CENTA Project Proposal Form – 2024 entry

Project Title	**Tree greenhouse gas emissions in response to stress and environmental change**
University (where student will register)	The Open University
Which institution will the student be based at?	As above
Theme (Max. 2 selections)	Climate & Environmental Sustainability ☒ Organisms & Ecosystems ☒ Dynamic Earth ☐
Key words	Land-atmosphere interactions; terrestrial biogeochemical cycles; biosphere; atmosphere
Supervisory team (including institution & email address	**PI: Alice Fraser-McDonald** **The Open University, alice.fraser-mcdonald@open.ac.uk** **Co-I: Carl Boardman** **The Open University, carl.boardman@open.ac.uk**
Is the PhD suitable for part time study?	Yes ☒ This is a requirement of NERC

Project Highlights:

- Biogeochemistry project with links to climate change consequences
- Practical project with potential for field and lab-based experiments.
- Impact on current GHG budgets and future emissions predictions

Overview:

Greenhouse gases (GHGs), such as methane (CH_4) and nitrous oxide (N_2O), contribute to the warming of the lower atmosphere and planetary surface. Atmospheric GHG concentrations have increased dramatically since the industrial revolution, causing a significant warming trend in the Earth's climate. It is important to quantify natural and human-induced GHG emissions for the development of climate research and global GHG budgets. The aim of this project is to investigate how GHG emissions from plants are affected by stress and environmental change (Figure 1).

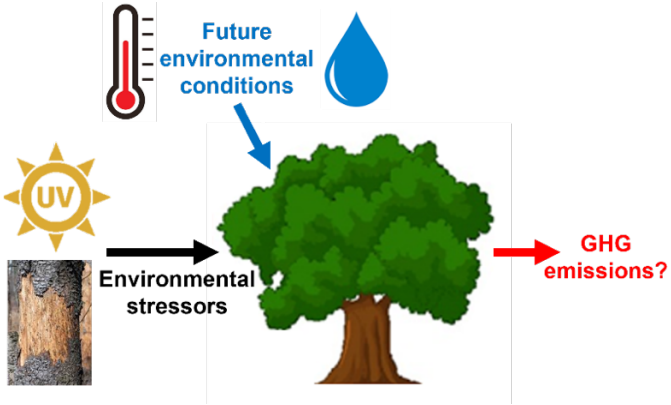

Figure 1: Graphical representation of the scope of the research project.

Alt Text: An image summarising the main themes of the PhD project. Arrows from images representing environmental stressors (herbivory, UV radiation) and future environmental conditions (temperature and moisture) point towards a tree in the centre. An arrow labelled 'GHG emissions?' points away from the tree to represent the unknown change in GHG emissions due to the factors represented by the arrows that point towards the plant.

Plants directly release GHGs under aerobic conditions (Keppler *et al*., 2006), as well as indirectly providing an emission pathway for GHGs produced in anoxic soils (Pangala *et al*., 2015). Aerobic GHG production in plants can be caused by environmental stressors such as UV radiation, temperature, water, and herbivory (Bruhn *et al*., 2009; Gorgolewski *et al*., 2022). Evidence for aerobic methanogenesis caused by environmental stressors is either from laboratory studies rather than *in situ* measurements, or from the foliage and branches of trees rather than stems. This project would involve novel investigations into the effect of environmental stressors on the magnitude of GHG emissions from trees.

Under future climatic and atmospheric conditions, variations in environmental conditions are likely to alter the magnitude of GHG emissions from plants. The average global surface temperature from 2018-2100 is predicted to be higher than the 1850-1900 average by up to 1.8°C under the lowest GHG emissions scenario and up to 5.7°C under the highest emissions scenario. Variables such as temperature and moisture are known to affect GHG production and transport through trees over seasonal timescales (Pangala *et al*., 2015). However, the potential effects of changing environmental conditions due to predicted global warming on plant GHG emissions (from either aerobic or anaerobic GHG sources) have yet to be assessed. During this project, experiments will be developed to determine the expected changes in GHG emissions from plants under future climate and environmental scenarios.

Methodology:

This project would involve fieldwork, including measuring CH_4 and N_2O emissions from tree stems and plants. These measurements would likely be conducted using a gas sampling method which uses a recirculating closed-loop system between gas flux chambers and a GHG analyser. There may also be the potential to measure larger fluxes using gas sensors affixed to a drone. These techniques can be used to measure GHG fluxes *in situ*. Laboratory and mesocosm experiments would be developed to investigate how GHG emissions from plants may change under altered environmental conditions. The gas sampling method would be used in a laboratory setting to measure emissions from plants growing in controlled environment units. Data would be scaled up to provide estimates of national and international significance in terms of GHG budgets and a global warming context.

Training and skills:

Students will be awarded CENTA2 Training Credits (CTCs) for participation in CENTA2-provided and 'free choice' external training. One CTC equates to 1⁄2 day session and students must accrue 100 CTCs across the three years of their PhD.

Training and support will be provided for planning and carrying out field and lab-based experiments. If appropriate, General Visual Line of Site (GVC) training will be arranged for the student to allow them to pilot an unmanned aircraft to collect gas emissions measurements. Students will also develop skills in statistical analysis and presentation of quantitative data using software such as R, SPSS and Origin.

Possible timeline:

Year 1: Undertake a literature review and develop methods required for experimental work including chamber design, training with GHG analyser, and drone training (if appropriate). Locate appropriate field sites and plan field and lab work.

Year 2: Carry out fieldwork across a range of sites to understand the effect of environmental stressors on the magnitude of GHG emissions from trees. Conduct lab work using controlled environment units to determine the expected changes in GHG emissions from plants under future climate and environmental scenarios. Perform statistical analysis of collected data and use preliminary results to inform follow-up lab and fieldwork.

Year 3: Final lab and fieldwork based on findings from the previous years and completion of data analysis. Write up the results of the project and submit a thesis. Possible publication of paper(s) would be strongly encouraged.

Further reading:

Bruhn, D., Mikklesen, T. N., Obro, J., Willats, W. G. T., and Ambus, P. (2009) 'Effects of temperature, ultraviolet radiation and pectin methyl esterase on aerobic methane release from plant material' *Plant Biology*, 11 (S1), pp. 43-48. DOI: 10.1111/j.1438-8677.2009.00202.x.

Gorgolewski, A., Vantellingen, J., Caspersen, J. P., and Thomas, S. C. (2022) 'Overlooked sources of methane emissions from trees: Branches and wounds', *Canadian Journal of Forest Research*, 52 (8), pp. DOI: 10.1139/cjfr-2021-028.

Keppler, F., Hamilton, J. T. G., Braß, M., and Röckmann, T. (2006) 'Methane emissions from terrestrial plants under aerobic conditions', *Nature*, 439(12), pp. 187-191. DOI: 10.1038/nature04420.

Pangala, S. R., Hornibrook, E. R. C., Gowing, D. J., and Gauci, V. (2015) 'The contribution of trees to ecosystem methane emissions in a temperate forested wetland', *Global Change Biology*, 21, pp. 2642 - 2654. DOI: 10.1111/gcb.12891.

Further details:

This project would suit someone with a strong background and interest in environmental science, or a related scientific discipline. A proven ability to conduct experimental work and carry out statistical analyses would be desirable, but not essential. The successful applicant would work in the Environment and Sustainability team in the School of Engineering and Innovation at the Open University.

For further information, please contact alice.fraser-mcdonald@open.ac.uk.