

Anna Treves Doctoral dissertation

Integrated approach to model the management of human-beaver interactions. A case study in Piedmont Region (Italy)

Abstract

Human-wildlife interactions are widely influenced by the impact of human activities on ecosystems, often leading to competition for resources and space. The fragile balance between needs and behaviours of species can lead to the arising of human-wildlife conflicts. These conflicts underscore the challenge of find a balance between conservation and socio-economic interests.

In this context, the beaver exemplifies these dynamics. This animal is an emblematic ecosystem engineer, and it represents a Nature-based Solution to increase the resilience of freshwater ecosystem to direct and indirect drivers of change. Although this rodent provides valuable ecosystem services such as enhancing biodiversity and improving freshwater ecosystems, it is often compared to pest as happen for other key species such as the wolf. In fact, beavers activities, i.e. cutting trees, building dams and lodges, digging dens and channels, can cause several damage to land property infrastructures, crops and tree when the proximity of human and his activities is strong. Therefore, in order to better manage freshwater ecosystem and species-related, it is necessary to implement innovative and interdisciplinary management approach that prioritize coexistence over conflict management by considering the entire socio-ecological system.

To address this challenge, the present research proposes and explores an integrated approach to manage human-beaver interactions by considering beavers as a resource. It applies habitat suitability models and complex system dynamics to investigate socio-ecological dynamics and support the development of sustainable management strategies. Moreover, the research emphasizes the role of beavers as crucial ecosystem engineers, whose reintroduction is not only essential for recovering a historically lost species but also for enhancing biodiversity, improving resilience, and restoring river habitats.

The present research aims to balance ecological conservation goals with the socio-economic needs of local communities, fostering coexistence over conflict, promoting biodiversity and ensuring the long-term sustainability of territories and local communities. By combining ecological, social, and economic dimensions, the research offers a flexible and adaptive management approach for sustainable human-beaver interactions. Four main phases structure the research: a literature review, a case study selection and ecological assessment, the development of a system dynamics model, and the setting of long-term goals.

The literature review offers an overview of the state of the art of methods and approaches about beaver management and represents a solid basis for the subsequent phases of the research. It reveals a growing interest in beaver-related studies due to their expanding populations and increasing recognition as ecosystem engineers. However, only 4.3% of these studies focus on practical restoration projects involving beavers. Moreover, it highlights a shift from conflict-based management approaches to participatory strategies that emphasize coexistence. It also identifies significant gaps, including the lack of socio-ecological models that holistically examine the impacts and benefits of beavers.

The second phase refers to the selection and ecological evaluation of a case study area. Using a criteria-based evaluation, the research investigates five potential reintroduction sites in the Province

of Turin (Italy) and Ivrea Lakes area is selected. This area demonstrated high habitat suitability, reduced potential human-beaver conflict and a proactive local community committed to environmental protection. Moreover, a carrying capacity equal to 4–20 beavers is estimated based on a previous habitat suitability model and ecological niche modelling through MaxEnt. These findings represent the foundation for the development of following phases and the implementation of management strategies. This analysis underscores the importance of integrating ecological criteria with socio-economic considerations to ensure species conservation and conflict mitigation.

Then, the development of a system dynamics model addresses the complexity of human-beaver interactions by integrating ecological, social, and economic factors. This model examines benefits (i.e. ecosystem services) and conflicts (i.e. flooding, crop damage) associated with beavers. It attends as a valuable tool for understanding cause-effect relationships, evaluating management strategies and engaging stakeholders in participatory processes. The model supports adaptive decision-making and offers a replicable framework for managing interactions in several ecological and socio-economic contexts.

Building on the insights from the system dynamics model, the fourth phase of the research defines strategic long-term goals essential for the future sustainable management of human-wildlife interactions. Key long-term objectives include the incorporation of beaver management into national and international biodiversity policies, improving the coexistence between beavers and local communities, promoting environmental education, and creating a scalable, adaptable management model for broader application. These long-term goals aim to foster a harmonious balance between ecological conservation and socio-economic needs, ensuring the resilience of both freshwater ecosystems and local communities.

This research provides a comprehensive interdisciplinary framework for managing beaver populations and freshwater ecosystems sustainably. It combines ecological tools like habitat modelling with socio-ecological dynamics to deliver practical solutions. The findings emphasize the dual role of the beaver, i.e. a Nature-based Solution for freshwater ecosystem restoration and a potential source of human-wildlife conflict, by advocating for coexistence strategies over conflict-based management approaches. The involvement of local communities is highlighted as essential to harmonizing conservation objectives with economic and social needs.

A distinctive feature of the study is its emphasis on adaptive and flexible management strategies. It provides clear guidelines for planning beaver reintroductions and managing coexistence in Piedmont region. Moreover, it represents a model that can be applied for other regions and species.

The resulting management approach is innovative in the field of human-beaver interactions and consistently contribute to the context of urban and regional development. It underscores the critical role of Eurasian beavers as agents of ecosystem restoration while providing a replicable model for fostering human-wildlife coexistence. Furthermore, it sets a foundation for future environmental policies that maximize ecological and social benefits by contributing to the resilience of ecosystems, the well-being of local communities and their involvement.

Future research should focus on the practical integration of beaver management policies into national strategies for the conservation of biodiversity and freshwater ecosystems. In this way, a more comprehensive and sustainable territorial management will be fostered.