ROLE OF WILD MAMMALS, ESPECIALLY WOODRATS, AND BIRDS IN SEED SURVIVAL: IMPLICATIONS FOR OAK REGENERATION AND CHESTNUT RESTORATION

An Eastern chipmunk strikes an "up and alert" pose to watch for potential predators as it forages from a GUD tray.

Current Status

First year of a three-year project

Funding Sources and Partners

DNR Nongame Fund, State Wildlife Grant (T07R12) Purdue University, and The Nature Conservancy

Project Personnel

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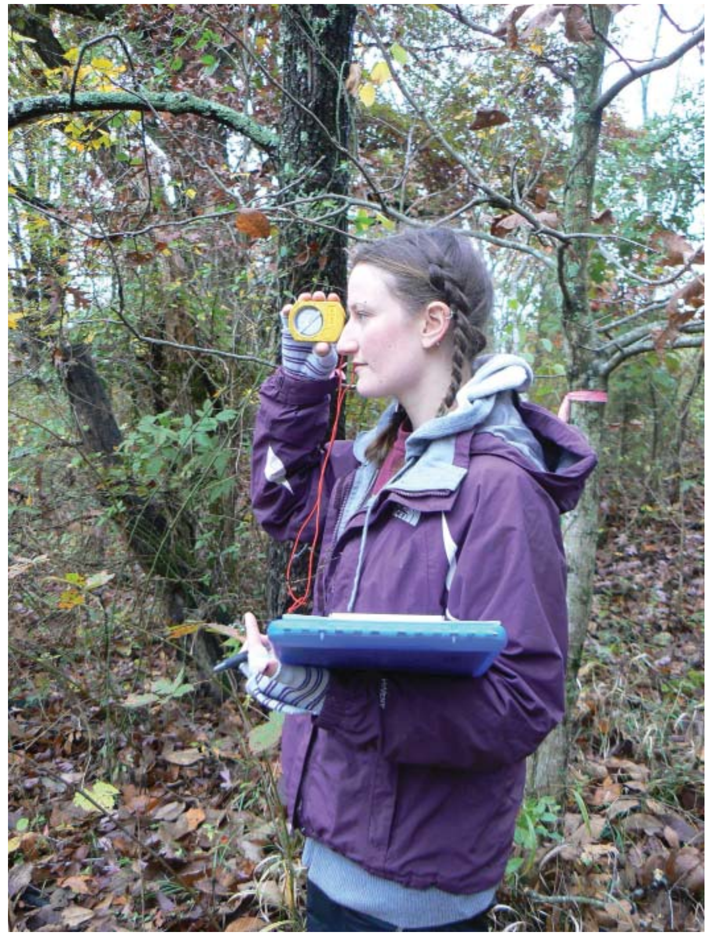
Background and Objective(s)

The American chestnut *(Castanea dentata)* once was the foundation species of much of the Eastern deciduous forest, numerically dominating and defining the ecological function of these habitats. The American chestnut was unique from other mast producers (i.e., trees that produce nuts) in both the high quantity and palatability of its annual seed crop. In 1904 the human-mediated introduction of the fungal pathogen chestnut blight *(Cryphonectria parasitica)* ultimately led to the functional extinction of the American chestnut, playing out during the next 50 years as the pathogen spread throughout

A nocturnal Southern flying squirrel is small enough to fit through the squirrel exclosure entrance holes.

A white-footed mouse investigates a GUD tray as a potential food source.



Jen Hoffman collects microhabitat data at a feeding station.

the species' range. In response to the rapid removal of the American chestnut from forest ecosystems, a pulse of light, water, and nutrient resources enabled the expansion of other tree species. Oaks *(Quercus spp.)* were most successful in filling the niche vacated by American chestnut. Accordingly, many wildlife species increasingly became reliant on energy-rich acorns for survival through the dormant season. A shift in patterns of mast availability resulted in the transitioning forest species' composition because oaks are much more prone to occasional "bumper crop" (highly productive) during intervening years of average-to-low acorn production.

In an effort to restore the ecological niche uniquely filled by the American chestnut, The American Chestnut Foundation (TACF) began an intensive research and breeding program to develop a blight-resistant American chestnut by crossing American chestnuts with naturally blight-resistant Chinese chestnuts. Ultimately, TACF bred a chestnut that is 94 percent American chestnut and resists blight. These blight-resistant chestnuts are in the final stages of plantation evaluations. Limited reintroductions are already underway in national forests in Ohio and Tennessee.

Although blight-resistant chestnuts are primarily American chestnut, numerous questions remain about their ecological properties, particularly as they pertain to granivores (animal species whose diets consist largely of seeds). It remains unknown whether blight-resistant chestnuts represent an ecological surrogate for the functionally extinct American chestnuts as a desirable and abundant food source for granivores like the fox squirrel, gray squirrel, chipmunk, white-footed mouse, white-tailed deer, wild turkey, American crow, blue jay, and tufted titmouse. Additionally, we have little understanding of the likely responses among the populations of granivore species to the re-establishment of a consistent and prodigious mast producer. Also, preferential seed consumption by granivores that disperse seeds (for example, the preference of blue jays for acorns of black oaks over those of other oak species) can have profound implications on species composition of the forest. Therefore, the shifts in the relative abundances among granivore species and relative preferences of these species for the nuts from blight-resistant chestnuts may have important implications for either promoting or limiting

A typical feeding station setup includes a squirrel exclosure, a platform, and two motion-activated cameras.

the expansion of the blight-resistant chestnuts from reintroduction sites.

Given the limited understanding of how the establishment of blight-resistant chestnuts and ensuing increases in mast availability will drive changes among the populations of granivore species, a series of field trials are in progress that will reveal:

1) The preference by granivores for blight-resistant chestnuts relative to other sources of mast (white oak, chinkapin oak, chestnut oak, Northern red oak, black oak, shagbark hickory, pignut hickory and black walnut) commonly available within the historic range of the American chestnut within Indiana;
2) How patterns of seed consumption (and inversely potential for germination) may vary across micro-habitats as a function of relative abundance/intensity of use by specific consumers and perceived predation risk within these habitat types;
3) How patterns of preference and variable seed consumption rates vary across landscapes and the subsequent impacts to the patterns and rates of blight-resistant chestnut expansion from introduction sites; and
4) How restoration of consistent and prodigious mast resources may impact small mammal population dynamics.

Methods

To meet these objectives, we are conducting the following four independent and complementary seed trials: 1) hard mast preference trials, 2) frequency-dependent mast preference trials, 3) giving-up-density trials, and 4) response of population dynamics of Allegheny woodrats to mast supplementation. All studies are being conducted throughout forested regions in Harrison and

Motion-actived cameras are used to monitor rodent visitation to seed trays.

During GUD trials, granivores are allowed to forage for sunflower seeds mixed with sand as a substrate to simulate natural challenges associated with foraging. Visitation is evidenced by tracks in the substrate and verified with photos.

A typical southern Indiana oak-hickory forest serves as a field site for seed trials.

Jen Hoffman secures a motion-activated camera over trays in an exclosure.

Crawford counties in southern Indiana.

Mast preference trials are addressing patterns of preference by granivores for hybrid chestnuts relative to other locally available hard mast food items, including white oak, Northern red oak, black oak, shagbark hickory, pignut hickory and black walnut. For these trials we established 30 stations, each consisting of three seed trays (one elevated to target squirrels and two on the forest floor to target mice and chipmunks, independently) passively monitored with motion-activated cameras. At the start of each trial, we present an array of 63 seeds consisting of equal numbers of the seven seed species listed. We use motion-activated cameras to document the pattern and rate in which the seeds of the various species are removed by granivores. In the trials targeting the various squirrel species, trays are placed on a 5-foot platform to exclude mice and chipmunks whereas trays on the forest floor are placed within a wire-mesh enclosure to exclude larger-bodied squirrels but allow in chipmunks and mice. Trays for squirrels and chipmunks are left open during daylight hours; trays for mice are left open throughout the night. Elevating seed trays, and closing and opening trays at different times throughout the day allows us to independently identify preference for each type of granivore in the community.

After a granivore removes a seed from the tray, it must decide to consume the seed immediately or save it for later consumption by burying it in leaf litter or some other available substrate. While we infer preference for the various species of seeds by the pattern of removal from the tray, these two differing seed fates have important implications for forest regeneration. Accordingly, we “tag” a subset of each species presented to evaluate the fate of the seeds after removal from the tray. Tagging consists of drilling a small lateral hole through the top of the seed and inserting fishing line tied to a piece of fluorescent-colored tape. Seeds are color-coded according to the granivore species for which they are accessible (squirrels, chipmunks, or mice). After the seeds are taken from the trays, we visually search for the tags in the surrounding leaf litter. If a tag is found without a seed, we assume the seed was eaten. An intact seed serves as evidence of hoarding by the granivore matching the color of the tag.

Patterns of seed preference among granivores have been shown to vary in response to the relative availabilities of seeds of multiple species. Therefore, in our frequency-dependent mast preference trials, we are evaluating shifting patterns in seed predation rates in response to variation in the presented ratios of acorns and chestnuts to evaluate the shifts in mast preferences

Seeds presented in an array allow a granivore to make a choice based on preference.

that will occur with the restoration of the American chestnut. As chestnuts are returned to the landscape, two scenarios of seed preference are possible: 1) Consumers may prefer common mast items, such as acorns. This scenario would reduce the loss of chestnuts to seed predation and promote chestnut expansion after initial introductions. 2) During initial restoration efforts, consumers may select novel chestnuts at a disproportionately high rate, hindering restoration efforts by slowing the rate establishment of the new trees and population expansion out of introduction sites. To evaluate this question, we use methods similar to those described for seed preference trials, but instead of presenting equal numbers of each species of seed on the trays, we evaluate preference among three seed species (chestnut, Northern red oak, and white oak) when presented at different ratios. Specifically we conduct paired trials for each of these three species (chestnut vs. red oak, chestnut vs. white oak, red oak vs. white oak), evaluating shifting patterns of preference across five different presentation ratios (1:9, 3:7, 5:5, 7:3, and 9:1). The sequence of seed removal by each type of granivore allows

Annie Spikes opens a tray for diurnal granivores before a GUD trial.

American chestnuts were once an important food source for granivores in eastern U.S. forests.

Acorns (black oak pictured here) replaced chestnuts in the diets of many granivores.

A chestnut seed (far left) is pictured along with currently available sources of mast, such as (top to bottom) northern red oak, chestnut oak, white oak, black walnut, chinkapin oak, pignut hickory, black oak, and shagbark hickory.

us to assess whether consumer selection of chestnuts is frequency-dependent (that is, dependent on the number of seeds available relative to other types of seeds) and what impact frequency-dependent preference will have for chestnut reintroduction efforts.

The third type of trial, giving-up-density (GUD) trials, will be used to evaluate the willingness of a granivore to forage for seeds as a function of predation risk. A small mammal's perceived predation risk varies across the landscape according to microhabitat characteristics associated with the ability to flee or hide from predators; such attributes include overhead forest canopy closure, density of vegetation in the understory, amount of woody debris on the ground, and proximity to the nearest tree trunks. "Giving-up-density" trials are a tool for measuring the density of resources left unconsumed by a forager in an artificial food patch to estimate perceived predation risk. In this case our resource patches consist of an aluminum pan filled with a known weight of sunflower seeds thoroughly mixed with sand. The amount of sunflower seeds left in the pan reflects a balancing point between the diminishing rewards of continuing to forage in a patch in which food resources are not replenished and a constant level of predation risk. For example, we would expect a squirrel to forage longer (leave fewer seeds in the pan) in an area where it has several options for escape (many small trees with low branches) than it would in an open area with just a few large trees. Once again we will present these resource patches (pans) on platforms or in exclosures in the manner described earlier to assess the giving-up-density of each type of granivore (squirrels, chipmunks and mice) independently. Additionally we will monitor each station with motion-activated cameras to confirm species identity and assess time spent foraging versus the time spent in an upright and alert vigilant stance. Ultimately these trials will allow us to map "landscapes of fear" for consumers and identify specific risky microhabitat types that would be well suited for chestnut introductions.

As the final component of these seed trials, we are evaluating the relationship between the extirpation of the American chestnut and the decline of the Allegheny woodrat. Allegheny woodrats are endangered in Indiana and are a species of conservation concern throughout their range. One factor hypothesized to be contributing to the range-wide decline of Allegheny woodrats is a loss of hard mast food resources, a food resource upon which woodrats heavily depend for survival through the winter months. Since oaks are prone to years of mast production failure, while American chestnuts were a consistent producer of highly palatable seeds, it is possible that the restoration of the American chestnut could facilitate the recovery of Allegheny woodrats. To evaluate the relationship between hard mast availability and woodrat recovery, we are supplementing the winter caches of woodrats by depositing 1 kilogram of acorns in occupied woodrat den sites. Specifically, we have assigned woodrat subpopulations in Indiana to two treatment groups: Group One will receive mast supplementation in 2011 while Group Two will serve as the unmanipulated control. In 2012, we will reverse the treatments, supplementing Group Two. Receiving this pulse of acorns simulates a highly productive oak mast year or expected ambient mast availability once chestnut has been fully restored. In the summer after supplementation, we will evaluate differences between treatment groups in change in abundance, over-winter survival rate, and female reproductive success.

Northern red oak seeds are tagged with species-specific colors.

Progress to Date

In preparation for the seed trials, we conducted small-mammal abundance assessments at both sites selected for the trials. At each station, we placed two Sherman box traps targeting mice and chipmunks and a Tomahawk live-trap targeting squirrels, and trapped small mammals for five consecutive days at each site. We sexed, weighed, and ear-tagged each captured animal. We found that white-footed mice were present in high densities, while densities of squirrels and Eastern chipmunks were relatively low.

Before beginning the giving-up-density trials, we sought to quantify each of the microhabitat characteristics that may contribute to a rodent's perceived predation risk. At the 60 stations distributed across the two sites, we measured the following microhabitat attributes associated with a small mammals perception of predator risk: 1) we quantified forest canopy closure using a hemispherical camera, 2) mapped the distance from the center of the station (location of the pan) to all trees within a 10-meter radius, 3) measured the height from the ground to the bottom of the tree canopy, 4) estimated understory density using a 2.5-meter high vegetation profile board, 5) quantified the density of the ground vegetation cover by taking photographs from a "rodent's eye view", and 6) measured the length and diameter of all downed woody debris within a 5-meter radius of the station center.

Other preparatory tasks included seed collection and processing, construction of platforms, exclosures, and seed trays, and assembly and mounting of motion-activated cameras. We have completed GUD trials at our first site, and more trials are scheduled to begin later this fall.

Allegheny woodrat live-trapping was conducted during the summer months for each subpopulation incorporated in the hard mast supplementation study. These surveys allowed us to document occupied den sites, and delivery of acorns to these den sites is underway. Population data collected in 2011 will serve as pretreatment data and allow us to measure difference in population dynamics between the two treatment groups in 2012 and 2013.

Challenges Encountered

The main challenge associated with beginning the series of seed trials has been developing a station infrastructure that would both suit our purposes and remain functional. Because of the large scale of the station grid setup, we needed equipment that was manageable to carry yet robust enough to support a foraging squirrel or exclude a persistent one as well as withstand inclement weather. Fine-tuning the motion-activated cameras also presented some difficulty. In order to get the quality of images we needed to document seed selection events, we had to tweak focal distance and the placement of seed trays under the cameras over several successive test runs. We continue to troubleshoot and refine our setup.

One additional issue we encountered this year was the availability of seeds for use in our trials. With only a moderate crop of black and Northern red oak and a failure of white oak and hickories this year, we had to be more creative in locating seed sources. While we were able to collect some of our seeds from our study sites, we had to obtain most from various distributors and unfortunately had to eliminate two of the oak species we had originally planned to include in the seed-preference trials (chinkapin oak and chestnut oak). We hope to include these species in the 2012 seed trials, depending upon annual mast crop production.

Cost: $259,758 for complete two and a half year study