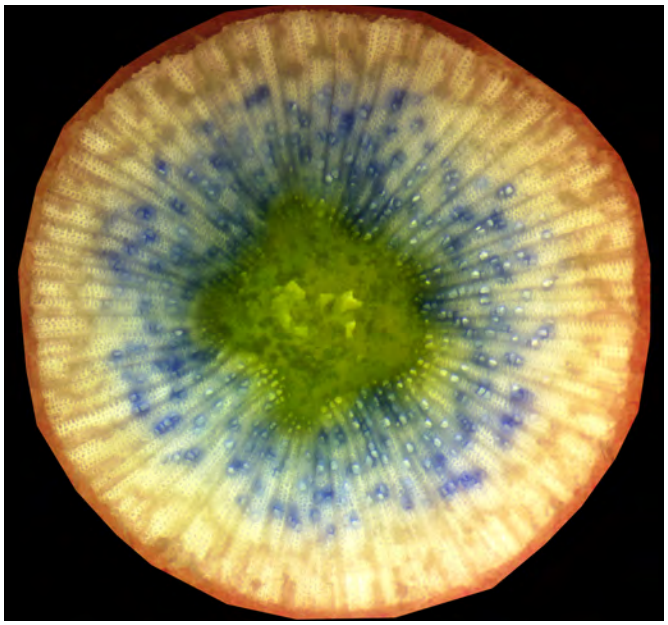
College of Agricultural, Consumer and Environmental Sciences

John T. Harrington Forestry Research Center

ANNUAL REPORT 2019



NM STATE

Agricultural Experiment Station

BE BOLD. Shape the Future. **New Mexico State University**

2019 Staff, John T. Harrington Forestry Research Center:

- Owen Burney, *Associate Professor and Superintendent*
- Tammy Parsons, *Nursery Manager*
- Josh Trujillo, *Senior Nursery Laborer*
- Lorenzo Gallegos, *Senior Farm Laborer*

Partners and Collaborators:

- New Mexico Highlands University
- New Mexico Forest and Watershed Restoration Institute
- Utah State University
- Purdue University
- Oregon State University
- Northern Arizona University
- University of New Mexico
- Southern Utah University
- The Nature Conservancy
- National Park Service
- US Forest Service
- NM State Forestry
- US Geological Survey
- Institute of Applied Ecology
- Wild Earth Guardians
- International Union of Forest Research Organizations
- Santa Clara Pueblo
- NM Soil and Water Conservation, Mora
- Imerys Minerals
- Philmont Scout Ranch – Boy Scouts of America

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1. Introduction

The John T. Harrington Forestry Research Center (JTH FRC) with New Mexico State University (NMSU) is the only research program in the southwestern US that focuses on forest nursery technologies, tree improvement, and eco-physiology of young forest trees to facilitate ecological restoration and/or commercial reforestation. These research interests are critical for establishing future forests in the region.

A subaward using McIntire-Stennis funds was provided to forestry faculty members at the Department of Natural Resources Management (NRM) with New Mexico Highlands University (NMHU) in Fall 2018. This award will continue through the end of June 2019 and serves to promote the research and educational relationship between the two forestry programs.

The research center produced 5 publications during 2019. The topics for the publications were: 1) regional differences in aspen seedling nursery production, 2) effects of growing media on polybag-raised whitegum, 3) plasticity of live oak seedlings under varied canopy conditions, 4) live oak response to vegetation and animal control treatments, and 5) challenges and opportunities for maintaining ponderosa pine in the southwestern US.

External funding generated by the research center for 2019 totaled approximately $5,150,040. The primary source for funding came from the National Science Foundation Center for Research Excellence in Science and Technology grant. Other sources include: seedling sales for forest conservation, US Forest Service, National Park Service, tree improvement grants with the State of New Mexico, and the McIntire-Stennis grant.

With regards to teaching and education, the JTH FRC has hosted multiple tours for research scientists, land managers, and students (NMSU and NMHU). Additionally, our program is involved with two graduate students (1 PhD student at Northern Arizona University and 1 MS student at NM Highlands University).

2. Forest Restoration Triangle (FORT)

The Forest Restoration Triangle (FORT) is a partnership among: 1) the JTH Forestry Research Center with New Mexico State University, 2) the Department of Natural Resources Management with New Mexico Highlands University, and 3) the New Mexico Forest and Watershed Restoration Institute. This partnership is focused on restoring proper ecological function and ecosystem services to the forest landscape in New Mexico and the greater southwestern US.

As our country, including the Southwest, has experienced the most destructive wildfires in history, it is more important than ever to research and implement effective and efficient forest management and restoration strategies. FORT was established in January 2018 to address these concerns through three main pillars common to other university/college forestry programs: research, education, and outreach/extension.

The FORT partnership continues to improve forest health conditions throughout the southwestern region. In 2019, the Collaborative Forestry Lab was successful in completing all plant tissue analyses for the drought conditioning study with the assistance of student workers at New Mexico Highlands University. However, the biggest achievement of the FORT partnership in 2019 was a successful award with the Center for Research Excellence in Science and Technology (CREST) sponsored by the National Science Foundation (NSF) (see below).

3. CREST Award

In December of 2019, the FORT program was awarded $5 million over 5 years by the CREST program sponsored by NSF. This grant provides support to the research capabilities of minority-serving institutions through the establishment of centers that effectively integrate education and research. The center aims to advance the understanding of the effects of restoration activities on forested areas in New Mexico through multidisciplinary research, education and stakeholder collaborations. It also will provide science-based solutions for private, tribal, state and federal forest managers, who face the threat of catastrophic fires due to

overgrown forests and the inability of post-fire plant communities and ecosystems to naturally regenerate.

The role of NMSU as co-principal investigator on the CREST grant is to administer Subproject 1 of the grant. This subproject with NMSU has a budget of $1,057,666 over 5 years. The research objective of this subject is to assess a nucleation strategy matched with improved seedling stocktypes for forest restoration efforts.

4. FORT Advisory Board

The FORT Advisory Board was formed in January 2018. In 2019, there were two meetings (Jan 2019 and Aug 2019). The board members were critical to the success in obtaining the CREST grant. Additionally, they helped the Forestry program at NM Highlands University secure accreditation by the Society of American Foresters.

FORT Advisory Board Mission:
The mission of the Advisory Board is to provide strategic guidance and direction for the scientific (both applied and foundational), educational, and outreach programs for all three institutions (FORT), both independently and collaboratively. It plays a key role in advocating the need for continued research, education, and outreach in forest restoration in New Mexico and within the greater southwestern US.

FORT Board Members:
Kent Reid – NMFWRI
Brent Racher – NM Forest Industry Association
Josh Sloan – NMHU
Owen Burney – NMSU
Anne Bradley – Nature Conservancy
Zander Evans – Forest Guild
Andrew Frederick – NMSF
Jim Youtz – USFS
Ellis Margolis – US Geological Survey
Andi Thode – NAU
Daniel Denipah – Santa Clara Pueblo

5. Forest Nursery Program

The JTH FRC is the largest producer of forest nursery seedlings in New Mexico with a capacity of 300,000 per year. These seedlings are used for both research and conservation efforts. In 2019, the center produced approximately 55,600 seedlings for forest restoration purposes. At a planting density of 200 trees per acre, this equates to approximately 278 acres of restored forests in New Mexico.

6. Ongoing Research Projects

a. Drought-conditioning during nursery production influences physiology and resource allocation of *Populus tremuloides* and *Pinus ponderosa* seedlings.

Objective

This study was developed to test the effects of drought stress induced during the nursery growth phase on aspen and ponderosa pine seedling morphology and physiology.

Impacts

- Preliminary results suggest that seedlings grown under limited irrigation during the nursery phase improve plant hydraulics. This translates to higher rates of both growth and survival compared to the operational standard.
- In 2019, multiple nurseries and land managers from around the US are showing interest in utilizing this protocol to improve forest restoration success.
- Two manuscripts have been drafted and will be submitted in Spring of 2020.

Funding

McIntire-Stennis Grant, NM Energy, Minerals, and Natural Resources Department (EMNRD), Imerys Mining Company, US Forest Service, and JTH FRC seedling program.

b. Genetic variation in aridity adaptation among *Pinus ponderosa* populations.

Objective

The objective of this study is to examine aridity adaptability of ponderosa pine populations from a range of temperature and precipitation.

Impacts

- Two new planting sites were established in Summer of 2019.
- Preliminary results have shown a pattern of increasing survival in relation to seed sources that are more southern or lower in elevation.
- One publications was produced on this topic with two more in draft form.

Funding

McIntire-Stennis Grant and Northern Arizona University

c. Assisted migration – defining seed transfer guidelines for *Pinus ponderosa* in a changing climate.

Objectives

The objective of this experiment is to assess the effectiveness of moving southern seed sources of ponderosa pine to a northern latitude located in the Valles Caldera National Park. Additionally, the use of log shading microsite environments on seedling performance will be examined.

Impacts

- Preliminary results are showing that southern seed sources are outperforming local sources. However, the biggest impact on seedling survival and growth is connected to the log microsite which improves soil water retention for the seedling during dry conditions.
- A master's level graduate student is near completion on this research project with a thesis and publication.

Funding
National Park Service and McIntire-Stennis Grant.

d. Southwestern white pine blister rust resistance gene conservation.

Objective
Develop a grafting and gene conservation orchard program for blister rust resistant Southwestern white pine

Impacts

- A fourth grafting occurred from in Spring of 2019. The successfully grafted seedlings will be outplanted in Fall 2020.
- Current outplanted grafted seedlings are thriving and will become the future seed orchard for SW white pine for the entire southwestern US.

Funding
US Forest Service

e. Maritime forest restoration on the Southern Atlantic Coast.

Objectives
The objective of this study is to conduct a comprehensive analysis of the effects of animal browse, weed competition, and light requirements for live oak restoration plantings in Coastal Georgia in three project phases.

Impacts

- Results from the first three phases of this project suggest that live oak restoration is most successful when seedlings are both protected from deer herbivory and absent of competing vegetation. Additionally, increasing overstory canopy area showed a significant decrease in seedling performance. Planting in clearcuts is currently recommended.
- Two publications were produced from this research.

7. Peer Reviewed Journal Articles

a. Howe A, Landhäusser S, **Burney OT,** Long J, Mock K (2019). Regional differences in aspen (*Populus tremuloides* Michx.) seedling response to an established nursery protocol. *New Forests*, 1-12.

Abstract: In seedling-based reforestation operations, the seed source is known to be an influential variable determining outplanting success. Adaptive variation among seed sources may also be an important factor in the effectiveness of standardized nursery protocols for seedling production. This is particularly important for wide-ranging species, where regional optimizations of nursery protocols may be necessary to ensure a consistent production of quality seedling stock. Quaking aspen (*Populus tremuloides* Michx.) is a widely distributed tree species in North America. However, research to date on nursery protocols specific to aspen has focused on seed sources from a limited region in western boreal Canada. A well-established protocol has shown to be very effective for these aspen that uses a shoot growth inhibitor designed to maximize desirable seedling quality traits for outplanting success. We used this protocol on seeds sourced from two different regions in the southwestern portion of the species range (Utah and New Mexico, USA) and compared their response in the same nursery environment to that of a seed lot from Alberta, Canada to determine whether this protocol is also applicable for these very different regions. Seedlings from Utah and New Mexico differed significantly in their response to the protocol from the Alberta source, developing smaller root-to-stem ratios and sequestering less carbohydrate and nutrient reserves. Seedlings from Utah and New Mexico sources also differed from each other, with New Mexico seedlings growing larger according to all metrics. These results indicate that nursery protocols will benefit from regional modification in order to optimize seedling stock quality and trait consistency.

b. Shalizi N, Goldfarb B, **Burney OT,** Shear T (2019). Effects of five growing media and two fertilization levels on polybag-raised Camden whitegum (*Eucalyptus benthamii* Maiden & Cambage) seedling morphology and drought hardiness. *Forests, 10* (7).

Abstract: In developing countries, tree seedlings are often produced in polybags filled with mixtures of locally available materials. Seedling growth and quality can be affected by the type and amount of these substrates used in the mixture. Differences in seedling growth and quality can also be significantly affected when fertilization is employed during the nursery growing period. In this study, we assessed the effects of five different growing media and two fertilization regimes on nursery growth, seedling morphology and early post-planting response to drought of *Eucalyptus benthamii* (Maiden & Cambage) seedlings. First, we evaluated the effects of each media by fertilizer treatment combination on morphological attributes during a nursery growing period. Seedlings raised in fertilized media without rice hulls yielded higher growth, root dry mass, shoot dry mass, total dry mass, Dickson quality index (DQI) scores, and number of first order lateral roots (FOLRs). Root to shoot ratio (R:S ratio) was, however, greater in non-fertilized media that contained rice hulls. We then conducted a simulated outplanting and drought hardiness experiment, in which seedlings were planted in 13.2 L containers and irrigated for one month, followed by the imposition of drought stress. Seedlings in fertilized media composed of sand, topsoil and compost showed greater growth than those in rice hull-containing media, during the irrigation phase. With the discontinuation of irrigation and prevention of precipitation reaching the seedlings, seedlings grown in non-fertilized media containing rice hulls survived longer than those in other media. There were not large differences in survival among other media or between fertilized and other non-fertilized seedlings. Seedling total size and shoot height at the time of planting played a major role in survival. Smaller seedlings with smaller shoot sizes and greater R:S ratios survived longer. This study demonstrates that growing media and fertilization can be manipulated to affect seedling morphology in the nursery

and, ultimately, seedling performance and survival under water stressed conditions.

c. Thyroff E, **Burney OT,** Mickelbart M, Jacobs D (2019). Unraveling shade tolerance and plasticity of semi-evergreen oaks: insight from maritime forest live oak restoration. *Frontiers in Plant Science, 10*.

Abstract: *Quercus* spp. (oaks) are generally intermediate in shade tolerance, yet there is large variation within the genus in shade tolerance and plasticity in response to varying resource availability. Ecophysiological knowledge specific to semi-evergreen *Quercus* spp. from subtropical maritime forests is lacking relative to temperate deciduous oaks. We studied the influence of light availability and plant competition on leaf physiology and performance of semi-evergreen *Q*. *virginiana* on a barrier island along the US southern Atlantic coast. Seedlings were underplanted in pine (*Pinus taeda*) plantation stands with varying overstory density (clearcut, heavy thin, light thin, and non-thinned; creating a gradient of understory light availability) and vegetation (no competition removal or herbaceous competition removal) treatments. After two years, seedling survival was higher with increasing light availability (clearcut = heavy thin > light thin > non-thinned). Seedling growth (i.e., diameter, height, and crown width) increased similarly with increasing thinning intensity, while vegetation control was mainly beneficial to seedling growth in clearcuts. These responses were partially explained by foliar nitrogen and leaf trait measurements, which followed the same pattern. *Q*. *virginiana* seedlings demonstrated high plasticity in their ability to acclimate to varying resource availability, as indicated by light response curves, specific leaf area, stomatal density, stomatal pore index, and maximum theoretical stomatal conductance. Light compensation and saturation points illustrated seedling capacity to increase net CO2 assimilation with increased light availability. Leaves on trees in the high light environment had the highest net CO2 assimilation, stomatal density, stomatal pore index, maximum theoretical stomatal conductance and lowest specific leaf area. Although we demonstrated the relative shade tolerance of

Q. *virginiana* in lower light environments (i.e., heavy and light thin plots), this semi-evergreen species shows high plasticity in capacity to respond to varying resource availability, similar to other *Quercus* spp. from mesic and Mediterranean environments.

d. Thyroff E, **Burney OT,** Jacobs D (2019). Herbivory and competing vegetation interact as site limiting factors in maritime forest restoration. *Forests, 10* (11).

Abstract: Herbivory and competition during the regeneration phase influence forest successional dynamics. We demonstrated the importance of using the Target Plant Concept to identify and overcome site limiting factors for subtropical maritime forest restoration associated with deer browsing and competition. *Quercus virginiana* Mill. (live oak) bareroot seedlings were planted into clearcuts along the US Southern Atlantic coast with different treatment combinations of herbivory control (fenced or non-fenced) against white-tailed deer (*Odocoileus virginianus* Zimm.) browsing and competing vegetation removal (none, one-year, or two-years). After three growing seasons, mean seedling survival was 61% with no significant treatment differences. Control of browse and vegetation interacted to facilitate growth of live oak; seedlings were significantly larger for all response parameters (diameter, height, crown width) when fenced and treated with vegetation control. Removal of vegetation improved seedling performance only in fenced plots, however, indicating a shift in pressure from herbivory to competition as the most limiting site factor when deer were excluded. After the second growing season, foliar nitrogen was greater in fenced plots than non-fenced plots and greater in two-year vegetation control subplots than non-vegetation control subplots. This result, however, was absent after the third growing season. Three years after clearcutting, there was no evidence of *Q*. *virginiana* natural regeneration in non-fenced plots. Even with artificial regeneration in non-fenced plots, *Q*. *virginiana* growth was slow, indicating that herbivory was a key limiting factor. Our findings illustrate the importance of accounting for site limiting factors and may aid in developing

management prescriptions to promote semi-evergreen oak regeneration in ecosystems with high pressure from herbivory and competing vegetation.

e. Kolb T, Dixit A, **Burney OT** (2019) Challenges and opportunities for maintaining ponderosa pine forests in the southwestern U.S. *Tree Planters' Notes. 62(1-2) 104-112.*

Abstract: Deforestation caused by wildfire and bark beetle attacks in southwestern ponderosa pine (*Pinus ponderosa* Douglas ex P. Lawson & C. Lawson.) forests have increased over the past century due to climate warming. Continued warming is expected to increase deforestation. Ponderosa pine regeneration after deforestation often is inadequate in the region. Opportunities exist for active management to mitigate deforestation. First, planting can promote reforestation, but survival of planted seedlings is generally poor and highly variable among sites. The region needs more research about improving early seedling performance. Secondly, improving aridity adaptation of planted seedlings by seed source selection may improve outplanting performance. New common garden studies of seedling aridity adaptation of Arizona and New Mexico provenances suggest genetic variation in aridity adaptation among populations. Early results show genetic variation in survival under extreme drought conditions. Greenhouse experiments are investigating genetic variation in mechanisms of aridity tolerance. Promotion of forest recovery using these emerging approaches will be critical for sustaining forests in the increasingly arid southwestern U.S.

8. Presentations

a. Dixit A, Kolb T, Burney OT, Mock K. “Differences in seedling drought adaptation between southwestern provenances of ponderosa pine”. 15th Biennial Conference of Science and Management for the Colorado Plateau and Southwest Region, Flagstaff, AZ. (Sep 9-12, 2019)

b. Dixit A, Kolb T, Burney OT, Mock K. “Differences in drought adaptation between southwestern provenances of ponderosa pine”. 12th North American Forest Ecology Workshop, Flagstaff, AZ. (Jun 23-27, 2019)

c. Pinto J, Burney OT, Sloan J. "Overcoming limiting factors to seedling establishment: physiological, spatial, and temporal tactics", 8th World Conference on Ecological Restoration: Restoring Land, Water & Community Resilience, Society of Ecological Restoration, Cape Town, South Africa, (Sep 25, 2019).

d. Burney OT. "Use of the Target Plant Concept to Promote Successful Post-Fire Forest Restoration", Reforestation after Fires, Southwest Fire Science Consortium, Webcast. (April 9, 2019)

e. Burney OT. "Pu’u Wa’awa’a Demonstration Thinning", Advisory Board Meeting, Tropical Hardwood Tree Improvement Research Center, Hilo, HI. (January 28, 2019).

9. Funding for 2018

Our receipt of external funding for 2019 was approximately $5,150,040.

a. Burney OT (Co-Principal), Reid K (Principal), Cespedes B (Co-Principal), Conley C (Co-Principal). "CREST Center for Forest Restoration Triangle", Sponsoring Organization: National Science Foundation/New Mexico Highlands University. NMSU Co-PI Award: $1,057,671 (NMSU), Total Award: $5,000,000.

b. Burney OT (Principal). "Conservation of Blister Rust Resistant Southwestern White Pine through Clonal Propagation", Sponsoring Organization: US Department of Agriculture/Forest Service. Total Award: $15,000.

c. Burney OT (Principal). "Defining Seed Transfer Guidelines and Planting Strategies for Ponderosa Pine (P*inus ponderosa*) to Aid in Post-Fire Recovery in the Jemez Mountains", Sponsoring Organization: US Department of Interior/National Park Service. Total Award: $50,000.

d. Burney OT (Principal). "Tree Improvement and Forestation Plan", Sponsoring Total Award: $8,000.

e. Burney OT (Principal). "Seedling Conservation for EMNRD Forestry Division", Sponsoring Organization: NM Energy, Minerals, and Natural Resources Department. Total Award: $47,040.

f. Burney OT (Principal). “McIntire Stennis”, Sponsoring Organization: USDA.Total Award: $30,000.

10. Students

a. Jon Woerheide (MS), New Mexico Highlands University, “Seed transfer guidelines for Pinus ponderosa in the East Jemez Mountains”.
Advisor: Dr. Joshua Sloan, New Mexico Highlands University.
Current

b. Aalap Dixit (PhD), Northern Arizona University, “Genetic variation in aridity adaptation among *Pinus ponderosa* populations”.
Advisor: Dr. Tom Kolb, Northern Arizona University
Current

11. Field Tours at JTH FRC

a. General Public. “JTH FRC Field Day”. Audience: public, landowners, scientists, legislators, 50 participants. (September 2019)

b. Mora County School System. “Outdoor Classroom”. Audience: middle school kids, 200 participants. (October 2019)

12. Total Monthly Precipitation for JTH FRC 2019

Month	Rainfall (in)
Jan	0.51
Feb	0.30
Mar	2.02
Apr	2.71
May	1.17
Jun	1.78
Jul	2.59
Aug	1.56
Sep	1.09
Oct	0.92
Nov	1.60
Dec	0.66
TOTAL	16.91