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LIFE Peat Restore

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„Reduction of CO_2 emissions by restoring degraded peatlands in Northern European Lowland“

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FIRST GEST GHG BALANCE SCENARIOS

Content

I. Introduction

The EU aims to reduce greenhouse gas emissions by 40 percent until 2030 compared to 1990. Therefore conservation of peatlands must be integrated in the climate and energy policy. Especially the Baltic States as well as Poland and Germany have huge areas of peatlands, which are partly heavily degraded and which need conservation and restoration. The project area is one of the global emission Hot Spots, where the potential to save greenhouse gas emissions is exceptionally high.

Intact peatlands store about 30 percent of the global carbon on three percent of the land area, which is twice as much as all woods together. The peatland vegetation absorbs carbon dioxide from the atmosphere and stores it with the help of biological processes in the peat from a long term. Intact peatlands, especially several meters deep ones, are therefore huge stores of greenhouse gases and contribute to a long-term cooling of the atmosphere.

The LIFE Project Peat Restore aims to rewet degraded peatlands in the partner countries Estonia, Germany, Latvia, Lithuania and Poland, covering an area of 5.300 hectares to restore the function as carbon and climate sinks.

One of the main goals of the Project is the reduction of Greenhouse Gas (GHG) emissions from these degraded peatlands by rewetting and restoring the hydrological regime. To estimate and evaluate the climate effect of the restoration measures and to quantify the reduction potential of the GHG-emissions we used different scenarios based on the GEST-Approach. In this report we describe at least two main GEST-scenarios for our project sites: (1) Baseline scenario (without changes) and (2) Post Restoration scenario (after restoration measures). On the basis of the results of the GEST analysis monitoring report we could calculate the GHG-emissions for both scenarios and we could compare the climate impact of the restoration measures with the situation without any actions.

Due to the high spatial amount of forested GEST-Types, the high variability of forest inventory data, different goals related to forest restoration measures and also due to missing data in the Updated GEST-catalogue we calculated next to the baseline and post-restoration scenario two emission-scenarios for the forested GEST-Types: (1) without woods and (2) with woods.

This report presents the first results of the different scenarios and gives first information about the predicted impact of the restoration measures to the climate.

II. Methods

II.1. Calculations

For the calculation of GHG-emissions in non-forested GESTs, we used the emission data of the updated GEST-Catalogue (given in tons CO_2-equivalents * ha^{-1} * a^{-1}) and multiplied this factors by the area of each GEST. For areas for which the vegetation compostition doesn't provide a clear indication of GHG emissions, we used water table measurements as additional input to assess the GHG fluxes.

For forested GESTs we estimated the GHG-emissions (especially the CO_2-emissions) by using a combination of flux data for open unused peatlands with similar hydrological conditions and additional information about the growth rates of the wooden biomass. In this report we also calculated two GHG-estimations for each scenario (1) without and (2) with forest biomass carbon.

For the calculation of fixed carbon in living (wooden) Biomass, we used the BEF-Method (according to IPCC 2003, Equation 1):

(1) $$C = \frac{([V * D * BEF] * (1+R) * CF)}{1000}$$

whereas:

C = fixed carbon in wooden Biomass per year [t]
V = Stem volume of tree species [m^3 * ha^{-1}]
D = Basic wood density of species
BEF = Biomass expansion factor for conversion of stem biomass to above-ground tree biomass per species, also use of national forestry factors for estimation of the growth rate
R = Root:Shoot ratio
CF = Carbon fraction [IPCC 2003; Standard-Value 0,5]

The stem volume of trees depends on species, age, number of trees per area and also on the "yield level" (in forestry) and is often listed for different species in forest inventory tables. The stem volume of a single tree could also be calculated by equation 2 and multiplied by the estimated numbers of trees per hectar.

$$V = \left(\frac{DBH^2}{1000}\right) + \left(\frac{DBH^2}{1000}\right) * (h - nH) * volume\ correction\ (percent)\ per\ meter \quad (2)$$

whereas:

V = Stem volume of tree [m^3]
DBH = Minimum stem diameter in breast height (in cm; ca. 130 cm above ground; also application of the mean DBH)
H = Height of the tree (also application of the mean tree/stand height)
nH = Normal height

Some values of normal heights and the volume correction factors are given in Table II-1.

Tab.II-1: Normal Height of different tree species and volume correction factors

Tree Species	Normal Height [m]	Volume correction factor per meter [%]
Alnus spec.	27	3
Betula spec.	31	3
Picea spec.	19 + 2 * DBH (dm)	4
Pinus spec.	28	3

As far as possible we also used data from national forest inventories for the calculation.

Table II-2 and Table II-3 present some values of Biomass Expansion Factors given in the literature.

Tab.II-2: Biomass Expansion Factors (BEF), means and ranges are shown; lower values originate from younger forests or forests with a small stock; higher values originate from mature forests or forests with a higher stock

Forest Type	Minimum stem diameter in breast height	BEF (with bark) Application for stock data	BEF (with bark) Application for growth rate
Spruce/fir	0-12,5	1,3 (1,15-4,2)	1,15 (1-1,3)
Pine	0-12,5	1,3 (1,15-3,4)	1,05 (1-1,2)
Broadleaf forest	0-12,5	1,4 (1,15-3,2)	1,2 (1,1-1,3)

Tab.II-3: Selected Biomass Expansion Factors (BEF) from Swedish sites

Tree Species	BEF [constant; Mg * m^{-3}]*	BEF [age-dependent; 10-19 years]*	BEF [age-dependent; 60-69 years]*	BEF [age-dependent; > 140 years]*
Scot's Pine	0,52	0,697	0,710	0,69
Norway Spruce	0,62	0,862	0,791	0,788
Birch	0,64	0,544	0,554	0,544

* data from JALKANEN et al. (2005) & LEHTONEN et al. (2004)

Table II-4 shows selected values from wood densities of stems for different species.

Tab.II-4: Wood densities of stems

Genus	Species	Stem density
Alnus	spec.	0,45
Betula	spec.	0,51
Fraxinus	excelsior	0,57
Populus	spec.	0,35
Pinus	sylvestris	0,42
Quercus	robur	0,58
Salix	spec.	0,45
Picea	abies	0,40

Table II-5 presents selected values from Root:Shoot ratios for different vegetation types.

Tab.II-5: Root : Shoot Ratios (R) for calculation of below ground biomass (acc. IPCC 2003)

Vegetation Type	Aboveground Biomass [t * ha^{-1}]	R [Average]	Standard deviation
Conifer forest/Plantation	<50	0,46	± 0,21
	50-150	0,32	± 0,08
	>150	0,23	± 0,09
Oak forest	>75	0,35	± 0,25
Other broadleaf forest	<75	0,43	± 0,24
	75-100	0,26	± 0,1
	>150	0,24	± 0,05

II.2. Scenarios

To balancing the Greenhouse Gas (GHG) emissions of the restoration measures we have to consider at least two different scenarios: (1) the baseline scenario without any restoration measures and (2) the post-restoration scenario after the implemented restoration measures. For both scenarios we calculated the GHG emissions based on the data given in the Updated GEST-catalogue. The differences of both scenarios result in a GHG reduction potential of the considered measures. Usually we regard a certain time period of 30, 50 or 100 years for scenario GHG-estimations. In these report we compared only two scenarios based on a single annual balance and not for a certain period.

II.2.1. Estonia

II.2.1.1. Drainage-induced successions (Baseline scenario)

Long lasting (more than a century) drainage resulted in changes of the open rich fen vegetation (Fig. II-1). GEST Types at Suursoo-Leidissoo project site, except very moist calcareous meadow, are the result of drainage-induced successions that take place in different directions.

Succession from Very moist calcareous meadow (minerotrophic fen) to Wet peat moss lawn or very moist forests and shrubberies (oligotrophic) is comparable with natural mire development, but is proceeding much faster than is characteral to the natural succession.

The another pathway, stimulated by drainage is from Very moist calcareous meadow to Moist forests and shrubs (swamp forests). This succession can be natural but in our site is mainly caused or accelerated by weak drainage.

The third type of succession is going on under greatest drainage impact, where Very moist calcareous meadow (minerotrophic fen) has turned to Moist forests and shrubberies (drained peatland forests). These types are heavily drained, peat has compressed and mire vegetation disappeared.

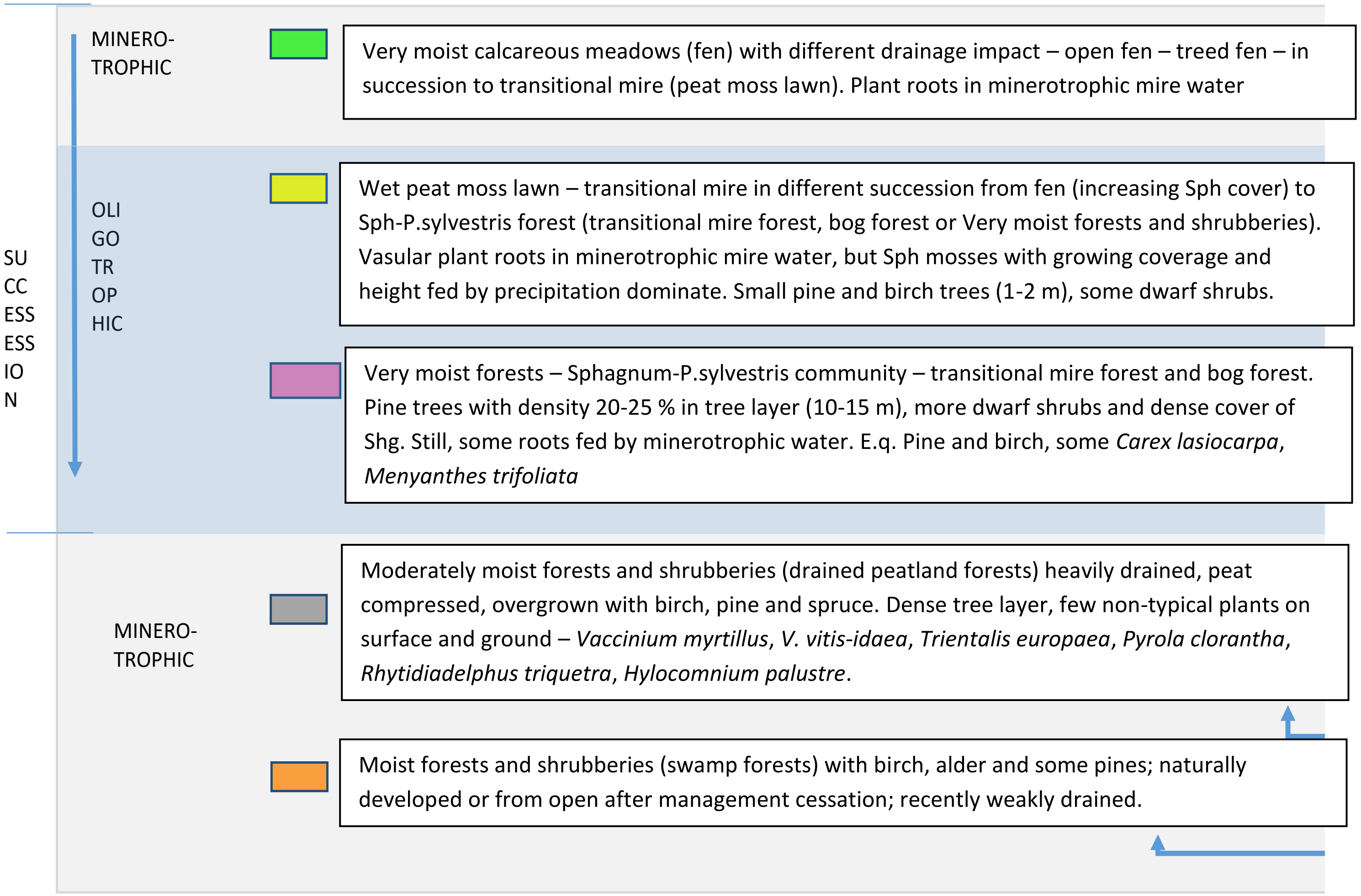


Fig.II-1: GEST-types on the Leidissoo project area and their development pathways from open fen vegetation due to the drainage-induced succession. Blue arrows show the different successional ways.

II.2.1.1. Developing the Post-restoration scenario

In developing the scenario, the peat composition, present vegetation, soil surface and the influence of drainage are taken into account. The calculations in the scenario are given for 100 years perspective (Fig.II-2). The part with dense tree layer the forests on our site is with first generation woods formed on the earlier open fen habitats up to some 50-60 years ago. After hundred years perspective the first forest generation should be replaced with the next generation. The present trees will be almost all dead and the aboveground parts decayed. Our assumption is that the overall carbon sequestration by trees of the new generation should be equal with carbon emission from the dead wood. Possibly certain part of the underground dead wood will be accumulated into the peat. At the same time surface peat will continuously decompose and CO_2 should be emitted. We assume that accumulation because of the dead roots the amount of carbon should be balanced with the rate of peat decomposition. In this case the share of forests into carbon should be near zero in 100-years perspective.

For the Very moist forests and shrubberies (both oligo- and mesotrophic) minor part of biomass, supposedly 20% (mainly belowground one) will remain in the peat. So the actual carbon sequestration in very moist forest is slightly higher and budget of the whole site is consequently slightly more negative.

First GEST GHG balance scenarios

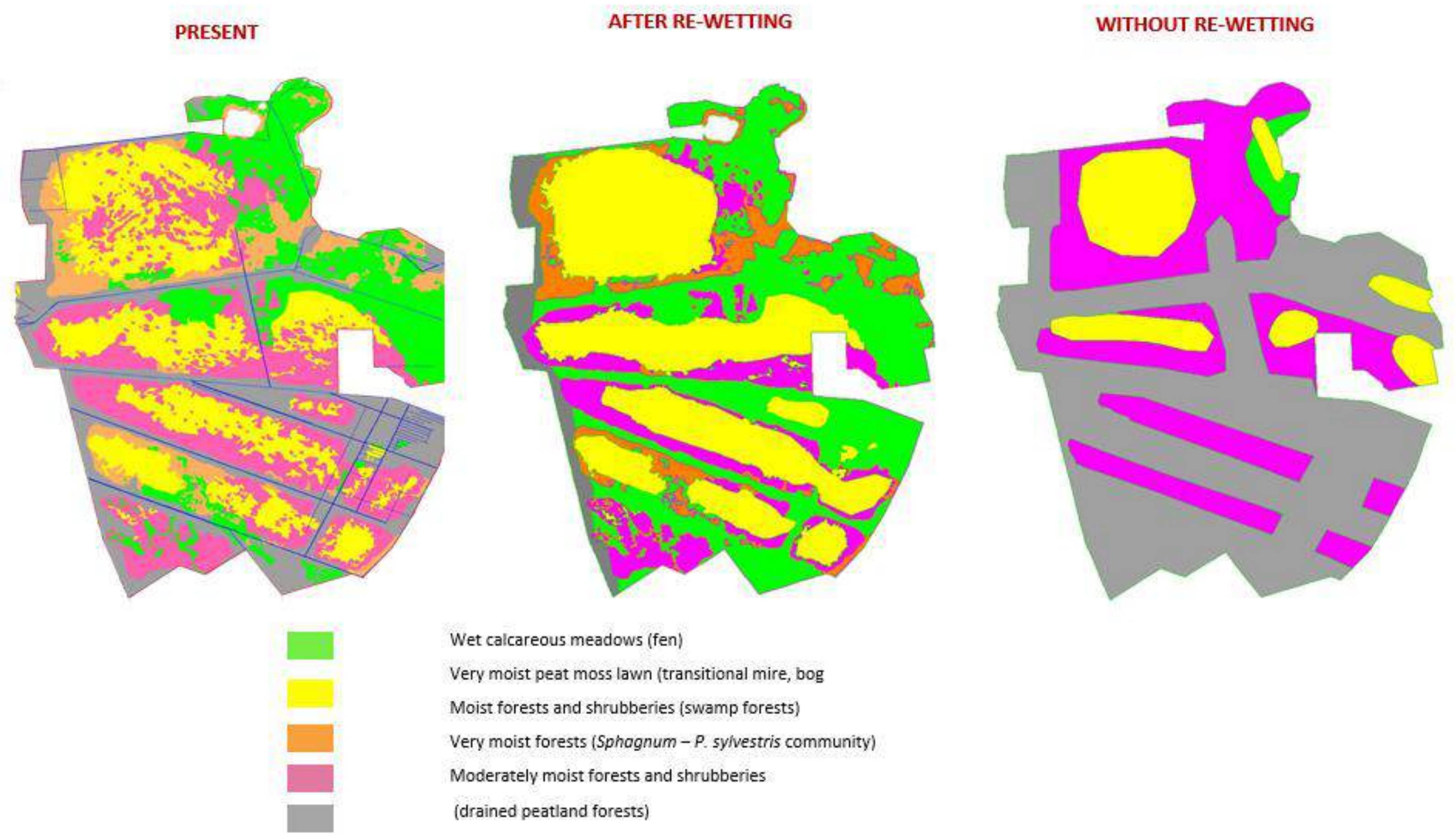


Fig. II-2: Further GEST-Types succession after present (A) if rewetted (B) and without rewetting

II.2.2. Latvia

In Latvia, there are three LIFE Peat Restore project (Project) sites – Lake Engure Nature Park, Baltezers Mire Nature Reserve and Augstroze Nature Reserve. In total, 14 GEST-Types were identified in all sites. However, only relatively small part of these protected nature territories will be directly affected by restoration actions within the Project. As a result, six GEST-types will be affected. From these, only two are expected to change to another GEST-type after rewetting and tree and shrub removal. Comparing the baseline scenario with different post-restoration scenarios, the total predicted amount of GHG emissions in Baltezers and Augstroze is significantly smaller after peatland restoration, thus reaching the Project goals. The aim in Engure site is to improve the functioning of mire ecosystem, including carbon sequestration capability, although in short term no significant changes in GHG emissions are expected.

II.2.2.1. Lake Engure Nature Park

Main Assumption

In Engure, at the end of the Project neither significant changes in GEST-types, nor in the total cover of GEST-types and in GHG emissions are expected. The assumptions of scenario include the tendency of ecosystem development observed during the last three decades and long-term climate change tendency in Latvia. The assumption on the ecosystem development tendency is based on long-term observations by the project experts in the Engure area (previous research done by PAKALNE (1994)) and studies on alkaline fen succession in the nearby areas with similar abiotic and hydrogeological conditions (LAIVINS et al. 2010; RUSINA et al. 2014). As suggested by earlier succession studies in the neighbouring areas, overgrowing with tree leads to increased cover of mesic species in ground vegetation that indicates drier conditions. In longer term, this may lead to decline or even extinction of peat-forming vegetation.

Emission Calculations

Calculations are challenging as it is a new GEST-type for the Method, **Wet calcareous Meadows, forbs**,.... The CO_2, CH_4 emissions and GWP estimate were taken from DRÖSLER et al. (2013) and AURELA et al. (2007). Although there is a scarce tree cover in the site, it was not taken into account in emission measuring.

Restoration Methods

The restoration aim in Engure is to prevent overgrowing of alkaline fen and its transformation into mesic forest. Activities in the project restoration area include blocking of two ditches by installing plastic pilling in the northern part of the area (two dams). It is planned to raise the average water table by 20-25 cm (will be regulated by spillway). In the southern and central part of the restoration area, cutting of excessive shrub and tree cover is proposed (20 ha). This will be done manually by removing the biomass from the area. The cutting will be done in winter 2018/2019 or, if the ground conditions will not be suitable, in the dry period at the end of summer 2019. After that, repeated cutting of shoots will be done in 2020 and 2021 (Annex II-1).

II.2.2.2. Baltezers Mire Nature Reserve

Main Assumption

Drainage, peat extraction and deposition of air-borne calcium carbonate particles from the nearby cement factory are the main causes of transition mire degradation in Baltezers Mire. Historical data about peat pH and degree of peat decomposition indicate that Baltezers Mire was raised bog but transformed back to transition mire due to upper peat surface mineralization and alkalinity (KABUCIS (red.) 2004). Comparing the situation of the territory from 1969 when the first map of Baltezers Mire was made with marked border of mire, it was concluded that approximately 30 ha of former open mire has been overtaken by forest during 50 year period until nowadays.

Useful data about historical management, habitat and vegetation development of Baltezers Mire during the last 15 years was taken from the Management Plan of the Nature Reserve (LATVIJAS UNIVERSITĀTE, 2018). In the document, it is mentioned that transition mire habitat can become endangered due to further establishment of tree layer, therefore elimination of drainage effects is needed. However, we assume that restoration would be more effective if also the trees will be removed to eliminate shading and to decrease evapotranspiration.

Knowledge about transition mire restoration in Latvia is summarized in the habitat management guidelines (PRIEDE 2017). Restoration in transition mires in Latvia has been performed before, but only in small scale and mostly just one kind of the actions – tree removal, without elimination of drainage effects. As it is planned both blocking of ditches and clearing of trees in the Baltezers Project restoration area, we assume that the restoration will be successful. Currently the vascular plant and bryophyte composition in forest area is more characteristic to bog woodland and bog margins. We expect development of two different open peatland GEST-types in post-restoration scenario – **Wet Meadows and forbs** in the central part of the mire as before (no significant change), and **Wet peat moss lawn with pine trees** in the former forest area.

In a case if tree cutting will be impossible due to weather conditions (too wet ground, inaccessible for harvesters), as the area is located relatively close to the Baltic Sea where the climate is mild and winters with only short periods of frost are characteristic, only rewetting will be performed. In such post-restoration scenario, we assume that only minor changes are expected in GEST-types and GHG emissions. Although peat around the blocked ditches will become wetter, the tree layer along them is too dense to expect sharp changes. Forests along the ditches is adapted to moist conditions, and we are not planning significant raise of water table therefore massive tree die-off is not predicted.

Emission Calculations

For the both **oligotrophic** forested GEST-types in Baltezers, **Moderately moist Forests and shrubberies** and **Moist Forests and shrubberies**, emissions were calculated with and without the tree biomass. In both GEST-types, the dominant tree species is Pinus sylvestris with small admixture of Picea abies and Betula spp. Information about tree layer composition and forest age was taken from the Latvian State Forest Database. The forest stands in restoration area are on average 55 years old, but one forest compartment reaches age of 140 years. Tree number per hectar is rather low, on average 300 trees, with higher density in the oldest plot with 500 trees/ha. The height of trees varies from 5-10 meters in younger stands to 15 meters in the oldest stand. Overall, the forest biomass has a minor impact to the total calculated GHG emission amount in Baltezers.

Restoration Methods

To eliminate the drainage impact, eight peat dams will be built on ditches with total length of 1.6 km in the mire periphery. In addition, since the tree cover in the restoration area has established mostly due to drainage impact and considerably contributes to evapotranspiration, it is planned to cut out the trees and bushes in the former transition mire area, in total of 34 hectares (Annex II-2).

II.2.2.3. Augstroze Nature Reserve

Main Assumption

Degradation of raised bogs in Latvia has several reasons, but in most cases it results from drainage that has improved the tree growing conditions, and peat extraction. Northern part of Augstroze Mire was drained for forestry management purposes.

In Latvia, raised bog restoration has a 20 years long history. The first dams were built in 1999 in Teiču Mire Nature Reserve (BERGMANIS 2005). Since then, in more than 30 sites the drained peatlands were rewetted using peat, wood or plastic dams or filling up the ditches and removing the tree layer. Long-term permanent monitoring in the restored raised bogs confirm that mire vegetation recovery starts at least within 2-3 years period after restoring the water table and removal of trees (SALMINA & BAMBE 2008, AUNINA 2013, PRIEDE 2013).

There are different results about the tree layer which has not been removed during management. In most cases, the trees remain for a long time, and slow withering has been observed only occasionally. Therefore, we assume that tree cover in Augstroze in the 1st post-restoration scenario will remain in current condition, whereas the ground vegetation will recover to a condition similar to intact bog. In a case if the groundwater level rise is rapid and the trees cannot adapt to the new conditions, tree die-off is possible, as predicted in the 2nd post-restoration scenario.

Emission Calculations

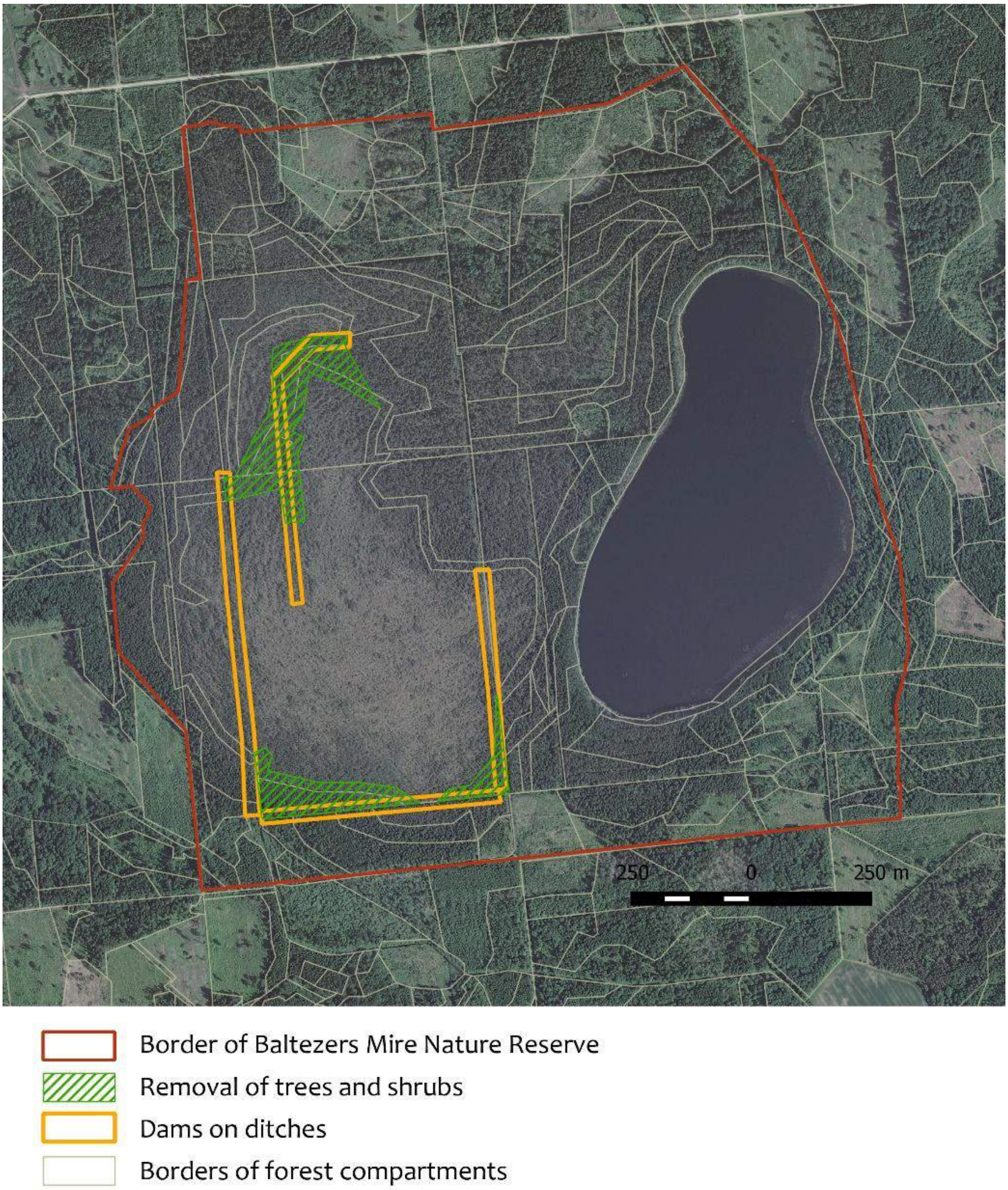
For the forested GEST-type of a baseline scenario, **Moderately moist Forests and shrubberies**, and its succeeding type of 1st post-restoration scenario, **Moist Forests and shrubberies**, emissions were calculated with and without the forest biomass. In both GEST-types, the dominant tree species is Pinus sylvestris. Information about tree layer composition, tree stem diameter (on average 10 cm) and height (7 meters) was obtained from GEST monitoring of the site adding the tree growth effect to the future perspective. Tree number per hectar is rather low, on average 100 trees. Overall, the forest biomass has a minor impact to the total GHG emission calculation in Augstroze

Restoration Methods

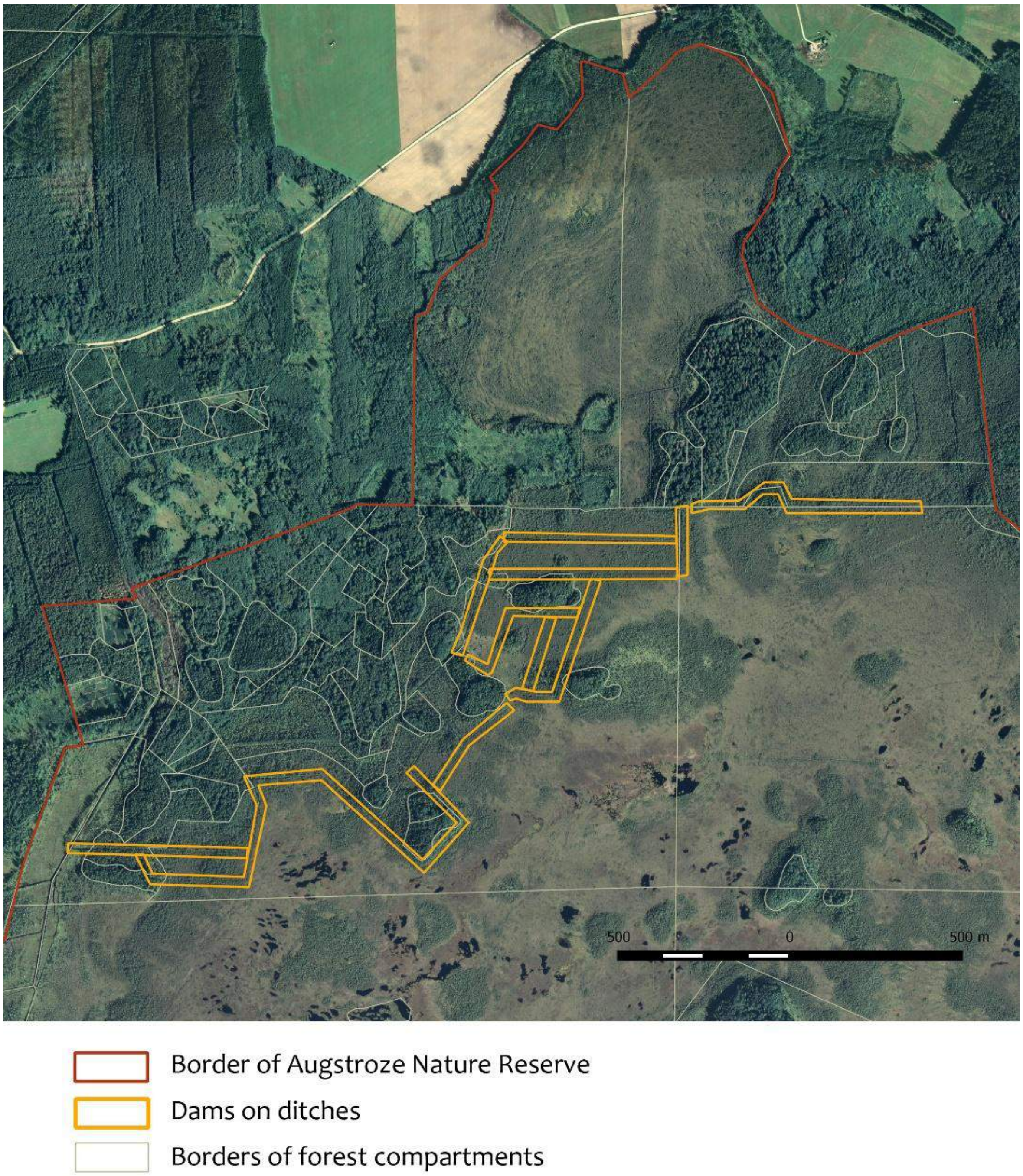
In the restoration area, 23 peat dams will be built on drainage ditches in total length of 6.2 km (Annex II-3). Previous experience in Latvia in raised bog restoration shows that peat dams are more effective than wooden-peat or wooden dams. Peat dams are more stable and resistant against water erosion for a longer period of time, they are almost unrecognizable after overgrowing by surrounding vegetation and also serve as bridges to berry-pickers, hunters and wild animals who can cross the ditches.

Annex II-1: Proposed restoration measures in the Engure project restoration area

Annex II-2: Proposed restoration measures in the Baltezers project restoration area



Annex II-3: Proposed restoration measures in the Augstroze project restoration area



II.2.3. Lithuania

Main Assumption

Success of habitat restoration activities in damaged peatland on climate change mitigation can be estimated by reduction of greenhouse gas emissions. To achieve this goal, we used the GEST approach (COUWENBERG 2011; COUWENBERG et al. 2011, THIELE et al. 2011; EMMER & COUWENBERG 2017). In order to estimate expected reduction of GHG emissions, current data of vegetation cover – Fixed baseline 2018 (based on GEST vegetation type mapping and water table depth measurements) are compared with predictable data on vegetation development in the ‚Post restoration‘ (PR) or ‚Project‘ scenario. This scenario is related with vegetation cover changes after the implementation of nature management actions for the next 30 years. After the implementation of restoration activities, a water table depth will rise in damaged areas and vegetation will start to develop in more wet conditions (moist (3+), very moist (4+) and wet (5+) habitats) (KOSKA et al. 2001). Prediction of developing of a newly formed vegetation cover (GEST types) is related to special features (water level, peat properties – trophy level, base richness) of restored habitats, implemented restoration activities (i.e. cutting woody vegetation, clearing offshoots, etc.) and physical location in the site (central part, margins of the restored site, etc.).

Restoration Methods

For the restoration of all Lithuanian abandoned peatlands almost all hydrotechnical plans haves been accomplished. These plans consist of very precise surface height modeling, location and type of hydrotechnical constructions. In addition, all the necessary nature management plans have been prepared and approved. Based on these documents most important nature management measures: hydrological restoration and tree cuttings can be performed. Altogether, approx. 410 hydrotechnical constructions (plastic/peat dams, embankments) will be installed and 300 ha of forest will be cleared.

For the restoration of **Amalva peatland LT01** 36 comnplex dams will be installed. The site is surrounded by intenively farmed agricultural land, therefore project aims to secure high water level inside the peatland. Therefore complex dams with the pipes for the water outflow will be constructed on the edges of the site. Almost whole site is overgrown by forest. To increase the area of open peatland habitats and to reduce negative impact of tree evapotranspiration approx. 200 ha of forest (pine trees, birch shrubs) will be cut.

Restoration of **Plinksiai peatland LT02** is under discussion. EC confirmed that due to complicated situation in the peatland and valid peat excavation, the site could be ommited from the list of project sites. However, the clarification of costs of forest removal is still in process. Any savings under forest management (C2) could be reallocated to the Plinksiai peatland.

For the restoration of **Sachara peatland (LT03)** approx. 100 dams and 3 embankments will be installed. To increase the area of open peatland habitats and to reduce negative impact of tree evapotranspiration 30 ha of young forest (pine trees, birch and shrubs) will be cut. Sphagnum diasporas will be spread in the bare peat habitats.

For the restoration of **Pūsčia peatland LT04** altogether 240 dams will be installed. To ensure stable water level in addition approx. 10 protective embankments from peat and plastic will be constructed. To increase the area of open peatland habitats and to reduce negative impact of tree evapotranspiration altogether 30 ha of trees, mainly pine trees, birch and shrubs offshoots will be cut. Sphagnum diasporas will be spread in the bare peat habitats.

For the restoration of abandonded **Aukštumala cut-over peatland (Aukštumala LT05 site)**, Sphagnum spreading following the Canadian approach (Rochefort et al. 2003) will be performed. To ensure favorable hydrological conditions water will be supplied from the blocked ditches and shallow water pond. Experimental Sphagnum spreading field will be divided into smaller parts, which will be surrounded by the embankments.

II.2.4. Germany

The german project site „Biesenthaler Becken“ consists of three small locations (BB01; BB02 and BB03). Figure II-3 shows the location of the three locations.

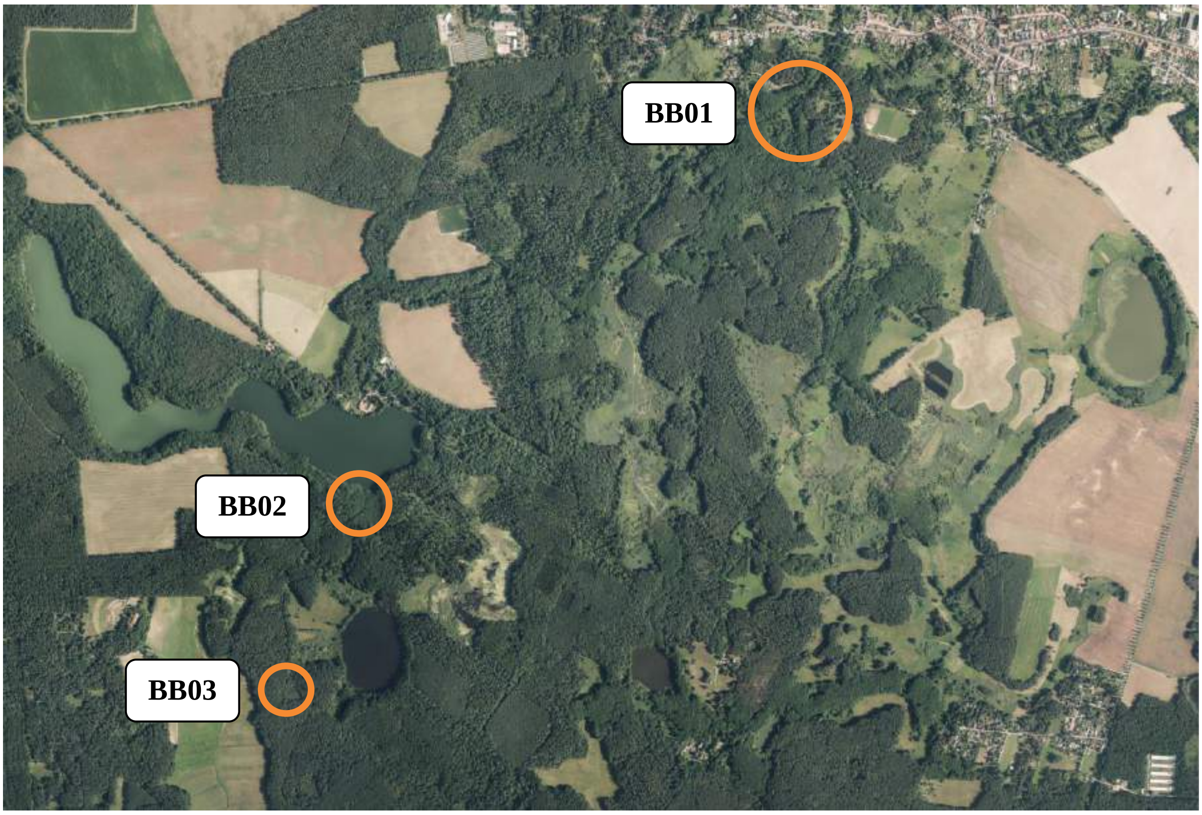


Fig.II-3: German Project area with position of the three locations
Basic Geo Data: © GeoBasis-DE/LGB 2018

<u>Location 1 – (BB01) – Alder Forest on the „Pfauenfließ“- River</u>

Main Assumption

In general the **baseline scenario** describe the development of the project area without any restoration measures. As base we recorded the current situation of the project area and predicted also the future development regarding land-use or the manner of treatment of the whole area, natural succession and also the predicted regional climate changes.

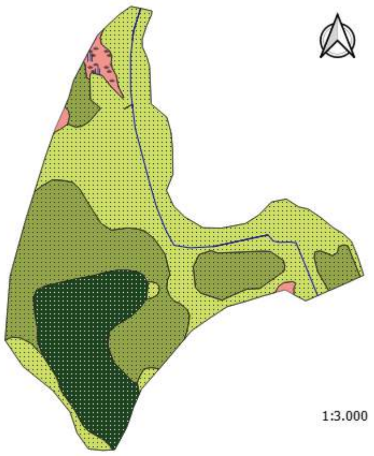
Location 1 is characterised by thick sedges peat layer, which are subordinated by calcareous gyttja layers, and a percolation regime. Based on historical soil data this area was used as grassland 60 years ago with numerous small ditches, however the drainage intensity was moderate (ca. 20-30 cm). Since this time the area was overgrown by alders and the former grassland was replaced by *Carex remota-Alnus glutinosa-Fraxinus excelsior communities* and in some wetter depressions by *Carex elongata-Alnus glutinosa communities.*

The whole site is protected as conservation area, so that we expect no land-use change in the future due to human activites.

Based on the results of different regional climate models (LUA 2010) the mean daily air temperature in Brandenburg will be increase to min. 1 °C until the middle of the 21th century and to 3 °C until the end of this century. The strongest changes will be expected in the winter time (ca. 4°C) As a result the vegetation period will be extend to a minimum of three weeks – this will affect the carbon sequestration rate of the trees and also of the whole forest biomass. The annual amount of precipitation will not changed significantly, however the summer precipitations will be decrease and the winter precipitations will be increase.

In the shaded light of these statements we expected in the baseline scenario no or only small changes of the GEST-composition compared to the current situation (Fig.II-4).

Baseline Scenario (BB-1)



Post-Restoration Scenario (BB-1)

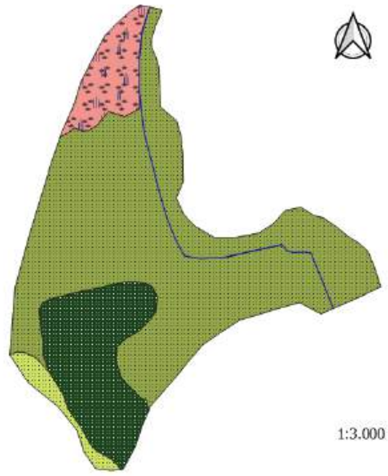


Fig. II-4: Distribution and composition of the expected GEST-types for the baseline and the post-restoration scenario of location 1

<u>Emission Calculations</u>

For both open peatland GESTs we used the emission factors given in the updated GEST-catalogue. For the three mesotrophic and eutrophic forested peatland GESTS we calculated the total emissions with and without tree biomass. In almost all GEST-types the dominant tree species is *Alnus glutinosa*, except the **Wet Forests and shrubberies**, where *Betula pubescens* is predominant with small admixtures of *Alnus glutinosa* and *Pinus sylvestris*. The forest stands are on average 60 years and the stocking density at least for alder, but also for pines is low with 200-400 trees per hectar. The tree number of the birches is higher with 1100 trees per hectar. The diameter in breast height (DBH) of *Alnus glutinosa* amount to ca. 110 cm, however in the mixed stand only 64 cm. The DBH of *Betula pubescens* and *Pinus sylvestris* are 57 and 71 cm respective. The height of the trees varies between 12-15 meters. The resulted stem volumes differ between ca. 2800 and 3400 m^3 per hectar for the pure alder stands and ca. 500 m^3 per hectar for the mixed stands. The stem volumes of the pines and birches amount ca. 900 and 1900 m^3 per hectar respective. For the basic stem wood density we used 0,45, 0,51 and 0,42 for *Alnus spec*., *Betula spec*. and *Pinus sylvestris* respective (Tab. II-4). As Biomass Expansion Factor (BEF) we used 1,3 (Broadleaf forests, Tab. II-2) for alder and birches and 1,2 for pines (Tab. II-2). For the Root:Shoot ratio (R) we used for the pure alder stands with relatively higher aboveground biomass 0,24 and 0,26 for the mixed stands (Other Broadleaf Forests; Tab. II-5). For pines we used 0,32 (Conifer forest, Tab. II-2).

Restoration Methods

The aim of the restoration measures in location 1 is the improvement of the hydraulic characteristics (e.g. flow features) of the Pfauenfließ-River and the establishment of a water table not lower than 10 to 20 cm below the local surface. We plan to build a river bed glide within the river close to the Finow-River in the northern part to make the hydrological conditions of the Pfauenfließ-River more independent from the water table of the Finow-River. Furthermore we plan to build several ditch fillings to minimize the drain effect of the ditches and the whole peatland area As a result of these plannings we assume, that the water table close to the River will be near the current surface with smaller declines in the surrounded area. As material for the river bed glides and also the fillings we will use local dead wood from alder and willow bushes as well as material from small peat soil excavation as much as possible. In this context it is planned to cut the current woods and shrubs in the northern part of location 1.

Regarding the vegetation and also the GEST-type development we expect in the **post-restoration scenario**, that the driest (3+) communities like the *Carex remota-Alnus glutinosa community* will be replaced by *Cardamine amara-Alnus glutinosa community* according to SUCCOW & JOOSTEN (2001). With regard to the GEST-types it means that the Moist mesotrophic Forests and Shrubberies close to the western part of the Pfauenfließ will be transformed into Very Moist mesotrophic Forests and Shrubberies. We also expect, that the small cutted area in the north will be overgrown by *Carex nigra-Caltha palustris-Filipendula ulmaria-community* direct after the measures and later once again a spreading of *Salix cinerea* and *Alnus glutinosa*. The GEST-types in this small area will be replaced by Very Moist Meadows, Forbs and Small Sedges reeds (Fig.II-4). In future perspective we can’t exlude the disturbation by boars, which use this area often as a retreat or disturbation by local residents, who plant non-resident shrubs in this area.

Location 2 – (BB02) – Alder forest on the „Plötzenseefließ“

Main Assumption

Location 2 is characterised by tight alder peat layers with lots of wooden residues, which are subordinated by calcareous gyttja layers only in the norteastern parts close to the Hellsee. Based on historical data this area was never used for agricultural purposes in the last 100 years, however moderately drained for forestry. Due to the drainage activities and also because of the proximity to the mineral edge the south-western part is drier than the rest of this area closer to the lake. The small mire was covered by *Alnus glutinosa* in the last century, only the small mineral-based elevations and the willow shrubs in the northern and southern part close to the road are relicts of human activities. At least the mineral-based domes will be excluded in our GEST-considerations because of missing peat.

The whole site is protected as conservation area, so that we expect no land-use change in the future due to human activites.

In context of the regional climate models the summer precipitations will decrease, so that we expect drier summer and a bigger amplitude of the water table. Apart from that we also observed beaver activities, which results in a seasonal daming of the water in the western and southern part, leading to a longer water retention. Despite of this different situation we expect in the **baseline scenario** no or only small changes (at least the western edge of location 2 will be drier) of the GEST-composition compared to the current situation (Fig.II-5).

Baseline Scenario (BB-2) **Post-Restoration Scenario (BB-2)**

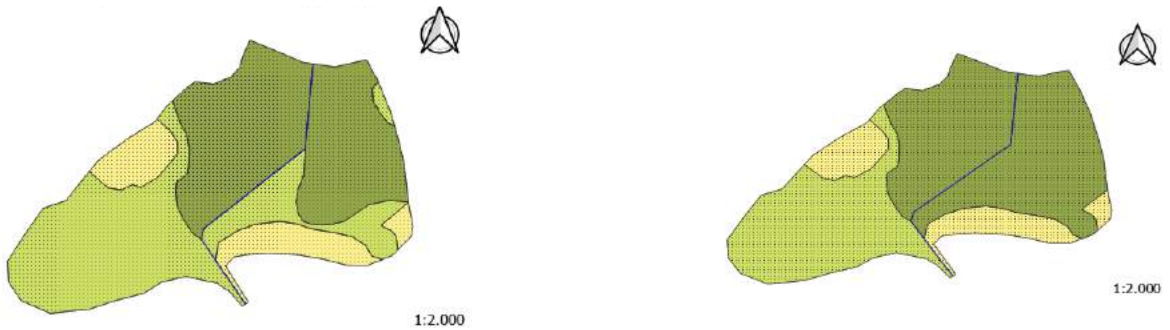


Fig.II-5: Distribution and composition of the expected GEST-types for the baseline and the post-restoration scenario of location 2

<u>Emission Calculations</u>

For both mesotrophic and eutrophic forested peatland GESTS we calculated the total emissions with and without tree biomass. In all GEST-types the dominant tree species is *Alnus glutinosa* with small admixtures of *Betula pubescens*. The forest stands are on average 100 years. The stocking density is quite higher than location 1 and varies between 900-1100 trees per hectar for alder and 100-200 trees for birches. The DBH of *Alnus glutinosa* varies from 85 to ca. 120 cm, the DBH of *Betula pubescens* varies between ca. 100 and 130 cm. The height of the trees varies only between 12-13 meters. The resulted stem volumes differ between ca. 3600 and 8700 m^3 per hectar for alder stands and between ca. 900 and 1500 m^3 per hectar for birch stands. For the basic stem wood density we used 0,45 and 0,51 for *Alnus spec*. and *Betula spec*. respective (Tab. II-4). As Biomass Expansion Factor (BEF) we used 1,3 (Broadleaf forests, Tab. II-2), for the Root:Shoot ratio (R) we used 0,24 (Other Broadleaf Forests; Tab. II-5).

Restoration Methods

In contrast to Location 1 the aim of the restoration measures in location 2 is not the improvement of the hydraulic characteristics, though also an increase of the water table by closing the ditch, which is called „Plötzenseefließ“ and the transformation of the whole area in a more near-natural mire character. We plan to construct different ditch fillings in the „Plötzenseefließ“, so that the current water level will raise on average of 30 to 40 cm close to the ditch from the southern part near the road to the first bend and depending on the water table of the lake „Hell-See“ a maximum rise of 25 cm close to the lake. As material for the fillings we will use peat or loam from different small excavations close to the ditch and the mineral edge respective. As result we expect water tables near below the surface in the summer and a few centimeters above the surface in the winter time. The water table of the two small mineral elevations will not change significantly in the future, as well as the eastern part.

Regarding the vegetation and also the GEST-type development we expect in the **post-restoration scenario**, that the driest (3+) communities like the *Carex remota-Alnus glutinosa community* will be replaced after a transition phase with a thinner alder stand (because of the removal of 40 trees during the restoration) by *Cardamine amara-Alnus glutinosa community* according to SUCCOW & JOOSTEN (2001). With regard to the GEST-types it means that the Moist mesotrophic Forests and Shrubberies southern to the „Plötzenseefließ“ will be transform into Very Moist mesotrophic Forests and Shrubberies. We also expect, that the small *Carex acutifomis-Salix cinerea* community later will also replace by alder. All changes are presented in Fig. II-5.

Location 3 – (BB03) – Birch forest southern to the Lake „Plötzensee“

Main Assumptions

Location 3 is also characterised by tight peat layers with lots of wooden residues. Based on historical data this area was never used for agricultural purposes in the last 100 years, however moderately drained. Due to a ditch the small birch forest (91D1) is draining in the surrounding mineral sites. Therefore the current mire shows actually no mire-typical water conditions with the result of a loss of peat by subsidence and mineralisation and an immigration of non-native woods like *Fagus* or *Pinus*.

The whole site is protected as conservation area, so that we expect no land-use change in the future due to human activites.

In context of the regional climate models the summer precipitations will decrease, so that we expect drier summer and a bigger amplitude of the water table. Therefore we expect a further drainage of this area in the **baseline scenario**, which leads to drier conditions as today. On a long-term perspective (100 years) we expect a shift also in the GEST-Type to a Moderately Dry Forest and Shrubberies (Fig.II-6).

Baseline Scenario (BB-3) **Post-Restoration Scenario (BB-3)**

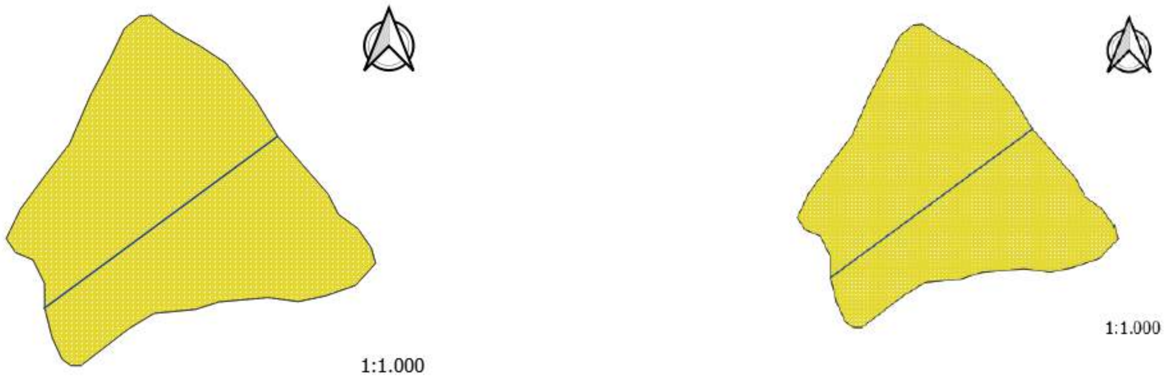


Fig.II-6: Distribution and composition of the expected GEST-types for the baseline and the post-restoration scenario of location 3

<u>Emission Calculations</u>

For the mesotrophic and eutrophic forested peatland GEST-Type Moderately dry/moist Forests and Shrubberies we calculated the total emissions with and without tree biomass. In the baseline scenario *Pinus sylvestris* is the dominant tree species with admixtures of *Betula pubescens*, in the post-restoration scenario *Betula pubescens* will be the dominant one. The forest stands are on average 100 years. The stocking density of *Betula pubescens* amounts to 1500 trees per hectar and was also used in the post-restoration scenario. In the baseline scenario we assume, that the stock density of birches will be much lower (300 trees per hectar) and of pines ca. 500 trees per hectar like similar mixed stand close to this location. The DBH of *Betula pubescens* in the baseline and also in the post-restoration scenario will be similar to the current situation with 40 cm (average), the DBH of *Pinus sylvestris* in the baseline scenario will be 75 cm like similar mixed stands close to the area. The height of the trees will not differ too much and amounts to ca. 10 m in both scenarios. The resulted stem volumes amounts to ca. 890 m^3 per hectar for pure birch stands in the post-restoration scenario and ca. 180 m^3 per hectar in mixed stands in the baseline scenario. For pines we calculated a stem volume of ca. 1300 m^3 per hectar only in the baseline scenario. For the basic stem wood density we used 0,42 and 0,51 for *Pinus spec*. and *Betula spec*. respective (Tab. II-4). As Biomass Expansion Factor (BEF) we used 1,3 (Broadleaf forests, Tab. II-2) for birches and 1,2 for the pines. For the Root:Shoot ratio (R) we used 0,24 (Other Broadleaf Forests; Tab. II-5) for birches and 0,32 for pines (Conifer Forest; Tab. II-5).

Restoration Methods

To ensure the birch forest stand in a long-term perspective, the restoration of a more typical peat water level is necessary. Therefore the drainage effect of the ditch must be stopped. By closing the ditch with loamy fillings in the transition area to the mineral periphery the leaching from the ditch should be stopped. Additionally we plan to fulfill the ditch with high decomposed peat to rise the water table. Due to the small hydrological catchment area of only 3 ha the water supply is very low, so that we expect only a slight rise of the water table of only 5 cm. To increase the water resources it is planned to convert the surrounding pine forests into beech forests. For the GEST-scenario calculations we don‘t consider these forest conversion measures.

Regarding the vegetation and also the GEST-type development we expect in the **post-restoration scenario**, that the moderately moist (2+) *Rubus fructicosus-Betula pubescens*-community will be remain. With regard to the GEST-types it means that the current situation will not change significantly and will be remain as Moderately Moist Mesotrophic and Eutrophic Forests and Shrubberies (Fig.II-6).

II.2.5. Poland

The subject are three former peat bogs in the southern part of the Slowiński National: (1.) Kluki peatbog, (2.) Ciemińskie Błota and (3.) Wielkie Bagno peatbog. All three mires are currently heavily degraded and constitute of peat deposits overgrown with mostly non-peat-forming forest vegetation, however there are also peat-forming peat moss patches preserved.

Main Assumptions

For the **baseline scenario** we assume, that the current emissions of the project site will remain relatively constant for the time period of 30 years. There will be no sucession, but the estimation of the emissions are calculated both – with and without forest biomass (sequestration from trees) – as the issued peatlands are forested.

We also assume, that the forest stand has a reduced productivity due to unstable water conditions.

With regard to the greenhouse gas balances the trees accumulate indeed carbon, however the losses due to the disappearance of peat-forming vegetation and the peat mineralization are greater than the profits from the accumulation of carbon in wood biomass.

To calculate emissions from each site detailed vegetation maps were prepared according to the GEST vegetation mapping methodology (see Results) and hydrological maps of the area.

In the **post-restoration scenario** the current emissions of the project site will change on the time period of 30 years, because of the restoration measures, but peatlands will partially remain forested. So the estimation of the emissions are calculated with and without forest biomass, which will remain on the site (sequestration from trees, which did not die-off or was cut out during the restoration measures).

The project doesn't assume any fundamental changes in the vegetation of the Park, i.e. it doesn't assume extensive artificial deforestation of peatlands. The assumption is that – in addition to the above-mentioned surfaces, where urgent interferences are needed to protect the current peat-forming process – vegetation changes towards peat-forming will occur gradually as a result of natural processes caused by the improvement of hydration.

On the basis of hydrological maps a mathematical model was applied (matflow) to model new water conditions of the sites after rewetting (blocking the ditches). We assume, that blocking of the ditches in approx.. 214 points in all three sites will rise the water table in spatially limited manner. Based on new water conditions (new hydrological maps) we predicted a vegetation change and used it to recalculate the emissions on the assumed new GEST vegetation.

Restoration Methods

The total area of peat deposits covered by the project is a bout 1310 ha, and their volume according to the existing documentation is about 40 million m^3. Peat-forming plant communities currently occupy approx.. 57 ha and this surface require active protection against disappearance.

The activities planned for the protection of the peat deposits and the peat-forming processes are the same for the needs of the protection of the natural habitats 7110, 7120 and 91D0 and of the biological diversity of these sites. It is due to the fact, that they are also activities, which restore the development of peat bog and bog vegetation and counteract the development of vegetation towards degeneration communities on peat.

1. Inhibition of dehydratation and degradation of peat deposits

Peat deposits of the sites are still drained by numerous remains of former ditches. Some of these ditches have become overgrown and have disappeared, but in a larger part of them still periodically water is siphoned off, worsening the water balance of the sites. On the large surface of peatlands, the level of groundwater is reduced due to dehydration, the top layers of peat are decaying, degrading and releasing CO_2. Only on small areas peat forming layers are preserved, accumulating CO_2. These patches are at risk of disappearance due to overgrowth with trees which would mean the disappearance of peat accumulation processes.

To prevent this process, drainage ditches will be blocked by partitions made as peat dams, which are reinforced with a wooden sheet wall or fixed wooden partition in the form of a sheet piling. Such technical solutions have been tested in many projects implemented by the Naturalists' Club, as well as in activities carried out so far by the SPN on the Wielkie Błoto peatbog. Natural partitions made of natural materials will, in long-term, blend into the peatbog and gradually overgrow ditches.

214 priority points were selected (out of 600 that are planned in SPN), guided by the assumption that restoration of proper water conditions in peats (i.e. water conditions preserving peat and protecting it from decay) should be of several stages to give time the vegetation to adapt to the new water conditions and avoid sudden changes, e.g. rapid dieback of trees on large surfaces. The places of blockage o ditches in this stage concentrate on former peat "domes", and due to such location, the their influence on water conditions will be limited spatially, but concentrated in key places.

<u>2. Protection of the peat-forming process by removing trees and shrubs from the surface of high peat bogs and regenerative communities of gray peatlands</u>

Due to overdrying, the project's sites have been undergoing a strong expansion of trees, resulting in the disappearance of open peat-forming phytocenoses. At present, they have survived, or were re-formed, in the regenerating peat-cut basins as small peat-forming areas. Their existence and development, however, are threatened by the expansion of trees.

Although from the point of view of the balance of greenhouse gases, also trees accumulate carbon, losses due to the disappearance of peat-forming vegetation and replacement of the peat-forming process with decay are greater than profits from the accumulation of carbon in wood biomass. In order to prevent this threat and to enable the continuation of the development of peat-forming vegetation, and thus the accumulation of CO_2, along with the improvement of water conditions, the following will be performed:

- One-time removal of trees and shrubs shading regeneration communities of moss vegetation from the dam between peat bogs in the post-mining areas (Wielkie Bagno and Kluki). Total area: 10,51 ha.
- One-time partial removal of trees and shrubs from the patches with Sphagnum vegetation overgrown with trees (all three sites). Total area: 10,78 ha.
- Removal of raids and undergrowth of trees and shrubs, which appeared after previous active protection measures (Kluki, Wielkie Bagno). Total area: 35,72 ha;
- In the last year of the project implementation (2021), all areas covered by the action will be checked for possible emergence of sprouts and raids, and if necessary a return will be made to remove the air raids and undergrowth.

The biomass will be left on the bog, but mostly outside the patches of uncovered vegetation. This will ensure the maximum long-term accumulation of carbon in this biomass.

III. Results & Discussion

III.1. Estonia

For Wet peat moss lawn with pine trees, Very moist forests and shrubberies (minerotrophic) and Very moist forests and shrubberies (oligotrophic) GHG emissions describe the situation with drainage impact (Tab.III-1).

For Moderately moist forests and shrubberies most appropriate carbon sink data are for the rich peatland forest site type in Finland (OJANEN et al. 2013). That type of forests are carbon emitters as the peat mineralization is substantial. High wood production of these sites (Tab.III-2) does not mean carbon sink of these sites – aboveground part of trees decompose on surface fast (Fig.III-1). Also, dead roots in the aerated zone increase the emission. Measurements and calculations made on project sites (tree height and diameter measurements and biomass calculations (Tab.III-2)) do not allow us to estimate the carbon sink of trees.

Fig.III-1: Decomposing dead wood in GEST-Type Moderately moist forests and shrubberies at Suursoo-Leidissoo project site.

Tab.III-1: GEST types and GHG emissions of Suursoo-Leidissoo project area (Coordinates 59° 10'; 24° 1'). Trees are not included, except for belowground tree biomass in type Moderately moist forests and shrubberies.

GEST-Type	Area [ha]	CO_2 [t CO_2-equiv./ha/yr]	CH_4 [t CO_2-equiv./ha/yr]	GWP [t CO_2-equiv./ha/yr]	GWP sum (before restoration) [t CO_2-equiv./yr]	Remarks-References
Very moist calcareous meadows, forbs …	602	0,2	0,5	0,7	421,4	Data from DRÖSLER et al. (2013) and AURELA et al. (2007)
Wet peat moss lawn with pine trees	823	3,9	0,2	4,1	3374,3	Data from DRÖSLER et al. (2013)
Very moist forests and shrubberies (minero-trophic)	297	-0,5	2,1	1,6	475,2	Data from AUGUSTIN (2001)
Very moist forests and shrubberies (oligo-trophic)	859	1,7	3,0	4,7	4037,3	Data from HOMMEL-TENBERG et al. (2014)
Moderately moist forests and shrubberies	733	-0,7 in poor sites and 1,9 in fertile sites	Minimal (0,0)	1,9	1392,7	OJANEN et al. (2013). Our site corresponds to the boreal Vacc. Myrt. Type of drained peatland forest.
		0,1-1,0		0,1-1,0	733,0	OJANEN et al. (2014)

Carbon sink calculations are very rough. Carbon content calculated as 50% of the total (aboveground and belowground tree biomass), and carbon sink in tree biomass was found as the share of biomass to the tree age (Tab.III-2).

Biomass production of trees is probably overestimated because tree stand is relatively old (especially in drained forests) and increment of trees is slowing down. So the tree stand biomass of older forests can reach to the plateau already during some decades. Also our method do not include mortality of trees and emissions from deadwood.

Tab.III-2: Tree biomass in GEST-Types on the Suursoo-Leidissoo project site

GEST-Type	Very moist calcareous meadows (fen)	Very moist peat moss lawn (transitional mire, bog)	Very moist forests (*Sphagnum-P. sylvestris* community)	Moist forests and shrubberies (swamp forests)	Moderately moist forests and shrubberies (drained peatland forests
No. of analyses	29	22	15	3	11
BM; [t * ha^{-1}], Mean	7,54	31,136	287,7	167,456	531,215
S.D.	19,97	73,38	170,32	76,00	200,86
BM, Min [t * ha^{-1}]	0	1,22	59,56	79,77	274,41
BM, Max [t * ha^{-1}]	83,33	351,99	635,67	214,60	743,21

Tab.III-3: Carbon accumulated in trees in GEST-types on the Suursoo-Leidissoo project site.

GEST-Type	Very moist calcareous meadows (fen)	Very moist peat moss lawn (transitional mire, bog)	Very moist forests (*Sphagnum-P. sylvestris* community)	Moist forests and shrubberies (swamp forests)	Moderately moist forests and shrubberies (drained peatland forests)
Carbon [t C * ha^{-1} * yr^{-1}]	0,1	0,2	1,9	2,5	3,6
Carbon [t CO_2-equiv. * ha^{-1} * yr^{-1}]	0,37	0,74	7,03	9,25	13,32

In case we add the carbon accumulation into trees (Tab.III-3) to the total carbon balance the last turns from carbon source to carbon sink (Tab.III-4). In this way the most effective carbon accumulating vegetation type is the most drained GEST-Type Moderately moist forests and shrubberies with deep mire water (below 70 cm) and compressed and mineralized peat.

Tab.III-4: GEST-Types and GHG emissions on the Suursoo-Leidissoo project site (coordinates 59° 10'; 24° 1'). Trees are not included, with tree biomass in type Moderately Moist Forests and Shrubberies.

GEST-Type	Area (current) [ha]	GWP [t CO_2-equiv. * ha^{-1} * yr^{-1}]	GWP sum without trees; (before restoration) [t CO_2-equiv. * yr^{-1}]	GWP sum with trees; (before restoration) [t CO_2-equiv. * yr^{-1}]
Very moist calcareous meadows, forbs, …	602	0,7	421,4	198
Wet peat moss lawn with pine trees	823	4,1	3374,3	2765,3
Very moist forests and shrubberies (minerotrophic)	297	1,6	475,2	-1612,7
Very moist forests and shrubberies (oligotrophic)	859	4,7	4037,3	-3908,5
Moderately moist forests and shrubberies	733	1,9	1392,7	-19030,6
Total			**9700,9**	**-21588,5**

Tab.III-5: Post-restoration scenario. Emission data from Suursoo-Leidissoo project area before and after restoration. According to the Updated GEST catalogue.

GEST-Type	Total area before [ha]	Total area after restoration [ha]	Total area without restoration [ha]	GWP emission before restoration [t CO_2-equiv. / yr	GWP emission after restoration [t CO_2-equiv. / yr	GWP emission without restoration [t CO_2-equiv. / yr
Very moist calcareous meadows, forbs, …	602	1175	51	198	822,5	35,7
Wet peat moss lawn with pine trees	823	1207	435	2765,3	4948,7	1783,2
Very moist forests and shrubberies (minero-trophic)	297	284	0	-1612,7	424,4	0
Very moist forests and shrubberies (oligo-trophic)	859	504	974	-3908,5	2368,8	4577,8
Moderately moist forests and shrubberies	733	144	1854	-8370,9	273,6	3522,6
Total	**3314**	**3314**	**3314**	**-10928,1**	**8868**	**9919,6**

III.2. Latvia

III.2.1. Lake Engure Nature Park

Baseline Scenario

Engure project restoration area is an alkaline fen, which has developed in a large, shallow inter-dune depression. The fen is still in relatively good condition. However, without restoration and continuous post-restoration management the fen is overgrowing with trees and shrubs. Overgrowing is promoted by drainage effect caused by two old ditches. Moreover, the shrub encroachment increases the evapotranspiration leading to drier conditions. This may lead to replacement of peat-forming *Schoenus ferrugineus*, *Cladium mariscus* and brown mosses dominated vegetation by plant communities of drier conditions (most probably, Molinia caerulea dominated vegetation). In few decades, this may result in interruption of peat-formation and establishment of calciphilous, mesophytic pine forest community.

Considering the climate change tendency in Latvia, there is positive trend in the amount of precipitation, especially in winters. However, also the periods of extreme drought and high temperatures could be more frequent than before (PRIEDE 2017). Overall, in combination with other climate variables, this trend could be beneficial for overgrowing of the fen in Engure project area, as dry periods in summer with suitable conditions for establishment of trees could become longer. In spite of predicted precipitation extremes, the average annual “wetness” of the area could remain averagely more or less same as before, however, the tree established during the extended dryness periods may endure the periods of excessive water level.

Overgrowing of open fen which may lead to decline of peat-forming vegetation cover is enhanced by lack of traditional management. Regular management in the past have had an important impact on the area for decades up to early 1980s, when free-roaming cattle grazing management was ceased.

Post-Restoration Scenario

We assume that after restoration the fen area could become wetter (decreased runoff due to blocking of ditches, longer wetness periods in the fen, and higher and/or more stable water level in the nearby Lake Engure). This may be promoted also by increased precipitation in a case if the climate change with large precipitation amounts or more frequent precipitation extremes increases the average water table in the area. Most probably, blocking ditches will make slightly wetter only the northern part of Engure area (ca. 80-90 ha including some non-peatland forests, as suggested by hydrogeological modelling results). However, after restoration no changes in GEST-Types is expected.

Changes in the next 30-50 years very much depend on the water level in the nearby Lake Engure, as well as climate change. Since the climate change might bring extended periods of extreme drought, the possibility to preserve open fen with peat-forming vegetation largely relies on grazing or other type of management. The bedrock is permeable (sand), thus the hydrological situation can be improved by ditch blocking, though due to high infiltration amount the water table cannot be maintained to certain desired level.

Most probably, blocking of two ditches in the northern part will make the fluctuations of water level smoother, the dry periods may become shorter. This may hinder overgrowing of the fen with forest.

Increased wetness, especially extended wetness periods during the summer, may favour expansion of *Cladium mariscus*, currently dominating only in lower depressions; it may overwhelm the *Schoenus ferrugineus* dominated vegetation. However, since *Cladium mariscus* is a vigorous competitor, it may be an important factor limiting overgrowing with trees, as C. mariscus forms dense stands and thick layer of litter.

In a case if due to climate change the area becomes drier, blocking of ditches will partially compensate loss of water, and the area could remain more or less the same as today, before restoration. In the worst case, if it becomes considerably drier, the ditch blocking would not help to extend the wetness periods and there would be no grazing/mowing management, within the next 50-100 years most of area could turn into forest.

In case of introducing grazing management, the fen may turn into grassland-like vegetation with larger proportion of plant species of mesophytic (e.g. *Molinia caerulea*, *Sesleria caerulea*, species of *Festuca-Brometea*).

In any case, in Engure site after blocking of ditches regular habitat management is necessary to maintain the fen open (low-intensity grazing would be the best option).

As mentioned before, emissions in Engure site will not change significantly after restoration. Therefore, the calculated GWP is identical in all scenarios, 32,2 t CO_2-eq. annually and 1610,0 t CO_2-eq. in 50 years (Tab.III-6-9).

III.2.2. Baltezers Mire Nature Reserve

Baseline Scenario

In Baltezers, the baseline situation results from drainage effect. Because of ditches, open peatland GEST-Type, Wet meadows and forbs, has been overtaken by two oligotrophic forested peatland types, Moderately moist Forests and Shrubberies and Moist Forests and Shrubberies. Forest cover might increase even more during the next 50 years following the succession, as was concluded from older maps of the area. Approximately 30 ha of open mire area has already overgrown by trees during the last 50 years. In the overgrown places, the vegetation has also changed from sedge and brown moss dominated plant communities to bog woodland vegetation. Due to climate change in the last decade, there is slightly higher air temperature during summers and more rain in winters. As a result, the peat surface and shallow hollows dry out faster during summers which negatively affects mire plants and bryophytes and promotes establishment and survival of trees.

The optimal way to restore the mire conditions is to stabilize hydrology regime and remove trees. Current emissions from all four GEST-Types in the site annually and in 50 years respectively are 308,04 and 15.402,2 t CO_2-eq. without forest biomass, and 307,32 and 15.366,2 t CO_2-eq. with the forest biomass (Tab.III-6-9). The largest emissions, two thirds of the total amount in the site, are produced by **Wet meadows and forbs** which dominates in the restoration area in the site.

Post-Restoration Scenarios

The 1st post-restoration scenario. After blocking the drainage ditches and cutting down the trees and shrubs in both forested peatland GEST-Types, the peat will become wetter and tree cover density much lower. Development of a new GEST-Type, **Wet peat moss lawn with pine trees**, is expected. It is crucial to perform both of the planned restoration actions. Previous experience in similar areas with only tree cutting shows that trees tend to grow back, therefore rewetting is very important. Vice versa, only hydrology restoration without tree cutting will be not so effective, as large amounts of water is lost via evapotranspiration, and the trees create suitable conditions for shade-loving plants instead of open peatland vegetation. Total emissions in this scenario are lower for 66,3 t CO_2-eq. than in baseline situation, i.e. 241,79 t CO_2-eq. annually and 12.089,7 t CO_2-eq. in 50 years (tab.III-7-9).

There is a risk that mild winters during the Project time can hinder tree removal making it technically impossible due to unstable ground in the mire. In such case, the baseline scenario becomes also a 2nd post-restoration scenario with identical amount of emissions (Tab.III-8-9). But only slight changes in vegetation and GEST-Types are expected after hydrology stabilization alone. Ditches in Baltezers are about 3 meters wide and 2 meters deep, many of them reach the mineral ground and affect also the groundwater. To restore the “original” hydrological regime, many large peat dams would be necessary. However, it is not possible, as the nearby forest lands on the margins of the nature reserve are of economic value to the land owner, Latvian State Forests Ltd. Therefore, the current restoration approach is a compromise between two land use interests (peatland restoration/conservation vs. economic use of forests).

From the GHG emission reduction perspective, more suitable restoration of Baltezers site follows the 1st post-restoration scenario.

III.2.3. Augstroze Nature Reserve

Baseline Scenario

In Augstroze in the baseline scenario, without restoration measures the raised bog degradation continuous in the marginal area. The open raised bog or **Wet peat moss lawn** has overgrown by oligotrophic forested peatland GEST-Type, **Moderately moist Forests and shrubberies**. If no restoration actions are performed, the upper layer of peat remains dry which causes increased decomposition. Drainage promotes development of tree layer and change from mire vegetation to vegetation typical for forests – less *Sphagnum* mosses and more dwarf shrubs. Current emissions from three GEST-types in the site annually and within 50 years are 749,33 and 37.466,3 t CO_2-eq. without the forest biomass, respectively, and 749,22 and 37.460,6 t CO_2-eq. with the forest biomass, respectively (Tab. III-6 & III-9). The largest amount of GHG emissions is produced by **Oligotrophic Moderately moist Forests and Shrubberies** or degraded raised bog, which take only one quarter from the entire restoration area in Augstroze.

Post-Restoration Scenarios

The 1st post-restoration scenario implies to rewetting of the degraded parts of the mire after blocking the drainage ditches. Although the upper layer of peat becomes wetter, the tree layer remains as before resulting in development of a new GEST-Type, **Moist Forests and Shrubberies**. As shown by other studies (DAUŠKANE 2010, ČUGUNOVS et al. 2016), the peat surface and vegetation after drainage is strongly affected in a 10-15 meter distance from the ditch, while further away the effect may be milder. Similarly, after restoration, the highest effect is reached in area nearby the closed drains. As a result, the degraded raised bog which is the largest producer of GHG emissions in Augstroze restoration area, will be significantly improved. In this scenario, the total annual emissions and within the next 50 years is by one half smaller than in the baseline situation, i.e. 346,53 and 17.326,3 t CO_2-eq. without the forest biomass, and 346.42 and 17.320,6 t CO_2-eq with the forest biomass (Tab.III-7 & III-9).

In the 2nd post-restoration scenario, we assume that increase of water level after dam building is so high that tree roots cannot adapt to new conditions, thus the trees may rapidly die-off. As a result, new GEST-Type of open peatlands develop, **Wet peat moss lawn with pine trees**. Emissions annually and within 50 years are even smaller than in the 1st scenario, i.e. 145,13 and 7.256,3 t CO_2-eq. without the forest biomass, and 145,13 and 7.256,3 t CO_2-eq. with the forest biomass (Tab.III-8 & III-9). From the GHG reduction perspective, this scenario is most suitable for Augstroze site.

First GEST GHG balance scenarios

Tab.III-6: Baseline Scenario in Project sites in Latvia

Site (GPS coordinates	GEST-Type	Area (current) [ha]	Water level	CO_2 emissions [t CO_2-eq./ha/year]	CH_4 emissions [t CO_2-eq./ha/year]	GWP estimate [t CO_2-eq./ha/year]	CO_2 emissions [t CO_2-eq./ha/year]	CH_4 emissions [t CO_2-eq./ha/year]	GWP estimate [t CO_2-eq./ha/year]
				Without Forest Biomass			With Forest Biomass		
Engure Lake NR (N 57° 15.803' E 023° 08.710')	Wet calcareous Meadows, forbs,…	46	4+/5+	0.2	0.5	0.7	-	-	-
Baltezers Mire NR (N 56° 40.621 E 022° 37.112')	Wet meadows and forbs	34,48	5+	0	5.8	5.8	-	-	-
	Wet peat moss hollows resp. flooded peat moss lawn	1,86	5+	-3,1	12	8,9	-	-	-
	Oligotrophic Moderately Moist Forests and Shrubberies	3,17	2+	20	0	20	20	0	19,987
	Oligotrophic Moist Forests and Shrubberies	2,99	3+	9,4	0	9,4	9,4	0	9,173
Augstroze NR (N 57° 34.902' E 025° 02.381')	Wet peat moss lawn	105	5+ (4+)	-0,5	0,3	-0,3	-	-	-
	Wet peat moss hollows resp. flooded peat moss lawn	2,34	5+	-3,1	12	8,9	-	-	-
	Oligotrophic Moderately moist Forests and Shrubberies	38	2+	20	0	20	20	0	19,997

Tab.III-7: Post-restoration Scenario-1 in Project sites in Latvia

Site (GPS coordinates	GEST-Type	Area (predicted) [ha]	Water level	CO_2 emissions [t CO_2-eq. /ha/year]	CH_4 emissions [t CO_2-eq. /ha/year]	GWP estimate [t CO_2-eq. /ha/year]	CO_2 emissions [t CO_2-eq. /ha/year]	CH_4 emissions [t CO_2-eq. /ha/year]	GWP estimate [t CO_2-eq. /ha/year]	Remarks
				Without forest biomass			With forest biomass			
Engure Lake NR (N 57° 15.803' E 023° 08.710')	Wet calcareous Meadows, forbs,…	46	4+/5+	0,2	0,5	0,7	-	-	-	-
Baltezers Mire NR (N 56° 40.621' E 022° 37.112')	Wet meadows and forbs	34,48	5+	0	5,8	5,8	-	-	-	All planned restoration activities are implemented
	Wet peat moss hollows resp. flooded peat moss lawn	1,86	5+	-3,1	12	8,9	-	-	-	
	Wet peat moss lawn with pine trees	6,16	4+	3,9	0,2	4,1	-	-	-	
Augstroze NR (N 57° 34.902' E 025° 92.381')	Wet peat moss lawn	105	5+ (4+)	-0,5	0,3	-0,3	-	-	-	Forest remains after rewetting
	Wet peat moss hollows resp. flooded peat moss lawn	2,34	5+	-3,1	12	8,9	-	-	-	
	Oligotrophic Moist Forests and shrubberies	38	3+	9,4	0	9,4	9,4	0	9,397	

Tab.III-8: Post-restoration Scenario-2 in Project sites in Latvia

Site (GPS coordinates)	GEST-type	Area (predicted) [ha]	Water level	CO_2 emissions [t CO_2-eq. /ha/year]	CH_4 emissions [t CO_2-eq. /ha/year]	GWP estimate [t CO_2 eq. /ha/year]	CO_2 emissions [t CO_2-eq. /ha/year]	CH_4 emissions [t CO_2-eq. /ha/year]	GWP estimate [t CO_2 eq. /ha/year]	Remarks
				Without forest biomass			With forest biomass			
Engure Lake NR (N 57° 15.803' E 023° 08.710')	Wet calcareous Meadows, forbs,…	46	4+/5+	0.2	0.5	0.7	-	-	-	
Baltezers Mire NR (N 56° 40.621 E 022° 37.112)	Wet Meadows and forbs	34.48	5+	0	5.8	5.8	-	-	-	Due to weather conditions only rewetting is implement-ted
	Wet peat moss hollows resp. flooded peat moss lawn	1.86	5+	-3.1	12	8.9	-	-	-	
	Moderately moist Forest and shrubberies, Oligotrophic	3.17	2+	20	0	20	20	0	19.987	
	Moist Forests and shrubberies, Oligotrophic	2.99	3+	9.4	0	9.4	9.4	0	9.173	
Augstroze NR (N 57° 34.902' E025° 02.381')	Wet peat moss lawn	105	5+ (4+)	-0.5	0.3	-0.3	-	-	-	Tree die-off after rewetting
	Wet peat moss hollows resp. flooded peat moss lawn	2.34	5+	-3.1	12	8.9	-	-	-	
	Wet peat moss lawn with pine trees	38	4+	3.9	0.2	4.1	-	-	-	

First GEST GHG balance scenarios

Tab.III-9: Summarized emissions in all scenarios from all Project sites in Latvia

Site	GEST-type	Area [ha]	Emission GWP/a	Emission GWP/50a	Emission GWP /a	Emission GWP /50a
			Without forest biomass		With forest biomass	
Current						
Engure Lake NR	Wet calcareous Meadows, forbs,…	46,0	32,2	1610,0	32,2	1610,0
		SUM	**32,2**	**1610,0**	**32,2**	**1610,0**
Baltezers Mire NR	Wet Meadows and forbs	34,48	199,98	9999,2	199,98	9999,2
	Wet peat moss hollows resp. flooded peat moss lawn	1,86	16,55	827,7	16,55	827,7
	Moderately moist Forest and shrubberies, Oligotrophic	3,17	63,4	3170,0	63,36	3167,94
	Moist Forests and shrubberies, Oligotrophic	2,99	28,11	1405,3	27,43	1371,36
		SUM	**308,04**	**15402,2**	**307,32**	**15366,2**
Augstroze NR	Wet peat moss lawn	105,0	-31,50	-1575,0	-31,50	-1575,0
	Wet peat moss hollows resp. flooded peat moss lawn	2,34	20,83	1041,3	20,83	1041,3
	Moderately moist Forest and shrubberies, Oligotrophic	38,0	760,0	38000,0	759,89	37994,3
		SUM	**749,33**	**37466,3**	**749,22**	**37460,6**
		IN TOTAL	**1089,57**	**54478,5**	**1088,74**	**54436,8**
After management						
Engure Lake NR	Wet calcareous Meadows, forbs,…	46,0	32,2	1610,0	32,2	1610,0
		SUM	**32,2**	**1610,0**	**32,2**	**1610,0**
Baltezers Mire NR – Scenario 1	Wet Meadows and forbs	34,48	199,98	9999,2	199,98	9999,2
	Wet peat moss hollows resp. flooded peat moss lawn	1,86	16,55	827,7	16,55	827,7
	Wet peat moss lawn with pine trees	6,16	25,26	1262,8	25,26	1262,8
		SUM	**241,79**	**12089,7**	**241,79**	**12089,7**
Baltezers Mire NR – Scenario 2	Wet Meadows and forbs	34,48	199,98	9999,2	199,98	9999,2
	Wet peat moss hollows resp. flooded peat moss lawn	1,86	16,55	827,7	16,55	827,7
	Moderately moist Forest and shrubberies, Oligotrophic	3,17	63,4	3170,0	63,36	3167,94
	Moist Forests and shrubberies, Oligotrophic	2,99	28,11	1405,3	27,43	1371,36
		SUM	**308,04**	**15402,2**	**307,32**	**15366,2**
Augstroze NR – Scenario 1	Wet peat moss lawn	105,0	-31,50	-1575,0	-31,50	-1575,0
	Wet peat moss hollows resp. flooded peat moss lawn	2,34	20,83	1041,3	20,83	1041,3
	Moist Forests and shrubberies, Oligotrophic	38,0	357,2	17860,0	357,09	17854,3
		SUM	**346,53**	**17326,3**	**346,42**	**17320,6**
Augstroze NR – Scenario 2	Wet peat moss lawn	105,0	-31,50	-1575,0	-31,50	-1575,0
	Wet peat moss hollows resp. flooded peat moss lawn	2,34	20,83	1041,3	20,83	1041,3
	Wet peat moss lawn with pine trees	38,0	155,8	7790,0	155,8	7790,0
		SUM	**145,13**	**7256,3**	**145,13**	**7256,3**
		IN TOTAL - Scenario 1	**620,52**	**31026,0**	**620,41**	**31020,3**
		IN TOTAL - Scenario 2	**485,37**	**24268,5**	**484,65**	**24232,5**

III.3. Lithuania

Most of Lithuanian project sites are abandoned degraded cut-over peatlands, which were neglected right after the collapse of Soviet Union (except Aukštumala peatland) (Fig. III-2). Disturbances of natural ecosystems by drainage, peat cutting activities and lack of proper nature management in post-mining period have resulted unfavorable peatland formation conditions in these sites. Although spontaneous revegetation during the last decades is noticed, nevertheless the vast majority of secondary vegetation are still far from the natural status. According to GEST type mapping (performed in 2017) 20 GEST types were inventoried in all project sites. Currently about 284 ha (63 %) of all project area can be considered as forested GEST units. The rest area (168 ha) is assigned as open peatlands, however majority (137 ha) of these open GEST units are considered as severally damaged. Both forested and severely damaged open peatland GEST types emit considerably big amounts of GHG gasses.

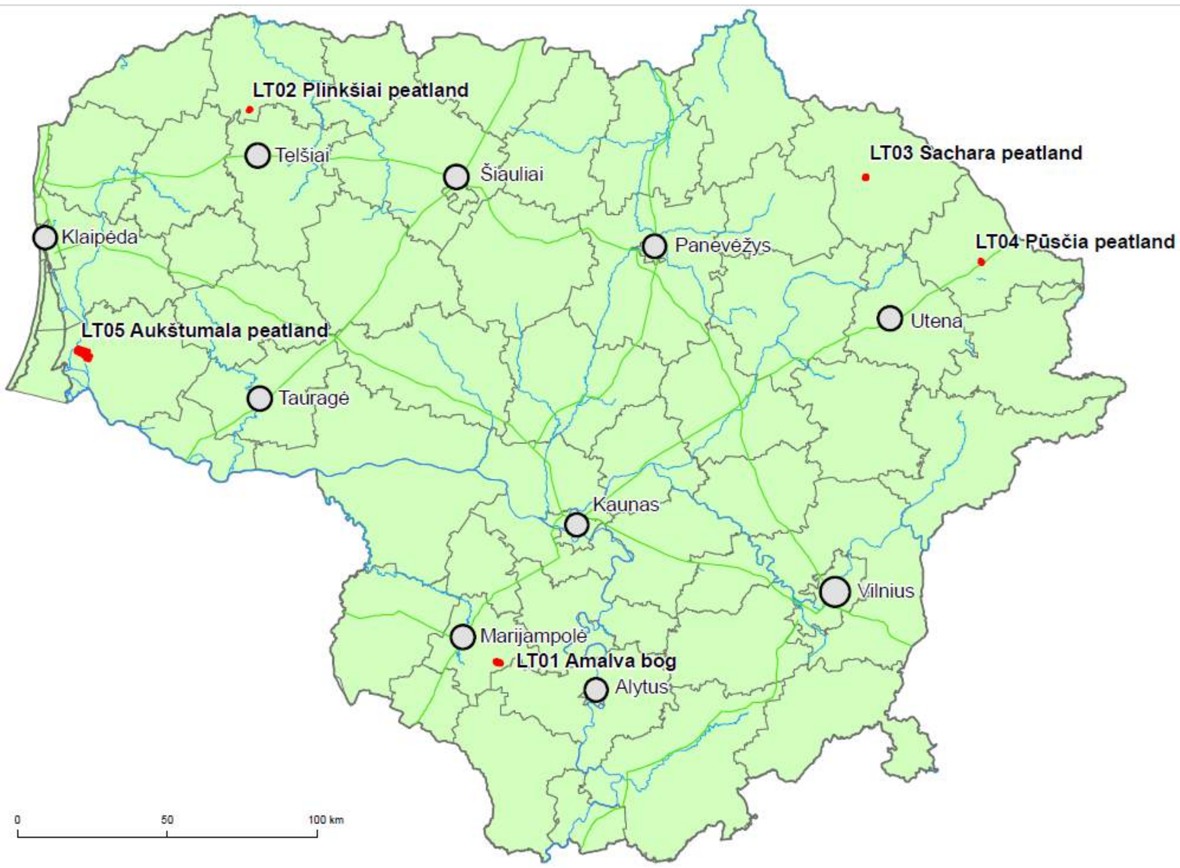


Fig.III-2: Distribution of project sites in Lithuania

III.3.1. Amalva LT01 site

On the ‘baseline scenario’, the biggest emissions were estimated in Amalva peatland, which is also the largest of all Lithuanian project sites 215 ha). The edges of the site are heavily drained, water level during the dry season falls to 1 m beneath peat surface. Forested GEST types occupy about 86 % of the area and emit 97 % of all estimated CO_2 emissions from the site. However estimated CH_4 emissions from these GEST types in Amalva site are considerably low. According to the ‘project scenario’, after the implementation of nature management actions forested peatlands will turn either into Wet peat moss lawn or Moist/Very moist eutrophic/mesotrophic forests and shrubberies. All the open peatland GEST types will develop into Wet peat moss lawn or Wet peat moss lawn with pine trees. Thus, the emissions of CO_2 will be reduced from 5809 to 759 t CO_2-eq./year and GWP from 5819 to 1530 t CO_2-eq./year Whereas CH_4 emissions will increase from 16 to 763 t CO2-eq./year (Tables III-10, III-11, III-12). This peatland was intensively drained but industrial peat mining did not take place in the site. This has resulted that dry and moderately moist forested peatland GEST types currently dominate in the area. Tree cutting and ditch blocking would help to improve habitat conservation status and significantly reduce CO_2 emissions.

III.3.2. Sachara LT03 site

Peat mining was carried out until 1981. At present, the territory is abandoned, thin layer of peat deposits has been left. Part of the peatland is spontaneously recovering by typical bog vegetation with dominant *Sphagnum* species (*S. cuspidatum, S. magellanicum*, etc.), *Eriophorum vaginatum, Ledum palustre and other.* 7 GEST types were inventoried in the site. Almost half of the site is characterized by open peatland habitats. The biggest CO_2 emissions are estimated from the forested peatlands (Moist and Moderately moist oligotrophic forests and shrubberies) and Bare peat GEST units, which are characterized by relatively low water level values (24–51 cm beneath the peat surface). Whereas CH_4 is mostly emitted from the Wet small sedges reeds mostly with moss layer GEST unit. According to the ‘Post restoration scenario’ almost all open peatland GEST units will be gradually replaced by Wet peat moss lawn. Hydrological restoration activities (damming of diches, tree cutting) will accelerate vegetation succession from forested GEST units to Wet peat moss lawn with pine trees. Thus the emissions of CO_2 will decrease from 780 to 46 t CO_2-eq./year, GWP from 851 to 250 t CO2-eq./year Whereas CH_4 emissions will increase from 69 to 204 t CO2-eq./year (Tables III-10, III-11, III-12).

III.3.3. Plinkšiai LT02 site

The site is quite homogenous. Only 3 GEST types were inventoried. The northern and central part of Plinkšiai peatland is occupied by GEST type Peat moss lawn on former peat-cut off areas. This habitat has formed after the end of industrial peat mining, which resulted the formation of hollows-embankment system. Currently embankments are starting to overgrow by birch and pine trees (tree coverage up to 20 %). Therefore, this GEST type should be considered as a mix of open (60 %) and forested (40 %) habitats. The southern part of the site was drained more intensively, thus mostly occupied by Moderately moist oligotrophic forests and shrubberies. Small fragments of Bare peat habitats can also be found in the southern part of the site. According to the ‘project scenario’, forested habitats will be gradually replaced by Wet peat moss lawn with pine trees. Bare peat GEST unit will turn into Very moist bog heath. Thus, CO_2 emissions will be reduced from 779 to 261 525 t CO_2-eq./year, GWP from 791 to 277 t CO_2-eq/year, CH_4 emissions will remain almost the same (Tables III-10, III-11, III-12).

III.3.4. Aukštumala LT05 site

The smallest of all Lithuanian project sites. Nevertheless, the site is very heterogeneous (6 GEST types). Almost all site is covered by open peatland habitat types. The biggest CO_2 emissions are estimated from Bare peat (dry), Moderately dry bog heath. Whereas Very moist meadows forbs and small sedges reeds and Wet tall reeds acts as the CO_2 sequestrators, but emits significant amount of CH_4 (38 t CO_2-eq/year). Project aims to establish *Sphagnum* dominated habitats in the former peat cutting area. Therefore part of the existing GEST units (Bare peat (dry), Moderately dry bog heath) will be replaced by Wet peat moss lawn. The rest of the GEST units will either be gradually changed by Wet small sedges reeds mostly with moss layer or remain the same. Thus CO_2 emissions will be reduced from 35 to -25,85 t CO_2-eq./year, GWP from 74 to 33 t CO_2-eq. /year/… CH_4 emissions will increase from 38 to 59 t CO_2-eq./year/ (Tables III-10, III-11, III-12).

First GEST GHG balance scenarios

Tab.III-10: Fixed baseline 2018. GEST types, area, emission factors and GHG emissions in Lithuania sites

Site (WGS Coordinates)	GEST-Type	Area [ha]	CO_2 Emission factor	CH_4 Emission factor*	GWP Emission factor*	CO_2 Emissions**	CH_4 Emissions**	GWP Emissions**	Remarks
Amalva LT01 54.495783, 23.544817	Very moist bog heath	2,03	1,7	3,0	4,6	3,45	6,09	9,34	
	Wet peat moss lawn with pine treles	20,60	3,9	0,2	4,1	80,34	4,12	84,46	
	Moderately moist bog heath	3,60	9,4	0	9,4	33,84	0	33,84	
	Open water/ditches	2,00	-	2,8	-	-	5,6	-	
	Moderately moist oligotrophic forests and shrubberies	89,3	20	0	20	1786,0 / (1768,14)	0	1786,0 (1768,14)	
	Moderately moist eutrophic forests and shrubberies	1,1	20	0	20	22 (21,89)	0	22 (21,89	
	Dry eutrophic forests and shrubberies	89,5	43,4	0	43,4	3884,3 (3857,45)	0	3884,3 (3857,45)	
					Total	**5809,93 (5765,11)**	**15,81**	**5819,94 (5775,12)**	
Sachara LT03 55.942547, 25.492139	Bare peat (moist)	8,78	6,2	0	6,2	54,44	0	54,44	
	Wet peat moss lawn with pine treles	10,43	3,9	0,2	4,1	40,67	2,09	42,76	
	Peat moss lawn on former peat-cut off areas	3,78	1,5	0,4	1,9	5,67	1,51	7,18	
	Wet small sedges reeds mostly with moss layer	9,66	-3,5	6,8	3,5	-33,81	65,69	33,81	

First GEST GHG balance scenarios

	Moist oligotrophic forests and shrubberies	34,51	9,4	0	9,4	324,40 (320,94)	0	324,40 (320,94)	
	Moderately moist oligotrophic forests and shrubberies	19,44	20	0	20	388,80 (384,91)	0	388,80 (384,91)	
	Open water/ditches	0,74	-	2,8	-				
					Total	**780,167 (772,82)**	**71,358**	**851,385 (844,04)**	
Pūsčia LT04 55.680165, 26.101178	Bare peat (moist)	23,88	6,2	0	6,2	148,06	0	148,06	
	Wet meadows and forbs	9,79	0,0	5,8	5,8	0	56,78	56,78	
	Very moist meadow, forbs and small sedges, reeds	0,42	-0,5	2,3	1,9	-0,21	0,97	0,80	
	Moist bog heath	6,37	9,4	0	9,4	59,88	0	59,88	
	Wet peat moss lawn with pine treles	0,19	3,9	0,2	4,1	0,74	0,04	0,78	
	Wet tall reeds	0,65	-2,3	6,3	4,0	-1,50	4,01	2,6	
	Moist reeds and (forb) meadows	4,22	4,6	7,5	12,2	19,41	31,65	51,49	
	Open water/ditches	5,58	-	2,8	-	-	15,62		
	Moderately moist mesotrophic and eutrophic forests and shrubberies	20,41	20	0	20	408,2 (404,12)	0	408,2 (404,12)	
	Moist mesotrophic and eutrophic forests and shrubberies	0,96	4,6	7,5	12,2	4,42 (4,22)	7,20 (7,10)	11,71	
	Moderately moist oligotrophic forests and shrubberies	11,47	20	0	20	229,40 (227,11)	0	229,40 (227,11)	

First GEST GHG balance scenarios

	Moist oligotrophic forest and Shrubberies	0,56	9,4	0	9,4	5,26 (5,15)	0	5,26 (5,15)	
	Open water/ditches	5,58	-	2,8	-	-	15,62	-	
					Total	**873,66 (866,98)**	**116,36 (116,26)**	**974,953 (968,48)**	
Plinkšiai LT02 56.141796, 22.19389	Bare peat (moist)	0,89	6,2	0	6,2	5,52	0	5,52	
	Peat moss lawn on former peat-cut off areas (60%)/ Moderately moist oligotrophic forests and shrubberies (40 %)	50,49	1,5/20	0,3/0	0,3/20	449,35	12,12	461,47	Mixed GEST unit
	Moderately moist oligotrophic forests and shrubberies	16,19	20	0	20	323,80 (320,56)	0	323,80 (320,56)	
					Total	**778,67 (775,43)**	**12,12**	**790,79 (787,55)**	
Aukstumala LT05 55.391833, 21.431127	Bare peat (dry)	1,34	6,2	0	6,2	8,31	0	8,31	
	Moderately dry bog heath	1,43	9,4	0	9,4	13,44	0	13,44	
	Moderately moist (forb) meadows	0,86	20	0	20	17,20	0	17,20	
	Very moist meadows forbs and small sedges reeds	3,82	-0,5	2,3	1,9	-1,91	8,79	7,26	
	Wet tall reeds	4,67	-2,3	6,3	4,0	-10,74	29,42	18,68	
	Moderately moist mesotrophic/eutrophic forests and shrubberies	0,44	20	0	20	8,80 (8,76)	0	8,80 (8,76)	
					Total	35,10 (35,06)	38,207	73,69 (73,65)	

* - emission factor t CO_2-eq. /ha/year

** - emissions CO_2-eq. /year with the C sequstration rates in forested peatland GEST types provided in brackets

First GEST GHG balance scenarios

Tab.III-11: Post restoration scenario, GEST-Types, area, emission factors and GHG emissions in Lithuanian sites.

Site (WGS Coordinates)	GEST-Type	Area [ha]	CO_2 Emission factor*	CH_4 Emission factor*	GWP Emission factor*	CO_2 Emissions**	CH4 Emissions**	GWP Emissions**	Remarks
Amalvas 54.495783, 23.544817	Wet peat moss lawn with pine trees	94,93	3,9	0,2	4,1	370,22	18,99	389,21	
	Very moist peat moss lawn	20,6	-1,1	3,4	2,3	-22,66	70,04	47,38	
	Very moist eutrophic mesotrophic Forests and shrubberies	1,1	-0,5	2,1	1,6	-0,55 (-0,77)	2,31 (2,09)	1,76 (1,54)	
	Moist eutrophic mesotrophic Forests and shrubberies	89,5	4,6	7,5	12,2	411,7 (384)	671,25 (644,40)	1091,9 (1065,05)	
					Total	**758,72 (730,79)**	**762,59 (735,52)**	**1530,25 (1503,18)**	
Sachara 55.942547, 25.492139	Wet peat moss lawn with pine treles	28,22	3,9	0,2	4,1	110,06	5,64	115,70	
	Wet peat moss lawn	58,38	-1,1	3,4	2,3	-64,22	198,492	134,274	Possible vegetation shifts to Wet peat moss hollows resp. flooded peat moss lawn instead of Open water/ditches GEST type
					Total	**45,84**	**204,14**	**249,98**	
Pūsčia 55.680165, 26.101178	Wet peat moss lawn with pine trees	23,88	3,9	0,2	4,1	93,13	4,78	97,91	
	Wet peat moss lawn	21,93	-1,1	3,4	2,3	-24,12	74,56	50,44	Possible vegetation shifts to Wet peat moss

First GEST GHG balance scenarios

									hollows resp. flooded peat moss lawn instead of Open water/ditches GEST type
	Very moist meadow, forbs and small sedges, reeds	1,07	-0,5	2,3	1,9	-0,54	2,46	2,03	
	Wet small sedges reeds mostly with moss layer	4,22	-3,5	6,8	3,3	-14,77	28,70	13,93	
	Moist eutrophic Forests and shrubberies	20,41	4,6	7,5	12,2	93,89 (89,80)	153,08 (148,99)	249,00 (244,92)	
	Very moist eutrophic Forests and shrubberies	0,96	-0,5	2,1	1,6	-0,48 (-0,57)	2,02 (1,92)	1,54 (1,44)	
	Moist oligotrophic Forest and shruberies	11,47	9,4	0	9,4	107,82 (105,52)	0	107,82 (105,52)	
	Very Moist oligotrophic Forest and shruberies	0,56	1,7	3	4,7	0,952 (0,90)	1,68 (1,62)	2,63 (2,58)	
					Total	**255,88 (249,35)**	**267,27 (263,03)**	**525,29 (518,77)**	
Plikšiai 56.141796, 22.19389	Very moist bog heath	0,89	1,7	3	4,6	1,513	2,67	4,094	
	Wet peat moss lawn with pine trees	66,68	3,9	0,2	4,1	260,052	13,336	273,388	
					Total	**261,57**	**16,01**	**277,48**	
Aukštumala 55.391833, 21.431127	Wet peat moss lawn	2,77	-1,1	3,4	2,3	-3,047	9,418	6,371	
	Wet small sedges reeds mostly with moss layer	5,97	-3,5	6,8	3,3	-20,895	40,596	19,701	
	Very moist meadows forbs and small sedges reeds	3,82	-0,5	2,3	1,9	-1,91	8,786	7,258	
					Total	**-25,85**	**58,80**	**33,33**	

* - emission factor t CO_2-eq. /ha/year

** - emissions t CO_2-eq/year with the C sequstration rates in forested peatland GEST types provided in brackets

Tab.III-12: Summarized data on GHG emissions according to 'Fixed baseline 2018' and 'Post restoration' scenario in Lithuanian project site

	GEST type	Total area	Total CO_2 Emission*	Total CH_4 Emission*	Total GWP Emission*
Fixed baseline 2018	Bare peat (dry)	1,34	8,308	0	8,308
	Bare peat (moist)	33,55	208,01	0	208,01
	Moderately dry bog heath	1,43	13,442	0	13,442
	Moderately moist (forb) meadows	0,86	17,2	0	17,2
	Moderately moist bog heath	3,6	33,84	0	33,84
	Moist bog heath	6,37	59,878	0	59,878
	Moist mesotrophic and eutrophic forests and shrubberies	0,96	4,416	7,2	11,712
	Moist reeds and (forb) meadows	4,22	19,412	31,65	51,484
	open water/ditches	8,32	0	23,296	0
	Peat moss lawn on former peat-cut off areas	34,07	51,105	13,628	64,733
	Very moist bog heath	2,03	3,451	6,09	9,338
	Very moist meadow, forbs and small sedges, reeds	4,24	-2,12	9,752	8,056
	Wet meadows and forbs	9,79	0	56,782	56,782
	Wet peat moss lawn with pine trees	31,22	121,758	6,244	128,002
	Wet small sedges reeds mostly with moss layer	9,66	-33,81	65,688	33,81
	Wet tall reeds	5,32	-12,236	33,516	21,28
	Dry eutrophic forests and shrubberies	89,5	3884,3	0	3884,3
	Moderately moist eutrophic forests and shrubberies	21,95	439	0	439
	Moderately moist oligotrophic forests and shrubberies	156,596	3131,92	0	3131,92
	Moist oligotrophic forests and shrubberies	35,07	329,658	0	329,658
		Total	**8277,532**	**253,846**	**8510,753**
Post-Restoration scenario	Very moist bog heath	0,89	1,513	2,67	4,094
	Very moist meadows forbs and small sedges reeds	4,89	-2,445	11,247	9,291
	Very moist peat moss lawn	20,6	-22,66	70,04	47,38
	Wet peat moss lawn	83,08	-91,388	282,472	191,084
	Wet peat moss lawn with pine trees	213,71	833,469	42,742	876,211
	Wet small sedges reeds mostly with moss layer	10,19	-35,665	69,292	33,627
	Moist eutrophic mesotrophic Forests and shrubberies	109,91	505,586	824,325	1340,902
	Very moist eutrophic mesotrophic Forests and shrubberies	2,06	-1,03	4,326	3,296
	Moist oligotrophic Forest and shruberies	11,47	107,818	0	107,818
	Very Moist oligotrophic Forest and shruberies	0,56	0,952	1,68	2,632
		Total	**1296,15**	**1308,794**	**2616,335**

*** -** emissions t CO_2-eq/year

First GEST GHG balance scenarios

Mapping of GEST units indicates unfavorable peatland habitat status of Lithuanian project sites. Low water level has accelerated peat mineralization process, as a result not only valuable habits are lost, but significant amounts of GHG are released to the atmosphere. Estimation of GHG emissions of 5 Lithuanian project sites shows, that currently 8277 t of CO_2-eq. are released every year. The biggest part of these emissions comes from various types of drained forest GEST types and Bare peat habitats, which dominates in the project sites. On the other hand, according to 'Fixed baseline 2018' methane emissions form Lithuanian sites are comparably low (254 t of CO_2-eq/year). This is partly determined by the fact that CH_4 emission factor form the forested peatland and Bare peat GEST types is usually comparably low. However, considering the estimation of GWP emission amounts, the impact for the climate change is still very significant (8510 t CO_2-eq/year).

For the precise estimation of GHG emissions carbon sequestration by trees was also taken into consideration. Calculation shows, that carbon sequestration rates in forested peatland GEST types is comparably low. This is partly determined by the fact that most of the trees are comparably young and grows on the nutrient poor conditions. According to 'Fixed baseline 2018' carbon stored in tree biomass helps to sequestrate CO_2 emission only by 0,6 % (8277,53 t CO_2-eq/year with tree biomass; 8224,64 t CO_2-eq/year without tree biomass) and GWP by 0,7 % (8510,75 t CO_2-eq/year with tree biomass; 8848,44 t CO_2-eq/year without tree biomass). However, carbon potentially stored in wooden biomass might release significantly bigger GHG amounts in case of fire accidents, keeping in mind that drained peatlands are very vulnerable.

The project aims to restore abandoned and degraded peatlands by implementing various restoration methods. Without nature management peatland habitat succession would further continue to change towards forested, degraded and other severally damaged habitat types. Thus, the total GHG emissions within the next 30 years would increase significantly if restoration measures will not be implemented. Direct estimation of the scenario "no conservation measures" is complicated, because global warming potential should be taken into consideration.

Project actions will have positive impact on GHG emission reduction. Based on 'project scenario' total amount of CO_2 emission will be reduced by 84 % (from 8277,53 to 1296,15 t CO_2-eq/year , GWP by 69 % (from 8510,75 to 2616,33 CO_2-eq/year) (Table III-13). The biggest CO_2 reduction is expected from the Amalva LT01 site, which is also the largest project site in Lithuania.

Based on the "Post restoration scenario" emissions of methane will increase in all sites from 253,85 to 1308,80 t CO_2-eq/year. This is especially evident in Amalva and Sachara sites. This temporary CH_4 emission increment can be explained by raised water level and increased input of organic material from dying vegetation. However, considering the estimation of GWP emission reduction, expected impact of project actions for the climate change mitigation is still very significant (Table III-13). It is expected that due to the project actions methane emissions will start to decrease within upcoming 100 years

Tab.III-13: Summarized table of GHG emission reduction in 5 Lithuanian project sites

	CO_2 [t CO_2-eq. /year]	CH4 [t CO_2-eq. /year]	GWP [t CO_2-eq. /year]
Baseline, 2018	8277,53	253,85	8510,75
Post restoration scenario	1296,15	1308,80	2616,34
Savings (%)	84	-415	69

III.4. Germany

Location 1 (BB01)

Based on the results of the GEST monitoring analysis report we identified five GEST Types in Location 1 (Tab.III-14). We calculated two different GHG estimations for both scenarios: (1) without biomass and (2) with biomass.

The open peatland GESTs Moist reeds and (forb) meadows and Very moist Meadows, forbs and small sedges reeds are small GHG sources. The moist reeds and (forb) meadows emit 0,65 t CO_2-equivalents per year in the baseline scenario. Because of the expected disappearance after the restoration measures, we calculated no emissions for this type in the restoration scenario. The annual emissions of the Very moist meadows, forbs and small sedges reeds increase slightly from 0,3 t CO_2-equivalents in the baseline scenario to 1,6 t CO_2-equivalents in the post-restoration scenario. The GWP Reduction potential is therefore 0,65 t CO_2-equivalents for the moist reeds and (forb) meadows and a slight shift of the GWP of around 1,3 t CO_2-equivalents per year for the very moist meadows, forbs and small sedges reeds.

The GEST-Type Moist mesotrophic Forests and shrubberies emit in the baseline ca. 0,5 and only 0,03 t CO_2 per year (with woods) for the baseline and the post-restoration scenario respective. Regarding also the methane emissions the global warming potential of this GEST-Type is a quite higher. It is around 36,5 t and only 2,25 t CO_2-equivalents per year for baseline and post-restoration scenario respective. Compared with the baseline scenario the GWP-Reduction potential of this GEST-Type with woods is 34,2 t CO_2-equivalents per year.

Compared with studies by AUGUSTIN et al. (2001) in a similar alder forest with a water level of 3+ (moist, water table Ø 25 cm below the surface) our calculated annual GWP-factor per hectar with woods (7,7 t CO_2-eq.) is much higher (ca. 0,03 t CO_2-eq.). The reason for that differences could be the very small methan emissions (only 0,005 t CO_2-eq.; measured with chambers vs. 7,5 t CO_2-eq.; according to the updated GEST-Catalogue). The factor is extrapolated from the open GEST-Type Moist reeds and forb meadows and referred to KOCH et al. (2014), WILSON et al. (2016) and FORTUNIAK et al. (2017), who measured in different stands of reeds and sedges. It is well known, that this plants have a wide arenchyma-system and transport huge amounts of soil-borne methane directly in the atmosphere. Fortunately in the reviewed GEST-List from REICHELT (2015) the calculated methane emission factors are similar to the measured ones by AUGUSTIN et al. (2001). Consequently the GWP-reduction potential must be corrected. Therefore the reduction potential amounts only by 0,48 t CO_2-eq. per year (Tab. III-14).

The Very moist mesotrophic Forests and shrubberies capture in the baseline scenario ca. 15,2 t and ca. 31,6 t CO_2 per year in the post-restoration scenario. Regarding also the methane emissions the global warming potential of this GEST-Type is a bit higher, but in total this GEST-Type is a GHG-sink with around -7,6 t and -15,9 t CO_2-equivalents per year for the baseline and the post-restoration scenario respective. Whereby a negative sign means a Netto-CO_2-uptake. Compared with the baseline scenario the GWP-reduction potential of this GEST-Type with woods is 8,3 t CO_2-equivalents per year due to the expected GEST-Shifts induced by the restoration measures.

Compared with studies by AUGUSTIN et al. (2001) in a similar alder forest with a water level of 4+ (very moist; water table Ø 10 cm below the surface) our calculated annual GWP-factor per hectar with woods (-2,3 t CO_2-eq.) fits well with the given range of AUGUSTIN et al. (2001) (ca. -7,5 to ca. -1,7 t CO_2-eq. per hectar and year).

The Wet mesotrophic Forests and Shrubberies are also carbon sinks with ca. 12,1 t CO_2-eq. per year in both scenarios, because we expect no spreading of this GEST-Type in the future. Together with the methane emissions sequestrate in the baseline and also in the post-restoration scenario the global warming potential lies around ca. 1,6 t CO_2-eq. per year and consequently this GEST-Type has a slight warming effect to the climate. There is no GWP-reduction potential expected.

Compared with studies by AUGUSTIN et al. (2001) in a similar alder forest with a water level of 5+ (wet; water table Ø 5 cm above the surface) our calculated annual GWP-factor per hectar with woods (ca. 0,8 t CO_2-eq.) fits also well with the given range of AUGUSTIN et al. (2001) (ca. -4,9 to ca. 6,6 t CO_2-eq. per hectar and year)

Location 2 (BB02)

Based on the results of the GEST monitoring analysis report we identified only two GEST Types in Location 2 (Tab.III-14). We calculated two different GHG estimations for both scenarios: (1) without biomass and (2) with biomass.

The GEST-Type Moist mesotrophic Forests and shrubberies take up in total ca. 10,5 t CO2 (with woods) annually in the baseline and ca. 7,7 t CO2 in the post-restoration scenario. Regarding also the methane emissions the global warming potential of this GEST-Type is bit higher. It is around 1,9 t and 1,7 t CO_2-equivalents per year for baseline and post-restoration scenario respective and transform this GEST-Type in a GHG source. Compared with the baseline scenario the GWP-Reduction potential of this GEST-Type with woods is only ca. 0,2 t CO_2-equivalents per year.

Compared with studies by AUGUSTIN et al. (2001) in a similar alder forest with a water level of 3+ (moist, water table Ø 25 cm below the surface) our calculated annual GWP-factor per hectar with woods (1,6 t CO_2-eq.) is slight higher (ca. 0,03 t CO_2-eq.). The reason for these differences was discussed above. Depending on the used factors the GWP can be decrease slightly (0,2 t CO_2-equivalents) or increase significantly (+ 2,8 t CO_2-eq.) (Tab. III-14).

The Very moist mesotrophic Forests and shrubberies capture in the baseline scenario ca. 8,3 t and ca. 10,2 t CO_2 per year in the post-restoration scenario. Regarding also the methane emissions the global warming potential of this GEST-Type is a bit higher, but in total this GEST-Type is a GHG-sink with around -4,6 t and -5,7 t CO_2-equivalents per year for the baseline and the post-restoration scenario respective. Whereby a negative sign means a Netto-CO_2-uptake. Compared with the baseline scenario the GWP-reduction potential of this GEST-Type with woods is 1,1 t CO_2-equivalents per year due to the expected GEST-Shifts induced by the restoration measures.

Compared with studies by AUGUSTIN et al. (2001) in a similar alder forest with a water level of 4+ (very moist; water table Ø 10 cm below the surface) our calculated annual GWP-factor per hectar with woods (ca. -4,6 t CO_2-eq.) fits well with the given range of AUGUSTIN et al. (2001) (ca. -7,5 to ca. -1,7 t CO_2-eq. per hectar and year).

Location 3 (BB03)

Based on the results of the GEST monitoring analysis report we identified only one GEST Types in Location 3 (Tab.III-14). We calculated two different GHG estimations for both scenarios: (1) without biomass and (2) with biomass.

The GEST-Type Moderately Moist mesotrophic Forests and shrubberies emit in total ca. 12,3 t CO_2 (with woods) annually in the baseline and only a bit lesser, ca. 12,1 t CO_2 in the post-restoration scenario. Due to missing methane emissions the global warming potential of this GEST-Type is the same amount like CO_2. Compared with the baseline scenario the GWP-Reduction potential of this GEST-Type with woods is only ca. 0,2 t CO_2-equivalents per year.

Compared with studies by OJANEN et al. (2014) in a mesotrophic herb-rich forest with a similar water level of 3+ (moist) our calculated annual GWP-factor per hectar with woods (ca. 12,3 t CO_2-eq.) is much higher than the given values by OJANEN et al. (2014) (-6,9 t CO_2-eq./ha/yr.), but this study was conducted in a boreal climate with a lower respiration rates. Furthermore it refers to a forestry-drained stand with optimal tree growth condition, so that we cannot compare this study with our values.

Tab.III-14: Estimated GEST-GHG emissions in the baseline scenario in the German Project site with and without woods (all GHG-emissions are given in t CO_2-eq. /ha/yr)

GEST-Type	Area [ha]	CO_2 Without woods	CH_4 Without woods	GWP Without woods	CO_2 With woods	CH_4 With woods	GWP With woods
Location 1							
Open Peatlands							
Moist reeds and (forb) meadows	0,05	0,24	0,40	0,65	0,24	0,40	0,65
Very moist Meadows, forbs and small sedges reeds	0,16	-0,08	0,37	0,30	-0,08	0,37	0,30
Forested Peatlands							
Moist Forests and shrubberies	4,80	22,06	0 (35,96)*	22,06 (58,02)*	0,52	0 (35,96)*	0,52 (36,48)*
Very Moist Forests and Shrubberies	3,58	-1,79	7,53	5,73	-15,15	7,53	-7,63
Wet Forests and Shrubberies	2,01	-7,02	13,65	6,62	-12,09	13,65	1,56
Location 2							
Forested Peatlands							
Moist Forests and shrubberies	1,65	7,59	0 (12,37)*	7,59 (19,95)*	-10,51	0 (12,37)*	-10,51 (1,86)*
Very Moist Forests and Shrubberies	1,77	-0,88	3,71	2,83	-8,33	3,71	-4,61
Location 3							
Forested Peatlands							
Moderately Moist Forests and Shrubberies	0,65	12,98	0	12,98	12,27	0	12,27

* higher emissions in brackets based on the higher methane emission factor extrapolated from moist reeds and (forb) meadows according to the updated GEST-Catalogue

Tab.III-15: Estimated GEST-GHG emissions in the post-restoration scenario in the German Project site with and without woods (all GHG-emissions are given in t CO_2-eq. /ha/yr)

GEST-Type	Area [ha]	CO_2	CH_4	GWP	CO_2	CH_4	GWP
		Without woods			With woods		
Location 1							
Open Peatlands							
Very moist Meadows, forbs and small sedges reeds	0,83	-0,42	1,91	1,58	-0,42	1,91	1,58
Forested Peatlands							
Moist Forests and shrubberies	0,30	1,36	0 (2,22)*	1,36 (3,58)*	0,03	0 (2,22)*	0,03 (2,25)*
Very Moist Forests and Shrubberies	7,47	-3,73	15,68	11,95	-31,57	15,68	-15,89
Wet Forests and Shrubberies	2,01	-7,02	13,65	6,62	-12,09	13,65	1,56
Location 2							
Forested Peatlands							
Moist Forests and shrubberies	1,25	5,75	0 (9,37)*	5,75 (15,11)*	-7,70	0 (9,37)*	-7,70 (1,67)*
Very Moist Forests and Shrubberies	2,17	-1,08	4,55	3,47	-10,22	4,55	-5,67
Location 3							
Forested Peatlands							
Moderately Moist Forests and Shrubberies	0,65	12,98	0	12,98	12,10	0	12,10

* higher emissions in brackets based on the higher methane emission factor extrapolated from moist reeds and (forb) meadows according to the updated GEST-Catalogue

Tab.III-16: Summarized estimated GEST-GHG emissions in both scenarios and the reduction potentials in the German Project site with and without woods (all GHG-emissions are given in t CO_2-eq. /ha/yr)

GEST-Type	Area [ha]		CO_2		CH_4		GWP		CO_2		CH_4		GWP	
			Without woods						With woods					
	base	post	base	post	base	post	base	post	base	post	base	post	base	post
Open Peatlands														
Moist reeds and (forbs) meadows	0,05	-	0,24	-	0,40	-	0,65	-	0,24	-	0,40	-	0,65	-
Very Moist Meadows, forbs and small sedges reeds	0,16	0,83	-0,08	-0,42	0,37	1,91	0,30	1,58	-0,08	-0,42	0,37	1,91	0,30	1,58
Forested Peatlands														
Moderately Moist Forests and Shrubberies	0,65	0,65	12,98	12,98	0	0	12,98	12,98	12,28	12,10	0	0	12,28	12,10
Moist Forests and Shrubberies	6,44	1,55	29,64	7,11	0	0	29,64	7,11	-9,99	-7,67	0	0	-9,99	-7,67
Very Moist Forests and Shrubberies	5,35	9,63	-2,68	-4,82	11,24	20,23	8,56	15,41	-23,48	-41,78	11,24	20,23	-12,24	-21,55
Wet Forests and Shrubberies	2,01	2,01	-7,02	-7,02	13,56	13,56	6,62	6,62	-12,09	-12,09	13,56	13,56	1,56	1,56
Sum	**14,66**	**14,66**	**33,08**	**7,83**	**25,57**	**35,70**	**58,75**	**43,70**	**-33,12**	**-49,86**	**25,57**	**35,70**	**-7,44**	**-13,98**
Reduction Potential				**-25,25**		**+10,13**		**-15,05**		**-16,74**		**+10,13**		**-6,54**

base means baseline scenario; post means post-restoration scenario

III.5. Poland

Tab.III-17: Estimated GEST-GHG emissions in the baseline scenario in the Polish Project site with and without woods (all GHG-emissions are given in t CO_2-eq. /ha/yr)

GEST-Type	Area [ha]	CO_2	CH_4	GWP	CO_2	CH_4	GWP
		Without Forest Biomass			With Forest Biomass		
Ciemińskie Błota							
Moderately Moist Forests and Shrubberies	80,37	1607,4	0,00	1607,40	1600,5	0,00	1600,5
Moderately Moist Meadows	1,08	21,60	0,00	21,60	21,5	0,00	21,5
Moist Forests and Shrubberies (Mesotrophic/Oligotrophic)	23,24	107,40	175,11	282,49	105,40	175,11	280,56
Peat Moss lawn on former peat-cut off areas	2,36	3,60	0,87	4,48	3,10	0,87	3,99
Very Moist Forests and Shrubberies (Mesotrophic/Oligotrophic)	7,48	12,70	22,44	35,16	12,70	22,44	35,16
Very Moist Peat Moss Lawn	5,61	-6,10	19,32	13,18	-6,10	19,32	13,18
Very Moist Bog Heath	1,21	3,70	26,15	29,89	3,70	26,15	29,89
Wet Forests and Shrubberies	36,77	-129,70	249,83	120,12	-131,00	249,83	118,85
Wet Small Sedges Reeds mostly with moss layer	1,68	-5,90	11,41	5,49	-5,90	11,41	5,49
Wet Tall Sedges Reeds	3,47	-0,30	29,50	29,15	-0,60	29,50	28,92
Kluki							
Moderately Moist Forests and Shrubberies	432,63	8652,60	0,00	8652,60	8614,90	0,00	8614,90
Moist Bog Heath	0,43	4,04	0,00	4,04	4,04	0,00	4,04
Open Water/Ditches	1,11	N/D	3,15	N/D	N/D	3,15	N/D
Peat Moss Lawn on former peat-cut off areas and Moist Forests	0,75	1,1	0,28	1,42	1,1	0,28	1,42
Wet small sedges reeds mostly with moss layer	0,01	0,0	0,07	0,03	0,0	0,07	0,03
Very Moist Peat Moss Lawn	1,36	-1,5	4,68	3,20	-1,5	4,68	3,20
Moderately Dry Forests and Shrubberies	9,82	255,5	0,00	255,52	254,3	0,00	254,3
Very Moist Forests and Shrubberies	1,5	2,6	4,50	7,05	2,5	4,50	7,01
Peat moss lawn on former peat-cut off areas	14,91	22,8	5,50	28,33	21,4	5,50	26,86
Moist Forests and Shrubberies	29,93	138,3	225,52	363,80	135,6	225,52	361,11
Moderately Moist Meadows (forb)	14,29	285,8	0,00	285,80	285,5	0,00	285,5
Wielkie Błoto							

First GEST GHG balance scenarios

Moderately Moist Forests and Shrubberies	265,9	5318,0	0,00	5318,0	5289,8	0,00	5289,8
Moderately Moist Meadows	6,8	136,0	0,00	136,00	135,3	0,00	135,3
Very Moist Forests and Shrubberies	0,55	0,9	1,65	2,59	0,8	1,65	2,44
Very Moist Peat Moss Lawn	23,02	-25,2	79,29	54,10	-25,6	79,29	53,71
Peat Moss Lawn on former peat-cut off areas	86,46	132,4	31,88	164,26	126,6	31,88	158,45
Moderately Dry Forests and Shrubberies	4,95	128,8	0,00	128,8	128,1	0,00	128,1
Moist Forests and Shrubberies	98,59	455,5	742,88	1198,38	448,8	742,88	1191,70
Moderately Moist Bog Heath	8,63	N/D	N/D	N/D	N/D	N/D	N/D
Very Moist Bog Heath	12,95	21,6	38,51	60,11	21,6	38,51	60,11
Wet Peat Moss Lawn with pine trees	14,07	54,2	3,10	57,69	54,2	3,10	57,69
Wet Peat Moss Lawn	0,67	-0,4	0,17	-0,19	-0,4	0,17	-0,19
Bare Peat (Moist)	0,57	3,5	-0,01	3,53	3,5	-0,01	3,53
Bare Peat (Wet)	1,71	2,5	0,14	2,74	2,5	0,14	2,74
Moist Bog Heath	0,03	0,3	0,00	0,28	0,3	0,00	0,28
Open Water/Ditches	21,38	N/D	60,58	N/D	N/D	60,58	N/D
Wet Peat Moss Hollows resp. flooded peat moss lawn	0,25	-0,8	3,01	2,23	-0,8	3,01	2,23
Wet small sedges reeds mostly with moss layer	1,93	-6,8	13,11	6,30	-6,8	13,11	6,30
Wet tall sedges reeds	0,55	-0,1	4,68	4,62	-0,1	4,68	4,62
Wet tall reeds	0,04	-0,1	0,25	0,16	-0,1	0,25	0,16

First GEST GHG balance scenarios

Tab.III-18: Estimated GEST-GHG emissions in the post-restoration scenario in the Polish Project site with and without woods (all GHG-emissions are given in t CO_2-eq. /ha/yr)

GEST-Type	Area [ha]	CO_2	CH_4	GWP	CO_2	CH_4	GWP
		Without Forest Biomass			With Forest Biomass		
Ciemińskie Błota							
Moderately Moist Forests and Shrubberies	59,97	1199,4	0,00	1199,4	1191,8	0,00	1191,8
Moderately Moist Meadows	0,29	5,8	0,00	5,80	5,8	0,00	5,80
Moist Forests and Shrubberies (Mesotrophic/Oligotrophic)	37,49	173,2	282,49	455,70	172,1	282,49	454,59
Peat Moss lawn on former peat-cut off areas	2,57	3,9	0,95	4,88	3,8	0,95	4,75
Very Moist Forests and Shrubberies (Mesotrophic/Oligotrophic)	12,55	21,3	37,65	58,99	21,3	37,65	58,99
Very Moist Peat Moss Lawn	6,25	-6,8	21,53	14,69	-6,8	21,53	14,69
Very Moist Bog Heath	0,57	1,8	12,32	14,08	1,8	12,32	14,08
Wet Forests and Shrubberies	36,77	-129,70	249,83	120,12	-131,00	249,83	118,85
Wet Small Sedges Reeds mostly with moss layer	1,68	-5,90	11,41	5,49	-5,90	11,41	5,49
Wet Tall Sedges Reeds	3,71	-0,4	31,54	31,16	-0,4	31,54	31,16
Moist Reeds and Meadows	1,43	6,6	10,78	17,38	6,6	10,78	17,38
Kluki							
Moderately Moist Forests and Shrubberies	326,32	6526,4	0,00	6526,4	6488,9	0,00	6488,9
Moist Bog Heath	0,43	4,04	0,00	4,04	4,04	0,00	4,04
Open Water/Ditches	1,1	N/D	3,12	N/D	N/D	3,12	N/D
Wet small sedges reeds mostly with moss layer	0,59	-2,1	4,01	1,93	-2,1	4,01	1,93
Very Moist Peat Moss Lawn	2,79	-3,1	9,61	6,56	-3,1	9,61	6,56
Moderately Dry Forests and Shrubberies	9,53	248,0	0,00	247,97	247,1	0,00	247,1
Very Moist Forests and Shrubberies	16,31	27,7	48,93	76,66	27,7	48,93	76,66
Peat moss lawn on former peat-cut off areas	25,5	39,0	9,40	48,45	37,6	9,40	47,0
Moist Forests and Shrubberies	115,3	532,7	868,79	1401,49	530,2	868,79	1398,99
Moderately Moist Meadows (forb)	3,93	78,6	0,00	78,6	78,0	0,00	78,0
Moist Reeds and Meadows	4,2	19,40	31,5	50,90	19,40	31,5	50,90
Wielkie Błoto							

First GEST GHG balance scenarios

Moderately Moist Forests and Shrubberies	217,76	4355,2	0,00	4355,2	4327,7	0,00	4327,7
Moderately Moist Meadows	1,0	20,0	0,00	20,00	19,4	0,00	19,4
Very Moist Forests and Shrubberies	30,23	51,4	90,96	142,08	51,3	90,69	141,99
Very Moist Peat Moss Lawn	32,17	-35,2	110,81	75,60	-35,5	110,81	75,31
Peat Moss Lawn on former peat-cut off areas	109,73	168,0	40,46	208,47	164,8	40,46	205,26
Moderately Dry Forests and Shrubberies	4,71	122,6	0,00	122,6	121,9	0,00	121,9
Moist Forests and Shrubberies	106,91	493,9	805,57	1299,51	488,1	805,57	1293,67
Wet Peat Moss Lawn	32,43	-17,4	8,11	-9,32	-17,5	8,11	-9,39
Open Water/Ditches	27,07	N/D	76,70	N/D	N/D	76,70	N/D
Wet Peat Moss Hollows resp. flooded peat moss lawn	0,25	-0,8	3,01	2,23	-0,8	3,01	2,23
Wet small sedges reeds mostly with moss layer	0,07	-0,2	0,48	0,23	-0,2	0,48	0,23
Wet tall sedges reeds	0,55	-0,1	4,68	4,62	-0,1	4,68	4,62
Wet tall reeds	0,04	-0,1	0,25	0,16	-0,1	0,25	0,16

Tab.III-19: Summarized estimated GEST-GHG emissions in both scenarios and the reduction potentials in the Polish Project site with and without woods (all GHG-emissions are given in t CO_2-eq. /ha/yr)

GEST-Type	Area [ha]		CO_2		CH_4		GWP		CO_2		CH_4		GWP	
			Without woods						With woods					
	base	post	base	post	base	post	base	post	base	post	base	post	base	post
Open Peatlands														
Moderately Moist (forb) Meadows	22,17	5,22	443,4	104,4	0,00	0,00	443,4	104,4	443,4	104,4	0,00	0,00	443,4	104,4
Peat Moss Lawn on former peat-cut off areas	104,48	137,8	159,9	210,9	38,53	50,81	198,43	261,71	159,9	210,9	38,53	50,81	198,43	261,71
Very Moist Peat Moss Lawn	29,99	41,21	-32,8	-45,1	103,29	141,95	70,49	96,85	-32,8	-45,1	103,29	141,95	70,49	96,85
Very Moist Bog Heath	14,16	0,57	25,3	1,8	64,66	12,32	89,96	14,12	25,3	1,8	64,66	12,32	89,96	14,12
Wet Small Sedges Reeds mostly with Moss Layer	3,62	2,34	-12,7	-8,2	24,59	15,9	11,89	7,7	-12,7	-8,2	24,59	15,9	11,89	7,7
Wet Tall Sedges Reeds	4,02	4,26	-0,4	-0,5	34,18	36,22	33,78	35,72	-0,4	-0,5	34,18	36,22	33,78	35,72
Moist Bog Heath	0,46	0,43	4,34	4,04	0,00	0,00	4,34	4,04	4,34	4,04	0,00	0,00	4,34	4,04
Open Water/Ditches	22,49	28,17	N/D	N/D	63,73	79,82	N/D	N/D	N/D	N/D	63,73	79,82	N/D	N/D
Moderately Moist Bog Heath	8,63	-	N/D	-	N/D	-	N/D	-	N/D	-	N/D	-	N/D	-
Wet Peat Moss Lawn with pine trees	14,07	-	54,2	-	3,10	-	57,69	-	54,2	-	3,10	-	57,69	-
Wet Peat Moss Lawn	0,67	32,43	-0,4	-17,4	0,17	8,11	-0,19	-9,32	-0,4	-17,4	0,17	8,11	-0,19	-9,32
Bare Peat (Moist)	0,57	-	3,5	-	-0,01	-	3,53	-	3,5	-	-0,01	-	3,53	-
Bare Peat (Wet)	1,71	-	2,5	-	0,14	-	2,74	-	2,5	-	0,14	-	2,74	-
Wet Peat Moss Hollows resp. flooded peat moss lawn	0,25	0,25	-0,8	-0,8	3,01	3,01	2,23	2,23	-0,8	-0,8	3,01	3,01	2,23	2,23

First GEST GHG balance scenarios

Wet Tall Reeds	0,04	0,04	-0,1	-0,1	0,25	0,25	0,16	0,16	-0,1	-0,1	0,25	0,25	0,16	0,16
Moist Reeds and Meadows	-	5,63	-	26	-	42,28	-	68,28	-	26	-	42,28	-	68,28
Forested Peatlands														
Moderately Moist Forests and Shrubberies	778,9	604,05	15578	12081	0,00	0,00	15578	12081	15505,2	12008,4	0,00	0,00	15505,2	12008,4
Moist Forests and Shrubberies	151,76	259,7	701,2	1199,8	1143,51	1956,85	1844,71	3156,65	689,8	1190,4	1143,51	1956,85	1833,31	3147,25
Very Moist Forests and Shrubberies	9,53	59,09	16,2	100,4	28,59	177,54	44,79	277,94	16	100,3	28,59	177,54	44,59	277,84
Wet Forests and Shrubberies	36,77	36,77	-129,70	-129,70	249,83	249,83	120,12	120,12	-131,00	-131,00	249,83	249,83	118,85	118,85
Moderately Dry Forests and Shrubberies	14,77	14,24	384,3	370,6	0,00	0,00	384,3	370,6	382,4	369	0,00	0,00	382,4	369
Reduction Potential			**-3298,8**		**+1017,32**		**-2281,48**		**-3296,2**		**+1017,32**		**-2278,88**	

Tab.III-20: Summarized GWP with tree biomass for both Scenarios given in t CO_2-eq. / yr. and all project sites

Site	Baseline	Post-Restoration
Estonia - Suursoo-Leidissoo	9919,6	8868
Latvia – Engure Lake NR	32,2	32,2
Latvia – Baltezers Mire NR*	307,32	241,79
Latvia – Augstroze NR*	749,22	145,13
Lithuania – Amalva LT01	5775,12	1503,18
Lithuania – Sachara LT03	844,04	249,98
Lithuania – Pūsčia LT04	968,48	518,77
Lithuania – Plinkšiai LT02	787,55	277,48
Lithuania – Aukstumala LT05	73,65	33,33
Germany – Biesenthaler Becken	-7,44	-13,98
Poland – Slowinski NP	18802,8	16507,23
Total	**38252,54**	**28363,11**
Reduction Potential		**9889,43** **25,85 %**

* only the optimal scenario was used

IV. Concluding Remarks

Our first GEST-GHG calculations suggest a significant reduction of the global warming potential, ca. 25 % lesser amounts compared to the current situation. These results are still preliminary and need further evaluation, but they show a relative positive mitigation trend.

However there are some critical remarks related to the GEST-approach. First of all the published data in the GEST catalogue referred to very few measurements per GEST and for many GEST, especially for the forested types, emission data are missing and were transferred from similar types. Additionally we created some new GESTs with unknown emission character. Second most of the original published GEST-data are taken from studies in Central Europe and cannot be applied directly to other regions, e.g. to boreal peatlands. Furthermore the application of different data from literature leads to a risk of an over- or underestimation of the fluxes, because of the site-specific variability or the methodical differences. The generalized estimated fluxes in the GEST catalogue don't describe the real conditions of GESTs on sites. This could be difficult in the assessment of the climate effect of the site, e.g. if the GEST-type doesn't change after the rewetting measures, we cannot quantify a significant shift in the fluxes, although the conditions will turn more favourable for mire plants and the site will transform from a carbon-source to a carbon-sink.

Almost all project sites shows a positive (warming) climate effect for both scenarios, although forested peatlands make up the biggest spatial amounts of the identified GESTs. The effect of the forest biomass to the carbon balance and also the c-sequestration rate by the trees is not consistent for all sites. In Latvia, Lithuania and also in Poland the effect of the wooden biomass is very low and resulted only in a small decrease of the total emissions. Studies in the

boreal zone (Ojanen et al., 2013, 2014; Uri et al., 2017) show, that on average, the carbon balance in drained peatland forests should be close to zero. The carbon source/sink function depends on the soil fertility, tree age or weather conditions. The magnitude of carbon sink into tree biomass is a magnitude higher than carbon exchange from soil. But, accumulation into tree biomass decreases with increasing tree age, and possibly may changes to carbon source when trees are dying.

Independent of all drawbacks of the GEST approach the relative reduction trend still remain and we will update and monitor the changes in the field with direct measurements and supplementary forest inventory records.

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