A Title: **Reseeding restored forests: Can seed dispersal mutualisms amplify restoration of American Chesnut (*Castanea dentata*)? [Year 2]**

James R. Wright

Collaborator**: Leila Pinchot**
Faculty supervisors**: Christopher M. Tonra and Stephen N. Matthews**

B SUMMARY (100 words)

Seed dispersal is a fundamental mutualism between wildlife and trees. Wildlife, such as birds, often cache abundant seed from trees to enable them to survive the winter, and unrecovered seed ensures dispersal and persistence of tree species. Rapid environmental change can disrupt this critical process, potentially threatening the persistence of the ecosystem. Both the loss of American chestnut and the declines in Oak-Hickory forest represent historic and contemporary perturbations to plant-animal interactions. Understanding the capacity of Blue Jays, a prolific seed disperser, to facilitate chestnut and oak dispersal, and their seed preferences, is an important piece to sustaining these forests.

C Principal Investigators and Institutional Affiliations

James Wright: PhD student, School of Environment and Natural Resources, Ohio State University
Cornelia (Leila) Pinchot: Research Ecologist, USDA Forest Service Northern Research Station
Christopher Tonra: Assistant Professor, School of Environment and Natural Resources, Ohio State University
Stephen Matthews: Assistant Professor, School of Environment and Natural Resources, Ohio State

D Duration of Project

Three years of research (2018-2020). This proposal resubmission is a funding request for Year 2.

E Total amount requested

We are requesting $8,080 to support a research technician and supplies to tag Blue Jays and Chestnuts. We recently received additional funding of $49,000 to support a graduate student and field supplies to focus on relationships between Jays and Oaks, and the proposed research here will allow us to continue the novel Chestnut component. In total, we will be able to more fully consider seed utilization and dispersal of large nut producing trees by scatter-hoarding birds. In addition to the funds requested we also will ask if TACF can provide chestnut seed (n=2,000) to implement the feeding and germination trials. Because we are primarily utilizing these seeds during feeding selection trials there are not limitations and can be from open pollinated stock.

F Short and long-term goals of the project

Our short-term goals are to build capacity to evaluate important plant animal interactions in forested settings. By considering the role of Blue Jays in the dispersal of seed producing trees we can gain a better understanding of how these relationships are critical to sustaining healthy forests and can facilitate the restoration of American chestnut. Our long-term goals aim to build on these initial results to incorporate how these patterns vary over time as mast cycles undergo natural fluctuations to capture the full dynamic of the system. Understanding these relationships will provide needed insights to the processes regulating seed dispersal and regeneration potential of chestnut and oak across the landscape.

G Narrative

Introduction

Plant-animal interactions are a fundamental determinant of ecosystem function and production. Like many systems, historic chestnut and contemporary Oak-Hickory forests of eastern North America consist of trophic interactions that link energy flows from primary consumers to predators. Perhaps overlooked are the essential mutualisms (Bascompte, 2010) that occur via pollination and seed dispersal in this ecosystem. With the success of The American Chestnut Foundation's (TACF) efforts to develop blight-resistant American chestnut, understanding the capacity of these key mutualisms to facilitate establishment and dispersal are important steps as maintaining these mutualisms are essential for sustainable forest productivity, through processes such as gene flow.

Of the multiple species that facilitate seed dispersal of plants, the avian family *Corvidae* (jays, crows, and magpies) exemplifies the role plant-animal mutualisms play in ecosystem structure and function across their global distribution (Pesendorfer et al., 2016). Key to this relationship is the benefit the tree receives from scatter hoarding behavior, where seeds are transported and stored in various cache locations for later consumption. Inevitably, a portion of caches are not recovered, and thus may germinate (reviewed in Pesendorfer et al., 2016). Key traits that have evolved in this system can facilitate these interactions. For example, seed size will influence ability to disperse. Palatability and time to germination can facilitate immediate consumption or storage for overwinter. Finally, consistency of seed production across years will mediate wildlife responses. Specifically, dispersal can be enhanced by mast cycles that ensure a lag in population synchrony (i.e. "swamping" hoarders in some years with more seeds than can be consumed to ensure germination). Across the Appalachian forest region, the historic dominance of American chestnut with large seeds and consistent annual seed production provided an abundant food resource (Dalgleish and Swihart, 2012, Diamond et al. 2000). Today these same forests, dominated by oak (Quercus sp.) and hickory (Carya sp.; key mast producers supporting wildlife), have more varied seed production, with many of the red oak group showing regular biannual mast while others show more consistent, albeit lower, annual production of acorn crop. Animal behaviors, such as caching, provide a key mechanism for long distance dispersal, where not only competition from the parent tree is reduced, but genotypes are moved greater distances over heterogeneous landscapes (Siepielski et al. 2008).

If our goals are to reestablish chestnut to the landscape and sustain productive oak forests and wildlife communities, we must gain a better understanding of the role that plant-animal interactions play in shaping these forests. Across the former range of chestnut, Blue Jays (*Cyanocitta cristata*) are vital scatter hoarders of Fagaceous species (Vander Wall 1990). Evaluating the preferences of Blue Jays in selecting and dispersing seeds based on species composition and abundance will provide key insights to developing restoration plans. Appalachian forests face multiple threats (Butler et al. 2015), and forest change and loss could be exacerbated if these threats alter the relationships between trees and their mutualists. Thus, it is crucial we elucidate the effect of ongoing forest declines while at the same time critically examining opportunities to restore forests and reestablish chestnut, in an integrated approach that considers both trees and services that wildlife provide. Our objectives are to understand 1) how Blue Jay caching behavior, with a focus on distance moved and preference, responds to chestnut and acorn availability, and 2) how caching location can influence germination success. By elucidating how this plant-animal interaction changes with variation in seed abundance, we will be able to predict the ripple effects forest community changes will have in this critically important ecosystem.

Rationale and Significance

Animal dispersal is a fundamental process in forests of nut bearing trees (e.g. McShea et al., 2007). The mechanism of dispersal and co-evolution between trees and wildlife has emerged across the global distribution of many species within the temperate forests (Pesendorfer et al., 2016). For example, in many systems, the balance of food consumption by the seed predator is compensated for by the dispersal of large seed away from intraspecific competition of the parent tree, promoting gene flow and genetic diversity (McShea and Healy, 2002). In turn, the diversity of wildlife that depend on nuts (hickory, oak, formerly chestnut) for a portion of their energetic stores is impressive. For example, by some estimates over 90 species of wildlife utilize acorns as a portion of their diet within eastern North America (McShea et al., 2007). In the oak system, the benefits to dispersal trees obtained by scatter-hoarding behaviors (Pesendorfer et al. 2016) greatly outweigh the benefits of wildlife species that are larder-hoarders (where caches contain a larder of seeds often in unsuitable germination conditions), or those that do not hoard. Chestnuts and oaks have evolved a combination of considerable secondary structural and metabolic defenses and large seed size to limit direct seed predation (both by invertebrates and vertebrates), while maintaining close mutualistic relationships with scatter hoarding species (Pesendorfer et al. 2016). Jays (several genera in *Corvidae*; e.g. *Aphelocoma* sp., *Cyanocitta* sp.) have long been identified as essential dispersers of large seeds (Darleyhill and Johnson, 1981). This mutualism has even been linked to rapid expansion of nut-bearing trees, including chestnut, following the retreat of the last ice age (Johnson and Webb, 1989). Thus, these important relationships will certainly be essential to increasing resilience and adaptive capacity of restored chestnut. In particular, understanding how far Jays might transport chestnut would improve models predicting American chestnut population expansion, such as that described in Rogstad and Pelikan (2014), and would inform decisions of placement of founder population sites to maximize restoration success. Finally, understanding Jay preference for caching site and the fate of chestnuts across cache sites would help guide forest management strategies for American chestnut reintroduction plantings.

The close association between scatter-hoarders and seed-bearing trees highlights the importance of maintaining functional biodiversity, and demonstrates the critical need to understand plant-animal interactions in a time of rapid change and active restoration. Therefore, revealing how these processes shape patterns of species demography and distributions of both seed producers and their dispersers are essential. A key component to the mutualistic benefits of scatter-hoarding is that mast cycles ensure that there are years with high and low availability of specific oak species, such that in high mast years production will exceed consumption. It is critical that we understand how mast cycles of oaks may influence dispersal probability and eventual germination rates of reintroduced chestnuts. The behaviors of Blue Jays (*C. cristata*) and other scatter-hoarders show a preponderance of caching more food resources than will be retrieved. Darleyhill and Johnson (1981) found that 56% of oak acorn crops were moved by Blue Jays and only 20% of that was consumed, allowing the rest the opportunity to germinate. However, during low mast years most of the cached resource will be consumed (Kelly and Sork, 2002). Jays are regularly observed consuming and utilizing a variety of species, and there appears to be a tradeoff between consumption and storing (Moore and Swihart, 2006), depending on availability. Therefore, the reintroduction of American chestnut with less annual variability in mast has the potential to reshuffle this dynamic and provide insights into how the mutualisms have been perturbed when chestnut was removed from the forest post blight.

Dispersal of seeds by scatter-hoarders is clearly a key service that animals are providing in Eastern deciduous systems. Blue Jays are particularly important to this service as they have been shown to distribute seeds over very large areas, with dispersal distances that can range from hundreds to thousands of meters, while most mammalian scatter-hoarding is on a scale of tens of meters (e.g. Pesendorfer et al., 2016). In heterogeneous landscapes, such as Mediterranean systems, long distance dispersal of acorns by jays is critically important to facilitate movement across otherwise unsuitable conditions (Gomez, 2003). This benefit is of great relevance to chestnut restoration, given the currently fragmented landscape of the eastern United States, where forest loss leaves many trees dependent on avian dispersal of larger body seeds to increasingly isolated suitable locations. The movement away from the parent tree serves two critical functions: 1) reducing competition from parent tree (with light levels being critical for recruitment and growth) and 2) preventing accumulation of seeds under the parent tree, which makes them more susceptible to insect damage. Jays are important not only for moving seeds across the landscape, but the act of caching them facilitates establishment of nut-bearing trees. By burying seeds into the soil they are protected from disturbance, insects, burning, and some predation. Evidence of direct selection for cache locations that are optimal for germination is variable (Garcia et al., 2002; Sipes et al., 2013), but the act of actively moving and burying is a clear benefit. Numerically, an individual Blue Jay can cache 3000-5000 seeds in a season (Smith et al. 2013), scaling up to a tremendous capacity for population growth.

Clearly, the interactions between Jays and nut bearing trees are a critical component of the persistence of these forest ecosystems. This mutualism has developed and persisted in the face of dramatic forest change when the American chestnut was removed from the system. As we begin to push toward reintroduction of chestnut, it becomes critical to evaluate how the dynamic between a primary scatter-hoarder and nut-bearing trees may respond to the return of the chestnut to Oak-Hickory forests. While Heinrich (2014) clearly demonstrates the potential for Blue Jays to facilitate both dispersal and subsequent germination success of chestnuts, it is necessary to investigate how this association is influenced by other food sources. Therefore, we are proposing a study that quantifies seed selection of chestnut and acorn under differing densities, as well as tracking caching location and germination to examine resulting demographic and behavioral responses of Blue Jays. These data will shed light on an important plant-animal interaction and provide insight into the ability of Blue Jays to facilitate chestnut dispersal from founder populations across a heterogonous landscape.

Approach

Hypotheses, predictions, and tests

Hypothesis 1 – Scatter-hoarders disperse seeds proportional to their availability.

Prediction 1A – When acorns are more abundant, Jays will select fewer chestnuts.

Test 1A – We will establish feeding stations at our study sites and present seed sets that vary in the relative abundance of acorns and chestnuts (seed selection trials). Camera traps will be used to monitor feeders and determine which seeds jays are removing. We will use Bayesian discrete choice models to test the prediction that removal rate of each seed type (seed selection) will be proportional to its availability.

Prediction 1B – Jays will prefer to remove different seeds in different parts of the season, depending on whether they are predominantly caching or consuming seeds.

Test 1B – We will repeat the seed selection trials described above during two distinct phases of the season: early (Sep-Oct), when birds are primarily caching, and late (Nov-Dec), when birds are primarily consuming cached resources.

Alternative outcomes – If Jays choose chestnuts over acorns, even when they are less abundant, we will conclude that they actually prefer (i.e. are selecting for) chestnut seeds. This would mean Blue Jays would have a positive influence on restoration, even in oak mast years. However, if they only select chestnuts late in the season, this may mean they will primarily act as seed predators rather than dispersers.

Hypothesis 2– Where and how acorns and chestnuts are deposited will influence their viability.

Prediction 2A – Jays will cache seeds in sites more suitable to germination than random sites.

Test 2A – Using radio telemetry of tagged jays and tags placed in hollowed out seeds we will locate caches and plant viable seeds in these locations in protective cages. We will pair these with random planting locations and use linear mixed models to compare germination rates.

Prediction 2B – Jays will cache seeds in sites less suitable to seed predation than random sites.

Test 2B – At each located cache and paired random location, we will also plant seeds outside the protective cages, to monitor seed predation rate (from birds or mammals).

Alternative outcomes – If germination rates do not differ between cache and random locations we will conclude that while Jays may facilitate long distance dispersal, they do not enhance recruitment of tree progeny. Likewise, if planted seeds at cache locations are predated at a very high rate, the ability of Jays to act as effective dispersers will be limited by the abundance of other seed predators (e.g., squirrels).

Study site and study species

The study takes place at Vinton Furnace State Experimental Forest in southeast Ohio, where long term research to understand sustainable oak management is ongoing (Hutchinson *et al.*, 2008), and experimental chestnut plantings have been established. In Year 1 of the study, we established six replicate feeding platforms separated by ~1km, three located in contiguous forest and three on forest edges. We have approximately 10 years of acorn abundance data at this site from the Ohio Division of Wildlife and U.S. Forest Service, which will allow us to control for important background densities of acorns during the feeding trials. Additionally, we will perform acorn counts throughout the season at each platform during each year of the study, in order to quantify fine-scale variability of oak mast.

The Blue Jay is a widespread species in the eastern United States in the Family *Corvidae*. Blue Jays are known to be a prolific scatter-hoarding disperser (i.e. caching seeds for later consumption over a wide spatial area) of acorns of multiple oak species (Richardson et al., 2013; Pesendorfer et al., 2016). In our study area, the major oak species that depend on wildlife dispersal and have acorns small enough for Blue Jay consumption are black (*Quercus velutina*) and white oak (*Q. alba*). We will, therefore, consider chestnut and the two oaks in our study design detailed below.

Field data collection

Feeding choice trials – In the first year of the study, we conducted two seed selection trials of 6 replicates each, and a third trial with only one replicate. Following Richardson et al. (2013), we presented 50 seeds each of black oak and chestnuts (trial 1) on 6 elevated feeding stations (Figure 1) ~1km apart designed to exclude mammalian removal. As acorns and chestnuts were removed by birds (primarily Blue Jays, but also Red-bellied Woodpeckers *Melanerpes carolinus* and Tufted Titmice *Baeolophus* *bicolor*), the existing choice set changed organically. We monitored each selection event with video recorders to quantify the changing choice set and determine selection. We repeated the above trial with white oak and chestnuts (trial 2), and performed a third trial at one high-use platform where all 3 seed species were presented. In Years 2 and 3 of the study, we will significantly boost our sample size and test for context-dependence (Prediction 1B) by repeating the trials described at all platforms, both early and late in the season (6 platforms x 3 trials x 2 season stages = 36 replicates each year).

Seed tracking and germination - Pons and Pausas (2007) developed a method of tracking seed dispersal of oaks by Eurasian Jays (*Garrulus glandarius*), by placing VHF transmitters inside hollowed out acorns in Europe. This method was subsequently validated for Blue Jays in North American oaks by Sipes et al. (2013). Following these studies, we placed tagged chestnuts and acorns (n = 42) at our feeding platforms and began systematically searching the area after they were removed, until we found either the cached seeds or the remains of consumed ones (we were able to determine fate for 94% of tagged acorns/chestnuts). We then measured the proportion consumed and the distance dispersed for caches. At each cache location (n = 14) and paired random location (same dispersal distance in a random direction) we planted 4 viable chestnuts in a manner mimicking Jay deposition, two located inside and two outside a predator-proof cage. We returned on a monthly basis to monitor germination and seedling growth (Figure 2), and will continue to monitor seedling growth throughout the duration of the study. We also monitored predation rate of external seeds, and quantified vegetation characteristics relevant to germination and growth (litter depth, canopy cover, shrub density, etc.). In order to determine how background acorn abundance impacts dispersal distance, we will repeat the seed tracking and germination trials in Years 2 and 3 of the study. As in the feeding choice trials, we will also track seed dispersal both early and late in the season to determine context-dependence of dispersal distance.

Blue Jay tagging - During the fall caching period, we used feeding stations baited with peanuts to trap both juvenile and adult jays in walk-in potter traps. Marking a representative sample of individuals will allow us to quantify spatial and temporal distribution of birds, which is essential to relate our feeding trials to the distribution and density of birds. Each tagged bird was fitted with a USGS numbered aluminum band and a unique combination of 3 colored plastic bands, such that individuals can be distinguished. We affixed a 1.5 gram (<3% of body mass) digital nanotag transmitter (model NTQB-6-1; Lotek Inc.) to 30 individuals in Year 1 (Figure 3), and will repeat this sample size in Years 2 and 3 of the study. Tags were attached using a leg-loop harness (Rappole and Tipton 1992). We also collected data on body size (wing chord), bill size, body mass, age, and a feather for DNA sexing in Tonra's lab at OSU. Using body mass and body size we will be able to estimate body condition using scaled mass index (Peig and Green, 2009), which removes variation in mass due to structural size.

Limitations and potential pitfalls

We learned much from Year 1 of our study, including what will likely succeed and what may fail. We found that locating dispersed seeds was not as difficult as we feared (only 2 tagged seeds went missing, and the farthest recorded dispersal event was 124 meters), but this could still pose a problem if dispersal distances are much larger in upcoming seasons. We are relying in part on natural variation in acorn crop to produce the desired variation in background mast abundance, which could be a pitfall if variation in the former is low. However, based on long term data from Ohio Division of Wildlife, over the past 10 years variation has been substantial on an every-other year basis, thus we expect to see substantial fluctuation during the study. Furthermore, running experimental trials both early and late in the season will provide variable background conditions even if yearly abundances do not.

Figure 1. Blue Jay selecting between acorns and chestnuts at a feeding platform

Figure 2. Two chestnut seedlings growing from a cache site.

Figure 3. Placing a nanotag on a Blue Jay.

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H Timeline (gray areas completed)

Activity	2018 AU	2019 WI	SP	AU	2020 WI	SP	AU	2021 WI	SP/SU
OBJ 1: Seed Choice Trial									
Establishment of field sites and materials	X			X			X		
Data collection-Seed selection trials	X	X		X	X		X	X	
OBJ 2: Dispersal and germination									
Data collection-acorn and chestnut caching	X	X		X	X		X	X	
Data collection-planting chestnuts, monitoring growth and predation	X	X	X	X	X	X	X	X	
Caching data analyses			X			X		X	
Prepare progress/final project report			X			X			X
Submit manuscripts									X

I How results will be measured and reported

The primary aim for the project will be to prepare a peer-reviewed manuscript presenting the results of the project. We also will engage in outreach via presentations and reports to disseminate the important interactions and mutualisms between Blue Jays and nut producing trees.

J Budget narrative

The funds requested will provide necessary personnel to manage the experimental trials and to purchase tags to track chestnut seed dispersal. Other contributing funds that will be essential to the project were recently secured to conduct the core study of the mutualism between oaks and Blue Jays. These contributing funds of $49,000 will support a graduate student, travel funds for conducting the research and field supplies to monitor Blue Jays and acorns. The funds requested here will allow us to continue the important chestnut component of the project, to provide needed information about the ability of Blue Jays to distribute seed across the landscape. In addition, the PIs are also committing to supplement up to an additional 10 tags ($1,800) that can be used to mark additional chestnuts to increase power of the dispersal trials for chestnut.

PERSONNEL	COST	F&A Rate	F&A	COST + F&A
Res Assistant (temp Salary 3 months @ $1,800/month)	5,400	0%	0.00	5,400
Fringes (16.3%)	880	0%	0.00	880
Subtotals	**6,280**		**0.00**	**6,280**
Supplies				
Ten Lotek nanotag ($180 each) for tracking Chestnuts dispersal	1,800	0%	0.00	1,800
Subtotals	**1,800**		**0**	**1,800**
Totals	**8,080**		**0**	**8,080**

K Brief CV (2 pages each)

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Education

The Ohio State University: current Ph.D. student, beginning January 2018, Columbus OH
Academic Advisors: Drs. Christopher Tonra and Steve Matthews

The Ohio State University: M.S., Wildlife Ecology, December 2017, Columbus OH
Academic Advisor: Dr. Christopher Tonra

Vassar College: **B.A.**, Environmental Studies, May 2005, Poughkeepsie NY

Competitive Grants/Awards

- The Hesse Research Award, American Ornithologists' Union, $2,496 (2016)
- The E. Alexander Bergstrom Memorial Research Award, Association of Field Ornithologists, $1,500 (2016)
- Ohio Avian Project Initiative, Kirtland Bird Club, $1,000 (2016)
- Mewaldt-King Award, Cooper Ornithological Society, Honorable Mention (2016)
- Teaching Assistantships, The Ohio State University (Spring 2016 and 2017)

Oral and Poster Presentations

- Ohio Bird Banding Association, Waynesville, OH, *The influence of a seed dispersal mutualism on forest change in Ohio* (2019)
- American Ornithological Society Conference, Tucson, AZ, *Automated telemetry reveals staging behavior in the migratory Rusty Blackbird* (2018)
- Kirtland Bird Club meeting, Cleveland, OH, *Migration ecology of a declining songbird, the Rusty Blackbird (Euphagus carolinus)* (2018)
- Ohio Avian Research Conference, Granville, OH, *Shorebirds in disguise: Prealternate molt-migration and extended stopover of Rusty Blackbirds* (2017)
- American Ornithological Society Conference, Lansing, MI, *Shorebirds in disguise: Prealternate molt-migration and extended stopover of Rusty Blackbirds* (2017)
- North American Ornithological Conference, Washington, D.C., *Do migratory Rusty Blackbirds have a third stationary period in their annual cycle? Automated telemetry reveals the "stopover" ecology of a species in decline* (2016)
- International Rusty Blackbird Working Group meeting, NAOC, Washington, D.C., *Habitat use and migratory stopover ecology of Rusty Blackbirds in the Western Lake Erie Basin* (2016)
- State of Stopover Symposium, Milwaukee, WI, *Habitat use and migratory stopover ecology of Rusty Blackbirds in the Western Lake Erie Basin* (2016)
- Ohio Avian Research Conference, Granville, OH, *Do migratory Rusty Blackbirds have a third stationary period in their annual cycle? Automated telemetry reveals the "stopover" ecology of a species in decline* (2016)

Publications

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Ames, E., M. Gade, C. Marroquin, C. Nieman, C. Tonra, A. Tutterow, J. **Wright**, and S. Gray. Striving for population-level conservation: integrating physiology across the biological hierarchy. In Prep.

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Tonra, C. M., J. R. **Wright**, and S. N. Matthews. Remote estimation of overwintering home ranges in an elusive, migratory nocturnal bird. Ecology and Evolution: In Review.

Bulluck, L., E. Ames, N. Bayly, J. Reese, C. Viverette, J. **Wright**, A. Caguazango, and C. Tonra (2019). Habitat-dependent occupancy and movement in a migrant songbird highlights the importance of mangroves and forested lagoons in Panama and Colombia. Ecology and Evolution: In Press.

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Wright, J. R., C. M. Tonra, and L. L. Powell (2018). Prealternate molt-migration in Rusty Blackbirds and its implications for stopover biology. The Condor 120:507-516.

Professional Experience

Research Assistant, **The Ohio State University, Ohio** May to Dec 2015, 2016, 2017

Biology Volunteer, **Tetlin National Wildlife Refuge, Alaska** May to Sep 2014

Field Technician, **Smithsonian Migratory Bird Center, Jamaica** Jan to May 2014 & 2015

Seabird Technician, **Kauai Endangered Seabird Recovery Project, Hawaii** May to Dec 2013

Pinniped Field Crew Leader, **NOAA Antarctic Ecosystem Research Division, South Shetland Islands, Antarctica** Oct to Mar 2012 & 2013

SEFI Fall Migratory Bird Intern, **PRBO Conservation Science, Farallon Islands NWR, California** Sep to Oct 2012

Point Count Field Technician, Management Indicator Species project, **PRBO Conservation Science, Sierra Nevada range, California** Apr to Aug 2012

Field Associate, Nest Monitoring Crew, **Wildlife Conservation Society, Ikpikpuk River, North Slope, Alaska** May to Jul 2011

Field Assistant, **Cooperative breeding of Sociable Weavers, South Africa** Feb to Apr 2011

Biological Intern, **Monomoy National Wildlife Refuge, Chatham, MA** May 2010 to Jan 2011

Marine Fisheries Observer, **A.I.S., Inc., NOAA National Marine Fisheries Service, New Bedford, Massachusetts** Sep 2008 to May 2010

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Education

Ph.D., Biology, Dec 2011, **University of Maine**, Orono, ME
Advisors: Dr. Rebecca Holberton and Dr. Peter Marra
M.S., Wildlife Biology, May 2006, **Humboldt State University**, Arcata, CA
Advisor: Dr. Matthew D. Johnson
B.A., Anthropology, May 1999 **State University of New York, Albany**, NY
Research interests: conservation biology, physiological ecology, behavioral ecology, population biology, stable isotope ecology, animal migration, habitat ecology

Appointments and Awards

Asst. Professor, School of Environment and Natural Resources, The Ohio State Univ. (2014-present)
George Didden Conservation Biology Fellowship, Smithsonian National Zoo (2014)
Post-doctoral Fellowship, Smithsonian Conservation Biology Institute (2012)
Outstanding Student Research Presentation Award, American Ornithologist Union (2011)
Graduate Prize in Animal Biology, University of Maine School of Biology and Ecology (2011)
Research Assistantship, University of Maine School of Biology and Ecology (2007-2010)
Teaching Assistantship, Humboldt State University Dept. of Wildlife and Dept of Biology (2004-2006)

Fellowships and Grants

Ohio Sea Grant, *Emerald ash borer tree mortality and invasive species penetration into forested wetlands in the Lake Erie coastal zone: developing habitat restoration priorities*, $9,933 (2016)
Columbus Audubon Society, *Thinking inside the box: Evaluating the relative value of natural vs. artificial cavities in habitat patches of varying size for Prothonotary Warblers*, $5,000 (2016)
U.S. Fish and Wildlife Service, *Stopover Ecology and Migratory Connectivity of the Rusty Blackbird (Euphagus carolinus)*, $10,000 (2016)
Ohio Division of Wildlife, *Responses of colonial wading bird populations within the Lake Erie Marsh Focus Area to cormorant control and wetland management*, $237,482 (2015, 2016)
Ohio Division of Wildlife: *Population ecology and habitat relationships of Sora and Virginia rails in northwestern Ohio*. Amount received: $158,311 (co-PI, PI: Bob Gates; 2015-2016)

<u>Peer-reviewed Publications</u> *(* - indicates undergraduate author*)

13. Tonra, C.M., K. Sager-Fradkin, and P.P. Marra. 2016. Barriers to salmon migration impact body condition, offspring size, and life history variation in an avian consumer. **Ecography** DOI: 10.1111/ecog.02014
12. Tonra, C.M., K. Sager-Fradkin, S. Morley, J. Duda, and P.P. Marra. 2015. The rapid return of marine-derived nutrients to a freshwater food web following dam removal. **Biological Conservation** 192:130-134.
11. Marra, P.P., E.B. Cohen, S.R. Loss, J. Rutter, and C.M. Tonra. 2015. A call for full annual cycle research in animal ecology. **Biology Letters** 11: 20150552.
10. Tonra, C.M., C. Both, and P.P. Marra. 2015. Incorporating site dependence and year-specific deuterium ratios (δ^2H) from precipitation into geographic assignments of a migratory bird. **Journal of Avian Biology** 46: 266-274.
9. Tonra, C.M., K.L.D. Marini*, P.P.Marra, R.R. Germain, R.L. Holberton, and M.W. Reudink. 2014. Color expression in experimentally regrown feathers of an overwintering migratory bird: implications for signaling and seasonal interactions. **Ecology and Evolution** 4: 1222-1232.
8. Tonra, C.M., P.P. Marra, and R.L. Holberton. 2013. Experimental and observational studies of seasonal interactions between overlapping life history stages in a migratory bird. **Hormones and Behavior** 64: 825–832.
7. Croston, R.*, C.M. Tonra, S.K. Heath, and M.E. Hauber. 2012. Flange color differences in brood parasitic Brown-headed Cowbirds from nests of two host species. **Wilson Journal of Ornithology** 124: 139-145.
6. Tonra, C.M., P.P. Marra, and R.L. Holberton. 2011. Early elevation of testosterone advances migratory preparation in a songbird. **Journal of Experimental Biology** 214: 2761-2767.
5. Tonra, C.M., P.P. Marra, and R.L. Holberton. 2011. Migration phenology and winter habitat quality are related to circulating androgen in a long-distance migratory bird. **Journal of Avian Biology** 42: 397-404.
4. Angelier F., C.M. Tonra, R.L. Holberton, and P.P. Marra. 2011. Short-term changes in body condition in relation to habitat and climate in American redstarts during the non-breeding season. **Journal of Avian Biology** 42: 355-341.
3. Angelier F., C.M. Tonra, R.L. Holberton, and P.P. Marra. 2010. How to capture wild passerine species to study baseline corticosterone levels. **Journal of Ornithology** 151: 415-422.
2. Tonra, C.M., M.D. Johnson, M.E. Hauber, and S.K. Heath. 2009. Does nesting habitat influence hatching synchrony between brood parasitic brown-headed cowbirds (*Molothrus ater*) and two hosts? **Ecography** 32: 497-503.
1. Tonra, C.M., M.E. Hauber, S.K. Heath, and M.D. Johnson. 2008. Ecological correlates and sex differences in early development of a generalist brood parasite. **Auk** 125: 205-213.

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Professional Preparation

2004-2008 Ph.D., Natural Resources, Ohio State University, Columbus, Ohio
2000-2003 M.S., Wildlife Ecology, University of Maine, Orono, Maine
1993-1997 B.S., Wildlife Biology, Frostburg State University Frostburg, Maryland

Professional appointments

2014-	The Ohio State University	Assistant Professor
2011-2014	The Ohio State University US Forest Service, Ohio	Research Assistant Professor
2008-2011	The Ohio State University US Forest Service, Ohio	Post-Doctoral Researcher

AWARDS

U.S. Department of Agriculture Forest Service Chief Award, 2016
U.S. Department of Agriculture Forest Service Certificate of Merit, 2007
Student Travel Award, American Ornithologists' Union, 2006
Outstanding Wildlife Ecology Graduate Student Award, University of Maine, 2003
Howard Mendall Memorial Award, Department of Wildlife Ecology, University of Maine, 2002

PUBLICATIONS

Selected Journal peer-reviewed (* represent graduate student advisee articles)

Matthews, S.N. and Iverson, L.R. 2016 Managing for Delicious Ecosystem Service Under Climate Change: can United States Sugar Maple (Acer saccharum) Syrup Production be Maintained in a Warming Climate? International Journal of Biodiversity Science, Ecosystem Services & Management. In press

Malpass, J.S.*, Rodewald, A.D., and Matthews, S.N. 2016. Species-dependent effects of bird feeders on nest predators and nest survival of two urban birds. Condor. 119: 1:16

James S. Clark, J.S., Iverson, L., Woodall, C.W., Allen, C.D., Bell, D.M., Bragg, D.C., D'Amato, A.W., Davis, F.D.,Hersh, M.H., Ibanez, I., Jackson, S.T., Matthews, S., Pederson, N., Peters, M., Schwartz, M., Waring, K.M., and Zimmermann, N.E. 2016. The impacts of increasing drought on forest dynamics, structure, and biodiversity in the United States. *Global Change Biology* 22:2329-2352

Dossman, B.*, Mitchell, G.W.; Norris, R., Taylor, P.D., Guglielmo, C., Matthews, S.N., Rodewald, P.G. 2016. The effects of wind and fuel stores on stopover departure behavior across a migratory barrier. *Behavioral Ecology 27:567-574*

Iverson, L.R., Knight, K., Prasad, A., Hearms, D., Matthews, S.N., Peters, M., Smith, A., Hartzler, D., Long, R. 2015. Potential species replacements for black ash (Fraxinus nigra) at the confluence of two threats: emerald ash borer and a changing climate. *Ecosystems* 19:248-270.

McDermott, M. E.*, Rodewald, A. D., and Matthews, S. N. 2015. Managing tropical agroforestry for conservation of flocking migratory birds. *Agroforestry Systems* 89: 383-396

Malpass, J.S.*, Rodewald, A.D., and Matthews, S.N. 2015. Woody cover does not promote activity of nest predators in residential yards. *Landscape and Urban Planning* 135:32-39.

Matthews, S.N., Iverson, L.R., Peters, M.P., Prasad, A.M., and Subburayalu, S. 2014. Assessing and comparing risk to climate changes among forested locations: implications for ecosystem services. *Landscape Ecology* 29:213-228

Janowiak, M.K., Swanston, C.W., Nagel, L.M., Brandt, L.A., Butler, P.R., Handler, S.D., Shannon, D.P, Iverson, L.R, Matthews, S.N., Prasad, A.M. and Peters, M.P. 2014. A practical approach for translating climate change adaptation principles into forest management actions. *Journal of Forestry 112: 424-433*

Prasad, A.M., Gardiner, J., Iverson, L.R., Matthews, S.; and Peters, M. 2013. Exploring tree species colonization potentials using a spatially explicit simulation model: implications for four oaks under climate change. *Global Change Biology* 19:2196-2208

Yaussy, D.A., Iverson, L.R., Matthews, S.N. 2013. Competition and climate affects U.S. hardwood-forest tree mortality. *Forest Science* 59:416-430.

Matthews, S.N., Iverson, L.R., Prasad, A.P., and Peters, M.P. 2011. Changes in potential habitat of 147 North American breeding bird species in response to redistribution of trees and climate following predicted climate change. *Ecography* 34: 933-945.

Matthews, S.N., Iverson, L.R., Prasad, A.M., Peters, M.P., and Rodewald, P.G. 2011. Modifying climate change habitat models using tree species-specific assessments of model uncertainty and life history factors. *Forest Ecology and Management* 262:1460-1472.

Matthews, S.N. and Rodewald, P.G. 2010. Urban forest patches and stopover duration of migratory Swainson's Thrushes. *Condor* 112:96-104.

Curriculum Vitae: **Cornelia (Leila) Pinchot**

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Education:

University of Tennessee, Knoxville, TN, Natural resources Ph.D., 2011
Yale School of Forestry and Environmental Studies, New Haven, CT, Master of Forestry, 2008
Oberlin College, Oberlin, OH, Biology, B.A., 2003

Professional Experience:

2014 to present: Research Ecologist, USDA Forest Service, Northern Research Station, Delaware, OH
2012-2014: Research Fellow, The Pinchot Institute for Conservation, Milford, PA
2011-2012: Postdoctoral Fellow, The University of Tennessee, Knoxville, TN
2008-2011: Graduate Teaching Assistant, The University of Tennessee, Knoxville, TN
2006-2008: New England Regional Science Coordinator, The American Chestnut Foundation, New Haven, CT

Grants Received:

Site quality impacts on long-term chestnut growth, competitive ability, and blight resistance durability, 2019-2022. Funded by Forest Service State and Private Forestry in the amount of $35,046. Co-investigator.
Developing a framework for restoring American elm along the urban-rural gradient in the United States, 2017-2020. Forest Service State and Private Forestry in the amount of $190,000. Co-investigator.
Invasive shrub removal and restoration of degraded urban riparian forests, 2017. Funded by Region 9/Northeastern Area/Northern Research Station Youth Engagement Funding Request in the amount of $4,633. Co-investigator.
Reseeding restored forests: Can seed dispersal mutualisms amplify restoration of American Chestnut (*Castanea dentata*)? 2017. Funded by The American Chestnut Foundation in the amount of $7,906. Co-investigator.
Planting American Chestnut Trees in National Forests, 2015. Submitted by The American Chestnut Foundation. Funded by the National Forest Foundation in the amount of $4,807. Collaborator.
Defining methods for reintroducing American chestnut to oak-hickory forests of the Allegheny Plateau, 2015-2017. Funded by The American Chestnut Foundation in the amount of $9,905. Co-investigator.
Restoring Dutch elm-disease tolerant American elm in the Eastern United States, 2015-2020. Funded by the Manton Foundation in the amount of $1,432,609. Co-investigator.

Selected Publications:

Royo, A.A.; Pinchot, C.C.; Stanovick, J.S.; Stout, S.L. 2019. Timing is Not Everything: Assessing the Efficacy of Pre- Versus Post-Harvest Herbicide Applications in Mitigating the Burgeoning Birch Phenomenon in Regenerating Hardwood Stands. Forests, 10(4): 324.
Morgan, Q., Johnstone-Yellin, T.L., Pinchot, C.C., Peters, M., Royo, A.A., 2018. Partitioning and predicting forage biomass from total aboveground biomass of regenerating tree species using dimensional analyses. Canadian Journal of Forest Research, 49(3): 309-316.
Pinchot, C.C., Hall, T., Saxton, A., Schlarbaum, S., Bailey, J. 2018. Effects of Seedling Quality and Family on Performance of Northern Red Oak Seedlings on a Xeric Upland Site. Forests, 9(6): 351.
Pinchot C.C., Schlarbaum S.E., Clark S.L., Saxton A.M., Sharp A.M., Schweitzer C.J., Hebard FV. 2017. Growth, survival, and competitive ability of chestnut (*Castanea* Mill.) seedlings planted across a gradient of light levels. New Forests 48(4): 491-512.

Pinchot, C.C., Clark, S. L., Schlarbaum, S.E., Saxton, A. M., Sung, S.J. S., Hebard, F.V. 2015. Effects of Temporal Dynamics, Nut Weight and Nut Size on Growth of American Chestnut, Chinese Chestnut and Backcross Generations in a Commercial Nursery. Forests, 6(5):1537-1556.
Clark, S.L., Schlarbaum, S.E., Pinchot, C.C., Anagnostakis, S.L., Saunders, M. R., Thomas-Van Gundy, M., Schaberg, P.G., McKenna, J., Bard, J., Berrang, P., Casey, D.M., Casey, C.E., Crane, B., Jackson, B. Kochenderfer, J., Lewis, R., MacFarlane, R., Makowski, R., Miller, M., Rodrigue, J., Stelock, J.,Thornton, C.,Williamson, T. 2014. Reintroduction of American Chestnut in the National Forest System. J Forest 112(5): 501-512.
Pinchot. C.C., Schlarbaum, S.E., Clark, S.L., Schweitzer, C., Saxton, A.M., Hebard, F.V. 2014. Impact of Silvicultural Treatment and Seedling Quality on Chestnut Seedling Growth and Survival. In: Proceedings of the Fifth International Chestnut Symposium, September 4 – 8 2012. Double, M.L., and MacDonald, W.L. (eds.), West Virginia University. Acta Hort. (ISHS) 1019:205-209.
Anagnostakis, S.L., Pinchot, C.C. 2014. Restoration of chestnuts as a timber crop in Connecticut. In: Proceedings of the Fifth International Chestnut Symposium, September 4 - 8 2012. Double, M.L., and MacDonald, W.L. (eds.), West Virginia University. Acta Hort. (ISHS) 1019:17-19
Pinchot, C. C., Schlarbaum, S.E., Franklin, J.A., Buckley, D.S., Clark, S.L., Schweitzer, C. J.; Saxton, A.M.; Hebard, F.V. 2012. Early results of a chestnut planting in eastern Kentucky illustrate reintroduction challenges. In: Butnor, John R., ed. Proceedings of The 16th Biennial Southern Silvicultural Research Conference. e-Gen. Tech. Rep. SRS-156. Asheville, NC: U.S.
Pinchot, C.C., Schlarbaum, S.C., Saxton, A.M., Clark, S.L., Schweitzer, C.L., Smith, D.R., Mangini, A.M., Hebard, F.V. 2011. Incidence of *Craesus Castanea* Rohwer (Insecta: Hymenoptera: Tenthredinidae) on chestnut seedlings planted in the Daniel Boone National Forest, Kentucky. J. Entomological Sci. 46(3): 265-268.

Popular Press Articles

Pinchot, Leila. 2014. American chestnut: A test case for genetic engineering? Forest Wisdom:2014(3).
Pinchot, Leila. 2012. Reproduction in the American chestnut – an overview, Journal of the American Chestnut Foundation, Issue. 2, volume 27, July – August, 2012.
Pinchot, Leila. 2008. American chestnut – the return of an American legacy, Forest Wisdom: 2008(3).

L. Conflict of interest

The PI's do not have any conflict of interests for the proposed study.