2024 ANNUAL REPORT

JOHN T. HARRINGTON FORESTRY RESEARCH CENTER AT MORA

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College of Agricultural, Consumer and Environmental Sciences
Agricultural Experiment Station

John T. Harrington
Forestry Research Center at Mora

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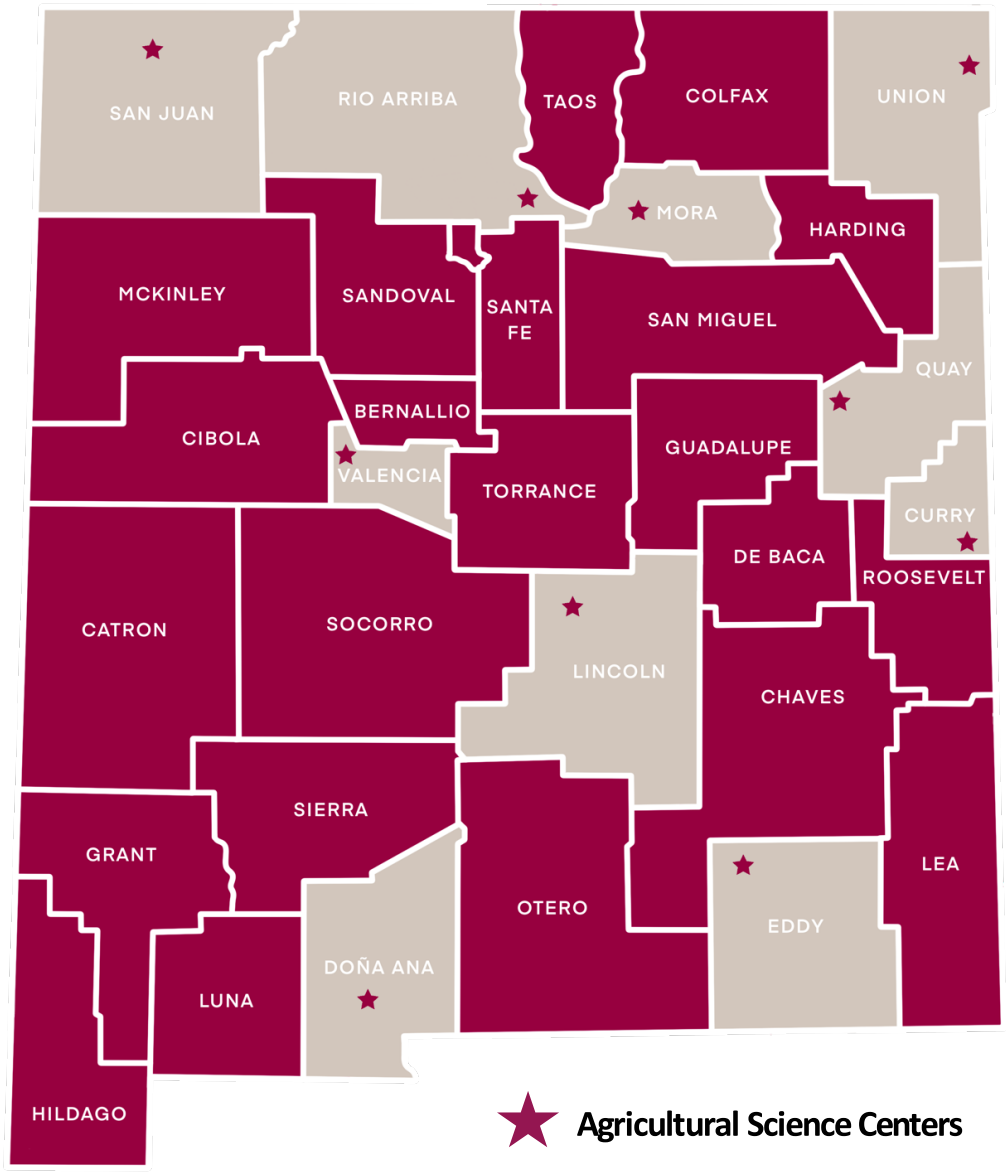
Agricultural Science Center Locations Map



Executive Summary

New Mexico's forests are vital for sustaining communities, providing between 50% and 75% of the water used by cities and agriculture, yet they are rapidly declining due to past fire suppression, increased fuel loads, prolonged drought, and inadequate forest management. These factors have led to dangerously overgrown woodlands, fueling some of the most severe wildfires in the region's history, a trend expected to persist. Many high-severity burn areas fail to regenerate naturally, leading to permanent forest loss, making investment in reforestation, through seed collection, nursery cultivation, and large-scale planting, essential for restoring ecosystems, improving water resources, enhancing carbon sequestration, supporting wildlife, and sustaining recreation. However, current seedling survival rates in the southwestern U.S. are alarmingly low, estimated at just 25%, which may still be an overestimation based on ongoing research. This high mortality rate presents both ecological and economic challenges, as the resulting changes in forest structure and function could have long-term environmental consequences, while financially, a 75% seedling loss represents a significant setback for reforestation investments. To address this, it is critical to invest in the entire reforestation pipeline, including outplanting operations, to ensure higher survival rates that will promote both ecological resilience and economic stability.

The New Mexico Reforestation Center (NMRC) represents a major investment in expanding and accelerating reforestation efforts across the Southwest. By integrating seed banking, nursery operations, and large-scale planting with research, education, and outreach, NMRC aims to strengthen the reforestation pipeline and serve as a model for other regions. Committed to closing critical gaps in forest restoration, NMRC is focused on ensuring the long-term health and resilience of forested landscapes. As of 2024, the center has secured $41 million in state and federal funding to support the design, construction, and initial operations of its facility, which will be located at the JTH Forestry Research Center in Mora, NM.

Current research at the JTH Forestry Research Center focuses on four key objectives. The first enhances climate resiliency through genetic testing, including a provenance study of 75 Pinus ponderosa sources to refine seed transfer guidelines and survival models. The second evaluates nursery practices to improve outplanting success, with studies on drought-conditioning for aspen and ponderosa pine, revealing improved xylem function and water-use efficiency, and another examining fungal pathogens in the rhizosphere. The third explores outplanting strategies, assessing the effects of residual snags, planting density, vegetation control, and animal protection methods like fencing and shelters. Lastly, research on reforestation's social and economic impacts includes developing allometric equations to estimate seedling carbon stocks for carbon markets, though high mortality rates on USDA Forest Service planting sites present challenges to sequestration potential.

In 2024, the JTH FRC produced 3 publications addressing: 1) the response of live oak regeneration to planting density, fertilizer, and mulch, 2) nursery cultural practices that influence morphological and physiological aspen seedling traits, and 3) carbon sequestration through sustainable land management practices in arid and semiarid regions. Multiple manuscripts are currently "in-progress" with expected submissions in 2025. The NSF CREST research projects is starting the final year (Year 5) with implementation of new projects and the analysis of on-going research. As of 2024, there are at least 14 different research projects that are currently active across 6 states and Canada with most occurring in New Mexico.

Research Highlights

Evaluating Rhizosphere Microbiome-Pathobiome Dynamics in Nursery-Grown Conifer Seedlings for Enhancing Reforestation in Wildfire-Impacted Landscapes

Investigators: Dr. Owen Burney (oburney@nmsu.edu), Dr. Gregory Reynolds, Dr. Nicholas Wilhelmi, Dr. Mee-Sook Kim, Grace Ganter, and Dr. Jane Stewart (PI)

Project Overview: Reforestation efforts rely on nursery-grown conifer seedlings. However, pathogens frequently impact seedling survival, reducing post-planting success and threatening native vegetation, especially if invasive pathogens are outplanted with seedlings. This study investigates pathogens in the rhizosphere microbiome of ponderosa pine and Southwestern white pine during growth in two nurseries and after planting for reforestation.

Meeting the Needs of New Mexico: This research will benefit all communities of New Mexico due to the added value it has on many ecosystem services that reforestation has on water, recreation, wildlife, timber, and many other valuable resources.

Impacts: Understanding microbiome-pathobiome interactions is critical for optimizing nursery management and enhancing long-term forest restoration.

Funding Acknowledgement: USDA Forest Service, NSF/CREST, McIntire-Stennis

A New Approach to Reforestation: Nucleation Planting Strategies for Climate-Resilient Forests

Investigators: Dr. Owen Burney (oburney@nmsu.edu) (PI), Dr. Andrei Toca, Dr. Christopher Marsh, and Dr. Matthew Hurteau

Project Overview: The JTH Forestry Research Center, in collaboration with the University of New Mexico, initiated a research project to investigate nucleation planting strategies as a means to improve reforestation outcomes. This study focuses on:

- Survival Probability: Using spatial survival models, 24 nuclei (1/4 acre each) were selected and categorized into high and low survival probability groups.
- Planting Density: Testing four density levels (194, 436, 889, and 1742 trees per acre) to evaluate their impact on seedling survival, establishment, and resilience to environmental stressors.
- Competing Vegetation Control: Examining the effects of mechanical vegetation removal versus no removal to determine the role of grasses and forbs in seedling growth and survival.

Meeting the Needs of New Mexico: This research addresses critical challenges in reforestation by promoting innovative strategies that mimic natural regeneration patterns. These methods can help create resilient forests capable of withstanding fire, drought, and other climate-driven stressors. By involving tribal communities in reforestation efforts, this project also fosters collaboration and respect for Indigenous knowledge, ensuring sustainable forest management practices.

Impacts: This long-term study will evaluate how nucleation planting strategies influence reforestation success and forest resilience. By incorporating survival models, planting densities, and vegetation management, the project aims to optimize reforestation practices for different environments. Initial data collection will inform future planting efforts, while the study's longevity will allow researchers to assess forest development over decades.

Funding Acknowledgement: NSF/CREST, McIntire-Stennis

Nursery Cultural Practices Influence Morphological and Physiological Aspen Seedling Traits: Implications for Post-Fire Restoration

Investigators: Dr. Owen Burney (oburney@nmsu.edu) (PI) and Dr. Aalap Dixit

Project Overview: There is an increasing demand for high-quality aspen seedlings to assist with forest restoration efforts. Nursery cultural practices can be used to alter aspen seedling traits to improve adaptability to dry planting conditions. The objective of this study was to examine the effects of nursery irrigation limitation and container size on morphological and physiological traits of aspen seedlings.

Meeting the Needs of New Mexico: This research will benefit all communities of New Mexico due to the added value it has on many ecosystem services that reforestation has on water, recreation, wildlife, timber, and many other valuable resources.

Impacts: This research supports New Mexico's post-fire reforestation efforts by improving aspen seedling survival in dry, high-elevation environments. It helps restore critical ecosystem services—like water retention, wildlife habitat, and scenic value—across fire-impacted landscapes.

Funding Acknowledgement: NSF/CREST, McIntire-Stennis

Developing Carbon Sequestration Models for Post-Fire Reforestation Efforts in the Southwestern US

Investigators: Dr. Owen Burney (oburney@nmsu.edu) (PI), Dr. Chris Marsh, Dr. Matthew Hurteau, Dr. Doug Cram, and Dr. Andrei Toca

Project Overview: Climate change and high-severity wildfires are causing widespread tree loss in the southwestern US, disrupting natural conifer regeneration, and reducing carbon sequestration. While planting seedlings can accelerate reforestation and boost carbon storage, the semi-arid climate creates uncertainty about their long-term benefits due to limited data on seedling growth. To address this, we studied eight post-wildfire reforestation sites and developed allometric equations to predict carbon sequestration based on directly measured seedling size, as well as indirectly using seedling age and varying climate scenarios. This approach helps evaluate reforestation efforts and their potential impact on carbon dynamics under changing conditions.

Meeting the Needs of New Mexico: This research will benefit all communities of New Mexico due to the added value it has on many ecosystem services that reforestation has on water, recreation, wildlife, timber, and many other valuable resources.

Impacts: This research equips New Mexico land managers with tools to estimate carbon gains from post-fire reforestation under future climate conditions. It supports data-driven decisions to maximize carbon sequestration and forest recovery in semi-arid landscapes.

Funding Acknowledgement: United States Department of Agriculture-Natural Resources Conservation Service

Experiments to Enhance Post-Fire Aspen Seedling Survival and Growth

Investigators: Dr. Owen Burney (oburney@nmsu.edu), Dr. Karen Mock, and Dr. Larissa Yocom (PI)

Project Overview: Experimentally assess the impacts of specific microsite characteristics on the survival and growth of aspen seedlings in field conditions, with two objectives. First, researchers sought to determine the effect of shading structures (logs) and biochar on the survival and growth of outplanted aspen seedlings in a recent fire footprint. The second objective was to determine whether experimentally placed shading structures affected the survival or growth of naturally occurring aspen seedlings in a recent fire footprint.

Meeting the Needs of New Mexico: This research will benefit all communities of New Mexico due to the added value it has on many ecosystem services that reforestation has on water, recreation, wildlife, timber, and many other valuable resources.

Impacts: Results from this research are and will continue to be used to inform land managers throughout the western US on reforestation strategies that improve seedling survival and growth.

Funding Acknowledgement: McIntire-Stennis

Influence of Post-Fire Snags on Microsite Planting Environments

Investigators: Dr. Owen Burney (oburney@nmsu.edu), Dr. Simon Landhäusser (PI), and Dr. Charles Nock

Project Overview: The main objective of this study is to determine if residual stems in burned forested landscapes influence regeneration efforts via tree planting. Specific objectives include: 1) determine if snags aid in soil moisture concentration through stemflow, 2) impacts of stemflow on planted aspen, and 3) determine stem flow patterns in relation to weather events. Second year data across the two replicated research sites (New Mexico and Alberta) will be collected in 2025 and used for both the final thesis and manuscript.

Meeting the Needs of New Mexico: This research will benefit all communities of New Mexico due to the added value it has on many ecosystem services that reforestation has on water, recreation, wildlife, timber, and many other valuable resources.

Impacts: This research helps New Mexico land managers understand how post-fire snags influence soil moisture and seedling survival, especially for aspen. Findings will support more effective reforestation strategies in drought-prone, fire-impacted landscapes.

Funding Acknowledgement: NSF/CREST, McIntire-Stennis

Assessing Combinations of Nucleation Size and Planting Density to Improve Survival and Performance of Planted Ponderosa Pine Seedlings

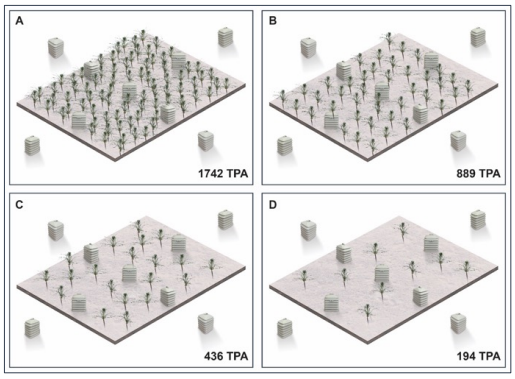
Investigators: Dr. Owen Burney (oburney@nmsu.edu) (PI), Dr. Joshua Sloan, and Dr. Aalap Dixit

Project Overview: This study aims to determine the effects of nucleation size and planting density on ponderosa pine seedling survival and the performance of planted seedlings on a post-fire site. The objective of this study is to provide baseline data on the growth and survival of ponderosa pine seedlings in response to different nucleation sizes and density treatments in post-fire environments. Moreover, the interaction between the combination of nucleation size and planting density on ponderosa pine has never been studied or published to date in the southwestern US.

Meeting the Needs of New Mexico: This research will benefit all communities of New Mexico due to the added value it has on many ecosystem services that reforestation has on water, recreation, wildlife, timber, and many other valuable resources.

Impacts: The findings from this research are actively guiding land managers across the western United States in developing reforestation strategies that improve seedling survival and growth, with continued contributions expected in the future.

Funding Acknowledgement: NSF/CREST, McIntire-Stennis



Pinus Ponderosa Carbon Modeling and Provenance Test

Investigators: Dr. Owen Burney (oburney@nmsu.edu) (PI), and Dr. Aalap Dixit

Project Overview: Climate change is occurring more rapidly than trees can naturally migrate or adapt through traditional regeneration and planting methods. To address this, researchers aim to enhance climate resiliency in future forests by establishing a network of provenance and common garden tests that evaluate diverse genetic sources for traits that boost genetic diversity and adaptability. These insights will guide seed source selection to ensure long-term reforestation success. This study specifically examines the impact of climate change on 75 sources of ponderosa pine, assessing survival, growth, physiological responses, and carbon sequestration over a 10-year period. Notably, this is the only study of its kind in the Four Corner States, providing critical, region-specific data to support sustainable reforestation strategies in this unique and climate-vulnerable region.

Meeting the Needs of New Mexico: To address the challenges of climate change and support New Mexico's long-term reforestation efforts, this research focuses on building climate-resilient forests by identifying genetic traits that enhance tree survival, growth, and adaptability, ensuring the sustainability of vital ecosystems.

Impacts: The findings from this research are actively guiding, and will continue to guide, land managers across the western U.S. in developing reforestation strategies that enhance seedling survival and growth.

Funding Acknowledgement: McIntire-Stennis

Evaluating Resource Competition of Live Oak Forest Restoration Regeneration to Support Maritime Forest Restoration

Investigators: Dr. Owen Burney (oburney@nmsu.edu) (PI), and Dr. Douglass Jacobs (Co-PI)

Project Overview: Maritime forests, vital coastal ecosystems, stabilize shorelines, recharge aquifers, and buffer storm surges. Their decline, driven by urbanization, agriculture, climate change, and the spread of native loblolly pine (*Pinus taeda*), threatens these benefits. Restoration efforts focus on re-establishing southern live oak (*Quercus virginiana*) as the dominant canopy species, though research on its cultivation in such settings is limited. In a former loblolly pine plantation, we tested the effects of planting density (1–3 m), mulch, and fertilizer on live oak seedling growth over four seasons. Fertilizer boosted diameter early on, while mulch improved height, diameter, and crown width in later years. Planting density showed no consistent impact at this time. These findings highlight the value of mulch and fertilizer in restoration and suggest continued monitoring of planting density to guide future strategies.

Meeting the Needs of New Mexico: This research expands the visibility of NMSU and the JTH FRC in Mora. As a result, national and global recognition as being forest restoration experts will provide added value to all forest restoration efforts conducted in New Mexico.

Impacts: As the only programs focusing on maritime forest restoration research, these research findings are actively guiding, and will continue to guide, land managers within the southeastern region.

Funding Acknowledgement: St Simons Land Trust; McIntire-Stennis

State of Hawai'i Nursery Assessment

Investigators: Dr. Owen Burney (oburney@nmsu.edu) (PI), and Dr. Douglass Jacobs (Co-PI)

Project Overview: This project aimed to survey Hawaii's state-managed forest tree seedling nurseries and recommend strategies for potential expansion to meet future demand. We identified 12 nurseries across four islands and used pre-visit and on-site surveys to assess production capacity, species grown, seed protocols, propagation methods, quality control, sanitation, revenue, and customer interactions. We also consulted reforestation partners to evaluate current and future seedling needs. Private nurseries supply most seedlings (~300,000–500,000 annually), while state nurseries produce about 110,000 (22–37%). Future demand will exceed current capacity, but expansion is limited by gaps in seed protocols and nursery production. We propose three options for nursery improvements, varying by resource availability, and recommend consolidating state nurseries to one per island, appointing a DOFAW Nursery Director, and establishing a comprehensive seed banking program. Options 1 and 2 include new greenhouse facilities, while Option 3 focuses on upgrading existing structures.

Meeting the Needs of New Mexico: This research expands the visibility of NMSU and the JTH FRC in Mora. As a result, national and global recognition as being forest restoration experts will provide added value to all forest restoration efforts conducted in New Mexico.

Impacts: The findings from this project are actively guiding and will continue to guide nursery and land managers across the state of Hawai'i. This leads to enhanced forest restoration in a highly distinctive and fragile ecosystem.

Funding Acknowledgement: State of Hawai'i (Division of Forestry and Wildlife), USDA Forest Service

By the Numbers

Research Publications

- Dixit A, Burney OT (2024) Nursery cultural practices influence morphological and physiological aspen seedling traits: implications for post-fire restoration. *Canadian Journal of Forest Research*, doi.org/10.1139/cjfr-2024-0031
- Ghimire R, Arayal DR, Hanan NP, Boufous S, Burney OT, Idouw OJ, Geli HME, Hurd B, Prihodko L (2024) Carbon sequestration through sustainable land management practices in arid and semiarid regions: Insights from New Mexico. *Agrosystems, Geosciences, and Environment*, doi.org/10.1002/agg2.70019
- Innusa BN, Burney OT, Jacobs DF (2024) Response of live oak regeneration to planting density, fertilizer, and mulch. *Forests*, doi.org/10.3390/f15091594
- MS Thesis "Assessing combinations of nucleation size and planting density to improve survival and performance of planted Ponderosa pine seedlings" – Dilshad Sifullah (May 2024)
- Yocom LL, Kreider MR, Burney OT, Parson T, Choi RT, Liese EK, Mock KE (2025) Experiments to enhance post-fire aspen seedling survival and growth. *New Forests*. Accepted.

Outreach Activities

Regenerating Forests, Rebuilding Community – Dr. Owen Burney, the JTH Forestry Research Center staff, and State Forester Laura McCarthy hosted a public event with USDA Deputy Secretary Xochitl Torres Small to recognize the second anniversary of the Hermit's Peak Calf Canyon fire and look towards the future of forest regeneration through funding the New Mexico Reforestation Center. (April 16, 2024)

Field Day – The JTH Forestry Research Center held a field day for the public to discuss the importance of the reforestation pipeline. New Mexico Highlands University and the University of New Mexico provided support to the exhibits and discussion (September 12, 2024)

Southwest Reforestation Partnership – Dr. Owen Burney, in collaboration with the Colorado Forest Restoration Institute, New Mexico Highlands University, and American Forests is developing a "partnership" for reforestation efforts across the Four Corner states. An initial meeting to discuss the SWRP was held on June 20, 2024. In attendance were State Foresters from the 4 states, Regional Forest Service leadership, universities, private land managers, Tribal leaders, and other interested parties. The mission of the Southwest Reforestation Partnership is to support current and future reforestation needs in Arizona, Colorado, New Mexico, and Utah by building cross boundary partnerships to exchange information, technology, and expertise in support of the development of critical capacity, research, and infrastructure.

Hermit's Peak Planting – In October 2024, over 5,000 seedlings were planted on the Hermit's Peak / Calf Canyon Fire footprint at Johnson Mesa near Las Vegas, New Mexico. The Ancestral Lands Conservation Corps, including Hopi and Acoma tribal members, played a crucial role in this planting effort. This effort was led by Dr. Owen Burney, the JTH Forestry Research Center staff, and collaboration with University of New Mexico researcher.

People

Cooperators and Collaborators

Other Universities

- New Mexico Highlands University
- Utah State University
- Colorado State University
- Purdue University
- Northern Arizona University
- University of New Mexico
- University of Hawai'i
- University of Alberta

State of New Mexico

- New Mexico Forest and Watershed Restoration Institute
- State Forestry Division, New Mexico EMNRD

Federal Agencies

- National Park Service
- US Forest Service
- US Geological Survey

Non-government Organizations

- Institute of Applied Ecology
- Philmont Scout Ranch – Boy Scouts of America
- The Nature Conservancy
- International Union of Forest Research Organizations

Tribal

- Santa Clara Pueblo
- Jemez Pueblo

Industry/Private

- Imerys Minerals

Advisory Committee

- Owen Burney, New Mexico State University
- Josh Sloan, New Mexico Highlands University
- Alan Barton, NM Forest & Watershed Restoration Institute
- Matt Piccarello, The Nature Conservancy
- Linda Nagel, Utah State University
- Lindsay Quam, NM State Forestry Division
- Daniel Denipah, Santa Clara Pueblo
- Jim Youtz, USDA Forest Service
- Eytan Krasilovsky, Forest Stewards Guild

Graduate Students

- Grace Ganter – Colorado State University, MS
- Dillon Alexander - New Mexico Highlands University, MS
- Alex Britz - University of Alberta, MS
- Dilshad Safiullah – New Mexico Highlands University, MS
- Brianne Innusa – Purdue University, MS

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Tammy Parsons, Nursery Manager

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Josh Trujillo, Ag Science Center Laborer

Donna Ebler, Fiscal Assistant

Marisol Martinez, Student Intern

Isabella Martinez, Student Intern