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

Deliverable title	**Report on implementation of CCM measures in demo sites in Latvia**
Deliverable No	C3/2
Agreement No.	LIFE18 CCM/LV/001158
Report No.	2021- C3/2
Type of report	Final
Organization	Latvian State Forest Research Institute "Silava"

Report title	**Report on implementation of CCM measures in demo sites in Latvia**
Work package	Implementation of climate change mitigation measures in selected demo sites (C.3)
Authors	A.Lazdiņš, I. Līcīte, M.Vanags-Duka, R.Ancāns, A.Butlers, A.Lagzdiņš
Photos and drawings	A.Lazdiņš
Report No.	2021- C3/2
Type of report	Final
Place	Salaspils
Organization	Latvia State Forest Research Institute "Silava"
Contact information	Riga street 111, Salaspils, LV-2169
	Phone: +37129183320
	E-mail: ieva.licite@silava.lv
	Web address: www.silava.lv
Date	2020
Number of pages	47

"LIFE OrgBalt compiled the first regional Baltic/ Finnish GHG emission factors for managed nutrient-rich organic soils (current and former peatlands), which have been made available for the customary scientific review and further verification for national GHG inventories in the hemiboreal region in Finland and the Baltic countries. While the project analysed selected CCM measures for drained organic soils in agriculture and forestry and developed spatial models and tools, it also identified remaining knowledge gaps. To bridge the remaining limitations and fill the gaps, it is essential to continue GHG measurements and model development, as well to broaden and complete the scope of the evaluated CCM measures in the after-LIFE-project period, notably by including rewetting and restoration of peatlands that are currently considered to be among the most recommended CCM measures on drained peatlands in the EU. In addition, the developed Simulation and PPC models still include limited macroeconomic considerations and lack assessment of all environmental impacts. For all these reasons, these models should be used carefully in CCM strategy development for identification of gaps in climate neutrality transition policy and funding frameworks and need further optimization for broader applicability as decision-making tools."

SUMMARY

Report summarizes applied and planned activities to implement CCM measures in selected demonstration sites and reference sites on nutrient-rich organic soils in forest land, cropland and grassland in Latvia.

Demonstration sites are established to demonstrate to the possibly wide and purposefully selected audience climate change mitigation potential of the specific mitigation practices to be implied in nutrient –rich organic soil management by considering cost-effectiveness. Demonstration sites are to be used for monitoring of the impact of implemented measures (GHG emissions and carbon stock changes measurements) and as a basis for assessment of transferability potential. Demonstration sites are mainly established in the land owned/managed by the project partners – Latvian State Forest Research Institute "Silava" and Latvia University of Life Sciences and Technologies. These are forest and agriculture land research areas managed by the agency "Forest Research Station" and the training and research farm of LLU "Vecauce" respectively. Although some demonstration sites in agricultural land are also placed in privately owned land where there are specific agreements with private landowners.

Each demonstration site is linked to 1-2 reference sites thus allowing: (1) evaluation of the situation prior to CCM measure implementation (so called WOM (without CCM measures) scenario) and after (so called WAM (with additional CCM measures) scenario) to assess the long term impacts (e.g. grassland afforested 20 years ago); (2) controlling of the CCM effects by establishing control plots besides demonstration sites (e.g. cropland still remaining cropland beside an area where cropland is converted to grassland). Similar measurements of GHGes and environmental data (GHG, water, soil and biomass data gathering and analyses) are done in demonstration and reference sites.

Summary of research activities to be implemented in different demonstration and reference sites is given in Table 1, but summary of the practical implementation activities of the sites in Table 2.

Table 1: Research activities to be implemented in demonstration and reference sites of LIFE OrgBalt project

Brief description and identification of demonstration (C3) and reference (C1) sites	P01	P02	P03	P04	P05	P06	M01	M02	M03	M04	M05	M06	M07	Y01	Y02	Y03	C01	C02	C03
LVC101 Cropland with grain production (Lazdini)	x	x				x		x	x	x	x	x	x				x	x	x
LVC102 Grassland on drained organic (semi-hidromorphic soil) (Rucava, 024-3-70	x	x				x		x	x	x	x	x	x		x		x	x	x
LVC103 Grassland on drained organic soil (Lazdini)	x	x				x		x	x	x	x	x	x		x		x	x	x
LVC104 Middle-aged spruce stand on drained organic soil (409-474-21)	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	
LVC105 Spruce stand on organic soil where wood ash has been applied at least 5 years ago (301-209-13)	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	
LVC106 Control area in spruce stand on organic soil for characterization of wood ash application (301-209-13P)	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	
LVC107 Pine stand on drained organic soil (609-175-5)	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	
LVC108 Birch stand on drained organic soil (Mežole, 031-99-9)	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	
LVC109 Black alder stand on naturally wet organic soil (505-84-3)	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	
LVC110 Pine stand on naturally wet organic soil (508-88-11)	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	
LVC111 Birch stand on naturally wet organic soil (Mežole, 012-186-1)	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	
LVC112 Regeneration felling in spruce stand on drained organic soil (Smiltene, 031-51-11)	x	x	x	x	x	x	x	x	x		x	x	x				x	x	
LVC113 Spruce stand on drained organic soil, control area for wood ash application (Mežole, 012-203-1)	x	x	x	x	x	x	x	x	x		x	x	x		x		x	x	
LVC114 Pristine bog (*zemais purvs*) (213-327-1)	x	x	x			x		x	x	x	x	x	x		x	x	x	x	x

LVC115 Birch stand on drained organic soil in ex agricultural land (503-432-8)	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	
LVC116 Regeneration felling in pine stand on drained organic soil (Mežole, 012-193-27)	x	x	x	x	x	x	x	x	x		x	x	x				x	x	
LVC303 Paludiculture – afforestation of grassland with black alder and birch (Mežole, 031-1-1)	x	x				x		x	x	x	x	x	x				x	x	
LVC302 Conventional afforestation considering shorter rotation (Rucava, 024-4-1 un 024-3-7)	x	x				x		x	x	x	x	x	x		x		x	x	x
LVC306 Agroforestry – fast growing trees and grass (Andrupēni)	x	x				x		x	x	x	x	x	x		x		x	x	x
LVC308 Continuous forest cover as a forest regeneration method in spruce stand (Mežole, 031-21-21)	x	x	x	x	x	x		x	x		x	x	x				x	x	
LVC313 Strip harvesting in pine stand (Mežole, 012-193-27)	x	x	x	x	x	x		x	x		x	x	x				x	x	
LVC309 Semi-natural regeneration of regeneration felling site with grey alder without reconstruction of drainage systems (Mežole, 012-218-4)	x	x	x	x	x	x		x	x		x	x	x				x	x	
LVC307 Application of wood ash after commercial thinning in spruce stand (Mežole, 012-203-1)	x	x	x	x	x	x	x	x	x		x	x	x		x		x	x	x
LVC301 Conversion of cropland used for cereal production into grassland considering periodic ploughing (Andrupēni un Vecauce)	x	x				x		x	x	x	x	x	x				x	x	x
LVC305 Controlled drainage of grassland considering even groundwater level during the whole vegetation period (Vecauce)	x	x				x		x	x	x	x	x	x		x		x	x	x
LVC304 (a,b) Introduction of legumes in conventional farm crop rotation (Lazdiņi, Slampe)	x	x				x		x	x	x	x	x	x				x	x	x
LVC310 Fast growing species in riparian buffer zones (Andrupēni)	x	x				x		x	x	x	x	x	x		x		x	x	x
LVC311 Riparian buffer zone in forest land planted with black alder (Smiltene, 012-218-8)	x	x	x	x	x	x		x	x		x	x	x				x	x	
LVC312 Forest regeneration (coniferous trees) without reconstruction of drainage systems (Mežole, 031-108-4)	x	x	x	x	x	x		x	x		x	x	x				x	x	

Research activities:

P01 - soil sampling and analysis
P02 - carbon stock in herbaceous vegetation
P03 - carbon stock in shrubs
P04 - carbon stock in tree biomass
P05 - carbon stock in fine roots
P06 - soil infrared spectroscopy tests
M01 - periodic litter sampling and analysis
M02 - heterotrophic respiration, small chambers
M03 - measurements of N_2O, CH_4 and CO_2 emissions
M04 - transparent chambers - photosynthesis
M05 - water temperature, pH, conductivity, oxygen content
M06 - periodic soil moisture measurement
M07 - periodic water sampling and analyses
Y01 - litter decomposition trials
Y02 - root ingrowth trials
C01 - continuous soil temperature measurements
C02 - continuous water level measurements
C03 - continuous PAR measurements

Table 2: Summary of demonstration and reference sites establishment activities

Brief description and identification of demonstration (C3) and reference (C1) sites	Soil preparation (even)	Fast growing trees planting	Sowing of cereals, legumes or grass	Fertilizing and plant protection	Crop harvesting, estimation of harvested volume	Grass harvesting and estimation of harvested volume	Forest thinning	Regeneration felling with selective felling method	Regeneration felling with strip harvest method	Regeneration felling with clear felling method	Clearance and maintaining of drainage systems	Footbridge installation to access the objects	Furrows network establishment	Soil preparation with mounding method (medium mounds)	Soil preparation with mounding method (large forest mounds)	Planting (forest species depending on site type and planting method)	Agro technical cleaning and plant protection
LVC101 Cropland with grain production (Lazdini)																	
LVC102 Grassland on drained organic (semi - hidromorphic soil) (Rucava, 024-3-70						x											
LVC103 Grassland on drained organic soil (Lazdini)																	
LVC104 Middle-aged spruce stand on drained organic soil (409-474-21)																	
LVC105 Spruce stand on organic soil where wood ash has been applied at least 5 years ago (301-209-13)																	
LVC106 Control area in spruce stand on organic soil for characterization of wood ash application (301-209-13P)																	

LVC107 Pine stand on drained organic soil (609-175-5)																	
LVC108 Birch stand on drained organic soil (Mežole, 031-99-9)											x						
LVC109 Black alder stand on naturally wet organic soil (505-84-3)																	
LVC110 Pine stand on naturally wet organic soil (508-88-11)																	
LVC111 Birch stand on naturally wet organic soil (Mežole, 012-186-1)																	
LVC112 Regeneration felling in spruce stand on drained organic soil (Smiltene, 031-51-11)										x	x			x		x	x
LVC113 Spruce stand on drained organic soil, control area for wood ash application (Mežole, 012-203-1)							x										
LVC114 Pristine bog (zemais purvs) (213-327-1)																	
LVC115 Birch stand on drained organic soil in ex agricultural land (503-432-8)																	
LVC116 Regeneration felling in pine stand on drained organic soil (Mežole, 012-193-27)										x	x			x		x	x
LVC303 Paludiculture – afforestation of grassland with black alder and birch (Mežole, 031-1-1)											x		x		x	x	x
LVC302 Conventional afforestation considering shorter rotation (Rucava, 024-4-1 un 024-3-7)											x	x		x		x	x
LVC306 Agroforestry – fast growing trees and grass (Andrupēni)	x	x	x	x		x					x						x
LVC308 Continuous forest cover as a forest regeneration method in spruce stand (Mežole, 031-21-21)								x			x						
LVC313 Strip harvesting in pine stand (Mežole, 012-193-27)									x		x			x		x	x
LVC309 Semi-natural regeneration of regeneration felling site with grey alder without reconstruction of drainage systems (Mežole, 012-218-4)										x	x		x		x	x	x

LVC307 Application of wood ash after commercial thinning in spruce stand (Mežole, 012-203-1)				x			x				x						
LVC301 Conversion of cropland used for cereal production into grassland considering periodic ploughing (Andrupēni un Vecauce)	x		x			x					x						
LVC305 Controlled drainage of grassland considering even groundwater level during the whole vegetation period (Vecauce)						x					x						
LVC304(a,b) Introduction of legumes in conventional farm crop rotation (Lazdiņi, Slampe)	x		x	x	x						x						
LVC310 Fast growing species in riparian buffer zones (Andrupēni)	x	x	x			x					x						x
LVC311 Riparian buffer zone in forest land planted with black alder (Smiltene, 012-218-8)										x			x		x	x	x
LVC312 Forest regeneration (coniferous trees) without reconstruction of drainage systems (Mežole, 031-108-4)										x			x		x	x	x

ABBREVIATIONS

CCM – climate change mitigation

CH_4 – methane

CO_2 – carbon dioxide

GHG – greenhouse gas

LLU – Latvia University of Life Sciences and Technologies

LSFRI "Silava" – Latvian State Forest Research Institute "Silava"

N_2O – nitrous oxide

TABLE OF CONTENTS

Figures

Tables

1. IMPLEMENTATION OF CLIMATE CHANGE MITIGATION MEASURES IN DEMONSTRATION SITES IN FOREST LAND

CCM measures selected for testing to be implemented in forest land can be divided into three groups: (1) measures related to afforestation and forest restoration, (2) measures that target increasing of tree cover through agroforestry and (3) measures that aim at increase in forest carbon stocks (in soil and biomass) through the modification of forest management practices. In the following chapters the selected measures and activities needed and done for their implementation are described.

1.1 Conventional afforestation considering shorter rotation (Site LVC302)

Area requirements: nutrient – rich organic soil (low bog peat soil according to Latvian classification), peat layer thickness at least 30 cm, groundwater level at least 30 cm during the growing season.

Research task: to demonstrate the reduction of GHG emissions from area previously used as pasture or perennial grassland for fodder production by afforestation this area with spruce.

Research activities: according to Table 1 GHG measuring plots are to be established after soil preparation activities are done.

Interrelated demonstration and reference sites:

- Demonstration sites – none;
- Reference sites – site LVC102, grassland in semi-hydromorphic soil with lowered groundwater level (Fig. 18);

Reference sites that characterize GHG balance before and after implementation of the CCM measure:

- Balance before implementation of CCM measure – LVC102 and LVC103;
- Balance after implementation of CCM measure - LVC104, LVC106 and LVC105 (for evaluation of the effect of wood ash application on GHG fluxes and carbon sequestration)

Site characteristics:

- existing land use - game animal feeding glade, planned land use – forest stand. Forest compartments schemes are given in Figures 2 and 3, area to be afforested is marked with yellow;
- because of unmaintained drainage system groundwater level is decreased. After study site is established normal functioning of the drainage system should be ensured;
- total area of the compartment 024-4-1 is 4,21 ha and of the compartment 024-3-7 7,76 ha including already afforested area. Area to be afforested within the project activities in the compartment 024-4-1 is 1,5 ha, but in the compartment 024-3-7 4,5 ha;
- planned forest type Kp (Latvian classification – platlapju kūdrenis), the dominant tree species – spruce, forest stand formula 10E+B;
- height and diameter of the average tree – none;
- basal area, growing stock and site index of the stand – none.

Figure 1: Dich that crosses compartment 24-4-1, site LVC302

Implementation activities:

- cleaning of drainage diches and Kalnišķu water course to ensure water runoff from the dich (without maintenance dich is full of water during vegetation season (Figure 1));
- establishment of footbridge in at least 70 cm width across the drainage dich in southeast part of the compartment 024-4-1 (along the inflow into Kalnišķu water course);
- soil preparation (mounding) in the area to be afforested in spring 2021. At least 1600 planting plots ha^{-1} should be established;
- planting of spruce (seedlings with qualified root system or container plants) in spring 2021 ($1600/ha^{-1}$) by using plant protection products if needed. In case if machine methods are applied soil preparation and planting can be merged;
- help-planting in the spring 2022 if needed;
- agro technical (grass) cleaning during the first 3-5 years after planting by choosing the cleaning frequency by need;
- maintenance of drainage system;
- additional plant protection activities if needed.

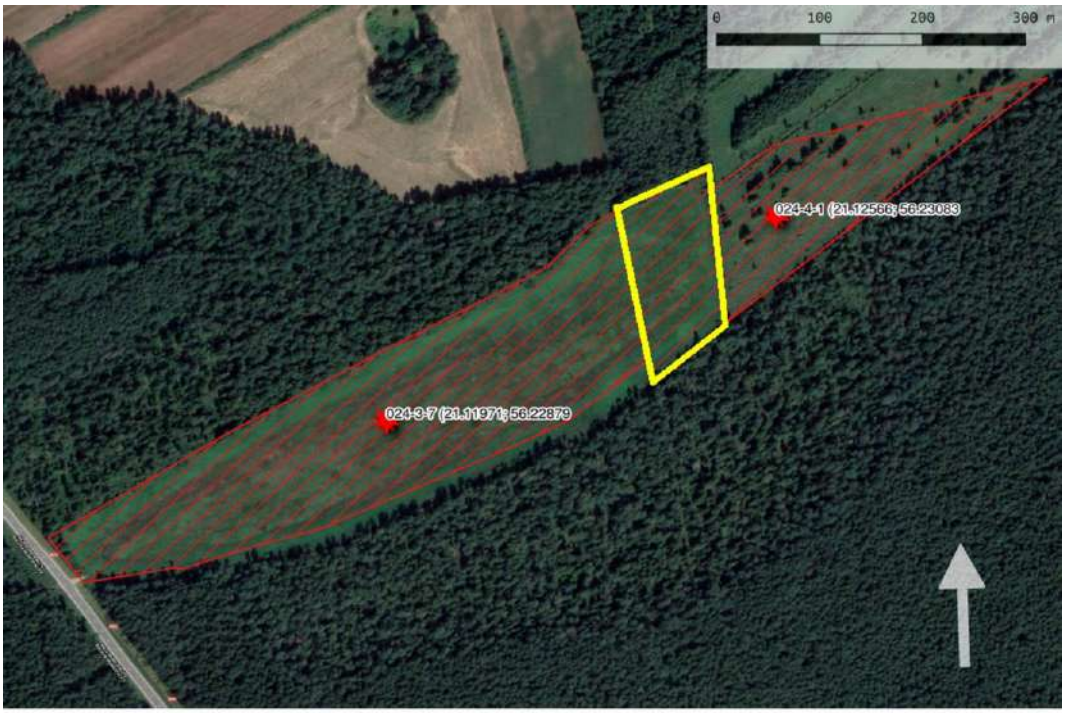

Figure 2: Demonstration of conventional afforestation (compartment 024-4-1,

site LVC302)

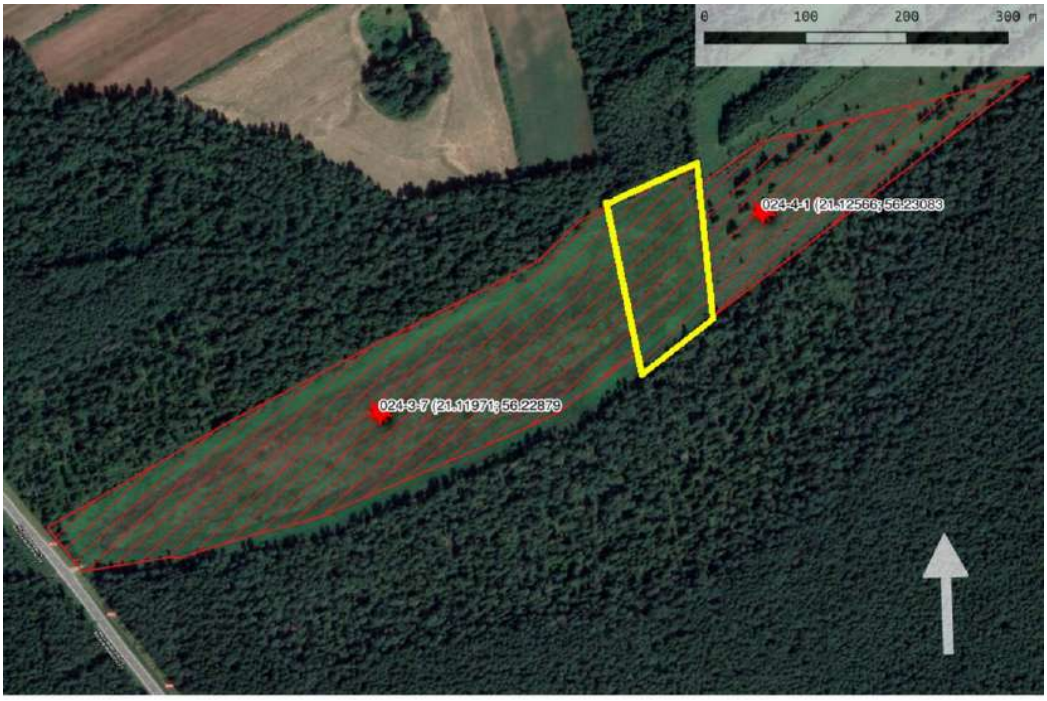

Figure 3: Demonstration of conventional afforestation (compartment 024-3-7, site LVC302)

Forest Research Station implements managing activities, LSFRI "Silava" establishes gas exchange measurements plots (in accordance with scheme in Figure 17) and does data gathering activities within the **period of 24 months after gas measurement plots are established**.

Site management requirements:

- during the performance of planting and agro technical cleaning activities all equipment installed in the site must be maintained (groundwater level measuring wells, photosynthetically active radiation measuring sensors, gas exchange measuring rings, footbridges, etc.). In case of damages LSFRI "Silava" contact person should be informed;
- Forest Research Station informs LSFRI "Silava" about all done and planned activities in the site
- There are no managing restrictions planned in study site. After GHG measurement activities are completed site should be managed in accordance to the best management practice for spruce plantation forest on organic soil.

1.2 Paludiculture – afforestation of grassland with black alder and birch (Site LVC303)

Area requirements: nutrient – rich organic soil (low bog peat soil according to Latvian classification), peat layer thickness at least 30 cm, groundwater level at least 30 cm during the growing season.

Research task: to demonstrate the reduction of GHG emissions by establishing forest paludiculture (dominant species - black alder and birch) in grassland with nutrient –rich organic soil

and increased groundwater level.

Research activities: according to Table 1 GHG measuring plots are to be established after soil preparation activities are done.

Interrelated demonstration and reference sites:

- Demonstration sites – none;
- Reference sites – none.

Reference sites that characterize GHG balance before and after implementation of the CCM measure:

- GHG balance before implementation of CCM measure – LVC102 and LVC103;
- GHG balance after implementation of CCM measure - LVC109 and LVC111.

Site characteristics:

- existing land use - game animal feeding glade, planned land use – forest stand. Forest compartment scheme is given in Figure 4, area to be afforested is marked with yellow;
- existing drainage diches that inflow into collecting diche (crossing the road P27) are worn-out and out of functioning thus during soil preparation dich maintenance is needed to avoid overflow of the area;
- total area of the compartment 031-1-1 is 1,8 ha, in the framework of the research the whole compartment is to be afforested;
- planned forest type Db (Latvian classification – dumbrājs), the dominant tree species – black alder, forest stand formula 6Ma4B;
- height and diameter of the average tree – none;
- basal area, growing stock and site index of the stand – none.

Implementation activities:

- cleaning of existing overgrowth to prepare the area for afforestation;
- cleaning of drainage diches by preparing up to 50 cm deep furrows to ensure (if needed) water runoff from the bordering areas;
- preparation of up to 50 cm deep furrows also in the site area to ensure runoff of excess surface water. Furrows are located by respecting the local relief of the site;
- soil preparation (mounding – 1x1 m mounds) in the area to be afforested in spring 2021. At least 1200 planting plots ha^{-1};
- planting of black alder (60%) and birch (40%) seedlings with qualified root system in spring 2021 (1200/ha^{-1}) by using plant protection products if needed. Birch should be planted in a row (on elevation) along the road P27;
- help-planting in the spring 2022 if needed;
- agro - technical (grass) cleaning during the first 3-5 years after planting by choosing the cleaning frequency by need;
- maintenance of drainage system;
- additional plant protection activities if needed.

Figure 4: Demonstration of forest paludiculture (compartment 031-1-1, site LVC302)

Forest Research Station implements managing activities, LSFRI "Silava" establishes gas exchange measurements plots (in accordance with scheme in Figure 18) and does data gathering activities within the **period of 24 months after gas measurement plots are established**.

Site management requirements:

- during the performance of planting and agro - technical cleaning activities all equipment installed in the site must be maintained (groundwater level measuring wells, photosynthetically active radiation measuring sensors, gas exchange measuring rings, footbridges, etc.). In case of damages LSFRI "Silava" contact person should be informed;
- Forest Research Station informs LSFRI "Silava" about all done and planned activities in the site;
- there are no managing restrictions planned in study site. After completion of GHG measurement activities site should be managed in accordance with the best management practice for mixed deciduous tree stands in wet circumstances.

1.3 Continuous forest cover as a forest regeneration method in spruce stand (Site LVC308)

Area requirements: nutrient – rich organic soil (low bog peat soil according to Latvian classification), peat layer thickness at least 30 cm, groundwater level at least 30 cm during the growing season. Dominant tree species – spruce, stand age or basal area of dominant tree species has reached thresholds set for regeneration felling.

Research task: to demonstrate GHG emissions reduction in spruce stand by replacing clear

felling with selective felling. Projected reduction of GHG emissions is related to the increase of groundwater level in an alternative – clear felling scenario. Increase of groundwater level is associated with significant increase of CH_4. In the case of selective felling increase of groundwater levels should be smaller thus also increase of GHG emissions is smaller.

Research activities: according to Table 1 GHG measuring plots are established in autumn 2020.

Interrelated demonstration and reference sites:

- Demonstration sites – none;
- Reference sites – none.

Reference sites that characterize GHG balance before and after implementation of the CCM measure:

- GHG balance before implementation of CCM measure – LVC308 and LVC104; LVC106;
- GHG balance after implementation of CCM measure – LVC308 and demonstration sites in Finland.

Site characteristics:

- existing land use - forest stand. Forest compartment scheme is given in Figure 5, area to be cut in selective felling is marked with yellow;
- total area of the forest compartment is 2,97 ha, selective felling to be performed in the whole forest compartment;
- forest type Kp (Latvian classification – platlapju kūdrenis), the dominant tree species – spruce, forest stand formula according to State Forest Register 8E2B138;
- in accordance to State Forest Register data – average tree height 26m, diameter – 30cm, forest stand basal area – 29 m ha^{-1}, growing stock – 341 m^3 ha^{-1}, site index - III;

Implementation activities:

- cleaning of drainage diches along the demonstration site during the winter 2020.-2021 to ensure (if needed) optimal water runoff from the forest stand;
- marking of technological corridors (with 20 m distance) for selective felling during winter season 2020.-2021 to ensure preconditions for establishing of GHG exchange equipment;
- selective felling during winter period 2021.-2022. Felling residues should be placed into technological corridors;
- maintenance of drainage system in good technical condition.

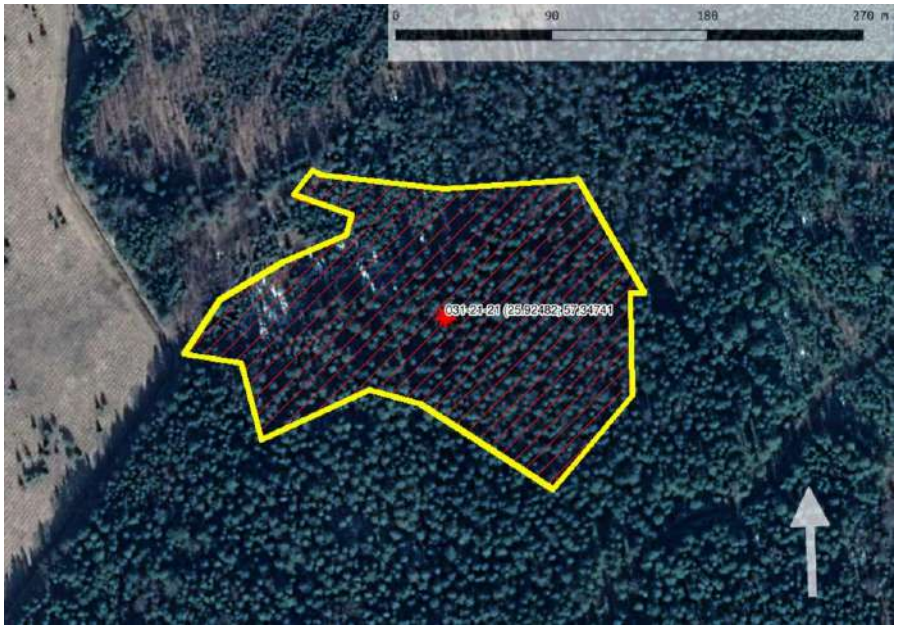

Figure 5: Demonstration of selective felling in spruce stand (compartment 031-21-21, site LVC308)

Forest Research Station implements managing activities, LSFRI "Silava" establishes gas exchange measurements plots (in accordance with scheme in Figure 17) and does data gathering activities within the **period of 24 months after gas measurement plots are established**.

Site management requirements:

- during the performance of forest management activities all equipment installed in the site must be maintained (groundwater level measuring wells, photosynthetically active radiation measuring sensors, gas exchange measuring rings, footbridges, etc.). In case of damages LSFRI "Silava" contact person should be informed;
- Forest Research Station informs LSFRI "Silava" about all done and planned activities in the site;
- there are no managing restrictions planned in the study site. After GHG measurement activities are completed, site should be managed in accordance to the best management practice for coniferous tree stands in wet circumstances.

1.4 Strip harvesting in pine stand (Site LVC313)

Area requirements: nutrient – rich organic soil (low bog peat soil according to Latvian classification), peat layer thickness at least 30 cm, groundwater level at least 30 cm during the growing season. Dominant tree species – pine, stand age or basal area of dominant tree species has reached thresholds set for regeneration felling.

Research task: to demonstrate GHG emissions reduction in pine stand by replacing clear felling with strip harvesting. Projected reduction of GHG emissions is related to the increase of groundwater level in an alternative – clear felling scenario. Increase of groundwater level is associated with significant increase of CH_4. In the case of strip harvesting increase of groundwater levels should be smaller thus also increase of GHG emissions is smaller.

Research activities: according to Table 1 GHG measuring plots are established in autumn 2020.

Interrelated demonstration and reference sites:

- Demonstration sites – none;
- Reference sites – LVC116 (clear felling in pine stand).

Reference sites that characterize GHG balance before and after implementation of the CCM measure:

- GHG balance before implementation of CCM measure – LVC116 and LVC107;
- GHG balance after implementation of CCM measure – LVC313 and demonstration sites in Finland.

Site characteristics:

- existing land use - forest stand. Forest compartment scheme is given in Figure 6, strip harvesting area is marked with yellow;
- total area of the forest compartment is 2,1 ha, strip felling to be performed in 1,1 ha;
- forest type Ks (Latvian classification – šaurlapju kūdrenis), the dominant tree species – pine, forest stand formula according to State Forest Register 10P138;
- in accordance with State Forest Register data – average tree height 22m, diameter – 33 cm, forest stand basal area – 26 m ha^{-1}, growing stock – 350 m^3 ha^{-1}, site index - IV;

Implementation activities:

- marking of technological corridors (with 20 m distance) for strip felling during winter season 2020.-2021 to ensure preconditions for establishing of GHG exchange equipment;
- strip felling in 1.1 ha during winter period 2021.-2022. Felled strip width 20 m, unfelled strip width 20m. Clear felling in winter season 2021.-2022. In 1,0 ha;
- Soil preparation (mounding method) in spring 2022 (clear felled and strip felled area). At least 1200 planting places ha^{-1}. Dimensions of planting places – 60cmx60cm.
- planting of pine seedlings with qualified root system in spring 2022 by using plant protection products if needed;
- help-planting if needed and agro technical (grass) cleaning during the first 3-5 years after planting by choosing the cleaning frequency by need.

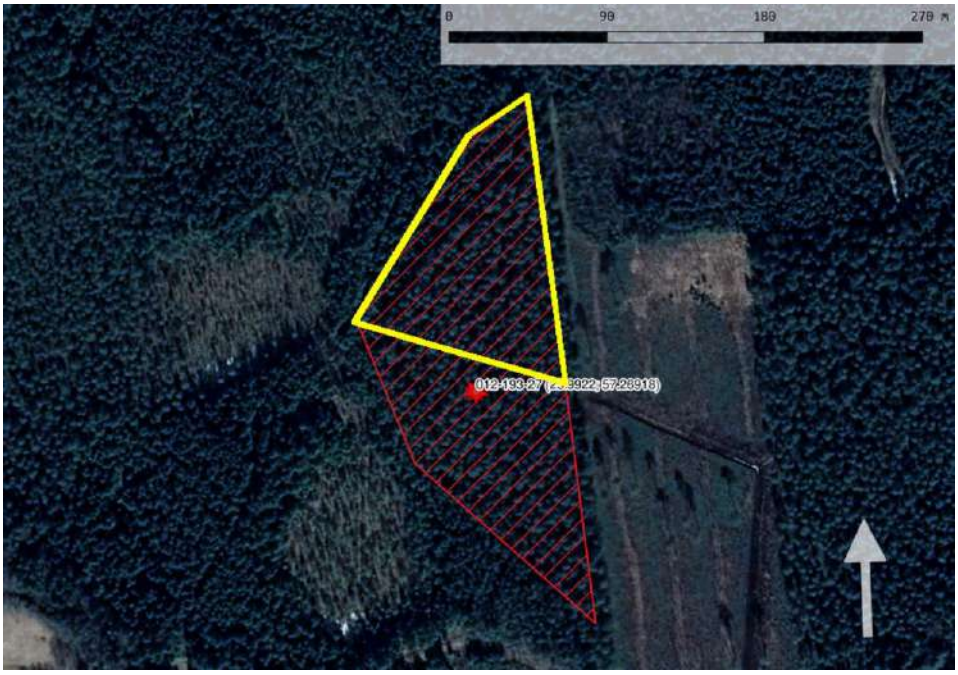

Figure 6: Demonstration of strip harvesting in pine stand (compartment 12-193-27, site LVC313)

Forest Research Station implements managing activities, LSFRI "Silava" establishes gas exchange measurements plots (in accordance with scheme in Figure 17) and does data gathering activities within the **period of 24 months after gas measurement plots are established**.

Site management requirements:

- during the performance of forest management activities all equipment installed in the site must be maintained (groundwater level measuring wells, photosynthetically active radiation measuring sensors, gas exchange measuring rings, footbridges, etc.). In case of damages LSFRI "Silava" contact person should be informed;
- Forest Research Station informs LSFRI "Silava" about all done and planned activities in the site;
- there are no managing restrictions planned in the study site. After GHG measurement activities are completed, site should be managed in accordance to the best management practice for coniferous tree stands in wet circumstances;
- unfelled strips should be felled and planted within the 15-20 year period after strip felling.

1.5 Semi-natural regeneration of regeneration felling site with grey alder without

reconstruction of drainage systems (Site LVC309)

Area requirements: nutrient – rich organic soil (low bog peat soil according to Latvian classification), peat layer thickness at least 30 cm, groundwater level at least 30 cm during the growing season. Dominant tree species – black alder or birch, stand age or basal area of dominant tree species has reached thresholds set for regeneration felling.

Research task: to demonstrate GHG emissions reduction in black alder or birch stand by using genetically selected planting material and improving hydrological regime – furrows to ensure excess water runoff to the relief lows. Projected reduction of GHG emissions is related to groundwater level stabilizing during forest regeneration phase and better growth conditions and increased CO_2 removals in forest biomass and other carbon stocks. Stabilized groundwater levels (by establishing deep furrows for excess water runoff) will decrease CH_4 emissions, but mounds will ensure better growth conditions for forest regeneration during the first decades after planting. Improved planting material ensure considerably better forest increment and stand resistance to environmental conditions during the whole rotation period.

Research activities: according to Table 1 GHG measuring plots are established in autumn 2020.

Interrelated demonstration and reference sites:

- Demonstration sites – none;
- Reference sites – none.

Reference sites that characterize GHG balance before and after implementation of the CCM measure:

- GHG balance before implementation of CCM measure – LVC309;
- GHG balance after implementation of CCM measure – LVC309 and LVC109.

Site characteristics:

- existing and planned land use - forest stand. Forest compartment scheme is given in Figure 7, research area is marked with yellow;
- total area of the forest compartment is 0,74 ha, forest regeneration is planned in the whole area;
- forest type Db (Latvian classification – dumbrājs), the dominant tree species – spruce, forest stand formula according to State Forest Register 9E1B80;
- in accordance to State Forest Register data – average tree height 21m, diameter – 21cm, forest stand basal area – 31 m ha^{-1}, growing stock – 320 m^3 ha^{-1}, site index - II;

Implementation activities:

- mapping of technological corridors during winter season 2020.-2021 to ensure preconditions for establishing of GHG exchange equipment outside of technological roads. Distance between technological roads in clear felling area - 20 m;
- clear felling during winter period 2021.-2022. Felling residues to be put in technological roads;
- soil preparation (mounding method) in spring 2022. At least 1600 planting places ha^{-1}. Dimensions of planting places – 100 cm x 100 cm;
- planting of black alder seedlings with improved root system or at least 50 cm long container plants in spring 2022;
- help-planting if needed and agro technical (grass) cleaning during the first 3-5 years after planting by choosing the cleaning frequency by need.

Figure 7: Demonstration of regeneration by mounding method with black alder and birch after spruce stand felling (compartment 012-218-4, site LVC309)

Forest Research Station implements managing activities, LSFRI "Silava" establishes gas exchange measurements plots (in accordance with scheme in Figure 17) and does data gathering activities within the **period of 24 months after gas measurement plots are established**.

Site management requirements:

- technological maps and forest logging work has to be coordinated with LSFRI "Silava";
- during the performance of forest management activities all equipment installed in the site must be maintained (groundwater level measuring wells, photosynthetically active radiation measuring sensors, gas exchange measuring rings, footbridges, etc.). In case of damages LSFRI "Silava" contact person should be informed;
- Forest Research Station informs LSFRI "Silava" about all done and planned activities in the site;
- there are no managing restrictions planned in the study site. After GHG measurement activities are completed site should be managed in accordance to the best management practice for deciduous tree stands in wet circumstances.

1.6 Application of wood ash after commercial thinning in spruce stand (Site LVC307)

Area requirements: nutrient – rich organic soil (low bog peat soil according to Latvian classification), peat layer thickness at least 30 cm, groundwater level at least 30 cm during the growing season. Dominant tree species – spruce, stand basal area in dimensions to perform thinning by establishing up to 4 m wide technological corridors in every 20 meters (if such are no established before).

Research task: to demonstrate GHG emissions reduction in spruce stands on organic soils and lowered ground water table by implementation of wood ash after thinning thus enhancing stand growing conditions. Projected reduction of GHG emissions is related to groundwater level reduction, related to increase in growing stock increment and increased water amount used for transpiration processes – thus decreasing CH_4 emissions and increasing CO_2 removals in living biomass.

Research activities: according to Table 1 GHG measuring plots are established in autumn 2020.

Interrelated demonstration and reference sites:

- Demonstration sites – none;
- Reference sites – LVC113, control plots where wood ash is not spread.

Reference sites that characterize GHG balance before and after implementation of the CCM measure:

- GHG balance before implementation of CCM measure – LVC104 and LVC113;
- GHG balance after implementation of CCM measure – LVC307, LVC105 and LVC106 (difference between fertilized and unfertilized area).

Site characteristics:

- existing and planned land use - forest stand. Forest compartment scheme is given in Figure 8, research area is marked with yellow (ash is to be spread in 40m wide strips that alternates with 40 m wide strips without ash spread. In total 3 strips where ash is spread and 2 control strips);
- total area of the forest compartment is 2,48 ha, area where ash is spread – 1,5 ha;
- forest type Kp (Latvian classification – platlapju kūdrenis), the dominant tree species – spruce, forest stand formula according to State Forest Register 7E45 3B42;
- in accordance to State Forest Register data – average tree height 16 m, diameter – 15 cm, forest stand basal area – 30 m ha^{-1}, growing stock – 240 m^3 ha^{-1}, site index - II;

Implementation activities:

- mapping of technological corridors during winter season 2020.-2021 to ensure preconditions for establishing of GHG exchange equipment outside of the technological roads. Distance between technological roads - 20 m (if there are no already established technological roads);
- thinning during winter period 2022.-2021. Felling residues to be put in technological roads. Stand basal area after thinning – in accordance to allowed minimal basal area after thinning;
- wood ash spreading in May –June 2021, the dose - 5 t/ha. Wood ash material – retained ash that is already carbonized (hardened). Wood ash spreading is to be coordinated with LSFRI "Silava" and spreading has to be done by LSFRI "Silava" assistance ensuring possibility to take ash samples.

Figure 8: Wood ash spreading demonstration (compartment 012-203-1, site LVC307)

Forest Research Station implements managing activities, LSFRI "Silava" establishes gas exchange measurements plots (in accordance with scheme in Figure 17 (in total 2 plots in this site)) and does data gathering activities within the **period of 24 months after gas measurement plots are established**.

Site management requirements:

- technological maps and forest logging work has to be coordinated with LSFRI "Silava";
- during the performance of forest management activities all equipment installed in the site must be maintained (groundwater level measuring wells, photosynthetically active radiation measuring sensors, gas exchange measuring rings, footbridges, etc.). In case of damages LSFRI "Silava" contact person should be informed;
- Forest Research Station informs LSFRI "Silava" about all done and planned activities in the site;
- there are no managing restrictions planned in the study site. After GHG measurement activities are completed, site should be managed in accordance to the best management practice for spruce stands in wet circumstances.

1.7 Forest regeneration (coniferous trees) without reconstruction of drainage systems (Site LVC312)

Area requirements: nutrient – rich organic soil (low bog peat soil according to Latvian classification), peat layer thickness at least 30 cm, groundwater level at least 30 cm during the growing season. Dominant tree species – birch, aspen or black alder. Stand age or basal area of dominant tree species has reached thresholds set for regeneration felling.

Research task: to demonstrate GHG emissions reduction in coniferous stands on organic soils and increased ground water table by application of forest regeneration with high quality coniferous planting material and by using mounding method (and deep furrows to drain excess surface water during springtime and after heavy rains) for soil preparation. Projected reduction of GHG emissions is related to groundwater level reduction, related to establishment of deep furrows - as a result decreasing CH_4

emissions and increasing CO_2 removals in living biomass because of enhanced forest growing conditions.

Research activities: according to Table 1 GHG measuring plots are established in autumn 2020.

Interrelated demonstration and reference sites:

- Demonstration sites – none;
- Reference sites – none.

Reference sites that characterize GHG balance before and after implementation of the CCM measure:

- GHG balance before implementation of CCM measure – LVC312, LVC309 and LVC109;
- GHG balance after implementation of CCM measure – LVC110 (GHG emissions from coniferous tree stands), LVC109, LVC111 (GHG emissions from deciduous tree stands).

Site characteristics:

- existing and planned land use - forest stand. Forest compartment scheme is given in Figure 9, research area is marked with yellow;
- total area of the forest compartment is 4,05 ha, forest regeneration to be done in the whole site area;
- forest type Db (Latvian classification – dumbrājs), the dominant tree species – birch, forest stand formula according to State Forest Register 6B2E2M93;
- in accordance to State Forest Register data – average tree height 20 m, diameter – 28 cm, forest stand basal area – 21 m ha^{-1}, growing stock – 212 m^3 ha^{-1}, site index – III.

Implementation activities:

- mapping of technological corridors during winter season 2020.-2021 to ensure preconditions for establishing of GHG exchange equipment outside of the technological roads. Distance between the technological roads - 20 m;
- clear cutting during winter period 2022.-2021. Felling residues to be put in technological roads;
- deep furrows establishment during spring 2022 to drain excess surface water and soil preparation with mounding method. Mounds – with large dimensions (100x100 m) and must be pressed with excavator bucket. At least 1200 planting places/ha.
- Planting of spruce seedlings with qualified root system or container plants in the whole site area during spring 2022, except the wet part of the site in the West direction where black alder seedlings with qualified root system or container plants should be planted. Area appropriate for deciduous tree planting is marked with red in Figure 9.
- help-planting and agrotechnical (grass) cleaning during the first 3-5 years after planting – with frequency by need.

Figure 9: Forest regeneration by using soil preparation method - mounding (compartment 031-108-4 , site LVC312)

Forest Research Station implements managing activities, LSFRI "Silava" establishes gas exchange measurements plots (in accordance with scheme in Figure 18) and does data gathering activities within the **period of 24 months after gas measurement plots are established**. In the period between forest logging and soil preparation activities there can be interruption in GHG measurements.

Site management requirements:

- technological maps and forest logging work has to be coordinated with LSFRI "Silava";
- during the performance of forest management activities all equipment installed in the site must be maintained (groundwater level measuring wells, photosynthetically active radiation measuring sensors, gas exchange measuring rings, footbridges, etc.). In case of damages LSFRI "Silava" contact person should be informed;
- Forest Research Station informs LSFRI "Silava" about all done and planned activities in the site;
- there are no managing restrictions planned in the study site. After GHG measurement activities are completed, site should be managed in accordance to the best management practice for spruce stands in wet circumstances.

1.8 Riparian buffer zone in forest land planted with black alder (Site LVC311)

Area requirements: nutrient – rich organic soil (low bog peat soil according to Latvian classification), peat layer thickness at least 30 cm, groundwater level at least 30 cm during the growing season. Dominant tree species – birch, aspen or black alder. Stand age or basal area of dominant tree species has reached thresholds set for regeneration felling.

Research task: to demonstrate GHG emissions reduction in deciduous tree stands on organic soils with increased ground water table by enhancing tree growing conditions, using high quality planting material and preparing soil with mounding method including establishing of deep furrows for excess surface water drainage in spring time and after rainfalls. Projected reduction of GHG emissions is related to groundwater level reduction, related to establishment of deep furrows - as a result decreasing CH_4 emissions and increasing CO_2 removals in living biomass because of significantly

enhanced tree growing conditions in riparian zone.

Research activities: according to Table 1 GHG measuring plots are established in autumn 2020.

Interrelated demonstration and reference sites:

- Demonstration sites – none;
- Reference sites – none.

Reference sites that characterize GHG balance before and after implementation of the CCM measure:

- GHG balance before implementation of CCM measure – LVC311, LVC303 and LVC109;
- GHG balance after implementation of CCM measure – LVC119 and LVC111.

Site characteristics:

- existing and planned land use - forest stand. Forest compartment scheme is given in Figure 10, research area is marked with yellow;
- total area of the forest compartment is 0,88 ha, forest regeneration to be done in the whole site area in 20m wide stripe along the river by planting black alder and by planting spruce in the rest of the area;
- forest type Db (Latvian classification – dumbrājs), the dominant tree species – spruce, forest stand formula according to State Forest Register 6E872B1A1M80;
- in accordance to State Forest Register data – average tree height 24 m, diameter – 26 cm, forest stand basal area – 40 m ha^{-1}, growing stock – 475 m^3 ha^{-1}, site index – II.

Implementation activities:

- mapping of technological corridors during winter season 2020.-2021 to ensure preconditions for establishing of GHG exchange equipment outside of the technological roads. Distance between the technological roads - 20 m;
- clear cutting during winter period 2021.-2022 in the whole site area or in 20 m wide stripe along the protecting zone of Melnupīte river. Felling residues to be put in technological roads;
- deep furrows establishment during spring 2022 to drain excess surface water and soil preparation with mounding method. Mounds – with large dimensions (100x100 m) and must be pressed with excavator bucket. At least 1200 planting places/ha.
- Planting of black alder seedlings with qualified root system or container plants in the 20 m wide stripe along the river during the spring 2022. Spruce seedlings with enhanced root system or container plants to be planted in the rest of the site area;
- help-planting and agro technical (grass) cleaning during the first 3-5 years after planting – with frequency by need.

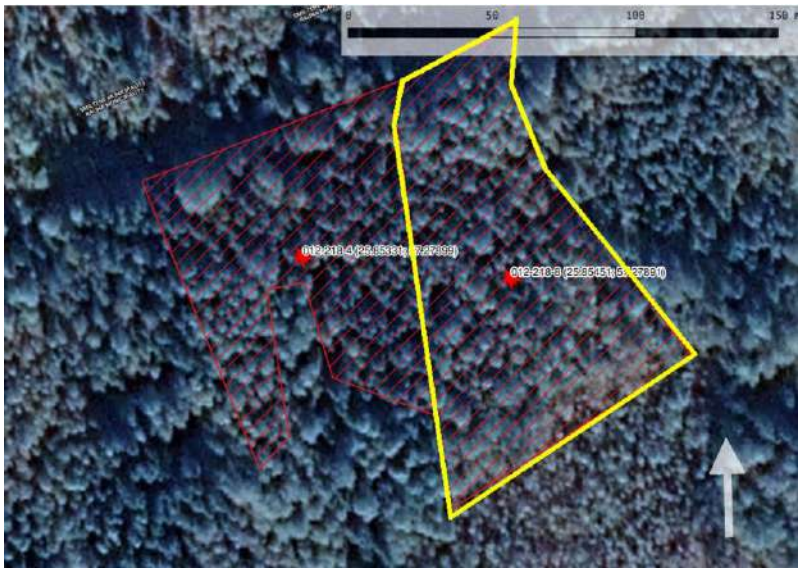

Figure 10: Black alder stand in riparian zone (compartment 012-218-8, site LVC311)

Forest Research Station implements managing activities, LSFRI "Silava" establishes gas exchange measurements plots (in accordance with scheme in Figure 18) and does data gathering activities within the **period of 24 months after gas measurement plots are established**. In the period between forest logging and soil preparation activities there can be interruption in GHG measurements.

Site management requirements:

- technological maps and forest logging work has to be coordinated with LSFRI "Silava";
- during the performance of forest management activities all equipment installed in the site must be maintained (groundwater level measuring wells, photosynthetically active radiation measuring sensors, gas exchange measuring rings, footbridges, etc.). In case of damages LSFRI "Silava" contact person should be informed;
- Forest Research Station informs LSFRI "Silava" about all done and planned activities in the site;
- there are no managing restrictions planned in the study site. After GHG measurement activities are completed, site should be managed in accordance to the best management practice for deciduous tree stands in wet circumstances.

2. IMPLEMENTATION OF CLIMATE CHANGE MITIGATION MEASURES IN DEMONSTRATION SITES IN AGRICULTURE LAND

CCM measures Project will implement in agriculture land are selected based on Projects experts` previous experience and scientific literature. Measures include agroforestry, land use change (from cropland to grassland), riparian buffer zones management, controlled water level and crop change (introduction of legumes) related activities whose CCM potential is based either on decrease of soil emissions, reduced leaching of nutrients or increase of CO_2 removals in living biomass on other carbon pools.

2.1 Agroforestry – fast growing trees and grass (Site LVC306)

Area requirements: nutrient – rich organic soil (low bog peat soil according to Latvian classification), peat layer thickness at least 30 cm, groundwater level at least 30 cm during

the growing season. Area is managed as cropland.

Research task: to demonstrate GHG emissions reduction through transformation of cropland to tree plantation. Projected reduction of GHG emissions is related to the decrease of N_2O and CO_2 emissions from soil as well as to the increase of CO_2 removals in living biomass and other carbon pools.

Research activities: according to Table 1 GHG measuring plots are established in autumn 2020.

Interrelated demonstration and reference sites:

- Demonstration sites – LVC310 and LVC301 (area where cropland is transformed to grassland and area where tree species buffer zones in riparian area are established);
- Reference sites – none.

Reference sites that characterize GHG balance before and after implementation of the CCM measure:

- GHG balance before implementation of CCM measure – LVC101;
- GHG balance after implementation of CCM measure – LVC115.

Site characteristics:

- existing land use – cropland, planned – tree planting (forest). The scheme of the site is given in Figure 11, research area is marked with yellow. Detailed description of research object is given in Annex 2, Figure 20 and Figure 21.
- total area of the forest compartment is 2,7 ha, tree planting in 1,5 ha, including buffer zone along drainage diches (site LVC310)
- planned forest type Kp (Latvian classification – dumbrājs), the dominant tree species – poplar, forest stand formula 10Pa;
- tree cover is not present, planned site index – I.

Implementation activities:

- poplar hybrid planting and perennial grassland sowing and maintenance 1 year after establishing in 1,5 ha area;
- tree planting in lines in perpendicular to the diches in North-South direction. Distance to the diches from 1st and last plant in the row – 3,5 m, distance from the last line to the edge of the field or dich – 3,5 m. In these lines willows are planted in two rows. Distance between poplar lines – 3,5 m, distance between trees in line – 2 m.
- planting with poplar planting material adapted to the climatic conditions of Latvia and appropriate for organic soils (clones: Vesten, OP42 or equivalents with scientifically approved suitability to grow in organic soils). The length of cuttings – 150-200 cm, diameter of the thickest part – 2 cm, cuttings to be planted in the soil in the depth that corresponds to 1/3 of the cutting length;
- agro technical (grass) cleaning once per vegetation season and help-planting (if needed to replace cuttings that are dried or damaged by animals) at the beginning of 2nd vegetation season to ensure at least 90% success of the planting at the beginning of the 2nd vegetation season (end of June 2022)
- sowing of Festuca rubra or equivalent before poplar planting (at least 20 kg seeds ha^{-1}). Soil improvement in accordance with the best practice for integrated farms – mineral fertilizer dose 180-200 kg ha NPK 16-16-16 (in the 1st year N:P2O5:K2) 66:43:85)

Figure 11: Fast growing trees planting in cropland (Andrupēni, site LVC306)

The successful bidder of the procurement organized by the LLU ensures the establishment of the site and covers the expenses related to the maintenance of the site. LSFRI "Silava" installs gas exchange measurement plots (according to the scheme given in Figure 17) and ensures data acquisition within 24 months after the installation of gas exchange measurement plots.

Site management requirements:

- technological map preparation and execution of the tree plantation installation works must be coordinated with the LSFRI Silava contact person;
- during the performance of site management activities all equipment installed in the site must be maintained (groundwater level measuring wells, photosynthetically active radiation measuring sensors, gas exchange measuring rings, footbridges, etc.). In case of damages LSFRI "Silava" contact person should be informed;
- landowner informs LSFRI "Silava" about all done and planned activities in the site;
- there are no managing restrictions envisaged in the study site. After GHG measurement activities are completed, the site should be managed in accordance to the recommendations of good practice, envisaging up to 20 years rotation period for poplar and up to 5 years for willows.

2.2 Conversion of cropland used for cereal production into grassland considering periodic ploughing (Site LVC301)

Area requirements: nutrient – rich organic soil (low bog peat soil according to Latvian classification), peat layer thickness at least 30 cm, groundwater level at least 30 cm deep during the growing season. Area is managed as cropland.

Research task: to demonstrate GHG emissions reduction through transformation of cropland to grassland. Projected reduction of GHG emissions is related to the decrease of N_2O and CO_2 emissions from soil.

Research activities: according to Table 1 GHG measuring plots are established in autumn 2020.

Interrelated demonstration and reference sites:

- Demonstration sites – none;
- Reference sites – none.

Reference sites that characterize GHG balance before and after implementation of the CCM measure:

- GHG balance before implementation of CCM measure – LVC101;
- GHG balance after implementation of CCM measure – LVC102; LVC103.

Site characteristics:

- existing land use – cropland, planned - grassland. The scheme of the site is given in Figure 12, research area is marked with red and labeled.
- total area of the site is 2,5 ha, grassland should be established in the whole area.

Implementation activities:

- grass sowing in the whole site area;
- soil improvement in accordance with the best management practice for integrated farms – by using optimal sowing standard and mineral fertilization dose;
- regular (2-3 times/year) mowing of the grassland for hay or forage production.

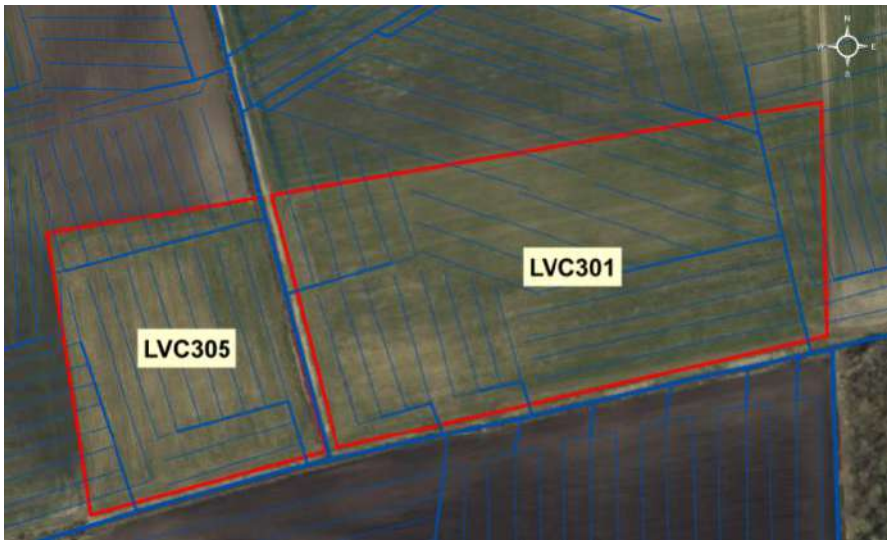

Figure 12: Cropland conversion to grassland (Vecauce, site LVC301)

LLU ensures the establishment of the site and covers the expenses related to the maintenance of the site. LSFRI "Silava" installs gas exchange measurement plots (according to the scheme given in Figure 19) and ensures data acquisition within 24 months after the installation of gas exchange measurement plots.

Site management requirements:

- during the performance of site management activities all equipment installed in the site must be maintained (groundwater level measuring wells, photosynthetically active radiation measuring sensors, gas exchange measuring rings, footbridges, etc.). In case of damages LSFRI "Silava" contact person should be informed;
- land manager informs LSFRI "Silava" about all done and planned activities in the site, e.g. about need to remove GHG and environmental measurements equipment that hinders grass mowing and collecting ;
- there are no managing restrictions envisaged in the study site. Ploughing should be avoided within at least 5 years period.

2.3 Fast growing species in riparian buffer zones (site LVC310)

Area requirements: nutrient – rich organic soil (low bog peat soil according to Latvian classification), peat layer thickness at least 30 cm, groundwater level at least 30 cm during the growing season. Area managed as cropland.

Research task: to demonstrate GHG emissions reduction through transformation of strip areas along drainage diches in cropland to tree plantation areas that avoid nutrient leaching and increase carbon removals in living biomass and other carbon pools. Projected reduction of GHG emissions is related to the decrease of N_2O and CO_2 emissions from soil as well as to the increase of CO_2 removals in living biomass and other carbon pools.

Research activities: according to Table 1 GHG measuring plots are established in autumn 2020, will be removed during spring season 2021 (to not disturb site management) and placed back after management activities are done.

Interrelated demonstration and reference sites:

- Demonstration sites – LVC301 and LVC306 (area where cropland is transformed to tree plantation and area where cropland is transformed to grassland);
- Reference sites – none.

Reference sites that characterize GHG balance before and after implementation of the CCM measure:

- GHG balance before implementation of CCM measure – LVC101;
- GHG balance after implementation of CCM measure – LVC115.

Site characteristics:

- existing land use – cropland, planned land use – tree plantation (forest). Site scheme is given in Figure 13, research area is marked with yellow. In an attachment (annex 2, Figure 20 and Figure 21) detailed characteristics of the site is given.
- total area of the site is 2,7 ha, tree plantation – established in 0,4 ha including protection zone along the drainage diches (sites LVC310 and LVC301).

Implementation activities:

- establishment of poplar and willow plantation and maintenance 1 year after establishing in 0,5 +/- 0,2 ha (band of poplar hybrids and willows - 680 +/- 50 m and 110 +/- 50 m long willow band along poplar plantation perimeter) along drainage diches in accordance with scheme of Annex 2 Figure 20 and Figure 21;
- tree rows in parallel to drainage diches. Poplar plantations have to be established in a distance of 3,5 m from the edges of the drainage diches. Poplars should be planted in 3 rows with the distance of 2 m, plants placed in the form of chess boxes – meaning plant from the row no. 3 in front of the plant from row no. 1. Willows should be planted in 2 rows in the dich side looking from the plantation of hybrid poplar – distance among plants in the row – 0,5 m, distance among rows – 0,7 m. Distance between the center of two row willow plantation to row of poplar hybrids – 2,5 m. Willow plantation should be established along the whole perimeter of the site and in addition two row plantation to the West from the plantation of hybrid poplars – in accordance to the scheme in Annex 2, Figure 20 and Figure 21;
- planting with poplar hybrid planting material adapted to the climatic conditions of Latvia and appropriate for organic soils (clones: Vesten, OP42 or equivalents with scientifically approved suitability to grow in organic soils). Length of the cuttings –

150-200 cm, diameter of the thickest part – at least 2 cm, cuttings to be planted in the soil in the depth that corresponds to 1/3 of the cutting length. Willow hybrid cuttings are suitable for Latvian climatic conditions and peat soils (*Salix* spp. male clones with scientifically proven suitability for cultivation in organic soils), the length of the cuttings – 20-25 cm, the diameter of the thinnest part – at least 0,8 cm, at least 3 dormant buds are present on the cutting, cuttings planted in a way that at least 3-5 long shoots are left above the soil level;

- removing of tree and bushed overgrowth in drainage diches, agro technical (grass) cleaning during the first vegetation season and help-planting (if needed to replace cuttings that are dried or damaged by animals) at the beginning of 2nd vegetation season to ensure at least 90% success of the poplar and willow planting at the beginning of the 2nd vegetation season (end of June 2022).

Figure 13: Riparian buffer zone (Andrupēni, site LVC310)

The successful bidder of the procurement organized by the LLU ensures the establishment of the site and covers the expenses related to the maintenance of the site. LSFRI "Silava" installs gas exchange measurement plots (according to the scheme given in Figure 17) and ensures data acquisition within 24 months after the installation of gas exchange measurement plots.

Site management requirements:

- technological map preparation and execution of the tree plantation installation works must be coordinated with the LSFRI Silava contact person;
- during the performance of site management activities all equipment installed in the site must be maintained (groundwater level measuring wells, photosynthetically active radiation measuring sensors, gas exchange measuring rings, footbridges, etc.). In case of damages LSFRI "Silava" contact person should be informed;
- land manager informs LSFRI "Silava" about all done and planned activities in the site;
- there are no managing restrictions envisaged in the study site. After GHG measurement activities are completed, the site should be managed in accordance to the recommendations of good practice, envisaging up to 20 years rotation period for poplar and up to 5 years for willows.

2.4 Controlled drainage of grassland considering even groundwater level during the whole vegetation period (site LVC305)

Area requirements: nutrient – rich organic soil (low bog peat soil according to Latvian classification), peat layer thickness at least 30 cm, groundwater level at least 30 cm from ground surface during the growing season. The area managed as grassland.

Research task: to demonstrate reduction in GHG emissions from organic soils due to limited fluctuations of groundwater level during and outside the growing season, reduced leaching of nutrients to surface water bodies as drainage water will be stored in the field. It is expected that during the summer season additional water will be available to meet crop demand thus ensuring higher carbon inputs into soil.

Research activities: according to Table 1 GHG measuring plots are established in the autumn of 2020.

Site characteristics:

- existing and planned land use – grassland. The scheme of the site is given in Figure 14, the research area is marked with red and labeled.
- total area of the site is 2,26 ha.

Implementation activities:

- grass at the area of interest has been sowed 1 year prior to establishment of the controlled drainage demonstration site, therefore, no additional implementation activities related to vegetation cover are needed. If density and quality of the grass will decrease over time, repeated sowing of grass might be considered;
- installation of two water level control structures at the outlets of existing subsurface drainage systems. One water level control structure represents conventional (free) drainage conditions, in this case adjustable boards are removed to ensure discharge of excess water from the agricultural field. Another structure represents controlled drainage conditions, in this case adjustable boards are used to raise the groundwater level in the field and increase water retention and storage within the soil profile. Installation of water level control structures consist of digging a trench, leveling and preparation of a foundation, filling with supporting materials, establishment of connection between structure and existing subsurface drainage system, retrofitting existing outlet;
- autonomous sensors for water pressure and temperature measurements, along with a sensor for measurements of atmospheric pressure are used at both water level control structures in order to quantify the amount of water leaving the fields.

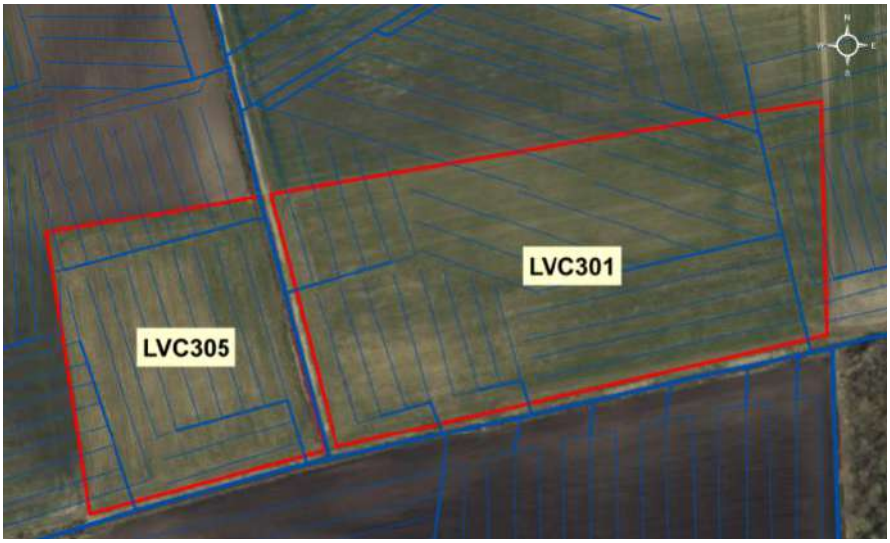

Figure 14: Controlled drainage area (Vecauce, site LVC305)

LLU ensures the establishment of the site and covers the expenses related to the maintenance of the site. LSFRI "Silava" installs gas exchange measurement plots and ensures data acquisition within 24 months after the installation of gas exchange measurement plots.

Site management requirements:

- during the performance of site management activities all equipment installed in the site must be maintained (groundwater level measuring wells, photosynthetically active radiation measuring sensors, gas exchange measuring rings, footbridges, etc.). In case of damages LSFRI "Silava" contact person should be informed;
- land manager informs LSFRI "Silava" about all done and planned activities in the site, e.g. about need to remove GHG and environmental measurements equipment that hinders grass mowing and collecting;
- there are no specific managing restrictions envisaged in the study site.

2.5 Introduction of legumes in conventional farm crop rotation (site LVC304a)

Area requirements: nutrient – rich organic soil (low bog peat soil according to Latvian classification), peat layer thickness at least 30 cm, groundwater level at least 30 cm deep during the growing season. Area is managed as cropland.

Research task: to demonstrate GHG emissions reduction by introduction of legumes (biomass and nitrogen attraction) to crop rotation. Projected reduction of GHG emissions is related to the decrease of N_2O and CO_2 emissions from soil.

Research activities: according to Table 1 GHG measuring plots are established in autumn 2020.

Interrelated demonstration and reference sites:

- Demonstration sites – none;
- Reference sites – LVC103 (perennial grassland on organic soil).

Reference sites that characterize GHG balance before and after implementation of the CCM measure:

- GHG balance before implementation of CCM measure – LVC101;
- GHG balance after implementation of CCM measure – LVC102; LVC103.

Site characteristics:

- existing and planned land use – cropland. The scheme of the site is given in Figure 15, research area is marked with yellow.
- total area of the site is 2,5 ha, grassland should be established in the whole area.

Implementation activities:

- area is managed in accordance with good practice guidelines for integrated farms, that uses legumes in crop rotation;
- legumes should be sawn at least once within the period of 24 months while measurements are performed (species and variety chosen by land manager). Legumes should be sawn in the part of area in 2021 and 2022;
- gas exchange measurement equipment is installed (in accordance to the scheme given in Figure 19) in the part of the area where legumes are grown in 2021. Equipment is placed in parallel to the technological roads to avoid disturbing of the site management. Distances to the diches and other parameters are given in Figure 19 as an example – exact placement is coordinated in the site with the land manager. Another similar measurement plot is established in area where cereals (species and variety chosen by land manager) are grown in 2021;
- Measurements will be continued in 2021 and 2022. In area where in 2021 legumes are grown in 2022 cereals (species and variety chosen by land manager) should be sown, but in area where in 2021 cereals are grown – legumes (species and variety chosen by land manager) should be sown.

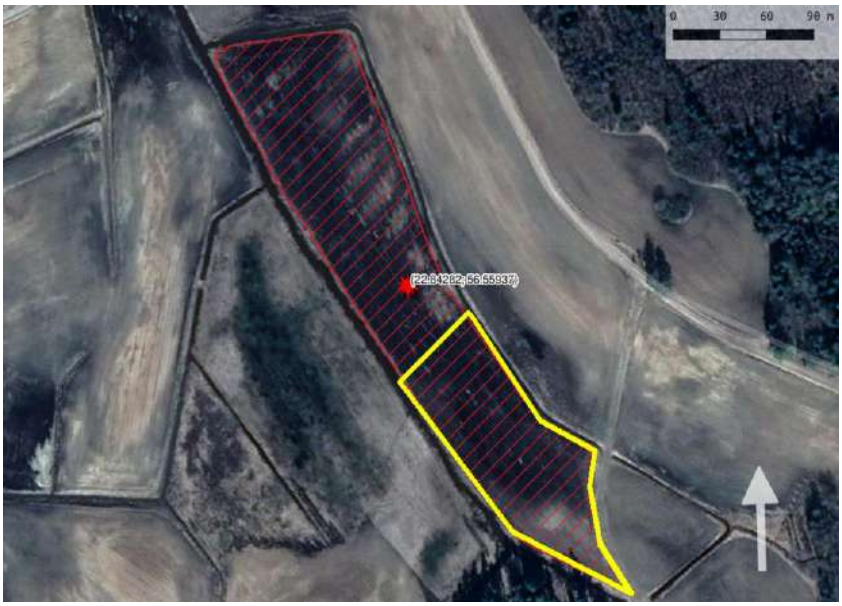

Figure 15: Legumes in crop rotation (Lazdiņi, site LVC304a)

The successful bidder of the procurement organized by the LLU ensures the establishment of the site and covers the expenses related to the maintenance of the site. LSFRI "Silava" installs gas exchange measurement plots (according to the scheme given in Figure 19) and ensures data acquisition within 24 months after the installation of gas exchange measurement plots.

Site management requirements:

- to ensure unbiased data collection land manager should inform LSFRI "Silava" contact person about soil treatment, distribution of fertilizers or other management

activities at least 3 days before the planned activity;
- LSFRI "Silava" removes measuring equipment that could cause troubles while performing land management activities and informs land manager who in turn informs LSFRI "Silava" contact person about when management activity is done and equipment can be returned back. If equipment is not bothering performance of land management activities it stays in the field;
- land manager informs LSFRI "Silava" about all management activities (soil treatment and performance date, fertilization (type, amount and spreading time), plant protection activities and dates, harvested amounts and harvesting dates) by the end of 2021 and 2022 respectively;
- in case of questions or problems land manager gets in contact with LSFRI "Silava" contact person and situation is solved in a way that does not hinder neither land management nor GHG and environmental data measurements.

2.6 Introduction of legumes in conventional farm crop rotation (site LVC304b, Slampe)

Area requirements: nutrient – rich organic soil (low bog peat soil according to Latvian classification), peat layer thickness at least 30 cm, groundwater level at least 30 cm deep during the growing season. Area is managed as cropland.

Research task: to demonstrate GHG emissions reduction by introduction of legumes (biomass and nitrogen attraction) to crop rotation. Projected reduction of GHG emissions is related to the decrease of N_2O and CO_2 emissions from soil.

Research activities: according to Table 1 GHG measuring plots are established in autumn 2020.

Interrelated demonstration and reference sites:

- Demonstration sites – none;
- Reference sites – none.

Reference sites that characterize GHG balance before and after implementation of the CCM measure:

- GHG balance before implementation of CCM measure – LVC101;
- GHG balance after implementation of CCM measure – LVC102; LVC103.

Site characteristics:

- existing and planned land use – cropland. The scheme of the site is given in Figure 16, research area is marked with yellow.
- total area of the site is 18,0 ha, grassland should be established in the area of 12 ha.

Implementation activities:

- area is managed in accordance with good practice guidelines for integrated farms, that uses legumes in crop rotation;
- legumes should be sawn at least once within the period of 24 months while measurements are performed (species and variety chosen by land manager). Legumes should be sawn in the part of area in 2021 and 2022;
- gas exchange measurement equipment is installed (in accordance to the scheme given in Figure 19) in the part of the area where legumes are grown in 2021. Equipment is placed in parallel to the technological roads to avoid disturbing of the site management. Distances to the diches and other parameters are given in Figure 19 as an example – exact placement is coordinated in the site with the land manager. Another similar

measurement plot is established in area where cereals (species and variety chosen by land manager) are grown in 2021;

- Measurements will be continued in 2021 and 2022. In area where in 2021 legumes are grown in 2022 cereals (species and variety chosen by land manager) should be sown, but in area where in 2021 cereals are grown – legumes (species and variety chosen by land manager) should be sown.

Figure 16: Legumes in crop rotation (Slampe, site LVC304a)

The successful bidder of the procurement organized by the LLU ensures the establishment of the site and covers the expenses related to the maintenance of the site. LSFRI "Silava" installs gas exchange measurement plots (according to the scheme given in Figure 19) and ensures data acquisition within 24 months after the installation of gas exchange measurement plots.

Site management requirements:

- to ensure unbiased data collection land manager should inform LSFRI "Silava" contact person about soil treatment, distribution of fertilizers or other management activities at least 3 days before the planned activity;
- LSFRI "Silava" removes measuring equipment that could cause troubles while performing land management activities and informs land manager who in turn informs LSFRI "Silava" contact person about when management activity is done and equipment can be returned back. If equipment is not bothering performance of land management activities it stays in the field;
- land manager informs LSFRI "Silava" about all management activities (soil treatment and performance date, fertilization (type, amount and spreading time), plant protection activities and dates, harvested amounts and harvesting dates) by the end of 2021 and 2022 respectively;
- in case of questions or problems land manager gets in contact with LSFRI "Silava" contact person and situation is solved in a way that does not hinder neither land management nor GHG and environmental data measurements.

Annex 1

Schemes of GHG flux measurement plots

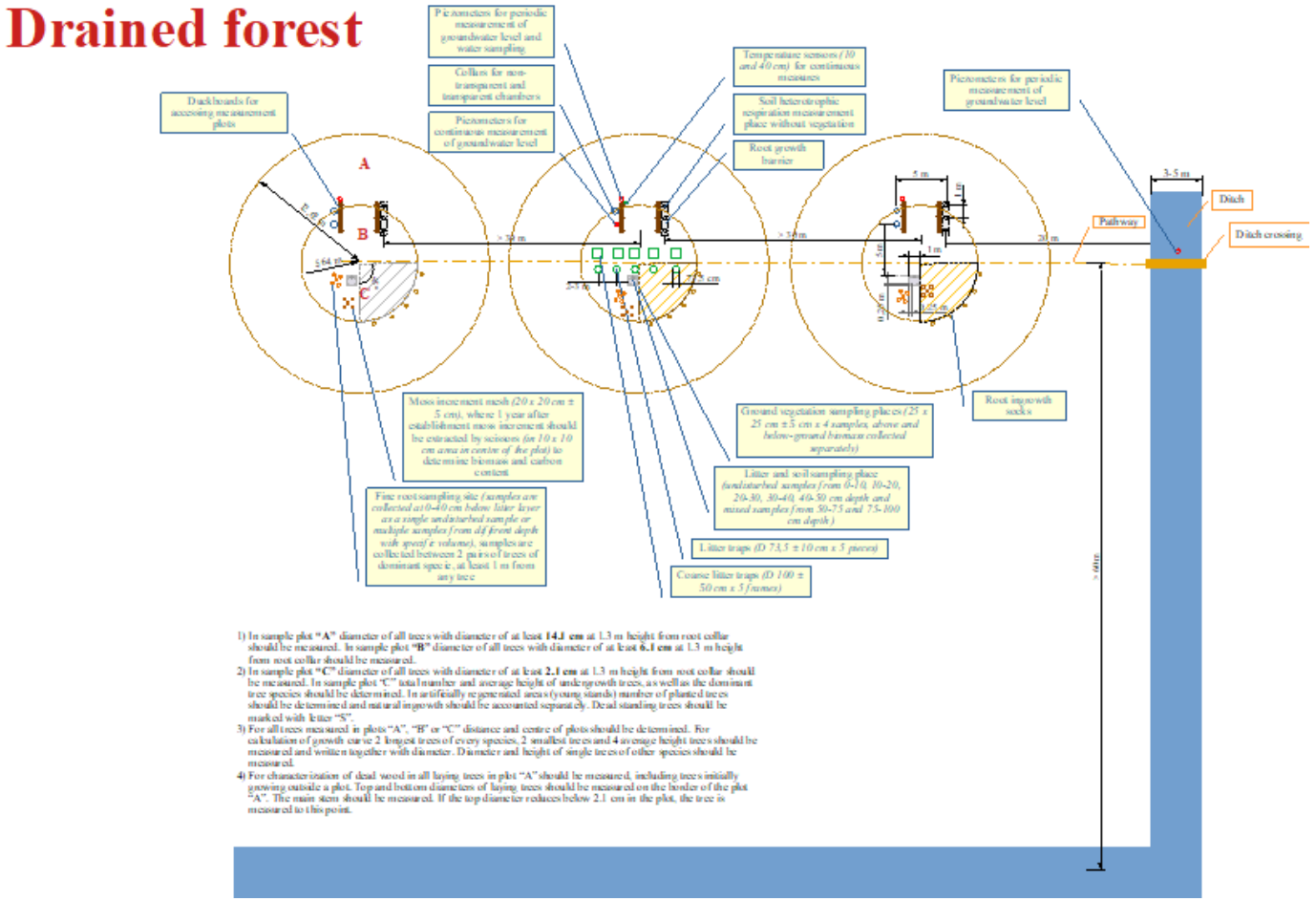

Figure 17: Gas exchange measurements scheme for forest stand on drained organic soil.

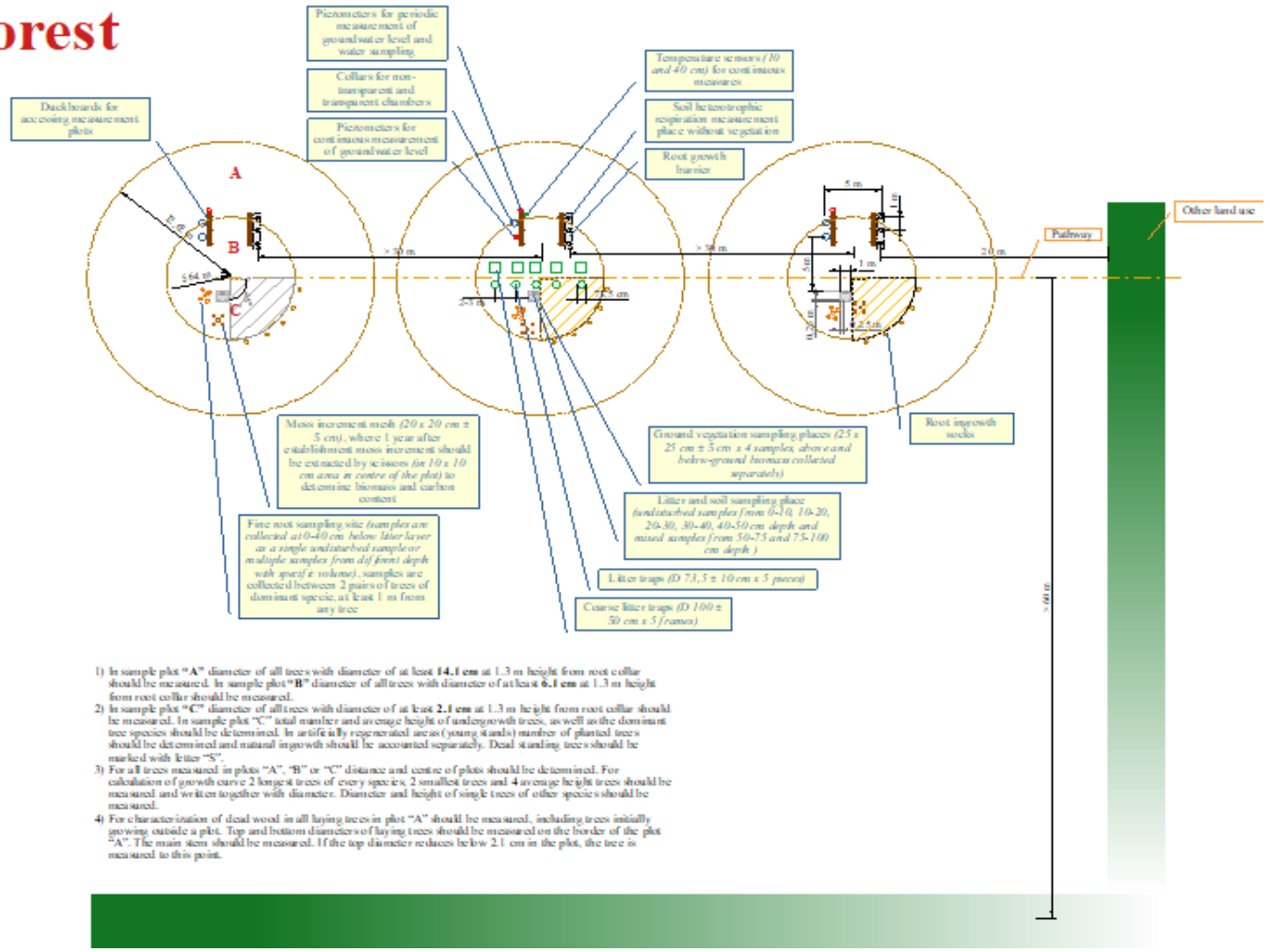

Figure 18: Gas exchange measurements scheme for forest stand on naturally wet organic soil.

Grassland & cropland

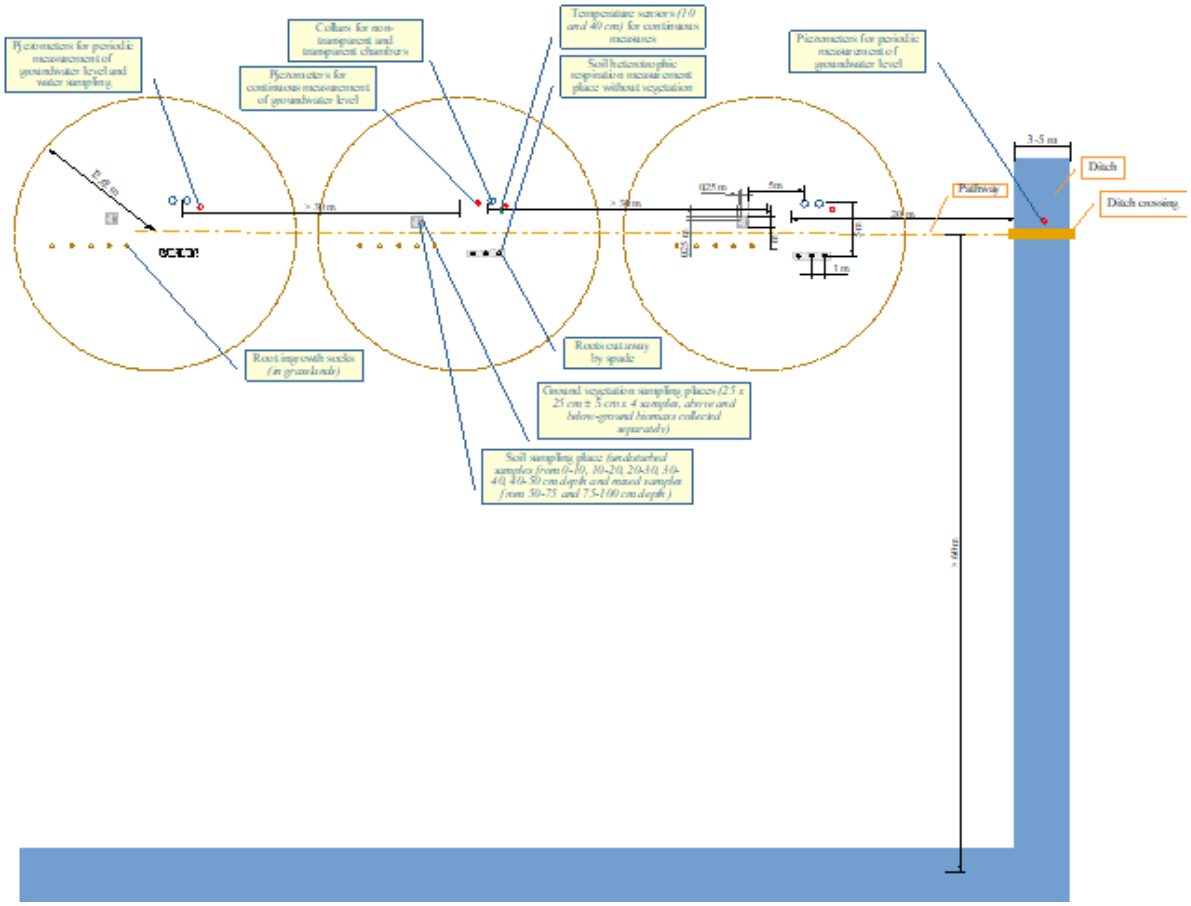

Figure 19: Gas exchange measurements scheme for cropland and grassland with drained organic soil.

Annex 2

GHG flux measurements scheme for sites LVC306 and LVC310

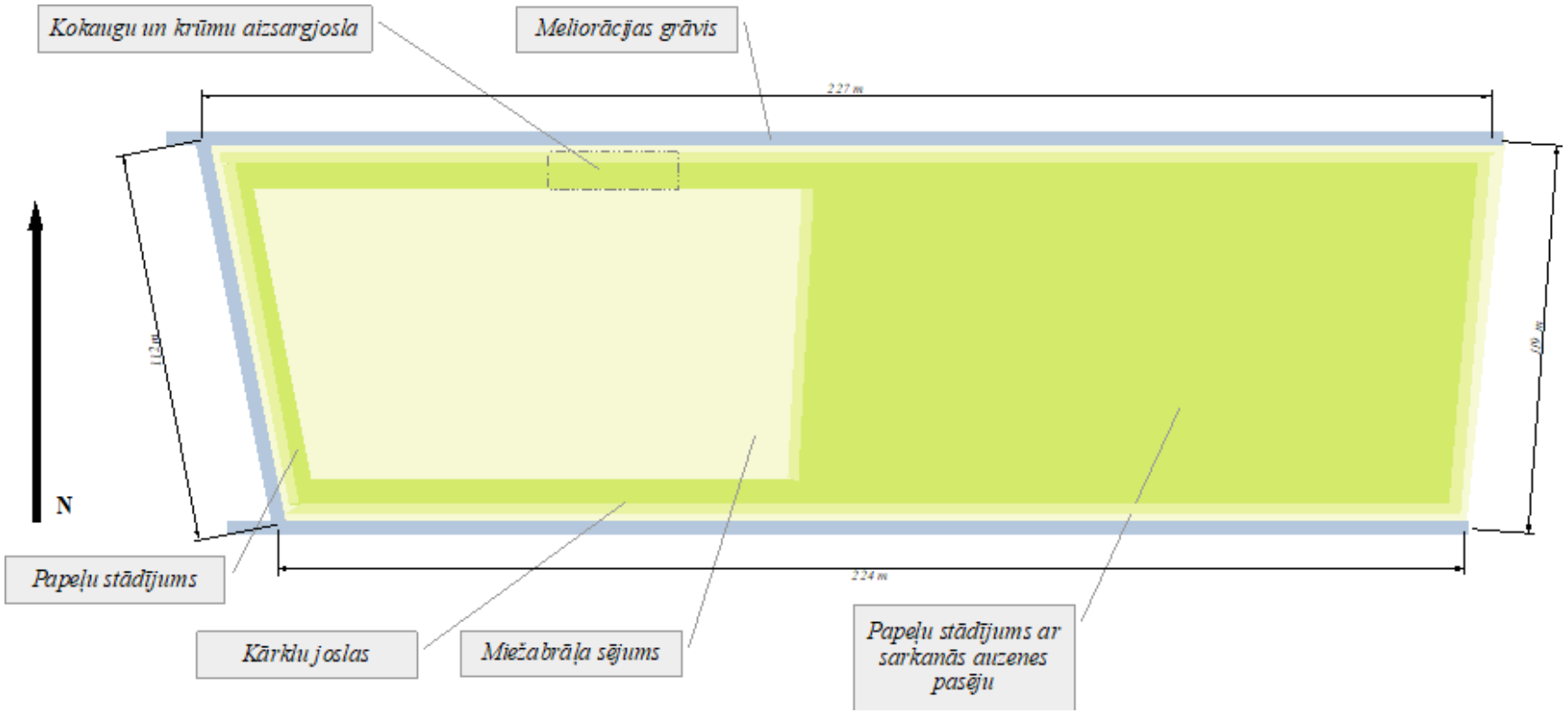

Figure 20: Research scheme (general) for sites LVC306 and LVC310.

Figure 21: Research scheme (detailed) for sites LVC306 and LVC310.