

# Resilience of stream ecosystems to drought: an experimental test

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## *Project summary*

Climate change and human activities are expected to change the quantity of water entering rivers and streams, with potentially dramatic impacts on animals and plants resident in these ecosystems. 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 is known about impacts on important processes, such as decomposition, and primary and secondary production, that affect water quality and shape ecosystem goods and services.



Our study will use novel experiments to understand the ecological effects of droughts in streams, with a view to identifying structural and functional indicators of low flow stress. We will use a series of artificial stream channels (e.g. left) to directly manipulate flows over patches of stream bed, thereby simulating drought episodes, and measure the responses/resilience of flora and fauna, and a series of processes that reflect the ecological health of the ecosystem. We will compare the ecological effects of simulated droughts that reduce flows in streams with more severe droughts that cause local periodic drying of the stream

bed. The results will help to set ecologically sustainable abstraction levels in managed catchments.

## *Research Theme*

Water scarcity and ensuing drought are among the most pressing environmental issues of the 21<sup>st</sup> century (Vörösmarty *et al.* 2010). Freshwater ecosystems, already under pressure from the overuse of water by growing populations, stand to be further affected by climate change (IPCC 2007). Climate models predict widespread shifts in regional rainfall patterns (Beniston *et al.* 2007) that are likely to exacerbate droughts (Poff & Zimmerman 2010). 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 (IPCC 2007). Despite its growing prevalence, research on the ecological impacts of drought in rivers and streams lags far behind that of other stressors (e.g. acid pulses or floods) (James *et al.* 2008), and has focused on community-level effects, whereas consequences for the many ecosystem processes that ultimately provide the emergent 'goods and services' significant to human society are still largely unknown (Acuña & Tockner 2010).

Droughts typically reduce hydrological connectivity and habitat availability in streams and increase the deposition of fine sediments, over a range of spatiotemporal scales (Wood & Armitage 1999; Dewson *et al.* 2007). In any given river system, impacts on the biota are likely to be a function of the hydrologic characteristics of the disturbance regime itself (James *et al.* 2008). 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) (Dewson *et al.* 2007). For example, benign low flow conditions may intensify biotic interactions (e.g. herbivory) and other processes (e.g. leaf litter decomposition, secondary production) whereas harsh dewatering droughts may extirpate some species, thereby lessening processes rates. 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.

Chalk streams, the focus for our research, are particularly susceptible to drought since water extraction abstraction occurs routinely from the underlying aquifer, but their resilience to low flow

stressors, both natural and anthropogenic, remains unclear. Chalk streams are priority habitats under the EC Habitats Directive, and many watercourses are Sites of Special Scientific Interest (SSSI) or Special Areas of Conservation (SAC). To implement holistic biodiversity conservation strategies, and guide sustainable water management schemes at these sites, organisations such as Wessex Water plc, require a comprehensive understanding of chalk stream ecology, especially their resilience to environmental stressors such as low flows, be they caused by abstraction and periods of low rainfall.

### *Research Aims*

The main aim of this research project is to understand how low flows affect the structure and functioning of chalk stream ecosystems, at multiple spatial (mesocosms, streams) and temporal (experiments, long-term data sets) scales. Our experimental approach will use mesocosm flow manipulations (see e.g. Ledger et al. 2008, 2011; Brown et al. 2011) and field experiments to inform management. The research will yield data that improve 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 key ecosystem processes.
2. To determine the effect of natural drought vs. abstractions on stream communities via statistical analysis of long-term datasets, together with additional data from field-implemented substrata (leaf packs etc) at monitored sites along abstraction gradients incorporating indicators to assess ecological impact.

*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 and Environmental Sciences (GEES), University of Birmingham. GEES supports a large, vibrant and well resourced community of postgraduate researchers. We offer Birmingham postgraduates a range of workshops, events and resources to support personal development and career management in four areas, consistent with the national Researcher Development Framework and Vitae programme: knowledge and intellectual abilities, personal effectiveness, research governance and organisation, and engagement, influence and impact. The student will gain an appreciation of the practical implications of the research, and will gain experience in translating primary research in to decision making and practical management of water resources in rivers designated as SSSI and SACs.

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