Going to extremes: impact of severe drought on riverine ecosystems

Supervisors; Prof. Alexander Milner, Dr Mark Ledger, Dr Scott Hayward (BioSciences), Dr Francois Edwards (CEH)

Project summary

In many regions, climate change is expected to reduce rainfall and bring about drought conditions, and water abstraction and river diversions may also reduce flows in rivers and streams. To date, relatively little work has been done to measure the effect of low flows on aquatic biodiversity, and less known about impacts on important processes, such as decomposition, and primary and secondary production, that affect water quality and shape ecosystem goods and services. The main aim of the proposed research project is to understand how low flows influence the structure of stream ecosystems, at the mesocosm scale and temporal (experiments, long-term data sets) scales and the effect on ecosystem functioning. Our experimental approach will use mesocosm flow manipulations (e.g. Ledger et al. 2008, 2011, 2013; Brown et al. 2011) at a new outdoor laboratory on the Birmingham campus and associated field experiments to inform our understanding of these systems. We will also employ physiological assessments of stress tolerance and determine how effective laboratory indices are in predicting species performance within the mesocosms. The research will yield data that improves the assessment of drought and further understanding of resilience under climate change. Specifically, the primary objectives of the project are:

1. To determine the impact of, and resilience to, varying intensities of low flow stress on natural assemblages (algae, macroinvertebrates), and associated ecosystem processes.
2. To determine the effect of drought on the stress tolerance of macroinvertebrates and how this tolerance influences ecosystem functioning.

Research Theme

Climate models predict widespread shifts in regional rainfall patterns that are likely to exacerbate droughts. Across Europe, droughts have already increased dramatically, in frequency and intensity, over the past thirty years (1976-2006), with the number of people affected expanding by almost 20% on the preceding period. Droughts typically reduce hydrological connectivity and habitat availability in streams and increase the deposition of fine sediments, over a range of spatiotemporal scales. In any given river system, impacts on the biota are likely to be a function of the hydrologic characteristics of the disturbance regime itself. Despite its clear logical appeal, this general hypothesis has not been tested in field manipulations. Droughts do vary in severity and the ecological effects of events causing low flows (low severity) are likely to be very different from more extreme events producing substratum drying and periodic loss of wetted habitat (high severity). An important knowledge gap, and key to defining system tipping points, is to quantify the stress tolerance limits of species within these communities. It is imperative that we identify how drought regimes influence riverine ecosystem structure and functioning if we are to develop a mechanistic understanding, and ultimately, an ability to predict and effectively monitor the consequences of future hydrologic change.

Research Training: The successful candidate will receive inter-disciplinary training in hydroecology and hydrochemistry from staff and students within the Water Sciences Research Group in the School of Geography Earth an Environmental Sciences (GEES) and the Biosystems and Environmental Change (BEC) theme within the School of Biosciences, University of Birmingham. Both Schools support a large, vibrant and well resourced community of postgraduate researchers.

Further reading:

Ledger, M.E., Brown, L.E., Edwards, F.K., Hudson, L.N., Milner, A.M., Woodward, G. (2013). Extreme climatic events alter complex food webs: evidence from a mesocosm drought experiment. *Advances in Ecological Research*, 48, 343-395.

Ledger M.E., Brown L.E., Edwards F., Woodward G., Milner A.M. (2013) Drought impacts on the structure and functioning of complex food webs. *Nature Climate Change*, 3, 223-227.

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Ledger, M.E., Edwards, F., Brown, L.E., Woodward, G. & Milner, A.M. (2011) Impact of simulated drought on ecosystem biomass production: an experimental test in stream mesocosms. *Global Change Biology*, 17, 2288-2297.

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Woodward, G., Benstead, J.P., Beveridge, O.S., Blanchard, J., Brey, T., Brown, L., Cross, W.F., Friberg, N., Ings, T.C., Jacob, U., Jennings, S., Ledger, M.E., Milner, A.M., Montoya, J.M., O'Gorman, E.O., Olesen, J.M., Petchey, O.L., Pichler, D.E., Reuman, D.C., Thompson, M.S., Van Veen, F.J.F., and Yvon-Durocher, G. (2010) Ecological networks in a changing climate. *Advances in Ecological Research*, 42, 71-138.

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Contact details for applications: Gretchel Coldicott: m.e.ledger@bham.ac.uk g.coldicott@bham.ac.uk; for further information about the project contact Mark Ledger:

This PhD is competition funded at Home&EU level, and applicants should apply via http://www.birmingham.ac.uk/postgraduate/courses/research/gees/geog-environ-sciences.aspx where they should click on ‘Apply now’ and choose the option ‘PhD in Department of Geography and Environmental Science (Physical Geography)’ and give the PhD title in the ‘Funding details’ section of the online application.