2017 Annual Report

John T. Harrington Forestry Research Center
New Mexico State University
Mora, NM

prepared by: Owen Burney, Assistant Professor and Superintendent

2017 Staff, John T. Harrington Forestry Research Center:

- Owen Burney, *Assistant Professor and Superintendent*
- Tammy Parsons, *Nursery Manager*
- Carmen Rose, *Laboratory Coordinator*
- Josh Trujillo, *Senior Nursery Laborer*
- Lorenzo Gallegos, *Senior Farm Laborer*
- Donna Ebler (on-campus), *Senior Fiscal Assistant*

Partners and Collaborators:

- New Mexico Highlands University
- 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

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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.

In the spring of 2017, A Memorandum of Understanding (MOU) was established between the Department of Natural Resources Management (NRM) with New Mexico Highlands University (NMHU) and the JTH FRC with NMSU. An element of the MOU is to promote activities of collaboration between the Participants in order to strengthen forestry research. As a first step in our collaborative efforts, both programs established a collaborative Forestry Research Lab located at the NMHU campus in October 2017. The Forestry Research Lab will support both current and future research projects that are lead by the JTH FRC and/or faculty with NRM. Additionally, this lab will serve as an educational platform for both classroom activities as well as research opportunities for both undergraduate and graduate level students at NMHU.

The research center produced three publications during 2017. The topics for the publications were: 1) plant growth in amended molybdenum mine waste rock growth, 2) using plastic beverage bottles as an alternative nursery growing container for reforestation in developing countries, and 3) Species selection – A fundamental silvicultural tool to promote forest regeneration under high animal browsing pressure. In addition to these publications, four new research projects have been implemented during 2017.

External funding generated by the research center for 2017 totaled approximately $326,931. The funds came from multiple sources including: seedling sales for forest conservation, cooperative agreements with the National Park Service, tree improvement grants with the State of New Mexico, and the McIntire-Stennis grant.

With regards to teaching and education, the research center has hosted multiple tours for NMHU students (graduate and undergraduate). Additionally, our program is involved in the research of two master level students at NMSU, Gohkan Ervan and Furkan Atalar.

2. Memorandum of Understanding with NM Highlands University

In the spring of 2017, A Memorandum of Understanding was established between the Department of NRM with NMHU and the JTH FRC with NMSU. The focus of this MOU is for both parties to coordinate efforts and cooperate with special emphasis on:

a. the education of undergraduate and graduate students;
b. the implementation and production of a feeder program or programs from NMHU to PhD programs at NMSU;
c. the utilization of faculty and students for increased research activites/productivity;
d. partnering on and equitably benefiting from grant proposals for research and interdisciplinary projects and programs;
e. providing volunteer, internship, et cetera, programs for undergraduate students;
f. increasing faculty resources and expertise;
g. organizing short-term and long-term training/workshops;
h. sharing credit to assure that appropriate citation and attribution is given for work performed under this MOU; and;
i. other areas of cooperation of mutual interest.

3. Forestry Research Lab

In the fall of 2017, the Forestry Research Lab (FRL) was established as a collaborative program between the Department of NRM with NMHU and the JTH FRC with NMSU. Through continued research, the FRL will work to restore proper ecological function to the forest landscape throughout the southwest. Additionally, the FRL will serve as an educational platform for both classroom activities as well as research opportunities for both undergraduate and graduate level students at NMHU.

4. JTH FRC Advisory Board

The first advisory board meeting for the research center was held in July 2017. However, the role of the board will change in 2018. It was voted that this board would represent three forestry-based programs here in New Mexico: 1) JTH FRC with NMSU; 2) the Department of NRM with NMHU; 3) New Mexico Forest

Watershed Restoration Institute (FWRI). This collaboration among the three institutions has been name the Forest Restoration Triangle (FORT).

FORT collaboration:
The partnership among 1) JTH FRC with NMSU, 2) the Department of Natural Resources Management with NMHU, and 3) New Mexico FWRI will work to restore proper ecological function to the forest landscape in New Mexico and the greater southwestern US.

FORT Board Members:
Kent Reid – NMFWRI
Craig Conley – NMHU
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
Andy Quam – BIA

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.

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 2017, the center produced approximately 235,000 forest tree seedlings for restoration purposes. At a planting density of 300 trees per acre, this equates to approximately 783 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.

Introduction

Planted tree seedlings in arid and semi-arid regions experience harsh site conditions due to drought and disturbances such as wildfire and surface mining. Future climate regimes in these regions are predicted to be warmer and drier on average, further impeding reforestation success using conventional stocktypes. It is therefore critical to develop methods for the production of high quality seedling stocktypes with improved survival and performance after transplanting into these environments. Current and historical nursery practices employ optimal (i.e. non-limiting) growing conditions from germination until lifting for either outplanting or storage. However, these optimal conditions may produce physiological and morphological seedling characteristics that do not match those required for post-transplant survival on harsh sites, resulting in restoration failures on such sites.

Objectives

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.

Research

Containerized aspen and ponderosa pine seedlings were grown under greenhouse conditions, with each species represented by three seed sources collected from latitudinal gradients within their native ranges. Seedlings were exposed to one of three levels of moisture availability (well-watered control, moderate drought, and severe drought) shortly after germination until the end of their first growing season. A portion of the seedlings were assessed for physiological (e.g., photosynthesis, hydraulically active xylem tissue, xylem flow velocity) and morphological (e.g., biomass and root volume) parameters after the first growing season. The remaining seedlings were planted at two field sites and as a greenhouse drought study. This research was sponsored/funded through the McIntire-Stennis Grant, NM

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

Accomplishments

- Developed MOU with Imerys Mining Company regarding mine reclamation and drought conditioned seedlings.
- Presentation at International Union of Forest Research Organizations – Forest Regeneration in Changing Environments; Corvallis, OR.
- Developed methodology for measuring hydraulically active xylem in Populus tremuloides and Pinus ponderosa.
- Planted approximately 4,000 seedlings for reclamation and post-fire restoration research.

b. A seedling-based approach to aspen restoration in the southwestern US.

Introduction

Quaking aspen (*Populus tremuloides*) in the western US is currently impacted by combinations of disturbances (e.g. drought, disease, wildfire, and intense browsing), which are leading to dramatic losses of aspen in many landscapes. Additionally, there are concerns that a significant portion of the population in the southwestern region is triploidy/polyploidy. Polyploidy individuals typically have low seed production and are more prone to drought stress. There is a critical need for silvicultural practices that effectively maintain and restore western aspen. Advantages of seedling-based restoration (in contrast to current coppicing approaches) include the ability to target currently unoccupied but suitable habitat, to use seed sources which may be better adapted to current and future climate conditions, and to dramatically increase the local genetic diversity.

Objectives

The objective of this study is to assess the effectiveness of a planted seedling-based “nucleation” strategy for aspen restoration.

Research

Aspen seed was collected from three sources: Alberta Canada, northern Utah, and northern New Mexico in the Spring 2014. Seedlings were grown in the JTH FRC nursery in Mora, NM. A total of 7,200 seedlings (2,400 per seed source) were planted in 15 exclosures over three sites on Cedar Mountain in

southwestern Utah in the Fall of 2015. Seedling performance and mortality measurements were taken during the first two growing seasons (Summer 2016 and 2017). This research is funded through Utah State University, McIntire-Stennis Grant, and Cedar Mountain Initiative.

Accomplishments

- First successful large-scale outplanting of aspen seedlings in United States.
- Poster at Society of American Foresters National Convention, Madison, WI.

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

Introduction

Recent wildfires in the southwest have burned with uncharacteristic severity and extent within biophysical settings not adapted to such fires. Recovery towards the natural successional pathway is further impeded by a warming climate. Efforts to restore resilience through tree planting have been largely unsuccessful due to the combination of climate, drought, and harsh planting environments associated with severely burned sites. Planting efforts in the southwest on these post-fire sites have reported an average of 25% survival in ponderosa pine. If we define resilience as the ability of a system to return to its successional pathway following disturbance, then the burned areas have seen a decline in resilience.

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.

Research

There are two log treatments (planting on the north side of the log vs. control of no log) and six ponderosa pine seed source treatments (All are NM sources: 2 southern, 2 central, and 2 northern). Seedlings were planted at the Valles Caldera National Park in Fall 2016. Primary measurements include

shoot height, stem diameter, stomatal conductance, plant biomass, and survival. This project was funded by the National Park Service.

Accomplishments

- Poster at Southwest Jemez Mountains Resilient Landscapes, National Park Service, Santa Fe, NM.
- Outplanting success exceeding operational rates in southwestern US.

d. Southwestern white pine blister rust resistance gene conservation.

Introduction

Southwestern white pine (*Pinus strobiformis*), native to the high-elevation forests in the southwestern US, is threatened by a non-native fungus (*Cronartium ribicola*) that causes the disease white pine blister rust. The collection and long-term conservation of resistant genotypes of southwestern white pine to blister rust through clonal propagation and orchard establishment is imperative given the overall fire susceptibility of southwestern forests and the fact that these genotypes exist in relatively localized populations. These collections will serve as a resource for researchers studying resistance of *P. strobiformis* to *C. ribicola* as well as a potential source of seed for seedling propagation and planting throughout the Lincoln National Forest and surrounding areas.

Research

The gene conservation efforts will be accomplished by: 1) identifying new and previously surveyed trees for their resistance to the pathogen and cloning them by grafting them to *P. strobiformis* rootstock propagated from locally collected seed; 2) develop an efficient and effective protocol for grafting *P. strobiformis* to open-pollinated *P. strobiformis* rootstock; and 3) planting grafted clones into an orchard using 3-5 replicates of each grafted clone. This project was funded by the US Forest Service.

Accomplishments

- First successful grafting of southwestern white pine.
- Established first orchard of southwestern white pine with some level of rust resistance.

e. *Pinus ponderosa* provenance test and assisted migration assessment.

Introduction

The 2012 Ponderosa Pine Provenance test is the result of over thirty years of tree improvement research in New Mexico. New Mexico seed sources were identified by the baseline selection method through the NMSU/New Mexico Forestry Division joint tree improvement program. Out-of-state seed sources were collected by cooperators in those regions, or were purchased from commercial seed vendors. Testing this broad range of seed sources will allow for the continuation of superior seedlings for reforestation in New Mexico, and will also yield critical information to the understanding of the species relationship to changing climatic conditions.

Research

Seedlings from 75 sources ranging from southern New Mexico to British Columbia, Canada were planted in the fall of 2012. Measurements have been taken on seedling morphological and phenological responses by seed source. Long-term measurements are required to properly model the effects of climatic change on survival, growth, and physiological parameters. This project was funded through NM EMNRD.

Accomplishments

Establishment of long-term provenance test and assisted migration study. Completed the establishment phase allowing for physiological and morphological measurements in response to natural climatic conditions.

f. Maritime forest restoration on the Southern Atlantic Coast.

Introduction

The maritime forest is a keystone ecosystem that supports numerous threatened and endangered species along the United States' Southern Atlantic Coast. Live oak trees dominate this ecosystem and stabilize coastal soil, provide roosting for migratory birds, and perform other important ecological functions. Since human settlement of the eastern barrier islands, live oak forests have been clear-cut to make way for agricultural, residential, and commercial development. This once-dominant and deeply important ecosystem has been significantly depleted and degraded to its current

fractional state. This situation is not sustainable and demands serious investments by land managers and conservation programs in the restoration of maritime forest ecosystems. Despite the importance of maritime forest ecosystems and the general agreement that restoration practices are required, there is a surprising dearth of research on the most effective methods of live oak regeneration. This lack of knowledge prevents forest and conservation managers from prescribing silvicultural management activities that will lead to maritime forest restoration success.

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.

Accomplishments

- First successful live oak restoration planting in United States.

g. Defining seed transfer guidelines and planting strategies for ponderosa pine (*Pinus ponderosa*) to aid in post-fire recovery in the Jemez Mountains.

Introduction

The successful natural establishment of conifer seedlings in the southwestern United States is often hindered by harsh site conditions related to drought and severe disturbances such as wildfire. Additionally, future climate changes are predicted to be warmer and drier further complicating the potential for natural forest regeneration.

Tree planting efforts on adjacent National Forest Service lands have been largely unsuccessful due to the combination of climate warming and the impacts of severe burning, with some efforts reporting less than 5 percent survival in ponderosa pine. By conducting experimental plantings of ponderosa and Douglas fire, this project will assess seed sources from a range of ecotypes for use in restoration via reforestation of severely burned areas within Bandelier National Monument. More specifically, seedling performance (i.e., survival, growth, physiological responses) will be measured through the comparison of seed source ecotypes. The results will help park managers better understand potential forest restoration strategies

and will provide future seed sources by re-establishing genetically appropriate trees in areas influenced by high severity fires and floods.

Objectives
The objectives of this study are to improve the resilience of once-forested areas under warming and drying climate by planting tree species that are within the natural range of variability for the biophysical setting of Bandelier National Monument, but may be better suited to the warmer drier site; and to conduct research that will inform future restoration projects in post-burned areas.

Accomplishments
- Building map layers based on climatic, soil, and vegetation characteristics to define the ecotypes for seed collection.

7. Peer Reviewed Journal Articles

Accepted or Published

a. Burney OT, Jacobs DF (2018) Species selection - A fundamental silvicultural tool to promote forest regeneration under high animal browsing pressure. *Forest Ecology and Management* 408: 67-74. (accepted in Dec 2017)

Abstract: Heavily disturbed post-mining sites are often difficult to restore to forestland due to chemical and physical soil limitations, as well as frequent animal herbivory of planted tree seedlings. Forest tree species differ in how they allocate resources to defensive compounds or growth in order to resist abiotic and biotic stresses after outplanting. However, the influences of plant nutrition and secondary metabolite production on browse susceptibility and recovery are not well understood within and among species, especially for temperate deciduous forest trees. We investigated foliar tannin and nutrient responses under fenced (to exclude white-tailed deer, *Odocoileus virginianus*) and non-fenced environments on an abandoned mine land in southwestern Indiana, USA. Using field fertilization (15N-9P-10K controlled-release fertilizer at 0, 30 g, and 60 g per seedling), we also created a gradient of nutrient availability for planted black cherry (*Prunus serotina* Ehrh.), bur oak (*Quercus macrocarpa* Michx.), northern red oak (*Quercus rubra* L.), and

white oak (*Quercus alba* L.) seedlings. Fencing improved growth relative to non-fenced seedlings; fertilization improved growth for all species except northern red oak, but only when combined with fencing. Fertilization reduced foliar tannin concentrations for black cherry and white oak, but did not change browsing preference or browse recovery for any species. Without fencing, browsing selection was solely driven by tree species, whereby black cherry had a higher likelihood of being browsed compared to all oak species. This response was likely associated with differences among species in resource allocation patterns; black cherry prioritizes structural growth and recovery, while oaks allocate resources to both growth and secondary metabolite production. As fencing is often considered cost-prohibitive for mine reclamation and other restoration efforts, species selection is perhaps the most fundamental silvicultural tool to promote forest regeneration success under conditions of high animal browsing pressure.

b. Khurram S, Burney OT, Morrissey RC, Jacobs DF (2017) Bottles to trees: plastic beverage bottles as an alternative nursery growing container for reforestation in developing countries. *Plos One* 12(5):e0177904.

Abstract: Reforestation is needed globally to help restore degraded sites, combat desertification, protect watersheds, and provide forest products. This involves planting forest tree seedlings grown in local nurseries, but technologies to produce quality seedlings are lacking in developing countries. Modern nursery containers used to propagate seedlings have internal-surface barriers (ribs or ridges) or side-slits to prevent root spiraling. These are cost prohibitive or unavailable in developing countries and so polybags (plastic bags) are more commonly used, despite their tendency to produce seedlings with deformed root systems that have less potential to establish on field sites. Discarded plastic bottles, which are readily available worldwide, may be a feasible alternative for seedling propagation. We conducted two experiments to assess the potential of repurposed plastic beverage bottles to grow quality trees: 1) Container Comparison – to evaluate Arizona walnut (*Juglans major* [Toor.] Heller) and Afghan pine (*Pinus eldarica* Medw.) seedling root and shoot development in two plastic bottle types compared to modern nursery containers and polybags, and 2) Bottle Modification – to examine the effects of root spiraling prevention

techniques (side-slits, internal-ridges, and control) and container opacity (green, black, and clear) on Afghan pine seedling morphological attributes. Nursery growth and first-year seedling field performance were evaluated for both experiments. In experiment one, seedlings of both species had fewer spiraled roots in bottle containers compared to polybags. Arizona walnut had more fibrous root systems in polybags, while Afghan pine root system fibrosity was greatest in bottle containers. First-year field performance of both species was not affected by container type. In experiment two, less spiraled roots occurred in containers with air-slits and interior-ridges compared to the control. The effects of container opacity on seedling morphology were inconsistent. Root spiral prevention and opacity had no significant influence on Afghan pine one-year survival, field height and diameter, with the exception of opacity for height growth, whereby seedlings grown in green containers were taller than those grown in black containers, but seedlings grown in clear containers were similar to both. Our results provide the first evidence that plastic bottle containers may provide an effective alternative for the production of high quality seedlings, which may be of particular benefit to agroforestry, reforestation, restoration, and conservation programs in developing countries.

c. Burney OT, Redente EF, Lambert CE (2017) Plant growth in amended molybdenum mine waste rock. *Environmental Science and Pollution Research* 24(12): 11215-11227.

Abstract: This greenhouse study examined the use of organic and inorganic soil amendments in waste rock material from the former Questa Molybdenum Mine in northern New Mexico to promote beneficial soil properties. Waste rock material was amended with 11 soil amendment treatments, that included municipal composted biosolids, Biosol®, inorganic fertilizer, and two controls (pure waste rock and sand). *Elymus trachycaulus* and *Robinia neomexicana* growth performance and plant chemistry were assessed across all treatments over a period of 99 days and 141 days, respectively. Even though waste rock material had more than 200 times the molybdenum concentration of native soils, adverse effects were not observed for either species. The two main limiting factors in this study were soil nutritional status and soil water retention. The biosolid amendment was found to provide the greatest buffer against these limiting factors due to

significant increases in both nutrition and soil water retention. As a result, both species responded with the highest levels of biomass production and the least amount of required water demands. Use of organic amendments such as biosolids, even though short lived in the soil, may provide plants the necessary growth stimulus to become more resilient to the harsh conditions found on many mine reclamation sites.

8. Presentations and Posters

Presentations

a. Burney OT (Presenter), Sloan JL, Pinto JR, "Drought-conditioning during nursery production influences physiology and resource allocation of *Populus tremuloides* and *Pinus ponderosa* seedlings", Conference on Forest Regeneration in Changing Environments, International Union of Forest Research Organizations, Corvallis, OR. (July 12, 2017)

b. Burney OT (Presenter), Sloan JL, Pinto JR, "Nursery conditioning seedlings for improved dry site performance", 3rd Restoring Forest Congress: Regeneration and ecosystem functions for the future, International Union of Forest Research Organizations, Lund Sweden. (September 12, 2017)

c. Burney OT (Presenter), "Assisted Migration – A Southwestern US Perspective", Western Forestry and Conservation Nursery Association and the Pacific Northwest Reforestation Council, Corvallis, OR. (October 12, 2017)

d. Howe AA (Presenter), Landhäusser SM, Burney OT, Violett RD, Mock KE, "A seedling-based approach to aspen restoration", Conference on High Altitude Restoration, Society of Ecological Restoration, Ft. Collins, CO. (March 7, 2017)

Posters

a. Burney OT, Sloan JL, "Defining seed transfer guidelines for *Pinus ponderosa* in a changing climate: Valles Caldera National Preserve", Resilient Landscapes National Park Service, Santa Fe, NM. (April 13, 2017)

b. Thyroff EC, Burney OT, Jacobs DF, “Restoration of maritime forests: evaluating limiting factors of *Quercus virginiana* regeneration”, International Union of Forest Research Organizations, Lund, Sweden. (September 12, 2017)

9. Funding for 2017

Our receipt of external funding for 2017 was approximately $326,931. The sales account has generated enough funds to help support the overall deficit for the AES program with a tax of approximately $20,000.

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

b. Burney OT (Principal), "Tree Improvement and Forestation Plan", Sponsoring Organization: NM Energy, Minerals, and Natural Resources Department; PI Total Award: $8,000

c. Burney, O. (Principal), "Seedling Conservation for EMNRD Forestry Division", Sponsoring Organization: NM Energy, Minerals, and Natural Resources Department; PI Total Award: $47,760

d. Burney OT (Principal). “Seedling Conservation”,
Sponsoring Organization: Santa Clara Pueblo; Total Amount: $199,163

e. Burney OT (Principal). “McIntire Stennis”,
Sponsoring Organization: USFS; Total Amount: $30,000

10. Students

a. Gokhan Ervan (MS), New Mexico State University, “Evaluation of drought conditioned *Pinus ponderosa* seedlings after the nursery growth phase”. Advisor: Dr. Owen Burney

b. Furkan Atalar (MS), New Mexico State University, “Rainfall simulation on thinned and burned forests in New Mexico”. Advisor: Dr. Alexander “Sam” Fernald

c. Emily Thyroff (MS), Purdue University, “Maritime forest restoration along the southern Atlantic coast”. Advisor: Dr. Doug Jacobs

d. Alex Howe (MS), Utah State University, “Developing seedling-based restoration strategies for western aspen”. Advisor: Dr. Karen Mock

e. Ben Wright (MF), Oregon State University, “Siberian Elm in Northern New Mexico”. Advisor: Paul Ries

11. Field Tours at JTH FRC

a. New Mexico Highlands University. Forestry Field Practice FOR 200. Audience: students/faculty, 15 participants. (August 2017)

b. Bandelier National Monument. Fire Ecology Group. Audience: staff, 8 participants. (July 2017)

c. Facilitated meeting and tour with the Regional Forester US Forest Service (Region 3) at the JTH FRC to discuss restoration strategies in New Mexico and Arizona. Additionally, we discussed current and future directions in research and collaboration. (March 2017)

12. Average Monthly Precipitation for JTH FRC 2017

Month	Rainfall (in)	Snow (in)
Jan	0.00	11.5
Feb	0.00	1.5
Mar	0.00	0.0
Apr	0.00	6.8
May	0.59	0.0
Jun	1.58	0.0
Jul	3.66	0.0
Aug	3.92	0.0
Sep	6.26	0.0
Oct	0.55	0.0
Nov	0.00	0.0
Dec	0.00	1.5
TOTAL	16.56	21.3

* Temperature sensor malfunctioned for most of 2017. NMSU Climate Center installed new sensor late October 2017