REPORT

ON IMPLEMENTATION OF THE PROJECT

DEMONSTRATION OF CLIMATE CHANGE MITIGATION MEASURES IN NUTRIENTS RICH DRAINED ORGANIC SOILS IN BALTIC STATES AND FINLAND

WORK PACKAGE

IMPLEMENTATION OF CLIMATE CHANGE MITIGATION MEASURES IN SELECTED DEMO SITES (C.3)

ACTIONS

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Authors	Jyrki Jauhiainen, Timo Penttilä, Päivi Mäkiranta, Tuula Larmola, Helena Rautakoski, and Raija Laiho
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Contact information	Riga street 111, Salaspils, LV-2169 Phone: +37129183320 E-mail: ieva.licite@silava.lv Web address: www.silava.lv
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SUMMARY

Boreal and subarctic peatlands are substantial reservoirs of carbon, and provide ecosystem services such as timber production, climate regulation, water quality control, flood abatement, biodiversity conservation, as well as recreational benefits. More than half of the peatland area of 104 000 km2 in Finland has been drained, mostly for forestry.

The most common method of forest management in the Nordic countries has been rotational even-aged forestry with 60–100 years long stand rotation, during which 2-3 intermediate thinnings are recommended, and a clear-cut at the end of rotation. Regeneration of tree stand is ensured by site preparation (e.g. by mounding or scalping), ditch network maintenance (DNM), and tree stand regeneration by sowing, planting or naturally from surrounding seed trees. Clear-felling compromises the site net C-sequestration capacity up to 20 years. Clear-cutting increases soil temperature, which potentially increases organic matter decomposition in harvest residues and in soil. DNM after clear-cutting lowers water level in clear-cut sites, which accelerates the peat decomposition rate and often leads to higher carbon dioxide (CO2) emissions from the soil, and nutrient leaching to outflow.

The current alternative management approach is continuous cover forestry (CCF) which does not aim at even-aged stand structure, retains a significant proportion of the tree stand after periodical forest cover harvesting by selective cutting, and is based on primarily natural regeneration of tree stand. Reduced need or avoided DNM is the outcome of maintained transpiration in continuous tree cover and ground vegetation after partial harvests. Managing peatland forests according to the principles of CCF instead of rotation-based management aims at less harmful environmental consequences due to avoiding (i) removal of entire tree C storage and C sink function, ii) undesirably high WLs and consequently export of nutrients in water, increased CH4 and N2O emissions, and reduced tree growth, (iii) unnecessarily deep WL’s causing enhanced decomposition of deep peat layers resulting in high CO2 and N2O emissions and (iv) need for DNM in forest management.

LIFEOrgBalt includes three forest sites demonstrating CCF management aiming to reduce CO2 emissions from peat soils in Finland. Two sites are in the southern part, and one in the northern part of the boreal climate region. In this report we summarize alternative forest management practices (rotational even-aged forestry and CCF), and activities aiming at climate change mitigation in site management and environment monitoring.

ABBREVIATIONS

C = carbon

CCF = Continuous Cover Forestry

CCM = climate change mitigation

CH_4 = methane

CO_2 = carbon dioxide

DNM = Ditch network maintenance

GHG = greenhouse gas

LAI = leaf area index

N_2O = nitrous oxide

WL = water level

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1. CONTINUOUS COVER FORESTRY (CCF) AS A CLIMATE CHANGE MITIGATION OPTION IN DRAINED PEATLANDS

1.1 CCF definition in this report

The CCF in broad sense can be defined to include all management options which do not aim at even-aged stand structure, are based on natural regeneration of tree stand, and retain a significant proportion of the tree stand after harvesting.

1.2 Natural and forestry drained peatlands

Around 4 000 000 km2 (c. 3%) of the Earth's land surface is covered by peatlands (Clarke and Rieley, 2010) and the majority of these are located in the boreal region (Fischlin et al., 2007). Boreal and subarctic peatlands are substantial reservoirs of carbon (C), storing 270–550 PgC in total (Turunen et al., 2002; Yu, 2011). Peatlands provide ecosystem services such as timber production, climate regulation, water quality control, flood abatement, biodiversity conservation, as well as recreational benefits (Zedler and Kercher, 2005; Tolvanen et al., 2013). Drainage for forestry, agriculture and peat extraction cause a change in the multiple ecosystem services these peatlands provide prior to drainage (Chapman et al., 2003; Bonn et al., 2016). Altogether, around 15 Mha of peatlands and wetlands have been drained for forestry in the boreal and temperate zones since the early 1900s (Paavilainen and Päivänen, 1995). More than half of the peatland area of 104 000 km2 in Finland (Montanarella et al., 2006) has been drained, mostly for forestry (Päivänen and Hånell, 2012). In Finland, drained peatlands are an integral part of operational forestry, covering about 25% (4.7 Mha) of the total forest land area.

1.3 Peatland forest management in Finland

The most common method of forest management in the Nordic countries has been rotational even-aged forestry with 60–100 years long stand rotation, during which 2-3 intermediate thinnings are recommended, and a clear-cut at the end of rotation (Kojola et al., 2004) (see Figure 1). In clear-cutting, stem wood is removed, while branches, foliage biomass, stumps and roots (i.e. the logging residues) are either removed or left on site. Ditch network maintenance (DNM) is recommended every 20–40 years as a maintenance against ditch deterioration over time (Sikström and Hökkä, 2016). Regeneration of tree stand is ensured by site preparation (e.g. by mounding or scalping), DNM, and tree stand regeneration by sowing, planting or naturally from surrounding seed trees.

Drainage conditions play a key role in forestry on peatlands, as the lowered water level (WL) increases the root zone aeration and creates more favorable conditions for tree growth. After clear-cutting, DNM is considered necessary to control WL that is temporarily raised by harvesting the tree stand resulting in a significant reduction in evapotranspiration capacity (Heikurainen and Päivänen, 1970,1982; Lundin, 2000). Reduced transpiration after tree cover removal raises the WL (Sarkkola et al., 2010), which may slow down the organic matter decomposition rate in soil due to the reduced volume of aerated peat. On the other hand, the rise of WL to near the soil surface results in anoxia, which may cause CH4 emissions (Korkiakoski et al., 2019) and enhance the mobilization and outflow of redox-sensitive compounds, such as phosphate, iron, and dissolved organic nitrogen and carbon (Kaila et al., 2014, 2015; Nieminen et al., 2015). The shape and strength of the relationship between tree stand and WL vary with climatic conditions, site type, and drainage network configuration (Hökkä et al., 2008; Sarkkola et al., 2010). DNM operations in peatland forests is currently regarded as the most harmful forestry operation affecting surface water quality in Finland and affected downstream aquatic habitats, mainly through erosion induced by DNM (Finér et al., 2010; Stenberg et al., 2015; Nieminen et al., 2017). Maintaining a ditch network also means extra costs.

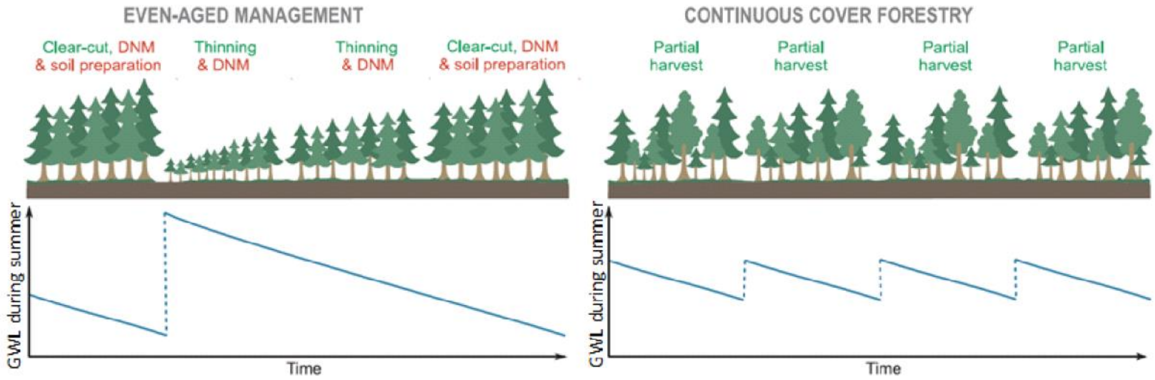


Figure 1. *Schematic presentation of tree stand development and growing season WL depth in even aged management and CCF in drained peat soils in Nordic conditions, where thinning from below and DNM are standard management practices in the even-aged grown forests (modified from Nieminen et al., 2018).*

1.4 Motivation to implement CCF in peatland forests

Currently peatland forests in Finland act as a carbon sink. This is mainly due to forest C sequestration that compensates the soil C emissions. This is especially the case with nutrient rich site types where soils are mainly sources of C (Ojanen et al., 2010, 2014). Clear felling is a forestry action that at least in short term has the most drastic effect on both ecosystem C storage and C sink. Even though ground vegetation recovers rather fast in a peatland forest after clear-cutting (Mäkiranta et al., 2010; Korkiakoski et al., 2019), the C-sequestration capacity of the regenerated tree stand to restore the site net sink may take up to 20 years (Schulze et al., 1999; Rannik et al., 2002; Kolari et al., 2004; Fredeen et al., 2007; Mäkiranta et al., 2010).

Clear-cutting changes the microclimate by allowing more solar radiation to the soil surface, which increases soil temperature (Edwards and Ross-Todd, 1983; Londo et al., 1999) and its diurnal variation. Higher soil temperature potentially increases organic matter decomposition in harvest residues and in soil, enhancing soil loss in organic carbon rich peat soils. DNM after clear-cutting lowers water table level (WL) in clear-cut sites, which accelerates the peat decomposition rate and often leads to higher carbon dioxide (CO2) emissions from the soil (Maljanen et al., 2010; Mäkiranta et al., 2012; Ojanen et al., 2013, 2017). Several studies on forestry drained peatlands in Finland have shown that (i) the condition of ditch networks has only a marginal effect on the WL depth in mature stands (Sarkkola et al., 2010), and (ii) WL deeper than ca. 30cm from soil surface is beneficial for optimal tree growth especially during late summer and this level is commonly obtained even without DNM due to tree stand evapotranspiration (Sarkkola et al., 2012; Leppä et al., 2020).

Managing peatland forests according to the principles of CCF instead of rotation-based management aims at less harmful environmental consequences due to avoiding (i) removal of entire tree C storage and C sink function, ii) undesirably high water levels and consequently WL enhanced export of nutrients (e.g. phosphorus), increased CH4 and N2O emissions, and reduced tree growth, (iii) unnecessarily deep WL's causing enhanced decomposition of deep peat layers resulting in high CO2 and N2O emissions and (iv) need for DNM in forest management (see Figure 1). The feasibility of CCF in peatland forests thus relies on controlling site hydrology via managing the evapotranspiration capacity of tree stand and ground vegetation and applying DNM operations only when essential for assuring stand productivity.

Potential of CCF in mitigating climate change and reducing anthropogenic environment impacts

- Lower impact to environment conditions in forest stand
- Controlled rise in soil water-table level due to impact of remaining tree stand evapotranspiration;
- Reduced/no need for ditch network maintenance;
- Reduced soil CO2 emissions from peat due to reduced change in soil water-table after harvesting;
- Reduced inputs of water and plant nutrients to surface water bodies

1.5 State of knowledge form boreal peatland CCF forests

Due to relatively short time spent in organized data collection on CCF sites, vegetation dynamics, C-balance, and environmental impacts as GHG fluxes exchanged with the atmosphere and emissions in draining waters are still in need of further data collection and experiences.

- Concerning seedling establishment and height development in several commercially valuable species, there is need for experimental data on natural regeneration after CCF partial harvesting on drained peatlands. Such data is available only for Norway spruce (Hökkä et al., 2011, 2012; Hökkä and Mäkelä, 2014, Hökkä and Repola, 2018).

- After partial harvest in CCF, the understory becomes dynamically more united with the atmosphere as it receives more throughfall and light. The field layer vegetation community is subject to rapid changes after disturbance and changes in microclimate (Mäkiranta et al., 2010; Bergstedt and Milberg, 2001; Hamberg et al., 2019). However, the field layer vegetation development and role in peatland energy balance and WL after harvesting are poorly understood.

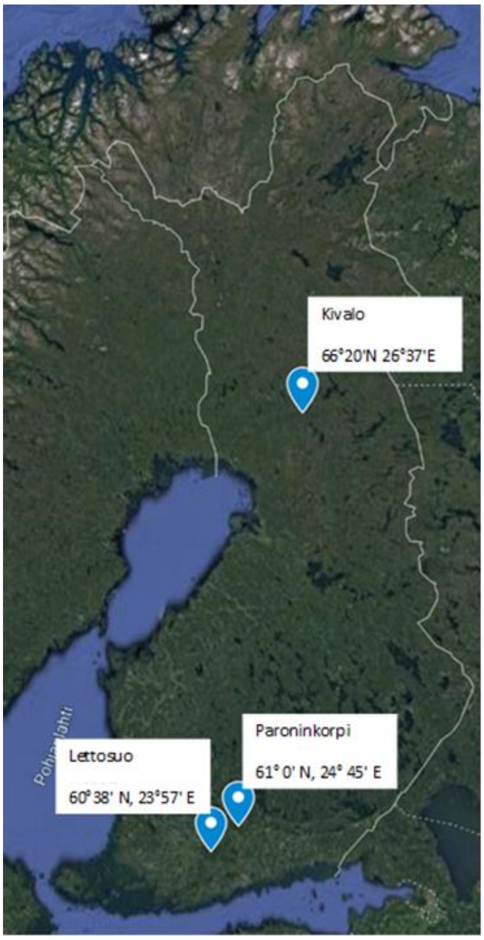
- Excess water is considered as the key growth-limiting factor in peatland forests, where the water uptake by the large trees may help to maintain satisfactory drainage conditions for smaller-size trees in understory. Despite the maintained unevenness in drained peatland stand structure, there is no data on the CCF forest system long-term responses and development to CCF management.

- The tree stand growth rates and total yields in drained peatland stands and in upland forests are considered similar. However, there are no long-term comparative data on growth and productivity responses in CCF forests in drained peatlands and upland sites in comparable nutrient conditions.

- Long-term experiences from CCF sites characterized by uneven age forest structure resulting from repeated harvests are still very rare (Saarinen et al., 2020), and thus best management practices for tree stock density and diameter distribution are to be formed.

- Impact of CCF harvests on aboveground- and belowground litter deposition, and decomposition rates in litter.

2. CCF SITES ON ORGANIC SOILS IN FINLAND - DATA COLLECTION IN LIFEORGBALT



LIFEOrgBalt includes three forestland sites demonstrating CCF management aiming to reduce CO2 emissions from soils in Finland. Two sites are in the southern part and one in the northern part of the boreal climate region (Figure 2).

Paroninkorpi (FIC301) represents CCF in spruce stands using selective felling without full ditch network maintenance for studying forest regeneration and greenhouse gas fluxes in nutrient rich peatland spruce forest. Conventional clear cut and uncut plots are used as comparison.

Lettosuo (FIC302) represents shifting to CCF by overstorey harvesting and release of spruce-birch understorey in originally Scots pine dominated forest on fertile organic soil. Conventional clearcut + ditch mounding + planting of spruce seedlings, as well as uncut forest, are used as control treatments.

Kivalo (FIC303) represents CCF by using small gap harvesting and natural regeneration as a forest regeneration method in mixed stands on fertile organic soil. Spruce shelter tree stand with advanced natural regeneration is used as comparison. Ditch network maintenance has not been applied in the study area.

Figure 2. *Locations of Life OrgBalt continuous cover forestry management demonstration sites in Finland.*

2.1 Paroninkorpi (Site FIC301)

The Paroninkorpi site was initially drained in the 1940's when the main ditches were dug. The ditch network was complemented in the beginning of the 1960's. The site was classified as herb-rich peatland forest (Rhtkg II), and the >1m thick peat layer was mostly sedge (*Carex spp.*) peat. The tree stand originated from advance-growth spruce seedlings evolved after drainage under a birch cover stand that had been harvested earlier. The stand has been managed by successive commercial thinnings from below; the last one carried out in the 1980s. Consequently, the stand structure is distinctively even-sized and the stand diameter distribution was close to normal or bimodal with the second peak in the small diameter classes. Spruce and birch seedlings occurred as undergrowth with varying sizes and densities (Juutinen et al., 2020).

In 2016, an experiment aiming to monitor the impacts of CCF on regeneration and long-term tree stand growth was set up by applying a randomized blocks design including three replicates with the following treatments: i) thinning from above to a retained stand basal area of 12 m2/ha, ii) thinning from above to a retained stand basal area of 17 m2/ha, and iii) control (no cuttings). The selective cuttings were carried out in February 2017.

For assessing GHG fluxes, treatments i) and iii) on two of the blocks (treatment plots 2, 3, 5, 6 in Figure 3) were selected and the subplots for that purpose were set up in early spring 2017. To match the demands of the LIFEOrgBalt project, subplots were set up in May 2020 on a clearcut area of the same site bordering the selective cutting plots. In Paroninkorpi demonstrated CCM measures, site establishment activities, and implemented measurement activities are described in Table 1.

Table 1. Paroninkorpi (site FIC301) description, demonstrated CCM measures, site establishment activities, and implemented measurement activities.

Identification (name, number)	Site Paroninkorpi, FIC301
Location (municipality, coordinates)	Janakkala municipality 61° 0' N, 24° 45' E X: 61.011907, Y: 24.744357
Area, ha	Site including partial cut (CCM) and control plots: 3.5 ha; clear-cut reference 0.6 ha. The site involves treatment plots following randomized blocks design, so not one uniform treatment area as in other sites.
Characterisation	Herb-rich type II drained peatland forest site type according to the national classification. Peat layer depth exceeds 1 m.
Owner	Private company UPM Forest. Luke has an agreement with UPM Forest on using the site for research and demonstration until 2026/12/31, with an option to prolongation. The company has been very supportive and interested in getting information on the application of CCM measures. https://www.upm.com/businesses/upm-wood-sourcing-forestry/
Demonstrated CCM measure	Continuous forest cover without full ditch network maintenance in spruce stands on nutrient-rich organic soil using selective felling. Comparison of soil emissions in demo plots with emissions in conventional forestry practice plots. CCM is based on reduced soil emissions due to controlled rise in soil water-table level, which is controlled through retained tree stand evapotranspiration.

Short description of the site	Partial harvesting (2017) of mature spruce stand to a target basal area. Uncut plots as reference, clearcut area as reference. The partial harvest treatments and unharvested controls were established on experimental plots based on a randomized block design. The site was established in a project New options for forestry on peat soils funded by Luke. Soil emission measurements were made in 2017-2019 in a project 'Uneven-structured management as an alternative to intensive forestry on peatlands', funded by Kone Foundation.
Establishment activity	Implementation of the CCM measure: ● Selective cutting performed in February 2017 Setting up soil greenhouse gas emission measurement subplots, installation of duckboards, piezometers, continuous soil temperature measurements, continuous soil water-table level measurements: ● Basic measurement grid established spring 2017 implementation of extra plots for LIFEOrgBalt project in May 2020 Litter traps: ● Litter collection since June 2019 Ground vegetation cover: ● Yearly measurements since 2017 Above ground biomass sampling: ● August 2020 Moss biomass growth: ● Setting up the sampling plots May 2020 Below ground root production: ● Incubation 2018-2020 Soil sampling (nutrient analysis and total root biomass): ● Aug 2020
Implemented measurement activities	Measurement activities during year 2020 (see detailed description of measurement procedures from protocols): ● 13 measurement rounds of soil CO2 and CH4+ auxiliary measurements ● 4 measurement rounds of soil N2O, CO2 and CH4+ auxiliary measurements ● Vegetation coverage Aug 2020 ● Litter collection monthly, samples separated and dry mass determined ● Above ground biomass sampling Aug 2020, samples separated and dry mass determined ● Tree stand measurements Sep 2020 ● Peat samples collected Aug 2020, dry mass determined ● Moss growth samples collected Dec 2020
Driving distance, km	Departure point 1, Helsinki (Viikki): driving distance 115 km. Departure point 2, Lammi (Biological Station): driving distance 25 km

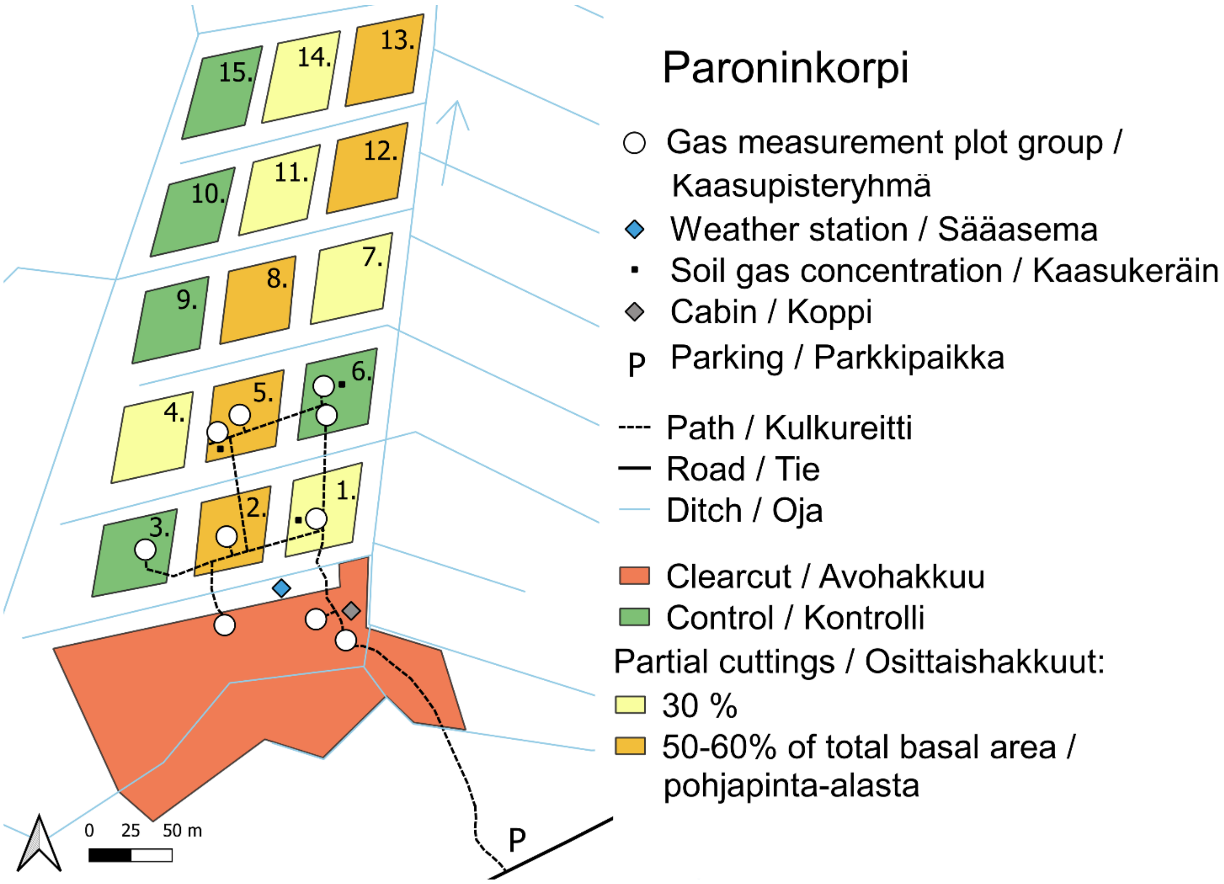


Figure 3. *Paroninkorpi (FIC301) continuous cover forestry treatments and GHG monitoring setup (graphics by Helena Rautakoski).*

2.2 Lettosuo (Site FIC302)

The Lettosuo site is a fertile peatland forest located in southern Finland (60°38′N, 23°57′E). The site was originally a mesotrophic birch-pine fen, drained with widely spaced, manually dug ditches probably during the 1930s, and later in 1969 more effectively with ditches spaced ca. 45 m apart and ca. 1 m deep. The area is flat, with an average slope of 0.2°. The thickness of the peat layer, dominated by Carex remains, varies within 1.5–2.5 m, and the average carbon-nitrogen (C:N) ratio is 27, which is typical for sites with mesotrophic fen history. Fertilization with phosphorus and potassium was done in the early 1970s (year not exactly known).

Before the harvest treatments in 2016, the two-storied tree stand consisted of a mixture of Scots pine (*Pinus sylvestris*, stem volume 180 m3 ha−1) and pubescent birch (*Betula pubescens*, 48 m3 ha−1) in the dominant layer, with a dense undergrowth of Norway spruce (*Picea abies*, 34 m3 ha−1). Field layer vegetation was patchy, featuring mostly herbs (*Dryopteris carthusiana*, *Trientalis europaea*) and dwarf shrubs (*Vaccinium myrtillus*). The forest floor was covered by litter and a patchy moss layer dominated by feather mosses (*Pleurozium schreberi* and *Dicranum polysetum*) with some Sphagnum mosses, such as *Sphagnum capillifolium*, *S. angustifolium* and *S. russowii*, in moist patches.

In winter 2016 (between 29 February and 16 March), two harvesting treatments were carried out, creating three parallel sites: an area of 2.3 ha was clear-cut, 13 ha were partially harvested by removing the dominant pine trees, and the remaining 3.1 ha were left intact as a control (Figure 4). After clear-cutting, the logging residues were left at the site. The previous ground vegetation was almost totally destroyed in the harvesting operation and the following drastic increase in solar radiation. In the following summer, some species adapted to the open, well-lit conditions; for example, *Rubus idaeus*, *Carex canescens* and *Dryopteris carthusiana* were observed here and there within the clear-cut site. Mounding was performed on 1–2 August 2016, and spruce (*Picea abies*) seedlings were planted in 2017. In Lettosuo demonstrated CCM measures, site establishment activities, and implemented measurement activities are described in Table 2.

Table 2. Lettosuo (site FIC302) description, demonstrated CCM measures, site establishment activities, and implemented measurement activities.

Identification (name, number)	Site Lettosuo, FIC302
Location (municipality, coordinates)	Tammela municipality 60°38' N, 23°57' E X: 60.642423, Y: 23.958931
Area, ha	13 ha under CCM plus clearcut and uncut reference areas (2.3 ha and 3.1 ha)
Characterisation	*Vaccinium myrtillus* type II drained peatland forest site type according to the national classification. Peat layer depth varies between 1.5 and 2.5 m.
Owner	State forest managed by the state forest company Metsähallitus Forestry Ltd. Luke has an agreement with Metsähallitus Forestry Ltd concerning management of research forests.
Demonstrated CCM measure	Continuous forest cover (utilization of existing spruce understorey) as a forest regeneration method in originally mixed forest dominated by Scots pine on fertile organic soil to reduce CO_2 emissions from soil. Comparison of emissions in demo plot with emissions in conventional forestry practice plots.
Short description of the site	Partial harvesting (2016) of mature mixed pine-dominated stand, demo site. Uncut plot as reference, clearcut plot as reference. Finnish Meteorological Institute has run micrometeorological measurements (Eddy Covariance) on the site since 1997 (CO_2) and 2010 (CH_4). This is an ICOS network site (https://www.icos-finland.fi/stations), providing valuable background information to support the measurements done in the LIFEOrgBalt project.

Establishment activity	Implementation of the CCM measure: ● Harvesting of overstorey pine and release of spruce-birch understorey in March 2016 Setting up soil greenhouse gas emission measurement subplots, installation of duckboards, piezometers, continuous soil temperature measurements, continuous soil water-table level measurements: ● implementation of LIFEOrgBalt measurement plots in May 2020 ● Continuous automated chambers since 2015 Litter traps: ● Litter collection since May 2020 Ground vegetation cover: ● Yearly measurements since 2009 Above ground biomass sampling: ● Aug 2020 Moss biomass growth: ● Setting up the sampling plots May 2020 Below ground root production: ● Incubation 2009-2012 (before harvest) ● Incubation 2015-2017 (after CCF) Soil sampling (nutrient analysis and total root biomass): ● Aug 2020
Implemented measurement activities	Measurement activities during year 2020 (see detailed description of measurement procedures from protocols): ● 9 measurement rounds of soil CO2 and CH4+ auxiliary measurements ● continuous N2O, CO2 and CH4 data from automatic chambers on CCF site + auxiliary measurements ● Vegetation coverage Aug 2020 ● Litter collection monthly, samples separated and dry mass determined ● Above ground biomass sampling Aug 2020, samples separated and dry mass determined ● Peat samples collected Aug 2020, dry mass determined ● Tree stand measurements Sep 2020 ● Moss growth samples collected Dec 2020
Driving distance, km	Departure point 1, Helsinki (Viikki): driving distance 100 km. Departure point 2, Lammi (Biological Station): driving distance 100 km.

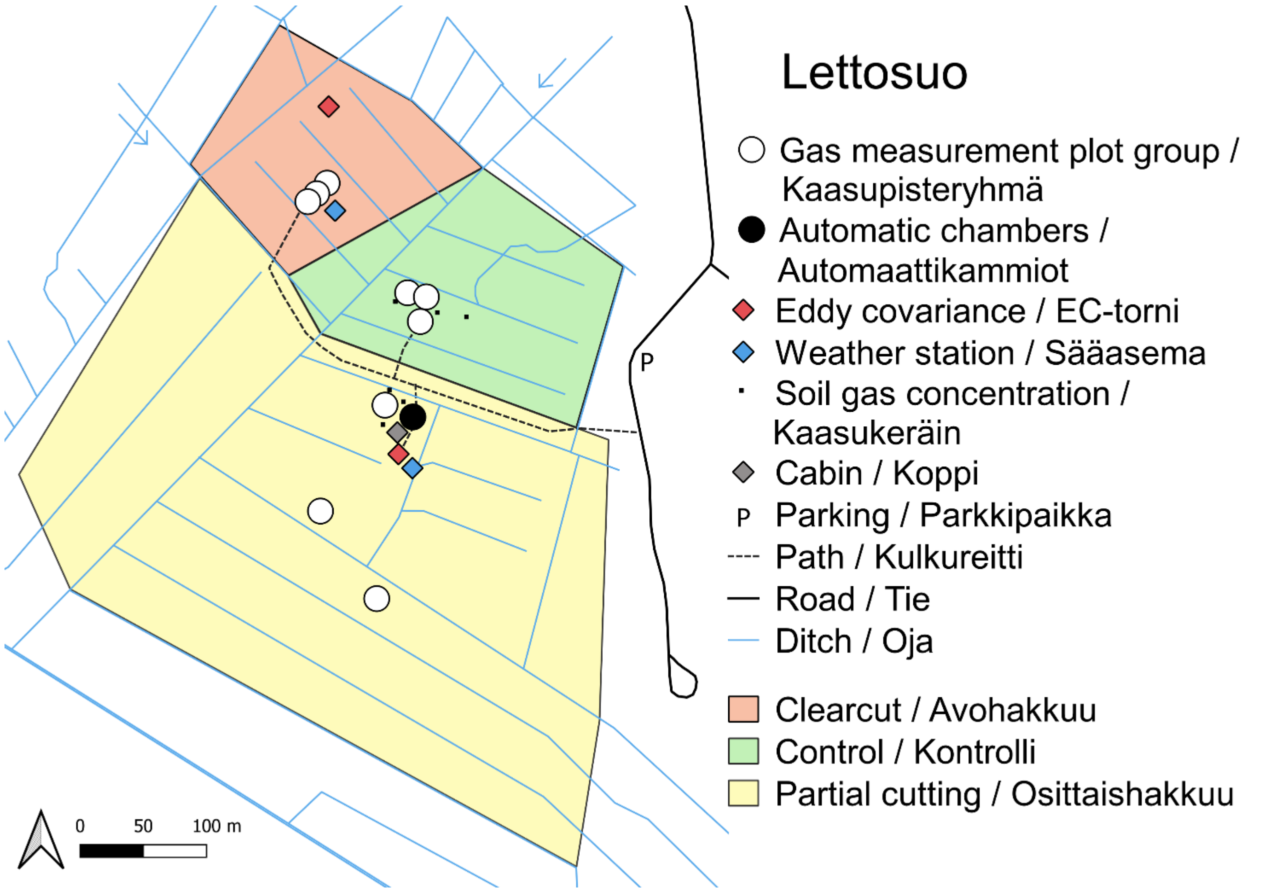


Figure 4. *Lettosuo (FIC302) continuous forestry treatments and GHG monitoring setup (graphics by Helena Rautakoski).*

2.3 Kivalo (site FIC303)

The Kivalo site is located within the Kivalo Research Forest of Luke, in the southern part of *Tampurijänkä*, a peatland area of ca. 200ha lying on the northern slope of Kumpukivalo, a forested hill typical of the region. As a mire complex, Tampurijänkä is a sloping, ground-water-fed aapa mire fen with a fairly thin peat layer (<1m) consisting of mostly sedge peat. Spruce-birch dominated transitional sites prevail in higher elevations close to the upland sites while the lower parts are mostly pine-birch sedge fens. Since 1930's, Tampurijänkä has been one of the experimental forest drainage areas of the former Finnish Forest Research Institute. Most of Tampurijänkä was first drained in 1932-1934 by manually dug ditches with 80 to 120m spacing. The ditches were manually cleaned in 1950. In the 1950's, harvesting of old, overstorey trees was conducted to enhance natural regeneration and the growth of younger trees. Airborne PK-fertilization of the peatland area was done in 1968. Complementary ditching, resulting in the present ditch spacing of 30-35m, was carried out in 1985 following extensive thinnings of young stands in most of the area.

In the spruce-dominated parts of Tampurijänkä, including the LIFEOrgBalt experimental site, a shelter-wood cutting in which approximately 200 close-to-mature spruce and birch trees/ha were retained, was conducted partly in 2006 and partly in 2010. By 2017, adequate evidence of advanced growth of understorey saplings as well as fresh natural regeneration of spruce had shown up under the shelterwood stands. Based on this, an experiment comparing further regeneration success and young stand development following small gap harvesting (<0,2ha/gap) and more extensive overstorey cutting (0,5-2ha/block) of the shelter wood trees was set up and these cuttings were carried out during winter conditions in April 2018. Blocks of uncut shelterwood stands were left intact as controls (Figure 5). Subplots of LIFEOrgBalt demonstration site were set up on two blocks of small gap harvesting and one control block (Figure 6). In Kivalo demonstrated CCM measures, site establishment activities, and implemented measurement activities are described in Table 3.

Figure 5. *Kivalo site small gap harvesting in the front, overstorey cutting and control forest in the back.*

Table 3. Kivalo (site FIC303) description, demonstrated CCM measures, site establishment activities, and implemented measurement activities.

Identification (name, number)	Site Kivalo, FIC303

Location (municipality, coordinates)	Rovaniemi 66°20'N 26°37'E X:66.343791, Y: 26.624550
Area, ha	2.0 ha under CCM plus reference area (3.1 ha)
Characterisation	Partly herb-rich type II, partly V. myrtillus type II drained peatland forest site type. Peat depth varies between 30 and 50 cm.
Owner	State forest/Kivalo research forest managed by the state forest company Metsähallitus Forestry Ltd according to guidance by Luke. Luke has an agreement with Metsähallitus Forestry Ltd concerning management of research forests.
Demonstrated CCM measure	Continuous forest cover (small gaps) as a forest regeneration method in mixed stands on fertile organic soil to reduce CO_2 emissions from soil. Comparison of emissions in demo plot with emissions in conventional forestry practice plots.
Short description of the site	Small gaps harvesting (2018) of mixed spruce & birch stand. Uncut areas as reference. This site was established based on the agreement between Luke and Metsähallitus Forestry Ltd in anticipation of the LIFEOrgBalt project.
Establishment activity	Implementation of the CCM measure: ● Small gap harvesting winter 2018 Setting up soil greenhouse gas emission measurement subplots, installation of duckboards, piezometers, continuous soil temperature measurements, continuous soil water-table level measurements: ● Basic GHG measurement grid established in June 2018; implementation of extra plots for LIFEOrgBalt project in May 2020 Litter traps: ● Litter collection since Aug 2020 Ground vegetation cover inventory: ● Aug 2020 Above ground biomass sampling: ● Aug 2020 Moss biomass growth: ● Setting up sampling plots Aug 2020 Below ground root production: ● In-growth bags installed Sep 2020 Soil sampling for nutrient analysis and total root biomass: ● Aug 2020

Implemented measurement activities	Measurement activities during year 2020 (see detailed description of measurement procedures from protocols): ● 4 measurement rounds of soil CO2 and CH4+ auxiliary measurements ● Vegetation coverage Aug 2020 ● Above ground biomass sampling Aug 2020, samples separated and dry mass determined ● Peat samples collected Aug 2020, dry mass determined
Driving distance, km	Departure point 1, Rovaniemi: driving distance 65 km. Departure point 2, Helsinki (Viikki): driving distance 835 km.

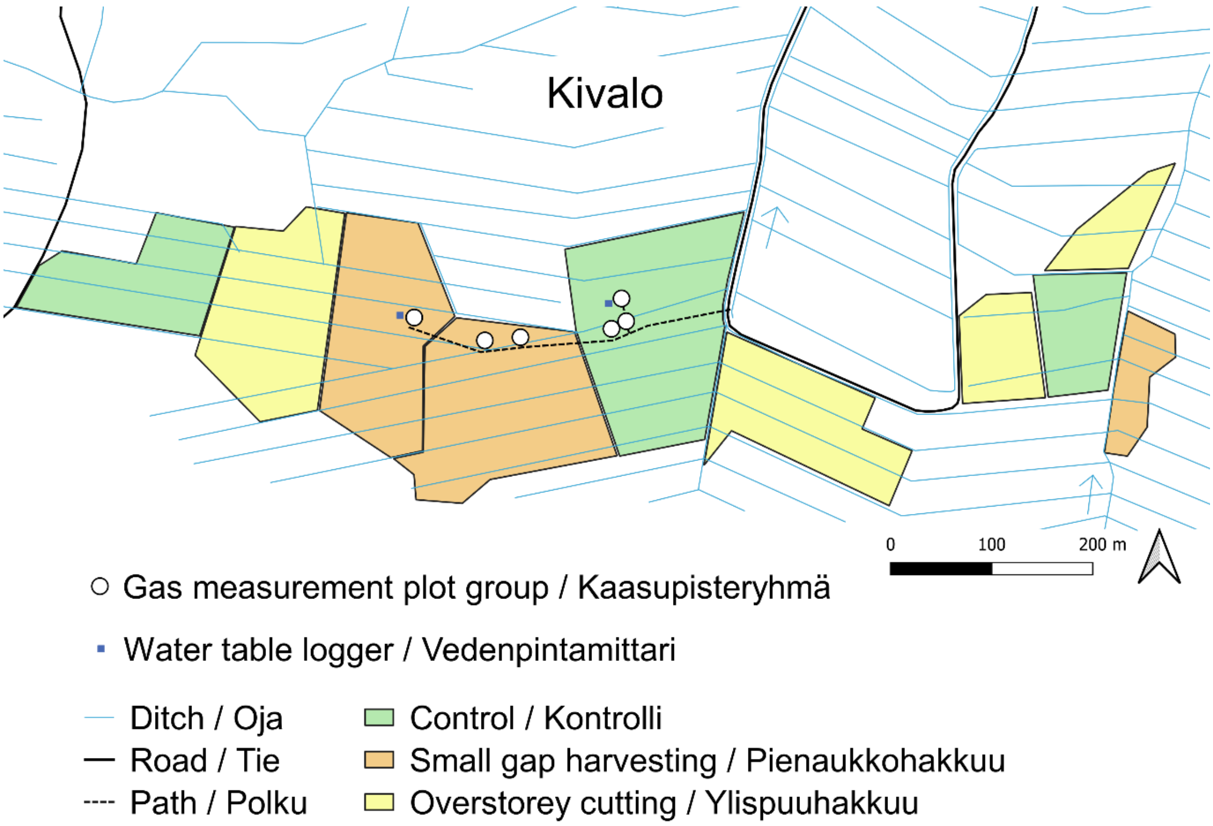


Figure 6. *Kivalo (FIC303) continuous cover forestry treatments and GHG monitoring setup (graphics by Helena Rautakoski).*

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