OrgBalt LIFE project

EU LIFE Programme project
"Demonstration of climate change mitigation potential of nutrients rich organic soils in Baltic States and Finland"

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

REPLICABILITY TOOLS FOR POLICY PLANNING (C.5)

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"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."

2022

SUMMARY

Default parameters for calculation of the climate change mitigation (CCM) effect provides the set of activity data, calculation parameters and EFs applied in the calculation model so that they can be implemented as modules in other tools and adopted to other regions and conditions.

Table of parameters is supplied as supplement to the spreadsheet model to support end users, as well as separate report for researchers and others concerned. The report includes information valuable for calculation of the CCM effect like average values characterizing climate change mitigation measures evaluated in the project. The project provides averaged growth curves assuming regenerative felling at certain age, ignoring dimensions of trees and threshold values permitting harvest when trees reach certain size.

Since several CCM measures do not have sufficient information on the GHG reduction effect and lacks significant activity data, for these activities mainly listing of the necessary information is provided.

Since the most comprehensive information is available for Latvia, the report is based on the assessment of the situation in Latvia as an example, supporting elaboration and validation of data sets for other countries.

The measures described in the report are conversion of cropland to pasture or intensively cultivated grassland for fodder production; afforestation of cropland, grassland or pastures using black alder, birch, pine and spruce including afforestation and rewetting; drainage or rewetting of forests with organic soils, including change of dominant species (birch, black alder, spruce and pine); establishment of plantation of fast growing trees (hybrid aspen or hybrid poplar) in cropland, grassland and pastures. Rewetting of pastures is not considered since this measure sooner or later results in afforestation and formation of forest stands with wet organic soils. Nutrient-rich organic soils are considered in the calculation.

Carbon pools considered in the calculation are living biomass (trees and forest floor including grasses, mosses and lichens), dead wood including carbon input with above- and below-ground litter, soil carbon pool and harvested wood products. Sources of GHG emissions considered are N_2O and CH_4 emissions from soil and carbon losses with leaching water. Where possible country specific emission factors are used; however, in case of litter input equations elaborated mainly in Finland are applied.

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3. Affected area, ha;
4. Initial number of trees par ha^{-1};
5. Stand age in years (if used in calculation);
6. Diameter of average tree, cm;
7. Height of average tree, m;
8. Basal area, m^2 ha^{-1};
9. Growing stock, m^3 ha^{-1}.

1.2. Calculation

The first step of the baseline calculation to estimate current level of GHG emissions in forest lands is calculation of annual potential gross increment. Elaboration of long term forest growth projections is described in further chapters. Calculation is done according to equation 1, using equations from tab. 1 (Donis et al., 2013). Long term projections are elaborated using AGM model, based on the assumptions determined on management activities and current stand conditions demonstrating actual growth potential (Lazdiņš et al., 2019; Šņepsts et al., 2018). Other models can be used instead; however, it is important to keep in mind that the potential increment of the living trees at the beginning of the period is estimated by equation 1 and used in further calculations.

$$Z_M = a_1 * A^{a_2} * a_3^B * G^{a_4} \quad (1)$$

where

Z_M – periodic potential increment of actual stand, $m^3 ha^{-1} gadā$;

A– age of dominant stand trees, years;

B– site index (according to Orlov site bonity range Ia=0, I=1...IV=4; V=5);

G– stand basal area, $m^2 ha^{-1}$.

Tab. 1. Coefficients for calculation of periodic potential increment of actual stand (Donis et al., 2013)

Species	Inventory unit	a_1	a_2	a_3	a_4
Pine	Dominant species	3.9878	-0.5260	0.8766	0.9140
	First floor	4.0724	-0.5062	0.8658	0.9017
	Total	3.9049	-0.4473	0.8518	0.8571
Spruce	Dominant species	7.5328	-0.6104	1.0000	0.8113
	First floor	8.5071	-0.5868	1.0000	0.7557
	Total	8.7959	-0.5371	1.0000	0.6810
Birch	Dominant species	12.6641	-0.6299	0.8996	0.6299
	First floor	11.0285	-0.5755	0.8915	0.6598
	Total	9.6997	-0.4776	0.8772	0.6097

Species	Inventory unit	a_1	a_2	a_3	a_4
Black alder	Dominant species	8.2851	-0.6452	0.8814	0.8313
	First floor	9.2240	-0.5437	0.8829	0.6992
	Total	10.7240	-0.5133	0.8822	0.6234
Aspen	Dominant species	13.5951	-0.6185	1.0000	0.6838
	First floor	14.2491	-0.5161	1.0000	0.5526
	Total	12.4910	-0.3753	1.0000	0.4480
Grey alder	Dominant species	16.5590	-0.8165	1.0000	0.6639
	First floor	15.7085	-0.6095	1.0000	0.5040
	Total	11.5837	-0.4727	1.0000	0.4737

Natural mortality is calculated bases on dominant species using equation 2, using coefficients provided in tab. 2 (Donis et al., 2013). The coefficients for aspen are used to calculate mortality of other species. Other equations can be used to estimate the mortality.

$$Z_M(\text{-}) = \frac{A * G}{a + b * A + c * G} \quad (2)$$

where

$Z_M(\text{-})$ – average periodic mortality of actual stand, $m^3 ha^{-1} gadā$;
A– age of trees of dominant species in the 1st floor, years;
G– basal area,$m^2 ha^{-1}$;
$a, b, c - coefficients$.

Tab. 2. Coefficients for calculation of natural mortality

Species	Inventory unit	a	b	c
Pine	Dominant species	300,94217	24,72256	-26,77060
Spruce	Dominant species	196,76581	5,99927	-2,71843
Birch	Dominant species	173,04410	7,71451	-4,20134
Black alder	Dominant species	293,67071	4,72598	-0,65462
Aspen	Dominant species	-29,13739	10,31567	0,24534
Grey alder	Dominant species	32,20676	2,51643	0,98351

Biomass calculation is based on the species specific equations separately for every diameter class (Liepiņš et al., 2017, 2021). Simplified assumption considering only dominant species is used here. For all species, except birch below-ground biomass, equation 3 is used, and for below-ground biomass of birch – equation 4. Coefficients for the equations are provided in tab. 3. Equations and coefficients for aspen are used for other species.

$$B = \left(k * exp\left(a + \frac{b * D}{D + m} + c * H + d * ln(H) \right) \right) * \frac{N}{1000} \quad (3)$$

where

B – biomass (AGB, SB, BB, BGB, SRB),$tons ha^{-1}$;
D– stand average tree diameter,cm;
H– stand average tree height,m;
N– number of trees perha^{-1};
a, b, c, d, m, k - coefficients.

$$B = \left(k * exp(a + ln(D) * b)\right) * \frac{N}{1000} \quad (4)$$

$where$

B – below-ground birch biomass (BGB), $tonsha^{-1}$;

D– stand average tree diameter, cm;

N– number of trees per ha^{-1};

a, b, k - coefficients.

Tab. 3. Coefficients for biomass equations

Species	Biomass[1]	a	b	c	d	m	k
Spruce	AGB	-0.5244	8.8563	0.0000	0.3879	19.0000	1.0127
	SB	-2.5842	7.0769	0.0232	0.9631	15.0000	1.0022
	BB	0.3300	12.0986	0.0000	-1.0682	16.0000	1.0121
	BGB	-2.4967	10.8184	0.0000	0.0000	14.0000	1.0388
	SRB	-3.3454	7.5401	0.0000	0.0000	9.0000	1.0680
Pine	AGB	-1.4480	8.7399	0.0000	0.5624	16.0000	1.0086
	SB	-2.8125	7.1368	0.0118	1.1270	15.0000	1.0053
	BB	-1.6032	14.7696	0.0000	-1.5888	11.0000	1.0415
	BGB	-3.2937	9.0334	0.0000	0.5353	14.0000	1.0350
	SRB	-4.1683	1.4686	0.4263	0.0000	0.0000	1.0613
Birch	AGB	-2.1284	9.3375	0.0221	0.2838	11.0000	1.0041
	SB	-2.9281	8.2943	0.0184	0.7374	11.0000	1.0020
	BB	-1.0091	16.9249	0.0000	-2.0462	12.0000	1.0745
	BGB	-3.6432	2.5127	0.0000	0.0000	0.0000	1.0060
	SRB	-4.1485	8.6630	0.0000	0.0000	7.0000	1.0090
Aspen	AGB	-1.9434	9.7506	0.0337	0.0000	11.0000	0.9900
	SB	-2.8955	8.3896	0.0226	0.6148	11.0000	1.0058
	BB	-2.3703	14.3352	0.0000	-1.0849	12.0000	1.0040
	BGB	-2.3114	10.3644	0.0000	0.0000	15.0000	0.9917
	SRB	-2.2732	14.1612	0.0000	-1.7449	10.0000	0.9945
Alksnis	AGB	-2.1284	9.3375	0.0221	0.2838	11.0000	1.0041
	SB	-2.9281	8.2943	0.0184	0.7374	11.0000	1.0020
	BB	-1.0091	16.9249	0.0000	-2.0462	12.0000	1.0745
	BGB	-3.6432	2.5127	0.0000	0.0000	0.0000	1.0060
	SRB	-4.1485	8.6630	0.0000	0.0000	7.0000	1.0090

Recalculation of biomass to carbon stock in living trees is done using simplified approach (equation 5):

$$C = B * 50\% \quad (5)$$

$where$

C – carbon stock in biomass (AGB, SB, BB, BGB, SRB), $tonsCha^{-1}$;

B– biomass (AGB, SB, BB, BGB, SRB), $tonsha^{-1}$.

Biomass calculation in the periodic potential increment of actual stand is calculated using equation 6 for above ground biomass and 7 for below ground biomass.

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[1] ABG – above-ground biomass; SB – stem biomass; BB – branch biomass; BGB – below-ground biomass; SRB – small root biomass.

$$B_P(AGB) = \frac{B_{AGB}}{M} * M_P \quad (6)$$

$where$

$B_P(AGB)$ − above-ground biomass in increment, $tons ha^{-1}$;

B_{AGB} − above ground biomass of growing trees, $tons ha^{-1}$;

M − growing stock of living trees, $m^3 ha^{-1}$;

M_P – increment of growing stock, $m^3 ha^{-1}$.

$$B_P(BGB) = \frac{B_{BGB}}{M} * M_P \quad (7)$$

$where$

$B_P(BGB)$ − below ground biomass of increment, $tons ha^{-1}$;

B_{BGB} − below ground biomass of growing trees, $tons ha^{-1}$;

M − growing stock of living trees, $m^3 ha^{-1}$;

M_P – increment of growing stock, $m^3 ha^{-1}$.

Biomass calculation in natural mortality is calculated using equations 8 and 9.

$$B_A(AGB) = \frac{B_{AGB}}{M} * M_A \quad (8)$$

$where$

$B_A(AGB)$ − above ground biomass of natural mortality, $tons ha^{-1}$;

B_{AGB} − above-griund biomass of growing trees, $tons ha^{-1}$;

M − growing stock of living trees, $m^3 ha^{-1}$;

M_A – natural mortality, $m^3 ha^{-1}$.

$$B_A(BGB) = \frac{B_{BGB}}{M} * M_A \quad (9)$$

$where$

$B_A(BGB)$ − below-ground biomass of natural mortality, $tons ha^{-1}$;

B_{BGB} − below-ground biomass of growing trees, $tons ha^{-1}$;

M − growing stock of living trees, $m^3 ha^{-1}$;

M_A – natural mortality, $m^3 ha^{-1}$.

Carbon stock in the increment is calculated using equation 5. Carbon stock in natural mortality is calculated using equation 5.

Carbon stock changes are calculated by substraction of increment and natural mortality. Carbon losses due to harvesting should be subtracted separately.

GHG emissions from organic soil are calculated using emission factors provided in tab. 4. For clear-fellings and other tree species emission factors for aspen are used. Equations 10, 11, 12, 13, 14 and 15.

$$CO_2 = EF_{CO2} * \frac{44}{12} \quad (10)$$

$where$

CO_2 − emissions from soil (heterotrophic soil respiration), $tons CO_2 ha^{-1}$;

EF_{CO2} – emission factors, $tons CO_2 - C ha^{-1}$.

$$CH_4(grāvji) = EF_{CH_4} ditches * \frac{25}{1000} * ditcharea \quad (11)$$

$where$

$CH_4(ditches) - CH_4$ emissions from ditches, $tons CO_2 eq ha^{-1}$;

$EF_{CH_4} ditches$ – $emission factor$, $kg CH_4 ha^{-1}$;

$Ditcharea$ − share of ditch area%;

25 − CO_2 emission equivalent.

$$CH_4 = \left(EF_{CH_4} * \frac{25}{1000}\right) * (100\% - ditcharea) \quad (12)$$

where

$CH_4 - CH_4$emissions from soil,$tons CO_2 eq ha^{-1}$;

$EF_{CH_4} ditches$– emission factor, $kg CH_4 ha^{-1}$;

$Ditcharea$ – share of ditch area%;

$25 - CO_2$emission equivalent.

$$N_2O = EF_{N_2O} * \frac{298}{1000} \quad (13)$$

where

$N_2O - N_2O$emissions from soil, $tons CO_2 eq ha^{-1}$;

$EF_{N_4O} ditches– emission factor, kg N_2O ha^{-1}$;

$298 - CO_2$emission equivalent.

$$DOC = EF_{DOC} * \frac{44}{12} \quad (14)$$

where

DOC – DOC emissions from soil, $tons CO_2 ha^{-1}$;

EF_{DOC}– emission factor, $kg C ha^{-1}$.

$$GHG_{soil} = CO_2 + CH_4(ditches) + CH_4 + N_2O + DOC \quad (15)$$

where

GHG_{soil} – net GHG emissions from soil, tons CO_2 eq ha^{-1}.

Tab. 4. Emission factors from organic soil

Dominant species	Forest type	CH_4 from ditches, kg CH_4 ha^{-1} yr^{-1}	Share of ditches	CH_4 emissions, kg CH_4 ha^{-1} yr^{-1}	N_2O emissions, kg N_2O ha^{-1} yr^{-1}	CO_2 emissions (heterotrophic respiration), tons CO_2 ha^{-1} yr^{-1}	DOC emissions, tons CO_2 ha^{-1} yr^{-1}
Spruce	Nutrient-rich drained organic soil	217	3%	-6.2857	1.5714	12.3200	1.1
	Nutrient-poor drained organic soil	217	3%	25.5898	-0.0751	4.2120	1.1
	Nutrient-rich wet or rewetted organic soil			-2.7429	0.9429	10.6700	0.9
	Nutrient-poor wet or rewetted organic soil			32.4505	0.0680	6.7820	0.9
Pine	Nutrient-rich drained organic soil	217	3%	-1.5887	0.9764	9.5333	1.1
	Nutrient-poor drained organic soil	217	3%	25.5898	-0.0751	4.2120	1.1
	Nutrient-rich wet or rewetted organic soil			-2.7429	0.9429	10.6700	0.9
	Nutrient-poor wet or rewetted organic soil			32.4505	0.0680	6.7820	0.9
Birch	Nutrient-rich drained organic soil	217	3%	-1.9429	1.4143	15.0700	1.1
	Nutrient-poor drained organic soil	217	3%	25.5898	-0.0751	4.2120	1.1
	Nutrient-rich wet or rewetted organic soil			-4.2286	4.2429	11.4620	0.9
	Nutrient-poor wet or rewetted organic soil			32.4505	0.0680	6.7820	0.9

Dominant species	Forest type	CH_4 from ditches, kg CH_4 ha^{-1} yr^{-1}	Share of ditches	CH_4 emissions, kg CH_4 ha^{-1} yr^{-1}	N_2O emissions, kg N_2O ha^{-1} yr^{-1}	CO_2 emissions (heterotrophic respiration), tons CO_2 ha^{-1} yr^{-1}	DOC emissions, tons CO_2 ha^{-1} yr^{-1}
Aspen	Nutrient-rich drained organic soil	217	3%	-1.9429	1.4143	15.0700	1.1
	Nutrient-poor drained organic soil	217	3%	25.5898	-0.0751	4.2120	1.1
	Nutrient-rich wet or rewetted organic soil			228.3429	3.9286	13.4200	0.9
	Nutrient-poor wet or rewetted organic soil			32.4505	0.0680	6.7820	0.9
Alksnis	Nutrient-rich drained organic soil	217	3%	7.7714	0.9429	10.1017	1.1
	Nutrient-poor drained organic soil	217	3%	25.5898	-0.0751	4.2120	1.1
	Nutrient-rich wet or rewetted organic soil			228.3429	3.9286	13.4200	0.9
	Nutrient-poor wet or rewetted organic soil			32.4505	0.0680	6.7820	0.9

Taking into account the possible changes in GHG inventory methods, the calculation was made for 3 variants of GHG emission calculations of organic soils – GHG emissions from drained, rewetted and naturally wet organic soils, GHG emissions from drained soils (currently the approach used in GHG inventory) and GHG emissions calculated as a difference between GHG emissions from drained and naturally wet organic soils (this approach is proposed as an improvement of the GHG inventory system in Latvia in the next accounting period).

Determination of initial carbon accumulation in dead wood and wood products is calculated using values from tab. 5; however, actual values can be used to improve accuracy, if the data are available. For other species factors for aspen can be used.

Tab. 5. Average carbon stock in dead wood and harvested wood products

Dominant species	Growth conditions	Initial carbon stock in dead wood, tons C ha^{-1}	Initial carbon stock in coniferous sawn-wood, tons C ha^{-1}	Initial carbon stock in deciduous sawn-wood, tons C ha^{-1}	Initial carbon stock in pulpwood, tons C ha^{-1}
Spruce	Dry soils and drained mineral and organic soils	60.2	33.9	0.0	2.6
	Wet organic and mineral soils	47.7	21.6	0.0	11.2
Pine	Dry soils and drained mineral and organic soils	42.5	41.0	0.0	10.0
	Wet organic and mineral soils	42.0	22.3	0.0	7.8
Birch	Dry soils and drained mineral and organic soils	32.8	0.0	17.9	34.7

Dominant species	Growth conditions	Initial carbon stock in dead wood, tons C ha^{-1}	Initial carbon stock in coniferous sawn-wood, tons C ha^{-1}	Initial carbon stock in deciduous sawn-wood, tons C ha^{-1}	Initial carbon stock in pulpwood, tons C ha^{-1}
	Wet organic and mineral soils	24.6	0.0	9.0	29.3
Aspen	Dry soils and drained mineral and organic soils	37.5	0.0	22.1	0.0
	Wet organic and mineral soils	25.6	0.0	14.5	0.0
Alders	Dry soils and drained mineral and organic soils	37.5	0.0	22.1	0.0
	Wet organic and mineral soils	25.6	0.0	14.5	0.0

Carbon stock in forest floor vegetation and carbon input into soil with plant residues are calculated using equations in Tab. 6, 7 and 8. Due to limited knowledge about carbon stock changes in mineral soils, this carbon pool is not considered in the calculation of carbon stock changes in soil in mineral soils.

Tab. 6. Carbon stock changes in forest floor vegetation and carbon transfer in pine stands[2]

No.	Parameter	Calculation	Source
a	Stand age, years	-	Stand data
b	G, m^2 ha^{-1}	-	Stand data
c	Stem biomass, tons ha^{-1}	-	Stand data
d	Litter biomass, tons ha^{-1} yr^{-1}	$d = 0{,}597 * b^{0{,}489}$	Unpublished REstore research results
e	C input with litter, tons C ha^{-1} yr^{-1}	$e = 0{,}323 * b^{0{,}489}$	Unpublished REstore research results
f	Fine root biomass, tons ha^{-1}	$f = 0{,}02 * c$	Neumann et al., 2019
g	Mortality of fine roots, t ha^{-1} yr^{-1}	$g = f * 0{,}61$	Neumann et al., 2019; Yuan, Chen, 2012
h	Carbon content in fine roots, ton ton^{-1}	0,5	Lamlom, Savidge, 2003; IPCC, 2006
i	Carbon input with fine roots, t C ha^{-1} yr^{-1}	$i = g * h$	Neumann et al., 2019; Yuan, Chen, 2012; Lamlom, Savidge, 2003; IPCC, 2006
j	Biomass of undergrowth bushes, kg ha^{-1}	$j = (16{,}68 + 0{,}219 * 2 + 0{,}0004 * a^2)^2 - 0{,}5$	Muukkonen, Mäkipää, 2006
k	Biomass of grasses, kg ha^{-1}	$k = (11{,}725 - 0{,}098 * a^2)^2 - 0{,}5$	Muukkonen, Mäkipää, 2006

[2] Sources: (Eggleston et al., 2006; Havas & Kubin, 1983; Lamlom & Savidge, 2003; Mälkönen, 1974; Muukkonen, 2006; Muukkonen et al., 2006; Neumann et al., 2018; Palviainen et al., 2005; Yuan & Chen, 2012)

No.	Parameter	Calculation	Source
l	Above ground biomass of moss, kg ha⁻¹	$l = (27{,}329 + 0{,}138 * a - 0{,}0005 * a^2)^2 - 0{,}5$	Muukkonen, Mäkipää, 2006
m	Above-ground biomass of lichens, kg ha⁻¹	$m = (7{,}975 - 0{,}0002 * a^2)^2 - 0{,}5$	Muukkonen, Mäkipää, 2006
n	Above-ground litter of undergrowth bushes, kg ha⁻¹ yr⁻¹	$n = j * 0{,}25$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
o	Above-ground residues of grasses, kg ha⁻¹ yr⁻¹	$o = k * 1$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
p	Above-ground mortality of mosses, kg ha⁻¹ yr⁻¹	$p = l * 0{,}33$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
q	Above-ground mortality of lichens, kg ha⁻¹ yr⁻¹	$q = m * 0{,}1$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
r	Total input with above-ground biomass of forest floor, kg ha⁻¹ yr⁻¹	$r = n + o + p + q$	-
s	Total input with below-ground biomass of forest floor, kg ha⁻¹ yr⁻¹	$s = \frac{r * 100}{30} * 0{,}7$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; Mälkönen, 1974; Havas, Kubin, 1983; Palviainen et al., 2005
t	Carbon input with above-ground plant residues, kg C ha⁻¹ yr⁻¹	$t = r * 0{,}475$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; FAO, 2005
u	Carbon input with below-ground plant residues, kg C ha⁻¹ yr⁻¹	$t = s * 0{,}475$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; Mälkönen, 1974; Havas, Kubin, 1983; Palviainen et al., 2005
v	Total carbon input with forest floor vegetation, tons C ha⁻¹ yr⁻¹	$v = \frac{t + u}{1000}$	-
w	Total carbon input with forest litter, tons C ha⁻¹ yr⁻¹	$w = v + i + e$	-
x	Total carbon stock in forest floor, tons C ha⁻¹ yr⁻¹	$x = (j + k + l + m) * 0{,}7 * 0{,}475$	-

Tab. 7. Carbon stock changes in forest floor vegetation and carbon transfer in spruce stands[3]

No.	Parameter	Calculation	Source
a	Stand age, years	-	Stand data
b	Basal area, m² ha⁻¹	-	Stand data
c	Stem biomass, tons ha⁻¹	-	Stand data
d	Litter biomass, tons ha⁻¹ yr⁻¹	$d = 0{,}404 * b^{0{,}726}$	Unpublished REstore research results

[3] Avoti: (Eggleston u.c., 2006; Havas & Kubin, 1983; Yuan & Chen, 2012; Lamlom & Savidge, 2003; Mälkönen, 1974; Muukkonen, 2006; Muukkonen u.c., 2006; Neumann u.c., 2018; Palviainen u.c., 2005)

No.	Parameter	Calculation	Source
e	C input with litter, tons C ha⁻¹ yr⁻¹	$e = 0{,}211 * b^{0{,}726}$	Unpublished REstore research results
f	Fine root biomass, tons ha⁻¹	$f = 0{,}02 * c$	Neumann et al., 2019
g	Mortality of fine roots, t ha⁻¹ yr⁻¹	$g = f * 0{,}84$	Neumann et al., 2019; Yuan, Chen, 2012
h	Carbon content in fine roots, ton ton⁻¹	0,5	Lamlom, Savidge, 2003; IPCC, 2006
i	Carbon input with fine roots, t C ha⁻¹ yr⁻¹	$i = g * h$	Neumann et al., 2019; Yuan, Chen, 2012; Lamlom,Savidge, 2003; IPCC, 2006
j	Biomass of undergrowth bushes, kg ha⁻¹	$j = (10{,}375 - 0{,}033 * a + 0{,}001 * a^2 - 0{,}000004 * a^3)^2 - 0{,}5$	Muukkonen, Mäkipää, 2006
k	Biomass of grasses, kg ha⁻¹	$k = (15{,}058 - 0{,}113 * a + 0{,}0003 * a^2)^2 - 0{,}5$	Muukkonen, Mäkipää, 2006
l	Above ground biomass of moss, kg ha⁻¹	$l = (19{,}282 + 0{,}164 * a - 0{,}000001 * a^3)^2 - 0{,}5$	Muukkonen, Mäkipää, 2006
m	Above-ground biomass of lichens, kg ha⁻¹	0	Muukkonen, Mäkipää, 2006
n	Above-ground litter of undergrowth bushes, kg ha⁻¹ yr⁻¹	$n = j * 0{,}25$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
o	Above-ground residues of grasses, kg ha⁻¹ yr⁻¹	$o = k * 1$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
p	Above-ground mortality of mosses, kg ha⁻¹ yr⁻¹	$p = l * 0{,}33$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
q	Above-ground mortality of lichens, kg ha⁻¹ yr⁻¹	$q = m * 0{,}1$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
r	Total input with above-ground biomass of forest floor, kg ha⁻¹ yr⁻¹	$r = n + o + p + q$	-
s	Total input with below-ground biomass of forest floor, kg ha⁻¹ yr⁻¹	$s = \frac{r * 100}{30} * 0{,}7$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; Mälkönen, 1974; Havas, Kubin, 1983; Palviainen et al., 2005
t	Carbon input with above-ground plant residues, kg C ha⁻¹ yr⁻¹	$t = r * 0{,}475$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; FAO, 2005
u	Carbon input with below-ground plant residues, kg C ha⁻¹ yr⁻¹	$t = s * 0{,}475$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; Mälkönen, 1974; Havas, Kubin, 1983; Palviainen et al., 2005

No.	Parameter	Calculation	Source
v	Total carbon input with forest floor vegetation, tons C ha⁻¹ yr⁻¹	$v = \frac{t+u}{1000}$	-
w	Total carbon input with forest litter, tons C ha⁻¹ yr⁻¹	$w = v + i + e$	-
x	Total carbon stock in forest floor, tons C ha⁻¹ yr⁻¹	$x = (j + k + l + m) * 0{,}7 * 0{,}475$	-

Tab. 8. Carbon stock changes in forest floor vegetation and carbon transfer in birch stands[4]

No.	Parameter	Calculation	Source
a	Stand age, years	-	Stand data
b	G, m² ha⁻¹	-	Stand data
c	Stem biomass, tons ha⁻¹	-	Stand data
d	Litter biomass, tons ha⁻¹ yr⁻¹	$if b \preccurlyeq 10; d = 0{,}013 * b$ $if b \succ 34; d = -0{,}00639 * 34^2 + 0{,}433 * 34 - 2{,}391$ $if 10 \succ b \preccurlyeq 34; d = -0{,}00639 * b^2 + 0{,}433 * b - 2{,}391$	Nepublicēti REstore pētījuma dati
e	C input with litter, tons C ha⁻¹ yr⁻¹	$if b \preccurlyeq 10; d = 0{,}007 * b$ $if b \succ 34; d = -0{,}00344 * 34^2 + 0{,}233 * 34 - 1{,}286$ $if 10 \succ b \preccurlyeq 34; d = -0{,}00344 * b^2 + 0{,}233 * b - 1{,}286$	Nepublicēti REstore pētījuma dati
f	Fine root biomass, tons ha⁻¹	$f = 0{,}02 * c$	Neumann et al., 2019
g	Mortality of fine roots, t ha⁻¹ yr⁻¹	$g = f * 1{,}22$	Neumann et al., 2019; Yuan, Chen, 2012
h	Carbon content in fine roots, ton ton⁻¹	0,5	Lamlom, Savidge, 2003; IPCC, 2006
i	Carbon input with fine roots, t C ha⁻¹ yr⁻¹	$i = g * h$	Neumann et al., 2019; Yuan, Chen, 2012; Lamlom,Savidge, 2003; IPCC, 2006
j	Biomass of undergrowth bushes, kg ha⁻¹	$j = (7{,}102 + 0{,}0004 * a^2)^2 - 0{,}5$	Muukkonen, Mäkipää, 2006
k	Biomass of grasses, kg ha⁻¹	$k = (20{,}58 - 0{,}423 * a + 0{,}004 * a^2 - 0{,}00002 * a^3)^2 - 0{,}5$	Muukkonen, Mäkipää, 2006
l	Above ground biomass of moss, kg ha⁻¹	$l = (13{,}555 - 0{,}056 * a)^2 - 0{,}5$	Muukkonen, Mäkipää, 2006
m	Above-ground biomass of lichens, kg ha⁻¹	0	Muukkonen, Mäkipää, 2006
n	Above-ground litter of undergrowth bushes,	$n = j * 0{,}25$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006

[4] Avoti: (Eggleston u.c., 2006; Havas & Kubin, 1983; Yuan & Chen, 2012; Lamlom & Savidge, 2003; Mälkönen, 1974; Muukkonen, 2006; Muukkonen u.c., 2006; Neumann u.c., 2018; Palviainen u.c., 2005)

No.	Parameter	Calculation	Source
	kg ha⁻¹ yr⁻¹		
o	Above-ground residues of grasses, kg ha⁻¹ yr⁻¹	$o = k * 1$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
p	Above-ground mortality of mosses, kg ha⁻¹ yr⁻¹	$p = l * 0{,}33$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
q	Above-ground mortality of lichens, kg ha⁻¹ yr⁻¹	$q = m * 0{,}1$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
r	Total input with above-ground biomass of forest floor, kg ha⁻¹ yr⁻¹	$r = n + o + p + q$	-
s	Total input with below-ground biomass of forest floor, kg ha⁻¹ yr⁻¹	$s = \frac{r * 100}{30} * 0{,}7$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; Mälkönen, 1974; Havas, Kubin, 1983; Palviainen et al., 2005
t	Carbon input with above-ground plant residues, kg C ha⁻¹ yr⁻¹	$t = r * 0{,}475$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; FAO, 2005
u	Carbon input with below-ground plant residues, kg C ha⁻¹ yr⁻¹	$t = s * 0{,}475$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; Mälkönen, 1974; Havas, Kubin, 1983; Palviainen et al., 2005
v	Total carbon input with forest floor vegetation, tons C ha⁻¹ yr⁻¹	$v = \frac{t + u}{1000}$	-
w	Total carbon input with forest litter, tons C ha⁻¹ yr⁻¹	$w = v + i + e$	-
x	Total carbon stock in forest floor, tons C ha⁻¹ yr⁻¹	$x = \frac{(j + k + l + m) * 0{,}7 * 0{,}475}{1000}$	-

CO_2 emissions due to decomposition of dead wood are estimated using mineralization factor of 20 years in deciduous tree stands and 40 years in coniferous stands; respectively, the stock of dead wood at the beginning of the year including natural mortality in the current year will decompose during 20 and 40 years, accordingly (equation 16).

$$DW_{CO_2} = \frac{DW_{\mathrm{IN}}^{1} + DW_{\mathrm{ST}}^{-1}}{Years} \quad (16)$$

$$where$$
$$DW_{CO_2} - CO_2 \text{emissions from dead wood}, tonsCO_2ha^{-1};$$
$$DW_{\mathrm{IN}}^{1} - CO_2 \text{input with dead wood in current year}, tonsCO_2ha^{-1};$$
$$DW_{\mathrm{ST}}^{-1} - CO_2 \text{accumulated in dead wood at the end of the current year}, tonsCO_2ha^{-1};$$
$$Years - \text{decomposition period (40 years for cconiferous 20 years for deciduous).}$$

$$DW_{ST}^{1} = DW_{\mathrm{IN}}^{1} + DW_{\mathrm{ST}}^{-1} - DW_{CO_2} \quad (17)$$

$$where$$
$$DW_{ST}^{1} - \text{carbon stock in dead wood, } tonsCO_2ha^{-1};$$
$$DW_{\mathrm{IN}}^{1} - CO_2 \text{ input with dead wood in a current year, } tonsCO_2ha^{-1};$$
$$DW_{\mathrm{ST}}^{-1} - CO_2 \text{ accumulated in dead wood at the end of previous year, } tonsCO_2ha^{-1};$$
$$DW_{CO_2} - CO_2 \text{ emissions from dead wood during the current year, } tonsCO_2ha^{-1}.$$

Average CO_2 losses from harvested wood products (HWP) in 2020 was -0,7 tons CO_2 ha^{-1} yr^{-1} (Ministry of Environmental Protection and Regional Development, 2021). Carbon input with harvested wood products can be assumed only in areas without management restrictions. Export of wood and local consumption are not separated; however, use of the above mentioned average input value points out that only locally produced HWP are considered. Recalculation factors are provided in tab. 9 and 10. Equation 18 is used to calculate carbon stock changes in sawn-wood, plate-wood and pulpwood.

Tab. 9. Half-life independent recalculation factors for HWP

Coefficient	Value
e	2.7
ln(2)	0.7

Tab. 10. Half-lifes dependant calculation factors

Coefficient	Sawnwood	Platewood	Pulpwood
HL – half-life in years	35.0	25.0	2.0
k	$\frac{ln(2)}{HL}$	$\frac{ln(2)}{HL}$	$\frac{ln(2)}{HL}$
e^{-k}	$e^{-\frac{ln(2)}{HL}}$	$e^{-\frac{ln(2)}{HL}}$	$e^{-\frac{ln(2)}{HL}}$
	$\frac{1-e^{-k}}{k}$	$\frac{1-e^{-k}}{k}$	$\frac{1-e^{-k}}{k}$

$$c(i) = HWP_{st} * e^{-k} * \frac{44}{12} \quad (18)$$

$where$

$c(i) -$ CO_2 emissions from HWP, $tonsCO_2ha^{-1}$;

$HWP_{st} -$ carbon stock in HWP at the beginning of the year, $tonsCha^{-1}$;

$e^{-k} -$ coefficients characterizing decomposition.

Calculation of total emissions is completed using equation 19, summarizing annual carbon stock changes and GHG emissions.

$$CO_2eq(tot) = -\big(CO_2(HWP) + CO_2(DW) + CO_2(litter) + CO_2(LB)\big) + CO_2ekv.(soil) \quad (19)$$

$where$

$CO_2eq(tot) -$ net GHG emissions, $tonsCO_2eqha^{-1}$;

$CO_2(HWP) -$ carbon stock changes in HWP, $tonsCO_2ha^{-1}$;

$CO_2(DW) -$ carbon stock changes in dead wood, $tonsCO_2ha^{-1}$;

$CO_2(litter) -$ carbon input with plant residues (in organic soils), $tonsCO_2ha^{-1}$;

$CO_2(LB) -$ carbon stock changes in living biomass, $tonsCO_2ha^{-1}$;

$CO_2eq(soil) -$ GHG emissions from soil, $tonsCO_2ekv.ha^{-1}$.

2. DEFAULT CALCULATION PARAMETERS FOR NON-FOREST LANDS

Non-forest lands includes cropland and grassland (drained organic soils), including poor soils used for cranberry and blueberry production. Data for calculations summarized in tab. 11 are acquired in GHG guidelines and LIFE REstore project results (Eggleston et al., 2006; Priede & Gancone, 2019).

Emission factors for non-forest soils are provided in tab. 12. They are based on the results of LIFE REstore project and IPCC guidelines (Hiraishi et al., 2013; Priede & Gancone, 2019).

Tab. 11. Carbon stock and stock changes in non-forest lands

Land use	Management	Water regime	Nutritional regime	Carbon stock at a steady stage, tons C ha^{-1}		Rotation period	Soil carbon input, tons C ha^{-1} yr^{-1}			
				above ground	below ground		above ground	below ground	fine root	other input
Cropland	Conventional	Drained	Rich	4.4	0.9	3.0	2.7	0.6	0.3	
Cropland	Conventional with legumes	Drained	Rich	3.6	0.7	3.0	2.2	0.5	0.2	
Cropland	Organic farming	Drained	Rich	3.6	0.7	3.0	2.2	0.5	0.2	
Cropland	Cranberry field	Wet	Poor	13.6		5.0				
Cropland	Blueberry field	Wet	Poor	25.0		5.0				
Grassland	Fodder production	Drained	Rich	3.2	1.2	3.0	0.9	0.5	0.7	
Grassland	Regulated groundwater	Drained	Rich	3.2	1.2	3.0	0.9	0.5	0.7	
Grassland	Pastures	Drained	Rich	6.8		3.0	0.9	0.5	0.7	2.0
Wetland	Peat extraction	Drained	Poor	0.0	0.0	0.0				
Wetland	Restored wetland	Wet	Poor	6.8			1.9			
Wetland	Restored wetland	Wet	Rich	6.8		3.0	1.9			

Tab. 12. Emission factors for non-forest lands

Land use	Management	Water regime	Nutritional regime	Proportion of ditch area	CH_4 emission factor for ditches, kg CH_4 ha^{-1} yr^{-1}	CH_4 emission factor, kg CH_4 ha^{-1} yr^{-1}	N_2O emission factor, kg N_2O ha^{-1} yr^{-1}	CO_2 emission factor, tons CO_2 ha^{-1} yr^{-1}	DOC emission factor, tons CO_2 ha^{-1} yr^{-1}
Cropland	Conventional	Drained	Rich	5%	1165.0	2.0852	9.6643	15.9465	1.1367
Cropland	Conventional with legumes	Drained	Rich	5%	1165.0	2.0852	9.6643	15.9465	1.1367

Land use	Management	Water regime	Nutritional regime	Proportion of ditch area	CH_4 emission factor for ditches, kg CH_4 ha^{-1} yr^{-1}	CH_4 emission factor, kg CH_4 ha^{-1} yr^{-1}	N_2O emission factor, kg N_2O ha^{-1} yr^{-1}	CO_2 emission factor, tons CO_2 ha^{-1} yr^{-1}	DOC emission factor, tons CO_2 ha^{-1} yr^{-1}
Cropland	Organic farming	Drained	Rich	5%	1165.0	2.0852	9.6643	15.9465	1.1367
Cropland	Cranberry field	Wet	Poor	5%	542.0	5.7164	0.8019	2.7318	0.8800
Cropland	Blueberry field	Wet	Poor	5%	542.0	25.8694	3.2851	4.1554	1.1367
Grassland	Fodder production	Drained	Rich	5%	1165.0	26.5641	0.5029	11.7282	1.1367
Grassland	Regulated groundwater	Drained	Rich	5%	1165.0	26.5641	0.5029	11.7282	1.1367
Grassland	Pastures	Drained	Rich	5%	1165.0	26.5641	0.5029	11.7282	1.1367
Wetland	Peat extraction	Drained	Poor	5%	542.0	10.8262	0.6913	3.9934	1.1367
Wetland	Restored wetland	Wet	Poor			133.2245	0.7594	4.8006	0.8800
Wetland	Restored wetland	Wet	Rich			274.4283	5.2494	6.0635	0.8800

3. Forest growth projections for different species and site conditions

AGM model is used to develop averaged forest growth scenarios for different species and site conditions (drained or wet organic soils) The parameters calculated by the model are site index (can change during stand growth, used by AGM model to initiate forest growth), diameter and height of dominant species, basal area, number of trees per ha, growing stock, potential annual increment of actual stand, natural mortality and harvested trees. Mortality and harvested trees are characterized by the same parameters as the growing trees (average tree height, diameter, basal area and stock.

Following tables (tab. 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23 and 24) characterizes every 5th year of the stand development summarizing 120 years long modelling period. The calculation can be extended to loger period and manually combined together, e.g. assuming planting of spruce instead of pine in the next rotation.

Parameters used in the tables:

- Bonity – site index;
- A – stand age in years;
- H – height of average living tree, m;
- D – diameter of average living tree, cm;
- G – basal area of stand, m^2 ha^{-1};
- N – number of living trees per ha^{-1};
- M – growing stock of living trees, m^3 ha^{-1};
- Incr. – average potential potential increment of the current stand, m^3 ha^{-1} yr^{-1};
- Hnoc – height of average harvested tree, m;
- Dnoc – diameter of average harvested tree, cm;
- Gnoc – basal area of trees harvested during the period, m^2 ha^{-1};
- Nnoc – number of trees harvested during the period per ha^{-1};
- Mnoc – stock of trees harvested during the period, m^3 ha^{-1};
- Hatm – height of average dead tree, m;
- Datm – diameter of average dead tree, cm;
- Gatm – basal area of dead trees, m^2 ha^{-1} yr^{-1};
- Natm – number of dead trees per ha^{-1} yr^{-1};
- Matm – stock of dead trees, m^3 ha^{-1} yr^{-1}.

Tab. 13. Summary of growth parameters in birch stands with naturally wet or rewetted nutrient rich organic soils

Parameter	Stand age in years																							
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
Bonity	3	3	4	4	3	3	3	3	3	3	2	2	2	2	3	3	4	4	3	3	3	3	3	3
A	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	4.0	9.0	14.0	19.0	24.0	29.0	34.0	39.0	44.0	49.0
H	1.5	3.1	5.1	7.3	9.3	11.3	13.1	14.7	16.2	17.6	19.2	20.3	21.3	22.2	1.2	2.7	4.7	6.8	8.9	10.9	12.7	14.4	16.0	17.3
D	1.6	3.6	6.0	8.2	10.3	12.2	13.9	15.4	16.8	18.0	19.9	21.0	22.0	22.9	1.3	3.1	5.5	7.8	9.9	11.8	13.6	15.1	16.5	17.8
G	0.3	1.4	3.3	5.4	8.2	10.8	13.2	15.5	17.6	19.6	16.5	18.0	19.3	20.3	0.2	1.1	2.9	5.0	7.6	10.3	12.8	15.1	17.2	19.2
N	1458	1435	1197	1022	983	925	873	830	796	769	534	521	509	495	1469	1453	1244	1050	994	936	882	838	803	774
M	0.4	3.0	10.0	21.1	38.9	60.0	83.4	108.3	134.0	159.9	145.8	167.0	187.4	205.6	0.2	2.1	8.3	18.5	35.0	55.5	78.5	103.2	128.8	154.7
Incr.	0.2	1.0	2.0	3.1	4.2	5.1	5.7	6.0	6.2	6.1	5.0	5.0	4.8	4.6	0.1	0.8	1.8	2.9	4.0	5.0	5.6	6.0	6.1	6.2
Hnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.6	0.0	0.0	0.0	22.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	23.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	20.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	216.5	0.0	0.0	0.0	492.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.0	0.0	0.0	0.0	208.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hatm	1.2	2.7	4.7	6.8	8.9	10.9	12.7	14.4	16.0	17.3	18.9	20.1	21.1	22.1	0.9	0.0	4.3	6.4	8.5	10.5	12.4	14.1	15.7	17.1
Datm	1.3	3.1	5.5	7.8	9.9	11.8	13.6	15.1	16.5	17.8	19.6	20.8	21.8	22.7	1.0	0.0	5.0	7.3	9.5	11.5	13.2	14.8	16.3	17.5
Gatm	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Natm	10.7	17.8	46.8	27.8	11.0	11.4	9.6	7.7	6.2	4.9	2.7	2.5	2.4	3.1	10.5	0.0	49.9	31.2	10.1	11.6	10.0	8.1	6.4	5.2
Matm	0.0	0.0	0.3	0.5	0.4	0.7	0.9	1.0	1.0	1.0	0.7	0.8	0.8	1.2	0.0	0.0	0.3	0.5	0.3	0.6	0.8	0.9	1.0	1.0

Tab. 14. Summary of growth parameters in birch stands with drained nutrient rich organic soils

Parameter	Stand age in years																							
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
Bonity	1	1	1	1	1	0	0	0	0	0	0	1	1	2	1	1	0	0	0	0	0	0	0	1
A	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	2.0	7.0	12.0	17.0	22.0	27.0	32.0	37.0	42.0	47.0	52.0	57.0	4.0
H	2.3	5.1	8.9	12.3	15.6	18.3	20.5	22.4	24.4	25.8	27.0	0.9	3.3	6.6	10.3	13.6	16.8	19.3	21.3	23.5	25.0	26.3	27.4	1.9
D	2.9	6.4	10.5	14.0	17.6	20.4	22.7	24.6	27.4	29.0	30.3	1.1	4.0	8.1	11.9	15.2	18.8	21.3	23.5	26.3	28.0	29.5	30.8	2.3
G	0.9	4.4	9.7	14.3	13.8	17.3	20.4	23.4	20.2	22.5	24.5	0.2	1.8	6.6	11.6	16.0	15.2	18.6	21.6	18.8	21.2	23.3	25.3	0.6
N	1 430	1 390	1 126	931	568	530	507	494	344	341	340	1 484	1 390	1 300	1 035	879	551	519	501	347	343	341	340	1 449
M	1.6	13.2	43.8	85.3	101.3	145.9	191.7	237.6	223.1	260.8	296.9	0.2	3.8	23.9	59.3	104.0	119.1	164.1	210.1	199.8	238.3	275.5	310.9	0.9
Incr.	0.7	4.4	8.8	11.4	12.7	10.6	10.5	10.1	8.2	7.7	7.2	0.1	1.3	6.4	10.0	12.0	10.3	10.6	10.4	9.7	8.1	7.5	6.9	0.5
Hnoc	0.0	0.0	0.0	0.0	14.8	0.0	0.0	0.0	21.9	0.0	0.0	27.6	0.0	0.0	0.0	0.0	14.8	0.0	0.0	21.9	0.0	0.0	0.0	27.6
Dnoc	0.0	0.0	0.0	0.0	15.2	0.0	0.0	0.0	22.3	0.0	0.0	31.0	0.0	0.0	0.0	0.0	15.2	0.0	0.0	22.3	0.0	0.0	0.0	31.0
Gnoc	0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	5.6	0.0	0.0	25.7	0.0	0.0	0.0	0.0	4.6	0.0	0.0	5.6	0.0	0.0	0.0	25.7
Nnoc	0.0	0.0	0.0	0.0	252.8	0.0	0.0	0.0	143.5	0.0	0.0	340.3	0.0	0.0	0.0	0.0	252.8	0.0	0.0	143.5	0.0	0.0	0.0	340.3
Mnoc	0.0	0.0	0.0	0.0	32.3	0.0	0.0	0.0	56.2	0.0	0.0	317.7	0.0	0.0	0.0	0.0	32.3	0.0	0.0	56.2	0.0	0.0	0.0	317.7
Hatm	1.9	4.4	8.1	11.7	14.8	17.8	20.1	22.1	24.1	25.5	26.7	0.5	2.8	5.9	9.6	13.0	16.3	18.8	20.9	22.7	24.7	26.1	0.0	1.4
Datm	2.3	5.5	9.7	13.3	16.4	19.8	22.2	24.2	27.0	28.7	30.0	0.6	3.4	7.2	11.2	14.6	18.2	20.9	23.1	24.9	27.7	29.2	0.0	1.7
Gatm	0.0	0.0	0.4	0.4	0.4	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.4	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0
Natm	18.5	9.9	53.5	30.7	17.2	6.3	3.8	2.0	0.9	0.4	0.1	16.5	20.9	60.2	43.3	24.3	8.3	5.2	3.0	1.2	0.7	0.3	0.0	17.6
Matm	0.0	0.1	1.7	2.4	2.5	1.6	1.3	0.9	0.5	0.3	0.1	0.0	0.0	0.8	2.1	2.5	1.6	1.5	1.2	0.6	0.4	0.2	0.0	0.0

Tab. 15. Summary of growth parameters in black alder stands with naturally wet or rewetted moderately nutrient rich organic soils

Parameter	Stand age in years																						
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
Bonity	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2
A	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	4.0	9.0	14.0	19.0	24.0	29.0	34.0	39.0	44.0	49.0
H	1.9	4.2	6.8	9.4	11.7	13.8	15.6	17.2	18.6	19.9	21.0	22.0	22.9	23.7	1.5	3.6	6.3	8.9	11.3	13.4	15.2	16.9	18.3	19.6
D	2.1	4.6	7.2	9.6	11.8	13.8	15.6	17.3	18.8	20.2	21.5	22.6	23.7	24.7	1.7	4.0	6.7	9.1	11.4	13.4	15.3	17.0	18.5	19.9
G	0.5	1.8	3.1	4.4	6.4	8.6	10.8	12.8	14.8	16.6	18.3	20.0	21.5	22.7	0.3	1.6	2.8	4.2	5.9	8.2	10.3	12.4	14.4	16.3
N	1 444	1 114	756	611	585	577	562	546	532	519	507	496	486	475	1 458	1 242	802	632	584	579	565	549	534	521
M	0.8	4.7	11.8	22.0	38.3	59.5	83.0	108.0	133.9	160.0	185.9	211.2	235.7	257.8	0.4	3.6	10.1	19.7	34.4	55.1	78.2	102.9	128.7	154.7
Incr.	0.3	1.4	2.2	3.0	3.9	4.7	5.3	5.7	5.9	6.0	5.9	5.9	5.7	5.5	0.2	1.3	2.1	2.8	3.8	4.5	5.2	5.6	5.8	6.0
Hnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	472.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	261.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hatm	1.5	3.6	6.3	8.9	0.0	13.4	15.2	16.9	18.3	19.6	20.8	21.8	22.7	23.5	1.1	3.1	5.8	8.4	0.0	13.0	14.9	16.6	18.1	19.4
Datm	1.7	4.0	6.7	9.1	0.0	13.4	15.3	17.0	18.5	19.9	21.2	22.4	23.5	24.5	1.3	3.4	6.2	8.7	0.0	13.0	14.9	16.6	18.2	19.7
Gatm	0.0	0.2	0.2	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.2	0.1	0.0	0.0	0.1	0.1	0.1	0.1
Natm	14.4	127.7	46.8	20.5	0.0	2.5	3.2	3.1	2.8	2.5	2.2	2.0	1.9	2.6	14.2	156.0	56.3	23.9	0.0	2.2	3.1	3.1	2.9	2.6
Matm	0.0	0.4	0.6	0.6	0.0	0.2	0.4	0.6	0.7	0.7	0.8	0.8	0.9	1.4	0.0	0.3	0.6	0.6	0.0	0.2	0.4	0.6	0.7	0.7

Tab. 16. Summary of growth parameters in black alder stands with naturally wet or rewetted nutrient rich organic soils

Parameter	Stand age in years																							
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
Bonity	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	4.0	9.0	14.0	19.0	24.0	29.0	34.0	39.0	44.0	49.0
H	2.5	5.4	9.0	12.1	14.8	17.1	19.0	20.7	22.1	23.3	24.6	25.6	26.4	27.1	1.9	4.7	8.3	11.5	14.3	16.6	18.7	20.4	21.8	23.1
D	2.9	6.2	9.8	12.9	15.6	18.1	20.2	22.0	23.6	25.0	27.3	28.6	29.7	30.8	2.3	5.5	9.1	12.3	15.1	17.6	19.8	21.7	23.3	24.8
G	0.9	3.3	5.9	9.5	12.9	16.1	19.1	22.1	24.8	27.5	22.8	24.7	26.5	28.0	0.6	2.8	5.2	8.8	12.2	15.4	18.5	21.5	24.3	27.0
N	1 425	1 089	787	726	669	628	599	580	567	559	390	385	381	376	1 445	1 211	792	739	679	635	604	583	569	560
M	1.6	10.5	28.1	58.2	94.4	134.4	176.7	220.1	263.6	306.7	267.4	301.5	333.1	361.3	0.9	8.0	23.0	51.6	86.8	126.2	168.1	211.4	254.9	298.2
Incr.	0.8	3.3	5.3	7.5	8.9	9.6	9.9	9.9	9.7	9.3	9.0	7.1	6.8	6.4	0.5	2.8	4.7	7.1	8.7	9.5	9.9	9.9	9.7	9.3
Hnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.7	0.0	0.0	0.0	27.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.6	0.0	0.0	0.0	31.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2	0.0	0.0	0.0	28.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	164.7	0.0	0.0	0.0	374.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	81.6	0.0	0.0	0.0	366.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hatm	1.9	4.7	8.3	11.5	14.3	16.6	18.7	20.4	21.8	23.1	24.1	25.4	26.2	27.0	1.4	4.0	7.6	10.9	13.8	16.2	18.3	20.0	21.5	22.8
Datm	2.3	5.5	9.1	12.3	15.1	17.6	19.8	21.7	23.3	24.8	26.0	28.3	29.5	30.6	1.7	4.7	8.4	11.7	14.6	17.1	19.4	21.3	23.0	24.5
Gatm	0.0	0.3	0.0	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.0	0.3	0.3	0.1	0.2	0.2	0.2	0.1	0.1	0.1
Natm	19.5	122.3	5.7	13.0	10.0	7.1	4.9	3.3	2.2	1.3	0.7	0.8	0.7	1.2	18.9	149.7	53.2	13.2	10.7	7.6	5.3	3.6	2.4	1.5
Matm	0.0	0.8	0.2	0.9	1.3	1.4	1.4	1.2	1.0	0.7	0.4	0.6	0.6	1.1	0.0	0.6	1.2	0.8	1.2	1.4	1.4	1.2	1.0	0.8

Tab. 17. Summary of growth parameters in black alder stands with drained nutrient rich organic soils

Parameter	Stand age in years																							
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
Bonity	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	4.0	9.0	14.0	19.0	24.0	29.0	34.0	39.0	44.0	49.0
H	2.6	5.7	9.3	12.5	15.3	17.6	19.6	21.2	22.6	24.0	25.2	26.1	26.9	27.5	2.0	4.9	8.6	11.9	14.8	17.2	19.2	20.9	22.3	23.6
D	3.0	6.5	10.2	13.4	16.2	18.6	20.7	22.6	24.2	26.6	28.0	29.2	30.4	31.4	2.4	5.7	9.5	12.8	15.7	18.2	20.3	22.2	23.9	25.3
G	1.0	3.6	6.7	10.5	14.1	17.4	20.7	23.7	26.7	22.4	24.5	26.6	28.4	30.0	0.6	3.1	5.9	9.8	13.4	16.8	20.0	23.1	26.1	28.9
N	1 422	1 084	823	745	683	640	611	593	581	404	399	395	393	389	1 442	1 206	836	760	693	647	616	596	583	576
M	1.8	11.7	32.9	66.5	106.3	150.0	195.9	242.7	289.5	257.3	294.9	330.2	364.0	394.2	1.0	8.9	27.1	59.2	97.9	141.0	186.6	233.3	280.1	326.4
Incr.	0.8	3.7	6.2	8.5	9.9	10.5	10.7	10.6	10.2	9.9	7.9	7.5	7.0	6.6	0.5	3.2	5.5	8.1	9.6	10.4	10.7	10.6	10.3	9.8
Hnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.2	0.0	0.0	0.0	0.0	27.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.0	0.0	0.0	0.0	0.0	31.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0	0.0	0.0	0.0	30.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	170.8	0.0	0.0	0.0	0.0	387.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78.5	0.0	0.0	0.0	0.0	399.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hatm	2.0	4.9	8.6	11.9	14.8	17.2	19.2	20.9	22.3	23.6	25.0	25.9	26.7	27.4	1.5	4.2	7.9	11.3	14.2	16.7	18.8	20.6	22.1	23.3
Datm	2.4	5.7	9.5	12.8	15.7	18.2	20.3	22.2	23.9	25.3	27.7	29.0	30.2	31.2	1.7	4.9	8.8	12.2	15.1	17.7	19.9	21.9	23.6	25.0
Gatm	0.0	0.3	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.3	0.0	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Natm	20.4	121.3	12.7	15.1	10.7	7.2	4.8	3.1	1.8	1.0	0.9	0.6	0.4	1.0	19.7	148.5	7.2	15.8	11.6	7.8	5.2	3.4	2.1	1.1
Matm	0.0	0.9	0.4	1.2	1.5	1.6	1.4	1.2	0.9	0.5	0.6	0.5	0.4	1.0	0.0	0.7	0.2	1.1	1.5	1.6	1.5	1.3	1.0	0.6

Tab. 18. Summary of growth parameters in spruce stands with naturally wet or rewetted nutrient rich organic soils

Parameter	Stand age in years																						
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
Bonity	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3	3
A	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	4.0	9.0	14.0	19.0	24.0	29.0	34.0	39.0
H	0.9	1.8	3.0	4.6	6.3	8.0	9.6	11.1	12.8	14.2	15.5	16.6	18.1	19.1	20.1	21.0	0.8	1.6	2.7	4.3	6.0	7.6	9.3	10.8
D	1.0	2.0	3.6	5.7	7.7	9.5	11.2	12.7	14.7	16.2	17.5	18.7	20.7	21.9	22.9	23.9	0.8	1.8	3.2	5.3	7.3	9.1	10.8	12.4
G	0.1	0.4	1.9	4.4	7.6	11.2	14.7	18.2	16.3	19.1	22.0	24.8	20.9	23.1	25.3	27.4	0.1	0.4	1.4	3.9	6.9	10.5	14.0	17.5
N	1 493	1 482	1 860	1 743	1 655	1 583	1 501	1 433	956	933	915	902	622	616	612	609	1 494	1 485	1 804	1 788	1 661	1 600	1 517	1 445
M	0.3	1.3	5.8	15.6	31.5	53.5	80.1	110.7	109.8	139.8	172.3	206.7	185.9	215.9	246.6	277.9	0.2	1.0	4.3	13.3	27.7	48.8	74.4	104.3
Incr.	0.1	0.2	1.5	2.6	3.9	5.3	6.4	7.3	8.1	6.8	7.3	7.5	6.3	6.4	6.5	6.5	0.1	0.2	1.3	2.4	3.7	5.0	6.2	7.2
Hnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.8	0.0	0.0	0.0	16.2	0.0	0.0	0.0	21.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.7	0.0	0.0	0.0	17.2	0.0	0.0	0.0	24.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4	0.0	0.0	0.0	6.3	0.0	0.0	0.0	27.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	425.3	0.0	0.0	0.0	271.5	0.0	0.0	0.0	608.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.3	0.0	0.0	0.0	52.9	0.0	0.0	0.0	284.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hatm	0.8	1.6	0.0	4.3	6.0	7.6	9.3	10.8	12.3	13.9	15.2	16.4	17.9	18.9	19.9	20.8	0.6	1.4	0.0	3.9	0.0	7.3	8.9	10.5
Datm	0.8	1.8	0.0	5.3	7.3	9.1	10.8	12.4	13.9	15.9	17.2	18.5	20.4	21.6	22.7	23.7	0.7	1.6	0.0	4.9	0.0	8.8	10.5	12.1
Gatm	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1
Natm	1.9	2.1	0.0	45.3	5.7	16.8	15.6	12.3	9.1	4.2	3.2	2.3	1.3	1.0	0.8	0.5	1.9	2.0	0.0	40.3	0.0	16.3	16.1	13.0
Matm	0.0	0.0	0.0	0.3	0.1	0.5	0.8	0.9	0.9	0.6	0.6	0.5	0.4	0.4	0.3	0.2	0.0	0.0	0.0	0.2	0.0	0.4	0.7	0.9

Tab. 19. Summary of growth parameters in spruce stands with drained nutrient rich organic soils

Parameter	Stand age in years																							
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
Bonity	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0
A	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	4.0	9.0	14.0	19.0	24.0	29.0	34.0	39.0	44.0	49.0	54.0	59.0
H	1.5	3.0	5.5	8.1	10.9	13.3	15.7	17.7	19.4	21.4	22.8	24.1	1.2	2.7	5.0	7.6	10.4	12.8	15.3	17.3	19.1	21.1	22.5	23.8
D	2.0	4.1	7.7	10.9	14.3	17.0	20.2	22.4	24.4	27.3	29.1	30.7	1.6	3.7	7.0	10.3	13.8	16.5	19.7	22.0	24.0	27.0	28.8	30.4
G	0.5	1.9	8.6	15.1	15.8	20.7	19.2	23.1	27.0	23.3	26.4	29.5	0.3	1.6	7.3	13.8	14.8	19.7	18.4	22.4	26.3	22.7	25.8	28.9
N	1 486	1 465	1 841	1 606	978	914	601	585	578	397	397	398	1 490	1 470	1 872	1 650	994	924	605	588	578	398	396	398
M	1.1	5.3	30.6	69.0	89.1	137.0	145.4	194.1	246.8	231.0	277.6	325.7	0.7	4.1	24.4	60.3	80.5	126.8	136.2	184.0	236.0	221.9	268.1	316.0
Incr.	0.4	1.1	6.6	10.3	9.9	11.6	10.1	10.9	11.2	9.4	9.5	9.7	0.3	1.0	5.8	9.6	9.1	11.4	10.1	10.8	11.2	9.3	9.4	9.7
Hnoc	0.0	0.0	0.0	0.0	9.1	0.0	13.8	0.0	0.0	19.2	0.0	0.0	24.3	0.0	0.0	0.0	9.1	0.0	13.8	0.0	0.0	19.2	0.0	0.0
Dnoc	0.0	0.0	0.0	0.0	11.4	0.0	16.6	0.0	0.0	22.6	0.0	0.0	31.0	0.0	0.0	0.0	11.4	0.0	16.6	0.0	0.0	22.6	0.0	0.0
Gnoc	0.0	0.0	0.0	0.0	5.0	0.0	6.0	0.0	0.0	7.1	0.0	0.0	30.1	0.0	0.0	0.0	5.0	0.0	6.0	0.0	0.0	7.1	0.0	0.0
Nnoc	0.0	0.0	0.0	0.0	484.5	0.0	278.2	0.0	0.0	177.5	0.0	0.0	399.1	0.0	0.0	0.0	484.5	0.0	278.2	0.0	0.0	177.5	0.0	0.0
Mnoc	0.0	0.0	0.0	0.0	25.2	0.0	42.3	0.0	0.0	66.1	0.0	0.0	335.5	0.0	0.0	0.0	25.2	0.0	42.3	0.0	0.0	66.1	0.0	0.0
Hatm	1.2	2.7	5.0	7.6	10.4	12.8	15.3	17.3	19.1	21.1	0.0	0.0	0.9	2.4	0.0	7.1	9.7	12.4	14.6	16.9	18.8	20.8	22.3	0.0
Datm	1.6	3.7	7.0	10.3	13.8	16.5	19.7	22.0	24.0	27.0	0.0	0.0	1.2	3.3	0.0	9.7	12.6	16.0	18.4	21.6	23.7	26.6	28.4	0.0
Gatm	0.0	0.0	0.1	0.4	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0
Natm	3.6	4.8	30.4	44.0	16.5	10.5	4.3	2.5	0.9	0.5	0.0	0.0	3.5	4.5	0.0	47.2	17.8	11.6	4.7	2.8	1.2	0.6	0.0	0.0
Matm	0.0	0.0	0.4	1.6	1.3	1.4	1.0	0.8	0.4	0.3	0.0	0.0	0.0	0.0	0.0	1.5	1.2	1.4	0.9	0.8	0.5	0.3	0.0	0.0

Tab. 20. Summary of growth parameters in pine stands with naaturally wet or rewetted nutrient rich organic soils

Parameter	Stand age in years																						
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
Bonity	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
A	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	3.0	8.0	13.0	18.0	23.0	28.0	33.0	38.0
H	1.0	2.0	3.3	4.8	6.4	7.9	9.3	10.6	12.1	13.3	14.5	15.5	16.7	17.7	18.6	19.5	0.6	1.6	2.7	4.2	5.7	7.3	8.7	10.1
D	1.4	2.8	5.0	7.4	9.5	11.5	13.2	14.8	17.0	18.4	19.8	21.1	23.1	24.4	25.5	26.6	0.9	2.2	3.9	6.4	8.7	10.7	12.5	14.2
G	0.3	1.2	4.8	9.4	13.2	16.6	19.8	22.8	19.3	21.6	23.7	25.8	21.0	22.6	24.2	25.7	0.1	0.8	2.6	7.7	11.7	15.3	18.5	21.6
N	1 973	1 931	2 484	2 187	1 844	1 607	1 442	1 323	854	808	770	740	499	484	472	461	1 987	1 949	2 205	2 356	1 966	1 692	1 502	1 366
M	0.6	2.6	12.8	30.5	50.9	74.0	99.3	126.4	117.8	141.9	166.8	192.4	166.2	188.1	210.0	232.0	0.2	1.6	6.5	23.2	42.4	64.5	89.0	115.4
Incr.	0.2	0.6	3.4	4.7	5.8	6.5	7.1	7.4	6.1	6.3	6.5	6.6	6.7	5.4	5.4	5.4	0.1	0.4	2.5	4.1	5.4	6.2	6.9	7.3
Hnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	0.0	0.0	0.0	16.0	0.0	0.0	0.0	19.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.1	0.0	0.0	0.0	20.0	0.0	0.0	0.0	27.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	0.0	0.0	0.0	6.8	0.0	0.0	0.0	26.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	389.8	0.0	0.0	0.0	216.4	0.0	0.0	0.0	457.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mnoc	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.1	0.0	0.0	0.0	52.4	0.0	0.0	0.0	240.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hatm	0.8	1.8	0.0	4.5	6.1	7.6	9.0	10.4	11.8	13.1	14.2	15.3	16.3	17.6	18.5	19.3	0.4	1.4	0.0	3.9	5.4	7.0	8.4	9.8
Datm	1.1	2.5	0.0	6.9	9.1	11.1	12.9	14.5	16.6	18.1	19.5	20.8	22.0	24.1	25.3	26.4	0.6	2.0	0.0	6.0	8.3	10.3	12.2	13.9
Gatm	0.0	0.0	0.0	0.3	0.4	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.2	0.4	0.4	0.4	0.4
Natm	7.2	9.1	0.0	83.1	58.9	40.6	28.8	21.1	10.7	8.5	6.8	5.5	4.5	2.8	2.4	2.0	6.7	8.2	0.0	86.4	68.4	46.9	32.9	23.8
Matm	0.0	0.0	0.0	1.0	1.4	1.7	1.8	1.9	1.4	1.4	1.4	1.4	1.3	1.0	1.0	1.0	0.0	0.0	0.0	0.7	1.3	1.6	1.8	1.9

Tab. 21. Summary of growth parameters in pine stands with drained nutrient rich organic soils

Parameter	Stand age in years																							
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
Bonity	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	2.0	7.0	12.0	17.0	22.0	27.0	32.0
H	1.6	3.3	5.8	8.2	10.5	12.6	14.8	16.6	18.2	20.0	21.4	22.6	23.8	25.2	26.2	27.1	27.9	0.6	2.3	4.3	6.8	9.2	11.4	13.6
D	2.1	4.3	7.6	10.4	12.9	15.0	17.7	19.5	21.2	23.8	25.3	26.8	28.1	30.6	31.9	33.1	34.3	0.8	3.0	5.7	8.8	11.4	13.7	16.4
G	0.7	2.7	9.7	15.3	20.1	24.5	21.4	24.5	27.5	23.1	25.4	27.7	29.8	24.1	25.8	27.5	29.1	0.1	1.3	5.9	12.1	17.3	21.9	19.4
N	1 951	1 864	2 156	1 794	1 549	1 388	872	819	779	522	505	491	480	329	323	318	314	1 989	1 921	2 338	1 998	1 683	1 477	913
M	1.5	7.5	36.6	71.9	112.8	157.7	155.2	195.6	237.3	215.1	250.7	286.7	322.9	275.2	305.0	334.7	364.3	0.2	3.2	18.7	49.9	87.7	130.3	131.9
Incr.	0.6	1.7	7.3	9.7	11.2	12.1	10.0	10.3	10.5	8.6	8.7	8.6	8.5	7.0	6.9	6.8	6.7	0.1	1.0	6.1	8.4	10.4	11.6	12.4
Hnoc	0.0	0.0	0.0	0.0	0.0	0.0	12.9	0.0	0.0	18.2	0.0	0.0	0.0	23.7	0.0	0.0	0.0	28.4	0.0	0.0	0.0	0.0	0.0	12.9
Dnoc	0.0	0.0	0.0	0.0	0.0	0.0	14.2	0.0	0.0	19.7	0.0	0.0	0.0	26.0	0.0	0.0	0.0	35.0	0.0	0.0	0.0	0.0	0.0	14.2
Gnoc	0.0	0.0	0.0	0.0	0.0	0.0	6.8	0.0	0.0	7.0	0.0	0.0	0.0	7.6	0.0	0.0	0.0	30.0	0.0	0.0	0.0	0.0	0.0	6.8
Nnoc	0.0	0.0	0.0	0.0	0.0	0.0	426.5	0.0	0.0	231.6	0.0	0.0	0.0	143.6	0.0	0.0	0.0	312.5	0.0	0.0	0.0	0.0	0.0	426.5
Mnoc	0.0	0.0	0.0	0.0	0.0	0.0	44.8	0.0	0.0	60.8	0.0	0.0	0.0	82.4	0.0	0.0	0.0	381.9	0.0	0.0	0.0	0.0	0.0	44.8
Hatm	1.3	3.0	5.3	7.8	10.1	12.2	14.4	16.2	17.9	19.7	21.1	22.4	23.5	25.0	26.0	26.9	27.8	0.3	2.0	0.0	6.3	8.7	11.0	13.0
Datm	1.7	3.8	7.0	9.9	12.4	14.6	17.3	19.2	20.9	23.4	25.0	26.5	27.9	30.3	31.7	32.9	34.1	0.4	2.5	0.0	8.2	10.9	13.3	15.4
Gatm	0.0	0.0	0.3	0.5	0.5	0.5	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.4	0.5	0.5	0.4
Natm	13.5	20.5	78.5	62.8	41.0	27.3	12.8	9.5	7.1	3.9	3.1	2.5	1.9	1.3	1.0	0.9	0.7	11.3	15.7	0.0	77.7	53.0	34.7	23.3
Matm	0.0	0.1	1.1	2.2	2.7	2.9	2.1	2.1	2.1	1.6	1.5	1.4	1.3	1.0	1.0	0.9	0.8	0.0	0.0	0.0	1.6	2.4	2.8	2.9

Tab. 22. Summary of growth parameters in spruce stands with drained nutrient rich organic soils periodically treated with wood ash

Parameter	Stand age in years																							
	5	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**	**105**	**110**	**115**	**120**
Bonity	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
A	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	4.0	9.0	14.0	19.0	24.0	29.0	34.0	39.0	44.0	49.0	54.0	59.0
H	1.5	3.0	5.5	8.1	11.0	13.3	15.5	17.7	19.7	21.4	23.4	24.7	1.2	2.7	5.0	7.6	10.2	12.9	15.1	17.0	19.3	21.1	23.1	24.5
D	2.0	4.1	7.7	10.9	14.3	17.0	19.3	22.2	24.5	26.4	29.1	30.7	1.6	3.7	7.0	10.3	13.2	16.5	18.9	21.0	24.0	26.0	28.7	30.4
G	0.5	1.9	8.6	15.1	14.8	19.6	24.3	22.4	26.7	31.0	28.3	31.9	0.3	1.6	7.3	13.8	20.0	18.7	23.3	28.0	25.9	30.2	27.6	31.2
N	1 486	1 465	1 841	1 606	921	862	826	581	570	568	426	430	1 490	1 470	1 872	1 650	1 467	872	831	810	571	568	426	429
M	1.1	5.3	30.6	69.0	84.2	130.0	182.8	188.2	248.1	312.1	306.8	364.7	0.7	4.1	24.4	60.3	108.2	120.2	171.8	229.3	235.7	299.0	295.4	353.0
Incr.	0.4	1.1	6.6	10.3	12.9	11.1	12.2	12.8	12.9	13.1	11.4	11.7	0.3	1.0	5.8	9.6	12.4	10.8	12.1	12.7	12.9	13.0	12.5	11.6
Hnoc	0.0	0.0	0.0	0.0	10.1	0.0	0.0	16.5	0.0	0.0	21.3	0.0	25.0	0.0	0.0	0.0	0.0	10.1	0.0	0.0	16.5	0.0	21.3	0.0
Dnoc	0.0	0.0	0.0	0.0	12.5	0.0	0.0	19.1	0.0	0.0	24.3	0.0	31.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	19.1	0.0	24.3	0.0
Gnoc	0.0	0.0	0.0	0.0	6.4	0.0	0.0	6.5	0.0	0.0	6.7	0.0	32.6	0.0	0.0	0.0	0.0	6.4	0.0	0.0	6.5	0.0	6.7	0.0
Nnoc	0.0	0.0	0.0	0.0	519.0	0.0	0.0	226.9	0.0	0.0	144.7	0.0	430.9	0.0	0.0	0.0	0.0	519.0	0.0	0.0	226.9	0.0	144.7	0.0
Mnoc	0.0	0.0	0.0	0.0	34.9	0.0	0.0	53.2	0.0	0.0	69.1	0.0	376.4	0.0	0.0	0.0	0.0	34.9	0.0	0.0	53.2	0.0	69.1	0.0
Hatm	1.2	2.7	5.0	7.6	10.2	12.9	15.1	17.0	19.3	0.0	0.0	0.0	0.9	2.4	0.0	7.1	9.7	12.4	14.6	16.6	18.9	20.8	0.0	0.0
Datm	1.6	3.7	7.0	10.3	13.2	16.5	18.9	21.0	24.0	0.0	0.0	0.0	1.2	3.3	0.0	9.7	12.6	16.0	18.5	20.6	23.6	25.7	0.0	0.0
Gatm	0.0	0.0	0.1	0.4	0.4	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.2	0.2	0.1	0.1	0.0	0.0	0.0
Natm	3.6	4.8	30.4	44.0	26.5	9.9	5.7	2.4	1.4	0.0	0.0	0.0	3.5	4.5	0.0	47.2	29.6	10.9	6.4	3.0	1.8	0.0	0.0	0.0
Matm	0.0	0.0	0.4	1.6	2.0	1.4	1.2	0.7	0.6	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.9	1.4	1.2	0.8	0.7	0.0	0.0	0.0

Tab. 23. Summary of growth parameters in spruce stands managed using continuous forest methods with drained nutrient rich organic soils

Parameter	Stand age in years																						
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
Bonity	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0	95.0	100.0	105.0	110.0	115.0	120.0
H	1.5	3.0	5.5	8.1	10.9	13.3	15.7	17.7	19.4	21.4	22.8	24.1	5.7	6.7	7.2	9.5	5.5	6.7	7.7	9.8	11.5	13.1	14.5	16.0
D	2.0	4.1	7.7	10.9	14.3	17.0	20.2	22.4	24.4	27.3	29.1	30.7	7.3	8.7	9.6	12.6	7.2	8.8	10.1	12.9	15.2	17.2	19.3	21.2
G	0.5	1.9	8.6	15.1	15.8	20.7	19.2	23.1	27.0	23.3	26.4	29.5	24.7	27.5	24.3	28.0	25.3	29.8	28.8	34.1	33.1	38.5	36.3	40.9
N	1 486	1 465	1 841	1 606	978	914	601	585	578	397	397	398	1 470	1 461	1 401	1 196	2 128	2 090	1 925	1 691	1 351	1 304	1 045	1 005
M	1.1	5.3	30.6	69.0	89.1	137.0	145.4	194.1	246.8	231.0	277.6	325.7	286.8	327.8	288.4	328.8	291.4	334.9	308.4	357.3	329.5	382.1	353.2	404.3
Incr.	0.4	1.1	6.6	10.3	9.9	11.6	10.1	10.9	11.2	9.4	9.5	9.7	8.0	8.3	7.9	8.8	8.4	9.5	10.2	11.7	11.6	13.0	12.3	13.1
Hnoc	0.0	0.0	0.0	0.0	1.7	0.0	2.6	0.0	0.0	3.5	0.0	0.0	4.4	0.0	3.7	0.0	4.0	0.0	2.9	0.0	3.2	0.0	3.2	0.0
Dnoc	0.0	0.0	0.0	0.0	2.3	0.0	3.3	0.0	0.0	4.5	0.0	0.0	5.6	0.0	4.7	0.0	5.1	0.0	3.7	0.0	4.1	0.0	4.1	0.0
Gnoc	0.0	0.0	0.0	0.0	1.0	0.0	1.2	0.0	0.0	1.4	0.0	0.0	1.5	0.0	1.4	0.0	1.3	0.0	1.2	0.0	1.2	0.0	1.4	0.0
Nnoc	0.0	0.0	0.0	0.0	96.9	0.0	55.6	0.0	0.0	35.5	0.0	0.0	24.6	0.0	31.6	0.0	24.7	0.0	46.1	0.0	36.1	0.0	43.2	0.0
Mnoc	0.0	0.0	0.0	0.0	5.0	0.0	8.5	0.0	0.0	13.2	0.0	0.0	16.5	0.0	16.7	0.0	16.2	0.0	15.7	0.0	15.2	0.0	15.8	0.0
Hatm	1.2	2.6	5.1	7.7	10.5	12.7	15.3	17.2	18.8	21.1	0.0	0.0	0.7	1.6	3.1	4.9	5.1	8.0	5.8	6.5	16.0	13.0	15.0	16.8
Datm	1.6	3.7	7.0	10.3	13.8	16.5	19.7	22.0	24.0	27.0	0.0	0.0	1.0	2.2	4.3	6.7	7.0	10.7	7.8	8.8	20.5	16.9	19.3	21.6
Gatm	0.0	0.0	0.1	0.4	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.3	0.1	0.3	0.2	0.3
Natm	3.6	4.8	30.4	44.0	16.5	10.5	4.3	2.5	0.9	0.5	0.0	0.0	1.8	2.0	23.8	41.7	2.0	9.7	29.9	47.4	4.0	11.2	8.2	7.7
Matm	0.0	0.0	0.4	1.6	1.3	1.4	1.0	0.8	0.4	0.3	0.0	0.0	0.0	0.0	0.1	0.5	0.1	0.5	0.9	1.6	1.2	2.2	2.3	2.8

Tab. 24. Summary of growth parameters in hybrid poplar stands with drained nutrient rich organic soils

Parameter	Stand age in years																						
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
Bonity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A	5.0	10.0	15.0	20.0	4.0	9.0	14.0	19.0	3.0	8.0	13.0	18.0	2.0	7.0	12.0	17.0	1.0	6.0	11.0	16.0	21.0	5.0	10.0	15.0
H	9.1	16.0	21.2	25.2	7.5	14.7	20.3	24.5	5.8	13.4	19.3	23.7	3.9	12.1	18.2	22.9	2.0	10.6	17.1	22.1	25.8	9.1	16.0	21.2
D	12.7	21.8	28.2	32.9	10.5	20.2	27.1	32.1	8.1	18.5	25.9	31.2	5.6	16.7	24.6	30.3	2.9	14.8	23.2	29.3	33.6	12.7	21.8	28.2
G	9.1	25.5	40.7	52.6	6.3	22.1	37.9	50.5	3.8	18.8	35.0	48.3	1.8	15.4	31.9	45.9	0.5	12.2	28.8	43.4	54.5	9.1	25.5	40.7
N	720	685	650	620	727	692	657	626	734	699	664	632	741	706	671	638	748	713	678	644	614	720	685	650
M	32.5	110.4	221.8	354.6	22.0	91.8	197.4	326.9	13.4	74.6	174.0	299.7	6.8	58.9	151.6	273.0	0.1	44.8	130.4	247.0	382.7	32.5	110.4	221.8
Incr.	10.7	19.6	26.5	30.9	8.7	18.0	25.3	30.1	6.7	16.3	23.9	29.2	6.7	14.5	22.6	28.3	0.0	12.6	21.1	27.3	0.0	10.7	19.6	26.5
Hnoc	0.0	0.0	0.0	0.0	25.2	0.0	0.0	0.0	25.2	0.0	0.0	0.0	25.2	0.0	0.0	0.0	25.2	0.0	0.0	0.0	25.2	0.0	0.0	0.0
Dnoc	0.0	0.0	0.0	0.0	32.9	0.0	0.0	0.0	32.9	0.0	0.0	0.0	32.9	0.0	0.0	0.0	32.9	0.0	0.0	0.0	32.9	0.0	0.0	0.0
Gnoc	0.0	0.0	0.0	0.0	52.6	0.0	0.0	0.0	52.6	0.0	0.0	0.0	52.6	0.0	0.0	0.0	52.6	0.0	0.0	0.0	52.6	0.0	0.0	0.0
Nnoc	0.0	0.0	0.0	0.0	620.0	0.0	0.0	0.0	620.0	0.0	0.0	0.0	620.0	0.0	0.0	0.0	620.0	0.0	0.0	0.0	620.0	0.0	0.0	0.0
Mnoc	0.0	0.0	0.0	0.0	354.6	0.0	0.0	0.0	354.6	0.0	0.0	0.0	354.6	0.0	0.0	0.0	354.6	0.0	0.0	0.0	354.6	0.0	0.0	0.0
Hatm	7.5	14.7	20.3	24.5	5.8	13.4	19.3	23.7	3.9	12.1	18.2	22.9	2.0	10.6	17.1	22.1	0.0	9.1	16.0	21.2	25.2	7.5	14.7	20.3
Datm	10.5	20.2	27.1	32.1	8.1	18.5	25.9	31.2	5.6	16.7	24.6	30.3	2.9	14.8	23.2	29.3	0.0	12.7	21.8	28.2	32.9	10.5	20.2	27.1
Gatm	0.1	0.2	0.4	0.5	0.0	0.2	0.4	0.5	0.0	0.2	0.3	0.4	0.0	0.1	0.3	0.4	0.0	0.1	0.3	0.4	0.5	0.1	0.2	0.4
Natm	7.0	7.0	7.0	6.0	7.0	7.0	7.0	6.0	7.0	7.0	7.0	6.0	7.0	7.0	7.0	6.0	0.0	7.0	7.0	6.0	6.0	7.0	7.0	7.0
Matm	0.2	0.9	2.1	3.1	0.1	0.7	1.8	2.8	0.1	0.6	1.6	2.6	0.0	0.4	1.3	2.3	0.0	0.3	1.1	2.0	3.4	0.2	0.9	2.1

4. Concluding remarks

The elaborated tables with parameters for GHG emission calculation are implemented in the tier 2 (according to Eggleston et al., 2006) based emission calculation model on a spreadsheet base, which can predict GHG emissions for a single field, as well as to compare different management options described in details in Annex 1.

Climate and other environmental parameters driven model will be elaborated within the scope of the OrgBalt project to ensure conformity with requirements for the tier 3 GHG modelling methods.

The provided growth parameters characterizes averaged situation, but may be improved according to local conditions. Still, the forest floor and other non-woody biomass carbon input is not well addressed in the studies and should be addressed

The provided tables can be used to evaluate effect of conversion of cropland to pasture or intensively cultivated grassland for fodder production; afforestation of cropland, grassland or pastures using black alder, birch, pine and spruce including afforestation and rewetting; drainage or rewetting of forests with organic soils, including change of dominant species (birch, black alder, spruce and pine); establishment of plantation of fast growing trees (hybrid aspen or hybrid poplar) in cropland, grassland and pastures. Rewetting of pastures is not considered separately since this measure sooner or later results in afforestation and formation of forest stands with wet organic soils, which can be used as a scenario for management of rewetted grasslands. Nutrient-rich organic soils are considered in the calculation. For nutrient-poor soils modelling solutions elaborated within the scope of the LIFE REstore project should be used in Latvia. In other countries these results should be validated using limited amount of measurements in relevant conditions.

Example of result of the application of the elaborated parameters' tables is provided in following charts demonstrating effect of afforestation of cropland with birch. Fig. 1 shows annual carbon stock changes and GHG fluxes in afforested lands. Fig. 2 demonstrates annual GHG emissions and difference between the scenarios, and fig. 3 demonstrates cumulative effect of afforestation. Total emission reduction during the 120 years period in this case equals to 881 tons CO_2 eq ha^{-1} or 7.3 tons CO_2 eq ha^{-1} yr^{-1}. The provided example demonstrates also the afforested area, even in organic soils is significant sink of CO_2 removals, which is fully compensating GHG emissions from soil, starting from 34th year from establishment. Afforested area periodically turns into a net source of emissions during regeneration period, therefore, the model also helps to identify which forest management stages are critical to reduce GHG emissions even more.

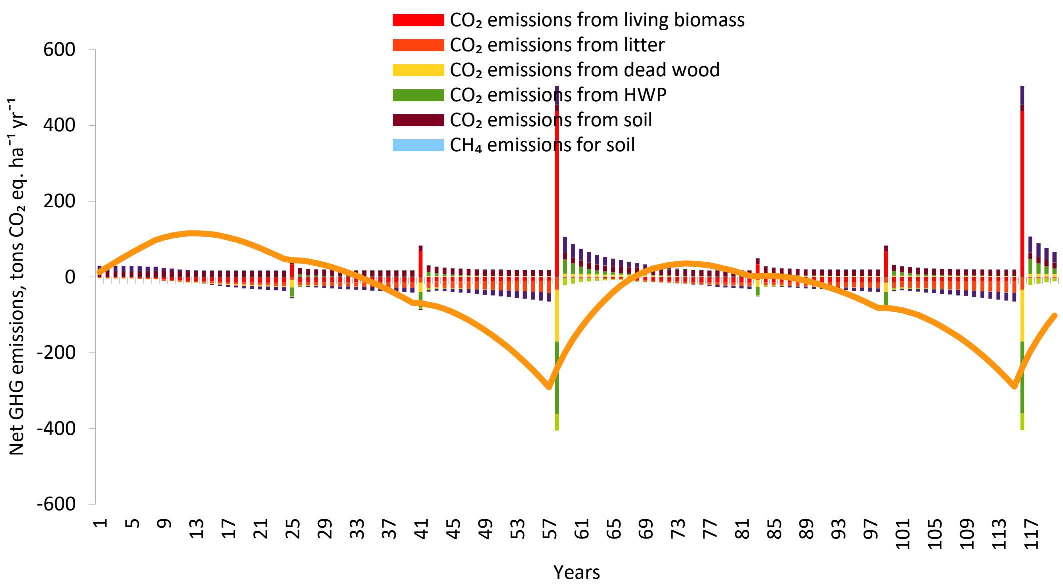

Figure 1: Net GHG emissions in area afforested with birch.

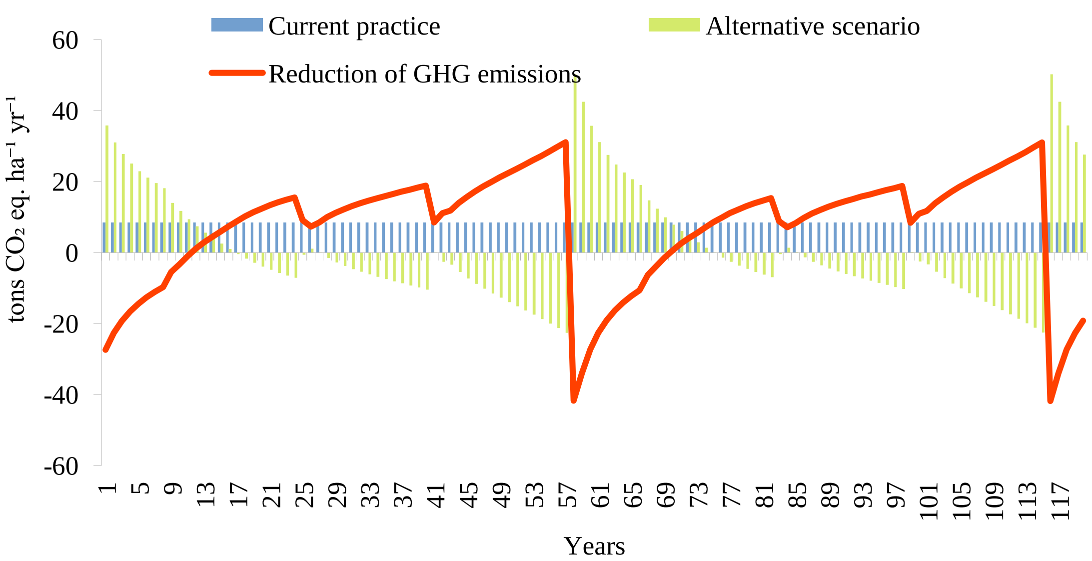

Figure 2: Comparison of GHG emissions from cropland and area afforested with birch.

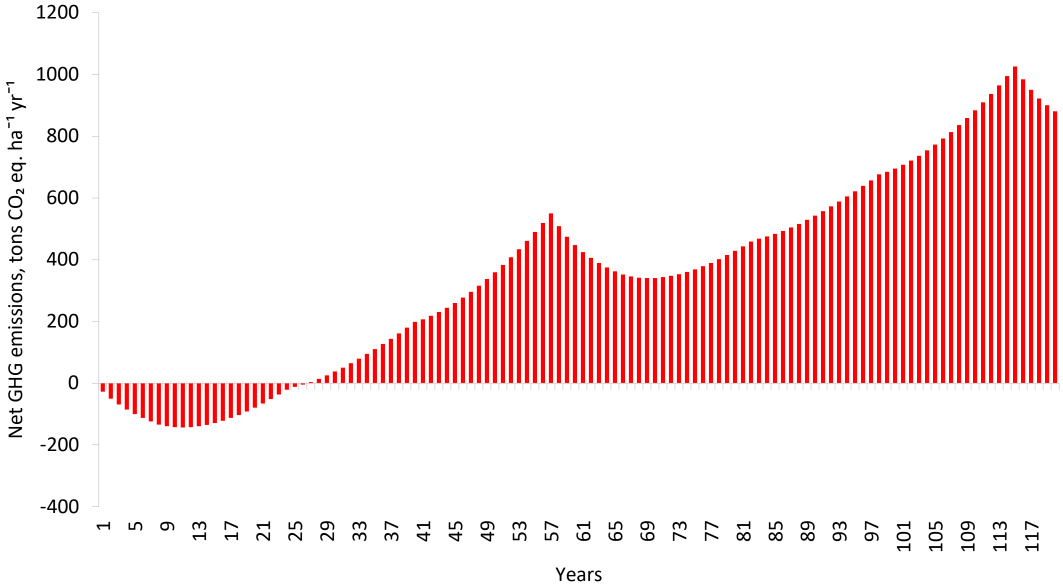

Figure 3: Cumulative GHG emission reduction in case of afforestation.

5. References

1. Ahtikoski, A., & Hökkä, H. (2019). Intensive forest management—Does it pay off financially on drained peatlands? *Canadian Journal of Forest Research*, *49*(9), 1101–1113. https://doi.org/10.1139/cjfr-2019-0007
2. Bardule, A., Lazdins, A., Sarkanabols, T., & Lazdina, D. (2016). Fertilized short rotation plantations of hybrid Aspen (Populus tremuloides Michx. × Populus tremula L.) for energy wood or mitigation of GHG emissions. *Engineering for Rural Development*, *2016-January*, 248–255. Scopus.
3. Conant, R. T., Cerri, C. E. P., Osborne, B. B., & Paustian, K. (2017). Grassland management impacts on soil carbon stocks: A new synthesis. *Ecological Applications*, *27*(2), 662–668. https://doi.org/10.1002/eap.1473
4. Conant, R. T., Paustian, K., & Elliott, E. T. (2001). Grassland Management and Conversion into Grassland: Effects on Soil Carbon. *Ecological Applications*, *11*(2), 343–355. https://doi.org/10.1890/1051-0761(2001)011[0343:GMACIG]2.0.CO;2
5. Donis, J., Šņepsts, G., Zdors, L., & Šēnhofs, R. (2013). *Mežaudžu augšanas gaitas un pieauguma noteikšana izmantojot pārmērītos meža statistiskās inventarizācijas datus* (5.5.-5.1/000t/101/11/13; p. 73). LVMI Silava.
6. Eggleston, S., Buendia, L., Miwa, K., Ngara, T., & Kiyoto, T. (Eds.). (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Agriculture, Forestry and Other Land Use. In *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (Vol. 4, p. 678). Institute for Global Environmental Strategies (IGES).
7. Havas, P., & Kubin, E. (1983). Structure, growth and organic matter content in the vegetation cover of an old spruce forest in Northern Finland. *Annales Botanici Fennici*, *20*(2), 115–149.
8. Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Fukuda, M., Troxler, T., & Jamsranjav, B. (2013). *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (p. 354). IPCC. http://www.ipcc-nggip.iges.or.jp/public/wetlands/pdf/Wetlands_Supplement_Entire_Report.pdf
9. Hökkä, H., Repola, J., & Moilanen, M. (2012). Modelling volume growth response of young Scots pine (*Pinus sylvetris*) stands to N, P, and K fertilization in drained peatland sites in Finland. *Canadian Journal of Forest Research*, *42*(7), 1359–1370. https://doi.org/10.1139/x2012-086
10. Huotari, N., Tillman-Sutela, E., Moilanen, M., & Laiho, R. (2015). Recycling of ash – For the good of the environment? *Forest Ecology and Management*, *348*, 226–240. https://doi.org/10.1016/j.foreco.2015.03.008
11. Karki, S., Elsgaard, L., Audet, J., & Lærke, P. E. (2014). Mitigation of greenhouse gas emissions from reed canary grass in paludiculture: Effect of groundwater level. *Plant and Soil*, *383*(1–2), 217–230. https://doi.org/10.1007/s11104-014-2164-z
12. Kekkonen, H., Ojanen, H., Haakana, M., Latukka, A., & Regina, K. (2019). Mapping of cultivated organic soils for targeting greenhouse gas mitigation. *Carbon Management*, *10*(2), 115–126. https://doi.org/10.1080/17583004.2018.1557990
13. Korkiakoski, M., Tuovinen, J.-P., Penttilä, T., Sarkkola, S., Ojanen, P., Minkkinen, K., Rainne, J., Laurila, T., & Lohila, A. (2019). Greenhouse gas and energy fluxes in a boreal peatland forest after clear-cutting. *Biogeosciences*, *16*(19), 3703–3723. https://doi.org/10/gf963f

14. Lamlom, S. H., & Savidge, R. A. (2003). A reassessment of carbon content in wood: Variation within and between 41 North American species. *Biomass and Bioenergy*, *25*(4), 381–388. https://doi.org/10.1016/S0961-9534(03)00033-3
15. Lazdiņa, D., Krīgere, I., Dreimanis, I., Kalniņa, L., & Lazdiņš, A. (2019). A type of peatland recultivation: Reforesting. *Sustainable and Responsible Management and Re-Use of Degraded Peatlands in Latvia*, 76–78.
16. Lazdiņš, A., Šņepsts, G., Petaja, G., & Kārkliņa, I. (2019). Verification of applicability of forest growth model AGM in elaboration of forestry projections for National forest reference level. *Rural Development*, 289–294. https://doi.org/10.15544/RD.2019.065
17. Liepiņš, J., Lazdiņš, A., & Liepiņš, K. (2017). Equations for estimating above- and belowground biomass of Norway spruce, Scots pine, birch spp. And European aspen in Latvia. *Scandinavian Journal of Forest Research*, 1–43. https://doi.org/10.1080/02827581.2017.1337923
18. Liepiņš, J., Liepiņš, K., & Lazdiņš, A. (2021). Equations for estimating the above- and belowground biomass of grey alder (Alnus incana (L.) Moench.) and common alder (Alnus glutinosa L.) in Latvia. *Scandinavian Journal of Forest Research*, *0*(0), 1–12. https://doi.org/10.1080/02827581.2021.1937696
19. Mälkönen, E. (1974). *Annual primary production and nutrient cycle in some scots pine stands*. [s.n.].
20. Ministry of Environmental Protection and Regional Development. (2021). *Latvia's National Inventory Report Submission under UNFCCC and the Kyoto protocol Common Reporting Formats (CRF) 1990 – 2019* (p. 545). Ministry of Environmental Protection and Regional Development of the Republic of Latvia. https://unfccc.int/documents/271530
21. Muukkonen, P. (2006). Forest inventory-based large-scale forest biomass and carbon budget assessment: New enhanced methods and use of remote sensing for verification. *Dissertationes Forestales*, *2006*(30). https://doi.org/10.14214/df.30
22. Muukkonen, P., Mäkipää, R., Laiho, R., Minkkinen, K., Vasander, H., & Finér, L. (2006). Relationship between biomass and percentage cover in understorey vegetation of boreal coniferous forests. *Silva Fennica*, *40*(2). https://doi.org/10.14214/sf.340
23. Neumann, M., Ukonmaanaho, L., Johnson, J., Benham, S., Vesterdal, L., Novotný, R., Verstraeten, A., Lundin, L., Thimonier, A., Michopoulos, P., & Hasenauer, H. (2018). Quantifying Carbon and Nutrient Input From Litterfall in European Forests Using Field Observations and Modeling. *Global Biogeochemical Cycles*, *32*(5), 784–798. https://doi.org/10/gdjx6j
24. Nieminen, M., Piirainen, S., Sikström, U., Löfgren, S., Marttila, H., Sarkkola, S., Laurén, A., & Finér, L. (2018). Ditch network maintenance in peat-dominated boreal forests: Review and analysis of water quality management options. *Ambio*, *47*(5), 535–545. https://doi.org/10/gdcctq
25. Norberg, L. (2017). *Greenhouse Gas Emissions from Cultivated Organic Soils* [Doctoral thesis, Swedish University of Agricultural Sciences]. https://pub.epsilon.slu.se/14284/1/norberg_l_170427.pdf
26. Ojanen, P., & Minkkinen, K. (n.d.). Rewetting offers rapid climate benefits for tropical and agricultural peatlands but not for forestry-drained peatlands. *Global Biogeochemical Cycles*, *n/a*(n/a), e2019GB006503. https://doi.org/10.1029/2019GB006503

27. Ojanen, P., Penttilä, T., Tolvanen, A., Hotanen, J.-P., Saarimaa, M., Nousiainen, H., & Minkkinen, K. (2019). Long-term effect of fertilization on the greenhouse gas exchange of low-productive peatland forests. *Forest Ecology and Management*, *432*, 786–798. https://doi.org/10.1016/j.foreco.2018.10.015
28. Palviainen, M., Finér, L., Mannerkoski, H., Piirainen, S., & Starr, M. (2005). Responses of ground vegetation species to clear-cutting in a boreal forest: Aboveground biomass and nutrient contents during the first 7 years. *Ecological Research*, *20*(6), 652–660. https://doi.org/10.1007/s11284-005-0078-1
29. Paquel, K., Bowyer, C., Allen, B., Nesbit, M., Martineau, H., Lesschen, J. P., & Arets, E. (2017). *Analysis of LULUCF actions in EU Member States as reported under Art. 10 of the LULUCF Decision* (p. 163) [Final study]. DG CLIMA of the European Commission. https://ieep.eu/uploads/articles/attachments/50d55380-e29d-4e41-9a96-f1d011328828/Art%2010%20study%20final%200108%20clean.pdf?v=63687224233
30. Pardon, P., Reubens, B., Reheul, D., Mertens, J., De Frenne, P., Coussement, T., Janssens, P., & Verheyen, K. (2017). Trees increase soil organic carbon and nutrient availability in temperate agroforestry systems. *Agriculture, Ecosystems & Environment*, *247*, 98–111. https://doi.org/10.1016/j.agee.2017.06.018
31. Priede, A., & Gancone, A. (Eds.). (2019). *Sustainable and responsible after-use of peat extraction areas*. Baltijas Krasti.
32. Renou-Wilson, F., Müller, C., & Wilson, D. (2016). *Vulnerability of drained and rewetted organic soils to climate change impacts and associated adaptation options*. *18*, EPSC2016-11485.
33. Renou-Wilson, F., Wilson, D., & Müller, C. (2012). Methane Emissions From Organic Soils Under Grassland: Impacts of Rewetting. *Proceedings of the 14th International Peat Congress*, 6.
34. Sarkkola, S., Hökkä, H., Koivusalo, H., Nieminen, M., Ahti, E., Päivänen, J., & Laine, J. (2010). Role of tree stand evapotranspiration in maintaining satisfactory drainage conditions in drained peatlands. *Canadian Journal of Forest Research*, *40*(8), 1485–1496. https://doi.org/10.1139/X10-084
35. Schoeneberger, M., Bentrup, G., Gooijer, H. de, Soolanayakanahally, R., Sauer, T., Brandle, J., Zhou, X., & Current, D. (2012). Branching out: Agroforestry as a climate change mitigation and adaptation tool for agriculture. *Journal of Soil and Water Conservation*, *67*(5), 128A-136A. https://doi.org/10.2489/jswc.67.5.128A
36. Šņepsts, G., Kārkliņa, I., Lupiķis, A., Butlers, A., Bārdule, A., & Lazdiņš, A. (2018). *AGM model description* (Draft No. 2018-01–1; Elaboration of Forest Reference Level for Latvia for the Period between 2021 and 2025, p. 98). LSFRI Silava. https://drive.google.com/open?id=1VeylfH2F8angICoU1QfnUGPwBI29ezBX
37. Wang, Y., Lehtomäki, M., Liang, X., Pyörälä, J., Kukko, A., Jaakkola, A., Liu, J., Feng, Z., Chen, R., & Hyyppä, J. (2019). Is field-measured tree height as reliable as believed – A comparison study of tree height estimates from field measurement, airborne laser scanning and terrestrial laser scanning in a boreal forest. *ISPRS Journal of Photogrammetry and Remote Sensing*, *147*, 132–145. https://doi.org/10.1016/j.isprsjprs.2018.11.008
38. Yuan, Z. Y., & Chen, H. Y. H. (2012). A global analysis of fine root production as affected by soil nitrogen and phosphorus. *Proceedings of the Royal Society B: Biological Sciences*, *279*(1743), 3796–3802. https://doi.org/10.1098/rspb.2012.0955

Annex 1 Climate change mitigation measures evaluated by the project

6. CLIMATE CHANGE MITIGATION ACTIONS IN FOREST LAND

Climate change mitigation in forests with organic soils is not straightforward. Forestry affects the environment in many different ways, depending on the type of forestry, the initial state of the forest and the climate. In general, forest management practices that increase carbon sequestration include:

- afforestation, reforestation and forest restoration;
- increase of tree cover through agroforestry, urban forestry and tree planting in rural landscapes;
- enhancement of forest carbon stocks (in both, biomass and soils) and sequestration capacity through the modification of forestry management practices.

High ground water tables (GWT) are beneficial for maintaining the carbon stocks in organic soil. Over-drainage should always be avoided. Although deepening the water table increases productivity, in Finland it is not necessary after the tree stand volume has exceeded 100–150 cubic metres per hectare (Sarkkola et al., 2010). After this threshold has been reached, the tree stand itself, through efficient transpiration, maintains sufficient drainage. In Latvia growing stock on peat soils

Drainage of forests on organic soils often leads to carbon dioxide (CO_2) net emission from soil due to loss of peat. This emission can be compensated for by the increased tree growth. However, many drained peatlands have low tree growth due to nutrient limitations. Tree growth at these peatlands can be effectively increased by fertilization, but fertilization has been also found to increase decomposition rates. Ojanen et al. (2019) in the study in Finland concluded that fertilization of low-productive peatland forests has potential for climate change mitigation in the decadal time scale. The study revealed that the great increase in productivity due to fertilization leads to a long-term increase in tree stand CO_2 sink that clearly exceeds the increase in soil CO_2 net emissions. The effect of fertilization on CH_4 emissions was generally negligible. CH_4 emissions from ditches would also be reduced if ditches were cleaned in addition to fertilization. While fertilization may increase N mineralization through enhanced decomposition, also net primary production increases leading to increased N demand. Thus, fertilization does not seem to induce a risk of N_2O emissions (Ojanen et al., 2019).

In Finland, main attention has so far focused on the regulation of GWT levels, due to the identified contribution of deep drainage to increased CO_2 emissions. The working hypothesis has been put forward that taking advantage of the biological drainage of the tree stand through continuous-cover management, and simultaneously shifting from regular DNM to maintaining only a limited proportion of the ditches, based on catchment-based evaluation, might reduce soil emissions. This is based on an idea that in such management, the GWT remains at a moderate or shallow-drained level (30 cm below the soil surface as in IPCC 2014), which reduces CO_2 emissions but still prevents CH_4 emissions, while being the minimum requirement for sustained forest growth (Sarkkola et al., 2010). Research on such management has started in 2016, but so far there are no published results. One challenge is that a harvesting operation, such as realizing the shift into continuous-cover management, always results in a disturbance in the soil and thus, reduction in the emissions may emerge only after the disturbance impact has passed. In Latvia according to National coniferous forest inventory growing stock in forests with drained organic soils can reach 800 m^3 ha^{-1}. In birch stands with drained nutrient-rich soils growing stock in average is 33% bigger than in forests with wet soils, in spruce stands this difference is 75%. Pine is uncommon in nutrient-rich non-drained soils.

Another option currently considered and studied is replacing the maintenance of drainage systems with fertilization by wood ash. The idea behind this is that the reduced tree growth rate under moderate or shallow-drained GWT may rather be due to low nutrient availability in the limited oxic soil layer than the wetness as such. Wood ash increases tree stand carbon sequestration and tree litter inputs to the soil, both being beneficial for the site carbon balance. If simultaneously the decomposition processes in the soil are not accelerated to the relatively high GWT, CCM is achieved.

6.1. Conventional afforestation considering shorter rotation (LVC302)

<table>
<tr><td>Short description of the action</td><td colspan="3">Afforestation is restoration on ecosystem on deforested lands and nutrient-rich bogs and in spite of potentially negative impact of species closely associated with artificial landscapes (cropland and grassland) afforestation contributes to formation of semi-natural forest land dominant ecosystems typical for Latvia. Efficient use of abandoned farmlands which do not produce any added value contributes to social and economic sustainability.</td></tr>
<tr><td>CCM impact</td><td colspan="3">Values typical for the highest fertility classes can be used in calculation; however, the afforestation period depends from quality of soil preparation, planting material and early tending. The highest uncertainty of the impact of afforestation on GHG emissions is characteristic for the first 2 decades after afforestation. Tier 2 methods can be used to estimate impact on soil carbon stock change and GHG emissions. The net GHG reduction potential in case of 70 years long rotation is 1855 tons CO_2 eq ha^{-1} (26 tonnes CO_2 ha^{-1} yr^{-1}). The net GHG reduction potential in case of 40 years long rotation is 1218 tonnes CO_2 eq ha^{-1} (30 tonnes CO_2 ha^{-1} yr^{-1}). Actual GHG emission reduction potential may be about twice smaller because the GHG emissions from soil in cropland in grassland can be overestimated in Temperate climate zone.</td></tr>
<tr><td>Area characteristics</td><td colspan="3">Nutrient- rich organic soil, peat layer sickness at least 30cm, groundwater at least 30 cm during the growing season.</td></tr>
<tr><td>Any associated risks or potential implementation obstacles</td><td colspan="3">Afforestation may compete with requirement to retain certain area of grasslands and rewetting initiatives. Production of planting material appropriate to organic soils requires investments in forest nurseries, similarly, soil scarification requires investments in machinery and workforce hampering quick implementation of the measures.</td></tr>
<tr><td rowspan="5">Costs and benefits associated with implementation of the action</td><td rowspan="2">Cost/benefit position</td><td colspan="2">Costs (“+”)/benefits (“-”), EUR ha^{-1}</td></tr>
<tr><td>First floor year</td><td>Next years</td></tr>
<tr><td>Investment</td><td>1500</td><td>300</td></tr>
<tr><td>Management costs</td><td>-</td><td>900</td></tr>
<tr><td>Income</td><td>-</td><td>8000</td></tr>
<tr><td>CCM potential</td><td colspan="3">Measure has long term impact; for conventional management systems for living and dead wood, litter and HWP it is 71-91 years according to the age based rotation lengths, for intensified plantation forest scenario it is 40-50 years. Impact on soil depends from carbon stock in organic soil, respectively it depends from carbon stock in soil at steady state and difference in decomposition rate. Two alternatives are evaluated in the project – intensified and extensified coniferous forests. The area of organic soils considered in the calculation is 152 kha. Use of conventional management systems for spruce or pine would lead to increase of CO_2 removals and reduction of GHG emissions by 79 mill. tons CO_2 in all carbon pools during 20 years period. Intensified management and shortening of rotation would lead to 90 mill. tons CO_2 removals during 20 years period. It should be noted that GHG emissions from soil in cropland and grassland may be overestimated now, therefore the emission reduction will be smaller. GHG emissions from soil in nutrient-rich organic soils in forest land can also be smaller than the estimated emission rates, which will also affect GHG emission reduction rate.</td></tr>
</table>

6.2. Paludiculture – afforestation of grassland with black alder and birch (LVC303)

Short description of the action	Planting trees or enhancing of natural afforestation by scarification of soil. Tree species tolerant to periodic flooding, e.g. birch or alder should be used. Mounding is recommended as soil scarification method. Duration of the impact of the measure is at least one full rotation of trees; further reduction or increase of GHG emissions

	depends from management practices applied to the next generation of trees. Impact on soil GHG emissions is continuous, however the "sign" of the impact and the scale is not yet evaluated. There is significant probability that rewetting (if it is not already done) can increase soil GHG emissions.		
CCM impact	Quantitative impact of this measure is not yet estimated in Latvia due to lack of reliable activity data and soil emission factors. In case of planting birch net GHG reduction equals to 2.5 tons CO_2 eq. ha^{-1} yr^{-1} during 120 years period.		
Area characteristics	Nutrient- rich organic soil, peat layer sickness at least 30cm, groundwater at least 30 cm during the growing season		
Any associated risks or potential implementation obstacles	Management risks due to floods significantly affects the net reduction of GHG emissions in forested paludicultures. Significant increase of emissions may be also associated with soils due to seasonal fluctuations of groundwater level.		
Costs and benefits associated with implementation of the action	**Cost/benefit position**	**Costs ("+")/benefits ("-"), EUR ha^{-1}**	
		First floor year	**Next years**
	Investment	2000	-
	Management costs	-	900
	Income	-	6000
CCM potential	Not estimated yet. Due to high risk of natural disturbances this measure is hardly predictable and can be recommended in areas, where conventional afforestation methods becomes expensive due to investments in drainage systems or to ensure implementation of the nature conservation targets,		

6.3. Continuous forest cover as a forest regeneration method in spruce stands (LVC308)

Short description of the action	The scope of the measure is to replace clear-felling with repeated selective felling and formation of uneven age stands. The effect is based on assumption that continuous forest coverage avoids increase of groundwater level and CH_4 emissions from soil. The measure is applicable in management of shade-tolerant species, in Latvia it is only spruce.		
CCM impact	CCM impact is not estimated and proved yet. However, the method has been included in national guidelines for good forest management in Finland. The method should be treated equally with conventional management in the revised support scheme that is under evaluation currently (Korkiakoski et al., 2019; Nieminen et al., 2018; Ojanen & Minkkinen, n.d.). Duration of impact is not verified yet, can be considered as long term in case of strip cleaning and short term in case of selective harvest, because artificial forest regeneration is possible only in strips. Negative effect can be associated with distribution of root rot and other forest pests negatively affecting resilience of ecosystems; however no scientific verification is done.		
Area characteristics	Nutrient- rich organic soil, peat layer sickness at least 30cm, groundwater at least 30 cm during the growing season		
Any associated risks or potential implementation obstacles	Current experience in commercial thinning demonstrates significant increase of mortality in spruce stands after thinning sooner or later leading to salvage logging and regeneration of the stand. However there should be potential of strip harvesting in pine stands with following artificial regeneration with pine or birch. Area of clearfellings in Latvia is much smaller than in Finland, therefore, the effect might be much smaller than expected in Latvia, since in small felling site surrounding stands can compensate reduction of evapotranspiration in the felling site. Selective felling considerably increase harvest costs reducing competitiveness of wood deliveries from organic soils and limits possibility to invest in forest regeneration.		
Costs and benefits associated with implementation of the action	**Cost/benefit position**	**Costs ("+")/benefits ("-"), EUR ha^{-1}**	
		First floor year	**Next years**
	Investment	-	-
	Management costs	-	-

	Income[5]	3000	6000
CCM potential	The applicability of the measure is not validated in Baltic states. Up to 1.5 million hectares can be subjected to this measure in Finland. The measure cannot be recommended in Latvia.		

[5] Potential incomes due to extraction of currently growing trees as stumpage price.

38.1 Strip harvesting in pine stands (LVC313)

<table>
<tr><td>Short description of the action</td><td colspan="3">Actually this measure means reduction of area clear-felling sites by creating of small openings sufficient for regeneration of forest or extraction of long strips (20 to 40 m wide) following with strips of trees. This measure is applicable in forests dominant by tree species, which can’t regenerate under canopy of other species (the most of tree species in Latvia except spruce). The measure is aimed to avoid increase of groundwater level and CH_4 emissions after harvesting.</td></tr>
<tr><td>CCM impact</td><td colspan="3">Retaining of low groundwater level ensures that CH_4 emissions are not increasing periodically, while CO_2 emissions from soil remains at initial level and surrounding trees ensures substitution of carbon stock in litter and soil during regeneration of openings or strips.</td></tr>
<tr><td>Area characteristics</td><td colspan="3">Nutrient- rich organic soil, peat layer sickness at least 30cm, groundwater at least 30 cm during the growing season.</td></tr>
<tr><td>Any associated risks or potential implementation obstacles</td><td colspan="3">Smaller felling sites increase harvesting and forest regeneration costs and may have negative effect on surrounding stands due to root damages. Smaller openings also increase areas affected by the side effect, where forest regeneration is problematic due to shading of young trees and competition for nutrients.</td></tr>
<tr><td rowspan="5">Costs and benefits associated with implementation of the action</td><td rowspan="2">Cost/benefit position</td><td colspan="2">Costs (“+”)/benefits (“-”), EUR ha^{-1}</td></tr>
<tr><td>First floor year</td><td>Next years</td></tr>
<tr><td>Investment</td><td>-</td><td>-</td></tr>
<tr><td>Management costs</td><td>-</td><td>-</td></tr>
<tr><td>Income[6]</td><td>3000</td><td>6000</td></tr>
<tr><td>CCM potential</td><td colspan="3">The CCM potential is not estimated yet. The threshold values of area of clear-felling sites affected by the increase of groundwater level is not estimated, therefore the measure cannot be recommended for implementation without further investigation.</td></tr>
</table>

6.4. Semi-natural regeneration of felling site with grey alder without reconstruction of drainage systems (LVC309)

<table>
<tr><td>Short description of the action</td><td colspan="3">Grey and black alder, as well as birch, are tree species with the highest level of tolerance to periodic flooding while retaining high productivity by planting trees on mounds and improvement of surface drainage to avoid losses due to natural disturbances caused by periodic increase of groundwater level. Planting of trees on mounds also reduces duration of forest regeneration period when carbon losses significantly exceeds removals.</td></tr>
<tr><td>CCM impact</td><td colspan="3">The CCM effect is associated with increase of CO_2 removals in living biomass and other carbon pools including harvested wood products (HWP) due to faster growth. Mounding and shallow drainage furrows ensures that upper soil layers are continuously aerated thus avoiding CH_4 emissions. However, effect of the measure is not scientifically proved yet. Assuming that growth rate after implementation of the measure changes from values typical for wet forests to values characteristic in drained soils, the net emission reduction reach 9,9 tons CO_2 eq. ha^{-1} yr^{-1} during 120 years period; however, this effect is diminished by natural disturbances and limitations in local conditions.</td></tr>
<tr><td>Area characteristics</td><td colspan="3">Lower bog peat soil, peat layer thickness at least 30 cm, during the groundwater vegetation season higher than 30 cm, the dominant species black alder or birch, stand age or diameter of stand trees has reached the limit values specified for regeneration felling.</td></tr>
<tr><td>Any associated risks or potential implementation obstacles</td><td colspan="3">Natural disturbances (periodic increase of groundwater level) may limit or completely diminish climate change mitigation effect and result in significant economic losses. Improvement of water regime might be problematic in many cases due to inappropriate terrain.</td></tr>
<tr><td rowspan="2">Costs and benefits associated with</td><td rowspan="2">Cost/benefit position</td><td colspan="2">Costs (“+”)/benefits (“-”), EUR ha^{-1}</td></tr>
<tr><td>First floor year</td><td>Next years</td></tr>
</table>

6 Potential incomes due to extraction of currently growing trees as stumpage price.

implementation of the action	Investment[7]	1500	300
	Management costs	-	900
	Income	-	8000
CCM potential	CCM potential is not estimated yet, additional CO_2 removals may reach 20% or more depending from local conditions and possibilities to improve water regime.		

6.5. Application of wood ash after commercial thinning in spruce stands (LVC307)

Short description of the action	Complex forest management measure – wood ash recycling in drained organic soils. Similarly to forest fertilization with mineral fertilizers this measure integrates application of wood ash, pre-commercial thinning, commercial thinning and regenerative felling and, particularly, maintenance of drainage systems. Wood ash can be applied 10-15 years before commercial thinning or regenerative felling. Respectively it can be done once per rotation (before regenerative felling) or several times (2-4) per rotation applying wood ash right after thinning. Strip roads are mandatory necessary for all types of fertilization, therefore permanent network of strip-roads is necessary. In combination with more intensive and regular thinning fertilization can double CO2 removals in forest lands. Wood ash has easily accessible short term and uncertain long term impact.		
CCM impact	Application of wood ash in forests with drained soils, specifically, spruce forests reduces GHG emissions by 1.7 tons CO_2 eq. ha^{-1} yr^{-1} (204 tons CO_2 eq. ha^{-1} yr^{-1}). The impact is ensured by additional increment in living biomass to to increase of reserves of potassium, phosphorus and other nutrients in soil. Additional increment is also associated with higher level of evapotranspiration and reduction of groundwater level resulting with smaller CH_4 emissions. However, this effect is not yet estimated. Fertilization with wood ash instead of ditch network maintenance is accepted form of management in Finland. Is expected to be profitable and cost-effective for the forest owner (Ahtikoski & Hökkä, 2019; Hökkä et al., 2012; Huotari et al., 2015).		
Area characteristics	Nutrient- rich organic soil, peat layer sickness at least 30 cm, groundwater at least 30 cm during the growing season.		
Any associated risks or potential implementation obstacles	Wood ash may not be efficient in areas, where limited resources of nitrogen are prohibiting of forest growth. It may be a case in nutrient poor soils. Spreading of wood ash may be complicated in soils with low bearing capacity and improperly implemented can result in soil damages and increase of natural disturbances.		
Costs and benefits associated with implementation of the action	**Cost/benefit position**	**Costs ("+")/benefits ("-"), EUR ha^{-1}**	
		First floor year	**Next years**
	Investment[8]	120	-
	Management costs	-	-
	Income[9]	-	420
CCM potential	The effect of this measure may reach more than 1 mill. tons CO_2 eq. yr^{-1} only in Latvia, if wood ash is applied in peatlands.		

6.6. Forest regeneration (coniferous trees) in naturally wet sites (LVC312)

Short description of the action	Mounding, improvement of water regime and use of high quality planting material ensures increase of CO_2 removals in living biomass in forests with naturally wet organic soils, where natural forest regeneration methods results in low quality stands.
CCM impact	The climate change mitigation effect in optimal conditions reach 5.8 tons CO_2 eq. ha^{-1} yr^{-1} (694 tons CO_2 eq. ha^{-1} in 120 years period). This estimate considers reduction of carbon losses and GHG emissions from soil and additional removals in living biomass due to improvement of water regime and shorter forest regeneration period.

7 Additional forest regeneration costs comparing natural and artificial regeneration.
8 Spreading of wood ash.
9 Stumpage price of additional increment.

Area characteristics	Nutrient-rich organic soil, peat layer sickness at least 30 cm, groundwater above 30 cm during the growing season		
Any associated risks or potential implementation obstacles	Natural disturbances may diminish effect of the measure and result in economic losses. Local terrain conditions may not be favourable to improve water regime, therefore, CH_4 emissions remains high. Many areas, where the measure can be implemented, are subject of different management restrictions; therefore, the real potential is significantly smaller than the theoretical estimates.		
Costs and benefits associated with implementation of the action	**Cost/benefit position**	**Costs ("+")/benefits ("-"), EUR ha⁻¹**	
		First floor year	**Next years**
	Investment	1500	300
	Management costs	-	900
	Income	-	8000
CCM potential	CCM potential is not estimated since activity data (groundwater level maps) are not developed to the level necessary to model emissions under different management regimes. The total emission reduction potential in Latvia is about 1 mill. tons CO_2 eq. yr^{-1}.		

6.7. Riparian buffer zone in forest land planted with black alder (LVC311)

Short description of the action	Management of riparian zones is aimed to utilize nutrients approaching to the water bodies from surrounding forest stands and agricultural soils. Better soil scarification methods, planting material and improved water regime by establishment of network of shallow furrows increases capability of plants to utilize nutrients and exceeding soil water. Managed buffer zones are bends of trees around water streams.		
CCM impact	Climate change mitigation is associated with CO_2 removals in living biomass and reduction of CH_4 emissions from soil. The net impact is not yet estimated however, significant improvement of stand composition and growth rate would result in net reduction of GHG emissions by 1.2 tons CO_2 eq. ha^{-1} yr^{-1} (148 tons CO_2 eq. ha^{-1} in 120 years period). The removals of CO_2 in living biomass is compensated partly by increased carbon losses from soil.		
Area characteristics	Nutrient-rich organic soil, peat layer sickness at least 30 cm, groundwater above 30 cm during the growing season.		
Any associated risks or potential implementation obstacles	Management of buffer zones is restricted by legal acts prohibiting clearfellings and other management activities around water streams, therefore trees can be planted at certain distance from the water streams significantly decreasing areas suitable for this measure.		
Costs and benefits associated with implementation of the action	**Cost/benefit position**	**Costs ("+")/benefits ("-"), EUR ha⁻¹**	
		First floor year	**Next years**
	Investment	1500	300
	Management costs	-	900
	Income	-	8000
CCM potential	CCM potential is not estimated yet due to limited information on CH_4 emissions and area potentially suitable for establishment of buffer zones.		

7. CLIMATE CHANGE MITIGATION ACTIONS IN AGRICULTURE LAND

Paquel et al. (2017) concluded that the main option to reduce GHG emissions from organic soils in Netherlands is to elevate the groundwater level in order to reduce the oxidation of the organic material. This can be done either by technical measures or through increasing the water level and extensification of the land use. One of the technical options is the use of submerged drainage, which still allows for agricultural activities, but reduces emissions. A first analysis for the Netherlands shows that the use of submerged drains and raising water levels for grassland areas with deep drainage could reduce emissions from organic soils by 1-2 mill. tons CO_2 per year, which would be a reduction of about 35%. Extrapolating this reduction to all grassland under organic soils in the EU would lead to a potential mitigation of about 13 mill. tons CO_2 per year. In addition N_2O emissions from cultivated organic soils, which are reported under the sector Agriculture, will be reduced as well if measures are taken. These emissions are currently reported at 13 mill. tons CO_2-eq per year (EU NIR 2017) and could be reduced by 4.7 mill. tons CO_2-eq (36%, which is the same reduction percentage as for CO_2). Consequently a total mitigation potential of about 30 mill. tons CO_2-eq yr^{-1} would be possible for organic soils under grassland and cropland (Paquel et al., 2017).

Kekkonen et al. (2019) within the study in Finland reported that for the fields on organic soils potentially removable from cultivation, afforestation is a viable option from a life-cycle analysis viewpoint, but the emissions of N_2O at least will continue at a rate similar to those of cultivated soils, excluding fertilization related emissions. Afforestation involves drainage as well, and as long as there is peat above the groundwater level it will be prone to decomposition. The most efficient mitigation measure in these cases can be rewetting. It runs the risk of high CH_4 emissions and high nutrient losses to watercourses, but in some cases has been found to turn agricultural sites carbon neutral or to carbon sink. With the right crop selection, it may even be possible to continue cultivation in rewetted conditions (i.e. paludiculture).

The conversion of agricultural land into nature or paludiculture (i.e. productive use of wet and rewetted peatlands) is a more effective option, but also has a larger impact and might be more appropriate in areas where land is cheaper and less intensively used. In the EU, for cropland on organic soils a land use conversion to extensive grassland or nature would be the most relevant option, as the cropland area on organic soils is relatively small, only about 1.3% of the total cropland area, whereas emissions from that land are very high. It is assumed that half of this land could be taken out of production or converted to more extensive grassland use. This could result in an emission reduction of about 12 mill. tons CO_2-eq yr^{-1} (assuming emissions are reduced by 75% after conversion). Several EU Member States consider or have already policies for the conversion of arable land on organic soils to nature or grassland, e.g. Denmark, Luxembourg, Latvia, and Germany. However, a quantification of the mitigation potential is mostly not provided. Latvia reported for instance that "conversion of 1 ha of cropland to grassland considering 5.2% share of organic soils [in Latvia] would reduce CO_2 emissions by 0.3 tonnes CO_2 ha^{-1} annually" (Paquel et al., 2017). As noted before there is no scientific approval for this assumption.

Combination of rewetting and paludiculture is pursued as a wider CO_2 mitigation option in drained organic soils. Paludiculture combines biomass production at higher water levels by using both light-weight harvesting machines and flood tolerant crop species (e.g. *Typha*, *Azolla*, *Sphagnum*, *Phragmites*, *Salix* and *Alnus*). However, information on the overall GHG balance for paludiculture is lacking. Karki et al. (2014) investigated the GHG balance of peatlands grown with reed canary grass (RCG) and rewetted to various extents. Raising the GWL to the surface decreased both the net ecosystem exchange (NEE) of CO_2 and N_2O emissions whereas CH_4 emissions increased. Total cumulative GHG emissions (for 10 months) corresponded to 0.08, 0.13, 0.61, 0.68 and 0.98 kg CO_2 eq. m^{-2} from the GWL treatments at 0, -10, -20, -30 and -40 cm below the soil surface, respectively. The results showed that a reduction in total GHG emissions can be achieved without losing the productivity of newly established RCG when GWL is maintained close to the surface (Karki et al., 2014).

In Sweden, Norberg (2017) evaluated GHG emissions from cultivated organic soils including effect of cropping system, soil type and drainage. The overall conclusion was that no specific crop can be considered as a way to mitigate climate change by reducing greenhouse gas emissions from drained cultivated peat and carbon-rich soils during the growing season. Site-specific effects were a key factor for the greenhouse gas emissions rather than the cropping system. Furthermore, there was no difference in carbon dioxide emissions between a groundwater level at 50, 75 and 100 cm below the soil surface. Only carbon dioxide emissions at near water-saturated conditions deviated significantly. In most peat soils, maximum carbon dioxide emissions occurred already at low soil water suction (0.5 m water column).

For instance, in Finland, instead of intensive food or feed production, some cultivated peatlands are in extensive use due to poor productivity or challenging cultivation conditions. Such low-yielding, thick layered peat soils in extensive use would be more useful to either be rewetted, restored or under paludiculture in order to meet the emission targets. Such plots can be found in Finland about 23,000 ha, which is approximately 1% of the total cultivated area (Kekkonen et al., 2019). By rewetting, restoring or transferring these fields to paludiculture, Finland could reduce about 10% of the emissions from cropland in the land use and land use change sector. In general, paludicultures are considered as natural ecosystems. In the long term, mire vegetation captures carbon and "stores" it in peat.

In agricultural land including organic soils, agroforestry provides for greater C sequestration than through conventional options alone while leaving the bulk of the land in agricultural production. In large parts of temperate and boreal Europe, implementation of afro-forestry remains rather limited. Besides uncertainties on the legislative and economic level, this might result from a lack of actual quantification of the ES provided and the lack of knowledge on implications of agroforestry on field management. Under temperate and boreal climatic conditions actual quantitative estimates of climate mitigation impact especially in lands on organic soils remain extremely scarce. Thus, further research and quantification is needed regarding the effect of tree presence on soil organic carbon and net GHG emissions in organic soils (Pardon et al., 2017; Schoeneberger et al., 2012).

A key component for sustaining production in grassland ecosystems is the maintenance of soil organic matter (SOM), which can be strongly influenced by management. Many management techniques intended to increase forage production may potentially increase SOM, thus sequestering atmospheric carbon. (Conant et al., 2001) reviewed studies examining the influence of improved grassland management practices and conversion into grasslands on soil C worldwide to assess the potential for C sequestration. Results from 115 studies containing over 300 data points were analysed. Management improvements included fertilization (39%), improved grazing management (24%), conversion from cultivation (15%) and native vegetation (15%), sowing of legumes (4%) and grasses (2%), earthworm introduction (1%) and irrigation (1%). Soil C content and concentration increased with improved management in 74% of the studies, and mean soil C increased with all types of improvement. Carbon sequestration rates were highest during the first 40 years after treatments began and tended to be greatest in the top 10 cm of soil. Impacts were greater in woodland and grassland biomes than in forest, desert, rain forest, or shrubland biomes. Conversion from cultivation, the introduction of earthworms, and irrigation resulted in the largest increases. Rates of C sequestration by type of improvement ranged from 0.11 to 3.04 Mg C ha^{-1} yr^{-1}, with a mean of 0.54 Mg C ha^{-1} yr^{-1} and were highly influenced by biome type and climate. Conant et al. (2001) concluded that grasslands can act as a significant carbon sink with the implementation of improved management. Also Conant et al. (2017) concluded that improved grazing management, fertilization, sowing legumes and improved grass species, irrigation, and conversion from cultivation all tend to lead to increased soil C, at rates ranging from 0.105 to more than 1 Mg C ha−1 yr−1. These are general assumptions that apply mainly to SOM in mineral soils. Further studies are necessary to specify impacts of different management approaches in grasslands on organic soils on net GHG emissions at ecosystem level in boreal and temperate cool moist climate zone at ecosystem level.

Within the study in the Republic of Ireland Renou-Wilson et al. (2012, 2016) concluded that extensive grassland over organic soil is on average, an annual source of CO_2 when drained (138-232 g C m^{-2} yr^{-1}) and a sink when rewetted (-40 g C m^{-2} yr^{-1} in the ungrazed rewetted grassland). A wet organic soils under grassland display high CH_4 emissions especially if the water is close to the surface. However, maintaining the water table at – 20 cm may be sufficient to reduce CO_2 losses from respiration while keeping CH_4 emissions low and therefore raising the water table could be used as a GHG mitigation tool in organic soils under grassland.

In Finland, as forage production as rotational grasses is classified as cropland in the GHG inventory, Finnish grasslands are mainly abandoned fields and thus there are limited possibilities to guide their management. Some abandoned fields have been successfully rewetted and restored to close to natural state.

7.1. Agroforestry – fast growing trees and grass (LVC306)

<table>
<tr><td>Short description of the action</td><td colspan="3">One of the most efficient measure in agricultural soils considering planting of trees and bushes and intensive management for HWP and solid biofuel production. During the first years after establishment the areas are used for fodder or seed production ensuring early economic benefic. Rotation period – around 20 years.</td></tr>
<tr><td>CCM impact</td><td colspan="3">Planting of poplars in grassland and continuation of fodder production for several years ensures GHG emission reduction by about 15,5 tons CO_2 eq. ha^{-1} yr^{-1} (1855 tons CO_2 eq. ha^{-1} in 120 years period). This include carbon stock change in living and dead biomass and reduction of carbon losses and GHG emissions from soil (Bardule et al., 2016; Lazdiņa et al., 2019).</td></tr>
<tr><td>Area characteristics</td><td colspan="3">Nutrient- rich organic soil, peat layer sickness at least 30cm, groundwater at least 30 cm during the growing season</td></tr>
<tr><td>Any associated risks or potential implementation obstacles</td><td colspan="3">Establishment of agroforestry systems requires considerable investments, which are not available for farmers, and even if the funding is available, planting material and relevant management services may not be accessible due to high demand. Natural disturbances may significantly limit the GHG emission reduction potential.</td></tr>
<tr><td rowspan="5">Costs and benefits associated with implementation of the action</td><td rowspan="2">Cost/benefit position</td><td colspan="2">Costs (“+”)/benefits (“-”), EUR ha^{-1}</td></tr>
<tr><td>First floor year</td><td>Next years</td></tr>
<tr><td>Investment</td><td>3000</td><td>300</td></tr>
<tr><td>Management costs</td><td>-</td><td>900</td></tr>
<tr><td>Income</td><td>-</td><td>9000</td></tr>
<tr><td>CCM potential</td><td colspan="3">Assuming that at least 50% of organic soils are transferred into agroforestry systems, only in Latvia the GHG mitigation potential 1.2 mill. tons CO_2 eq. yr^{-1}.</td></tr>
</table>

7.2. Conversion of cropland used for cereal production into grassland considering periodic ploughing (LVC301)

Short description of the action	Conversion of cropland to grassland to reduce GHG emissions from soil. The measure has continuous impact equal to time necessary to decompose exceeding organic matter in soil. In long term difference between both systems is reducing, because in both cases exceeding organic matter will be decomposed at some point and the difference is determined by N_2O and CH_4 emissions. The measure is not associated with additional cost, however income of farmers should be compensated. The measure reduces agriculture production potential; however, due to reduction of N_2O emissions provides opportunity to retain management activities in other sectors.
CCM impact	The implementation potential in Latvia is about 8.5 tonnes CO_2 eq. ha^{-1} both in agriculture and LULUCF sector. However this impact can be overestimated due to decomposition of organic matter not represented by soil maps or overestimated GHG emissions from cropland. The measure interfere with afforestation of organic soils

<table>
<tr><td></td><td colspan="3">providing significantly higher mitigation effect.</td></tr>
<tr><td>Area characteristics</td><td colspan="3">Nutrient- rich organic soil, peat layer sickness at least 30cm, groundwater at least 30 cm during the growing season</td></tr>
<tr><td>Any associated risks or potential implementation obstacles</td><td colspan="3">Implementation of the measure is associated with transfer of emissions, since production stopped in one place is moved to another. There is no warranty that the production is not moved to another organic soil or production is continued in deforested area, resulting thus in the increase of GHG emissions.</td></tr>
<tr><td rowspan="5">Costs and benefits associated with implementation of the action</td><td rowspan="2">Cost/benefit position</td><td colspan="2">Costs (“+”)/benefits (“-”), EUR ha^{-1}</td></tr>
<tr><td>First floor year</td><td>Next years</td></tr>
<tr><td>Investment</td><td>-</td><td>-</td></tr>
<tr><td>Management costs</td><td>-</td><td>-</td></tr>
<tr><td>Income</td><td>-</td><td>-</td></tr>
<tr><td>CCM potential</td><td colspan="3">About 677 ktons CO_2 eq yr^{-1} if all organic soils in cropland are transferred to grassland in Latvia.</td></tr>
</table>

7.3. Fast growing species in riparian buffer zones (LVC310)

<table>
<tr><td>Short description of the action</td><td colspan="3">Another kind of agroforestry system considering growing of 15-20 m wide bands of trees and bushes nearby the drainage systems in agricultural lands. The measure is aimed to utilize residual nutrients and water to produce biomass in cropland and intensively managed grassland.</td></tr>
<tr><td>CCM impact</td><td colspan="3">Duration of the impact depends from life-time of buffer zone. Further removals can be ensured by application of more productive crops. Organic soils are not separated in the assessment. Following to proportion of the organic soils impact of areas on organic soils can be 10-15%. Cost – benefit ratio of the measure is not estimated yet.</td></tr>
<tr><td>Area characteristics</td><td colspan="3">Nutrient- rich organic soil, peat layer sickness at least 30cm, groundwater at least 30 cm during the growing season</td></tr>
<tr><td>Any associated risks or potential implementation obstacles</td><td colspan="3">Establishment of agroforestry systems including bends of trees and bushes around water streams requires considerable investments, which are not available for farmers, and even if the funding is available, planting material and relevant management services can be limited or their cost quickly increases due to high demand. Natural disturbances may significantly limit the GHG emission reduction potential.</td></tr>
<tr><td rowspan="5">Costs and benefits associated with implementation of the action</td><td rowspan="2">Cost/benefit position</td><td colspan="2">Costs (“+”)/benefits (“-”), EUR ha^{-1}</td></tr>
<tr><td>First floor year</td><td>Next years</td></tr>
<tr><td>Investment</td><td>3000</td><td>300</td></tr>
<tr><td>Management costs</td><td>-</td><td>900</td></tr>
<tr><td>Income</td><td>-</td><td>9000</td></tr>
<tr><td>CCM potential</td><td colspan="3">According to preliminary assessment the net GHG emission reduction potential in Latvia is 0.75 mill. tons CO_2 yr^{-1}.</td></tr>
</table>

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

<table>
<tr><td>Short description of the action</td><td>Groundwater regulation systems ensures retaining of certain groundwater level, e.g. 30 cm ensuring relative low CH_4 ans CO_2 emissions from organic soils. The measure can be used both, in cropland and grassland.</td></tr>
<tr><td>CCM impact</td><td>Duration of the impact equals to period of implementation of the measure and life-time of drainage systems. Total impact of the measure is not estimated.</td></tr>
<tr><td>Area characteristics</td><td>Nutrient-rich organic soil, peat layer sickness at least 30 cm, groundwater at least 30 cm during the growing season.</td></tr>
<tr><td>Any associated risks or</td><td>Data on the emission reduction are not verified by scientific evidences therefore</td></tr>
</table>

potential implementation obstacles	climate change mitigation potential may be overestimated. The terrain conditions in the most cases are not suitable for establishment of controlled drainage systems.		
Costs and benefits associated with implementation of the action	**Cost/benefit position**	**Costs ("+")/benefits ("-"), EUR ha^{-1}**	
		First floor year	**Next years**
	Investment[10]	1200	-
	Management costs	-	-
	Income	-	-
CCM potential	Implementation potential, as well as cost-benefit ratio at a national scale is not estimated yet. No controversial impacts are known with the sustainability criteria. The measure may have adverse impact on accessibility of fields during spring and summer season; however, limited data are available on impact of different strategies in regulation of drainage systems.		

7.5. Introduction of legumes in conventional farm crop rotation (LVC304a, LVC304b)

Short description of the action	Introduction of legumes into crop rotation in farmland managed in accordance with good practice guidelines for integrated farms. Legumes are sawn in rotation with cereal crop.		
CCM impact	GHG emission reduction related to the decrease of N20 and CO2 emissions from soil. Additional biomass – carbon sequestration, reduced nitrogen - effect results from the substitution of synthetic nitrogen fertilizers by biological nitrogen fixation (Wang et al., 2019).		
Area characteristics	Nutrient- rich organic soil, peat layer sickness at least 30 cm, groundwater at least 30 cm during the growing season. Area – managed as cropland.		
Any associated risks or potential implementation obstacles	Risks: 1) farmers continue usual fertilizing practice without considering legume effect – because of the lack of knowledge; 2) GHG reduction is not reflected in National GHG inventory report because of the lack of necessary data.		
Costs and benefits associated with implementation of the action	**Cost/benefit position**	**Costs ("+")/benefits ("-"), EUR ha^{-1}**	
		First floor year	**Next years**
	Investment	-	-
	Management costs	-	-
	Income	-	-
CCM potential	From scientific literature: Increased legume share in crop rotations is recognized as climate change mitigation measure. NO3 (plus ammonium and nitrite) leaching losses would be reduced by up to 20%. There would be associated reduction in direct (up to 50%) and indirect (up to 20%) N2O emissions, and NH3 emissions (c.50%) (Newell Price, J.P., et al., 2011). Annual mitigation potentials are quantified between 0.5 and 1 t CO_2 equivalents per hectare for Great Britain through increased use of nitrogen fixation of clover and introduction of additional species (including legumes) in crop rotations (Rees, R.M., et al., 2013). National report: According to the IPCC guidelines, after introduction of legumes in crop rotation the management system in the affected fields would be changed to "High, without manure" due to increased input of organic materials and the carbon stock change factor for input will increase to 1.11. 20 years' transition period is considered in calculation of soil carbon stock changes. Implementation of the measure according to the tier 1 method will contribute to the net CO2 removals in soil –1.32 tonnes CO^2 ha^{-1} annually (26.4 tonnes CO_2 ha^{-1} in total) during 20 years' period. Carbon sequestration in soil (0-30 cm depth) after 20 years transition period would increase from 65.6t C ha^{-1} to 72.8 t C ha^{-1}.		

[10] Depends on area. Current estimate is based on 3 ha field.