**Project title:** Methane and N\textsubscript{2}O fluxes in temperate forests: reconciling scales and source-sink attribution of powerful greenhouse gases at high temporal resolution (CASE)

**Project code:** OU8

**Host institution:** The Open University

**Theme:** Evolution & Ecosystems /Biogeochemistry

**Key words:** Greenhouse gases, ecosystems, forests, climate, biosphere-atmosphere exchange.

**Supervisory team:** Prof. Vincent Gauci, Open University (vincent.gauci@open.ac.uk), Dr. Kadmiel Maseyk, Open University, (kadmiel.maseyk@open.ac.uk), Dr Sirwan Yamulki (Forest Research, CASE Partner)

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**Project Highlights:**
- Work to understand the true climate benefits of forests and forestry.
- Gain highly employable technical skills in quantifying the exchange of powerful greenhouse gases.
- Work in a climate related area of ecosystem science and biogeochemistry

**Overview:**
What exactly are the climate benefits of forests? This project seeks to train a student to answer this question for temperate forests using the latest analytical techniques to examine how trees exchange powerful greenhouse gases with the atmosphere. In doing so they will add to existing knowledge on CO\textsubscript{2} exchange and sequestration in forests. Trees are well known to exchange CO\textsubscript{2} and water vapour with the atmosphere. However, it has recently been shown by the Open University group that trees on free draining soils can also exchange the powerful trace greenhouse gases methane (CH\textsubscript{4}) and nitrous oxide (N\textsubscript{2}O). This overturns our current understanding of how forest ecosystems function since only forest soils are currently considered as exchange surfaces for these gases. This is important as 1) CH\textsubscript{4} and N\textsubscript{2}O are ~30 and 300 times more powerful than CO\textsubscript{2} at trapping incoming solar radiation and 2) tree stem surfaces can represent a much larger exchange surface than the soil surface. With a limited number of flux measurements from upland tree stems in the Amazon, Panama, the UK and Sweden, there is evidence that tree trunk bases can emit CH\textsubscript{4} and N\textsubscript{2}O but this switches to uptake above breast height. The net effect for tropical and boreal forests is that trees can enhance uptake of CH\textsubscript{4} which makes the trees as large a methane sink as the soils in which they are growing. Our limited studies of UK forest, however, show that trees can switch from net sinks to sources of CH\textsubscript{4} depending on the season. It is therefore critical to identify the direction of exchange of fluxes of CH\textsubscript{4} and N\textsubscript{2}O in UK forests and their controlling variables since this has important implications for the UKs greenhouse gas inventory as well as for properly quantifying the climate impact of the biofuel and timber industries. Should UK temperate forests show a similar net uptake of CH\textsubscript{4} as tropical and boreal forest this would mean that natural forest and the timber and wood-based biomass industries may be more climatically beneficial than previously thought.

**Methodology:**
The student will quantify methane and N\textsubscript{2}O exchange at a range of scales over full annual cycles at a Forest Research managed oak woodland in Surrey, UK (Alice Holt). There, two methods will be employed, firstly eddy covariance using the latest analytical instruments positioned on a tall tower to measure ecosystem scale exchanges of methane and N\textsubscript{2}O and secondly, flux chambers at the forest floor/tree stem level in order to quantify the various exchange paths of the greenhouse gases in question and reconcile them with the tower measurements. The chamber measurements will be made using a combination of syringe sampling (for later analysis at the Open University) and in situ sampling and analysis using laser spectrometers.

**Training and skills:**
The student will gain training in the latest equipment for the measurement of N\textsubscript{2}O and CH\textsubscript{4} using both eddy
covariance (EC) and chamber methods at the Forest Research field site at their Alice Holt site in Surrey. The OU researchers specialize in chamber methods from soils and tree stems whereas Forest Research have an eddy covariance tower in operation and the latest optical methods for measuring N2O at high temporal resolution integrating over a large forest footprint. VG and SY have been developing the project for some time and all required expertise to train the student is in place. KM is a plant physiologist with expertise in EC across a range of landscapes.

NERC CENTA students are required to complete 45 days training throughout their PhD including a 10 day work placement. In the first year, students will be trained as a single cohort on environmental science, research methods and core skills. Throughout the PhD, training will progress from core skills sets to master classes specific to CENTA research themes.

Partners and collaboration
The project benefits from close collaboration with the CASE partner institution Forest Research. They have excellent access to well instrumented and monitored forests and they have expertise in eddy covariance methods of quantifying GHG exchange at the ecosystem level.

Possible timeline:
Year 1: Perform a literature review, identify monitoring sites. Learn the eddy covariance technique and establish the soil and tree collar setup to commence monitoring.
Year 2: Perform the bulk of the measurements of methane and N2O. Identify, for a single measurement campaign, how the bottom-up and top-down measurements correspond. Submit manuscript 1 on initial findings/early campaign. Present at British Ecological Society.
Year 3: Finalise data collection and analysis, submit manuscripts 2 and 3 on each of CH4 and N2O fluxes at all scales, and complete thesis, present at European Geophysical Union in Vienna.

Further reading:


Further details:
Students should have a strong background in ecology/geography/environmental science be numerate together with an enthusiasm for fieldwork. Experience of fieldwork is desirable. A full UK driving license is essential. The student will join a well-established team researching forest ecosystems at the Open University and at Forest Research.

Please contact Prof. Vincent Gauci (v.gauci@open.ac.uk) for further information.

Applications should include:
- a cover letter outlining why the project is of interest and how their skills match those required,
- an academic CV containing contact details of three academic references
- a CENTA application form, downloadable from: http://www.centa.org.uk/media/1202/centa-studentship-application-form.docx
- and an Open University application form, downloadable from: http://www.open.ac.uk/students/research/sites/www.open.ac.uk.students.research/files/documents/Application%20form.docx

Applications should be sent to STEM-EEES-PhD-Student-Recruitment@open.ac.uk by 5 pm on Monday 22nd January 2018