



## Consequence of the loss of large frugivores

Chairs : **Dave Kelly** (School of Biological Sciences, University of Canterbury) and **Kim McConkey**.



Large frugivores are disproportionately affected by humans, whether from habitat loss or direct hunting. This means that there is greater pressure on dispersal mutualisms for

large-fruited species which depend on larger frugivores. In this symposium we intend to look at the extent of losses of large frugivores in different parts of the world, and the consequences of this. Are fruits still being dispersed? Can new animals or smaller animals compensate? How likely is mutualism failure? Contributed papers on this topic are welcomed for inclusion in the symposium. See [Hansen & Galetti 2009. The forgotten megafauna. Science 324: 42-43.](#)



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### **Large fruits without large frugivores: can variance save dispersal?**

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Large frugivores have been disproportionately reduced in many parts of the world, which raises concerns for the dispersal of the largest-fruited plant species which may be left without a competent dispersal agent. However, evaluations of likely risks are often based on only the mean sizes of fruit and frugivores. Here we consider whether considering variances as well as means reduces the apparent risk of dispersal failure, using New Zealand as an example. In New Zealand a number of large frugivorous birds have become extinct, leaving the New Zealand pigeon *Hemiphaga novaeseelandiae* as the sole apparent disperser of fruits for 11 tree species with fruits over 10 mm mean diameter. However, recent work shows that nine of these 11 species are sometimes dispersed by other birds, which is possible because larger-than-average individual birds can swallow below-average sized fruits. Only one tree species, *Beilschmiedia tarairi* (Lauraceae), has no fruits small enough for other common birds to swallow and is thus entirely dependent on the NZ pigeon for dispersal. Hence the variance in fruit size and bird gape size is not just a sampling problem – it also provides opportunities for alternative dispersers to maintain dispersal service in the face of fauna losses.

### **Seed dispersal with the wreckage of an avifauna: consequences for large-seeded trees in New Zealand**

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Large-seeded plants may be more prone to dispersal failure, as fewer animal species are capable of dispersing the seeds, and large frugivores are more often affected by human impacts. Human arrival in New Zealand drove a number of large frugivorous birds to extinction. The extant New Zealand pigeon (*Hemiphaga novaeseelandiae*, Columbidae) is the primary disperser for five large-seeded native trees. However, this mutualism is at risk as pigeon numbers have declined from illegal hunting, habitat loss, and introduced mammalian predators. We investigated the consequences of dispersal failure and introduced mammal seed and seedling predation for the large-seeded tree species taraire (*Beilschmiedia tarairi* Lauraceae, seed 16 x 29 mm) and karaka (*Corynocarpus laevigatus* Corynocarpaceae, 15 x 23 mm). We recorded seed predation, germination, and seedling survival for two years in the field for seeds under conspecific adults (“parents”) vs. 20 m away, whole fruits vs. cleaned seeds, at high vs. low densities, and enclosed in mammal-proof cages vs. uncaged. For both species, undispersed seeds (whole fruits, under parent at high density) had much lower survival than dispersed seeds (53–80% decrease in survival over two years). The combined effects of dispersal failure and introduced mammals decreased survival after two years by 82–



90%. Both dispersal failure and introduced mammals have substantial negative effects on the regeneration of large-seeded trees in New Zealand forests.

### **Big fruit for small mouths: the ability (or inability) of gibbons and flying foxes to disperse megafaunal fruits**

*Kim McConkey*<sup>1</sup>

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The largest fruit found in Asia's tropical forests ("megafaunal" fruit) may have evolved to attract a succession of very large frugivores. Only declining remnants of these megafaunal communities remain, however, making it critical to determine whether smaller frugivores can compensate for the lost roles of large dispersers. Gibbons (5-8 kg) and flying foxes (0.3–1.6 kg) are considered to be among the most effective seed dispersers in Asian forests, but the extent to which their effectiveness is limited by fruit size is poorly understood. Here I investigate the ability of gibbons and flying foxes to disperse seeds of megafaunal fruits.

Both animal groups regularly consume large fruits. Gibbons can swallow and disperse large seeds (<23mm wide) for their size, but this excludes the seeds of many megafaunal fruit species and dispersal distances (<500m) are constrained by home range size. Dispersal by flying foxes is limited primarily by fruit weight; they can carry fruit >20% of their body weight for 100s of meters, with lighter fruit carried at least 2 km. For some plant species with megafaunal fruit, gibbons and flying foxes can function as effective dispersers; however, other plant species may be dependent on megafauna for the large quantities of seeds moved and/or specific factors influencing post-dispersal fate. In summary, some large-fruited plant species can be dispersed efficiently by under-sized frugivores, but the extent to which these frugivores contribute to effective plant recruitment is variable.

### **Successional trajectories of defaunted tropical forests: effects of vanishing large frugivores and the role of remaining seed dispersers**

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Forest fragmentation, hunting and habitat degradation reduce populations of large vertebrates but can favor small-bodied frugivores such as fruit-bats. Therefore, the study of seed dispersal in defaunted forests is crucial to understand successional trajectories of altered habitats. We aimed to show how shifts in seed rain as well as seedling recruitment patterns along a fragmentation/defaunation gradient can be correlated with changes in composition of fauna of seed dispersers. First, in a semi-deciduous forest of southern Mexico, we successfully demonstrate that seed rain in defaunted forest fragment tend to be more clumped and varied greatly between years due to low activity of seed dispersers. Furthermore in the same site, we were able to show that seedling recruitment in small forest fragments lacking large frugivores was biased towards a low representation of large-seeded species. Finally, we studied seed rain generated by small tent-roosting in Costa Rica and demonstrate the potential role of



frugivorous bats in disperse several species of large-seeded plants of both mature forest and successional habitats. Therefore, understanding the balance between the effects of elimination of large-bodied vertebrates as well as the role of the remaining fauna on the composition and dynamics of the regenerating stands should be crucial to predict differing successional trajectories of forests in response to habitat alteration and defaunation.

### **Bush meat hunting disrupts forest regeneration in African rainforest**

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Changes in forest composition resulting from the decimation of large seed-dispersing species by hunting in continuous, otherwise intact Neotropical forests have been recently reported. However, in previous studies mature tree composition, which may to a large extent determine what is present on the forest floor, has not been accounted for. It is also not known if the reported trend is a pan-tropical phenomenon as evidence from Africa has been lacking. Here we compare continuous unlogged forests in southeastern Nigeria, differing in protection from hunting, but with similar composition of mature trees. Forests that are hunted, and so have few large primates, experience lower recruitment of primate-dispersed trees, and have higher recruitment of abiotically-dispersed trees. Our results show that recruitment of a group of focal fruiting tree species with large fleshy fruits, adapted to dispersal by large frugivores, was different between hunted and protected sites, even though the densities of mature trees of these species did not differ between sites. Our findings are similar to effects reported for forests in the Neotropics and Asia, suggesting that changes on the forest floor caused largely by hunting is a pan-tropical phenomenon.

### **A basin-wide study of seed rain patterns in lowland western Amazonia**

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We analyzed seed rain patterns of several common lowland western Amazonian tree species using data collected from high-density seed trap grids (a total of 1269 individual traps) set up at six mature floodplain forest sites distributed across the ~85,000 sq.km Madre de Dios River basin in southeastern Peru. Three sites are located in forests with an intact faunal assemblage and three in defaunated forests. For the majority of species examined, seed fall decreases sharply with increasing distance from fruiting trees, with a small subset of potential adult trees making disproportionately large contributions. Contrary to previous studies, we found that dispersal at faunally intact sites is limited in fecundity but not spatially. Spatial distribution patterns of undispersed and dispersed propagules are drastically different, with dispersed seeds found at significantly greater distances away from fruiting adults than undispersed fruit, forming a diffuse tail of the seed shadow. The average distance “gain” from dispersal was 6.9m or 1.7 crown radii. Seed rain patterns of primate dispersed species were drastically different in faunally intact vs. defaunated sites, with spatial patterns in the latter sites closely resembling the distribution of only undispersed propagules at the former sites. We examine



long-term consequences of hunting-induced defaunation and absence of primate seed dispersal on sapling recruitment processes and patterns.

**What is the fate of a silent forest? The impact of the complete loss of frugivorous forest birds from the island of Guam**

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The ecological importance of vertebrate seed dispersal is difficult to study due to the large spatial and temporal scales over which vertebrate seed dispersal occurs, as well as the functional redundancy present in many dispersal systems. The Mariana Islands provide a unique opportunity to learn about the role of frugivorous birds in tropical forest: four islands - Guam, Saipan, Tinian and Rota - contain similar native forest communities, with about 70% of the tree species dispersed by birds. However, all forest birds were functionally extirpated from Guam by the invasive Brown Treesnake in the 1980's. Saipan, Tinian and Rota have relatively healthy bird populations and thus are suitable controls. To examine the importance of bird dispersal for forest structure, we focused on three bird-dispersed tree species across the four islands. We used seed traps to measure the effect of birds on dispersal distance and greenhouse experiments to determine whether bird handling influences germination. Finally, we measured the distance between a randomly selected seedling and its nearest conspecific adult to determine if differences in dispersal could be observed at the seedling stage. On Guam (no birds), seeds fall directly underneath the parent tree and are less likely to germinate, and seedlings are found closer to a conspecific adult than in forests with birds. Collectively, our results suggest that birds play an important role in the recruitment of fleshy-fruited species.