FORMAS

Application

2023-03-30

2023-00994	Pommerening, Arne	Brg2301

Information about applicant

Project leader: Arne Pommerening

Doctoral degree: 1997-06-01

Birthdate: 19690221

Academic title: Professor

Gender: Male

Employer: Sveriges lantbruksuniversitet

Administrating organisation: Sveriges lantbruksuniversitet

Project site: Forest Ecology and Management

Information about application

Call name: Annual open call 2023

Type of grant: Research project

Focus: Initiated by researchers

Call for proposals subject area: Formas

Project title: How continuous cover forestry can help with carbon sequestration

Project start: 2024-01-01

Project end: 2026-12-31

Review panel applied for: Brg2301, Brg2303, Brg2308

Classification code: 40104. Forest Science incl. Forest Inventory, Forest Planning, Silviculture, Forest Protection, Regeneration, Forest Management, Forest Genetics, Forest Mycology, Forest Pathology, Forest Technology, Forest History

Application subject area: 5201. 23.9 Forestry research, other, 5202. 23.0 Forestry

Keywords: Climate change, Carbon sequestration, Continuous cover forestry

Funds applied for

Year:	2024	2025	2026	Total amount applied
Amount:	927,037	1,385,016	678,786	2,990,839

Participants

Participating researchers: Matthias Peichl

Doctoral degree: 2009-11-20

Birthdate: 19761101

Academic title: Professor

Gender: Male

Employer: Sveriges lantbruksuniversitet

Country: Sweden

Basic information

Number of project years

3

Calculated project time

2024-01-01 - 2026-12-31

Project title (Swedish, max 200 characters including spaces)

Hur hyggesfritt skogsbruk kan hjälpa till med kolbindning

Project title (English, max 200 characters including spaces)

How continuous cover forestry can help with carbon sequestration

Popular science description in Swedish (max 4 500 characters including spaces)

Under de senaste 20 åren har mänskligt framkallade klimatförändringar blivit verklighet över hela världen och att mildra dess konsekvenser kommer att vara en av de största utmaningarna för de kommande generationerna av mänskligheten. Olika åtgärder och policyer diskuteras för att mildra hotet mot livet på vår planet. En av de mest effektiva mildrande strategierna är att öka det globala skogstäcket, eftersom de flesta skogsekosystem är nettokolsänkor, det vill säga kol avlägsnas från atmosfären och låses in i träden och i skogsmarker. Större delen av skogskolet lagras faktiskt under jord i skogsmark, som därför bör störas eller exponeras så lite som möjligt.
Uppmärksamhet måste dock också ägnas åt befintliga skogar som används för virkesproduktion. De flesta av dem sköts som plantager inklusive kalhygge när deras ekonomiska livslängd har uppnåtts. Renfällning tar bort all trädvegetation från en given plats och lämnar jordar exponerade för väder och vind under ett antal år. Under denna tid släpps stora mängder kol ut i atmosfären och denna förlust återvinns endast delvis och långsamt efter att
platsen har återplanterats med träd. Vi föreslår därför en kolskogsbruksstrategi som bygger på principerna för Continuous Cover Forestry (CCF). Den viktigaste principen för CCF är att undvika storskalig hygge och att hela tiden behålla skogstäcket. Tillämpningen av CCF på den boreala skogen har hittills inte ansetts mycket. Myndigheter i Sverige har upprepade gånger bett om forskningsbaserade råd om CCF. Vi antar att kolretention i skogens ekosystem kan förbättras med ökande komplexitet i skogens struktur. Denna hypotes antyder att mer kol kan bindas ju mer strukturellt varierande, särskilt i det vertikala trädkronan en skog är. Att gå mot större strukturell komplexitet är en av grundsatserna för CCF.

För att övervinna denna brist på forskningsbaserad kunskap och för att skapa en brygga mellan teori och praktik, föreslår vi att studera sambandet mellan komplexitet i skogsstruktur och kolbindning och att undersöka om strategin att koncentrera kolbindning i stora träd är bättre än totalbeståndet. optimering av kolbindning. Optimering av den totala kolbindningen av skogsbestånd har hittills varit en vanlig strategi i många länder. Att optimera kol i ett fåtal enskilda träd har dock logistiska fördelar och fördelar för virkesproduktkedjan. I så fall kan

virke från några stora träd i varje bestånd förädlas till långlivade skogsprodukter så att kolet låses in i virket och säkras i många år. Skogsförvaltning med individuella träd är också en viktig grundsats för CCF. Våra forskningsplatser kommer att ligga i en modern fältforskningsinfrastruktur i norra Sverige, Krycklan Catchment Study (KCS, www.slu.se/Krycklan), en av de mest avancerade fältforskningsinfrastrukturerna i Europa. Resultaten kommer att sätta oss in i den unika situationen att använda vetenskapsbaserad evidens för att informera såväl myndigheter som skogsbruk om förvaltningsimplikationer av kolskogsbruk, att peka på fördelar och nackdelar och att förklara hur horisontell och vertikal skogsstruktur måste utformas för att optimera kolbindningen. En referensgrupp och dedikerade utbildningsseminarier kommer att underlätta upptagandet av våra resultat och specifikt implementeringen av CCF som en del av kolskogsbruk. Regelbundna workshops och praktiska ledningsövningar kommer att vara en del av vår unika kommunikationsstrategi.

Abstract in Swedish (max 1 500 characters including spaces)

Skogens ekosystem är viktiga globala kolsänkor som lagrar cirka två tredjedelar av dess kolpool under jord. Kolbindningen i skogarnas ekosystem kan markant förbättras genom att man undviker hyggesavverkningar och att säkra markens kolöverskott kan vara avgörande för att mildra klimatförändringarna. Avverkningar leder vanligtvis till perioder på flera år då marken exponeras och stora mängder kol släpps ut i atmosfären igen. Den senaste tidens skogspolitik har föreslagit en större övergång av Sveriges skogsbruk mot Continuous Cover Forestry (CCF), en typ av skogsbruk som syftar till att undvika hyggesavverkningar. Strukturell komplexitet i CCF-skogsmarker kommer sannolikt att vara en nyckelfaktor för kolbindningshastigheter. Hittills har synergierna mellan kolskogsbruk och CCF inte utforskats mycket i den boreala skogen. I detta projekt föreslår vi att studera sambandet mellan komplexitet i skogens struktur och kolbindning och att undersöka om strategin att koncentrera kolbindning i stora träd är bättre än övergripande beståndsoptimering av kolbindning. Våra forskningsplatser kommer att ligga i en avancerad fältforskningsinfrastruktur i norra Sverige, Krycklan Catchment Study. Dessutom kommer vår forskning att ge vetenskapligt baserade bevis för att förfina förvaltningsmetoderna för kolskogsbruk jämfört med traditionell virkes- och massaproduktion i Sverige.

Abstract in English (max 1 500 characters including spaces)

Forest ecosystems are important global carbon sinks storing about two third of its carbon pool belowground. Carbon sequestration in forest ecosystems can be markedly enhanced by avoiding clearfellings and securing the soil carbon surplus may be crucial to mitigating climate change. Clearfellings typically lead to periods of several years when the soils are exposed and large amounts of carbon are released again into the atmosphere. Recent forest policies have
suggested a greater move of Sweden's forestry towards Continuous Cover Forestry (CCF), a type of forest management that aims at avoiding clearfellings. Structural complexity of CCF woodlands is likely to be a key driver of carbon sequestration rates. Up to now the synergies of carbon forestry and CCF have not been much explored in the boreal forest. In this project, we propose to study the relationship between complexity of forest structure and carbon sequestration and to investigate whether the strategy of concentrating carbon sequestration in large trees is better than overall stand optimisation of carbon sequestration. Our research sites will be located in an advanced field research infrastructures in northern Sweden, the Krycklan Catchment Study. In addition, our research will provide science-based evidence for refining the management practices of carbon forestry when compared to traditional timber and pulp production in Sweden.

Tick the box if this application is part of the Science Europe collaboration Weave where you act as a main applicant and Formas is the Lead Agency. If your application is not a collaboration within Weave, do not tick the box.

☐

Research programme

You should write the application in English since the review panel consists of many international reviewers. For applications written entirely in Swedish, only the research program will be translated by professional translators into English. In such cases, it will not be possible for applicants to view or make linguistic adjustments to the application after it is translated and submitted to Formas's review panel for assessment. Therefore, please, write these in English, even if you write otherwise in Swedish and enter the application in the Swedish version of the application system

Aims and objectives of the proposed project and a background description containing an overview of the research area (max 7 000 characters including spaces)

Background, theory

In the past 20 years human-induced climate change has become a reality and its dramatic consequences will concern the overwhelming majority of people on earth. Different measures and policies have recently been proposed to mitigate the threat to life on our planet. Forests are a significant part of the global carbon (C) cycle, because they contain the largest store of terrestrial carbon. Natural forests are important global carbon sinks and among these measures much emphasis has therefore been placed on increasing woodland cover and on avoiding any kind of forest management that leads to a sudden, large-scale exposure of forest soils to the atmosphere so that carbon emissions are minimised. Forest carbon optimisation

and management strategies are therefore often included in climate mitigation policies (Ontl et al., 2020). Boreal forests represent approximately 30% of global forest area and store about one third of the global forest carbon. Most of the carbon in boreal forests is in belowground dead pools, particularly in the soils (Hoover and Riddle, 2020). Carbon forestry has now become an
established term to denote forest management with the explicit objective of increasing carbon sequestration (Pukkala, 2018). Currently there are three primary strategies for optimising forest carbon sequestration and storage: **(1)** Maintain and increase the area of forest land, **(2)** maintain and increase forest carbon stocks and **(3)** increase the use of timber products (Hoover and Riddle, 2020). On closer inspection these broad strategies suggested for increasing forest carbon sequestration markedly overlap with tenets of continuous cover forestry (CCF). Continuous cover forestry or close-to-nature forestry is forest management based on ecological principles without clearfelling, thereby avoiding the sudden removal of all aboveground carbon and subsequent gradual loss of belowground carbon. Clearfelling is a typical harvesting and regeneration method of plantation or rotation forest management (RFM), which currently is the dominant management type in Sweden. Clearfelling also results in a temporary carbon net loss (Hoover and Riddle, 2020). This large carbon loss is avoided in CCF, hence the great interest in employing this management type for carbon forestry. The general idea of CCF is to promote managed forests with structures, management practices and/or species compositions that are more akin to the potentially natural stages of forest development and to the processes of potentially natural tree vegetation on any particular site than those that are commonly observed in rigid plantation management (O'Hara, 2014). As part of ongoing transformation of plantation forests to CCF horizontal and particularly vertical forest structure usually becomes more complex. CCF practices also include increasing the resilience to natural disturbance and enhancing forest recovery following disturbance (Ontl et al., 2020) thus reducing the probability of sudden, large carbon losses. In Sweden, CCF has recently been adopted as "non-clearcut forestry" (hyggesfritt skogsbruk in Swedish) by Skogsstyrelsen and there is currently a widespread discussion on replacing 20% of RFM by CCF (Skogsstyrelsen, 2021). However, the exact effects of this management type on C allocation are not well understood at present. In addition, appropriate management designs of carbon forestry are largely unknown to date.

Goal/aim: The ultimate goal of this proposal is to advise forest practice after identifying and evaluating the main strategies of CCF management for optimised carbon sequestration.

Objectives:

- To explore the relationship between the complexity of forest structure and carbon sequestration,
- To investigate whether the strategy of concentrating C sequestration in large trees

is better than overall stand optimisation of C sequestration,

- To evaluate the differences between traditional forestry for timber production and carbon forestry and the management implications for the forest industry.

Description of the project, including a summary of the structure, theory, methods, performance, and a concrete and realistic plan for scientific publication and communication of results (max 15 000 characters including spaces)

Rationale:

Despite continued, regular interventions CCF woodlands are net carbon sinks at all times. Compared to Rotation Forest Management (RFM), the main advantage of CCF woodlands is that they remain to act as net carbon sinks at all times and that the lifetime of trees and associated carbon storage is generally much longer. Their increased structural complexity and thinning frequency (as opposed to large-scale harvesting operations) further reduce the probability of large-scale disturbances and associated large carbon losses (Hanewinkel et al., 2014). On the other hand overall carbon storage in tree biomass – depending on species and environmental factors – might on average be lower in CCF stands relative to RFM (Lundmark et al., 2016), because CCF requires more open forest canopies. This, however, might be compensated for by a growth stimulation effect caused by repeated thinning interventions that has previously been observed for tree volume growth of forest stands (Assmann, 1970). To date the research community knows little about the effects of selective thinnings on carbon sequestration (Franklin et al., 2018). Increasing and maintaining structural complexity is considered a very important pre-requisite for achieving the objectives of CCF, since structural complexity fosters self-organisation of the associated tree vegetation and thus reduces the need for management input (Pommerening and Murphy, 2004; Franklin et al., 2018). Forest structure is therefore an important tenet of CCF. Increasing structural complexity can result in increasing niche complementarity of trees in different canopy layers and thus to increased carbon sequestration (Binkley, 2021).

Another unresolved key question is whether it may be beneficial to concentrate sequestered carbon in a few large and long-living trees rather than maximising overall carbon sequestration by spreading carbon across many small and medium-sized trees. From a logistic point of view, the former option is perhaps more suitable to a concept of long-term insurance of carbon sequestration by converting the timber of individual large trees to long-term wood products such as furniture and construction timber along the chain of custody. Alternatively, it has been considered to put large tree stems into long-term underground storage (Zeng, 2008).

However, to our knowledge no study has to date explored the benefits of concentrating C sequestration efforts on selected 'carbon trees' as opposed to an even distribution of carbon across all tree size classes.

Methods:
To fill the current knowledge gaps, we intend to measure annual carbon sequestration rates in comparatively fast growing forests such as those that predominantly include *Picea abies* as the main species. This is accompanied by soil flux measurements and by assessing the deadwood carbon pool. The tree and soil flux measurements will provide information on the C balance during the three years of the project. In addition we will assess the long-term carbon build-up by studying soil C stock and tree rings in combination. As previously explained, in CCF, horizontal
and vertical forest structure is instrumental in delivering ecosystem goods and services (Pommerening and Murphy, 2004). Forest management interventions in CCF are usually defined by *thinning regime*, *thinning type*, *thinning cycle* and *thinning intensity*. According to our research vision, these four criteria can be generalised by studying what might be the optimum spatial forest structure for sequestering carbon and ensuring that it stays in the forest ecosystem for a very long time. In our approach, forest structure consequently acts as experimental treatment. In order to be able to obtain results within a project period of three years, we will study a gradient including three levels of increasing horizontal and vertical structural complexity in existing *P. abies* forests in northern Sweden. By comparing the structure of the best carbon variant with that of traditional *P. abies* plantations in northern Sweden we will also explore the management requirements necessary to achieve optimised carbon sequestration. In addition we will use available data on the carbon storage in 50 RFM plots as a reference to better understand the carbon-storage potential of CCF. These data were collected in a project previously funded by Formas (grant number 942-2015-49). RFM including clearfelling has until now been the standard in Swedish forestry and it makes therefore much sense to compare CCF results against this standard.

Project description, summary of structure, theory, methods, performance, plan for scientific deliverables:
We plan to structure the project into establishment of the experimental setup (FW) and three work packages (WP):

FW: *Plot establishment*. New areas for testing CCF with increasing structural complexity will be established within the Krycklan Catchment Study (KCS, www.slu.se/Krycklan). KCS is an advanced research platform designed to study biogeochemical change over time (Laudon et al., 2013). The site has long-term, continuous monitoring records including climatic variables measured at the same location (www.silvaboreal.com). We will select 50 × 50 m

replicated plots that reflect forest structure as expected from CCF management to establish a structural
gradient spanning three levels of complexity. Each complexity level includes three replicated plots, thus this experimental plan will result in a total of nine spatially explicit plots. We will evaluate and compare the CCF effects with already established and monitored locations within the Trollberget Experimental Area (TEA; part of KCS). We will map all trees in the replicated 0.25-ha plots (n = 3 for each of the three types of structural complexity).

WP 1: *Forest structure and carbon sequestration rates*. This work includes the analysis of the mapped tree data from the nine plots including detailed spatial analyses of tree and forest structure based on point process statistics providing a solid theory of discerning different spatial patterns. Horizontal and vertical spatial forest structure is quantified so that the level of global structural complexity can be established for each complexity level. For this purpose we will apply second-order characteristics, i.e. the pair correlation, mark correlation functions, the mark connection function and the mark variogram (Illian et al., 2008). In addition, we will quantify the micro-structural context of each individual tree using structural and competition indices (Pommerening and Grabarnik, 2019, chapter 4). This will allow us to relate the micro-structural information with growth and carbon sequestration rates. WP 1 also includes the analysis of growth patterns from tree ring data. The tree rings will be measured analysed on a sample basis as detailed in the description of WP 2. This growth information will be used to quantify absolute (AGR) and relative growth rates (RGR) (Pommerening and Grabarnik, 2019, chapter 6) and these will be converted to carbon sequestration rates (see description of WP 2). In a second step, carbon AGR and RGR will be estimated for all trees in the nine plots.Carbon AGR and RGR will then be related to the aforementioned individual-tree structural and competition indices to establish the contribution of forest structure to individual tree carbon sequestration.

WP 2: *Tree and soil C fluxes*. The potential for C sequestration in CCF relative to RFM systems is poorly understood to date. In WP2, we will determine the long-term and contemporary C balance for a gradient of CCF plots and compare these to extensive data collected from previous research in adjacent RFM stands. We will determine annual tree production from repeated tree inventory measurements (including stem diameter, total tree height and species) in three circular sub-plots (radius = 10 m) established in each of the 50 × 50 m plots (see FW) following the protocol of the Swedish Forest National Inventory (NFI). In addition, we will collect increment cores from five selected trees in each sub-plot to determine the long-term tree growth rates. The increment cores also provide information on wood density. Using established allometric functions (Marklund, 1988), tree diameter and height data will be used to estimate whole tree biomass (including canopy and root biomass) and C pools as well

as annual absolute (AGR) and relative (RGR) carbon sequestration rates (see WP 1). The annual C uptake rates via net primary production (NPP) and are then determined from the annual change in the pools. To obtain the contemporary net C balance, we will quantify C losses from soil heterotrophic respiration (RHs) and decomposing deadwood (RHdw). We will use the chamber technique to measure RHs fluxes from experimental subplots (1 m) where all living ground vegetation will be removed and lateral roots trenched (i.e. applying the 'trenching technique'; Bond-Lambert et al 2011) in bi-weekly intervals during the growing season. RHdw will be estimated by applying a decay constant to the deadwood pool determined as part of the tree inventory measurements and added to RHs to obtain an estimate of total heterotrophic respiration (RH). The annual net C balance, i.e. the net ecosystem production (NEP), of each CCF plot will then be estimated by the balance of C input and loss, i.e. NEP = NPP – RH. To assess the difference in soil C storage among the structural gradient in the CCF plots, we will take at three soil cores to a depth of 50 cm in each inventory plot. The soil bulk density and C concentration (for each 10 cm depth interval) will then be determined in the lab. We will then evaluate the carbon-storage potential of CCF through the comparison with existing data on the carbon storage and balance in 50 RFM forest stands across the Krycklan catchment, estimated by co-applicant MP in a previous Formas project.

WP 3: *Synthesis and management consequences*. In this work package, we will synthesise the project outcomes from WP 1 and WP 2 by jointly analysing their results through established methods of the analysis of variance (ANOVA) and correlation analyses (Montgomery, 2013). In this synthesis, global plot forest structure constitutes the treatment. This global forest structure will be quantified using different spatial characteristics from point process statistics (Illian et al., 2008) as detailed in the description of WP 1 and these will be used as measures of global
forest structure. In the analysis of variance, we will study how overall carbon sequestration varies with global forest structure. In a second step, we will analyse to what degree individual-tree carbon fluxes trees depend on the forest structure in their immediate neighbourhood, i.e. on the micro-structural context of each tree. Based on the results in this work package, we will also make conclusions and recommendations as to the management implications when considering an optimisation of carbon sequestration. These management implications provide import information for the research communication.

Expected outcomes:

1. New knowledge of the effect of spatial forest structure on population carbon sequestration and the relative and absolute carbon sequestration of individual trees of different sizes (WP 1).
2. Novel strategies for maximising overall carbon sequestration in relation to tree size (WP 2).

3. Insights into C sequestration potentials of alternative forest management strategies through comparison of CCF to the aforementioned reference provided by 50 RFM plots from a previously funded Formas project (grant number 942-2015-49) (WP 3).
4. New management prescriptions for carbon forestry that will guide forest managers in designing forest stands for optimum carbon sequestration.

Subject to the results coming from this project we anticipate the following potential publications:

- Continuous Cover Forestry Forest management for carbon sequestration – a review
- Does size matter? Carbon sequestration in large and small forest trees
- Optimising forest structure for carbon sequestration: From evidence to implementation
- Differences in carbon sequestration of RFM forests compared to CCF woodlands

Performance:
The work packages and papers define the overall structure of the project and the temporal sequence in which scientific tasks will be accomplished. The supervisory team will initialise the project in year 1. We expect that it takes approximately six months to employ the postdoc so that s/he will continue to work for some time in year 3. Particularly in the first year, the postdoc researcher will also spend considerable time on setting up the nine 0.25-ha base plots. The tree mapping related to package FW will continue well into year 2. WPs 1-3 are anticipated for
years 2 and 3 and the supervisory team will finalise the project after the two-year postdoc's employment has concluded.

Compliance, gender, supervision
We confirm that we will fully comply with international agreements and regulations. The post of a postdoc researcher that we propose in this project, will be publicly advertised, is open to all genders and the person eventually employed will receive our full support including equal opportunities in accordance with the regulations of our University and Swedish legislation. The postdoc researcher will be jointly supervised by the two authors of this proposal and we will strive for a gender-balanced supervisory committee and reference group.

Description of the societal value of the research question (max 8 000 characters including spaces)
Social benefits:
There is a great need for optimising carbon forestry worlwide and in Sweden. As such a project is part of an international effort to reduce carbon emissions and to mitigate climate cange. This project explores the synergies between CCF and general carbon forestry, which is a logical step given the current forest policies in Sweden. Since CCF is forest management based on ecological principles, the introduction of this management method will partially lead to a more natural state of Swedish forests, while still allowing selective timber production. The project will

provide scientific evidence for fine tuning CCF for the purpose of carbon sequestration. The idea of CCF is very popular in Swedish society and exploring the benefits of adopting CCF will send out important, positive signals suggesting that the Swedish forest industry supported by the Swedish University of Agricultural Sciences is willing to move forward with introducing more environmentally friendly forest management. This work will assist Sweden's long-term strategy for reducing greenhouse gas emissions and help Sweden meet the objectives of transforming
plantations to a good ecological status in the next ten years.

We have identified a number of target groups (TGs):
Forest managers and policy makers: In this project, we will actively engage with various stakeholders including social media, popular information notes and field trips. As part of this we engage our partners in a project reference group including Dr. Helena Dehlin and Carl Appelqvist at the Swedish Forestry Agency. Furthermore, the Swedish Environmental Protection Agency, seven County Administrative Boards, as well as all the regional Forest Owners Associations will be involved. The results of our project work will be of direct relevance to and actively used in the new regional and national strategies for reducing greenhouse gas emissions. In addition, through our industrial partners (TG1), Holmen Skog and Sveaskog, as well as through the Swedish Forest Agency, we will also reach out to forest industry representatives involved in managing CCF. Through this close cooperation with our forestry
stakeholder partners we will be in a position to use our findings to develop and discuss best practice for carbon forestry that is of direct societal relevance.

The experimental plots will also be organised as management demonstration plots (MDP) and serve as the basis for CCF education for those interested in carbon forestry. KCS and TEA are only 30 minutes by car from the university campus at Umeå. Training events will be offered once
a year in 2024 and 2025 as an appendix to the annual Krycklan symposium, i.e. symposium participants can chose to take part in a separate one-day training seminar immediately before or after the symposium. We will invite practitioners (TG2), i.e. landowners, forest managers, authorities and NGOs (TG3) to participate. Participation is free of charge, i.e. it is paid for by the project grant. The training events are a combination of in-door seminars, field trips (visiting the MDPs) and hands-on tree selection and thinning exercises involving marteloscope techniques (Pommerening and Grabarnik, 2019, chapter 7) where the participants have to select trees for thinning and their choices are afterwards checked against a number of meaningful statistical summary characteristics. The purpose of the tree selection is to diversify horizontal and vertical forest structure with a view to transform plantations to CCF woodlands and thus to optimise carbon sequestration. Even beyond the project's lifetime this training component will also be used for teaching purposes as part of our MSc and PhD forest

science degree programmes (TG4). We will also offer specialised field trips for high school classes (TG5), university and postgraduate courses where our MDPs will feature prominently. Key results of the project will be published in scientific journals and reported at the annual Krycklan symposium and at other international conferences (TG6). The Krycklan symposium attracts approximately 120 scientists, authorities and general public participants annually.

Plan for communication:
In the project, we will closely cooperate with the Future Forests programme (www.futureforests.se) and the Krycklan research community (www.slu.se/Krycklan) providing even broader opportunities for collaboration with the forest industry, forest owners and policy makers (TG2 and 3). Woodland owners/managers and conservationists are among those who would most benefit from information on the outcomes of our project. These target groups are directly involved in managing woodlands and they can consider our results in their day-to-day decisions. We will address the four forest owner associations in Sweden through the roof organisation National Forest Cooperative Organisation (LRF). In terms of conservation and related bodies we will target Naturskyddsföreningen, FSC and WWF in Sweden and Skogsstyrelsen for their important roles in the country. Skogsstyrelsen will be supported in their endeavour to define standards and management prescriptions for the Swedish version of CCF, i.e. *hyggesfritt skogsbruk* (non-clearcut forestry).

In the second and the third year of this project, we intend to hold stakeholder workshops and training seminars for discussing and disseminating our findings. There will be an indoor session with presentations of our ongoing research and on CCF/carbon management. This is followed up by a field trip highlighting different situations of carbon fluxes and the management required to enhance carbon sequestration. Finally, marteloscope exercises are used to give the participants a hands-on experience. Marteloscopes are fully mapped forest plots with numbered trees where the participants in the exercise are asked to note those trees they want to favour in carbon forest management as well as other trees they intend to remove (Pommerening and Grabarnik, 2019). At the end of each exercise the individual and group decisions are analysed and feedback is given to the participants on site. To maximise the outcome of such dissemination we may combine our seminars with existing conference and workshop plans such as the annual Krycklan Symposium.

During the training events and the field trips we will inform about our research results whilst pointing out best practice examples in the field. At the same time we will communicate the complex issues and considerations of our research.

Both authors of this proposal have had much contact with target groups over the years and were involved in dissemination of research results in various countries. The experience we made has been always positive and we look forward to similar experience in this project. The nicest experience and reward we had was that many members of these target groups stayed in contact even long after the project's lifetime and continued to ask for advice. We also actively engage on Twitter (with close to 900 followers), have our personal websites and maintain a
university blog which we will use for communicating the project, its results and publications world-wide. All authors have great experience in combining research with training and field trips as a means of research dissemination. This combination is very successful, because it allows the stakeholders to put research results into a practical context and inspires creative thinking as well as professional pride.

Data handling: All data collected in the project will be stored under the unique Krycklan open access data portal (www.slu.se/Krycklan). There will also be a detailed data management plan. A project website will be placed on the Krycklan homepage and designed to provide a portal for general information and guidance the research and free download of all data collected in the project.

References (max 5 000 characters including spaces)

Assmann, E., 1970. The principles of forest yield study. Studies in the organic, production, structure, increment and yield of forest stands. Pergamon Press, Oxford.

Binkley, D., 2021. Forest ecology. John Wiley & Sons, Chichester.

Bond-Lamberty, B., Bronson, D. Bladyka, E. Gower, S.T., 2011. A comparison of trenched plot techniques for partitioning soil respiration, Soil Biology and Biochemistry, 43, 2108-2114.

Franklin, J.F., Johnson, K.N., Johnson, D.L., 2018. Ecological forest management. W aveland Press Inc., Long Grove, 2018.

Hanewinkel, M. Kuhn, T., Bugmann, H., Lanz, A., Brang, P., 2014. Vulnerability of uneven-aged forests to storm damage. Forestry 87, 525–534.

Hoover, K., Riddle, A.A., 2020. Forest carbon primer. Congressional research service.

Illian, J., Penttinen, A., Stoyan, H., Stoyan, D., 2008. Statistical analysis and modelling of spatial point patterns. John Wiley & Sons, Chichester.

Laudon, H., Taberman, I., Ågren, A., Futter, M., Ottosson-Löfvenius, M., Bishop, K., 2013. The Krycklan Catchment study – A flag ship infrastructure for hydrology, biogeochemistry, and climate research in the boreal landscape. Water Resources Research 49, 1-5.

Lundmark, T., Bergh, J., Nordin, A., Fahlvik, N., Poudel, B.C., 2016. Comparison of carbon balances between continuous-cover and clear-cut forestry in Sweden. Ambio 45, 203-213.

Marklund, L.G., 1988. Biomass functions for pine, spruce and birch in Sweden. Department of Forest Surveying, Swedish University of Agricultural Sciences, Umeå, Report 45.

Montgomery, D. C., 2013. Design and analysis of experiments. 8 edition. John Wiley & Sons, New Delhi.

O'Hara, K.L., 2014. Multiaged silviculture. Managing for complex forest stand structures. Oxford University Press, Oxford.

Ontl, T.A., Janowiak, M.K., Swanston, C.W ., Daley, J., Handler, S., Cornett, M., Hagenbuch, S., Hendrick, C., McCarthy, L., Patch, N., 2020. Forest management for carbon sequestration and climate adaptation. Journal of Forestry 118, 86-101.

Pommerening, A., Grabarnik, P., 2019. Individual-based methods of forest ecology and management. Springer, Cham.

Pommerening, A., Murphy, S.T., 2004. A review of the history, definitions and methods of continuous cover forestry with special attention to afforestation and restocking. Forestry 77, 27-44.

Pukkala, T., 2018. Carbon forestry is surprising. Forest Ecosystems 5, 11.

Skogsstyrelsen, 2021. Hyggesfritt skogsbruk. Skogsstyrelsens definition. [Forestry without clearfelling. The definition of the Forestry Authority of Sweden.] Rapport 2021/8.

Zeng, N., 2008. Carbon sequestration via wood burial. Carbon Balance Management. 3, I.

Budget

Note that you should always write the budget and budget specification in English; any Swedish budget specification will not be translated but will instead be reviewed as it is by the international review panel.

All amounts should be written in full. For example, 1 million SEK should be written as: 1 000 000 SEK.

Salaries including social fees

Role in the project	Name	Percent of salary
1 Applicant	Arne Pommerening	10%
2 Participating researcher	Matthias Peichl	10%
3 Post-doc	NN	100%
Total		

	2024	2025	2026	Total
1	0	0	0	0
2	0	0	0	0
3	445,562	681,709	231,781	1,359,052
Total	445,562	681,709	231,781	1,359,052

Dedicated time for this project

Role in the project	Name	Percent of full time
1 Applicant	Arne Pommerening	10%
2 Participating researcher	Matthias Peichl	10%
3 Post-doc	NN	100%
4 Participating researcher	Matthias Peichl	

Running Costs

	Running Cost	Description	2024	2025	2026	Total
1	Travel & subsistence	Field work including rental cars, allowances, lodging, conferences, field trips	60,000	80,000	60,000	200,000
2	Dissemination workshops	This includes most of the stakeholder and communication work	0	60,000	50,000	110,000
3	Computer	Hardware for the post-doc	20,000	0	0	20,000
4	Open-access publishing	Costs of publishing open access	0	5,000	7,000	12,000
5	Hiring of computer theodolite and associated equipment	Required for mapping trees	100,000	110,000	70,000	280,000
6	Lab materials and chemical analyses	Required for measuring carbon fluxes	0	100,000	100,000	200,000
7	Mesurement equipment other than theodolite	Required for measuring carbon fluxes	40,000	0	0	40,000
8	Base frames for chamber flux measurements	3 frames in each of the 9 plots	75,000	0	0	75,000
9	Hiring a technician from the Svartberget field station	Supporting the C flux measurements and the mapping of trees	0	63,000	63,000	126,000
Total			295,000	418,000	350,000	1,063,000

Equipment costs and depriciation costs

Depreciation cost	Description	2024	2025	2026
No information added				

Premises

	Type of premises	2024	2025	2026	Total
1	University facilities	29,273	44,788	15,228	89,289
Total		29,273	44,788	15,228	89,289

Total budget

	Specified costs	2024	2025	2026	Total, applied	Other costs	Total cost
1	Salaries including social fees	445,562	681,709	231,781	1,359,052	0	1,359,052
2	Running costs	295,000	418,000	350,000	1,063,000	0	1,063,000
3	Depreciation costs				0	0	0
4	Premises	29,273	44,788	15,228	89,289	0	89,289
5	Subtotal	769,835	1,144,497	597,009	2,511,341	0	2,511,341
6	Indirect costs	157,202	240,519	81,777	479,498	0	479,498
7	Total project cost	927,037	1,385,016	678,786	2,990,839	0	2,990,839

Budget specification (max 7 000 characters including spaces)

The budget calculations including the costs of premises and overheads have been carried out according to the rules and regulations of the Swedish University of Agricultural Sciences and the Department of Forest Ecology and Management.

Personnel costs: The project includes a 2-year post-doctoral fellow (referred to as NN - not nominated in the budget tables). The two professors (Pommerening, Peichl) will work in the project as in-kind.

Travel & subsistance costs are estimated to be 200 tkr: This includes travelling for repeated field work including rental cars, allowances, lodging, participation in one national and one international conference.

Dissemination/communication workshops are estimated to cost 110 tkr. This includes travelling/organisation for/of the training seminars/workshops.

Open-access publishing is estimated to be 12 tkr: This includes 3-4 high-profile publications in total taking into account that SLU now has open-access publishing agreements with a number of journals in place. We will aim for top-tier scientific journals such as Global Environmental Change, but also more specialised journals such as Forest Ecology and Management and Ecological Applications.

Hiring of theodolite and associated equipment is estimated to be 280 tkr: This equipment is necessary for mapping the trees in the research plots as a pre-requisite for quantifying spatial horizontal and vertical forest structure.

Total costs of carbon-research materials are estimated to be 275 tkr: This includes the costs of lab materials and chemicals as well as the costs of lab analyses + the costs of base frames for chamber flux measurements (3 in each of 9 plots).

Hiring of mensuration equipment is estimated to be 40 tkr: These costs relate to hiring equipment used for measuring individual trees in the research plots such as diameter tapes, hypsometers and increment borers.

Hiring a technician from the Svartberget field station to help with the carbon flux measurements is estimated to be 126 tkr.

The post-doc fellow is provided with a computer (tkr 20) that is assumed to be of little residual value at the end of the project. tkr 200 is required for the communication part of the project, specifically for the workshops and
training seminars, see T&S.

Ethics

Reporting of ethical considerations (max 4 000 characters including spaces)

Compliance, gender, supervision

We confirm that we will fully comply with international agreements and regulations. The post of a postdoc researcher that we propose in this project, will be publicly advertised, is open to all genders and the person eventually employed will receive our full support including equal opportunities in accordance with the regulations of our University and Swedish legislation. The postdoc researcher will be jointly supervised by the two authors of this proposal and we will strive for a gender-balanced supervisory committee and reference group. Our research is not expected to collect or use personal data or to include research involving experiments on humans or animals. All our activities will be entirely focussed on plants.

Select also the specific aspects below that may affect your application.

Personal data

No

Animal testing

No

Human testing

No

Classifications

Subject area

52. PROGRAM AREA: FORESTRY AND THE NATURAL ENVIRONMENT > 5201. 23.9 Forestry research, other

52. PROGRAM AREA: FORESTRY AND THE NATURAL ENVIRONMENT > 5202. 23.0 Forestry

Research subject (SCB-code)

40104. Forest Science incl. Forest Inventory, Forest Planning, Silviculture, Forest Protection, Regeneration, Forest Management, Forest Genetics, Forest Mycology, Forest Pathology, Forest Technology, Forest History

Sustainable Development Goals

13 Climate action

Keyword 1

Climate change

Keyword 2

Carbon sequestration

Keyword 3

Continuous cover forestry

Appendices

Appendix for illustrations

No file has been uploaded

CV

CV - Arne Pommerening

Project leader: Arne Pommerening
Birthdate: 19690221
Gender: Male
Country: Sweden

Doctoral degree: 1997-06-01
Academic title: Professor
Employer: Sveriges lantbruksuniversitet

Doctors degree

Examination	Organisation	Dissertation title (original language)	Supervisor
10599. Other Earth and Related Environmental Sciences, 1997-06-01	Georg-August-University Göttingen	An analysis of new sampling approaches in well-structured forests	Klaus von Gadow

Educational history

Research education

Examination	Organisation	Dissertation title	Name of supervisor
PhD degree, 10799. Other Natural Sciences not elsewhere specified, 2009-06-01	University of Natural Resources and Life Sciences, Vienna, Austria, Institute of Forest Growth	Habilitation: Analysing & modelling spatial woodland structure	Hubert Sterba
PhD degree, 10599. Other Earth and Related Environmental Sciences, 1997-06-01	Georg-August-University Göttingen, Germany	An analysis of new sampling approaches in well-structured forests	Klaus von Gadow

Basic education

Year	Examination
2002	1. Natural Sciences, Degree in Teaching in Higher Education, Bangor University, United Kingdom
1995	10799. Other Natural Sciences not elsewhere specified, Degree of Master of Science in Forestry, Georg-August-University Göttingen, Germany
1995	10799. Other Natural Sciences not elsewhere specified, Degree of Bachelor, Georg-August-University Göttingen, Germany

Professional history

Employments

Period	Position	Part of research in employment	Employer
april 2014 - Present	Professor, Permanent employment	100	Swedish University of Agricultural Sciences, Sweden, Skogens Ekologi och Skötsel
januari 2011 - januari 2013	Professor, Permanent employment	100	University of Bern, Switzerland, Applied Sciences (CH)
juni 2000 - juni 2011	Lecturer, Permanent employment	100	Bangor University

Post doctoral assignments

Period	Organisation	Subject
september 1997 - juni 2000	Munich Technical University, Germany, Forest Biometrics	10799. Other Natural Sciences not elsewhere specified

Research exchange assignments

Period	Type	Organisation	Subject
oktober 2019 - november 2019	Visiting professor	University of Natural Resources and Life Sciences, Vienna	40104. Forest Science incl. Forest Inventory, Forest Planning, Silviculture, Forest Protection, Regeneration, Forest Management, Forest Genetics, Forest Mycology, Forest Pathology, Forest Technology, Forest History
oktober 2015 - november 2015	Visiting professor	Virginia Polytechnic Institute	40104. Forest Science incl. Forest Inventory, Forest Planning, Silviculture, Forest Protection, Regeneration, Forest Management, Forest Genetics, Forest Mycology, Forest Pathology, Forest Technology, Forest History
oktober 2013 - mars 2014	Sabbatical	Swiss Federal Institute of Technology in Zurich	10799. Other Natural Sciences not elsewhere specified
juli 2013 - september 2013	Sabbatical	Warsaw University Life Sciences	10799. Other Natural Sciences not elsewhere specified
april 2013 - juni 2013	Sabbatical	Estonian University of Life Sciences	10799. Other Natural Sciences not elsewhere specified
juni 2013 - juni 2013	Sabbatical	Chinese Academy of Forestry	10799. Other Natural Sciences not elsewhere specified

Merits and awards

Supervised persons

Year	Supervised persons	University (supervisee)	Role
2019	PhD student, Xin Zhao	Swedish University of Agricultural Sciences, Sweden	Main supervisor
2008	PhD student, Stephen T. Murphy	Bangor University, United Kingdom	Main supervisor
2006	PhD student, Owen Davis	Bangor University, United Kingdom	Main supervisor
2015	PhD student, Sebastian Schnell	Swedish University of Agricultural Sciences, Sweden	Secondary supervisor
2014	PhD student, Lucie Vítková	Swedish University of Agricultural Sciences, Sweden	Secondary supervisor
2017	Postdoc, Jaime Uria Diez	Swedish University of Agricultural Sciences, Sweden	Main supervisor
2013	Postdoc, Mihail Hanzu	University of Applied Sciences, Bern, Switzerland	Main supervisor
2008	Postdoc, Jens Haufe	Bangor University, United Kingdom	Main supervisor
2008	Postdoc, Owen Davis	Bangor University, United Kingdom	Main supervisor
2020	Guest postdoc, Gongqiao Zhang	Swedish University of Agricultural Sciences, Sweden	Main supervisor

Year	Supervised persons	University (supervisee)	Role
2019	Guest postdoc, Hongxiang Wang	Swedish University of Agricultural Sciences, Sweden	Main supervisor
2018	Guest postdoc, Zhonghua Zhao	Chinese Academy of Forestry, China	Main supervisor

Research grants awarded in competition

Period	Funder	Project leader	Your role	Sub amount (SEK)	Total amount (SEK)
2014 - 2016	Sweden - Research and technology organisations,	Arne Pommerening	Applicant	0	600 000
2011 - 2011	Not Sweden - Other private actors,	Arne Pommerening	Applicant	0	0
2009 - 2009	Not Sweden - Companies,	Arne Pommerening	Applicant	0	12 000
2009 - 2013	European Union (EU),	Arne Pommerening	Co-applicant	0	1 700 000
2008 - 2008	Not Sweden - Governmental agencies,	Arne Pommerening	Applicant	0	9 000
2007 - 2008	Not Sweden - Governmental agencies,	Arne Pommerening	Co-applicant	0	4 800 000
2005 - 2006	Not Sweden - Governmental agencies,	Arne Pommerening	Applicant	0	72 000
2004 - 2004	Not Sweden - Higher education institutes,	Arne Pommerening	Applicant	0	60 000
2003 - 2004	Not Sweden - Governmental agencies,	Arne Pommerening	Applicant	0	64 000
2001 - 2004	Not Sweden - Governmental agencies,	Arne Pommerening	Applicant	0	447 000

Other merits

Period	Type of merit	Description
2010 - 2022	Editorial experience	Canadian Journal of Forest Research – Associate editor for forest biometrics.
2014 - 2022	Editorial experience	Forest Ecosystems – Member of the editorial board.
2015 - 2022	Editorial experience	Forest Ecology and Management – Member of the editorial board.
1995 - 2022	Review Manuscripts	Reviewer for over 30 different scientific journals (Acta Oecologica; Agroforestry Systems; Allgemeine Forst- und Jagdzeitung (German Journal of Forest Research); Annals of Botany; Annales Botanici Fennici; Annals of Forest Science; Biometrical Journal; Bioresource Technology; Canadian Journal of Forest Research; Canadian Journal of Remote Sensing; CAB Reviews; Computers and Electronics in Agriculture; Ecography; Ecological Modelling; Ecological Research; Environmental Conservation; Environmental Management; European Journal of Forest Research; Experimental Marine Biology; Forest Ecology and Management; Forestry; orest Science; Forest, Snow & Landscape Research; Journal of Forest Research; InternationalWood Products Journal; Methods in Ecology and Evolution; The International Forestry Review; Landscape Ecology; New Forests; New Zealand Journal of Forestry Science; Scandinavian Journal of Forest Research; Schweizerische Zeitschrift für Forstwesen).

Period	Type of merit	Description
2005 - 2022	International Management	Deputy coordinator of IUFRO working party 4.01 "Forest mensuration and modelling".
2017 - 2018	National Management	Director of the Centre for Statistics (Statistics@SLU), and SLU centre offering consultation in statistics to PhD students and researchers.
2014 - 2018	National Management	Head of the SLU Research School in Applied Forest Statistics and Scientific Computing.
2017 - 2018	National Management	Member of the departmental research-education committee.
2006 - 2006	Conference Organisation	International forest-ecology conference at Bangor.
2003 - 2004	Advisory Roles	Scientific adviser of the ForestBIOTA project (pan-European project for the test implementation of forest biodiversity assessments, www.forestbiota.org).
2001 - 2001	Conference Organisation	International workshop at Bangor.

CV - Matthias Peichl

Participating researchers: Matthias Peichl
Birthdate: 19761101
Gender: Male
Country: Sweden
Doctoral degree: 2009-11-20
Academic title: Professor
Employer: Sveriges lantbruksuniversitet

Doctors degree

Examination	Organisation	Dissertation title (original language)	Supervisor
10502. Environmental Sciences (social aspects to be 507), 2009-11-20	McMaster University, School of Geography and Earth Sciences	Carbon dynamics and greenhouse gas exchange in an age-sequence of temperate pine forests	Altaf Arain

Educational history

Research education

Examination	Organisation	Dissertation title	Name of supervisor
PhD degree, 10502. Environmental Sciences (social aspects to be 507), 2009-11-20	McMaster University, Canada, School of Geography and Earth Sciences	Carbon dynamics and greenhouse gas exchange in an age-sequence of temperate pine forests	Altaf Arain

Basic education

Year	Examination
2005	10502. Environmental Sciences (social aspects to be 507), Degree of Master, McMaster University, Canada
2003	10503. Geosciences, Multidisciplinary, Degree of Bachelor of Science in Forest Management, University of Freiburg, Germany

Professional history

Employments

Period	Position	Part of research in employment	Employer
oktober 2021 - Present	Professor, Permanent employment	70	Swedish University of Agricultural Sciences, Sweden, Forest Ecology and Management
februari 2016 - september 2021 (Present)	Senior lecturer, Permanent employment	100	Swedish University of Agricultural Sciences, Sweden, Skogens ekologi och skötsel
april 2015 - januari 2016 (Present)	Researcher, Temporary employment	100	Swedish University of Agricultural Sciences, Sweden, Skogens ekologi och skötsel
april 2011 - mars 2015 (Present)	Assistant professor, Temporary employment	100	Swedish University of Agricultural Sciences, Sweden, Skogens ekologi och skötsel

Post doctoral assignments

Period	Organisation	Subject
oktober 2009 - mars 2011	University College Cork, Ireland, Department of Civil and Environmental Engineering	10502. Environmental Sciences (social aspects to be 507)

Interruptions in research

Period	Description
2021-11-01 - 2022-01-30	Parental leave
2019-05-06 - 2019-06-28	Parental leave
2019-01-07 - 2019-03-08	Parental leave

Merits and awards

Docentur

Year	Subject	Organisation
2015	105. Earth and Related Environmental Sciences	Swedish University of Agricultural Sciences, Sweden, Skogens ekologi och skötsel

Supervised persons

Supervised persons	University (supervisee)	Role	Number
PhD student	Swedish University of Agricultural Sciences, Sweden, Skogens ekologi och skötsel	Main supervisor	3
PhD student	Swedish University of Agricultural Sciences, Sweden, Skogens ekologi och skötsel	Secondary supervisor	3
Postdoc	Swedish University of Agricultural Sciences, Sweden, Skogens ekologi och skötsel	Main supervisor	8
Postdoc	Swedish University of Agricultural Sciences, Sweden, Skogens ekologi och skötsel	Secondary supervisor	6

Supervised persons	University (supervisee)	Role	Number
Licentiate	Swedish University of Agricultural Sciences, Sweden, Skogens ekologi och skötsel	Secondary supervisor	1
Student	Swedish University of Agricultural Sciences, Sweden, Skogens ekologi och skötsel	Main supervisor	8
Student		Secondary supervisor	3

Research grants awarded in competition

Period	Funder	Project leader	Your role	Sub amount (SEK)	Total amount (SEK)
2022 - 2025	Formas, Sweden - Other financing agencies and organisations	Hjalmar Laudon	Co-applicant	0	16 000
2021 - 2023	Formas, Sweden - Other financing agencies and organisations	Matthias Peichl	Applicant	0	3 000 000
2020 - 2023	VR - The Swedish Research Council, Sweden - Other financing agencies and organisations	Matthias Peichl	Applicant	0	3 682 000
2019 - 2022	VR - The Swedish Research Council, Sweden - Other financing agencies and organisations	Mats Nilsson	Co-applicant	3 380 000	3 380 000
2018 - 2021	Sweden - Oterh private actors,	Matthias Peichl	Applicant	0	2 000 000
2018 - 2020	Sweden - Oterh private actors,	Matthias Peichl	Applicant	0	2 700 000
2017 - 2019	Formas, Sweden - Other financing agencies and organisations	Matthias Peichl	Applicant	0	2 984 001
2016 - 2020	Knut och Alice Wallenbergs Stiftelse, Sweden - Other financing agencies and organisations	Torgny Näsholm	Co-applicant	5 933 000	39 450 000
2016 - 2018	Sweden - Oterh private actors,	Matthias Peichl	Applicant	0	540 000
2015 - 2017	Formas, Sweden - Other financing agencies and organisations	Matthias Peichl	Applicant	0	6 572 000

Awards and distinctions

Year	Country	Name of award/distinction	Issuer	Description
2014	Sweden	Kungl. Skytteanska Samfundets prize for a Young Researcher	Kungl. Skytteanska Samfundets	

Year	Country	Name of award/distinction	Issuer	Description
2014	Canada	Appointment as Adjunct Assistant Professor at the School of Geography and Earth Sciences, McMaster University, Hamilton, ON, Canada	School of Geography and Earth Sciences, McMaster University, Hamilton, ON, Canada	
2009	Canada	PhD thesis nominated for the Governor General Academic Medal by the School of Geography & Earth Sciences, McMaster University	School of Geography & Earth Sciences, McMaster University	
2008	Canada	Ontario Graduate Scholarship (OGS; 15,000 Can$)	Ontario provincial government	

Other merits

Period	Type of merit	Description
2014 - 2022	Swedish representative in European COST Action	Swedish representative at the European COST Action ES1309 Innovative Optical Tools For Proximal Sensing Of Ecophysiological Processes (OPTIMISE); 2014-2018 Swedish Representative in the Management Committee at the European COST Action CA17134 Optical synergies for spatiotemporal SENsing of Scalable ECOphysiological traits (SENSECO); 2018-2022
2014 - 2022	Member of PHD Thesis Evaluation Committees	Member of PhD Thesis Evaluation Committee for Elin Sundqvist, Lund University, June 12, 2014, Lund, Sweden Member of PhD Thesis Pre-Evaluation Committee for Eduardo Martínez García, University of Castilla-La Mancha, Spain, 2018 Member of PhD Thesis Pre-Evaluation Committee for Laura Matkala, University of Helsinki, Finland, 2020
2010 - 2022	Referee for international journals	Reviewer for peer-reviewed journals including: Global Change Biology, Environmental Research Letters, Agricultural and Forest Meteorology, Biogeosciences, Journal of Geophysical Research – Biogeosciences, Plant and Soil, Canadian Journal of Forest Research, Environmental Science & Technology, Science of the Total Environment, Biogeochemistry, Forest Ecology and Management, Global Biogeochemical Cycles
2018 - 2022	Editorial assignments	Editorial Board Member of the journal 'Forests' since 2018; Associate Editor, Frontiers in Forests and Global Change Topic Editor for special issue 'Wetland Ecology and Biogeochemistry Under Natural and Human Disturbance' in the journal Frontiers.
2012 - 2022	Member of MSc Thesis Evaluation Committees	Member of the MSc Thesis Evaluation Committees for Cormac O'Doherty, 2012-2013, North Carolina State University, USA; Ilse Vermeij, 2013-2014, Wageningen University and Research Centre, The Netherlands; Eefje de Goede, 2014-2015, Radboud University Nijmegen, The Netherlands; Quan Zhou, 2017-2018, Wageningen University and Research Centre, The Netherlands; Itziar Aguinaga Gil, 2017-2018, Wageningen University and Research Centre, The Netherlands; Thalisa Slier, 2018-2019, Wageningen University and Research Centre, The Netherlands; Hanna Glöd, 2018, Swedish University of Agricultural Sciences, Sweden; Jenny Dahl, 2018, Swedish University of Agricultural Sciences, Sweden; Jelle Visser, 2020-2021, Wageningen University and Research Centre
2007 - 2022	Invited talks	A total of 12 invited and keynote talks at international conferences, workshops and university seminars
2012 - 2022	Reviewer for grant application	Invited reviewer for AgreenSkills Fellowship Research Project Application; Reviewer of research grant application to the Swiss National Science Foundation

Period	Type of merit	Description
2007 - 2022	Conference presentations	24 first-author oral presentations and 14 first-author poster presentations from 2007-2020 at international conferences including the Fall Meeting of the American Geophysical Union (AGU), the European Geosciences Union (EGU) General Assembly, the General Meeting of the Canadian Climate Program, the International Peat Society and the ICOS-Europe/Sweden Annual Meetings.
2019 - 2022	Activity in ICOS-Sweden and SITES	Member of the ICOS-Sweden Management Team, Principle Investigator (PI) at the ICOS-Svartberget and ICOS-Degerö ecosystem stations; Co-PI of SITES-Spectral (since 2015)
2006 - 2022	Bibliometric summary	In total (since the first publication in 2006): 110 peer-reviewed publications, 17 first-author peer-reviewed publications, > 5200 citations in total, h-index = 38 (based on Google Scholar). 1 popular science article, each 1 first-author paper in Scientific Reports and Ecology Letters, senior author for 1 paper in Nature Communications, senior author on 3 papers in Global Change Biology, co-author for 2 papers in Nature Climate Change, 2 papers in Nature Communications and 1 paper in Nature Science Data In the last five years (since 2017): 67 peer-reviewed publications, 1 popular science article, 9 senior author peer-reviewed publications. 1 first-author paper in Scientific Reports, senior author for 1 paper in Nature Communications, senior author on 3 papers in Global Change Biology, each 1 co-author paper in Nature Climate Change, Nature Communications and Nature Science Data A total of 24 oral conference presentations + 12 invited/keynote talks and 14 first-author poster presentations since 2006.

Publications

Publications - Pommerening, Arne

Project leader: Arne Pommerening
Birthdate: 19690221
Gender: Male
Country: Sweden
Doctoral degree: 1997-06-01
Academic title: Professor
Employer: Sveriges lantbruksuniversitet

Scientific publication - peer-reviewed

Original journal article

Title: Understanding and modelling the dynamics of data point clouds of relative growth rate and plant size
Authors: Arne Pommerening, Guillermo Trincado, Christian Alas-Eljatib
Date of publication: 2022-11-25 **Volume:** 529
Name of journal: Forest Ecology and Management
Academic publication - peer-reviewed: Original journal article

Title: Sampling theory inspires quantitative forest ecology: The story of the relascope kernel function
Authors: Arne Pommerening, Hubert Sterba, Philip West
Date of publication: 2022-03-01 **Volume:** 467
Name of journal: Ecological Modelling
Academic publication - peer-reviewed: Original journal article

Title: Spatial patterns of correlation between conspecific species and size diversity in forest ecosystems
Authors: Hongxian Wang, Xiaohong Zhang, Yanbo Hu, Arne Pommerening
Date of publication: 2021-08-12 **Volume:** 457
Name of journal: Ecological Modelling
Academic publication - peer-reviewed: Original journal article

Title: CanopyShotNoise - An individual-based tree canopy modelling framework for projecting remote-sensing data and ecological sensitivity analysis
Authors: Arne Pommerening, Rachel Gaulton, Paul Magdon, Mari Myllymäki
Date of publication: 2021-07-27 **Volume:** 42
Name of journal: International Journal of Remote Sensing
Academic publication - peer-reviewed: Original journal article

Title: Unravelling the mechanisms of spatial correlation between species and size diversity in forest ecosystems
Authors: Arne Pommerning, Gongqiao Zhang, Xiaohong Zhang
Date of publication: 2020-10-19 **Volume:** 21 **Issue number:** 106995
Name of journal: Ecologcal Indicators
Academic publication - peer-reviewed: Original journal article

Title: Democratising forest management: Applying multiwinner approval voting to tree selection
Authors: Arne Pommerening, Markus Brill, Ulrike Schmidt-Kraepelin
Date of publication: 2020-08-13 **Volume:** 478 **Issue number:** 118509
Name of journal: Forest Ecology and Management
Academic publication - peer-reviewed: Original journal article

Title: Change in drivers of mangrove crown displacement along a salinity stress gradient
Authors: Vovides Alejandra G., Berger Uta, Grueters Uwe, Guevara Roger, Pommerening Arne, Lara-Domínguez Ana Laura, López-Portillo Jorge
Date of publication: 2018-09-02
Name of journal: Functional Ecology
Academic publication - peer-reviewed: Original journal article

Title: Tamm review: Tree interactions between myth and reality. Forest Ecology and Management
Authors: Arne Pommerening, Andrew J. Sánchez Meador
Date of publication: 2018-04-27 **Volume:** 428
Name of journal: Forest Ecology and Management
Academic publication - peer-reviewed: Original journal article

Title: Rating experiments in forestry: How much agreement is there in tree marking?
Authors: Arne Pommerening, Carlos Pallarés Ramos, Kedziora Wojciech, Haufe Jens, Stoyan Dietrich
Date of publication: 2018-03-22 **Volume:** 13
Name of journal: PLOS ONE
Academic publication - peer-reviewed: Original journal article

Title: Do large forest trees tend towards high species mingling?
Authors: Arne Pommerening, Jaime Uria-Diez
Date of publication: 2017-12-01 **Volume:** 42
Name of journal: Ecological Informatics
Academic publication - peer-reviewed: Original journal article

Publications - Matthias Peichl

Participating researchers: Matthias Peichl
Birthdate: 19761101
Gender: Male
Country: Sweden
Doctoral degree: 2009-11-20
Academic title: Professor
Employer: Sveriges lantbruksuniversitet

Scientific publication - peer-reviewed

Original journal article

Title: Landscape-variability of the carbon balance across managed boreal forests
Authors: Peichl, M., E. Martínez-García, J. E. S. Fransson, J. Wallerman, H. Laudon, T. Lundmark, M. B. Nilsson
Date of publication: 2022-12-04 **Volume:** 29
Name of journal: Global Change Biology
Academic publication - peer-reviewed: Original journal article

Title: Effects of drought and meteorological forcing on carbon and water fluxes in Nordic forests during the dry summer of 2018
Authors: A. Lindroth, J. Holst, M.-L. Linderson, M. Aurela, T. Biermann, M. Heliasz, J. Chi, A. Ibrom, P. Kolari, L. Klemedtsson, A. Krasnova, T. Laurila, I. Lehner, A. Lohila, I. Mammarella, M. Mölder, M. Ottosson Löfvenius, M. Peichl, K. Pilegaard, K. Soosar, T. Vesala, P. Vestin, P. Weslien, M.B. Nilsson
Date of publication: 2020-09-07 **Volume:** 375
Name of journal: Phil. Trans. R. Soc. B
Academic publication - peer-reviewed: Original journal article

Title: Increasing contribution of peatlands to boreal evapotranspiration in a warming climate
Authors: Manuel Helbig, James Michael Waddington, Pavel Alekseychik, Brian Amiro, Mika Aurela, Alan G. Barr, T., Andrew Black, Peter D. Blanken, Sean K. Carey, Jiquan Chen, Jinshu Chi, Ankur R. Desai, Allison Dunn, Eugenie, Euskirchen, Thomas Friborg, Lawrence B. Flanagan, Inke Forbrich, Achim Grelle, Silvie Harder, Michal Heliasz, Elyn R., Humphreys, Hiroki Ikawa, Hiroki Iwata, Pierre-Erik Isabelle, Rachhpal Jassal, Juliya Kurbatova, Mika Korkiakoski, Lars Kutzbach, Takeshi Ohta, Anders Lindroth, Mikaell Ottosson-Löfvenius, Annalea Lohila, Trofim Maximov, Ivan Mammarella, Philip Marsh, Joe R. Melton, Paul A. Moore, Daniel F. Nadeau, Erin M. Nicholls, Mats B. Nilsson, Matthias Peichl, Richard M. Petrone, Roman Petrov, Anatoly Prokushkin, William Quinton, Nigel T. Roulet, David E., Reed, Benjamin R. K. Runkle, Oliver Sonnentag, Ian B. Strachan, Pierre Taillardat, Eeva-Stiina Tuittila, Juha-Pekka, Tuovinen, Jessica Turner, Masahito Ueyama, Andrej Varlagin, Martin Wilmking, Steve Wofsy, Vyacheslav Zyrianov
Date of publication: 2020-05-11 **Volume:** 10
Name of journal: Nature Climate Change
Academic publication - peer-reviewed: Original journal article

Title: The Net Landscape Carbon Balance – integrating terrestrial and aquatic carbon fluxes in a managed boreal forest landscape in Sweden.
Authors: Chi, J. M.B. Nilsson, H. Laudon, A. Lindroth, N. Kljun, J. Wallerman, J. Fransson,T. Lundmark, M. Ottosson Löfvenius and M. Peichl
Date of publication: 2020-02-19 **Volume:** 26
Name of journal: Global Change Biology
Academic publication - peer-reviewed: Original journal article

Title: The carbon balance of a managed boreal landscape measured from a tall tower in northern Sweden
Authors: Chi, J. , M.B. Nilsson, N. Kljun, J. Wallerman, J. Fransson, H. Laudon, T. Lundmark and M. Peichl
Date of publication: 2019-05-01 **Volume:** 274
Name of journal: Agricultural and Forest Meteorology
Academic publication - peer-reviewed: Original journal article

Title: How do disturbances and climate effects on carbon and water fluxes differ between multi-aged and even-aged coniferous forests?
Authors: X, H. Tang, Li, M. Ma, L. Yao, M. Peichl, A. Arain, X. Xu, and M. Goulden
Date of publication: 2018-05-18 **Volume:** 599
Name of journal: Science of The Total Environment
Academic publication - peer-reviewed: Original journal article

Title: Slash and stump harvest have no general impact on soil and tree biomass C pools after 32-39 years
Authors: Arnis Jurevics, Matthias Peichl, Bengt Olsson, Monika Strömgren, Gustaf Egnell
Date of publication: 2016-07-01 **Volume:** 371
Name of journal: Forest Ecology and Management
Academic publication - peer-reviewed: Original journal article

Title: Carbon and greenhouse gas balances in an age sequence of temperate pine plantations
Authors: Matthias Peichl, Matthias Peichl, TR Moore, A. M. Arain, J. J. Brodeur, M. Khomik, S. Ullah, N. Restrepo-Coupé, J. McLaren, M. R. Pejam
Date of publication: 2014 **Volume:** 11 **Issue number:** 19
Name of journal: Biogeosciences
Academic publication - peer-reviewed: Original journal article

Title: Biometric and eddy-covariance based estimates of carbon fluxes in an age-sequence of temperate pine forests
Authors: Matthias Peichl, Jason J. Brodeur, Myroslava Khomik, M. Altaf Arain
Date of publication: 2010 **Volume:** 150 **Issue number:** 7-8
Name of journal: AGRICULTURAL AND FOREST METEOROLOGY
Academic publication - peer-reviewed: Original journal article

Title: Above- and belowground ecosystem biomass and carbon pools in an age-sequence of temperate pine plantation forests
Authors: Matthias Peichl, A. Altaf Arain
Date of publication: 2006 **Volume:** 140 **Issue number:** 1-4
Name of journal: AGRICULTURAL AND FOREST METEOROLOGY
Academic publication - peer-reviewed: Original journal article

Register

Terms and conditions

Ansökan ska förutom av den sökande även signeras av behörig företrädare för medelsförvaltaren. Företrädaren är vanligtvis prefekten vid den institution där forskningen ska bedrivas, men ska i vissa fall utgöras av exempelvis rektor. Detta framgår i sådana fall av den aktuella utlysningstexten för bidraget.

Signering av *den sökande* innebär en bekräftelse av att:

- uppgifterna i ansökan är korrekta och följer Formas instruktioner
- bisysslor och kommersiella bindningar har redovisats för medelsförvaltaren och att det där inte framkommit något som strider mot god forskningssed
- nödvändiga tillstånd och godkännanden ska finnas senast vid projektstart, exempelvis avseende etikprövning.

Signering av *medelsförvaltaren* innebär en bekräftelse av att:

- den beskrivna forskningen, anställningen och utrustningen kan beredas plats inom institutionen under den tid och i den omfattning som anges i ansökan
- institutionen godkänner kostnadsberäkningen i ansökan
- projektet bedrivs i enlighet med svensk lagstiftning.

Ovanstående punkter ska ha diskuterats mellan parterna innan företrädaren för medelsförvaltaren godkänner och signerar ansökan.

Ansökningar där en organisation är sökande signeras automatiskt vid registrering av ansökan.