supported the project with 6% of the costs during the period.

, The projects in each river were initiated and started before *Life*. The *Life* support however, has enabled realisation in full scale and has given the project national and international recognition. After *Life,* the project will continue but again separated between the rivers.

Discussion of the organisational and financial prerequisites

Background documents
Prerequisites for the relatively smooth start of this large co-operation were the carefully prepared background documents including a breakdown of costs and allocated quotas of wetland and buffer-strip area in each municipality. The programs were ratified on a high political level in all municipalities before external finances were applied for. Thus when funds were available the implementation of measures was not interrupted by major organisation or economical disputes.

Municipality support
The project has broad support on a high political level in all involved municipalities and is incorporated in the normal activities of local authorities through the employees involved in project administration and working groups. As the measures are an investment for sustainable development where the results will be obvious principally on a longer time scale, it is important to keep up the motivation among local authorities. Political impatience may otherwise become a problem as a major part of the financing is dependent on local political decisions. Politicians are interested in easy understandable and obvious results. Therefore a solid follow up program of the effects of the measures as well as regular meetings where presentations are given of the achievements of the project, are crucial to the continuation of the project.

External economical support
Surprisingly little national support has been directed to these kind of projects. The goal, to reduce nutrient transport to the coastal waters has been stated on a regional, national and international level and still the basic economy of this project relies on municipal tax money in a region with the highest nutrient loads in Sweden.

A basic economy is important for the long-term continuation of the project. It enables a well established organisation with long-term goals. Moreover, an established organisation more easily applies for and incorporates external funding. However, external funding may give rise to some obvious difficulties.

External money often has to be used during a specific period of time. The risk of fixed time limits is that the quality of the measures may suffer in order to fulfil the quantitative agreements stated in the application. Implementation of measures in the landscape is a long-term process and landowners often need time to think twice before they join the project. In Höje River, where a pilot project has been running before the start of this Life project, some farmers joining lately have expressed their change in attitude towards the project since the start eight years ago.

Another problem with external financing concerns geographical restrictions in the use of the support. Recent state environmental funds available in Sweden are restricted to the administrative border of a municipality. This is contrary to the idea of regional co-operation initiated in this project where measures are implemented throughout the watershed.

A long-term regional or national basic financial support, not directed to specific municipalities, would facilitate implementation in an environmentally most efficient way. The risk of a basic economy relying on municipal money is that each municipality for political reasons primarily try to protect their own interests. This might be most obvious in the municipalities that are represented by small geographical areas in the watershed, as few practical measures will be constructed within their borders.

Implementation work
The involved municipalities have chosen to commission a consultant a central role in the management of the project instead of enrolling staff from the involved municipalities. Implementation through an independent consultant may be advantageous when measures are planned and accomplished throughout the watershed independently of administrative borders. The consultant is neutral towards

each municipality, which may be an advantage in the official ordering of services. Moreover, at a consultant office it may be easier to take advantage of the long term gathered experience of wetland implementation which is difficult to have at hand in a municipality during a temporary project period. However, the risk in the long run may be that experiences from the project are lost from the municipality, as most of the practical knowledge will be gathered at a consultant office.

Another important difference between a consultant and employees from the local authorities may be in the dialogue with landowners. A consultant is more independent from the landowners point of view while a representative from the authority may be seen as a controller.

The environmental officer in the municipality of Kävlinge, with experience of intra-municipal implementation in another river system, points out that better insight into the process of implementation is gained with the use of internal project personnel. The disadvantage mentioned was the lack of overview and possibilities to give opinions on implementation of measures outside the municipality border.

Another municipality in the region, Helsingborg, with long experience of wetland construction, without consultants involved, points out the advantage of close connection with water-related issues in other parts of the local administration (local plans, outlets, discharge etc). The local administration may in this way develop a very good local instrument for water protection and planning. A disadvantage mentioned was that intensive bureaucracy may result, when the municipality administrates implementation, as each step in the process of each wetland has to be entered into a diary.

The future responsibility of the municipality is more obvious when implementation has been administered locally. Future management of the wetlands may be an underestimated task and the responsibility is not clearly expressed. The continuous management of the wetlands is by contract the responsibility of the landowner, but functional, technical or e.g. legal aspects will, to a large extent, be a responsibility of the project (the municipality). If a consultant is responsible for all practical work during implementation it may be difficult to transfer the responsibility of practical issues to inexperienced employees at the local authority once the commission is finished.

Conclusion:

- Background documents with clear objectives and aim together with a realistic plan for implementation and breakdown of costs facilitates the start and fulfilment of a project.
- An organisation where all paying members are equally represented facilitates an engagement independently of size (“status”).
- Focus on the watershed should be a principal rule of all economical support directed to water related environmental issues.
- A basic and long-term economical support, national or regional, which in future may be directed through the regional water administration, is requested when local authorities try to fulfil the national goal for reduction of nutrient transport.
- With a consultant commissioned to implement the measures, mediation of experiences is important, as there will be a need of practical project experiences at the municipality when aims are fulfilled and the consultant dismissed.
- Implementation through a consultant may be an advantage to implementation through municipality employees in regional co-operations with many actors, while the opposite may be true in intra municipal projects.
- Dissemination of knowledge is important initially, but also continually, to increase the motivation among landowners, politicians and the public.

Main tasks

Apart from project management the work may be separated into three tasks, tightly linked together; **implementation** of wetlands and buffer-strips, **evaluation** of effects, **dissemination** of experiences.

The central task of the project is practical, **implementation** of wetlands and buffer-strips in the agricultural landscape, a task which has carried out continuously during the project period. The stepwise process, starting with information to landowners through projecting (fig. 4) and construction until vegetation establishment is described in details in annex 1 (The process of wetland construction) while the results in terms of number and area of wetlands and length of buffer-strips are presented in chapter 3 (Technical actions and results).

Figure 4. *Important work during practical implementation - control of levels and construction.*

Important for the success of wetland and buffer-strip implementation are:

1. *Landowners interest*: The landowners participate voluntarily, thus the project depends on their willingness to convert some of their land to wetlands and buffer-strips. The consultant manages the co-operation with landowners. Once a wetland or a buffer-strip is established a contract is drawn up between the landowner and the municipality. The contracts regulate the landowners use of the area and the rent paid for the conversion of land. The rent offered varies between 10 000 – 55 000 SEK / hectare depending on land-use and soil quality. The length of the agreement is 30 years for wetlands and 10 years for buffer-strips. Landowners interest is discussed below and in chapter 3.
2. *Physical prerequisites*: The physical prerequisites of pond and wetland construction differ largely throughout the watershed. The areas with good possibilities to create wetlands are not necessarily those with the highest need of wetlands. This fact complicates the planning and implementation of wetlands as cost effectiveness is aimed at. Physical and technical possibilities are discussed more in chapter 3.
3. *Consideration of other interests*: Each object is evaluated by the regional authorities with respect to other potentially conflicting interests and Swedish environmental laws(. Additional permissions might be needed from neighbours or different groups of interest. Conflicting interests are presented in chapter 3 while authority handling of conflicting interests is discussed below.

Evaluation of the effects of the measures includes continuous studies of nutrient retention in four wetlandss. Birds have been studied in selected wetlands each year. During 1998 the studies of biology in the wetlands were extended with vegetation and invertebrate inventory studies in 26 of the constructed wetlands. The results of the studies are presented in chapter 4 (Environmental benefit).

Dissemination of project information to landowners has been mediated through meetings, leaflets and media as well as through diffusion of information among colleagues/neighbours. The project meetings have been the main forum for dissemination of results and experiences to local politicians, interest organisations, scientists and regional authorities. Dissemination of knowledge to the public is mainly done through local media and through material produced within the project. Different dissemination activities are presented in chapter 5 (Dissemination).

Discussion of other interests on which implementation of the project depends

The following discussion deals with two important parts within the implementation task - landowners interest / attitudes as well as how to deal with conflicting interests. Discussions about the practical parts of construction (including further evaluations of landowners interest) about evaluation and dissemination are mainly presented in chapter 3, 4 and 5.

Landowners interest
The farmer's attitudes towards the measures are crucial to the project. Ponds, wetlands and buffer strips cannot compete with the normal land-use on expensive agricultural land, unless the farmers find them valuable.

Among landowners (n=119) in the watershed of Kävlinge river, an independent inquiry (Söderquist 1999) showed that 46% were interested in participating in the project while 35% were not interested and 19% did not know. The motives for interest in participation were dominated by environmental arguments and only around 10 % referred to private agricultural benefits such as grants, irrigation or moderation of water-flow. Among landowners which were not interested financial motives were mentioned in 10-20% of the answers, practical reasons in 30 % and uncertainty about the project around 20 % of the answers.

An inquiry (Ekologgruppen 1999) addressed to landowners (n= 100) already contracted with wetlands or buffer-strips, in Höje River, indicate the attitudes of farmers with a practical experience of the project. Most farmers are positive (94% of the answers, n=32) about the project and feel that they have received enough information. The environmental motive for participation dominates (>80%) but also hunting and bird-life are also mentioned as strong motives (65%). The wetlands live up to the expectations in 83% of the cases and although farmers stress that the loss of land is not fully compensated most of them answer that the wetland is worth its price.

After a few years of implementation in Höje River, wetlands seemed to appear in a patchy pattern throughout the landscape. Thus, constructed wetlands didn't seem to deter neighbouring farmers but were rather good examples, which may have encouraged them to join the project.

In parts of the watershed however, a lack of sites available for wetland construction seems to be correlated to the value of the land. In order to achieve large scale implementation of wetlands successfully, the rent offered may have to reflect the market value of the land better than today.

Conflicting interests – authority policies and legal aspects
Construction of ponds and wetlands is a rather new action with significant impact on the landscape. The authorities have not been prepared to handle the large number of initiatives to create and restore waters in drained agricultural areas. The lack of a strategy is obvious and the question of how the wetland interest should interact with other interests in the landscape has not made clear. During this project a lot of energy has been spent on policy discussions for each single object. Large-scale fulfilment of measures is difficult without a regional policy on construction and restoration of wetlands.

Fishing interests (of salmon fishes) has been the major conflict in preparation of permissions at the regional authority, while drainage has been the dominating subject in local conflicting interests. Both subjects are closely connected to legal issues and the regional authorities have had difficulties in presenting a policy on the issue. The regional environmental judgement take into consideration the aspects of nature conservation and cultural history, while the salmon fishing issue is transferred back to the project. According to the Swedish environmental law the activity practiser has the responsibility to prove that no public interests (fishing interests is counted as one of those), are influenced negatively. The project often has to prepare documents concerning whether fishing interests are influenced or not and discuss plans with the interest organisations as well as with the fishery department at the regional authority. The question of priorities between environmental effects of nutrient reduction and negative effects on salmon fishes should be discussed in a wider perspective than single wetlands.

An open discussion is going on in Sweden whether all wetland constructions ought to be tested in the court from a legal point of view (this imply a long handling time and a significant extra cost for each wetland). Related wetland projects in other parts of Sweden have the same problem and wetland constructions in connection to streams, watercourses or drainage tiles may be in the “grey zone” of Swedish water-legislation. This is unsatisfactory as projects may be prosecuted (by anyone) for construction of wetlands even if the regional authority, interest organisations and landowner have supported the constructions.

Most watercourses in farmland are regulated for agricultural reasons, 50 – 100 years ago the water level in most areas was lowered by ditching and drainage. Groups of landowners have interests in the drainage and by law have the right as well as duty to maintain the ditches and watercourses. This management is not concerned with environmental values and the efforts to restore the water levels, bottom structures or physical structures (e.g. meanders) for environmental reasons are not legally supported. Reasonable possibilities to reconsider selected legal water acts by environmental reasons on a national level is desirable.

Some conflicts of interests could be avoided if wetlands and buffer-strips were introduced in the physical planning process of each municipality. Measures may be incorporated in exploitation plans (infrastructure, areas for buildings and industries) in the beginning of the process. Created wetlands may then be combined with storm-water treatment and promote recreation. This is already the case in some municipalities but stronger incentives and general directives, maybe through legal instruments, are needed.

Conclusions:

- The landowners take part in the project on a voluntary basis. and this is important for a positive attitude among farmers to the project and to a solution of the environmental problems the project is dealing with.
- The main reasons for landowners interest are environmental concern, hunting and bird life interest.
- Farmers involved in the project are to a large extent satisfied with the measures. Created wetlands may encourage nearby farmers to participate.
- The rent of land offered does not reflect the market value of high quality arable land, a fact which decreases the landowners interest to convert intensively used agricultural land into wetlands.
- A regional policy on construction and restoration of wetlands, with consideration of other interests in the agricultural landscape, is needed.
- A national treatment of the legal aspects of wetland construction as well as restoration of streams is desirable.
- New legal instruments or stronger incentives ought to be developed in dialogue with farmers organisations and other interest groups. A good atmosphere of co-operation is valuable for the success of large scale implementation of wetlands.

3. TECHNICAL ACTIONS AND RESULTS

Different factors interact in the work on construction of wetlands. In order to fulfil the aims, a number of recommendations/criteria, for how and where wetlands should be constructed have been developed. Aspects such as cost effectiveness in terms of nutrient reduction, aesthetic aspects –how the constructions fit in the landscape and bio-diversity aspects– how to cover the needs of plants and animals are taken into consideration. Moreover, a number of different interests have to be taken into account during the planning of each object while, at the same time, projecting time must not be too long in order to fulfil the goals within the given project period.

Wetlands

Construction

In the effectively drained agricultural landscape the ground water level is often considerably lower than it was 150 years ago. Most of the streams have been straightened or put in to culverts and their bottom-levels have been lowered. This action is regulated by legal acts and raising the bottom-levels without agreements with landowners or a reconsidered legal act is not permitted. Thus, restoration of wetlands by simply raising the water level is not often accomplished. All ponds and wetlands in this project are constructed by excavation. When possible, that is when negative effects on drainage upstream the pond/ wetland can be avoided, the water level has been raised in order to minimise the depth of excavation.

Recommendations /general characteristics of the constructed wetlands

Every pond/wetland constructed within the project is unique and its shape depends on the main purpose and the situation at the specific site. Some general characteristics, common to most ponds/wetlands may be mentioned:

A varied outer **shape** of a pond/wetland resulting in a long shoreline is promoted, but often restricted by the limited area of land available for pond/wetland construction. To imitate the qualities of natural wetlands smooth, variable and not too steep **slopes** (1:4-1:20) are aimed at. The **depth** is varied with alternating deep (1.5-2.0 m) and shallow (0.3-0.5 m) sections that promote sedimentation as well as denitrification. Large areas with shallow water (<0.5 m) are rarely constructed due to the risk of rapid over-growth, an outspoken concern from the landowners point of view. However, with grazing cattle available a few successful shallow wetlands have been fulfilled.

The inlet /outlet may be constructed as an open ditch, pipe, adjustable culvert or a dam. The use of other technical solutions with artificial materials are minimised but needed in some cases to solve problems such as leakage, erosion or regulation of water levels.

In order to achieve a sufficient hydrological load (see chapter 4, Nutrient retention), , a certain **drainage area /size** is recommended. A minimum of 75-100 hectares agricultural land should be drained to each pond/wetland, and/or a pond/wetland size not bigger than 0.5 - 1% of the drainage area should be created.

Ponds constructed for **irrigation** normally hold a larger volume of water than other ponds. The water is collected during high flow in wintertime and used during dry periods in summer time. A smaller part of the water (corresponding to low flow), from upstream areas, continuously passes by the pond and thereby the irrigation can be carried out without a negative effect on downstream areas during low flow periods.

The shape, depth and localisation of inlets and outlets may be used to make the **water circulate** in order to optimise nutrient reduction (Persson, 1997). Moreover, the shape of the pond/wetland and the establishment of **plants and vegetation** should as far as possible imitate the qualities of natural wetlands in order to promote biological variation.

Type of wetland

The ponds/wetlands constructed may be divided into three main groups referring to the supply of water (fig. 5);

- stream widening pond/wetland(fig. 6A)
- side pond/wetland (fig. 6B)
- pond/wetland in piped system (fig. 6C)

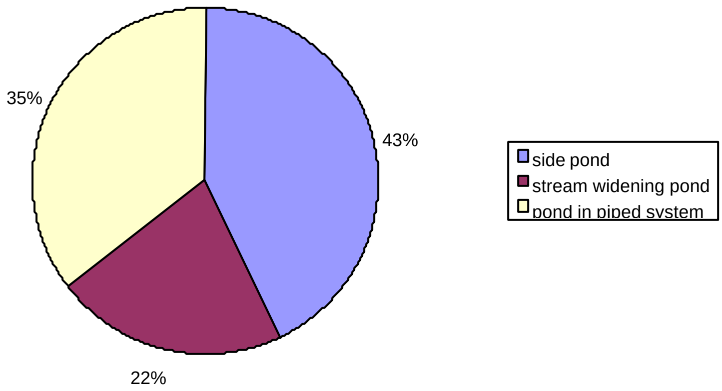


Figure 5. *Ponds and wetlands constructed within the Life project, divided into three different categories (n= 65).*

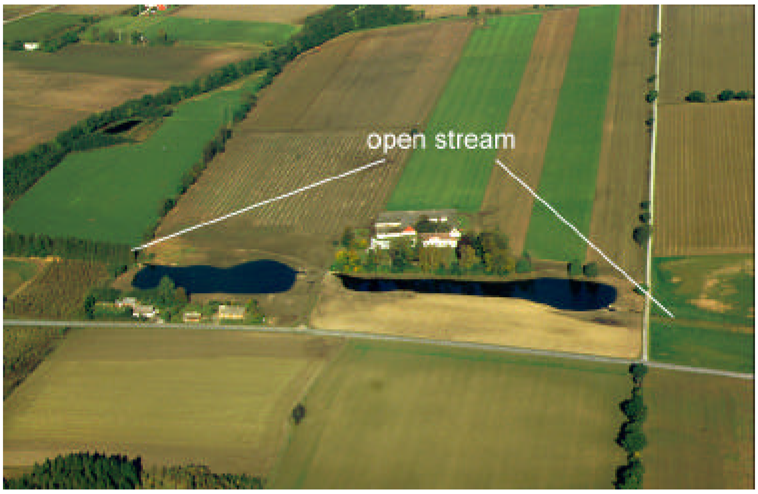
In a stream widening pond/wetland the river banks are excavated and levelled off resulting in a larger water surface in the stream at that locality. A dam may be constructed in the outlet, ensuring a minimum water level in the stream widening pond/wetland. A side pond/wetland is constructed parallel to the main stream, from which water is “borrowed” through pipes or open ditches. Ponds/wetlands in piped systems are mainly those situated between a drainage system and an open stream.

General characteristic of wetland types

The **”stream widening” ponds/wetlands** are effective nutrient traps as they are loaded with all the water passing in the stream (see chapter 4, Retention of nutrients). The water level in the pond/wetland is dependent on the water level in the stream and unless it is possible to dam up the water, the pond/wetland surface may be small during low flow periods. Fishing interests and nature conservation interests may be in conflict with stream-widening ponds/wetlands, especially if a dam is constructed, as this may be a barrier for migrating fish and other organisms.

The **”side pond/wetland”** may be an effective nutrient trap if the topography admits water to pass the pond/wetland throughout the year. In many side-ponds/wetlands however, only a part of the total hydrological load passes through the pond/wetland, which is not optimal for nutrient retention efficiency. In side ponds/wetlands the level of the inlet and outlet can be constructed to guarantee a specific water level in the pond/wetland. Thus during low flow no water passes through the pond/wetland as the threshold is higher than the minimum water level in the passing stream. This may be aesthetically attractive, as the water level may be kept closer to the ground level.

”Ponds/wetlands in piped systems” are often effective nutrient traps as long as the drainage area is large enough. The recommendation in the project is a minimum of 75-100 hectares agricultural land drained to each pond/wetland, and/or a pond/wetland size not bigger than 0.5 - 1% of the drainage area. The environmental gain in terms of bio-diversity is large as covered drainage water is brought to the surface and made available to organisms.



A. Stream widening pond

B. Side pond

C. Pond in a piped system

Figure 6. *The different kind of pond types constructed within the project, see description on page 14.*

Which type of pond/wetland is selected in each case depends on the conditions at the site, e.g. topography and soil type, and conflicting interests, e.g. agriculture, fishing or nature conservation. The choice also depends on the main objectives of the construction, e.g. nutrient retention, recreation, irrigation or nature conservation. Each type has its advantages and difficulties and the optimal construction in terms of nutrient reduction may not be the best in other respects (e.g. nature protection, drainage). Within the project five irrigation ponds have been constructed. Five old mill ponds have also been restored including rebuilding of dams and excavation in the former pond magazine areas.

Number and area of wetlands

During the project period 65 wetlands have been created in the watersheds of Höje and Kävlinge rivers (Annex 2) with a total area of 74 hectares. The aim stated in the *Life*-application (85 hectares) is thereby not fully accomplished (see chapter 6, Economical summary). The size of the constructions vary from 0.2 up to 6.1 hectares but most wetlands are in the range of 0.6 – 1.5 hectares (fig. 7). The average pond/wetland size is 1.1 hectares.

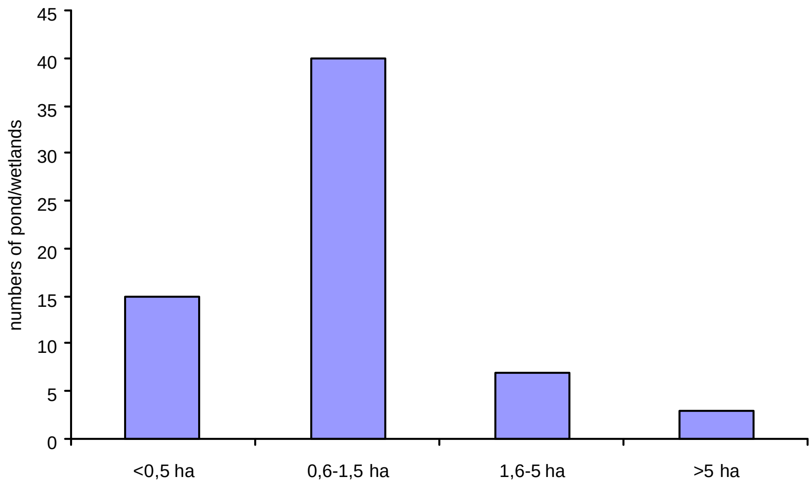


Figure 7. *The sizes of the 65 constructed wetlands range from 0.2– 6.1 hectares, but most of the constructions falls within the range 0.6 -1.5 hectares. The average pond/wetland size is 1.1 hectares*

An important factor determining the size of the wetlands is how much land the landowner is willing to offer the project. Normally, smaller areas than 0.5 hectares are not considered as cost-effective to handle due to a high projecting cost compared with the amount of area established.

Distribution of wetlands

The wetlands are distributed unevenly over the watershed (fig. 8), the localisation of each object depends on;

- The interest of the landowner
- The physical conditions of an area (topography, hydrology, soil qualities)
- The drainage area and land use in up-stream areas (resulting in different nutrient loads)
- Conflicting interests

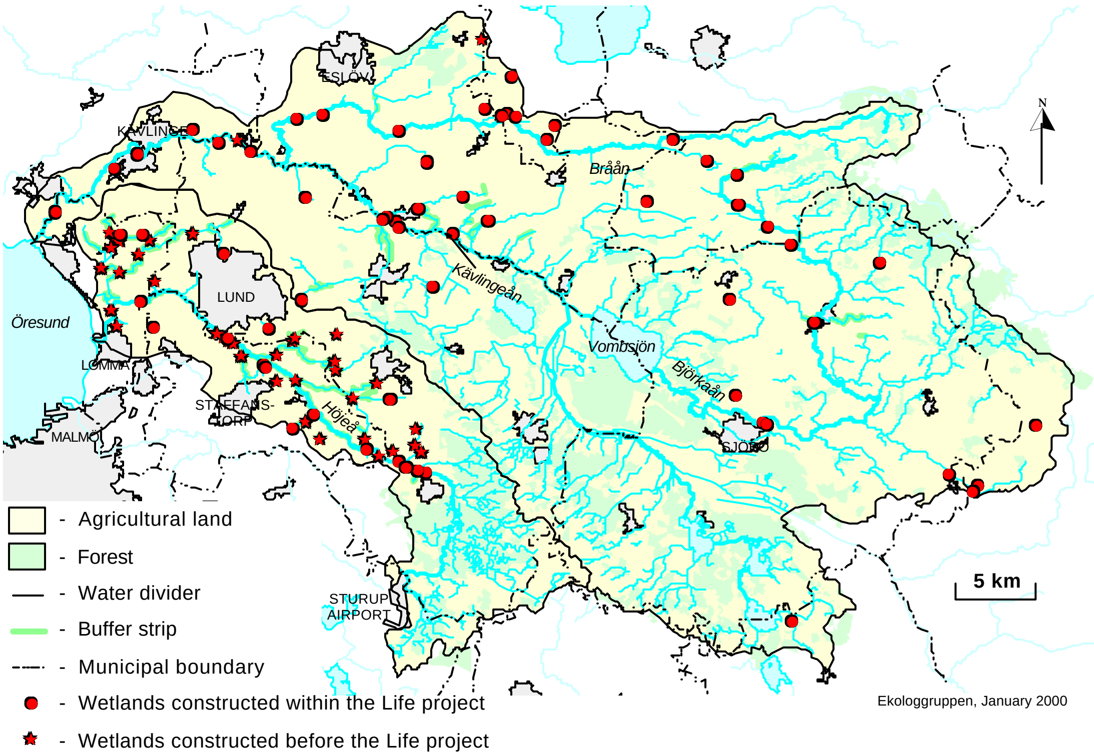


Figure 8. *Wetland sites in Kävlinge and Höje river watershed. In Höje river 34 of the wetlands were constructed prior to the Life project and 19 wetlands were constructed during the Life-project.*

Localisation of measures is carried out in dialogue with the farmer/ landowners which is why most of the wetlands are situated with the least possible interference with intensive land-use. From the landowners point of view margin areas or areas with low agricultural value are preferred. The former land-use of sites transferred to wetlands is shown in figure 9.

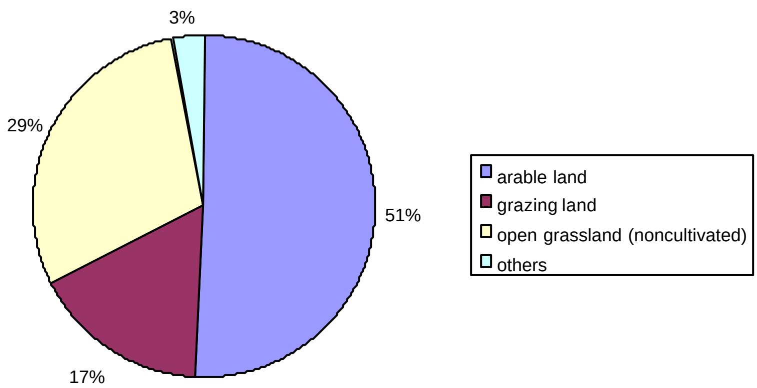


Figure 9. *The former land-use of sites transferred to wetlands.*

Technical problems

Technical problems finding a site for construction
A possible wetland site may be disqualified, not only due to unwillingness of the landowners or conflicting interest, see below, but also due to technical aspects of the site.

Topography: In a flat and well drained arable land the water level in streams and culverts is often far below the surrounding ground level (sometimes deeper than 2 m, see figure 10). Consequently, the possibilities to dam up water are small, as large drained areas will be influenced by a higher water table. In order to create any open water excavation down to the low water level is necessary. This means removing a large soil volume, as excavation depth may be 2-2.5 m. which is neither cost effective nor aesthetically attractive.

Figure 10. *A deep ditch/stream showing the low water levels in the agricultural landscape.*

In a steep topography the stream valleys may be too narrow to construct side-ponds/wetlands. "Stream widening ponds/wetlands" or dams are seldom an alternative as they come in conflict with fishing interest along rapid sections of the stream. It is also difficult to create ponds/wetlands in steep downhill locations as this may result in high dam constructions.

Drainage area: A minimum drainage area is required to each pond/wetland in order to support the wetland with enough nutrient throughflow in order to become a cost-effective nutrient trap. Many landowners have sites of interest in the periphery of a drainage area where enough water to "feed" the wetland is not available. These sites are often disqualified for pond/wetland construction.

Soil masses and soil quality: Soil masses have to be placed in close proximity to the ponds and wetlands, when it is far to expensive transporting the soil long distances. Locations for ponds/wetlands where the soil masses can not be spread out nearby the excavated area are therefore disqualified.

Sites with sandy soils may be disqualified for pond and wetland construction due to the risk of leakage and an undesired low water level during dry periods.

Technical problems during and after construction
Some technical difficulties have been identified during and after the construction process:

Drainage:	Due to shorter transportation distances and thereby lower costs the excavated soil often is placed in the nearby field to minimize the cost of transportation. As the ambition is to create aesthetically attractive wetlands no heaps or dikes are allowed, the soil has to be spread out on a large area. This might imply a risk of damages on the drainage system due to transport with heavy vehicles. Moreover, the soil structure may be affected due to packing, especially if the work is carried out during wet weather conditions. The area used for soil masses from the excavation often has to be re-drained.
Soil masses:	If masses are to be placed in arable land, the quality has to be considered carefully. For example a lot of stones or a high percentage of organic soil may cause problems in future cultivation.
Maintenance:	After the pond/wetland has been constructed the maintenance is managed by the contracted landowner. There are no obligations though, in the agreement between the landowner and the municipality, and the extent of the maintenance is uncertain. Especially in the side-ponds/wetlands (see above) it is important to check the function of the in-and outlets. Other problems such as leaking dams, erosion and a need to remove the sediment of the ponds/wetland may occur in the long run.

As pointed out in the text above, excavation has an effect on the landscape and environment not only at the spot of the pond/wetland, but also on the field where the soil masses are placed. An inquiry among landowners (Ekologgruppen 1999) showed that the excavated soil from constructed ponds/wetlands were placed on arable land in 18 of 23 cases. In 50 % of these 18 cases the fields had still not regained their previous arable quality after 3-5 years of farming.. In most of the cases the problem pointed out was the drainage.

Conflicts with other interests

Some interests that may be in conflict with wetland construction are:

Agricultural interests:	The price of farmland is high and in the intensively used areas it may be difficult to find interested landowners willing to transform productive farmland into wetlands at the rent-levels offered (up to 55 000 SEK/hectare). If a need of irrigation is present an economic incentive facilitates the access to farmland for pond/wetland construction. Drainage interests may be in conflict with wetlands either by the direct effect of water levels in the pond/wetland or the indirect effects of damages on drainage tiles due to the construction work or the change in soil profile.
Nature conservation:	Flora and fauna values may be in conflict with a wetland construction as the land available often is that of least agricultural interest (such as already wet spots, a pasture or a vegetated refuge close to the stream). The ecological values of an open stream may be in conflict with wetland construction as a construction in the stream make a significant change of the stream habitat.
Fishing interests:	Wetland constructions in open streams are often in conflict with salmon fishing interests, especially if dams are constructed. Considering this, a

	number of wetlands have been constructed as side ponds/wetlands to minimise the negative effects on fish. However, this design is often less optimal in terms of nutrient reduction(see description of different wetlands above).
Archaeology:	Areas close to the water often have historical values and each wetland construction is judged by the regional authority in this respect. Three potential sites have been disqualified for archaeological reasons but preliminary archaeological surveys and minor adjustments of constructions are more common.
Infrastructure:	Due to roads, cables, pipelines or other infrastructure elements in the area, the design of a wetland often has to be adjusted. In some cases the costs have increased or the wetland have been disqualified for that reason.
Water-regime and quality:	When water passes a pond/wetland during summer time, water temperature may rise and influence the water quality further downstream. A pond/wetland will also increase evaporation which is negative during periods with low water flow.

Buffer-strip establishment

Buffer-strips have been established along 59 km of riverside. The width of the buffer-strip is often 6 m, resulting in an area of around 35 hectares, which has been transferred from arable land to grass vegetation along the streams. Thus the goal of 25 hectares is more than fully accomplished. Landowners accomplish the establishment of vegetation while seeds and plants are supplied by the project.

According to the Swedish agro-environmental support system however, plantations of trees and bushes on the buffer strips are not permitted. This fact limits the efforts to increase the biological values along the streams.

Figure 11. *The pictures show a stream without buffer strips (left) and with buffer strips (right).*

The localisation of buffer-strips is presented on the map (fig. 8). Most bufferstrips are established along tributaries to Höje and Kävlinge river, areas where the need of vegetation along the streams is great (fig. 11).

New wetlands and bufferstrips in agricultural areas – discussion

What is the limit of creating wetlands in a watershed?

The main obstacles of large scale pond/wetland and wetland implementation are presented above, in chapter 2 and in this chapter. Although the quantitative goals of this project were near fulfilment, and large environmental benefits have been reached, it is obvious that implementation is not a smooth or easy process.

In the Höje water-basin, wetlands and bufferstrips have been created during the last 8 years. So far an area of totally 57 hectares (0.6 km^2) wetlands have been created corresponding to an area around 0.2 % of the watershed. At present it appears that the implementation wetlands is approaching a limit in the area and the most obvious reason is a lack of sites. In the perspective that 90 % of the former 9.5 km^2 wetlands in the Höje water-basin has been drained, and only 6 % of these have been recreated, there ought to be more sites available for wetlands in the landscape.

A technical explanation to the lack of possible sites concerns the low water levels in streams and culvert systems. The water that should be treated in the constructed wetlands is today normally found 1-2 m below ground level. This situation has hindered the possibilities of creating ponds and wetlands by dams as large areas of agricultural land then would be affected. The early project plans to r ecreate wetlands principally at their former sites have therefore not been possible to fulfil. In most cases wetland construction in modern agricultural landscapes is difficult to achieve without excavation.

Another of the major limiting factors in pond and wetland implementation is the lack of sites where landowners will set aside their land. The farmers strive to keep large and effectively shaped cultivation units and therefore most of the wetlands created are localised in the margin of the fields. Thus, after almost 8 years of wetland implementation, which is the situation in Höje river watershed, the most evident sites are already selected for wetlands.

Moreover the geographical situation may restrict the possibility of finding suitable sites. This has been obvious in the municipality of Kävlinge, where a quota of wetland area has been set up by the project. The municipality is situated near the mouth of the Kävlinge river with a narrow watershed along the main stream. Although the river is bounded by intensive arable land, localities for wetlands receiving enough drainage water are scarce. In this area where the natural conditions frequently are unfavourable and energy has to be used finding localities for wetlands. This exemplifies the difficulties with a fixed quota of wetland area in each municipality. The environmental gain will be larger if wetlands are implemented without consideration of administrative borders.

Can limiting factors be adjusted?

Would it be possible to make landowners give up more land if other incentives were used? A higher grant for the arable land might make some landowners more willing. It might also help if the laws affecting the implementation were changed and if measures were incorporated in the planning process of the municipalities (see chapter 2, Conflicting interests - authority policies and legal aspects"). Another strategy, in wetland and stream restoration in Denmark ((County of Sønderjyllnad 1997), is the use of land exchange. In Denmark a decentralised decision making system where the elected county councils may draw up their own policies of environmental protection, facilitates the implementation of project plans. Moreover the Danish agro environmental subsidies are directed towards farming along streams and around lakes which provides the authorities with a larger economical incentive. Land exchange may improve the accessibility of land as many farmers strive to increase their farming area, an aim that may be in conflict with their willingness to convert agricultural land to wetlands. As in the Danish example however, this method of working need a larger involvement of regional and/or national authorities in the management of stream and wetland restoration.

Figure 12. *A shallow water with a size of 5 hectares has been constructed in the watershed of Kävlinge river. The inlet from a main contributary stream is located 600 meters upstream and the water flows to the wetland in a long channel.*

Figure 13. *In irrigation ponds environmental benefits are combined with a commercial benefit for the landowner. In this irrigation pond with a size of 5 hectares, more than 100 000 m³ water is stored during the winter season for irrigation purposes during summertime.*

Figure 14. *The wetland in the picture has a size of 6 hectares and is the largest in the project. Because the main stream is very deep, with a water level far below the ground level, the water had to be fetched 850 meters upstream. The water runs first in a culvert and in the end in an open channel.*

Whatever incentives are used, ponds and wetlands still have to be created by excavation in order to minimise the negative effects on the surrounding arable land.. New incentives facilitate the establishment of measures in sites were topographical circumstances are more favourable (less excavation) than at the locations given by landowners today. It could also make it possible to influence larger areas by a higher water table and thereby minimise the need for excavation.

How should buffer strip establishment be carried out?

Buffer strip establishment encounters fewer conflicts and the only significant limiting factor is the amount of the rent offered for the land. Buffer strip establishment is a fairly accepted measure among farmers and at this moment the main issue is who should be responsible for the costs, implementation and follow up.
When buffer strip establishment started in the Höje river watershed eight years ago no other support than that from the project was offered to the landowners. Today, subsidies are available within the Swedish agro environmental support and has to become a common environmental demand from the agricultural market. This has made landowners more willing to establish buffer strips during the last years. Thus, the role of the project as promoter for buffer strips has become less important. The risk is however that one of the outspoken aims of this project, increased biological diversity along streams, is lost as buffer-strips must still be kept as “agricultural land” , which implies that only grass vegetation may be established and plantation of trees and bushes on the buffer strips is prohibited.

A discussion is going on about whether buffer strip establishment should be considered a task fulfilled by other interests or if the project still should support this work. Neither the national/regional authorities (through the support system) nor the market however, aim towards getting a geographical overview of where buffer strips have been established. Consequently, the possibilities of following up the effects of buffer strips are small. Further more there is no direction of the support towards areas of high erosion risk or areas disposed to overflow, ambitions that we have tried to fulfil within this project. In the near future the project will follow up the establishment of buffer-strips fulfilled by other actors within the watershed in order to evaluate the environmental effects. It may be questioned whether this should be the responsibility of the project.. It would probably be more effective if the regional authorities, which are responsible for the agro environmental subsidies, could carry this follow up. A general demand of bufferstrips along all open waters is desirable. The incentives from the market and the environmental support is not enough if the bufferstrips also aim at functioning habitats and corridors for plants and animals.

Conclusions

- The project has successfully implemented wetlands and buffer-strips in the agricultural landscape.
- Technical problems as well as different landscape interests complicate the implementation of wetlands.
- Some limiting factors of large scale implementation of measures may be overcome by increased rent for land or possibilities given for land exchange, to the landowners
- Wetland construction in the modern agricultural landscape is difficult to achieve without excavation. The localisation depends more on where modern agricultural practices will allow wetlands, than where wetlands historically were situated.
- Administrative borders may limit an optimal implementation, even within a co-operation if the breakdown of costs implies a certain quota of wetlands in each municipality
- The role of the project as buffer-strip promoter has decreased throughout the project period as buffer strip establishment is performed by agro environmental support and by market demands.
- A legal demand of bufferstrips along all open waters is desirable to reach a better effect on biological diversity as well on nutrient reduction.

4. ENVIRONMENTAL BENEFITS

Investigations

Four wetlands (Råbytorp, Slogstorp Genarp and Lomma) have been investigated over periods of 1 to 6 years with respect to their retention capacity of nutrient (nitrogen and phosphorus) and suspended matter.

Biological diversity concerning bird life, invertebrates and vegetation has been studied in many of the constructed wetlands. The bird life was studied during 1994-1998 in totally 42 wetlands. Benthic macroinvertebrates and vegetation were studied during September-October 1998 in 26 wetlands. The wetlands differed in many aspects such as size, depth, age at the time for the inventory and the location in the landscape. The size varied between 0.1 and 5.3 hectare and the mean size was 1.0 hectare. The age of the wetlands at the time of the inventory varied from some months to 6 years.

Retention of nutrient and suspended matter

Nutrient retention studies were started in two wetlands (Råbytorp and Lomma) prior to the initiation of the Life project. During the Life project investigations in two additional wetlands (Slogstorp and Genarp) were started. Continuous sampling of in- and out- coming water was performed in Råbytorp, Slogstorp and Genarp with automatic water-samplers. The water-samplers were emptied twice a week and the samples were analysed for their concentrations of tot-N, NO_3-N, NH_4-N, tot-P, PO_4-P and suspended matter. To calculate the flow, the water levels at the outlets of the wetlands were continuously registered at all measuring sites. In Lomma a less detailed study of the nutrient retention was performed. Samples were taken in the inlet and outlet 5-6 times a year and analysed for tot-N, NO_3-N, NH_4-N, tot-P, and PO_4-P. There was no registration of the water flow in this wetland, instead the water flow was calculated from the average runoff in the area.

The wetlands in Råbytorp, Slogstorp, and Genarp have been constructed by excavation and receive water from areas dominated by arable land. The wetland in Lomma was an already existing wetland originating from an old clay pit filled with water. A ditch with a drainage area of 600 hectares arable land was lead to the wetland and an outlet was constructed at the opposite end.

Three of the wetlands (Råbytorp, Slogstorp and Genarp) have sizes ranging from 0.65-1 hectares, with catchment areas ranging from 300 to 880 hectares. The smallest wetland (Slogstorp) receives water from the largest catchment area and the largest wetland (Genarp) is receiving water from the smallest catchment area. Thus, despite their similar sizes, the wetlands receive highly different nutrient loads. The catchment areas are all dominated by agriculture, which explains the high concentrations of nutrients in the water. The fourth wetland, Lomma, has a considerably larger wetland area (7.9 hectares) in relation to its catchment area (600 hectares).

A general conclusion from the results is that the wetlands have a positive effect on the concentration of nutrients and suspended matter in the water, i.e. the retention capacity is good. Results from 6 years of retention studies in the wetland at Råbytorp are shown in figures 15 and 16. We also found that the nutrient reduction varies between different wetlands as well as within the individual wetlands due to seasonal differences. The most important factor determining these variations seems to be the nutrient load.

The **relative retention** capacities (tab. 2) in three of the wetlands (Råbytorp, Slogstorp and Genarp) differed from each other by a factor 2 or less, comparing each investigated parameter separately. The nitrogen retention varied between 5 – 9 %, while the phosphorus retention was 11 – 25 %. With the best retention of 30-50%, suspended matter was the parameter which was most efficiently retained in the wetland.

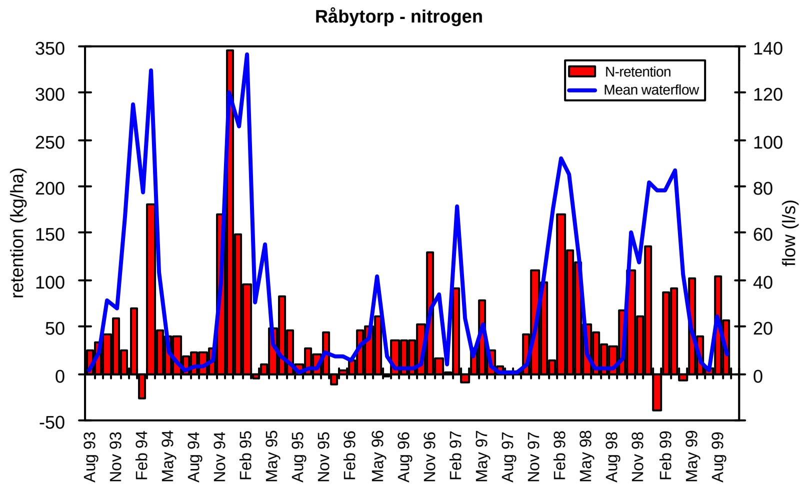


Figure 15. *Monthly nitrogen retention and waterflow in the wetland at Råbytorp.*

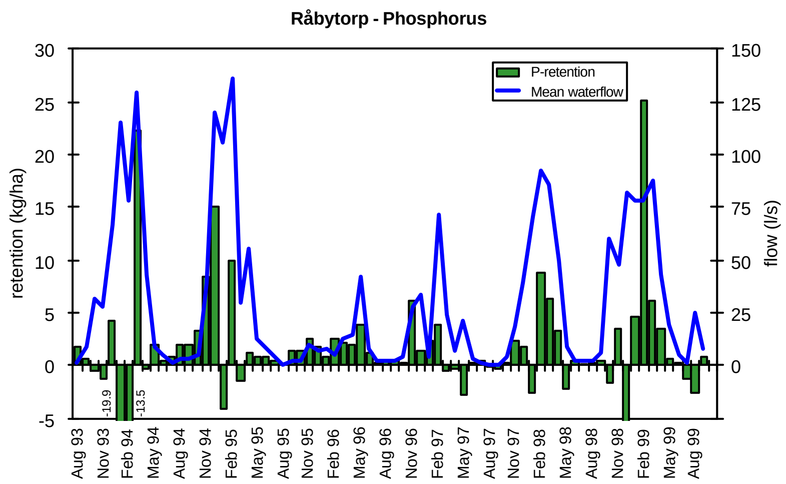


Figure 16. *Monthly phosphorus retention and water flow in the wetland at Råbytorp.*

The nutrient load is the single most important factor determining the amount of **absolute retention**. Expressed in absolute amounts per unit wetland area and year (kg/hectare/yr) the reduction of nutrients showed a significantly higher variation between the different wetlands (tab. 2) compared to the relative retention. For example nitrogen retention differed by a factor > 10 comparing the Slogstorp and Genarp wetlands. The Slogstorp wetland had the highest load and the highest absolute retention (4 tons N/hectare/yr, 84 kg P/hectare/yr and 14 tons susp/hectare/yr).

Due to a larger wetland area in relation to the catchment area and consequently a lower nutrient load, the wetland in Lomma has a higher relative reduction especially concerning nitrogen (50%). In spite of the relatively low load of nutrients the absolute retention of nutrient and phosphorus is still comparatively high.

Table 2. *Data and results (until Sept/Dec 1999) from the four wetlands where nutrient retention was studied.*

	Slogstorp	Råbytorp	Genarp	Lomma
Physical data				
Age (yrs)	2	7	2.5	> 50
Duration of investigation (yrs)	2	6	1	4
Wetland area (hectare)	0.65	0.75	1.0	7.9
Drainage area (hectare)	880	380	300	600
Turnover time*-normal (days)	1	2.9	2.9	39
Turnover time*-min (hours)	2.2	6.5	23	96
Mean water flow (l/s)	130	30	24	54
Nitrogen				
Mean concentration, inlet (mg/l)	9.2	10.6	5.6	9.9
Load (kg/hectare/yr)	57 500	13 600	4 300	2140
Retention, absolute (kg/hectare/yr)	4 110	650	380	1080
Retention, relative (%)	7.1	4.8	8.8	50
Phosphorus				
Mean concentration, inlet (µg/l)	80	130	120	197
Load (kg/hectare/yr)	471	171	94	42
Retention, absolute (kg/hectare/yr)	84	19	24	23
Retention, relative (%)	18	11	25	45
Suspended matter				
Mean concentration, inlet (mg/l)	4.5	18	7.2	-
Load (kg/hectare/yr)	28 100	22 600	5 600	-
Retention, absolute (kg/hectare/yr)	14 200	8 100	1 800	-
Retention, relative (%)	50	36	33	-

*Turnover times are based on registered mean water flow and maximum flow in Råbytorp, Slogstorp and Genarp. In Lomma the waterflow is based on the average surface runoff in the actual area.

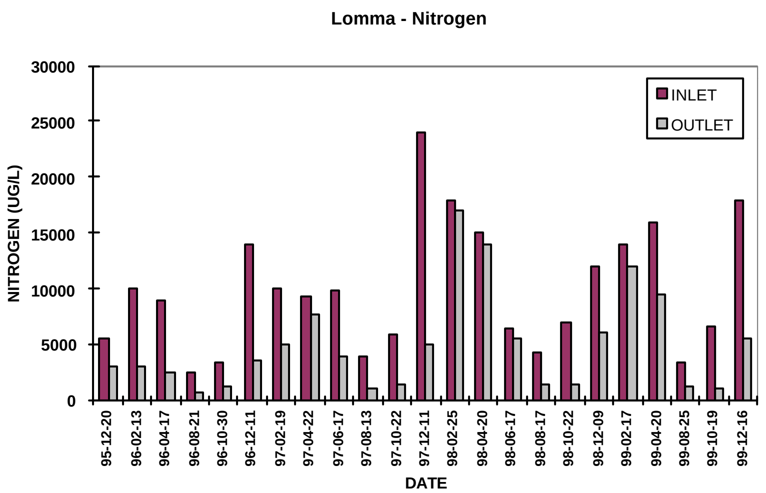


Figure 17. *Nitrogen concentration in the inlet and outlet of the wetland at Lomma.*

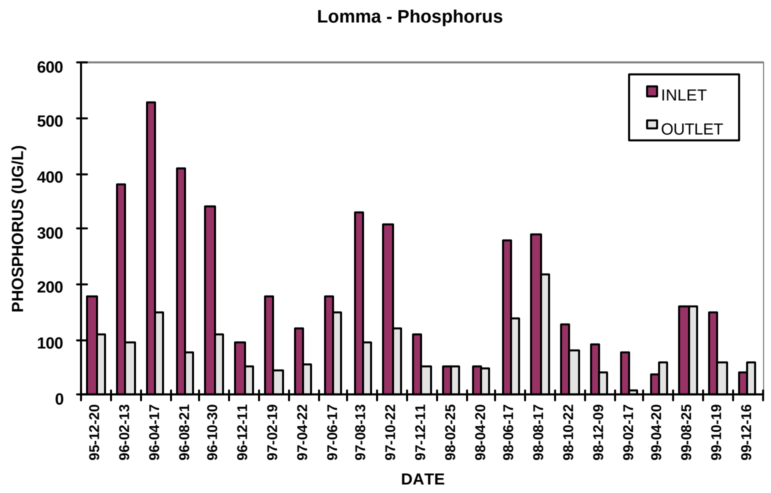


Figure 18. *Phosphorus concentration in the inlet and outlet of the wetland at Lomma.*

In all wetlands the analyses show that 70-90% of the total nitrogen content consists of nitrate. Further more, common for all wetlands is that the relation nitrate/total nitrogen is 2-8% lower in the outlets than in the inlets. Thereby it could be stated that most of the nitrogen retention concerns nitrate and consequently the dominating retention process is denitrification. Denitrification is a metabolic process and thus temperature dependent. In spite of the fact that the lowest temperatures occur during the winter season the highest absolute retention rates were found during this season (fig. 19). This can be explained by the high water flow and thereby a high nitrogen load during this time of the year. In Råbytorp for example, 64 % of the total nitrogen retention occurred during October to March. The relative nitrogen retention though, may be around 5 % or less during winter time while in the summer it may reach 80% when low amounts of nitrogen is passing through the wetland, (fig. 19).

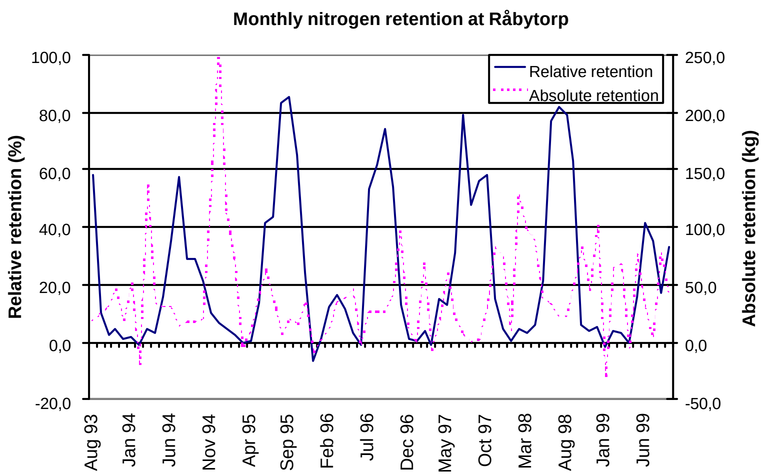


Figure 19. *Monthly nitrogen retention in the wetland at Råbytorp. Note that the highest absolute retention normally occurs when the relative retention is low.*

When comparing the wetlands with each other there does not seem to be a disadvantage in exposing the wetlands to a high load. The Slogstorp wetland, which has a load per unit wetland area > 4 times higher than Råbytorp, not only has a higher absolute nitrogen retention but also a better relative retention. Certainly, the load is not the only factor determining the reduction capacity for nitrogen but in terms of cost efficiency it is obvious that a high load is desirable.

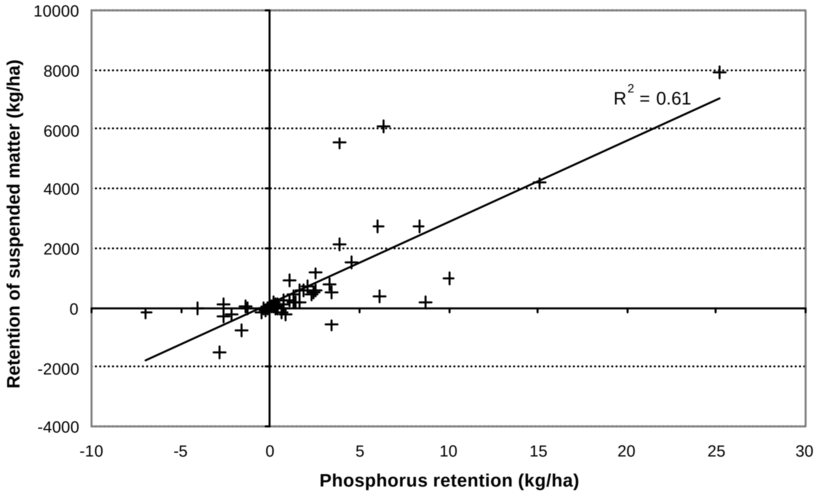


Figure 20. *Diagram showing the relation between monthly retention at Råbytorp of suspended matter versus phosphorus.*

Phosphorus and suspended matter commonly correlate well with respect to their concentrations in the water as well as in the monthly retention amounts (fig. 20). This correlation is a consequence of the fact that phosphorus often appears bound to particles. As for nitrogen, it is concluded that a higher total load of phosphorus and suspended matter will increase the absolute retention. Still, within the individual wetlands and during shorter periods the relation between the load and the retention is not always simple. On some occasions, mostly during high flow situations, there was an outflow of suspended matter and phosphorus. Occasions of outflow of nitrogen are not correlated with high flow situations as they are for suspended matter and phosphorus. The fractions of nitrogen of the out coming water indicates that organic material was not rinsed out of the wetlands at high flow situations. Thus, there seems to be no loss of organic matter, which is the energy source for the denitrification and, consequently, no negative effect on the nitrogen retention was noticed after high flow situations.

A measure of the long term retention capacity in a wetland may be obtained by studying the accumulated relative retention of the nutrients. It is evident that the retention capacity in the 7 years old wetland at Råbytorp, has not diminished as the wetland has aged (figure 21). The nitrogen retention has been fairly stable, just below 5%, during the last 3 years, whereas the phosphorus retention still shows a slightly increasing trend.

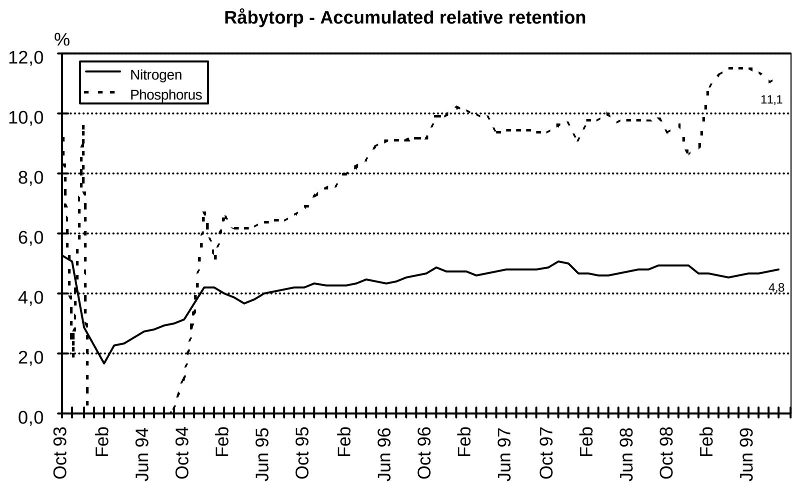


Figure 21. *Accumulated relative retention of nitrogen and phosphorus in the wetland at Råbytorp.*

Biological diversity in constructed wetlands

Bird life

The bird life was studied in 42 constructed wetlands during 1994-1998. The investigations were performed during the breeding season, and each wetland was visited once or twice. All the observed birds were recorded and indications of breeding were determined. Some of the wetlands were visited during more than one season and the total numbers of occasions when wetlands were studied during the whole period was 81.

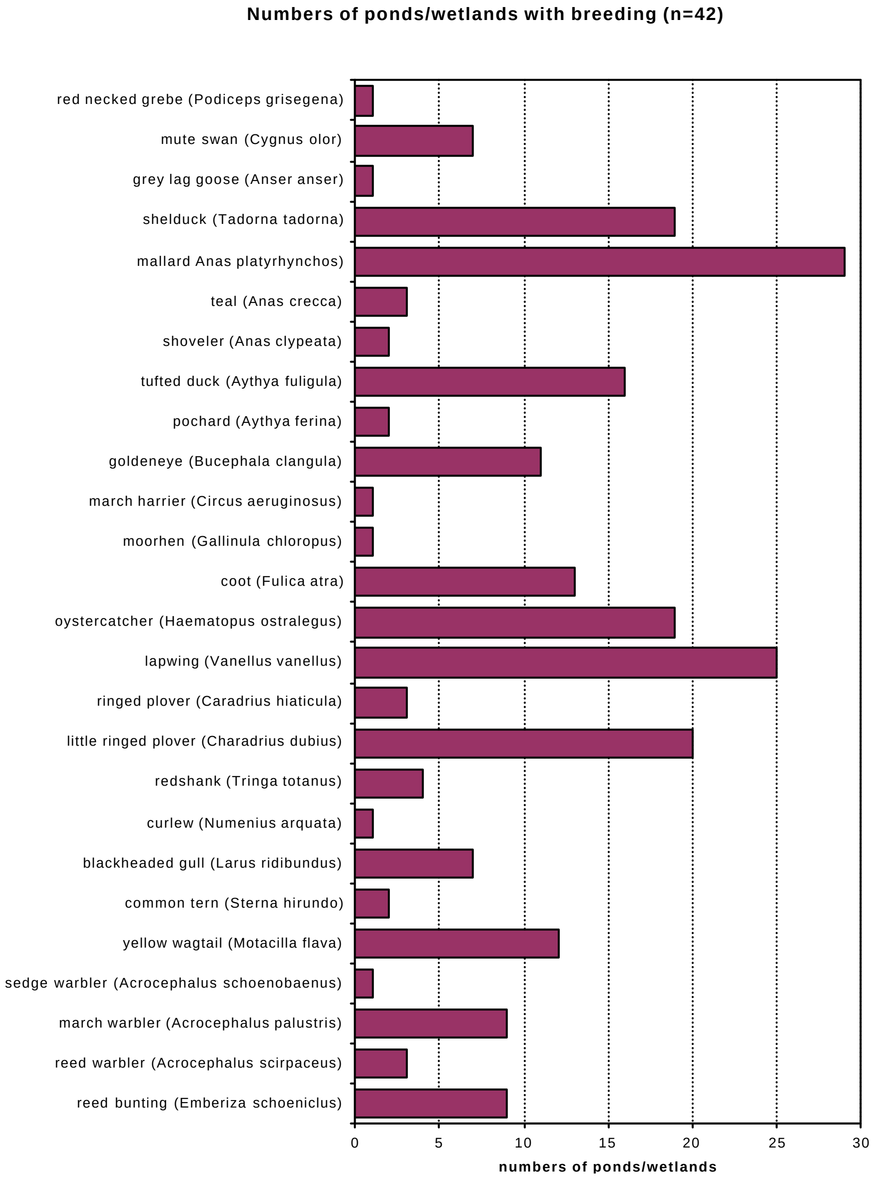


Figure 22. *The total number of wetlands (n=42) where breeding occurred for each bird species during 1994 - 1998.*

36 different bird species bred in the wetlands or in their proximity, 26 of which are connected to water and wetlands (fig. 22, Annex 4). The most common breeding species in the wetlands were mallard, shelduck, oystercatcher, lapwing and little ringed plover.

The age of the wetlands at the time of the inventory, showed that the colonisation of birds was rapid. Only a few months old, some wetlands were inhabited by several breeding birds. As many as 16 pairs were found breeding in a recently constructed wetland. Some species such as the little ringed plover and the shelduck seemed to be especially attracted to recently constructed.wetlands. Other species, like the mallard and the coot, preferred older wetlands likely because of their denser vegetation.

The highest numbers of species were recorded in large wetlands (> 1 hectare), but also small wetlands(<0.4 hectare) seemed to be very attractive to the birds both in respect to species richness and number of breeding pairs. Many birds, other than breeding species, were observed in and around the wetlands, which shows the importance of wetlands for foraging and resting birds.

Some of the breeding birds recorded in this investigation; yellow wagtail, curlew, rednecked grebe, little ringed plover and march harrier, are classified as “care demanding” in the Swedish red list of threatened species.

Benthic macroinvertebrate fauna

Benthic macroinvertebrate fauna was studied in 26 wetlands in September - October 1998. The sampling was done by handnet (method: SS 028191) and the examination was carried out in a laboratory through a microscope. The total number of taxa and individuals as well as diversity were determined The colonisation of invertebrates in the constructed wetlands was fast, and already the first year they showed a high number of species and individuals. There was no correlation between the number of species and the age of the wetlands. Many different groups were represented already during the first year such as worms, leeches, snails, crustacean, mayflies, dragonflies, water bugs, beetles, caddis flies, moths, flies and midges. The abundances were as high as in the running waters in the area

A total of 184 species were recorded in the 26 wetlands (Annex 5). The most frequent were beetles (54 species), water bugs (29 species) and snails (20 species). The number of taxa per wetland varied between 23 and 53.

The most common species, which were found in all or nearly all the wetlands, were the mayfly *Cloeon dipterum,* non biting midges (*Chironomidae*), worms (*Oligochaeta*), the snail *Radix ovata/peregra,* waterlouse (*Asellus aquaticus*) and the water boatman *Sigara striata.*

Some invertebrates were typical in new wetlands but not observed in a few years old wetlands. The caddis fly *Oecetis ochracea* and the water bugs *Sigara limitata* and *Sigara longipalis* are examples of invertebrates that were found only in young wetlands (0.5 – 2 years). Some species only occurred in the older wetlands (4 – 6 years) for example the water scorpion *Nepa cinerea*, the beetle *Noterus clavicornis* and the caddis fly *Holocentropus picicornis*.

The age of the wetlands (and thereby related factors) seemed to play an important role in the invertebrate community composition (fig. 23). Non biting midges (*Chironomidae*) were among the dominating species in all of the 0.5 to 2 years old wetlands. Snails, especially *Radix ovata/peregra*, were often found in high numbers in the 1 to 2 year old wetlands. The waterlouse *Asellus aquaticus* was very common and dominating in the five wetlands that were 4 – 5 years old.

The size and form of the wetlands did not seem to affect the community composition. No relation was found in invertebrate community between wetlands with different types of inflow. Wetlands with culvert inflow had as many species and individuals as wetlands with inflow from open running waters. The explanation is probably that most of the invertebrates are efficiently spread through the air.

The water vegetation and thereby related factors were of great importance to community relationships. In the wetlands with dense submerged vegetation, the waterlouse *Asellus aquaticus* was often the dominating species together with the mayfly *Cloeon dipterum*. In wetlands with badly developed submerged vegetation, or mostly floating vegetation, the fauna often was dominated by non biting midges (*Chironomidae*).

There are of course other important factors in the wetland ecosystem that have not been investigated. The fish community for instance may have a substantial effect on the invertebrate community.

Taxa from the red list of threatened species in Sweden were found in 25 of the 26 wetlands. These species were found both in 0.5 year and 6 year old wetlands. One beetle from the category 3 (rare) was found (*Hydroporus obsoletus*). From the category 4 (care-demanding) three species of water bugs and three species of snails were found.

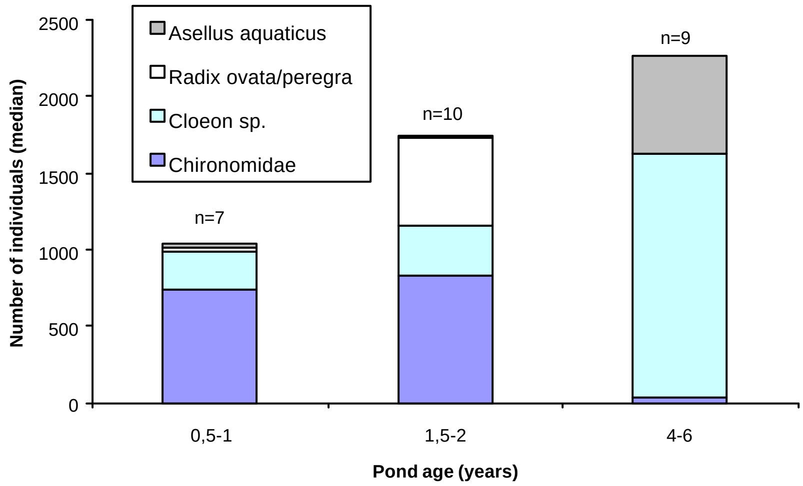


Figure 23. *The median numbers of individuals of four common taxa from the invertebrate study of 26 wetlands dividing on different wetland age.*

Vegetation

Vegetation was studied in 26 wetlands during September 1998. All observed species in each wetland (including the surroundings) were listed and their frequencies were estimated according to a three-degree-scale. The approximate extension of clumps of reed and stands of other large macrophytes, were drawn on a map. Plant species in the adjacent area above the shore, the epilittoral zone, were recorded separately.

Plant colonisation in the new wetlands was rapid, and the number of species present was high already after the first year. Common early colonisers were *Juncus bufonius, J. effusus, Alisma plantago-aquatica* (fig. 24), *Typha latifolia* and, among the submerged species, *Potamogeton berchtoldii*. 1.5 – 2 year-old wetlands had a well-developed aquatic flora of *Elodea canadensis, Potamogeton spp., Ranunculus spp., Persicaria amphibia* and many other species. The shoreline was also to a large extent covered with vegetation.

In the oldest wetlands (4 – 6 years) the shores were usually covered with extensive stands of large, emergent macrophytes, such as *Schoenoplectus lacustris, Phragmites australis, Glyceria maxima, Typha latifolia* and *Eleocharis palustris*. Above this zone there was commonly a several meters high border of willows (*Salix spp.*). The surface was to a varying extent covered with duckweed and floating-leaved macrophytes, such as *Potamogeton natans* and *Persicaria amphibia*, whereas submerged macrophytes, mainly elodeids, filled out a lagre part of the water volume.

In all wetlands a total of 184 vascular plants were noted (Annex 6) of which 113 of these were wetland species whose colonisation, in most cases, were entirely due to the wetland establishment. On average 41 vascular plants, out of which 31wetland plants, were found per wetland. In the epilitoral (above the highest water level) zone 115 taxa of vascular plants were recorded with a mean of 13 per wetland.

Seven of the encountered species are listed on the Swedish red list of threatened species, out of which two (*Isolepis cetaceus* & *Euphorbia exigua*) belong to category 2 (vulnerable) and are very rare in the entire country. The other threatened species were; *Ceratophyllum submersum, Rumex palustris, Juncus inflexus* (category 3-rare), *Veronica catenata* and *Stachys arvensis* (category 4–care demanding). Apart from these, several other uncommon plants occurred in many of the wetlands.

As the wetlands differ from each other in many aspects, it is difficult to sort out the effect of single factors on species richness and composition. Some trends, however, can be seen. Among 0.5 to 2 years old wetlands there was a clear tendency towards increasing species richness with age. In 4 – 6 year old wetlands the number of species then seemed to decrease slightly compared to 2-year old wetlands, which, if this is the case, could be because early colonising, but less competitive, plants are forced aside when the vegetation closes.

Figure 24. *The colonisation of vegetation at the created wetland is fast.*

Species richness was also influenced by the origin of the incoming water. The highest number of species occurred in wetlands receiving water from main streams, followed by open tributaries, while the lowest number of species were found in wetlands with a water supply from piped drainage systems. The number of wetland plants also increased with wetland size, at least up to a size of about 1.5 – 2 hectares. There also seamed to be a weak correlation between species richness and the amount of shoreline undulation, but this connection was less certain.

The high species richness in general, and the large occurrence of rare and threatened species indicate that the wetlands constitute an important habitat for many plants, which are rapidly able to colonise the new environments. Due to extensive drainage many of these plants have today largely been forced away from the agricultural landscape of south-western Scania. The new wetlands provide a valuable increase in living space for these species, and thereby also make a large contribution to the biodiversity of the region.

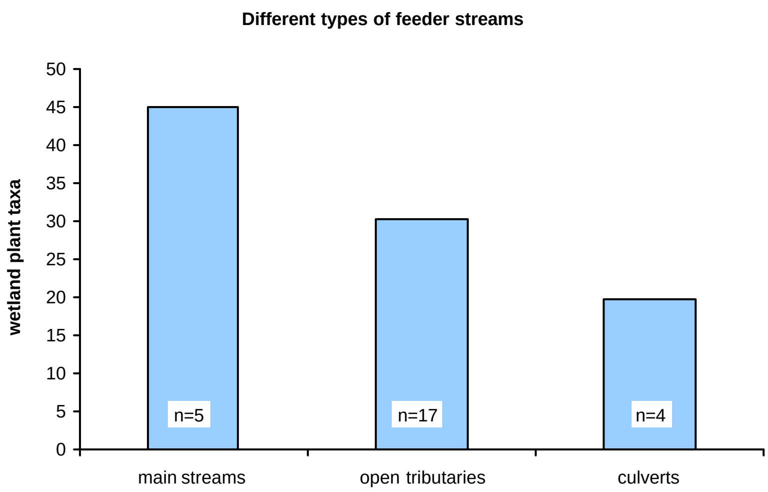


Figure 25. *Number of plant taxa in wetlands with different types of feeder streams.*

Benefits of buffer strips

No studies have been performed within this project to evaluate the environmental benefits of buffer strips along the streams. From investigations for example in Norway (Syversen, 1994) and Finland (Uusi-Kämppä and Yläranta, 1992), it can be concluded that buffer strips reduce concentrations of nutrients transported by overland flow from arable land. The results show that there is a reduction of nitrogen, phosphorus and suspended matter in the buffer strips. Buffer strips of 5 m along the streams also reduce the risk of pesticides deposition in the open streams.

The buffer strips also serve as valuable ecological zones along which animals and vegetation can spread. If the buffer strips are planted with bushes and trees they increase the biological diversity along the streams.

Other environmental effects of wetland and buffer strip implementation

The studies presented above show that wetlands and buffer strips are effective as nutrient and sediment traps as well as important for vegetation and animal life bound to these habitats. Furthermore, other benefits may be expected such as purification of metals, bacteria and probably also pesticides.

The biological effects described above only concern some of the plants and animal groups that benefit from these environments. Positive effects can also be expected for amphibians, fish, and mammals of the agricultural landscape as well as invertebrates bound to the shore-zone just above the waterline.

Hydrological aspects

Ponds and wetlands can, in limited parts of a watershed, contribute to a better water-regime and decrease the risk of flooding in the surrounding agricultural land. The ponds constructed for irrigation decrease the demand for water from the streams during low-flow. The irrigation from irrigation during dry periods also means less nutrient leakage from the arable land as the plants can assimilate a larger part of the fertilisers given to them.

Recreational aspects

In the intensively used agricultural areas where most of the open watercourses has been covered and the areas of differing land-use are minimal, wetlands and buffer-strips will be important contributions as recreational areas used for walking, bathing, riding, ice skating, hunting and bird watching.

In the area of the Höje river there is a developing project (The Höje-river nature and cultural path) trying to establish foot paths that connects the river to villages and the town of Lund. If the buffer-strips along the Höje river and its tributaries had not been established this had been a difficult mission. Another aim of the project is to make it easy for schools to use the streams, wetlands and other interesting places along Höje å as an out door class room.

Within the Life-project a total of about 100-hectares of arable land have been transformed to areas available for recreation. According to Swedish law the public are permitted to attend these areas as soon as they have been established. Unfortunately all areas are not accessible though and a project like the one described above might be necessary to make them available.

Historical aspects

At some of the sites where wetlands have been created it has also been possible to restore historical values connected to the water, both landscape elements and older technical solutions. One example is mill ponds where not only the water body has been recreated but the ambition has also been to rebuild dams and other technical constructions so that they resemble their genuine historical appearance. Another example is the use of old channels systems, which were used for irrigation of pasture areas to increase the yield. In this project the channels have been restored and used to transport water to the constructed pond or wetland. Excavating old meanders and connecting them with the main stream has also been done within the project and can also be seen as a restoration of the old "water landscape"

Figure 26. *Ponds and wetlands are attractive environments for outdoor activities in the area.*

Conclusions

- Studies of nutrient reduction in four wetlands clearly showed their good capacity to retain nutrients (nitrogen and phosphorus) and suspended matter. The relative retention of nitrogen varied between 5 – 50 %, phosphorus 11 – 45 % and suspended matter 30 – 50 %.
- The absolute retention of nitrogen was strongly correlated to the load (amount of nitrogen entering the wetland). The absolute retention in the studied wetlands ranging from 0,4 to 4 tons nitrogen/hectare/yr.
- As a response of the load the absolute reduction of nitrogen is generally highest during the winter season.
- The retention of phosphorus was correlated to the sedimentation of particles in the wetland. The phosphorus retention were the same as for nitrogen, i.e. a higher load increased the absolute retention.
- There was no indication of decrease in retention over time during the investigation period.
- The wetlands provide a valuable increase in living space for many species of plants and animals, and thereby make a large contribution to the biodiversity in the agricultural landscape.
- The colonisation of plants and macroinvertebrates was fast, which also explains the rapid establishment of breeding birds.
- The species richness was high in the created wetlands and a total of 18 threatened species from the Swedish red list were noted.
- The fast colonisation of vegetation in the created wetlands implies no need for artificial vegetation establishment.
- A high richness of species was recorded in one of the wetlands were the nutrient reduction was high. Thus there seems to be no conflict between a high retention capacity of nutrients in a wetland and species richness.
- Additional environmental benefits are the creation of new attractive areas for recreation and hunting as well as increased possibilities for irrigation and improved water-regimes in the nearby areas of each wetland.

5. DISSEMINATION

Since the very beginning of our contact with Life, through guidelines for application, guidelines for reporting and general information about the Life fund, we have been reminded that the main idea of Life is demonstration and dissemination. The experiences gained, negative or positive, are useful for others with related needs. During the project period we have experienced that inquiries for information and that the interest from outside has increased throughout the period as experiences have been gained. Thus the information seems to have reached the external target groups concerned. However, distribution of information within the project is just as important. Knowledge of the underlying problems, the measures and their effects have increased the motivation among farmers to join the project. It has also inspired politicians to further support the project and the public to support the environmental investment in the municipality.

TV , radio and newspapers

The project has attracted attention in local, regional and national newspapers both before and after the Life application was funded. In connection the announcement of the Life money, regional TV- and national radiobroadcasts presented the project. In July 1997 a report about the project was broadcast on a national radio programme. The programme was broadcast from one of the constructed wetlands (Skarhult, Eslövs municipality). The chairman in the steering committee and the consultant (working with planning and practical implementation of the measures) represented the project. Moreover representatives from the bird-watching organisation and the department of social geography (university of Lund) gave their view of the project. During a seminar in Lund, March 1998, with related Nordic Life projects the local Swedish newspaper paid attention to the Life projects.

Folders and project information

In August 1996 we published an information folder for the public, regarding the Höje river part of the project. The folder was distributed to politicians, farmers, landowners, libraries and schools. It has also been used on guided tours and generally whenever information was requested. In April 1997 and 1998 the progress of measures, in each river separately, has been published. The reports are in Swedish and include colour photos and maps of the wetlands and buffer-strips. The reports are being brought up to date and will be distributed to the target groups during the spring 2000. The target groups for this type of report are politicians, local and regional authorities, interest organisations and landowners. Folders containing short information about the project, in order to enlist landowners to join, have been distributed through the farmers interest organisation. The project has been presented in the EU-commission publication “Success stories”. English information about the project was distributed to about 40 LIFE-projects during and after the presentation of the project at the Life week in Brussels in October 1999. There has also been done a compilation of all information available concerning the project such as folders, posters, videos, film slides and transparencies.

Scientific publication

Results from the follow up study in a wetland outside Lund were published in the national journal ”Vatten” (Dellien and Wedding 1997). Moreover, a second article discusses the cost efficiency of nutrient reduction in wetlands related to that in a sewage plant (Dellien 1997). The results from the follow up studies of birds, plants and macroinvertebrates in the wetlands are being prepared for publication.

Work shops and seminars

Results and experiences from the project have been presented at a work shop in Flyinge (Swedish nature conservation organisation, September 1996), a meeting in Helsingør, Denmark (”Öresunds kommittén”, Mars 1997), and at a wetland workshop in Kalmar, SE Sweden (Mars 1997). The project was represented at research seminars in Hässleholm (Nov 1997) and Stensoffa Ecological field station (Dec 1997).

During a seminar in Lund in March 1998 nine Life projects from the three Nordic member states met to discuss results, problems and applicability of their findings in a wider perspective. All projects are involved with the management of agricultural runoff water and have a lot in common. One aim of the seminar was to discuss a new approach of the dissemination task.

During a congress organised by the Nordic Association of Agricultural Scientists (NJF) in Aas, Norway, June 1999, the experiences from the project was presented at a poster session. The poster was also used when the project was represented at the Life week in Brussels in October 1999.

During a national meeting at the Swedish EPA in October 1999, representatives from eight Swedish water protection programmes met. The projects were selected through an inventory study of almost 50 water protection programmes in Sweden. The collection of experiences from implementation projects is part of the Swedish preparations for the introduction of the European Water directive.

Guided tours

Guided tours with information about the project have been given to politicians among the municipalities involved, to local authorities and politicians from other regions of Sweden (e.gHallsberg Oct. 96, Götene Nov. 96, Nynäshamn Feb. 97, Munkedal and Sollentuna Jun. 97), for student groups (e.g. Kalmar University, Dec. 96, Nov 98, Swedish Agricultural University, Jan./ Feb. 97, 98 and 99 , Lund University, May 97 , Landbohøjskolen, Copenhagen, 1999 and exchange students within an EU-financed program, May 98) as well as for groups of farmers. Other Life projects have visited, e.g. representatives of Tandlaåprojektet (S96/ 339) (April 97). In connection to the Life seminar in Lund (March 98) one Swedish, three Danish and four Finnish Life projects were guided in the area. The water conservation organisation for the adjoining river system south of Höje river (Sege river) spent a day with representatives from Höje river project group in May 1997. In December 1999 the project was presented by a guided tour for people from the ministry of agriculture in the Netherlands visiting Lund. In October 1998 participants in a conference of bio-diversity and restoration of biotopes, in Lund, were guided in the watershed.

The World Wildlife Fund was informed about the project in connection with an application for money towards biological studies in the wetlands. Representatives from WWF were guided in the watershed in August 1999. The response was positive and during 2000 WWF will support a biological research programme in a number of the wetlands created.

Video

Three video films about the project are completed, one film about each river (Swedish) and one film about the joint Life project (English) – “*Wetlands in agricultural areas”*. The films present the background to the problem (landscape history, changes in agricultural practices and increased urbanisation) and the present eutrophication situation. Moreover the film introduces the viewer to the natural processes of nutrient reduction in wetlands and buffer-strips, positive forces used in the project to reduce the problems. The films are distributed by the local authorities and have been an appreciated element at information meetings with landowners, politicians and in schools. The films have been used by the Swedish environmental protection agency at information meetings about the Life fund. The English version of the video was also shown during the Life week in Brussels in October 1999 and was then distributed to many other LIFE-projects.

Posters

Posters have been produced both in Swedish and in English. The Swedish posters present each river project separately and have been used for presentation of the project in Sweden (see below). The English posters present two parts of the project *“Implementation of wetlands in agricultural areas – organisation and results”* and *“Benefits of constructed ponds in intensively used farmland areas in south of Sweden”.* The English posters have been used internationally (see above).

Internet

The project homepage on the Internet is regularly updated with results and information about the project. The basic information from our reports within the project is used. The page is linked to all municipalities involved and to related projects. The homepage address is *http://www.ekologgruppen.com/wetnet.htm*

Research linked to the project

An attitude study performed by a research group from Lunds University in co-operation with the Beijer Institute in Stockholm is linked to the project. A questionnaire has been sent to farmers and landowners in the Kävlinge river watershed and information/discussion meetings have been held. Results and evaluations of the study are referred to in this report. The costs connected with excavation of wetlands are studied within the research project Economic Analysis of Wetlands: Functions, Values and Dynamics (ECOWET), with funding from the EU/DGXII Environment and Climate Programme.

Within the Swedish environmental research program VASTRA (Vattenstrategiska forsknings programmet) a number of studies have shown interest in the result of this Life project. The studies range from practical - nutrient retention and function of different vegetation in wetlands, to theoretical – the role of different actors in water related environmental issues within a watershed.

International contacts

Apart from the dialogue with other Nordic countries a few international contacts have been taken. A group from an English school project visiting Lund had information about the project. During an environmental exchange project between one Swedish and one Estonian municipality the wetland project was introduced.

Other activities

In July / August 1997 the Höje part of the project was presented on a poster at the Swedish housing exhibition - BO 97 in Staffanstorp. In total the exhibition registered almost 100 000 visitors. The poster is now circulating among the involved local authorities and is used at libraries, schools and local administrations. A similar poster has been produced within the Kävlinge part of the project and is circulating among the nine municipalities involved in Kävlinge River.

In February 1998 and 1999 the project was presented on the academic course ” River restoration in Sweden and in Europe” at the Lund Institute of Technology.

6. TOTAL COSTS OF A LARGE SCALE PROJECT

In this chapter the total costs of the project, including those not covered by the Life budget, are presented. The aim of this chapter is to disseminate experiences of what the “real” costs of a project like this may be and to explain what the money have been used for. A cost summary of the Life budget only, is presented in chapter 7 and details may be found in the Financial report.

Costs above the Life budget

The total expenditure of the project involves costs not included in the Life budget, such as rent of land and compensation for losses of crop. The rent of land amounts to 1 950 000 SEK (wetlands 1 465 000 and bufferstrips 570 000) and compensation for loss of crop to 440 000 SEK. Moreover the project has spent 340 000 SEK on fish studies, 230 000 SEK on internal information and 200 000 SEK are reserved for future management of the wetlands. These costs are not included in the Life budget.

Main expenses

As the central task of the project is wetland construction, most of the money has been directed to that. The actual costs of a wetland include the working hours for construction (part of *External assistance*, tab 3) apart from the machinery costs (*Infrastructure*, tab 3). When adding these costs the construction of wetlands in this project totally amounts to almost 17 800 000 SEK. In addition to this the costs of planning and technical projecting of the wetlands 4 460 000 SEK (part of *External assistance* in tab 3), may be added to the cost of wetland construction.

Other major costs of the project include follow-up studies, information and administration. The costs of follow-up, considering nutrient retention and biological variation, amounts to about 1 100 000 SEK (included in *External assistance,* tab 3). Dissemination, including information meetings, brochures, reports and videos amounts to 850 000 SEK (*Dissemination* + part of *External assistance,* tab 3), and administration of the project, including costs for project meetings and financial service amounts to around 960 000 SEK (*Personnel, Travel* + part of *External assistance*, tab 3). The total amount of money spent on the project during 3,5 years is more than 28 000 000 SEK.

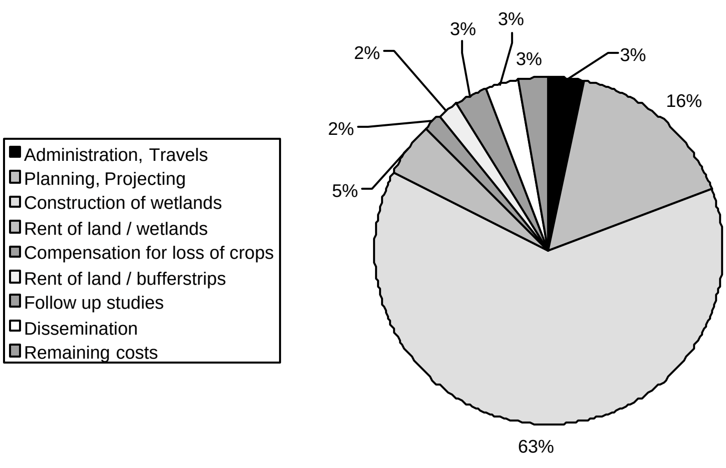


Figure 27. *Total costs divided into subjects on which the project has spent money.*

Financial support and subsidies

In addition to the money from the Life fund (795 175 ECU ≈ 6 642 000 SEK), the project has been supported by a regional environmental fund (Landstinget / Region Skånes miljövårdsfond, 1 420 000 SEK). Moreover, landowners that benefit financially from a pond/wetland (e.g. irrigation) pay part of the construction costs themselves (4 cases), in total 1 600 000 SEK.

The Swedish agro environmental support has been used when possible to compensate for part of the rent for land, especially concerning buffer strips. The rent of land is not included in the Life project and the grants to individual farmers have not changed the financial situation of the project, it has however decreased the municipality's expenses in total.

The costs of a single wetland

The total costs for constructing a wetland, calculated as an average during the project period, amounts to about 260 000 SEK/hectare. Tender prices have varied during the period and increased dramatically during the last year (fig 28).

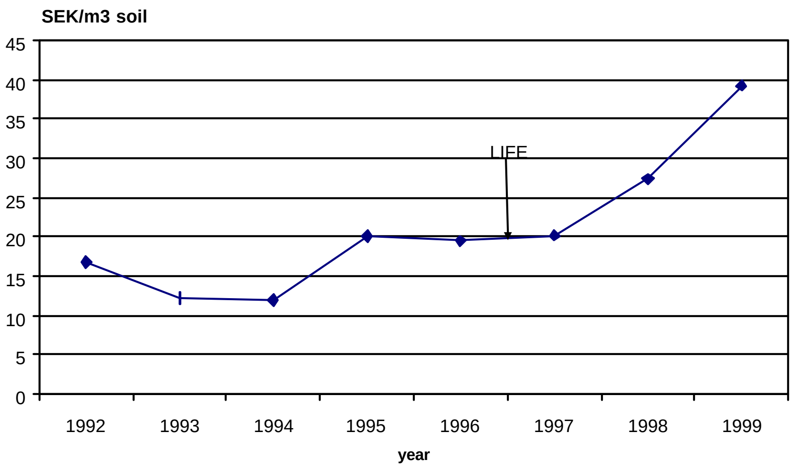


Figure 28. *Development of construction cost in SEK/cubic metre soil since 1992. Since 1996 the Life fund has supported the project.*

The costs per object (and hectare) differ greatly, not only because of the current price level but also depending on the construction efforts needed. The cheapest object constructed, per hectare (62 000 SEK/hectare) is a large shallow wetland in an area with good topographical conditions for wetland construction. This object was constructed 1997. The most expensive wetland is excavated in soft organic soil, the masses had to be transported, a concrete construction built, > 100 m piping laid and the drainage system restored. This object was constructed in September 1999 and the price per hectare amounts to 730 000 SEK.

The rent of land offered to the landowners (not included in the Life budget) varies between 10 000 and 55 000 SEK depending on the land-use and the soil quality. The contract between the landowner and the municipality (for wetlands) is valid throughout a period of thirty years. The rent of land for buffer-strips varies between 15 000 and 30 000 SEK / hectare depending on other subsidies available for the landowner (e.g agro environmental support). The contract for buffer-strips lasts for 10 years. Buffer-strips are only supported on cultivated land while wetlands may be located on areas with other forms of land-use.

Value for money

When considering value for money, all environmental benefits should be taken into account. It is difficult however to economically evaluate the increase in biological variation and the improved accessibility to water in the agricultural landscape. During the last decade, a discussion on cost-effective ways of reducing nitrogen transport (sewage treatment / agricultural efforts / wetlands) has taken place. Thus nutrient retention, especially that of nitrogen, may be evaluated.

The results from the follow-up studies indicate a mean reduction of 1 700 kg N/ hectare, yr. in the wetlands, but in the calculation of cost effectiveness we assume a reduction capacity of 1000 kg/hectare, yr. The reason is that many of the 65 constructed objects within the project receive a smaller load of nutrients than the mean study object. As the efficiency of nutrient retention is connected to the load of nutrients it may be expected that the mean nutrient retention among all 65 wetlands is less than that in the mean study wetland. Thus, we stick to the nutrient capacity of 1000 kg N/hectare, yr. predicted in the project plans. A calculated cost efficiency based on the construction costs presented above (including compensation for the land and crops to the landowners) indicate that the average costs of nitrogen retention in wetlands constructed within the project amounts to 24 SEK/ kg N (interest rate 6%, writing off period - 30 years), including planning, projecting, construction, rent of land and compensation for loss of crops. Similar evaluations (Söderquist, 1999) indicate a cost of 14–22 SEK /kg N (5-7 % interest rate, preferens of time 2-4%) writing off period 30-50 years) while Dellien (1997) concluded that costs of nitrogen retention in wetlands amounts to 35-45 SEK/kg N (12% interest rate, 30 years writing off period). Although the studies partly evaluate the same set of data (different time periods and number of objects) the results differ due to different assumptions and calculating methods, which is important to consider.

The Swedish agricultural board suggests, a combination of measures to reduce the nutrient leakage from arable land. The mean society costs to reduce nitrogen by construction of wetlands in agricultural areas of Sweden was estimated to 47 SEK/kg N (Jordbruksverket 2000)

It is interesting to compare the reduction costs in wetlands presented above with the cost of other measures reducing nitrogen. Darte (personal communication) states that the actual costs for improved nitrogen reduction in the sewage plant at Lunds kommun is 51 SEK/kg N (7.9 % interest rate, writing off period 12-30 year). Another promising measure, reducing nutrient leakage from arable land, is catch crops. The effect of the catch crops depends on soil quality, type of crop, crop rotation scheme and weather conditions. For use in a simulation model of nitrogen dynamics, catch crops were estimated to reduce standard leaching rates by 30% on an average for different soils and regions (Hoffman 1999). In the region of Höje and Kävlinge River the leakage from arable land is often around 30 kg/hectare. In fields were catch crops can be used successfully the reduction may thus be estimated to 9 kg N /hectare. If the costs for growing catch crops in spring crops are 500 SEK/hectare (900 – 1100 in autumn crops) (Hoffman 1999) the costs per kg N may be estimated to at least 56 SEK per kg nitrogen.

Although the comparisons of costs per kg nitrogen are approximate, the conclusion is that in addition to the environmental benefits of biological variation and increased recreational area, other major aims of the project, pond and wetland creation in agricultural areas give great value for money.

When considering value for money in total, it may be concluded that a large part of the investments in the project have been used for wetland and buffer-strip constructions (fig 27) and a smaller part of the money have been used for administration and planning. Thus, most of the money have been used for real improvements in the agricultural landscape, which also was the aim of the project.

Conclusions

- A major part of the project costs have been used for wetland construction.
- The real costs of construction of an average wetland object amounts to 260 000 SEK/hectare, in this project. Additional to that are costs of planning and projecting (68 000 SEK/object) and rent of land 24 000 SEK/hectare.

- In addition to the value of environmental benefits of biological variation and increased recreational area the cost effectiveness of nutrient retention supports the conclusion that wetland creation in agricultural areas gives great value for money.

7. LIFE – COST SUMMARY

A summary of the costs included in the Life budget only, is presented in table 3. The budget refer to a changed budget, applied for in December 1998 and accepted by the commission in February 1999 (no 18.02.99/XI/02169). Thus the budget presented in the table is the ”new” budget dated February 1999. The costs of the Life budget have been exceeded by almost 1 million SEK, which have been covered by an increase of the proposer contribution. The total contribution of the EC remains as stated in the original decision and is not changed due to the new budget nor to the expenditure deviations from that budget.

Table 3. *Expenditure statements of the Life project LIFE96ENV/S/346. The expenditure throughout the project period is presented both as total costs and as eligible costs.*

Cost category	Budget Total costs	Budget Eligible costs	Expenditure in SEK (total)	%	Expenditure in SEK (eligible)	%	ref
Personnel	1 544 000	1 544 000	**793 433**	**51**	793 433	51	*1
Travel	70 000	70 000	**89 549**	**128**	89 549	128	*2
External assistance	13 113 000	13 113 000	**14 047 872**	**107**	14 047 872	107	
Infrastructure	7 863 000	786 300	**8 697 722**	**111**	869 772	111	*3
Durable equipment	60 000	12 000	**57 789**	**96**	11 558	96	
Prototypes	500 000	500 000	**468 125**	**94**	468 125	94	
Consumable equipment	198 000	198 000	**202 017**	**102**	202 017	102	
Dissemination	620 000	620 000	**608 249**	**98**	608 249	98	
Other costs	0	0	**0**	**0**	0	0	
Total	**23 968 000**	**16 843 300**	**24 964 756**	**104**	**17 090 575**	**101**	***4**

Significant deviations from the budget exist along some of the budget lines. Deviations from the budget are referred to in the table and explained below. More detailed explanations may be found in the separate Financial report.

*1 The significant deviation of expenditure in personnel costs in comparison with the budget is to a great extent due to a miscalculation during the preparations of changes in the distribution of budget-lines 1998.

The budgeted costs of beneficiary personnel was aimed for management / administration. As a large part of management and administrative work has been purchased from the consultant, the surplus of budgeted money have been transferred to external assistance for fulfilment of those tasks.

*2 Deviations from the budgeted travel costs may in large be explained by two unexpected journeys (to Stockholm and Brussels) by the project managers.

*3 Infrastructure investments are greater than planned due to a larger increase in construction costs than expected (fig 28) and a deliberate increased investment in wetland construction, covered by the proposer.

*4 The total costs of the project has been exceeded. The extended costs have been covered by an increase of the proposer contribution. The total contribution of the EC remains as stated in the original decision and is not changed due to the new budget nor to the expenditure deviations from that budget.

More details about the costs under each budget line may be found in the separate Financial Report.

8. GENERAL CONCLUSIONS

Results and experiences

The experiences from this project may be used in other agricultural areas, especially those in Europe's coastal regions. A summary of conclusions important for implementation of similar projects is presented below.

Environmental benefits

Considerable environmental gain may be achieved by implementation of measures in the agricultural landscape through the methods and the organisation used in the project. The main results and experiences are:

- Nutrient retention and sedimentation of particles may be considerable in constructed wetlands.
- Biological diversity may increase significantly after construction of wetlands in the intensively used agricultural landscape. Colonisation of plants and animals is spontaneous and relatively fast in these "virgin waters"
- Increased accessibility to agricultural land for recreation.

Other experiences

Other experiences important for the re-use of the methods are:

- Regional co-operation within a watershed, with many municipalities involved, is an appropriate method to solve water related environmental issues.
- Voluntary participation of landowners vouches for an engagement in the project.
- The mean costs of construction of the measures established in this project are equal to or lower than other available measures with comparable environmental gain.
- Time consumption for implementation of measures is often underestimated. Each object constructed is preceded by a number of steps where all actors involved have to take many different interests into consideration.
- Environmentally less optimal and more expensive constructions may be the result if time limits for implementation of measures are too tight.
- Open and honest relations between actors are important for successful project implementation.
- Future management of wetlands may be an underestimated task. The responsibility of different actors (landowners-municipality) must be clarified in the contract in order to minimise future conflicts.
- A more rational and cost-effective fulfilment of measures is possible if construction may be directed to localities with the best physical conditions and expected environmental gain. Any geographical restrictions due to administrative borders or local interests within a watershed ought to be avoided.

Problems and difficulties

Although experiences from the project are generally good, some problems and difficulties have appeared throughout the fulfilment of the measures. As a project continues some difficulties may be more prominent than others:

- Unfavourable physical conditions such as topography, permeable soils, or a large difference between the water level in the streams and the surrounding ground level.
- Infrastructure elements like different cables, piping and roads.
- At existing levels of rent offered to the landowners, only a limited number are willing to join the project, that is, to transfer productive land into wetlands. Moreover, the land put aside to the

disposal of the project is restricted to the margin of fields or spots with a less agricultural value (which in some parts of the watershed are very few).

- Conflicting interests like legislated agricultural drainage and salmon fishing.

General views on large scale wetland implementation

To achieve significant and long-term effects on nutrient transport in the main streams, relatively large areas of land are required for measures like wetlands and buffer-strips as a complement to other efforts for nutrient reduction. To enable this a number of the above mentioned difficulties must be reduced. Except for the physical and geographical limitations difficulties may be reduced by a substantial increase in national or European financial support. Important facts for the basis of this support are:

- An awareness of the insufficient levels of support available within the Swedish agro-environmental program. This is especially clear when measures are to be established in the environmentally most optimal areas, that is, intensively used arable land.
- To be able to direct national environmental support to localities and constructions giving the most environmental gain, each measure ought to be followed by a number of criteria, which has to be fulfilled.
- Costs of construction presented in this report may be used as guidance for acceptable levels for wetland construction in intensively used agricultural areas.
- The rent of land offered must be adjusted to other support available, or the annual returns for normal use of land. Thus the rent of land ought to be adjusted to the price level in the region.

A number of conflicts can be avoided if the wetland interest is taken into consideration early in the local and regional planning process.

Legal instruments have to be adjusted to fulfil the requests from the new wetland interest, which among other things also claims land. Legal instruments are needed for:

- Environmentally more sound drainage routines. The nature conservation aspect ought to be taken into consideration when streams and ditches are kept for drainage reasons.
- Reasonable legal demands for wetland implementation in the agricultural landscape (where 90% of former wetlands have been drained). It is an open question if all wetlands ought to be tested in the court from a legal point of view. There is a need for more clear recommendations and criteria for legal demands on wetland constructions.
- A legal demand for bufferstrips along all open waters in order to promote permanent areas of importance for biological diversity and nutrient retention.

A basic and long-term economical support, national or regional may be a reasonable request which would facilitate implementation of wetlands in the environmentally most optimal way.

There is also a great need of more knowledge and thus research resources regarding how to optimize the design of wetlands for the best result concerning nutrient reduction and biodiversity.

The basic idea of this project is that wetlands and buffer-strips constitute a complement to other efforts to reduce nutrient loads on inland and coastal waters. The conclusions from this project support this idea. Although major environmental gain may be achieved by large scale construction of wetlands and buffer-strips in agricultural areas, the need of measures to reduce nutrient leakage from agricultural soils, point source outlets from sewage treatment as well as from aerial down-fall from the traffic, are still urgent.

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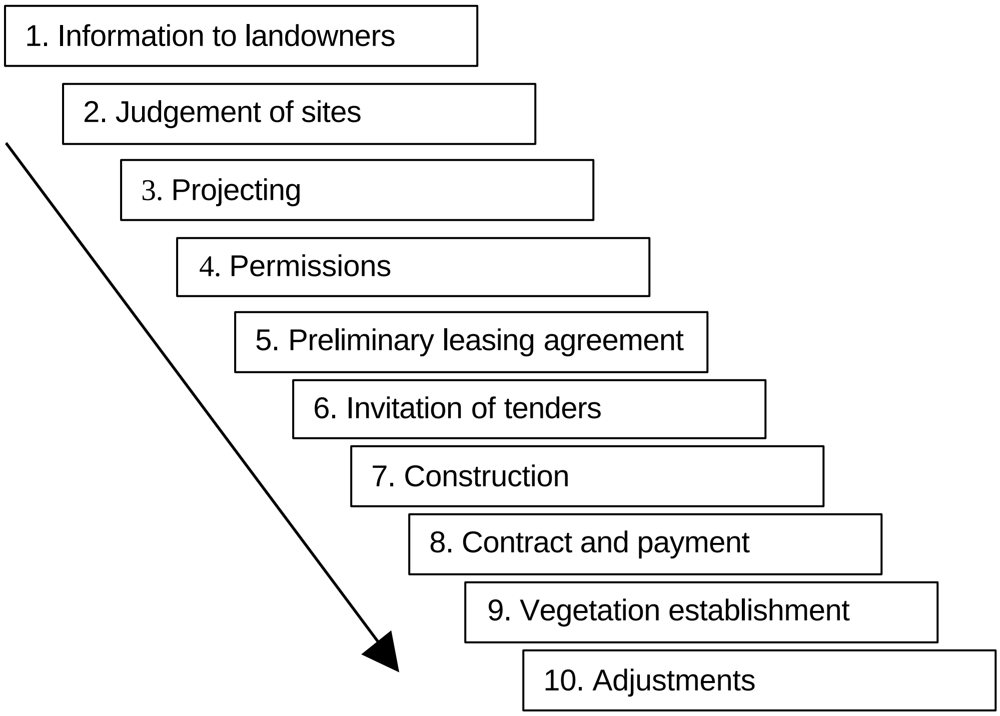
The process of wetland construction

The process from plan to pond/wetland may be illustrated as a series of steps described below.



The work process from plan to wetland.

1. Information to landowners
Landowners have been informed regularly about the project. Already during the period of project planning, many farmers were reached through their interest organisations. Moreover, information and invitations to join the project has been spread through folders and leaflets. In the Höje river part of the project two farmers are engaged as spokesmen for the project which has been very valuable especially during initiation of the project.

2. Judgement of sites
Landowners who register interest are visited and their objects judged. The sites are evaluated on basis of e.g. size and land use in the drainage basin and on topographic prerequisites. In addition, specially prioritised areas are visited and owners of land that is of particular strategic importance for the implementation are called upon. Localisation of measures is an ongoing process, not all sites are defined before the construction is started.

3. Projecting
Each suitable site is levelled and geologically surveyed. Depending on the conditions of the site each pond/wetland is designed with necessary technical details. The size and design of the wetland is discussed with the landowner.

4. Permissions
The regional authorities judge the construction with respect to potentially conflicting interests and Swedish environmental laws. Additional permissions might be needed from neighbours or different interest groups.

5. Preliminary leasing agreement
An agreement about design and localisation of the wetland as well as the rent of land and the responsibilities of the municipality, is written between the local municipality (in which the wetland is situated) and the landowner.

6. Invitation of tenders
Tenders from the region are invited for the construction work. The most favourable offer with regard to e.g. prize and quality is selected.

7. Construction
Each wetland is constructed in consultation with the consultant, who regularly visits the site and, in dialogue with the landowner, supervise the contractor to see that they fulfil their engagement. When the work is finished the wetland is examined by the consultant.

8. Contract and payment
The consultant prepares the final contract between the local municipality and the individual landowner. Landowners are compensated for the loss of lands (a cost which is not included in the Life budget). The duration of the contract is 30 years for pond/wetlands (10 years for buffer-strips). Within the area of contract, which cover the wetland and surroundings (>5m), the landowner is not allowed to use pesticides or fertiliser. Grazing animals or harvest of hay is however encouraged, in favour of the biological diversity in and around the wetland.

9. Vegetation establishment
Landowners are responsible for creating a vegetation cover but the project supplies them with seeds. Plants as well as planting, trees and bushes (only naturally occurring species), have been bought from a nursery. The design of the plantation is decided by the consultant in dialogue with the landowner.

10. Adjustments
Adjustments of created wetlands are an underestimated task, but is often needed 6-12 months after examination. The most common adjustments concern correction of drainage tiles, soil fillings or leaking outlet-constructions.

Ponds/wetlands constructed

Location/ real estate	Munici-pality	Pond type*	Landuse before constru-tion **	Time of con-struc-tion	Pond area (ha)	Total area (ha)	Costs for construc-tion (SEK) ***	Compen-sation for the land (SEK)	Excava-tion masses (m^3)	Costs per ha pond area (SEK/ha)
Höje river watershed:										
Björnstorp 1:1	Lund	P	A	sep-96	3,5	7	933 600	182 000	45 000	266 743
Genarp 8:9	Lund	P	O	sep-96	0,6	1	210 000	30 318	11 600	350 000
L:a Bjällerup 7:1	Staffanst	P	A	okt-96	1,1	1,5	334 000	33 020	17 000	303 636
Genarp 7:6 m fl	Lund	W	A	feb-97	1,2	2	192 000	84 000	13 000	160 000
Laxmans Åkarp 2:1	Lomma	P	A	jun-97	0,4	0,6	90 000	11 400	6 200	225 000
Äspet 1:26	Lund	P	A	apr-98	1,6	2,5	334 000	81 900	17 500	208 750
Vragerup 1:1	Staffanst	P	A	okt-98	0,5	0,6	216 000	21 760	5 200	432 000
Alberta 4:9	Staffanst	S	G	okt-98	0,2	0,4	87 000	6 600	3 000	435 000
Lunnarp 4:3	Lund	W	G	nov-98	0,3	6,6	103 000	13 350	2 600	343 333
Kyrkheddinge 20:1 m	Staffanst	P	O	jul-99	0,5	0,5	37500*	0	6 900	
Vesum 4:2	Staffanst	P	A	aug-99	1,4	1,9	351 000	33 300	11 000	250 714
St Råby 36:7	Lund	P	A	aug-99	1,5	2,0	481 600	90 000	15 000	321 067
Kannikemarken 1:1	Lomma	S	G	aug-99	6,1	5,9	1 077 080	147 500	10 500	176 570
Annehem	Lund	P	G	sep-99	1,1	1,1	562 200	0	13 000	511 091
Vallkärra 22:4	Lund	S	A	sep-99	0,6	0,6	309 000	24 000	5 700	515 000
Fjelie 54:1	Lomma	S	A	okt-99	0,7	0,9	316 393	27 000	8 000	451 990
Höjebromölla 1:1	Staffanst	P	A	okt-99	0,7	1,0	510 800	24 500	15 000	729 714
Kyrkheddinge 5:1	Staffanst	W	A	okt-99	0,5	0,6	196 128	25 600	6 900	392 256
Kävlinge river watershed:										
Ellinge 34:1 m fl	Eslöv	S	A	nov-96	1	1,26	223 000	17 850	14 800	223 000
Böstofta 19:3	Höör	S	G	nov-96	0,9	0,95	172 000	9 500	8 000	191 111
Skarhult 2:3 m fl	Eslöv	P	A	apr-97	1,1	1,5	237 300	0	10 600	215 727
Kristinetorps gård	Eslöv	W	A	maj-97	5	5,5	848 000	0	54 000	169 600
Skarhult 13:10	Eslöv	S	G	maj-97	5,3	5,5	330 000	0	12 500	62 264
Flyinge	Lund	S	O	maj-97	1,5	1,5	375 700	0	14 700	250 467
Flyinge	Lund	S	O	maj-97	1	1	115 000	0	4 500	115 000
Flyinge	Lund	S	O	maj-97	1,6	1,6	382 100	0	14 950	238 813
Knutstorp 1:1	Lund	S	A	maj-97	1,1	1,1	328 000	0	11 100	298 182
Hjärås 5:3	Hörby	S	G	jul-97	0,8	1,42	216 000	24 250	10 000	270 000
Trulstorp 17:8	Eslöv	P	O	aug-97	0,6	0,8	145 000	0	6 100	241 667
Hoby 3:2	Lund	W	A	sep-97	0,5	0,7	155 000	8 110	6 700	310 000
Slogstorp 17:8	Eslöv	W	O	okt-97	0,8	0,9	254 000	0	9 200	317 500
Åkarp 4:3	Hörby	S	A	okt-97	0,8	1,3	263 000	30 450	11 300	328 750
Västerstad 29:65	Hörby	S	O	okt-97	0,7	1	175 000	10 000	10 900	250 000
Snogarp 2:1	Ystad	W	A	okt-97	0,6	0,75	128 000	11 850	10 700	213 333
Böstofta 19:3	Höör	P	A	dec-97	0,5	0,62	68 000	14 800	2 600	136 000
Jordboen 1:1	Höör	S	A	dec-97	1	1,57	165 000	42 800	7 000	165 000
Rolsberga 10:7	Höör	W	A	jan-98	0,9	13,5	127 000	42 000	8 100	141 111
Gummastorp 10:61	Hörby	P	A	apr-98	0,5	0,8	159 000	0	6 600	318 000
Stora Harrie	Kävlinge	P	X	maj-98	1,3	1,3	391 000	0	15 200	300 769
Boaröd 15:1	Tomelilla	S	O	maj-98	0,35	0,48	85 000	7 200	3 500	242 857
Bösamöllan 1:1	Lund	W	O	jul-98	1	1,6	305 000	16 000	10 800	305 000
Nöbbelöv 8:2	Eslöv	S	O	sep-98	0,8	0,8	202 000	0	7 500	252 500
Arendala 4:3	Lund	P	O	jan-99	0,9	1	337 000	10 500	12 000	374 444
Igelösa 9:1,12:1	Lund	W	A	feb-99	1,6	2,4	764 840	95 200	22 000	478 025
Bjärröd 6:4	Sjöbo	S	A	mar-99	0,6	1	225 000	17 500	10 500	375 000
Västerstad 19:29	Hörby	S	A	apr-99	0,5	0,9	207 300	31 550	6 500	414 600
Äsperöd 72:1	Tomelilla	P	A	maj-99	0,85	1,1	302 840	39 900	11 400	356 282
Gårdstånga 3:9,1:1	Eslöv	W	A/G	jun-99	0,9	1	225 000	8 550	6 600	250 000
Gårdstånga 3:9,1:1	Eslöv	S	O	jun-99	0,9	0,9	59 920	0	400	66 578

Location/ real estate	Munici-pality	Pond type*	Landuse before constru-tion **	Time of con-struc-tion	Pond area (ha)	Total area (ha)	Costs for construc-tion (SEK) ***	Compen-sation for the land (SEK)	Excava-tion masses (m^3)	Costs per ha pond area (SEK/ha)
Västerstad 4:61	Hörby	S	A	jul-99	0,4	0,6	159 000	21 000	6 600	397 500
Hjärås 1:10	Hörby	S	G	jul-99	1,3	2	574 810	50 000	17 600	442 162
Rolsberga 23:1	Höör	P	A	aug-99	0,56	0,5	323 500	0	9 300	577 679
Pugerup 1:16	Höör	P	A	aug-99	1,6	1,6	620 000	0		387 500
Borgeby 1:1	Lomma	P	O	aug-99	1,1	1,5	215 000	27 000	6 500	195 455
Grimstofta 8:42	Sjöbo	S	G	aug-99	2	2,5	669 300	0	18 100	334 650
Åsum 22:1	Sjöbo	S	G	aug-99	1,2	1,2	263 000	25 200	5 400	219 167
Vanstad 18:50	Sjöbo	S	O	aug-99	0,3	0,3	50 000	0		166 667
Hammarlunda 2:1	Eslöv	W	A	sep-99	1,2	1,95	464 000	68 250	9 600	386 667
Holmby 7:4	Eslöv	S	A	sep-99	1,3	2,1	345 000	54 780	11 500	265 385
Lackalänga 7:21m fl	Kävlinge	S	O	sep-99	1	1	409 000	0	10 000	409 000
Vollsjö 31:178	Sjöbo	W	O	sep-99	0,8	0,8	277 000	0	5 400	346 250
Stävie 2:1	Kävlinge	S	X	okt-99	1	1	126 500	0	0	126 500
Frörum 1:1	Tomelilla	P	O	okt-99	0,6	0,6	148 450	0		247 417
Vallarum 13:4...	Sjöbo	W	G	okt-99	0,4	0,4	55 000	4 500	2 300	137 500
Södra Åsum 17:12	Sjöbo	P	A	okt-99	0,5	0,6	110 000	30 000	5 400	220 000
Sum/mean:					74	111	19 084 361	1 464 988	661 550	259 087

***- Pond type**

W=Stream widening pond

S=Side pond

P=Pond in piped system

**** - Landuse before construction**

(further explanations are found in chapter 3)

A=Arable land

G=Grazing land

O=Open grassland(not cultivated)

X=Other type of landuse

***** - Costs for construction**

The total cost for construction. The construction costs for the project are less than the sum in the table because other finaciers have paid parts of the cost (e.g. landowners have paid parts of the construction costs for irrigation ponds)

Buffer-strips constructed

Location/ Real estate	**Stream/river**	**Municipality**	**Buffer strip area (m^2)**	**Compensation for the land (SEK)**
Höje river watershed:				
Genarp 8:3	Höje å	Lund	990	1 485
Genarp 7:6	Ellebäck+Höje å	Lund	6 700	10 200
Kronedal	Dalbydiket	Lund	7 308	10 962
Äspet 1:25	Höje å	Lund	648	1 944
Nöbbelöv 21:1	Önnerupsb.	Lund	4 092	6 138
Lunnarp 2:7	Källingab./ Dalbyd.	Lund	14 640	21 960
Vallkärratorn 4:1	Vallkärrabäcken	Lund	7 158	10 737
Nöbbelöv 11:1	Önnerupsbäcken	Lund	3 420	5 130
Lunnarp 4:3	Källingab.Dalbydiket	Lund	810	1 215
Vallkärra 20:1	Vallkärrabäcken	Lund	2 940	4 410
Kornheddinge 7:1	Kornheddinge mosse	Staffanstorp	2 448	3 672
Alberta 2:26	Höje å	Staffanstorp	6 996	17 900
Vesum 3:1	Höje å	Staffanstorp	5 856	8 784
L:a Bjällerup 8:1	Råbydiket	Staffanstorp	10 308	15 462
L:a Bjällerup 11:3	Råbydiket	Staffanstorp	8 376	14 328
L:a Bjällerup	Råbydiket	Staffanstorp	5 580	8 370
Kyrkheddinge 4:2	Åkärrsdiket	Staffanstorp	3 300	4 950
Örup 7:9	Höje å	Staffanstorp	4 716	7 074
Örup 5:1	Höje å	Staffanstorp	6 174	10 314
Alberta 1:16	Höje å	Staffanstorp	4 812	7 830
Örup 7:9	Höje å	Staffanstorp	4 812	3 582
St Bjällerup 12:1, 16:1-2	Råbydiket	Staffanstorp	6 552	9 828
Stävie 1:34	Önnerupsb.	Lomma	2 880	4 320
Fjelie 54:1 m fl	Önnerupsb.	Lomma	7 824	11 736
Borgeby 37:2, 29:1	Önnerupsb.	Lomma	6 000	9 000
Fjelie 7:26	Önnerupsb.	Lomma	6 240	9 360
Fjelie 34	Önnerupsb.	Lomma	3 192	4 788
Fjelie24:1	Önnerupsb.	Lomma	10 380	15 570
Flädie 7:10, 7:2	Önnerupsb.	Lomma	7 110	10 665
Fjelie 42:1	Önnerupsb.	Lomma	3 930	5 895
Fjelie 5:21	Önnerupsb.	Lomma	1 884	2 826
Önnerup 3:27	Önnerupsb.	Lomma	5 700	9 303
Önnerup 9:3, 9:4, 9:5	Önnerupsb.	Lomma	14 262	21 843
Borgeby 19:2	Önnerupsb.	Lomma	2 298	3 447
Fjelie 5:12	Önnerupsb.	Lomma	14 724	22 086
Fjelie 5:20, 5:9	Önnerupsb.	Lomma	1 590	2 385
Fjelie 42:1	Önnerupsb.	Lomma	1 848	2 772
Fjelie 15:1	Önnerupsb.	Lomma	7 044	10 566

Location/ Real estate	Stream/river	Municipality	Buffer strip area (m^2)	Compensation for the land (SEK)
Kävlinge river watershed:				
Sandby 54:1	Sularpsbäcken	Lund	8300	13 200
Flyinge 4:15	biflöde, Sularpsbäcken	Lund	7 320	10 980
Flyinge 4:13	biflöde, Sularpsbäcken	Lund	1 800	5 400
Flyinge 25:1	Sularpsbäcken	Lund	4 110	12 330
Flyinge 6:7	Sularpsbäcken	Lund	6 070	9 705
Sularp 2:1, Sularpsbäcken	Sularpsbäcken	Lund	9 384	14 076
Arendala 4:1	Sularpsbäcken	Lund	5 364	8 046
Kristinetorp 1:2	biflöde, Kävlingeån	Eslöv	13 140	21 780
Holmby 27:1	biflöde, Kävlingeån	Eslöv	14 420	24 360
Holmby 4:1, 7:4	biflöde, Kävlingeån	Eslöv	5 670	8 505
Hammarlunda 4:1, 8:1	biflöde, Kävlingeån	Eslöv	9 600	14 400
Hunneberga 4:27	biflöde, Kävlingeån	Eslöv	5 660	9 510
Hammarlunda 2:1	biflöde, Kävlingeån	Eslöv	4 716	7 074
Hammarlunda 1:24	biflöde, Kävlingeån	Eslöv	1 320	3 960
Västerstad 29:65	Sniberupsån	Hörby	1 668	5 004
Sallerup 9:12	biflöde, Sniberupsån	Hörby	1456	4368
Omsed 1:13, Tullsåkra 1:1	biflöde, Sniberupsån	Hörby	5400	8100
Hjärås 1:10	Sniberupsån	Hörby	3 240	9 720
Vollsjö 31:410	biflöde, Vollsjöån	Sjöbo	6 510	9 765
Vollsjö 60:5	biflöde, Vollsjöån	Sjöbo	10 110	15 165
Vollsjö 31:26	biflöde, Vollsjöån	Sjöbo	7 170	10 755
Vollsjö 31:178	biflöde, Vollsjöån	Sjöbo	8 352	12 528
			140780	571 568

Birds

Number of breeding birds (pairs) and number of non-breeding birds of different species observed in 42 investigated wetlands in Höje å and Kävlingeå watershed during 1994-1998. The inventories are performed by Martin Granbom.

= species associated with pond/wetland habitats

English name (latin name)	Number of breeding pairs	Number of birds not breeding
red necked grebe (Podiceps grisegena)	1	2
heron (Ardea cinerea)	0	13
white storch (Ciconia ciconia)	0	2
whooper swan (Cygnus cygnus)	0	3
mute swan (Cygnus olor)	13	15
grey lag goose (Anser anser)	1	1
shelduck (Tadorna tadorna)	41	32
mallard (Anas platyrhynchos)	79	49
teal (Anas crecca)	3,5	4
shoveler (Anas clypeata)	3	3
tufted duck (Aythya fuligula)	41,5	23
pochard (Aythya ferina)	4	3
goldeneye (Bucephala clangula)	28	18
kite (Milvus milvus)	0	1
march harrier (Circus aeruginosus)	2	4
pheasant (Phasianus colchicus)	0	3
moorhen (Gallinula chloropus)	1	1
coot (Fulica atra)	32,5	22
oystercatcher (Haematopus ostralegus)	29	33
lapwing (Vanellus vanellus)	78	41
ringed plover (Caradrius hiaticula)	3	4
little ringed plover (Charadrius dubius)	36	30
temmincks stint (Calidris temminickii)	0	1
green sandpiper (Tringa ochropus)	0	26
redshank (Tringa totanus)	7	9
common sandpiper (Actitis hypoleucos)	0	2
curlew (Numenius arquata)	1	2
blackheaded gull (Larus ridibundus)	16	43
herring gull (Larus argentatus)	0	1
common gull (Larus canus)	0	6
common tern (Sterna hirundo)	2	5
wood pigeon (Columba palumbus)	0	4
stock dove (Columba oenas)	0	1
collared turtle dove (Streptopelia decaocto)	1	1
swift (Apus apus)	0	21
swallow (Hirundo rustica)	0	45
sandmartin (Riparia riparia)	0	9
housemartin (Delichon urbica)	0	26
meadow pipit (Anthus pratensis)	2	2
white wagtail (Motacilla alba)	1	49
yellow wagtail (Motacilla flava)	26,5	23
starling (Sturnus vulgaris)	1	4
sedge warbler (Acrocephalus schoenobaenus)	1	1
march warbler (Acrocephalus palustris)	20,5	15
reed warbler (Acrocephalus scirpaceus)	3,5	3
lesser whitethroat (Sylvia curruca)	0	1
whitethroat (Sylvia communis)	1	2
wheatear (Oenanthe oenanthe)	0	2
whinchat (Saxicola rubetra)	1	1
trush nigthingale (Luscinia luscinia)	1	1
redstart (Phoenicurus ochruros)	0	1
tree sparrow (Passer montanus)	1	7
grey sparrow (Passer domesticus)	1	3
linnet (Achantis cannabina)	6	21
reed bunting (Emberiza schoeniclus)	18	17

Benthic macroinvertebrates

Results from handnet samplings in constructed ponds/wetlands, situated in the watersheds of Höjeå and Kävlingeån, in the south of Sweden. Sampling period: September-October 1998. Method: SS028191. Four samples per pond were taken (an area of approximately 1 m^2). In addition one qualitative sample, in table marked with X, was taken.

Det. Cecilia Torle and Jan Pröjts, Ekologgruppen.

Taxa	Number of ponds (n=26)	Total number of individuals
Turbellaria		
Dugesia sp.	1	1
Planaria-Dugesia	4	26
Planaria torva	1	1
Polycelis sp.	9	336
Dendrocoelum lacteum	3	10
Nematoda		
Nematoda	2	2
Gastropoda		
Bithynia leachii	2	2
Bithynia tentaculata	6	103
Bithynia sp.	1	1
Valvata piscinalis	1	4
Acroloxus lacustris	1	X
Lymnaea stagnalis	11	777
Stagnicola palustris	1	8
Stagnicola sp.	1	1
Galba truncatula	3	23
Radix auricularia	2	2
Radix ovata	1	81
Radix ovata/peregra	25	10974
Radix sp.	2	2
Planorbidae	3	113
Planorbis carinatus	1	3
Planorbis planorbis	5	41
Planorbis sp.	1	1
Anisus vortex	6	49
Anisus sp.	1	2
Bathyomphalus contortus	5	819
Gyraulus albus	10	1151
Gyraulus crista	9	83
Gyraulus sp.	3	8
Hippeutis complanatus	2	14
Planorbarius corneus	3	44
Physa fontinalis	12	3124
Physella acuta	1	66
Bivalvia		
Sphaeriidae	3	421
Sphaerium sp.	7	118
Pisidium sp.	7	186
Oligochaeta		
Oligochaeta obest	25	6083
Eiseniella tetraedra	1	1
Stylaria lacustris	6	1233
Hirudinea		
Piscicola geometra	3	X
Glossiphoniidae	1	2
Theromyzon tessulatum	21	193
Hemiclepsis marginata	1	2
Glossiphonia complanata	7	39
Glossiphonia heteroclita	3	7
Glossiphonia sp.	3	6
Boreobdella verrucata	1	1
Helobdella stagnalis	11	57
Erpobdellidae	1	6
Erpobdella octoculata	19	486
Erpobdella testacea	3	33
Erpobdella sp.	10	89
Crustacea		
Trichoniscus sp?	1	2
Asellus aquaticus	23	13556
Gammarus lacustris	2	112
Gammarus pulex	21	2171
Gammarus sp.	2	6
Ostracoda	16	424
Arachnida		
Argyroneta aquatica	4	5
Hydracarina	16	304
Collembola		
Collembola	14	160

Taxa	Number of ponds (n=26)	Total number of individuals
Ephemeroptera		
Baetidae	1	1
Baetis macani	1	1
Baetis macani/vernus	2	8
Baetis sp.	2	92
Centroptilum luteolum	2	7
Cloeon dipterum	25	4021
Cloeon praetextum/simile	1	X
Cloeon sp.	23	16212
Leptophlebia sp.	1	1
Caenis horaria	13	169
Caenis luctuosa	2	7
Caenis robusta	6	136
Odonta		
Zygoptera	1	1
Platycnemis pennipes	2	2
Coenagrionidae	21	330
Erythromma najas	1	1
Coenagrion hastulatum	7	32
Coenagrion	1	11
Coenagrion pulchellum/puella	5	19
Coenagrion sp.	13	135
Enallagma cyathigerum	1	1
Ischnura elegans	7	78
Aeshna cyanea	1	1
Aeshna grandis	3	6
Aeshna sp.	1	3
Coleoptera		
Gyrinus aeratus	1	1
Gyrinus marinus	5	3
Gyrinus sp.	2	2
Orectochilus villosus	2	6
Haliplidae	1	1
Brychius elevatus	1	X
Haliplus confinis	1	1
Haliplus fluviatilis	3	3
Haliplus fulvus	1	2
Haliplus immaculatus	14	143
Haliplus laminatus	8	3
Haliplus lineatocollis	3	3
Haliplus ruficollis	9	22
Haliplus ruficollis?	1	1
Haliplus sp.	13	337
Haliplus sp. (annan)	1	1
Noterus clavicornis	3	3
Dytiscidae	2	2
Acilius canaliculatus	1	X
Acilius sulcatus	1	1
Hydroporinae	4	4
Hydroglyphus pusillus	1	X
Hygrotus confluens	3	24
Hygrotus inaequalis	1	X
Hygrotus nigrolineatus	3	18
Hygrotus parallelogrammus	1	2
Hygrotus versicolor	2	2
Hygrotus sp.	1	1
Hyphydrus ovatus	5	19
Hydroporus obsoletus	1	1
Hydroporus palustris	2	2
Hydroporus planus	1	X
Porhydrus lineatus	3	1
Scarodytes halensis	5	5
Nebrioporus canaliculatus	1	1
Nebrioporus depressus	7	481
Nebrioporus sp.	2	8
Colymbetinae	19	34
Platambus maculatus	4	8
Ilybius fenestratus	6	32
Ilybius fuliginosus	9	40
Ilybius quadriguttatus	1	2
Ilybius sp.	8	42

Taxa	Number of ponds (n=26)	Total number of individuals
Agabus bipustulatus	2	3
Agabus chalconatus	1	1
Agabus nebulosus	3	4
Agabus sturmii	1	1
Agabus sp.	2	6
Rhantus exsoletus	1	3
Rhantus frontalis	1	1
Rhantus sp.	1	2
Laccophilus minutus	7	15
Dytiscus dimidiatus	1	X
övriga Dytiscidae	1	1
Elmis aenea	4	4
Limnius volckmari	2	4
Scirtidae	1	X
Elodes sp.	2	2
Scirtes sp.	3	17
Donacia sp.	1	1
Hydraena sp.	1	1
Helophorus sp.	1	X
Hydrophilidae	3	2
Anacaena lutescens	1	1
Laccobius minutus	7	32
Laccobius sinuatus	1	X
Enochrus melanocephalus	2	8
Enochrus sp.	1	1
Hydrobius fuscipes	1	1
Hemiptera		
Hemiptera obest	1	1
Mesovelia furcata	2	2
Gerridae	4	3
Gerris argentatus?	1	1
Gerris lacustris	3	X
Gerris odontogaster	1	X
Gerris thoracicus	1	1
Nepa cinerea	5	1
Ranatra linearis	1	X
Plea leachi	9	70
Notonecta glauca	19	48
Notonecta sp.	2	2
Ilyocoris cimicoides	5	3
Corixidae	1	3
Corixinae	18	1195
Glaenocorisa propinqua	1	1
Arctocorisa germari	7	116
Callicorixa praeusta	15	153
Callicorixa sp.	3	8
Corixa dentipes	5	6
Corixa panzeri	16	82
Corixa punctata	19	55
Corixa sp.	4	10
Hesperocorixa linnaei	2	1
Hesperocorixa sahlbergi	4	2
Paracorixa concinna	12	277
Sigara distincta	16	63
Sigara falleni	20	344
Sigara fossarum	10	16
Sigara iactans	8	109
Sigara lateralis	9	76
Sigara limitata	3	4
Sigara longipalis	7	15
Sigara stagnalis	1	1
Sigara striata	22	544
Sigara sp.	18	973
Sigara sp. (annan)	1	X
Megaloptera		
Sialis lutaria	2	3
Sialis lutaria -grupp	2	10
Sialis sp.	1	X
Lepidoptera		
Lepidoptera obest	8	6
Cataclysta lemnata	5	43
Parapoynx stratiotata?	2	46
Nymphula stagnata?	1	X
Lepidoptera (annan)	2	2

Taxa	Number of ponds (n=26)	Total number of individuals
Trichoptera		
Trichoptera obest	1	X
Agraylea sexmaculata?	1	9
Agraylea sp.	3	17
Polycentropodidae	1	1
Holocentropus dubius	1	1
Holocentropus picicornis	5	73
Phryganea bipunctata	4	2
Phryganea sp.	1	1
Limnephilidae	11	53
Limnephilus rhombicus?	5	20
Limnephilus sp.	9	8
Molanna angustata	1	1
Leptoceridae	2	2
Athripsodes aterrimus	2	8
Athripsodes cinereus	1	X
Athripsodes sp.	1	1
Mystacides longicornis	2	4
Mystacides longicornis/nigra	1	1
Mystacides sp.	2	2
Oecetis ochracea	7	244
Triaenodes sp.	3	5
Diptera		
Tipulidae	1	1
Tipula sp.	13	30
Limoniidae	2	2
Ormosia sp.	1	1
Helius sp.	1	X
Pericomini	3	6
Dixidae	3	4
Dixella sp.	1	X
Chaoborus crystallinus	1	1
Chaoborus crystallinus?	1	1
Chaoborus flavicans	2	5
Chaoborus obscuripes	7	1260
Chaoborus sp.	1	X
Culicidae	1	2
Culex sp.	1	3
Simuliidae	4	2
Ceratopogonidae	17	136
Chironomidae	25	18028
Chironomus sp.	5	256
Tabanidae	3	4
Stratiomyidae	1	1
Oplodonta sp.	1	X
Oxycera sp.	1	5
Dolichopodidae	1	1
Syrphidae	1	1
Sciomyzidae	2	2
Ephydridae	1	1
Övriga Brachycera	3	6

Annex 6

Vegetation

Results from the inventory of vegetation in and arround constructed ponds/wetlands, situated in the watersheds of Höjeå and Kävlingeån, in the south of Sweden. Inventory period: September 1999. Det. David Reuterskiöld, Ekologgruppen.

Latin names	Plant-category*	Number of ponds (n=26)
Achillea ptarmica	o	2
Acorus calamus	w	1
Aegopodium podagraria	o	2
Agrostis capillaris	o	1
Agrostis gigantea	o	1
Agrostis sp.	o	2
Agrostis stolonifera	w	7
Alisma plantago-aquatica	w	23
Alnus glutinosa	p	3
Alnus glutinosa	w	7
Alopecurus geniculatus	w	13
Alopecurus pratensis	o	5
Angelica sylvestris	w	1
Apera spica-venti	r	3
Artemisia vulgaris	r	2
Atriplex prostrata	r	3
Barbarea vulgaris	r	5
Berula erecta	w	3
Betula pendula	o	1
Betula pubescens	w	1
Bidens cernua	w	6
Bidens tripartita	w	15
Bolboschoenus maritimus	w	3
Bromus inermis	o	2
Butomus umbellatus	w	3
Callitriche cophocarpa	w	3
Callitriche platycarpa	w	8
Callitriche sp.	w	1
Caltha palustris	w	4
Calystegia sepium	w	5
Cardamine amara	w	2
Cardamine pratensis	w	5
Carex acuta	w	6
Carex disticha	w	2
Carex flacca	w	1
Carex hirta	o	4
Carex pseudocyperus	w	2
Carex sp (nigra?)	w	1
Carex sp. (acuta?)	w	1
Carex sp. (disticha?)	w	1
Carex spicata	o	1
Cerastium fontanum	o	1
Ceratophyllum demersum	w	3
Ceratophyllum submersum	w	5
Chamomilla suaveolens	r	2
Charales sp.	w	4
Chenopodium polyspermum	r	1
Chenopodium rubrum	r	1
Chlorophyceae sp.	w	17
Cicuta virosa	w	2
Cirsium arvense	r	3
Cirsium oleraceum	w	5
Deschampsia cespitosa	w	8
Eleocharis acicularis	w	1
Eleocharis palustris	w	9
Eleocharis sp. (palustris?)	w	1
Elodea canadensis	w	8

Latin names	Plant-category*	Number of ponds (n=26)
Elytrigia repens	o	5
Enteromorpha sp.	w	7
Epilobium angustifolium	o	1
Epilobium hirsutum	w	23
Epilobium palustre	w	1
Epilobium roseum	r	8
Epilobium tetragonum	r	6
Equisetum arvense	r	8
Equisetum fluviatile	w	3
Equisetum palustre	w	2
Eupatorium cannabinum	w	2
Euphorbia exigua	r	1
Festuca arundinacea	o	1
Festuca pratensis	o	2
Festuca rubra	o	6
Filipendula ulmaria	w	14
Galeopsis bifida	r	2
Geum rivale	w	3
Glecoma hederacea	o	1
Glyceria declinata	w	3
Glyceria fluitans	w	9
Glyceria maxima	w	10
Glyceria notata	w	7
Glyceria sp.	w	1
Gnaphalium uliginosum	w	9
Holcus lanatus	o	1
Hydrocharis morsus-ranae	w	1
Hypericum tetrapterum	w	2
Impatiens glandulifera	w	1
Impatiens parviflora	o	1
Iris pseudacorus	w	1
Isolepis setacea	w	1
Juncus articulatus	w	24
Juncus bufonius	w	17
Juncus compressus	w	16
Juncus conglomeratus	w	4
Juncus effusus	w	17
Juncus inflexus	w	5
Lamium purpureum	r	1
Lathyrus pratensis	o	3
Lemna gibba	w	1
Lemna minor	w	23
Lemna triscula	w	1
Lolium perenne	o	6
Lychnis flos-cuculi	w	3
Lycopus europaeus	w	17
Lysimachia vulgaris	w	5
Lythrum salicaria	w	3
Matricaria perforata	r	14
Mentha aquatica	w	2
Mentha arvensis	w	4
Mentha sp.	w	1
Mentha x verticillata	w	6
Myosotis arvensis	r	1
Myosotis scorpioides	w	17
Myosoton aquaticum	w	1
Myriophyllum spicatum	w	2

Annex 6

Latin names	Plant-category*	Number of ponds (n=26)
Nymphaea alba	p	1
Odontites vernalis	r	1
Persicaria amphibia	w	18
Persicaria hydropiper	r	2
Persicaria lapathifolia	r	7
Persicaria maculosa	r	7
Phalaris arundinacea	w	22
Phleum pratense	o	14
Phragmites australis	w	10
Plantago lanceolata	o	1
Plantago major	r	6
Poa annua	r	11
Poa compressa	o	1
Poa palustris	w	14
Poa trivialis	w	21
Polygonum aviculare coll.	r	3
Populus sp.	o	1
Potamogeton berchtoldii	w	11
Potamogeton crispus	w	12
Potamogeton friesii	w	1
Potamogeton lucens	w	1
Potamogeton natans	w	17
Potamogeton pectinatus	w	5
Potamogeton sp.	w	1
Potentilla anserina	w	10
Potentilla thuringiaca	r	1
Prunella vulgaris	w	1
Ranunculus acris	o	2
Ranunculus aquatilis	w	1
Ranunculus flammula	w	2
Ranunculus peltatus	w	1
Ranunculus repens	w	24
Ranunculus sceleratus	w	16
Ranunculus sp.	w	5
Roegneria canina	o	1
Rorippa amphibia	w	5
Rorippa palustris	w	11
Rumex acetosa	o	1
Rumex crispus	r	10
Rumex hydrolapathum	w	1
Rumex obtusifolius	r	11
Rumex palustris	w	4
Sagina procumbens	r	1
Salix alba	w	12
Salix caprea	p	3
Salix caprea	w	4
Salix cinerea	p	8
Salix cinerea	w	4
Salix fragilis	w	1
Salix pentandra	p	1
Salix pentandra	w	1
Salix purpurea	p	1
Salix purpurea ´nana´	p	1
Salix viminalis	w	15
Salix viminalis	p	2
Sambucus nigra	o	1
Schoenoplectus lacustris	w	13
Scirpus sylvaticus	w	4
Scutellaria galericulata	w	1
Sinapis arvensis	r	1

Latin names	Plant-category*	Number of ponds (n=26)
Sium latifolium	w	9
Solanum dulcamara	w	8
Sonchus arvensis	r	2
Sonchus asper	r	3
Sparganium emersum	w	3
Sparganium erectum	w	16
Sparganium sp.	w	1
Spirodela polyrhiza	w	9
Stachys arvensis	r	1
Stachys palustris	w	8
Stellaria alsine	w	1
Succisa pratensis	o	1
Taraxacum sekt. Ruderalia	o	1
Trifolium fragiferum	w	2
Trifolium hybridum	o	1
Trifolium repens	o	9
Tussilago farfara	r	14
Typha latifolia	w	19
Typha sp. (latifolia?)	w	1
Urtica dioica	o	5
Valeriana dioica	w	1
Valeriana sp.	w	1
Veronica anagallis-aquatica	w	15
Veronica arvensis	r	1
Veronica beccabunga	w	19
Veronica catenata	w	5
Veronica persica	r	1
Vicia cracca	o	3
Zannichellia palustris ssp. pal.	w	1

<u>* - plant categories</u>
w= wetland plants
o= not typical wetland plants
p= planted plants
r= ruderal plants