PROJECT TITLE AND ACRONYM

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Project Website: https://www.helsinki.fi/en/projects/reducing-the-effects-of-forest-management-to-inland-waters

Project code: WaterWorks2017-REFORMWATER

Duration of project:

Start date: April 1, 2019 **End date: March 31, 2022**

Period covered by this report: April 1, 2019 - October 31, 2020

1. Publishable Summary

Large lakes are often important raw water sources of major cities, but show regular brownification, i.e. due to an increase in amounts of dissolved organic matter and humic substances, water is becoming darker. This phenomenon, common in the northern latitudes, has primarily been suggested to result from processes related to recovery from acid deposition and increase in winter precipitation. However, in countries where peatlands are abundant, forest management on drained peatlands also plays an important role in brownification. As the demand for timber, pulpwood, renewable energy sources and biodegradable materials is increasing, there is ongoing pressure to use the large timber stock on drained peatlands and reopen and clean the ditches to allow reestablishment of new forests. There is significant timber stock in the large drained peatland forests that are soon coming to harvesting age. Since 62-72% of the land area in the countries of this project (Finland, Sweden, Estonia, Ireland) is covered by forests of which up to 25% on drained peatlands, increases in dissolved organic matter (DOM) and nutrient fluxes from such forests is a major threat to water quality. Large scale ditch maintenance will possibly affect the water quality in recipient water bodies. The aim of this study is therefore to quantify the effects of current management practices (harvesting and subsequent ditch maintenance) on peatland forests on transport of dissolved compounds and their quality to aquatic systems. Besides the traditional methods of forest harvesting based on clear cut, we will investigate the potential of continuous cover forestry as a useful tool in water protection. In addition, we will try to use biochar to decrease the harmful loads to aquatic systems. Finally, we aim to develop a model which can be used for assessing the effects of forest management practices on water quality in peatland-dominated catchments. It can also be used when optimizing timber production in a way which besides wood production minimizes the adverse environmental impacts.

Our biochar experiments in the lab show that biochar effectively adsorbs both inorganic and organic nitrogen from runoff water, which is then potentially reflected in water quality drained from peatlands. Biochar made of birch adsorbs nitrogen more efficiently than biochar made of spruce. For practical applications, we still need more large scale demonstrations.

The lab and field experiments are now producing data needed in model development which will be started in spring 2021.

https://www.helsinki.fi/en/projects/reducing-the-effects-of-forest-management-to-inland-waters

2. Work Performed and the Results achieved during the reporting period

a. Scientific and technological progress

In WP 1 ('Less-invasive forest management as a tool for reducing DOM load') the aim was to study the potential to reduce DOM and nutrient load from forested peatland catchments using different management options and biochar. To fulfill this we have established field experiments in Southern Finland, Northern Sweden, Estonia and Ireland. have two large scale field experiments, the Paroninkorpi drained peatland

In Finland the field site is an old drained forested peatland (drained ca. 70 years ago) 'Paroninkorpi' where the draining was done traditionally using a dense ditch network. The site was established by the Natural Resources Institute Finland (LUKE) where they study the effects of clear cut and continuous cover forestry (CCF) on tree growth (Norway spruce) and carbon balance. The experimental setup in 'Paroninkorpi' consists of the following treatments: uncut control, thinning in CCF (basal area 12 m2/ha) and clearcut (done a year before the project was started). The main ditch network in the area was cleaned simultaneously. Our role in this collaboration is to study the effects on hydrology and water quality (load of DOM and nutrients) as well as atmospheric fluxes of GHGs from water surfaces. The research site was changed from the original 'Lakkasuo' peatland in Hyytiälä to 'Paroninkorpi' because the landowner suddenly changed the management regime of the peatland forest just before the project was supposed to start. This change turned to be a lucky one since it provides a real collaboration with LUKE which will ease the knowledge transfer to forest owners and other end users. It is worth noticing that the site is owned by a large global forest company UPM-Kymmene plc. The company welcomed us to the site, but has no intentions to intervene with the research.

Our activities in the site started in 2019 when we installed the groundwater wells in the clearcut, but LUKE had already constructed the infrastructure in control and CCF plots (ground wells, temperature loggers, tree and vegetation measurement plots). We also installed rainwater collectors (vol. 2 L) as well as poles to snow depth measurements to all of the measuring plots. A continuously operating weather station was installed in the clearcut in spring 2019. Monthly sampling from groundwater and ditches was started in June 2019. The biodegradability of DOM was studied from the monthly samples by measuring the CO2 production from the incubations of 21 days. Water quality was determined with spectral measurements and samples were prepared for detailed FT-ICR-MS measurements to be carried out in winter 2021.

In autumn 2019 we collected peat columns from the 'Paroninkorpi' measuring plots as well as a nearby pristine peatland ('Sudenpesänkangas') administered by the national board of forestry 'Metsähallitus'. Between October 2019 and February 2020 we collected peatcolumns also from the Swedish site 'TEA', the Estonian sites 'Ess-soo' and 'Ullika' close to Järvselja and the Irish site close to 'Lough Atorik' (see below for further information on the sites). The columns were stored at + 4 C before the experiment was started in late February in UEF Joensuu campus greenhouse facility. To simulate the drainage effects we set up high and low water table treatments in the columns and they were left to settle down for ca. 2 months. The water was sampled once a month from the columns using suction lysimeters and the samples were measured similarly to field samples (see above). The experiment was

terminated at the end of September 2020 when the columns were harvested for layered soil analyses (to be carried out in winter 2021).

In Sweden, we have initiated a large, catchment-scale experiment at a site called "Trollberget Experimental Area" (TEA) to quantify the impact of peatland forest harvesting and DNM on nutrient and DOM export. In Sweden, due to steeper terrain, the draining network differed from the Finnish one and had a less dense ditch network following the topography. Weirs were installed in four catchments and nutrients and DOM have been monitored bi-weekly for one year and in August 2020, the catchments were harvested. DNM will be performed in two of the catchments in 2021. TEA is located just 1 km from the long-term Krycklan Catchment Study (KCS) area that is used as our unharvested, drained control.

Mechanisms for the change in nutrients and DOM in runoff water are being tested using standardized litter bags (tea bag index), which is also being replicated in Finland (by LUKE), Ireland, and Estonia. Furthermore, ground water wells have been installed in all of the TEA treated and KCS reference catchments, and ground water level is monitored manually biweekly and 1/3 of wells have automatic loggers. Groundwater DOM was quantified in Fall of 2020. The downstream implications of changes in nutrients and DOM for instream biofilms are also being quantified seasonally using nutrient diffusing substrate (NDS). Tea bags as well as NDS experiments are spin offs created as a result of monthly brainstorming events in Zoom.

In the Estonian sites, DNM effect on DOC and nutrient export was estimated in Scots pine forests at Ullika close to Järvselja research station, where we set up drainage gradient measurements from a heavily drained stand to an undrained natural bog forest. In Estonia forest management as well as peatland drainage follows the German tradition based on rectangular forest compartments. Three subplots were set along the drainage gradient: intensively drained, moderately drained, and undrained, nearly natural forests and two sampling points: excavated and maintained working ditch and overgrown ditch, excavated more than 100 yrs ago. For estimating clear-cut effect on peatland forests, we set up two plots, i.e. a drained and a nearly natural in Ess-soo, which is a reference area for abandoned peat extraction sites under a different restoration treatment. The clear-cut was planned in winter 2020, but postponed to winter 2021 (due to unfrozen soil and Covid-19 restrictions).

In Estonia, water sampling was performed every month since October 2019, and for both sites earlier data (TOC, TC, DOC, DON, DN, also GHG measurements) are available. Soil temperature was monitored by loggers, and 2019/20 data will be downloaded at the end of October. For estimating the role of plant root and rhizosphere in DOM dynamics in forests affected by DNM, fine root samples were collected along drainage gradients in both study areas in October 2019 (Ullika) and April 2020 (Ess-soo). Roots were washed out in the lab, separated to tree and understory roots, and weighed. Root and peat characteristics will be later assessed by FTIR. Along the drainage gradient in Ullika, soil samples for estimating drainage effect on microbial communities were collected in the frame of earlier projects and the analyses are in progress. Stands characteristics (height, basal area, breast height diameter) will be measured in November 2020. Studies on fine root and rhizosphere microbial community effects on forest soil DOM and nutrients dynamics along the drainage gradient is in progress.

In Ireland, site selection has been ongoing involving field visits to assess the suitability of sites which have a range of management ('crowning' at 50%, clearfelling, CCF). Ongoing problems associated with Covid-19, delays and changes in felling licences, and weather conditions, have caused significant delays to WP1 (see section 10). Three sites have now been instrumented, representing a range of forest management ('crowning' involving 50% tree removal, clearfelling, and CCF). However, the CCF site can no longer be used (see section 10) and so site selection is ongoing to source another CCF forest site. Fortnightly samples have been collected and analysed from dipwells at Lough Atorick since early September, when the water table reached sufficient levels to be sampled following a dry spell, although the ditches have remained dry. Crucially, this site is instrumented, so past (5 years previous) and recent (currently taking place) felling impacts can be compared. This forested area is currently undergoing felling of 50% of trees, and so future fortnightly analysis of ground water samples can be used to assess the effects of felling on chemistry resulting. Regular sampling is beginning now for Annaleacka (a recently clear-felled site) as this was recently selected as a suitable site and instrumented.

In Finland and Sweden the water quality samples are currently being analysed and the results will be available in winter 2021. In Estonia and Ireland some preliminary data on DOC and nutrients are already available. In Estonia, DOC and DN concentrations were highest in the heavily drained forest in Ullika, while the concentrations in ditch water as well as in soil water in the moderately drained and nearly natural plots were lower and quite similar along the whole study period. Up to 25% more C and 63% N leached out from the drained forests compared to the nearly natural stands. Root studies indicate higher availability of nutrients in the soil, i.e. less absorbing roots per above ground unit, from 5.5 tons of fine roots (trees+understory) per ha in natural peatland forest to 17 tons per ha in drained forest. Root effect on DOM dynamics will be analysed after measurement of stand characteristics, when root traits can be properly calculated per above ground unit of trees. In Ireland, the preliminary results show greater TN and lower DOC concentrations for the forested site compared to the site which was clear-felled 5 years previously. Further analysis of nutrient concentrations also showed greater concentrations of ammonia (~2 mg/l, compared to ~0.05 mg/L in the previously clear-felled site).

In WP2 we aim to assess the potential of biochar in reducing the export of DOM and nutrient load to adjacent water bodies. In summer 2019, we conducted laboratory experiments to determine the adsorption rate and capacity for Norway spruce and silver birch biochars for removing inorganic and organic nitrogen as well as DOC and to design a biochar-filled reactor to a ditch drain. In a 10-day laboratory experiment, biochar was stirred with runoff water from a clear-cut peatland forest, and changes in water pH, total nitrogen, nitrate nitrogen, ammonium nitrogen, phosphorus and total organic carbon concentrations were measured. Based on the concentration changes, adsorption was quantified and a model containing the adsorption rate and capacity was fitted to the data. Our results indicate that biochar effectively adsorbs both inorganic and organic nitrogen from runoff water. Birch biochar had higher adsorption capacity of nitrogen than spruce biochar.

Based on the results of the previous lab experiments, we built a novel lab-operating meso-scale biochar reactor and evaluated its efficiency in runoff water purification and consecutive nutrient recycling in clear-cut peatland forests. The goodness of the method was tested in a meso-scale reactor experiment by circulating runoff water through wood biochar-filled columns and by determining

water nutrient concentrations in the column inlet and outlet. The concentration of total nitrogen (TN) decreased by 58% during the 8 weeks experiment. In addition, NO_3-N and NH_4-N concentrations decreased below the detection limit in 5 days after the beginning of the experiment. The maximum adsorption capacity of the biochar reactor varied between 0.06-0.063 mg g^{-1} biochar for TN, and between 0.03-0.04 mg g^{-1} biochar for NO_3-N. The results suggest that a biochar reactor can be a useful and effective method for runoff water purification in clear-cut forest areas. The field tests in the ditches of a clear-cut area were carried out in later autumn 2019 - early winter 2020, but the results are still under evaluation.

We are currently using the results from WP1 and WP2 in developing the processed based simulation model ('SUSI') to calculate the production (from the column experiment) and transport of DOM as is planned in WP3. For the model development, we will also use water retention curves measured from the columns.

How has the progress of the project promoted multi-disciplinary work?

The development of the process-based model combining hydrological and soil processes is an integral part of the project, and the measurements carried out in WP1 and WP2 enable the development of this model. It is also the main tool of multi-disciplinary work in this consortium. The modeller is involved in every step of the project, including the field work, which strengthens multidisciplinarity.

b. Collaboration, coordination and mobility

From the beginning of the project all partners have been actively involved in project tasks, e.g. planning, collection and preparation of peat column experiments. The common field and lab campaigns have strengthened commitment of partners who had not collaborated earlier. Thus, the group has succeeded in creating a strong communal sense and there is a uniform understanding among the participants about the importance of collaboration and transnationality despite the Covid-19 outbreak.

The contribution of each partner was clarified in the project kick-off meeting in April 2019. All partners have been very active and it looks already now that the project facilitates new collaboration between the partners. For instance, a postgraduate student from the Finnish group is now a post-doctoral researcher in the Swedish group.

People participating in the project are as follows: In Finland Pumpanen, Ojala, Laurén, Berninger, Palviainen, Peltomaa, Aaltonen, Saarela, Kinnunen, Zhu, Pesonen, Khatun, Lafdani; In Sweden Laudon, Maher Hasselquist, Mosquera Salles; In Estonia Ostonen, Kull, Veber, Maddisson, Uri, Truu, Rohula Okunev, Truu; In Ireland Renou-Wilson, Pschenyckyj.

We were active in mobility before the outbreak of Covid-19 after and organized a well-attended kick-off meeting in Helsinki, Finland at the beginning of April. Pumpanen and Ojala participated in the Water JPI 2018 kick off meeting of funded projects in Stockholm April 12, 2019. Pumpanen gave an invited talk at the 16th annual Krycklan Symposium on September 24, 2019 at SLU in Umeå, Sweden. Additionally, Finnish researchers, Pumpanen and Ojala along with their PhD student Xudan Zhu , and Swedish researchers, Maher Hasselquist and PhD student Mosquera, worked together to take peat columns from Trollberget for the incubation experiment in Fall of 2019.

On October 14-16, 2019 Finnish researchers Pumpanen and Ojala visited Estonia for collecting peat columns in collaboration with the Estonian team. On January 13-17, 2020 Finnish researchers Pumpanen, Ojala, Laurén, Palviainen and Peltomaa visited Ireland to collect the peat columns. During both visits meetings with the local researchers were arranged.

The 17th annual Krycklan Symposium was held via Zoom webinar on September 23, 2020, and focused entirely on the effects of management of forest ditches on water quality and quantity. We had two invited speakers from Finland and other speakers were from Swedish universities. In total 137 unique viewers participated in the webinar from eight countries. An additional 55 individuals have watched the recorded version of the symposium afterwards.

The Swedish PhD Virginia Mosquera visited Finland in February 2020 to help start up the incubation experiment and is now running the samples for nutrients on the columns. She also gave a presentation on her ongoing research at the Department of Environmental and Biological Sciences in the University of Eastern Finland. The plan was that she should have revisited the experiment several times, but because of Covid-19 related travel restrictions this has not been possible.

Eliza Maher Hasselquist (EMH) visited Finland January – March 2020 and met with project partners regularly in Helsinki during this time.

The field and column experiments in Finland will be synchronized with an Academy of Finland funded project 'Cascading carbon flows in boreal forested catchments' (CASCAS) 2019-2023 which studies the effect of priming on the production of DOM in drained peatlands. The WP2 focusing on biochar has synergy with the ongoing project of Marjo Palviainen.

c. Impact and knowledge output

Already now our results on utilization of biochar show the potential of this technique in reducing the nutrient (N) load in sites where there is high risk of nutrient transport after clearcut or drainage of peatland forest. Otherwise, the main impacts will be achieved after the management tool is developed in WP3. We expect that the project will have the highest impact on forest owners, forest companies as well as policies. The intellectual property protection has not been considered since we do not expect to have results finalizing e.g. in patents.

3. Table of Deliverables

Deliverable name	Lead partner (country)	Date of delivery (dd/mm/yyyy)	Changes, difficulties encountered and new solutions adopted
WP1	**Finland**		
1.1. Quantified responses and parameterized equations on the effect of water table level on DOM release from soils to be used for modelling in WP3			Slightly behind the schedule since we had to change the location of the main research site in Finland. In Ireland the Covid-19 restrictions have hampered the progress of the project. In Finland as well as in Ireland the exceptional weather conditions in winter also caused some problems in field measurements.
1.2. Coefficients for biodegradability of DOM of different quality **1.3.** Manuscript on the column incubation experiment **1.4.** Manuscript on the water incubation experiment**.**			Slightly behind the schedule of the deliverable 1.2. Due to the Covid-19 restrictions and overloaded DOC-measurement and gas chromatograph facility at UEF, we are behind the schedule for the deliverable 1.3., which will finalize in autumn 2021. The deliverable 1.4. is ahead of the schedule and the manuscript is supposed to be ready in spring 2021. This fortunate situation is due to the politics of University of Helsinki who in the Covid-19 situation gave a status of time

			critical research for this activity.
WP2	**Finland**		
2.1. Technical report on the design and laboratory tests of the biochar filter **2.2.** Technical report on the water purification efficiency of the biochar filter in field conditions **2.3.** Scientific manuscript on the biochar filter method.			We decided to combine the deliverables 2.1. and 2.2. and follow now the schedule of the original deliverable 2.2. The deliverable 2.3. was well ahead of the schedule since there are two manuscripts already published in international peer reviewed journals (online publications 10 February 202 and 5 May, 2020)
WP3	**Finland**		

3.1. Calibrated and tested model for soil DOM production **3.2**. Calibrated and updated Peatland simulator **3.3.** Technical report on the overall effects of DNM on DOM load and GHG emissions from peatland forests **3.4.** Guidelines and protocols for management operations on forested peatlands **3.5.** Scientific manuscript on the combined effects of different harvesting methods and biochar filters on water quality			The deliverable 3.1. is behind the schedule due to the problems described in WP1 deliverables and the Covid-19 restrictions. The rest of the deliverables in WP3 are scheduled towards the end of the project and thus in schedule

4. Budget review

FINLAND:

University of Eastern Finland cost breakdown until the end of September 2020.

TOTAL INCOME								
REFORMWATER	2019				2020 until the end of September			
	Income	Academy 52,5%	EU 17,5%	University 30%	Income	Academy 52,5%	EU 17,5%	University 30%
Salaries (Post graduate student)	**10336**	5426	1809	3101	**10440**	5481	1827	3132
Salaries (Post doctoral researcher)	**24983**	13116	4372	7495	**37853**	19873	6624	11356
Personnel costs 45%	**15894**	8344	2781	4768	**21732**	11409	3803	6520
Overhead costs 77%	**39434**	20703	6901	11830	**53919**	28307	9436	16176
Materials and consumables	**3400**	1785	595	1020	**2000**	1050	350	600
Travel	**3000**	1575	525	900	**3000**	1575	525	900
Other costs	**3000**	1575	525	900	**5000**	2625	875	1500
	100047	**52525**	**17508**	**30014**	**133944**	**70321**	**23440**	**40183**

THE REFORM WATER PROJECT WAS DIVIDED INTO TWO SECTIONS AT THE UEF ACCOUNTING SYSTEM (projects number 14551 and 14552) WHICH ARE PRESE							
COSTS	REFORMWATER 14551		Academy of Finland + UEF own funding				
	2019				2020 until the end of September		
	Income	Realized costs		Unused	Income	Realized costs	Unused
Salaries (Post graduate student)	**8003**	0		8003	**8085**	22328	-14243
Salaries (Post doctoral researcher)	**19346**	0		19346	**29313**	0	29313
Personnel side costs 45%	**12307**	0		12307	**16829**	10047	6782
Overhead costs 77%	**30535**	0		30535	**41755**	24930	16825
Materials and consumables	**2109**	796		1313	**1549**	4514	-2965
Travel	**2323**	188		2135	**2323**	690	1633
Other costs	**2323**			2323	**3872**	1230	2642
	76946	**984**		**75962**	**103726**	63739	**39987**

COSTS	REFORMWATER 14552		EU 17,5% + UEF own funding			
	2019			2020 Until the end of September		
	Income	Realized costs	Unused	Income	Realized costs	Unused
Post graduate student	**0**	1389	-1389	**5454**	880	4574
Post doctoral researcher	**5000**	0	5000	**8089**	0	8089
Personnel side costs 45%	**2250**	625	1625	**6094**	396	5698
Overhead costs 77%	**5583**	1550	4032	**15121**	982	14139
Materials	**1103**	241	862	**639**	1573	-934
Travel	**396**	967	-571	**958**	2017	-1059
Other costs	**960**	0	960	**847**	0	847
	15292	**4772**	**10519**	**37202,11**	**5847,57**	**31355**

Budget breakdown, University of Helsinki, Finland, given on 26 October 2020.

Translations: Tuotot = Income; Kulut = Costs; Palkat = Salaries; Henkilösivukulut = personal side costs; Aineet ja tarvikkeet = consumables; Ostetut palvelut = services; Matkat = travels; Yleiskustannukset = overhead; Budjetti = budget; Toteuma = realized costs; Ennuste= prognosis; Varaus = reservation: yhteensä = altogether/sum; proj. alku – ed. vuoden loppuun = beginning of project – till the end of previous year; kumulatiivinen = cumulative; päätösbudjetti = final budget; rahoittajalle raportoitava toteuma = realized costs reported to the funding body

Projektin perustiedot

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WBS numero	Proj. alk.pvm.	Proj. päät.pvm.	Tulosyks.	Akronyymi	Projektin johtaja	Kustannusmalli	Myöntö	Oma osuu
1326831	4/1/2019	3/31/2022	H8201	1326831	Anne.Ojala@helsinki.fi	kokonaiskustannus	191,093	

B. KUMULATIIVINEN

Kumulatiivinen

Päätösbudjetti. Rahoittajalle raportoitava toteuma. Rahoittajan yleis.kust. toteutuneissa palkkakustannuksissa- ja varauksissa. SA
SALDO = budjetti-toteuma-palkkavaraus.

Tuotot / kulut **All Values**

WBS numero	Kululajit	Budjetti yhteensä	Toteuma yhteensä	Saldo yhteensä	Ennuste: varaus yhteensä 100%	Ennuste: saldo yhteensä	Saldo: proj.alku - ed. vuoden loppuun	2020 Budjetti	2020 Toteuma
1326831	SA myöntö / tuotot	191,093	81,733	0	0	0	0	95,868	52,927
	Jaksotus	0	37,002	0	0	0	0	0	27,785
	Yksikön omarahoitus	-81,896	-51,436	0	0	0	-10,115	-41,086	-34,591
	Tuotot Total	272,989	170,171	0	0	0	-10,115	136,954	115,304
	Palkat (jyvitetyt)	75,836	49,698	26,138	17,443	8,695	8,638	38,207	34,601
	Henkilösivukulut	42,468	27,831	14,637	9,768	4,869	4,838	21,396	19,377
	Aineet ja tarvikkeet	7,000	869	6,131	0	6,131	3,166	3,000	35
	Ostetut palvelut	8,000	823	7,177	0	7,177	3,272	4,000	95
	Matkat	6,000	3,343	2,657	0	2,657	-143	3,000	200
	Yleiskustannukset	133,684	87,607	46,076	30,748	15,328	15,228	67,351	60,995
	Kulut Total	272,988	170,171	102,816	57,960	44,857	34,999	136,954	115,304

SWEDEN:

Budget review in (SEK) 30.10.2010

Salaries, including social costs	154 654,87
Travel	14 310,71
Materials	53 850,50
Other costs	8 564,09
Localities	11 276,96
Indirect costs	55 633,20
Total costs	**298 290,33**

ESTONIA

Salaries	24 363 eur
Taxes	8040 eur
Insurance	195 eur
Research	2297 eur
Mobility	40 eur
Overhead	3262 eur

Research costs include some repair and maintenance costs for Vario TOC machine. Mobility is low, because of the Covid-19 and use of university cars (goes partly to overhead). Soil samples are collected, and some we need to collect for chemical analyses that is then quite expensive, and were planned to do during the winter.

IRELAND

FINANCIAL SUMMARY

Reporting period covered:	From:	1 January 2020	To:	30 June 2020	
Project Title:		Reducing the Effects of Forest Management to Inland Waters			
Project Code:		2019-W-MS-40	Proposal / Ref. Code:	RT9486	
Project Duration:	From:	1 April 2019	To:	31 March 2022	Time extension:
Lead organisation:		UCD			
Participant:					
Level of Approved Funding:					

COSTS DETAILS:

Cost Category	Previously reported	Prior Period Adjustments	Current Report	Current Report incl. Adjustments	Total Cumulative
Labour Costs	€ 3,501.77	€ 0.00	€ 21,007.26	€ 21,007.26	€ 24,509.03
Travel & Subsistence	€ 0.00	€ 0.00	€ 335.76	€ 335.76	€ 335.76
Consumables	€ 0.00	€ 0.00	€ 1,741.64	€ 1,741.64	€ 1,741.64
Other Costs (incl. Publishing costs)	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00
Overheads	€ 1,050.53	€ 0.00	€ 6,925.40	€ 6,925.40	€ 7,975.93
Participants' costs = project partners	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00
External Assistance - Subcontracts	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00
Communication Costs (Ongoing)	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00
Plant & Equipment	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00
VAT	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00
TOTAL	€ 4,552.30	€ 0.00	€ 30,010.06	€ 30,010.06	€ 34,562.36

BUDGET VARIANCE:

Cost Category	Total Budget - originally approved	Revised budget (original / post reallocation)	Budget Variance
Labour Costs	97,559.04	€ 0.00	€ 73,050.01
Travel & Subsistence	5,500.00	€ 0.00	€ 5,164.24
Consumables	6,050.00	€ 0.00	€ 4,308.36
Other Costs (incl. Publishing costs)	€ 0.00	€ 0.00	€ 0.00
Overheads	32,732.71	€ 0.00	€ 24,756.78
Participants' costs = project partners	€ 0.00	€ 0.00	€ 0.00
External Assistance - Subcontracts	3,155.00	€ 0.00	€ 3,155.00
Communication costs (Ongoing)	€ 0.00	€ 0.00	€ 0.00
Communication costs (Post Completion Dissemination)	€ 0.00	€ 0.00	€ 0.00
Plant & Equipment	€ 0.00	€ 0.00	€ 0.00
VAT	€ 0.00	€ 0.00	€ 0.00
TOTAL	€ 144,996.75	€ 0.00	€ 110,434.40

Budget reallocation approved by the EPA (date):	

5. Consortium Meetings

N°	Date	Location	Attending partners	Purpose/ main issues/main decisions?
1	4 April 2019	Helsinki, Finland	Pumpanen, Ojala, Laudon, Ostonen, Lauren, Palviainen, Maher Hasselquist, Berninger, Köster	Kick-off meeting. Decision of the model parameters to be measured in the field as well as in the lab experiments
2	12 April 2019	Stockholm Sweden	Pumpanen, Ojala	Water JPI; kick-off meeting of the 18 funded projects of the 2018 Water JPI joint call
3	24 - 26 September 2019	Umeå & Krycklan Sweden	Pumpanen, Ojala, Zhu, Laudon, Maher Hasselquist, Mosquera Salles	Project presentation as a part of Krycklan symposium & detailed planning among the Swedish and Finnish partners
4	14-15 October 2019	Järvselja, Estonia	Pumpanen, Ojala, Ostonen, Kull, Maddisson	Detailed planning among the Estonian and Finnish partners
5	15-16 January	Portumna, Ireland	Pumpanen, Ojala, Palviainen, Lauren, Peltomaa, Renou-	Detailed planning among the Irish and Finnish partners

			Wilson, Pschenyckyj	
6	regular zoom meetings of the consortium starting in April 2020	Zoom	Everybody who could attend	Annual consortium meeting in April 2020. Monthly morning coffees in May, June, August, September. Updates and brainstorming.

6. Stakeholder/Industry Engagement

So far despite the Covid-19 restrictions the project has succeeded in engaging with stakeholders and industry. In Finland, Pumpanen, Ojala and Peltomaa attended a stakeholder field trip to Paroninkorpi on 13 June 2019. The trip was organised by the 'SOMPA' project which is led by LUKE and closely related to 'REFORMWATER'. The representative of the forest company UPM, i.e. the land owner, was among the attendants and together with LUKE representatives expressed strong interest in 'REFORMWATER' and considered the research topic important from industry's point of view. This interest made the change in the research location from Hyytiälä to Paroninkorpi possible. This will most probably ease in the later phase of the project knowledge transfer to the forest industry. Ojala attended on 2 October 2019 and 19 November 2019 and Pumpanen on 2 October 2019 a research panel on 'Biodiversity and water protection in peatland forests as a part of forest politics forum' arranged by 'TAPIO', which is an advisory and consultancy company specialised in forest management related questions in Finland. Pumpanen and Ojala attended 12 November 2010 a meeting of the national support group of JPI Water including the Finnish advisory board of JPI Water. In this event Pumpanen gave a presentation on 'REFORMWATER' consortium.

Results on biochar were presented for stakeholders in 'Water protection days' (Vesiensuojelupäivät 17.-18.9.2019, Savonlinna, Finland). In addition, the use of biochar in water protection was demonstrated for stakeholders in field excursion. The seminar was organized by the Ministry of Agriculture and Forestry, Finnish Forest Centre, Metsähallitus, Natural Resources Institute of Finland (LUKE), Finnish Environment Institute (SYKE) and TAPIO (leading advisory and consulting service provider in the field of forest management in Finland). The results have also been presented to a biochar producing company (visit to Carbofex, Tampere, Finland 12.2.2020).

In Sweden, Maher Hasselquist attended a CCF workshop in October 2019 organized by the Swedish Forest Agency where she discussed ideas about using CCF to avoid DNM with workshop participants from all branches of the Forest Industry. Laudon and Maher Hasselquist organized three stakeholder meetings, one on November 15, 2019 and again on February 26, 2020, and in March 2020, that included stakeholders from the Swedish Forest Agency and County Administrative Board, the forest industry, namely Holmen Skog, as well as our fellow researchers. These meetings have been paused due to the Corona pandemic.

The Krycklan Symposium led by Laudon has been an annual event for 17 years that typically has more than 100 attendees that include stakeholders from a variety of sectors. In 2020, the 17th annual Krycklan Symposium had the theme of "Wetlands – forestry and restoration" and highlighted the

research done within ‘REFORMWATER’ on the effects of ditch cleaning. In total 137 unique viewers participated in the webinar from eight countries. An additional 55 individuals have watched the recorded version of the symposium afterwards.

7. List of Publications produced by the Project - Open Access

	Peer-reviewed journals	1.Truu, M., Nõlvak, H., Ostonen, I., Oopkaup, K., Maddison, M., Ligi, T., Espendberg, M., Uri, V., Mander, Ü.,Truu, J. Soil bacterial and archaeal communities and their potential to perform N cycling processes in boreal forests growing on well-drained peat. Frontiers in Microbiology (revised version submitted in 30.10.2020). 2. Kakaei Lafdani, E., Saarela, T., Lauré,n A., Pumpanen, J., Palviainen, M. 2020. Purification of forest clear-cut runoff water using biochar: A meso-scale laboratory column experiment. Water 12: 478; doi:10.3390/w12020478. 3. Palviainen, M., Aaltonen, H., Laurén, A., Köster, K., Berninger, F., Ojala, A., Pumpanen, J. 2020. Biochar amendment increases tree growth in nutrient-poor, young Scots pine stands in Finland. Forest Ecology and Management 474, 118362. https://doi.org/10.1016/j.foreco.2020.118362. 4. Saarela, T., Kakaei Lafdani, E., Laurén, A., Pumpanen, J., Palviainen, M. 2020. Biochar as adsorbent in purification of clear-cut forest runoff water: adsorption rate and adsorption capacity. Biochar https://doi.org/10.1007/s42773-020-00049-zInternational 4. Hasselquist, E.M., Martilla, H., Nieminen, M. & Laudon, H. *In prep.* Loads and characteristics of organic matter in suspended sediment draining ditched forested catchments. 5. Mosquera, V. et al. *In prep*. The effect of simulated Ditch Network Maintenance on soil nutrient leaching. 6. Mosquera, V. Sponseller, R., Hasselquist, E.M., and H. Laudon. *In prep*. How does land use affect long-term changes in nutrient and DOM export?

		7. Pschenyckyj,C., O'Driscoll, C. & Renou-Wilson, F. A review of current knowledge of environmental risks and approaches for Irish peatland utilisation.' Includes detailed review of peatland forestry in Ireland. Authors. *In prep*.

	Books or chapters in books	
	Communications (presentations, posters)	1.Pschenyckyj C. & Renou-Wilson F. Peatlands International magazine, issue 2 June 2020; Improving water quality from Irish bogs: Reform Water and Swamp projects; authors 2. Hasselquist E.M. and Laudon H. 2019. Side-by-side comparison of the effects of management of old forest drainage ditches on water quality & quantity. Gordon Research Conference. June 2019, Andover, NH, USA. 3. Laurén A. (Invited speaker). Biochar in purification of runoff water in forest management. The First International Conference on Biochar Research and Application. September 20-23, 2019, Shenyang, China. 4. Ostonen, I. Relationships between fine root dynamics and forest soil functional biodiversity. CAR-ES annual workshop at NIBIO, 18-19 of November, 2019. 5. Palviainen M., Laurén A., Saarela T., Pumpanen J. 2019. Biochar in purification of runoff water from clear-cut forest area. Geophysical Research Abstracts Vol. 21, EGU2019-3083, EGU General Assembly 2019.
Finnish	Peer-reviewed journals	1.Palviainen M., Laurén A., Saarela T., Kakaei Lafdani E., Pumpanen J. 2020. Biohiili valumavesien puhdistajana. Vesitalous 2/2020: 14-16 — Luontopohjaisia ratkaisuja metsätalouden vesiensuojeluun. 2. Laurén A., Hökkä H., Urzainki I., Palviainen M., Haahti K., Stenberg L., Launiainen S., Nieminen

		M., Leinonen A. 2020. Vesiensuojelua tiedon avulla – suosimulaattori kertoo missä kunnostusojitusta ei kannata tehdä. Vesitalous 2/2020: 25-27 — Luontopohjaisia ratkaisuja metsätalouden vesiensuojeluun.
	Books or chapters in books	
	Communications (presentations, posters)	1. Palviainen, M. 2019. Hiilletty puu vesien puhdistajana (Biochar in purification of runoff water in forestry), presentation and field demonstration in Water protection days (Vesiensuojelupäivät 17.-18.9.2019, Savonlinna, Finland)
Dissemination initiatives	Popular articles	
	Popular Conferences	1.Palviainen, M. 2019. Hiilletty puu vesien puhdistajana (Biochar in purification of runoff water in forestry), presentation and field demonstration in Water protection days (Vesiensuojelupäivät 17.-18.9.2019, Savonlinna, Finland)
	Others	1.Interview in Newspaper Metsälehti (Biohiiltä suo-ojiin (Biochar to ditches in peatland forests)/ Marjo Palviainen (27.2.2020)

Ireland	Peer-reviewed journals	
	Books or chapters in books	1. C. Pschenyckyj, C. O'Driscoll & F. Renou-Wilson. EPA report 'A review of current knowledge of environmental risks and approaches for Irish peatland utilisation.' Includes detailed review of peatland forestry in Ireland. Authors
	Communications (presentations, posters)	1.Pschenycky, C. & Renou-Wilson, F. Poster 'Improving water from managed bogs: SWAMP and Reform Water projects' presented at EPA Research programme Virtual workshop (October) & EPA/HSE Environment conference (November);

Estonia	Peer-reviewed journals	
	Books or chapters in books	

	Communications (presentations, posters)	1. Kull, A. 'Kaugseire andmete lisandväärtus turvasmuldadega alade täpsustamisel ja niiskusreziimi muutuste jälgimisel' Oral presentation in frame of the initiative 'Use of remote sensing data for elaboration and development of public services' 7th of Oct 2020 2. Kull, A. 'Eesti soode seisund ja roll ökosüsteemiteenuste pakkujana' Oral presentation in public seminar organized by Environmental Research Agency, 29th of Oct 2020

8. Knowledge output transfer

Web page	Completed by Finnish project members. https://www.helsinki.fi/en/projects/reducing-the-effects-of-forest-management-to-inland-waters They have also produced a blog page: https://blogs.uef.fi/reformwater/
Social media	https://twitter.com/ReformWater_IE https://www.researchgate.net/project/ReformWater Twitter hashtag #Trollberget launched in 2018 to document activities associated with this JPI funded infrastructure.
Courses	In September 2019, we organized and taught in the PhD course called "Watershed Ecology and Biogeochemistry", lead by Laudon. We used the Trollberget Experimental Area (TEA) as a field trip location to discuss issues around DNM and practical forestry around water and wetlands. Maher Hällquist gave a lecture on DNM and forestry for the PhD students that complemented the field trip.

RTD protocol/technical manual	- February 2019: A description of the Trollberget Research Infrastructure was published in the “Field Guide of the Krycklan Catchment” https://www.slu.se/globalassets/ew/org/inst/esf/forsoksparker/vindeln/krycklan/krycklan_field_2019_3.pdf
Product	December 2019: GIS information published on our website to help stakeholders explore and understand the Trollberget Research Infrastructure. https://www.slu.se/en/departments/field-based-forest-research/experimental-forests/vindeln-experimental-forests/krycklan/

Scientific publication	Zhu X., Zhu T., Pumpanen J., Palviainen M., Zhou X., Kulmala L., Bruckman V., Köster E., Köster K., Aaltonen H., Makita N., Wang Y., Berninger F. 2020. Short term effects of biochar on soil CO_2 efflux in boreal Scots pine forests. Annals of Forest Science 77, 59. https://doi.org/10.1007/s13595-020-00960-2. Ide J., Ohashi M., Köster K., Berninger F., Miura I., Makita N., Yamase K., Palviainen M., Pumpanen J. 2020. Molecular composition of soil dissolved organic matter in recently-burned and long-unburned boreal forests. International Journal of Wildland Fire. https://doi.org/10.1071/WF19085. Urzainki I., Laurén A., Palviainen M., Haahti K., Budiman A., Basuki I., Netzer M., Hökkä H. 2020. Canal blocking optimization in restoration of drained peatlands. Biogeosciences 17: 4769-4784. Palviainen M., Laurén A., Pumpanen J., Bergeron Y., Bond-Lamberty B., Larjavaara M., Kashian D.M., Köster K., Prokushkin A., Chen H.Y.H., Seedre M., Wardle D.A., Gundale M.J., Nilsson M.-C., Wang C., Berninger F. 2020. Decadal-scale recovery of carbon stocks after wildfires throughout the boreal forests. Global Biogeochemical Cycles *34*, e2020GB006612. https://doi.org/10.1029/2020GB006612. Laurén A., Lappalainen M., Kieloaho A.-J., Karhu K., Palviainen M. 2019. Temperature sensitivity patterns of carbon and nitrogen processes in decomposition of boreal organic soils – quantification in different compounds and molecule sizes based on a multifactorial experiment. PloS ONE 14(10): e0223446. doi:10.1371/journal.pone.0223446. Palviainen M., Kakaei Lafdani, E., Cvetkovic J., Saarela, T., Pumpanen, J., Laurén, A. 2020.

Communications (presentations, posters)	Concentration affects significantly the capacity of biochar to adsorb nitrogen from forest runoff water. EGU2020-3429 https://doi.org/10.5194/egusphere-egu2020-3429, EGU General Assembly 2020 Palviainen, M. (Invited speaker). Biochar as soil amendment and carbon sequestration tool in forests. The First International Conference on Biochar Research and Application. September 20-23, 2019, Shenyang, China. Laurén A., Lappalainen M., Kieloaho A.-J., Karhu K., Palviainen M. 2019. Carbon and nitrogen release in decomposition of boreal organic soils – Temperature sensitivity patterns. Geophysical Research Abstracts Vol. 21, EGU2019-3082, EGU General Assembly 2019.

Sectors & Subsectors *Choose as many options as required from the list. Pick those sectors that you think would benefit from the application of this Knowledge Output.*	· **Basin Management** · Flood Risk Management · Water Scarcity and Droughts · **Drinking Water** · Bathing Water · Emissions and Water Reuse · **Adaptation to Global Change** · Others o Other General o Agriculture o Governance o Consumer Health & Welfare o Finance o Modelling & Prediction o Socio-Economics o Stakeholder Involvement
End User *Choose as many options as required* *Per identified End User, please identify possible applications of the Knowledge Output.*	o **Education & Training** oEnvironmental Managers & Monitoring o Industry o **Policy Makers / Decision Makers** o **Scientific Community** o Civil Society o Other
IPR *Please indicate whether IPR has been applied to this Knowledge Output (applied for a patent, copyright etc), or not.* *Please insert "n/a" if no IPR has been applied.*	n/a

Policy-Relevance If the Knowledge Output is relevant to the WFD or any other related Directives, please list and explain why	not known yet
Status *Please identify whether the Knowledge Output is finalised, is still being generated or whose status/future is unknown. Consider:* *• Is your knowledge conclusive enough that it provides sufficient evidence to make an impact on, or be applied by, an End User?* *• Is there a corroborating body of evidence, or are contradictory results, available?* *• Does your knowledge progress beyond the current state-of-the-art / evidence base?* *• Is more research or demonstration needed to validate the results?*	Not ready yet. At least in biochar applications, more demonstration is needed.

9. Open Data

We will make all data and associated metadata as well as the models readily available to other scientists, authorities, and interested users using the open access Krycklan database. In the final reporting, we will also follow the instructions and protocols of JPI Water.

10. Problems Encountered during Project Implementation

Since we had managed to get all the samples for the column experiments from Sweden, Estonia and Ireland before February 2020, the problems caused by Covid-19 restrictions were surprisingly small in Finland. The largest impact came from several months' delay in recruitment of the postdoc whose defense, due to Covid-19 restrictions, was postponed from February 2020 to June 2020. Therefore, we hired the postgraduate student Niko Kinnunen in UEF to carry out essential lab work. Although the Finnish universities permitted us to continue the field as well as lab work under the Cvid-19 restrictions, we had to make some adjustments in our protocols; for instance, instead of using university premises in incubation experiments we had to find an alternative place which in this case was a private outdoor sauna of our postdoc.

In Sweden the exchange trip to Finland by Maher Hasselquist was cut short due to the covid-19 pandemic. The field work in Sweden proceeded as planned, but working from home due to the Covid-19 pandemic caused some reduction in efficiency. Hiring a PhD student took longer than expected

since the aim was to have the student in action by May, but due to visa issues the student, who is from Guatemala, finally arrived in September.

In Ireland there were problems related to exceptional weather conditions and Covid-19 outbreak. Flooding during early March 2020 impeded site accessibility and instrumentation. National covid restrictions forbid non-essential research activities from taking place between mid-March and late May, and thus fieldwork and lab analyses could not continue. Permissions were granted to restart fieldwork during June, but dry weather over the summer resulted in the sites being particularly dry, with no water in either dipwells or ditches during all of the summer. Sites remained dry (both groundwater and ditches) until late August. There has also been ongoing delays in laboratory equipment delivery, due to suppliers prioritising hospitals and other essential health providers over universities. Delays have been ongoing since March, with some lab consumables taking 3 months to arrive. Instruments within the lab have also broken down, and one is still waiting for parts to be fitted (Dionex cation and anion analyser).

The Irish Forest Services have experienced ongoing disruption due to Covid-19, resulting in delays in felling licences being approved. The main field site (Lough Atorick) was finally approved recently, and felling will take place shortly. Another site which was the instrumented (Meeneen bog) CCF site, had the licence and felling plans changed meaning CCF management will no longer take place. Therefore a new site where CCF management is taking place is needed, and so site selection is again ongoing for this.

11. Suggestions for improvement regarding project implementation?

In Ireland, work is being done to quickly locate and instrument another site to assess CCF management in collaboration with Coillte. In addition, the monitoring of water chemistry from sites will continue throughout the winter, as Ireland has milder winter temperatures than the other countries in this project, enabling year long field campaigns. Another site was also recently found and has been instrumented (Annaleacka) to study the effects of recent clear-felling.