Biodiversity and the water cycle: can rewilding mitigate the impacts of hydrological extremes?
End of project report, July 2022

Project details

Council	NERC/ ESRC
Scheme	Directed
Call	Synthesising evidence in economics of biodiversity
Project title	Biodiversity and the water cycle: can rewilding mitigate the impacts of hydrological extremes?
Grant ref	NE/W007460/1
Lead institution	Queen Mary University of London (QMUL)
Principal Investigator	Gemma Harvey
Co-Investigators	Alex Henshaw (QMUL), Stewart Clarke (National Trust), Chris Sandom (University of Sussex)
Partner organisations	Environment Agency (Judy England), Natural England (Orlando Venn), Rewilding Britain (Sara King)
Project duration	3 months
Total funds awarded	£ 40,027

Project rationale
Anthropogenic modifications to the water cycle have exacerbated the economic impacts of hydrological extremes such as floods and droughts. The economic costs of flooding and managing flood hazard in the UK are vast, for example £333 million in losses from the winter 2019/20 floods and £5.2 billion spending on flood and coastal risk management between 2021-2027 (Environment Agency, 2020). Extreme low flows can also be economically, as well as ecologically costly (Van Loon et al., 2016). Hydrological extremes and damages arising from them are projected to increase substantially with climate change (Kundzewicz et al., 2014). Water resource management is increasingly emphasising the importance of working with natural ecosystem processes to create resilient ecosystems that deliver multiple environmental, social and economic benefits. Yet prevailing approaches, such as Natural Flood Management do not explicitly consider biodiversity.

Rewilding is a radical landscape conservation approach that involves restoring wildness to anthropogenically altered landscapes. Rewilding is rapidly gaining momentum globally and has been advocated as a vital tool in reversing global biodiversity decline. In Britain there is currently a network of over 100 rewilding sites covering over 120,000 ha of rewilded landscapes (Rewilding Britain, 2022), and this is rapidly evolving. Types of biodiversity change include natural regeneration of grassland, woodland and scrubland, increased soil fauna biodiversity, reintroduction of large herbivores (e.g. cattle, deer, pigs) and keystone species (e.g. beavers). Dramatic biodiversity gains have been achieved over relatively short timeframes at rewilding sites and many reintroduced or recolonising species are effective 'ecosystem engineers' capable of modifying resource flows and increasing ecosystem functioning and restoration success. These changes offer potential for much wider-ranging benefits to natural capital assets and ecosystem services but these are largely unexplored or unquantified.

This project addresses the key research question: ***what role can the biodiversity gains from landscape rewilding play in modifying the water cycle and mitigating the impacts of hydrological extremes?*** This new knowledge will contribute to the economics of biodiversity by helping to deliver more (cost) effective water resource and water hazard management and help to address the climate change adaptation gap, for which water is at the frontline.

Project objectives and research questions
(O1) Determine the ways in which rewilding influences hydrology and hydrological extremes.
(O2) Support decision-making in rewilding practice across public and private sectors.
(O3) Inform future research priorities and improved monitoring of rewilding programmes.

To achieve our objectives we posed the following research questions:

Table 1 Links between research objectives, questions and outcomes.

	Research question	**Outcomes**
O1	RQ1 How do the types of biodiversity change driven by rewilding alter hydrological processes?	Conceptual model Evidence summary
O1 O2	RQ2 How do these effects differ across rewilding scenarios and environmental contexts?	Evidence summary Meta-analysis
O1 O2	RQ3 To what extent have these hydrological effects delivered measurable effects on mitigation of hydrological extremes?	
O3	RQ4 Where are the knowledge gaps across RQs 1-3	Priority areas Inform monitoring

Project activities
We undertook a systematic review of the literature to synthesise existing evidence on the influence of rewilding-driven biodiversity change on hydrological processes and the extent to which these effects have delivered measurable effects on mitigation of hydrological extremes (floods and low flows). Literature searches were carried out in Scopus and Web of Knowledge according to standard PRISMA guidance and combined with references from 12 key review papers addressing different aspects of rewilding and Natural Flood Management. We uncovered a lack of studies focusing directly on rewilding or nature-based solutions and mitigation of hydrological extremes, so we included broader terms representing more sustainable land management trajectories (e.g. regenerative agriculture, land abandonment). The searches recovered > 8,000 published papers which were screened and assessed for eligibility for inclusion to yield a total of 160 empirical studies. This new data set has been analysed to deliver the project outcomes below.

The review process and outcomes were guided by discussion at four project meetings involving all researchers and partner organisations. These focused on: (i) refining the search strategy; (ii) frameworks for evidence summary, and approaches and objectives for meta-analysis; (iii) discussion of preliminary results; (iv) review of results, and dissemination and articulation of key messages to stakeholders.

Project outcomes
1. Summary of the biomes and management contexts (including but not limited to rewilding) for which relevant data are available
2. Creation of a framework for classifying evidence types
3. Summary of the evidence available to support attenuating, exacerbating or variable effects of rewilding-style biodiversity changes on mitigation of hydrological extremes
4. Identification of the principal factors attributed to generating variable effects on extreme flow attenuation
5. Quantitative meta-analysis uncovering the magnitude of change in hydrological variables for rewilding-type biodiversity change trajectories.
6. Refined conceptual model taking into account the new information revealed by the review

Dissemination and impact

1. Conference presentation (poster): *The hydrological highs and lows of landscape rewilding* British Hydrological Society Annual Conference September 2022. Further conference submissions under consideration.
2. Journal paper: *The hydrological highs and lows of landscape rewilding*, Nature (in draft).
3. Infographic: for dissemination among stakeholders, communicating monitoring requirements for future rewilding projects (in draft).
4. Findings from the project are contributing to the future development of the REWILD Tool led by Sandom in collaboration with Rewilding Britain. The tool supports decision-making in rewilding practice, allowing users to evaluate the influence of rewilding scenarios on ecosystem processes. Specifically, findings from the *Biodiversity and the water cycle* project are shaping the incorporation of spatial dimensions of rewilding-driven hydrological (and other) change into the modelling processes and revealed levels of (un)certainty and knowledge gaps in the hydrological impacts of reintroduced species.
5. The revised conceptual model supports a new funding bid by Sandom and collaborators (EPSRC call; Enabling human centred decision making through data visualisation, August 2022). The project will build interactive software to help scientists and decision makers understand interactions and outcomes within complex systems for application across disciplines including climate science, environmental science and conservation biology.

References

Environment Agency 2020 ISBN 978-1-5286-1791-8; Van Loon AF et al. 2016 Nat Geosci 9:89-91; Kundzewicz ZW et al. 2014 Hydrolog Sci J 59:1-28; Rewilding Britain 2022 Rewilding Britain.