Management of Heaths and Inland Dunes in Denmark – a Manual of Methods

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Arnica montana
1 Foreword

1.1 The LIFE-Hede project and background to this publication

Heathland as a natural habitat is regarded as being threatened and vulnerable – not just in Denmark, but also at the European level. To restore natural habitats in some of Denmark’s biggest heathland areas, the Nature Agency implemented the LIFE RAHID project: “Restoration of Atlantic Heaths and Inland Dunes in Denmark” (LIFE09 NAT/DK/000370) between 2010 and 2016, supported by EU-LIFE. The project is referred to below simply as “LIFE-Hede”.

“A rapid and extensive campaign of major significance to halt the decline of heathland and restore it to good preservation status. This will be achieved by restoring old heath biotopes and creating new, potential biotopes close to the existing ones. The project was implemented at 6 locations of national importance, involving a total area of 6,566 ha.” (The Nature Agency, 2016a).

A number of well-known methods were used for heath management in the LIFE-Hede project, such as burning, grazing, clearance and mowing, but the main focus was also the development of new methods and a combination of management methods. The results form the basis of this report, which presents the latest experience gained with heathland management in Denmark, supplemented by perspectives from abroad.

This publication is part of the LIFE-Hede project, and is a manual of methods that describes practical methods used within the project to counter the threats to heathland. The project worked with stripping, burning, harvesting, grazing, water and cultivation on heathland. Considerations regarding choice of method, practical execution, legislation, effect and financial key figures are described for each method.

The target audience for the publication is people engaged professionally with caring for heaths, namely public authorities such as local authorities, but also private consultants and contractors. Our hope is to make it possible to use the methods used and described in the LIFE-Hede project. Material
on heathland management has previously been published, which is referred to in brief in the following chapters.

1.2 A brief history of heathland management in Denmark
Recognition of the fact that management was necessary. At the end of the 19th century, many scientists were convinced that heathland vegetation stemmed directly from that found in tundra zones that had developed after the end of the last ice age over 10,000 years ago. In other words, heathland was pure and genuine nature. It was well into the 20th century before science recognised that heathland vegetation is not natural and eternally unchangeable, but that it is due to the cultural effects of centuries or even millennia. This process included the significant step of Böcher’s pioneering work from 1941 (Böcher, 1941).

As in many other instances, a number of years were to pass from the point when a few scientists had described the link until it became generally accepted.

The first person to write on caring for the natural habitat of heathland was Thamdrup (1958). The subject was the indigenous birdlife and the condition of the heaths. He referred to the same decline in the black grouse being seen in Holland as in Denmark, and burning heathland had started in the same way as in Scotland for the sake of grouse hunting.

The same year, an experiment was started in the Ulborg national forest district, looking at various ways of preserving heathland in the district, some of which were grouse reservations. The results were first published a number of years later (Johansen, 1970). They contained a clear description stating that heaths were previously “as beautiful as they were and apparently untouched, because they were not untouched.” They had actually been used for a wide range of purposes.

Arouns 1960, local initiatives were taken elsewhere to improve the condition of heathland at Harrild Hede, Kompedal, Randbøl Hede and Tihøje. It was noted that heather was getting old and being replaced by grasses. Initially, the preferred method was burning heather off. The results were so convincing that they became one of the methods of caring for heathland and helped set initiatives going in even more areas.

But what had the biggest practical effect was without a doubt a major study of the black grouse (Joensen, 1967). The population at that time was over 1,000 birds in the spring. Once again, it was stated that the original perception of preservation as being passive (“nothing should be done”) was only rarely appropriate. Burning and other forms of management were necessary. And the fact that it was necessary to start using such forms of management was because heathland was no longer used by man.

This study was a major contributor to recognition that heathland needed management to be preserved. The major impact of the study was due to two things: the author had personal contact to just about every administrator, owner etc. of large tracts of heathland in Jutland. Secondly, the vast majority of such owners, administrators etc. had a personal interest in the state of their heaths. And that was the black grouse, a particularly sought-after hunting prey. Healthy heathland was one of the criteria for healthy grouse populations.

1.2.1 Heathland management in the 1960s and 70s
The removal of trees was a major theme, most of which were mountain pine. When the visible part of an evergreen tree is removed, e.g. by felling or burning, it ceases to be of concern. No new growth springs from the stumps or roots, and it therefore dies. Deciduous trees are different, as they continue to shoot from the roots once they have been felled or burnt. But there are not as many problems with deciduous trees then as there are now. One of the current problems is the invasive black cherry (prunus serotina). A well-known botanist said, as late as the 1970s, that the species did not propagate in nature. Nowadays, seedlings are far from a rarity. Other deciduous trees that can be a local problem include birch, oak and European aspen (Holst-Jørgensen, 1992).

Burning was initially one of the most commonly used methods of heathland management, most likely inspired by Scotland where it was a well-established routine.

Burning was also documented (Sørensen 2016) as being part of traditional heath cultivation in Denmark, as a method of generating fresh heather for sheep grazing.
Large areas were often burnt in one go, and to control the fires, broad firebreaks were ploughed around the area. These can still be seen many places.

Harvesting heather is perhaps the most commonly-used method for heathland management, and is an unbroken tradition from heather farmer harvesting using a heather scythe up to modern machinery.

Common heather was cut during both World Wars for cattle feed, and after the dry summer of 1959, landowners in western Himmerland sold feed heather by the lorry load (Brøndergaard, 1987).

Harvesting becoming more common after the early 70s is linked to safety measures. Summers were experienced when burning was made impossible or it got out of control. This was a risk that could be avoided by harvesting.

Ordinary farming implements were used initially, such as small tractors with a mower attached. The mown heather was collected by a Pick-Up presser, and pressed into the familiar small, cubic bales. The machinery got bigger and the cut heather could be pressed into big bales, weighing up to a tonne.

Forestry implements were also used for mowing, such as rotor mowers ("Texas") and flail mowers. These crushed the vegetation, leaving a thick mat of it on the ground. But as time went by, these methods were largely abandoned. The reason was that it was found that leaving the cut vegetation on the ground prevented new heather from sprouting, whilst wavy hair grass could thrive. Phasing them out would nowadays probably also have been justified by it being important to remove nutrients from heathland.

Harrowing should also be mentioned as a method. It was initially used many places (Johansen 1970, Øvig, 1980, Christensen, 1981, Riis-Nielsen et al., 1991). The implement used could be a dish harrow, spade harrow, Hankmo harrow or spring tooth harrow. Because harrowing alone often resulted in yet more grass, a level surface and disruption of the mor layer, it was abandoned as a method of management.

The previously mentioned methods are copies of the use made of heathland by heather farmers. They did not manage their heaths, but saw heather as a resource, and harrowing of heather-covered areas was probably not part of their farming.

### 1.2.2 Heathland management after around 1980

**Removal of trees.** With regard to evergreen trees, not much new has happened. Although we should mention that some of the specialised machinery for mowing heather and grass simultaneously remove trees and bushes with a trunk diameter of less than 10 cm. With regard to deciduous trees and bushes, the army introduced the principle in its land catalogue (FBE 2013) that deciduous trees - including black cherry - should not be felled, but pulled up or dug out by the roots. That avoided new sprouts shooting from the stumps or roots.

Burning now takes place pretty much without the use of ploughed firebreaks. Mowing very narrow firebreaks is now standard, often with flail mowers, possibly combined with the use of intensive irrigation from a water tanker. Tankers are used to spray water in advance to limit the area to be burnt and to put out fires where they are not wanted.

**Grazing** is now common on many heaths, not least because public subsidies are paid and because this is a traditional use of heathland. Grazing by a wide range of different species of cattle, sheep and horses has been tried. Goats are also used in some places (including Holst-Jørgensen, 1992) and a 4-year trial was recently run with goats (Buchen-schan, 2010). After the strong increase in the red deer population in recent years, the effect of grazing on wild animals can also be acknowledged, especially red deer. This applies to fenced-in parks and the open landscape.

**Harvesting heather and grass** is performed nowadays using different machinery from farming and other industries, and special machines have also been developed for natural habitat management (Fodgaard, 2003, Hansen, 2014). Something new is the fact that mowing can be used for more than heather renewal and crowberry removal. Repeated mowing and the removal of fresh purple moor grass can remove so many nutrients that heather once again can thrive and even dominate (Degn, 2012).

**Stripping the mor layer** was first tried in this country on a very modest scale on Randbøl Hede, but with very convincing results. For example: an area of around 1,150 m² was stripped in 1996 down to the mineral soil (Degn, 2005, b). The objective was to
attempt the regeneration of earlier vegetation with individual heather bushes, with lichen and exposed soil between. Only 11 years later, 36% of all lichen species found on the whole heath were found in the modest area of just 0.014% (Søchting & Degn, 2015).

A new Danish machine was developed a few years ago that can remove the mor layer (Hansen, 2014).

Revival of historical farming by laying out fields on heathland has only been used a few places so far. The lack of enthusiasm is to a large part due to ploughing being seen as a violent act in a protected or preserved heathland. The method should therefore only be used with a lot of consideration on areas that have been previously ploughed (old fields, former plantations, firebreaks etc.).

Over the years, a succession of different plants will grow on such ploughed areas, along with insects such as butterflies, grasshoppers etc. That will give biodiversity that is much higher than in pure heather heathland. 42 plant varieties were found 9 years later on a former field of 1,150 m², left fallow in 1975 (Degn, 2001). Twenty years after farming ceased, heather was so dominant that few people could see that it had ever been a field.

1.2.3 The future
There is little doubt that the future will mean other and better machines to management for natural habitat on heathland. What will be harder to predict is precisely what and how. As late as in 2014, a new method was tried on Harrild Hede for removing the mor layer (see chapter 6.1 on stripping) Grazing has been restarted in recent years to a greater extent as a result of a change in subsidy rules. We can hope for more focus on how grazing can contribute to maintaining or restoring stable heathland communities.

There is considerable research in Denmark and abroad into the effect of grazing on heathland vegetation, as there is little knowledge of its effect on soil acidification and eutrophication.

A major challenge is what to do with the material removed from heathland as a result of management. Ordinary common heather mown with the right machines can be sold to thatchers to put on the ridge of thatched roofs. This helps reduce costs or even generate a modest income. But a lot of other material (grass, litter and mor layer) have almost come to represent a waste problem. There is clearly a challenge in changing the classification of such organic material from a negative form of waste to a positive form of biological material. Doing so can support society’s general current buzzwords of sustainability, green policies etc. Whether we could use it for incineration, biogas, soil improvement, organic livestock shed bedding or the like, only time will tell. Several initiatives have been taken, often at local level. They may be the way forward, as they minimise one of the cost factors – transport.

1.3 Hedeplejebogen (the book of heathland management)
Hedeplejebogen was published in 1991 as the first compendium on the heathlands and their management. It looks at a number of aspects related to heathlands, from definition and history, through ecology, vegetation and wildlife to management methods, monitoring etc. It gives an overview of research and management experiments performed up until 1991.

1.4 Pamphlet published by the Department of Geosciences and Natural Resource Management (IGN), at University of Copenhagen
The department disseminates the results of its research to professionals, students and others working in forestry, farming and planning. Such results are presented primarily in short pamphlets designed to be used when working with nature management. The pamphlet on heathland management covers such subjects as combating invasive species, choice of grazing livestock, burning and mechanical management.

1.5 Portal for Nature Management (web-page)
This portal is aimed at anyone responsible for organising and performing nature management. It includes descriptions of types of natural habitats, and the management, management and maintenance needed to ensure and develop the right flora and fauna. It primarily covers the types of habitat protected by Section 3 of the Nature Protection Act, plus scrub and small biotopes. The emphasis is on precise diagnoses for what the specific problems for the given area are prior to choice of management method, and to set precise objectives for the results. The portal is run by the IGN for the Agency for Water and Nature Management.
2 Definition of heathland

2.1 Heathland as defined in Section 3 of the Nature Protection Act

“Heathland includes areas dominated by dwarf shrubs and grass heaths dominated by grasses such as purple moor grass or wavy hair grass that have clearly developed from dwarf shrub heaths. Heathland consists of dune heaths along the coasts and on inland sand, heaths that have developed on acidic, low-nutrient soils after deforestation and soil exhaustion.” (The Nature Agency, 2016b).

Plant growth therefore plays a key role. The dwarf shrubs that commonly occur on Danish heathland are common heather, crowberry, lingonberry, cross-leaved heath, blueberry, bog bilberry, bearberry, creeping willow and species of the same. Heath vegetation is low-growth, but bushes and trees such as birch, European aspen, Scotch broom, solitary and self-sown evergreens are also a major element of the vegetation on many areas (By- og landskabsstyrelsen, 2009).

On some types of heathland, grasses, sedges, lichens and mosses are the dominant element in plant growth, where the aforementioned types of dwarf shrub are still present. The following grass varieties in particular can represent the dominant element in plant life: wavy hair grass, sheep fescue, genista, purple moor grass, grey hair grass and matgrass (By- og landskabsstyrelsen, 2009).

2.2 Heathland natural habitat types

The decline in the total area of heathland in Europe and their condition have meant that a number of heathland types have been designated as nature habitat types: 2140 * Coastal Dunes with dwarf shrub vegetation (dune heathland), 2310 Inland Dunes with heather and broom, 2320 Inland Dunes with heather and crowberry, 4010 Wetland Dwarf Shrub Habitats with cross-leaved heath and 4030 Dry Dwarf Shrub Habitats (heaths).

* indicates nature types prioritised by the EU for protection (Buchwald & Søgaard 2000).

All 6 project areas in the LIFE-Hede project are inland heaths. Inland heaths are nowadays only found in Jutland. All the aforementioned natural habitat types are found on inland heaths, except “2140 * Coastal Dunes with dwarf shrub vegetation (dune heathland)”. The succession on inland dunes is much faster than in coastal areas, and many former inland dunes have been grown over. Coastal dunes are less vulnerable, as the harsher climate causes sand drift, which means that succession is slower.
3 The natural and cultural history of heathland

3.1 Origins and development
There has been a lot of speculation over the origins of European heathland, regarded as being a natural vegetation type. It is now recognised that the development of heathland began around 4,000 years ago as a result of human use from the Neolithic age, bronze age, iron age and onwards in the form of deforestation, grazing, peat cutting and harvesting the vegetation for feed and fuel. This type of use prevents reforestation (Webb, 1998).

“Heathland arose by the heather farmers felling forests to create farmland. The soil was abandoned after a number of years as being barren, and heather began to colonise. Grazing livestock and mowing have prevented trees from growing again. Grazing and mowing have removed nutrients from the soil, which has created ideal conditions for heathers, which thrive best under poor nutritional conditions. Heathland was most widespread around 1750–1800. After that time, cultivation and planting of heathland once more became more intensive. This was a task that Hedeselskabet (the Danish Heath Society, now HedeDenmark) took an active part in from the mid-20th century, in which large areas of heathland were transformed into woodland and arable land. Heaths are most common nowadays in west Jutland. There are extensive areas at Borris Sønderland, Lønborg Hede and on the moraine hills of the area, e.g. Skovberg.” (The Nature Agency, 2016b).

3.2 Heather farmer farming
The methods of management now used on heathlands are similar to those used by heather farmers, except that the objective today is not exploitation of heathland resources, but maximising natural value. What modern management and heather farming have in common is that the methods can be used to keep heathlands as heathland.

Heather farming consisted of grazing, cutting heather and peat, plus intentional or unintentional fires that could have disastrous results.

For example, burning was a regular occurrence in Timring Sogn, a place described annually or regularly. This was done very cautiously for fear of...
spreading, which caused massive heathland fires. An old farmer tells the story of heathland burning in the parish of Nørre Omne, which was performed every 3 years for sheep grazing (Sørensen, 2016).

Farmers could add the small cultivated areas of heather peat from adjacent areas, perhaps from twice as big as the area to be cultivated. Heather peat from the total area was burnt and the ash fertiliser was thus concentrated on 1/3rd of the total stripped area.

Most of the nitrogen was removed by burning, whilst phosphorous remained. That effect could not be achieved by removing vegetation and mor layer.

Apart from harvested crops, the effect was that the stripped areas were colonised by annual, biannual or perennial herbs and grasses, that have probably given a significant nutritional boost to grazing livestock.

Similar methods are used in modern heathland management. Stripping is basically the same as peat cutting, and heather mowing is the same as harvesting.

Peat stripping is a radical operation, which the heather farmers used to perform on a small percentage of the heath every year, approx. 1 ha per year out of 300–500 ha. They would cut peat for fuel and peat ash, which formed part of the nutritional cycle that was key to heathland farming.

They grazed sheep on the heath all year round, whilst calves and bullocks grazed certain areas in the summer. In the winter, livestock was fed with feed consisting of heather and hay.

Heather was used for feed, fuel, thatching etc. It was cut using a heather scythe just above the ground. Thatching heather was also picked by hand.

Heather peat for fuel was cut using a peat spade. The briquettes measured around 50 x 40 cm. The annual consumption of peat for fuel for a farm was between 9,600 and 12,800 briquettes, equivalent to annual cutting of an area of between 0.19 and 0.26 ha.

Heather peat was also cut and used as a component in manure along with shed manure. Before ending up there, it could have been used for other purposes such as covering the farmyard, building material or insulation.

Heather peat was also burned (ash peat) and the ash used as fertiliser.

Heathland farming followed an extensive pattern. Farmers could have a number of small fields (outlying fields) that were only cultivated for a few years. They were then left fallow for at least 20–30 years, when the earliest fields began to grow heather again.

The heather farming culture no longer exists, and many former heathland areas are now planted with evergreen forestry or are farmed. The heathland areas that still exist have to be managed to survive.

And the historically-inspired methods for caring for them can well prove to be the most rational in financial and biodiversity terms.
4 Heathland biodiversity

Heathland has relatively few species, and is dominated by those that have adapted to poor, acidic soil. They are a habitat for a number of highly specialised and rate flora and fauna, including butterflies and other insects. A mosaic of habitats with exposed of thinly-vegetated sandy surfaces, common heather of all ages, grass patches, marshes and bogs, individual bushes and trees is the criterion for the richest occurrence of small wildlife on heathland (Jensen & Vestergaard, 2007).

4.1 Plants
The most characteristic varieties found on heathland are dwarf shrubs such as common heather, cross leaf heath and crowberry. Some varieties of broom, which is also a dwarf shrub, are found to a lesser extent. Wavy hair grass is the most common grass variety, and purple moor grass is also quite common. Heath bedstraw, goldenrod, viper’s grass, Arnica montana, pill sedge, eyebright, thyme and others are more widespread (Jensen & Vestergaard, 2007, p. 219).

Heath spotted orchid, spring pasqueflower and varieties of clubmoss are some of the rarer plants.

4.1.1 Common heather
Common heather is a dwarf shrub and highly characteristic of the heathland natural habitat (The Nature Agency, 2016c). Common heather belongs to the heather family. It is a perennial dwarf shrub that grows in dry soils. It has a reddish/violet colour from August to September from small, pot-shaped flowers in clusters. The crowns usually remain after flowering. Common heather is common in western and northern Jutland, on Bornholm and elsewhere around the country. It grows on heaths, in bogs, woodland and scrub. Common heather has an exciting lifecycle, with colonisation, growth, propagation and death, and is an indicator of high natural habitat quality, as it reacts quickly to changes in the environment, such as changes in nutrients (The Nature Agency, 2016c).

4.1.2 Cross-leaved heath
Cross-leaved heath is a perennial glandular haired dwarf shrub growing to 10–25 cm with needle-like leaves. It grows on peat or sandy soils low in calcium in heathland pools, high bogs, dune heaths and on pond banks (Mossberg & Stenberg, 2003). Cross-leaved heath has been the dominant species so far in two types of Danish natural habitats: wet dune depressions and wet inland heaths (Strandberg et al., 2012). It became apparent in 2010 that it was disappearing. There was a living colony on Vejrup Søhede in 1999, which was dead by 2010 (Strandberg et al., 2012). “The NOVANA monitoring programme showed that cross-leaved heath cover
has fallen significantly between 2004–2008, from 28% to 19%. Purple moor grass covers around 40%, and is therefore the most dominant species on cross-leaved heath heathlands. Acidification is the most likely explanation for why it is dead or dying on the wet heathlands. It is also apparent that there is no sure experience of management for wet heathlands with cross-leaved heath that is not also acidic.” (Strandberg et al., 2012).

4.1.3 Crowberry
Crowberry is a perennial dwarf shrub with needle-like leaves and very small wind-pollinated flowers. Grows on poor soils – heaths, bogs, open woodlands, windbreaks (Mossberg & Stenberg, 2003). It therefore dominates on heathlands in the late succession stages, where the heathland has become old. It grows especially in the north of Denmark, with its southern limit in northern Germany. Crowberry can tolerate salt and wind, but not moist soil (Jensen & Vestergaard, 2007). Compared to common heather, crowberry produces fewer and larger seeds, which mean they are not spread as far (Jensen & Vestergaard, 2007). When it has sprouted, it spreads overwhelmingly by root-bearing shoots. Crowberry can out-compete other varieties in a slow process. After many years, it can form a thick carpet. In contrast to heather, crowberry plants do not have a maximum age, meaning that a carpet of them can last for many years (Jensen & Vestergaard, 2007). It is sensitive to fire, trampling by livestock etc. It is damaged by frost or drought, and can die out on large areas. A dense carpet of crowberry is therefore an indication that a heath has been left undisturbed for some time (Jensen & Vestergaard, 2007).

4.1.4 Wavy hair grass
Wavy hair grass is a loose, tuft-forming grass that grows on dry soils low in nutrition, woodland, clearings and heaths (Mossberg & Stenberg, 2003). It is low and slow-growing. Given time, a 30 cm-thick litter layer of withered grass tussocks that shut out all light from soil and prevent other species from getting established. On eastern heaths in Denmark, it has out-competed common heather in many places (Jensen & Vestergaard, 2007).

4.1.5 Purple moor grass
Purple moor grass is a perennial, dense, tuft-forming grass that grows on wet peat or sandy soils, often low in nutrition. Pond banks, marshes, woodland bogs, water meadows, wetland heaths and ditches. It is more linked to a thick mor layer than wavy hair grass. Purple moor grass, in common with wavy hair grass, develops thick tussocks that prevent other species from sprouting and getting established. It represents a growing problem on the heaths of Denmark. Despite considerable effort, purple moor grass has spread at the expense of common heather and other dwarf shrubs on wet and drier heathland, such as Randbøl Hede. Purple moor grass is not only a problem in Denmark, but also on the heaths of north-western Europe in general (Buttenschøn et al., 2005).

Its coverage of Randbøl Hede and Hessellund Hede at the Karup air base has been studied using aerial photography. It could be seen that purple moor grass had advanced remarkably both places from 1954 to 2005/6 (Degn, 2015). Pollen analyses in the UK have shown that purple moor grass has never been as widespread as now (1999) (Buttenschøn et al., 2005).

Experience (anno 2005) from and the results of foreign research projects indicate that traditional heathland management methods using burning, grazing or mowing are insufficient to restore dwarf shrub-dominated heathland habitats where purple moor grass is dominant (Buttenschøn et al., 2005). Purple moor grass can out-compete crowberry and common heather. It can dominate dry heaths and bogs (Jensen & Vestergaard, 2007).

4.2 Lichen
On dry heathland with mature common heather, reindeer lichen in particular, along with a few other varieties of cup lichen grow. Erosion and wear from animal/human passage creates small biotopes in the form of windbreaks where numerous lichen grow – often together with grey hair grass. Lichen and mosses will bind loose sand over time, making the soil more stable. After grazing, burning, peat-cutting or other uses of heathland have ceased, widespread lichen areas become less common and grazing or other forms of disturbance seem to be essential for the formerly extensive lichen colonies (Jensen & Vestergaard, 2007). Management in the form of burning or peat removal creates the opportunity for a succession rich in species that will typically be visible in 20-30 years (Vestergaard & Alstrup, 2015).

4.3 Birdlife
We will initially address a number of species only found on heathland in Denmark. We will then discuss a number of species that are either very rare here, or can be found in other habitats than open heather heaths.
4.3.1 Black grouse
The black grouse was declared extinct in Denmark in 2001. Its last habitats were Kongenshus Hede near Viborg, Vind Hede and Randbøl Hede. Its decline is believed to be due to a combination of the lack of its preferred habitat, open heathland and high moors, coupled with modern farming’s huge fields free of weeds and insects, but there is probably no definitive explanation (DOF 2006).

4.3.2 Wood sandpiper
Denmark represents the southern limit of the wood sandpiper. Its main territory is in Scandinavia and Russia. It nests in heath and peat bogs, near ponds and marshes on heathland where vegetation is low. Good breeding conditions entail a lack of disturbance in the immediate area of the nest during the breeding period. It also benefits from the removal of mountain pine and other trees and bushes in the vicinity of the nest site. It is only found in a few isolated locations in western Jutland nowadays. The biggest population is found on the Hansted Reservation, Thy. Nature management and restoration have stabilised the population. Raising the water table level of heathland bogs in southern Jutland and mountain pine clearance in Thy have benefited the species (DOF, 2006).

4.3.3 Nightjar
The nightjar nests in heathland areas and evergreen woods on sandy soil. The area has to be relatively open, but large trees can be present, as they encourage the presence of nocturnal insects, which are the main sustenance of the nightjar. The nightjar was a common nesting bird on the heathlands of Jutland in the 19th century. The decline of heathland in terms of area has also meant the decline of the nightjar. As mentioned above, the nightjar also nests in open evergreen stands, and the Danish population of an estimated 500–600 pairs is deemed to be reasonably stable (DOF, 2006).

4.3.4 Great grey shrike
The great grey shrike only breeds in Denmark in Jutland, especially on open heath and bog areas with isolated shrub growth. Good nesting areas are military exercise grounds that are kept clear through management, including Karup, Holstebro, Borris and Oksbøl. Sparse, low vegetation is an important habitat requirement. (Birdlife International 2015). Food consists in the summer of large insects, amphibians, reptiles, mice and small birds, and in the winter of mice and small birds. The Danish population currently consists of only a few pairs, and it is believed that there have never been more than 100 nesting pairs in the country (DOF, 2006).

4.3.5 Other species of birds
Apart from the species referred to above, a number of others nest or have nested on heathland. The woodlark nests in clearings in evergreen woods or fields with sandy soil surrounded by woodland and dune heaths with tree windbreaks or isolated trees and bushes. Golden plover nest on large heath areas with short, sparse heather vegetation and clear of any trees. It only nests at a few locations in northern and western Jutland. The crane nests in large bogs, including those on heathland. Its nesting sites have to be undisturbed and have water-covered areas for nest building.

There are also tawny pipit (only on open, dry dune terrain in coastal areas), gull-billed tern (seeks food over land in open areas, nests in black-headed gull colonies), Eurasian teal (heath bogs), Eurasian curlew (open bogs, heath bogs, meadows and heathland) and European stonechat (dunes, heathland, heath bogs, large clearings in evergreen plantations) and Eurasian wryneck (open woodland, heathland plantations).

There are also many other species that can also be found in other open natural habitat types including heaths. The most common species are the Eurasian skylark and common linnet.

4.4 Amphibians and reptiles
Danish heathlands, their wet areas and inland dunes are vital to the spread and survival of the species of amphibians and reptiles found in Jutland. Several of the species found in central Jutland are primarily expected to survive on heathland in the future, as farming is often too intensive for species such as common spadefoot, natterjack toad and moor frog, and heathland is just as important to the sand lizard and adder.

All Danish amphibians and reptiles found in Jutland except the common spadefoot and alpine newt have been found on the heaths of Jutland. The common spadefoot is only found near the Danish heathlands near Vojens. The northern crested newt is a typical amphibian found in eastern Jutland, but is also found here and there on Jutland’s heathlands near soils with clay or sandy clays, such as Bjerlev Hede near Vejle and Slauggård plantation near Billund.
We will look at the typical amphibians and reptiles found on heathland in the following.

4.4.1 Common spadefoot
The common spadefoot needs the presence of ponds with good water quality and sandy soil to dig itself into. Such conditions used to be found in farming areas in central Jutland and along the Hærvejen, but due to the decline in pond quality in such areas, the species is in rapid decline there.

It continues to survive on the other hand in several heathland areas such as Bjerlev Hede and Frederikshåb Plantation and the 7 year ponds near Vejle, the Slauggård plantation near Billund and very close to the LIFE project area of Randbøl Hede. It in sharp decline in farming areas around Vejle, and it has been decided to introduce them to the state-owned heathland area at Tinnet Krat to ensure a safe haven in the northern part of the local authority.

The spread of the species on the heathlands of Jutland is only partially known, and best in the local authorities of Vejle and Billund, but it is believed that its best chances of survival are on the heathland of central Jutland.

Heathland pools should be kept open and with good water quality, with open sand on inland dunes or old heathland fields.

4.4.2 Natterjack toad
The natterjack needs the presence of very shallow temporary pools with good water quality and sandy soil to dig itself into. Such conditions used to be found on the heathlands of central Jutland, but the natterjack is now found only on Nordoe Heide, a former military area in Schleswig-Holstein, north of Hamburg. The species has only survived in central Jutland in a few quarries, where it is expect to die out. It could probably survive in central Jutland if it were reintroduced to well-managed heathland with inland dunes. Dune heaths and dunes with open sand and natural dynamics are important areas for the natterjack along the coast from Rømø, Fanø, through Kallesmærks Hede, the dunes of Thy and up to Skagens Odde.

The species was found in Kompedal in 2015.

Heathland pools should be maintained (kept open and with good water quality), with open sand on inland dunes or old heathland fields.

4.4.3 Moor frog
This species has some of its most important colonies in central Jutland on inland heaths, including the project area around Randbøl Hede and near Frederikshåb Plantation. It requires well-managed heathland ponds (open, with low vegetation and open sand) and bogs to breed. It forages in the wet parts of open heathland.

Natural hydrology must be provided and old ditches sealed off to create temporary pools and large, swampy areas of heath and heath bog.

4.4.4 Sand lizard
This species only thrives on heathland with areas of open sand of varying size. It needs such sand to lay its eggs. It is found in small locations on a number of heaths in central Jutland.

Clearings with open sand, especially on inland dunes on heathland must be provided. Not all bushes and trees must be removed, as it uses them for cover from predators. It needs shelter from the wind, when it has to regulate its temperature.

4.4.5 Adder
This species thrives sporadically on many heathland areas, and can be found locally in very dense colonies if sufficient food is present. Young adders eat a lot of frogs, which is why natural hydrology is important on heaths and heath bogs, to keep a high population of moor frog and common frog.

The species requires areas with bushes and shelter from the wind, which help the adder find concealment from predators and regulate their body temperature.

4.5 Insects
There are a number of insects that specialise in living on heathland, although we will only look at the marsh fritillary butterfly. The main feature of the marsh fritillary is its distinctive markings in black, yellow and orange. It has a wingspan of about 4 cm and is only found in a few places nowadays in northern Jutland, having suffered severe decline. It used to be a very common species throughout the country. It lives on wet heaths and meadows, where fertiliser is not used. There also has to be a plentiful supply of the devil’s bit plant, which the larvae live on (The Nature Agency, 2016d). Devil’s bit grows where there is open, moist soil, low in nitrogen.
5 Threats against heathland

5.1 Nutrient addition
Atmospheric deposition of nutrients has caused widespread changes to the European heathlands (Härdtle et al., 2006). Emissions of nitrogen (NOx, NHy) and sulphur (SOx) over the last 100 years have increased significantly, and resulted in much higher deposits of nitrogen and the acidification of soil. Acidification caused increased leaching of base cations (P+, Na+, Ca2+, Mg2+), which curtail the buffer capacity of soil. Increased acidification appears to have caused much faster chemical disintegration of soil minerals (Vogels et al., 2015). As a result of acidification, the nutritional quality has also declined, as it causes a higher N:P ratio, which affects the number of species and density of herbivores and decomposition agents (Vogels et al., 2015).

Nutrients added from the air are one of the factors that make heather more susceptible to attack from the heather beetle, and in the long term will create the dominance of nitrogen-loving grasses such as purple moor grass and wavy hair grass at the expense of dwarf shrubs and other species related to a low-nitrogen environment, with the loss of biodiversity to follow (Vogel & Siepel, 2013). In Holland, host plant specialists such as pearly heath, *Alcon blue* and silver-spotted skipper have either sharply declined or become extinct (Vogels & Siepel, 2013). The same trend has also been seen in other Western European countries. Species dependant on low nutrient conditions often show the biggest decline. In Holland, significant bird species such as the great grey shrike, Eurasian wryneck and tawny pipit have almost disappeared (Vogels & Siepel, 2013).

5.2 Wild growth
Heathland is vulnerable to the wild growth of trees, a process that can occur from invasion of trees from nearby plantations. Such encroachment means that the special flora and fauna linked to heathland risk being wiped out. Wild growth of plants is a part of the natural succession of most types of natural habitat, including heathland, but it has accelerated due to the abandonment of old...
forms of farming with grazing and mowing, the division of heathland into smaller units and the drainage of wet bogs.

Wild growth is accelerated by disturbance of plant cover, e.g. management and burning, mowing or grazing, when follow-up is insufficient (Buttenschøn & Buttenschøn, 2015). Dense plant cover of dwarf shrubs or grasses inhibits wild growth, as developments on Nørholm Hede demonstrate. The 350 ha heath there has been left under free succession for nearly 120 years. Around half of the heath remains open, dominated by crowberry (Schmidt et al., 2015).

5.3 Unnatural hydrology
Draining and growing field irrigation on areas adjacent to heathland affect hydrological conditions. Due to the previous use of grazing, mowing or peat-cutting on many heaths, drainage has often been created by cut ditches. These can often be filled in providing they do not drain neighbouring areas.

The biggest problem for heathland is probably, the drainage of farming or plantation areas close by. Small patches of low-lying bogs and crossleaved heath are especially affected by intensive drainage.

5.4 Heather beetle
The heather beetle is a natural part of the heathland ecosystem. But it is also an unknown factor in heath management. Because its attack is unpredictable, it can change the criteria for planned management. An attack can thus change the prioritisation applied to management of a heathland area.

The beetle lives as larvae and adult exclusively on heather. They attack heather plants in the spring and autumn, but it is the intense gnawing of heather leaves by the larvae in the summer that causes the worst damage. In the late summer, the larvae transform into pupae in the ground, and after a couple of weeks, a new generation of adult beetles emerge to eat the heather until their fat reserves are filled up. They then go into hibernation in the peat under the heather plants for the winter. On warm spring days, they emerge from hibernation and can continue their attack on the spot, or fly to new areas. The plants attacked and partially defoliated heather plants are characteristically red/brown and later turn grey.

Experience from attacks of heather beetle in 2013 and other years show that if the spring and early summer are warm and wet, the defoliated heather can survive, but if they are dry, there is a high risk of them drying out and dying. The nitrogen content in common heather rises when nitrogen addition rises (Sand-Jensen, 2000). There are examples of the scope of insect attack rising because the nutritional content of the plants gives better food utilisation, growth and egg production.

As mentioned earlier, the beetle is dependent on peat (moss) for concealment, egg-laying, pupation and hibernation. Therefore, it can be seen that firebreaks that are often mown are free of beetle attack directly adjacent to unmown heather that has suffered heavy attack.

Substantial attack on large, uniform areas is only a problem when the heath is old, where there is often a lot of peat to the benefit of the beetle and heather weakened by age (senile), which is less resistant to attack. Young heather, on the other hand, usually regenerates after beetle attack.
Heathland management nowadays is often based on the historic use of heaths, with regular adaptation of the machinery used and requirements for efficient utilisation of resources. This chapter describes the available methods, focusing on practical application, the machinery used, options and known limitations, plus financial aspects.

The choice of management method depends on several factors, such as the actual and potential content of flora and fauna, but also the farming history of the area, the degree of eutrophication and how overgrown the area is.

Heathland management involves renewing the vegetation and removing nutrients as much as possible, so that the typical heathland vegetation can be retained. A surplus of nutrients on heathland alters the vegetation, encouraging grass and discouraging heather. The various methods of management remove all nutrition from the heath, but to different extents. Studies have been conducted on Lüneburger Heide in northern Germany to see how effective the various management methods were at reducing the effects of atmospheric deposition of nutrients (Härdtle, 2006). Most effective was peat-cutting, which removed nitrogen equivalent to 89 years of atmospheric deposition. In comparison, the amount of nitrogen removed by mowing and burning was equivalent to only 5 years of atmospheric deposition (Härdtle, 2006).

That is insufficient to prevent accumulation of nutrients when e.g. mowing or burning with 10-15 year intervals.
### Management of Heaths and Inland Dunes in Denmark – a Manual of Methods

<table>
<thead>
<tr>
<th>Management method</th>
<th>Removal kg/ha/year:</th>
<th>Comments</th>
</tr>
</thead>
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<tr>
<td><strong>Nitrogen</strong></td>
<td><strong>Phosphorous</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Managed sheep grazing.</strong>&lt;br&gt;The sheep graze for 8 hours and are then moved to their rest and night fold.</td>
<td>24.3</td>
<td>1.9</td>
</tr>
<tr>
<td>Sheep grazing all year round on the area</td>
<td>16.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Summer grazing with cattle. Grazing pressure approx. 0.3 DE per ha.</td>
<td>5-8</td>
<td>Annual treatment. Figures calculated from surveys on Mols**</td>
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<td>All-year grazing</td>
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<tr>
<td>Burning</td>
<td>Approx. 10</td>
<td>0.1</td>
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<tr>
<td>Cutting</td>
<td>Approx. 10</td>
<td>0.4</td>
</tr>
<tr>
<td>Turf scraping</td>
<td>Approx. 60</td>
<td>2.7</td>
</tr>
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</table>

**6.1 Stripping**

Total stripping removes the humus layer and nutrients within it, revealing mineral soil. It can be regarded as resetting the heath, from which a new succession starts on the low-nutrient substrate. For heathland farmers, stripping helped ensure that there was common heather in all stages of age. At the time, heather peat could be stripped at 50 year intervals. It may be necessary to reduce the peat layer more often nowadays, when levels of nitrogen in particular are higher.

Peat stripping removes heather peat and mor layers wholly or partially from the upper soil layer. Along with the peat, plant roots, shoots and the seed deposits of most plants are removed. Heather seeds are very small and lie deeper than e.g. purple moor grass seeds. Peat stripping removes nutrients and created good conditions for heather sprouting.

**6.1.1. Objective and things to consider**

Stripping is used on areas with a thick humus layer. It can also be used to combat purple moor grass on drier parts of heathland. At Randbøl Hede and Nørlund Hede, it has been shown that stripping can recreate dwarf shrub-dominated heathland with mosses and lichen in the long term (15 year horizon). When stripping purple moor grass, it is important to go so deep that the peat layer is removed as well. Harvesting purple moor grass tussocks can be advantageous before stripping.

Historically, the peat layer was removed because peat was needed. 1 ha per farm per year was typically removed. The objective nowadays is primarily to maintain or regenerate dwarf shrub growth. Total stripping will often result in heather monoculture and a varied heathland vegetation will first occur after 20-30 years. The fact that peat stripping can also affect many organisms should

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* The figures from Lüneburger Heide comes from a series of studies conducted by Härdtle etc. (2007) at Lüneburger University. The deposits on Lüneburger Heide was measured to 228 kg N/ha/year and 0.3 kg P/ha/year.

** The annual deposits at Mols was measured at approximately 15 kg N/ha/year. There are many variable factors that affects the nutrient cycle, and the effect of the various processes are far from known. So is the knowledge of the tolerance levels of different nature-types in various management conditions.

From Naturplejeportalen (Naturstyrelsen 2016b) management of heaths.
also be borne in mind, and the landscape can easily be levelled depending on the method, damaging stones and historical remains.

The LIFE-Hede project therefore worked with methods for gentler and varied stripping on dwarf shrub heathland. Stripping to bare sand on around 50% and partial stripping of peat on the other 50% of the area retained variation and growth criteria for other species than common heather, and disturbed the landscape less. Special areas with *Arnica montana*, clubmoss, anthills etc. can be retained by the machine running around them. This retains seeds and means that the plans can recolonise newly-managed areas.

**6.1.2 Suitable areas**

Stripping in its most radical format will destroy geological and historical remains, and level out rolling terrain. The heavy machinery can cause problems on soggy soil. If the tractor sinks and leaves deep tracks, the machine itself cannot work on the tracks, leaving them clearly untouched. Waterlogged areas are not suitable for stripping. The method should not be used on large areas at a time, as rapid recolonisation by flora from the areas left untouched should be possible.

It is hoped that the gentler methods developed during the LIFE project (primarily method 2, dish harrowing and pick-up) under favourable conditions will be usable on areas with certain historical remains. The Nature Agency and Danish Agency for Culture and Palaces is working elsewhere to study whether this will be possible.

**6.1.3 Methods and machinery**

**Method 1. Stripping using crushers with flails or machines that resemble fixed stump grinders**

Stripping using Bio-Pick Up crushers with flails or machines that resemble fixed stump grinders, with pick-up via conveyors to tipper lorries. The vegetation is first harvested and collected (that which is in demand) and the tipper lorry empties its load. The area is run over again and the peat layer stripped and collected, the tipper dumps the peat in another pile.

When the Bio-Pick Up has been used in the LIFE project, the operator has been instructed to strip so that approx. 50% of the area is left exposed as white sand. Some of the peat layer is left on the remaining area.

**Method 2. Harrowing with pick-up, a gentle method of removing the mor layer.**

The LIFE project worked on Harrild Hede to develop a method which used less radical impact than stripping the surface to reveal mineral soil and removing nutrients, whilst leaving greater variation of microbiotopes. The focus was on smaller, standard machinery to keep costs down and to use the method on smaller, hillier areas.

1) The area is burned
2) A dish harrow is run over the area to loosen the mor layer in belts
3) A hay rake arranges the loosened material in long rows
4) The cut material is collected using a beach cleaner/roadside grass collector/Bio-Pick Up
5) The material can be used for laying football pitches, or used by private or public institutions for acidic flower beds and kitchen gardens, or used for structural improvement of farmland.

The method is relatively gentle towards wind-faceted stone, reptiles and insects. It leaves some peat on the area, which counters subsequent heather monoculture. It is flexible, does not require very large flat areas. It is possible for example to avoid dunes or juniper bushes with dish harrows, hay rakes and beach cleaners, and such machines do not affect the topography to any great extent. Even though some peat is left behind, it removes nutrients from the area and rakes up the mineral soil.

Practical experience gained from the trial shows that thorough burning of the area prior to mechanical processing is important. Harrowing and pick-up of the loosened peat is not nearly as effective if there is a lot of dwarf shrubbery left on the area. One also has to bear in mind that if the peat is moist, it forms clumps that are difficult to rake together. Pick-up using a roadside grass collector was effective but complicated, as the tractor with trailer had to reverse to follow the collector. Pick-up using beach cleaners is more effective, but their capacity for the material collected is low, and
frequent emptying is required. A pick-up (collector) on caterpillar tracks is being developed. As with all machinery, development is constant, making it necessary to keep updated with what’s on offer to always be able to find the best solution.

Method 3. Scraping with a scraper, front loader or the like
A third form of scraping tried out in the LIFE-Hede project is removal of the peat layer at the base of parabolic dunes to completely reveal the sand. The objective is to scrape completely bare patches from dead, thin areas to the benefit of insects etc. A scraper was used able to scrape right down to the bottom without crushing stone. A front-loader digger will be able to achieve the same.

6.1.4 Scraping purple moor grass with a Dutch heathland plough
Trials have been conducted previously on Randbøl Hede and others involving various methods, including scraping purple moor grass. Scraping was performed in 1999 using a special Dutch machine that removes plants and mor layer in one pass. The shallow ploughed material was removed from the areas. The machine was set precisely to only take the uppermost peat layer, but under the growth point of purple moor grass. For a detailed description of the method, refer to Buttenschøn et al., 2005.
6.1.5 Timing
To take into consideration the fauna and flora on the heath, radical scraping (method 1) was performed between October and April. The gentler method (method 2) is expected to be used from September to April, and with special dispensation also in the drier part of the year.

Use of method 1 can cause problems during frosty weather with the flail cutter, as the peat can form ice plates that prevent optimum scraping. Rain can cause problems for method 2. If the ground is wet, the harrow can easily run too deep raking up a lot of sand, which prevents effective gathering.

6.1.6 Disposal of by-products
The shallow ploughed material is peat with a varying amounts of sand for all the methods referred to here. It can be used for soil improvement for farming or forestry. However, there is no actual market for it, but local farmers have been willing to take it in several locations.

Normally, the material contains a lot of sand, and can therefore not be used in incineration plants or bedding for livestock. Trials have been conducted with scraping heather areas twice, with the machine taking all above ground plant parts and the upper mor layer which can be used as bedding and foraging material for cattle, pigs and organic hens. On the second pass, the machine takes the lower mor layer, which is spread on nearby woodland.
**Trials on use of shallow ploughed material in farming**

Three organic farmers tested harvested heather and shallow ploughed bracken as bedding and foraging material in their sheds over one year.

The organic pig farmer used heather material as a foraging material and mixed with straw bedding in the shed. It was popular with slaughter pigs and kept them busy with the bonus that it dried out any ear wounds caused by bites, helping them to heal faster.

The egg farmer laid the heather material out in the chicken run. It made good outdoor foraging material for the hens, and had a draining effect, preventing the formation of puddles. As heather chips absorb some of the nutrients from chicken manure, surplus nutrition can be removed from the chicken run and can be used for fertilising fields.

The dairy farmer had a loose-housing system with a bed of composted material in which the heather material could not be used as an alternative to wood chips, because it contained too much sand. It was therefore initially sieved to remove the sand. Only the surface element without sand was then used, with improved effect. It gave a pleasant aroma in the shed, which the cattle liked. Heather tends to compress more than wood chips though, making the compost bedding more compact and reducing oxygen input to the composting process. This was resolved by harrowing and adding new heather each day.

The conclusion of the trial was that harvested heather and bracken are ideal as bedding and foraging material for livestock, if they do not contain too much sand and a minimum content of 55-60% dry matter.

The problem of reducing sand content was solved by running over the areas twice with the Bio-Pick Up harvester. The first run harvested above-ground plant parts and the upper mor layer, giving the product the minimum of sand that can be used for farming. The lower mor layer was then shallow ploughed, which can be used for soil improvement.

6.1.7 Effect
Experience shows that common heather responds well and sprouts after methods 1 and 2. After method 1, scraping 50% of the area to white sand, new common heather sprouts within the first year on exposed mineral soil, and remaining common heather and other heathland plants sprout from stumps on peat patches. After the use of method 2, common heather, wavy hair grass and various herbs sprout the first year, and there are mosses and lichen on the area. The method is very gentle towards wind-faceted stone, reptiles and insects. It leaves some peat on the area, which counters subsequent heather monoculture. It is flexible, does not require very large flat areas. It is possible for example to avoid dunes or juniper bushes with dish harrows, rakes and beach cleaners. The machines hardly affect the topography. Even though some peat is left behind, it removes nutrients from the area and rakes up the mineral soil so that heather etc. sprouts well, although there are not many root sprouts.

Experience from Harrild Hede and Randbøl Hede show that Arnica montana, blue clubmoss and many other plants reappear after scraping by Bio-Pick Up and dish harrows.

No data has been gathered from the effect of method 3 as yet. It is hoped that the method will give room for insects such as the thread wasted wasp, and that mosses and lichen will appear on the areas.

Scraping on Randbøl Hede was performed on 3 trial fields in 1999. The vegetation cover was significantly reduced in 2000 to a few percent, and in 2003 there was still at least 25% bare soil in all 3 trial fields. Purple moor grass and wavy hair grass were still present in 2003 (Buttenschøn et al., 2005). There were still areas of bare sand between heather bushes in 2006, but most of the surface was now covered by mosses, lichen and algae (Degn, 2015). Heather covering by 2014 was still significant at around 80%.

6.1.8 Necessary permits
Scraping requires dispensation from Section 3 of the Nature Protection Act, and has to be considered with regard to Natura 2000.

Contact the local museum first, to avoid destroying any historical remains, such as ancient fields, earthworks, sand erosion banks and sunken roads.
6.1.9 The finances
The cost per hectare depends on factors such as the surface of the landscape, the size of the area, driving distances, volume of material, etc.

The costs of scraping purple moor grass at Randbøl Hede are stated as DKK 23,600-29,500 per ha. (Buttenschøn et al., 2005).

Method 1
Stripping using crushers with flails or machines that resemble fixed stump grinders
Scraping of 50% of the area down to white sand, partial scraping of the other 50% and pick-up can easily cost DKK 20,000 per ha., plus removal of the material from the stripping. This is an expensive method, but the fact that there are many years between repeats has to be taken into account.

Method 2
Harrowing with pick-up, a gentle method of removing the mor layer.
Tractor-towed dish harrow and hay rake, pick-up and beach cleaner costs around DKK 5,000-6,000 per ha., plus removing of the material. A cheaper method, which is a lot more gentle, working towards heathland management as a biotope more than heather management. This is a new method, so the long-term effect is unknown as yet.

Method 3
Scraping with a scraper, front loader or the like
The cost per hectare is hard to quantify, as the method is used on very small areas at a time. A machine costing between DKK 500 and 1,000 per hour can take care of many patches within an hour!

Shallow ploughing can contravene local conservation orders for heathland (a ruling made by a Nature Conservation Board). Many old heathland conservation orders are status quo orders, that don’t give many opportunities for active management. Talking to the Nature Conservation Board is therefore always recommended to get a long-term management plan for conservation agreed.
6.2 Burning

Originally, heath burning was used to a certain extent to maintain and achieve better grazing, as young heather sprouted after a fire is better fodder than old heather. Unfortunately, accidental heath fires have occurred which can last several days. Consequently, an attempt at banning burning was introduced in the late 18th century.

Accidental fires could be a disaster for heathland farmers. But in the long run, they have played a major role in preserving heathland plants, especially at a time in history when there was no pressure from other pioneer species. If the peat was also burnt off, the following sand erosion created new exposed areas.

Controlled burning is now a frequently used form of management. Burning renews heathland vegetation. It also removes nutrition to the benefit of the frugal heathland plants, especially if it was effective, partially burning the peat. Formerly, firebreaks were ploughed to control the fires. During the LIFE-Hede project, the Nature Agency sought to develop methods of controlling fires using mown firebreaks and water.

Repeated burnings were also tried on Randbøl Hede to combat purple moor grass.

6.2.1. Objective and things to consider

Burning is used when a varied heath is threatened by old, dying common heather, colonisation, dominance of crowberry and purple crow grass, including on dry areas. Burning is regarded as maintenance management. Even though it may seem brutal, it does not completely wipe out heathland vegetation, which is perfectly capable of resprouting. The objective of burning is to renew common heather, restrict crowberry and wavy hair grass, burn off saplings and thus re-establish a dwarf shrub heath with common heather, cross-leaved heath and other common heathland species.

Fire is a brutal method for animals and insects on heathland, and it is therefore important to bear them in mind when planning burning. If the habitats of rare species are known, the fire can be directed around them – ants and the northern birch mouse are examples.

Fire control has been the focus of the LIFE-Hede project, a skill that became so highly developed that it became possible to protect junipers, the presence of which meant that heaths where they were found were never burnt. The effective control of fire also makes it possible to burn larger areas at a time, even if undesirable to do so from a biodiversity perspective. Areas of over 20 ha. were burnt as part of the LIFE-Hede project. When burning such large areas, the recolonisation of heathland flora from surrounding, unburnt areas is made difficult.

Mosaic burning involves burning smaller fields at a time over a number of years. This method has been most used with regard to safety and variation on the heath. Burning of large areas in the LIFE-Hede project has, however, proven that variation is retained, because there is a difference in the fire intensity on different parts of the area burnt, depending on the weather, soil, wetness and vegetation cover. Bare patches and areas with little vegetation, wet depressions and areas with bog bilberry do not burn during periods when the peat is wet (usually in March).

Areas can be burned so that the flames run with or against the wind, known as downwind and upwind fires. In upwind fires, the flames spread slowly and are easier to control, whilst they move rapidly in...
downwind fires. These factors can be used in combination to create safe, effective fires.

There is no indication in practice that upwind fires burn any deeper. The same effect is achieved as with downwind fires that burn at very high temperatures. Sidewind fires can also be used in practice.

A more important factor for burning off peat, is the moisture content of the area. If the aim is to ensure that peat is also burnt off, it should ideally be done in the summer. However, this is not permitted under current rules. Burning in the summer is also a problem from a safety point of view. The risk of flames spreading to areas which are not to be burnt is high, and fire watchers can be needed for many days.

### 6.2.2 Suitable areas

Ideal areas for burning are those with senile heather, crowberry and purple moor grass. In principle, the concept of “If it can burn, then burn it” can be applied (but of course, only after careful evaluation), and will often be the cheapest if the equipment needed for burning has been obtained in advance.

Areas that have been heavily colonised by small trees and bushes can be cleared by burning. Experience shows that areas where trees have green branches to the ground with ground vegetation underneath, they can be burned along with everything else, whilst where they are densely grouped, there is no ground vegetation or green branches reaching all the way down and they should not be burnt, but will have to be cleared first, as the effect will otherwise be poor.

Burning is the best – and at this time the only – method of management on hilly areas or where wheeled machinery cannot be used. The method can also be used where there are wheel tracks, ancient fields and other historical remains, where physical work and running machinery will be in conflict with conservation interests. It should be borne in mind that burning requires permits where there are stones of historical value, e.g. barrows.

It is possible to perform controlled burns on areas from a few hectares up to 50-60 hectares. Often, there are several small or one large area burnt in one day. What takes the most time is creating firebreaks, so the bigger the area, the cheaper it is per hectare. A desire to burn in a mosaic pattern compared to economic considerations will dictate the size of the area to be burnt.

Dwarf shrub heaths from a few hectares up to 20-30 were burnt in the LIFE-Hede project. Burning of up to 25% of small, isolated heathland areas with old and half-dead (heather beetle attack) heather was performed. This was not the case on large areas. Large areas dominated by purple moor grass were burnt on Randbøl Hede as part of trials for repeated burning as a radical measure.

### Burning on historical monuments

Barrows are by far the most common historical monument found on heathland. Section 29 of the Museums Act says: “No changes can be made to the condition of historical monuments.” The Agency for Culture and Palaces has determined that burning is a change to an ancient monument. The section referred to is not, however, an absolute ban. According to the act, it is possible to obtain dispensation for burning. Understandably, the local museums administer this provision restrictively, as they are worried about damage to ancient objects that are near the ground surface.

The conditions for burning common heather heathland are defined in a classic Scottish study (Hobbs & Gimingham, 1984). The result clearly indicated that the maximum heating up of the soil by burning heather is 70°C just 1 cm below the surface. This should be regarded in the context of the upper 5 cm of a soil profile on heathland consists of organic material (heather peat, mor layer). Because the mor layer as a rule of thumb grows by ½ mm in thickness per year, it will be roughly around 100 years old. Any historical remains such as pottery shards, flint tools etc. will therefore lie in the mineral soil layer under the mor layer. These layers are not affected to any measurable extent by heating from burning heather or the like.

There are also other types of historical remains on heathland, especially roads (wheel tracks), earthworks and field traces. These are only included when the owner has received special notification of their existence. They should also in principle be at least 100 years old. However, the practice applied is that wheel tracks, field traces and the like can be freely burnt in accordance with the Museum Act.

But it is a good idea to clear this with the local museum the first time an area is to be managed by burning. A big advantage in relation to the type of historical remains is that burning is highly suited to areas where heavy machinery cannot be used.
6.2.3 Timing

Heath burning is often performed in early spring before 1 April and before birds and small animals begin to breed. The weather is a major factor determining when burning can be done. It is best to burn following a few days of dry weather. There should not be too much wind, as otherwise the flames can be difficult to control. Spring burning is only possible practically on certain days between late February and 1 April. Some years, the ideal conditions only occur for around 5 days in March.

The best weather is wind of 2–6 metres per second and sunshine, to dry things out. That means that it is only possible to start at 10 am in March, when the dew has evaporated. In the autumn, a start cannot be made before 12 noon, and burning can only be done while it is light, so time is short. Sea fog can also delay the start time, especially in western Jutland.

The amount of peat that can be burnt in the spring, when heathland is wet, is limited. In the few burnings performed in the autumn, during September, the humus layer was burnt right through in places, and there were problems putting out the fire because it smoulders in the dry peat layer.

Spring burning is easier to control, because the peat is damp and therefore a large number of fire watchers is not needed, but it can be less effective.

Autumn burning (after 1 September) is not used to such a large extent, but should be given more attention, because, as referred to above, there are often only a few days in the spring when conditions are right. There can often be periods of dry weather and bright sunshine in early September, when conditions are favourable. One should not be fooled by the fact that the vegetation is still alive. Even green purple moor grass can burn at this time.

It may even be that burning takes place at a time when a number of nutrient substances are still in the above ground part of purple moor grass vegetation. Around 1 September, purple moor grass begins to draw nutrients – especially phosphate – down into the root system (see also page 42). If some of these nutrients from the ash are leached, the soil nutrient level will be lower, which is of course one of the general objectives for heathland management.

Burning in the late summer and autumn can be harder to control if the peat is very dry. Fire watchers can be needed for many hours, which can increase costs. But as can be seen from the photo at the foot of page 26, it can give more variation to regeneration. The heather peat is more or less intact on part of the area shown, whilst other parts of the peat are burnt off right down to the sand.

All in all, we can only encourage more use of burning in early September. The conclusion from “The lowland heathland management handbook” (Gimingham 1992), published by English Nature is: “Well managed fires in autumn result in at least as good, if not better, heather regeneration as in early spring, and do not seem to have any particular disadvantages.”
6.2.4 Methods
To ensure safety, it is important to plan burning carefully, and to only burn when wind conditions permit. See the chapter on “Timing”. Permits must also be obtained, notification given and signs set up. To follow is a description of the practical aspects of burning an area.

Method for burning large areas
The Nature Agency’s method for controlled burning of large areas uses tractors with water spreaders and sprays to control the flames.

Personnel: Minimum 6-8 men in radio contact, of whom 1 is the fire supervisor, 1 fire watcher and 2 tractor drivers.
A fire break can be cut around the area using a brush crusher just before burning starts. The next step is to ignite a line around the edge on the inside of the newly-cut fire break, so that the fire slowly burns inwards and can be controlled. Once the fire has spread a few metres into the area to be burnt, it’s time to put out remaining flames on the burnt area on the inside of the fire break. Small plumes of smoke indicate where the fire is smouldering in the peat layer, grass tussocks or in half-rotten tree stumps. Once a sufficiently wide fire break is established, the process can be repeated on a new section. Once the fire line is established on the leeward side, work can progress upwind at a faster rate. The flames are easy to control here with hosepipes, and there is little exposure to smoke. Risks include a sudden wind change, or smouldering fire in the edge of the fire break. Subterranean mouse nests with dry grass or rotten tree stumps can smoulder for a long time, and suddenly burst into flame if oxygen is added. Along the way, the flames should be directed around e.g. juniper bushes and anthills by spraying them with water.

Once the area is burnt, damp down with water, tractor, and set up a fire watch if needed. It can take up to 4-6 hours to create a fire break and the fire edge to ensure control over the flames, whilst a downwind fire can be over within 30 minutes.
The method for controlled burning of small areas using manual flame control.

Personnel: Minimum 5 men, of whom 1 is the fire supervisor and 1 fire watcher.

The principles of this method are the same as for large areas, except that the flames are solely controlled using the cut/burnt fire break and fire beaters.

The first step is to create a fire break where the flames are to stop. This can be done by creating an edge and starting an upwind fire on its inside that can be put out using beaters when the fire break is satisfactory. In hilly terrain, it will be easiest to put out the fire on a hill top where the flames lose energy. Previously burnt areas and wet depressions can also be used as fire breaks. Be cautious when there is dry frost on the ground, as the grass in heathland bogs can be dry, and therefore cannot act as a fire break.

The fire can then be lit as an upwind fire at the opposite end of the area, and the sides controlled along the way by the personnel using beaters as the flames progress across the area. Putting out the fire behind the leading edge is important before moving forwards.

When putting out flames using beaters, it is important to use calm, deliberate movements, and to focus on fully extinguishing the flames, not just damping them. The beater must not be lifted too...
The fire is controlled using fire beaters.

It looks dark - but the moisture on heath creates variation.

high, causing a downward draught that can add oxygen and spread sparks, causing the fire to spread.

The flames will run over the area under control until they meet the fire break, where they will stop.

Once the area is burnt, damp down as necessary and set up a fire watch. Never leave a smoking area!

Remember that dry grass is very combustible, and that the fire spreads faster on dry grass than on a dwarf shrub heathland. Purple moor and other grasses should therefore always be burnt upwind.
Checklist for burning

Preparation
- Obtain all necessary permits (see “Necessary Permits”)
- Check insurance cover before burning (see “Necessary Permits”)
- Train personnel, first aid and firefighting courses
- Prepare and test equipment (see equipment list)
- Inform the public by announcements of burning period

Just before lighting
- Draw up map and aerial photos of the areas to be burned
- Inform the fire service and local bodies
- Inform the public via the press and social media
- Agree on chain of command, appoint a fire supervisor and fire watchers
- Ensure communication by compiling updated phone lists

Prepare burn site
- The fire supervisor is in charge, takes decisions on burning and reporting, ensures overview and directs personnel, determines scope of the fire watch
- Materiel depot and assembly area at burn site, plus ensure passage and evacuation routes
- Sweep area to protect any shrubs, plants and wildlife refuges
- Protect fire breaks
- Assess wind direction and strength

Burning
- Perform initial/test burning
- Estimate number of lightings depending on prevailing conditions
- Start burning
- Keep a check on fire breaks and maintain overview
- Execute any damping down necessary
- Count personnel

After burning
- Set up fire guard for observation or supervision
- The fire guard will be responsible after burning, and call help from the fire services or colleagues in the event of problems
- Report the burn to the fire services
- Remove signs

Repeated purple moor grass burnings
Repeated annual burns were tested in the LIFE-Hede project, as a method of combating purple moor grass. It appears to be beneficial, as the mineral soil is revealed when the withered material around the tussocks is gone, allowing heather to sprout. In some places, the tufts were completely undermined after burning for the 3rd year in a
row, with heather and lingonberry sprouting from their centre. But will purple moor grass take over again when there is still a lot of nutrition in the soil? The trial was also intended to find out whether repeated burning combined with massive, targeted grazing of purple moor grass had an effect, if the grass tussocks were cropped right down and trampled into pieces?

6.2.5 Effect
The intensity of the fire on individual parts of the area will always vary as a result of wind, humidity, vegetation and topography. There are almost always patches that do not burn. The result of burning will therefore be a mosaic of microbiotopes, supporting the conditions needed for life for many heathland plants and fauna. Heathland plants can survive fire and react positively. Practical experience shows that rare species such as *Arnica montana* and blue club-moss show vigorous growth shortly after a fire.

**Upwind fire vs. downwind fire**
There is no indication in practice that upwind fires burn any deeper. The same effect is achieved as with downwind fires that burn at very high temperatures. Sidewind fires can also be used in practice.

**Effect on nutritional content**
Burning common heather removes a relatively large amount of nitrogen and only a little phosphate compared with other management methods. The ash left on the area causes an immediate drop in nutrition levels in the upper mor layer, exploited by lingonberry and grasses etc.

**Effect on tree growth**
Evergreen trees are burnt off and effectively combated if under 1-1.5 m in height, but seed sprouting is also initiated. Deciduous trees also appear to die, but usually sprout from the stump again. These include birch, oak and European aspen. Small evergreen trees die, but there will often be a number of bushes and trees left on the heath that survive, and subsequent clearance of the area is therefore recommended. Either manually, if they are few and small, e.g. mountain pine, where it is important to cut off the lowest branches, or they will sprout again. Or using a brush crusher that crushes the smaller bushes (around 0.75 m). The crushed remains will rot down within a few years.
If there are trees left on the area, they should also be cleared and removed. A few Scots pine, which are an indigenous species, could be left standing for nightjars.

A tool for manual extraction, called an “Extractigator” can be used for newly-sprouted trees that have not yet established a root system. The advantage of pulling them up rather than cutting them down is that they are removed permanently. If opting to simply cut deciduous trees down, they will sprout again from the stump and the root system will grow, making pulling them up at a later date difficult.

**Effect on heathland plants**
Young common heather plants usually put out new shoots from the lower part of their stems after burning. These start the plant’s lifecycle from scratch, giving it an expected lifetime of 25–40 years from that point in time. The litter layer is often removed to some extent by burning (the layer of dead plant parts), which covers the mineral soil and any compact peat, giving much better chances of sprouting for heather and other seeds.

Older heather plants have a much reduced ability to produce new shoots from the stump. One is therefore always more dependent on effective burning, which will remove the dead plant material that prevents the generation of new heather. Older heather plants attacked by heather beetle often die after burning.
Other dwarf shrubs such as lingonberry, bog bilberry and cross-leaved heath also produce new shoot from their stumps. Many herblike plants with their tubers below ground or in the soil surface, also survive burning (e.g. heath spotted orchid, tormentil and sand star). Experience from the LIFE-Hede project also indicates that species such as Arnica montana and blue clubmoss show a positive response to burning.

On the other hand, crowberry dies. Neither is it very fast to reproduce from seed. Its tactic is survival and if possible dominance through a much greater age than its competitors, spreading slowly by putting out adventitious roots. Specific examples have been found to achieve an age of 140 years, established by counting their annual rings (Good, 1927). Burning off patches of a crowberry-dominated area will give a mosaic of crowberry and sprouting heather.

The two dominant grass species on heathland react to fire in totally different ways. A good burn can remove the majority of wavy hair grass growth. On the other hand, this species is quick to colonise the area again by seed. But if the heather sprouts, the wavy hair grass will once again become insignificant within a few years.

Purple moor grass is not affected to any great extent by a single fire. Its tussocks are very compact, and its growth points at the base of the stalks are very well protected against brief heating. New blades appear from the tuft only a short time after a fire.

Heath star moss, which is an invasive species, can dominate the first year or two after burning areas with crowberry, but after a few years heather will sprout through the cracks in the moss and it therefore does not prevent regeneration of common heather. But it is a problem, because it is so dominant that it out-competes indigenous mosses and lichens.

The invasion of flora and fauna on areas after burning is a problem that has been discussed with some of the expert group in the LIFE project. One of the conclusions was that it is the distance from the unburnt heathland to the furthest point on the burned area that is important, more than the size of the burned area. By burning in strips 50-100 m wide, no problem was encountered from burning even very large areas.
As an example, if burning 100 x 100 metres (1 ha), the longest distance from the unburnt heath to a burnt area will be 50 m. If burning 10 ha in the form of strips of 100 x 1000 m, the longest distance will be the same, i.e. 50 m.

**Repeated purple moor grass burning on Randbøl Hede**

A theory that burning off purple moor grass 4 years in a row during the spring could reduce its occurrence was investigated in the EU LIFE project.

In several places it was observed that many tussocks of purple moor grass were dead and that heather was sprouting, but it cannot be said at this time on the long-term effect.

Examples of both a clear effect and almost no effect can be found on the test areas.

Careful follow-up monitoring is therefore needed to determine the effect of the method.

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**Equipment for burning**

- Fireproof suits, gloves, helmet, leather safety boots
- Smoke and fresh air masks
- First aid kits
- Fire blankets
- Powder extinguishers
- Fire beaters
- Storm matches
- Handheld flamethrowers + fuel (petrol/diesel) with user guide
- Chain saw
- Tractor with front loader/heather cutter
- Tractor no. 2 with water trailer and sprayer/Tractors with field sprayers and hose reels
- Pipe wrench for opening hydrants
- Tool box with spare parts
- Extra fire hoses and couplings + large hose for hydrants
- Chain for vehicle recovery
- Heavy duty jack + beams
- Radios with fully charged batteries
- Telephones and phone lists
- Aerial photo of area
- Warning signs for public roads
The method has to be regarded at this time as a possible weapon, but cannot stand alone when it comes to reducing purple moor grass dominance.

6.2.6 Equipment
Burning is dangerous for personnel and machinery. There is also the risk of a fire spreading uncontrollably to adjacent areas. That’s why a number of requirements are made to equipment and safety equipment. And if the right equipment is not in place, burning should never be commenced!

On the bottom of page 37 is a list of the equipment the Nature Agency has used for burning heathland in the LIFE-Hede project. It covers personal safety equipment, communications devices, lighting and extinguishing equipment plus tools and spare parts that are important to have, to be able to deal with problems as they arise quickly and on-site.

Tractor no. 2 is primarily intended as a backup, should tractor no.1 break down.

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The Statutory Order on fire safety precautions when burning, using naked flames, lights, heat sources etc., Section 7 (SO no. 1339 of 10/12/2014, applicable from 1 January 2015)

The local authority has to give permission before heather on the root, heath and bog peat, plus heath and bog soil can be burnt. The local authority will decide whether burning is safe with regard to managing natural habitats, and will set the safety conditions for undertaking it, including the size of the personnel team needed.

The local authority has to obtain the Nature Agency’s opinion prior to notification of a permit for burning between 1 March and 31 October.
6.2.7 Necessary permits
Permits have to be obtained for burning from the fire authorities. A single permit for all burning conducted throughout the year is usually obtained, and then the fire service is informed the day before the actual burn.

The general terms and conditions in Chapter 2 also state that the danger of fire has to be prevented, and reasonable rescue and firefighting options are provided, and that burning will not take place in hard wind, that the smoke cannot annoy neighbours, that the area must be kept under supervision until any smouldering is extinguished and that burning can only be performed from dawn to one hour after sundown.
Burning can contravene the Status Quo conservation of heathlands.

It requires dispensation from Section 3 of the Nature Protection Act, and has to be considered with regard to Natura 2000.

Contact the local museum first, to be able to consider historical remains, such as ancient fields, earthworks, sand erosion banks and sunken roads.

Check insurance cover for burning. There are contractors who have taken out insurance that covers any damage occurring from heathland management by burning. The Nature Agency is self-insured. Dansk Plantageforsikring offers insurance against forest fire at www.skovbrand.dk. Insurance against forest fire is also offered by other insurance companies. Checking the insurance products on offer in advance is recommended, and whether fire in connection with using burning as a form of management is covered.

6.2.8 The finances
It is hard to put a value on the cost of burning, as it depends heavily on wind and weather. It lies between DKK 700 and 3,000 per ha., depending on size of area and number of personnel.

Fire belts for safety are the most expensive and the most time-consuming to create, and therefore the bigger the area that can be burnt within them the lower the overall cost in principle.
6.3 Harvesting

Mowing, even without the removal of the material cut, has been used for heathland management through time (see also chapter 3.2 on traditional heathland farming).

Nowadays, there is a lot of focus on removing the cut material, and thereby nutrition, from the heath. In other words, actual harvesting takes place. Heather and grass can be harvested on heathland. Harvesting creates a change in the vegetation for a short period, and is primarily used for maintenance.

6.3.1. Objective and things to consider

Harvesting is used in particular to counter the threat of purple moor grass growth, and to renew old heather. Another aspect is that the material harvested can often be sold.

The objective of harvesting heather is to renew the heather and remove nutrients from the area. It can also be a form of preparation for grazing or stripping. The objective on areas infested with purple moor grass is to reduce the grass and promote sprouting of common heather and other typical heathland plants.

Harvesting has the immediate advantage of removing a number of nutrients with mown material, and selling it helps cover the overheads of management. However, it should be borne in mind that heather harvesting gives a relatively similarly aged and monotonous heathland. The operation can be radical for the fauna on the heath if large areas are mown at one time. Leaving small, uncut patches will not cause any harm.

6.3.2 Suitable areas

Mechanical harvesting requires a more or less level heath. The method can be used on heaths of any size, and creates variation on large heaths by cutting smaller fields in different years.

Harvesting is usually not applicable where there are historical remains such as high-backed fields etc. The machines will also destroy wind-eroded stone. An alternative to mechanical mowing on small, vulnerable areas can be use of a motorised, two wheel manual tractor with blade cutters, and on very small areas annual mowing with scythes. Financially only viable on very small areas and/or using voluntary labour.
The use of machinery that does not dig into the ground is, however, possible on certain areas and with care, e.g. disc harvesters. But always make sure that agreement is in place with the local museum before starting.

6.3.3 Methods and machinery
Cutting is used to harvest heathland either by cutting or crushing with flails. The material cut should always be removed to take away nutrition, revealing areas for sprouting. On the other hand, material left on the ground does provide nutrition for the soil and suppresses regrowth.

Picking up cut material is vital, to remove nutrients from the heath. That's why it is important to either press it into bales that can easily be removed at a later date, or if it is shredded, it can be collected directly in a trailer as it is cut.

A brush cruiser is effective on coarse vegetation with a lot of tree growth, whilst blade and rotary mowers are best for fine vegetation without any major tree growth. Flail cutters can be widely used, except on areas with many large trees.

A disc harvester can be used for thorough cutting. The method is relatively cheap to use, and manageable big bales can be produced. With care and by agreement with the local museum, a disc harvester can be used in certain instances where there are historical remains.

A heath/heather harvester with a flail cutter can cut lower, and can be set to also remove some of the litter layer. It also cuts pine shrubbery in the same process. The resultant material can be removed in a trailer in the same process.

Harvesting purple moor grass
This method is not a copy of heathland farming as most other forms of heathland management methods are. There are no historical records of whether heathland farmers cut grass for hay on the heath. And the large, dry areas dominated of purple moor grass as we know them today were not a feature of the heathland farmer's time.

Over the last few decades, this species of grass has spread across many Danish heaths and has become a growing problem, as it is a strong competitor that forces out other typical heathland plants. The problem is further exacerbated by the fact that it can-
not be easily killed-off using traditional methods of heathland management such as burning, grazing or cutting. This is due to the excellent protection of its growth points on the basis of each single stalk.

Increasing amounts of nutrients on the heaths seem to be a contributory factor to the drastic expansion of purple moor grass. Heathland plants are adapted to low nutrient growth sites. They can certainly grow where there are higher concentrations of nutrients, but under such circumstances, purple moor grass out-competes heather. That’s why a trial was started in 2003 aimed at discovering whether removing some of the nutrients could change the situation in favour of heather.

To maximise nutrient removal, the majority of the above-surface biomass was cut and removed over a three year period from 2003-2005, in early August. This month was chosen because Dutch studies have shown the biomass of purple moor grass grows until around 1 September, after which it draws phosphate and nitrogen in particular from its leaves and down into the root system (Aerts 1989).
When the trial commenced in 2003, the vegetation consisted of 85% purple moor grass and 13% wavy hair grass cover. No clear effect from cutting could be seen the first couple of years as can be seen from the figure on page 43. But a slow increase in heather from 0% to 12% can be seen between 2003-2006. The new heather plants were dominant by 2011, covering 76% of the surface. Heather can therefore in such conditions win over purple moor grass. The result was achieved without damaging the tussocks of purple moor grass mechanically.

When this method is applied to former heathland totally dominated by purple moor grass, it leads to a remarkable advance for heather and thus improved natural habitat when heather dominance is the objective. Purple moor grass dominance in 2003 (85% cover) was converted to common heather dominance (76%) in 8 years. Unfortunately, species diversity is low with few typical heathland plants.

As yet, the results have not led to any extensive use in practice, but it was used on one of the heaths in the LIFE-Hede project. However, the results so far are not totally convincing. If the final evaluation later reveals that the results are unsatisfactory, two contributory explanations can already be identified. Firstly, the areas were not cut until September in a couple of years, and secondly because it was believed that cutting could be performed closer to the ground.

Purple moor grass was cut on a wet area at the point of descent into a bog on another area during the LIFE-Hede project. Normal machinery cannot run here, but a disc harvester on a snowcat running on wide tracks can be used. The machine can cut the tussocks right down, and the material can then be collected by a pick-up presser also running on wide tracks (photo, page 44, top).

However, experience has shown that heather/heath harvesters (flail cutters) are more effective for combatting purple moor grass than disc harvesters.

It became possible to obtain subsidies for cutting over a 5-year period in 2015, as part of a subsidy scheme for grass and natural habitat management. The areas concerned must be cut at least once between 21 June and 15 September.

This method was not tested in the project, but is worth trying in line with repeated burning referred to elsewhere.

6.3.4 Timing

According to the Statutory Order on soil resources from 2010, heathland areas protected by the Nature Protection Act can only be cut or cleared between 1 August and 30 April, and haymaking must take place between 1 July and 30 April. This is for the protection of fauna and flora.

A good time for cutting common heather is February - March if the ground is dry. If the heather is cut in the autumn, there is a risk of frost damage in periods of ground frost. Purple moor grass must be cut before 1 September when it draws down nutrition, to weaken it as much as possible.
6.3.5 Selling harvested material

Good quality, whole disc-harvested heather (6–7 years old preferred by thatchers) can be sold for ridging thatched roofs. 1,000 heather bales (small) are sold from Harrild Hede for this purpose every year. 100–600 heather balls per hectare are usually harvested, mostly where there is a lot of crowberry. 2–5 hectares are harvested on Harrild Hede annually, mostly in April, but also in September.

The harvested and cut heather (plus any crowberry) can be sold as bedding for riding schools, as biofuel or for cover and soil improvement in gardens and on fields. Crushed material from heather harvesting can be used in composting sheds if the sand content is low.

Purple moor grass and heather can be pressed into round bales for biofuel. Round bales of purple moor grass have a high content of dry matter. Experience from the LIFE-Hede project showed that the market is unstable. District heating plants were happy to take the first year’s harvest of purple moor grass bales, but the following year, the market was flooded with biofuel and heathland bales could not be sold.

There is however hope that biogas and electricity generating plans will be able to handle products containing some sand in time.

6.3.6 Effect

Blade and disc cutters have been found to promote vegetative renewal of heather, whilst heath harvesters/scrapers from Aarestrup (Bio-Pick Up) also result in enhanced seed production. Cutting individual plots at intervals of 6–10 years produces a uniform heather, well suited to thatching. Such frequent cutting results in a relatively uniform heath, and cutting at longer intervals is therefore recommended for heathland diversity.

A trial was conducted on Randbøl Hede where purple moor grass was dominant to cut and remove parts of the upper humus layer with heath harvesters three years in succession1 in August (2003-2005). Cutting was very close to the ground, and the material removed to get rid of nutrients. Before cutting, purple moor grass coverage was 85% and there was no heather. Coverage of heather was registered as 78% in 2011. The results from between 2003 and 2011 look promising, and the method can certainly be improved by removing heather once a large biomass has been built up (Degn 2015).

When cutting only is involved, the heath harvester is better at recreating heath harthland and reducing the cover of purple moor grass than a disc harvester, as it can go deeper and remove more grass tussocks which suffer more. But please refer to the reservations concerning historical remains mentioned earlier.

6.3.7 Necessary permits

According to farming legislation, haymaking/cutting can only take place between 1 July and 30 April. Contact the local museum first in the event of any mechanical use, to avoid destroying any historical remains, such as ancient fields, earthworks, sand erosion banks and sunken roads.

6.3.8 The finances

Harvesting heaths can be divided into models, depending on flora and topography. The following three models are in use in the LIFE project.

A heath surface dominated by lush, older heather ready for harvesting can typically be sold for thatching material. A contractor currently pays between DKK 8 and 14 net per bale of heather they can use. This work is typically done by heath harvesters and a standard small bale press. Use of this method contributes DKK 4,000–6,000 per ha. to overheads.

On tufted and uneven areas, heath harvesters are often used, as they are relatively narrow and very robust. They run with a collector and the material is often left in piles at exits to roads. They are then removed by road and can often be used as bedding and soil improvement material by local farmers.

The price per hectare for harvesting is DKK 4–5,000. In addition is the removal of the material, when the price depends on the distance by road to the buyer.

Large disc harvesters can be used on flat, homogenous areas, combined with hay rakes and round bale pressers. This method has been found to cost DKK 1,800–2,200 per ha., plus the cost of transporting round bales from the area.

The same method can be used on tufted areas, if they have been harvested with a heath harvester the year before. The round bales in the LIFE project have been sold to district heating and power stations, and to local farmers for bedding.

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1 There is increasing awareness of possible acidification as a result of repeated biomass removal. Bach et al. http://bios.au.dk/om-instituttet/organisation/plante-og-mektoekologi/natuurpleje/
6.4 Grazing
Grazing affects heathland vegetation in a number of ways. Apart from the livestock eating the plants, they also trample them to pieces to some degree. Amongst the trampled plants, the opportunity is created for seeds to sprout, and cropped vegetation, including common heather, can put out new shoots. The effect of grazing depends on the livestock used. Sheep eat the freshest and most nutritious parts of the plant, whilst cattle tend to be less selective, eating the coarser and withered parts as well. The LIFE-Hede project worked with intensive short-term grazing of purple moor grass using sheep, and with more permanent cattle grazing of large, varied areas of heathland.

6.4.1. Objective and things to consider
Grazing generally creates a more varied form of plant growth, with higher grass content. On better soils, it can develop heathland in the direction of pasture (Buttenschøn and Buttenschøn, 2015). It is used as continuous management, either seasonally or all year round, and as follow-up combined with burning, clearance and cutting. Either over a series of years within permanent fencing, as intensive short-term grazing with mobile fences or as targeted herd grazing, often combined with burning.

Grazing has been – and still is – the most widely-used heath management method, often used continuously without any other form of activity than supplementary clearance of trees.

It is used in particular to counter the growth of trees and bushes, and to renew old common heather and dwarf shrubs. When used as a follow-up, it can prevent grass colonisation on dwarf shrub heaths, e.g. patchy purple moor grass, which spreads after burning or regrowth of grass after being cut with a heath harvester. The objective is to crop the grass down and destroy purple moor grass tussocks to encourage more competition, and to promote the growth of common heather and other characteristic heathland species.

Grazing with sheep, cattle and horses is an authentic management method that is reminiscent of heathland grazing in times gone by, and that also is a natural part of the heaths where there are large herds of red deer. Wildlife primarily grazes heathland in the winter. That means that there is generally no high grazing pressure from wildlife in the summer that can suppress purple moor grass. Once grazing has been started, it requires regular supervision, maintenance of fencing, provision of water supplies and shade/shelter for the animals. Managing grazing pressure can be a problem. Especially if the budget is dependent on subsidies with requirements for fixed grazing deadlines or vegetation heights, which can be a problem when grazing with mobile fencing or herd grazing.

With the latter, it is possible to target grazing against e.g purple moor grass, and to place night folds on relief areas that can tolerate the extra manure (Buttenschøn and Gottlieb, 2016). Large flocks of sheep have been built up in Holland and Germany with their own herders, who can be ordered to graze areas at a fixed price per day. This practice has not become widespread in Denmark, but Lystbækgaard in west Jutland is working intensively on such a scheme. They have a sheep herd and a herder.

On heaths with public access, public safety and protection have to be taken into account when walking on areas with grazing livestock, e.g. bulls. Deer gates can be built in permanent fencing to ensure easy access, whilst mobile fencing can mean that the public are denied access for a while.

6.4.2 Suitable areas and their size
Grazing can be established on most heathland areas in principle. All-year grazing is best on large, varied areas with wet and dry zones, plus shelter and shady trees. Short-term grazing can be targeted to newly burnt areas with purple moor grass growth, and herd grazing is suitable for areas with patchy occurrence of the same, and where the conditions make fencing difficult.

Because of the risk of damage, grazing can be a problem on sensitive ancient monuments.

Livestock used for traditional grazing is usually on the Nature Agency’s land from 1 May to 1 October. If grazing is used as a follow-up after burning, it can be used on grass-dominated areas the same year as the heathland is burnt in the early spring. On purple moor grass-dominated areas, it is important that the livestock is put out as soon as possible to control the boost the grass often gets immediately after burning.

6.4.3 Fencing and equipment
The Nature Agency uses the following fencing types: two-wire permanent electric fences for...
cattle and horses, three or four wire permanent electric fences for sheep and four wire movable electric fences for sheep. When Viborg County Council put fences around Kongenshus Hede in 1997, it used 25 km of woven fencing combined with a single electric wire. As most heathland areas are far from buildings and electricity, solar cell-powered batteries are usually used for power supply.

Where natural water is available, no watering facilities are provided. The alternative is a pasture pump. Where there is insufficient water, it is transported by a water tanker that can be connected to a water trough by a valve. It can also be necessary to drill for water.

Access to water governs animal movement, and is a means of spreading them within large enclosures by providing several watering facilities.

Shade and shelter in the form of sheds should only be provided if necessary, otherwise folds should be created to make use of the natural features for shade and shelter in shrubbery and coppices on dry land.

If a subsidy is paid by the Nature Agency, supplementary food can only be given in calving shelters. Mineral feed is permitted, and is needed all the time to meet the needs of the livestock on the low nutrition soils of the heath. Mineral high in phosphate and magnesium should be added on acidic soils.
When grazing with sheep, precautions should be taken to counter problems with intestinal parasites.

The technical problems involved with grazing are particularly linked to provision of water and electricity in remote areas, and not least controlling grazing pressure. Finding the right grazing level in consultation with the livestock owner can be difficult, and requires close control throughout the year. Grazing pressure that is too low can mean colonisation by neighbouring plants or the regeneration of purple moor grass. If the latter spreads despite grazing, supplementary cutting can be attempted on those areas where it accounts for more than 50%.

In large enclosures where there are problems getting the livestock to graze the entire area, temporary fencing can be put up to concentrate them where the need is greatest.

Controlling grazing pressure is one of the strengths of herd grazing, as the herder can control the flock’s daily movement over the heath, and target grazing.

6.4.4 Feed value
How many animals can be grazed on an area will always depend on the nature of the area, but the following rule of thumb can be used for the number of animals that can be put out on 1 hectare of heath:

<table>
<thead>
<tr>
<th>Animal Type</th>
<th>Feeding Rate per ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bullocks</td>
<td>0.42</td>
</tr>
<tr>
<td>Beef cattle</td>
<td>0.13</td>
</tr>
<tr>
<td>Hardy beef cattle</td>
<td>0.1</td>
</tr>
<tr>
<td>Sheep</td>
<td>0.73</td>
</tr>
</tbody>
</table>

Figures from Kristensen & Horsted, assuming that bullocks, calves from the dairy cattle herd, lambs and beef cattle graze 150 days a year, whilst sheep and hardy beef cattle graze 180 days. The livestock are indoors the rest of the year with feed. Hardy beef cattle graze outdoors all year round.

Purple moor grass reaches maximum production between mid-July and mid-August, when hard grazing pressure is necessary, and it should ideally be grazed between 1 June and 1 September. Food production is around 600-1000 FE per ha. After 3–4 years, grass production drops and food production falls to around half. All grazers eat purple moor grass. In a trial using cattle grazing on the Himmerland heaths, purple moor grass was consumed to a relatively large extent with a factor of 3–5 in relation to the proportion it represented of available plant growth (Buttenschøn and Buttenschøn, 2015).

Wavy hair grass
Wavy hair grass growth peaks in April to May, and it has another growth period in August to September if there is sufficient rain. If grazed in the spring, it produces no seeds and is maintained in a fresh growth phase that gives good winter fodder as long as the grass is green. If it is allowed to seed, blade growth late in the year is not so high and feed quality is lower. Feed production varies between 300–600 FE per ha, and falls in the event of consistent grazing management of the area. Wavy hair grass is also rejuvenated after a fire, which disappears again after a few seasons. Despite poor production, livestock and wild animals prefer wavy hair grass most of the year to common heather. That could be linked to results from a trial that showed that the digestibility of wavy hair grass is higher than common heather (Buttenschøn and Buttenschøn, 2015).

Winter grazing Hardy beef cattle (Galloway) finds food under the snow.
somewhat lower than that of grass at 200–300 FE per ha. That means that livestock put out to winter grazing only receive the energy they need to convert their food. Natural habitat management is also included, but no new growth during this period. The first growth season after management actions such as burning, harvesting etc., leave dwarf shrubs very attractive to grazing livestock, and if grazing pressure on e.g. burnt dwarf shrub heath is too hard the first year, it can result in grass plains with very low-cropped heather rather than rejuvenated dwarf shrub heath.

Crowberry
Crowberry has a low food value, and is the last thing livestock will eat. Experience shows that if the livestock eat crowberry, they are on the verge of starvation. If burning of crowberry-dominated areas is under consideration, followed by an application for grazing subsidy, such areas must be burnt 1–3 years in advance, as the plant cover with other heathland plants takes time to form, making them no longer suitable for grazing.

6.4.5 Grazing livestock
The grazing habits of different livestock species and their food preferences differ widely. They do not eat the same plants and therefore have varying impact on heathland types. An increase in grazing pressure gradually erodes the effect of the difference in grazing methods and choice of food between livestock species.

Cattle
Cattle are omnivores. When they graze, they tear up grass and plants with their tongues and using the teeth of the lower jaw and the dental pad in the upper jaw. They can crop close to the ground, and vegetation has to be over 6 cm high before they can take a mouthful.

There method of grazing means that they have difficulty selecting specific plants. Instead, they choose to graze their preferred plant types.

Experiments have shown that cattle prefer grasses and semi-grasses to herbs, and are not keen on bitter-tasting feed (Buttenschøn, 2007). They like to eat leaves and deciduous tree twigs, and secondary plant growth can be severely damaged by cattle, although they cannot keep heathland free of colonisation in the long term. They avoid grazing closer than 10–20 cm of dung, which helps limit the spread of parasites.

Sheep
Sheep crop grass off and can use their split upper lip to select small, specific herbs and plant parts, cropping them close to the ground.

They like bitter-tasting food, and therefore eat bitter herbs such as hawkweed and many other herbs of the daisy family (Asteraceae). They generally eat more broad-leaved herbs than cattle and horses, resulting in plant growth that tends to be low in species. Most sheep eat dwarf shrubs, deciduous trees and bushes, and some species even eat evergreen trees. Their ability to effectively select quality food items enables them to survive on poor soils such as heathland. They avoid eating close to their own dung if there are large amounts in e.g. their rest areas, otherwise they are not so fussy.

Sheep are herd animals, remaining in either large flocks or smaller family groups, following the same routes between water, food, rest areas and grass every day in different periods. Older animals teach the younger ones the best way of grazing on heath-
land. They often graze at sunrise and sundown, and prefer to rest in the shade during the middle of the day to chew the cud. What’s special about sheep is that they have to be sheared, taking them away from the fold once or twice a year. They prefer to graze on dry areas. When grazing with other animals, it must be borne in mind that they cannot tolerate large amounts of copper, and cannot therefore share minerals with cattle and horses.

**Goats**

If there are problems with scrub vegetation, goats are worth considering. Goats are ‘top grazers’, who prefer to graze at shoulder height and up, reaching up to heights of 2 metres. They can select specific food items using their mobile upper lips, and their strong teeth and chewing muscles enable them to bite through branches. Neither are thorns a problem, as they have a strong mandible enabling them to eat blackberries, thistles and roses.

Goats select the most nutritious part of plants, but also need a certain amount of fibrous plant material in their food. Around 60% of their food intake can consist of secondary growth, and they prefer high herbs to grass (Buttenschøn, 2010). In an experiment on grazing heathland, goats have been found to eat a larger proportion of common heather than sheep. They do not graze close to dung, as they are very sensitive to parasites.

Goats are very active herb animals. They investigate their food carefully before eating it, are highly mobile and comb an area to find the food they seek. Even though they are small animals, their presence can cause damage problems, e.g. to historical remains. They do not like wind and rain, and therefore the provision of shelter from the weather is necessary. If current is always kept in an electric fence and good conditions are ensured for goats so that they prefer being enclosed, it is possible to keep them penned. Otherwise they are clever animals and good at breaking out.

**Horses**

Horses can graze herbs and grass very close to the ground, as they have teeth in their upper and lower jaws that bite the grass. They can select specific plants with their upper lips, using it to detect and avoid poisonous plants they are sensitive to. Horses are not ruminants, and robust equine species can manage on areas dominated by coarse food with high dry matter content by consuming large quantities, because it passes faster through their digestive system. Experience has shown that horses, for example, eat common rushes, and they can be used to graze areas with coarse grass such as purple moor grass and wavy hair grass. They

**Medicating grazing livestock**

Ivermectin (or avermectin) is a broad-spectrum drug used against parasites, used to a large degree to combat worms and other parasites, especially in cattle. Sadly, it has an unfortunate side effect. The dung from treated livestock contains such high levels of residual medicine that many different insects that normally breed in dung and that are specially adapted to this way of life are affected. The number of species (biodiversity) and reproduction of individuals is reduced to a fraction (Iglesias et al. 2006).

This is an aspect to be aware of, and whether natural habitat management should follow the same guidelines as apply to organic production should be considered.

In organic production, dung samples are always required first to prove the need (eggs/larvae in the sample). Treatment can only be administered by a vet, only individual animals can be treated and a log book has to be kept of treatment etc. (a voluntary agreement could mean dropping the requirement for a vet and log book)

But parasites are a limited problem on the dry areas, and could mainly be tackled by changing folds and robust, healthy livestock.
often steer away from secondary growth and will therefore not prevent the growth of saplings to such a great extent. However, they can become used to doing so, and become good for natural habitat management. Horses typically have certain areas where they deposit their dung and do not graze. Such areas will be dominated by plants that require high nitrogen levels.

Horses are also herd animals, but to a lesser extent that sheep and cattle. In common with the other grazers, they are most active at sunrise and sundown, and rest in during the middle of the day and at night.

**Multi-species grazing and rotation grazing**

The differences in the way different animals graze can be exploited by having them graze together or one after the other on heathland. The idea is to achieve better use of the limited amount of food, and reduce the disadvantages of any given species and its grazing habits. Cattle and sheep, for example, will to some extent graze the areas horses deposit their dung, preventing the growth of herbs that require high levels of nutrition, and horses and goats will eat coarser, less nutritious food than the others.

Sheep and goats will eat and renew dwarf shrubs to a greater extent, whilst keeping trees and bushes down. Goats only compete to a limited extent with other animal species for food, if there is plenty of secondary growth available.

Remember mineral supplements for multi-species grazing: sheep must not have access to cattle minerals as they contain too much copper.

Extra focus on parasites is recommended, as they can represent a risk of cross-infection and spread due to multi-species grazing. This is particularly true with sheep and goats, as the latter have lower tolerance to parasites than sheep.

But multi-species grazing can also be used to limit parasites, as species-specific parasites will be ingested by the wrong species, preventing them from reproducing. On areas with low infection rates, young animals will be able to achieve natural immunity, making them ideal for habitat management.

**Game**

There are substantial herds of red deer on some areas of heathland, which have a significant impact on the vegetation.

### 6.4.6 Effect

The overall effect of managed grazing on heathland is that purple moor grass, wavy hair grass and trees can be kept down to an acceptable level, and the sprouting of dwarf shrubs and typical heathland plants ensured, developing vegetation rich in structure and species offering a habitat for many insects and animals.

The problem with heathland grazing is the relatively low food quality, meaning that the robust and hardy species are the best-suited. But experiments conducted in Denmark and abroad show that calves can learn to exploit the available food better from experienced adult cattle, either their mothers or from other species (Buttenschen and Buttenschøn, 2015). As such, setting up heathland management using family or related groups of cattle can
be an advantage. The quality of food generally declines during the season, mostly for purple moor grass, whilst wavy hair grass maintains a more stable level of quality, and common heather is available all year round. It is most digestible in the summer, although hardly eaten at this time because livestock prefer other foods. As such, it is important that the livestock can switch food types during the season as their quality changes.

Another problem is managing grazing pressure. A level that is either too high or too low is non-beneficial to the development of a varied dwarf shrub heath. If grazing pressure is too low, litter accumulates, food value is reduced, the grass is not cropped and there will be insufficient rejuvenation of heathland vegetation. If it is too high, grass and dwarf shrubs will be cropped too far down helping create a grass plain. Common heather can only tolerate grazing of up to 40% of its annual shoots.

Low grazing pressure is usually the problem, especially with regard to combatting purple moor grass, when the physical undermining and starvation of tussocks is vital. The Nature Agency has countered this problem by cutting areas with strong regrowth of purple moor grass during the season, or by increasing grazing pressure in problem areas temporarily using mobile fencing. Targeted herd grazing is the best option for managing grazing pressure. All-year grazing and late season grazing can be a solution which are currently restricted by requirements for subsidy schemes.

In general, it can be said that grazing only removes small amounts of nutrients from the areas grazed. Grazing primarily redistributes nutrients on the heath. Nutrients can be deliberately removed from some areas and relocated to others by putting livestock in night folds or stables at night, from where nutrient-rich matter can be collected, a tactic used by heathland farmers, to whom the heath was a source of nutrients. An idea can be gained of nutrient redistribution from an experiment conducted in Holland with extensive grazing, in which cattle ate between 40–60% of the annual above-ground plant production, and deposited the resultant urine and manure on 1-4% of the area.

Cattle defecate most often when walking between grazing areas or when rising from rest, which means they distribute nutrition evenly around the area. Horses often use special latrine areas, and do not defecate on their preferred grazing areas, causing

There is room for sundew and grass-like sedge when purple moor grass is grazed.

March gentian (Gentiana pneumonanthe) tolerates grazing.

The sheep graze purple moor grass tussocks close in some places.
a definite concentration of nutrition in certain areas. The use of sheep spreads dung more evenly over the area, although with a concentration where they rest.

Extensive grazing on the heath can lead to exhaustion in the long term, via enhanced leaching of nitrogen in the form of nitrates and associated substances such as calcium, magnesium and potassium, maintaining and recreating a low-nutrition heath.

Grazing has an effect on competition between plants, e.g. when livestock prefers grass such as purple moor grass to dwarf shrubs. Where purple moor grass is cropped down, heather plants can sprout. The physical impact livestock has on an area helps maintain dynamism by mechanical effect and physical wear and tear. Developments in the range of species as a result of grazing is due to changes in access for light to the soil, the nutritional status of the soil and changes in its structure as a result of the trampling and physical impact of the livestock. Summer grazing prevents a number of flowers from blooming and seeding, something avoided by autumn/winter grazing. Different species are therefore favoured. The spreading of seeds is another important function of grazing. Spreading is achieved via seeds caught in the coat of the livestock, on their hooves and claws, and via their digestive systems.

The most common heathland plants have medium to high tolerance of grazing, and rarer species such as Arnica montana, devil’s bit and common moonwort have medium tolerance.

Purple moor grass and wavy hair grass
Both these grass species can be curbed by the right grazing pressure.

In contrast to wavy hair grass, purple moor grass withers in the winter – but before it does, it draws nutrients down into its root system, and does so regardless of whether it flowers or not.

The withered material takes a very long time to decompose. Purple moor grass thrives and spreads when there is soil that makes it highly competitive in relation to other vegetation.

Grazing has to ensure that it is cropped right down, and is not left with a lot of blade mass that withers in the autumn, and that will to some degree protect the new, attractive blades against grazing when it begins to sprout again the following year.
Purple moor grass tussocks are broken down mechanically by being trampled by livestock. It takes many more years to exhaust the nutrition reserves through grazing rather than cutting. Purple moor grass has to be grazed hard in the summer, when the nutritional content is high, to prevent it establishing tall tussocks with a dense concentration of withered grass blades that will prevent livestock from grazing fresh shoots in the spring. The livestock must be removed from the area before they begin to eat heather, which they do when the heather begins to flower. This helps tip the balance between heather and purple moor grass with the help of grazing.

The best time to graze purple moor grass is in the first growth season after burning or harvesting. The first growth season after burning is when the grass is more nutrient-rich, which can be seen by its colour and the fact that red deer prefer to eat it at this time. In the event of repeated burnings, the nutrient wealth from the ash is phased out.

Wavy hair grass has a growth period in early spring, when livestock are keen to eat it. If grazed down at this point, it will only be able to seed sporadically. It has another growth period in the early autumn. If heaths with wavy grass hair and heather (without purple moor grass) are grazed, it is a good idea to decrease the grazing pressure in midsummer to give the heather good growing conditions until it flowers, after which, it can be grazed hard. Hard grazing on heather can also be done in the winter.

Managed grazing on heathland requires continuous supervision of grazing pressure if a varied heathland rich in species with many visible dwarf shrubs is the aim.

**Secondary growth**

The growth of deciduous trees such as willow, European aspen and black cherry can be curbed by grazing. But grazing alone cannot prevent them in the long run, unless goats are used. Goats can effectively hold tree growth in check and eliminate existing deciduous scrub – including juniper, meaning that care has to be taken if the heathland under management has protected juniper scrub.

Evergreen trees are eaten only to a very limited extent. Horses can eat the bark on trees, which will then die, and most animals will rub against secondary growth, weakening them. Scotch broom can be curbed by grazing, but experience has shown that it often has to be supplemented with cutting the first few years. The timing of grazing is significant. Most secondary growth is very sensitive to grazing in the spring, but some species, such as willows, are edible all year without any particular seasonal variation.

**Dwarf shrubs**

Common heather and cross-leaved heath are rejuvenated by grazing. Crowberry is not eaten by livestock. Sheep and goats eat dwarf shrubs more often than cattle, who usually only eat heather late in the season, when grass quality begins to decline. All year grazing has a bigger effect on dwarf shrubs. Apart from being cropped, they are affected to a great degree by trampling, and trampling of the old, senile heather plants creates sprouting beds for new ones, supporting rejuvenation.
Birdlife
Grazing heathland and meadows in the vicinity of nightjar habitats can cause favourable foraging conditions for the nightjar, because the grazing cattle either disturb insects or are surrounded by them in the air. The wood sandpiper also benefits from grazing. It nests in heath and peat bogs, near ponds and marshes on heathland where vegetation is low. By grazing heaths the vegetation is kept down to a level that makes them suitable as a nesting ground for the wood sandpiper.

6.4.7 Permits and legislation
The Danish Animal Welfare Act lays down a number of rules for animal welfare. The general provisions of chapter 1 of the act state that animals must be treated in accordance with their needs. They must be given protection against wind and weather, and free range animals on grass must be inspected regularly. The most important things are the adequate supply of available food, access to fresh water and minerals, along with a dry place to sleep, shelter and protection from rain.

If the livestock is kept outdoors during the winter from (November) December - February (March), dry bedding and shelter must in principle be provided by access to a shed or building, but can also be present on large, varied heaths as natural features in the form of areas with especially well-drained ground and vegetation that provides a high degree of shelter and protection against rain, e.g. access to woods/plantations.

Sheep are generally regarded as being very hardy, so as long as they are prepared for being outdoors and under supervision, there are no requirements for a shelter.

Dispensation has to be applied for from Section 3 of the Nature Protection Act to introduce grazing on heathland areas. Grazing can affect ancient monuments and historical remains on the heath. If a heath is protected, grazing can require dispensation.

6.4.8 Selling animal products
The sale of young animals and mature animals for slaughter is a source of income for livestock owners, e.g. by marketing the meat as “free range.” Setting up a grazing cooperative that provides the management for grazing natural habitats is another option for direct sales, when consumer focus is on the protection of nature and its by-products (e.g. meat and wool).

6.4.9 The finances
The publication “Financial analyses of natural habitat management methods in protected areas,” from 2012, model calculations showed that heathland is the cheapest form of natural habitat to manage using cutting and grazing. The analyses also show that there is no profit to be made without subsidies. A subsidy of around DKK 500-2,700 per ha. Is needed depending on the type of livestock, size of area and nature of the terrain, with free range cattle on the biggest, flattest areas as the cheapest, and hardy ammekvæg on small, hilly areas as the most expensive.

When traditional grazing is established, there are overheads for fencing, water provision (if needed), electricity, transport and supervision of the livestock, maintenance, winter stabling and winter feed.
The potential income comes from selling fattened animals and their descendants, and from any subsidies for natural habitat management and any area subsidies. There has been a series of various programmes over the years with subsidies from EU pools. These can be granted to either the landowner or livestock owner.

The Nature Agency has found that permanent grazing with subsidies for management can make a profit, whilst grazing using mobile fencing makes a loss, but would break even or make a small profit if subsidised.

Permanent fences are not erected for herd grazing, but fences are often erected along roads and for night folds using mobile fencing and water might need to be provided. In addition are the costs of transporting sheep and the herder’s wages. This is a relatively expensive form of natural habitat management, for which subsidies can make all the difference to the budget.

Unfortunately, the subsidy programmes currently available (2016) are not specifically intended for heathland management, as the control requirements for either fixed animal pressure in the summer (June-August) or visible grazing of the vegetation cover in September can often not ensure optimum heathland care.

The time limit for checking grazed vegetation of 15 September for dwarf shrub heathland is too early in relation to optimum utilisation of the food resource inherent in dwarf shrubs. The vegetation suitable for grazing between the heather is what is checked. September is a suitable time for checking purple moor grass, which should ideally be cropped short before it draws nutrition to into the roots during the autumn.

Otherwise, the requirement for grazing the same area within permanent fencing for 5 years gives a problem in terms of qualifying for a subsidy for herd grazing and grazing using mobile fencing. The latter two methods can be highly suitable to combatting purple moor grass, as grazing is easy to target, ensuring extra high grazing intensity on those areas where purple moor grass is a particular problem. There is also a requirement for actual plant cover that can sometimes cause problems when grazing is used as a follow-up measure after burning. Areas which have previously been dominated by crowberry will often not have any plant cover in the first grazing season after being burnt, and thus fail to fulfil the conditions for subsidies, in contrast to areas dominated by common heather and grasses.

6.5 Clearing
The progression towards woodland is a natural one, and clearing tree colonisation is a conscious retention of heathland as an open succession phase that can be compared to the results of the heathland farmers.

The trees that grow on the dry areas tend to be invasive evergreen species that spread from seed sources in old plantation areas, plus the invasive species of black cherry and Scotch broom. Birch and willow spread on the wet heaths. Removing felled materials and stumps is important, to remove nutrients from heathland.
6.5.1. Objective and things to consider
The objective of using clearance as a form of management is to curb colonisation, to recreate and retain open heathland. A secondary objective is to combat invasive species and remove seed sources that contribute to further spreading of the same. Some clearings can also be intended to recreate an open landscape, such as around barrows and inland dunes.

Some heathland organisms are linked to the trees that grow there, and for the sake of fauna such as the nightjar and great grey shrike, individual large trees (e.g. pine) are left standing. In time, that can mean new growth that will need removing. Juniper is another indigenous species found on heathland. Tree groups on heathland and its margins also fulfils a function as shelter for game, which to a large degree helps place grazing pressure on heathland in Jutland, where herds of red deer in some areas are large and help to keep heathland open.

If clearing is used, it is always a good idea to remove timber and branches cut. For example: to remove felled evergreens before they start to lose their needles. When evergreen needles decompose, they fertilise the soil and plant species that need high nutrition can colonise.

But of course, the budget and circumstances should always be taken into consideration.

If the trees are so small and are spread that they will die in the event of burning, it may be preferable to allow them to do so.

If trees are very sparse and perhaps growing in exposed or wet areas, it would be best to fell and leave them, especially if they can be burned later. The tracks of heavy machinery in such areas remain for many years, and can have a greater negative impact than removal of the felled trees.

6.5.2 Suitable areas
In principle, any area can be cleared. But some can be so wet or hilly that doing so can be very expensive. The method of clearance should be chosen according to the nature of the area.

Old evergreen plantations, willow coppice that is not too wet and growth on flat or slightly rounded heathlands are typical candidates for clearing.

6.5.3 Methods and machinery
The process of clearing includes cutting, extraction and chipping (if relevant) of felled trees and scrub.

Manual clearing is performed using chain saws, axes, brushcutters with saw blades or spades. Mechanical clearing is often performed using tracked forestry machines that can fell and extract trees, disc mowers, tractors and trailers, stump grinders and chippers can also be used. If the ground is wet, tracked machines or steel road plates can be used.

Clearing scrub with a heath harvester
In some instances, there can be dense tree and scrub growth on heathlands. If there are pines (contorta, Scots or mountain pine), it can be relevant to combat the problem with a heath harvester able to crush and collect the material in the pick-up.

Crusher on caterpilars is good for levelling stumps.

A period of frost is a good opportunity to chip and transport the chips away.
It is usual to wait until saplings have reached a certain size. At the age of 4 or 5 years, they are easy to see and the lower green branches are only a few cm above the ground. The machine will cover a given area, but will only lower its crusher when there are trees present. Trees are cut off under the lowest branches and die. The crushed material naturally contains a lot of heather, and can therefore be sold as bedding or for some other purpose. Performance will depend on the amount of scrub involved, but will usually be over one hectare per hour.

The result is also diversity of heather age on the area, and there will be places where the flails clear heather peat, leaving small patches of white sand.

Remember that the machine has flails, and there can therefore be problems working areas with a lot of stones. The price per hour is less than DKK 1,000.

**Clearing scrub with a Texas disc mower**

Where there is sparse growth of evergreen trees on open areas, one solution can be the use of a Texas disc mower, a machine that resembles an overgrown rotary lawn mower. It requires little power from the tractor’s PTO. The machine can manage trees with a trunk diameter of up to 10 cm. Most forestry districts and many private wood owners have such a machine.

The technique is to run over the area and only lower the implement directly over trees. The tree is usually crushed so effectively that it can be hard to see anything left than a round patch on the heather. Its performance is very high – taking up to several hectares of sparse scrub growth per hour. There are no untidy, withered evergreen trees left, and there is no need to collect the residue. Small clearings in the heather carpet are created to the benefit of reptiles and insects, and because only patches are affected, only small amounts of nutrient are left.

**Manual clearance of tree growth using a tree puller**

Pulling up trees manually is a good task for partnerships and voluntary labour. But it can be hard work – some trees are always tough to pull up by their roots. The rules of the Working Environment Act for lifting can easily be broken, but there is help to be had in the form of an “Extractigator”, a tool available in Denmark from Bakkebjerg Naturpleje at a price of around DKK 2,000. It comes in two
sizes and can be fitted with a foot if it is to be used on soft ground. The Extractigator works in much the same way as a crowbar. It is attached to the root throat of the tree, and then pulled backwards. It is easy to operate and can manage most trees if you keep to the 5 year interval between clearing often recommended. If a tree has been cut down previously and has sprouted again (as is often the case with deciduous trees) the roots will be so well entrenched that the tool will pull the tree over instead of extracting the root.

First-time clearance of dense scrub is performed mechanically, including clearing, extraction and chipping (if relevant). If there are full grown trees, they are felled, but scrub can be cleared with a rotary flail and subsequently collected. Remaining stumps should be removed. They can be ground or crushed mechanically, or pulled up and chipped - see the example from Gyttegård plantation in the box. If clearing areas that will also be burnt, there is yet another incentive to remove stumps. Smouldering stumps require more effort to put out using water that can take up to several hours, depending on the number of stumps.

Maintenance clearance of scrub after clearing or burning is often performed manually, cutting down stumps, saplings and bushes. Any bushes or saplings left after burning can be taken care of by a disc mower.

When combatting invasive species such as black cherry, it is important to focus on removing seed sources and felling at a time when there are no mature seeds (see Buttenschøn and Thamdrup, 2012, Practical guidance on prevention and combatting black cherry).

Black cherry is pulled up by the roots on Lønborg Hede - large ones using a tractor and grab and the small ones by spade and manual labour.

Clearing and crushing can be brutal methods, and it is therefore important to identify biological values on the areas to be cleared to be able to take them into account. Wind-faceted stone can be damaged by crushing, and stones can damage the blades. One solution is to set the machine to work at surface level.

First-time clearing requires follow-up in the form of regular clearance of new growth, grazing or burning.

Evergreen trees die after being felled, which means the problem is primarily the sprouting of new plants if the right conditions are created for them to do so. Experience has shown that if follow-up clearance of mountain pine is repeated approx. every 5 years, they never manage to produce cones. This will eventually reduce seed sources on the area cleared.

On the other hand, deciduous trees will shoot from the stump. Birch in particular grows rapidly from dormant seeds near the soil surface. If first-time clearing is followed-up with effective manual cutting-down of stump sprouts the first few years after clearance - preferably 2-3 times annually during the growth season from May to August, the problem of regrowth can be reduced and stumps starved. Another alternative is to follow-up clear-
ance with grazing so that the livestock can assist by eating new stump sprouts and seedlings.

6.5.4 Timing
Willow scrub is best cleared in the late summer when it is at its driest. Evergreen trees can be cleared in the winter, preferably when there is frost.

According to the Statutory Order on soil resources from 2010, heathland areas protected by the Nature Protection Act can only be cut or cleared between 1 August and 30 April for the sake of fauna and flora. However, extensive clearing can be performed all year round.

Clearing farmland is mandatory, i.e. it must be kept clear of trees and bushes under 5 years old. The obligation does not extend to heathland dwarf shrub vegetation. In reality, the effect of this provision is negligible, mostly because there is little awareness of it. The periods defined for clearing tree and brush growth were set with animals and flora in mind.

6.5.5 Disposal of by-products
Timber and woodchips can be sold. On the other hand, there can be problems dealing with the material collected after crushing if there is a lot of sand in it. If there is, it cannot be used in incineration plants. Excavated and cleaned stumps and roots can be sold as chips for district heating fuel.

6.5.6 Effect
In the short term, clearing has a major effect on the landscape, with the recreation of open heathlands. In the long run, clearing is only effective if followed up by management. If a decision is taken to clear an area of heathland, the decision is also taken in principle to allocate resources to future maintenance to keep it clear.

The methods and machinery discussed above are primarily most effective against evergreen trees. What's important during planning and execution is to recognise that there is a fundamental difference between deciduous and evergreen trees: the latter die out after felling, whilst the former will sprout again from the stump. Felling deciduous trees on its own is therefore not a long-term solution.

Cutting back shoots from stumps and roots after clearance 2-3 times in the growth season for the following 2-3 years can be an effective, if expensive, way of killing off the stumps.
Clearing plantations and re-establishing heathland at Gyttegaard Plantation

Experiments have been conducted on post-treatment of a cleared stand at Gyttegaard Plantation. This was a rolling inland dune, planted with evergreen trees 100 years ago. The objective is to open up the dune landscape to restore it to its original status, and increase the area of heathland on the former plantation area.

Once the plantation was cleared and trees removed, what was left was an area with lots of stumps and thick humus layer accumulated on the former woodland floor. The thick humus layer is a problem because it contains a lot of nutrients that will be released when it breaks down, resulting in nitrophyte vegetation. The question was: how could the area best be converted to heathland?

Experiments using three methods of post-treatment were conducted:

A. Mechanical removal of stumps. The stumps were pulled up using a digger and excavator. They were then cleaned, run through a large sieve and then chipped to remove as much sand as possible. The chips that were largely sand-free could be sold as coarse district heating fuel.

B. Crushing roots – material left on the site.

C. Crushing roots – material removed using a Bio-Pickup crusher.

The immediate effects of the three rounds of treatment were:

A. The ground surface has been disturbed so much that the mineral soil is revealed many places, and forms a mosaic with the humus layer. New common heather is sprouting in the exposed soil, and there are few nitrophilic species in this area.

B. There is a thick humus layer everywhere along with branch cut-offs that prevent common heather from sprouting, and there are a number of nitrophilic species such as chamerion, raspberries and blackberries.

C. There is still a thick humus layer and a lot of chamerion, raspberries and blackberries, but common heather is also sprouting where branch cut-offs have been removed.

It looks as if method A will be the fastest at recreating heathland. It’s a relatively radical method that has a hard affect on the area. It is also the most expensive: the cost of clearing stumps, the rest of the area and chipping amounted to around DKK 20,000 per ha. Selling the chippings made around DKK 2,000 per ha. The price for method A is therefore DKK 18,000 per ha. plus the costs of removing the sieved material. The costs of methods B and C were around DKK 6,000 per ha. and DKK 20,000 per ha. respectively.

NB: When choosing to clear plantations to convert them to heathland, it takes time and subsequent management to keep the area open – a factor to consider if the alternative is natural woodland. Check whether a permit according to the Forest Act is required, and remember to inform woodland users, some of whom may not be so pleased with the wood being felled.
Another alternative is to follow-up clearance with grazing so that the livestock can assist by eating new stump sprouts and seedlings. This has achieved good results most places.

A third alternative can be the total removal of deciduous tree root systems to avoid new sprouts growing from stumps again. Very small plants can be pulled up by hand, perhaps using an Extractigator. Larger plants can be pulled up in the same manner after cutting the roots with a spade, and even bigger bushes/trees can be pulled up with a tractor, digger etc. The first phase of such clearance should be removal on the heath itself. If this is repeated every 4-5 years, the amount of effort needed will gradually reduce, as new plants are removed before they seed. In the second phase, a closer look should be taken at existing seed sources around the heath. Both initiatives will reduce costs in the long term.

The measures referred to above on deciduous trees include black cherry. This has been put on the blacklist (search for “sortlisten” on www.svana.dk for the latest version). This is a list of unwanted species known as invasive species, compiled by the Agency for Water and Nature Management. This species is so widespread in some areas that it has to be accepted that we can never get rid of it again. On the other hand, there are areas (including heaths) where it is still so sparse that it is still possible to stop it becoming a major problem in the long term with relatively little effort.

The above methods have been used against black cherry in the LIFE-Hede project.

A number of different-sized examples were found in and around an evergreen wood. A tractor and grab pulled the big ones up, whilst the small ones were dealt with by spade and manual labour. This was more or less the only occurrence on the heath of this species. Planned follow-up every 5 years or so will therefore be able to keep the problem in check.

Black cherry is not just an annoying weed tree. The Danish Economic Councils calculated the cost of black cherry in 2014 to be around DKK 2 million (Anon., 2014).

And it is a problem that is not getting any less.

6.5.7 Necessary permits
Dispensation is usually required from Section 3 of the Nature Protection Act for clearance on heathland. And clearance can contravene status quo conservation of cleared heathlands. When clearing old plantations, a permit is needed in pursuance of the Forest Act.

6.5.8 The finances
The costs of clearance depend on parameters such as the number of standing trees, extraction distance and access, plus the chances of selling off the by-products. Another thing of significance is whether standard machinery can be used, or whether special machines and steel road plates are
needed. And the sooner any new growth can be removed, the cheaper it will be in the long run.

6.6 Water on the heath
One of the biggest threats to many heaths is drainage. The growth in field irrigation is also drawing on groundwater reserves, causing the drying-out of heathland areas as a result. The effect is worst on small heaths and around the edges of large ones. Draining affects low-lying bogs and heathland covered with cross-leaved heath left on some of the smaller pockets in the landscape.

The first victim of lowering the water table is bird-life. Most of the characteristic heathland birds are wholly or partially dependent on wetland areas. A large part of the rare and threatened plants and insects are also found here. Restoration of natural hydrology has been a minor, but important part of the LIFE-Hede project.

An actual drop in the water table is a rare event on the large heaths, but such areas are drier now than they were just a few years ago. Some old ditches can be seen on many heaths, but they were dug many years ago (maybe 50–100), and equilibrium in water table and vegetation was realised long ago. These ditches are slowly deteriorating, and their effectiveness as drains is therefore reduced a little.

Covering-over ditches can be in the nature of restoration of the former landscape. But other initiatives can also help provide more water on heathland. Shallow dams can be created, or former depressions that have filled up with purple moor grass or that have lost any botanical value in some other manner can be scraped clear. Digging out overgrown peat pits should generally be avoided, as the vegetation that has established itself in them, such as peat moss and common cotton grass, also have value.

The oft-held belief that draining is a threat to heathland can be correct, but only if the observer is sure about which time perspective is involved. There is also another and opposite trend in motion. The amount of precipitation in Denmark is rising. That means that the frequency of water cover in occasional ponds on 7 of the bigger heaths in central and western Jutland has more than doubled from 1944 to present day (Degn, 2013). That must also mean that the surrounding heaths have become wetter, which must have a long-term impact on them.
6.6.1. Objective and things to consider
The objective is to create wet areas on heathland by establishing shallow depressions for the wood sandpiper and amphibians, and to restore natural hydrology on low areas by stopping drainage.

The hydrological conditions can typically be altered by filling-in drainage ditches and scraping depressions in wet areas to once again bring more water to the heath.

Another option used in Holland is herringbone scraping – removing peat in a herringbone pattern. The depressions created become wetter, encouraging the creation of wet heathland, pond bank vegetation and heathland bogs. Once again, the focus is on creating variation on heathland, to provide suitable conditions for many different organisms.

Analysis of meteorological data and aerial photos show that more water has started to appear on heathland in line with the increase in precipitation of around 200 mm in recent years. Analysis of aerial photos from 1944 to present day have shown that water cover in occasional ponds on 7 of the bigger heaths in Jutland has more than doubled (Degn, 2013). The 7 heaths in question are all inland.

6.6.2. Methods and machinery
This work is usually performed with traditional machines such as diggers and bulldozers. Steel road plates can be required in wet areas. Herringbone scraping can be done with tracked snowcats,
Closing the ditches results in more water on the heath.

Diggers and dumpers running on a temporary firm surface composed of steel road plates.

Shallow scrapes for wood sandpiper and amphibians can be created on open heathland, typically in depressions that have filled up with purple moor grass or that have lost any botanical value in some other manner. The scrapes are max. ½ metre deep and have very shallow-angled banks.

If using scraping, care must be taken not to breach any hardpan layer.

The material should be removed from the heath, but in some places is used for back-filling trenches.

When filling in ditches dug to drain low-lying areas of the heath, whether they are internal or external must first be established. If they drain neighbouring areas, check that drainage of those areas will not be adversely affected by filling them in. Drains were sealed in the project by filling them with material from the scrapes performed on the heath.

**Herringbone scrape – Inspiration from Holland**

Herringbone scrapes are relevant in large, wet depressions being colonised by purple moor grass. The Dutch started by scraping a ‘spine’ followed by individual herringbones. The machine operator was familiar with valuable species and habitat types on the heath, and was instructed to stop if he encountered anything interesting, such as a colony of march gentian. Consequently, the branches were of different lengths, giving rare species and valuable habitats the chance to establish themselves on newly-revealed areas. One way of getting maximum return for minimum effort.

The work was performed by a crusher that broke down vegetation to the underlying layer of mud only a few cm thick, that lay over the solid sand bed. The crushed material was then removed by a digger and taken away in a dumper. Steel road plates had to be used in some instances.

Action works – an example from Borris Hede

The breeding colony of wood sandpiper on Borris Hede was around 30 pairs in 1955 (Salomonsen 1955). Only between 1 and 3 pairs were registered in 2010 (Olesen & Østergaard 2010). After the army expanded the area considerably via expropriation in 1953, peat extraction in the area stopped, and the pits gradually became overgrown with peat moss, common cotton grass and other plants. The number of open peat pits and ponds in the area was reduced by over two-thirds during the same period. That naturally had an effect on the wood sandpiper, which feeds on the pond banks.

An enclosed area showed the same trend, and there were no breeding wood sandpipers by 2010. The army therefore dug some of the old peat pits out again, and made completely new depressions with totally uninteresting vegetation of purple moor grass. The year after the first ponds were re-established, a wood sandpiper nest was found just 1 m from the water’s edge of one of the new ponds.

The following year, 1-2 breeding pairs were found in the same location. By way of comparison, only one breeding pair was found that year in the old breeding grounds.
The result of herringbone stripping looks promising – colonisation by various species (including sundew) takes up to 10 years, whereas total treatment results in a wait of up to 30 years.

6.6.3 Effect
Species such as cranes and wood sandpiper in particular benefited from more water on the heaths. See the chapter on Biodiversity on the heath for other criteria required by different species.

Cross-leaved heath is a pioneer plant that colonises areas scraped for wood sandpiper and amphibians. Colonisation by cross-leaved heath is a difficult matter, and the question is far from being answered. Some Natura 2000 plans recommended raising the water table. But it can be said with certainty that if the problem is purple moor grass, raising the water table will not be of benefit to the cross-leaved heath.

Cross-leaved heath should also be expected to benefit from herringbone scraping.

Burning before raising the water table can also help create the right conditions for cross-leaved heath.

To keep depressions open and prevent them becoming overgrown, cattle grazing can be started later.

Red deer also create dynamism thanks to their constant change of mudholes. They create biotopes

Shallow ploughing after burning.

Buckwheat and rye first year of cultivation.

Buckwheat and rye second year of cultivation.
Historical cultivation on Harrild Hede

In partnership with the local museum, the LIFE-Hede project tried cultivating heather plots on a series of trial fields.

The crops chosen were rye and buckwheat, because they were the main crops grown in this area well into the 19th century. Other options could include corn spurry, an ancient food crop from the heathlands of Jutland, and potatoes, which grew well on the marginal soils when given fertiliser.

The first years of cultivation, rye and buckwheat were grown in seed rotation. Results with rye were overall very poor the first year, but buckwheat went well. When the seeds were rotated the following year, rye continued to struggle, and buckwheat also failed to do so well. It was therefore decided to sow well-spread buckwheat in the third year.

Game ate the buckwheat seeds each year, leaving little to harvest, but the stubs left behind were cut to remove as much nutrition as possible. Historically, heathland farmers would have stopped cultivation when the yield was 3-5 fold. As a rule, each field was cultivated for 5-7 years.

Soil exhaustion can be clearly seen for the buckwheat after 3 years of the experiment, when the crop was poorer year after year – without being able to determine the yield.

In the long term, it will be interesting to see whether heathland vegetation will be re-established. A 50-year cycle is expected.

that correspond to the wet depressions in the bottom of parabolic dunes. These are very low in nutrition, and in some places are home to large colonies of clubmoss, sundew and brown beak sedge.

6.6.4 Necessary permits
Creating waterholes and altering the water table on heathland requires dispensation from Section 3 of the Nature Protection Act, and has to be considered with regard to Natura 2000.

Filling in ditches can also require a permit in pursuit of the Consolidation Act on Watercourses.

Ditches can also be historical remains, and the local museum should be contacted first.

6.6.5 The finances
The price of scraping is typically between DKK 5,000 and 10,000 per scrape, depending on how far the material removed has to be transported.

6.7 Historical use – exhaustion due to crops
This method of management is based on an aspect of heathland farming activities that has not attracted much attention so far. It looks as if it was standard practice to cultivate a small area of heathland with crops for 2-5 years until the nutrition accumulated there by the vegetation over perhaps the last 100 years was used up, and to then let the area return to heather. A new area was then cultivated somewhere else, and so on. There were two major advantages for the heathland farmer. He could produce seeds for seeding without the usual high content of weed seeds, and such fields were not subject to the general levy that was the basis for tax collection.

Because the objective of heathland management is to degrade the soil and remove nutrients, fertiliser is not used for cultivation at all – whereas heathland farmers used manure and peat ash for the first few years.

It may not seem obvious why abandoned fields are referred to here as a method of heathland management. Part of the explanation lies in the fact that an abandoned field can become totally dominated by common heather within the course of a few years. But abandoned fields do not return directly to heather. Over a few years, the vegeta-
tion on the field goes through a number of phases in which different plants dominate. There are a number of descriptions of this from the early 20th century. There was even a special name for it: “the fields sprang in heather again”.

There is also a more recent study that ran over a period of 22 years of the vegetation that colonised a field that was withdrawn from cultivation in 1975 (Degn, 2001). A very characteristic phase was found to take place 3-6 years after farming ceased on the field, when it was totally dominated by the red colour of sheep’s sorrel and the blue of sheep’s bit scabius. Some years later (7-9 years after the start date), the characteristic species included common catsear, mouse-ear hawkweed and wavy hair grass. Even 12 years after farming ceased, the vegetation was still very open, with lots of common catsear and only a few heather bushes. 20 years passed before common heather dominated.

The main interest is in the process leading to that dominance. There is a period in which a number of plant species are found which are not present on heather-dominated heathland. In the instance described, there were 42 species on an area of 1,150 m2 9 years after farming stopped. Many of these are food for butterflies, grasshoppers and a number of other insects that are not found on heather-dominated heathland either. Increased biodiversity is the result if looking at the area in a time perspective and if looking at a large heathland area divided into fields in different phases of development.

6.7.1. Objective and things to consider

The primary objective is to create a completely bare mineral soil on which a succession of flora and fauna can start right from scratch. Not even after scraping is it possible to start from scratch to such a degree. Achieving that objective is essential to achieve herb variation of before heather once again becomes dominant.

The secondary objective is to exhaust the soil by removing crops and the nutrients they contain. However crop cultivation is sometimes so modest that removal will not change much. Removing nutrients before ploughing can therefore be considered, e.g. by removing vegetation or even the mor layer.
Overheads per ha

<table>
<thead>
<tr>
<th>Year</th>
<th>Activity</th>
<th>Cost (DKK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First year</td>
<td>Burning</td>
<td>2,000</td>
</tr>
<tr>
<td></td>
<td>Shallow ploughing</td>
<td>1,050</td>
</tr>
<tr>
<td>Second year</td>
<td>Ploughing</td>
<td>1,050</td>
</tr>
<tr>
<td></td>
<td>Harrowing</td>
<td>525</td>
</tr>
<tr>
<td></td>
<td>Sowing</td>
<td>525</td>
</tr>
<tr>
<td>Third year</td>
<td>Harrowing</td>
<td>525</td>
</tr>
<tr>
<td></td>
<td>Sowing</td>
<td>525</td>
</tr>
<tr>
<td></td>
<td>Harvesting:</td>
<td>1,050</td>
</tr>
<tr>
<td></td>
<td>50 kg rye at DKK 3 per kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 kg buckwheat at DKK 60 per kg</td>
<td></td>
</tr>
<tr>
<td>Fourth year</td>
<td>Harrowing</td>
<td>525</td>
</tr>
<tr>
<td></td>
<td>Sowing</td>
<td>525</td>
</tr>
<tr>
<td></td>
<td>Seed</td>
<td>1,950</td>
</tr>
<tr>
<td></td>
<td>Harvesting</td>
<td>1,050</td>
</tr>
<tr>
<td>Total per ha</td>
<td></td>
<td>11,300</td>
</tr>
</tbody>
</table>

Estimated costs of historic cultivation. Machine price 600 kr. per hour.

Finally, it is possible to demonstrate the use of arable farming and crop-growing on the heath in ancient times.

### 6.7.2 Suitable areas
Ploughing is a brutal method to use on a protected or preserved heathland. It should therefore only be used with great care. The most important thing is that it should only be used on areas that have been previously ploughed such as plantations, fire belts, game cover etc. Virgin ground should not be touched, as it has a special layer structure (mor, white sand etc.) developed over centuries or millennia.

Such a restriction will rarely be a problem. There will be areas on most heaths that have previously been cultivated. As far as is known, actual records have only been kept for Randbøl Hede (Degn, 2005). A total of 136 ha has been ploughed within the last approx. 130 years out of 800. That’s probably a perfectly normal ratio. Some formerly ploughed areas can be identified on old maps (1:20,000) or aerial photos (especially from 1954). Others can be recognised in the landscape from furrows in the soil surface after ploughing.

### 6.7.3 Machinery and equipment
Tractor, dish harrow, plough, forage harvester, trailer and seeding machine.

### 6.7.4 Methods and machinery
The areas are burned in March the first year, and shallow-ploughed shortly afterwards. Shallow ploughing turns the peat. Harrowing is done in the summer on grass peat with regrowth.

In the second year, surface ploughing is performed to a depth of around 20 cm to keep the hardpan layer intact, after which it is dish harrowed and sown with crops – buckwheat in the spring or rye in the autumn. Other crops which the heather farmer grew and which could be tried again, include ’svedjerug’ (an old Nordic form of rye), grey oats and corn spurry.

Crop rotation is performed every third year and thereafter. The crop is harvested and transported
from the area every year. After 4 years, there are no more crops to harvest.

6.7.5 Effect
Experience from cultivation has not been collated yet.

However, there are records of a former field on acidic and low nutrition soil surrounded by heathland with common heather and crowberry, where cultivation was stopped in 1975, after which the succession was monitored over 22 years (Degn, 2001). During the first 2 years after cultivation was stopped, the area was completely dominated by individual weeds. More permanent species such as wavy hair grass and common catsear slowly colonised, but died out again after 13-14 years. Over the final 10 years, common heather and sheep fescue became widespread. By 1997, common heather was so widespread that the area was classified as Section 3 heathland. A total of 76 species of vascular plants were recorded throughout the study period from 1976-1997, peaking at 41 in 1984. The number of species fell over the last 13 years (1984-1997) gradually to around half.

But the observations from the Karup air force base cannot be directly applied to how the succession could be expected to go on Harrild Hede. Cultivation had taken place there on areas that were last farmed over 100 years ago, and had subsequently returned to heather. Succession at Karup was immediately followed by cultivation being abandoned.

6.7.6 Necessary permits
Permits were obtained from the local authority, which consulted the Nature Conservation Board, and evaluated the application in relation to Natura 2000. All potentially relevant organisations were then informed, including DOF (Danish Ornithological Society) and DN (Danish Society for Nature Conservation). Once a permit is granted, a four week period to hear objections has to pass before it can be used.

Experience has shown that it is easier to gain a permit for soil-working measures when they concentrate on areas that have previously been farmed, bracken-covered sandy areas or former woodland.

6.7.7 The finances
See table 2. Estimating the costs of historical cultivation on Harrild Hede. A machine price of DKK 600 per hour has been calculated.

6.8 Addition of micronutrients – experience from abroad
Heathland acidification caused mineral leaching (see chap. 5.1 Nutrient addition). Calcification of heathland, i.e. the addition of calcium and magnesium carbonate, restores the soil’s buffer capacity, encourages sprouting and establishment of threatened species (Vogels et al., 2015). The downside is the risk of increased mineralisation by organic nitrogen compounds, followed by the growth of grass, and that only Ca and Mg are added, not other leached-out minerals. Due to the imbalance of other micronutrients, the flora and thus the fauna can react badly to calcification. Neither is calcium a natural substance on heathland (Vogels et al., 2015).

Experiments are in progress in Holland (2016) at Strabrechtse Heide and in the Hoge Veluwe national part with spreading of Rock Dust on heaths to compensate for the chemical leaching of minerals due to acidification (Vogels et al., 2015). Rock Dust is crushed stone with a typical grain size of less than 500 µm. The composition of minerals varies, depending on geology, which make sit possible to choose the best material for restoring the original composition of minerals in the soil (Vogels et al., 2015).
# 7 List of management methods

The list summarises the most important experience gained from management methods in chapters 6.1 to 6.7. Please note that the list describes the individual methods. These can often not be used alone, but have to be combined in a manner conducive to achieving the desired objective.

<table>
<thead>
<tr>
<th>Method</th>
<th>Suitable areas</th>
<th>Suitable on areas with historical remains?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stripping</strong>&lt;br&gt;Stripping using Bio-Pickup crusher or equivalent</td>
<td>Minor areas with level ground, dry bed, thick humus layer and senile common heather or grass dominance.</td>
<td>No</td>
</tr>
<tr>
<td><strong>Stripping</strong>&lt;br&gt;Dish harrowing and subsequent collection</td>
<td>Minor area, level + rolling terrain with dry bed, thick humus layer and senile common heather or grass dominance.</td>
<td>Maybe Currently being studied. Results expected in 2017/18.</td>
</tr>
<tr>
<td><strong>Stripping</strong>&lt;br&gt;Scraping with a scraper or similar</td>
<td>Dead areas, e.g. at the bottom of parabolic dunes.</td>
<td>No</td>
</tr>
<tr>
<td><strong>Burning</strong></td>
<td>Minor areas with senile common heather, crowberry, wavy hair grass or purple moor grass, with or without scattered small trees and bushes. Can be used on both level and rolling terrain.</td>
<td>Partially. Burning requires permits in areas with stones of historical value, e.g. barrows.</td>
</tr>
<tr>
<td>Method</td>
<td>Suitable areas</td>
<td>Suitable on areas with historical remains?</td>
</tr>
<tr>
<td>--------</td>
<td>----------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td><strong>Stripping</strong></td>
<td><strong>Using Bio-Pickup crusher or equivalent</strong></td>
<td><strong>Minor areas with level ground, dry bed, thick humus layer and senile common heather or grass dominance.</strong></td>
</tr>
<tr>
<td><strong>Effects</strong></td>
<td></td>
<td><strong>No</strong></td>
</tr>
<tr>
<td>Reveals mineral soil, removes mor layer, plants and roots and most seed depots.</td>
<td></td>
<td>• Reveals mineral soil, removes mor layer, plants and roots and most seed depots.</td>
</tr>
<tr>
<td>Effectively combats purple moor grass and regenerates dwarf shrub heath.</td>
<td></td>
<td>• Effectively combats purple moor grass and regenerates dwarf shrub heath.</td>
</tr>
<tr>
<td>Very slow succession after management, monoculture of common heather.</td>
<td></td>
<td>• Very slow succession after management, monoculture of common heather.</td>
</tr>
<tr>
<td>Crushes stone, levels out terrain.</td>
<td></td>
<td>• Crushes stone, levels out terrain.</td>
</tr>
<tr>
<td>Very effective but brutal method for the landscape, flora and fauna – above and below ground.</td>
<td></td>
<td>• Very effective but brutal method for the landscape, flora and fauna – above and below ground.</td>
</tr>
<tr>
<td>Removes almost all nutrition from the area, meaning the effect lasts for many years.</td>
<td></td>
<td>• Removes almost all nutrition from the area, meaning the effect lasts for many years.</td>
</tr>
<tr>
<td><strong>Stripping</strong></td>
<td><strong>Dish harrowing and subsequent collection</strong></td>
<td><strong>Minor area, level + rolling terrain with dry bed, thick humus layer and senile common heather or grass dominance.</strong></td>
</tr>
<tr>
<td><strong>Effects</strong></td>
<td></td>
<td><strong>Maybe</strong></td>
</tr>
<tr>
<td>Reveals mineral soil, removes plants.</td>
<td></td>
<td>• Reveals mineral soil, removes plants.</td>
</tr>
<tr>
<td>Mor layer, roots and seed depots partially removed.</td>
<td></td>
<td>• Mor layer, roots and seed depots partially removed.</td>
</tr>
<tr>
<td>Some of the peat is left on the area.</td>
<td></td>
<td>• Some of the peat is left on the area.</td>
</tr>
<tr>
<td>Microbiotopes: mosaic of peat/sand.</td>
<td></td>
<td>• Microbiotopes: mosaic of peat/sand.</td>
</tr>
<tr>
<td>Effective method, a lot of nutrition is removed.</td>
<td></td>
<td>• Effective method, a lot of nutrition is removed.</td>
</tr>
<tr>
<td>More considerate to reptiles and insects compared to other stripping methods.</td>
<td></td>
<td>• More considerate to reptiles and insects compared to other stripping methods.</td>
</tr>
<tr>
<td><strong>Stripping</strong></td>
<td><strong>Scraping with a scraper or similar</strong></td>
<td><strong>Dead areas, e.g. at the bottom of parabolic dunes. No</strong></td>
</tr>
<tr>
<td><strong>Effects</strong></td>
<td></td>
<td><strong>• Scrapes down to white sand on small spots at a time.</strong></td>
</tr>
<tr>
<td>Leaves a sharp scar in the sand.</td>
<td></td>
<td>• Leaves a sharp scar in the sand.</td>
</tr>
<tr>
<td>Allows sand erosion.</td>
<td></td>
<td>• Allows sand erosion.</td>
</tr>
<tr>
<td>No experience of the effect of the method</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Burning</strong></td>
<td></td>
<td><strong>Minor areas with senile common heather, crowberry, wavy hair grass or purple moor grass, with or without scattered small trees and bushes. Can be used on both level and rolling terrain.</strong></td>
</tr>
<tr>
<td><strong>Effects</strong></td>
<td></td>
<td><strong>Partially. Burning requires permits in areas with stones of historical value, e.g. barrows.</strong></td>
</tr>
<tr>
<td>Burnt: surface grass and dwarf shrub, scattered small trees and bushes.</td>
<td></td>
<td>• Burnt: surface grass and dwarf shrub, scattered small trees and bushes.</td>
</tr>
<tr>
<td>Peat does not burn during spring burn in March.</td>
<td></td>
<td>• Peat does not burn during spring burn in March.</td>
</tr>
<tr>
<td>Not burnt: waterlogged areas, dense clumps of trees and bushes, with no ground vegetation between them, bog bilberry, areas of poor vegetation, bare patches.</td>
<td></td>
<td>• Not burnt: waterlogged areas, dense clumps of trees and bushes, with no ground vegetation between them, bog bilberry, areas of poor vegetation, bare patches.</td>
</tr>
<tr>
<td>Heathland plants generally react well after a fire.</td>
<td></td>
<td>• Heathland plants generally react well after a fire.</td>
</tr>
<tr>
<td>Arnica montana and blue clubmoss respond well to burning.</td>
<td></td>
<td>• Arnica montana and blue clubmoss respond well to burning.</td>
</tr>
<tr>
<td>Lingonberry thrives for the first few years after a fire.</td>
<td></td>
<td>• Lingonberry thrives for the first few years after a fire.</td>
</tr>
<tr>
<td>Bog rosemary does well after burning and flowers again especially in the second growth season after a fire.</td>
<td></td>
<td>• Bog rosemary does well after burning and flowers again especially in the second growth season after a fire.</td>
</tr>
<tr>
<td>Wavy hair grass also sprouts, but usually disappears again.</td>
<td></td>
<td>• Wavy hair grass also sprouts, but usually disappears again.</td>
</tr>
<tr>
<td>Purple moor grass sprouts after a fire. A single burning cannot restore dwarf shrub heath on areas dominated by purple moor grass.</td>
<td></td>
<td>• Purple moor grass sprouts after a fire. A single burning cannot restore dwarf shrub heath on areas dominated by purple moor grass.</td>
</tr>
<tr>
<td>Smaller bushes and trees burn, and most do not survive.</td>
<td></td>
<td>• Smaller bushes and trees burn, and most do not survive.</td>
</tr>
<tr>
<td>Evergreen trees under 1-1.5 m die.</td>
<td></td>
<td>• Evergreen trees under 1-1.5 m die.</td>
</tr>
<tr>
<td>Crowberry dies.</td>
<td></td>
<td>• Crowberry dies.</td>
</tr>
<tr>
<td>Heath star moss can dominate the first few years after crowberry has been burnt. It can outcompete indigenous mosses and lichens.</td>
<td></td>
<td>• Heath star moss can dominate the first few years after crowberry has been burnt. It can outcompete indigenous mosses and lichens.</td>
</tr>
<tr>
<td>Peat is also partially burnt during burning in the summer and autumn.</td>
<td></td>
<td>• Peat is also partially burnt during burning in the summer and autumn.</td>
</tr>
<tr>
<td>Burning in the summer can be problematic, as fires can easily spread. And they are not allowed at the moment.</td>
<td></td>
<td>• Burning in the summer can be problematic, as fires can easily spread. And they are not allowed at the moment.</td>
</tr>
<tr>
<td>Method</td>
<td>Suitable areas</td>
<td>Suitable on areas with historical remains?</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Harvesting</td>
<td>Fairly level areas with putative growth of purple moor grass or old heather. Preparation for grazing or stripping.</td>
<td>In principle, no. In some instances, disc harvesters are used however. Manual cutting is excepted.</td>
</tr>
<tr>
<td>Grazing</td>
<td>Subsequent management combined with burning, clearing and cutting. Random growth with grass on dwarf scrub heath after burning. Regeneration of grass after cutting with a forage harvester.</td>
<td>Grazing can affect ancient monuments and historical remains on the heath. Grazing can be a problem on sensitive ancient monuments.</td>
</tr>
<tr>
<td>Clearing</td>
<td>Typical old evergreen plantations, willow coppice that is not too wet and growth on flat or slightly rounded heathlands.</td>
<td>Some clearings can be intended to recreate open areas around barrows.</td>
</tr>
<tr>
<td>Water on the heath</td>
<td>Scraping: depressions with e.g. purple moor grass, with no particular botanical value. Heaths with unnatural hydrology due to drainage.</td>
<td>No</td>
</tr>
<tr>
<td>Historical farming</td>
<td>Formerly cultivated areas with a large nutritional pool where heathland is to be recreated.</td>
<td>No</td>
</tr>
<tr>
<td>Effects</td>
<td>Special factors</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>• Cutting or crushing of vegetation with or without litter layer.</td>
<td>• Bear in mind the needs of animals for nutrition.</td>
<td></td>
</tr>
<tr>
<td>• Makes changes to the vegetation for a brief period.</td>
<td>• Mineral feeds are always necessary.</td>
<td></td>
</tr>
<tr>
<td>• Vegetative renewal of heather (blade and disc cutters).</td>
<td>• Power and water supply can be problems in remote areas.</td>
<td></td>
</tr>
<tr>
<td>• Vegetative renewal of heather and rejuvenation of seed sprouting</td>
<td>• The problem of managing grazing pressure.</td>
<td></td>
</tr>
<tr>
<td>(forage harvester/Bio-Pickup).</td>
<td>• Financing – varies depending on grazing livestock, size of area and its</td>
<td></td>
</tr>
<tr>
<td>• Restores common heather by cutting with a forage harvester several</td>
<td>characteristics, plus the opportunity for subsidies.</td>
<td></td>
</tr>
<tr>
<td>years in a row.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Intensive short-term grazing with mobile fences, targeted herd</td>
<td>• Biological values have to be defined before clearing starts.</td>
<td></td>
</tr>
<tr>
<td>grazing, grazing year-on-year with permanent fencing.</td>
<td>• The European nightjar benefits from spread indigenous trees such as the</td>
<td></td>
</tr>
<tr>
<td>• Grazing alone often favours grass and initiates the development of</td>
<td>Scots pine.</td>
<td></td>
</tr>
<tr>
<td>pasture.</td>
<td>• Subsequent clearing has to be planned and executed to ensure effectiveness</td>
<td></td>
</tr>
<tr>
<td>• Common heather and cross-leaved heath are rejuvenated by being</td>
<td>and keep the area open.</td>
<td></td>
</tr>
<tr>
<td>cropped if the plants are not too old.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Trampling of vegetation causes more sprouting from seeds.</td>
<td>• Remember to avoid flooding neighbouring areas when sealing external ditches!</td>
<td></td>
</tr>
<tr>
<td>• Purple moor grass, wavy hair grass and deciduous trees can be kept</td>
<td></td>
<td></td>
</tr>
<tr>
<td>down to an acceptable level.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Crowberry is not eaten.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Grazing pressure too low: accumulation of litter, reduced food value,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Grazing pressure too high: grass and common heather cropped down,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>movement towards grass plain.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Dry heathland: clearing of invasive evergreens, black cherry and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scotch broom in particular.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Marshy heathland: Clearing birch and willow in particular.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• There is no regrowth after felling evergreens.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Deciduous trees regrow from their stumps.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Repeated clearance of mountain pine approx. every 5 years before</td>
<td></td>
<td></td>
</tr>
<tr>
<td>they can produce cones eventually reduces the source of seeds.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• If black cherry is pulled or dug up by the roots before it seeds,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>the source of seeds is eventually reduced.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Scraper, levelling off ditches with material scraped up.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Cross-leaved heath likes plenty of water, but does not necessarily</td>
<td></td>
<td></td>
</tr>
<tr>
<td>grow amongst wet purple moor grass.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• The result of herringbone stripping looks promising – colonisation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>by various species takes up to 10 years, whereas total treatment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>results in a wait of up to 30 years.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Cranes and wood sandpiper, amphibians (mainly moor frog and common</td>
<td></td>
<td></td>
</tr>
<tr>
<td>spadefoot) and adders benefit from water on heathland.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• The method does not yield any significant crops.</td>
<td>• First year after burning, followed by cultivation for 4 years with buckwheat</td>
<td></td>
</tr>
<tr>
<td>• The effect of cultivation in the LIFE-Hede project has not been</td>
<td>or rye without fertiliser.</td>
<td></td>
</tr>
<tr>
<td>observed yet.</td>
<td>• After 4 years, there are no more crops to harvest.</td>
<td></td>
</tr>
<tr>
<td>• Experience from 22 years in succession on previously cultivated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fields gave slow colonisation of common heather over a period of years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and many different flowering plants.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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8 Literature

1 Foreword

NATURSTYRELSEN, 2016a. LIFE-Hedeprojektet - projektbeskrivelse. Taken from Naturstyrelsen.dk [2016, 15-05-2016].


DEGN, H. J. 2005,b, “Vegetationens indvandring på afskrabet areal på Randbøl Hede”, Notes, Randbøl Skovdistrikt, 10 s. Taken from: http://naturstyrelsen.dk/media/nst/12285172/vegetationens_indvandring_p__afskrabet_areal_p__randb_l_hede__notat.pdf [March 2016].


2 Definition of heathland

3 The natural and cultural history of heathland

4 Heathland biodiversity


ØVIG, J. K. 1980, Hedepleje i Kongenshus Mindepark, Det danske Hedeselskab, Forsøgsvirksomheden, Beretning no. 24, 21 s. + appendix.


Ku.dk – Videntjenesten – Park og Landskab – Landskabspleje og Naturgenopretning – Overdrev og Hede [May 2016].

NATURSTYRELSEN 2016b, taken from Naturplejeportalen på Naturstyrelsens hjemmeside - § 3 beskyttede naturtyper – heder, [May 2016].


NATURSTYRELSEN 2016b, Naturplejeportalen på Naturstyrelsens hjemmeside - § 3 beskyttede naturtyper – heder, [May 2016].


NATURSTYRELSEN 2016c: Hedelyng. Taken from Naturkanon – Hedelyng [2016, 2016-05-01].


5 Threats against heathland


6 Management methods and experience of their use


NATURSTYRELSEN 2016b, Naturplejeportalen på Naturstyrelsens hjemmeside - § 3 beskyttede naturtyper – heder, [2016, 01-05-2016].


