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Drainage in Sweden -the past and new developments

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ABSTRACT

Land drainage in Sweden has been regulated in various laws since the Middle Ages. The lowering of lake surfaces and the ditching of wetlands has been considered a valuable task to gain cultivable land, and more recently, to promote forest growth. However, in recent years the debate surrounding drainage in forests has been a matter of considerable discussion. The dry and hot summer of 2018 has awakened new views on the subject. Monitoring has shown an exceptionally low groundwater levels countrywide. Especially the islands of Öland and Gotland have faced groundwater shortages and the groundwater levels are still low in both small and large aquifers. Drainage within forest land has lacked any scientific basis until rather recently. Still, it has been a supported activity during the twentieth century. However, this has gradually as knowledge on the activity has increased and the ecology of downstream water bodies has been considered. Today, only the rinsing of existing drainage is actively practised, and it is surrounded by a number of recommendations which are still under discussion.

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Introduction



Drainage was already mentioned in Swedish law during the Middle Ages, e.g. in the so-called Uppland Law of 1296. In later years, Gustav Vasa, who was king in Sweden 1523–1560, gave orders to his subordinates to check that ditches were kept in order by farmers. Ditching was considered an honourable activity. In a novel by the Swedish author Sara Lidman (Lidman 1977), there is a story about a man who rose early on Sunday mornings in the light summer of northern Sweden to dig ditches, something which was observed by his neighbours in the pious countryside and considered to be a sin against God and the Sunday rest. When the neighbours accused him of not observing the day of rest he murmured: 'Lazy fellows who do not come to their distant fields until five o'clock in the morning'.

Today, the water levels in 2,500 lakes has been lowered to gain cultivable land. In the county of Uppland, only two lakes remain untouched from this practise. Ditching in forest land has created very extensive lengths of ditches. In an area in northern Sweden that was drained during the 1980's the extent of ditches is 400 km in an area of 30 km². This means that there approximately 100 m of ditch in an area slightly larger than a football field. Wetlands, which could be

considered as impediments from forest productivity view, have been ditched and become sources for carbon dioxide emission.

Agricultural land

The lowering of water levels in lakes has been a common century-old method of gaining agricultural land. Sweden has about 100 000 lakes larger than 1 ha. The largest project in this connection is the lowering of the water level in Lake Hjälmaren in south central Sweden, the fourth largest lake in the country (Wikipedia 2018). Several times, farmers around the lake have tried to dismantle the dams that have stood there for centuries, the oldest recorded dam is from the year 1422. One objection to the lowering of the water level came from ship-owners on the lake, which was understandable as the maximum depth of the lake is 18 m. Nevertheless, the project was accepted and put in practice from 1878 to 1887 by lowering the water level by 1.3 m which created up 15 000 ha of new land that could be used for cultivation. In addition, 3500 ha of other land was created. The project included the digging of several canals but was accompanied by local problems, such as the compaction of organic rich soils which made it

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necessary to construct embankments along the areas affected.

Agricultural land was originally drained by open ditches but, by and large, they are today pipe-drained. Most of the conversion work was done during the 20th century. The area drained by pipe-drainage is 1.6 M ha. This drainage needs to be maintained. Today about 20% of the drainage is in need of maintenance (Swedish Board of Agriculture 2018).

Drainage of sulphide containing soils is a special problem as they leach acidic water with a high metal content (Åström et al. 2007). In Sweden, we find such soils mainly along the shores of the Bothnian Bay. In Finland, they are common in Ostrobothnia and have been studied in detail there (Mattbäck et al. 2017). A possibility to avoid oxidation of sulphides and acid leaching is a controlled drainage which makes the groundwater level fluctuate less (Österholm et al. 2015).

Forest drainage

Ditching in forest land has been a debated subject since the late 19th century, where belief has been more important than real knowledge (Eliasson 2008). In the later part of that period, it was considered that drainage would decrease the risk of frost. This is mirrored in the Finnish poet Johan Ludvig Runebergs description of the life of the farmer Paavo in a poem from 1830. Later this belief could be proven to be wrong. In the beginning of the

20th century, however, another myth became a popular belief, namely that sphagnum moss could cause water logging in spruce forests. Even this could be proven to be wrong by studies conducted over time relating to tussocks of sphagnum in forests (Eliasson 2008).

Other facts lie behind two intense drainage periods, one during the 1930's and the other during the 1980s and 1990s (Figure 1). In the 1930's, ditching was considered to be something good for the environment. There was an abundant work force during the economic crisis of the time that could be mobilised for digging work. At most about 10 000 km of ditches per year were dug during the peak of this period. From 1910 to 1950, rinsing of small streams was an ongoing activity. The background was timber rafting in streams. Two factors caused this activity to fade out: one was that rafting became less practised and the other was that the removal of stones in streams decreased the surface area where insects and other sources of nutrition could attach, which decreased the food availability for fish (World Wildlife Foundation 2018). The second period of increased ditching was to avoid water logging after clearcutting the forest, resulting in less evapotranspiration. This activity has also decreased as it has mobilised fine grained particles that have disturbed the downstream water quality (Hansen et al. 2013). The Swedish Forest Agency (2014) recommends the use of lateral groundwater seepage areas downstream as protection

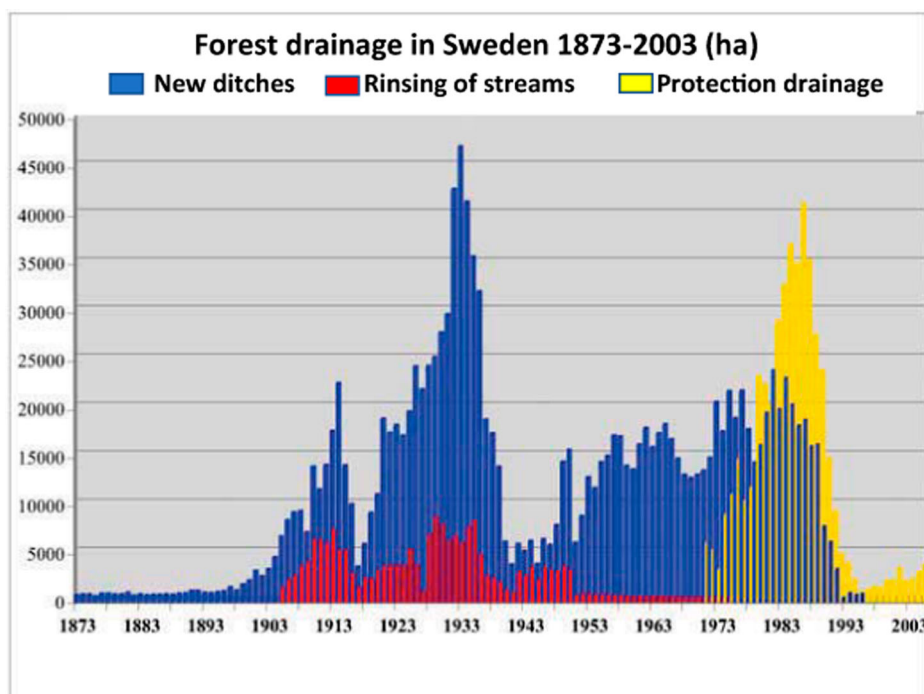


Figure 1. Forest drainage in Sweden. Swedish Environmental Agency (2017). Data from Ahlbäck (2002) and Päivinen and Hänell (2012).



Figure 2. Protection drainage after clear-cutting. The reddish areas are sites for lateral groundwater seepage to collect suspended material and nutrients leached from upstream areas where the protection rinsing of drains has been practised (Swedish Forestry Board 2017. Figure drawn by Bo Persson, Swedish Forestry Board).

when rinsing drains (Figure 2). The rinsing of drains in connection with clearcutting was almost on the same scale as the drainage projects in the 1930's (Figure 1). The reason for this was because the technology had developed in the form of ditch blasting, ditch ploughing and the use of digging machines. This last period of drainage is dominated by the protection rinsing of ditches. It was, and remains, the main activity to avoid water logging after clearcutting. The rinsing of ditches was later questioned as it was found to cause inorganic nitrogen leaching (Hansen et al. 2013).

An interesting evaluation of ditches for improving forest growth has been made in a M Sc thesis (Gunnarsson 2009). The 545 km² area investigated in the thesis in SW Sweden comprises 3.7 km of forest ditches and 3.2 km of ditches along forest roads. As per the evaluation, 1/3 of the forest ditches did not promote forest growth. Another conclusion was that forest roads should be allocated in a way that ensures unnecessary and disturbing drainage can be avoided.

Wetlands have received increased protection through the Ramsar Convention (Ramsar Homepage 2018). This was signed in 1971 and adapted in 1975. It is a convention which lies outside the United Nations but is, as per 2018 signed by 170 nations. In Sweden, there are 66 areas which are listed as Ramsar areas (Swedish Government Office 2016).

Forest drainage is subject to increasing restrictions and there is a continued discussion between forest

production interests and demands to increase the care of the water environment (World Wildlife Foundation 2018). The ditching of peatlands to increase forest production is no longer practised as it did not produce any beneficial results. By ditching peatlands, the peat is locally degraded and becomes less permeable which has had the effect that ditching itself has counteracted drainage.

Since the digging of new ditches now requires permission, interest for rinsing of old ditches has come more into focus (Hansen et al. 2013). It is especially in connection to the clearcutting of forests that this is practised. Rinsing helps to avoid water logging when the transpiration of the forest is removed. The most serious problem with rinsing, however, is a pronounced increase of suspended material. In the short term, the leaching of mercury has been found after drainage clearing. This problem with suspended material could be solved, however, by leading the water via lateral groundwater seepage, which would cause the suspended material to largely decrease (Figure 2). The Swedish Forest Agency has written a proposal for care to be taken in connection to forest management which contains special care regarding the rinsing of existing ditches (Swedish Forest Agency 2014). This proposal is subject to commentaries by different actors in this connection (e.g. Swedish University of Agriculture 2017, Henriksson 2017). It is evident that there are certain conflicts of interest between the forest production interests and those

who look more at the effect of receiving drainage water downstream.

The forestry and drainage in Sweden and Finland are similar as the conditions are much the same. In Norway, with a more pronounced topography, higher precipitation and less forest land, floods are more in the focus. In the HYDRA programme (Eikenaes et al. 2000) it is considered that changes in forestry has not much changed the flood risks in the Glomma catchment. A Norwegian report deals with carbon dioxide release and sequestration in different environments. The conclusion is the same like in Finland and Sweden that there are still knowledge gaps what concerns wetlands like mires (Bioforsk report 2010).

New developments

Ditching on the island of Gotland in the Baltic Sea has traditionally involved a lot of ditches. To combat the lack of groundwater for the water supply, the Swedish Geological Survey has recently compiled a report illustrating how it would be possible to increase the recharge, by installing obstacles to decrease the runoff, e.g. filling in ditches among other suggestions (Dahlqvist et al. 2017). Instead of straight ditches they recommend meandering drains to extend the runoff period and increase the infiltration (Figure 3.) Dams and barriers can be built in open ditches. The report identifies 16 well fields where there is a possibility the increase the groundwater recharge through different actions.

Wetlands

Wetlands are important in relation to the climate change. They can play both a positive and a negative role depending how we act (Swedish Environmental Protection Agency 2017). Wetlands can contribute in decreasing effects of variations in precipitation. Wetlands can contribute in decreasing nitrogen leaching by denitrification (Tonderski et al. 2003). Drained wetlands cause about 1/5 of the Swedish emission of greenhouse gases (Swedish Environmental Protection Agency 2017). Although ditches were dug in wetlands during the 20th century, today it is time for wetlands to be restored to their original condition. An effect of ditching is that the wetlands have become carbon dioxide sources instead of having been sinks. In addition, other factors are contributing like nitrogen deposition which has increased forest growth on wetlands causing lowered groundwater level and increase in degradation of peat.

In this respect suitably located peatlands can decrease nitrogen leakage by increasing denitrification by ca 1000 kg N per ha per year. During the years from 1996 to 2006, more than 2000 wetlands were constructed to remove nutrients from community sewage treatment plants and other points sources of nutrient leakage. This activity has been government supported. Some wetlands aimed at 'polishing' community sewage are placed near habitations and have become nice areas for strolling and enjoying a rich birdlife. However, an evaluation (Arheimer and Pers 2017) of their nutrient removal shows that they are rather moderate traps for nutrients.

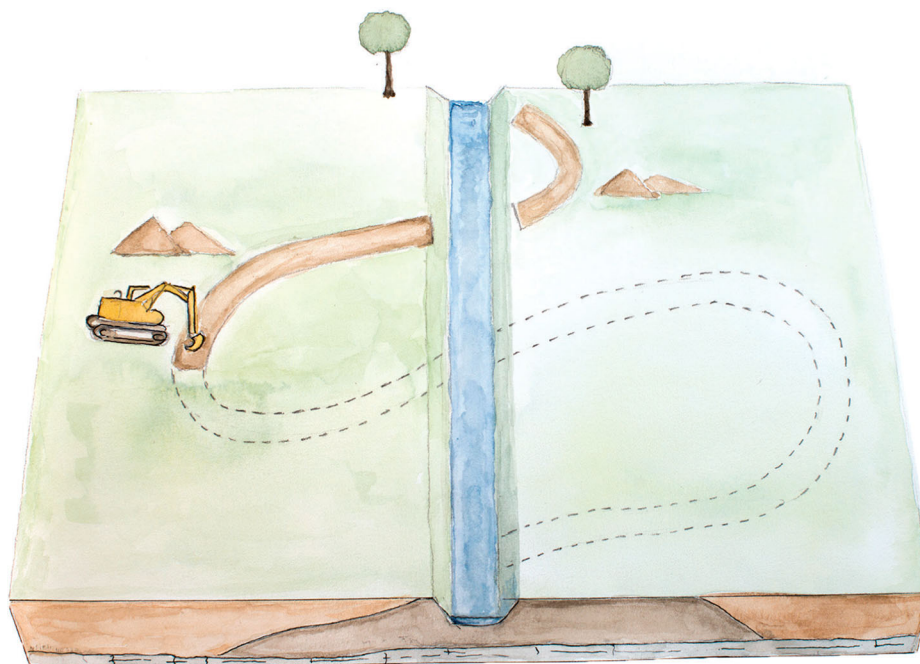


Figure 3. Meandering ditch to increase the runoff rate and increase infiltration on the island of Gotland (Dahlqvist et al. 2017).

In the southern part of the country, the removal of nitrogen and phosphorus was only up to 1% of the total export to the Baltic Sea (Gren 2008). One of the reasons for this is that the wetlands are not built at suitable sites. Obviously, more must be learnt to increase the removal of nutrients.

Concluding remarks

Drainage of land by lowering lake levels and ditching forests and wetlands has been a long-established practise over the last few centuries. For many years the practise was not based on knowledge but for a long time on several myths. It was only during the last few decades that investigations have presented a better knowledge base. Since the early 20th century, two periods of drainage have taken place, the first one during the economic of the 1930's, when high unemployment meant that a large number of workers were engaged to dig ditches manually. The second period, during the 1980s and 1990s was due to the development of technology in the form of ditch blasting, ditch ploughing and the use of digging machines. Today, the main drainage activity in forestry is the rinsing of existing ditches in connection to clearcutting. Special care needs to be taken in this activity with respect to downstream water areas. However, this aspect of ditch management is still under discussion.

Many wetlands have been drained in the past, turning them into carbon dioxide sources instead of sinks. However, the restoration of wetlands to create sinks for nutrients and suspended matter has been in action during the last few decades. So far this has had a limited effect on the nutrient loss to the Baltic Sea.

Climatic variations are believed to be more pronounced in the future and some regions in Sweden have already experienced water shortages like the islands of Öland and Gotland in the Baltic Sea. Initiatives to delay runoff and increase recharge are on the way. The summer 2018 was very warm and dry and groundwater levels remain low in both small and large aquifers.

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Notes on contributor

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