Project Title: Interactions between American chestnut establishment, groundcover, and ectomycorrhizal colonization

Summary: The purpose of this research is to investigate the influence of herbaceous species on chestnut establishment and ectomycorrhizal (ECM) root colonization on restored surface mines in eastern Tennessee. This study will utilize previous plantings of TACF restoration chestnut to collect a new data set on growth and survival, and ECM colonization, over the first 7 years of establishment. Seedling survival and growth, and the density and species composition of vegetation surrounding each seedling will be assessed. ECM fungi present on root samples will be identified by DNA sequencing of the ITS region. Results will inform future protocols with regard to the groundcover species best used for the establishment of both restoration American chestnut and ECM symbiont on sites that have been impacted by surface mining.

Principle Investigators:

Dr. Jennifer Franklin
Associate Professor
University of Tennessee
Department of Forestry, Wildlife and Fisheries
274 Ellington Plant Sci.
Knoxville, TN 37996

Dr. Jenise M. Bauman
Assistant Professor of Environmental Science
Western Washington University
Huxley College of the Environment on the Peninsulas
1000 Olympic College Way
Poulsbo, WA 98370

Duration of the Project: January 1, 2017 – December 30, 2017

Total Amount requested: $6,080

Short and Long Term goals of this project:

The **three short-term goals** of this current grant application are to determine: **1)** The influence of herbaceous species (density and composition) surrounding restoration chestnuts on surface coal mined sites with regard to survival and tree growth, **2)** The influence surrounding vegetation has on the symbiosis (root colonization and fungal species composition) between chestnut and ECM fungi, and **3)** The interactions between neighboring vegetation and ECM root colonization with regard to nitrogen acquisition by chestnut on surfaced mined lands.

The **long-term objectives** are to assist in re-establishing chestnut in the coalfields of Appalachia by ensuring high survival rates of planted seedlings. Chestnut's native range corresponds with the coal fields in the Appalachian region of the eastern forests and these current hybrids may offer a native forest tree to be used in future restoration projects. Field studies in mine reclamation sites are in the process of developing strategies for chestnut re-introduction into the Appalachian forests of North American. This study will utilize previous plantings of TACF restoration chestnut to compare to other chestnut plantings in the region with regard to growth and survival, and ECM root colonization, over the first seven years of establishment. Results will add information to inform restoration protocols with regard to the groundcover species best used for the establishment of chestnut trees and ECM symbionts on replicated sites that have been impacted by surface mining. The second long-term goal will add to the ecological knowledge of fungal colonization and ECM community composition as they relate to soil disturbance and nutrient acquisition under herbaceous competition.

Project Narrative:

The American Chestnut Foundation (TACF) has partnered with the Appalachian Regional Reforestation Initiative (ARRI) since 2008 in an effort named "Operation Springboard" to use reclaimed surface mines for the planting of TACF backcross chestnuts as a regional and widespread approach to reintroduce the species. Since that time, ARRI researchers have planted American chestnut on minesites throughout the original range of the species, from Pennsylvania to Tennessee. Seedlings provided by TACF have been planted on older reclaimed sites where soil compaction has been relieved by deep ripping along with control of herbaceous competition (Swiegard et al. 2007), as well as on sites that have been newly reclaimed using the Forestry Reclamation Approach (Angel et al. 2005). Follow-up assessment of these plantings is crucial to evaluate the success of this approach.

Large-scale soil disturbances due to surface mining for coal have removed nearly one million hectares of native forests and induced long-term changes in soil properties and vegetative communities. Plant species that have been used for reclamation are often selected due to their high seed availability and fast establishment on coal mine reclamation soils. Years after initial reclamation, many sites have degraded to unproductive landscapes comprised of a few invasive, non-native plant species. In the past three decades, 7,000 km^2 of historic forest area in the Appalachian region of the U.S. has been reclaimed to non-native grasslands (Franklin et al. 2012). Methods utilizing soil compaction and aggressive herbaceous groundcover are not conducive to forest tree recovery, as evident by the lack of natural recruitment of native herbaceous plants and trees (Burger 2011; Cavender et al. 2014) and low survival of directed tree plantings (Rathfon et al. 2004; Zipper et al. 2011; Franklin et al. 2012). Competition and compaction deters access to water and nutrients, which are key factors determining the success or failure of a planted tree seedling. Landscape consequences include large-scale forest fragmentation and decreases in biodiversity, native habitat, and biomass production (Krieger 2001; Evans et al. 2013). Many of these older sites are now being treated and replanted.

As restoration goals shift from reclaiming ecosystem process to restoring ecosystem structure and native habitat, more active restoration to promote forest recovery is required (Burger 2011). ARRI outlined planting methods, the Forestry Reclamation Approach, that encourage healthy tree establishment (Angel et al., 2005; Zipper et al. 2011). These methods include incorporating proper substrate selection, preparation of a deep rooting zone (> 1 m deep), integration of appropriate herbaceous vegetation, and the proper planting methods of valuable tree species. A hardwood species with the potential to be a valuable restoration tree for use in the Appalachian region (Jacobs et al. 2013) is the American chestnut (*Castanea dentata* Marsh. Borkh.). TACF is currently assessing multiple advanced breeding lines from progeny that are predicted to be blight-resistant (Burnham 1988). Chestnut's native range corresponds with the coal fields in the Appalachian region of the eastern forests and these current hybrids may offer a native forest tree to be used in future restoration projects (Skousen et al. 2013; Gilland and McCarthy 2013; Bauman et al. 2014).

Like other hardwoods used in coal mine reclamation, American chestnut form beneficial ectomycorrhizal (ECM) symbioses with root colonizing fungi. ECM fungi form characteristic root sheaths around the host plant root and produce radiating hyphae that allow for greater access to nutrients and water (Smith and Read 2008). These fungal symbionts are essential for healthy tree growth, particularly in forest restoration on mined landscapes (Iordache et al. 2009). Encouraging functional ECM symbiosis in restoration projects have resulted in improved chestnut establishment, lower metal accumulation, and a positive correlation with tree growth (Bauman et al. 2012; Bauman et al. 2013). It is clear that as the density of herbaceous vegetation on a reclaimed minesite increases above 60% cover the growth and survival of planted tree seedlings declines (Franklin et al. 2012). That herbaceous species differ in their effects on tree seedlings is also clear, but these interactions have not been well characterized. Herbaceous species differ in their rate of resource use, the preferred form and ratio of nutrients used, the timing and spatial distribution of resource use, and microbial associations (Eviner and Hawkes 2008). It is thus reasonable to expect them to differ in their degree of competitiveness with young trees. Research suggests that ground cover species composition can have a significant influence on tree growth (Rizza et al. 2007), but some species show no evidence of negative effects (Franklin and Buckley 2009). Belowground, root competition and allelopathic compounds produced by some herbaceous species have been shown to inhibit fungal root colonization, which may impede the success of tree establishment (Wolfe et al. 2008). In addition, aboveground competition with herbaceous canopies can deter seedling establishment and diminish the carbon available to maintain an ECM symbiont.

The objective of this study is to investigate the influence of herbaceous species on chestnut establishment, and ECM fungal colonization on restored surface mines in eastern Tennessee. This study will utilize previous plantings of TACF restoration chestnut to collect a new data set on growth and survival, and ECM root colonization, over the first seven years of establishment. Seedling survival and growth, and the density and species composition of vegetation surrounding each seedling will be assessed. ECM fungi present on root samples will be identified by DNA sequencing of the ITS region. Results will inform future protocols with regard to the groundcover species best used for the establishment of both the hardwood tree and ECM symbiont on sites that have been impacted by surface mining.

Methods

This study will utilize plots on reclaimed minesites in Tennessee on which American chestnut was planted as part of three separate research studies: 1) a planting methods study on a newly reclaimed site established in 2008, 2) a ground cover study on a newly reclaimed mine planted in 2010, and 3) a ground cover study on an older mine site planted in 2015.

Study 1 was designed to test the influence of fertilization, a gel polymer, and the application of forest soil on the emergence, growth and survival of seeds from different chestnut genetic lines (pure Chinese, pure American, and several hybrids) (Miller et al. 2011). This was a newly reclaimed site, and although no herbaceous cover was seeded, the application of forest soil resulted in pockets of native species across the site.

Study 2 was designed to test the influence of herbaceous cover on tree seedlings, and was replicated on three newly reclaimed sites in different areas within the TN coalfield, and with different mine operators. Three surface coal mine sites were each divided into four plots, planted in 2010 with hardwood seedlings including American chestnut, and assigned to one of four groundcover treatments: 1) bare ground left as a control, 2) alfalfa (*Medicago sativa*) seeded at a rate of 17 kg/ha, 3) switchgrass (*Panicum virgatum*) 5.8 kg/ha, 4) goldenrod (*Solidago nemoralis*) 1.3 kg/ha. Chestnut survival as of June 2016 is approximately 40%, and a diverse and highly variable herbaceous community has developed on these plots.

Study 3 was also designed to investigate tree seedling and herbaceous interactions, this time on an older mine site that was treated by deep ripping prior to planting in spring of 2015. Pre-treatment vegetation was measured, and four treatments were applied: herbicidal control around each seedling (applied in June 2015), Jan. 2015 seeding of a deer-preferred native herbaceous mixture, Jan. 2015 seeding of a deer-deterrent native herbaceous mixture, and ripping only. A total of 283 chestnut were planted along with other hardwoods, with chestnut being planted in the herbicide and “deer preferred” treatments which have resulted in differing densities and species of ground covers.

We propose to collect a new data set by re-measuring chestnut planted in these studies. Samples will be collected from study 2 for ECM colonization and nitrogen analysis, while chestnut growth and vegetation measurements will utilize all three studies.

Ectomycorrhizal (ECM) Root Colonization:

Eight chestnuts per treatment (× 4), per mine site (× 3), will be selected for non-destructive root sampling (*n=96*). To ensure roots are being sampled from chestnut and not a part of the surrounding vegetation, soil will be carefully removed with a spade to expose the chestnut root system at a depth of 25 cm and a width of 45 cm. Roots will be carefully sifted away from the soil and then stored on ice. In the laboratory, chestnut roots will be washed, quantified for ECM colonization, and sorted into morphotypes based on their appearance. Two root tips of each morphotype will be selected for DNA extracting and sequencing using a 3-mm section of the root tip. Fungi will be identified to species by DNA sequencing of the internal transcribed spacer (ITS) region. The DNA will be extracted by manufactures guidelines using the QIAgen DNeasy® Plant Mini Kit.

Primers ITS1-F (5’ cttggtcatttaggaagtaa 3’) and ITS4 (5’ tcctccgcttattgatatgc 3’) will be used to amplify internal transcribed spacer sequences (ITS) and sent to UT Genomic Core, Knoxville, TN for sequencing using ABI 3730 capillary electrophoresis instrument. The DNA sequences will be analysed and edited using the Sequencher 4.2 software (Gene Codes, Ann Arbor, Michigan). To identify the fungus found on roots, ITS sequences from samples will be compared to those in the GenBank using the BLAST search. The genera of the fungi reported in this study will be based on the best matches of those in the GenBank with a > 97% ITS sequence similarity as a threshold.

Total Nitrogen:

Approximately 5 g of fresh leaves will be harvested in the field, packaged in paper bags, and oven dried at 100 ˚C. Dry, homogenized leaf samples will be analyzed for total nitrogen (N) using a Thermo Electron NC Soil Analyzer Flash EA 1112 Series (Thermo Electron Corporation, Milan, Italy) at Western Washington University, Department of Environmental Sciences. Approximately 2 g will be measured into a tin capsule and compressed to seal in the material and to remove any air prior to insertion into an autosampler. The calibration curve will be made from atropine (MP Biomedicals, Santa Ana, CA), which contains 48.4 g kg-1 N.

Growth and herbaceous vegetation:

All study sites will be surveyed in mid-summer of 2017 to locate surviving chestnut, and the identity and origin of each tree will be determined from planting records wherever possible. Each tree will be measured for height, root collar diameter, DBH, and number of stems. A $1m^2$ quadrat will be placed around each seedling to quantify the surrounding herbaceous community. The total projected cover of live vegetation will be estimated by collecting digital images of each quadrat from above, and processing with ImageJ software by applying a color mask followed by particle analysis to determine area coverage. Vegetation within each quadrat will be identified to species, and visual cover estimates made of the 5 most abundant species in each plot. Maximum height of live or dead herbaceous vegetation will be recorded and, along with tree height, used as a proxy to estimate the relative degree of above-ground competition.

Statistical Analysis:

An analysis of variance (ANOVA) will be used to determine differences in root colonization among groundcover treatments. Significant values will be analyzed using a one-way analysis of variance (ANOVA) followed by a Tukey's Post Hoc test among the treatments at $\alpha = 0.05$. A permutational multivariate analysis of variance followed by a non-metric multidimensional scaling (NMDS) ordination using Bray-Curtis dissimilarities will be used to determine differences in ECM species composition among ground cover treatments and mine sites. A Pearson's correlation analysis will be used to test for associations between nitrogen concentration in plant tissue and root colonization by ECM fungi (arcsine square root transformation), andfor a relationship between chestnut growth rates and total herbaceous cover. Multiple linear regression will be used to test for relationships between density of common herbaceous species and chestnut growth rates. All statistical analyses will be performed using R software (R Development Core Team 2009) and SPSS 22.0.

Timeline

Work Performed	Jan 2017	Feb 2017	Mar 2017	Apr 2017	May 2017	June 2017	July 2017	Aug 2017	Sept 2017	Oct 2017	Nov 2017	Dec 2017
Root Processing	■	■										
DNA Sequencing		■	■	■								
Foliar Nutrient Analysis		■	■	■								
Data Analysis		■	■	■					■	■		
Growth and veg. data							■	■				
TACF Annual Report							■	■	■			
Manuscript Preparation									■	■	■	■

Quarterly Goal Outline:

January – April 2017
- Morphotyping, quantifying, and DNA extraction of chestnut roots
- Sequencing of fungal ITS region using Sanger sequencing
- Chestnut tissue nitrogen analysis
- Data analysis and research synthesis

May – August 2017
- Data analysis of ECM and nitrogen
- Collection of chestnut growth data and vegetation data from field sites

September – December 2017
- Analysis of growth and vegetation data and research synthesis
- Abstract preparation
- Final Report and manuscript preparation for TACF
- Proceedings paper submission for the American Society of Mining and Reclamation

Results: Reporting and Deliverables

A final project report will be submitted to the American Chestnut Foundation at the end of the project. Project results will contribute to research presentations to be made at meetings of the American Society of Mining and Reclamation, the Ecological Society of America, and the Appalachian Regional Reforestation Initiative in 2018. In addition, results will also be published in the ASMR meeting proceedings and submitted to the *Journal of American Chestnut.* Two comprehensive manuscripts will be authored and submitted to journals such as *Plant and Soil* and *Journal of Applied Soil Ecology*.

Budget

Quantity	Item	Unit Cost	Total Cost
1 kit	Qiagen DNeasy 250 Reactions	$985	$985
1 kit	GoTaq® Green Master Mix	$435	$435
1 kit	Wizard Clean-up	$493	$493
60 samples	C:N Foliar Analysis	$9	$540
2, 96 well plates	Sanger Sequencing	$255	$510
6 weeks	Graduate student	$308	$2,067
1500 miles	4WD mid-size SUV	$0.70	$1,050
		Total:	**$6,080**

Subcontract: Western Washington University: $2,963
Supplies required to molecularly identify ECM fungi and to analysis N concentration in chestnut leaf tissue: Qiagen DNeasy 250 Reaction Extraction Kit ($985.00), Taq polyermerase ($435.00), Wizard Clean-Up Kit ($493.00), Sequencing, two, 96 well plates ($510.00), and total nitrogen analysis ($540).

Field and Lab Assistance: $2,067
Funds are requested for one graduate student to spend 6 weeks (~27 hours/wk @ $12.79/hour) assisting with this project, to collect data on tree growth and herbaceous vegetation, and aid in data analysis and report preparation. No benefits are requested.

Travel: $1,050
Mileage is requested to pay for the cost of transportation to the sites, at the University rate of $0.70 per mile for a mid-size SUV with 4WD, capable of accessing the sites. Fifteen days of field sampling are planned, at an average distance of 100 miles return from Knoxville.

Indirect Costs: None requested

Total Request: $6,080

Matching Funds:
Although no matching funds are claimed directly, a number of in-kind contributions will be made to this project. These include the time and associated benefits of both PI's, as well as all indirect costs associated with this project from both UT and WWU. The cost of Jenise Bauman's travel to TN in the fall of 2016 for root sampling, and the transportation from Knoxville to the sites in fall 2016 occur prior to the start of the grant, and are being covered by

WWU and UT. The cost of establishing the original studies was provided by grants from TACF, the U.S. Office of Surface Mining, and the National Fish and Wildlife Foundation.

Literature Reviewed:

Angel P., Davis V., Burger J., Graves D., Zipper C. (2005) Forest Reclamation Advisory No. 1, US Office of Surface Mining, 2pp.

Bauman J.M., Keiffer C.H., Hiremath S. (2012) Facilitation of American chestnut (*Castanea dentata*) seedling establishment by *Pinus virginiana* in mine restoration. J Ecol 2012:1-12.

Bauman J.M., Keiffer C.H., Hiremath S., McCarthy B.C. (2013) Soil preparation methods promoting ectomycorrhizal colonization and American chestnut (*Castanea dentata*) establishment in coal mine restoration. J Appl Ecol 50:721-729.

Bauman J.M., Keiffer C.H., McCarthy B.C. (2014) Backcrossed chestnut seedling performance and blight incidence (*Cryphonectria parasitica*) in restoration. New Forests 45:813-828.

Burger J.A. (2011) Sustainable Mined Land reclamation in the eastern U.S. coalfields: a case for an ecosystem reclamation approach. Pp. 113–141, *In* R.I. Barnhisel (Ed.). The American Society of Mining and Reclamation Proceedings. Sciences Leading to Success. Lexington, KY.

Burnham C.R. (1988) The restoration of the American chestnut. Am Sci 76:478-486.

Cavender N., Byrd S., Bechtoldt C.B., Bauman J.M. (2014) Vegetation Communities of Recovering Reclaimed Grasslands Following Coal Mining in Southeastern Ohio. Northeast Nat 21:31-46.

Evans D.M., Zipper C.E., Burger J.A., Strahm B.D., Villamagna A.M. (2013) Reforestation practice for enhancement of ecosystem services on a compacted surface mine: Path toward ecosystem recovery. Ecol Eng 51:16–23.

Eviner V.T., Hawkes C.V. (2008) Embracing variability in the application of plant–soil interactions to the restoration of communities and ecosystems. Rest Ecol 16(4):713-729.

Franklin J.A., Buckley D.S. (2009) Effects of seedling size and ground cover on the first-year survival of planted pine and hardwoods over an extreme drought. *In* R.I. Barnhisel (Ed.). The American Society of Mining and Reclamation Proceedings. Sciences Leading to Success. Lexington, KY.

Franklin J.A., Zipper C.E., Burger J.A., Skousen J.G., Jacobs D.F. (2012) Influence of herbaceous ground cover on forest restoration of eastern US coal surface mines. New Forests 43:905-924.

Gilland K.E, McCarthy B.C (2013) Reintroduction of American Chestnut (*Castanea dentata*) on reclaimed mine sites in Ohio: microsite factors controlling establishment success. North J Appl

For 29:197-205.

Iordache V., Gherghel F., Kothe E. (2009) Assessing the effect of disturbance on ectomycorrhiza diversity. Int J Res Public Health 6:414-432.

Jacobs D.F., Dalgleish H.J., Nelson C.D. (2013) A conceptual framework for restoration of threatened plants: the effective model of American chestnut *(Castanea dentata)* reintroduction. New Phytol 197:378-393

Krieger D.J. (2001) Economic Value of Forest Ecosystem Services: A Review. The Wilderness Society, Washington, DC.

Miller C.R., Franklin J.A., Buckley D.S. (2011) Effects of soil amendment treatments on American chestnut performance and physiology on an East Tennessee surface mine. Pp 419-437 *In* R.I. Barnhisel (Ed.). The American Society of Mining and Reclamation Proceedings, Lexington, KY.

Rathfon R., Fillmore S., Groninger J. (2004) Status of reforested mine sites in southwestern Indiana reclaimed under the Indiana mining regulatory program. Purdue University Cooperative Extension Service, West Lafayette, IN. FNR-251. 15 p.

Rizza J., Franklin J.A., Buckley D.S. (2007) The influence of different ground cover treatments on the growth and survival of tree seedlings on remined sites in eastern Tennessee. Pp 633-677 *In* R.I. Barnhisel (Ed.). The American Society of Mining and Reclamation Proceedings, Lexington, KY.

Smith S. E., Read, D.J. (2008) Mycorrhizal Symbiosis, 3rd Edition. San Diego, CA, USA: Academic Press.

Skousen J., Cook T., Wilson-Kokes L., Pena-Yewtukhiw E. (2013) Survival and Growth of chestnut backcross seed and seedlings on surface mines. J Environ Qual 42:690-695.

Sweigard, R., et al. (2007) Forest Reclamation Advisory 4: Loosening compacted soils on mined sites. U.S. Office of Surface Mining.

Wolfe B.E., Rodgers V.L., Stinson K.A., Pringle A. (2008) The invasive plant *Alliaria petiolata* (garlic mustard) inhibits ectomycorrhizal fungi in its introduced range. J of Ecol 96: 777–783.

Zipper C.E., Burger J.A., Skousen J.G., Angel P.N., Barton C.D., Davis V., Franklin J.A. (2011) Restoring forests and associated ecosystem services on Appalachian coal surface mines. Environ Manag 47:751- 765.

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PROFESSIONAL PREPARATION:

Institution and Location	Degree	Year	Major
University of British Columbia, Vancouver, BC	B.S.	1997	Plant Biology
University of Alberta, Edmonton, AB	Ph.D.	2002	Renewable Resources (Forestry/Tree physiology)

APPOINTMENTS:

July 2009-present	Associate Professor with tenure, Department of Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville.
June 2003- Jul 2009	Assistant Professor, Department of Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville
June 2002-June 2003	Postdoctoral Research Associate, Department of Biological Sciences, University of Calgary, Calgary, AB

RESEARCH EMPHASIS

Ecological physiology of southeastern hardwood trees. Research projects revolve around gaining an understanding of how trees alter their structure or function to acclimate to environmental stresses. Field studies of the response of trees to stress have been focused on reclaimed minesites and high elevation forests; extremely stressful environments where trees experience multiple, interacting stresses. Controlled studies in the lab and greenhouse are used to support field studies. The role of carbohydrates in the stress response is one of the primary targets of these investigations. Our lab is equipped for measurements of physiology and basic plant biochemistry, including sugar analysis, and has most equipment needed for field and greenhouse studies.

PAST AND CURRENT PROJECTS

- Barton C, Franklin J. (2016-2018) Mineland reforestation for upland habitat improvement on the Cumberland Plateau. National Fish and Wildlife Foundation, $140,000.
- Franklin J, McKinney M (2014-2016) Appalachian Forest Renewal Initiative: Tennessee. National Fish and Wildlife Foundation, $140,000.
- Hathaway J, Franklin J (2013-2018) Stormwater Goes Green? Investigating the Benefit and Health of Urban Trees in Green Infrastructure Installations. USDA Forest Service $148,890.
- Franklin J, Warren J (2012) Partitioning in Trees and Soils (PiTS), Oak Ridge National Lab, $2000
- Franklin J (2011-2013) Rapidan Camp and Big Meadows Cultural Landscape Technical Assistance, National Park Service $40,000
- Franklin J, Henning J (2010-2013) Frasier fir health in high-elevation Appalachian ecosystems. National Park Service $43,000
- Franklin J, Buckley DS (2008-2011) Reforestation of steep slopes in Appalachia. USDI Office of Surface Mining $170,616

- Evans R, Buckley D, Franklin J (2008-2011) Effects of topography and soil chemistry on forest establishment on quarry tailings. Rogers Group LLC $50,000
- Franklin J, Buckley D. (2008) American Chestnut Restoration on Mined Sites. American Chestnut Foundation. $22,680.

PROFESSIONAL MEMBERSHIPS

- American Society of Mining and Reclamation, Associate Editor, Journal of the American Society for Mining and Reclamation (2013-present), Chair of Forestry and Wildlife Division (2005-present), National Executive Council (2011-2016), member (1999-present)
- Appalachian Regional Reforestation Initiative (http://arri.osmre.gov/) – Science Team (2005-present)
- Society for Ecological Restoration, Tennessee State Representative on Southeast Chapter board (2011-present), member (2003-present)
- Society of American Foresters, member (2003-present)

SELECTED PUBLICATIONS (PEER REVIEWED)

Macdonald SE, Landhäusser S, Skousen J, Frouz J, Quideau S, Hall S, Franklin J, Jacobs D. (2015) Forest Restoration Following Surface Mining Disturbance: Challenges and Solutions. New Forests, 46(5-6): 703-732.

Coots C, Lambdin PL, Franklin JA, Grant JF, Rhea R (2015) Influence of Hemlock Woolly Adelgid Infestation Levels on Water Stress in Eastern Hemlocks within the Great Smoky Mountains National Park, USA. Forest, 6:271-279.

Trigiano RN, Franklin JA, Gray DJ (2014) A Brief Introduction to Plant Anatomy and Morphology. Book Chapter, Pp.15-27. In: Beyl, C.A. and R.N. Trigiano (Eds.). Plant Propagation Concepts and Laboratory Exercises, Second Edition. CRC Press, Boca Raton, FL.

Frouz J, Jílková V, Cajthaml T, Pizl V, Tajovski K, Hanel L, Burasova A, Simacova H, Kolarikova K, Franklin JA, Nawrot J, Groninger J (2013) Soil biota in post-mining sites along a climatic gradient in the USA: simple communities in shortgrass prairie recover faster than complex communities in tallgrass prairie and forest. Soil Biol Biochem 67:212-225.

Franklin JA, Zipper CE, Burger JA, Skousen JG, and Jacobs DF (2012) Influence of herbaceous ground cover on forest restoration of eastern US coal surface mines. New Forests 43:905-924.

Harley G, Grissino-Mayer HD, Franklin JA, Anderson C, Köse N (2012) Cambial activity of Pinus elliottii var. densa reveals influence of solar radiation on seasonal growth dynamics in the Florida Keys. Trees - Structure and Function 26:1449-1459.

Jean-Philippe SR, Franklin JA, Buckley DS, Hughes K (2011) The effect of mercury on trees and their mycorrhizal fungi. Environmental Pollution 159:2733-2739.

Miller CR, Franklin JA, Buckley DS (2011) Effects of soil amendment treatments on American chestnut performance and physiology on an East Tennessee surface mine. National Meeting of the American Society of Mining and Reclamation, Bismarck, ND. Reclamation: Sciences Leading to Success June 11-16, 2011. R.I. Barnhisel (Ed.) Published by ASMR, 3134 Montavesta Rd., Lexington, KY 40502.

SHORTENED CURRICULUM VITAE

JENISE M. BAUMAN, PH.D.
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PROFESSIONAL PREPARATION:

Ph.D. in Botany, Miami University, Oxford OH	December 2010
M.S. in Plant Pathology, West Virginia University	May 2005
B. S. in Horticulture, Eastern Kentucky University	July 1998

APPOINTMENTS:

Western Washington University – Assistant Professor	August 2014 – present
Miami University, Ohio - Visiting Faculty	August 2012 –August 2014
The Wilds Conservation Center, Ohio-Postgraduate	August 2010– August 2012

RESEARCH EMPHASIS:
The development of protocols for large-scale plant establishment after industrial disturbances that include: 1) the influence of planting methods on beneficial microbial interactions during plant establishment 2) the interference of plant and microbial growth by invasive species and 3) the ecology and disease susceptibility of native trees used in habitat restoration.

RECENT PEER-REVIEWED PUBLICATIONS (2015-2012):
Citations indicated by an asterisk(*) have received TACF grant funding

Bauman, J.M., Hiremath, S., and Santas, A. *In Review*. Abiotic and biotic factors in coal mine soils influence ectomycorrhizal composition and symbiosis. *Applied Soil Ecology*

*** Bauman, J.M.,** *Cochran, C., *Chapman, J., and Gilland, K. 2015. Plant community development following restoration treatments on a legacy reclaimed mine site. *Ecological Engineering.* 83: 521-528

*** Bauman, J.M.**, Cochran, C., Chapman, J., and Gilland, K.E. 2015. Bur production and canker incidence on backcrossed restoration chestnut trees. *Journal of the American Society of Mining and Reclamation.*

Bauman, J.M. 2015. A comparison of the growth and asexual reproduction by *Cryphonectria parasitica* isolates infected with hypoviruses CHV3-County Line, CHV1-Euro7, and CHV1-Ep713. *American Journal of Plant Sciences*. 6:73-83.

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Cavender, N., Byrd, S., Bechtoldt, C.L., and **Bauman, J.M.** 2014. Vegetation Communities of Recovering Reclaimed Grasslands Following Coal Mining in Southeastern Ohio. *Northeastern Naturalist.* 21: 31-46.

Santas, A.J., Persaud, T., Wolfe, B. and **Bauman, J.M.** 2013. Non-invasive method for state-wide survey of *Cryptobranchus a. alleganiensis* (Eastern Hellbender) using environmental DNA. *International Journal of Zoology.* Article ID 174056: 1-6.

Bauman, J.M., Keiffer, C.H., Hiremath S., and McCarthy, B.C. 2013. Soil preparation methods promoting ectomycorrhizal colonization and American chestnut (*Castanea dentata*) establishment in coal mine restoration. *Journal of Applied Ecology*. 50: 721-729.

* **Bauman, J.M.**, Cochran, C., Keiffer, C.H., and McCarthy, B.C. 2013. American chestnut's role in the ecological restoration of coal mined landscapes. *The Journal of the American Chestnut*. 5:15-18.

Bauman, J.M., Keiffer, C.H. and Hiremath, S. 2012. Facilitation of American chestnut (*Castanea dentata*) seedling establishment by *Pinus virginiana* in mine restoration. *International Journal of Ecology*. 2012: 1-12.

Hiremath, S., Lehtoma, K., and **Bauman, J.M.** 2012. Survey for the presence of *Phytophthora cinnamomi* on reclaimed mined lands in Ohio chosen for restoration of the American Chestnut. *Journal American Society of Mining and Reclamation*. 2: 68-79.

CURRENT CONFERENCE PRESENTATIONS (2013-2016)

Citations indicated by an asterisk(*) have received TACF grant funding

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* **Bauman, J.M.**, and Santas, A. 2015. The presence of chestnut blight (*Cryphonectria parasitica*) decreases ectomycorrhizal inoculum potential and seedling recruitment survival in restoration plantings. International Conference on Mycorrhiza, August 3-7, Flagstaff, AZ.

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