Restoration of raised bogs in Denmark using new methods
- a LIFE Project
Restoration of raised bogs in Denmark using new methods

Experience gained from the restoration of raised bogs and recommendations for further projects. This report is based on the results of the project and on the discussions at the national seminar on 9/10 September 2010.
LIFE Project
Restoration of raised bogs in Denmark using new methods
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Text

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Kongens Mose viewed from the southwest. Photograph: Jydsk Luftfoto

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The project period ran from 2005 to 2011.
The project was run by the Danish Nature Agency.
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LIFE Project · Restoration of raised bogs in Denmark using new methods
Introduction

This booklet collates the experiences gained throughout the entire project period. These include our own experiences, but also those of similar projects both in Denmark and elsewhere. One thing is certain, and that is that each project area is unique and there are no cut-and-dried solutions. The remnants of raised bogs in Denmark are all affected by the interventions of the community surrounding them to such an extent that there are no “ready-made” formulas for their restoration.

What solutions are to be used in an individual project depends on many different parameters, but with the aid of this compendium of examples we hope it will become easier to put together solutions based on the factors that apply to the project that is about to begin.
In restoring raised bogs, hydrology that is as close to the optimal as possible will be crucial. It will therefore always be a case of changing the drainage conditions, and that can have consequences for biology, for the exploitation of neighbouring areas, for technical facilities and so on. Preparatory studies will usually be necessary, to one extent or another, in each of the following fields before a restoration project:

- Hydrological studies
- Ownership studies
- Biological studies
- Technical studies

Preparatory hydrological studies
There is always a need to evaluate how a rise in the water level affects the project area in question and its surroundings. As a minimum, there should be a survey of the terrain and existing drainage of the project area and its surroundings. Contour lines can be obtained using grid levelling, aerial laser scanning or by purchasing the Danish National Survey and Cadastre’s digital elevation model of Denmark. An overview of the drainage conditions can be obtained from drainage plans and plans of the ditch systems, where these exist. Sources may include previous drainage projects or DDH’s drains archive. Long-term neighbours and landowners can also be good sources of such information.

The information about the type of terrain and existing drainage will still be too imprecise to enable evaluation of the impact on the project area and surroundings.

The need for further studies of the hydrology can be assessed on the basis of the following parameters, among others:

- The complexity of the hydrological conditions
- The number of private owners
- The types of sites
- Technical facilities
- Natural assets
- Economic interests

One option is to get an experienced adviser to assess this need. It is a good idea to clarify with the authority responsible for the watercourse in question what requirements they have in respect of documentation of the impact on drainage of any action on cases under the Watercourse Act.

In the most complicated projects, it may be necessary to actually produce a hydrological model based on setting up sounding pipes and measuring the water level over a relatively prolonged period. Producing a model of this kind is quite costly and usually requires external advice. The project included both sites like Kongens Mose that need extensive surveys and sites like Store Øksso and Boestmose, where there were adequate knowledge of the ditch and drainage systems.

Example:

Kongens Mose
Kongens Mose is a very large bog with complicated drainage conditions, which has been extensively exploited and drained. For the state-owned areas of the bog, no drainage plans exist. There are significant economic interests in agricultural land in the border areas along the bog, which mean that any inaccuracy in working out the area of impact will have major economic consequences.

It was therefore decided to produce an integrated watercourse and groundwater model to illustrate the drainage conditions and the effects of closing up various ditch systems. One prerequisite for being able to set up such a model is that sounding wells have been put in place in order to record groundwater levels.

The model is an excellent tool with which to target the ongoing work, so that drainage systems are closed where they impact the conditions of the bog. The model has also been used to determine the consequences for privately-owned land areas in and beyond the bog, for access roads and other facilities. The model is also an important tool in future management of the bog, as it gives some insight into future moisture conditions. This allows one to assess whether, following the closure of ditches, the bog will still be dry enough for the birch to survive, which means that clearance of tree growth will have no long-term effect.

The report describing the model is very technical, and it is not, in itself, suitable for public use, but it is a good starting point for communicating the impact of a project, and particularly for communicating the knowledge and the painstaking work behind the decisions about activities to be undertaken.

Producing such a model is a specialist job, and quite an expensive one (the Kongens Mose model, for example, cost DKK 300,000). Parameters to consider when purchasing the production of a model shall include the size of the project area, the complexity of drainage conditions, existing basic data (it costs time and money to collect data), the anticipated scale of impact beyond the project area, and the overall economy of the project.
**Recommendations:**

- The impact of changed hydrology should always be studied.
- The level of the preparatory studies should be adapted to the topography and ownership situation of the project area.

**Preparatory studies relating to ownership**

The ownership situation in the project area and the closest surroundings must always be known. Both municipalities and the state now have easy access to ownership data via cadastral maps, the Geographic Information System (GIS) and the land register.

There are 3 important reasons to know the ownership situation:

1. In order to be able to inform owners and neighbours about the project - perhaps right from the concept stage.
2. In order to be able to evaluate the need for hydrological studies.
3. In order to be able to evaluate whether there is a need, in connection with the project, for actually purchasing land, for land swaps or substitute land from a government pool.

In the last of these cases and in projects where multiple private owners are affected, it may be a good idea to carry out a proper preparatory study into ownership that includes the following elements:

- Mapping the ownership structure so as to provide an overview of who owns what and the types of ownership that are involved.
- Clarification of the landowners’ opinion of the concept of the project.
- Clarification of the options and desire for land distribution, purchase/sale of land, land substitution and so on.

The majority of information can be obtained independently, but another option is to purchase a preparatory study into ownership. However, when purchasing a study, it is recommended that you participate in the questions period that makes up the core of the study so as to ensure continuity in relations with private landowners.

**Preparatory biological studies**

When an original raised bog is highly degraded (for example as a result of peat extraction) and at the same time is left untouched for decades, secondary natural habitats can develop. These habitats can include natural assets, which are normally considered very valuable and therefore important to protect. As these assets will be affected by restoration, it is important to have them investigated and registered at an early point in time through a preparatory biological study. The data obtained should be incorporated into any assessment of whether a project should be set in motion. The data should also be used if the project progresses any further, for example in applications to the various authorities. At the same time, the data represent an important element of the work that should always be taking place to inform the public.

**Preparatory technical studies**

It is important to have an overview of what technical facilities could be affected by the project, both those that are visible and those that may be below ground. For a fee, data about cables can be searched in the Danish Register of Underground Cable Owners (LER) database (www.ler.dk), or this can be done via a contractor where appropriate. If there are technical facilities or cables in a given land area, it is important to contact their owners as changes in the hydrology and digging work, in particular, can represent problems that may have practical and economic consequences for the project.

Example:

**Brandstrup Mose**

In preparatory technical studies, it was discovered that the pylons for a 60 kV high-voltage power line passed through the bog and needed protection against the planned raising of the water level. Routing the power line through a cable avoiding the bog would involve considerably higher costs. However, through discussions with the power company, an agreement was reached to route the power line through a cable avoiding the bog in return for the project contributing the projected costs of reinforcing the pylons.
There can be quite a large number of official permits that need to be obtained in connection with both clearing of scrub and trees and raising water levels.

As a rule of thumb it is always the municipality that is the access point for the various authorities, and normally, the municipality will forward applications to the relevant authorities.

Making contact with the municipality at an early stage may therefore be recommended, as the municipality is responsible for the majority of processing by the authorities. Therefore, they can help explain the progress of the case-processing, the relationship with other authorities, requirements pertaining to applications, options for parallel case-processing and have a realistic case-processing timetable produced.

If an environmental impact assessment (EIA) report is to be produced, it is important that this be commenced early on in the process as it is often quite a long procedure.

Set out below are the types of processing by the authorities that we came across during the project period, as well as the types of processing that we believe could occur. This list is a snapshot of what applied during the project period. It is therefore a good idea to have your own list on this model that you should update as legislation and rules change.

<table>
<thead>
<tr>
<th>Type of case-processing</th>
<th>When?</th>
<th>Authority</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>EIA notification</td>
<td>Forest clearance. Regulation of watercourses.</td>
<td>Municipality (passes on to the Danish Nature Agency where the state is in charge of the project).</td>
<td>The process to produce an EIA is extensive and time-consuming.</td>
</tr>
<tr>
<td>Protection of Nature Act</td>
<td>For any impact on protected natural habitats.</td>
<td>Municipality</td>
<td></td>
</tr>
<tr>
<td>Historic monuments</td>
<td>Any impact within protected areas around fixed historic monuments.</td>
<td>Municipality</td>
<td></td>
</tr>
<tr>
<td>Museums Act</td>
<td>Declaration that preparatory archaeological studies are required.</td>
<td>Local museum</td>
<td>It is the principal that pays for preparatory archaeological studies unless it is determined no such studies are required.</td>
</tr>
<tr>
<td>Conservation</td>
<td>Where a conservation order is in place.</td>
<td>Local Conservation Board</td>
<td>You can ask the Board whether the project requires dispensation before you actually apply for a dispensation.</td>
</tr>
<tr>
<td>Watercourse Act</td>
<td>Changes to drains ditches and watercourses. In certain circumstances the Watercourse Act requires that a case be processed in respect of alterations to a watercourse.</td>
<td>Municipality</td>
<td>Watercourse alteration cases are extensive and require all other permits/approvals to be granted. The municipalities may have different procedures for parallel/co-ordinated case-processing.</td>
</tr>
<tr>
<td>Planning Act</td>
<td>Change of land use. Facilities such as bird-watching towers car parks and so on.</td>
<td>Municipality</td>
<td></td>
</tr>
<tr>
<td>Building permit</td>
<td>Certain facilities such as bird-watching towers and so on.</td>
<td>Municipality</td>
<td></td>
</tr>
<tr>
<td>Forestry Act</td>
<td>Land which is required to be kept as protected forest.</td>
<td>The Danish Nature Agency</td>
<td></td>
</tr>
<tr>
<td>Habitats Directive</td>
<td>Natura 2000 designation. Habitat species.</td>
<td>Municipality</td>
<td>It is a good idea to produce an evaluation of the impact of the project on the basis of designation and on habitat species as part of the EIA notification.</td>
</tr>
<tr>
<td>Fisheries Act</td>
<td>Blockages in watercourses.</td>
<td>The Danish Directorate of Fisheries</td>
<td>The necessary consultation of the Danish Directorate of Fisheries is normally undertaken by the authority responsible for the watercourse in connection with case-processing under the Watercourse Act.</td>
</tr>
</tbody>
</table>
By far the majority of decisions by the authorities have an appeals deadline – typically 4 or 8 weeks – during which the decisions can be appealed to a higher body. In most cases the body in question is the Nature and Environment Board of Appeals, where a case-processing time of up to 8 months is to be expected. Nearly all appeals have a delaying effect.

Conclusion/tips:

- Early and ongoing contact with the municipality about the case-processing is recommended.
- Feel free to produce a schedule and case plan for the processing by the authority together with the municipality.
- A meticulous approach to filling in application forms, providing descriptions, map annexes, lists of landowners and so on in connection with applications makes the work of the authority easier.
- Be aware that meeting dates for political committees, obligations to consult involved parties, public hearings and announcements in weekly newspapers with long publication deadlines can push back schedules.
Contact with nearby residents and landowners

It is important for the success of the project that there is a positive response amongst neighbours, in particular from any private owners within the project area. Therefore, it is important to establish a good contact with neighbours and the local area – contact with affected landowners being particularly important. This contact can take place in a number of ways – for example discussion in the media, newsletters, public meetings and guided tours, invitational meetings, visits to individual landowners, landowners’ committees, steering groups and monitoring groups. Most of the time, the methods used will be a combination of these adapted to the individual project and to the stakeholders involved.

Especially when the project involves changes in drainage, there may be concerns amongst neighbours which even the best preparatory studies and repeated talks cannot overcome. It may become necessary to decide whether the project should come to an end or be altered, or whether the natural assets involved are so important that the project should be carried through in full awareness that there is a certain amount of local resistance.

Experience gained from this project can be summed up through the following tips:

- Carry out a careful analysis of stakeholders in the project, who is advantaged or disadvantaged by the project and how important they are for the implementation of the various phases of the project.
- Adapt the form of communication to the different types of stakeholder.
- It can be beneficial to get the most important stakeholders closely tied in with the project and perhaps even directly involved in it in order to have the best possible contact with them and prevent major conflicts.
- There needs to be room for differing viewpoints and opinions to be put forward, without this necessarily leading to conflict.
- It is not always possible to avoid conflict, so do not regard a conflict as a defeat, but as a natural consequence of opposing interests.
- Know your mandate for negotiations and your bottom lines for compromises.
- Build confidence that everyone is treated according to the same principles and rules.
- Maintain continuity in direct contact with affected landowners – try not to change project managers during the project.
Information for the local community should be very targeted and adapted to the specific locality and the context in which the project is being carried out.

However, in general it is recommended to be as open as possible throughout the process, from the planning phase, through the implementation and afterwards when the results are becoming known.

The compendium of examples at the end of this booklet provides an illustration of how the task of providing information has been tackled in the various locations within the project.

As with information, public facilities must also be adapted to suit the specific locality. The following may be taken into consideration in the planning stage:

Is the public to have access to the project area, or is it too sensitive or inaccessible for this?
If there is to be public access, both the signage and the marking of paths must be considered.
Some paths should perhaps take the form of boardwalks in wet or sensitive areas.

Boardwalks have not been used to a significant degree in this project, and making contact with Swedish or Finnish projects may therefore be recommended.
One of the factors to consider in relation to boardwalks is that they can become slippery over time and will therefore need treatment of one kind or another. The Swedes use a biodegradable lino tar (wood tar mixed with linseed oil) that does not contain turpentine.

If no access is to be allowed, it is worth considering whether it would be a good idea to set up viewing platforms, bird-watching towers etc., which make it possible to look out over the raised bog.

Otherwise, however, it is possible to add public facilities, depending on the location, as with all natural sites. The compendium of examples at the end of this booklet provides an illustration of what choices were made in respect of public facilities at the various locations within the project.
Boestmose

Velkommen til Boestmose

Boestmose er et af de 7 områder, som indgår i et stort projekt, der skal være med til at redde de sidste rester af højmose i Danmark.


Anbefalede visiter er efterhånden at bo.

Derved bliver mosen langsomt højere end det omgivende terræn – deraf navnet.

Højmoserne er en naturtype, der gennem de seneste lighundre har været krævet på retur i Danmark. Der er nu så få højmose tilbage, at der gøres en særlig indsats for at gennemkalde og bevare dem.

Flere af højmoserne ligger indenfor de udpegede ”Natura 2000-områder” og EU har bevilget økonomisk støtte i form af såkaldte ”Life-midler” til at genskabe og pleje højmoser.

Projektet startede i januar 2005 og slutter i december 2009.

Skovrydning og vandstandsøkning

Rydning af selvsåede træer og sitkagran i Boestmose, kombineret med en vandstandsøkning, vil gøre det muligt at genskabe en hydren mose med indvandring af arter, som er naturligt hjemme-hørende.

Vandstanden højes ved at blokere de gravede grøfter.

Den højere vandstand betyder at spagnummosset igen kan trives, så højmosen atter bliver levende og begynder at vokse i højden.

Smalbladet Kæruld. Foto: Thomas Eske Holm, www.fugleognatur.dk

På vej mod restaurering af højmoseområderne

Flere højmoser ligger indenfor de udpegede ”Natura 2000-områder” og EU har bevilget økonomisk støtte i form af såkaldte ”Life-midler” til at genskabe og pleje højmoser.

Projektet startede i januar 2005 og slutter i december 2009.

Livet på højmosen

Højmoserne er hjemsted for en række plante- og dyremarter, der ikke træffes så mange andre steder.

Det er her, du finder kærvild i tusindvis samt blåbær, tyttebær og tranebær. Det er her, du træffer farvestrålende sommerfugle, som blåfugl og perlemorsfugl. Det er her, bynkefuglen slår sine triller og bekkasinen bræger i den lyse nat, og det er her flyskører fra forskellige arter som spandtør og kviktrappe, afleter velkendte fuglearter.

Bynkefugl. Foto: NatureEyes

Observation tower in Svanemosen.

Public event in Svanemosen May 2010.
Clearance of scrub and trees

When planning clearance scrub and trees, there is a series of circumstances to be considered when choosing what method to use. A thorough review of the land areas is a prerequisite for evaluating the choice of a method and whether the land in question is suitable for a tendering process. The review will shed light on what parameters can be used in the clearing process. The following factors have a significant impact on decisions about whether clearance should take place and what methods should be used.

1. The volume of trees on the land in question
The quantity and size of the vegetation on the land in question is of crucial importance to the choice of methods.

a. Vegetation of less than 2 m in height.
This can be cut down immediately using strimmers or chainsaws and left on the land unless highly flammable conditions dictate that the material needs to be removed. As a rule, the work of removing the large quantity of branches from this type of vegetation is very expensive and without any subsequent income from wood sales.

b. Vegetation from 2 m and upwards or vegetation greater than 10 cm in diameter at chest height.
In this case a specific estimate of the total quantity per hectare is required in order to decide whether or not to remove the material. Sparse vegetation is usually simply cut down and left on the land, while heavier vegetation over 30 m³/ha usually needs to be cut down and then removed.

2. The hydrology
When clearing raised bogs, the hydrology of the land at the time of clearance is also a significant parameter. All the technical solutions depend on the ability to move about on the land in question to one extent or another (with the exception of helicopters) (see Forest and Landscape's working report 44/2008, "Analyse af det bedst egnede eksisterende udstyr til brug for restaureringsopgaver på højmoser" [Analysis of the most suitable existing equipment for use in restoration work on raised bogs]). It is therefore important to undertake actions when movement is most possible. Hard frost or light precipitation are very helpful in this context. Yet even with a hard frost over a prolonged period you should not count on being able to use ordinary machinery on a Danish raised bog. In Finland, for example, there is a rule of thumb that, if a raised bog is to sustain vehicles, two weeks of black frost are required, and if there is snow on the ground, -20°C is optimal.

3. Exit separations and logistics
Generally speaking, Denmark's raised bogs are located in difficult-to-access areas, with the result that exit separations and logistics have a significant impact on the cost of clearance work. The use of roadway plates is also a costly process. Laying, moving and collecting place major demands on logistics, and represent a parameter that can disrupt the timing of the clearance process.

4. Flora and fauna
Monitoring and locating valuable and particularly sensitive biotopes is one element on which a position needs to be taken when planning a clearance. If there are land areas where it is not possible to drive with machinery as a result of cultural history, biology and so on, this should, of course, also be mapped. Similarly, there may also be times of year where it is necessary to avoid working in a raised bog, for example a result of bird breeding, etc.

5. Size of land areas
Compared with the quantity of vegetation, the size of the selected land area is crucial to the method of clearance and the economy of the project.

6. Technical options
These are described in the report, “Analyse af det bedst egnede eksisterende udstyr til brug for restaureringsopgaver på højmoser” [Analysis of the most suitable existing equipment for use in restoration work on raised bogs], Forest and Landscape 44/208.
Experience of tendering process

The work in individual locations was often of such a scale or of such a character that it was put out to tender. This applies to both clearing work and work connected to the improvement of the hydrological conditions.

As stated in the section on clearance, a prerequisite for a good tendering process is good estimation and planning of the scope of the work and a precise description of the expected result.

Various tendering models were used in the project for clearing work.

**There were invitations to tender for turnkey contracts where the contractor removed the mass of wood on the land:** Storelyng and Nybo Mose.

**There were invitations to tender where tenderers had to deliver the wood via roads suitable for cars:** Havemo-sen, Store Øksø, Svanemosen, Boestmose.

**There were invitations to tender where only parts of the process were included in the tender while the rest was carried out in-house:** Kongens Mose.

Generally speaking, the clearing work was well described and therefore reasonably definable in relation to the choice of invitation to tender/form of tendering. The experiences with the invitations to tender and with contractors in the project were also positive.

The costs for clearance showed extreme variation from site to site. Some made a profit, some were almost cost-neutral while for a few the costs per hectare were significant.

The technical nature of the hydrological work varied widely between the individual sites; most were put out to tender as turnkey contracts. However, some work was of such a nature that it was carried out on a billed basis.

Generally speaking, there was a wide variation in the size of the bids received for individual jobs, which probably reflects the fact that there is no great experience in performing work in this type of land areas among potential tenderers.

The experience gained from the invitations to tender is briefly summarised as follows.

1. Evaluate whether the work requires a public invitation to tender or whether it would be enough to obtain offers from experienced contractors – the latter method saves lots of resources in terms of time and is not necessarily more expensive.

2. The invitation to tender should focus on the end result of the work. It is important to focus here on the hand-over of the land in question. Consideration should be given to the fact that the purpose of clearance work is to safeguard natural assets on the land in question.

3. The tender documentation should be specific, measurable, detailed and precise.

4. If the work in the invitation to tender is carried out by multiple contractors or if the landowner is involved in removing wood chips or firewood, a great deal of project management is required in order to prevent bottlenecks in the working process.

5. It may be advantageous for the invitation to tender to include a bonus for the contractor if the latter is able to complete the work more quickly than budgeted. This is particularly advantageous where other contractors, roadway plates or the like are involved in the project. It is possible, in this way, to save money on rent, through reduced dead time, etc.
Various methods are used to block ditches, both in terms of machinery and equipment.
We will go through the following methods below:

A. Blocking small ditches with a maximum width of 2 m using naturally occurring sphagnum peat.
B. Blocking ditches wider than 2 m using naturally occurring materials.
C. Blocking small ditches with a maximum width of 2 m using plates (wood, plastics).
D. Blocking ditches wider than 2 m using iron or plastic sheet piling.
E. Blocking/digging up drains.

A. Blocking small ditches using naturally occurring sphagnum peat

In Kongens Mose and Svanemosen, most small ditches on the raised bog surface were closed up using a small 3-7 tonne digger that provided and moved roadway plates itself. Every time blocking took place, the sides and bottom of the ditch in question were dug clear, and peat within the digger's working curve was “compressed”, which is to say compacted as possible using the bucket of the digger. The length of the blockage was dependent on the width of the ditch: the wider the ditch, the longer the blockage.
The blockages were spaced so that the drop on the ground was roughly 10 cm between each blockage. This method was quick and cheap, costing around DKK 100-150 per blockage, with 3-5 blockages an hour.
With this type of blockage it is important that the ditch is dug clear to a depth corresponding to at least the bottom of the original ditch. In addition, it should be ensured that pure peat is used for the dams – the material must be peat on peat. Furthermore, attention needs to be paid to making the dam sufficiently high, as peat settles over time. Moreover, it should reach far enough into the surrounding ground to ensure that water does not run along the side of the dam.

Outline drawings for the preparatory work carried out before the peat dam was put in place. The figure is based on a diagram that was originally produced in connection with a Scottish LIFE project.
(From Conserving Bogs – The Management Handbook by S. Brooks and S. Stoneman, Edinburgh 1997.)
B. Blocking ditches wider than 2 m using naturally occurring materials

The project in Kongens Mose was characterised by large, wide ditches that drained the bog. Depending on the drop and the width of the ditches, the choice was between two methods: either blockage using naturally occurring materials or using strong iron sheet piling. The deciding point for the use of iron sheet piling or natural materials was a ditch width of 4 m. Below 4 m, natural materials were used, while iron sheet piling was used when the width was above 4 m. When the ditches were originally dug, the excavated material was deposited on one side of the ditches. Roadways were then laid on this material.

Since the excavated material was thus on hand, it was an obvious choice to use it to fill in the ditches again. Where there was sufficient material, it was used to fill the entire ditch. In order to ensure that water did not simply continue to flow under the filling, the sides and bottom of the ditches were dug clear and then the filler material was compacted, just as with the dams for the small ditches. Compression can take place using the bucket of the digger or by driving the filling machinery over the ditch after filling, whichever is the most appropriate. This step was carried out with an appropriate separation of roughly 50 to 100 m. A roughly 25-30 tonne digger was used in excavation, compacting and so on.

The edges were also excavated out in order to ensure the free movement of water on the land areas in question in such a way that the water that is dammed up in the ditches is able to diffuse into the surrounding areas and is not retained by the dikes along the ditch.

Where there was insufficient material, dams were made. With wider ditches, too, it is important that the ditch is dug clear to a depth corresponding to at least the bottom of the original ditch. In addition, it should be ensured that pure peat is used for the dams – the material must be peat on peat.

General experiences for peat dams
Experience from covering the ditch plates with peat shows that people often underestimate just how much the dam will subsequently subside when working in partially water-saturated and buried peat.

It must also be considered that there can be significant wear and tear from game as the animals often seek out the dams when they want to cross the surface of the bog.

| Dam built, January 2008. During the winter, red deer and roe deer forage for food in the many new heather plants on the surface of the bog. They use the dams when they want to cross the ditches. The resultant wear and tear is considerable and will ultimately dislocate the top of the dams. However, in this case a plate was hidden under the peat (1 June 2010). As a rule, however, the dams need to be made higher and to extend further into the ground alongside the ditch than people imagine. In a 3 m wide ditch, the dam should be 30 to 50 cm above the ground, 3-4 m wide and be long enough to extend 1-1.5 m from the edge of the ditch. |

C. Blocking small ditches using plates (wood, plastics)

In the first year of the project, attempts were made in Kongens Mose to use large plates made of both (non-profiled) plastic and waterproofed plywood as a means of blockage. The plates were compressed, buried or pounded down either manually or compressed using a digger.

The plastic plates were produced in Denmark; they were completely smooth and considerably cheaper than the profiled types developed specifically for use as sheet piling.

Negative experiences of smooth plastic plates
The large non-profiled plastic plates were too unwieldy to be pounded down into place, while with burial the earth could not be properly compacted afterwards, with the effect that water quickly found its way around them.

This last point also partially applied to the plywood plates. It was a problem that it was difficult to determine whether the plates were far enough down to close off the flow of water in the bottom of the ditch.

With large bog areas, transporting large and heavy plates is tricky and costly, and this can make this method more expensive than peat dams.

Positive experiences of other types
There were better experiences with plates on other project sites, where both plywood and plastic plates were used.

Plates made of waterproofed plywood were used where transport was not a problem, whilst plastic plates were used where it was not possible to drive with machinery or where the vegetation was particularly sensitive.

The plastic plates used were the specially-developed and somewhat dearer plates that can be obtained in numerous versions from both the UK and the US.

One type is 33 cm wide and 150 cm long and the plates can be interconnected. The plates are fitted manually using a special metal rail that enables the plates to be pushed/pounded down into place. The plates are carried into the raised bog using a small winch rig.
The plywood plates have a standard size of 122 x 244 cm, which puts a limit on how large the ditches can be if they are to be closed up using such plates. On Nybo Mose, numerous plates were laid together at a width of 5 metres and a depth of 1.5 metres. The plywood plates were put in place using the bucket of a small digger. At some of the sites, the plywood plates were subsequently covered with peat so that in reality the result was a peat dam with additional plate. That was not the case with the linked plates, however.

**Wooden plates**

- Various types of plywood plates in the standard size of 21 mm x 122 cm x 244 cm were used. Use was made of some standard plates and of some special film-coated, waterproofed brown plates (moulded plates). The prices vary somewhat according to the market situation, from the current approximate cost of DKK 65 up to DKK 100 per square metre, which produces a cost of DKK 195-300 per plate.
- On the 16 km of ditches on St. Økssø Mose, a total of 730 blockages were put in place. The blockages are put in place for roughly every 10 cm of ground difference. Where the ditches were too wide or deep multiple plates were put in place together using screws and fittings on both sides.
- The plates are driven out to the area using a small caterpillar-tracked truck and a small winch rig.
- A 7-tonne digger with wide caterpillar tracks was used to lay the plates. In order to pave the way for the work, roots were slit using a sharp pit tooth. The plate was then put in place and pounded down using the bucket of the digger.
- In order to protect the plate, a strong iron U-section was placed above the plate when it was pressed into the ground. This is important, as a frayed edge will break down more quickly. For the same reason, the plates were not allowed to have tongues and grooves.
- Thereafter, the plates were covered with peat by excavating material upstream in the ditches.
- The plates cost between DKK 130 and DKK 220 each to put in place, depending on the job and the spacing.

**Plastic sheet piling**

- Some trial use was made of small-sized plastic sheet piling for manual implementation from the company HL Plastics. More information can be found on the company’s website at [www.hlplastics.co.uk](http://www.hlplastics.co.uk)
- This sheet piling is suitable for sites that are difficult to access, as it does not weigh very much. It can be purchased in the lengths required. The pieces are easy to cut either to the lengths needed or if the plate comes up against solid objects.
- They are pounded down into place with hammers, but where there are roots, forward incisions need to be cut into the peat using large chainsaws. That is also why only the flat mouldings were used.
- They cost somewhat more than the wooden plates at around DKK 250/m², which would correspond to DKK 750 per plate given the size of the plywood plates.
- If the peat is not properly compacted around the plates, water seeps through the tongues and grooves, in contrast to the wooden plates, which are entirely leak-proof.
- If not covered by peat, in the long term the recycled plastic will be broken down by UV light.

**LIFE Project · Restoration of raised bogs in Denmark using new methods**
Plywood plates being put in place, January 2008.

Same location, June 2010.

3 year-old blockage. The plywood plate can just be seen at the surface, partly as a result of the dislocation of the peat and trampling down by game and goats, but greening is well underway and the plywood plate will be overgrown.

It is really important that the plywood plates be covered with peat so that they are kept moist and are grown over. This plate was simply not covered and has begun to break down.

Blockage using plywood plates in Nybo Mose.

Plastic piling in Nybo Mose.
D. Blocking ditches wider than 2 m using iron sheet piling

**Kongens Mose**

This method was used for the main drainage channel at Kongens Mose, which is 4-6 m wide.

In order to find out how long the sheet piling would need to be, numerous trial holes were dug close to the channel in order to see how deep down it was necessary to dig before hitting a solid bed (i.e. a clay or sand layer).

The solid layer was between 4 and 5 m below ground level, meaning that in order to be entirely certain of sealing the bed, a sheet piling length of 6 m was chosen.

The thickness of the sheet piling was not of crucial importance. There will not be pressure on the sheet piling as there is stagnant water on both sides. The minimum thickness of 8 mm was therefore selected. The sheet piling has a simple U-shaped profile and each iron pile is roughly 1.2 m wide.

The price of the sheet piling at the time of purchase was DKK 8,298/1,000 kg, which corresponds to roughly DKK 5,400/pile, but be aware that this price can fluctuate widely.

The sheet piling was vibrated down into place rather than pounded down. The digger used was a 34-tonne machine with a vibrator fitted in its digging arm (hourly rate of roughly DKK 900).

No sealant was used as the interlock of the sheet piling sealed shut very quickly.

In order to control the sheet piling, there was a ground staff of 2 who ensured that the interlock of the sheet piling fitted in place. For safety reasons a peat dam was made wherever sheet piling was to be put in place. That provided a stable working platform for the ground staff, while also making it easier to vibrate the sheet piling down into place. The dam also ensures the blockage of the channels when the iron sheet piling corrodes over the years. How quickly that happens depends on the acidity of the water in the major drainage channels.

Iron sheet piling represents a very secure method of stopping the flow of water and can be recommended for very wide ditches.
E. Blocking/digging up drains

Ordinary drainage pipes are to be found only at one of the sites (Kongens Mose). On that site, however, the drainage pipes were present in many cases and were also of considerable size and depth.

In some places the pipes were shown on drainage plans, but in other places drains were discovered completely by accident. This means that it is impossible to rule out the presence of drains at other project sites.

In a central area in Kongens Mose (Russerfennen), on one occasion it was discovered that the whole area had drains running through it.

This area abuts right onto the intact part of the bog, but has a different type of vegetation to the kind in that area, namely purple moor grass with strong tussocking. It was this difference that gave an indication of the undiscovered drainage system of 100-year-old clay pipes.

In Russerfennen, the drains were dug through with one small channel every 20 metres, with peat being compressed into the said channels in the same operation.

This method was used everywhere else where drains were found, irrespective of their size.

As with the construction of peat dams, it is important that the sides and the bottom are dug clear before the peat added is compacted.
### Ditches of up to 2 m

<table>
<thead>
<tr>
<th>Method</th>
<th>Sites</th>
<th>Technique</th>
<th>Empirical data (average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blockage using sphagnum</td>
<td>Kongens Mose, Svanemosen, Brandstrup Mose</td>
<td>Roughly 1 blockage for every 10 cm drop.</td>
<td>3-5 blockages/hour, DKK 150-200/blockage with a large number of blockages and easy terrain. Up to DKK 850/blockage with a small number of blockages and difficult terrain.</td>
</tr>
<tr>
<td>Blockage using sphagnum plus wooden plates</td>
<td>St. Økssø, Boestmose, Svanemosen</td>
<td>Roughly 1 blockage for every 10 cm drop.</td>
<td>DKK 350-550/blockage</td>
</tr>
<tr>
<td>Plates, wooden</td>
<td>Nybo Mose, Portlandmosen</td>
<td>Roughly 1 blockage for every 10 cm drop.</td>
<td>DKK 720 pr m² (Portlandmosen)</td>
</tr>
<tr>
<td>Plates, smooth plastic</td>
<td>Kongens Mose</td>
<td>Roughly 1 blockage for every 10 cm drop.</td>
<td>DKK 250-350/blockage</td>
</tr>
<tr>
<td>Plates, profiled plastic</td>
<td>Store Økssø, Nybo Mose, Storelung, Portlandmosen</td>
<td>Roughly 1 blockage for every 10 cm drop.</td>
<td>DKK 1,000 pr m² with top stringer (Portlandmosen)</td>
</tr>
<tr>
<td>Filling in</td>
<td>Kongens Mose</td>
<td>Ditches filled using the material excavated when they were originally dug.</td>
<td>DKK 25-50/m</td>
</tr>
<tr>
<td>Filling in combined with blockage</td>
<td>Finland</td>
<td>Peat dams spaced 20-30 m apart. The ditch in between is filled in.</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### Ditches larger than 2 m

<table>
<thead>
<tr>
<th>Method</th>
<th>Sites</th>
<th>Technique</th>
<th>Empirical data (average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plates, profiled plastic</td>
<td>Portlandmosen</td>
<td></td>
<td>DKK 1,000 pr m² with top stringer</td>
</tr>
<tr>
<td>Filling in</td>
<td>Kongens Mose</td>
<td>Ditches filled using the material excavated when they were originally dug.</td>
<td>DKK 50-75/m</td>
</tr>
<tr>
<td>Filling in combined with blockage</td>
<td>Finland</td>
<td>Peat dams spaced 20-30 m apart. The ditch in between is filled in.</td>
<td>N/A</td>
</tr>
<tr>
<td>Filling in combined with blockage and large-sized iron sheet piling</td>
<td>Kongens Mose</td>
<td>The piles were vibrated down into place using a digger. A ground staff of 2 was on hand to control the sheet piling.</td>
<td>8.4 m of sheet piling (7 units) totalling roughly DKK 40,000/blockage. Highly dependent on the price per kg of iron sheet piling, which at the time of use was roughly DKK 8,300/tonne.</td>
</tr>
</tbody>
</table>
When it comes to the restoration of raised bogs, overgrowing is still the biggest land management challenge. Depending on the conditions, land management can be organised in various ways. The review of land management measures is split into the following sections:

- General conditions
- Old birch and coppice shoots
- Cutting down birch and coniferous trees
- Grazing

**General conditions**

An active raised bog that is in balance is naturally free of trees on the surface of the bog itself. The unfavourable environment for trees on the surface is the result of a combination of low pH levels (around 3.5 to 4), high water level, which is around 10 to 15 cm below the surface for a large part of the year, and finally the fact that the water supply for the surface consists of rainwater, which is low in nutrients. In addition, the established dwarf shrub vegetation on the surface of the raised bog provides so much shade that it is difficult for any new seedlings to establish themselves.

In the lagg zone it is natural for marginal woods to occur, primarily of birch, Scots pine, Norway spruce, Sitka spruce or willow, depending on the local seed sources. Trees are able to survive without difficulty here because at the edge of the bog the water supply comes partly from the surrounding areas of land, which provides more favourable growth conditions, that is higher pH levels and higher nutrient content.

All of the above conditions must be taken into consideration when organising land management. When restoring former raised bogs, the work does often include restoring the hydrology when blocking off ditches, and to a greater or lesser extent removing trees and vegetation.

The impact on nutrients can be difficult to control within the bog area. The process of cutting down and removing trees, brushwood and needles can remove nutrients from the surface. However, the increased quantity of nutrients in the rainwater which, depending on the location, can amount up to 20-25 kg of pure N/ha/year, constantly adding new nutrients. There is therefore some indication that the deficiency of nutrients no longer “acts” as a limiting factor for overgrowing for the majority of raised bogs in Denmark.

On the bog surface at St. Økssø Mose, it was clear that the deficiency of nutrients had “controlled” the commencement of natural overgrowth of the surface 50 to 70 years ago, as the oldest/largest trees, primarily birch, had just established themselves in former ditches, and on the edges of the old peat-cutting sites, where drying out and mineralisation of the peat had released nutrients and where it was also driest.

At present, however, it is almost the case that standing water is needed in order to hold back birch growth. Even in very wet conditions in former peat-cutting sites and on transition mires, small, strongly-growing birch plants can be observed.
Old birch: drowning and semi-shade

Older birch trees on bog surfaces often have large and flat root systems developed over a long period in connection with the water level present in the bog peat. It is the available oxygen in the soil that is the crucial factor for the development of the roots. Short periods with a higher water level do not kill the trees, but where the water level is raised permanently, they begin to die off after 2 to 5 years. If birch is felled too long before the water level rises, the re-growth reacts more like young birch, which is considerably more difficult to drown.

With older birch on a bog surface to which a lot of water can be added through the closing up of ditches or similar measures, raising the water level without carrying out clearance first constitutes an effective but slightly protracted method of killing the trees. This also means that there is no large-scale re-growth problem. With this method, you have to accept the fact that over a long period of 5 to 20 years, depending on their size, the trees will stand and fall together and that the nutrients remain on the surface.

In the project, this method was tested on a large scale at Brandstrup Mose, but it was so late in the course of the project that there is no result yet.

It is nonetheless possible to remove some of the trees by means of a kind of thinning, as the shade effect from the remaining trees can obstruct the survival of coppice shoots in the semi-shade.
Old birch: general conditions for coppice shoots
After felling, old birch will produce lots of new shoots from the stump. The growth potential for these shoots is optimal, with a large root, and it is not unusual to see 1-metre saplings at 1 year old.
Depending on the density of stock on the land in question, the re-growth after 2 years can be so massive that the available light for the bottom flora on the raised bog is actually less than when the old trees were still standing.
This means that if resources are not in place to combat the re-growth, the initial clearing can be almost wasted, as it will be many years before natural selection produces open-light conditions again in that area.

Old birch: cutting down of coppice shoots
The re-growth of birch trees takes place not from the stump surface itself but from sleeping buds just above or below the ground level.
Studies have shown that up to 90% of the shoots come from below ground level.
The stump and the end of the root make it very difficult to cut down new growth completely, especially in the case of larger stumps. This work can be performed using a chainsaw, which is also very capable of cutting through the peat surface without becoming blunt, but the working posture and the risk of the chainsaw “casting out” mean that most choose brush cutters with a circular saw blade.
The circular saw blade will also “cast out” when it saws into the stump, so in practice the vegetation will be trimmed a little above the level of the stump, resulting in even more growth points being left behind, which will shoot again the same year or the following year, depending on when the cutting takes place.
In addition, it is important to take into account the need for further clearance work during the initial clearance, as tips and brushwood left behind in the initial clearance can make the subsequent work very difficult. What is more, the brushwood protects the new shoots from being chewed down by roe deer and red deer. In the same way, re-growth can reach a height of over 2 metres in just two years and will, in itself, fill out to such an extent that movement in the area and further clearance will also become more difficult. It is therefore important from a costs point of view to have the work finished before the growth of vegetation is too large.

A method is being tested in Brandstrup Mose whereby the cleared trees are being left on the ground. This is being done where it is certain that the water level will remain high once the hydrology has been optimised. The expectation is that the water will prevent the re-growth, while the brushwood will form a medium for new sphagnum growth.

Coppice shoots just above and below the peat surface. The stump is too large for the work to be done using brush cutters.

Material from the first cutting is not removed and are a great nuisance to an effective reduction of regrowth.
**Old birch: felling with high stumps**

North Jutland County has discovered previously that leaving a high stump of around 1 metre may cause birch to die off. This method has also been used successfully in a small area of Holmegårds Mose in South Zealand, although in this case it was combined with grazing by sheep. This method has been studied on a small scale in the St. Økssø project and on a large scale in clearance work on Portlandmosen at Lille Vildmose. The resultant experience is now clear – the stumps provide just as vigorous coppice shoots as when stumps are cut to the normal level. Furthermore, the higher stumps make it harder to move around. This method is therefore not to be recommended.

**Old birch: starving out birch stumps**

All trees can be killed by destroying their basic life functions over a shorter or longer period. Previous attempts to cut off the water supply to old birch trees at St. Økssø by ringing the trees (using chainsaws) did not work. In order to starve the old birch stumps, an intensive programme of removing re-growth was initiated at St. Økssø in order to kill off the stumps by “blocking” photosynthesis. As described above, chainsaws and brush cutters are far from the ideal tools for this kind of work. After trying various kinds of pickaxe and spade, the tool chosen was a lightweight axe with a long handle.

These axes were the best tools to remove all the new shoots just above and below the ground level and in between the root ends. The felling of the trees was carried out in the autumn and the first action took place in the middle of June when the new shoots were 20-30 cm high. Most of the stumps produced new shoots, and at the end of July these were dealt with again, after which only very few shoots could be observed over the course of the autumn. In June the following year, the area was reviewed, and around 70% of the stumps were dead, with the coppice shoots on the remaining stumps being cut down. The assessment in August was that around 90% of the stumps were now dead.

The overall assessment is that this method:

- **Is very effective at preventing re-growth from old birch stumps.**
- **Saves time**, as 2-3 actions ultimately kill off the stump, as opposed to many years of repeated cutting down with brush cutters.
- **Is best suited to stumps of a certain size** – diameter roughly 5-6 cm and upwards – whereas old, 2-3-year-old coppice shoots are best eliminated using saws and cutting as low as possible, ideally down into the peat.
- **That from a cost point of view the method is, of course, very dependent on the number of stumps per hectare.** It became apparent that the number of stumps to be dealt with was greatly reduced in the course of the 2 years of action. On the St. Økssø project, the work varied between 3 to 5 hours per hectare per action. That is a considerably lower amount than for the corresponding use of brush cutters or chainsaws. It is, however, important that the shoots are no larger than roughly 20-30 cm before they are cut down so as not to pose an obstacle to the working process itself and in order to block photosynthesis and thus starve out the stump.
Old birch: crushing birch stumps
A method was tried on Svanemosen that involved crushing the stumps of old birch using a wood crusher transported on a snowcat.
The results were mixed: the old stumps and the growth from them did weaken decidedly, but on the other hand the crushing exposed a large amount of peat, which it is to be feared will become a seed bed for birch.
Young birch: cutting down growth

In many project elements, young birch growth was cut down. This consisted of older coppice shoots from previous clearance work, the cutting down of new coppice shoots or of new seedlings. The costs here are also very dependent on the number of stumps and trunks per hectare. Cutting down at 3-yearly intervals has been the land management policy of the Danish Nature Agency in Aalborg for old bog surfaces. The resultant empirical data is set out below.

The results show that cutting down growth every three years did not bring about any kind of reduction in the birch tree numbers for the areas in question. The cutting down took place immediately after the trees had used growth energy on leafing in early June, and the experience was that their growth could be pared back to the greatest extent at that time. At that time, young birch, with light green leaves, are also easy to find even on large bog surfaces. It is important to cut the stumps low as this reduces the number of shoots that manage to fight their way through the bog vegetation. In practice the brush cutter blades “hack” into the peat in order to cut the plants as far below the new re-growth points as possible.

<table>
<thead>
<tr>
<th>Site</th>
<th>Hours/hectare /action</th>
<th>DKK/hectare /action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Store Øksø</td>
<td>20</td>
<td>4,500</td>
</tr>
<tr>
<td>Svanemosen</td>
<td>12</td>
<td>3,200</td>
</tr>
</tbody>
</table>

In order to investigate whether the method can be developed so that it also provides a better long-term impact in terms of reducing the number of viable plants, including whether young plants can be killed off along with the old stumps through intensive cutting down, the Danish Nature Agency Aalborg has been carrying out a trial since 2007.

The trial encompasses the following actions:

- A zero plot (O), where no further action has been undertaken since the plots were cleared of brush in the autumn of 2005.
- A plot (A) with 1 cutting operation each year following leafing (around 1 June).
- A plot (B) with 2 cutting operations each year following leafing (around 1 June and in the middle of July).
- A plot (C) with 3 cutting operations each year following leafing (around 1 June, in the middle of July and around 1 September).
- A plot (D) with a cutting operation every third year (2005 and 2008); (no image looks like A).

(All cutting operations were carried out with low stumps, where possible even below the surface).

The results of the study are backed up by Swedish studies, the main results of which were as follows:

The Swedish study results calculated after 2 growing seasons with 1 or 2 cutting operations in the same year, and with low and high stumps. The starting basis is roughly 1.25 metre seedlings, 4 years of age.

Method of felling | Proportion of stumps with new shoots | Number of shoots per living stump | Height of shoots, average | Height of shoots, maximum |
<table>
<thead>
<tr>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>One action per year, in May, 20 cm stump height</td>
<td>77 %</td>
<td>2.1</td>
<td>1.20 m</td>
<td>1.56 m</td>
</tr>
<tr>
<td>One action per year, in May, low stump height</td>
<td>50 %</td>
<td>2.3</td>
<td>1.05 m</td>
<td>1.42 m</td>
</tr>
<tr>
<td>Two actions per year, in May and mid-July, low stump height</td>
<td>27 %</td>
<td>0.8</td>
<td>0.39 m</td>
<td>0.54 m</td>
</tr>
</tbody>
</table>

The title of the report is “Upprepad röjning av stubbskott – en metod för minskning av skottmängden” [Repeated clearing of coppice shoots – a method to reduce the quantity of shoots]. The report was written by Tord Johansson and Jan-Erik Lundh and published in FAKTA SKOG (Findings from the Swedish University of Agricultural Sciences), Issue 5, 2009.
For cutting operations with low stumps, the survival rate is 50%, as compared to 77% for ordinary stump heights. Where there are 2 cutting operations and low stumps, only 27% survive, and the number of shoots per stump and the height development are only a third of what they are with 1 cutting operation. It is also important that the second cutting operation takes place in the period from the middle of July to the middle of August, as cutting in September has proven largely ineffective, which is surely down to the fact that the trees are already feeding nutrients back to trunks and roots.

The main conclusion is that carrying out intensive cutting operations 1 or 2 years in a row considerably reduces the re-growth problem. From the point of view of costs and resources, this will also give a return on investment quickly in comparison with many years of close to completely ineffective brush clearance, such as every three years.
Young birch growth: seedlings and grazing

With first-time clearing, re-growth in the first few years is dominated by re-growth from old stumps and then young trees, but a few years later the emergence of new seedlings can be enormous, with up to 50 to 100 plants per square metre. It is most commonly birch, but if Norway spruce, Sitka spruce or Scots pine is located close by, they can also pose a problem in regard to self-sowing on this land. Numerous factors are of crucial importance for how serious the problem becomes.

If there are seed sources in the vicinity, such as larger solitary trees or actual tree stands, consideration may be given as to whether to remove them in order to reduce the problem. If there was birch on the land in question, there is a very large seed bank hidden in the earth which will germinate when the opportunity arises, requiring light, heat and a good germination site. Shade caused by trees that have been left behind can hinder the survival of seedlings, as can covered soil, for example where there is dwarf shrub vegetation on the land in question. The absolute best germination surface for birch seeds is exposed peat. This kind of surface warms the soil well and provides the optimum seed bed for the plants, which can be as close as in a nursery. It is therefore very important to prevent the exposure of peat on this land.
Where there is enormous growth of seedlings, brush clearance will be a very expensive land management task, and in light of this testing of goat grazing has been initiated at St. Øksso. In contrast to other domesticated grazing animals, goats prefer woody plants to herbs and grasses.

The trial was set up as follows.

- Fencing-off using 4-wire electric fencing, which is the most effective kind for goats.
- Goats also differ from the likes of sheep, for example, by being better able to get out of ditches or soft areas. Cattle would trample the bottom underfoot, with a risk of new seed germination.
- Durable Robinia posts were used, and the fencing cost was DKK 40-50 per metre of fencing.
- Livestock bridges over the ditches were set up in order to spread traffic out over the land as much as possible.
- The fencing included neighbouring areas (high-lying ground) for overnight areas, which meant that all of the dung produced overnight would not reach the bog itself.
- Boer goats were used (the best and hardiest), with dairy goats used earlier on. Rental costs were DKK 300/goat/season.
- The goats are released onto the land in question shortly before the birch leafs.
- At the start of grazing in the summer of 2008, the seedlings were roughly 2 years old and were roughly 1 metre high and very high in number.
- The grazing period obviously depends on the number of goats and how heavy the growth is. In the first 2 years, clearance was to take place, and grazing took place during the warmer half of the year, with 50 goats on 11 hectares.
- Going forward, the plan is for grazing to take place over shorter periods as the birch trees die off.
- Demonstration plots were set up, where various actions are combined with the previous population of 45-year-old Sitka spruce alone and roughly 50 to 70-year-old birch forests mixed with Scots pine and Norway spruce.
- The actions are zero parcel, grazing, brush clearance every year around 1 June and both grazing and brush clearance.

Happily, both birch and purple moor grass is on the top of goats’ bill of fare.

Store Øksso. The situation at the start of grazing in May 2008. Besides Heather and others characteristic bog species, there is plenty of birch and purple moor grass.
Four photos showing the situation after a grazing season, mid-September 2008.

At the end of the first grazing season. It is obvious that the re-growth of birch is completely defoliated.

At the end of the first grazing season. Here you see the goats and the heavily grazed tussocks of purple moor grass.

In the foreground the grazed area, in the background the high-lying ground where the goats can find dry conditions. In between one of the o-plots.

To the left one of the o-plots. It is clear that the birch outside the o plot is completely defoliated and the tussocks of purple moor grass have been chewed down. In the background can be seen the high-lying ground where the goats go to rest in both daylight hours and overnight, thus removing nutrients from the actual surface of the bog.
The goats really graze heavily on the tussocks of purple moor grass. A livestock bridge over the lagg zone can be seen to the right, while 0 plots can be seen in the centre.

The boundary between ω-parcel and grazed area. The picture speaks for itself.

Re-growth of birch defoliated and heavily grazed.

Defoliated young birch dug up, root growth tells of weakened and dead plants.

Among the defoliated young birch are new shoots coming up from dormant buds below the surface.

Four photos showing the situation on 1 June 2010. After 2 seasons where the goats have eaten most of the leaves, the assessment is that around 50% are completely dead, while the remainder still has living roots, including some that have begun to produce shoots from the dormant buds below the surface. This re-growth will presumably also be grazed away.
In the front the grazed area, 0-plot in the background (1 June 2010, after 2 seasons).

In parts of the bog there are some Sitka spruce seedlings. The goats are unable to kill these, but the new shoots are eaten (1 June 2010, after 2 seasons).

After clearing old Sitka spruce coverage (1 June 2010, after 2 seasons).

Grazing only.

Brush clearance.

Brush clearance and grazing.

Grazing only.
Foreign experience with grazing on raised bogs
In the Dutch LIFE project Bargerveen, grazing was successfully tried out.
Main conclusions on grazing

- The goats are very effective, especially in respect of birch and purple moor grass, which must be regarded as the biggest problems when restoring former raised bog surfaces.
- The behaviour of the peat base can be greatly limited by arranging fencing, rest areas and livestock crossings appropriately.
- The goats are selective in comparison with cutting down using brush cutters, as dwarf shrubs and other bog flora are at the bottom of their menus. Where there was a great deal of birch overgrowing, almost the entire surface of the bog was cut down, and with the recommendation of cutting stumps as low as possible, the dwarf shrub vegetation that was beginning to emerge was also cut down each time. This results in the area bursting out in grass rather than heather, which will, in the long term, provide more shade for any new birch plants.
- Grazing can be used both for short-term clearance and for subsequent periodic use, depending on new birch seedlings.
- When establishing grazing immediately after clearance, the goats remove both the re-growth of old and young stumps and any new seedlings.
- Grazing cannot be a long-term land management action for a raised bog. There needs to be both an implementation strategy and an "exit strategy".

Generally speaking, all land management actions, including the option of movement using special machinery or establishing grazing, are viewed from a holistic perspective of what is realistic, what is best and what cheaply ensures the restoration of the natural environment. Grazing as a means of managing raised bog surfaces is to be seen in this context and in relation to the major birch overgrowth risk of some bog surfaces, which, in the space of very few years, can transform the bog surface to a barren, dark surface beneath a young birch forest.

It is worth mentioning, as something of a special case, that on Nybo Bog there was no growth on the surface of the raised bog itself at the start. This was presumably as a result of grazing by the free game population there as, following the reduction in the roe deer population on Funen over recent years as a result of disease, the vegetation growth on the raised bog surface increased.
Controlling purple moor grass

A couple of trials have been conducted into controlling purple moor grass through mulching.

The first trial primarily involved mulching birch growth on a quite wet area in Svanemosen, but as there was also a large amount of purple moor grass on the land in question, a further objective was to see the effect of shredding on purple moor grass. There was a great deal of sphagnum in the ground prior to mulching. The birch on the land in question was completely removed by mulching, but in order to minimise the damage to the peat, the mulching did not go deep enough to completely crush the purple moor grass tussocks.

A real test of the method was carried out on the Russerfennen area of Kongens Mose. The area in question is right in the middle of the bog and – as a result of undiscovered drainage dating from the First World War – was completely overgrown with tussocks of purple moor grass nearly a metre in height. In connection with breaking up the old drains, the purple moor grass was crushed in the following ways.

- Crushing of the surface of the area, so only the green part was mulched.
- Result: no overall impact even after 3 rounds of mulching.
- Crushing using a crusher so that the uppermost roots themselves are mulched. The crusher was taken in deep and used twice on the area.
- Result: after two years of growth there is a clear and major impact using this method, but a longer period is required in order to observe whether the purple moor grass dies off after an action or simply stops growing.

Mulching took place in 2 of the areas in both the spring and the autumn, but it did not have a noticeable effect on the purple moor grass.

If an impact is to be achieved, there is still a need for complete peeling-off of the purple moor grass so that the earth is exposed and you start from the bottom.

The conclusion from Kongens Mose is thus that radical solutions are needed if the purple moor grass is to be eliminated. In addition, the purple moor grass has a very inhibitive effect on the growth of self-seeded birch, so that to some extent there is a choice to be made between wanting birch as a result of any peeling-off of purple moor grass or keeping the purple moor grass and hoping that it slowly drowns as the water level is raised.

The cost of crushing/mulching is between DKK 10,000 and DKK 15,000 per hectare.

General note on crushing

You should simply stay away from areas that have never been dug up, as that would destroy the naturally untouched structure of the bog surface.
Monitoring

In order to be able to document the impact of nature restoration, it is always good to have “before” and “after” records available. There follows a brief review of the methods used in this project.

**Before and after photos**
Clearances and other physical interventions are easily documented using before and after photos, complemented by aerial photos, both the recurrent general aerial photo and an oblique photo taken especially for the occasion.

**Line-based appraisal**
Generally speaking it is more difficult to document the impact on a specific natural habitat that you are aiming to restore. For raised bogs, specifically, this is possibly a little easier as the presence of peat moss – sphagnum – is a basic prerequisite for the development of a raised bog. Monitoring of sphagnum presence can be done in a more or less intensive way, but since the resources allocated for monitoring in the raised bog project were very limited, very crude and simple monitoring was chosen. We chose to target the monitoring on the presence of sphagnum. The restoration of the raised bog areas involved in the project aims to establish coverage with sphagnum such that the bogs can once again start producing peat.

The main ingredient of raised bog peat is sphagnum, and it is also sphagnum that creates the extremely specific conditions that prevail in raised bogs. On natural raised bog surfaces, the degree of sphagnum coverage is close to 100%.
In drained, afforestrated or overgrown raised bogs the degree of sphagnum coverage is often insufficient or low. There are often problems with the establishment of tree growth, first and foremost birch. Purple moor grass can also cause major problems as the evaporation from closely tussocked purple moor grass is very high.

The spread of sphagnum is therefore the best indicator of success in stabilising the water level and creating more favourable conditions for the bog to “heal” itself. In the first round of action, it is important that sphagnum be established. Any species of sphagnum is better than no sphagnum.

The method selected consists of laid-out lines (transects) in the individual project areas.
In the laid-out lines, for each metre it was noted whether any sphagnum was present or not. Over and above this, additional information is added on purple moor grass, the common reed, bog bilberry and other plants with the potential to be problematic for the re-establishment of the raised bog.

At the start of the project, 3 imaginary lines per site were laid out via an aerial photo of the sites. On the ground, the lines set were followed as best as possible using GPS coordinates. In practice, it still proved to be very difficult to plan a precise course of the entire line. This was only possible where there were no trees.
Using surveying poles, the first 20 to 200 metres of each line were marked and 100 m of tape measure laid out. Where tree growth was dense, it could be impossible to see more than 2 m ahead, and this made the work more difficult to a completely unpredictable extent. Relatively speaking, it therefore took much longer to lay out the transects than envisaged. When the first 100 m had been laid out, it was noted for each metre whether any sphagnum was present or not. Where nothing was noted, no sphagnum was growing. Where sphagnum was found, the species was stated, along with the approximate number of centimetres the species covered within 1 metre. The sphagnum had to occur within +/− 5 cm of the centre of the tape measure, otherwise the growth/occurrence was not counted as occurring on the line.

The lines were laid out, as far as possible, as straight lines. In areas with vegetation and larger trees, the specifications of UTM coordinates were very uncertain. In many cases, it was simply impossible to track the satellites. If some points on the line could just be retrieved when undertaking monitoring, it would be possible to use them to re-establish the line in connection with the notes, as the lines are straight.

The first monitoring using this method was carried out in 2006, and the next monitoring in 2010.

The determination of sphagnum mosses is something of a specialist discipline, but the method is also feasible, to some extent, as long as those carrying out the monitoring can at a minimum identify a moss belonging to the sphagnum group.

**Water level meters**

The water level is normally measured by sinking sounding pipes and measuring the water level in these pipes at appropriate intervals. When setting up the pipes, you need to be clear whether you wish to measure the water level in the peat layer itself, or if you want the pipes to be set deep enough that they also make contact with the water beneath the peat layer.

Both elements may be appropriate in the context of the project. In order to be able to use the soundings, they must normally be matched with the ground height, for which reason the contours for the sounding pipes and the ground surrounding them must be measured.

The measurements in the actual pipes can take place in a number of different ways, from manual measurement once a month to data loggers that measure on a continual basis at fixed intervals (such as every 6 hours) – the latter can additionally be linked up to mobile technology so that data can be read remotely, otherwise the data loggers need to be drained at certain intervals (3-12 months).

The results of the project monitoring will be presented in a separate report.
Experience from individual project sites

Store Økssø

Area and background information
St. Økssø Mose and Havemosen are located in Rold Skov. The whole area and adjoining land are owned by the State.

Purpose of information campaign
The St. Økssø area is a very popular visitor destination, with approximately 70,000 visitors a year. Clearing around 25 hectares of forest close to the lake represents a dramatic change to the landscape surrounding the lake. This change in the landscape and reduction of the sheltering effect of the forest could potentially generate criticism. A clear goal from the outset was therefore to disseminate the objective of the project to the local community so as to head off criticism that could arise from a lack of insight into the purpose of the clearance and the long-term impact.

Degree of media contact, public tours, tours on request (from schools, Scouts, organisations, etc.), internal tours, visits from other bodies, etc.
A public meeting was held early in the project; this was announced in local and regional newspapers. Around 50 people attended. Concern was expressed at the meeting in respect of the fact that the path around the lake would be flooded and thus inaccessible. Since then, signs providing information specifically about the building work have been put up in the project area.

Before the clearance activities, which took place over 2 periods, contact was made with the regional newspaper Nordjyske, which published articles on both occasions.

Activity days that were open to all were held, providing an opportunity to participate in the removal of birch from the bog and take the plants home.

The discussion resulting from the above generated a number of inquiries from the media and schools, which provided further opportunity to spread the message about the purpose of clearing and raising the water level.

Impact of the information; pros/cons
It is our clear perception that information about the background of the project has provided local users of the area with a good insight into the objective and means of restoring raised bogs, and as a result the criticism has been limited despite the major change in the landscape. The knowledge provided has sustained an interest in following the progress of the restoration of the natural environment.

Public facilities set up within the project area during the course of the project
- New path behind the bog
- Renovation of existing path
- Fishing platform, accessible for people with a disability
- Bathing jetty
- Cabin with fire place
- Barbecues, tables and benches

Clearance
Clearance of tree growth was carried out before the start of the project.
Area and background information
Protected enclave surrounded by agricultural land, located north of Rodkørsbro and south-east of Viborg.
The area is privately-owned protected land with approximately 70 landowners with very diverse backgrounds and interests.
There are cultivated areas right up to the boundary of the protected area and the Natura 2000 area.

Purpose of information campaign
The aim with the information provided has been to constantly keep owners and neighbours up-to-date with the project and its impact on their property.
Over time, it has proven to be the case that some of the neighbours, in particular, fear that their opportunities for cultivation will be reduced.

Degree of media contact, public tours, tours on request (from schools, Scouts, organisations, etc.), internal tours, visits from other bodies, etc.
A landowners’ committee was established right from the outset, and it has been kept up-to-date with the project and its progress.
The landowners’ committee has been the point of contact with the owners for the land management agency (initially Viborg County and then Viborg Municipality since 2007), although it has also been used by the Danish Nature Agency, as the agency responsible for the project.
Step by step, as the project approached the phase where the various applications to the authorities would be processed, targeted meetings were held with stakeholders – both neighbours with agricultural holdings and all owners.
Among the reasons for this was to present the land management plan jointly produced by Viborg Municipality and the Danish Nature Agency and in order to attempt to reach an agreement with the neighbours which would make them confident in the project.

Impact of the information; pros/cons:
It is very difficult to assess the impact of the landowners’ committee and the targeted meetings with the stakeholders. With so many owners, 100% backing for a project of this kind cannot be expected, irrespective of the methods and quantities in which information is provided.
The targeted methods are a good direct way of disseminating information and help to provide a public “face” for the authorities.
The difficult thing is getting people to take part, and the tendency is for those who are opposing the project to have the greatest incentive to attend the meetings.
However, it is our evaluation that the pros outweigh the cons.
The landowners’ committee is a very good idea as it facilitates continuous contact.
However, it can be difficult to determine whether such a committee covers all landowners.

Public facilities set up within the project area during the course of the project:
Information board
The project itself means that access to the area will be difficult, while it is also not an area that sees a large number of visitors.
At present there is only access pursuant to the rules of the Nature Protection Act, as the conservation order does not encompass provisions on public access. The way is thus only paved for visits to the bog on organised tours, although public access is not directly prevented.

Clearance
The land in question is completely overgrown with birch and with coniferous trees such as Scots and Lodgepole pines. The open land areas consist of large-scale peat banks with transition mires and a residual raised bog surface that has previously been cleared. Brandstrup Mose was the last area to be cleared.
The problems with birch re-growth seen at other project sites had therefore been taken into account. In Brandstrup, the water level is being raised by the introduction of a dike, which means that certain dug-up areas of land will have a high water level for a long period of the year. It was therefore decided that only birch would be cleared in such areas. In those areas of land where it was uncertain whether the rise in the water level would have an effect for long periods of the year, only coniferous trees were cleared.

Given the generally difficult terrain in the bog, and because the trees that were not to be cleared would be in the way, it was decided that the felled trees would be left on the ground. This also
had the side benefit that this material would have an inhibiting effect on the movement of water on larger water surfaces and would form a substrate for new growth of sphagnum.

Improving the hydrology
As well as the blocking of ditches and the demolition of drains, a third technique was used in Brandstrup Mose. On this site, it was necessary to build a low dike along the western edge of the bog. This was because peat extraction had removed so much material that blocking the ditches alone would not have an adequate effect. Building a dike of around 150 cm makes it possible to increase the water level in the western part of the bog by an additional 40 to 50 cm. The building of the dike itself is a well-known technique and is not described in any further detail. The dike was built using clay cores, but could also have been built using a membrane.
But in order to regulate the water level in the bog to the point where it is optimal without affecting the surrounding agricultural land, a construction with a continuously adjustable sluice weir gate was developed for the project. The control is based on well-known technology from the water and wastewater sector, agriculture and aquaculture, but has been adapted for this project, and its features include lockability in order to prevent curious hands from being able to adjust it.
Boest Mose

Area and background information
Boest Mose is situated north of Nørre Snede.
This is state-owned land – the majority of surrounding land is also state-owned, and the few neighbours are unaffected by the project.

Purpose of information campaign
To create interest in and understanding of the project.
A marked local walking trail and the national Hærvej trail run along the western side of the bog, and interest from visitors has been great.

Degree of media contact, public tours, tours on request (from schools, Scouts, organisations, etc.), internal tours, visits from other bodies, etc.
Clearances and raising of the water level have been discussed in the local newspapers Horsens Folkeblad and Vejle Amts Folkeblad, as well as on Ekspedition Syd on television station TV2. A public tour has been held each year.

Impact of the information; pros/cons
There has not been any criticism of the project, only positive feedback.

Public facilities set up within the project area during the course of the project
Apart from the setting up of information boards, no public facilities have been set up.

Clearance
4.5 hectares were cleared on the eastern side of Nordre Boest Mose. A total of 1,224 m³ of solid matter was cleared from a 58-year-old population of Sitka spruce.
The clearance was undertaken in March 2006 following a prolonged hard black frost, which meant that it was only necessary to make sporadic use of roadway plates for the ditches. The machinery chosen was standard forestry harvesters and removal machinery. The effective method was short timber for the lowest section and chipping for the remainder. This meant that there was minimal brushwood residues left in the area, while there was a reasonable contribution margin of DKK 115/m³ of solid matter in 2006 prices.
The process was relatively gentle on the land in question, but with different weather conditions it would have been necessary to lay out plates on a much bigger scale, with a much smaller contribution margin as a result.
On the western side of Nordre Boest Mose, 2.3 hectares of mixed birch and rough-branched Norway spruce, 75 years old, was cleared, totalling 750 m³ of solid matter. Clearance was undertaken during a dry period in August 2007, with sporadic use of roadway plates.
In order to spare the land as much as possible, a proportion of the trees were felled manually in such a way that the machinery could collect them from the top, thus limiting the driving on the land.
As a result of the poor quality, a felled wood extractor was used and everything was processed into chips. The contribution margin was DKK 0.00 per m³ of solid matter.
The land was relatively dry and the primary transport was laid on girders at the main ditch, with acceptable results as a consequence.
Svanemosen

Area and background information
Svanemosen is located south of Kolding and is primarily state-owned, although there are privately-owned sections in the eastern part of the bog, while the neighbouring land areas to the west and to the south are privately-owned.
In the early phase of the project, the privately-owned areas were removed from the project (see below).

Purpose of information campaign
Svanemosen is the only raised bog in the Kolding region and it is of such a considerable size that it provides great opportunities for all the experiences linked to this kind of biology.
The bog has always been well-known locally and is a favourite destination for visitors.
The information connected with the LIFE project has been highly targeted at those who did not know the site beforehand and at those who feel that clearing 35 hectares of birch forest is a violent act.
The information on site has provided visitors with a good insight into the geography, the scope of the clearance and the future of the bog, which has been one of the goals of the process.

Degree of media contact, public tours, tours on request (from schools, Scouts, organisations, etc.), internal tours, visits from other bodies, etc.
Early in the course of the project two official meetings were held, in which 80 and then 100 stakeholders took part.
At the first meeting, there were many concerned landowners who wanted to know whether they would be giving up land and hunting rights and having large amounts of water on their land.
At the second meeting, the project was adjusted in such a way that the privately-owned areas were removed. At the meeting, information was provided about how it could be prevented that neighbouring land areas would be affected by the raising of the water level.

Impact of the information; pros/cons
The information has clearly taken the sting out of the worst points of criticism, as well as illuminating the uncertainties that many people had about the project.
The information has turned latent negative public feelings into positive and favourable feelings.
The improved natural experiences and the greater access were clearly not at the forefront of people's awareness at the start, but later on this helped provide an entirely different approach to the project locally.

Public facilities set up within the project area during the course of the project:
- Improved pathway
- Extension of existing pathway
- Tables and benches
- New car park
- New information boards
- Bird-watching and lookout towers capable of accommodating larger groups

Clearance
In Svanemosen, 34 hectares of forest were cleared with a standing volume of trees at the time of clearance of 112 m³ per hectare. The species of tree that covered the bog were a mix of birch (70%), Norway spruce (15%), Scots pine (10%) and other species (5%). The land appeared to be closed forest, and with the above factors in mind, the Danish Nature Agency produced an invitation to tender where the tenderers would bid for cutting down, extraction and wood chipping on the land in question.
The invitation to tender did not include the sale of the finished wood chips and the laying of any roadway plates in connection with removing the material.
The interface in the invitation to tender was set up in this way because Danish Nature Agency had good sales for the wood chips and because the fact is that hiring roadway plates for a job like that is a very difficult factor to estimate which can be difficult to take account of for a tenderer.

In the meantime, signs had been put up explaining the work in the bog.
Public tours were held during the clearance work in order to explain about the work processes and so forth.
The local media was involved in the process in order to publicise the fact that the action had started and what was going to happen.
A local group (Skovtrolden) has held a large number of public tours in the bog, in which they explained its cultural history and the effects of the tree clearance.
The association in question also holds lectures on the same subjects.
A guided tour explaining about the project as a whole was organised in collaboration with the regional newspaper JyskeVestkysten in June 2010.

LIFE Project · Restoration of raised bogs in Denmark using new methods · Experience from individual project sites
HedeDanmark won the tender and had calculated in their bid on manual cutting down, extraction to planned roadways with 22 metre diggers on roadway plates and subsequent chipping and extraction using the same machinery.

The bid prices varied widely, with a span of 120%.

The work was commenced in the spring of 2007 and finished in late summer in mid-September.

The first stage of the work, namely cutting down and extracting the tree to fixed tracks and roads, went very smoothly and efficiently.

The weather was favourable for the work, with a very dry period, and this produced optimal working conditions. The second stage of the project began in August 2007, when the work ran into serious weather-related problems right from the outset. That summer was one of the wettest for a long time. This led both to problems with the access roads and to a need for a considerably greater number of roadway plates than anticipated.

The work on the bog was made much more difficult due to the quantities of rainwater and the large quantity of wood to be transported off site by both chippers and lorries. This led to a greater use of roadway plates than had been anticipated and also meant that the access roads had to be constantly repaired.

The total cost of clearing the 34 hectares was DKK 1.9 million. The wood chips were then sold for DKK 700,000, bringing up a total price per hectare of DKK 35,000.

In the Svanemose project, the 30 hectares of bog surface was also covered with birch vegetation between 0.5 and 3 m in height. This was performed by our own staff and by contractors equipped with brush cutters with saw blades. When it comes to the working environment, this method is clearly preferable to chainsaws. The problem of cutting using blades on brush cutters, however, is that it can be difficult to dispose of very low stumps.

The stump height can be crucial for re-growth and also for the ability to subsequently drown the birch plants. The price for cutting low is an average of DKK 4,000/ha, where the tree is left on the ground.

The cutting operation was carried out in May/June in order to stress the birch as much as possible, but the birch returned on quite a large scale, especially in fields that are not very wet after the raising of the water level.
Nybo Mose

Area and background information
Nybo Mose.
Privately-owned land with one owner and no possibility of public access.
All the adjoining land areas have the same owner.
This land is located in South Funen.

Purpose of information campaign
Information has been targeted at the landowner, Brahetrolleborg Skov og Landbrug.
There is no public access to the area.
The landowner has been kept up-to-date on the progress of the project via letters and meetings, especially in connection with the clearance in 2006, the subsequent raising of the water level in 2006-2007 and further clearance in 2009.

Degree of media contact, public tours, tours on request (from schools, Scouts, organisations, etc.), internal tours, visits from other bodies, etc.
At the behest of the landowner, there was only very limited information about the project in the press and only very limited public tours, etc.
In June 2009, an inspection visit was held in collaboration with the Odense Environment Centre in connection with the work on the Natura 2000 plan for the area.
In January 2010 an inspection visit was held in collaboration with Faaborg-Midtfyn Municipality in connection with the land management plan for the area and the further clearance of the raised bog surface.
In April 2010 an excursion was put on for the Danish Society for Nature Conservation, Funen Consultation Body.
An excursion was put on for the Danish Botanical Association in August 2010.

Impact of the information: pros/cons
Ongoing information about the project and meetings has resulted in a satisfied and accommodating landowner who supports the project.

Public facilities set up within the project area during the course of the project
No public facilities have been set up.

Clearance
4.25 ha of forest were cleared along the edge of Nybo Mose (predominantly downy birch, but also some black alder). The clearance was undertaken in the autumn of 2006.
The clearance was performed mechanically using roadway plates and a forestry harvester that was able to both fell and extract the trees.

Regeneration of peat 2010 (photo RisagerConsult).
**Storelung**

**Area and background information:**
Protected land on South Funen; the land is entirely surrounded by agricultural land. The majority of the raised bog is privately-owned (45 landowners).

**Purpose of information campaign**
One element of the information campaign was targeted at the private landowners in order to ensure their support for the project. Another element of the information campaign was targeted at the green organisations, including the Danish Society for Nature Conservation and the Danish Botanical Association, in order to secure support from these organisations. Storelung is Funen’s best example of a raised bog and is much visited in connection with various scientific purposes relating to flora and fauna interests. Storelung is less visited by the “ordinary citizen”.

**Degree of media contact, public tours, tours on request (from schools, Scouts, organisations, etc.), internal tours, visits from other bodies, etc.**
Landowners have been kept up-to-date about the programme of the project via letters and meetings. Excursions were held for landowners in 2007 and 2008. An event was planned for August 2010 to provide information about the work on raising the water level. The following excursions have been held:
There were two excursions for the Danish Society for Nature Conservation’s local committee for Faaborg-Midtfyn municipality in 2008 and 2009 and one for the Danish Society for Nature Conservation’s Consultation Body for Funen in 2009. There is information on the Internet, including on the Midtfyns Natur website and on the Danish Society for Nature Conservation’s website.

There was an excursion for the Danish Botanical Association’s Funen Group in 2008 and a presentation about the project for the Association’s members in 2009.
There was an excursion for Faaborg-Midtfyn Municipality’s Green Council in 2008.
There was a technical excursion to Storelung in August 2010 as part of the closing seminar for the project. In connection with the clearance of the raised bog in 2008, news about the project was released on the Danish Nature Agency, Funen’s website.
Work has commenced on participation by the Trente Mølle Nature and Energy School in relation to promotion and nature management in Storelung, with a view to local schools “adopting” a piece of raised bog and ensuring the annual manual clearance of their plot. The Danish Nature Agency provides technical knowledge about raised bogs which can form part of the teaching in the schools. Teaching material is being produced.

**Impact of the information; pros/cons**
Ongoing information and updates for private landowners and green organisations has ensured their understanding of the project, including clearance and raising the water level, and their support for the proposed solutions.
Public facilities set up within the project area during the course of the project:
As part of the LIFE project, an information board about the project in A3 format is being set up at the southern entrance to the raised bog.
In connection with the acquisition by the Danish Nature Agency of 5 plots of land on the raised bog in 2009, funds have been allocated to establish a small car park and further promote the raised bog. In the future, further work will take place in this connection in collaboration with Faaborg-Midtfyn Municipality.

**Clearance**
The project in Storelung encompasses further clearance of vegetation growth on the central raised bog surface (approximately 12 hectares) and felling actual birch trees in the south-eastern part of the bog (approximately 1.6 hectares). The clearance/further clearance was undertaken in the autumn of 2008. The birch trees were felled manually using chainsaws. The wood material is subsequently transported away using removal machinery and roadway plates.
Kongens Mose

Area and background information
Kongens Mose (also known as Draved Mose) is located in Southern Jutland, west of Draved Skov and south of Løgumkloster. The area is protected, with numerous private owners, but the state is the owner of the largest and central areas of the bog.

Purpose of information campaign
Even when working on the application it was clear that, with a relatively large number of private owners and neighbours for the project area, it would be necessary to provide some information. The information would create the basis for negotiations with each individual landowner. The strategy therefore became that the information would mainly be provided directly to the owners and neighbours and to a lesser extent via the media and to the general public. It was important that people had an understanding of the purpose of the project as well as confidence that we had investigated the impact thoroughly in advance.

Degree of media contact, public tours, tours on request (from schools, Scouts, organisations, etc.), internal tours, visits from other bodies, etc.
Tours were held in the bog in connection with the application, with neighbours and landowners being invited directly by letter. The purpose of these tours was to generate pride in the unique nature of the bog and co-ownership in regard to an attempt to take even better care of it. The focus of the tours was therefore the natural qualities of the bog and to get the participants’ opinions of what could actively be done to improve the conditions on the bog. After the first sheet piling work and clearances, there was a public tour. The area is often included in nature school activities, and there are some tours to the forest Draved Skov, where Kongens Mose was briefly involved in the programme.

There was a visit to the bog in connection with the LIFE platform meeting of September 2008, as well as specialist visits from 2 municipalities.

Impact of the information: pros/cons
It was quite clearly easier to continue contact and discussions with affected landowners and neighbours after the introductory tour of the bog. There was reasonable success in creating a positive response to looking after the bog, and there has not been much scepticism in relation to whether the consequences were under control.

The price rises on land in the period 2004-2009 made it impossible to reach agreement with those private owners who would have been involved in the project. This was therefore altered during the course of the project period. These disagreements were not based on a lack of information, however, but had purely economic causes.

Public facilities set up within the project area during the course of the project
- Information boards set up at 2 locations
- Access road moved and improved
- Turning place/lay-by
- Lookout platform accessible for people with a disability
- Disability-friendly path surface between the turning place and the lookout platform
- “Wellington boot path” marked with poles from the lookout platform and along the edge of the bog (outside the land where access is limited)

Clearance
Over 100 hectares of growth has been cleared using chainsaws. On one of the land areas, a method of removing the material from the area with a minimum amount of traffic on the land in question was tested. A digger with a long arm was used, which could reach 20 m to move the brushwood up to 40 m at a time. The method worked from a technical point of view, but it was too costly (DKK 17,000/hectare in 2006).

For most of the clearances, the cleared material was removed and chipped. Some areas were so wet that the material could not be removed.

On roughly half of the land areas, felled trees were removed using standard removal machinery with conveyor belts and then chipped. In the wettest areas, felled trees were left on the ground and are now nearly gone after roughly 4 years.

The trees and vegetation growth situated up to 50 m from the major drainage channel that was closed in connection with the project were moved into the channel using 15-20-tonne diggers with buckets in order to inhibit water movements and act as a substrate for new growth of sphagnum.
Portlandmosen

Area and background information
Portlandmosen forms part of the complex surrounding Lille Vildmose in Østhimmerland. The area is owned by the charity foundation Aage V. Jensen Naturfond.

Portlandmosen in Lille Vildmose
Material used to close up ditches and former peat cut channels. This project is not part of the LIFE project, but since it was run in parallel with that project, and since the Danish Nature Agency was the lead agency for the project, it was natural to incorporate experience gained from this project. Furthermore, this project is a collaboration with Aalborg Municipality as the authority and the Aage V. Jensen Naturfond as the owner.

In Portlandmosen there are still sections where the original surface of the raised bog is untouched. However, the extensive drainage in connection with peat extraction and the subsequent overgrowing with birch and pine was well on the way to destroying the raised bog vegetation even in the untouched areas. The project was carried out in the period 2008-2011 and incorporated the clearance of vegetation and windbreaks and the blockage of ditches and peat cut channels. The last part was carried out in May 2010 and covered 185 blockages using ply-wood plates and 54 using plastic sheet piling.

Choice of type of sheet piling
Plastic sheet piling because of the naturally low pH levels in water in a raised bog. With such low pH levels, traditional steel sheet piling would rust through in the course of a few years. In addition, plastic sheet piling was chosen because of its weight, which is of major importance for implementation on this type of terrain.

Various sizes of piles were used depending on the size of the ditches and peat cut channels and the quantity of water to be held. At the southern end of Portlandmosen, plastic sheet piling types from three different manufacturers were set up as demonstration models. In the wake of this, the American sheet piling designs CL9900 and SG324 in brown were chosen. They are used with their original top covering, which has a stabilising effect when the sheet piling is to be extended over longer distances.
Traffic in the bog
One desire was to reduce as much as possible the footprint of machinery used to ram sheet piling and plates into place, which led to the development of special machinery to perform the work with the lowest possible impact on the ground.
In order to reduce the level of traffic on the bog in connection with the work, the majority of the material was flown into the bog by helicopter. A large crane lifted material from a road close to the project area over one of the peat cut channels closest to the road. Finally, some of the materials were transported on a barge into the large peat cut channels, which runs through the bog.

Material used for ramming
The contractor that carried out the sheet piling work was very creative, developing and adapting special vehicles for the work. In order to put in place wooden plates and plastic sheet piling, a small caterpillar-tracked vehicle fitted with a long sawing/digging arm (the “Savemarie”) was developed. This machine made the work of installing the wooden plates a very manageable task, where the alternative was ramming down into place by hand.
For ramming sheet piling into place, the main equipment used was an amphibious vehicle known as a Truxor, with specially-developed sheet piling equipment.
When it was necessary to place sheet piling in peat cut channels containing water, the Truxor was fitted with buoyancy floats to provide better stability.
The Truxor worked well and left almost undetectable traces on the surface of the bog. It was not able to handle the longest piles and also had limited performance. For example, it was not able to put sheet piling in place through branches and roots, for which reason in many places prior sawing in the peat was required before the sheet piling could be pounded into place.
An archive containing plans from drainage made by the largest land reclaiming company in Denmark “Det danske Hedeselskab” (DDH), the archive goes back to 1860.
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(Restoration of raised bogs in Denmark using new methods – a LIFE Project)  
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If you have questions about the project and want more details about the methods used in the different areas, you are welcome to get in touch with the individual members of the project team.

**Further information can also be found on the project website:**
www.hoejmoseprojektet.dk
www.raisedbogs.dk
Lessons learned and recommendations for restoration of raised bogs in Denmark

This report is based on the results of the project and on the discussions at the national seminar on 9/10 September 2010.

This report forms part of the reporting of the LIFE Nature project, RERABOG.

The project aims to restore raised bogs in Denmark, including test of various methods and techniques under Danish conditions.

The project is implemented by the Danish Nature Agency in the period 2005-2011.

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LIFE Nature is an EU programme aiming to conserve natural habitats and the wild fauna and flora of European Union interest, according to the Birds and Habitats directives, thus supporting implementation of the European Union’s nature & biodiversity policy and the Natura 2000 Network.

Natura 2000 is the centrepiece of EU nature & biodiversity policy. It is an EUwide network of nature protection areas established under the 1992 Habitats Directive. The aim of the network is to assure the long-term survival of Europe’s most valuable and threatened species and habitats.