PROJECT TITLE: Comparative analysis of chestnut growth and survival on Appalachian surface mine lands

SUMMARY

Reclamation of previously mined lands and restoration of the American chestnut are two major ecological issues facing the Appalachian Region. The Appalachian Regional Reforestation Initiative and The American Chestnut Foundation have established a joint project to address these issues. In 2008, the Office of Surface Mining and Reclamation provided funding to plant chestnut seeds on reclaimed mine sites in six states. Heretofore, there has been no follow-up monitoring at most sites. Thus, it is time for a comprehensive reassessment of their current growth status. The proposed research will provide insight into early development of chestnut and reforestation on mine lands.

PRINCIPAL INVESTIGATORS

Lauren Bizzari	Ohio University
Brian C. McCarthy	Ohio University

DURATION OF THE PROJECT

One year (May 1, 2012 to December 31, 2012)

TOTAL AMOUNT REQUESTED

$3,132

SHORT AND LONG TERM GOALS OF THE PROJECT

Forests in the Appalachian Region have been hard hit in the last century by deforestation due to surface coal mining. Additionally, the loss of a dominant tree species (the American chestnut, *Castanea dentata* (Marsh.) Borkh.) to a devastating fungal pathogen has drastically changed the composition of these forests. To effectively support forest recovery in the region, forest managers need informative research that evaluates the success of reforestation and species reintroduction strategies.

The Appalachian Regional Reforestation Initiative (ARRI) and The American Chestnut Foundation (TACF) initiated a joint project in 2008 to address these needs. Specifically, the project intends to assess chestnut growth and survival on former surface mine lands, and the effect of the Forestry Reclamation Approach (FRA) on this growth. Long-term plots were established to study the growth and survival of a variety of American chestnut genotypes planted on mine sites in six Appalachian states. The sites were prepared using the guidelines of the FRA. This reclamation approach is being promoted by ARRI as a method for increasing tree establishment on mine lands.

Now that these saplings are five years old, the project is in need of a comprehensive analysis across the sites to assess early development of saplings. We plan to resurvey four of the six original sites at the end of the 2012 growing season (in August-September 2012). Results

from this study will shed light on the site conditions necessary for successful mine land reforestation, the feasibility of reintroducing different American chestnut genotypes into the reclamation landscape, and the role of genetic lineage in growth and survival. We also hope to identify interactions between chestnut genotypes and their growing environment to determine the optimal conditions for successful growth and survival in the early stages of sapling development.

NARRATIVE

The American chestnut was once a dominant species in Eastern forests, especially in the Appalachian region (Russell 1987). However, around 1905 a non-native parasitic fungus was accidentally imported into the United Sates and began decimating American chestnuts in the New York Botanical Garden. By the 1950s, the fungus, eventually identified as *Cryphonectria parasitica* (Murrill) Barr (chestnut blight), had nearly eliminated the chestnut from its former range in the Eastern US.

Cryphonectria parasitica is native to Asia and has co-evolved with the Chinese chestnut (*Castanea mollissima* Blume). Unlike its American cousin, the Chinese chestnut is able to mount a physiological response to an infection by the blight fungus. When The American Chestnut Foundation (TACF) was founded in 1983, one of its primary objectives was to begin a breeding program to harness this genetic resistance from the Chinese chestnut (Burnham et al.1986). Their goal was to create an American-Chinese hybrid that would be morphologically similar to the American chestnut, but contain the necessary genetic material from the Chinese trees to confer blight resistance. TACF has implemented a backcross breeding program to generate these hybrids, which are then screened to identify progeny demonstrating good blight resistance. The most recent generation of hybrids appear to have reached the program's morphological goals for resemblance to American chestnut (Diskin et al. 2006). The breeding program continues to screen these hybrids for resistance, hoping to move towards distribution of a blight-resistant seed. In order to ensure that the backcross hybrids will be able to survive and proliferate successfully once placed out in the forest landscape, environmental requirements and appropriate reintroduction sites still need to be identified (Jacobs 2007).

Abandoned surface mine lands in Appalachia represent a potential entry point for chestnut reintroduction using the blight-resistant hybrids. Many of these unoccupied tracts of open land in the heart of Appalachian coal country are conveniently located within the American chestnut's former range. In addition, results from an experiment by Latham (1992) suggest that American chestnut seedlings would be good competitors against native tree species, particularly under increased light conditions such as those found on former mine lands. More recently, McCament and McCarthy (2005) found that American chestnut seedlings had greater biomass in more open sites (thinned and thinned-and-burned) than control and burned forest treatment plots. These findings and others (e.g. Joesting et al. 2007) suggest that American chestnut will grow quickly and successfully under the high-light mine land conditions.

However, most mine sites are currently unable to support any forested habitat as a result of reclamation requirements laid out by the Surface Mining Control and Reclamation Act (SMCRA) of 1977. This act created regulations governing the specifics surrounding treatment of mine spoils after mining operations concluded, most of which resulted in considerable soil compaction and dominance of non-native herbaceous species. While these requirements helped reduce earlier problems associated with acid mine drainage and soil erosion, they unfortunately created a whole new set of ecological problems. As a consequence of the heavily compacted

soils and dense herbaceous vegetative cover, post-SMCRA mine lands have difficulty supporting tree growth. The sites can remain in an arrested early successional stage for decades (Skousen et al. 2006).

The Forestry Reclamation Approach (FRA) was recently developed to improve on the current reclamation guidelines and help return previously mined lands to their original forest state (Burger et al. 2005). The approach consists of 5 steps:

1) Establish an appropriate rooting medium (a mix of topsoil, weathered sandstone, or other high quality materials that are available).
2) Grade the rooting medium to decrease compaction.
3) Seed appropriate ground cover that will not out-compete tree growth.
4) Plant both early successional trees and valuable crop species.
5) Properly plant trees on sites (Burger et al. 2005).

These steps are currently being implemented throughout the Appalachian Region, but long-term monitoring is necessary to determine if the method will actually encourage growth of mature trees on the typically inhospitable mine lands.

Both the FRA and the backcross hybrid chestnuts are in need of further research to support their potential restoration values (Jacobs 2007; Zipper et al. 2011). Unpublished data obtained from Dr. Fred Hebard, Chief Scientist for TACF's Meadowview Research Farm, showed that survival rates of all five genotypes across all six sites ranged from 46.6%-54.1% after two growing seasons. B1-F3 hybrid saplings had the highest average survival rate while pure American chestnut saplings had the lowest average rate. Now that the saplings are further along in their development, perhaps more distinct survival patterns among the genotypes may begin to emerge. The proposed comparative analysis of these saplings will provide insight into the potential for the FRA and backcross breeding stock to work synergistically in ecological restoration.

The sites for this study are located on former mine lands in six different states in the Appalachian Region: Ohio, Pennsylvania, Maryland, West Virginia, Kentucky, and Tennessee. In May 2008, each site was planted with seed from 5 different lines of *Castanea*: American chestnut (*Castanea dentata*), Chinese chestnut (*Castanea mollissima*), and three different intermediate generations of American-Chinese backcross hybrids (B1-F3, B2-F3, and B3-F2). Approximately 150 seeds of each genotype were planted at each site. Prior to planting, each site was prepared using established FRA methods (e.g. ripping of soil, end-dump). While different methods were employed, all followed the FRA guidelines to reduce soil compaction and improve site conditions for the planted seed.

Four of the six original states will be participating in this research. Collaborators in Ohio (Dr. Brian McCarthy, Ohio University), Kentucky (Dr. Chris Barton, University of Kentucky), Tennessee (Dr. Jennifer Franklin, University of Tennessee-Knoxville), and Pennsylvania (Dr. Michael Jacobson, Pennsylvania State University) have all been contacted and expressed their interest in participating in the research. The Maryland site has since been reactivated as a working surface mine, and it is unlikely that the research site has survived (Dr. Keith Eshleman, University of Maryland Center for Environmental Science, personal communication, January 2012). The West Virginia site is currently under the direction of Dr. Jeffrey Skousen at West Virginia University. Dr. Skousen has elected to continue collecting annual data using his own resources as he currently has students working on the research site. He has offered to provide the growth and survival data necessary for the comparative analysis.

We will visit each of the four states twice: once in Spring 2012 (May 2012) and once at the end of the 2012 growing season (August or September 2012). During the initial visit in May, we will locate the sites, familiarize ourselves with the plot layouts, and collect soil samples (see Table 1). Soil samples will subsequently be analyzed at Ohio University for pH, soil bulk density, percent coarse fragment, soil texture, percent organic matter, total carbon and nitrogen, cation exchange capacity, and exchangeable base cations (freely exchangeable and bioavailable). Information on soil properties will be useful in making inferences about any differences in chestnut sapling mortality rates between sites.

During the second visit, we will collect chestnut growth and survival data at each site at the end of the growing season. All chestnut saplings will be surveyed to determine survival status (dead or alive). When it is possible to clearly identify the cause of death, this information will be recorded for all dead saplings (herbivory, disease (blight or other), or other natural causes). Sapling height (m) will be measured using a meter stick and stem diameter at breast height (cm) will be measured using calipers for living saplings.

We will also characterize other vegetation present at the sites during the second visit. Collecting this data will allow us to assess the diversity and abundance of other plants colonizing these sites, as they may be potential competitors with the chestnut saplings. Abundance of non-chestnut sapling species (dbh > 2.5cm) will be measured within two 2x10 m quadrats per block. This will need to be slightly modified for the Kentucky site, but at least six sapling quadrats will be measured at that site. At each end of the 2x10 m sapling quadrat, herbaceous vegetation cover will be measured within a 0.5x2 m quadrat (total of four herbaceous quadrats per block). Based on discussions with those who have sampled these sites before, we estimate that one full day of fieldwork will be required to complete all sampling at each site. Michael French (Forester and Restoration Scientist for TACF) will also participate in the August-September data collection. Mr. French's travel will be covered as part of his current employment with TACF.

Table 1. Site design information with expected soil sampling intensity for the proposed study.

Site	**# Blocks or Plots**	**# Samples per Block**	**# Samples per Site**
*Bent Mountain, KY**	30	N/A	16
Zeb Mountain, TN	4	5	20
Jockey Hollow WMA, OH	3	5	15
Snow Shoe, PA	3	5	15
Dushore, PA	3	5	15
English Center, PA	3	5	15
		Total # of Samples	***96***

* Kentucky site was not blocked and was planted with 30 plots. Each plot contained 25 seeds of a single lineage, and half of the plots were planted with tree shelters. We will sample eight plots with shelters and eight plots without shelters.

BIBLIOGRAPHY

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Burnham, C., P. Rutter, and D. French. 1986. Breeding blight-resistant chestnuts. Plant Breeding Reviews 4:347-397.

Diskin, M., K. C. Steiner, and F. V. Hebard. 2006. Recovery of American chestnut characteristics following hybridization and backcross breeding to restore blight-ravaged Castanea dentata. Forest Ecology and Management 223:439-447.

Jacobs, D. F. 2007. Toward development of silvical strategies for forest restoration of American chestnut (Castanea dentata) using blight-resistant hybrids. Biological Conservation 137:497-506.

Joesting, H. M., B.C. McCarthy, and K. J. Brown. 2007. The photosynthetic response of American chestnut seedlings to differing light conditions. Canadian Journal of Forest Research 37:1714-1722.

Latham, R. E. 1992. Co-occurring tree species change rank in seedling performance with resources varied experimentally. Ecology 73:2129-2144.

McCament, C. L., and B. C. McCarthy. 2005. Two-year response of American chestnut (Castanea dentata) seedlings to shelterwood harvesting and fire in a mixed-oak forest ecosystem. Canadian Journal of Forest Research 35:740-749.

Russell, E. W. B. 1987. Pre-blight distribution of Castanea dentata. Bulletin of the Torrey Botanical Club 114:183–190.

Skousen, J., P. Ziemkiewicz, and C. Venable. 2006. Tree recruitment and growth on 20-year-old, unreclaimed surface mined lands in West Virginia. International Journal of Mining, Reclamation and Environment 20:142-154.

Zipper, C. E., J. A. Burger, J. G. Skousen, P. N. Angel, C. D. Barton, V. Davis, and J. A. Franklin. 2011. Restoring forests and associated ecosystem services on Appalachian coal surface mines. Environmental Management 47:751-65.

TIMELINE

May 2012 – Visit all four sites to locate plantings (spend one day at each site) and collect soil samples for analysis.

June-July 2012 – Analyze soil samples at Ohio University.

August-September 2012 – Visit all four sites to measure sapling growth and survival; characterize other vegetation present at the sites.

October-December 2012 – Analyze and prepare data for report to The American Chestnut Foundation; prepare presentation for the Annual American Chestnut Foundation Conference.

January-June 2013 – Prepare manuscript for submission to journal by June 2013. Prepare data for presentation at conferences (Association of Southern Biologists, Appalachian Regional Reforestation Initiative).

DISSEMINATION OF RESULTS

In order to reach the appropriate audiences, both at the applied (forest managers and surface mine operators) and research level (chestnut researchers and mine land restoration scientists), the results will be disseminated in a variety of formats. Results will be presented at the Annual Meeting of the Association of Southern Biologists in April 2013, and potentially the ARRI Annual Conference in May 2013. Additionally, results will be prepared for a manuscript detailing our findings and will be submitted for peer-review to an appropriate journal (e.g., Forest Ecology and Management or Applied Vegetation Science) in 2013.

BUDGET

	TACF Funds
May 2012 Site Visit	
Travel	
Mileage costs for driving a private vehicle from the Athens, OH to sites listed below (@ $0.55 per mile, mileage from Google Maps)	
Jockey Hollow Wildlife Management Area, OH – 136 miles (1 roundtrip)	$75
Bent Mountain, KY and Zeb Mountain, TN – 701 miles (1 roundtrip, can visit sites together)	$385
Snow Shoe, English Center, and Dushore, PA – 916 miles (1 roundtrip)	$504
Lodging	
Ohio – none	
Kentucky and Tennessee (2 travel days, 2 fieldwork days) – 1 night at Mountaineer Hotel in Williamson, WV ($60/night) – 1 night at Super 8 in Hazard, KY ($56/night) – 1 night at Super 8 in Caryville, TN ($53/night)	$169
Pennsylvania (2 travel days, 3 fieldwork days) – 1 night at Endless Mountain Motel, Dushore, PA ($50/night) – 1 night at Little Pine State Park, English Center, PA ($17/night) – 1 night at Keystone Motel, Lock Haven, PA (@ $45/night) – 1 night at Best Travel Inn, Phillipsburg, PA (@ $43/night)	$155
Total for May 2012 Site Visit	**$1,288**
August-September 2012 Site Visit	
All costs for this second site visit are the same as those for May 2012. The two visits require the same number of travel and fieldwork days.	
Total for August-September 2012 Site Visit	**$1,288**
Soil Analysis (for 96 samples)	
Supplies	
Soil pH – all equipment provided by Ohio University	
Soil bulk density and percent coarse fragment – all equipment provided by Ohio University	
Soil texture – sodium hexametaphosphate (5g per sample) – Fisher Scientific (S333-500), 500g	$76

Percent organic matter	
– all equipment provided by Ohio University	
Total carbon and nitrogen	
– all equipment and supplies provided by Ohio University	
Cation exchange capacity and exchangeable base cations	
– ammonium acetate (19g per sample)	
– purchased by Ohio University ($136 value)	
– analysis on ICP-OES at Ohio University (@ $5 per sample)	$480
Total for Soil Analysis	**$556**
TOTAL TACF RESEARCH FUNDS REQUESTED	**$3,132**

TIMELINE FOR FUNDS

Date	Amount Requested	Purpose
May 1, 2012	$1,288	May 2012 site visit
June 1, 2012	$556	Soil analysis
August 1, 2012	$1,288	August-September 2012 site visit

BRIEF CURRICULUM VITAE FOR PRIMARY INVESTIGATORS

Lauren Bizzari

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Education

M.S. (in progress) Environmental and Plant Biology. Ohio University, Athens, Ohio. Advisor: Dr. Brian C. McCarthy. Expected June 2013.

B.A. in Biology, minor in Environmental Studies. Colby College**,** Waterville, Maine. May 2009.

Relevant Research Experience

2010 – 2011 **Field Crew Leader, University of Wisconsin-Madison** (Kennan, WI)
- Organized daily forest sampling field tasks for a crew of 3-6 people and assisted in electronically compiling end-of-season data

2009-2010 **Research Technician, Washington University in St. Louis** (New Ellenton, SC)
- Assisted with field work for project investigating plant community assembly and restoration of longleaf pine savannas

Summer 2009 **Land Stewardship Intern, The University of Vermont** (Burlington, VT)
- Completed natural resource inventories as part of a small team of interns

Academic Awards and Honors

2009 Graduated from Colby College *summa cum laude*, with distinction in Biology
Elected to Phi Beta Kappa

2008 Linda K. Cotter Award ($1,000) for participation in Coastal Conservation Research Program – Awarded to deserving students to help fund their participation in unpaid internships

Posters and Presentations

2010 **Bizzari, L.**, Collins, C.D., Brudvig, L. and Damschen, E. Effects of historical land use and fire frequency on soil properties in longleaf pine forests. Southeastern Ecology and Evolution Conference. Atlanta, Georgia. March 2010. (Poster; Manuscript in Preparation)

2008 **Bizzari, L.** Breeding ecology and census of colonial waterbirds on Gull Island. Summer Student Research Seminar, The Wetlands Institute. Stone Harbor, New Jersey. August 2008.

Bizzari, L. The effects of melatonin on thermoregulation in the nocturnal gecko, *Hemidactylus turcicus*. Colby College Undergraduate Research Symposium. Waterville, Maine. May 2008.

2007 **Bizzari, L.** Nitrate removal processes in permeable reactive barriers: Investigating groundwater denitrification using a $^{15}NO_3$ tracer. Semester in Environmental Science Student Research Symposium, The Marine Biological Laboratory. Woods Hole, MA. December 2007. (Also presented in April 2008 at Colby College Undergraduate Research Symposium, Waterville, Maine.)

BRIAN C. McCARTHY

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Education

Ph.D. Botany/Ecology. 1989. Rutgers University, Piscataway, New Jersey 08855. Thesis: "Reproductive biology of *Carya ovata* and *C. tomentosa* (Juglandaceae): determinants of flower and fruit production." Advisor: Dr. James A. Quinn.

Master of Science, Botany. 1984. Ohio University, Athens, Ohio 45701. Thesis: "Aspects of the population ecology of *Carya* spp. in southeastern Ohio." Advisor: Dr. Warren A. Wistendahl.

Bachelor of Science, Biology. 1982. Saint Peter's College, Jersey City, New Jersey 07306. Advisor: Dr. Michael E. Held.

Engineering Studies. 1978. Stevens Institute of Technology, Hoboken, New Jersey 07803.

Professional Experience

2011-present. Associate Dean, College of Arts & Sciences, Ohio University, Athens, OH.

2010-2011. Chair, Department of Environmental and Plant Biology, Ohio University, Athens, OH.

2002-present. Professor of Forest Ecology. Department of Environmental and Plant Biology, Ohio University, Athens, OH.

1996-2002. Associate Professor of Forest Ecology. Department of Environmental and Plant Biology, Ohio University, Athens, OH.

1992-1996. Assistant Professor of Forest Ecology. Department of Environmental and Plant Biology, Ohio University, Athens, OH.

1992-present. Graduate Faculty. Program in Environmental Studies, Ohio University, Athens, OH.

1989-1992. Assistant Professor of Plant Ecology. Department of Biology, Frostburg State University, Frostburg, MD.

1989-1992. Adjunct Professor of Forest Ecology. Appalachian Environmental Laboratory, Center for Environmental and Estuarine Studies, University of Maryland, Frostburg, MD. 21532.

1988-1989. Curator, Botanical Records Program. Willowwood Arboretum, Morris County Park Commission, P.O. Box 1295R, Morristown, NJ.

Academic Awards and Honors *(25):*

Outstanding Faculty Leadership & Service Award, College of Arts & Sciences, Ohio University; Editor-In-Chief, *Journal of the Torrey Botanical Society*, Associate Editor: *Open Ecology, Forests, International Journal of Forest Research;* Senior Ecologist—Ecological Society of America; Distinguished Off-Campus Scholar Award (Miami University); Associate Editor, *Journal of the Torrey Botanical Society*; Associate Editor, *Plant Ecology*; Fellow of The Ohio Academy of Science; Director, Dysart Woods Ecological Research Laboratory; President, Sigma Xi—The Scientific Research Society, Ohio University; two oral presentation awards; two outstanding research awards; multiple Dean's List and academic performance awards.

Grants & Contracts *(52 totaling $2.25M):*

United States Department of Agriculture, National Science Foundation, Department of Energy, U.S.D.A. Forest Service, Faculty Development Awards, MD Dept. of Natural Resources, The Nature Conservancy, Wildlife Conservation International, National Wild Turkey Federation, Ohio Biological Survey, John Houk Memorial Research Grant, Sigma Xi Grant-in-aid of Research.

Published Papers & Reports *(111 in 19 journals):*

American Journal of Botany, Journal of Ecology, Forest Ecology and Management, International Journal of Plant Science, Oecologia, Canadian Journal of Forest Research, Plant Ecology, Restoration Ecology, Dendrochronologia, Oikos, Ecological Research, Bulletin of the Torrey Botanical Club, The American Midland Naturalist, Economic Botany, The American Fern Journal, Coleopterists Bulletin, Castanea, The

American Biology Teacher, The Ohio Journal of Science, Plant Science Bulletin, The Ohio Woodland Journal.

Ten Recent Publications:

Hartman, K.M. and B.C. McCarthy. 2008. Changes in forest structure and species composition following invasion by a non-indigenous shrub, Amur honeysuckle (*Lonicera maackii*). Journal of the Torrey Botanical Society 135: 245-259.

Lombardo, J.A. and B. C. McCarthy. 2008. Silvicultural treatment effects on oak seed production and predation by acorn weevils in southeastern Ohio. Forest Ecology and Management 255: 2566-2576.

McCarthy, B.C., J.M. Bauman, and C.S. Keiffer. 2008. Mine land reclamation strategies for the restoration of American chestnut. Ecological Restoration 26(4): 292-295.

Joesting, H.M., B.C. McCarthy, and K.J. Brown. 2009. Determining the shade tolerance of American chestnut using morphological and physiological leaf parameters. Forest Ecology and Management 257: 280-286.

Albrecht, M.A. and B.C. McCarthy. 2009. Seedling establishment shapes the distribution of shade-adapted forest herbs across a topographical moisture gradient. Journal of Ecology 97: 1037-1049.

Lombardo, J.A. and B.C. McCarthy. 2009. Seed germination and seedling vigor of weevil-damaged acorns of red oak. Canadian Journal of Forest Research 39: 1600-1605.

Small, C.J. and B.C. McCarthy. 2010. Seed bank variation under contrasting site quality conditions in mixed oak forests of eastern North America. International Journal of Forest Research. Doi:10.1155/2010/419482

Albrecht, M.A. and B.C. McCarthy. 2011. Variation in dormancy and germination in three co-occurring perennial forest herbs. Plant Ecology 212: 1465-1477.

Beasely, R. R. and B. C. McCarthy. 2011. Effects of *Microstegium vimineum* (Trin.) A. Camus (Asian Stiltgrass; Poaceae) on native hardwood seedling growth and survival. Natural Areas Journal 31: 246-255.

DeForest, J. and B.C. McCarthy. 2011. Diminished soil quality in an old-growth mesophytic forest following chronic acid deposition. Northeastern Naturalist 18: 177-184.

Published Abstracts of Papers Presented *(226):*

Ecological Society of America, Botanical Society of America, International Botanical Congress, Society for Conservation Biology, Association of Southeastern Biologists, Ohio Academy of Science, New Jersey Academy of Science, Pennsylvania Natural History Society.

Invited Seminars *(38):*

Various state, regional, national and international colleges, universities, institutes, and government organizations.

Teaching Experience *(11 graduate and/or undergraduate courses and seminars):*

Plant Ecology, Biostatistics, Multivariate Statistics, Introductory Botany, Forest Ecology Seminar, Plant Competition Seminar, Plant Community Analysis, Forest Science, General Ecology, Dendrology.

Professional Society Affiliations *(11):*

American Association for the Advancement of Science, Ecological Society of America, Society of American Foresters, International Association for Vegetation Science, Sigma Xi, American Institute of Biological Sciences, Tree Ring Society, Torrey Botanical Society, Southern Appalachian Botanical Club, Ohio Academy of Science, Natural Areas Association.