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Cultivated and Abandoned Peatlands in the Nordics

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Past and Future of Cultivated Peatlands -

Nordic Environmental Challenges

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Peatlands cover a large proportion of the land area in the Nordic countries, especially in Iceland, Finland, Norway and Sweden. Peatland areas have special hydroecological regimes and other functions that are not well understood. They are also valuable for agriculture, forestry, horticulture and as a source of energy.

However, the uses of these areas have impacts locally, regionally, even globally. Some areas have been abandoned as their drainage and use have become difficult. Future management of these lands must take into account their unique features and possibilities for restoration, conservation and future socioeconomic use.

The Nordic Peat Network was founded in 2008 to gather peat researchers from the Nordic countries to cooperate and work on abandoned peatlands. The aim of the network is to gather information on peatland management research, to understand the diverse environmental consequences of peatland uses and to promote better management and cultivation procedures. This paper reviews peatland drainage and abandoned peatlands in the Nordic countries and identifies past trends and present challenges. The focus is on agricultural drainage and peatland use.

Figure 1. Installing gas probes on peat in Kannus, Finland. Photo: Marja Maljanen

Finland

In Finland, peatland drainage was started in the 1860s to increase agricultural yield and forest production. Peatland drainage on Finnish small farms was seen as hard, honest work which later received a national symbolic image of a durable and honest farmer laid down in the phrase "mire, shovel and Jussi". These are the famous opening words of one of Finland's best known literary works describing a family and its events in the period of 1880-1950, "Under the North Star" by Väinö Linna. These words symbolised an economy based on new land clearance by farmers, often under the auspices of larger farms (torp in Swedish). In the book, Jussi's tremendous efforts eventually give a good crop and he is rewarded with a 'land clearance medal' from the Finnish Cultivation Society.

In Finland, the total peatland area is about 30% of the land area. Around two-thirds of this area was drained for forestry between 1950 and 1980. Large-scale peatland drainage activities were often carried out using labour from prisons or the unemployed. A total of 0.7 Mha was drained for agriculture but 0.4 Mha have since been lost, while 0.5 Mha have been lost from forestry (Myllys and Sinkkonen 2004). It is estimated that 134,000 - 240,000 ha of peat soils are still in cultivation in Finland. Several organisations have suggested that these cultivated fields could be used in energy production, but they are likely to be lost from cultivation in any case.

Peatland drainage has had a number of direct environmental impacts such as loss of biodiversity, and indirect regional and downstream impacts on water quantity and quality. Changes in the hydrological regime have increased the loads of suspended solids, nutrients and other pollutants, thus impairing water quality and aquatic environment characteristics. Lowering of the watertable through drainage improves crop production and trafficking properties of peat soil and leads to repeated ploughing, fertilisation, liming and the addition of mineral soil. However, all these changes also affect the production and emissions of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) in the peat soil. As a result of their accelerated peat decomposition rate, cultivated peat soils are always sources of CO_2 and they are responsible for most of the N_2O emissions originating from all soils. However, after drainage, peat soil surfaces are more aerobic and therefore become minor sinks for atmospheric CH_4, in contrast to natural peatlands (Maljanen et al. 2007).

After active cultivation of peat soil, greenhouse gas emissions can continue (Maljanen et al. 2007). In abandoned peat fields, decomposition of the peat leads to CO_2 emissions. Similarly, high N_2O emissions can continue for decades. The partial degradation of the drainage system raises the watertable and can also result in minor CH_4 emissions. Afforestation of abandoned peat soil slightly decreases CO_2 emissions to the atmosphere because the decomposition rate of peat decreases and, in particular, because of the carbon stored in the biomass of the trees. However, N_2O emissions from afforested peat fields will continue for decades and emissions can be even higher than those from cultivated peat soil (Mäkiranta et al. 1997). During after-use of cultivated peatlands, N_2O emissions cannot be avoided, but emissions of CO_2 can be reduced by appropriate measures (e.g. afforestation).

Figure 2. Cultivated and abandoned peatland in Norway. Photo: Arne Grønlund

Iceland

Peatlands are a notable feature of the Icelandic landscape, covering a land area of around 9,000 km^2. However, considering that large parts of Iceland are non-vegetated deserts, peatlands amount to approximately one-third of all vegetated areas (Friðriksson 1979).

Draining of Icelandic peatlands started in 1940 and gained momentum relatively quickly. Two factors are considered to have contributed to the popularity of the practice, namely that drainage was subsidised by the government, and that the occupation of Iceland by a foreign army during the Second World War resulted in heavy machinery, capable of rapidly draining peatlands, being brought into the country.

In the period 1940-1990, over 32,000 km of open ditches were installed, effectively draining extensive areas (Geirsson 1998). No comprehensive estimate exists as to the total area of Icelandic peatlands drained, but two separate studies of drainage in farming regions in Western and Southern Iceland indicate that the majority of the peatlands in these regions have been drained or partly drained (Thórhallsdóttir et al. 1998; Óskarsson 1998). Based on the results of these studies it has been estimated that, for the country as a whole, between 45-65% of the peatlands have been drained (Óskarsson 1998a).

The initial aim of drainage operations in Iceland was the creation of agricultural fields for the production of hay as winter fodder for livestock. However, as drainage activities progressed, the reason for draining increasingly became that of rangeland improvement, partly in response to the criticism that farmers were extensively overgrazing the highland commons. Currently, less than 20% of the drained area is used for annual crops. The remainder is used for livestock grazing, or, more commonly, is not in any apparent use. It can therefore be surmised that more than half of Iceland's peatlands

Figure 3. CO_2 measurements in a peat field in Sweden. Photo: Kerstin Berglund

have been drained and that the majority of these peatlands are no longer in agricultural use, i.e. have been abandoned.

Norway

Peatlands in Norway constitute about 24,000 km^2 or 8% of the land area (Lappalainen, 1996). Due to climatic conditions, organic soils occur more frequently in western and northern parts of the country. During the last 100 years, 150,000 - 200,000 ha of peatland have been drained for cultivation (Grønlund et al., 2006). Recent surveys indicate that cultivated peatlands currently cover about 80,000 ha (Grønlund et al. 2008a), which is approximately 1 million ha less than the original area of natural and drained cultivated peatland. This difference is most likely due to peat degradation and the abandonment of some peatlands with drainage problems and decreased bearing capacity (Grønlund et al, 2008). In western and southern Norway some peat areas are expected to be abandoned because there is only a thin layer of peat overlying bedrock.

CO_2 emissions from peat degradation in Norway are estimated to range between 1.8 and 2 million tons CO_2 $year^{-1}$, which is equivalent to 3-4% of Norway's total anthropogenic greenhouse gas emissions (Grønlund et al., 2008a). In the case of CO_2, emissions have been found to increase with air temperature, but this trend could not be observed for N_2O and CH_4. Overall, CO_2 emissions have been found to be 17 times higher than those of N_2O on a CO_2-base equivalence (Grønlund et al., 2006), underlining the significance of CO_2 emissions due to peat degradation. Therefore, future measures for cultivated peat soils in Norway should aim at reducing CO_2 emissions as well as greenhouse gas emissions in general.

Sweden

Over one-quarter of the European peatland resource is located in Sweden (Montanarella et al., 2006), with more than 25% of the land area covered with peat of varying thickness (Fredriksson, 1996). Peatland drainage for agricultural purposes began on a small scale in the early 1800s and continued with many large drainage projects at the end of that century (Runefelt, 2008).

Many drainage projects involved lowering the surface of the great lakes and were subsidised by the government. Peatland agriculture was greatly encouraged by the Swedish Peat Cultivation Society (Svenska Mosskulturföreningen, 1886-1939) and later the Peat and Grassland Society. In 1946, the area of cultivated organic soils (peat and gyttja) was estimated to be 705,000 ha (Hjertstedt, 1946) which corresponded to 12.3% of the total area of organic soils in Sweden and 20% of the total area of agricultural soils.

More than half the acreage is now abandoned, mainly due to inadequate drainage. The acreage of cultivated peat and gyttja soils in 2003 was estimated to be 301,489 ha (8.6% of all arable land), with 202,383 ha of deep peat, 50,191 ha of shallow peat and 48,915 ha of gyttja soils (Berglund & Berglund, 2008). Due to high greenhouse gas emissions from drained peatlands, their future use is currently being debated very intensely.

Denmark

In Denmark, drainage of peat soils has been going on since the 19th century. A large effort to bring more land under farming started in 1940 and was supported financially by the Danish government. This led to the straightening of rivers and streams, drainage of wetland areas and large construction projects where lakes, wetlands and shallow fjords were converted into agricultural fields. In the 1970s, problems with eutrophication of surface waters, loss of biodiversity and ochre problems led to a stop on new drainage projects. Many of the drained areas have since been abandoned or re-established as wetlands or lakes due either to environmental regulations or to land subsidence and difficulties in maintaining drainage.

In Denmark, 440,000 ha are classified as deep organic soil (peat and gyttja) (Elsnab 2007). The actual area may be less due to organic matter degradation converting some of the organic soils into mineral soils. Approximately 200,000 ha are used for agriculture and 800-900 ha are used for peat extraction. The agricultural fields on organic soils are subjected to different intensities of management. Around half the area is used for annual crop rotations and the other half for set-aside, silage/hay grass or permanent pastures (Gyldenkærne et al. 2005).

It has been estimated that organic soils under agricultural management in Denmark contribute 1.15 Mt CO_2-eq/year to greenhouse gas emissions (Illerup et al. 2007), i.e. approximately the same amount of emissions as from agricultural mineral soils (1.54 Mt CO_2-eq/year; Illerup et al. 2007). This is despite the fact that organic soils used for agriculture cover only 6-7% of the agricultural area.

This means that there is scope for reducing emissions by new management strategies for organic soils. Denmark has chosen to fulfil article 3.4 in the Kyoto CO_2 Protocol, which recognises sources and sinks of carbon in forest and agriculture. This means that the spatial extent of organic soils and the stock of organic carbon in organic soils need to be determined.

Riparian zones (the margin between surface water and land) contain many of the organic soils in Denmark. These soils are often areas of discharge for water that has percolated through upland soils and that frequently contains large amounts of nutrients from the catchment. To reduce eutrophication of surface water bodies, leaching of nitrogen to surface waters is being controlled by the re-establishment of wetland areas along Danish lakes, streams and rivers since the 1970s.

These re-established wetland areas develop anaerobic conditions, leading to denitrification whereby large quantities of nitrate are converted to gaseous nitrogen and lost to the atmosphere. Concerns have been expressed about the amount of nitrous oxide lost in the process. There are also concerns that the flooding of organic soils heavily loaded with phosphorus from many years of agricultural use will lead to large diffuse losses.

Future of cultivated and abandoned peatlands

Peatland drainage was introduced in the Nordic countries in order to increase land areas for farming, notably after the Second World War. Cultivation of carrots, cereals and grass has been common. This has had negative impacts on water quality due to changes in hydrology and increases in climate gas emissions to the atmosphere, sedimentation, and nutrient and iron loads to watercourses. As a consequence, drainage of pristine mires is not carried out to any great extent.

Some drained peatlands have been abandoned in the Nordic landscape due to poor drainage and low productivity, and these sites deserve more attention for potential future use or restoration. A potential option is to restore the sites for environmental protection to increase carbon sequestration or improve water quality. Bioenergy fuel production is another option for future use of these sites.

The Nordic Peat Network brings together researchers from different backgrounds to combine knowledge and discuss the future management of cultivated and abandoned peatlands. More information about the Network and its activities can be found at: www.oulu.fi/poves/nordicpeatnetwork/index.html.

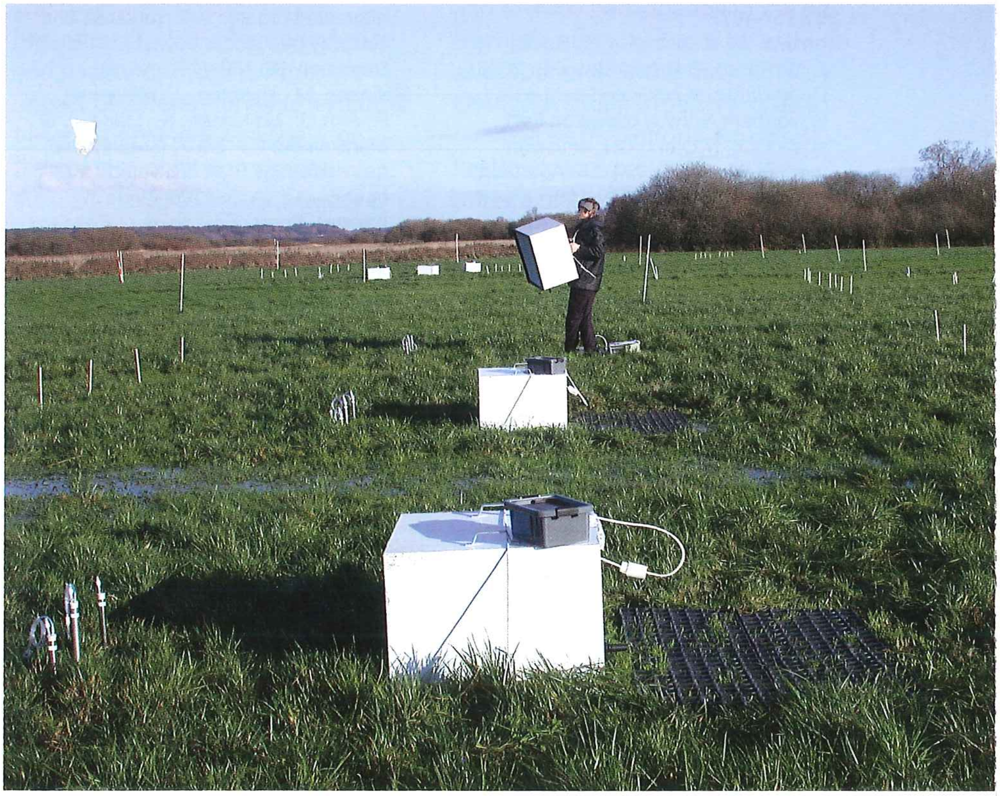

Figure 4. Gas measurements in Nørre Å valley, Denmark. Photo: Mette Lægdsmand

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Figure 5. Some of the network participants at a workgroup meeting in Uppsala, Sweden. Photo: Björn Klöve

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