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	**01.12.2016-31.12.2017**
Report No.	**07-V2**
Authors	**Kairi Sepp**

Tartu, 2017

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 01.12.2016 and 31.12.2017.

In cooperation with LSFRI Silava 40 sampling sites were established and 10800 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.

Field works in the selected experimental plots were started in November, 2016. The first month was used to visit sites for installation of collars and groundwater wells. Field works were done by LSFRI Silava; OÜ Severitas and University of Tartu helped with selection of the sampling plots taking in account terrain, vegetation, peat depth and other parameters. Gas analyses for the period from December (including) of 2016 to December (including) of 2017 were done by University of Tartu. 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, Ieva Bebre, Toms Sarkanabols, 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 12 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).

DECEMBER, 2016 (MONTH 1)

Sampling was started in December, 2016 in 40 sites after completion of setup of sampling sites by LSFRI Silava. In total 800 gas samples were collected. The sampling schedule is provided in Table 1, location of sampling sites is provided in Figure 1. Gas samples were analyzed during January, 2017 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. Recommendations for installation of footbridges in 12 plots were provided to LSFRI Silava to avoid fluctuations of measurement data due to soil impact.

Table 1: Gas sampling schedule in December, 2016

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
Kemeri_9	S																														
Kemeri_14	S																														
Cena_3		S																													
Cena_2		S																													
Cena_1					S																										
Cepla_7						S																									
Cepla_2						S																									
Naud_11							S																								
Naud_12							S																								
Silg_1								S																							
Silg_2								S																							
Silg_3								S																							
Silg_8								S																							
Kalna_11												S																			
Kalna_12												S																			
Mar_5												S																			
Kasku_4												S																			
Kazu_10													S																		
Vang_10													S																		
Virsi_2															S																
Lauga_9															S																
Lauga_12																S															
Lauga_2																S															
Liels_4																			S												
Liels_8																			S												
Liels_9																				S											
Gaven_5																				S											
Plece_8																					S										
Virsi_14																					S										
Dierv_5																						S									
Dierv_6																						S									
Krista_4																							S								
Stabul_4																							S								
Kaigu_11																											S				

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
Kaigu_7																											S				
Kaigu_14																												S			
Kaigu_1																												S			
Linu_10																													S		
Lamb_7																													S		
Brigi_13																														S	

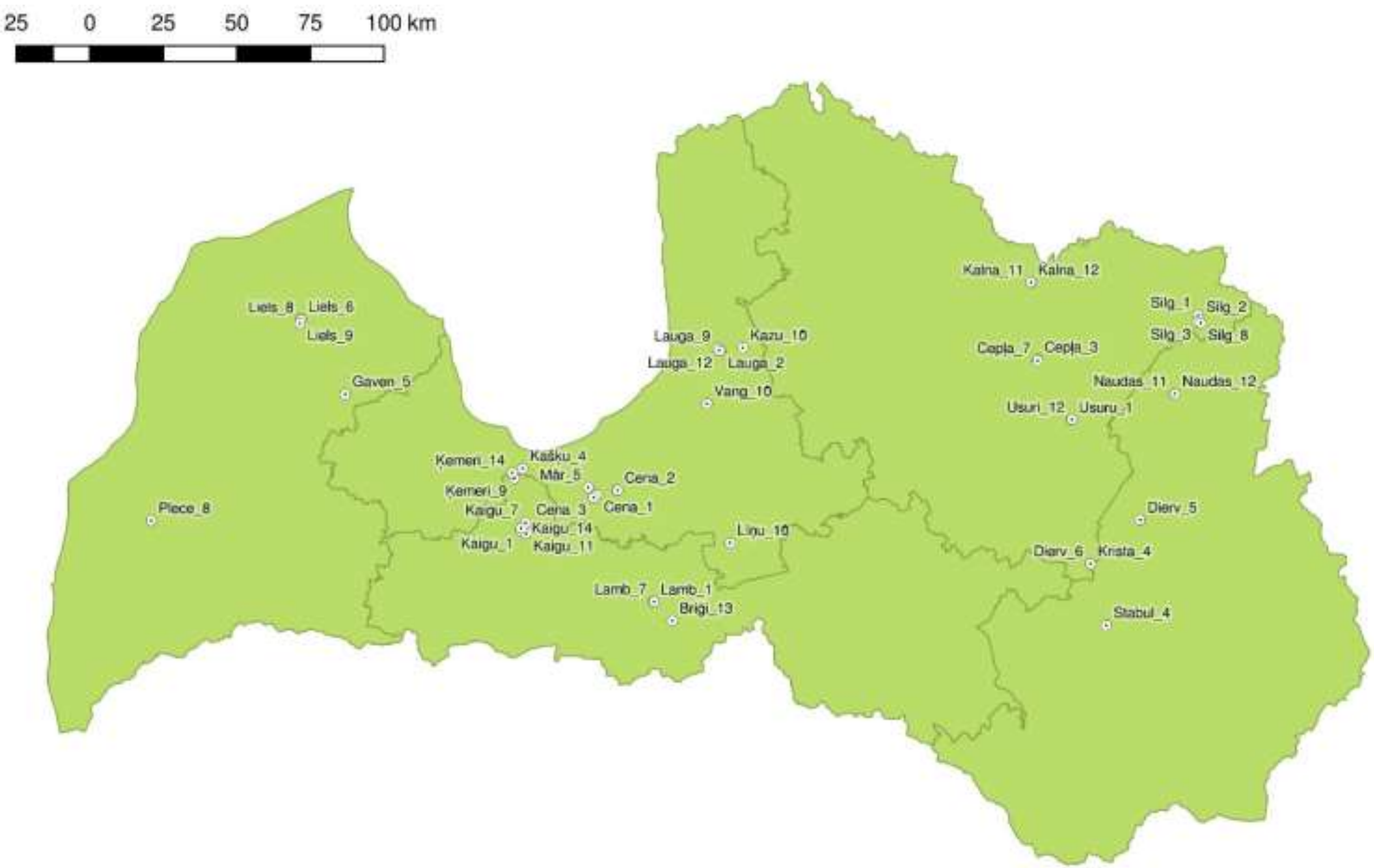

Figure 1: Location of sampling sites.

JANUARY, 2017 (MONTH 2)

In total 800 gas samples were collected in January. The sampling schedule is provided in Table 2. Organization of sampling was rescheduled considering previous experience to be able to visit at least 2 plots during the day.

Gas samples were analyzed during February, 2017 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 January, 2017

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_2																				S										
Cena_1																				S										
Cepla_7																	S													
Cepla_3																	S													
Dierv_5												S																		
Dierv_6												S																		
Ezera_3									S																					
Ezera_2									S																					
Gaven_5																									S					
Vang_10									S																					
Kaigu_11																								S						
Kaigu_7																								S						
Kaigu_14																								S						
Kaigu_1																								S						
Kalna_11																							S							
Kalna_12																							S							
Linu_10											S																			
Kasku_4					S																									
Kazu_10											S																			
Kem_9					S																									
Kem_14					S																									
Krista_4													S																	
Lamb_7																														S
Lauga_9										S																				
Lauga_12										S																				
Lauga_2										S																				
Liels_8																										S				
Liels_9																										S				
Liels_6																										S				
Virsi_14																				S										
Naud_11																		S												
Naud_12																		S												
Plece_8																									S					
Mar_5																														S
Silg_8																			S											
Silg_1																			S											
Silg_3																			S											
Silg_2																			S											
Stabul_4													S																	

FEBRUARY, 2017 (MONTH 3)

In total 800 gas samples were collected in February. The sampling schedule is provided in Table 3. Gas samples were analyzed during January, 2017 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 as described above. In cooperation with LSFRI Silava additional recommendations were elaborated to cover chamber and collar connection with snow and cleaning of collars from ice during preparatory works. Latvian and Estonian teams worked together where possible to increase productivity, particularly due to ice in collars, which had to be carefully cleaned out.

Table 3: Gas sampling schedule in February, 2017

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_2							S																					
Cena_1							S																					
Cepla_7																S												
Cepla_3																	S											
Dierv_5																	S											
Dierv_6														S														
Ezera_3														S														
Ezera_2																											S	
Gaven_5								S																				
Vang_10																				S								
Kaigu_11																				S								
Kaigu_7																				S								
Kaigu_14																				S								
Kaigu_1																						S						
Kalna_11																						S						
Kalna_12							S																					
Linu_10						S																						
Kasku_4								S																				
Kazu_10															S													
Kem_9																								S				
Kem_14									S																			
Krista_4									S																			
Lamb_7									S																			
Lauga_9			S																									
Lauga_12						S																						
Lauga_2																												S
Liels_8																												S
Liels_9																												S
Liels_6	S																											
Virsi_14	S																											
Naud_11																					S							
Naud_12																					S							
Plece_8																											S	
Mar_5																S												
Silg_8																							S					
Silg_1																							S					
Silg_3																							S					
Silg_2																							S					
Stabul_4															S													

MARCH, 2017 (MONTH 4)

In total 800 gas samples were collected in March, 2017. The sampling schedule is provided in Table 4. Organization of sampling was rescheduled to adopt to additional time needed to access sampling sites with non-drivable roads.

Gas samples were analyzed during April, 2017 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 March, 2017

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																						
Cena_1									S																						
Cepla_7													S																		
Cepla_2													S																		
Dierv_5								S																							
Dierv_6								S																							
Gaven_5																					S										
Vang_10										S																					
Kaigu_11															S																
Kaigu_7															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				
Lauga_9							S																								
Lauga_12							S																								
Lauga_2							S																								
Kem_14			S																												
Kem_9			S																												
Liels_8																						S									
Liels_4																						S									
Liels_9																												S			
Virsi_14																				S											
Med_14																				S											
Naud_11																	S														
Naud_12																	S														
Plece_8																					S										
Mar_5									S																						
Silg_8																							S								
Silg_1																							S								
Silg_3																							S								
Silg_2																							S								
Stabul_5						S																									

APRIL, 2017 (MONTH 5)

In total 800 gas samples were collected in April, 2017. The sampling schedule is provided in Table 5. Sampling schedule was not changed in comparison to March, 2017. Additional measures were implemented in cooperation with LSFRI Silava – in addition to ecosystem respiration, which is a base for GHG emission factors, measurements of photosynthetic activity (sequestration of CO_2 from atmosphere by plants) were done using transparent chambers and field CO_2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during May, 2017 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. Additional footbridges were installed by LSFRI Silava according to recommendations of Severitas personnel.

Table 5: Gas sampling schedule in April, 2017

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																							
Cena_1							S																							
Cepla_7										S																				
Cepla_2										S																				
Dierv_5					S																									
Dierv_6					S																									
Gaven_5																			S											
Vang_10											S																			
Kaigu_11																					S									
Kaigu_7																					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					
Lauga_9						S																								
Lauga_12						S																								
Lauga_2						S																								
Kem_14			S																											
Kem_9			S																											
Liels_8																				S										
Liels_4																				S										
Liels_9																				S										
Virsi_14													S																	
Med_14													S																	
Naud_11																								S						
Naud_12																								S						
Plece_8																			S											
Mar_5							S																							

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
Silg_8																											S			
Silg_1																											S			
Silg_3																											S			
Silg_2																											S			
Stabul_5				S																										

MAY, 2017 (MONTH 6)

In total 800 gas samples were collected in May, 2017. The sampling schedule is provided in Table 6. Sampling schedule was not changed in comparison to April, 2017. Measurements of photosynthetic activity (removals of CO2 from atmosphere by plants) were continued using transparent chambers and field CO2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during June, 2017 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 May, 2017

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														
Cena_1																	S														
Cepla_7																		S													
Cepla_2																		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		
Lauga_9															S																
Lauga_12															S																
Lauga_2															S																
Kem_14											S																				
Kem_9											S																				
Liels_8																									S						
Liels_9																									S						
Liels_4																									S						
Virsi_14																						S									
Med_14																						S									
Naud_11																										S					
Naud_12																										S					
Plece_8																								S							
Mar_5																														S	
Silg_8																															S
Silg_1																															S
Silg_3																															S
Silg_2																															S

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
Stabul_5									S																						

JUNE, 2017 (MONTH 7)

In total 800 gas samples were collected in June, 2017. The sampling schedule is provided in Table 7. 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 CO2 from atmosphere by plants) were continued using transparent chambers and field CO2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during July, 2017 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 June, 2017

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									
Cena_1																					S									
Cepla_7																			S											
Cepla_2																			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																													
Lauga_9	S																													
Lauga_12									S																					
Lauga_2									S																					
Kem_14		S																												
Kem_9								S																						
Liels_8								S																						
Liels_9																													S	
Liels_4																													S	
Virsi_14																													S	
Med_14																						S								
Naud_11																						S								
Naud_12																											S			
Plece_8																											S			
Mar_5																													S	
Silg_8																					S									
Silg_1																												S		
Silg_3																												S		

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
Silg_2																												S		
Stabul_5					S																									

JULY, 2017 (MONTH 8)

In total 800 gas samples were collected in July, 2017. The sampling schedule is provided in Table 8. Organization of sampling was rescheduled to adopt to accessibility of roads. Measurements of photosynthetic activity (removals of CO2 from atmosphere by plants) were continued using transparent chambers and field CO2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during August, 2017 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 July, 2017

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_2																			S												
Dierv_5											S																				
Dierv_6											S																				
Gaven_5																												S			
Vang_10																	S														
Kaigu_11																					S										
Kaigu_7																					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																												
Cena_1			S																												
Lauga_9													S																		
Lauga_2													S																		
Lauga_12																				S											
Kem_14						S																									
Kem_9						S																									
Liels_8																											S				
Liels_9																											S				
Liels_4																											S				
Virsi_14																								S							
Med_14																								S							
Naud_11																									S						
Naud_12																									S						
Plece_8																												S			

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
Mar_5																		S													
Silg_1																				S											
Silg_8																										S					
Silg_3																										S					
Silg_2																										S					
Stabul_5												S																			

AUGUST, 2017 (MONTH 9)

In total 800 gas samples were collected in August, 2017. The sampling schedule is provided in Table 9. Organization of sampling was rescheduled to adopt to accessibility of roads and vacation schedule of the teams in Latvia and Estonia. The position of three sample plots – Cena_1, Silg_1 and Lauga_12 were changed to Lamb_1, Usuru_1 and Usuru_12. 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, 2017 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 August, 2017

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_2															S																
Dierv_5									S																						
Dierv_6									S																						
Gaven_5																									S						
Vang_10														S																	
Kaigu_11																					S										
Kaigu_7																					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		
Cena_1																													S		
Lauga_9			S																												
Lauga_2			S																												
Lauga_12																															
Kem_14				S																											
Kem_9				S																											
Liels_8																								S							
Liels_9																								S							
Liels_4																								S							
Virsi_14																		S													
Med_14																		S													
Naud_11																							S								
Naud_12																							S								
Plece_8																									S						
Mar_5																	S														
Silg_1																						S									

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
Silg_8																						S									
Silg_3																						S									
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SEPTEMBER, 2017 (MONTH 10)

In total 840 gas samples were collected in September, 2017. The sampling schedule is provided in Table 10. 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 CO2 from atmosphere by plants) were continued using transparent chambers and field CO2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during September, 2017 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 September, 2017

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
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Usuru_1														S																

OCTOBER, 2017 (MONTH 11)

In total 800 gas samples were collected in October, 2017. 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 CO2 from atmosphere by plants) were continued using transparent chambers and field CO2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during September, 2017 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 October, 2017

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
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Usuru_1																		S													
Arosa 14									S																						

NOVEMBER, 2017 (MONTH 12)

In total 800 gas samples were collected in November, 2017. The sampling schedule is provided in Table 12. 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 CO2 from atmosphere by plants) were continued using transparent chambers and field CO2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during September, 2017 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 12: Gas sampling schedule in November, 2017

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
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Usuru_1																S															
Arosa_14									S																						

DECEMBER, 2017 (MONTH 13)

In total 800 gas samples were collected in December, 2017. The sampling schedule is provided in Table 13. 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 CO2 from atmosphere by plants) were continued using transparent chambers and field CO2 flux measurement equipment. Measurement dates in different plots were harmonized.

Gas samples were analyzed during September, 2017 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 13: Gas sampling schedule in December, 2017

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
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Arosa_14							S																								

1. RESULTS

1.1 CO2 fluxes

First year results indicate that NEE is positive for all of the studied land management practices (Figure 1), it means CO2 emissions are larger than CO2 removals and those ecosystems are sources of atmospheric CO2. The biggest sources are croplands, on average NEE is more than 4,0 tonnes ha-1 annually. The smallest NEE is for cranberry cultivation sites, where the NEE is 0,2 tonnes ha-1 annually.

In all of the land management practices, measured NEE is lower compared to respective IPCC default CO2-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 between measured NEE for berry cultivation and emission factor is 10 times or even more (for cranberries), showing the unsuitability of the use of default emission factor in drained cropland on organic soil for berry cultivation in peatland.

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 2017 was extremely wet, especially from mid of the summer until late autumn. It may influence the level of NEE, by reducing the decomposition of organic matter and lower ecosystem CO2 respiration. It is expected that ecosystem CO2 respiration in 2nd year of measurements will be higher, therefore the NEE will increase.

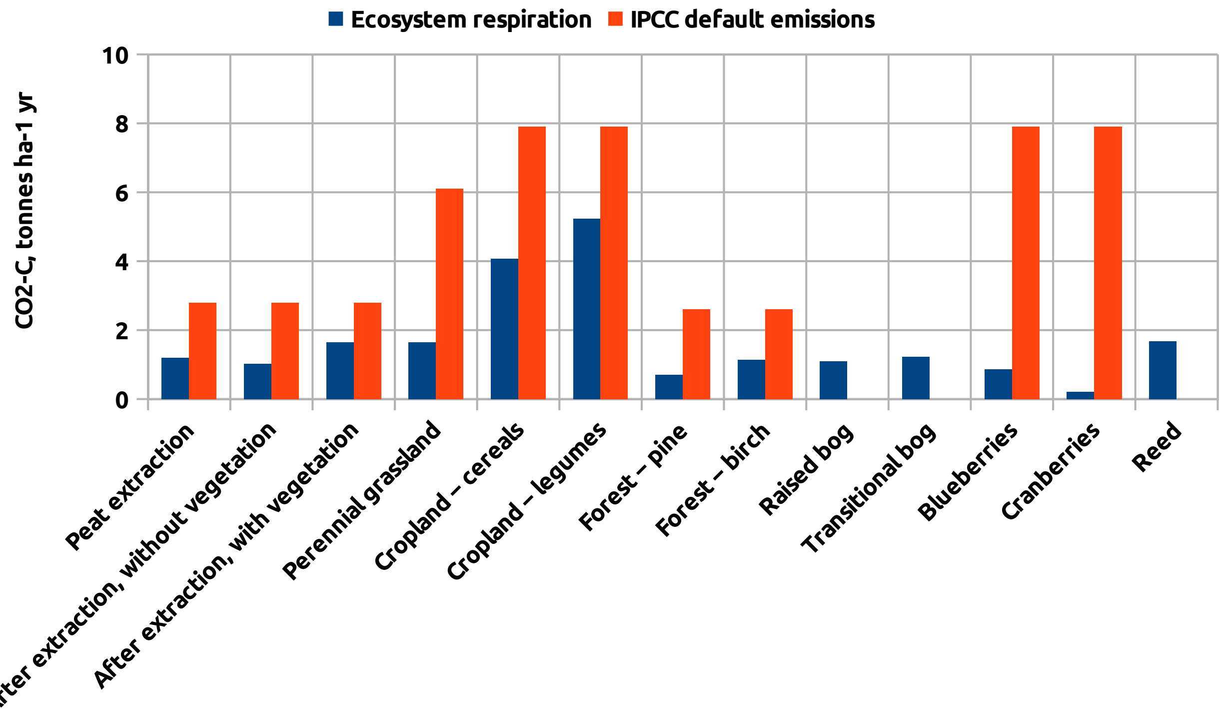

Figure 2: Mean Net ecosystem exchange in all land management types.

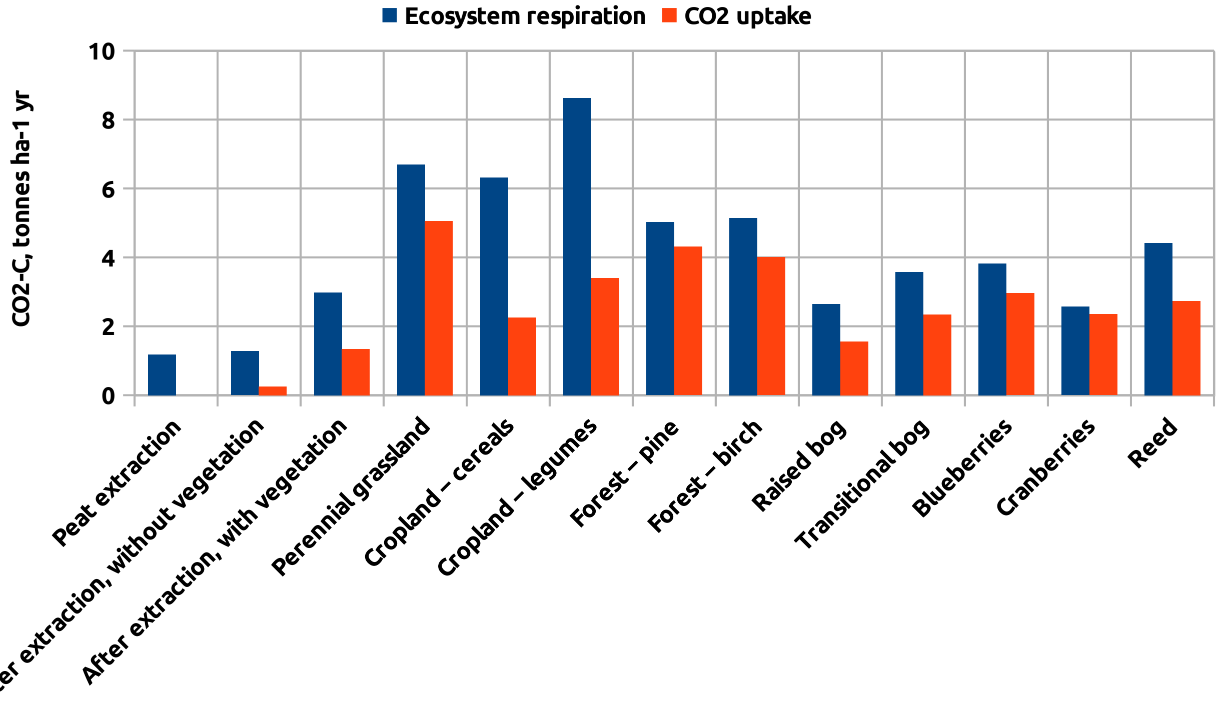

Figure 3: Mean Net ecosystem exchange in all land management types and respective IPCC default emission factors.

NEE is a balance of two components – ecosystem respiration and CO2 sequestration by plants. In case of forests and cropland, CO2 uptake is considered to be carbon which is accumulated in soil. Living biomass of trees in forest and crop biomass which is removed from the field in cropland is not considered to be a part of CO2 uptake, thus the results are showing net soil CO2-C balance. In all sites net balance is positive, it means that ecosystem respiration is higher than CO2 uptake and the sites are net sources of emissions (Figure 3).

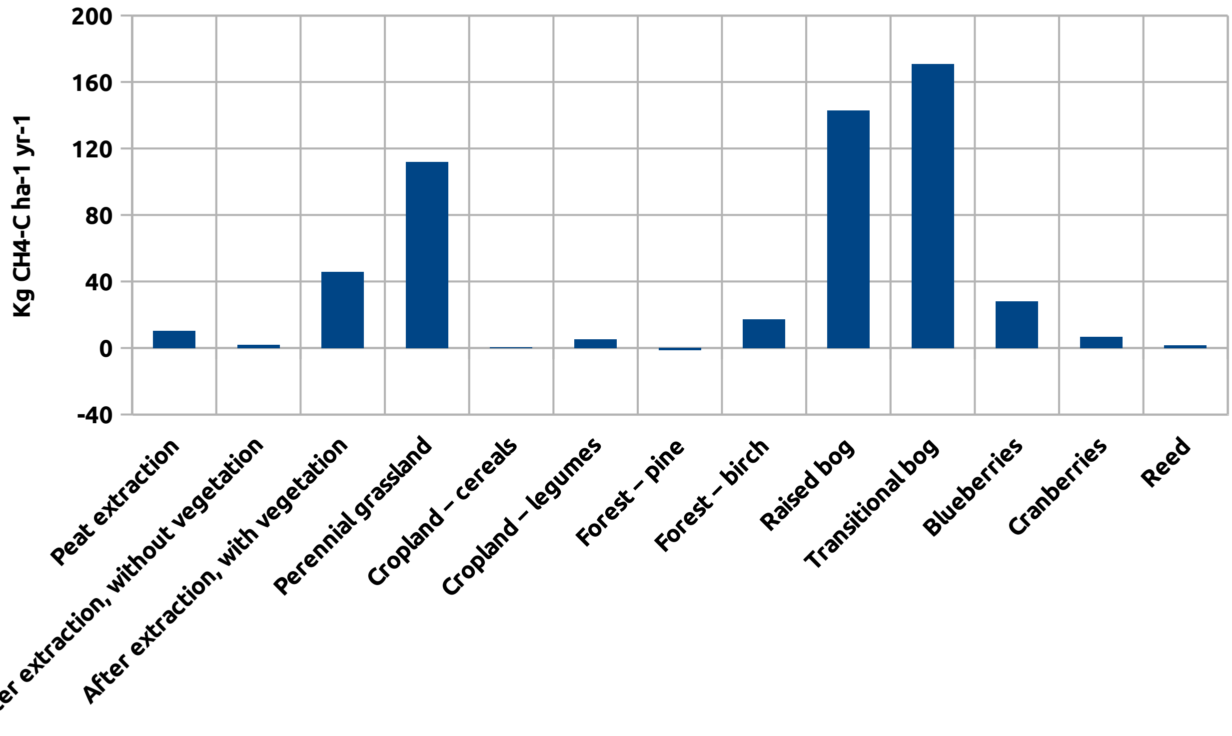

Figure 4: Mean ecosystem CO2 respiration and CO2 uptake in all land management types.

1.2 CH4 and N2O fluxes

Opposite to CO2 emissions, CH4 fluxes usually is the highest in wet conditions and drainage causes decrease in methane production and emissions of methane. As it was expected, highest CH4 emissions is in undrained ecosystems – raised and transitional bog (Figure 4). In raised bog CH4 emissions is 143 kg CH4-C ha-1 annually, but in transitional bog 171 kg CH4-C ha-1 annually.

Big source of CH4 emissions was also perennial grassland, with emissions 112 kg CH4-C ha-1 annually. The reason for such a high methane emissions is mainly one of the site, which was very wet in spring and autumn thus causing huge methane emissions. At the same time, one the sites with mean ground water level >70 cm in perennial grassland was a small sink of methane.

Pine forests on average was a small sink of CH4 with uptake 1.4 kg CH4-C ha-1 annually.

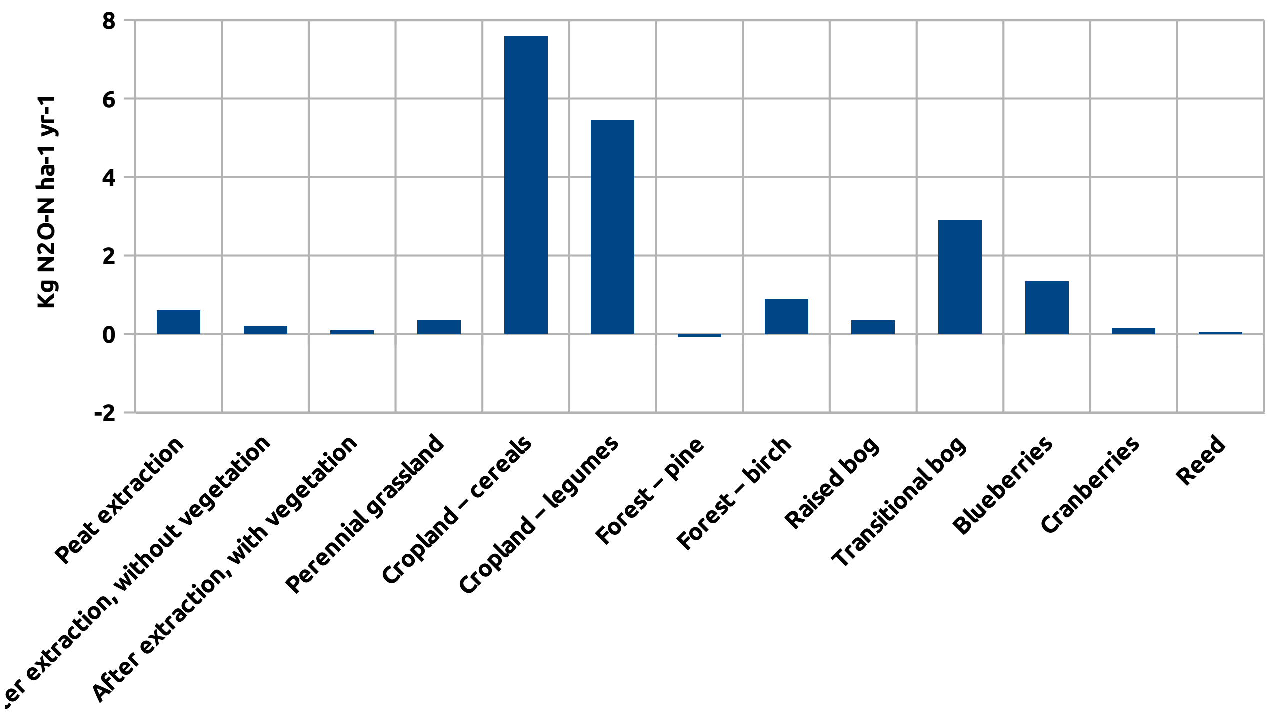

Figure 5: Mean CH4 fluxes in all land management types.

The biggest N2O fluxes was in cropland, where annual flux is around 8 kg N2O-N ha-1 under cereal cultivation and around 6 kg N2O-N ha-1 under legume cultivation (Figure 5). The reason for bigger N2O emissions in cropland is use of nitrogen fertilizers. Also transitional bog was substantial source of N2O, with around 3 kg N2O-N ha-1 annually. In most the year N2O emissions in transitional bog was close to zero, but in March there were huge emissions in all 3 sites of the transitional bog. It could be explained by melting of snow and ice, causing peaks in N2O emissions.

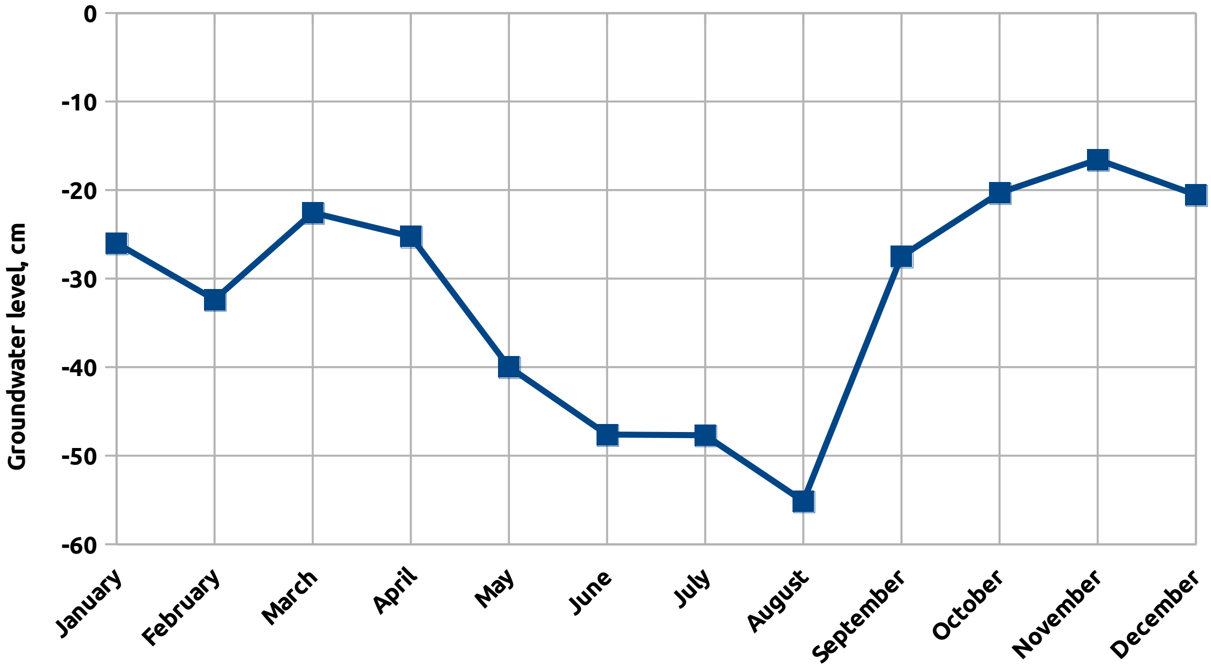

Figure 6: Mean N2O fluxes in all land management types.

2. AUXILIARY MEASUREMENTS

Different land management practices may have significant influence on greenhouse gas emissions, but management practice is just one of the many factors affecting level of emissions. Emissions can be largely variable between sites with similar land use and even within boundaries of one site. It is driven by many abiotic and biotic factors, also by human interference.

Measurements of different additional factors may help to better understand and explain processes controlling the level of emissions. It may be important also when estimating yearly gas fluxes, because it often requires modelling to estimate those fluxes.

2.1 Groundwater level

One of the main factors controlling the status of carbon balance (CO2 and CH4) 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 CH4. 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 CO2 emissions.

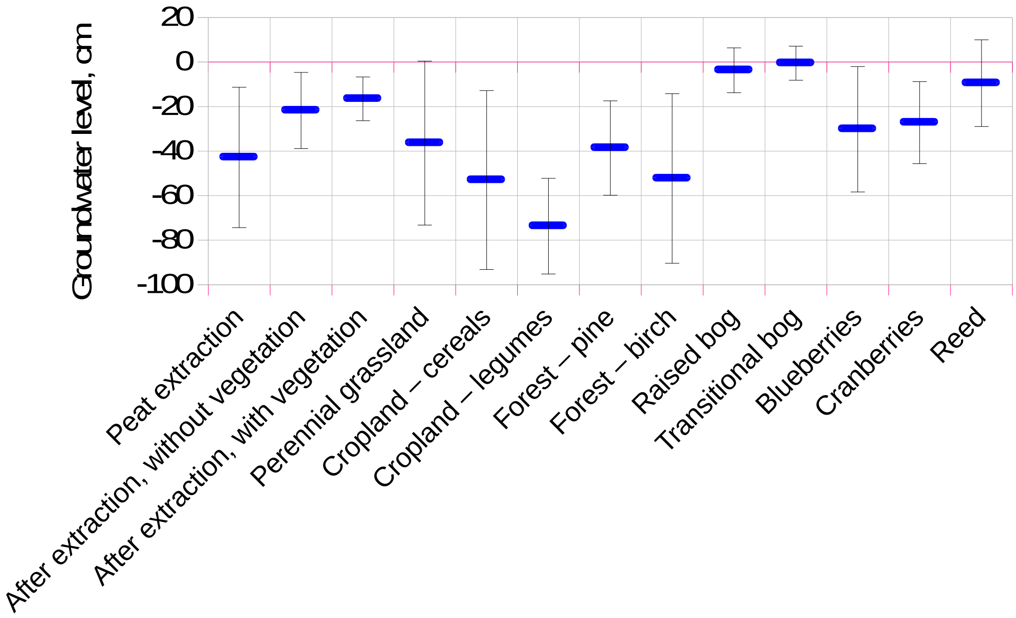

Figure 7: Mean Ground water level in all land management types (mean±stdev).

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 6). 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 - 75 cm) and in birch forests (~ 52 cm).

Lowest ground water was observed in august (Figure 7), when on average it was around 55 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.

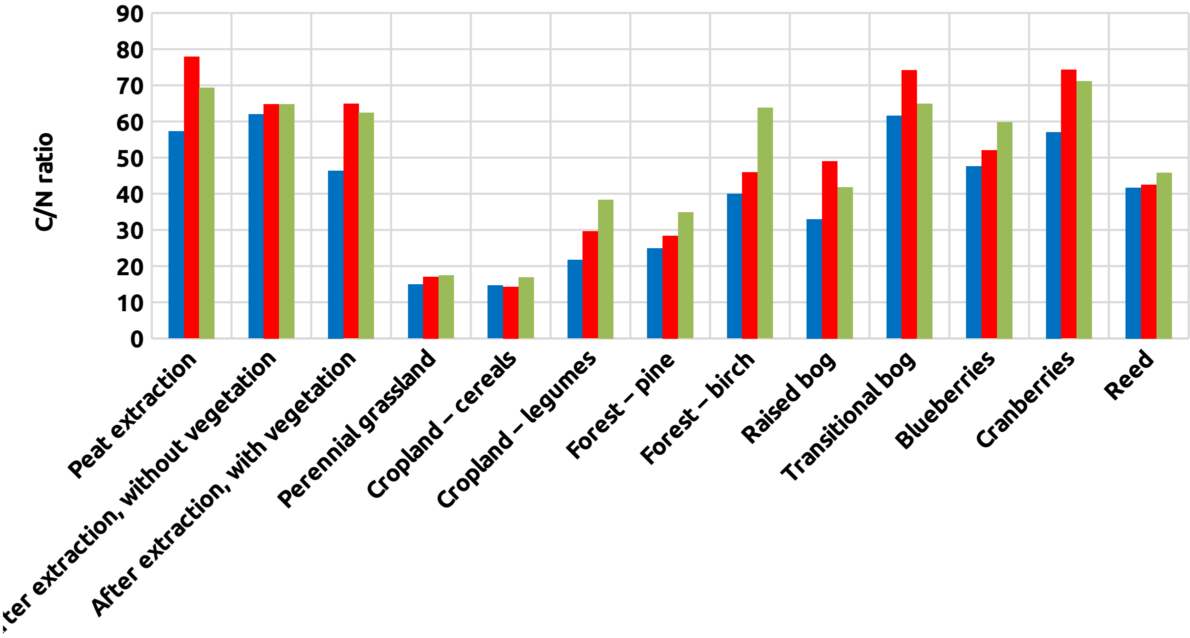

Figure 8: Ground water level in all land management types.

2.2 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 9), 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.

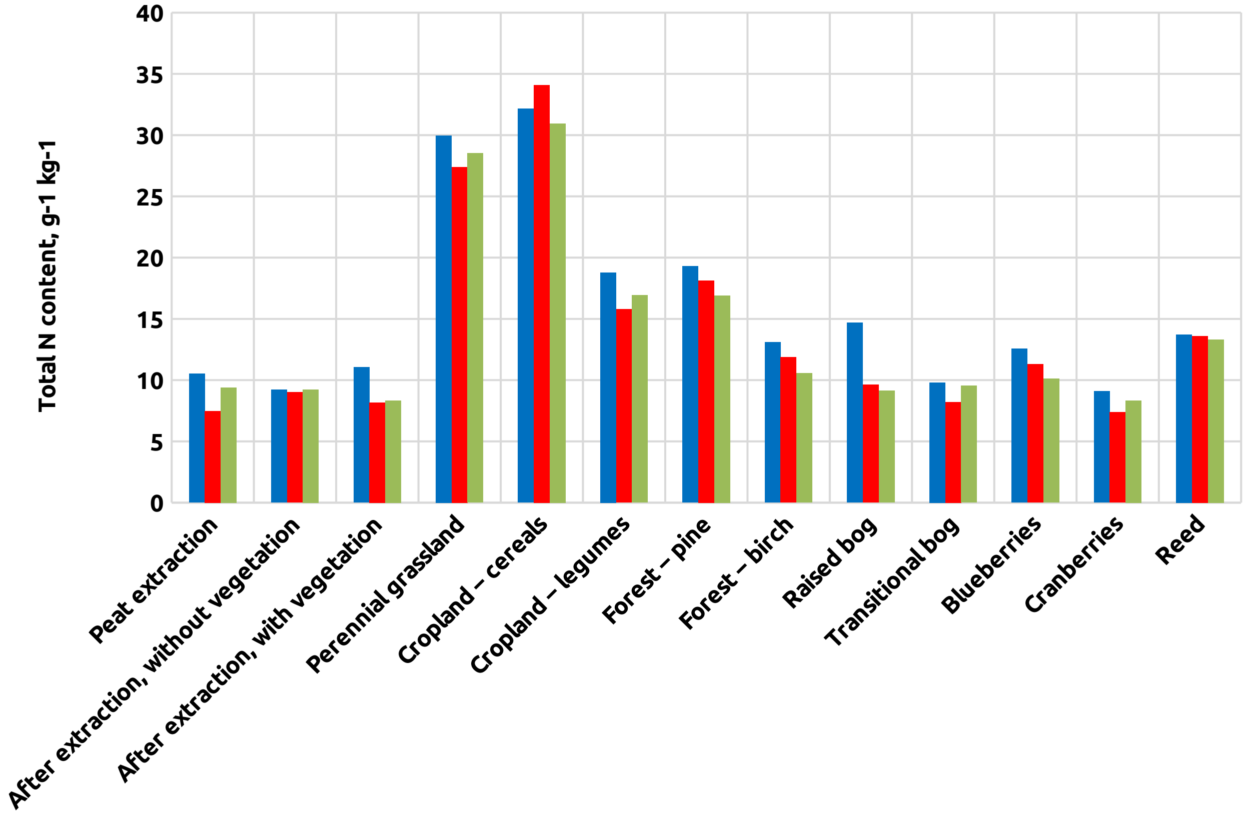

Figure 9: Mean C/N ratio in all land management types in 0-10, 10-20 and 20-30 cm depth.

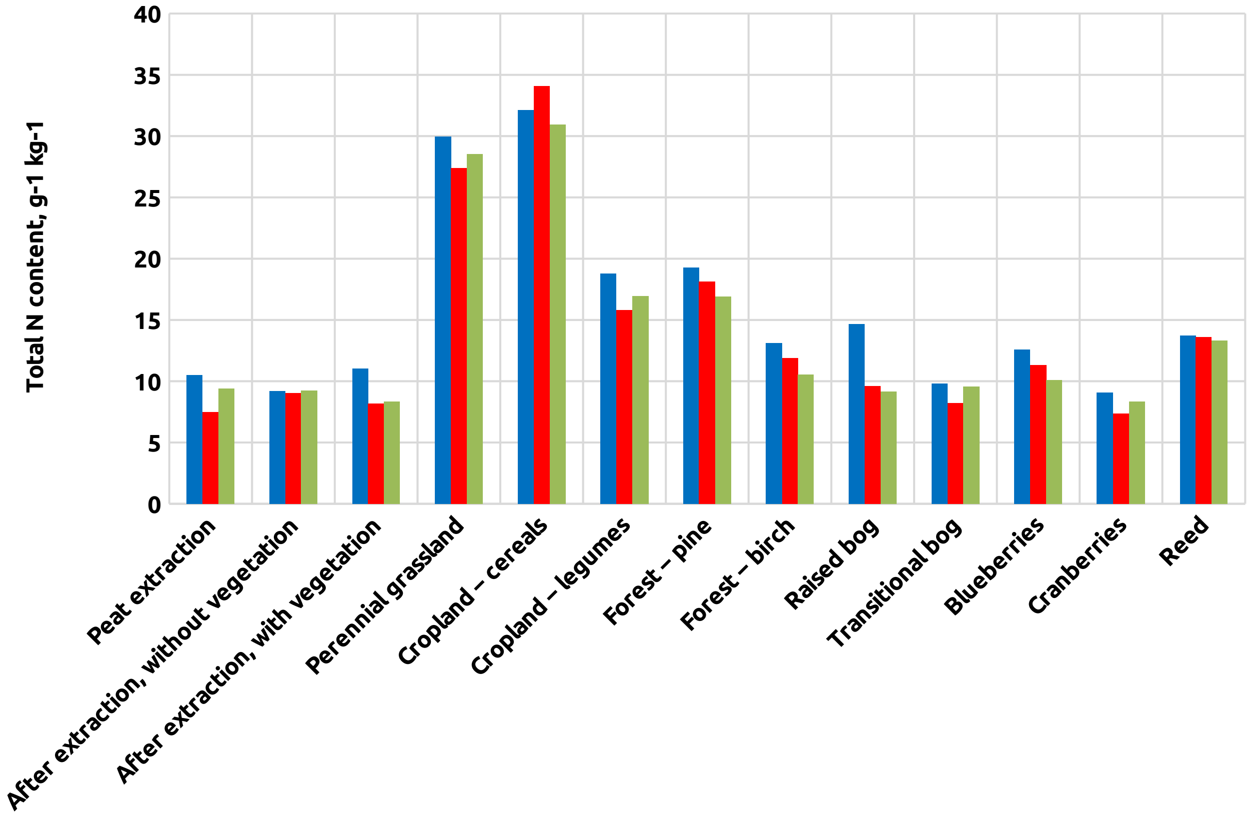

Figure 10: Mean total N content in all land management types in 0-10, 10-20 and 20-30 cm depth.

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 11).

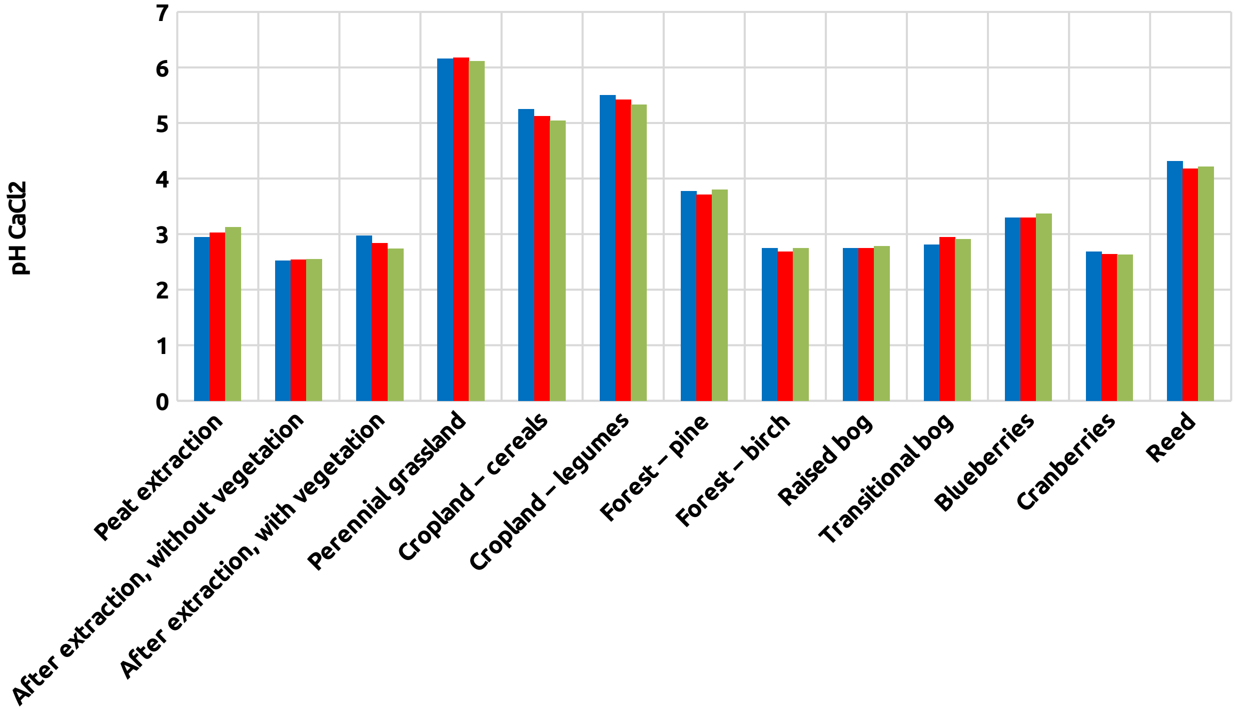

Figure 11: Mean soil pH (CaCl2) in all land management types in 0-10, 10-20 and 20-30 cm depth.

Ground water pH is higher than soil pH on average (Figure 12). 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.

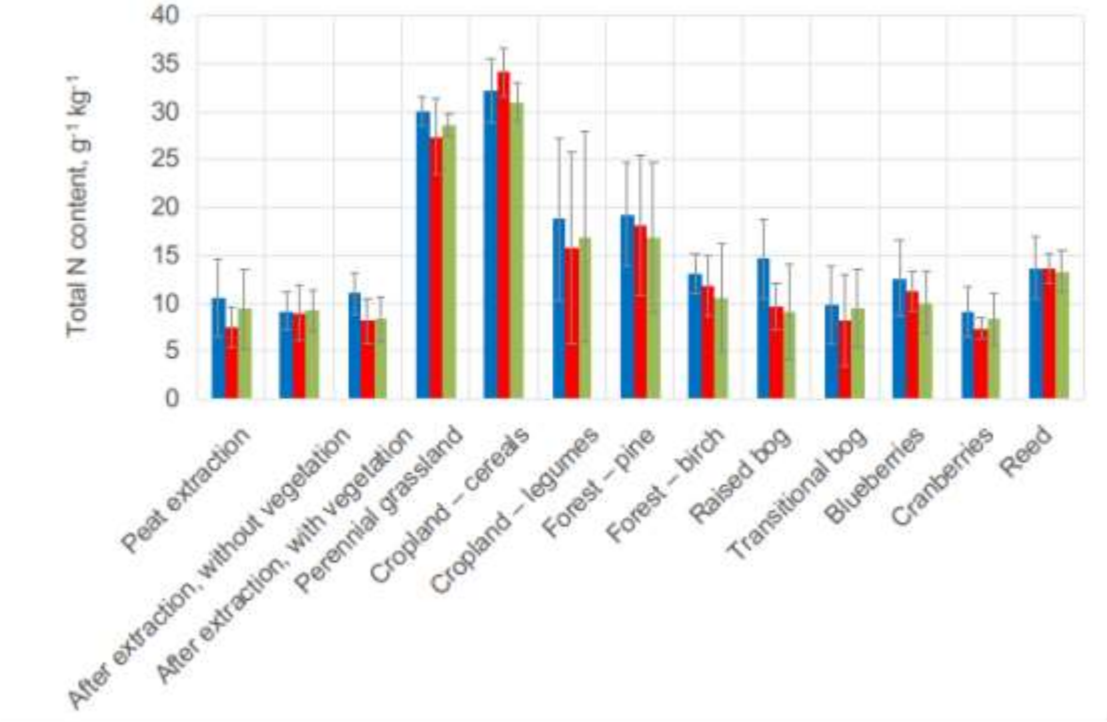

Figure 12: Mean ground water pH in all land management types (mean±stdev).

3. CONCLUSIONS

1. **Measured net ecosystem exchange (NEE) after measurements of the first year is smaller than IPCC default emission factors in all of the studied land management types. However, we must consider that sumer and autumn of 2017 was extremely wet and it might influence the results. It is expected that measured NEE will be higher after second year.**
2. **The largest source of CO2 emissions is cropland, but the smallest is cranberry cultivation sites and forested sites.**
3. **Biggest source of CH4 emissions are undrained sites – raised bog and transitional bog. Pine forests was a small sink during first year.**
4. **Croplands are the largest source of N2O emissions which is caused by use of nitrogen fertilizers.**