CREW CENTRE OF EXPERTISE FOR WATERS

Establishing the potential influence of beaver activity on the functioning of rivers and streams and water resource management in Scotland

Research Summary

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Establishing the potential influence of beaver activity on the functioning of rivers and streams and water resource management in Scotland

Josie Geris, Katya Dimitrova-Petrova, Mark Wilkinson

RESEARCH QUESTIONS

i. How does beaver activity affect the functioning of rivers and streams and water resources?

ii. What are the potential benefits and limitations of the ecosystem engineering capabilities of beavers for ecosystem restoration and environmental management in Scotland?

iii. What are the remaining knowledge gaps for which further research is needed?

BACKGROUND

Beavers are well known for their ability to transform ecosystems through dam building and other activities. By modifying physical processes in streams and rivers, beavers have the potential to play a role in providing ecosystem services that link to key water resource management issues in Scotland, alongside wider benefits such as carbon sequestration and river restoration. The water management benefits include improvement of water quality, water supply, and the management of floods and droughts. However, the evidence for the role of beaver activity in these various ecosystem services is typically diffuse or incomplete, especially for Scotland and Europe generally. In addition, beavers are increasingly spreading to prime agricultural land and other intensively used land in Scotland which has led to a range of conflicts.

This report provides an independent evidence review of the role of beavers in modifying physical processes, and the potential benefits they may bring for the provision of ecosystem services. It will inform the dialogue on the benefits and limitations of beaver expansion, including where trade-offs are required. It will also support decision making and policy related to the development of a National Strategy for beavers in Scotland.

RESEARCH UNDERTAKEN

Two mechanisms for capturing evidence were used: an international literature review of quantifiable metrics of beaver activity effects, specifically of dam building; and an expert evaluation and interpretation of the effects and remaining knowledge gaps. The review builds on NatureScot's 2015 'Beavers in Scotland' report (Gaywood *et al.,* 2015) and other recent international reviews. It specifically:

- Collates measurable evidence for trends (i.e., increase, decrease, or no change) associated with the effects of beaver dam building on water quantity and quality and the geomorphological characteristics of Scottish rivers.
- Provides confidence levels for the evidence of these trends, determined as a function of the amount of evidence and the level of agreement between different evidence sources.
- Explores the limits of knowledge on beaver activity effects, e.g., in terms of the types of environments, and the spatial and temporal scales for which evidence has been collected.
- Evaluates the results in the context of ecosystem services in Scotland.

KEY OUTCOMES

What is known

- Most of the evidence of beaver activity effects on the physical functioning of streams and rivers points to positive contributions to local ecosystem services. There is strong evidence that beaver dam-building results in wetland creation and the trapping of suspended sediment, nutrients and contaminants. In addition, high flows are typically lowered and delayed, while recharge, water storage and residence times increase. Beaver activity can therefore contribute to water supply and purification, the moderation of extreme events, nutrient cycling and river restoration.
- Enabling positive contributions to ecosystem services may also involve compromises and care must be taken to manage any disbenefits. Beaver activity effects may include the loss of land because of habitat creation and increased flooding behind dams. While flooding increases in the area behind beaver dams, beaver activity contributes to small-scale downstream decreases and delays in the flood peak. The relative effects will therefore depend on the location in relation to the beaver activity, as well as the surrounding land use (e.g., in most cases any flooding in built-up areas is likely to have larger socio-economic effects than the flooding of forested areas).
- Depending on site characteristics, other effects that could be considered as disbenefits include interruptions to fish passage because of decreased hydrological connectivity within a river network. In addition, average water temperature typically increases locally, but beaver activity is also associated with decreases in the maximum temperature. Changes in water temperature can have implications for in-stream ecology and private/industry water users.
- For carbon storage, beaver activity is simultaneously paired with increased carbon storage and increased methane and carbon dioxide emissions; the offsets between these two effects are highly variable and less known.
- Dam-breaching - part of the evolution of beaver systems - can have detrimental effects. These include exacerbating flood events and the release of sediment and contaminants that were being retained by a dam. The significance of these effects will depend on the timing and extent of breaching.

Remaining questions (future research needs)

- How do beaver activity effects scale to rivers that drain larger catchment areas? Most evidence has been recorded at the local scale, i.e., up to about 1 km^2; policy and practice for ecosystem services would benefit from evidence at larger scales.
- What are the effects of beaver activity on the full range of stream discharge? There is less evidence of the effects of beaver activity on low flows and storage-discharge relationships.
- What is the net effect of beaver activity on greenhouse gas emissions and carbon sequestration and so the carbon budget, and what controls the balance locally?
- What are the site-specific controls on the magnitude of beaver effects? Some effects depend strongly on local beaver activity and landscape characteristics. This poses problems for the transferability of effects to other sites, especially with different characteristics. The evidence base lacks studies from Scotland and the UK, non-forested environments, and at larger scales.

RECOMMENDATIONS

- The potential for beaver activity to contribute to a wide range of ecosystem services should be considered in relevant riparian management appraisals. These services include water supply and purification, the moderation of extreme flow events, nutrient cycling, and river restoration.
- To inform an appraisal and mitigate local adverse effects of beaver activity, discussion with landowners and wider societal groups is required. This should consider (i) the wider ecological and socio-economic aspects of beaver translocation and expansion, as well as (ii) mechanisms to ensure that those negatively affected are involved and appropriate 'payment for public goods' models are identified alongside other mitigation strategies.
- More empirical research is required to address the fundamental knowledge gaps, particularly on the scaling and magnitude of beaver activity effects. This needs to be supported by long-term experimental monitoring in Scotland and modelling. Monitoring efforts should involve interlinked characteristics of water quantity, water quality and geomorphology alongside effects on ecology, so that a holistic evaluation can be made for ecosystem services.

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