

Global warming drives range shifts of many organisms. Upslope shifts are often caused by the fact that conditions which used to be harsh at higher elevations become bearable. Thus, these areas can be occupied by species that previously lived at lower elevations. As a result, we can observe animals and plants moving upslope. However, while most of animals can move by themselves, plants are sessile organisms that depend on other vectors for dispersal.

Many tree species rely on animals as seed dispersal agents. One of the ways of such seed dispersal is collecting seeds by animals and burying them in stores for later consumption. But this is usually not the end of seeds' journey: such removed and buried seeds may be stolen and handled by other animals, leading to two-phase seed dispersal. Many of such buried seeds are left intact (because e.g., the cache owners die) and successfully germinate. This mechanism is used by nut-bearing tree species, both broadleaved and coniferous, for more effective spreading. Thus, it can have a huge impact on forest dynamics, including upslope movement of trees.

While the European beech is a common broadleaved tree species in lowlands and elevated areas, projections indicate that it will start to occupy higher elevations with progressive global warming. Nevertheless, this will only be possible if seed dispersers provide substantial upslope seed dispersal to microsites where recruitment is successful. Beech produces nuts that can be dispersed in a two-phase manner: first moved by avian seed dispersers, such as Eurasian jays, to their caches, and then stolen and reused by rodents. But dispersal is not enough to succeed. In the Alps, when beechnuts reach higher elevations in the future, they will have to additionally cope with indirect interactions with other nuts – seeds of Arolla pine, i.e. a tree species which often covers high elevations and forms a tree line. This means that seeds of both species will have to compete for seed dispersers, while minimizing seed predation, where the winner will have higher probability of successful recruitment.

The aim of this project is to test how biotic interactions can affect upslope shifts of trees in the Swiss Alps. More precisely, we will investigate the effects of seed dispersal by avian and rodent seed dispersers: whether does this activity slow down the beech recruitment and its encroachment into higher elevations, or on the contrary – intensive removal and burial of beechnuts by various dispersers as well as intensive pine seed consumption by rodents promotes beech upslope encroachment? Do jays already remove beechnuts upslope and store them above beech current range? What is the contribution of various seed dispersers to beech recruitment within and above its current range? Which ones: beech vs. pine seeds – will have a higher chance of being cached, while the other will be readily eaten by rodents? Will high-elevation plants help beech seeds cope with harsher conditions and germinate? We will carry out comprehensive experiments and observations to answer all of these questions. We will also create simulation models, into which we include the results obtained from our experiments and observations, to assess the potential indirect impact of climate change on population dynamics of trees in montane ecosystems and tree range shifts.

Understanding and predicting the ecological factors that limit species fitness and distribution is a fundamental goal in ecology and biogeography. However, the present comprehension of these factors, particularly in relation to climate change-induced range shifts, remains limited. This knowledge gap hinders our ability to effectively address conservation challenges. Our project aims to advance our understanding, provide explanations, and enhance predictions regarding the ecological factors driving tree distributions, the impact of non-climatic factors on range limits, and the mechanisms influencing range expansion. This will be supplemented and broadened by creating predictive models to forecast the effects of plant-seed disperser interactions in the future. The insights gained from this project will enhance our ability to predict the impacts of climate change on beech recruitment and distribution across elevational gradients, and understand the biotic drivers of potential shifts in its distribution. More generally, this research will illuminate how biotic interactions can modify simple predictions based solely on abiotic factors.