a. Facsimile or Functional? Evaluating whether hybrid American chestnuts manifest similar fitness and ecosystem function as the wildtype across a site productivity gradient.

b. Summary

We propose leveraging an existing long-term chestnut restoration study in Pennsylvania to address two of TAFC's research priorities: 1) assessing local adaptation and abiotic stress tolerance in backcross hybrid and wildtype American chestnut and 2) comparing the ecological functionality between hybrid and American chestnuts. Specifically, we will evaluate the impact of site productivity on drought tolerance and blight resistance and compare the carbon sequestration potential and support of tropic interactions of American, Chinese and hybrid chestnuts. Results will enrich our understanding of the ecological requirements and value of hybrid and American chestnuts to guide future restoration and breeding efforts.

c. PIs and affiliations

Dr. Cornelia Pinchot, Alejandro A. Royo, Dr. Vince D'Amico, Dr. Anna Conrad, and Dr. Charles Flower, USDA Forest Service, Northern Research Station

Dr. Scott E. Schlarbaum, School of Natural Resources, The University of Tennessee, Knoxville

d. Total amount requested.

We request $30,795 from TACF to fund salary and fringe for two summer technicians, vehicle rental and gas, technician travel expenses, and foliar isotopic carbon analysis. We will provide $36,928 in matching. See the Table 3 (pg. 6) for details.

e. Long- and short-term objectives of the project.

Long term objective: Evaluate long-term survival, growth and blight resistance durability of American, hybrid, and Chinese chestnuts planted on 15 sites spanning a gradient of site quality.

Short term objectives:

1. Assess how site moisture availability affects the fitness; stress tolerance, blight resistance, biomass accrual; of planted chestnut, and if these functional traits differ among the parental species and hybrids.

2. Assess whether American, Chinese and hybrid chestnuts differ in their ability to support ecosystem function, specifically carbon sequestration and trophic interactions, and if this capacity changes across a site moisture gradient.

f. Narrative

Species restoration is motivated not simply by the recovery of a species, but also by the recovery of the ecological functions once supported by the species, thereby increasing biodiversity and improving ecosystem resilience. Efforts to develop blight resistant populations of American chestnut for species restoration are advancing and now incorporate both traditional backcross breeding and transgenic approaches. The anticipated large-scale restoration of disease resistant chestnuts necessitates a deeper understanding of the potential fitness and ecological function of both the wildtype American and hybrid chestnuts. **Here we leverage an existing long-term chestnut restoration study in northwestern Pennsylvania to address two of TACF's research priorities: 1. assessing local adaptation and abiotic stress tolerance in backcross hybrid and wildtype American chestnut and 2. comparing the ecological functionality between hybrid and American chestnuts.** We plan to evaluate the impact of soil moisture availability on drought tolerance (via isotopic C and near-infrared spectroscopy), blight resistance, and biomass accrual of the chestnuts during their tenth growth season. Additionally, we will compare the capacity of the chestnut species to sequester carbon and to support food webs across the site moisture gradient. Results from this study will guide the selection of restoration sites that optimize the fitness of restoration material and will enrich our understanding of the ecological importance of the species. Furthermore, differential fitness and function of hybrid chestnuts relative to parental chestnut species could impact breeding decisions, e.g., how the proposed approach of breeding transgenic American chestnut with hybrids to increase genetic diversity may impact function.

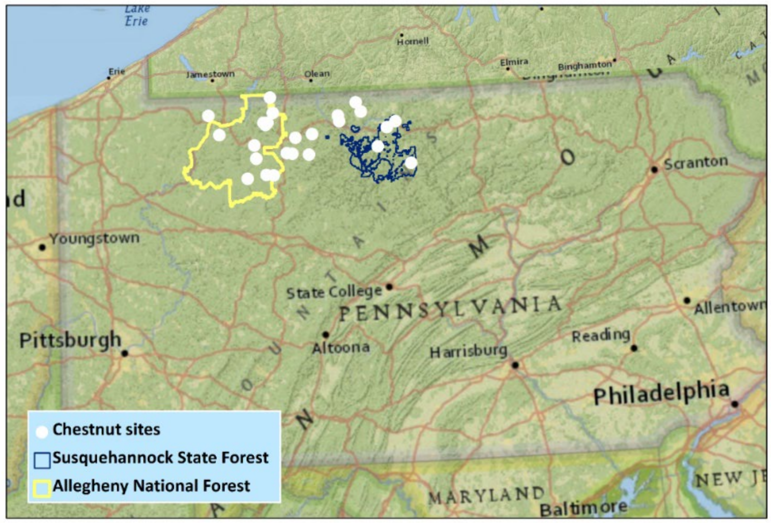

Figure 1. Map of the fifteen chestnut restoration study sites planted in 2015. Five sites are characterized as xeric, 5 as intermediate, and 5 as mesic.

Goal 1. Assess how site moisture availability affects the fitness; stress tolerance, blight resistance, biomass accrual; of planted chestnut, and if these functional traits differ among the parental species and backcross hybrids.

Selecting sites for American chestnut restoration that enhance fitness will help optimize the deployment of limited resources available for landscape-level restoration. Site characteristics and their interaction with species composition, however, may affect these metrics of establishment success differentially (Griffin et al. 2006). Greater soil moisture availability is known to increase light absorption (Bauerle et al. 2006) and early growth and blight resistance in American chestnut (Rhoades et al. 2009, Gao and Shain 1995). Faster growth of tree species typical of mesic sites, however, may ultimately reduce survival and growth of chestnuts (Griffin et al. 1991, McNab 2003), threatening the long-term restoration potential of chestnuts planted on high quality sites. Interactions between site characteristics and blight resistance can also inform breeding direction. Given the trade-off between blight resistance and American chestnut inheritance, earlier backcross generations of chestnut hybrids are now under consideration for restoration, as is the crossing of hybrid chestnut families with blight resistant transgenic lines (Westbrook et al. 2020). Understanding how hybrid chestnuts perform in forested settings relative to the wildtype American can inform these types of breeding directions.

We propose assessing impacts of site moisture availability on drought tolerance, blight resistance and biomass accrual of American, Chinese, and backcross hybrid chestnuts planted in fifteen sites. Natural blight incidence on the chestnuts, which has been evaluated annually or biannually since 2015, will be recorded for each tree, and blight severity will be ranked following methods described in Clark et al.

2019. We will use two methods to address drought stress. The first method will measure the bulk carbon (C) isotopic composition, $\delta^{13}C_{leaf}$ of leaves from each study tree. Carbon isotope ratio in tree tissue can be used as a proxy for intrinsic water use efficiency (Flower et al. 2018), which is directly related to drought stress. Two leaves from each of the surviving chestnuts (n=382) will be removed, dried, and sent to the University of Illinois at Chicago Stable Isotope Laboratory for isotopic analysis. A second method to assess drought stress of the chestnuts involves the use of a handheld near infrared (NIR) spectrometer (NeoSpectra Scanner). Reduced chlorophyll levels caused by water stress increase reflectance of vegetation, which can be measured using spectral imagery (Sanaeifar et al. 2023). We will use a handheld NIR spectrometer to collect spectral measurements on three leaves of each surviving chestnut tree in late summer (late July or early August), when higher levels of drought stress are expected. Spectra collected from each tree will be averaged and partial least squares regression will be used to relate spectral measurements to isotopic data. In addition, sparse partial least squares discriminant analysis will be used to assess effects of treatment groups on spectral bands associated with leaf water content. Finally, we will assess biomass accrual on each chestnut by measuring the height, basal diameter, diameter at breast height (DBH), and canopy depth (vertical distance between highest and lowest branches with leaves) of each chestnut.

Goal 2. Assess whether American and hybrid chestnuts differ in their ability to support ecosystem function, specifically carbon sequestration and trophic interactions, and if this capacity changes across a site moisture gradient.

The historic ecological role of American chestnut is not well documented, though the advancement of breeding and genetic engineering for blight resistance has prompted an interest in this topic, particularly the importance of American chestnut to wildlife (Dalgleish et al. 2012; Blythe et al. 2015, Wright et al. 2022), and chestnut's carbon sequestration potential (Jacobs et al. 2009; Gustafson et al. 2017). We plan to compare the ecological functionality of American and hybrid chestnuts, specifically potential for carbon sequestration and support of trophic chains, and how these capacities change along a site productivity gradient.

American chestnut has been found to exhibit higher rates of growth and greater biomass and carbon storage than several co-occurring species (Jacobs, 2009), suggesting the restoration of the species may favorably impact carbon sequestration of eastern forests. Gustafson et al. (2017), however, found American chestnut can only modestly increase the carbon sequestration potential of forests in a study that modeled the implications of chestnut restoration on forest composition and carbon storage. Nonetheless, a more precise understanding of how site quality may impact carbon sequestration by chestnut could increase the accuracy of future models and also test whether this capacity differs between American and hybrid chestnuts. We will use DBH measurements recorded for each chestnut to calculate total above ground biomass and carbon bole content using equations developed by Jacobs et al. (2009).

Insects play critically important roles in ecosystem function, from pollinating flowers and cycling nutrients, to supporting complex food webs. Lepidopteran species, in particular, transfer more plant energy than any other animal taxa and as such have been used as bio-indicators of biodiversity value and habitat restoration success (Syaripuddin, et al. 2015). The value of American chestnut to Lepidoptera is not well documented. Opler (1978) noted 60 Lepidopteran species that use American chestnut as a host. Tallamy and Shropshire (2009, supplemental data) list 125 North American Lepidopteran species on

Castanea and in informal lists Tallamy places it in the top 20 most important genera for supporting biodiversity in the Mid-Atlantic region of the US. Potential differences in the capacity of American and hybrid chestnuts to support Lepidoptera and other herbivorous insects, however, is understudied. Cooper and Rieske (2008) found differential tannin induction between American and Chinese chestnuts and speculated this could translate to differential susceptibility to insect herbivores between the species. In another study, Rieske, Rhoades and Miller (2003) found lower nutritional quality and higher tannin content in leaves of hybrid (Chinese x American second backcross) chestnut compared with American chestnut leaves, which could translate to a reduced capacity of hybrids to support herbivorous insects like Lepidoptera. To clarify if hybrid chestnuts provide similar values to insect herbivores as their parental species, we will monitor insect herbivory of each of the planted chestnut twice during the 2024 growing season. Specifically, we will estimate leaf damage caused by caterpillars and other insect leaf feeders as a simple way to assess herbivore preference (Christie et al. 2009, Johnson et al. 2016). We will randomly choose branches on each chestnut, count the number of leaves, and estimate percent damage on each leaf (up to 25 leaves/branch) to determine average predation by species/breeding generation.

To understand how differential support among chestnut species of insect herbivores may translate to differential use by other wildlife taxa (Tallamy et al. 2021), we will assess predation pressure of plasticine caterpillar models (Low et al. 2014, Piel et al. 2021) placed on the planted chestnut. Twice during the 2024 growing season we will distribute caterpillar models on 12 chestnuts (four American, four Chinese, and four hybrid) at each of three sites. On each selected tree, six caterpillar models will be glued to separate leaves. The caterpillars will be carefully retrieved five days later and impressions left on the clay will be visually examined to identify predators at a coarse taxonomic level (i.e., bird, mammal, arthropod; Low et al. 2014).

The existing study: The proposed work leverages a long-term American restoration study established in 2015 to evaluate the impacts of site quality on survival, growth, and blight resistance durability of planted American, Chinese, and backcross hybrid chestnut seedlings. In April 2015, we planted 540 1-0 bare-root chestnut seedlings; American, Chinese, and different generations of backcross hybrids (see Table 2) across 15 sites in northwestern Pennsylvania, spanning from Warren County to the west and Potter County to the east (Figure 1). To capture variation in soil moisture availability we calculated the integrated moisture index (IMI, Iverson et al. 1997) for 25 available sites and selected 15 sites that clustered into three soil moisture regimes; xeric, sub-mesic, and intermediate (Pinchot et al. 2020; Figure 2). In 14 of the 15 sites, managers conducted the initial cut of a shelterwood sequence to reduce stand relative density (the residual relative density to 31–61.5 percent and the residual basal area to 13.9–26.1 m2 /ha) and applied broadcast herbicides to control interfering plant species in the mid- and understory layers 3–6 years prior to planting. Since planting, six of the sites

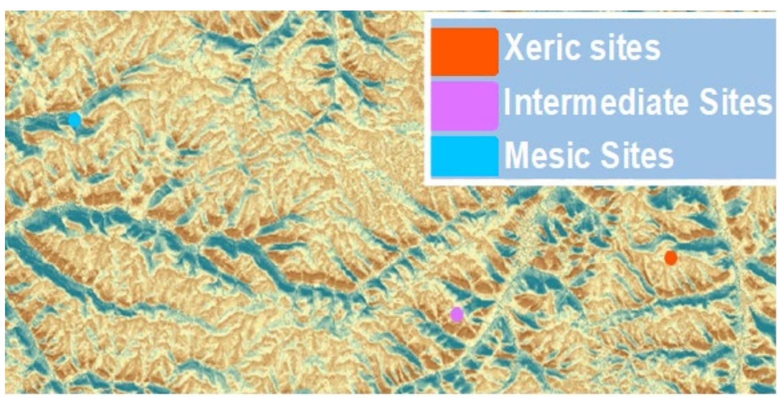

Figure 2. GIS map showing one study site for each of the three site moisture site categories: xeric, intermediate, and sub-mesic.

have received an overstory removal harvest; the final harvest in the shelterwood sequence. All chestnuts in the study were from open-pollinated seed collections made in the fall of 2013 and grown for one year at commercial or State tree nurseries. The American chestnuts were collected from one mother tree in Maryland and grown at the Kentucky State tree nursery (Grassy Creek, KY). The Chinese chestnuts were collected from multiple mothers from one orchard and grown at the Forrest Keeling Nursery (Elsberry, MO). The backcross hybrid American chestnuts (three families, Table 1) were collected at the Windsor Locks orchard of the Connecticut Agricultural Experiment Station (Anagnostakis 2012) and grown at the Vallonia Nursery in Vallonia, IN. All seedlings were lifted as 1-0 bare-root seedlings in the early spring of 2015, measured (height, root collar diameter), and distributed into treatment blocks based on their size to minimize seedling size differences across treatments. Chestnuts were stored in a cold room (~1° C) until they were planted in mid-April 2015. Chestnut species and family within species were arranged in incomplete planting blocks within each of the fifteen sites. Thirty-six chestnuts were planted in a 10m by 3m grid at each of the 15 sites. Survival, height, diameter, and blight incidence have been recorded for each of the chestnuts annually or biannually since 2015. As of August 2022, 382 chestnuts were alive, with an average height of 296 cm and basal diameter of 37 mm (Fig 3, Table 1).

Figure 3. UTK techs Emily Locke and Margarita Rivera standing next to a backcross hybrid chestnut during the study's sixth growing season (2020).

Soil samples were collected from each site (five soil pits/site) in 2020, separated by soil horizon, and analyzed for pH, percent organic matter, cation exchange capacity and nutrient levels (NO_3, NH_4, Ca, K, Mg, P, AL, Cu, Fe, Mn, Na, Sc, Zn).

Table 1. Basic information on the planted chestnuts, including the number planted (2015) and number alive (2022) per family and species and the height ± SE (cm) and basal diameter ± SE (mm) in 2022.

Species/generation	Family	# planted 2015	# alive 2022	Mean Height (cm) 2022	Mean basal diameter (mm) 2022
American	Bulk	90	58	418±25	47±3
Chinese	Chinese	90	47	222±21	23±2
BC_3F_2	W1-100	90	68	365±24	43±3
$BC_2F_1xBC_3F_1$	W3-20	90	64	338±27	37±3
$BC_2F_1xBC_3F_1$	W4-75	180	145	379±16	44±2
Total		**540**	**382**		

g. Timeline, showing start and completion dates for each goal

Table 2. Timeline		**2024**								**2025**
	Activity	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Winter**	
Admin	Outreach, hire summer techs	x	x	x						
	Onboard and orient techs				x					
Obj. 1	Rate blight incidence/severity				x	x		x		
	Foliar sampling for isotope analysis						x			
	NIR spectral image collection						x			
Obj. 2	Assess insect herbivory					x	x			
	Deploy dummy caterpillars					x	x			
	Measure chestnuts and competing veg						x	x		
	Data analysis								x	
	Manuscript preparation									x

h. How results will be measured and reported

Our goal is to report results in at least one peer-reviewed publication. Results will also be disseminated to the public and TACF through presentations and written reports.

i. Breakdown of how and when funds will be spent

Table 3. Budget

Cost	**Funds requested**	**Matching**	**Comments**
Housing		$2,250	Forest Service (FS)
Vehicle rental and gas	$4,500		
Salary	$15,360	$16,800	FS $12,000, UTK $3,800
Travel	$1,015	$3,020	
Supplies	$2,000	$1,000	
Sample analysis	$7,920		
Indirect costs		$13,857.75	UT indirect costs @45%
Total	**$30,795**	**$36,928**	

j. PI CVs. Pg. 7 – 18.

k. Conflict of interest or commitment statement. We know of no conflicts of interest.

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Education:

University of Tennessee, Knoxville, TN, Natural resources Ph.D., 2011. Dissertation: *Silvicultural considerations for the reintroduction of American chestnut, Castanea dentata, to the forests of the eastern United States*
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

Select Publications

Pinchot, C., Royo, A., Stanovick, J., Schlarbaum, S., Sharp, A., Anagnostakis, S. 2022. Deer browse susceptibility limits chestnut restoration success in northern hardwood forests. Forest Ecology and Management 523: 120481.

Mikolajewski, D., Roman, L., Flower, C., **Pinchot, C**., Sonti, N., D'Amico, V., Trammell, T. 2022. Restoring the iconic *Ulmus americana* to urban landscapes: early tree growth responds to aboveground conditions. Urban Forestry and Urban Greening 74, 127675.

Wright, J., Matthews, S., **Pinchot, C**., Tonra, C. 2022. Preferences of avian seed-hoarders in advance of potential American chestnut reintroduction. Forest Ecology and Management, 511, 120133.

Knapp, L., Rebbeck, J., Hutchinson, T., Fraser, J., **Pinchot, C**. 2022. Controlling an Invasive Tree with a Native Fungus: Inoculating *Ailanthus altissima* (Tree-of-Heaven) with *Verticillium nonalfalfae* in Highly Disturbed Appalachian Forests of Ohio. Journal of Forestry, 120(5):558-574.

Gustafson, E., Miranda, B., Dreaden, T., **Pinchot, C**., Jacobs, D. 2022. Forecasting the limiting effects of Phytophthora root rot on restoration of the American chestnut in the eastern United States. Ecosphere, 13(2), p.e3917.

Fotis, A, Flower, F., Atkins, J., **Pinchot, C.,** Rodewald, A., Matthews, S. 2022. The short-term and long-term effects of honeysuckle removal on canopy structural complexity and its implications for urban forest management. Forest Ecology and Management. 517(6): 120251.

Pinchot, C., Royo, A., Schlarbaum, S., Peters, M., Sharp, A., Anagnostakis, S. 2020. The effect of site quality on performance of American chestnut (*Castanea dentata*) seedlings bred for blight (*Cryphonectria parasitica*) resistance. IN: Gen. Tech. Rep SRS-252. Asheville, NC: U.S. Department of Agriculture Forest Service. Southern Research Station. www.fs.usda.gov/treesearch/pubs/61933

Royo, A., **Pinchot, C.,** Stanovick, J., Stout, S. 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, 324.

Pinchot, C., Schlarbaum, S., Tepke, S. Using oak silviculture to reintroduce American chestnut. 2020. Chestnut: Journal of The American Chestnut Foundation. 43(2):26-28. www.fs.usda.gov/treesearch/pubs/60464

Pinchot, 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., Schlarbaum, S., Clark, S., Saxton, A., Sharp, A., Schweitzer, C., and Hebard, F. 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., Clark, S., Schlarbaum, S., Saxton, A., Sung, S., Hebard, F. 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., Schlarbaum, S., **Pinchot, C.**, Anagnostakis, S., and others. 2014. Reintroduction of American chestnut in the National Forest System. Journal of Forestry 112(5): 501-512.

Pinchot, C., Schlarbaum, S., Saxton, A., Clark, S., Schweitzer, C., Smith, D., Mangini, A., and Hebard, F. 2011. Incidence of *Craesus castanea* Rohwer (Insecta: Hymenoptera: Tenthredinidae) on chestnut seedlings planted in the Daniel Boone National Forest, Kentucky. Journal of Entomological Science 46(3): 265-268.

Select Grants Received

The Manton Foundation. “American elm disease resistance breeding and restoration partnership”.

- 2023: **Pinchot, C.**, Knight, K., Goodwin, G., Flower, C. and others. $2.3 million, $1.6 million for NRS research. 2023-2026.
- 2020: **Pinchot, C.**, Knight, K., Goodwin, G., Flower, C. and others. $1.3 million, $884,015 for NRS research.
- 2016: Lutz, K., Slavicek, J., Knight, K., **Pinchot, C.**, Schaberg, P., Woeste, K., and Marks, C. $1.4 million, $800,000 for NRS research.

Forest Service Research & Development Bipartisan Infrastructure Law Ecosystem Restoration Research Project. 2023. “Early detection and accurate diagnosis of invasive forest pests with spectral imaging and DNA barcoding”. Conrad, A., Flower, C., **Pinchot, C.**, Dreaden, T., Jin, J, Fei, S., Bonello, P. $785,000.

USDA-FS Forest Health Protection FY22 Gene Conservation, Resistance and Restoration Projects. 2022 “Conserving and Restoring American Elm for Future Generations”. Flower, C., Fant, J., Rosa, C., **Pinchot, C.**, Hayes-Plazolles, N., Knight, K., Haugen, L., Pike, C., Vankus, V., McKeever, K., Bronson, D., Hoffman, K. $39,600.

USFS Targeted Allocations for Priority Research. 2020. “Multidimensional strategies and tools to assess, prevent and mitigate decline and loss of keystone tree species across the rural to urban continuum”. Palik, B., Kolka, R., Poland, T., Linder, D., Koch, K., Nislow, K, Donner, D., Nowak, D., Haight, R., Wagenbrenner, J. (**C. Pinchot** and others are collaborators). $1.2 million.

Forest Service State and Private Forestry. 2019. “Site quality impacts on long-term chestnut growth, competitive ability, and blight resistance durability”. **Pinchot, C.**, Schlarbaum, S. $35,046.

American Chestnut Foundation External Projects Fund. 2018 and 2019. “Reseeding restored forests: Can seed dispersal mutualisms amplify restoration of American chestnut?”. Wright, J., Tonra, C., Matthews, S., and **Pinchot, C.** $16,080.

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Professional appointments

2002 – Present Research Ecologist, USDA Forest Service, Northern Research Station

Professional preparation

1998 – 2005 Ph.D. Ecology and Evolutionary Biology; University of Pittsburgh, Pennsylvania.

1995 – 1998 M.S. Biology; University of North Carolina, Greensboro

1991 – 1993 B.A. Biology; University of North Carolina, Greensboro

Publications (last three years)

Royo, A.A., P. Raymond, C.C. Kern, B.T. Adams, D. Bronson, E. Champagne, D. Dumais, E. Gustafson, P.E. Marquardt, A.M. McGraw, J.R. Miesel, A.D. Munson, C. Périé, F.J. Tavares-Moreira, A. Ola, A., M. Bouchard and J.F. Bissonnette. 2023. Desired REgeneration through Assisted Migration (DREAM): implementing a research framework for climate-adaptive silviculture. Forest Ecology and Management. 546: 121298. https://doi.org/10.1016/j.foreco.2023.121298.

Knauer, A.R., T. Betras, A.A. Royo, T.P. Diggins and W.P. Carson. W.P. 2023. Understory plant communities fail to recover species diversity after excluding deer for nearly 20 years. Canadian Journal of Forest Research. 53:379-390. https://doi.org/10.1139/cjfr-2022-0234.

Refsland, T.K., B. Adams, D. Bronson, C.C. Kern, P. Marquardt, A.M. McGraw, A.A. Royo and J.R. Miesel. 2023. Trait-mediated effects of plant-soil feedbacks on the growth of eastern North American trees: implications for climate-adaptive forestry. Frontiers in Ecology and Evolution. Volume 11-2023. https://doi.org/10.3389/fevo.2023.1073724.

Pinchot, C., A.A. Royo, J. Stanovick, S. Schlarbaum, A. Sharp and S. Anagnostakis. 2022. Browsing by deer reduces growth and competitive ability of planted backcross chestnut seedlings despite also favoring slower-growing competing species. Forest Ecology and Management. 523:120481. https://doi.org/10.1016/j.foreco.2022.120481.

Royo, A.A. and Carson, W.P. 2022. Stasis in forest regeneration following deer exclusion and understory gap creation: a ten-year experiment. Ecological Applications. https://doi.org/10.1002/eap.2569.

Reed, S.P., Royo, A.A., Fotis, A.T., Knight, K.S., Flower, C.E., Curtis, P.E. 2022. The long-term impacts of deer herbivory in determining temperate forest stand and canopy structure. Journal of Applied Ecology. 59: 812 – 821. https://doi.org/10.1111/1365-2664.14095.

Nieves, J.M., Steiner, K.C., McDill, M.E., Kreye, J.K., Ward, J.S., Royo, A.A. 2022. Stand and site characteristics affect the probability of stump sprouting in some eastern North American hardwoods. https://doi.org/10.1016/j.foreco.2022.120136.

Kramer, D.W., Prebyl, T.J., Nibbelink, N.P., Miller, K.V., Royo, A.A., Frair, J.L. 2022. Managing moose from home: determining landscape carrying capacity for *Alces alces* using remote sensing. Forests. 13:150. https://doi.org/10.3390/f13020150.

Champagne, E., Royo, A.A., Tremblay, J.P., and Raymond, P. 2021. Tree assisted migration in a browsed landscape: Can we predict susceptibility to herbivores? Forest Ecology and Management 498: 119576. https://doi.org/10.1016/j.foreco.2021.119576.

Champagne, E., Raymond, Patricia, Royo, A. A.; Speed, J. D. M., Tremblay, J-P., Côté, S. D. 2021. A review of ungulate impacts on the success of climate-adapted forest management strategies. Current Forestry Reports. 7: 305 – 320. https://doi.org/10.1007/s40725-021-00148-5.

Royo, A.A., Vickers, L.A., Long, R.P., Ristau, T.E., Stoleson, S.H., Stout, S.L. 2021. The forest of unintended consequences: anthropogenic actions trigger the rise and fall of black cherry. Bioscience. 71: 683 – 696. https://doi.org/10.1093/biosci/biab002.

Competitive grants (last three years)

Pennsylvania Game Commission. 2023. "Empowering managers to mitigate habitat declines in regenerating Allegheny Hardwood Forests: Testing fungicide and fertilization as practical options." Vickers, L.A., Wurzbacher, S.J., Royo, A.A., and Ristau, T. $484,881

Quebec Ministry of Forests, Fauna and Parks. 2021. "Aménagement adaptif face aux changements climatiques: expérimentation de scenarios sylvicoles intégrant la migration assistée en forêt tempérée." Raymond, P., Dumais, D., Perie, A., Bedard, S., Champagne, E., Royo, A.A., Kern, C.C., and Tremblay, J.P. $1,544,720.

National Sciences and Engineering Research Council of Canada (NSERC) Alliance Program. 2020. Munson, A.D., Raymond, P., Bouchard, M., Dumais, D., Moore, J.D., Perie, C., Tremblay J.P., Mazerolle, M., Bissonnette, J.F., Royo, A.A., Kern, C. If you build it, will they come? On the potential and social benefits of assisted tree migration. $168,170.

USGS Midwest Climate Adaptation Science Center Grants. 2020. Donner, D., Royo, A.A., Miranda, B., Carstensen, M, and St. Louis, V. Can climate change mitigation through silviculture save sensitive boreal species? A case study of moose in Minnesota. $368,766.

Synergistic activities

Teaching & Mentorship: Core Instructor on Allegheny Hardwood Silviculture Training Sessions (SILVAH; 1999 - Present), USDA Forest Service, Northern Research Station.

University involvement includes multiple invited guest lectures, led several university fieldtrips, participation on 18 graduate student committees, and 23 undergraduate researcher mentorships.

Service: Associate Editor for *Forest Ecology and Management* (2020 – Present), *Forests* (2020 – 2022), and *Canadian Journal of Forest Research* (2013 – 2018).

Served on pre-proposal, *ad-hoc*, and panel reviews for NSF, AFRI, NERC, and NE-CASC. National Advanced Silviculture Workshop candidate panelist (2021 & 2022).

USFS Representative on the Kinzua Quality Deer Cooperative, USFS Science representative on the Pennsylvania Society of American Foresters Deer-Forest Committee, USFS-Northern Research Station representative on Allegheny Forest Health Collaborative.

CURRICULUM VITAE
Anna O. Conrad

EDUCATION

Ph.D. 2015. Plant Pathology, The Ohio State University M.S. 2013. Plant Pathology, The Ohio State University, non-thesis
B.S. 2010. Environmental Biology, SUNY College of Environmental Science and Forestry, *summa cum laude*

PROFESSIONAL EXPERIENCE

2020 – present	Research Plant Pathologist, USDA Forest Service, Northern Research Station, Hardwood Tree Improvement and Regeneration Center, West Lafayette, IN
2022	Acting National Program Lead for Entomology, Pathology, and Invasive Species Research, USDA Forest Service, Sustainable Forest Management Research, Washington, DC (120-day detail)
2017 – 2020	Postdoctoral Researcher, Department of Plant Pathology, The Ohio State University, Columbus, OH
2015 – 2017	Postdoctoral Scholar, Forest Health Research and Education Center, University of Kentucky, Lexington, KY
2010 – 2015	Graduate Research Associate, Department of Plant Pathology, The Ohio State University, Columbus, OH

PUBLICATIONS (5 most related to proposal)

Fearer, C.J., **Conrad, A.O.**, Marra, R.E., Georskey, C., Villari, C., Slot, J., and Bonello, P. 2022. A combined approach for early in-field detection of beech leaf disease using near-infrared spectroscopy and machine learning. Frontiers in Forests and Global Change. 5: 934545. doi: 10.3389/ffgc.2022.934545.

Conrad, A.O., Wei, L., Lee, D-Y., Wang, G-L., Rodriguez-Saona, L., and Bonello, P. 2020. Machine learning-based presymptomatic detection of rice sheath blight using spectral profiles. Plant Phenomics 2020: 8954085. doi: 10.34133/2020/8954085.

Conrad, A.O., Villari, C., Sherwood, P., and Bonello, P. 2020. Phenotyping Austrian pine for resistance to *Diplodia sapinea* using Fourier-transform infrared spectroscopy. Arboriculture & Urban Forestry 46(4): 276-286.

†Mukrimin, M., **Conrad, A.O.**, Kovalchuk, A., Julkunen-Tiitto, R., Bonello, P., and Asiegbu, F.O. 2019. Fourier-transform infrared (FT-IR) spectroscopy analysis discriminates asymptomatic and symptomatic Norway spruce trees. Plant Science 289: 110247. doi: 10.1016/j.plantsci.2019.110247

‡**Conrad, A.O.** and Bonello P. 2016. Application of infrared and Raman spectroscopy for the identification of disease resistant trees. Frontiers in Plant Science 6: 1152. doi: 10.3389/fpls.2015.01152

†Contributed equally as first author.
‡Invited review paper.

PRESENTATIONS (5 most related to proposal)

Conrad, A.O. Spectral-based tools for tree disease management. Invited oral presentation at the Northern Nut Growers Conference. Virtual. 2 August 2021.

Conrad, A.O. Spectral-based tools for disease resistance phenotyping in trees. Invited plenary presentation at the 36th Southern Forest Tree Improvement Conference. Virtual. 7 – 9 June 2021.

Conrad, A.O. and Bonello, P. Development of a tool for rapid identification of resistant trees in key species affected by alien invasive pathogens. Invited presentation at the USDA Forest Service Special Technology Development Program Region 6 Virtual Workshop Series. 6 August 2020.

Conrad, A.O. and Bonello, P. New approaches for identifying disease resistant forest trees. Invited oral presentation at the North American Invasive Species Management Association Annual Conference. Saratoga Springs, NY. 30 September – 3 October 2019.

Conrad, A.O. Chemical fingerprinting: a tool for identifying disease resistant trees. Invited oral presentation at the American Chestnut Foundation Annual Meeting. Huntsville, AL. 26 – 27 October 2018.

GRANTS

2023 **USDA Forest Service R&D Bipartisan Infrastructure Law Ecosystem Restoration Research**, $785,000. PI: **Conrad**; Co-PIs: Flower, Pinchot, Dreaden, Jin, Fei, and Bonello. "Early detection and accurate diagnosis of invasive forest pests with spectral imaging and DNA barcoding."

2023 **USDA Forest Service R&D Bipartisan Infrastructure Law Ecosystem Restoration Research**, $951,000. PI: Potter; Co-PIs: Chhatre, Nelson, **Conrad**, Pike. "Future proofing forests through genetically informed reforestation/restoration decision network."

2022 **Integrated Digital Forestry Initiative at Purdue University**, $20,000 for support of Purdue University postdoctoral researcher with D. Jacobs. "Chemotyping to support butternut conservation and resistance breeding."

2022 **USDA Forest Service State and Private Forestry**, $30,000. PI: Jacobs, D. Cooperators: Woeste, Warren, **Conrad**, Warwell, Pike, Jacobs, J., Williams, Isabel, and Ginzel. "Genotyping butternut for future conservation and resistance breeding efforts." Additional $30,000 in 2023.

2022 **Hardwood Tree Improvement and Regeneration Center**, Purdue University. $151,110. PIs: Jacobs, Couture, Ebrahimi, **Conrad**, Woeste, Fearer, Pike. "Integrating morphology, genotype, and chemotype based methods to support HTIRC butternut conservation and resistance breeding efforts."

2021 **USDA Forest Service State and Private Forestry**, $90,210. Collaborators: **Conrad**, Ginzel, and Jacobs (FHP sponsor). "Assessment of recent sassafras (*Sassafras albidum*) wilt along the northern edge of its range in the Midwest."

2017 **The American Chestnut Foundation**, $4,511. PI: **Conrad**, co-PIs: Abbott, Nelson, Bonello, Rodriguez-Saona. Renewal of "Evaluating chemical fingerprinting as a tool to rapidly screen hybrid chestnut for disease resistance."

2015 **The American Chestnut Foundation**, $3,000. PIs: **Conrad**, Abbott, Nelson. "Evaluating chemical fingerprinting as a tool to rapidly screen hybrid chestnut for disease resistance."

2015 **AFRI NIFA**, $425,220. PI: Abbott, co-PI's: Liu, Dardick, Zhebentyayeva, Staton, Nelson, **Conrad**. "Abiotic stress response and adaptive phenology in fruit trees."

Vincent D'Amico III

Institution: USDA Forest Service, NRS-08. Adjunct Faculty: University of Delaware.

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Biographical Sketch

I am an urban ecologist in USDA Forest Service, now a Team Leader in Unit NRS-08: Restoration and Conservation of Urban Forests (Philadelphia Team). As of 2001 I have been stationed at the University of Delaware in Newark, DE. Focusing on the eastern US Megalopolis, I initiated a long-term research project exploring challenges and opportunities in urban forest ecology. To this end I and my colleagues Prof. Tara Trammell and Prof. Greg Shriver (UDel) created the Forest Among Managed Ecosystems program (FRAME, website sites.udel.edu/frame), a scientific collaboration between researchers throughout the US. The goal of the FRAME is to provide information derived from long-term monitoring to inform management decisions. I am presently working with collaborators on this and related projects to: 1) quantify the effect of exotic plant invasion in forested riparian corridors in urban and suburban landscapes, 2) explore the effects of plant invasion of riparian corridors on foraging by native birds, 3) and learn how the herbivorous insects that underlie food webs are impacted by invasive replacement of native plants in urban and suburban landscapes 4) help in global efforts to extrapolate the effects of urbanization to predict future climate-driven changes in forests worldwide. I am an active participant in the scientific community, reviewing manuscripts and books for insect, ecology, and virus journals.

Graduate Students, Advisor or Committee Member

Jack Diedrich (PhD 2026 planned) - Plant & Soil Science, Urban forest seedbanks

Kendall McCoach (PhD 2026 planned) – Plant & Soil Science, Dendrochronology in urban forests

Emma Jonas (MS 2025 planned) – Entomology & Wildlife Ecology, Anthropogenic effects on larval Lepidoptera

Danielle Mikolajewski (MS 2022) – Plant & Soil Science; Elms in Urban Forestry

Eric Moore (PhD 2021) – Plant & Soil Science; Invasive Plant Ecology

Covel Mcdermot (PhD 2021) – Plant & Soil Science; Plant Biochemistry

Meg Ballard (PhD 2016) – Entomology & Wildlife Ecology; Invasive plant ecology

Zach Ladin (PhD 2016) - Entomology & Wildlife Ecology; Avian Ecology

Solny Adalsteinsson (PhD 2016) – Entomology & Wildlife Ecology; Invasive plant ecology, zoonoses

Emily Dunn (MS 2016) - Entomology & Wildlife Ecology; Cerambycid beetles in urban forests

Kaitlin Handley (MS 2014) - Entomology & Wildlife Ecology; Cerambycid beetles in urban forests

Gavin Ferris (MS 2015) – Entomology & Wildlife Ecology; Entomology & Wildlife Ecology; Invasive plants in riparian buffers

Amanda Conover (MS 2011) – Entomology & Wildlife Ecology; Invasive plants, bird response

Selected Recent Publications (2018-2023)

Ladin, Z. S., Eggen, D. A., Trammell, T. L. E., & D'Amico, V. (2023). Human-mediated dispersal drives the spread of the spotted lanternfly (Lycorma delicatula). Scientific Reports, 13(1), 1098. https://doi.org/10.1038/s41598-022-25989-3

Mitchell, J. C., D'Amico, V., III, Trammell, T. L. E., & Frank, S. D. (2023a). Nonnative plant invasion increases urban vegetation structure and influences arthropod communities. Diversity and Distributions, n/a(n/a). https://doi.org/10.1111/ddi.13755

Mitchell, J. C., D'Amico, V., Trammell, T. L. E., & Frank, S. D. (2023b). Carabid specialists respond differently to nonnative plant invasion in urban forests. Urban Ecosystems. https://doi.org/10.1007/s11252-022-01323-7

Moore, E., D'Amico, V., & Trammell, T. L. E. (2023). Plant community dynamics following non-native shrub removal depend on invasion intensity and forest site characteristics. Ecosphere , 14(1). https://doi.org/10.1002/ecs2.4351

Landsman A, Ladin Z, Gardner D, Bowman JL, Shriver G, D'Amico V & Delaney D. (2019). Landscapes and microhabitat characteristics are important determinants of urban-suburban bee communities. Ecosphere.

Shriver G, Ladin Z, Buler J, & D'Amico V. (2019) Local and landscape scale effects on territory density of birds breeding in urban forest fragments. Urban Ecosystems – in press.

Long, L. C., D'Amico, V., & Frank, S. D. (2019). Urban forest fragments buffer trees from warming and pests. The Science of the Total Environment, 658, 1523–1530.

Adalsteinsson, S. A., Buler, J. J., Bowman, J. L., D'Amico, V., Ladin, Z. S., & Shriver, W. G. (2018). Post-independence mortality of juveniles is driven by anthropogenic hazards for two passerines in an urban landscape. Journal of Avian Biology, 49(8), e01555.

Ladin, Z. S., Van Nieuland, S., Adalsteinsson, S. A., D'Amico, V., Bowman, J. L., Buler, J. J, Shriver, W. G. (2018). Differential post-fledging habitat use of Nearctic-Neotropical migratory birds within an urbanized landscape. Movement Ecology, 6, 17.

Adalsteinsson, S. A., Shriver, W. G., Hojgaard, A., Bowman, J. L., Brisson, D., D'Amico, V., & Buler, J. J. (2018). Multiflora rose invasion amplifies prevalence of Lyme disease pathogen, but not necessarily Lyme disease risk. Parasites & Vectors, 11(1), 54.

Charles E. Flower

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Professional appointments

2016 – Present	Research Ecologist, USDA Forest Service, Northern Research Station
2013 – 2016	Postdoctoral Researcher, Department of Biological Sciences, University of Illinois at Chicago

Professional preparation

2007 – 2013	Ph.D. Biological Sciences; University of Illinois at Chicago; Chicago, IL.
2005 – 2007	M.S. Evolution, Ecology and Organismal Biology; Ohio State University; Columbus, OH.
2000 – 2004	B.A. Biology & History; Lake Forest College; Lake Forest, IL.

Relevant Publications

Flower C.E., Pinchot C.C., Schaberg P.G., Swanson G.H., Knight K.S., Slavicek J.M. Accepted Pending Revision. Breeding Dutch elm disease tolerant American elm: do cold environments affect survival, cold tolerance, and disease tolerance? Journal of Forestry.

Mikolajewski D., D'Amico III V., Sonti N.F., Pinchot C.C., **Flower C.E.**, Roman L.A., Trammell T.L.E. 2022. Restoring the iconic Ulmus americana to urban landscapes: Early tree growth responds to aboveground conditions. Urban Forestry and Urban Greening 74:127675.

Reed, S.P., Royo, A.A., Fotis, A.T., Knight, K.S., **Flower, C.E.**, Curtis, P.E. 2022. The long-term impacts of deer herbivory in determining temperate forest stand and canopy structure. Journal of Applied Ecology. 59: 812 – 821.

Fotis A., **Flower C.E.**, Atkins J., Pinchot C.C., Rodewald A.D., Matthews S. 2022. The short-term and long-term effects of honeysuckle removal on canopy structure and its implications for urban forest management. *Forest Ecology and Management* 517: 120251.

Ebrahimi A., Antonides J.D., Pinchot C.C., Slavicek J.M., **Flower C.E.,** Woeste K. 2021**.** The complete chloroplast genome sequences of American elm (*Ulmus americana*) and comparative genomics of related species. *Tree Genetics and Genomes* 17(1):1-13.

Kibiş E.Y., Büyüktahtakin I.E., Haight R.G., Akhundova N., Knight K.S., **Flower C.E.** 2020. A multi-stage stochastic programming approach to the optimal surveillance and control of emerald ash borer in cities. *INFORMS Journal on Computing* 33(2):808-834.

Flower, C.E., Dalton, J., Brown, J.S., Gonzalez-Meler, M.A., Whelan, C. 2019. Arctic ground squirrels accelerate woody shrub encroachment in the Arctic tundra. *Oecologia* 190:243-254.

Flower, C.E., Lynch, D.J., Knight, K.S., Gonzalez-Meler, M.A. 2018. Biotic and Abiotic Drivers of Sap Flux in Mature Green Ash Trees (*Fraxinus pennsylvanica*) Experiencing Varying Levels of Emerald Ash Borer (*Agrilus planipennis*) Infestation. *Forests 9 (6)*: 301.

Flower, C.E., Fant, J., Hoban, S., Knight, K.S., Steger, L., Aubihl, E.[2], Gonzalez-Meler, M.A., Forry, S., Hille, A., Royo, A.A. 2018. Optimizing conservation strategies for a threatened tree species: In situ conservation of white ash (*Fraxinus americana*) genetic diversity through insecticide treatment. *Forests* 9(4): 202.

Costiow K.C., Knight K.S. **Flower C.E.** 2017. Disturbance severity and canopy position control the radial growth response of maple trees (*Acer* spp.) in forests of northwest Ohio impacted by emerald ash borer (*Agrilus planipennis*). *Annals of Forest Science* 74:10.

Flower C.E., Gonzalez-Meler M.A. 2015. Responses of temperate forest productivity to insect and pathogen disturbances. *Annual Review in Plant Biology* 66: 547-569.

Select Grants Received (last 3 years)

Co-PI: Manton Foundation: American elm breeding and restoration partnership. 2023-2026 ($2,494,685). (Co-PI's: Pinchot, Knight-USDA FS; Goodwin-TNC).

Co-PI-USDA Bipartisan Infrastructure Law Ecosystem Restoration Research: Early detection and accurate diagnosis of invasive forest pests with spectral imaging and DNA barcoding. 2023-25 ($785,000). (co-PI's: Conrad-NRS, Pinchot-NRS, Dreaden-SRS, Jin-Purdue, Fei-Purdue, Bonello-OSU).

PI: USDA FS FHP: Conserving and Restoring American Elm for Future Generations. 2022-24 ($110,375) (co-PI's: Fant-CBG, Rosa-PSU, Pinchot-NRS).

PI: USDA FS Chippewa National Forest: Restoring American Elm. 2022-24 ($16,000) (co-PI: Taylor-CNF)

Co-PI: USDA FS-WO-FHP: American elm clone banks for colder hardiness zones of the Great Lakes States; 2021-2023 ($60,000) (Co-PI's: Haugen S&PF, Pike S&PF, Moore NRS, Knight-NRS, Pinchot-NRS)

Co-PI: Manton Foundation: American elm disease resistance breeding and restoration partnership; 2020-2023 ($1,360,298) (Co-PI's: Pinchot, Knight-USDA FS; Marks-TNC)

Co-PI: USDA Forest Service S & P Forestry, Forest Health Protection Region 9 Emerging Pest; Geographic range and pathogenicity of elm phytoplasmas; 2020-2023 ($44,720) (Co-PI's: Rosa-PSU; Hayes-Plazolles-USDA FS)

Co-PI: USDA Forest Service Forest Health Protection Evaluation Monitoring Program; Monitoring ash health and emerald ash borer spread across the Allegheny National Forest; 2018-2020 ($46,899) (Co-PI's: Knight-USDA FS, Kilgore-WJC)

Synergistic Activities

Teaching & Mentorship: Adjunct Lecturer, Dept. of Biology, Dominican University, Fall 2014, Spring 2015; Adjunct Lecturer, Dept. of Biology, Roosevelt University Sp 2015; Lecturer in Biology, Dept. of Biology, Lake Forest College Fall 2015; Visiting Research Specialist Dept. of Biology Lake Forest College, 2016-2017. Visiting Research Specialist Dept. of Biological Sciences; direct or indirect participation on 4 graduate student committees, and 16 undergraduate researcher mentorships.

Elected Service: President, Ohio Academy Of Sciences 2016-present; Board of Trustee for the Ohio Academy Of Sciences 2016-present; Steering Committee, Central Ohio Partnership for Regional Invasive Species Management, 2018-present; Columbus Tree Score Equity Analyzer Committee 2023-present

2023 Short Vita

Scott E. Schlarbaum, Professor and Director
UT Tree Improvement Program
School of Natural Resources
The University of Tennessee, Knoxville

Scott E. Schlarbaum joined the School of Natural Resources (then Department of Forestry, Wildlife and Fisheries) in 1984 and is currently a Professor of Forest Genetics and Director of the University of Tennessee's Tree Improvement Program. The UT Tree Improvement Program is a 64-year-old research and development program, dedicated to improving and protecting forest tree species, particularly hardwood species. He is the author of numerous articles on forest genetics, tree improvement, forest health, and plant cytogenetics, first publishing in refereed journals in 1975. Professor Schlarbaum has testified as an expert witness on forestry and forest health issues before various subcommittees and committees of the U. S. House of Representatives and before Tennessee legislative committees. He was the Science Advisor for Exotic Forest Pests to the National Park Service from 2005-2010 and an associate editor for Silvae Genetica. Additionally, Professor Schlarbaum served for many years on the USDA Crop Germplasm Advisory Committee for Woody Landscape Plants.

Selected Recent Publications:

Granger, J. J., D. S. Buckley, **S. E. Schlarbaum**, and A. M. Saxton. 2022. Evaluation of four form classes of northern red oak (*Quercus rubra*) multicropped with shortleaf pine (*Pinus echinata*). New Forests 54: 29–48.

Pinchot, C., Royo, A., Stanovick, J., **Schlarbaum, S.E**., Sharp, A., Anagnostakis, S. 2022. Deer browse susceptibility limits chestnut restoration success in northern hardwood forests. Forest Ecology and Management 523: 120481.

Gailing, O., M. E. Staton, **S. E. Schlarbaum**, M. Coggeshall, J. Romero-Severson, H. Liang, and J. Carlson. 2021. Progress and prospects of population genomics of North American hardwoods. Population Genomics, Springer, Cham. https://doi.org/10.1007/13836_2021_99.

Clark, S. L., **S. E. Schlarbaum**, A. M. Saxton, and R. Baird. 2019. Eight-year blight (*Cryphonectria parasitica*) resistance of backcross-generation American chestnuts (*Castanea dentata*) planted in the southeastern U.S.. Forest Ecology and Management 433: 153-161.

Clark, S. L., **S. E. Schlarbaum**, and J. D. Clark. 2019. Restoring a forest icon: could returning the American chestnut remodel our wildlife landscape? The Wildlife Professional 13(4): 52-56.

Clark, S. L., **S. E. Schlarbaum**, B. S. Crane, C. C. Pinchot, P. G. Schaberg, and M. Thomas-Van Gundy. 2020. Restoration of the American chestnut will require more than a blight-resistant tree. In: Pile, L.S., Deal, R.L., Dey, D.C., Gwaze, D., Kabrick, J.M., Palik, B.J., Schuler, T.M., comps. The 2019 National Silviculture Workshop: a focus on forest management-research partnerships. Gen. Tech. Rep. NRS-P-193. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station: 38-40.

Clark, S. L. and **S. E. Schlarbaum.** 2018. Effects of acorn size and mass on seedling quality of northern red oak (*Quercus rubra*). New Forests 49(4): 571-583.

Pinchot, Cornelia C., Thomas J. Hall, James Bailey, and **Scott E. Schlarbaum.** 2018. Effects of Seedling Quality and Family on Performance of Northern Red Oak Seedlings on a Xeric Upland Site. Forests: https://doi.org/10.3390/f9060351.

Harmon M, Lane T, Staton, M., Coggeshall M.V., Best, T., Chen, C.C., Liang, H, Zembower, N., Drautz-Moses, D.I., Hwee, Y.Z., Schuster, S.C., **Schlarbaum S.E.**, Carlson, J.E., and Gailing, O. 2017. Development of novel genic microsatellite markers from transcriptome sequencing in sugar maple (*Acer saccharum* Marsh.). BMC Research Notes, 10(1): 369-376.

Wu, Y., Zhang, R., Staton, M., **Schlarbaum, S.,** Coggeshall, M., Romero-Severson, J., Carlson, J., Liang, H., Xu, Y., Drautz-Moses, D., Schuster, S., Gailing, O. 2017. Development of genic and genomic microsatellites in Gleditsia triacanthos L. (Fabaceae) using Illumina sequencing. *Annals of Forest Research,* 60(2): 343-350.

Pinchot, Cornelia C., **Scott E. Schlarbaum**, Stacy L. Clark, Callie Schweitzer, Arnold M. Saxton, Ami M. Sharp, Callie J. Schweitzer, and Frederick V. Hebard. 2017. Growth, survival, and competitive ability of chestnut (*Castanea* Mill.) seedlings planted across a gradient of light levels

Clark, S. L., **S. E. Schlarbaum**, A. M. Saxton, and F. V. Hebard. 2016. Establishment of American chestnuts (*Castanea dentata*) bred for blight (*Cryphonectria parasitica*) resistance: influence of breeding and nursery grading. New Forests 47: 243-270.

Staton, Margaret, Theodora Best, Sudhir Khodwekar, Sandra Owusu, Tao Xu, Yi Yu, Tara Jennings, Richard Cronn, A K Arumuganathan, Mark Coggeshall, Oliver Gailing, Haiying Liang, Jeanne Romero-Severson, **Scott Schlarbaum**, and John E. Carlson. 2016. Preliminary genomic characterization of ten hardwood tree species from multiplexed low coverage whole genome sequencing. PLOS One 10(12): e0145031.

Case, Ashley E., Albert E. Mayfield III, Stacy L. Clark, **Scott E. Schlarbaum**, and Barbara C. Reynolds. 2016. Frequency and Abundance of Asiatic Oak Weevil (*Cyrtepistomus castaneus)* on American, Chinese, and Hybrid Chestnut (*Castanea*) Seedlings. Journal of Insect Science (2016) 16(1): 29; 1–8.

Clark, Stacy L., **Scott E. Schlarbaum**, and Callie J. Schweitzer. 2015. Effects of visual grading on northern red oak (*Quercus rubra* L.) seedlings planted in two shelterwood stands on the Cumberland Plateau of Tennessee, USA. Forests 6: 3779-3798; DOI:10.3390/f6103779.

Pinchot, Cornelia C., Stacy L. Clark, **Scott E. Schlarbaum**, Arnold M. Saxton, Shi-Jean S. Sung, and Frederick V. Hebard. 2015. Effects of temporal dynamics and nut weight and size effects on growth of American chestnut, Chinese chestnut, and backcross generations in a commercial nursery. Forests 6: 1537-1556; doi:10.3390/f6051537.

Wheeler, Nicholas C., Kim C. Steiner, **Scott E. Schlarbaum**, and David B. Neale. 2015.
The evolution of forest genetic and tree improvement research in the United States. J. For. 113:500-510.

References

Bauerle, W.L., Wang, G.G., Bowden, J.D. and Hong, C.M., 2006. An analysis of ecophysiological responses to drought in American chestnut. *Annals of Forest Science*, *63*(8), pp.833-842.

Blythe, R.M., Smyser, T.J. and Swihart, R.K., 2015. Tree squirrel seed predation patterns may influence American chestnut restoration success. *New forests*, *46*, pp.593-600.

Dalgleish, H.J. and Swihart, R.K., 2012. American chestnut past and future: implications of restoration for resource pulses and consumer populations of eastern US forests. *Restoration Ecology*, *20*(4), pp.490-497.

Diamond, S.J., Giles Jr, R.H., Kirkpatrick, R.L. and Griffin, G.J., 2000. Hard mast production before and after the chestnut blight. *Southern Journal of Applied Forestry*, *24*(4), pp.196-201.

Flower, C.E., Lynch, D.J., Knight, K.S. and Gonzalez-Meler, M.A., 2018. Biotic and abiotic drivers of sap flux in mature green ash trees (Fraxinus pennsylvanica) experiencing varying levels of emerald ash borer (Agrilus planipennis) infestation. *Forests*, *9*(6), p.301.

Gao, S. and Shain, L., 1995. Effects of water stress on chestnut blight. *Canadian Journal of Forest Research*, *25*(6), pp.1030-1035.

Griffin, G.J.; Elkins, J.R.; McCurdy, D.; Griffin, S.L. 2006. Integrated use of resistance, hypovirulence, and forest management to control blight on American chestnut. In: Steiner, K.C.; Carlson, J.E, eds. Restoration of American Chesntut to Forest Lands - Proceedings of a conference and workshop. Natural Resources Report NPS/NCR/CUE/ NRR - 2006/001. Washington, DC: National Park Service: 97–105.

Griffin, G.J., Smith, H.C., Dietz, A. and Elkins, J.R., 1991. Importance of hardwood competition to American chestnut survival, growth, and blight development in forest clearcuts. *Canadian Journal of Botany*, *69*(8), pp.1804-1809.

Iverson, L.R., Dale, M.E., Scott, C.T. and Prasad, A., 1997. A GIS-derived integrated moisture index to predict forest composition and productivity of Ohio forests (USA). *Landscape Ecology*, *12*, pp.331-348.

Low, P.A., Sam, K., McArthur, C., Posa, M.R.C. and Hochuli, D.F., 2014. Determining predator identity from attack marks left in model caterpillars: guidelines for best practice. *Entomologia Experimentalis et Applicata*, *152*(2), pp.120-126.

McNab, H.W. 2003. Early results from a pilot test of American chestnut seedlings under a forest canopy. Journal of the American Chestnut Foundation. 16(2): 32–41.

Opler, P.A., 1978, January. Insects of American chestnut: possible importance and conservation concern. In *The American chestnut symposium* (pp. 83-85). Morgantown: West Virginia University Press.

Pinchot, C., Royo, A., Schlarbaum, S., Peters, M., Sharp, A., Anagnostakis, S. 2020. The effect of site quality on performance of American chestnut (*Castanea dentata*) seedlings bred for blight (*Cryphonectria parasitica*) resistance. IN: Gen. Tech. Rep SRS-252. Asheville, NC: U.S. Department of Agriculture Forest Service. Southern Research Station. www.fs.usda.gov/treesearch/pubs/61933

Rhoades, Chuck, David Loftis, Jeffrey Lewis, Stacy Clark, and USDA Forest Service. "The influence of silvicultural treatments and site conditions on American chestnut (Castanea dentata) seedling establishment in eastern Kentucky, USA." *Forest Ecology and Management* 258, no. 7 (2009): 1211-1218.

Rieske, L.K., Rhoades, C.C. and Miller, S.P., 2003. Foliar chemistry and gypsy moth, Lymantria dispar (L.), herbivory on pure American chestnut, *Castanea dentata* (Fam: Fagaceae), and a disease-resistant hybrid. *Environmental Entomology*, *32*(2), pp.359-365.

Sanaeifar, A., Yang, C., de la Guardia, M., Zhang, W., Li, X. and He, Y., 2023. Proximal hyperspectral sensing of abiotic stresses in plants. *Science of The Total Environment*, *861*, p.160652.

Westbrook, J.W., Zhang, Q., Mandal, M.K., Jenkins, E.V., Barth, L.E., Jenkins, J.W., Grimwood, J., Schmutz, J. and Holliday, J.A., 2020. Optimizing genomic selection for blight resistance in American chestnut backcross populations: A trade-off with American chestnut ancestry implies resistance is polygenic. *Evolutionary applications*, *13*(1), pp.31-47.

Wright, James R., Stephen N. Matthews, Cornelia C. Pinchot, and Christopher M. Tonra. "Preferences of avian seed-hoarders in advance of potential American chestnut reintroduction." *Forest Ecology and Management* 511 (2022): 120133.

Piel, G., Tallamy, D. W., & Narango, D. L. (2021). Lepidoptera Host Records Accurately Predict Tree Use by Foraging Birds. Northeastern Naturalist, 28(4), 527–540. https://doi.org/10.1656/045.028.0410

Tallamy, D. W., & Shropshire, K. J. (2009). Ranking lepidopteran use of native versus introduced plants. Conservation Biology: The Journal of the Society for Conservation Biology, 23(4), 941–947. https://doi.org/10.1111/j.1523-1739.2009.01202.x

Johnson, M. T. J., Bertrand, J. A., & Turcotte, M. M. (2016). Precision and accuracy in quantifying herbivory. Ecological Entomology, 41(1), 112–121. https://doi.org/10.1111/een.12280