Policy Brief No. 1 2022

BIOWATER

Photo: Maria Rajakallio

Forestry, water quality and ecology

With the emerging bioeconomy, it is expected that more biomass will be needed for food, fodder, fibre and fuel. This may mean harder exploitation of forested areas, which again can have negative impacts on freshwaters. Biowater has obtained new knowledge on forestry's impacts on water quality and ecology.

Whereas the perils of climate change clearly points towards the need for a green shift with less use of fossil fuel, it is important to be aware of the possible adverse consequences of a bioeconomy. Harder exploitation of forested areas may mean increased use of fertilization, harrowing of the forest ground after clear-felling, removal of branches and stumps for energy production, increased drainage ditching or ditch maintenance, as well as harvesting of riparian and other currently protected areas. These activities may affect water resources, but at the same time, researchers are exploring how mitigation measures can reduce the adverse impacts on water resources of forestry activities.

In this brief, we have gathered important information from new papers on this topic, mainly from Biowater but also with other references of interest.

BIOWATER (2017-2022) is a Nordic Centre of Excellence, funded by Nordforsk. Our main goal is to examine the impacts of a bioeconomy on land use, freshwater quality and quantity, and the society.

We are eight institutions in four Nordic countries (Denmark, Finland, Norway and Sweden), and with three European collaborating partners.

We cooperate closely with policy makers and stakeholder representatives to ensure calibration of our research questions with current needs.

Losses of nutrients from agriculture, forestry and natural catchments

Biowater studied data on water quality and land use data from 69 Nordic small catchments since year 2000. The catchments were either under agriculture, forestry, or had near-pristine conditions.

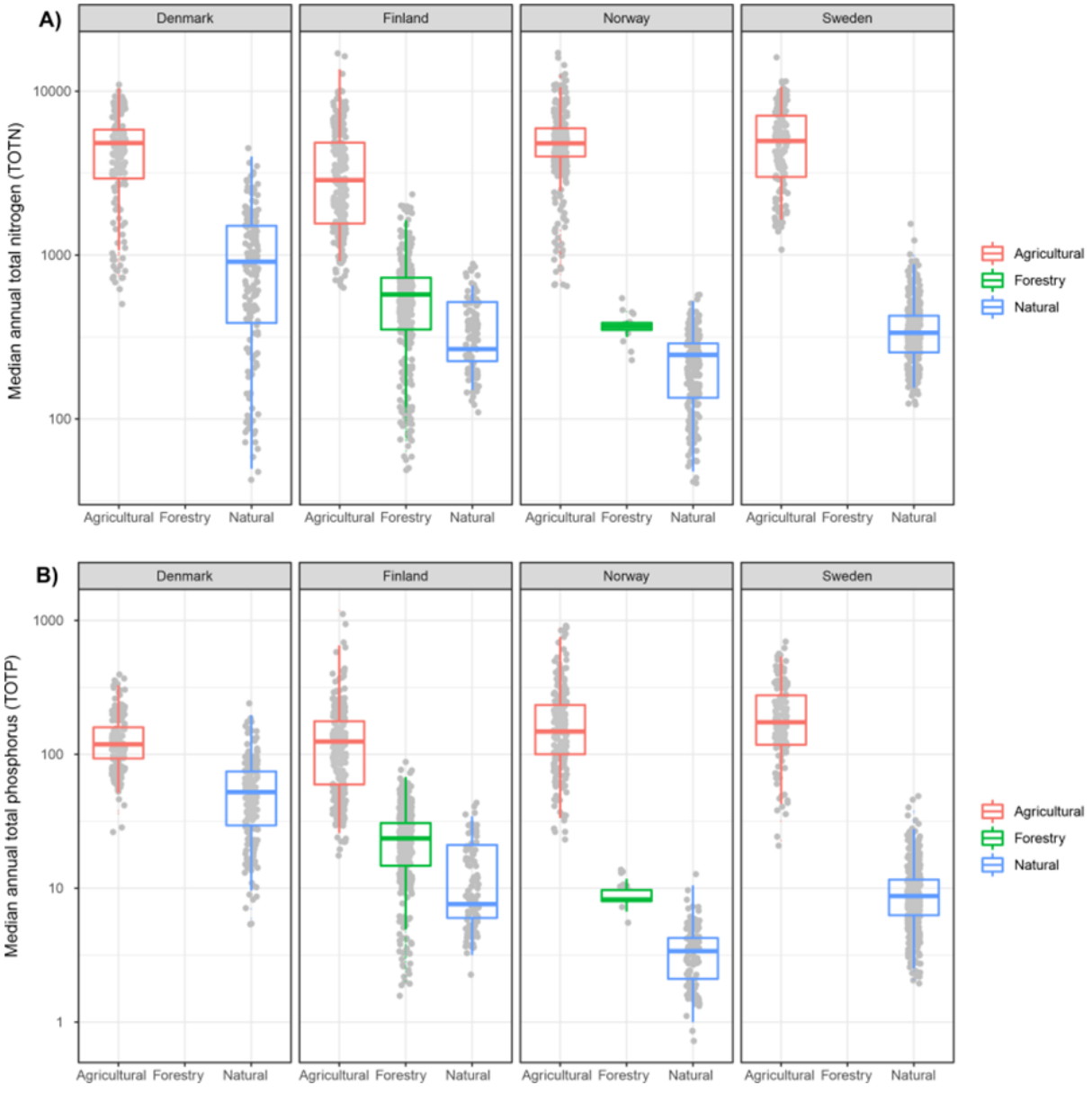
The data revealed that concentrations and fluxes of both nitrogen and phosphorus were highest in agricultural catchments, intermediate in forestry-impacted and lowest in near-natural catchments. Hence, if the green shift implies more intensive use of forests, the results of this research indicates that we can expect more nutrients in our waters if we do not implement measures to prevent this.

The study revealed that more effort should be given to collect consistent long-term data also from forestry catchments. There are well documented studies of this from forested peatlands in Finland, but there is a need for studies also from mineral soils/shallow moraine soils, for example in Norwegian woods.

Source: de Wit et al. 2020.

With the green shift, we can expect more nutrients in our waters if we do not implement measures to prevent this.

Based on: de Wit et al. 2020.



Drainage increases nutrient losses from forests

With the emerging bioeconomy it is important to understand how drainage of forests affects nutrient losses. A study of Finnish data from 28 pristine and 61 managed boreal forest catchments revealed that long-term impacts of forest drainage were much higher than previously estimated. This means that drained areas of forests are hotspots for the export of total nitrogen, total phosphorus and total organic carbon, also in decades after the ditching.

It was concluded that forest management contributed 17% of the total nitrogen export from forests, 35% of the phosphorus export and 12% of the total organic carbon export, respectively. This is more than two times higher than previous estimates of nitrogen and phosphorus exports. The differences may be explained by the long-term impacts of forest drainage.

Source: Finér, et al. 2021.

In another study, Finnish researchers from SYKE/FEI and LUKE, studied 12 small forested headwater catchments with monitoring records from 1990 to 2019.

They found that nitrogen in the streams increased with increasing area of drained forest land, and that this was linked to increasing organic carbon and brownification.

Source: Lepistö, et al. 2021.

Drainage ditches act as highways for nutrients from forested areas. Photo: Eva Skarbøvik

Ditch maintenance can be important for timber production, but is not good for water quality. Photo: Eva Skarbøvik.

Ditch maintenance and water quality

Ditch maintenance can be important to maintain the timber production, but intensified maintenance can increase losses of soil particles and nutrients. (Hokka et al. 2017).

A Finnish study on economy compared the profit from forestry (private sector) with reduced water quality (for society).

They found that ditch maintenance was profitable for the forestry sector, but that the negative effects on freshwaters made this a sub-optimal economic solution for the society.

The authors stressed that more studies on this issue should be encouraged.

Source: Miettinen et al. 2020.

Drained areas of forests are hotspots for the export of total nitrogen, total phosphorus and total organic carbon.

Based on: Finér, et al. 2021.

Fertilizing forests

The use of fertilizers can give a better regrowth of trees, and this can help the water environment: Studies have shown that the losses of nitrate and ammonium were clearly reduced when the re-vegetation reached 30-40 % after harvesting (Hedwall et al. 2015; Can. J. Forest Res. 45(1)).

However, fertilization can also cause problems for forest water bodies, especially if spread from the air: Studies have found increased nitrate and ammonium levels in forested streams after fertilization (e.g., Shah og Nisbet 2019).

Fertilizing forests in acid soils

In a coniferous forest in Southern Norway, researchers modelled the effects of fertilization and different forms of forest management on soil and streamwater. The results showed that intensified forestry may cause substantial effects on surface water quality in acid-sensitive areas. The stem-only harvest had a more pronounced effect on nitrogen leaching than the whole-tree harvest, but the nitrate peak diminished a few years after the clearcut. Due to poorly buffered soils at the study site, the nitrate leaching resulted in a brief, but significant decline in acid neutralising capacity (ANC) and pH. The greater biomass removal with the whole tree harvest resulted in a long-term depletion of soil base cations and a setback in the positive trend in stream acid neutralising capacity by several decades.

Due to poorly buffered soils at the study site, the nitrate leaching resulted in a brief, but significant decline in acid neutralising capacity and pH.

Based on: Valinia et al. 2021.

Nitrogen fertilisation was simulated ten years before the harvest. The modelling revealed that fertilization was not followed by an immediate nitrogen pulse in surface water, but gave elevated nitrogen leaching after clear-cut with both harvest methods. It should be noted that this study represented an extreme case where 100% clear-cut of a catchment was modelled.

Source: Valinia et al. 2021.

The use of fertilizers can ensure improved growth of trees after harvesting. Photo: Eva Skarbøvik.

Soil scarification by disc trenching, and other novel forestry operations have not been studied by Biowater. There exist some few studies on how such methods can affect water quality in forest streams and lakes. More studies are clearly needed.

Water ecology under forestry

At the University of Oulu, Finland, Biowater PhD student Maria Rajakallio has studied how forestry and drainage may impact aquatic ecology. Rajakallio and co-authors point out that the growing bioeconomy is increasing the pressure to clear-cut drained peatland forests. They therefore studied effects of peatland drainage and clear-cutting on stream *invertebrates* (see fact box).

This caddisfly larva is an example of an invertebrate inhabiting streams. Photo: Maria Rajakallio.

They found that peatland drainage reduced benthic biodiversity in both small and large streams, whereas clear-cutting did the same in the small streams. In general, small headwater streams were found to be more sensitive to forestry impacts than the larger, downstream sites.

Drained peatland forests in boreal areas are reaching maturity and will soon be harvested. The combined impacts of peatland drainage and clear-cutting can cause significant biodiversity loss in freshwater ecosystems. This information strongly suggests that continuous-cover forestry based on partial harvest will provide the most sustainable approach to peatland forestry.

Source: Rajakallio et al. 2021.

Stream invertebrates *are small animals such as insects, mites, crayfish, and worms. They are important as food for fish, reptiles, amphibians, and birds, and they help clean the stream waters of dead or decaying bacteria, plants, and animals. Invertebrates are used as indicators of stream water quality in monitoring related to the EU Water Framework Directive.*

Continuous-cover forestry based on partial harvest will provide the most sustainable approach to peatland forestry.

Based on: Rajakallio et al. 2021.

Trees along streams protect the ecology

Although this study is from agricultural streams, its findings on trees along streams is of high relevance also for forestry. Four scientists from Finnish and Canadian institutes investigated the effects on ecology of riparian land use, by studying 11 paired forested and open agricultural headwater stream reaches. The word ‘paired’ means that each stream had a sibling stream reach with similar habitat characteristics: The reaches within a stream had similar water quality, but different extent of riparian forest cover.

They found unmistakably evidence of the ecological benefits of forested riparian reaches in the agricultural headwater streams.

This suggests that riparian forests in agricultural streams can partly mitigate the adverse impacts of agricultural diffuse pollution on biota.

Moreover, they found that riparian forests reduced the fluctuation of stream water temperature and maximum water temperature. This is highly relevant, since climate change predictions include higher summer temperatures, which again may enhance algae growth and have negative impacts on species adapted to cold water temperatures.

Source: Turunen et al.2021

Unmistakably evidence of the ecological benefits of forested riparian reaches.

Based on: Turunen et al.2021

There is a large difference in conditions for aquatic life in streams with and without bank vegetation. Both photos: Jarno Turunen.

The benefits of riparian trees

In another study also on the effect of trees along agricultural streams, Finnish scientists used data from more than 900 river water bodies in Finland.

They found that the ecology of small to medium sized rivers in an agricultural landscape benefitted most from forested riparian zones. The ecological quality increased by almost one status class when the riparian forest cover increased from 10 % to 60 %.

For large rivers, the authors did not find the same effect of adjacent forested land, probably because these larger rivers have a multitude of pressures and, hence, the clear pattern found in smaller streams will be less obvious. Protecting and restoring wooded headwater riparian zones are likely to have advantages for ecological quality further downstream as well.

The authors emphasise the implications of this study for managers that strive to achieve the EU Water Framework Directive goal of good ecological status of rivers. The results demonstrate how forested riparian zones can have an independent positive effect on the ecological status of rivers. Therefore, forested buffer zones should be more strongly considered as part of river basin management strategies.

Source: Tolkkinen et al. 2021.

Trees along water bodies improves the aquatic ecology significantly. Photo: Eva Skarbøvik.

Editor: Eva Skarbøvik, NIBIO. Quality assured by Biowater colleagues J. Aroviita (SYKE), Ø. Kaste (NIVA), A. Lepistö (SYKE), M. Rajakallio (University of Oulu) and H. de Wit (NIVA).
The text is based on news items posted at www.biowater.info, approved by the main authors of the Biowater-papers.

The ecological quality increased by almost one status class when the riparian forest cover increased from 10 % to 60 %.

Based on: Tolkkinen et al. 2021.

Summary

In a future with bioeconomy, our Nordic forests may become an important source of biomass. However, harder exploitation of these forests may cause negative effects on water resources. To summarise,

- There is a general lack of data and studies of forestry and water quality. Although Finnish studies are of interest also to other Nordic countries, we still need more knowledge on forestry in shallow moraine soils, typical for Norway and Sweden.
- Forest ditches and ditch maintenance can significantly increase losses of sediments, nutrients and organic carbon from areas under forestry.
- Fertilization of forests can increase the concentrations of nutrients and should be done with care, especially in acid-sensitive areas.
- There is now clear proof that trees along streams improve the ecology and ecological status significantly, as compared to riparian zones without trees.
- Small headwater streams are the most sensitive to forestry impacts, and should receive increased emphasis in freshwater protection and management planning.
- Effects of environmentally friendly logging operations both for the water resources and for the economic interests of the timber companies, should be better studied.
- Recent evidence strongly suggest that continuous-cover forestry provides the most sustainable approach to future peatland forestry.

Certainly, forested areas are not harvested every year and this makes a major difference to agricultural areas. Nevertheless, with increased demand for biomass, managers should be aware of the potential perils for water quality and ecology of intensified forestry operations.