Seed Dispersal in Tropical Forests

Pre-Lab: Watch the following video prior to the class meeting.
https://www.youtube.com/watch?v=0m6AjWZ2p8I&feature=youtu.be

NOTE: Activity needs questions to ensure students watched the video

Introduction

A key challenge faced by flowering plants is **dispersal**: spreading offspring to a different location where they can grow into a new plant. In the angiosperms (flowering plants), offspring are packaged in **seeds** enclosed in **fruit**. Flowering plants have evolved a wide array of mechanisms, called **dispersal vectors**, to move seeds away from the parental plant to successfully establish a new plant. These dispersal vectors include **abiotic** (non-living, like wind, gravity, or water) or **biotic** (living organisms, like animals) methods.

The specifics of how various dispersal vectors move fruit and seeds determine how seeds, and ultimately individuals, are distributed on the landscape. The pattern of seed dispersal away from the parent plant is called the **seed shadow**. This spreading of seeds influences where new plants in the population establish.

Why is this important?

Understanding how seeds are dispersed can help explain the patterns of tree diversity in tropical forests. Over half of woody tropical species use animals to disperse their seeds. Birds and small mammals such as spider monkeys either eat the fruit from a tree and drop or spit the seeds below that tree where they are feeding or swallow the seeds in the fruit. The swallowed seeds will pass through the animal's digestive tract and be deposited in feces some time later. Small monkeys typically travel 100-400m before depositing feces that contain seeds from several different species. Birds can travel two to three times that distance before depositing seeds.[1]. Monkeys also require uninterrupted forest canopy to move from location to location, but typically birds do not have this limitation. Forest fragmentation can consequently restrict the ability of plants dependent on monkeys to move seeds to new locations. As habitat fragmentation reduces areas of forest into smaller, more isolated patches, it hinders these plant species' ability to successfully disperse their seeds and establish new indiviiduals. When species fail to reach new sites to establish seedlings, tropical forest diversity can decline.

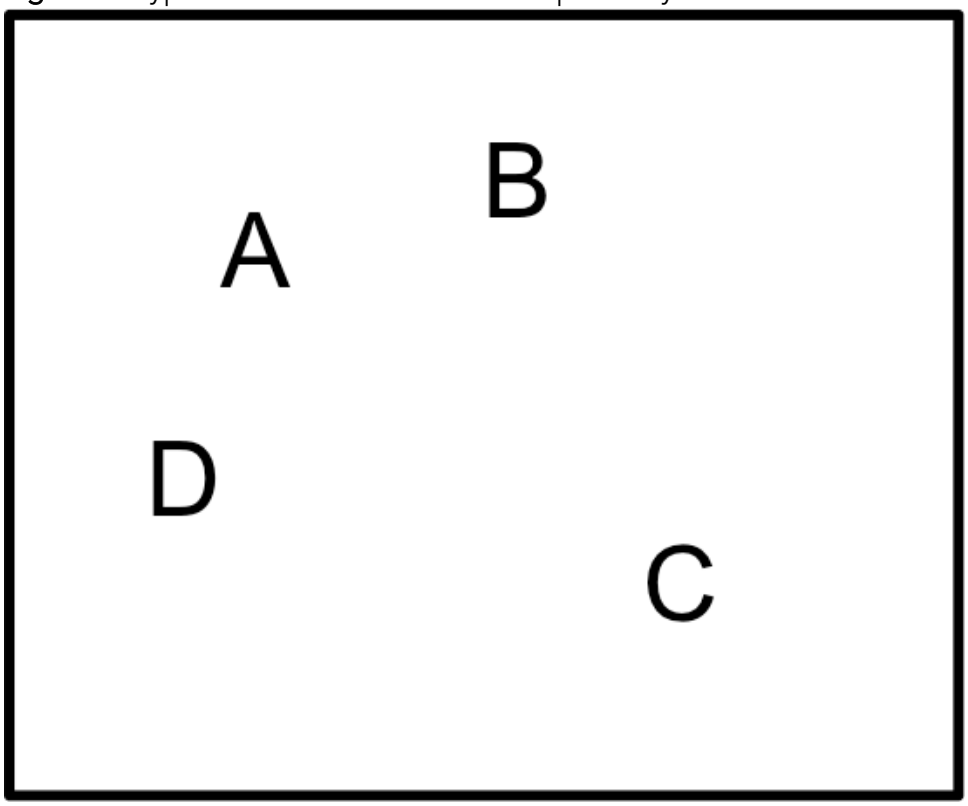
Predicting Patterns

What fruit or seed adaptations might plants use for dispersal using **abiotic vectors** such as wind?

What fruit or seed adaptations might plants use for dispersal using **biotic vectors** such as birds or small mammals?

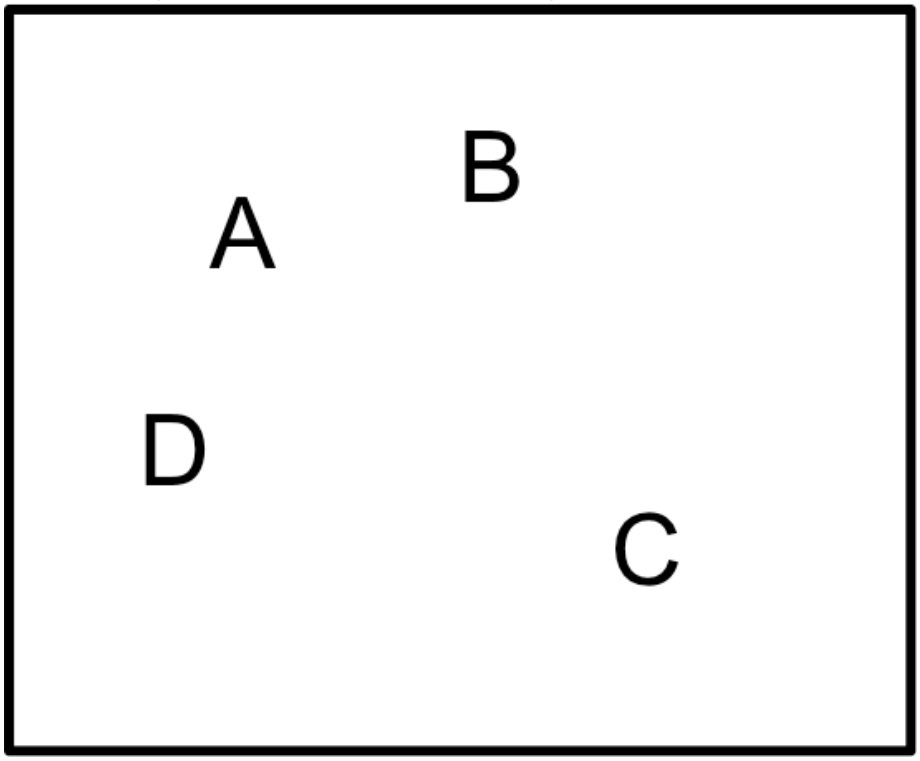
The box in Figure 1 below represents a hypothetical forest with four adult trees of the same species labeled A, B, C, & D. (There may be more trees from other species around them, but those trees are not shown.) If this species uses wind to disperse their seeds, what pattern of seed dispersal would you expect to observe for each tree? Draw multiple lowercase letters a-d to show the **seed shadow** you would expect for each of these four individuals.

Figure 1. Hypothetical forest with seed dispersal by wind.



Now, let the box in Figure 2 represent the same hypothetical forest, except now consider a species that uses animals to disperse seeds.. What would the seed shadow look like if the hypothetical tree species in Figure 2 used birds or monkeys to disperse its seeds? Use multiple lowercase letters a-d to show the seed shadow you would expect for each of these four individuals.

Figure 2. Hypothetical forest with seed dispersal by birds.



Describe the similarities and differences in the predicted seed shadows you drew for the wind-dispersed versus the bird-dispersed seeds.

Do you think seeds dispersed by birds would be affected by fragmentation in the same way as seeds dispersed by spider monkeys? What would be similar? What would be different?

As shown in the video, biologists have developed creative ways to use insects to help them find seeds that animals have dispersed. However, when these clues are not available, biologists use different approaches to investigate seed dispersal.
What other data do you think biologists could use to study seed dispersal?

Time to brainstorm ideas! How would you conduct a study to investigate seed dispersal by wind? How would you conduct a study to investigate seed dispersal by birds Would you use the same or different techniques than the researchers in the video? What data would you collect? What do you think those data would tell you?

Wind Dispersal in ***Platypodium elegans***[2]

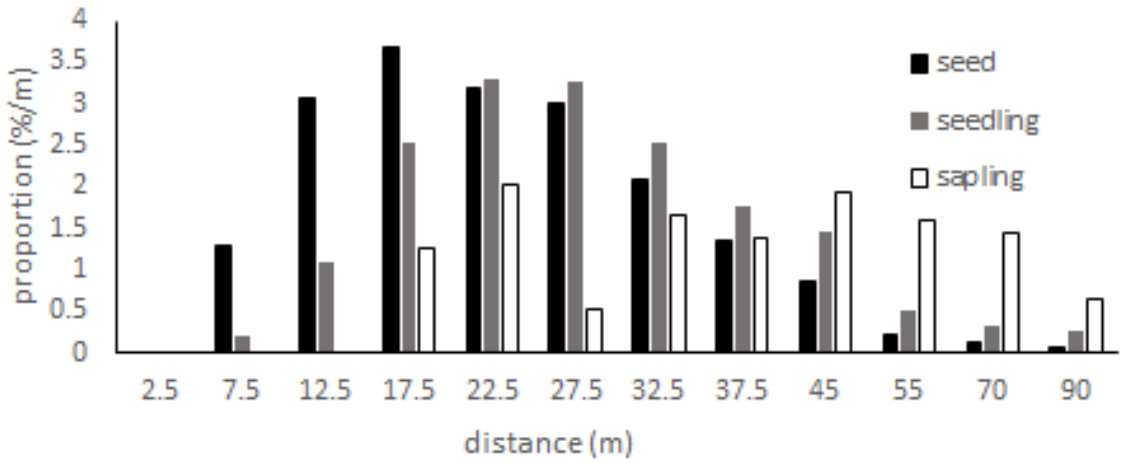
A group of researchers studied abiotic seed dispersal by wind in the tropical tree graceful platypodium (*Platypodium elegans).* This tree species is common in tropical forests from Panama to Brazil. It produces a single-seeded fruit called a samara (Figure 3). The seed has a large wing attached on one side, which causes the seeds to spin as they fall off of the tree. *Platypodium* seeds "helicopter" away from the parent plant, much like the samaras produced by maple trees in many temperate forests.

Figure 3. *Platypodium elegans* samaras. Note the single seed and long wing.

Working in a forest on Barro Colorado Island in Panama, researchers identified 20 trees that were isolated from one another so any seeds or seedlings nearby were produced by that specific adult tree. After seed dispersal finished for the season, researchers counted the number of samaras found around each of the *Platypodium* trees. They also measured the distance from the tree to the samara. Next, they counted and measured the distance to all of the germinated seedlings and the larger saplings (young trees) around the 20 trees. Their results are presented in Figure 4.

What can you determine about the seed shadow for *Platypodium elegans* from these data?

Figure 4. Proportion of seeds, seedlings, and saplings at different distances from twenty isolated *Platypodium elegans* trees.



What do the data indicate about survival of seedlings at different distances from the parental tree?

Explain what the combination of seed, seedling, and sapling data tells you about seed dispersal by wind.

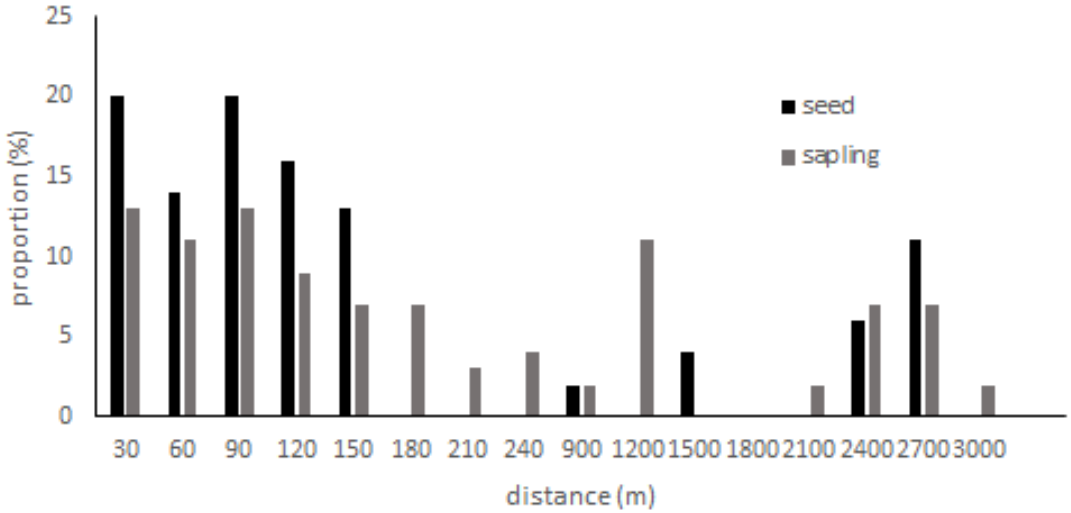
Bird Dispersal in *Ficus*[3]

Figs are common components of many tropical forests. In the limestone mountains of Yunnan Province in China, *Ficus cyrtophylla* grows in many of the moist valleys. This short, evergreen tree produces clusters of small, seed-filled figs two or three times each year (Figure 5). Three species of birds called bulbul's eat the figs. The seeds pass through their digestive tract and are dropped on the forest floor in the birds' feces.

Figure 5. Seed-filled interior of typical figs.

Because this fig species is so numerous, the research team used a different approach than the *Platypodium* researchers to study the seeds. They placed forty-six 1m x 1m mesh nets called **seed traps** around their study area. A **seed trap** is a container used to catch items that drop on to the forest floor, such as seeds. Researchers checked the traps weekly for one year and removed and counted the fig seeds. It is not possible to determine whether a seed or seedling came from a particular parent tree based on its appearance (**phenotype**) because they all look similar. Instead, the researchers germinated some of the fig seeds and collected leaf tissue from the seedlings to determine their **genotype** (set of alleles for specific genes) using genetic markers. The researchers also used the same genetic markers to genotype the adults and seedlings throughout their study area. They used the genotypes to match the seeds and seedlings to the mother tree. The data for seed and seedling distances from the maternal tree is show in Figure 6.

Figure 6. Proportion of seeds and seedlings at different distances from their maternal tree for *Ficus cyrtophylla*. Note x-axis scale changes after 240m.



What can you determine about the seed shadow for *Ficus cyrtophylla* based on these data?

What do the results indicate about survival of seedlings at different distances from the maternal tree?

Explain what the combination of seed and seedling data tell you about seed dispersal by birds.

Comparisons

Now that you have seen the data from the video and two separate studies, compare their results and conclusions. Are there any **similarities** in the observed seed shadows for the wind-dispersed, monkey-dispersed, and bird-dispersed tree species?

Are there any **differences** in the seed shadows of the tree species with different dispersal vectors?

How do the observed patterns compare to the predictions you drew?

Why do you think that the researchers studied not only seed dispersal distances but also the distances of seedlings?

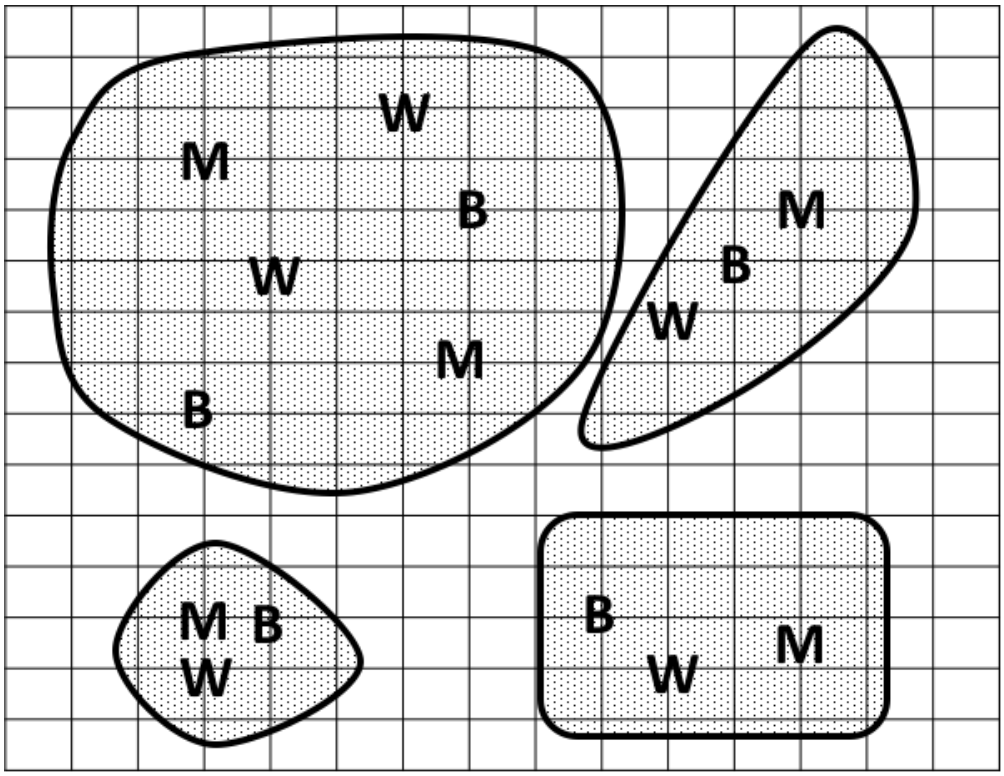
Estimate the likely dispersal distance for a *Platypodium* seed. Do the same for a *Ficus* seed.

Estimated *Platypodium* seed dispersal distance _____

Estimated *Ficus* seed dispersal distance _____

How does the distance that most seeds are moved compare to the distance where most seedlings establish? What do you think is the cause of this pattern?

Suppose the map in Figure 7 below represents a tropical forest that has been broken into four fragments as indicated by shaded areas. There is a representative of a monkey-dispersed (M), bird-dispersed (B) and wind-dispersed (W) tree species in each fragment. The prevailing wind in this region is from the East-Northeast. The open spaces between fragments are inhospitable to the three tree species' seedlings.
Figure 7. Map of a hypothetical forest with four fragments (shaded areas). Each square is 100 m x 100 m. M = monkey-dispersed, B = bird-dispersed, and W = wind-dispersed tree species.



Draw letters to indicate where the seedlings from the trees in the different fragments would be expected to establish. How do you predict that fragmentation will impact the three, different species? How could fragmentation potentially affect tree diversity in the forest fragments over time?

What might conservation biologists consider doing to promote establishment of trees and movement of seedlings among fragments to maintain healthy forests in each fragment?

Literature Cited

[1]Galindo-González, J., Guevara, S. and Sosa, V. J. (2000). Bat- and Bird-Generated Seed Rains at Isolated Trees in Pastures in a Tropical Rainforest. Conservation Biology, 14: 1693–1703. doi:10.1111/j.1523-1739.2000.99072.x

[2]Augspurger, C. K., Franson, S. E., Cushman, K. C., & Muller-Landau, H. C. (2016). Intraspecific variation in seed dispersal of a Neotropical tree and its relationship to fruit and tree traits. *Ecology and evolution*, *6*(4), 1128-1142.

[3]Zhou, H. P., & Chen, J. (2010). Spatial genetic structure in an understory dioecious fig species: the roles of seed rain, seed and pollen-mediated gene flow, and local selection. *Journal of Ecology*, *98*(5), 1168-1177.

Image Credits

Figure 3. Platypodium elegans (2) by João de Deus Medeiros. Licensed under the Creative Commons Attribution 2.0 Generic license. Available at: https://commons.wikimedia.org/wiki/File:Flickr_-_João_de_Deus_Medeiros_-_Platypodium_elegans_(2).jpg

Figure 5. Fresh figs by Eric Hunt. Licensed under the Creative Commons CC BY-SA 2.5. Available at: https://en.wikipedia.org/wiki/Common_fig#/media/File:Figs.jpg