Project Title	**Resilience of soil surface microbial communities and biogeochemical cycling proceses to extreme weather**
University (where student will register)	University of Warwick
Which institution will the student be based at?	As above
Theme (Max. 2 selections)	Climate & Environmental Sustainability ☒ Organisms & Ecosystems ☒ Dynamic Earth ☐
Key words	Extreme weather, soil, microbiome, biodiversity, erosion, biogeochemistry
Please explain how the project fits within the NERC remit	The project fits NERC science areas of ecology, biodiversity and systematics, environmental microbiology and environmental genomics
Supervisory team (including institution & email address	**PI:** Professor Gary Bending, School of Life Sciences, University of Warwick, gary.bending@warwick.ac.uk **Co-I:** Dr Ryan Mushinski, School of Life Sciences, University of Warwick, rymush@iu.edu Prof Jane Rickson, Cranfield Soil and Agrifood Institute, Cranfield University, j.rickson@cranfield.ac.uk

Project Highlights:

- Biological soil communities (BSC) at the soil surface perform vital ecosystem functions, including C and N fixation, and protection of the soil surface from erosion.
- You will quantify the ecosystem functions of BSC in temperate soils and investigate the way in which they will be affected by climate change, including extreme weather events
- You will use a wide variety of cutting edge microbiological, molecular biology and gas analysis techniques, including novel gas sensor technologies for continuous reporting of both greenhouse gas emissions from soil and other soil metabolic activity.

Overview (including 1 high quality image or figure):

Soil possesses a complex biological layer at the surface, comprised of cyanobacteria, bacteria, algae and bryophytes. These have been well studied in deserts, where they have considerable environmental importance because of their role in nitrogen and carbon fixation, determining water infiltration and evaporation and protecting the soil against erosion. We have shown that such biological soil crusts (BSC) can also form in temperate soils, and have similar biological compositions to those in desert soils, suggesting that they may perform similar, vital, ecosystem roles.

Climate change is affecting weather patterns, increasing the frequency, magnitude and duration of extreme weather events such as high temperature, drought, flooding and extreme rainfall. Since BSC inhabit the interface between the atmosphere and the soil, the resilience of BSC to changes in weather patterns is likely to play a key role in determining how extreme weather events impact soil sustainability and resilience of its ecosystem functions.

In this project you will investigate the functions of BSC in temperate soil, and the way in which these will be impacted by climate change, including extreme weather events.

Methodology:

You will investigate the ecosystem functions of BSC including their role in the production and consumption of greenhouse gases, and the extent to which they fix N from the atmosphere. This will be complemented with molecular profiling of functional genes and metagenomic profiling, to provide a mechanistic understanding of the way in which BSC drive soil biogeochemical cycles. You will also investigate the potential of the BSC to alter the physical structure of the soil surface and to protect the soil against erosion. You will use the unique rainfall simulation facilities at Cranfield to test the resilience of BSC ecosystem functions to future climatic regimes and extreme weather events. Within the programme you will investigate the potential for using sensor technology which is currently being developed at Warwick to provide continuous reporting of greenhouse gas and other metabolite emissions from soil, enabling fine level resolution of BSC community responses to weather.

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 will be provided in a wide range of molecular techniques (DNA extraction, PCR, sequencing), metagenome sequencing and bioinformatics, and in environmental analysis techniques, including soil physical and biological characterisation. Access to rainfall simulation facilities will also bring skills in replicating the dynamic processes of soil erosion at realistic spatial and temporal scales. You will also have opportunities to investigate biogeochemical processes, including greenhouse gas emissions

Partners and collaboration (including CASE):

Name of L1/L2 Partner (where applicable)	
Name of CASE partner (where applicable – project proposal **must** be accompanied by a letter of support from the CASE partner)	

Further information on partners and collaboration (including CASE):

Possible timeline:

Year 1: Development of sensor technologies and functional analysis of soil crust communities
Year 2: Characterise effects of weather treatments on BSC and their functional roles
Year 3: Fine level resolution of GHG and metabolite emissions from BSC using sensor techniques

Further reading:

Belnap, J. (2006) The potential roles of biological soil crusts in dryland hydrologic cycles. *Hydrological Processes* **20**, 3159-3178.

Mullan, D. (2013) Soil erosion under the impacts of future climate change: Assessing the statistical significance of future changes and the potential on-site and off-site problems. *Catena* **109** 234–246.

Porada et al. (2019) Global NO and HONO emissions of biological soil crusts estimated by a process-based non-vascular vegetation model. *Biogeosciences* **16**, 2003–2031.**Further reading:**

Further details:

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