



# Carbon Cycling: From Plants to Ecosystems

A joint meeting of the British Ecological Society's  
Plants, Soils, Ecosystems and Plant Environmental  
Physiology special interest groups.

University of Manchester, 16-17<sup>th</sup> October 2014

# Plants, Soils, Ecosystems

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Plants, Soils, Ecosystems is a special interest group on plant-soil interactions, with a focus on biogeochemical cycling, community dynamics, and ecosystem functioning.

Aims:

- To promote research on plant-soil interactions and their role in ecosystems through workshops, symposia, and events at BES meetings
- To provide opportunities for networking and collaboration among researchers involved in the study of plant-soil interactions and ecosystem ecology
- To serve as a platform to discuss and share techniques, expertise, and data
- To promote research across scientific disciplines to students, facilitate training opportunities in different techniques, and provide support for early-career researchers

## Plant Environmental Physiology Group

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The Plant Environmental Physiology Group is one of the special interest groups within the British Ecological Society and the Society for Experimental Biology.

Our remit is to:

- Advance and promote the science and practice of plant environmental physiology
- Integrate the plant environmental physiology community and research opportunities within and outside the BES and SEB
- Support, train and liaise with young plant environmental physiologists

# A warm welcome to 'Carbon Cycling: From Plants to Ecosystems', at the University of Manchester!

We hope you enjoy your time in Manchester. Here are some details you might find useful:

Talks will take place in the main lecture theatre in the Michael Smith building (off Oxford Road, Dover Street entrance). Posters will be displayed, along with refreshments and the wine reception, in the Michael Smith Lounge, Michael Smith building.

Drinks following the poster session will be in Sandbar on Grosvenor Street.

The conference dinner will be held at Tops Restaurant on Portland Street, from 7pm.

Bus number 147 passes close to all the venues – a single fare is 80p. There are stops along Oxford Road. See [www.route147.co.uk](http://www.route147.co.uk).

Manchester University switchboard: +44 (0) 161 306 6000

Meeting hashtag: #psepepg

All abstracts will be published online at [besplantsoileco.wordpress.com/pse-pepg-joint-meeting/](http://besplantsoileco.wordpress.com/pse-pepg-joint-meeting/)

If you have any questions, please feel free to ask.

The organising committee:

Ellen Fry, Sarah Pierce, Mike Whitfield



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[facebook.com/PlantEnvironmentalPhysiologyGroup](https://facebook.com/PlantEnvironmentalPhysiologyGroup)

# Day 1: The Small Scale

10:00	Registration
11:20	Welcome
11:30	<b>Keynote 1 – Howard Griffiths:</b> Managing your carb intake: isotopes and the partitioning of C and N above and below ground
12:15	<b>Aurore Kaisermann:</b> Soil biotic legacy effects on the drought response of microbial communities and carbon cycling
12:30	<b>Richard Nair:</b> Using $^{15}\text{N}$ to re-evaluate the Forest Carbon Response to Nitrogen Deposition
12:45	Panel discussion
13:00	Lunch
14:00	<b>Elly Morriën:</b> Transitions in belowground biodiversity, network structure and functioning in a chronosequence of restored old fields
14:15	<b>Cleo Chou:</b> Plant strategies and tropical rainforest nutrient limitation
14:30	<b>Relena Ribbons:</b> Mini-forests in the rhizotron: exploring single and mixed tree species effects on soil microbial communities and carbon dynamics
14:45	<b>Beth Brockett:</b> Dirt and Westminster
15:00	Panel discussion
15:15	Coffee
15:45	<b>Lorna Street:</b> Using stable isotopes to understand carbon allocation in Arctic ecosystems
16:00	<b>Ann Milbau:</b> Root phenology: a key factor in Arctic ecosystem functioning
16:15	<b>Thomas Parker:</b> Fast carbon turnover beneath shrub and tree vegetation reduces soil carbon stocks at a subarctic treeline
16:30	Panel discussion
16:45	Poster session and wine reception (sponsored by Wiley) Pub
19:00	Conference dinner

## Day 2: The Large Scale

08:30	Registration – coffee available
09:00	<b>Keynote 2 – Lisa Wingate:</b> Impact of microbial Carbonic Anhydrase on the atmospheric concentrations of CO <sub>18</sub> O and COS at large scales
09:45	<b>Tom Walker:</b> Vegetation composition modifies atmospheric warming effects on microclimate
10:00	<b>Melanie Hartley:</b> Does the timing of browsing matter? Investigating the influence of browsing on ecosystem carbon cycling
10:15	<b>Sue Ward:</b> Vulnerability of temperate grassland soil carbon to management
10:30	<b>Kadmiel Maseyk:</b> Developing carbonyl sulphide as a carbon cycle tracer: a cross-system comparison of leaf, soil and ecosystem fluxes
10:45	Panel discussion
11:00	Coffee
11:30	<b>Suzanne Benham:</b> Changes in the carbon in the forest soils under 70 year old oak, set with a 180 year chronosequence from the same forest.
11:45	<b>Aaron Thierry:</b> Modelling the role of vegetation type & fire on permafrost thaw
12:00	<b>Mike Whitfield:</b> From the ground up: modelling soil greenhouse gas emissions at the national level
12:15	<b>Silvia Caldararu:</b> Using multi-scale data to constrain a model of plant growth applied to wheat and maize
12:30	Panel discussion
12:45	Lunch
13:45	<b>Keynote 3 – Aimée T Classen:</b> From microbes to mountains, understanding ecosystems in a global change context
14:30	<b>Andy Moffat:</b> An assessment of the carbon stored in soils and deadwood in UK forestry
14:45	<b>Phoebe Morton:</b> A burning issue? Assessing the effects of heather managements on UK peatlands
15:00	<b>Maarten Schrama:</b> Using farmer traits or plant functional traits to increase soil carbon?
15:15	<b>Kate Storer:</b> Carbon cycling and crop yields: limitations, solutions and implications
15:30	Panel discussion
15:45	Awards (sponsored by the Society of Biology) and close



**Keynote 1: Managing your carb intake: isotopes and the partitioning of C and N above and below ground**

Howard Griffiths

Department of Plant Sciences, University of Cambridge

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Howard Griffiths is Head of the Physiological Ecology in the Department of Plant Sciences at Cambridge University. His group investigates plant molecular, physiological and environmental processes which regulate productivity and CO<sub>2</sub> sequestration, and aim to improve the operating efficiency of the primary carboxylase, Rubisco, and match water availability to use. Stable isotope methods are used to evaluate the origins and regulation of diverse photosynthetic carbon concentrating mechanisms (CCM). These include the C<sub>4</sub> pathway and Crassulacean Acid Metabolism (CAM), as well as the biophysical CCM in algae and hornworts, with a particular focus on the molecular determinants of the chloroplast pyrenoid. His group's work translates via fieldwork into food security and biomass crop productivity, as well as natural community diversity.

**Abstract:** We increasingly have to take a holistic view of plant and soil processes, moving beyond one's own specialist components, to consider the integrated soil-(microbe)-plant-atmosphere continuum. One area which continues to provide fascination is the role of stem carbohydrate budgets- whether for a crop such as wheat, or a giant redwood. The presentation will review some recent observations on carbohydrate partitioning for trees, crops and their associated soil microflora. The possibility of using either natural abundance or enriched stable isotopes to track sources and sinks will be described. Some key issues related to the maintenance of hydraulic continuity and resource acquisition, as they relate to bet-hedging (or spread betting?) of carbon partitioning for annuals, as compared to perennials, will be presented for discussion.

## **1. Soil biotic legacy effects on the drought response of microbial communities and carbon cycling**

Aurore Kaisermann, Franciska De Vries, Robert Griffiths, Bruce Thomson, Richard Bardgett

While there is growing evidence that drought affects plant growth and soil microbial communities, little is known about the effect of drought on the plant-soil feedbacks and the consequences for processes of carbon cycling. We set up a glasshouse experiment to test the hypotheses that plant growth is less affected by drought in soil conditioned by conspecific species (i.e. by the same species) and when soil has previously experienced drought conditions, and that these changes are related to shifts in the soil microbial community composition. Two plant species were grown in soils with four different histories (conspecific or not, undergone previously drought or not), in monoculture or in competition, and were then exposed to a drought. We found that conditioning changed soil microbial community composition. The response of soil microbial communities to drought depended on soil history, and also plant identity and competitive interactions. Associated effects on soil processes occurred as soil respiration and net ecosystem exchange are modified. Finally, plant resistance and resilience to drought have changed, with consequences for nutrient uptake by plants. Our findings suggest that recurrent droughts have long lasting effects on belowground communities with consequences for feedbacks to aboveground communities and for carbon cycling.

## **2. Using <sup>15</sup>N to re-evaluate the Forest Carbon Response to Nitrogen Deposition**

Richard Nair, Mike Perks, Maurizio Mencuccini

The forest carbon response to nitrogen deposition (NDEP) appears two to four times larger from correlative studies of NEP or forest inventories against NDEP than meta-analyses using stable isotopes or C and N budgets. A strong carbon uptake effect ( $\Delta\text{CAN}$ ) depends on nitrogen being sequestered in high C/N woody biomass in trees rather than soils which are the main sinks for experimental <sup>15</sup>N additions.

We investigated some of the assumptions of the isotope studies which assume that 1) the fate of NDEP made directly to the soil is representative of atmospheric deposition which otherwise also interacts with the canopy and 2) N recycled from the forest floor is partitioned within trees in a similar manner to NDEP additions. From small-scale experiments on saplings and the forest floor, we compared partitioning results using a simple mathematical model inferring C uptake effect from pool C:N ratios and found that a  $\Delta\text{CAN}$  two to three times higher than soil deposition methodologies may be achieved under canopy deposition, while a litter-derived <sup>15</sup>N signal may also be better obtained by trees. This may raise estimates of a carbon effect from NDEP experiments to similar magnitudes as the lower estimates from correlative studies.

### **3. Transitions in belowground biodiversity, network structure and functioning in a chronosequence of restored old fields**

Elly Morriën, Emilia Hannula, Basten Snoek, Wim van der Putten

For a number of decades, ecological restoration has focused strongly on abandoning arable land. Traditionally, resource availability and aboveground herbivory have been supposed to be major drivers of ecosystem dynamics, however, recent studies have revealed that soil biota can play a substantial role in vegetation succession. Here, we combined the results of an extensive field survey in a land abandonment chronosequence with stable isotope probing of C and N in intact soil cores. Our findings suggests that during this secondary succession the belowground biodiversity does not changes per se, but that over time soil networks develop where species abundances are stronger correlated resulting in more efficient nutrient use, so that plants have less nutrients available. We conclude that nutrient limitation and subsequent succession towards slower growing plant species can be explained by transitions towards stronger correlated belowground networks that prevent nutrients to become available for plant growth.

### **4. Plant strategies and tropical rainforest nutrient limitation**

Cleo Chou, Lars Hedin, Steve Pacala

Lowland tropical rainforests play a large role in the terrestrial carbon cycle, but we lack a comprehensive understanding of their dynamics necessary for predictions of their future as carbon sinks or sources. A large source of uncertainty comes from the nutrient dynamics in these ecosystems. In situ fertilization experiments in mature forests have provided incongruous results. To address this, we are studying the interaction between plant functional traits and competitive strategies with nutrient dynamics in these forests to better understand whether tree growth is nutrient limited, and if so, which individuals or species are, and the mechanisms by which they become nutrient limited. A two-year fertilization study at the tree-level in Costa Rica has shown that different species and functional types have varying responses to fertilizer depending on their light opportunities. To further understand these results, we have built a forest gap simulation model to test the consequences of varying leaf trait competitive strategies on nutrient dynamics and have shown that competitively optimal traits may reduce the fitness of the individual with ecosystem level carbon and nutrient consequences. This better comprehension of how tree traits and competitive strategies interact with nutrients provides insight to tropical rainforest nutrient limitation and carbon cycling.



## **5. Mini-forests in the rhizotron: exploring single and mixed tree species effects on soil microbial communities and carbon dynamics**

Relena Ribbons, Morag McDonald, Lars Vesterdal, Andrew Smith, John Healey

Tree species are known to influence biogeochemical cycling, but how multiple species interact to influence biogeochemical cycles is less well understood. We test the hypotheses that biomass and root growth are maximized in mixed species settings compared with pure species settings, because different functional traits of multiple tree species enable roots to more fully exploit physical soil space and resources. We make use of an experimental manipulation at an underground laboratory designed to explore plant-soil interactions, known as a rhizotron, to explore how four tree species grown in monoculture and two-species mixtures (*Quercus robur* paired with *Acer pseudoplatanus*; *Alnus rubra* paired with *Pseudotsuga menziesii*) influence soil microbial communities and carbon dynamics. These species mixtures were designed to represent tree species known for differences in key functional traits, including leaf decomposability, root growth form, and mycorrhizal fungal associations. We will review the experimental study design and some of the unique features of a rhizotron as an experimental platform. Baseline data on soil biological properties collected prior to tree seedling planting will be presented. A discussion of our hypothesized tree species effects on soil microbial communities will follow, along with planned future studies based on this experiment.

And now, time for something slightly different:

## **6. Dirt and Westminster**

Beth Brockett provides some reflections on her British Ecological Society Policy Internship.

## **7. Using stable isotopes to understand carbon allocation in Arctic ecosystems**

Lorna Street, Jens-Arne Subke, Robert Baxter, Mike Billett, Kerry Dinsmore, Jason Lessels, Philip Wookey

Arctic ‘greening’ is now a well-accepted phenomenon with multiple lines of evidence pointing to increases in Arctic productivity, driven by increases in shrub abundance. However, very little is known about how these changes will impact biogeochemical cycling, including the allocation and turnover of carbon. Recent research has shown, for example, that greater plant productivity is not necessarily associated with greater ecosystem C storage. Proliferation of a number of shrub species has been observed in different regions; for example increased willow growth in Arctic Russia, vs. primarily alder expansion in NW Canada, where stem density increased almost 70 % between 1968 -2004. It is not known the degree to which shrub functional type will determine the impacts of ‘shrubbification’ on the carbon cycle.

We use  $^{13}\text{C}$  pulse- labelling to trace the fate of recently photosynthesised carbon in vegetation dominated by two common Arctic shrubs, *Betula nana* (dwarf birch) and *Alnus viridis* (green alder) just above the Arctic treeline in NW Canada. We quantify the amount of  $^{13}\text{C}$  assimilated, and the proportion of assimilate returned to the atmosphere via respiration versus that allocated to plant tissues. We use these novel field data to address the hypothesis that belowground C allocation in alder (a symbiotic nitrogen fixing species) is a smaller proportion of total C assimilation, as this species supports less extensive ectomycorrhizal networks compared to *Betula nana*. This is the first time that ecosystem carbon allocation has been compared between N fixing and non-N fixing vegetation types and provides crucial data for parameterising predictive models of the Arctic carbon cycle.

## **8. Root phenology: a key factor in Arctic ecosystem functioning**

Ann Milbau, Gesche Blume-Werry, Scott D. Wilson, Jürgen Kreyling

Fine roots are a key player in terrestrial biogeochemical cycling and an important component of the soil food web. In cold-climate ecosystems, roots show a strong seasonal pattern of production and senescence, which relates to processes such as water and nutrient uptake, soil carbon input and microbial activity. First, I will give an overview of how changes in root phenology might influence arctic ecosystem functioning, and then I will discuss a recent study in which we used in situ measurements to compare the start, peak and end of the growing season above- and belowground in different arctic vegetation types. In all studied vegetation types and years, the growing season of roots continued 1.5 months longer than that of shoots, mainly due to longer root growth into autumn after aboveground senescence. Moreover, we observed a strong asynchrony in root and shoot growth with production peaks at different moments. Our data suggest that neglecting fine root phenology severely underestimates the actual duration of the arctic growing season and potentially obscures the response to a warmer climate of most of the arctic biomass. This may lead to erroneous predictions of the seasonal pattern of carbon exchange between the terrestrial ecosystem and the atmosphere.

## **9. Fast carbon turnover beneath shrub and tree vegetation reduces soil carbon stocks at a subarctic treeline**

Thomas Parker, Jens-Arne Subke, Philip A Wookey

Climate warming in the Arctic has caused an expansion of the range of deciduous shrub species in high northern latitudes. However significant the increase in shrub biomass carbon (C), it is modest in comparison with the amount of C stored in the soil in tundra ecosystems. In a Swedish subarctic landscape, we show a shift from tundra to shrubs could lead to a loss of soil carbon that out-weighs the increase in aboveground shrub biomass.

We sampled soil C stocks, soil surface CO<sub>2</sub> flux rates and fungal growth rates along replicated transitions from mountain birch forest (*Betula pubescens*), through shrub tundra (*Betula nana*) to tundra heaths (*Empetrum nigrum*) at Abisko, Sweden. Organic horizon soil C is significantly lower at shrub and forest plots than at heath plots. Shrub vegetation had the highest respiration rates, suggesting that despite higher rates of assimilation, C turnover was also very high. The action of ectomycorrhizal symbionts in the scavenging of organically bound nutrients may be an important pathway by which soil C is made available to microbial degradation. The expansion of shrubs onto potentially vulnerable arctic soils with large stores of carbon could therefore represent a counterintuitive, yet positive feedback to the climate system.



**Keynote 2: Impact of microbial Carbonic Anhydrase on the atmospheric concentrations of CO<sup>18</sup>O and COS at large scales**

Lisa Wingate

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Lisa Wingate is a research scientist at INRA's Physical and Functional Ecology of the Environment Research Unit (EPHYSE) in Bordeaux. She received a grant from the European Research Council (ERC) in 2013 for her promising work on the role of microorganisms in the soil in atmospheric carbon flow on a global scale, in particular through carbonic anhydrase, an enzyme she has studied and characterised.

**Abstract:** Photosynthesis (GPP), the largest CO<sub>2</sub> flux from the land surface, is currently estimated with considerable uncertainty between 100-175 Pg C yr<sup>-1</sup>. More robust estimates of global GPP could be obtained from the atmospheric budgets of other tracers such as, the oxygen isotopic composition ( $\delta^{18}\text{O}$ ) of atmospheric CO<sub>2</sub> or carbonyl sulfide (COS). However, the partitioning of GPP and soil respiration using these tracers hinges on a better understanding of how soil micro-organisms modify the atmospheric concentrations of CO<sup>18</sup>O and COS at large scales. In particular, understanding better the role and activity of the enzyme Carbonic Anhydrase (CA) in soil micro-organisms is a critical factor underpinning the successful partitioning of gross fluxes at the global scale. Within this presentation I will review our understanding of the function of CA in soil micro-organisms and how its activity is likely to be influenced by environmental drivers that give rise to variations in soil CA activity observed in the field.

## **10. Vegetation composition modifies atmospheric warming effects on microclimate**

Tom Walker, Susan E. Ward, Richard D. Bardgett, Nicholas J. Ostle

Warming may feedback to future climate by promoting ecosystem greenhouse gas emissions. However, climate change effects on most ecosystem processes depend on how atmospheric warming alters microclimate. Vegetation also has the potential to regulate near-surface and soil microclimate, but the extent to which the plant community modifies warming effects on microclimate is currently unknown. Here, we present a five-year dataset from a peatland warming and plant functional type (PFT) removal experiment. Our aim was to determine whether different PFTs differentially modify warming effects on canopy temperature, soil temperature, and water table height. We found that dwarf-shrub presence consistently lowered canopy and soil temperature, but also constrained (canopy) or reversed (soil) its responses to warming. Furthermore, graminoids and bryophytes lowered water table height and soil temperature, and graminoids promoted lower soil temperature and higher canopy temperature under warming. Consequently, we reveal that different PFTs strongly affect microclimate, and moreover modify atmospheric warming effects on microclimate. We detail possible mechanisms for these responses and discuss this in the context of peatland carbon cycle responses to a warmer world.

## **11. Does the timing of browsing matter? Investigating the influence of browsing on ecosystem carbon cycling.**

Melanie Hartley, Richard Bardgett, Pete Millard, Alison Hester

Browsing is ubiquitous in forest ecosystems and has been shown to have substantial effects on processes that control ecosystem functioning. We hypothesized that the effects of long term simulated browsing on naturally regenerating *Betula pubescens* influences belowground microbial communities and soil respiration, and that the timing of browsing will be crucial for this response. CO<sub>2</sub> flux data showed a positive feedback on soil respiration for simulated late summer browsing, a unique response when compared to other browsed/unbrowsed studies. This response appears to be facilitated by changes in the microbial community structure and nutrient cycling. To investigate this further we used a controlled mesocosm experiment reproducing field treatments. After 2 years of simulated browsing changes in soil properties and respiration were limited, however evidence of the accumulation of organic matter due to late summer clipping and increased nitrogen availability from dormancy clipping, highlights the importance of the timing of browsing when considering the role of browsing for ecosystem processes.

## **12. Vulnerability of temperate grassland soil carbon to management**

Sue Ward, Andy Wilby, Helen Quirk, Richard Bardgett

Grasslands are important for a range of ecosystem services, including soil carbon storage. Recent evidence suggests that managing grasslands has the potential to increase soil carbon sequestration. We present results from a UK grassland survey of soils to a depth of 1m, comparing soils from different grassland types and varying levels of management intensity. We show that large stocks of carbon are held in grassland soils at depth, which are not accounted for by standard carbon inventories. Further, that these stocks of carbon are vulnerable to management, and that this effect is seen to considerable depth. We found greatest carbon storage in grasslands with an intermediate level of management intensity, and lowest carbon storage in intensively managed low diversity grasslands. Our findings highlight the sensitivity of grassland carbon stocks to management, and the potential to increase grassland soil carbon sequestration alongside biodiversity conservation.

## **13. Developing carbonyl sulphide as a carbon cycle tracer: a cross-system comparison of leaf, soil and ecosystem fluxes**

Kadmiel Maseyk, Wu Sun, Celine Lett, Sabrina Juarez, Thierry Bariac, Ulli Seibt

Carbon cycle studies at ecosystem and regional scales are hampered by difficulties in separating the gross fluxes of photosynthesis and respiration from observations of net ecosystem CO<sub>2</sub> exchange. Tracer-based approaches offer the possibility to help partition these fluxes, the most recent being carbonyl sulphide (COS), which is taken up by leaves in a manner closely coupled with photosynthesis, but COS-CO<sub>2</sub> studies under field conditions are limited. We have measured fluxes of COS and CO<sub>2</sub> at the leaf and soil-scale, using chambers, and at the ecosystem level, by eddy covariance, in a range of ecosystems including agricultural, Mediterranean oak, fresh-water marsh, and tropical rain forest. These measurements support the view that ecosystem COS fluxes are typically dominated by canopy uptake, but the ratio of COS to CO<sub>2</sub> fluxes varies at diurnal and synoptic scales in response to environmental drivers. Soil fluxes vary in both magnitude and direction and are affected by biotic and abiotic factors. Night-time soil uptake and stomatal conductance can influence integrated diel fluxes and are therefore relevant for regional scale carbon flux analyses from airborne measurements. These datasets provide novel information at both component and ecosystem level necessary for the development of the COS-based approach for carbon cycle research.

#### **14. Changes in the carbon in the forest soils under 70 year old oak, set with a 180 year chronosequence from the same forest**

Suzanne Benham, R Pitman, E Vanguelova

The dynamics of soil properties within a 70 year old oak plot were assessed every five years (1994–2009), by depth and horizon to identify short term changes in soil carbon, nitrogen stocks, and acidity. The findings were set within a study of long term changes in soil properties in a 180 year chronosequence of oak plots from the same forest.

Carbon stock increased significantly in the top mineral horizon — overall increase was 5 t C ha<sup>-1</sup>, at a mean accumulation rate of 0.34 t C ha<sup>-1</sup> y<sup>-1</sup>, which was mainly due to increase in horizon thickness. No increase was seen when soils were sampled by depth, so changes are linked to measured inputs from litterfall from the canopy.

Differences obtained by depth or horizon sampling due to changes in horizon thickness over time highlight the importance of horizon in the correct evaluation of soil property change in small scale sampling programs. This is particularly important in forest soils with high litter accumulation and low turnover rates. In the chronosequence study; increases in soil C stocks of 0.1–0.2 t C ha<sup>-1</sup> y<sup>-1</sup> were calculated across young (~25 years), mid-rotation (~60 years) and old (120+ years) stands.

#### **15. Modelling the role of vegetation type and fire on permafrost thaw**

Aaron Thierry, Mathew Williams, James P. Fisher, Cristian Estop-Aragones, Iain P. Hartley, Julian B. Murton, Gareth K. Phoenix, Lorna Street

We tested the sensitivity of modelled active layer depth (ALD) to a series of factors linked to fire disturbance, which is common in boreal permafrost areas. We show how ALD responds to the removal of (i) vascular vegetation, (ii) moss cover, and (iii) organic soil layers. We compare model responses to observed patterns. We investigate the potential for permafrost to recover with reestablishment of vegetation, including mosses, post-fire, over realistic timescales

## **16. From the ground up: modelling soil greenhouse gas emissions at the national level**

Mike Whitfield, Bruce Osborne, Pete Smith, Mike Williams

Agricultural soils are a major global source of greenhouse gas (GHG) emissions. Changes in management, such as the application of fertiliser and tillage practices, offer potential for reductions in overall agricultural GHG emissions. IPCC Tier 1 and 2 approaches are currently used to predict the impact of land-use changes on GHG emissions, but these approaches cannot account for shifts that might occur as a result of management or climate change. Simulating GHG emissions using process-based models offers a way of accounting for these influences as part of a more robust Tier 3 approach.

We are using the DailyDayCent, DNDC, and ECOSSE models to simulate GHG emissions from a range of agricultural systems (pasture, arable crops, energy crops, and forestry), evaluating each model's performance against a validation dataset consisting of over 10,000 observations. Our simulations have highlighted important, ecosystem-specific differences in model performance, so we are also carrying out uncertainty analyses using factorial model runs and Monte Carlo simulations, to determine the most important sources of uncertainty. The best model for simulating each agricultural system will be used to map potential GHG emissions for Irish agriculture at the national level.

## **17. Using multi-scale data to constrain a model of plant growth applied to wheat and maize**

Silvia Caldararu, Matthew Smith, Drew W. Purves

One of the greatest challenges for vegetation models is making accurate predictions at large scales, often global scales, while still correctly representing physiological processes. Traditionally, model parameters are upscaled from field measurements, which results in large errors due to spatial and temporal heterogeneity. The alternative method is to use available data to constrain model parameters at the desired scale. We use remote sensing observations of vegetation from the MODIS and Landsat 7 ETM+ instruments combined with eddy covariance flux measurements and crop yield data to parameterise a process based crop growth model using a Bayesian fitting method. The model is based on the plant optimality hypothesis and predicts daily plant growth throughout the vegetative and reproductive stages. The model uses a representation of plant physiology and responses to temperature, light, water availability and atmospheric CO<sub>2</sub>. We fit this model for two crops, wheat and maize, at several locations corresponding to FLUXNET sites. We explore the extent to which each dataset constrains different model components and use these results to whether there is sufficient data to run this model at larger scales given available data and aim to identify future data needs for a larger scale study.





### **Keynote 3: From microbes to mountains, understanding ecosystems in a global change context**

Aimée T. Classen

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Aimée Classen is an Associate Professor in the Natural History Museum of Denmark at the University of Copenhagen and at the University of Tennessee. She is interested in ecosystems - pretty much everything about them - but her work has focused on understanding how interactions alter ecosystem function. When not thinking about science, she likes to hike (especially in mountains), swim (especially in oceans) and ride her bike (especially around Copenhagen) with her family. You can read more about work in the Classen lab, as well as the excellent team of collaborating students and post-docs, at the lab website:  
<http://web.utk.edu/~aclassen/Home.html>

**Abstract:** How much carbon will terrestrial ecosystems hold in the future? This important question remains uncertain, in part because we don't know how microbial communities will directly and indirectly respond to climatic change. Microbes may influence ecosystem carbon processes in a number of ways including by manipulating plant traits or plant nutrient uptake. These interactions may vary across seasons or ecosystem types. Classen's talk will explore how soil communities shape terrestrial carbon processes across scales from the microbe-root interface to forest range boundaries. Her talk will make four key points: (1) that microbes, even rare ones, can influence important plant traits, (2) Ecological interactions influence spatial variation in decomposition rates, (3) Seasonal variation plays an important role in how microbial communities respond to climatic change, (4) Patterns are not the same everywhere. Classen will end her talk by arguing that one way forward is to experimentally manipulate species interactions as well as warming across ecological systems to see if there are any general responses of ecosystems to global change.

### **18. An assessment of the carbon stored in soils and deadwood in UK forestry**

Elena Vanguelova, Andy Moffat, James Morison

Quantification of UK carbon stocks in forest soils and in deadwood is required for LULUCF reporting under the Kyoto Protocol, and to guide climate change mitigation and biodiversity policy. There have been few attempts to quantify the carbon stocks in forest soils and deadwood, but in this study they were evaluated from 167 plots in the 'BioSoil' survey of Great Britain. The average C stock to 80 cm depth ranged between 108 and 448 t C/ha and varied with soil and forest type. Litter and fermentation horizons on average contributed an additional 7.3 and 8.8 t C/ha, respectively. Upscaling across GB, gave estimates of 546 Mt C in the upper 80 cm, 664 Mt C to 1 m and an additional 42 Mt C in surface organic layers.

Conifers had the largest soil C pool but also in deadwood (5.7 t C/ha), compared to broadleaves (1.7 t C/ha). About 46-52% of the deadwood C stock is in fresh wood, 30-35% in medium decayed class and 15% in highly decayed wood classes. Deadwood C mass was negatively related with stand age and was higher in managed than unmanaged stands. It also declined with canopy density and the provision of fencing.

### **19. A burning issue? Assessing the effects of heather managements on UK peatlands**

Phoebe Morton, Andreas Heinemeyer

Peatlands cover about 3% of the world's surface but store over 30% of its soil organic carbon. This is made possible by constantly high water tables (WTs) that prevent much of the decomposition of *Sphagnum* mosses, which are the main component of British peat. In the UK, there are many threats to the integrity and longevity of peat stores including draining for extraction or farming, burning to encourage heather plants for grouse shooting, and climate change. Many drained peatlands are under restoration and peatlands have previously survived changes in climatic conditions, but effects of heather management on peatland carbon dynamics are underexplored.

This talk presents findings from an ongoing replicated Defra-funded catchment-scale five year study on three peatland sites in north-west England which compares different grouse moor managements, namely burning heather versus mowing it. Gaseous (CO<sub>2</sub> and CH<sub>4</sub>) and fluvial (DOC and POC) fluxes are used to create carbon budgets for different managements. Changes in vegetation composition, specifically *Sphagnum* cover, are also assessed and can be used with WT data to inform on which management strategy may be most effective at preserving and growing the long-term carbon store in the peat as well as sustaining a viable grouse moor.

## **20. Using farmer traits or plant functional traits to increase soil carbon?**

Maarten Schrama, S. Carvalho, W. H. van der Putten

Background/aim: Sustainable food production for a growing world population requires a healthy soil that can minimize its losses. Soil organic carbon (SOC) plays a vital role in providing the necessary soil ecosystem services. Over the last century, SOC has decreased, often with strongly negative consequences on soil fertility, nitrate leaching and yield. Here, we investigate two experiments which aim at changing SOC using different strategies.

Results: In the first (13-year) experiment, we studied the effect of different inputs of organic matter (OM) on SOC. This experiment shows that, although a significant increase in SOC occurs, it is dependent on exceptionally high OM-inputs.

In the second (5-year) experiment, effects of different annual and perennial bioenergy crops on SOC were investigated. Results show that different crops produce comparable yields, but they differ markedly in effects on belowground properties. Most species had a negligible effect on SOC (switchgrass/Miscanthus/maize). However, one species, willow, had a markedly positive effect on SOC, with subsequent positive effects on ecosystem services.

Conclusions: Where OM-availability is high, this can be used to improve SOC. However, high OM-inputs are often not achievable due to lack of locally available OM. Our study highlights the potential of using carbon-sequestering crops to increase SOC.

## **21. Carbon cycling and crop yields: limitations, solutions and implications**

Kate Storer, Pete Berry, Roger Sylvester-Bradley

In the face of an increasing population and changes in diets, there is increased demand for food and feed, and consequently pressure to improve crop yields. Current UK wheat yields have been stagnant for the past 20 years, yet over the same period the yield potential of new varieties has increased by 0.5 to 1% per year, indicating that genetic yield potential is not being fully exploited on farms. Furthermore, studies suggest that UK wheat yields have the potential to double, but this is not yet being realised. However, such a large increase in crop yields would require a substantial increase in the amount of carbon fixed by crops which would have significant implications for carbon cycling at a landscape scale. This presentation will discuss how improving carbon capture by UK wheat crops is necessary to increase crop yields, how this might be achieved, and how it may impact upon carbon cycling at the landscape scale.

### **Dwelling in the deep – increased plant root growth at the thawfront in degrading permafrost soils?**

Gesche Blume-Werry, Ann Milbau, Laurenz Teuber, Margareta Johansson, Ellen Dorrepaal

Northern peatlands contain one third of the global soil organic carbon pool, mostly in permafrost. However, climate warming has led to permafrost degradation and large increases in respiration from subsurface peat. Accompanying the thaw are increases in active layer depths (the soil volume that thaws in summer and is available for plant root growth) and releases of plant-available nitrogen. As plant roots proliferate into nutrient-rich spots, we hypothesize that 1) root growth will be stimulated near the thawfront, leading to local presence of living roots and root litter. This provision of labile carbon could potentially further stimulate (prime) carbon respiration from permafrost soils. Furthermore, we hypothesize that 2) differences in maximum rooting depth between species may shift competitive advantage, potentially affecting species dominance and composition. We use a long-term snow fence experiment (since 2005) increasing active layer depth through passive snow accumulation, combined with deep fertilization, in a permafrost peatland in Abisko, Sweden. We measure rooting depth, root growth and root turnover down to the thawfront with minirhizotrons, and study the uptake of deep N sources. This allows us to shed light on the role of plant roots in the changing carbon balance of degrading permafrost soils in the Arctic.

### **Determining the effects of plant functional traits and environmental variables on soil organic carbon in British lowland peatlands**

Fabio C G da Silva, Dr Kerry A. Brown, Prof Martyn P. Waller, Dr Arnoud Boom

Plant functional traits (PFT) have been shown to be a powerful tool in understanding the ecological mechanisms underlying ecosystem functioning, and enable a more empirically grounded representation of the role of vegetation in the provision of ecosystem services. Determining the response of ecosystem processes to variation in PFT in British peatlands is becoming increasingly important. This study determined whether PFT influences soil organic carbon content (SOC) in lowland fen communities in Britain. We measured leaf traits from 65 of 120 species of vascular plants growing in six distinct plant communities, distributed across two fen systems in East Anglia: Upton Fen, Norfolk and Woodwalton Fen, Cambridgeshire. Model selection showed that leaf carbon content (LC), specific leaf area (SLA) and leaf C/N ratio were the best predictors of SOC in a generalised linear model. LC and SLA were the only two variables consistently shown as important predictors in the top five models, with the best model containing only these two traits. It is expected that, in addition to PFT, other factors such as above ground biomass, litter decomposition and water table variation will also constrain SOC, which are subject to ongoing investigation.

### **Climate-smart *Brachiaria* grasses: advances in identifying role of root traits in soil carbon accumulation**

Juan Andrés Cardoso, Manuel Fernando Vergara, Juan de la Cruz Jiménez, Idupulapati M. Rao

Soil holds as twice CO<sub>2</sub> as does the atmosphere. Most of this carbon arises from plant photosynthesis that is therefore sunk into roots. *Brachiaria* spp. are perennial, C4 and deep-rooting grasses that are widely used to sustain animal production in the tropics. Very importantly, perennial and deep-rooting grasses sequester large amount of carbon in the soil. However, root traits of *Brachiaria* grasses that are involved in soil carbon accumulation are not well understood and this understanding will optimize their use for enhanced carbon sequestration. Advances in identifying root traits (architecture, fine-root turnover and stable carbon compounds: lignin and suberin) of *Brachiaria* grasses that might be involved in soil accumulation are in progress. This work is a component of an inter-institutional program that aims to improve livestock productivity in target areas of Eastern Africa while providing adaptation and mitigation to climate change with the use of climate-smart *Brachiaria* grasses.

### **Mechanisms and controls of priming effects in forest ecosystems**

John Crawford

Forest soils contain the largest terrestrial pool of carbon, which is regulated through complex interactions between plants and soil microbial communities. Although much of the soil carbon pool is relatively stable, environmental change may alter plant-soil interactions and impact upon the stability of soil carbon leading to carbon cycle feedbacks. One such interaction that remains poorly understood is the priming effect, which occurs when inputs of labile organic carbon stimulate microbial mineralisation of carbon stored in the soil. The mechanisms and controls that govern this interaction are still unclear despite its potential impact on carbon sequestration under climate change.

The key aims of my research are to: i) Determine the detailed mechanisms and controls of priming effects; ii) Compare priming effects across a wide range of soils from around the world to explore patterns in priming response and global relevance; iii) Compare small-scale lab incubations to large-scale field experiments

Here, I present ongoing and future experiments on priming effects and highlight some of the issues associated with using lab incubations to explain large-scale ecosystem-level processes.

### **Litter decomposition and home-field advantage during plant range shifts**

Marta Manrubia Freixa, G.F. (Ciska) Veen, W.H. (Wim) van der Putten

The current climate warming enables many native plants to expand ranges to higher altitudes and latitudes. Plants develop in close interaction with soil organisms in a direct (e.g. via pathogenesis) and indirect way (e.g. via the detritus food web). During range shifts, these interactions might become temporally disrupted since soil organisms have limited dispersal capacity. Range-expanding plants might benefit from enemy release. However, they might also lose positive interactions with specialized decomposer organisms.

The “home-field advantage” (HFA) hypothesis predicts that litter decomposes faster beneath the plant from which it originates than away from it due to the presence of specialized decomposer communities. Recent research provides evidence that plants have species-specific associations with decomposer communities. If decomposer microbes are indeed under selection of their host plants, range-expanding plants would possess different microbial decomposer communities than related native plants. How introduction of range-expanding plants will affect local decomposers and native plant communities in the new ranges is, however, an unanswered question. The present research aims to study local specialization by decomposers and HFA of plants that shift range along latitudinal gradients. We test the hypothesis that HFA is lost during range expansion, but that it may increase when time since introduction increases.

**The legacy of past erosion on SOC recovery through no-till agriculture: evidence from carbon-13 and caesium-137 analysis of samples from 40-year old no-till maize experiment at Coshocton, Ohio.**

Sankar Mariappan, Jennifer A.J. Dungait, Joshua Beniston, Timothy Quine

Soil erosion is the most important form of soil degradation and the identification of strategies to minimise the loss of soil organic carbon (SOC) through erosion and maximise its retention in land is of global importance with respect to both global climate change and food security. Adoption of no-till agriculture, residue management and manure application are considered important elements in the management and restoration of eroded landscapes. Nevertheless, there is a need to understand the legacy of past erosion on SOC and soil quality recovery rates over meaningful (decadal) timescales. We address this under-studied problem here through a novel combination of carbon-13 and caesium-137 analysis of samples from the North Appalachian Experimental Watershed at Coshocton (Ohio), USA. There, a 40 year investigation of the potential to use no-till agriculture to reduce erosion rates and restore SOC has been conducted. In the study reported here, we use caesium-137 to reconstruct erosion rates at the site and its influence on SOC recovery down the soil profile to 1 m. We elucidate the latter process by using carbon-13 to quantify the inputs and losses of carbon from long-term no-till maize cropping in the recovery of SOC along the slope profile.

**Tree species effect on soil carbon dynamics under climate change**

Eduardo Medina Barcenas, Emma Sayer

Forest ecosystems are widely recognized as the largest repositories of terrestrial carbon (C). However, despite the increase in forest dynamics research, little attention has been given to forest soils (which can contain more C than aboveground biomass), and the effect different tree species have on belowground C dynamics.

The aim of this research project is to understand how different tree species affect belowground C dynamics via organic matter inputs. Using a novel approach combining field and lab experiments at two forests in England, we will perform litter manipulation and root exclusion experiments to evaluate species-specific effects on C dynamics at multiple scales. The results obtained from my project will be used to improve our current understanding of forest C dynamics under climate change. Moreover, information on the impact of different tree species will provide an insight into reforestation efforts and forest management.

### **Carbon and nutrient by seed/cone additions to the forest floor: do mast years have lasting effects?**

Rona Pitman, Suzanne E. Benham, Brenda Mayle

Long term litterfall records in UK forest stands of the ICP Forests network have provided 10+ years of reliable measurement of coning/seeding under even aged broadleaf and conifer trees. Effects of latitude and rainfall are obvious and soil type drives site seed/cone productivity. Seed/cone C proportions of litterfall added to the forest floor was highest under Scots pine (6-30%), and lowest under oak species (3-5%). Beech cupule C loads varied between 5-17%. C:N ratios, highest for new pine cones and lowest in oak cups, are influenced by local atmospheric N levels.

Seed/cone release of C and N to the forest floor was followed in two pathways: A) by repeat winter sampling along transects monitoring mammal predation (2004-2011) and B) by depth analysis of selected soil profiles (2011). Decay rate values were calculated for seed/cone fractions in network A at all sites for year one (e.g. oak cups  $k=0.5-0.7$ ; pine cones 0.11), and over longer time spans at sites without new addition of seed. Long residence times of pine cones in acid soil litter and F horizons contrast with fast oak cup decay in base rich soils. Annual C release from seed/cone input was most variable at beech sites (125-600 kg.ha<sup>-1</sup>).

### **Home-field advantage: the role of specialized decomposers in accelerating decomposition processes**

Ciska Veen, David Wardle

The 'home-field advantage (HFA) hypothesis' predicts that plant litter is decomposed faster than expected in the vicinity of the plant where it originates from (i.e., its 'home') relative to some other location (i.e., 'away') because of the presence of specialized decomposers. However, HFA effects appear highly variable and context-dependent. Using a field experiment and a literature synthesis we evaluated if HFA effects were modulated by macroclimate, litter quality traits, and the dissimilarity between 'home' and 'away' plant communities. In our literature survey we found that decomposition was on average 7.5% faster at home than away, however HFA in our field experiment was limited. Both in the literature survey and the field study variation in HFA effects could not be explained by macroclimate and litter quality. The most significant drivers of home-field effects were the dissimilarity in plant community composition and litter quality between the 'home' and 'away' locations. Our study shows that rapid changes in plant community composition, particularly when new plants have very dissimilar litter quality, may disentangle plant species and specialized decomposer communities, resulting in altered decomposition processes.



**Carbon cycling in soil: unravelling the effects of soil heterogeneity and plant community diversity under variable climatic conditions**

Anna Wilkinson, Richard Bardgett, Nick Ostle, Simon Oakley, Liz Baggs, Dave Johnson

Responses of grassland communities to climate manipulations have yielded mixed results (e.g. Whytham vs. Buxton grassland manipulation studies; Grime et al. 2000) and it is thought that substrate heterogeneity may decouple community responses to climate forcing. Furthermore, it is possible that soil heterogeneity could play an important role in buffering plant communities against climatic fluctuations. However the relative roles that soil heterogeneity and plant community diversity play in carbon (C) cycling under variable climatic conditions remain unclear.

Using a mesocosm design that allowed us to manipulate soil depth and soil depth heterogeneity, we examined how two grassland communities of contrasting plant diversity (representing a MG6 *Lolium perenne*-*Cynosaurus cristatus* grassland and a MG3b *Anthoxanthum odoratum*-*Geranium sylvaticum* grassland) responded to a drought event when grown in pots containing either shallow (7 cm), intermediate (14 cm) or deep (21 cm) soil, or in pots where soil depth varied, with pockets of shallow, intermediate and deep soil.

We will report on changes with soil depth to plant community composition and productivity, following drought, within the two grassland plant communities, along with the response of the soil microbial community structure, and the subsequent effects on soil C pools and CO<sub>2</sub> emissions

## List of presenters



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- Ecosystem Ecology
- Climate Change & Ecosystem Services
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- Biodiversity, Conservation & Ecosystem Services
- Parasites, Pathogens, Predators, Pollinators and more Ps!

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- Gala Dinner with Warblefly (live music)
- Innovative, fun networking events

### Keynote Speakers:



**Pedro Jordano:**  
Heads Spanish panel for the National Research Plan, Ministerio de Ciencia e Innovación



**Anne Larigauderie:**  
Head of Science in Society at the International Council for Science



**Camille Parmesan:**  
In her capacity as a Lead Author, she shared the 2007 Nobel Peace Prize to IPCC

## 10 Thematic Symposia:

- **Ecological networks: from descriptions to predictions**  
*Sonia Kéfi, Timothée Poisot, Daniel B. Stouffer*
- **Eco-evolutionary feedbacks: theoretical and empirical perspectives**  
*Florence Débarre, François Massol*
- **Ecological Implications of Tree Diseases**  
*Alison Hester, Glenn Iason, Ruth Mitchell, Andy Taylor*
- **Pan-European Parasite Ecology: Linking Early-Career Researchers**  
*Jon Bielby*
- **Ménage à trois: ecological consequences of intricate interactions between plants, microbes and insects**  
*Arjen Biere, Enric Fraga*
- **Accelerating ecology and biodiversity research via ecometagenomics: species, communities, and environmental DNA**  
*Holly Bik, Simon Creer, Dorota Porazinska, W. Kelley Thomas*
- **Reforming and implementing the Common Agricultural Policy, the role of science and the need to understand policy-making**  
*Andras Baldi, Tim Graham, Guy Pe'er, Piero Visconti*
- **Biological impacts of climate change: Reconciling macro-scale patterns with local-scale processes**  
*Richard Pearson, Blake Suttle*
- **Extending freshwater management beyond shorelines by linking aquatic and terrestrial ecosystems**  
*Andrew J. Tanentzap*
- **Genomics in marine monitoring: New opportunities for assessing marine health status**  
*Matthias Obst, Elisabeth Paymal*