OÜ SEVERITAS

Title of report	**Approbation of greenhouse gas measurement methodology in peatlands in Latvia within the scope of LIFE REstore (LIFE14 CCM/LV/001103) project**
Title in original language	**Kūdrāju siltumnīcefekta gāzu emisiju uzskaites metodoloģijas aprobācija Latvijā projekta LIFE REstore (LIFE14 CCM/LV/001103) ietvaros**
Contracting agency	**Nature conservation agency (*Dabas aizsardzības pārvalde*)**
Contractor	**OÜ Severitas**
Agreement No.	**1.1.17.19.2/3/2016-P**
Type of report	**Yearly report**
Reporting period	**01.01.2018-30.11.2018**
Report No.	**12-V2**
Authors	**Kairi Sepp**

Tartu, 2019

SUMMARY

Yearly report is elaborated according to the article 2.2 in the list of deliverables of the Annex 1 of the agreement between OÜ Severitas and Nature conservation agency (No. 1.1.17.19.2/3/2016-P). The report covers the period between 01.11.2017 and 30.11.2018.

In cooperation with LSFRI Silava 40-42 sampling sites were established and 10080 individual gas samples were collected. Initial schedule of work was updated due to relocation of sampling plots and considerable increase of driving distance to the sampling plots after additional selection of sampling plots to replace the rejected (non-accessible due to different reasons) plots, as well as due to repeated visits to all sites in cropland, grassland and peat extraction sites to reinstall equipment a day before measurement and to find if the sampling collars are not damaged.

Gas analyses for the period from November (including) of 2017 to November (including) of 2018 were done by University of Tartu and completed. The Severitas in cooperation with LSFRI Silava implemented initial QA procedures (Severitas for gas analyses and Silava for other soil, water and physical environment related parameters). All the data is uploaded to Google Drive with an access by Andis Lazdiņš, Ainārs Lupiķis, Alar Teemusk, Ülo Mander, Kairi Sepp and Kaspars Paberzs.

LSFRI Silava secured initial setup of sampling plots (installation of collars and wells) as well as measured environmental parameters during gas sampling. Schedule of operations was harmonized with LSFRI Silava, which, in turn, coordinated activities with land owners.

According to proposal of Severitas LSFRI Silava installed additional temporal footbridges in 14 sampling plots to avoid soil impact during gas measurement.

All the tasks were done in an accordance and within LIFE program project "Sustainable and responsible management and re-use of degraded peatlands in Latvia" (LIFE REstore, LIFE14 CCM/LV/001103).

This report is extended and updated version of the annual report elaborated in 2018. Results of gas analyses are added to the report in digital format.

MEASUREMENTS

January, 2018 (month 14)

In total 800 gas samples were collected in January, 2018. The sampling schedule is provided in Table 1. Organization of sampling was rescheduled to adopt to accessibility of roads. Measurements of photosynthetic activity (removals of CO_2 from atmosphere by plants) were continued using transparent chambers and field CO_2 flux measurement equipment. Measurement dates in different plots were harmonized. Gas samples were analyzed during February, 2018 by University of Tartu (Climate Change Lab, Dr Alar Teemusk, Prof Ülo Mander) using gas chromatography and analytical procedure were approved by the project team. Initial QA was implemented directly after analyses by evaluation of linearity of the flux measurement data. Non-linear data were rejected and site averages calculated.

Table 1: Gas sampling schedule in January, 2018

Code	Date																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Brigi_13																													S		
Cena_3																S															
Cena_2																S															
Cepla_7											S																				
Cepla_3											S																				
Dierv_5			S																												
Dierv_6			S																												
Gaven_5			S																												
Vang_10	S																														
Kaigu_7																	S														
Kaigu_11																	S														
Kaigu_14																	S														
Kaigu_1																	S														
Kalna_11															S																
Kalna_12															S																
Linu_10										S																					
Kasku_4				S																											
Kazu_10										S																					
Krista_4		S																													
Lamb_7																													S		
Lamb_1																													S		
Lauga_9	S																														
Kem_14	S																														
Kem_9				S																											
Liels_8								S																							
Liels_9								S																							
Liels_4								S																							
Virsi_14																		S													
Med_2																		S													
Naud_11																				S											
Naud_12																				S											
Plece_8									S																						
Mar_5				S																											
Silg_8																									S						
Silg_3																									S						
Silg_2																									S						
Stabul_4		S																													
Usuru_12																							S								
Usuru_1																							S								
Arosa_14																		S													

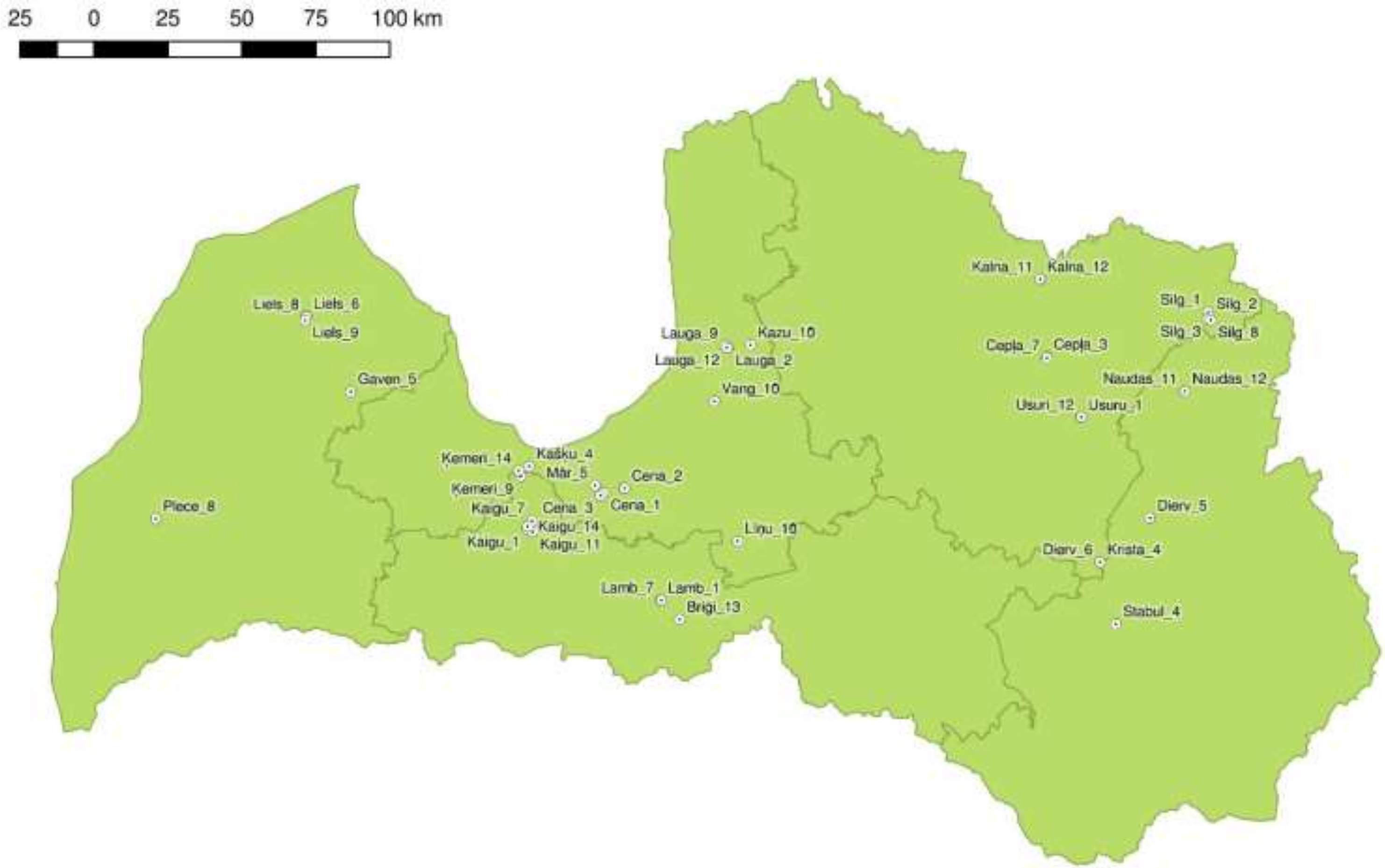

Figure 1: Location of sampling sites.

February, 2018 (month 15)

In total 800 gas samples were collected in February, 2018. The sampling schedule is provided in Table 2. Organization of sampling was rescheduled to adopt to accessibility of roads and vacation schedule of the teams in Latvia and Estonia. Measurements of photosynthetic activity (removals of CO_2 from atmosphere by plants) were continued using transparent chambers and field CO_2 flux measurement equipment. Measurement dates in different plots were harmonized. Gas samples were analyzed during March, 2018 by University of Tartu (Climate Change Lab, Dr Alar Teemusk, Prof Ülo Mander) using gas chromatography and analytical procedure were approved by the project team. Initial QA was implemented directly after analyses by evaluation of linearity of the flux measurement data. Non-linear data were rejected and site averages calculated.

Table 2: Gas sampling schedule in February, 2018

Code	Date																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Brigi_13																												S
Cena_3									S																			
Cena_2									S																			
Cepla_7														S														
Cepla_3														S														
Dierv_5		S																										
Dierv_6		S																										
Gaven_5		S																										
Vang_10	S																											
Kaigu_7																					S							
Kaigu_11																					S							
Kaigu_14																					S							
Kaigu_1																					S							
Kalna_11												S																
Kalna_12												S																
Linu_10							S																					
Kasku_4						S																						
Kazu_10							S																					
Krista_4					S																							
Lamb_7																												S
Lamb_1																												S
Lauga_9	S																											
Kem_14	S																											
Kem_9						S																						
Liels_8																										S		
Liels_9																										S		
Liels_4																										S		
Virsi_14																											S	
Med_2																				S								
Naud_11																				S								
Naud_12																						S						
Plece_8																						S						
Mar_5																											S	
Silg_8													S															
Silg_3													S															
Silg_2													S															
Stabul_4					S																							
Usuru_12																			S									
Usuru_1																			S									
Arosa_14																												

March, 2018 (month 16)

In total 800 gas samples were collected in March, 2018. The sampling schedule is provided in Table 3. Organization of sampling was rescheduled to adopt to additional time needed to access sampling sites with non-drivable roads. Measurements of photosynthetic activity (removals of CO_2 from atmosphere by plants) were continued using transparent chambers and field CO_2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during April, 2018 by University of Tartu (Climate Change Lab, Dr Alar Teemusk, Prof Ülo Mander) using gas chromatography and analytical procedure were approved by the project team. Initial QA was implemented directly after analyses by evaluation of linearity of the flux measurement data. Non-linear data were rejected and site averages calculated.

Table 3: Gas sampling schedule in March, 2018

Code	Date																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Brigi_13																												S		
Cena_3																S														
Cena_2																S														
Cepla_7																			S											
Cepla_3																			S											
Dierv_5						S																								
Dierv_6						S																								
Gaven_5							S																							
Vang_10		S																												
Kaigu_7														S																
Kaigu_11														S																
Kaigu_14														S																
Kaigu_1														S																
Kalna_11																							S							
Kalna_12																							S							
Linu_10												S																		
Kasku_4													S																	
Kazu_10												S																		
Krista_4					S																									
Lamb_7																												S		
Lamb_1																												S		
Lauga_9		S																												
Kem_14		S																												
Kem_9													S																	
Liels_8								S																						
Liels_9								S																						
Liels_4								S																						
Virsi_14															S															
Med_2															S															
Naud_11																					S									
Naud_12																					S									
Plece_8									S																					
Mar_5							S																							
Silg_8																											S			
Silg_3																											S			
Silg_2																											S			
Stabul_4					S																									
Usuru_12																						S								
Usuru_1																						S								
Arosa_14															S															

April, 2018 (month 17)

In total 800 gas samples were collected in April, 2018. The sampling schedule is provided in Table 4. Organization of sampling was rescheduled to adopt to accessibility of roads. Measurements of photosynthetic activity (removals of CO_2 from atmosphere by plants) were continued using transparent chambers and field CO_2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during May, 2018 by University of Tartu (Climate Change Lab, Dr Alar Teemusk, Prof Ülo Mander) using gas chromatography and analytical procedure were approved by the project team. Initial QA was implemented directly after analyses by evaluation of linearity of the flux measurement data. Non-linear data were rejected and site averages calculated.

Table 4: Gas sampling schedule in April, 2018

Code	Date																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Brigi_13																														S
Cena_3																		S												
Cena_2																		S												
Cepla_7																			S											
Cepla_3																			S											
Dierv_5					S																									
Dierv_6					S																									
Gaven_5						S																								
Vang_10			S																											
Kaigu_7																S														
Kaigu_11																S														
Kaigu_14																S														
Kaigu_1																S														
Kalna_11																									S					
Kalna_12																									S					
Linu_10											S																			
Kasku_4												S																		
Kazu_10											S																			
Krista_4				S																										
Lamb_7																											S			
Lamb_1																											S			
Lauga_9			S																											
Kem_14			S																											
Kem_9												S																		
Liels_8									S																					
Liels_9									S																					
Liels_4									S																					
Virsi_14																	S													
Med_2																	S													
Naud_11																							S							
Naud_12																							S							
Plece_8										S																				
Mar_5						S																								
Silg_8																										S				
Silg_3																										S				
Silg_2																										S				
Stabul_4				S																										
Usuru_12																								S						
Usuru_1																								S						
Arosa_14															S															

May, 2018 (month 18)

In total 800 gas samples were collected in May, 2018. The sampling schedule is provided in Table 5. Organization of sampling was rescheduled to adopt to accessibility of roads and vacation schedule of the teams in Latvia and Estonia. Measurements of photosynthetic activity (removals of CO_2 from atmosphere by plants) were continued using transparent chambers and field CO_2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during June, 2018 by University of Tartu (Climate Change Lab, Dr Alar Teemusk, Prof Ülo Mander) using gas chromatography and analytical procedure were approved by the project team. Initial QA was implemented directly after analyses by evaluation of linearity of the flux measurement data. Non-linear data were rejected and site averages calculated.

Table 5: Gas sampling schedule in May, 2018

Code	Date																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Brigi_13																														S	
Cena_3																					S										
Cena_2																					S										
Cepla_7																						S									
Cepla_3																						S									
Dierv_5							S																								
Dierv_6							S																								
Gaven_5								S																							
Vang_10		S																													
Kaigu_7																	S														
Kaigu_11																	S														
Kaigu_14																	S														
Kaigu_1																	S														
Kalna_11																												S			
Kalna_12																												S			
Linu_10														S																	
Kasku_4															S																
Kazu_10														S																	
Krista_4			S																												
Lamb_7																														S	
Lamb_1																														S	
Lauga_9		S																													
Kem_14		S																													
Kem_9															S																
Liels_8									S																						
Liels_9									S																						
Liels_4									S																						
Virsi_14																S															
Med_2																S															
Naud_11																							S								
Naud_12																							S								
Plece_8										S																					
Mar_5															S																
Silg_8																													S		
Silg_3																													S		
Silg_2																													S		
Stabul_4			S																												
Usuru_12																								S							
Usuru_1																								S							
Arosa_14															S																

June, 2018 (month 19)

In total 800 gas samples were collected in June, 2018. The sampling schedule is provided in Table 6. Organization of sampling was rescheduled to adopt to additional time needed to access sampling sites with non-drivable roads. Measurements of photosynthetic activity (removals of CO_2 from atmosphere by plants) were continued using transparent chambers and field CO_2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during July, 2018 by University of Tartu (Climate Change Lab, Dr Alar Teemusk, Prof Ülo Mander) using gas chromatography and analytical procedure were approved by the project team. Initial QA was implemented directly after analyses by evaluation of linearity of the flux measurement data. Non-linear data were rejected and site averages calculated.

Table 6: Gas sampling schedule in June, 2018

Code	Date																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Brigi_13																						S								
Cena_3																				S										
Cena_2																				S										
Cepla_7																					S									
Cepla_3																					S									
Dierv_5						S																								
Dierv_6						S																								
Gaven_5							S																							
Vang_10				S																										
Kaigu_7																		S												
Kaigu_11																		S												
Kaigu_14																		S												
Kaigu_1																		S												
Kalna_11																											S			
Kalna_12																											S			
Linu_10													S																	
Kasku_4														S																
Kazu_10													S																	
Krista_4					S																									
Lamb_7																						S								
Lamb_1																						S								
Lauga_9				S																										
Kem_14				S																										
Kem_9														S																
Liels_8											S																			
Liels_9											S																			
Liels_4											S																			
Virsi_14																			S											
Med_2																			S											
Naud_11																									S					
Naud_12																									S					
Plece_8												S																		
Mar_5							S																							
Silg_8																												S		
Silg_3																												S		
Silg_2																												S		
Stabul_4					S																									
Usuru_12																										S				
Usuru_1																										S				
Arosa_14														S																

July, 2018 (month 20)

In total 800 gas samples were collected in July, 2018. The sampling schedule is provided in Table 7. Organization of sampling was rescheduled to adopt to accessibility of roads. Measurements of photosynthetic activity (removals of CO_2 from atmosphere by plants) were continued using transparent chambers and field CO_2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during August, 2018 by University of Tartu (Climate Change Lab, Dr Alar Teemusk, Prof Ülo Mander) using gas chromatography and analytical procedure were approved by the project team. Initial QA was implemented directly after analyses by evaluation of linearity of the flux measurement data. Non-linear data were rejected and site averages calculated.

Table 7: Gas sampling schedule in July, 2018

Code	Date																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Brigi_13																											S				
Cena_3																		S													
Cena_2																		S													
Cepla_7																			S												
Cepla_3																			S												
Dierv_5				S																											
Dierv_6				S																											
Gaven_5					S																										
Vang_10		S																													
Kaigu_7											S																				
Kaigu_11											S																				
Kaigu_14											S																				
Kaigu_1											S																				
Kalna_11																							S								
Kalna_12																							S								
Linu_10						S																									
Kasku_4													S																		
Kazu_10						S																									
Krista_4			S																												
Lamb_7																										S					
Lamb_1																										S					
Lauga_9		S																													
Kem_14		S																													
Kem_9													S																		
Liels_8									S																						
Liels_9									S																						
Liels_4									S																						
Virsi_14												S																			
Med_2												S																			
Naud_11																				S											
Naud_12																				S											
Plece_8										S																					
Mar_5					S																										
Silg_8																									S						
Silg_3																									S						
Silg_2																									S						
Stabul_4			S																												
Usuru_12																								S							
Usuru_1																								S							
Arosa_14												S																			

August, 2018 (month 21)

In total 800 gas samples were collected in August, 2018. The sampling schedule is provided in Table 8. Organization of sampling was rescheduled to adopt to accessibility of roads and vacation schedule of the teams in Latvia and Estonia. Measurements of photosynthetic activity (removals of CO_2 from atmosphere by plants) were continued using transparent chambers and field CO_2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during September, 2018 by University of Tartu (Climate Change Lab, Dr Alar Teemusk, Prof Ülo Mander) using gas chromatography and analytical procedure were approved by the project team. Initial QA was implemented directly after analyses by evaluation of linearity of the flux measurement data. Non-linear data were rejected and site averages calculated.

Table 8: Gas sampling schedule in August, 2018

Code	Date																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Brigi_13																													S		
Cena_3																	S														
Cena_2																	S														
Cepla_7																S															
Cepla_3																S															
Dierv_5								S																							
Dierv_6								S																							
Gaven_5						S																									
Vang_10		S																													
Kaigu_7																					S										
Kaigu_11																					S										
Kaigu_14																					S										
Kaigu_1																					S										
Kalna_11																											S				
Kalna_12																											S				
Linu_10						S																									
Kasku_4													S																		
Kazu_10		S																													
Krista_4			S																												
Lamb_7																													S		
Lamb_1																													S		
Lauga_9	S																														
Kem_14	S																														
Kem_9													S																		
Liels_8									S																						
Liels_9									S																						
Liels_4									S																						
Virsi_14															S																
Med_2															S																
Naud_11																						S									
Naud_12																						S									
Plece_8										S																					
Mar_5													S																		
Silg_8																												S			
Silg_3																												S			
Silg_2																												S			
Stabul_4			S																												
Usuru_12																							S								
Usuru_1																							S								
Arosa_14															S																

September, 2018 (month 22)

In total 800 gas samples were collected in September, 2018. The sampling schedule is provided in Table 9. Organization of sampling was rescheduled to adopt to additional time needed to access sampling sites with non-drivable roads. Measurements of photosynthetic activity (removals of CO_2 from atmosphere by plants) were continued using transparent chambers and field CO_2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during October, 2018 by University of Tartu (Climate Change Lab, Dr Alar Teemusk, Prof Ülo Mander) using gas chromatography and analytical procedure were approved by the project team. Initial QA was implemented directly after analyses by evaluation of linearity of the flux measurement data. Non-linear data were rejected and site averages calculated.

Table 9: Gas sampling schedule in September, 2018

Code	Date																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Brigi_13																		S												
Cena_3																	S													
Cena_2																	S													
Cepla_7																								S						
Cepla_3																								S						
Dierv_5						S																								
Dierv_6						S																								
Gaven_5												S																		
Vang_10			S																											
Kaigu_7													S																	
Kaigu_11													S																	
Kaigu_14														S																
Kaigu_1														S																
Kalna_11																											S			
Kalna_12																											S			
Linu_10							S																							
Kasku_4												S																		
Kazu_10							S																							
Krista_4					S																									
Lamb_7																		S												
Lamb_1																		S												
Lauga_9			S																											
Kem_14			S																											
Kem_9												S																		
Liels_8										S																				
Liels_9										S																				
Liels_4										S																				
Virsi_14				S																										
Med_2				S																										
Naud_11																									S					
Naud_12																									S					
Plece_8											S																			
Mar_5				S																										
Silg_8																												S		
Silg_3																												S		
Silg_2																												S		
Stabul_4					S																									
Usuru_12																										S				
Usuru_1																										S				
Arosa_14											S																			

October, 2018 (month 23)

In total 800 gas samples were collected in October, 2018. The sampling schedule is provided in Table 10. Organization of sampling was rescheduled to adopt to accessibility of roads. Measurements of photosynthetic activity (removals of CO_2 from atmosphere by plants) were continued using transparent chambers and field CO_2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during November, 2018 by University of Tartu (Climate Change Lab, Dr Alar Teemusk, Prof Ülo Mander) using gas chromatography and analytical procedure were approved by the project team. Initial QA was implemented directly after analyses by evaluation of linearity of the flux measurement data. Non-linear data were rejected and site averages calculated.

Table 10: Gas sampling schedule in October, 2018

Code	Date																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Brigi_13																	S														
Cena_3															S																
Cena_2															S																
Cepla_7																						S									
Cepla_3																						S									
Dierv_5				S																											
Dierv_6				S																											
Gaven_5		S																													
Vang_10	S																														
Kaigu_7									S																						
Kaigu_11										S																					
Kaigu_14										S																					
Kaigu_1										S																					
Kalna_11																							S								
Kalna_12																							S								
Linu_10			S																												
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Kazu_10			S																												
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Arosa_14											S																				

November, 2018 (month 24)

In total 800 gas samples were collected in November, 2018. The sampling schedule is provided in Table 11. Organization of sampling was rescheduled to adopt to accessibility of roads and vacation schedule of the teams in Latvia and Estonia. Measurements of photosynthetic activity (removals of CO_2 from atmosphere by plants) were continued using transparent chambers and field CO_2 flux measurement equipment. Measurement dates in different plots were harmonized. Gas samples were analyzed during December, 2018 by University of Tartu (Climate Change Lab, Dr Alar Teemusk, Prof Ülo Mander) using gas chromatography and analytical procedure were approved by the project team. Initial QA was implemented directly after analyses by evaluation of linearity of the flux measurement data. Non-linear data were rejected and site averages calculated.

Table 11: Gas sampling schedule in November, 2018

Code	Date																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Brigi_13																			S												
Cena_3													S																		
Cena_2													S																		
Cepla_7																						S									
Cepla_3																						S									
Dierv_5									S																						
Dierv_6									S																						
Gaven_5														S																	
Vang_10					S																										
Kaigu_7																					S										
Kaigu_11																				S											
Kaigu_14																				S											
Kaigu_1																				S											
Kalna_11																										S					
Kalna_12																										S					
Linu_10							S																								
Kasku_4						S																									
Kazu_10					S																										
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Stabul_4								S																							
Usuru_12																							S								
Usuru_1																							S								
Arosa_14																					S										

RESULTS

CO_2 fluxes

The results indicate that NEE is positive for all of the studied land management practices (Figure 4), it means CO_2 emissions are larger than CO_2 removals and those ecosystems are sources of atmospheric CO_2. The biggest sources are croplands, on average NEE is 4.1 tonnes ha^{-1} annually. The smallest NEE is abandoned peat extraction sites without vegetation, where the NEE is 0.9 tonnes ha^{-1} annually.

In all of the land management practices, measured NEE is still lower compared to respective IPCC default CO_2-C emission factors (Figure 2). Some of the land management practices, like berry cultivation, is not included in IPCC guidelines, that why measured NEE is compared with emission factor estimated for drained cropland on organic soils. The difference with the first year data is not significant

Although the difference between measured and default values for the most of the land management practices is twofold or higher, it must be considered, that year 2018 was extremely dry. It may influence the level of NEE, by reducing the decomposition of organic matter and lower ecosystem CO_2 respiration. The ecosystem CO_2 respiration in 2nd year of measurements was higher in comparison to the 1st year but the difference was not significant.

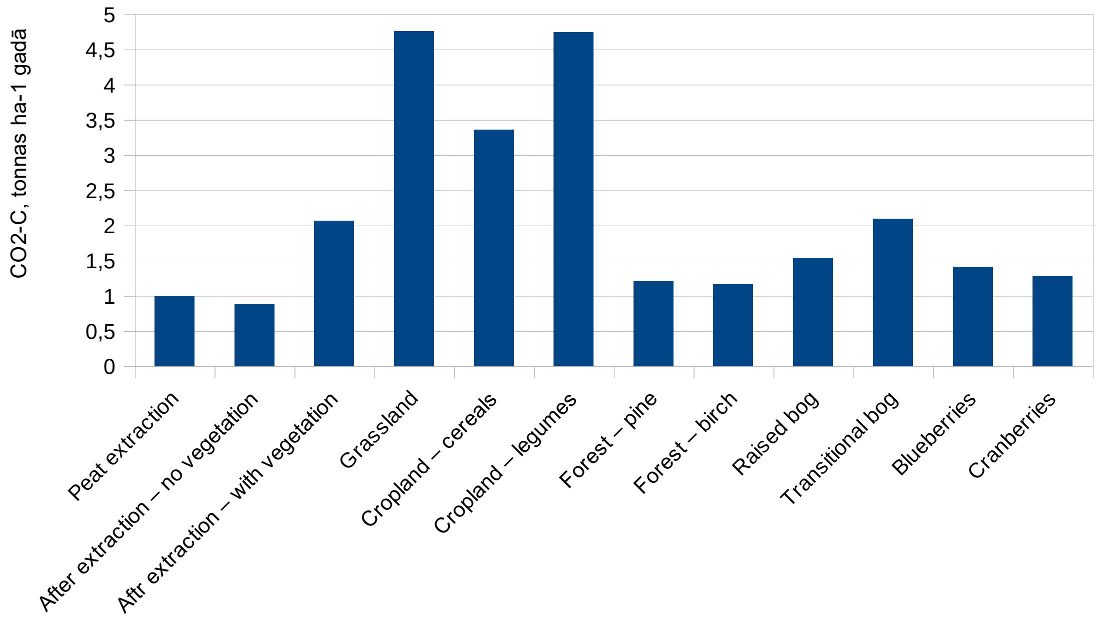

Figure 2: Mean Net ecosystem exchange in all land management types.

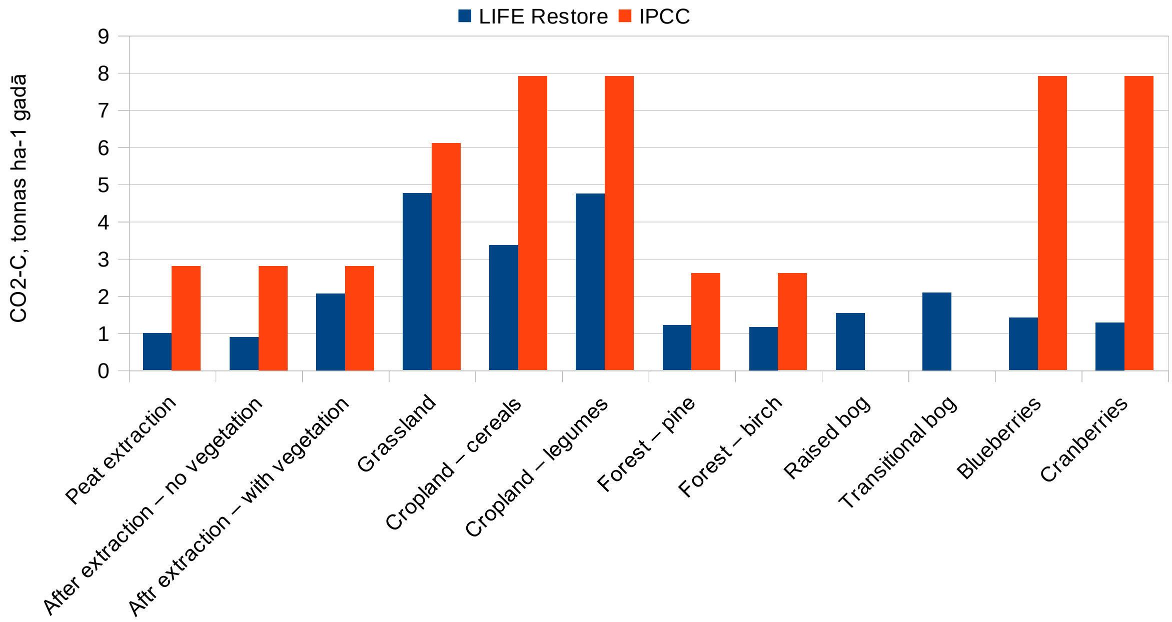

Figure 3: Mean Net ecosystem exchange in all land management types and respective IPCC default emission factors.

CH_4 and N_2O fluxes

In contrast to CO_2 emissions, CH_4 fluxes usually is the highest in wet conditions and drainage causes decrease in methane production and emissions of methane. As it was expected, highest CH_4 emissions is in undrained ecosystems – raised and transitional bog. In

transitional bog CH_4 emissions is 383 kg CH_4-C ha-1 annually, but in raised bog 163 kg CH_4-C ha-1 annually. If compared to 1st year data CH_4 fluxes for the most of categories CH_4 emissions reduced, but in grassland and abandoned peatlands with and without vegetation – increased (Figure 4). Summary of flux measurements is provided in Figure 5. Considering uncertainty only transitional and raised bogs should be accounted as source of CH_4 emissions.

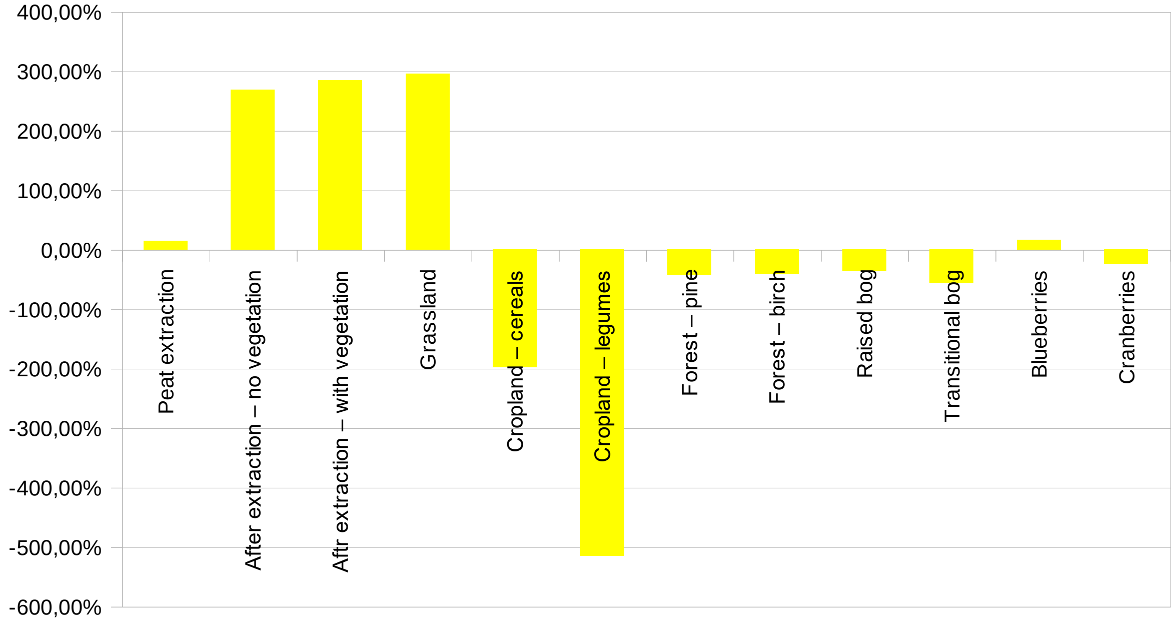

Figure 4: Comparison of CH_4 fluxes in all land management types - 1st and 2nd year data.

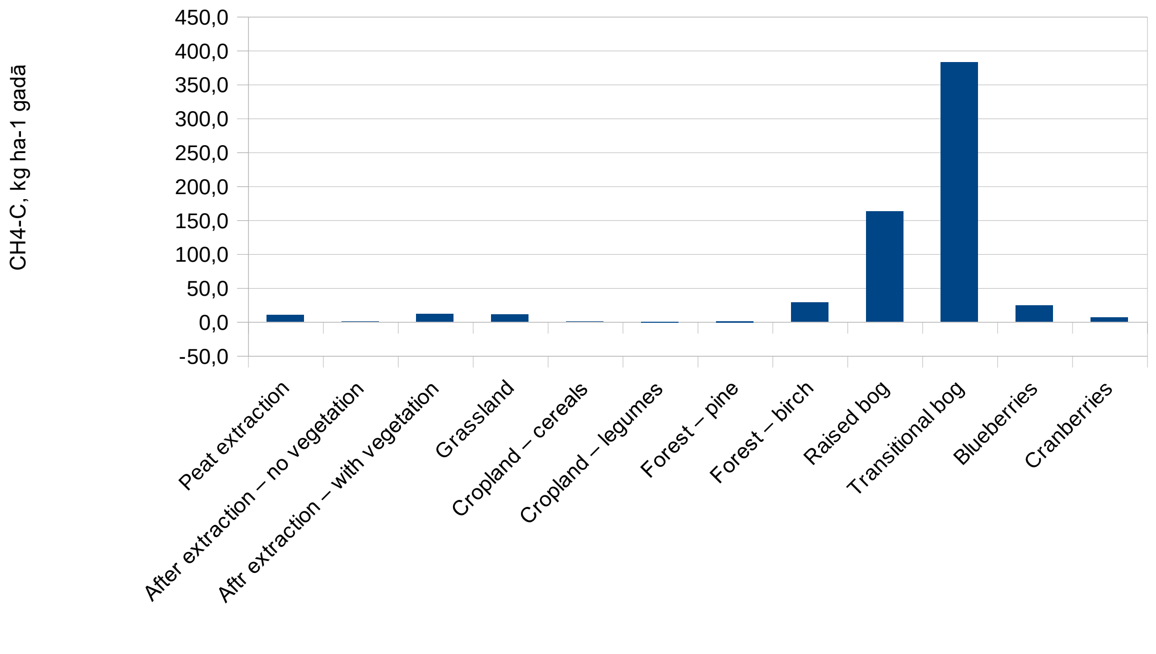

Figure 5: Mean CH_4 fluxes in all land management types.

The biggest N_2O fluxes was in cropland, where annual flux is around 8.0 kg N_2O-N ha^{-1} under cereal cultivation and around 3.6 kg N_2O-N ha^{-1} under legume cultivation (Figure 7). The reason for bigger N_2O emissions in cropland is more intensive use of nitrogen fertilizers.

The most significant change in the GHG emissions is found in transitional bog (Figure 6). Most probably this is associated with different measurement periods, because in the 1st year the most of the N2O emissions were observed in March during snow melting, when N2O emissions reach maximum in natural ecosystems, therefore these data has to be retained in the flux calculation.

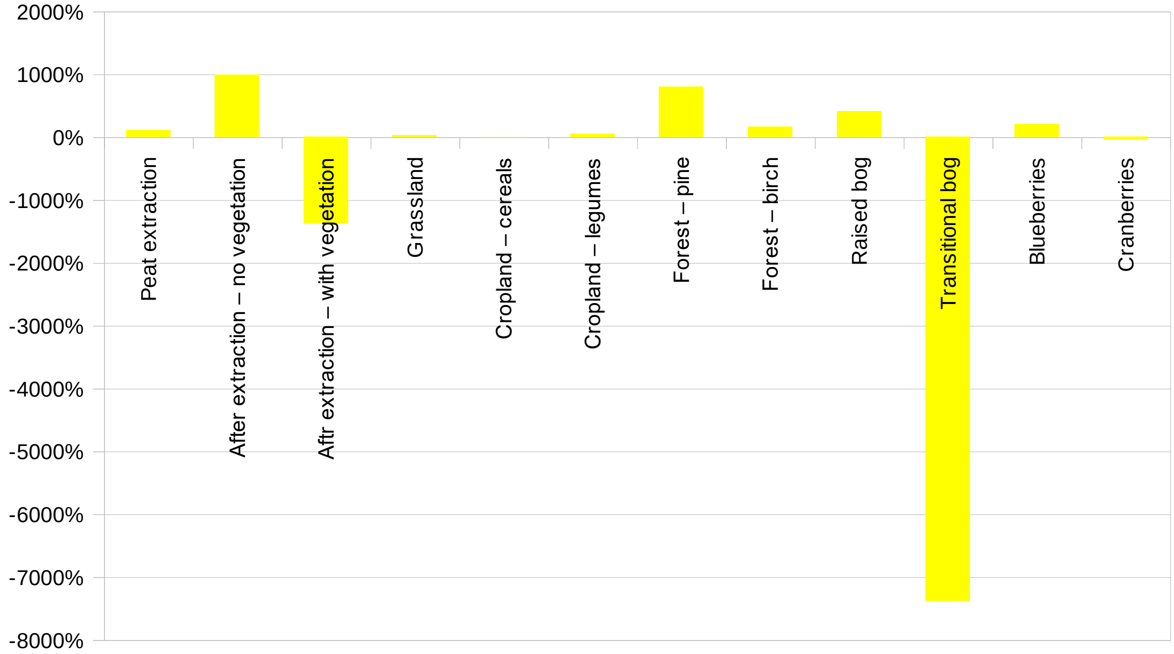

Figure 6: Comparison of N_2O fluxes in the 1st and 2nd year measurements.

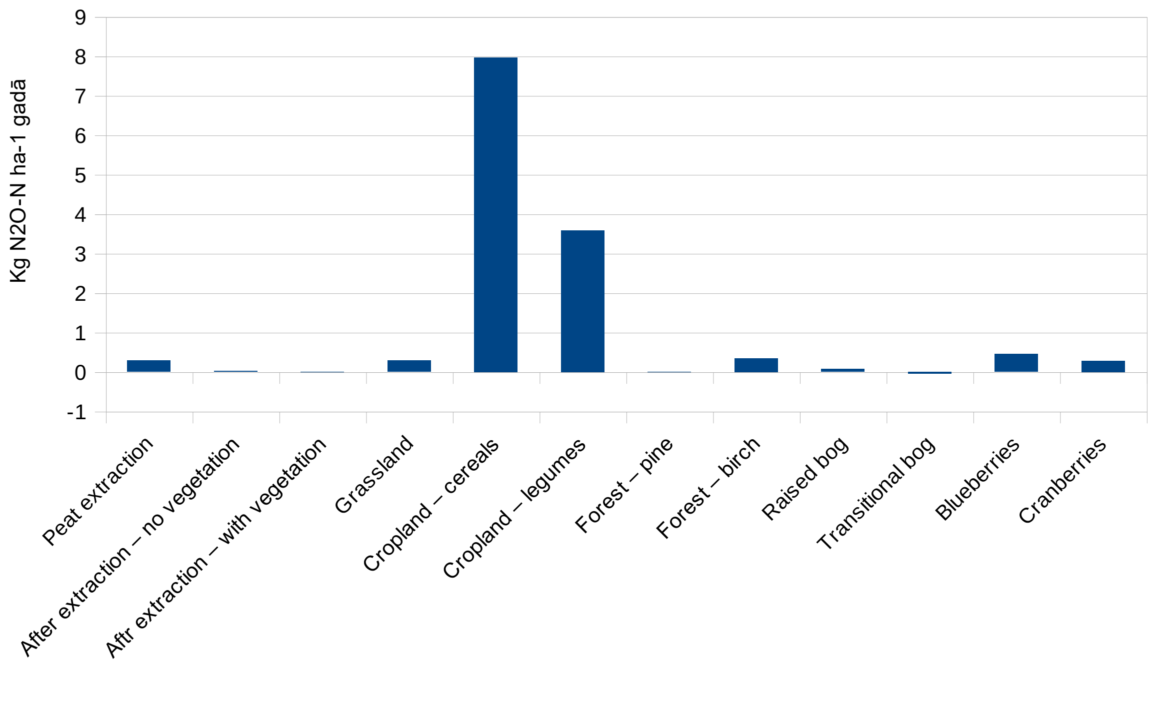

Figure 7: Mean N_2O fluxes in all land management types.

The net GHG emissions from soil according to the 2nd year measurement data is shown in Figure 8.

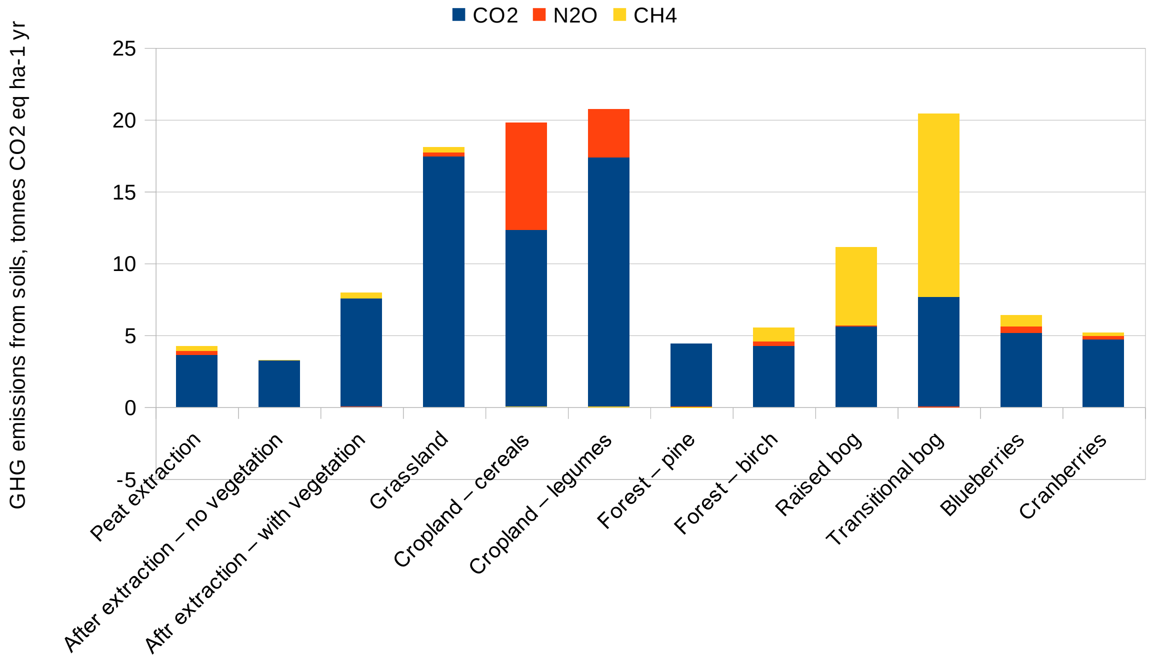

Figure 8: Net GHG emissions from soil.

AUXILIARY MEASUREMENTS

Groundwater level

One of the main factors controlling the status of carbon balance (CO_2 and CH_4) is ground water level. If the dead organic matter is stored under anaerobic conditions, it may accumulate, thus forming a peat layer. At the same time, anaerobic conditions is favourable for methanotrophic bacteria which is producing CH_4. Anaerobic conditions are interfering most of the commercial plant growth, so the ground water management by lowering it is the main management option in wetlands to this land for agriculture or peat extraction. This is causing decomposition of accumulated organic matter and increase on CO_2 emissions.

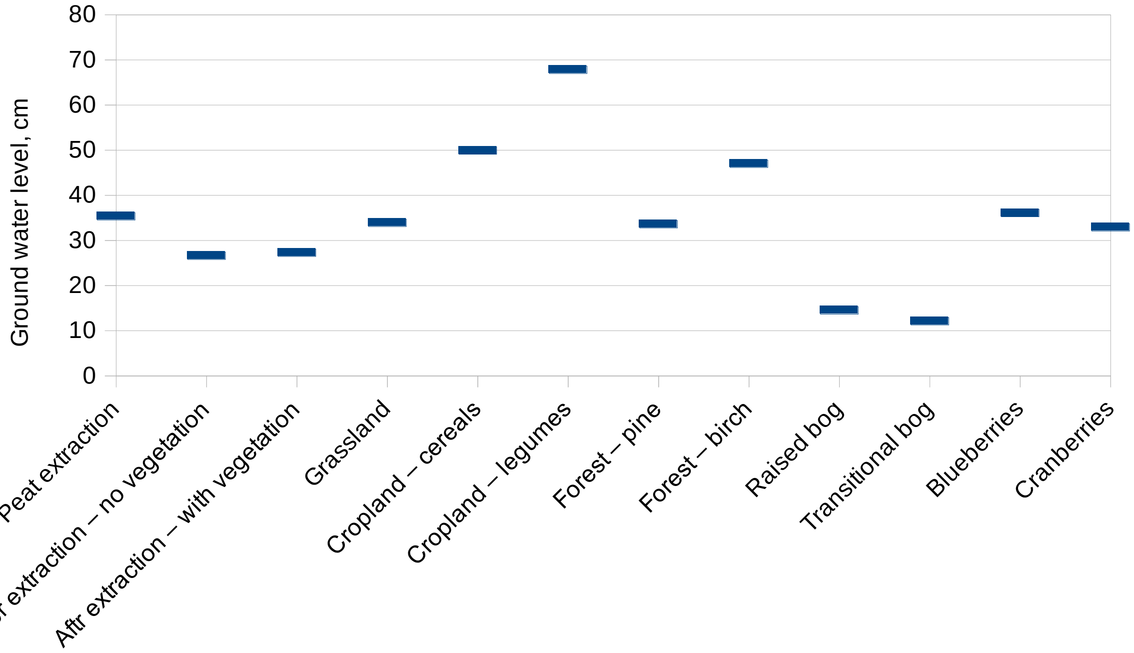

Figure 9: Mean Ground water level in all land management types.

The impact of groundwater level on land status is clearly evident also in sample plots established during the LIFE-Restore project. Monthly measurements of ground water level shows the highest ground water level in raised and transitional bog where ground water level in most of the year is near the surface (Figure 7). At some periods of the year ground water is even higher than ground surface and ground vegetation is under the water. Lowest ground water level is in croplands (50-68 cm) and in birch forests (~ 59 cm).

Lowest ground water was observed in June (Figure 9), when on average it was around 46 cm below ground surface on average on all sample plots. Ground water level raised in autumn, from August to November. In winter time, when the ground freezes and precipitation is mostly snow, ground water level starts to decrease, but in a spring, when snow melts, from February to March it is increasing again. From April to August, during summer time ground water level was decreasing.

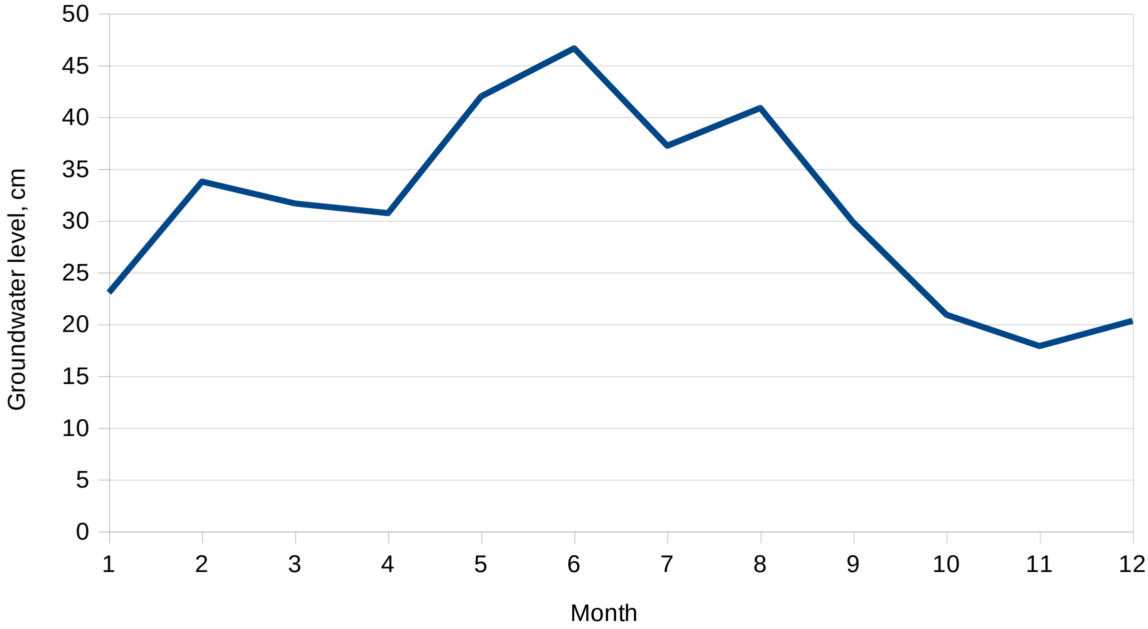

Figure 10: Ground water level in all land management types.

Soil properties

GHG emissions from organic soil largely depends on soil properties – nutrient status, acidity, bulk density etc. Nutrient status can be quantified by C/N ratio and nitrogen content in soil. Higher nitrogen content and lower C/N ratio characterizes nutrient rich soils.

The analyses of soil samples shows the lowest C/N ratio in cropland (cultivated with cereals) and grassland (Figure 11), where the C/N ratio is below 20 down to 30 cm depth. The highest C/N ratio is in extracted and abandoned peatlands, transitional bog and cranberry sites, where C/N ratio is above 50.

C/N ratio is mainly dependent on N content in organic soil. The Highest N content is in cropland (cultivated with cereals) and grassland (figure 9), where N content is around 30 g^{-1} kg^{-1}. In rest of the sites, N content is below 20 g^{-1} kg^{-1}. In extracted and abandoned peatlands, raised and transitional bog and cranberry sites N content drops below 10 g^{-1} kg^{-1}.

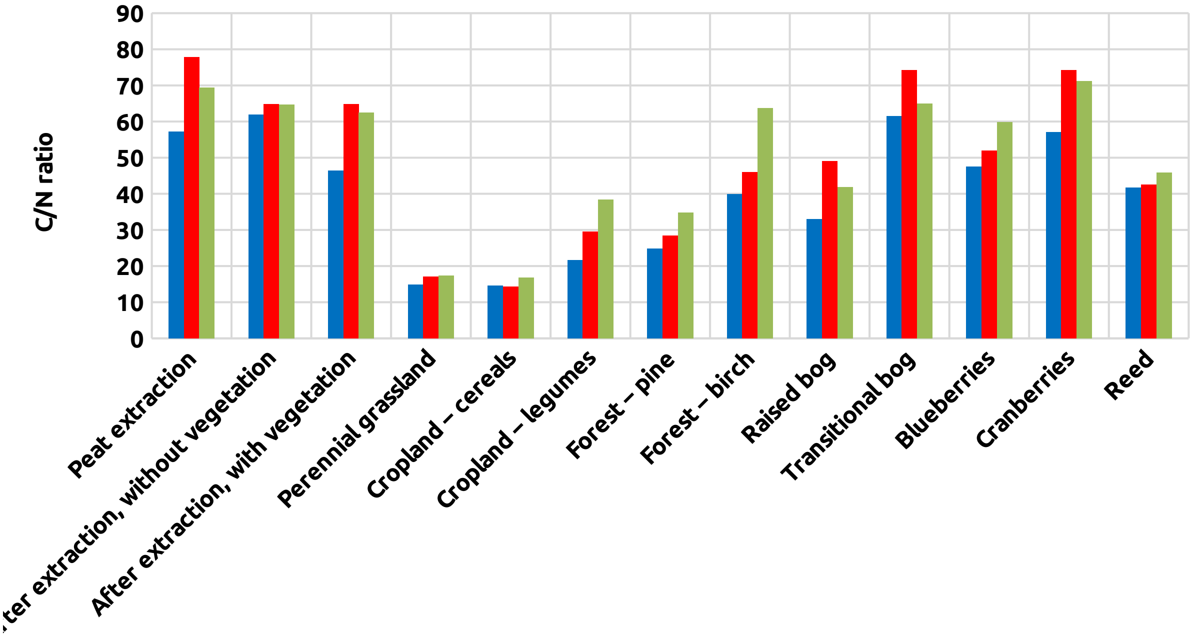

Figure 11: Mean C/N ratio in all land management types in 0-10, 10-20 and 20-30 cm depth.

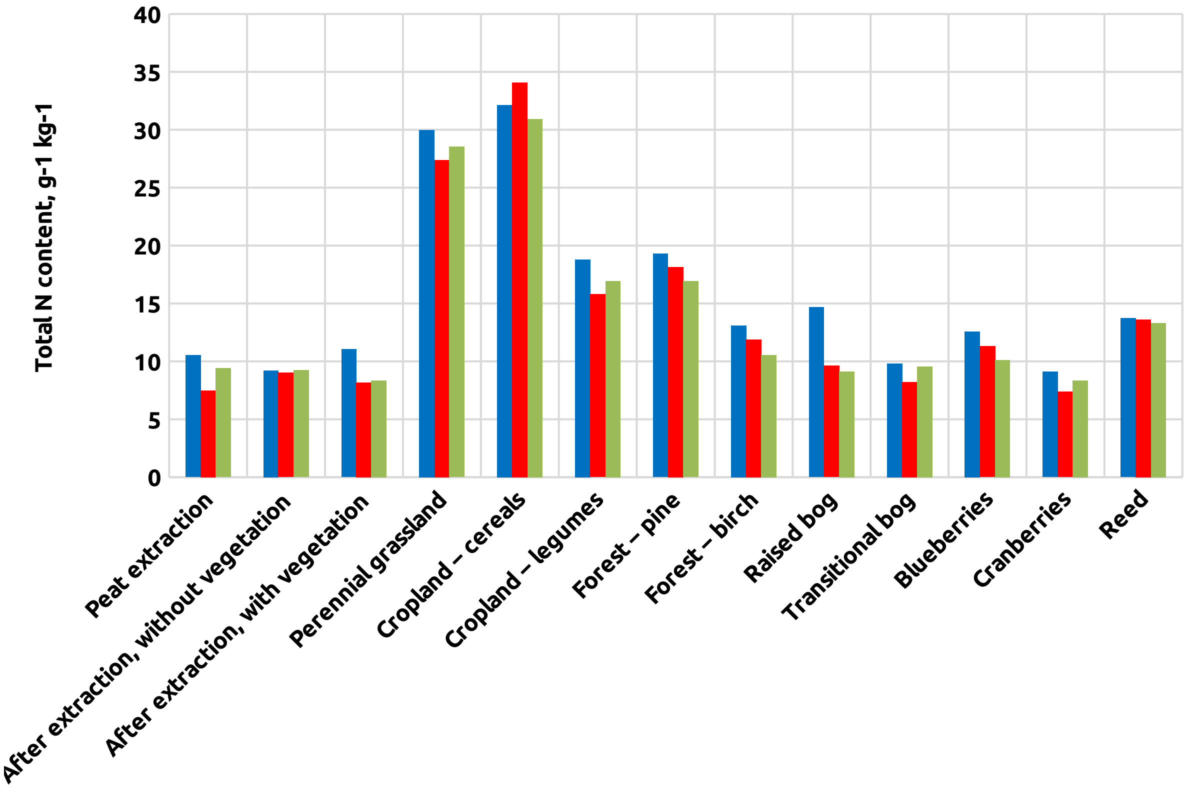

Figure 12: Mean total N content in all land management types in 0-10, 10-20 and 20-30 cm depth.

Soils for most of the sites can be described as a very acid. In almost all of the sites soil pH in the topsoil (0-30 cm) is below 4, except cropland and grassland and site with common reed (Figure 13).

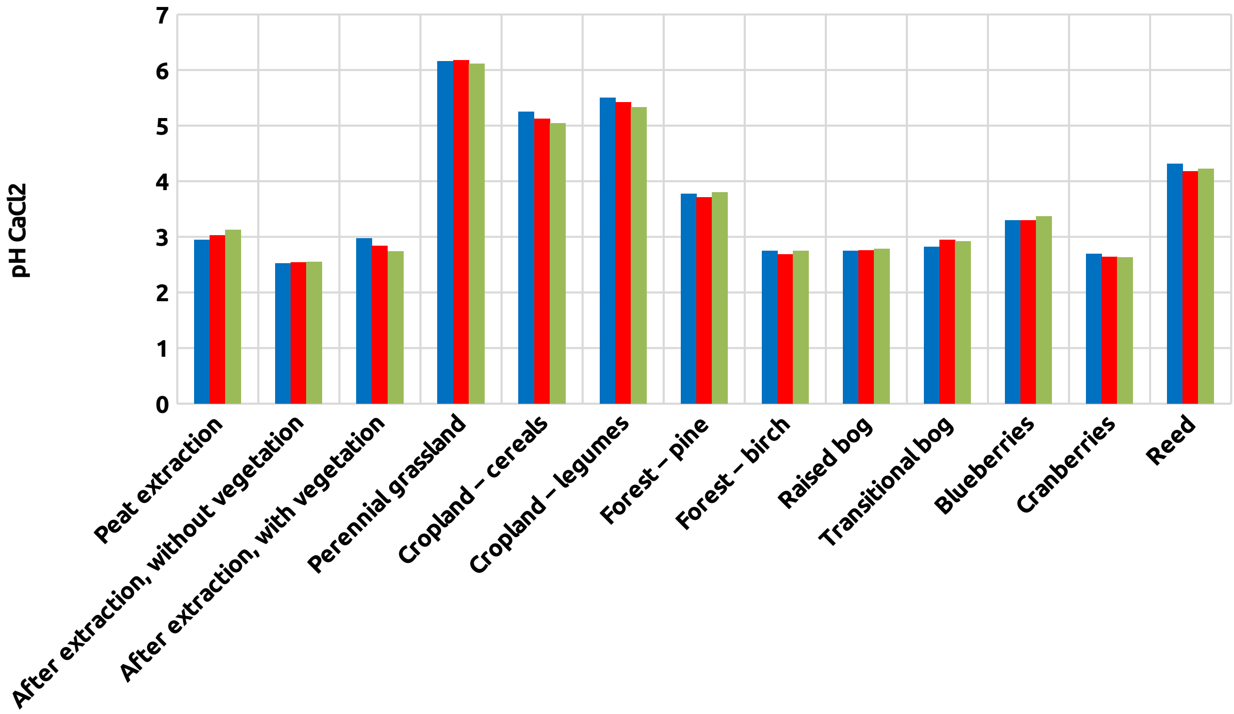

Figure 13: Mean soil pH (CaCl2) in all land management types in 0-10, 10-20 and 20-30 cm depth.

Ground water pH is higher than soil pH on average (Figure 14). The highest pH (>6) for ground water is in cropland and grassland and also in common reed site. In peat extraction sites and birch forests ground water pH is ~ 5, in rest of the sites it is below 5.

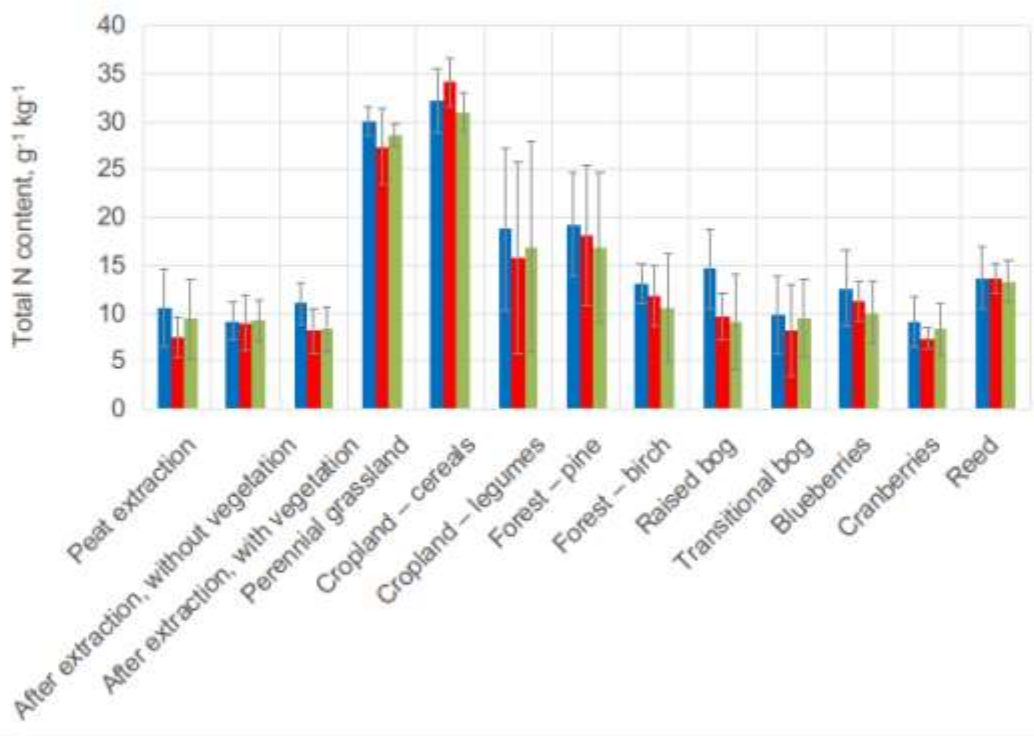

Figure 14: Mean ground water pH in all land management types (mean±stdev).

CONCLUSIONS

1. **Measured net ecosystem exchange (NEE) after measurements are smaller than the IPCC default emission factors in all of the studied land management types. However, we must consider that sumer and autumn of 2018 was extremely dry and it might influence the results by increasing uncertainty and range of GHG emission values.**
2. **The largest source of CO_2 emissions is cropland, but the smallest is afforestation.**
3. **Biggest source of CH_4 emissions are undrained sites – raised bog and transitional bog. Other land use categories are relatively small sources of CH_4 emissions.**
4. **Croplands are the largest source of N_2O emissions which is caused by use of nitrogen fertilizers, therefore in future studies it is important to separate this source to avoid double accounting of GHG emissions in agriculture sector.**