Application (2023-1131-Steg 2 2022)

Continuation funding

Enter the application to which this application for continuation funding applies

2022-1071-Steg 1 2022 (Tree-covered peatlands: separating carbon sinks from carbon sources)

Project Manager

First name

Joshua

Last name

Ratcliffe

Academic title

Dr.

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Male

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Co-applicant

First name: Matthias
Surname: Peichl
Affiliation: Sveriges Lantbruksuniversitet
Role in project: Collaborator

First name: Susanne
Surname: Möckel
Affiliation: University of Iceland
Role in project: Collaborator

Head of Department (or similar) authorised to sign agreements for the organisation

First nam: Hjalmar
Surname: Laudon
Email: Hjalmar.Laudon@slu.se
Affiliation: Sveriges Lantbruksuniversitet

Grant administrator

Swedish personal identity number or company identity number: 202100-2817
Name of organisation: Sveriges lantbruksuniversitet
Departmen: Norrländsk jordbruksvetenskap
Website
c/o
Postal address: Verkstadsgatan 13
Postcode: 90432
Town/City: Umeå

Subject area

Enter subject area

Klimatanpassat och hållbart skogsbruk– Climate-adapted and sustainable forestry

Project title

Enter project title

Tree-covered peatlands: separating carbon sinks from carbon sources

Estimated duration of project

Start date

Ange Start date

2023-06-01

End date

Ange slutdatum

2025-05-31

Popular scientific summary of the project – In Swedish

Write a summary of the project.

Många aspekter på svenskt skogsbruk är klimatpositiva. Virkesproduktion på torvmark kan däremot vara ett skarpt undantag från detta, vilket i sin tur har en potential att skada skogsbrukets anseende generellt. Att upphöra med virkesproduktion på alla torvmarker är varken genomförbart eller önskvärt. Vi behöver istället bättre förstå vilka skogbevuxna torvmarker som är stora kolkällor och sedan fokusera på dem för att utveckla nya skötselmetoder. Vanligtvis är det svårt och dyrt att mäta det kol som kommer in och ut från skog. Detta har lett till att bara ett fåtal studier har genomförts och ofta med resultat från en enda plats. Det generella budskapet från dessa studier är att kolbalansen i torvmarksskogar kan vara extremt varierande. Bristen på jämförbara resultat från olika platser som täcker in varierande miljöförhållanden gör det mycket svårt, kanske omöjligt, att dra allmänna slutsatser med den metodiken. Den planerade studien skiljer sig från de som har genomförts tidigare då den använder en metodik som är både billig och skalbar, men den är beroende av specialistkunskaper, s.k. tefrokronologi, i.e. vulkanaska av känd ålder vilket är extremt sällsynt både globalt och i Sverige. Huvudsökanden har tidigare haft möjlighet att studera under några av de bästa tefrokronologerna i världen. Om detta förslag finansieras kommer vi att använda denna kunskap och metodik för att besvara frågan om torv som är central för skogsbruket och som det helt enkelt inte finns några andra kostnadseffektiva sätt att besvara.

Background

Enter background

The boreal forest dominates the Swedish landscape as well as vast areas of the global north. While referred to as a forest, the Boreal is in fact a mosaic of forest and peatlands. It is often hard to neatly categorise one from another, tree-coverd peatlnds may exit across a wide range of tree-cover density.

Peatland and forest vegetation are often competing for the same location in the landscape. Pines and Sphagnum mosses, for example, have a competitive relationship 1,2 The dominance of trees or mosses is decided primarily by hydrological, and to a lesser extent, nutrient factors 3,4. As such draining sometimes in combination with fertilisation, can increase tree growth to the extent that peatlands can become commercially viable and highly productive forests.

Unfortunately drainage possibly in combination with increased evapotranspiration and shading caused by the increase in tree growth can lead to large emissions of CO_2 in Swedish5 and other forests 6. Alternatively, other peatland forests, may remain carbon sinks storing carbon in trees and as peat. These are usually on nutrient poor peatlands and where tree growth is sparse enough to allow a peatland understory vegetation to co-exist 7,8.

We draw such conclusions from a small number of ‘case studies’ and sites in Sweden and elsewhere. These existing studies have provided snapshots of the carbon balance over a period of a few years. We know practically nothing about the carbon exchange over the course of the rotation or the relative importance of the different factors implicated in carbon losses, for example is it the drainage per se or the tree density that is primarily driving C loss or gain over the long-term? How important exactly is the nutrient effect? Such questions are important. Vast areas of drained peatlands exist where timber production failed to be viable. Many of these are nutrient poor but some are nutrient rich, lacking trace elements such as boron. Such sites are tempting targets for restoration, but are they loosing carbon? is there any point in management intervention? Another question is at what point of tree density does a peatland forest lose the ability to sequester carbon as peat? Can we sequester more carbon in treeless peatlands by encouraging sparse or light tree cover? How dense is too dense?

In this project we aim to measure the effect of tree cover on peat carbon over the course of the whole rotation by measuring the carbon accumulated after 1875 when an identifiable volcanic ash layer from Iceland was deposited throughout Sweden and the Baltic region more generally,10. We will do this for an a) experimental forest where both nutrients and ditch intervals were controlled b) a site where we have ongoing contemporary CO_2 flux measurements and c) a natural tree invasion and die-off event, with this final component already mostly funded through the Icelandic research agency Rannis and for which we already have most of the laboratory analysis done.

Aim

Enter aim

The purpose of this project is to quantify the impact of trees on peat carbon, separating the impact of drainage and nutrient status from tree cover per se to distinguish sites that are most likely to be hotspots of carbon loss and to better direct management interventions against them

Objectives

Enter objectives (main objectives, target groups)

• Measure the carbon stored since 1875 in drained-forested peatlands that span a range of nutrient and drainage conditions

• Understand how tree cover, independent of management, drives peatland carbon accumulation

• Identify specific tree cover thresholds which permit carbon to be retained in peat under different nutrient and drainage conditions

• Compare the C balance over the course of the whole rotation with the C balance from recent years

• Identify peatland-forests most at risk of carbon loss

Method

Enter method

We propose to directly measure carbon accumulated as peat since the deposition of the Askja 1875 tephra (volcanic ash) layer across a minimum of 60 peat cores spanning different drainage and nutrient conditions. We will do this at a) Hälsingfors drained peatland forest and b) Totjärnmyran experimental forest. These sites are ideal as at Hälsingfors we have contemporary carbon flux data which is in the process of being published and for which the lead applicant is a co-author, this shows that part of the site is a carbon sink in the peat while another part, with denser trees and more nutrient rich conditions, is a carbon source. Totjärnmyran is an experimental site 4,11 and the drainage and fertilisation treatments applied there have resulted in strong gradients of stand volume. This will be perfect for exploring the effect of these treatments and the subsequent stand growth on peat carbon.

Our methology is centered around the field of tephrochronology, for which the lead applicant has published expertise 12,13. This method is robust and scalable in a way that many contemporary flux studies are not. The main technical challenge to doing this work is locating the volcanic ash layers, which are microscopic in Swedish peatlands, yet exist in a great number and are well mapped14. The lead applicant has successfully applied a rapid XRF core scanning technique for finding such ash layers in Scottish peats12 and this has been successful for ash falls lower than those reported in Sweden.

The top meter of peat will be cored and transported intact to Stockholm University where it will be scanned using the ITRAX following published work by the applicant12. This data will be used to identify areas of interest where peaks in elements such as Ti and Zn and corresponding bands and distortions in the x-ray imaging can be indicative of the presence of tephra. Following the identification of potential tephra layers, a sub-sample of peat will be burnt and the ash will be analyzed microscopically to confirm the presence of tephra. If the ITRAX is unable to identify tephra on some occasions a traditional incremental microscopic search can be carried out in a limited number of cores. Upon discovery of tephra layers, the shards are prepared for analysis using the method described by 15 and previously applied by the lead applicant in 12. In brief, the peat is digested in concentrated acid and mounted on slides. These are then analyzed using an electron microprobe (Edinburgh University) to provide a detailed geochemical fingerprint that can be matched to a specific time and eruption. Peat bulk density and C, N and P content will then be analyzed using the ovens at SLU facilities and performing elemental C&N analysis. From this dataset, we can look at the effect of drainage intensity and nutrient status both at high and low tree coverage.

Project organisation

Describe the project organisation. In this field you can refer to people who will carry out parts of the project, with their names.

The lead applicant (Joshua Ratcliffe) will be primarily responsible for co-ordinating the project and for field work and lab components. All co-applicants have been involved in planning the project and have contributed ideas and feedback.

Co-applicant Matthias Peichl is responsible for the contemporary flux data at Hälsingfors that we will use to compare with the long-term data generated in this project, additionally he will assist with the communication of results through his extensive contacts within industry.

External collaborator (not named as a co-applicant) Kylander, Stockholm University will assist with the ITRAX core scanning

Susanne Möckel will provide the peat core material from Iceland containing the record of tree colonisation and retreat and will provide accompanying data which will be used for calculating carbon stocks.

External collaborator (not named as a co-applicant) Roxane Andersen will be responsible for the P content analysis which will be carried out using an ICP-OES at the University of Highlands and Islands

Activity and time plan

Enter the activity and time plan

We anticipate the project will run for two years from June 1st 2023 until May 31st 2025.

The lead applicant will work 50% on this project over the coming two years and is the only member of project for which we request salary.

Field work will be carried out at Hälsingfors and Totjärnmyran during the summer of 2023 and we anticipate this will take up-to two months.
Once field work is complete we will transport the cores to Stockholm University where they will be scanned using the ITRAX combined XRF and radiography scanner. This will take 2-3 weeks depending on the resolution needed to locate the tephra.

The following 12 months will be spent analysing the cores in the laboratory, confirming the presence of tephra using microscopy and preparing and analysing slides using electronmicroprobe analysis and measuring carbon above the tephra layer. Data analysis can be conducted on a site-by-site basis as the data comes in and we will aim to have enough data to present preliminary results to IUFRO conference in Stockholm for June 2024

A further month in the autumn of 2024 will be required for preparing peat samples for AMS radiocarbon dates and nutrient analysis using an elemental analyser (SLU Umeå) and a ICP-OES (UHI, Scotland)

The final 8 months of the project will be spent finishing the data analysis and writing up the results of the work as well as communicating the results as per the plan below.

Plan for communication and implementation of results

Describe the plan for communicating and implementing the project results

There is an urgent need among stakeholders in forestry, industry and policy as well as the general public to obtain science-based information on carbon emissions associated with peatland forests. The purpose of this plan is to inform stakeholders about our project results with the main goals to i) increase knowledge of the various target groups and ii) develop guidelines which identify and separate factors (eg ditching intensity, fertilisation, tree density) that can lead to large carbon losses from others that are relatively benign. Our message will answer questions on i) carbon accumulation and its spatiotemporal variability for natural and managed peatland forests, ii) Carbon emissions associated with tree cover per se vs those associated with drainage and fertilization, and iii) How the effect of peatland tree cover, and associated management, causes peat carbon to change with time and what the urgency is for management intervention. The applicant team already has an extensive network of contacts with forest companies, industry and government agencies and all applicants have a strong record in disseminating results via publications, conference presentations and personal communication to stakeholders. Co-applicant MP is PI of the ICOS-Svb station which results in numerous interactions with stakeholders (SMHI, SFA, ICOS-Europe). We will communicate our results to a wide range of stakeholders including i) the scientific community, ii) forest and industries, iii) governmental / policy authorities and iv) the general public.

The key target groups are: Swedish Environmental Protection Agency (EPA), Swedish Forest Agency (SFA), Forest owners and companies (Holmen, Sveaskog, SCA Skog)

We will disseminate our findings in the following way:

Three publications in open-access scientific peer-reviewed journals, ensuring communication to the international scientific community and to stakeholders (eg SFA, EPA) which require a scientific data for decision-making.

Popular reporting in Skogs Eko issued by the SFA. Summarize the project results in a popular newspaper article (eg Västerbottens-Kuriren). Announce findings through SLU communication services eg press releases and news reports on the SLU homepage, policy briefs to EPA / SFA / SEA

Present our results at conferences such as the annual assemblies of the European Geophysical Union, the annual Krycklan Symposium and IUFRO congress, each of which attracts 100 to> 10 000 of scientists, environmental managers, policy makers and general public. Host a stakeholder workshop at the end of the project to present and discuss our results.

Regular communication with stakeholder contacts will occur. We will also distribute our results via social media services (eg Twitter). Incorporate new findings in our lectures within the SLU study program and contact high schools as well as' Forest in Schools'- (www.skogeniskolan.se/) -to arrange field trips and classroom lectures

Sustainable Development Goals

Describe how the project contributes to the SDGs (write the number and name of the global goal)

12. Responsible consumption and production:
13. Climate action
14. life below water

If timber is to be produced responsibly in Sweden we need to know what effect this is having on the environment. At a minimum we need to understand exactly how widespread large carbon losses may be in Swedish peatland forests. Peatlands that loose carbon also leach nutrients, metals and dissolved organic carbon into waterways. By better understanding which peatland forests are loosing carbon we can potentially remove a large source of CO_2 as well as reducing the impact of forestry on aquatic systems allowing us to meet three sustainable development goals

References

Enter references

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2. van Breemen, N. How Sphagnum bogs down other plants. Tree, 270–275 (1995).

3. Heijmans, M., et al., Persistent versus transient tree encroachment of temperate peat bogs: effects of climate warming and drought events. Glob. Chang. Biol., 2240–50 (2013).

4. Sundström, E. The impact of climate, drainage and fertilization on the survival and growth of pinus sylvestris L. in afforestation of open, low-production peatlands. Scand. J. For. Res., 190–203 (1995).

5. Meyer, A. et al. A fertile peatland forest does not constitute a major greenhouse gas sink. Biogeosciences, 7739–7758 (2013).

6. Ojanen, P., et al.,The current greenhouse gas impact of forestry-drained boreal peatlands. For. Ecol. Manage. 289, 201–208 (2013).

7. Kasimir, Å., et al., Mosses are Important for Soil Carbon Sequestration in Forested Peatlands, 1–19 (2021).

8. Minkkinen, K. et al. Persistent carbon sink at a boreal drained bog forest. Biogeosciences, 3603–3624 (2018).

10. Wulf, S. et al. Holocene tephrostratigraphy of varved sediment records from Lakes Tiefer See (NE Germany) and Czechowskie (N Poland). Quat. Sci. Rev., 1–14 (2016).

11. Sundström, E. Afforestation of low-productive peatlands in Sweden - a tree species comparison. Silva Fenn., 351–361 (1998).

12. Ratcliffe, J. L. et al. Contemporary carbon fluxes do not reflect the long-term carbon balance for an Atlantic blanket bog. Holocene, 140–149 (2018).

13. Ratcliffe, J. L. et al. Rapid carbon accumulation in a peatland following Late Holocene tephra deposition , New Zealand. Quat. Sci. Rev, 106505 (2020).

14. Newton, A. J., et al.,. Tephrabase : tephrochronology and the development of a centralised European database. J. Quat. Sci., 737–743 (2007).

15. Piltcher, J.R. & Hall, V.A. Towards a tephrochronology for the Holocene of the north of Ireland. Holocene 2, 255-259

Other financiers

Organisation	Funding period from	Funding period to	Pending decision	Applied amount (SEK)	Granted amount (SEK)
Rannis, Icelandic Research Foundation	2022-07-07	2025-07-07	No	5,776,000	5,776,000

Feasibility

Can the project in the application be carried out if applications for funding from co-financiers are rejected?

Yes

Year 2023

Salaries

Name	Monthly salary in project	Work time in project (%)	Annual salary in project (SEK)	Amount requested from Stiftelsen Skogssällskapet (SEK)
Joshua Ratcliffe (Dr.), joss.ratcliffe@slu.se	51,662	50%	309,972	309,972
Susanne Möckel (PostDoc), scm2@hi.is	72,656	20%	174,374	0
Matthias Peichl (Professor), Matthias.Peichl@slu.se	100,000	5%	60,000	0
			= 544,346	**= 309,972**

Budget items

Budget item	Total amount (SEK)	Amount requested from Stiftelsen Skogssällskapet (SEK)
Procurement of services	132,553	132,553
Travel	10,000	10,000
Communication	2,000	2,000
Premises	19,683	19,683
	= 164,236	**= 164,236**

Overhead costs

Budget item	Total value (SEK)	Requested Value (SEK)
Overhead costs	111,000	111,000
	= 111,000	**= 111,000**

	Budget total (SEK)	Requested total (SEK)
Total "Year 2023"	**= 819,582**	**= 585,208**

Year 2024

Salaries

Name	Monthly salary in project	Work time in project (%)	Annual salary in project (SEK)	Amount requested from Stiftelsen Skogssällskapet (SEK)
Joshua Ratcliffe (Dr.), joss.ratcliffe@slu.se	52,696	50%	316,176	316,176
Matthias Peichl (Professor), matthias.peichl@slu.se	100,000	5%	60,000	0
Susanne Möckel (PostDoctor), scm2@hi.is	72,656	5%	43,594	0
			= 419,770	**= 316,176**

Budget items

Budget item	Total amount (SEK)	Amount requested from Stiftelsen Skogssällskapet (SEK)
Procurement of services	85,000	85,000
Communication	2,000	2,000
Other	5,000	5,000
Premises	24,093	24,093
	= 116,093	**= 116,093**

Overhead costs

Budget item	Total value (SEK)	Requested Value (SEK)
Overhead costs	107,000	107,000
	= 107,000	= 107,000

	Budget total (SEK)	Requested total (SEK)
Total "Year 2024"	= 642,863	= 539,269

Year 2025

Salaries

Name	Monthly salary in project	Work time in project (%)	Annual salary in project (SEK)	Amount requested from Stiftelsen Skogssällskapet (SEK)
Joshua Ratcliffe (Dr.), joss.ratcliffe@slu.se	53,750	50%	322,500	322,500
Susanne Möckel (Postdoctor), scm2@hi.is	72,656	5%	43,594	0
Matthias Peichl (Professor), matthias.peichl@slu.se	100,000	5%	60,000	0
			= 426,094	= 322,500

Budget items

Budget item	Total amount (SEK)	Amount requested from Stiftelsen Skogssällskapet (SEK)
Premises	24,574	24,574
Communication	8,000	8,000
	= 32,574	**= 32,574**

Overhead costs

Budget item	Total value (SEK)	Requested Value (SEK)
Overhead costs	89,000	89,000
	= 89,000	**= 89,000**

	Budget total (SEK)	Requested total (SEK)
Total "Year 2025"	**= 547,668**	**= 444,074**

Amount requested

	Sum (SEK)
Sum	**= 1,568,551**

CV (obligatory)

Curriculum_Vitae_J_Ratcliffe_Jan2023.pdf	169 Kb (pdf)

1a. Personal details				
Full name	*Dr*	*Joshua (Joss)*	*Lee*	*Ratcliffe*

Present position	Forskningsingenjör		
Organisation/Employer	Sveriges Lantbruksuniversitet		
Contact Address	Hälsingfors 71, Vindeln, Sweden		
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Scopus Author ID:	57188735255		

1b. Academic qualifications

2020, PhD, Earth Sciences, University of Waikato New Zealand. Thesis title: Carbon exchange in the restiad peatlands of New Zealand

2015, MSc, Environmental Science, University of Highlands and Islands, Scotland, UK
Thesis title: Carbon accumulation rates over the Holocene in Flow Country peatlands and the direct comparison of open and afforested peatland carbon stocks using tephrochronology

2012, BSc (hons), Ecology, Lancaster University, England, UK
Thesis title: The effect of nutrient additions on blanket peat microbial respiration

1c. Professional positions held

2022- Current, Research Engineer, Svartbergets fältforskningsstation, Vindeln, Sweden
2021-2022, Associate Peatland Scientist, University of Highlands and Islands, UK
2020, Research Engineer, Svartbergets fältforskningsstation, Vindeln, Sweden
2019-2022, Postdoktor, Sveriges Lantbruksuniversitet, Umeå, Sweden
2016-2018, Sessional Assistant (Demonstrator), University of Waikato, New Zealand
2016, Research Assistant, University of the Highlands and Islands, Scotland
2013, Volunteer Ecologist, National Trust for Scotland, UK,
2002-2012: Butchers Assistant, Melville Tyson ltd, England, UK

1d. Present research/professional speciality

I am carrying out research primarily on the following topics:

- Drought response of boreal landscape components measuring CO_2 exchange using Eddy Covariance
- Spatial variability of CO_2 fluxes in boreal peatlands prior to nutrient fertilisation
- Carbon accumulation in response to natural phosphorus inputs from volcanic material, fire and tree pollen

In addition to these, I am involved as a collaborator in the following projects:

- Peatland lateral expansion and nutrient stoichiometry, Swedish University of Agricultural Science, Sweden
- Variability in methane fluxes across a boreal peatland complex, Swedish University of Agricultural Science, Sweden
- Carbon in drained and pristine New Zealand saltmarsh, University of Victoria, New Zealand

1e. Total years research experience	8 years

1f. Professional distinctions and memberships (including honours, prizes, scholarships, boards or governance roles, etc)

2021: Morice Fields award for best soils PhD thesis across NZ Universities for 2020
2020, Lilla Foundation for forest research, conference funding
2018, EU-Interact funding for project TREEPEAT
2017, John Mcraw Prize for communication of earth sciences research
2016, International Peat Society, Allan Robertson grant for young researchers
2015, Postgraduate Student of the year North Highland
2015, Alfred Topfer prize, science and conservation
2015, Flow Country conference best presentation prize

2015-2023: Member of the International peat society
2020: Member of the European Geosciences Union
2018-2019: Member of the New Zealand Ecological Society
2020-2021: Review support officer for the British Ecological Society peatland research group

1g. Active reviewer (last three years) for the following journals:

Nature Communications, Biogeosciences, Journal of Geophysical research: Biogeosciences, European Journal of Soil Science, Agriculture Ecosystems and Environment, The Holocene, Science for the Total Environment, Journal for Quaternary Science, Water, Land, Diversity

2a. Research publications and dissemination

Research metrics from Google Scholar: H index: 9. Citations: 227, Peer reviewed research papers: 15 of which 8 are first author. Accessed: 16/01/2023

Peer-reviewed journal articles
Ehnvall, B., **Ratcliffe, J.L.**, Bohlin, E., Nilsson, M.B., Öquist, M., Sponseller, R., Grabs, T. Accepted, in press. Landscape constraints on mire lateral expansion. Quaternary Science Reviews.
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Tsyganov, A.N., Zarov, E.A., Mazei, Y.A., Kulkov, M.G., Babeshko, K.V., Yushkovets, S.Y., Payne, R.J., **Ratcliffe, J.L.,** Fatyunina, Y.A., Zazovskaya, E.P. and Lapshina, E.D., 2021. Key periods of peatland development and environmental changes in the middle taiga zone of Western Siberia during the Holocene. Ambio, pp.1-14.

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Ratcliffe, J., Andersen, R., Anderson, R., Newton, A., Campbell, D., Mauquoy, D. and Payne, R., 2018. Contemporary carbon fluxes do not reflect the long-term carbon balance for an Atlantic blanket bog. The Holocene, 28(1), pp.140-149.

Ratcliffe, J.L., Creevy, A., Andersen, R., Zarov, E., Gaffney, P.P., Taggart, M.A., Mazei, Y., Tsyganov, A.N., Rowson, J.G., Lapshina, E.D. and Payne, R.J., 2017. Ecological and environmental transition across the forested-to-open bog ecotone in a west Siberian peatland. Science of the Total Environment, 607, pp.816-828.

Woodhouse, E.L., **Ratcliffe, J.L**., Andersen, R., Suggitt, A., Maclean, I. and Payne, R.J., 2017. A Modest Addendum to the English Sediment Core Meta-Database. Open Quaternary, pp.1-4.

Payne, R.J., **Ratcliffe, J**., Andersen, R. and Flitcroft, C.E., 2016. A meta-database of peatland palaeoecology in Great Britain. Palaeogeography, Palaeoclimatology, Palaeoecology, 457, pp.389-395.

Payne, R.J., Creevy, A., Malysheva, E., **Ratcliffe, J**., Andersen, R., Tsyganov, A.N., Rowson, J.G., Marcisz, K., Zielińska, M., Lamentowicz, M. and Lapshina, E.D., 2016. Tree encroachment may lead to functionally-significant changes in peatland testate amoeba communities. Soil Biology and Biochemistry, 98, pp.18-21.

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