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Valuable wetlands but difficult to manage


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Foreword

This is the final report from the project *Alkaline fens – valuable wetlands but difficult to manage*. The one-year project comprised two meetings in 2015, attended by nature conservation officers and experts on alkaline fens from Denmark, Estonia, Finland, Iceland, Norway and Sweden. The first meeting was held in Sweden (Mjölby, Östergötland) and the second in Finland (Kemi-Tornio). Both meetings included field visits to alkaline fen sites.

Alkaline fens are very important hotspots for biodiversity, providing a home to many endangered species. Drainage, intensive agriculture, lapsed active management, eutrophication, and acidification are some of the factors that have led to a reduction in the distribution and area of alkaline fens in Europe. In southern Sweden and in many other areas in the Nordic countries, the remaining alkaline fens are mere fragments of their former extent. Restoration is often laborious, and must be followed by continuous management, so it can be expensive. Restoration projects in Sweden in recent years show a need to find more appropriate ways to restore and manage alkaline fens.

Alkaline fens really need our attention – if not, many of them will disappear forever. This particularly applies to, for example, southern Sweden, where most of the fens have already disappeared. In the north of Sweden and Finland, there are still large areas of fens that are unique in Europe. New methods and new ways to manage, restore, connect and recreate alkaline fens are important, as well as continuing existing measures, such as filling ditches and removing shrubs.

Without the engagement of the participants at the meetings and the extended project group, the project would never have got off the ground. Many people worked hard to organise the meetings, both in

Finland and Sweden. Lisa Johansson and Olle Jonsson from Sweden, and Tuomas Haapalehto, Sakari Rehell, and Pauliina Kulmala from Finland contributed the texts about the visited sites, and the extended project group and the reference group helped to review the report. This project is hopefully the first step towards greater networking and cooperation between people in the participating countries working with alkaline fens.

Kristian Nilsson
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Abstract

Alkaline fens are species-rich wetlands that are currently under threat. Nature conservation officers and experts on alkaline fens from Denmark, Estonia, Finland, Iceland, Norway and Sweden held meetings and visited sites in Sweden and Finland to discuss the current situation. Restoration and management can be expensive, and more appropriate ways for managing and restoring alkaline fens must be found.

Summary

This is the final report from the project *Alkaline fens – valuable wetlands but difficult to manage*. The one-year project comprised two meetings in 2015, attended by nature conservation officers and experts on alkaline fens from Denmark, Estonia, Finland, Iceland, Norway and Sweden. The first meeting was held in Sweden (Mjölby, Östergötland), and the second in Finland (Kemi-Tornio). Both meetings included field visits to alkaline fen sites.

Alkaline fens are very important hotspots for biodiversity, providing a home to many endangered species. Drainage, intensive agriculture, lapsed active management, eutrophication, and acidification are some of the factors that have led to a reduction in the distribution and area of alkaline fens in Europe. In southern Sweden and many other areas in the Nordic countries, the remaining alkaline fens are mere fragments of their former extent. Restoration is often laborious and must be followed by continuous management, so it can be expensive. Restoration projects in Sweden in recent years show a need to find more appropriate ways to restore and manage alkaline fens.

The project goals were:

- To exchange experiences of restoring and managing alkaline fens.
- To find and present examples of best practice and good examples/methods for restoration and long-term management of alkaline fens.
- To identify knowledge gaps regarding restoration and management of alkaline fens, with a focus on conserving different organism groups.
- To make alkaline fens a model for management and conservation of habitats with high biodiversity that are difficult to manage.
- To produce a report that will be useful in practical aspects of managing alkaline fens and in future restoration and management projects for alkaline fens in northern Europe.

The final report will be submitted to specific Nordic environmental ministries in order to increase political awareness of alkaline fen management and protection. In EU countries, this will establish a synergy that will enable implementation of the Water Framework Directive and the Habitat Directive.

The project proved very successful in its goal to exchange knowledge and ideas between different countries. The main conclusions, based on the field excursions and seminars, are:

- Action plans, or at least a stronger focus on conservation of alkaline fens, are needed in all countries involved in the project. The threats facing alkaline fens are the same all over northern Europe, and urgent action is needed. Every effort should be made to prevent further loss and degradation of pristine and natural-state rich fens. More efforts should be made to increase restoration and management of degraded sites to halt the loss of rich fen biodiversity.
- Many different methods are used in restoring and managing alkaline fens; these need to be disseminated to conservation officers. However, knowledge gaps remain. This report contains project participants' suggestions for best practice, based on current knowledge.
- Successful restoration and management of rich fens and other peatlands requires a hydrological analysis. It is crucial to understand the flow routes of water into and within a site in its natural and present (degraded) state to decide what action is needed (e.g. filling ditches with peat) and where to restore the natural hydrological regime.
- Knowledge about the traditional use of fens is important when planning future management.
- Landscape analyses of fens can be useful when planning restoration. Findings may affect the conservation strategy and how to restore and manage the alkaline fens. For example, ecological connectivity between sites should be considered; restoration is more likely to be successful if there are other rich fens nearby rather than where sites are relatively isolated.
- Where financial constraints prevent restoration and long-term management of all degraded sites, prioritisation should be made on the basis of a cost-benefit analysis in terms of biodiversity and ecosystem services relating to each measure. Prioritisation is not an

easy task, but it significantly improves cost-efficiency, i.e. more can be achieved with the same amount of money.

- More international LIFE projects and networks would improve management of fens and disseminate knowledge to and among conservation officers.
- Greater collaboration between universities, research organisations and nature conservation officers will help to improve understanding of the factors affecting the long-term outcome of restoration, and improve implementation of best practice. Expert groups comprising both practitioners and scientists should be set up in each country to develop more detailed best-practice guidelines and to plan networks for monitoring, for example, vegetation and hydrology. An example of such a group is the Finnish Board on Ecological Restoration (http://www.metsa.fi/web/en/finnishboardonecologicalrestoration). Greater collaboration is also needed between experts on alkaline fen management and experts of other habitat types, both nationally and internationally.
- Management of fens by farmers must be seen in a broader context and not simply in relation to environmental management. Management must be considered in the context of agricultural subsidies programmes (at least within the EU) and in a socio-economic context. Meat from livestock reared on natural pasture is a high-value food requested by consumers, but processing and marketing is difficult. Studies are needed to examine such issues across the Nordic region – currently we use the rural development/subsidies programme in different ways.
- Greater understanding is needed of the potential of novel rich fen ecosystems, like roadsides and artificially created wetlands, as a cost-effective measure. Ecosystem surrogates could be a way to improve the habitat network and interconnect existing rich fens, thereby promoting colonisation by characteristic species.

Introduction

This is the final report from the project *Alkaline fens – valuable wetlands but difficult to manage*. The one-year project comprised two meetings in 2015, attended by nature conservation officers and experts on alkaline fens from Denmark, Estonia, Finland, Iceland, Norway and Sweden. The first meeting was held in Sweden (Mjölby Östergötland) and the second in Finland (Kemi-Tornio).

Both meetings included field visits to alkaline fen sites – four in Sweden and five in Finland. Some of the fens had been restored, while others had not. Discussions were held at the fen sites and in workshops. The aim of the field visits was to see and discuss various restoration methods, but also to see in practice other aspects of restoration, such as monitoring and long-term management.

Alkaline fens are species-rich in terms of mosses, vascular plants, fungi, beetles, molluscs and butterflies, and so comprise a very complex habitat ecosystem. Alkaline fens are very important hotspots for biodiversity, providing a home to many endangered species. Drainage, intensive agriculture, lapsed active management, eutrophication, and acidification are some of the factors that have led to a reduction in the distribution and area of alkaline fens in Europe. In southern Sweden and in many other areas in the Nordic countries, the remaining alkaline fens are mere fragments of their former extent.

Today, managing alkaline fens is often not viable. Restoration is laborious and much of the work has to be done manually. Restoration projects in Sweden in recent years show a need to find more appropriate ways to manage and restore alkaline fens.

The aims of the project were:

- To find and present examples of best practice and good examples/methods for cost-efficient management and restoration of alkaline fens.
- To involve stakeholders in the description of best practice, in view of their key role in managing alkaline fens.
- To establish a long-term network of conservation officers in northern Europe who work with alkaline fen management and restoration.

- To produce a report and create networks that will be useful in practical aspects of managing alkaline fens and in future restoration and management projects in northern Europe.

The goals of the project were:

- To exchange experiences of restoring and managing alkaline fens.
- To find and present examples of best practice and good examples/methods for restoring and managing alkaline fens in the long term. The project should also identify knowledge gaps in the restoration and management of alkaline fens, in order to conserve different organism groups.
- To make alkaline fens a model for management and conservation of habitats with high biodiversity that are difficult to manage.
- To produce a report that will be useful in practical aspects of managing alkaline fens and in future projects examining restoration and management of alkaline fens in northern Europe.

The final report will be submitted to specific Nordic environmental ministries in order to increase political awareness of alkaline fen management and protection. In EU countries, this will establish a synergy towards the implementation of the Water Framework Directive and the Habitats Directive.

This report presents the content and conclusions of the project.

1. Alkaline fens in Northern Europe

Alkaline fens, or rich fens, are a very diverse group of habitats. Rich fens in the countries participating in the project vary considerably due to biogeographical conditions. In northern parts of Fennoscandia (mainly central and middle boreal zones), rich fens cover large areas in a mosaic of different mire types. Rich fens are typically situated in areas influenced by base-rich or calcareous groundwater. Vegetation species of wet flark surfaces are very typical. In the southern part of the Nordic countries, fens are usually small and in a mosaic pattern, with semi-natural habitats where grazing and haymaking still take place. The peat layer can be quite thin (sometimes almost non-existent) and the habitats often resemble calcareous meadows.

Rich fens also vary due to factors that cause degradation. In the southern parts of the Nordic countries (corresponding mainly to the boreonemoral and nemoral zones), alkaline fens have been managed as part of traditional agricultural practice for hundreds of years. Many fens, used for haymaking in the past, have been drained and converted to arable land. The fens that remain are now threatened by abandonment, ending a long cultural history of traditional use: this has resulted in the present valuable and threatened habitats. In Finland, northern Sweden, and northern Norway, forestry drainage has been the main cause of the degradation.

However, it was not realised until recently that fens are dependent on management for long-term conservation of their biological values. Important work has been carried out in the past decades, but we still need to improve understanding of how traditional use has impacted the present state, influencing prospects for restoring alkaline fens.

It is also important to know how fens are classified. Natura 2000 divides fens into four different habitat types: 7230: Alkaline fens; 7220: Springs with tufa formation; 7210: Calcareous fens with Cladium mariscus; and 7160: Iron-rich types of Fennoscandian mineral-rich springs and spring fens. All these are rich fen habitats, characterised principally by their vegetation, which is found to correlate strongly with the pH of the water.

The classification of fens, as well as the characteristic features, seems to vary from country to country. The term “rich fen” can be regarded as being suitable for all countries. The term “alkaline fen” is not thought to be suitable for boreal districts, because there the sites are typically not alkaline, but neutral to slightly acidic. In Finland, the term “eutrophic fens” is often used as a synonym for rich fens, but this term can be confusing, because many rich fens are poor in terms of macronutrients. It is important to note that the rich fens span a large group of very different habitats, and best practice for their conservation and management varies greatly.

In addition to the profound geographical difference between fens in northern and southern districts, fens can also vary greatly between maritime and more continental areas. Even within broadly similar geographical regions (such as the central and northern boreal zones, where rich fens are locally common), there are large differences in fen ecology. Sites where the higher pH is mainly due to a high calcium and carbonate content can differ greatly from sites where the high pH is principally due to flowing, base-rich groundwater. These latter cases often contain high amounts of iron precipitates and phosphorus, which affect the changes that take place after drainage or restoration.

2. Future challenges for conservation of alkaline fens

One successful outcome of the project was the attainment of the goal to exchange knowledge and ideas between different countries. The main conclusions, based on field excursions and seminars, are:

- Action plans, or at least a stronger focus on conservation of alkaline fens, are needed in all countries involved in the project. The threats facing alkaline fens are the same all over northern Europe, and urgent action is needed. Every effort should be made to prevent further loss and degradation of pristine and natural-state rich fens. More efforts should be made to increase restoration and management of degraded sites to halt the loss of rich fen biodiversity.
- Many different methods are used in restoring and managing alkaline fens; these need to be disseminated to conservation officers. However, knowledge gaps remain. This report contains project participants' suggestions for best practice, based on current knowledge.
- Successful restoration and management of rich fens and other peatlands requires a hydrological analysis. It is crucial to understand the flow routes of water into and within a site in its natural and present (degraded) state to decide what action is needed (e.g. filling ditches with peat) and where to restore the natural hydrological regime.
- Knowledge about the traditional use of fens is important when planning future management.
- Landscape analyses of fens can be useful when planning restoration. Findings may affect the conservation strategy and how to restore and manage the alkaline fens. For example, ecological connectivity between sites should be considered; restoration is more likely to be successful if there are other rich fens nearby rather than where sites are relatively isolated.

- Where financial constraints prevent restoration and long-term management of all degraded sites, prioritisation should be made on the basis of a cost-benefit analysis in terms of biodiversity and ecosystem services relating to each measure. Prioritisation is not an easy task, but it significantly improves cost-efficiency, i.e. more can be achieved with the same amount of money.
- More international LIFE projects and networks would improve management of fens and disseminate knowledge to and among conservation officers.
- Greater collaboration between universities, research organisations and nature conservation officers will help to improve understanding of the factors affecting the long-term outcome of restoration, and improve implementation of best practice. Expert groups comprising both practitioners and scientists should be set up in each country to develop more detailed best-practice guidelines and to plan networks for monitoring, for example, vegetation and hydrology. An example of such a group is the Finnish Board on Ecological Restoration (http://www.metsa.fi/web/en/finnishboardonecologicalrestoration). Greater collaboration is also needed between experts on alkaline fen management and experts of other habitat types, both nationally and internationally.
- Management of fens by farmers must be seen in a broader context and not simply in relation to environmental management. Management must be considered in the context of agricultural subsidies programmes (at least within the EU) and in a socio-economic context. Meat from livestock reared on natural pasture is a high-value food requested by consumers, but processing and marketing is difficult. Studies are needed to examine these issues across the Nordic region – currently we use the rural development/subsidies programme in different ways.
- Greater understanding is needed of the potential of novel rich fen ecosystems, like roadsides and artificially created wetlands, as a cost-effective measure. Ecosystem surrogates could be a way to improve the habitat network and interconnect existing rich fens, thereby promoting colonisation by characteristic species.

3. Management and restoration

The effects of the following methods of restoring and managing fens were studied and discussed in the project:

- Blocking and filling ditches with peat to restore degraded hydrology.
- Removal of scrub and woodland to create more open areas.
- Different regimes of mowing and grazing to maintain open areas.
- Removal of the top layer of soil to reset rich-fen development.

Other methods, such as burning, were also discussed during the workshops.

3.1 Hydrology, blocking and filling ditches

If restoration and management of a fen are to be effective, its hydrology must be understood. If the hydrological conditions are disrupted and in poor condition, this can prevent the successful long-term conservation of a fen, even if the management is otherwise appropriate.

When restoring a fen, hydrology is the first phenomenon that should be investigated. Hydrological conditions are often disrupted by the digging of ditches for agriculture and forestry in order to lower the groundwater table. While detailed information on water chemistry requires chemical analyses and good understanding of hydrological processes, very important information such as site wetness and water flow routes can be obtained by comparing old and new aerial photographs and topographic maps. Particularly for rich fens, where typical species only exist in a very narrow ecological niche, it is crucial to carefully plan and carry out hydrological measures.

A site can be difficult to investigate and take a long time to restore if there are large ditches in the area. Aerial photos showing the fen before drainage provide useful information when the plan is to restore a fen by blocking ditches.

Restoration of hydrological conditions requires understanding of the hydrology in the entire catchment. The success of restoration and management may be severely hampered by ditches or other land use practices

located several hundreds of metres away from the site, so land ownership is another consideration when restoring a fen.

Finland has extensive experience of restoring hydrological conditions, because the digging of ditches to create conditions for forestry activities has been far more widespread than in other countries. Guidelines have been published about restoring fen hydrology (Simila *et al*. 2014). Methods employed in Finland involve filling or blocking ditches with peat, in order to raise the water table to its original level and lead the water back along its original courses.

Thinning of tree stands may be required. Pines are usually removed to replicate original tree stand structures, but birches are left to prevent sapling regrowth. If birches are cut and the water table does not rise sufficiently, sprouting of birches can become a problem. It has been observed that birch sprouting ceases after two or three annual cuttings, but this has not been verified by appropriate studies or sufficiently tested in practice.

Studies and monitoring show that the water table rises rapidly after measures to restore fen hydrology (Haapalehto *et al*. 2010, Haapalehto *et al*. 2014, Maanavilja 2014). During the first couple of years, the water table is typically unnaturally high, but then reverts to its natural level.

Restoration of hydrological conditions and original forest stand structure is expected to promote the recovery of typical species. However, it should be noted that the degree of degradation may affect the outcome of restoration; the likelihood of recovery is better where a site is less degraded and where original species are still present. For example, blocking and filling ditches cannot restore the original hydrological conditions if the site has changed too much since the ditches were dug. This is a typical problem on wet rich fens where, under natural conditions, large amounts of both surface and groundwater have flowed in the surface peat (rich birch fens and rich swamp fens). In this type of habitat, the surface peat has often subsided and become mineralized and compact. The original rich fen mosses have often disappeared completely, and the site has developed into dense peatland forest.

The optimum balance between surface and groundwater can be very difficult to attain; even very distant changes brought about by, for example, water pumping and drainage channels can reduce groundwater flow and, in the worst-case scenario after restoration, only acid surface water flows on the former rich fen.

It should also be noted that filling ditches should be supplemented by building peat dams across the top of the ditch. Such dams divert water away from the filled ditches, whose beds are often lower than adjacent areas. Water can still flow along the ditches and hamper the recovery on

each side. After restoring the hydrological conditions, further action should be delayed a couple of years to see how the trees respond. The trees may die, which saves the cost of felling.

Conclusions:

- Filling and blocking ditches may be used to improve the hydrological status of degraded fens.
- When restoring a fen, the first item for analysis should be its hydrology; restoration of the hydrological conditions is important in the long-term conservation of fens.
- Excellent guidelines are available from Finland about how to restore the hydrology of a fen.

3.2 Removal of scrubs and woodland, mowing and grazing

Open alkaline fens have decreased in Europe to such an extent that they now are at risk of completely disappearing in large areas. This is due to changes in land use and management. In the southern part of the Nordic region, there is a long tradition of grazing and haymaking in alkaline fens. When management ceases, they often become woodlands. In the north of the region, there are still quite extensive areas of rich fens. These fens usually remain open without management, but global warming may change this in the future. In the north of Sweden, many open mires are becoming increasingly forested. The reason for this is not completely clear but could be related to both forestry practices and climate change. Today in the north, any management carried out generally involves restoration, i.e. restoring hydrological conditions and removing trees and bushes that became established after extensive drainage.

Management often involves removing species such as common reed (*Phragmites australis*) or large tussocks of various *Carex* spp. Species like meadowsweet (*Filipendula ulmaria*) are sometimes regarded as a problem. Even if these species occur naturally in fens, they can be a problem if they become established in high densities because of the impact of drainage or large deposits of nitrogen (from agricultural areas in the surroundings or from airborne pollution).

There are various ways to remove or control unwanted species; for example, common reed could be cut twice a year, early and late in the season. There are still knowledge gaps, e.g. how high can we let *Schoenus* tussocks grow in unmanaged areas (natural succession)? Experiments could teach us the best height at which to cut the tussocks.

Norway has extensive experience of haymaking, and this is still extensively practiced. Rich fens in the south of Finland are small and decreasing in number and area. Even though there are several sites in Finland where hydrological conditions have been restored in rich fens, experience of fen management – like haymaking – is limited. While its impact is not well understood yet, decline of traditional agriculture is probably degrading the rich fen ecosystems, with a negative effect on species typical of such open conditions.

Haymaking has been a tradition on all types of sedge fens in Finland. One difficulty today is that these sites are typically very wet and contain thick peat, making the use of machines very difficult. In practice, only very small areas could be mowed, but this could be possible on specific sites with threatened species or beautiful scenery. In the northeast of Finland, there is a former flood irrigation system that would be interesting to revive.

Introducing grazing animals may be impractical in some areas, so alternative methods will be needed in the future, such as mowing. In Finland few fens are managed actively; generally, they are just protected, and goals set. In Denmark, the focus is on improving hydrological conditions, followed by grazing, and controlling groundwater is important. By increasing the number of alkaline fens, prioritising management of the most important sites, and creating corridors between them, they could be preserved in the long term.

However, there may be other ways to conserve alkaline fen species. Some of these species may be conserved with appropriate management of, for example roadsides and the ground under power lines. Ecosystem surrogates could be an alternative, perhaps by creating such sites as compensation areas linked to road and railway construction projects. However, natural ecosystems should not be destroyed to provide artificial novel ecosystems for a small number of species.

In northern parts of Finland, Sweden and Norway, the domestic reindeer still actively graze the rich fens, and this is one reason why such fens are in better condition in the north. In the future it may be important to continue summer grazing on fens, but winter pastures cannot support more animals.

Where rich fens are degraded to varying extents, but remain in quite large numbers (such as in many parts of Finland), prioritisation of sites is crucial. Protection of the last preserved rich fen sites outside the protected areas could be more cost-efficient than restoring severely damaged sites inside protected areas.

Conclusions:

- Grazing and mowing (haymaking) is important in the south of the Nordic region in order to conserve the last open alkaline fens that still exist.
- Knowledge gaps remain about removal of unwanted vegetation and bushes and trees.

3.3 Removal of the topsoil layer

This involves the removal of the highly degraded and eutrophic top layer of peat. During the project, the effect of topsoil removal was observed in Sweden on two sites (Styra and Lagmansro), and the method was also discussed at Hagebyhöga where there are plans to remove the topsoil. Top soil has been removed close to small isolated fens that would need to be expanded to ensure preservation of the fen in the future. The surrounding areas comprise agricultural land or land used for forestry.

Topsoil removal allows alkaline fens to be recreated. The practice exposes underlying calcareous soil and allows groundwater to influence vegetation by slowly flooding the exposed area. Rare species typical of alkaline fens can then colonise and become established. The top soil may also be removed if it is highly degraded (e.g. high amounts of N and P or Fe), generally caused by intensive agricultural use in the area.

Removing topsoil can be expensive, but the process can be made cheaper if the soil can be stored close to the restored area and then sold. Fen soil should be valuable, since it is not contaminated, and therefore easy to sell. After topsoil removal, vegetation (e.g. brown mosses) and animals (e.g. snails) may need to be transplanted, so extensive monitoring may be needed.

Conclusions:

- Fens can be restored by removing degraded top soil. This may be the only option to improve site conditions to target levels.

- Topsoil removal is expensive and should probably be used only to increase the size of tiny isolated fens with very high biological values.
- Due to the high cost, an analysis should always be carried out to see what else could be done with the same money.

3.4 Burning

Burning is a traditional practice in grasslands to improve pasture for cattle. Burning removes plants like heather, but also litter, and many species are known to adapt to the measure.

Burning of vegetation was discussed at the first meeting in Sweden. Burning is used in Iceland in pastures that need to be restored because no grazing has taken place for several years, but it is not a common management method. In Norway heathlands are burned to stimulate new grass vegetation. One risk of burning is that, if it is used too often, the species composition becomes altered. In Sweden some studies have shown that burning in alkaline fens can have a negative impact on land snails and moss cover. The Estonian participants reported on burning a mesotrophic fen, which after a few years was invaded by birch on a very large scale.

Burning is a relatively inexpensive method for restoration, but is not a practice suitable for more regular management of alkaline fens. Long-term studies are needed of burning in alkaline fens. If an area is to be burned, it must take place at the most appropriate time of the year. If there is a light headwind, and the peat is wet and the litter dry, the intensity and temperature of the burning can be controlled. The success of burning depends on temperature and moisture conditions, and the practice can be risky as it can be hard to keep under control.

Conclusions:

- Burning can be used as a method of removing litter when restoring alkaline fens.
- Long-term studies are needed about ecological burning in alkaline fens.

4. Conservation and restoration on a landscape level

In Estonia and northern Finland, fens are often quite large, with some connectivity at landscape level. However, in southern Finland, with a longer history of land use, the few remaining rich fens are located far from each other, limiting the possibilities for dispersal of species between fragments. In Denmark and Sweden, the fens are usually small, with little connectivity. For areas with large fens where management is not needed, it is probably best to concentrate on ecosystem functions and on restoring hydrological conditions.

For small fens, depending on the land use history of the site (they may be remnants of former large fens) and on the target of restoration, management is important in order to maintain different stages of succession. A focus must be on management of species, taking the isolation into account. In the most fragmented areas, species may have to be helped to move between areas.

Landscape-scale connectivity may be improved by working with clusters of fens. Goals for management and conservation can then be set for clusters rather for individual sites. Combining goals both at landscape level and on individual sites would make it easier to increase connectivity. Small areas often need to be increased in size, and the use of buffer zones is important, as they could prevent eutrophication in agricultural areas. In Denmark, buffer zones have been used in a LIFE project to combine with Natura 2000.

Conclusions for small areas:

- When only small fens are left, management is important to maintain different stages of succession; this will help preserve different species at the site.
- Another important focus is management of target species. In the most fragmented areas, species may have to be transplanted between fens.
- Buffer zones may be needed.

Conclusions for large areas:

- Where management is not needed, it is probably best to concentrate on ecosystem functions and on restoring hydrological conditions.

5. How do we work with stakeholders/landowner?

In many parts of the Nordic countries, alkaline fens are privately owned. The landowners are responsible for management, such as grazing and haymaking, so a good working relationship with stakeholders is very important. When a project is started it is often advantageous to involve the stakeholder as early as possible in the process – getting to know each other is a long process and time is needed. Continuity is necessary, and conservation workers must have good listening skills and patience. Information must be shared and good examples are important. It is important to explain to the landowner that the fen is very valuable and that they should be proud of it. Establishing a good dialogue is vital when it comes to managing fens, and valuable information can be gleaned from learning about the site history. Stakeholders that we met through the project were very interested, and happy to share their knowledge.

In Finland a better plan is needed for restoring wetlands where private landowners are involved. Strong arguments are required when discussing and initiating collaboration with private landowners. An argument used in Denmark is that restoring/creating natural areas increases the value of a property – a study has indicated that people are willing to pay more for properties if there is "nature" close by. Where fens are on public land, information about alkaline fens could be provided in the form of signs, and footpaths built. Sweden has a number of fens in nature reserves open to the public.

Conclusions:

- Conservation staff continuity is important, and they must have good listening skills and patience.
- Learning from stakeholders is very important.
- Important to inform the public about the value and importance of alkaline fens.

6. Monitoring alkaline fens

Alkaline fens are monitored to either evaluate the effects of management/restoration or to collect data over time to investigate long-term changes. Whatever the purpose, the monitoring must have clear objectives and goals. It may also be important to specifically monitor certain target species.

Before restoration can begin, it is important to be able to predict the outcome and carry out a risk assessment. Monitoring often comprises recording data about vascular plants, brown mosses, vegetation height and coverage, different types of structure, and water quality. Various types of plots are used. Monitoring can be costly and, unfortunately, is often never finished, evaluated and published.

In order to measure the impact of restoration, monitoring must begin before the work starts, to provide a benchmark. Another kind of reference site is often necessary, usually a natural ecosystem. Photographic documentation is crucial. Monitoring should be as simple as possible, and strong indicators should be chosen. Poorly planned or executed monitoring is a waste of time and money, because the results cannot be used. The studies must always be repeatable on the same site. Historical land use as shown on maps should be studied, since it can provide information about the earlier appearance of the fen. In Finland, a common objective of restoration is to restore ecosystem balances, structures and functions, thereby allowing characteristic species to recover. Site restoration may be made more specific, and decisions made on which species to conserve.

Conclusions:

- Use well-established simple and cost-efficient methods for monitoring.
- Photographs, accurate and careful recording, and documentation are important.

6.1 Monitoring hydrological conditions

Detailed documentation about the hydrology regime and soil before and after restoration is required, but this information is often lacking. Furthermore, there is often a shortage of reference areas. In Finland, restoration planning is based on a general description of the hydrological conditions when the fen is in its natural and degraded state, which is documented in the restoration plan. The recovery is followed up at each site after restoration, with general monitoring based on various robust variables, such as surface wetness.

The general hydrological balance of the area – catchment area, level of the water table, flow direction, and water quality – must be known. The catchment area can be defined using the contour lines on topographic maps. More detailed information on water flow routes and topography can be obtained from laser scanning or satellite data.

Monitoring the groundwater level is important so that the desired outcome of restoration can be defined. Monitoring the water table at the edge of the restored area is also important, to verify that no unwanted wetting is occurring in adjacent land (e.g. after blocking a ditch). In difficult cases, the effect of raising the water level can be modelled, and models built to simulate water flow using laser scanning, but this is not needed in simpler cases. Evaporation rates can sometimes be quite high, and this data is important.

Water quality can be measured (e.g. N, P, K, Ca, pH). In rich fens where species demand typical minerogenic and often alkaline water, it is especially important to understand the water chemistry and the origin of water feeding the site (i.e. whether it derives from groundwater).

Conclusions:

- In fen restoration, monitoring hydrological conditions is important, e.g. measuring groundwater level.
- The overall hydrological balance of the area must be known.

7. Network for conservation officers

This project was started by nature conservation officers who wanted to find out more about how neighbouring countries were working with the management of alkaline fens. This project is the first step in setting up a network for conservation officers in northern Europe who are working with alkaline fens. The meetings in this project have shown the importance of networking, and also showed that a lot of alkaline fen restoration and networking activities are taking place in different countries.

The network can be maintained and developed in a number of ways:

- Facebook group (already in place), for regular discussions with other conservation officers working with alkaline fens.
- Lync-meetings (video conferences), like the round-table meeting in Finland (an annual meeting between scientists and nature conservation officers), could be arranged in other countries and involve representatives from different countries.
- E-mail group for spreading information.
- Regular physical meetings and workshops, with field trips to fens.
- New projects based on identified problems.
- Collaboration with other projects involving alkaline fens. This network could collaborate with other existing networks, e.g. Natura 2000 Biogeographical Process, NorBalWet, LIFE platform.
- Focus on practical activities. Seeing restoration projects in situ is invaluable.
- Internships in other countries, both in the EU and in the Nordic countries.
- Rotate the project leader role between the different countries each year. This could increase engagement.
- Increase networking with universities.

8. Alkaline fens: Sites visited in the project

The sites were specifically selected to provide an overview of different types of restored, managed, or restorable alkaline/rich fens in the participating countries. Project participants also visited some natural-state fens to provide a basis for formulating goals. The Swedish fens were visited on 21–22 May 2015 and the Finnish fens on 6–7 October 2015.

8.1 Styra

Styra is an example of a fen restored by removal of top soil layer.

8.2 General description

The Styra site has been a nature reserve since 2013, and comprises a Natura 2000 area with three different areas of calcareous fen/fen meadows:

1. The southern part of the reserve (1.6 ha) has long fen continuity, but only moderate conservation values. At the start of the 21st century, the plant community was in poor condition (litter accumulation, tall grass-herb vegetation, several species lost, and large areas with a closed birch canopy). The area was restored in 2006 through clearance and birch logging. Today there are some calcareous fen areas but mainly fen meadows. No brown bogrush (Schoenus ferrugineus) is present in this part. The area is mainly managed through grazing (sheep), and a small area by mowing.
2. The northern part of the reserve (1.3 ha) contains calcareous fen and fen meadow areas with a rich orchid flora and very high conservation values. In the wettest part, there are small areas of brown bogrush, which has been increasing for the past ten years. This fen was recreated in 1967 by removing the topsoil in an overgrown area that may have been previously used for grazing. The aim of the topsoil removal was to prepare the land for forestry; birch was planted

but with little success. The area was restored by thinning the trees in 2006, and has since been extensively grazed by sheep. Bushes and the remaining birches were cleared in 2014/15. The spread of common reed is a problem in the area, and there are plans to mow the common reed as a complement to grazing.

3. The central part (1.3 ha) was, until recently, a poorly drained cultivated field used for grazing, situated between the northern and the southern fen areas of the site. The field was restored by topsoil removal (approx. 30 cm) and the drainage system was abandoned in 2013. Succession is currently at an early stage, with species able to colonise from the adjacent fens (and other habitats). In 2013, small soil-vegetation patches (30x30 cm) containing key plant species were transplanted from the northern neighbouring fen. In March 2015, moss mats of the poorly colonising key species Scorpidium cossonii were transplanted into the area from the Hagebyhöga site. This recreated area will probably require no management for 10–15 years.

Cost of top soil removal at Styra site:

- 1.1 ha alkaline fen was recreated at Styra 2013: costs approximately EUR 110.

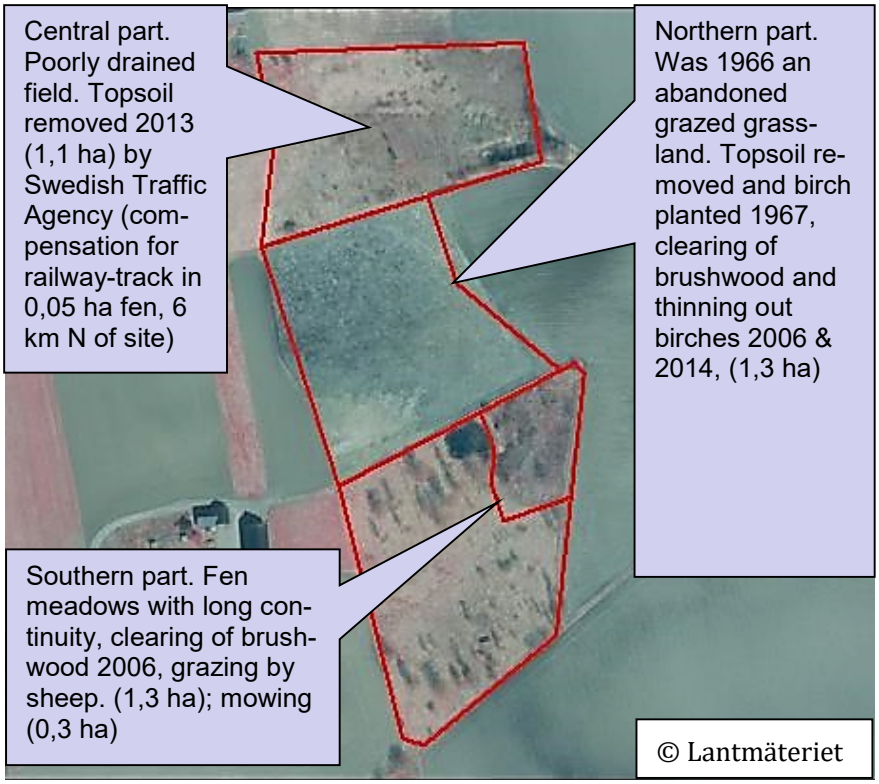
Quantity of topsoil removed:

- 1 ha x 0.35m depth of topsoil = 3,500 m3.

Species present:

- Vascular plants: *Schoenus ferrugineus, Dactyrorhiza incarnata ssp. incarnata, D. incarnata* ssp*. cruenta, D. incarnata* ssp*. ochroleuca, D. maculata* ssp*. fuchsii, D. maculata* ssp*. maculata, Epipactis palustris*.
- Mosses: several.
- Land snails: *Vertigo angustior* (N2000), *Pupilla pratensis*.

Figure 1: Aerial photo over Styra fen and the three areas that were visited



8.2.1 Northern part (created in 1967)

Questions discussed at the site:

- Is the species composition representative for alkaline fens and fen meadow?
- What type of management would be appropriate?
- How can the spreading of common reed be controlled?
- Should the snail Vertigo geyeri (NT, N2000) be introduced to the reserve now that the habitat is suitable? (We assume that this species was formerly present in the area).

At least some of the area could be considered alkaline fen. Sheep graze in the area, and horses could graze here too. The general opinion was that horses and cattle are much better than sheep for grazing on alkaline fens. Lightweight cattle types could be introduced to minimise the effect of trampling. More bushes need to be removed. The spreading of common

reed could be controlled by mowing twice a year (around Midsummer and in July–August) and grazing (late in the season). There is also some cattail (Typha latifolia) that should be removed, preferably by digging out.

A buffer zone could be necessary around the area to prevent leakage of nutrients from the surrounding farmland. There was a discussion about whether two pines standing in the northern area should be felled, but solitary, sunlit pines are important for invertebrates and should not be removed. The area contains an old pond and a pile of soil left from when the pond was dug. If the pile of soil were used to fill the pond, fen vegetation may develop at the current site of the pile. The snail Vertigo geyeri could be reintroduced, but a moss and plant cover would be needed first, as a layer of material would be needed to provide shelter (shade, humidity) for the snail.

Figure 2: Northern area at styra

Photo: Kristian Nilsson.

8.2.2 Central part (recreated in 2013)

Questions discussed at the site:

- Was it appropriate to speed up succession by transplanting plant-tussocks from the neighbouring fen, and by transplanting the poorly colonising moss Scorpidium cossonii (key species for threatened invertebrate fauna) from a distant fen (Hagebyhöga, 8 km away)?

- Topography and hydrology: Is the hydrology satisfactory? What could be done better? Should the drainage system have been completely removed? Is alkaline water spreading over the area?
- Possibilities for monitoring and documentation?

Figure 3: Styra site, central area

Photo: Kristian Nilsson.

Transplanting tussocks of plants and brown mosses (*Scorpidium cossonii*) on a small scale is acceptable, although slightly unnatural. In Iceland, mosses are mixed with water and spread on the soil to rapidly create a moss cover. Moss can also be mixed with sour cream, which prevents it from drying out by hindering evaporation. Hay could also be taken from a nearby fen and used as a cover for the reintroduced mosses, by providing humidity and shade.

It was clear that the restored part had been drained, and the drainage pipes were visible. The drainage system still seemed to be working. The hydrological conditions should be analysed because the soil was quite dry. It is very important to monitor this type of intervention so that results can be evaluated. Vegetation could be monitored with permanent plots around transplanted patches, including reference plots without transplanted patches.

Figure 4: Transplant of brown mosses and vascular plants has been done at Styra central area

Photo: Kristian Nilsson.

A discussion with the local farmer, who kept sheep on the site, suggested there were no problems with grazing. Previously, horses had grazed on the site, and this could be a possibility for the future.

8.2.3 Other comments at Styra

Danish project members had emphasised the importance of keeping unfertilised buffer zones around the fen area to prevent eutrophication. Here, the fen is surrounded by arable land, so a buffer zone is needed. Many project members felt the cost of removing the topsoil layer would be too expensive.

9. Lagmansro

Lagmansro is a good example of a fen where the site has been restored by removing the top layer of soil.

9.1 General description

The Lagmansro site contains two adjacent calcareous fen areas with different histories:

- A small calcareous fen (0.2 ha) with highest conservation values. The area also contains petrifying springs. The fen habitat has a long continuity (even though some restoration by removal of bushes and mowing has been needed). Brushwood was cleared in 1999/2000 and 2014. In 2014 the fen was mowed.
- A 0.5-ha fen with high conservation values. This fen was recreated by topsoil removal in 2000. Prior to restoration, the site was overgrown by a species-poor tall herb-brush community dominated by *Filipendula ulmaria*, *Salix* and *Betula*. Since the topsoil (approximately 30 cm) and litter layers were removed, calcareous fen species have spontaneously colonised the area from the neighbouring fen, where the vegetation is unspoiled. Today the fen has many of the typical calcareous fen species, but one key species, the moss *Scorpidium cossonii*, has not yet been able to colonise spontaneously from nearby areas. This fen required no management during the first ten years, and the first management measure took place in 2014 when it was mowed.

The Lagmansro site also contains areas (1 ha) of disturbed fens with tall herb-brush vegetation that could be recreated by topsoil removal. The area has been cleared from 3–5 m tall brushwood of *Salix* and *Betula*.

Figure 5: Lagmansro alkaline fen

Photo: Kristian Nilsson.

Figure 6: Aerial photo of Lagmansro with the different areas that were visited

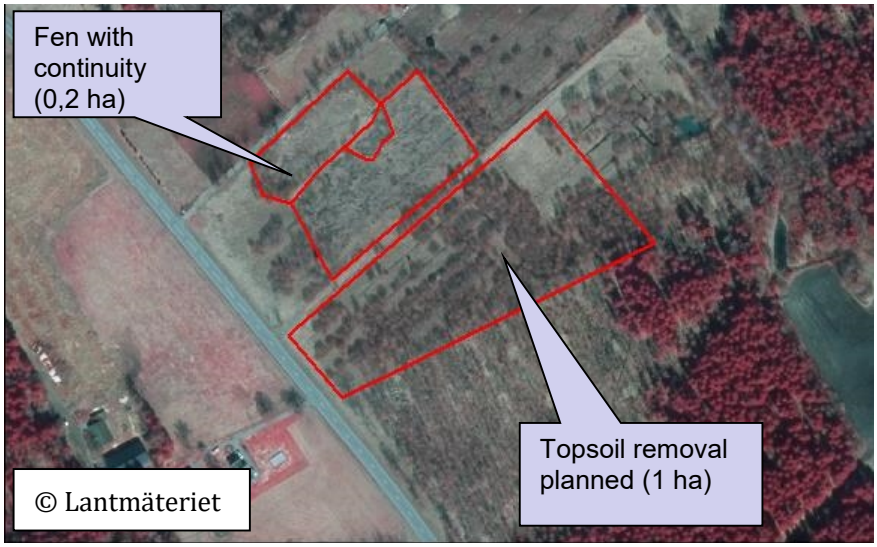


Figure 7: Lagmansro site: area where vegetation and topsoil are planned to be removed. The vegetation consists mainly of meadowsweet

Photo: Kristian Nilsson.

9.2 Area created in 2000

Questions discussed at the site:

- Is the species composition representative for alkaline fens?
- Did clearing of brushwood and grazing/mowing restore the site?
- How should the restored fen be managed?
- Is it worthwhile to restore such an isolated fen (nearest fen 3.7 km away)?
- Is the result satisfactory? What could have been done better?
- How do we obtain resources to restore large fen areas? How can we motivate the high cost to contributors? How can we reduce costs?
- Will restoration of alkaline fens by topsoil removal be important in the immediate future?

Figure 8: Area created in 2000 by topsoil removal

Photo: Kristian Nilsson.

The alkaline fen looked to be in good condition, but there was a lot of birch encroachment. However, there was no peat layer and no living brown mosses. Topsoil removal had probably been necessary to restore the fen. The fen could be managed by cutting seedlings, by grazing late in year with small cattle, and by increasing water flow from natural water sites. Water does not flow into the restored area. Openings could be made in the barrier of vegetation between the original fen and the restored area; the barrier currently prevents water flow. However, this would entail a risk of draining the original area, since the restored area is at a lower level than the original area.

If necessary, trees and bushes must be cut down annually. Birches should be removed in the summer, preferably with their roots. This measure should perhaps have started some years ago when the first birches started to appear.

Even though this fen is isolated, its size and the possibility to extend the area makes restoration worthwhile. To offset the costs of topsoil removal, it is important to find a good use for the soil. Mowing is required on the original site to remove litter.

10. Hagebyhöga

Hagebyhöga is a good example of a fen where restoration has been carried out by removing scrub and woodland, mowing and grazing. There are also plans to remove the top soil layer in the future.

10.1 General description

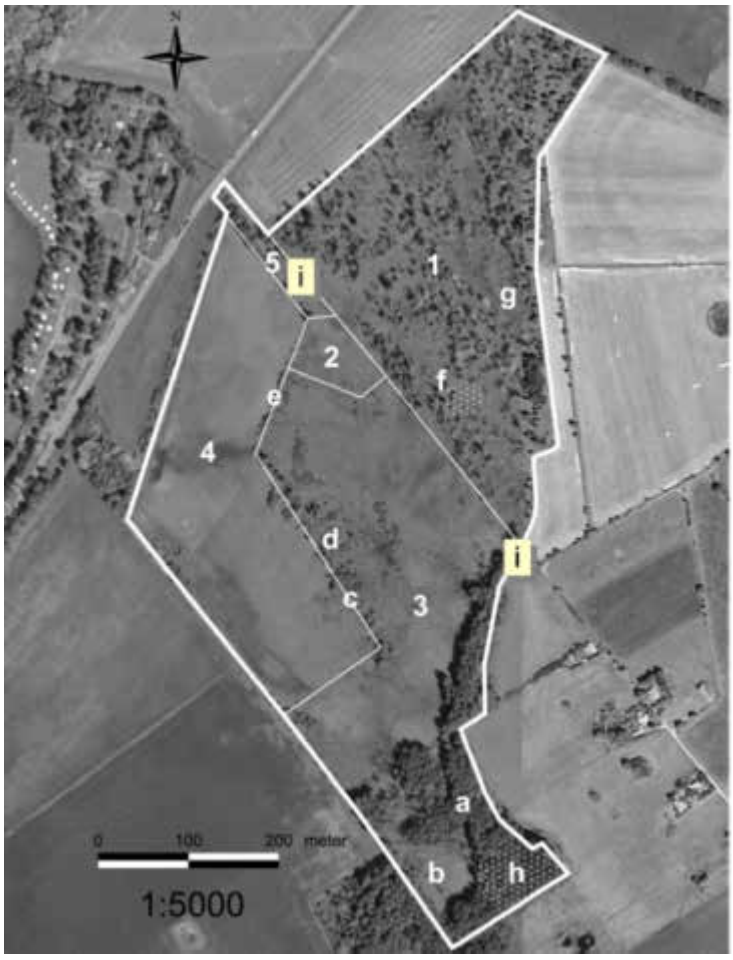
The Hagebyhöga site is one of the most interesting calcareous fens in the Swedish county of Östergötland, and has highest conservation value. This is also the only site in the county where *Liparis loselii* is found. The site is a nature reserve and a Natura 2000 area.

- The north-eastern part (10 ha) is a mosaic of open fen areas and fen/fen meadow/mesic grassland areas with a sparse cover of birch trees and shrubs. This part was restored by thinning and clearing brushwood in 2006, and was made part of the nature reserve in 2008. Further restoration, such as by thinning out the birch tree cover, is desirable, but requires acceptance from the landowner, who has received no compensation for protecting the area on his property. According to the management plan, the landowner may use the area to extract firewood. The area is managed by grazing.
- The central-southern part of the nature reserve (11 ha) contains a large open fen dominated by *Schoenus ferrugineus*. The area has been a nature reserve since 1978 and has been managed by grazing.
- To the west, the Hagebyhöga nature reserve has included a poorly drained field (6.8 ha) since 2008. The aim is to restore calcareous fen-fen meadow habitats by removing the topsoil. The field has been grazed for the past 15 years. Topsoil removal will provide 15,000–25,000 m3 of soil that will have to be disposed of. The measure will create 6.8 ha fen at an estimated cost of approximately EUR 330,000.

Species present:

- Vascular plants: *Schoenus ferrugineus*, *Bartsia alpina*, *Liparis loselii* (VU, N2000), *Ophrys insectifera*, *Dactyrorhiza incarnata* ssp. *incarnata*, *D. incarnata* ssp. *cruenta, D. incarnata* ssp. *ochroleuca, D. traunsteineri*.
- Mosses: *Scorpidium cossonii* dominates in large areas.
- Land snails: *Vertigo angustior* (N2000), *V. genesii* (NT, N2000), *V. geyeri* (NT, N2000), Pupilla pratensis.
- Soldier flies: *Stratiomys chamaeleon* (VU), *Oxycera pygmaea* (VU) and *Oxycera trilineata* (VU).

Figure 9: Aerial photo over Hagebyhöga (from management plan for nature reserve Hagebyhöga)



Source: Bakgrundskartor Lantmäteriet, dnr 106-2004/188).

10.2 North-eastern area, restored 2006

Questions discussed at the site:

- Status of habitat today? Trampling by cattle?
- Further restorations? Leave dying birches and dead wood in fen?
- How to manage the area?

The area had the characteristic species of an alkaline fen, and the hydrological conditions seemed suitable. Level of trampling was excessive because of grazing in the winter and spring, and the general intensity of grazing was too high; the intensity must be reduced in the long term. It is also detrimental that the cattle are kept in the area during the winter; if possible, other grazing areas should be used in the winter or spring. This would promote flowering in the area.

More trees (birch) and bushes could be cut down, but dead trees could be left standing/lying. Stumps could be removed from the area to prevent shoots growing. In the hawthorn area, some of the vegetation could be cleared to create more grazing areas for cattle.

10.3 Central-southern area, long continuity

Questions discussed at the site:

- Status of habitat today?
- Restoration needed? Establishment of common reed and brushwood?
- How to manage the area?

It is not clear whether the area of common reed is expanding and whether it really presents a problem. If the reed is a problem, then it could be appropriate to mow the area and remove the biomass every second year. Another measure could be to find some cattle that graze common reed. According to the farmer, cattle eat the common reed in late autumn after the first frost. The fencing could be rearranged so that areas with common reed could be grazed during winter. Another alternative would be occasional early grazing with a few animals in the spring. Small birches are common, and these need to be removed, preferably by pulling them up with their roots.

Figure 10: Picture Hagebyhöga, area with common reed that cattle grazed in late autumn

Photo: Kristian Nilsson.

Figure 11: Hagebyhöga. Farmer and nature conservations officer discussing topsoil removal

Photo: Kristian Nilsson.

10.4 Western area, poorly drained field, grazed for the past 10–15 years

Question discussed at the site:

- Can the area be restored? How?

A hydrological survey must be carried out before starting the project. Suitable hydrological conditions could be restored by plugging the ditches. The ridge forming a dam between the fen and field could be removed. Topsoil could be removed in smaller areas where the hydrological conditions are more natural. Removing the topsoil in only small areas would be advantageous, since removing all the topsoil in the area would be very expensive.

Combining mowing and grazing could be a way to manage the site. The farmer who grazed cattle in the area joined the group for discussions. For practical reasons, he was forced to allow the cattle to graze the northern area during the winter. The effects could be seen clearly, as in some areas the level of trampling indicated a high intensity of grazing. The farmer did not think that topsoil removal was necessary, because he had seen that the area was slowly becoming more and more natural. He also remembered the appearance of the site when he used it as a field, and he had seen plants like orchids slowly establish themselves there. He could agree to soil removal in a few small areas.

11. Mörkahålkärret, nature reserve and Natura 2000 area

Mörkahålkärret is a good example of a small fen with high conservation values that needs continuous management.

11.1 General description

The Mörkahålkärret site is an open calcareous fen (1.5 ha), with highest conservation values, surrounded by swamp forest. This fen is dominated by *Schoenus ferrugineus*. More regular management has been carried out since 2006, when the main part of the fen was fenced. Since then the area has been grazed by horses, but at low grazing intensity. The leaseholder has now terminated the contract and, as the area provides poor pasture, finding another leaseholder will be difficult.

Spruce saplings (0.5–1 m) were removed in 2014, and the cleared fen mowed. The plan is to manage the site by mowing in the future, from 2016. A small area in the site, but outside the fence, is mowed annually.

Species present:

- Vascular plants: *Schoenus ferrugineus, Bartsia alpina, Liparis loselii* (VU, N2000), *Ophrys insectifera, Dactyrorhiza incarnata* ssp. *incarnata, D. incarnata* ssp*. cruenta, D. incarnata* ssp. *ochroleuca, D. traunsteineri*.
- Mosses: *Scorpidium cossonii* dominates in large areas.
- Land snails: *Vertigo angustior* (N2000), *V. genesii* (NT, N2000), *V. geyeri* (NT, N2000), *Pupilla pratensis*.

Figure 12: Aerial photo of Mörkahålkärret

Questions discussed at the site:

- Status of the habitat today?
- How to manage the area cost-efficiently and at low cost (annual mowing, mowing every 3–4 years, grazing, spring burning?)
- How to remove the hay?
- Too few *Salix* bushes?

The current status of the alkaline fen is considered to be very good. Previously, the site was grazed by Icelandic horses, but there is now no interest in using the area for grazing; this is probably due to a shortage of edible vegetation and because the site is too remote for easy daily care of the horses. The site is now mowed instead.

The area outside the fen is in a better state than the fen itself, because the land outside the fence is regularly mowed. The fenced area contains more litter than the area outside the fence. This is not an easy area to use for grazing because there is little dry pasture.

Views varied on the desirable frequency of mowing: some project members suggested that the rich fen should be mowed every year, while others felt that the site should be mowed more infrequently. One option could be to divide the fen into two parts, each of which is mowed every second year. Other suggestions were to mow when necessary, or to mow a different quarter of the site every year, so each part would be cut every fourth year. Burning could also be incorporated into this schedule.

Figure 13: Pictures from Mörkahålkärret

Photo: Kristian Nilsson.

Figure 14: Pictures from Mörkahålkärret

Photo: Kristian Nilsson.

The bushes should be cut and removed every year, preferably in late summer rather than during winter. Hay could be burned during the winter. It is important to keep some *Salix* bushes and tussocks since they provide protection for snails. Mowing will lead to the decline of *Schoenus* tussocks over time.

Burning was discussed during the field visit. At this site, there is a risk that seedlings of birch from the surrounding area might invade the alkaline fen if the vegetation is burned, since burning promotes colonisation. However, at the Mörkahålkärret site, there is currently not enough litter for burning.

Figure 15: Searching and looking at snails (in this case *Vertigo Geyeri*)

Photo: Kristian Nilsson.

Figure 16: Searching and looking at snails (in this case *Vertigo Geyeri*)

Photo: Kristian Nilsson.

11.2 Land snails

At Mörkahålkärret, Olle Jonson from the County Administrative Board of Östergötland showed the group how to find land snails in alkaline fens. Land snails need litter for food, water/moisture, calcium and shelter. *Salix* contains calcium citrate, a form of calcium that is accessible for the snails. Tussocks of *Schoenus* are very good for snails because they supply both food and shelter, and old tussocks are particularly good in this respect. Neither birch nor alder contain calcium in a form that is accessible for land snails.

12. Vallgatan-Hälle källor, unprotected

Vallgatan-Hälle källor is an example of a small degraded fen.

12.1 General description

The Vallgatan-Hälle källor site is a small intermediate fen (0.1–0.2 ha), with previously high conservation values, surrounded by swamp woods. Not far from the site, down the slopes of Mount Omberg, there are several other alkaline fens. This fen has not been managed for a very long time and the vegetation is in poor condition, with dense litter accumulations and large areas of *Betula*, *Salix*, *Alnus glutinosa*, *Picea abies* and, in the field and bottom layer, *Molinia caerulea* and *Calliergonella cuspidata*. Some logging took place west of the fen around 2003, slightly improving the light conditions in the fen, but this was only temporary since new forest is now growing.

Figure 17: Aerial photo of Vallgatan – Hälle kälor

Questions discussed at the site:

- Status of the habitat today? Remnant species?
- Restoration needed?
- Hydrology suitable?
- Possible restoration methods?
- Management?

Whether the alkaline fens should be restored depends on many factors, such as whether there are other alkaline fens nearby, whether there is a landowner who is interested and could manage it, and whether there is sufficient funding available. The site could be restored by carefully creating small clearings over a few years, and then mowing the cleared areas every second or third year. The hydrological conditions seem to be suitable, but there are forestry sites quite close to the fen and forestry machines damage the ground. Many participants felt that the fen would be better preserved as the swamp forest it is today. Many of the trees are dying due to the damp soil, and it will probably remain more or less open in the future without management.

Figure 18: Pictures from Vallgatan – Hälle källor

Photo: Kristian Nilsson.

Figure 19: Pictures from Vallgatan – Hälle källor

Photo: Kristian Nilsson.

12.2 Kusiaiskorpi Natura 2000 area, Tornio, south-western Lapland

The Kusiaiskorpi Natura 2000 area (totalling 440 ha, of which about 25% can be classified as rich fen, and the rest poorer wooded fen) is situated in the "Triangle of Lapland", an area in south-western Lapland where carbonate rocks are especially abundant. The Natura 2000 area comprises four separate areas, three of which were visited during the project. The fen area is situated at 12–20 m asl, indicating that the fens are quite young (i.e. less than 2,000 years old), and the rich fens are influenced by the young age and the calcareous bedrock.

Several old ditches affect the hydrological conditions in the rich fens in the Natura 2000 area. The protected area is mainly state-owned, but the immediate surrounding land is private, making restoration difficult. A limestone mine situated adjacent to the Natura 2000 area may also have an impact on the fen hydrology.

Figure 20: Map over the location of the field excursion sites in Finland

Figure 21: Map over the location of the field excursion sites in Finland

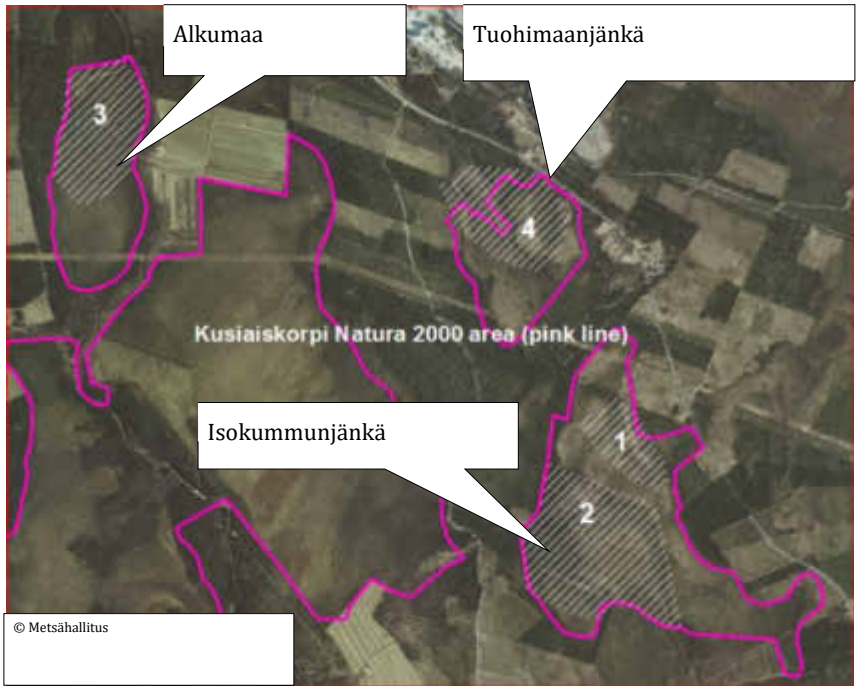


Figure 22: Pictures from Isokummunjänkä where Hamatocaulis vernicosus is found

Photo: Kristian Nilsson.

Figure 23: Pictures from Isokummunjänkä of a part of the restored ditch that haven't been filled

Photo: Kristian Nilsson.

12.3 Isokummunjänkä

Isokummunjänkä (about 60 ha) is one of the most valuable rich fens in the area, supporting a variety of endangered vascular plant and moss species. The eastern part of the alkaline fen with calcareous springs is in a natural state. Iron-rich water, with rare species like *Hamatocaulis vernicosus*, is very abundant.

A large channel was cut through the fen in the 1930s or 1940s. The channel was blocked in 2003 with peat dams, but there was not enough peat to fill it completely.

Although the surroundings of the blocked channel are wet, the recovery of the fen ecosystem further away seems to be insufficient. This is due to excessive water flow in the channel and insufficient diversion of water away from the blocked channel. The problem could be solved by reducing the unnaturally high inflow of drainage water from the catchment to the N2000 area, but this would be very difficult because the land outside N2000 is privately owned. Another solution could be to construct peat dams/surface embankments high and long enough to direct water away from the channel. Careful planning and the use of laser scanning data would be necessary to find suitable sites for additional peat dams and short ditches to divert the water. The National Land Survey of Finland (Maanmittauslaitos) has an accurate elevation model, and planning of supplementary restoration should be started as a matter of urgency.

The restored area also contains a monitoring plot for *Saxifraga hirculus*. No changes have been observed in *Saxifraga* abundance after restoration, which supports the hypothesis about hydrological problems being caused by the blocked channel.

Another discussion topic was the effect of tree removal near the electric power line crossing the fen. While excessively vigorous tree growth may hamper recovery in some places, this is apparently not the case in sites like this, where the current stand is probably very similar to the original tree cover.

An open ditch was clearly drying the surrounding spruce fen close to the eastern border of the Natura 2000 area. The area could be restored by filling the ditch with peat and constructing peat dams to direct the water flow along its original course within the fen. This would lead to rewetting and initiate the recovery of a rich fen ecosystem in the fen depression. The trees near the ditch can be left to increase the amount of dead wood in the ecosystem. Restoration of a small site like this would be most cost-efficient when combined with other measures in the area.

Figure 24: Nature conservation officers and scientists looking at alkaline fens in Finland

Photo: Kristian Nilsson.

12.4 Alkumaa

Alkumaa is an area of mainly rich pine and spruce fens in a natural and restored state. Most of the ditches were blocked in 2003 by filling them with peat. Some ditches had to be left open to prevent wetting of privately owned land. Despite the blocking of ditches, the open ditch at the border of the protected area was clearly hampering the recovery of the rich fen. This is very typical and an urgent situation in Finnish conservation areas; tens of thousands of hectares of protected peatlands are still degrading because of hydrological problems in the catchment outside the protected areas. Negotiations with the landowner would be needed, so that the ditch at the border could be blocked.

Since knowledge about best practice for restoring peatland was still somewhat poor in the early 2000s, filling the ditches was not supplemented by sufficiently high peat dams (surface embankments). This appears to result in a situation where the flow of mineral-rich water is mainly concentrated to the subsided areas along the filled ditches. In the long term, this would result in insufficient recovery of species typical of rich fens outside the filled ditches. It was suggested that supplementary peat dams could be constructed where possible, to direct water flow.

Figure 25: Pictures from Alkumaa

Photo: Kristian Nilsson.

12.5 Tuohimaanjänkä

Tuohimaanjänkä is an area that is severely drained because of ditching, and the nearby road and mine. Privately-owned land surrounding the area makes restoration difficult. Another problem is that a field cleared from the rich fen after the Second World War is negatively affecting the hydrological conditions in the undrained fen within the protected area. There is a proposal to purchase the surrounding areas to allow rewetting inside the N2000 area.

The participants favoured purchase of the privately owned land in the surrounding areas. The land would probably be cheap, since the field has not been used for agriculture for decades and timber growth appears to be poor. Purchasing the land would allow ditches to be blocked inside the Natura 2000 area. The blocking of ditches in the former field was also thought to be preferable, and this would be unlikely to cause any negative effects downstream.

Figure 26: Pictures from Tuohimaanjänkä. At the top, pristine mire and below the area that have been farmland and drained

Photo: Kristian Nilsson.

Figure 27: Pictures from Tuohimaanjänkä. At the top, pristine mire and below the area that have been farmland and drained

Photo: Kristian Nilsson.

13. Ajos rich fen

The 2-ha rich fen was protected due to its varied flora in the early 1980s. Based on a visual expert assessment, the development of some fen vegetation appears to be undesirable; for example, there are signs of excessively vigorous growth of birch and pine, as well as common reed. Rare species, like the white adder's mouth (Malaxis monophyllos), have not been observed lately. However, no data is available on water chemistry or changes in plant communities. There is a large groundwater pumping station nearby, where 400 litres of water are pumped daily.

The possible role of water uptake on fen ecosystem development was discussed during the field visit. Water uptake was expected to diminish the upwelling of groundwater to the site, and result in degradation of habitat conditions for species typical of rich fens. It was also noted that the site is located only 3 m above sea level. The land in the area is rising at approximately 1 cm/year, so the fen was estimated to be only about 300 years old.

There have been some studies of the natural succession in such young mires, but the process is still not well understood. It was also noted that such sites were probably used for grazing or haymaking as late as the 1950s, which typically kept them open. The vigorous tree growth might be due to natural overgrowth when agricultural use ceased.

Figure 28: Pictures from Ajos rich fen

Photo: Anette Persson.

13.1 Murhiniemi

This area on the Ajos peninsula is part of the Natura 2000 network, and comprises 60 ha of protected land area, of which perhaps 2 ha is rich fen. Nearly half of the protected area lies 0–3 m above sea level and is therefore very young, due to the land uplift. During the visit to the site, Sakari Rehell presented his studies on the development of mires. The development from coastal marshes to bogs and Aapa mires can be studied by examining mires located at different altitudes above sea level on the land uplift coast. There are several young rich fens in the area, parts of the land-uplift succession series.

Figure 29: Pictures from Murhiniemi

Photo: Anette Persson.

Figure 30: Pictures from Murhiniemi

Photo: Anette Persson.

The habitats on the land-uplift coast have several characteristic features. The sea contributes many nutrients to the ecosystem (especially P and K), and the succession is characterised by steadily changing conditions, with belts of young mires continuously moving to higher elevations. The result is a high diversity of habitats and species. The unusual conditions allow rare and threatened species to become established, and these require open sites. The situation is also expected to lead to rapid evolution, endemic species and subspecies. These conditions are quite well understood along the shoreline, but the situation regarding young successional mires remains unclear.

The studies show that, on the land-uplift coast, there has been a continuous chain of rich fens, even on calcium-poor sites. The rich fens seem to be quite different from other types of rich fens, and the conditions are basically due to unleached soils and, above all, diffuse groundwater discharge. If the flow of groundwater remains constant, the phase with especially large numbers of rich fens seems to last about 1,500–2,000 years after the site becomes land.

About 95% of the young mires on the land-uplift coast of Finland have been drained, and drainage is even more efficient on the young rich fens. Consequently, only very small and scattered remnants are left. The fragmentation has diminished the abundance of, for example, endangered moss species, even on the sites with no ditching.

In Finland, the Murhiniemi area is the only Natura 2000 area with rich fen areas below 5 m asl (where the catchment area is under 1,000 years old).

Groundwater pumping in the Ajos area may also affect the rich fens in the Murhiniemi Natura 2000 area. However, no monitoring has taken place, so its possible influence is unknown. Water uptake began before conservation started, so there seems to be no possibility to affect the pumping.

Most of the coastal fens were probably used for grazing or mowing until a few decades ago. This has probably affected their plant communities by favouring species typical to open habitats and species tolerant to such disturbances. However, such effects are not well understood.

A suggestion was made to use old aerial photos or data on land use practices to locate sites previously used for agriculture. Collaboration between fen restoration experts and experts on management of semi-natural grasslands should be encouraged. This would result in better understanding of the challenges relating to rich fen restoration and, where necessary, lead to the most efficient restoration and management methods.

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Sammanfattning

Detta är slutrapporten för projektet Rikkärr – värdefulla men svårskötta våtmarker. Projektet har varit ettårigt och bestått av två möten under 2015 där naturvårdsförvaltare och experter på rikkärr från Danmark, Estland, Finland, Island och Norge har träffats. Första mötet var i Sverige (Mjölby, Östergötland) och det andra mötet var i Finland (Kemi, Torneå).

Rikkärr är mycket viktiga värdekärnor för biologisk mångfald och hem för många hotade arter. Dikning, intensivt jordbruk, upphörd hävd, övergödning och försurning är några orsaker till att rikkärr har minskat i utbredning och antal i Europa. I södra Sverige, och i många andra delar av Norden är rikkärren numera endast en spillra av vad som en gång funnits. Restaurering är ofta arbetsamt med därefter återkommande skötselinsatser vilket är kostsamt. De senaste årens restaureringar av rikkärr i södra Sverige visar på att det skulle behövas nya sätt att restaurera och sköta rikkärr.

Projektmålen har varit:

- Utbyte av erfarenhet av att restaurera och sköta rikkärr.
- Visa på goda exempel/metoder för långsiktig skötsel av rikkärr Projektet borde också kunna påvisa kunskapsluckor när det gäller restaurering och skötsel av rikkärr för bevarande av olika artgrupper.
- Göra rikkärren till en modell för skötsel av biologiskt värdefulla men svårskötta livsmiljöer.
- Ta fram en rapport som kommer vara användbar i det dagliga arbetet med skötsel av rikkärr och för framtida projekt som fokuserar på restaurering och skötsel av rikkärr i norra Europa.

Projektrapporten kommer att skickas vidare till Nordiska ministerrådet med syfte att öka det politiska medvetandet om skötsel av rikkärr och skydd av dessa. Inom EU-länder kommer detta skapa synergier för genomförandet av vattendirektivet och habitatdirektivet.

Projektet har varit lyckosamt i sina mål om utbyte av kunskap och idéer. De viktigaste slutsatserna i projektet är:

- Åtgärdsprogram eller ökat fokus för bevarande av rikkärr är nödvändigt i alla länder som varit med i projektet. Hoten mot rikkärr är desamma i norra Europa och det finns ett behov av åtgärder. Alla insatser möjliga behövs för att hindra ytterligare förluster eller försämring i status av kvarvarande opåverkade rikkärr. Fler åtgärder behövs för att öka restaurering och skötsel av degraderade rikkärr för att hindra ytterligare förluster av rikkärrsarter.
- Det finns många metoder för restaurering och skötsel av rikkärr som behöver spridas bland naturvårdsförvaltare. Det finns fortfarande kunskapsluckor. Förslag till goda exempel finns i denna rapport och är baserat på nuvarande kunskapsläge.
- Framgångsrik restaurering och skötsel av rikkärr och andra myrmarker behöver hydrologiska undersökningar. Det är avgörande att ha kunskap om vattenflöden i och omkring ett område för att kunna återfå en ”naturlig hydrologi” och för att genomföra restaureringen på rätt sätt och på rätt ställe.
- Kunskap om traditionellt brukande av rikkärr i ett område är viktigt för att kunna bestämma framtida skötsel av området.
- Landskapsanalyser av rikkärr kan vara användbara vid planerandet av restaurering av rikkärr. Det kan påverka bevarandestrategin och hur restaurering och skötsel genomförs. Ekologisk konnektivitet mellan områden borde tas hänsyn till då det är mer sannolikt att restaureringen blir framgångsrik om det rikkärr i närheten än om rikkärret är helt isolerat.
- Då ekonomin inte möjliggör restaurering och långsiktig skötsel av alla degraderade rikkärr så behöver prioritering ske utgifrån från biologisk mångfald och ekosystemtjänster. Även om prioritering inte är lätt så ger det i längden en kostnadseffektivitet med mer åtgärder genomförda per krona.
- Fler internationella LIFE-projekt och nätverk skulle förbättra skötsel av rikkärr och sprida kunskap mellan naturvårdsförvaltare från olika länder.
- Förbättrat samarbete mellan Universitet, forskarorganisationer och naturvårdsförvaltare kommer förbättra kunskapen om de faktorer som påverkar de långsiktiga resultaten av restaureringar och kommer förbättra genomförandet av goda exempel. Grupper innehållande både personer med forskarerfarenhet och praktisk erfarenhet borde

finnas i varje land för att kunna ta fram mer detaljerade riktlinjer för restaurering samt planering av miljöövervakningsnätverk (till exempel av vegetation och hydrologi). Ett exempel på en sådan grupp är den finska arbetsgruppen för ekologisk restaurering (http://www.metsa.fi/web/en/finnishboardonecologicalrestoration). Även samarbetet mellan rikkärrsexperter och experter på andra naturtyper behöver öka såväl nationellt som internationellt.

- Lantbrukares skötsel av rikkärr behöver ses i ett större sammanhang och inte bara som skötsel av natur. Sålunda måste det ses i ett sammanhang av miljöersättning (åtminstone inom EU) och i ett socio-ekonomiskt sammanhang. Till exempel är naturbeteskött en produkt eftertraktat av konsumenter. Däremot är marknadsföring och kopplingen till landskapets bevarande något som skulle kunna förbättras och projekt inom området i Norden skulle vara av värde (olika länder använder EU:s olika fonder på olika sätt).
- En bättre förståelse för nyskapande av rikkärr, till exempel i anslutning till vägrenar, nyskapta våtmarker som ett kostnadseffektivt sätt att skapa nya rikkärr behövs. ”Surrogatekosystem” skulle kunna bryta den geografiska isoleringen för många kvarvarande rikkärr och göra det möjligt för rikkärrsarter att kunna sprida sig mellan olika områden.

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Alkaline fens

Alkaline fens are species rich wetlands that today are threatened. Nature conservation officers and experts of alkaline fens from Denmark, Estonia, Finland, Iceland, Norway and Sweden visited alkaline fens in Sweden and Finland to discuss the current situation. Restoration and management can be expensive and there is a need to find more appropriate ways to manage and restore alkaline fens.

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