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The impact of total bird loss on ecosystem services in the forests of Guam

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Birds are thought to provide essential ecosystem services including seed dispersal and control of insect herbivores. However, few studies have measured the importance of birds on a community-wide basis, in part because birds are difficult to manipulate experimentally at a scale relevant to their impact. We take advantage of a unique ecological catastrophe to study the role of birds in tropical forests. Virtually all forest birds were extirpated from the island of Guam by the introduction of the Brown Treesnake *Boiga irregularis*, whereas the nearby islands of Saipan, Tinian and Rota support relatively healthy bird populations and thus serve as suitable controls. We are investigating how the loss of frugivorous and insectivorous birds has affected Guam's forests.

On Guam, about 70% of tree species have fruit adapted for bird-dispersal, and bird loss has consistent negative impacts on seed dispersal and seedling survival. We compared seed rain patterns on Guam with those on Saipan, Tinian and Rota. Guam shows greatly reduced seed dispersal distance compared with nearby islands with birds. We also measured the strength of density-dependent mortality for five common species, and found that four had strong negative density dependence, such that they grew better at plots far from conspecific trees than they did near conspecifics. Species with strong density-dependent mortality on an island that has lost all dispersal will probably experience population decline and eventual extinction. In addition, we compared seed rain in degraded forest adjacent to native forest on Guam and Saipan. No seeds reached degraded forest areas on Guam whereas an average of 1.18 seeds/m² reached the degraded forest on Saipan. We predict regeneration of native trees in the degraded forest will proceed extremely slowly, if at all. Finally, in the two species we studied, seed germination of seeds not handled by birds was 50–78% lower than germination of handled seeds. The loss of frugivores has had a large impact on the forests of Guam.

The impact of bird loss on top down control of insect herbivores is less clear, possibly due to the complex response of the arthropod community. The strongest signal we have measured is in web-building spiders, which are 2–20 times more abundant on Guam than on islands with birds. Possibly because of this, bird loss does not consistently translate to reduced seedling survival, as would be expected in a simple trophic cascade. In a bird exclusion study conducted across all four islands, we found reduced seedling survival when birds were excluded (Saipan, Tinian or Rota) or missing (Guam) in only one species, and no difference or increased survival in four other species. Additional research is needed to determine whether birds play a role in reducing insect outbreaks or preventing new invasive insects from establishing.

Collectively, our results suggest that impacts of bird loss reverberate through the forests of Guam, and that the loss of frugivorous birds has a larger overall effect on trees than the loss of insectivorous birds.