**Project Title**

Does riparian woodland increase the resilience of stream ecosystems to floods and droughts?

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**Full Project Description**

Climate change is predicted to affect rivers both via a shift in average conditions (e.g. increasing temperatures) and more frequent and/or extreme floods and droughts. Whilst evidence for the effects of warming on river organisms is increasing e.g. [1], the effects of climatic fluctuations are less well studied in a climate change context, but could also have major impacts upon riverine communities [2]. In response to climate warming, recent research has demonstrated that riparian broadleaved trees and woodland have the potential to moderate temperature extremes via shading of the channel e.g. [3]. In theory, differences between wooded and open streams, such as coarse wood in the channel, basal resource quality, quantity and variability, and consequent food web structure could affect their resilience to extreme events too [4]: an increase would reveal a secondary benefit of riparian trees, whilst a reduction in resilience may moderate the extent to which trees are encouraged in riparian zones. Drawing on long-term data sets and newly-developed molecular methods for resolving food webs [5], the PhD would: i) assess the temporal variability of the invertebrate community and food web in wooded streams compared to those in open habitats, ii) test whether the presence of trees increases resilience to climatic fluctuations, and iii) model the link between basal resources, food web structure and temporal stability. By combining fieldwork, molecular analysis and modelling, the PhD will both document pattern and look at the underlying mechanisms. The results have the potential to directly inform conservation and policy. The project is a collaboration between Cardiff and Bristol Universities, Forest Research and the Woodland Trust. The student would be based primarily in Cardiff, but with regular visits to Bristol (<1h travel) and the project partners, and with extensive fieldwork in SW England/Wales. The programme of work draws on several contemporary approaches in ecology (e.g. network analysis; molecular dietary analysis), and works closely with two key stakeholders in the area, providing a rich training environment for the student and opportunities both to build professional networks and maximise research impact. This will be enhanced by training modules within the Fresh CDT and the extensive range of skills training courses provided by Cardiff and Bristol. References: 1. Durance I. & Ormerod S.J. (2007) Glob. Change Biol., 13, 942–957. 2. Woodward, G. et al. (2016) Phil. Trans. R. Soc. B, 371, 20150274. 3. Broadmeadow, S.B. et al. (2011) River Res. Appl., 27, 226–237. 4. Thomas, S.M. et al. (2016) Glob. Change Biol. 22, 310-324 5. Pearson, C.E. et al. (2018) Mol. Ecol., in press.

**Real Life challenges this project will address**

How can the integrity of freshwater ecosystems be maintained as the climate changes? Practical management tools are required to increase the resilience of freshwater ecosystems to climate change, reducing extinction risks, maintaining ecological processes and continuing to support ecosystem services supplied by rivers. Altering land management in the riparian zone could be an important approach, and recent work including some by Forest Research and Cardiff (e.g. [1, 2]) has shown the potential of broadleaved trees to reduce the temperature extremes associated with rising temperatures. Such work has fed into management recommendations (e.g. [3, 4]). An important second, often overlooked, component of climate change is the increasing frequency and/or magnitude of extreme events, and the PhD would address this aspect: whether broadleaved tree cover can increase the resilience of stream ecosystems to such events. References: 1. Broadmeadow, S.B. et al. (2011) The influence of riparian shade on lowland stream water temperatures in southern England and their viability for brown trout. River Res. Appl., 27, 226–237. 2. Thomas, S.M. et al. (2016) Beyond cool: adapting upland streams for climate change using riparian woodlands. Glob. Change Biol. 22(1), pp. 310-324 3. Nisbet, T. et al. (2011) Woodland for Water: Woodland measures for meeting Water Framework Directive objectives. Forest Research Monograph, 4, Forest Research, Surrey, 156pp. 4. Woodland Trust (2016) Keeping Rivers Cool: A Guidance Manual.

**What you should know about this project**

Rivers support high biological diversity, much of which is sensitive to climate change via rising temperatures and greater discharge variation (more frequent and/or larger floods and droughts). Land management within the riparian zone and wider catchment may provide a way of reducing this sensitivity, and increasing the resilience of rivers to global change. The PhD will test whether the changes in river communities associated with riparian broadleaved trees make them more resilient to floods and droughts. It will make an important contribution to this field, which in turn could guide management recommendations, as has work on the role of trees to reduce the effects of high summer temperature (e.g. [1]). The project builds on research and collaborations developed through the recent £3.1m NERC-funded 'Diversity of Upland Rivers for Ecosystem Service Sustainability' (Duress) project and BBSRC-funded work looking at agricultural effects on streams. It will apply cutting edge science to appraise a land management prescription. There will be rich training opportunities through the modern ecological methods used by the project (e.g. molecular analysis of trophic interactions, network analysis), combined with the training modules of the Fresh CDT and the graduate training programmes offered by Cardiff and Bristol, with stakeholder input from Forest Research and the Woodland Trust throughout. The supervisory team brings together leading researchers in freshwater/global change, woodland-hydrology interface, molecular dietary analysis and ecological networks, and two key stakeholders in woodland conservation, management and promotion. The supervisory team was selected to provide complementary expertise in the key areas of the project and has a proven track record of collaboration (e.g. >30 papers and 10 current/recent PhD projects feature two or more of the supervisory team). Reference: 1. Woodland Trust (2016) Keeping Rivers Cool: A Guidance Manual.

**What expertise you will develop**

Through the 3.5 years, the student will develop skills across three levels of specialisation: 1. Transferable scientific skills, including written and oral communication; data analysis with R software; standard molecular laboratory skills; fieldwork; health & safety assessment; and working with landowners and other stakeholders. Training on these will be provided by the supervisors and the extensive skills courses that are an integral part of the Fresh CDT, along with more general graduate courses e.g. those offered by Cardiff’s Graduate College 2. General freshwater expertise, supported by the CDT-specific courses that form part of Fresh. This will include policy, research techniques, contemporary issues in freshwaters and interactions with stakeholders/development of professional networks. 3. Project-specific skills and expertise, including: advanced data analysis and modelling of community data; freshwater taxonomy; molecular dietary analysis; riparian management policy and practice. These will be provided by the supervisory team and members of their research groups, along with dedicated courses, where appropriate. The mix of these three elements will depend upon the individual’s prior expertise and needs, guided by a skills gap analysis.

**Why this project is novel**

There are three novel factors: 1. The science. The effects of extreme climate events on freshwaters have been overlooked relative to changes in average conditions (Woodward et al. 2016), and this is certainly the case for the role of trees for potential climate mitigation. 2. The collaboration. The cross-sector supervisory team (academia, government and NGO) covers research, practice and policy, and should maximise dissemination of the results and impact. 3. The methods. We were amongst the first to use next generation sequencing to construct high-resolution food webs for freshwater invertebrates [1]. The PhD should provide a powerful demonstration of the approach and allow us to develop it further. The combination of approaches - long-term data, fieldwork, molecular analysis of trophic interactions and modelling of food web structure and dynamics – provides a contemporary, multifaceted approach to freshwater research. Reference: 1. Pearson, C.E. et al. (2018) The effects of pastoral intensification on the feeding interactions of generalist predators in streams. Molecular Ecology, in press.

**Rest of Supervisory Team:**

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