



Paludisilviculture: a novel approach for sustainable management of drained peatland forests

Drained peatland forests are an important forest resource in Northern Europe. However, current peatland forestry generates greenhouse gas (GHG) emissions from the soil, increases loading to watercourses, and contributes to biodiversity decline. Climate change is expected to intensify these impacts.

Paludisilviculture provides a new management alternative where negative environmental impacts can be reduced without giving up wood production.

Paludisilviculture relies on reduced and redesigned drainage, the use of native tree species, and the application of recycled ash fertilizers. Paludisilviculture reduces GHG emissions and loading to water bodies and improves habitat condition.

Guidance, regulation, and incentive schemes should be updated to allow and encourage owners and managers of drained peatland forests to practice forestry without excessive drainage.

Policy recommendations

- 1. Management practices of drained peatland forests must be adjusted** to ensure sustainable and continued provision of timber.
- 2. Up-to-date information on the benefits and methods of paludisilviculture should be urgently provided** to owners and managers of drained peatland forests, as well as forestry experts.
- 3. Incentive schemes and regulation should be updated** to support the transition to paludisilviculture, especially on sites where the expected environmental benefits are high.

Recommendation 1

Management practices of drained peatland forests must be adjusted to ensure sustainable and continued provision of timber

Northern Europe is regionally rich in peatlands, which have been extensively drained for agriculture and forestry. Drained peatland forests cover ca. 10 M ha and are found especially in Finland, Sweden, Estonia and Latvia, but also in, e.g., Northern Germany, Poland, and Lithuania.

Drained peatland forests are regionally vital forest resources, e.g., providing a quarter of timber production in Finland, but also sources of soil GHG emissions. In the EU, drained peatland forests are

estimated to be a source of 25 M tons CO₂ eq. of soil GHG emissions annually, with most of them coming from Finland and Sweden. Drainage also causes environmental loading to watercourses and degradation of biodiversity on mires and in water bodies that receive the drainage waters.

Climate change may result in more frequent summer droughts, further intensifying drainage and threatening water availability and tree growth in drained peatland forests.

Drained peatland forest

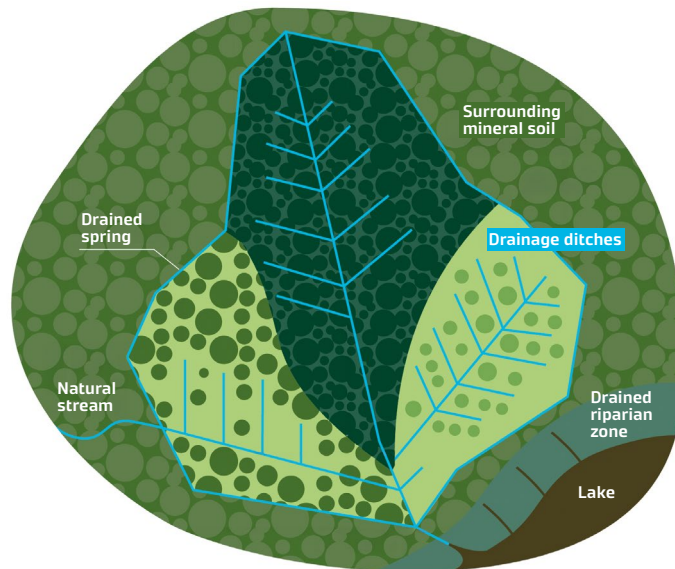
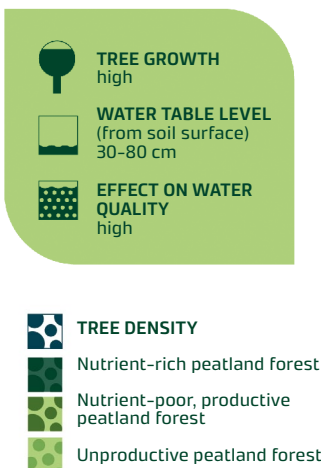


Figure 1 | Current business-as-usual peatland forestry in Finland. For efficient drainage, one-meter-deep ditches have been excavated with ~40-meter intervals. A natural stream has been dredged, and a spring drained. Drainage has lowered the water table and increased tree growth, while the ecological condition of downstream water bodies has deteriorated. The greatest environmental impacts originate from nutrient-rich peatland forests.

Paludiculture

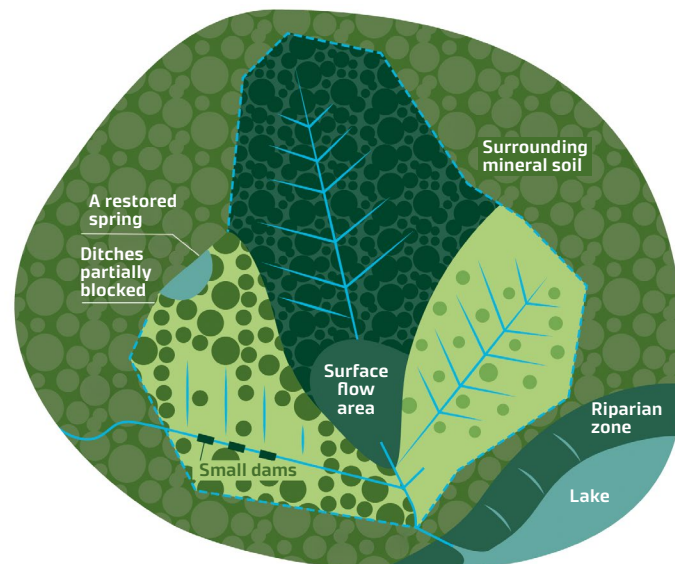
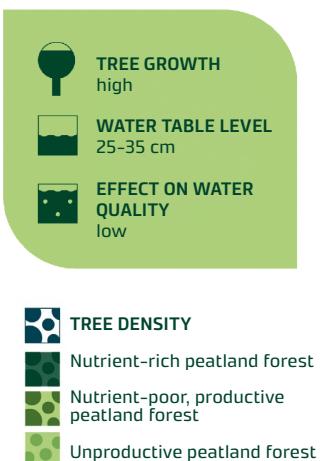


Figure 2 | The key elements of paludisilviculture. Drainage ditches have been partly blocked or allowed to shallow naturally. A surface flow field has been established to filter runoff. Water flow is regulated with small dams. The spring and the stream have been restored. Due to the elevated soil water-table level, GHG emissions and loading to water bodies are restrained through reduced peat decomposition. Wood production remains profitable.

Recommendation 2

Up-to-date information on the benefits and methods of paludisilviculture should be urgently provided

Current peatland forestry practices have been shaped by decades of guidance and incentive schemes focusing on intensive drainage (Figure 1). However, both the drained ecosystems and climate have evolved, rendering the old schemes obsolete. Owners and managers of drained peatland forests, as well as forestry experts, urgently need up-to-date information on the benefits and methods of paludisilviculture.

What is paludisilviculture?

Paludisilviculture is a novel concept inspired by paludiculture (Figure 2). Recent scientific results suggest that paludisilviculture could help to reduce the negative environmental impacts of peatland forestry without giving up wood production.

Paludisilviculture provides a new management alternative that imitates the structure and function of naturally forested undrained peatlands (Figure 3). It involves:

- Redesigning drainage systems to maintain higher soil water-table levels, which reduces peat decomposition
- Using the tree species naturally occurring on forested peatlands
- Applying recycled ash fertilizers from bioenergy production
- Shifting toward continuous-cover forestry on many, though not necessarily all, sites

Considerable potential to reduce greenhouse gas emissions

Paludisilviculture aims to balance climate change mitigation, biodiversity protection, and wood production. Because it maintains the carbon sink of the growing tree stock and can be applied on large areas, it has considerable potential for cost-effectively decreasing GHG emissions. Paludisilviculture can also complement other peatland restoration strategies.

Potential management options for drained peatland forests.

Practice	Benefits	Drawbacks
Current peatland forestry	Intensive wood production continues with existing practices and technology.	C emissions from soil to atmosphere are constant. Effects on water quality are negative and drive biodiversity loss in peatland and freshwater habitats. Wood production is vulnerable to climate change.
Paludisilviculture	Some mire species may emerge. Soil C emissions decrease while a strong carbon sink in tree stand is maintained. Water quality improves. Wood production becomes more resilient to climate change. Large scale potential.	Transitioning requires planning and changes in forest management practices and policy instruments. Wood production decreases on some sites.
Full-scale mire habitat restoration and nature conservation	Biodiversity is protected effectively. Soil C emissions decrease, and water quality improves. Soil C sink emerges or strengthens. In long term, ecosystem net C sink may increase.	Wood production ceases and tree stand C sequestration is decreased. Methane emissions emerge. Initial carbon and nutrient loading to watercourses may be high.

Recommendation 3

Incentive schemes and regulation should be updated to support the transition to paludisilviculture

Paludisilviculture can maintain wood production and be financially viable. However, the transition to paludisilviculture may involve costs, e.g., when redesigning the drainage system or actively raising the water-table level where it is too low. Incentive schemes should be designed to support the transition to paludisilviculture especially on sites where the expected environmental benefits are high. This can be achieved through measure-based schemes or, with improved monitoring and modelling, result-based schemes.

One of the challenges of the sustainable management of peatlands is that the flow of water transcends land- and water-ownership boundaries. Fostering collaboration between landowners and updating regulation is needed to ensure that the water-table levels can be raised in hydrologically functional areas and that water bodies are protected from harmful levels of runoff.



Figure 3 | Naturally forested, undrained peatland forests are a benchmark for paludisilviculture.

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