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Global change, biodiversity and seed dispersal in birds

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Among the ecosystem functions provided by birds, seed dispersal might be one of the most important. The seeds of up to 95% of the woody plants in most tropical forests are dispersed by vertebrates, mostly by birds (Howe & Smallwood 1982). Three principal hypotheses have been advanced to explain why seed dispersal is a crucial process in a plant's life cycle: escape of species-specific pathogens, fungi and herbivores near parent trees, colonization of new sites with adequate environmental conditions, and directed dispersal to sites that are particularly suitable for germination and recruitment (Howe & Smallwood 1982). All three hypotheses posit that seed dispersal enhances seedling recruitment and is thus crucial for maintaining genetic diversity and plant population viability.

Human disturbance threatens natural ecosystems globally. Tropical forests, in particular, are exposed to forest loss and fragmentation, as well as to more subtle effects of forest degradation, including selective logging and hunting (Kirika *et al.* 2008). A new threat is global climate change that forces plant and animal species to shift their geographical ranges to track their preferred climatic conditions. Seed dispersal by large vertebrates, especially by birds, plays a crucial role in allowing plant species to disperse among forests and forest fragments and to adapt to new environmental conditions. Here, I address the impact that land-use change has on the diversity of birds and on seed dispersal as well as the ability of birds to act as mobile links and to transport seeds across fragmented landscapes.

Land-use change, especially in the tropics, has profound impact on the diversity of frugivorous birds. We studied bird diversity in Kakamega Forest in Kenya comparing sites within the main forest block and in forest fragments as well as in sites with different degrees of local forest disturbance (Kirika *et al.* 2008). Our results demonstrate that, in particular, forest degradation through selective logging leads to declines in the species richness and total abundance of frugivorous birds. A network study in Kakamega Forest relating visits of frugivorous animals to fruiting woody plant species demonstrated that 88 animal species, among them 83 birds, visited 33 fruiting plant species (Schleuning *et al.* 2011). Plant–frugivore networks were little specialized (H_2¢ was 0.298), suggesting a large degree of redundancy in frugivore–plant interactions. Nevertheless, visitation rates of frugivores as well as seed removal rates of seeds were significantly lower in heavily disturbed than in less disturbed forest sites (Kirika *et al.* 2008). This case study is confirmed by a meta-analysis that showed that forest degradation (in contrast to forest fragmentation) has a strong negative impact on seed removal rates (Markl *et al.* in press). The meta-analysis further demonstrated that large-seeded plant species

have significantly lower visitation and seed removal rates than small-seeded plant species. As seed dispersal is linked to seedling establishment and gene flow of trees, this loss of seed dispersal leads to poor regeneration and a loss of genetic diversity, especially of large-seeded tropical trees.

On the other side, birds are mobile links in ecosystems. They can transport seeds over long distances and hence allow the transport of propagules and genes of plants also among fragmented forests. We studied seed dispersal of Wild Cherry (*Prunus avium*) by birds along a land-use gradient in Central Germany from undisturbed forest sites over structurally diverse agricultural sites with hedgerows and woodlots to structurally simple, intensively used agricultural sites. Local bird diversity in these sites showed the expected pattern with high bird diversity in forest and decreasing diversity with increasing intensity of human land-use (Breitbach *et al.* 2010). Surprisingly, in this system, tree visitation and seed removal rates did not change along the land-use gradient. Trees in structurally simple agricultural sites were visited as frequently and seeds were removed as well as from trees in forest. This suggests that birds change their movement behaviour along a land-use gradient.

To understand better the relationship between land-use intensity and the movement behaviour of birds, we studied Trumpeter Hornbills (*Bycanistes bucinator*) in South Africa using a new generation of GPS loggers (Lenz *et al.* 2011). In addition, we conducted feeding trials with captive Trumpeter Hornbills to measure gut passage times of seeds. Results showed that Trumpeter Hornbills can transport seeds over distances up to 15 km. Seed dispersal distances were modelled to be longer in fragmented agricultural landscapes (maximum 8140 m) than within closed forests (maximum 3015 m). Furthermore, seed dispersal distances in the agricultural landscape were modelled to be bimodal with a first peak at about 18 m and a second peak at about 512 m. Thus, transport among habitat patches is more frequent than previously assumed, allowing plants to disperse among habitat patches and to track changing climatic conditions. To conclude, birds provide important ecosystem functions, especially for the regeneration and resilience of ecosystems, an ecosystem service that is important for the long-term maintenance of ecosystems and that is often neglected.

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