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What Influences Seed Selection by Small Mammals?

Corina Danielson
University of New Hampshire

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Research Article

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Bartlett Valley in New Hampshire is alive with many species of animals. Just after the sun rises in the morning, you can hear dozens of frogs offering a chorus of croaks, and the beautiful echoing whistle of hermit thrushes can be heard throughout the valley. Red foxes can be seen trotting from forest edge to edge, and white-tailed deer pass through the trees silently with an uncanny grace. The traces of black bears' claws can be seen carved into the smooth bark of beech trees, and occasionally, the deep rumble of a moose call can be heard in the distance. These animals are all key parts of Bartlett's ecosystem, but there is another group of animals that often go entirely unseen, despite the fact that they are major forces of change within the forest: small mammals.

These animals include species like eastern chipmunks, flying squirrels, deer mice, red-backed voles, and northern short-tailed shrews. All of these species have many morphological and behavioral differences between them. Some of them—like squirrels, chipmunks, and even mice—can scale a tree in an instant, whereas others, like shrews, are nearly blind and use a form of echolocation to travel beneath leaf litter. Red squirrels are one of the few small mammals you can often hear anywhere in Bartlett Valley, because they aggressively chitter at each other from the trees during the daytime, but some of these species, like flying squirrels and mice, are entirely absent while the sun is out. Despite their numerous differences, these small mammals all share one trait in common: they are voracious seed predators.

Bartlett Valley is just a small part of the White Mountain National Forest.

Small mammals are generally not the first thing that come to mind when you think of predators, but because of their density and feeding habits, they are capable of influencing which plant species in a forest survive and thrive (Vander Wall 1990). Their seed preferences make them major drivers of change within forest ecosystems. The factors that determine what seed a small mammal takes, how far they move the seed, and how competition with other small mammals might impact feeding behavior can play a crucial role in understanding the natural regeneration of forests (Muñoz and Bonal 2011; Weighill et al.2017).

The influences of small mammals on forest regeneration have not been closely studied in New England, but they may have important implications in differently aged forests. As a wildlife and conservation biology major and a forestry minor, I am interested in understanding forest growth and ecosystem dynamics, and small mammals are one of the most important factors in forest regeneration. After all, plants and trees can't exactly move themselves to take advantage of a gap in the canopy or spread their seeds directly to an area without competition from other seedlings and saplings. It's the little mammals and birds that often do most of the legwork of moving seeds across the forest to suitable growing locations.

Working in Dr. Rebecca Rowe's small-mammal laboratory opened my eyes to the massive impacts these little animals have on ecosystem structure. Under her mentorship, I received a Summer Undergraduate Research Fellowship (SURF) award to study a few of the determinants of seed selection by small mammals, and set out to catch on film these animals foraging.

My study had two primary objectives. The first was to identify the seed preferences of each small mammal species present in my study area (the Bartlett Experimental Forest in Bartlett, New Hampshire) when given a choice between the seeds from three native tree species: American beech, red maple, and Eastern hemlock. The second was to determine which habitat factors had the greatest influence on foraging behavior.

To Catch a Mouse (on Camera)

To conduct my research, I worked as part of a UNH small-mammal monitoring project in Dr. Rowe's lab. The lab conducts a yearly capture-mark-recapture study within the Bartlett Experimental Forest. I was one of three undergraduate research assistants working on this monitoring study with a graduate student from Dr. Rowe's lab. This ongoing project is currently examining the effects of differing dominant forest types in the White Mountain National Forest on small mammal resource use and community interactions. Some of the primary goals are assessing small mammal occurrence across forest types (the three major ones being hardwood, softwood, and mixed forest), and collecting tissue, hair, and scat samples from which we can learn about genetics and diet.

An early morning outside the Bartlett Research Station's laboratory.

The monitoring study consists of trapping small mammals in aluminum box traps baited with birdseed, identifying the species and sex, marking them with a standard ear tag, clipping a small sample of hair, and collecting some of their feces from the trap they were in. Then, they are released where they were found. Clean traps are reset in the same spots, allowing the capture of new or already ear-tagged animals. Traps are set on twelve different 2.5-acre study grids. In each grid, sixty-four trap stations are spaced evenly apart and marked with flags.

At the beginning of a trapping session, one box trap is placed at each station. These grids are in various forest types, terrains, and slopes. We set traps in each study grid three times: once in June, once in July, and once in August. For four days, we would put traps on three of the twelve grids and check them twice a day at dawn and dusk, then wash all the traps at once and reset them on three other grids for another five days before taking our four-day break. The next session, we would repeat the process with the other six grids.

For my SURF project, I established eight camera stations across each study grid. We pounded in metal poles with a custom-made mounting system for trail cameras. The trail cameras were suspended facing downward at handmade wooden feeding trays. Each seed tray contained six wood panels drilled with sixteen individual compartments and held a total of ninety-six seeds per tray, which consisted of thirty-two seeds from each native seed species in my study: American beech, Eastern hemlock, and red maple. After each period of capture-mark-recapture trapping on a grid, we would start "camera trapping" on those grids.

A camera station, with a custom-made mounting system from which the trail camera was suspended.

The trail cameras I selected for my study were close-focus, high-definition video cameras that were motion and heat activated. Once motion or heat was sensed, the camera would record for one minute, and then record another minute if additional motion was detected. It was equipped with an invisible infrared flash for taking videos in the dark without alerting the animals by casting light on them. I used 16 GB SD cards to store video on the cameras until the camera was collected and the data was moved to a 1 TB external hard drive. By the end of the summer, the external hard drive was nearly full. I used rechargeable batteries in the cameras, which were rotated out with fresh batteries once we noticed the power level getting low. These cameras came with "viewers" that could be plugged into the trail camera to get a live view of what the camera was angled at and allowed us to manually adjust the camera in the field in case the wind, precipitation, or an animal moved the camera or the seed tray overnight.

Camera trapping occurred on two grids for three days, and then we switched the cameras to the next two grids. This offset was to avoid interfering with live trapping and to capture as many marked animals on camera as possible. Although the animals' tag numbers themselves were unreadable on camera, recording marked animals on film was important; the ear tags were given to captured animals in a manner that allowed us to determine the sex of the animal on camera, and additional markings allowed me to differentiate between deer mice and white-footed mice, two morphologically similar species.

The Trials and Tribulations of Seed Trays

Data collection was very successful. I captured several hundred hours of video data on small mammals. But, as with any study, there were a few challenges I had to address along the way. The largest issue involved the seed trays. They had mesh that allowed some water to drain without losing seeds, but during heavy rainfall they would not drain fast enough and instead flooded, releasing our seeds without setting the camera off. This caused a problem, because I wasn't sure if I was losing seeds because of small mammal activity or if they were lost to weather. To alleviate this issue, I outfitted the trays with towels stapled to the bottoms that would wick water from the mesh immediately. This drained them in all but the most extreme rainstorms.

Another problem we had was that at the very beginning of the study, our cameras had power issues because they were oriented downward, which would pull the batteries out of place in the camera. I placed a cardboard barrier to apply pressure to the batteries, which fixed the problem.

The trail camera captured an unexpected bear visit to a seed tray.

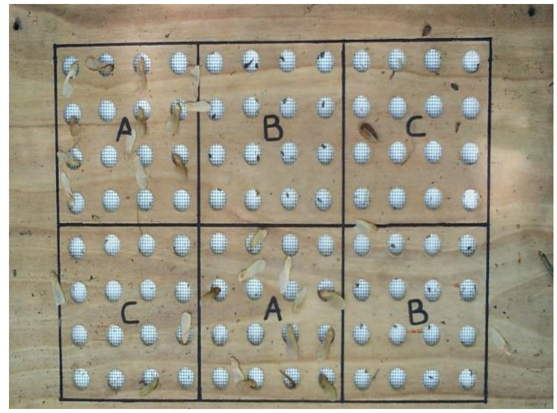
My final issue was a little more complicated. Black bears are common in the area, and they too like birdseed bait and beechnuts. We had prepared for these problems by purchasing bear boxes, which are steel boxes that protect trail cameras from bear damage, precipitation, and theft when they are out in the field. We had also reinforced the trays with wooden struts, so that they could hold the weight of a bear without snapping. Because of these modifications, our trays suffered from only two mesh punctures (from claws) and a couple of thin scratches, and the cameras came out without any damage at all, despite being batted around by bears a few times.

We caught multiple bears on camera at my seed trays, and often observed them on the video licking beechnuts up off the tray like dogs. Occasionally, there would be no evidence that a bear had stopped by a seed tray until I saw it on footage later that day. In case we encountered a bear in the field, my coworkers and I carried marine air horns, the screech from which discourages them from hanging around the traps and seed trays.

Preliminary Results

To analyze the footage, I created an Excel spreadsheet consisting of various data inputs, such as the date and location, the species of the small mammal subject, the type of seed it was taking, the method of removal (via eating or via offscreen caching), and the time spent on screen. Because of the extremely high number of squirrel and chipmunk videos we recorded, we narrowed our analysis to white-footed mice, deer mice, and red-backed voles. Using R, a statistical computing program, we organized the inputs for statistical analysis and examined the overall preferences of these small mammal species, as well as their activity levels at differing times of day and night. Video analysis took place in the Rowe lab after the summer field season because of the sheer volume of videos recorded.

Preliminary results show a strong preference for beechnuts by all three species (white-footed mice, deer mice, and red-backed voles), likely because of the nuts' high fat content, which is perfect for packing on weight for winter. However, we occasionally observed voles display resource partitioning, which is specializing in a certain food source to avoid competition with peers; later in the season, they sometimes focused on red maple seeds, which were less preferred by the two mice species. Voles also had a unique approach, where they took multiple red maple seeds at a time. This was possible because of the small, thin size of the red maple seeds, whereas it was difficult for voles and mice to remove more than one beechnut at a time because of the nut's size. Hemlock seeds, the smallest of the three offered seeds, were the least favored seed by far.



The view of the trail cameras on the experimental trays; only one beechnut remains untouched on this tray. A = red maple, B = hemlock; C = beechnut.

Resource use and foraging behavior by small mammals may change, depending on the yearly cycles of trees and the differing availabilities in seed quantities by season. Because beechnuts tend to mast (or drop in large quantities) every five to ten years, there may be increased or decreased competition over these seed types, depending on whether the tree is currently masting. When the project first started in early June, red maple seeds were dropping, so at that time there was little competition for those seeds, because there were plenty available everywhere. However, later in the season we saw an uptick in foraging activity on the trays, likely due to increased competition for food, which becomes scarcer as summer turns into fall.

In addition to these results, we have also found that foraging activity on our trays peak approximately 2-3 hours after sunset for all three target species, with minor secondary peaks following 5-6 hours post-sunset. Our results so far have shown that the amount of foraging by deer mice is most influenced by environmental factors such as moon luminosity, shrub cover, and how late in the summer it is, whereas white-footed mice and red-backed voles are less affected by environmental variables.

Looking Forward

I learned a lot about mammals last summer. I had so many encounters that it would take hours to detail them all: the flying squirrels gliding from tree to tree above our heads, the deer I nearly stumbled into headfirst on my last day, the raccoons who were deathly afraid of trail cameras, the bears who would pettily smash our traps, and many, many others. This study was an opportunity to catch a glimpse of some of the most underappreciated wildlife species and the important role they play in natural forest regeneration. Working up close with these animals was astoundingly fascinating and gave me a unique opportunity to examine their behavior, but there is still plenty to be curious about within this system. There are hidden drivers behind every action an animal makes, and despite

The author, a wildlife and conservation biology major.

how often we see things like squirrels caching acorns in a park, their choices are anything but arbitrary.

I will be presenting the results of my work at the 2019 UNH Undergraduate Research Conference and going back to the White Mountain National Forest to work for Dr. Rowe's lab this summer. I hope to graduate in December 2019 and continue pursuing a career in wildlife field research and monitoring. The effort I put into my SURF project has given me a new perspective on the rewards of working with wildlife.

First, I would like to thank my mentor, Rebecca Rowe, and her postdoctoral researcher Ryan Stephens for supporting me throughout the entirety of my research project. I am also incredibly grateful to the Forest Service's Northern Research Station for housing me in their facilities at the Bartlett Experimental Forest and allowing me to conduct my camera trapping research on their property. I would like to thank the three generous donors who funded my project, Mr. Hamel, Ms. Perreault, and Ms. Planz. Special thanks to Curtis Johnson for lending us his workshop and expertise while creating our seed trays and camera mounts. Finally, I want to express my gratitude toward my coworkers, Nick Moore, Benjamin Wymer, and Molly Donlan, as well as Mackenzie Meier for assisting in the video analysis.

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Author and Mentor Bios

Corina Danielson came to the University of New Hampshire (UNH) from her hometown of Nashua, New Hampshire. She is majoring in wildlife and conservation biology, with a minor in forestry, and will graduate in December 2019. She was awarded a Summer Undergraduate Research Fellowship (SURF) to study small mammal seed selection in the Bartlett Experimental Forest under the mentorship of Rebecca Rowe. Corina learned an incredible amount from her research project, even before she stepped foot in the forest, from researching tools needed to making seed trays in a carpenter's workshop to testing camera mount setups. Despite dealing with swarms of mosquitoes and humidity so high her sweat wouldn't evaporate, Corina loved working outdoors for the summer. She grew up in a city, so "waking up every morning to see the wispy fog trailing off the mountain peaks was phenomenally surreal. I saw a greater diversity of wildlife in that single summer than I probably have seen in the rest of my life." She hopes her *Inquiry* article will draw more attention to the study of small mammals in wildlife and forestry fields. Corina eventually plans to earn her master's degree in natural resources, with a general focus on wildlife. Her research gave her a taste of what it will take to earn a graduate degree.

Rebecca Rowe is an associate professor in the Department of Natural Resources and the Environment at the University of New Hampshire (UNH). The research in her lab focuses on the population and community dynamics of small mammals across space and over time. The lab is interested in how small mammals influence forest composition and structure through the consumption and dispersal of seeds and fungi. Corina was interested in learning more about these small forest mammals and their behaviors. Sparked by her interest, Dr. Rowe and her graduate students worked with Corina to develop the seed tray experiment—the first of this kind for Dr. Rowe's lab—to gather direct evidence of seed preferences of small mammals in the established research site in the Bartlett Experimental Forest. Dr. Rowe noted, "It was rewarding to see everyone work together to troubleshoot different design options. Corina was instrumental in the design and construction of the trays, and it was great to see her take such ownership of the project from the beginning." Dr. Rowe has mentored undergraduate researchers before; this is the first time their work has been published in *Inquiry*.