

Promoting the recovery of keystone species such as the beaver and wolf is regarded as a key strategy for halting or even reversing the ongoing decline in Europe's biodiversity, as these species can have outsized effects on ecosystems. Beavers ecologically engineer watercourses and river valleys, and shape riparian woody vegetation through their foraging. Through their selective foraging on trees, beavers alter forest composition and structure within ca. 60 m of a water's edge by resetting succession, and shifting tree stands to being dominated by conifers and deciduous trees less preferred by beavers. Whereas wolves by hunting and killing herbivores can indirectly affect woody plant communities (their prey's food). The beaver can comprise up to 45% of the wolf's diet in some areas of Poland, suggesting there is great potential for wolves to modify the distributions and ecosystem impacts of beavers. Yet we have at best only a partial picture of how they interact with one another.

A key way large carnivores like the wolf shape ecosystems is through the fear they inspire in prey. The perceived risk of predation can cause behavioural changes in prey that can cascade down food chains to the prey's food species, whose survival and/or abundance can increase as a consequence. But it remains unclear how wolves impact beaver behaviour, if at all. Understanding such predator-prey interactions in Europe can be particularly complicated, as wolves and beavers are recolonising landscapes that have been transformed by humans. Human impact can greatly modify how wolves and beavers interact with one another. This all means that European riparian systems, landscapes crucial for conservation and agriculture, are shaped by an interaction between three keystone species that we know little about. A key question arising from this story is what role do wolves play in suppressing beavers and their impacts in Europe's human dominated landscapes? Do wolves suppress the distributions and behaviour of beavers as they can do those of their ungulate prey, or do humans alter or prevent these impacts? **The aim of the project is to understand how wolf risk and human activities shape beaver behaviour, and hence their impacts on woody tree communities.**

- 1) In the first step, the project aims to understand how wolf risk and human activities shape beaver distributions across the landscape. We will inventory beavers using drone and aquatic surveys. We will then assess levels of wolf and human activity across the riparian landscape using camera trap and GIS analyses. By relating beaver occurrence to wolf and human activity, we will be able to determine how wolves and humans shape beaver distributions.
- 2) In the second step, the project aims to understand how wolf risk and human activities shape beaver foraging behaviour. We will assess beaver foraging activity via a terrestrial field survey and camera trapping. By relating beaver foraging behaviour to wolf and human activity, we will determine how wolves and humans shape the distances beavers forage away from water.
- 3) In the third step, the project aims to understand how wolf risk and human activities indirectly shape the beaver's impacts on tree communities along watercourses. To this end, we will carry out woody tree vegetation surveys in beaver territories but also at control sites without beavers. By relating the forest composition at both types of sites to the gradients of wolf and human activities across the landscape, we will be able to determine whether wolves and humans are reducing the beaver's impacts on woody tree communities.

The field work will be carried out at two study sites, one in Poland, Białowieża Forest, and one in the Netherlands, near Groningen. The former site hosts wolves, and the latter does not. By comparing the data collected at sites with and without wolves, we will be able to determine the role of the wolf in curtailing beaver distributions, foraging behaviour and ecological impacts. The field work in the Netherlands will be part of a 6-month fellowship hosted by the University of Groningen.

In recent years the landscape of fear has been a hot topic in ecology, with studies suggesting the fear inspired by large carnivores can suppress the behaviour and ecological impacts of ungulates and medium sized carnivores. **Here we aim to extend this framework to the beaver, which is an important prey species for the wolf.** The project aims to reveal whether the wolf excludes the beaver, and its ecological impacts and conflicts from parts of our landscapes, and whether humans are reducing these effects of the wolf. This knowledge will pave the way for better informed management of wolves, beavers and riparian landscapes, and help us to fine-tune wolf and beaver ecological functionality and potentially mitigate beaver conflicts where desired. As both species are often heralded as saviours of biodiversity, this knowledge is urgently needed to predict the ecological effects of the ongoing wolf and beaver recolonisations of Europe's human dominated landscapes.