Southwest Reforestation Pipeline Workshop Summary

Reforestation is a critical part of forest recovery following wildfire in Southwestern U.S. landscapes. While reforestation is a critical management tool, it is a complicated process that has numerous steps. Staff from the USDA Southwest Climate Hub, American Forests, Colorado Forest Restoration Institute, New Mexico Highlands University, New Mexico Reforestation Center, and USDA Forest Service Reforestation, Genetics, and Nurseries Resources group convened a virtual workshop on April 2, 2025, to provide an overview of the reforestation pipeline and critical reforestation resources to address these complications. Participants attended from over 25 different organization across managing agencies, research, and other interested and invested parties (Figure 1).

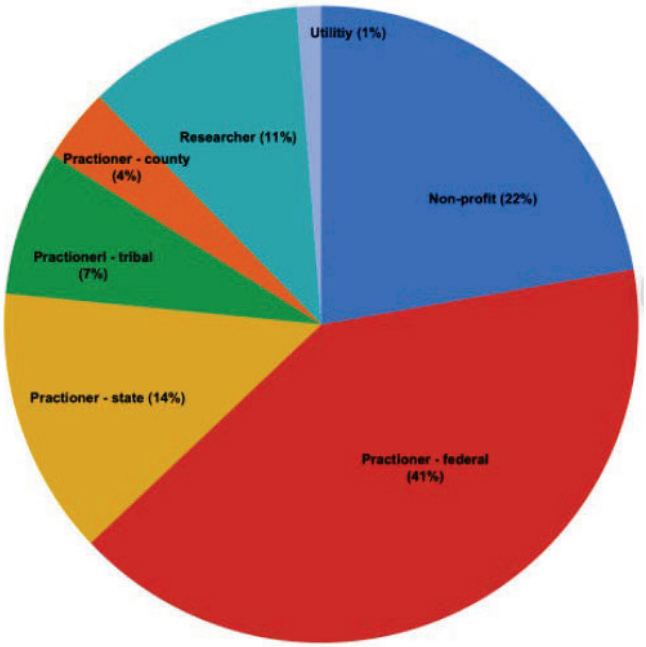

Figure 1: Pie chart displaying workshop attendees. Examples of organizations/agencies/Tribes in attendance from across Southwestern states included: federal and state forest managers; nonprofit organizations (e.g., The Nature Conservancy, Trees Water People, and numerous watershed coalitions); Tribes (e.g., Pueblo of Jemez and Santa Clara Pueblo); and research organizations (e.g., Southwest Ecological Restoration Institutes and numerous university representatives).

Goals and Objectives of the Workshop

This workshop aimed to enhance reforestation efforts in Southwestern U.S. forests by:

1. Providing scientific knowledge and practical experiences that inform management strategies along the reforestation pipeline.
2. Engaging with a diverse audience to learn about the needs and experiences of those across the region to develop future trainings and a more robust Southwestern reforestation network.

Workshop Summary

This workshop summary provides an overview of the major themes of the reforestation pipeline (Fargione et al., 2021; Figure 2) focused on the Southwestern U.S. geography and unique needs covered by presenters and concludes with overarching needs and next steps identified by workshop planners and participants.

Seed

Presentation by Dr. Joshua Sloan, New Mexico Highlands University, New Mexico Reforestation Center. Presentation recording: https://rngr.net/resources/webinars/reforestation-pipeline-virtual-workshop/seed

Sustainable forestry depends on effective and predictable regeneration, and regeneration for most conifers relies on seed. Thus, seed inventory management should be incorporated into forest management planning at both a tactical and strategic level, and across both temporal and spatial scales to meet reforestation needs. Artificial regeneration must be designed to succeed under both current and future projected climate conditions. When considering seeds, flexibility, opportunism, and adaptive management are the keys to success. The seed supply chain involves a wide range of entities, including foresters, scouts and monitoring personnel, cone collectors and tree climbers, transport personnel, extractories, seed banks, seed labs, nursery managers, and finance personnel.

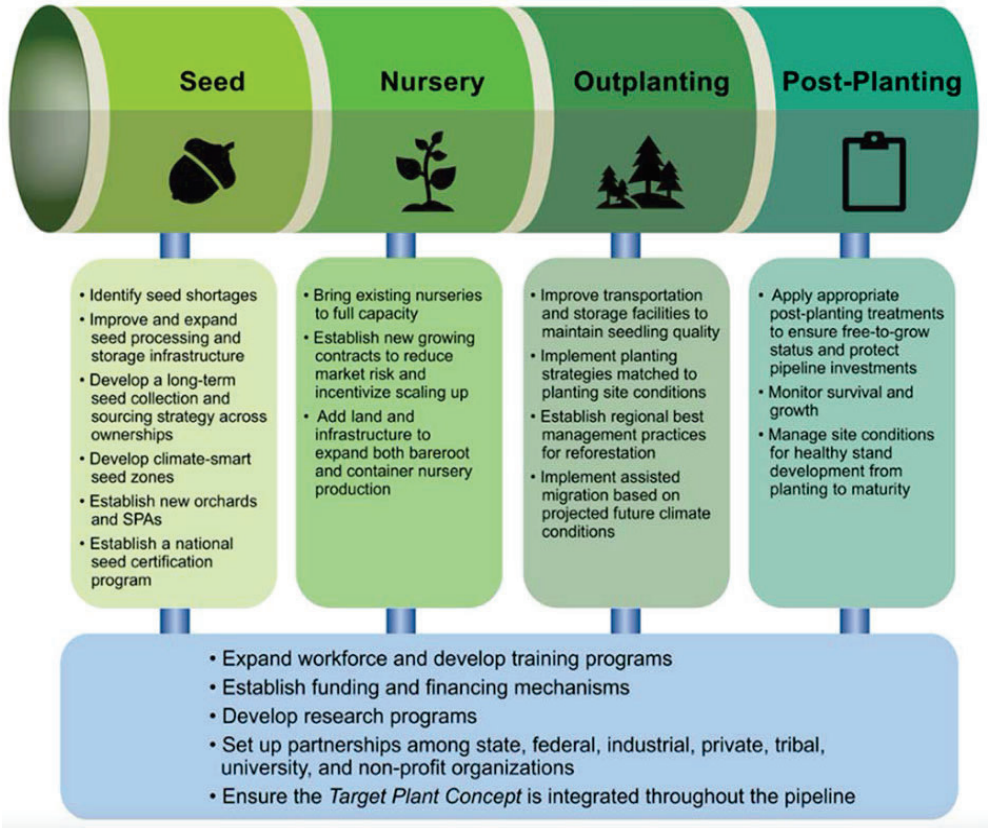

Figure 2: The reforestation pipeline provides a framework of reforestation supply chains, connectivity, and bottlenecks across seed collection, nursery production, outplanting, and post-planting activities. This figure from Fargione et al. (2021) serves as the foundation for major components covered by this workshop.

The seed collection process involves numerous steps both in the field and at the extractory, seed bank, and nursery, starting with the identification of seed collection needs. Next, scouting involves determining where the seed crops are via intentional or incidental observations. After scouting identifies potentially viable cone crops, monitoring is vital to understand how the cone crop is developing and ripening, the potential yield of the crop, and the condition of cones (e.g., levels of insect infestation; Figure 3).

This may be formalized as a cone crop survey, although monitoring of a crop must often recur every 1-3 weeks until it is fully ripe and ready for collection. Once monitoring confirms a cone crop is fully mature, crews can collect the crop. Tree climbing is the recommended collection method in most cases. In certain instances, fell and pick collections may also be an option if collections can be aligned sufficiently with felling operations.

Finally, cones must be properly dried, and collected seeds must be extracted, cleaned, tested, stored, and transferred if necessary. To ensure successful seed collection, it's important to consider best practices for working with partners. Sharing information and providing trainings, collaborating on operations, facilitating permitting, dividing labor among partners, and facilitating mutually beneficial seed transfers are key ways to foster collaborative partnerships.

Developing objectives and building capacity for your seed program involves determining what you want and need to accomplish, and to prioritize in what

Figure 3: Examples of cut cones to determine cone condition during the monitoring phase of cone collection. Photo credit: Rachael Foe, American Forests.

order. Objectives should be specific, covering forest cover types, species, seed sources, and elevations of interest.

They should be quantitative, highlighting the number of seed sources, budget, and amounts. They should be time-constrained, highlighting your specific timeline for collection and processing in relation to when the nursery is likely to need a particular seed source to fill a sowing order. Finally, they must be achievable given your available resources. Depending on the nature and scope of the project, other aspects of the objectives may need to be qualified as well.

Nursery Production and Seedling Quality

Presentation by Dr. Jeremiah Pinto, USDA Reforestation, Nurseries, and Genetics Resources. Presentation recording: https://rngr.net/resources/webinars/reforestation-pipeline-virtual-workshop/nursery-production-and-seedling-quality

Seedlings are the building blocks for nearly all healthy forest ecosystems. This is true whether reforestation occurs through natural regeneration or artificial regeneration. Utilizing nursery stock is an effective tool in the management toolbox to meet regeneration needs when natural regeneration is not sufficient. The Target Plant Concept (Dumroese et al., 2016) is a roadmap for designing desired seedlings, where land managers define the desired target plant and work with nursery managers to grow that plant to fit the project objectives. The Target Plant Concept first builds an understanding of the dynamics that contribute toward successful reforestation, then identifies factors on the outplanting site that limit seedling establishment. From this information, plant material is developed for the best chance of outplanting success.

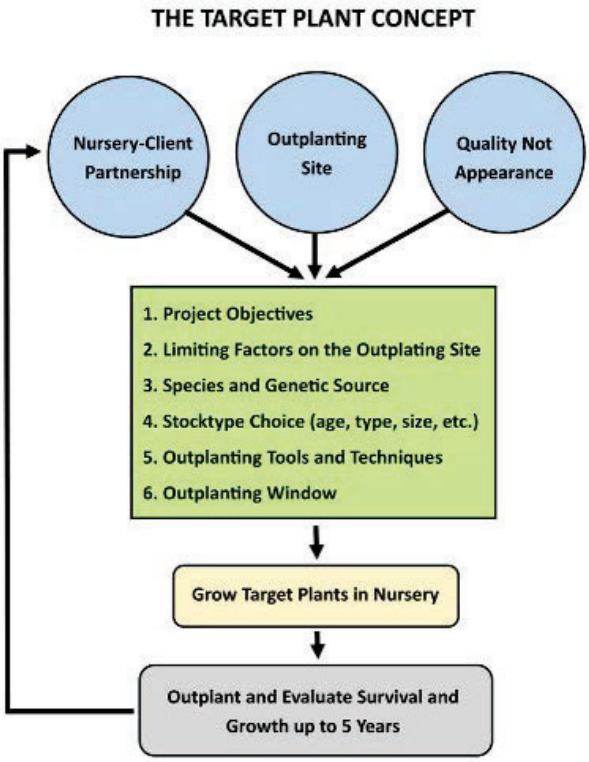

Figure 4: An overview of the Target Plant Concept, created by Dr. Jeremiah Pinto and adapted from Dumroese et al. (2016).

Three key overarching components guide the process to help define the target plant material, which are the nursery-client partnership, the outplanting site, and the seedling quality. Six other interrelated factors related to these overarching components further help to define target plant material. These include: 1) defining project objectives; 2) articulating the limiting factors on the outplanting site; 3) identifying appropriate species and genetic sources; 4) choosing a suitable stocktype; 5) using proper outplanting tools and techniques; and 6) defining the outplanting window (Figure 4).

Seedling stocktype choices vary widely. Recommendations for dry outplanting sites include long root systems, larger root systems, and favorable shoot-to-root ratios. Large seedlings tend to maintain size advantage and are more robust to physical damage. Small seedlings may be a suitable option for mesic sites and are more cost effective.

Quality seedling production requires a variety of skills and knowledge, including plant physiology, genetics, water management, culturing techniques, and more. In particular, timing is a key piece of the nursery production puzzle. It's important to work with a selected nursery to sync up seed planning, nursery production, and seedling delivery to line up with the best outplanting window. Assessing seedling quality should be done throughout the production and outplanting process.

It includes assessing morphological, physiological, and performance attributes. Quality seedlings are the key to successful seedling establishment.

Figure 5: Ponderosa pine seedlings germinating in a nursery. Photo credit: Dr. Jeremiah Pinto, USDA Forest Service.

Outplanting and Post-Planting

Presentation by Dr. Owen Burney, New Mexico State University, New Mexico Reforestation Center. Presentation recording: https://rngr.net/resources/webinars/reforestation-pipeline-virtual-workshop/the-reforestation-pipeline

The outplanting process involves many components. In addition to tree planting, the outplanting timeline also includes planting techniques, animal protection, inspections, numerous rounds of monitoring and data collection, post-planting silvicultural treatments, and the potential need to replant.

Outplanting begins with the initial site evaluation, which occurs both remotely and in the field. Remote assessment involves assessing site characteristics such as native seed sources, climate patterns, soil, vegetation, and additional environmental factors, and may incorporate survival probability models to inform planning. During an on-site initial site evaluation, managers can confirm site characterization including testing soil conditions and gauging access logistics. After assessing site conditions, planning the planting season is an important consideration. In this step, it's important to match the planting window with soil moisture, and work with the nursery on the growing schedule and appropriate stock type. Additional planning factors to determine as part of the outplanting process include planting design and planting logistics, such as a coordinated timeline, handling, transportation, onsite storage, outplanting, and budgeting. Site preparation may also be necessary before planting, whether through mechanical, chemical, or fire means. Because of these wide-ranging logistical needs, it's important to place nursery orders at least a year prior to planting but more than 18 months of notice is ideal. Finally, having a backup plan is vital in case unforeseen circumstances occur throughout the planning process.

Throughout this process, a variety of stressors can impact seedlings, including nursery storage, handling, shipping, onsite storage, and outplanting stresses. Stressors can range from temperature extremes to mechanical injuries. Through all stages of planning and implementation, it is necessary to work with the nursery on a schedule that will reduce stress to seedlings. Once seedlings are at the field site, the ability to control seedling condition is more limited, but it is still important to reduce the impact of temperature, sun exposure, and wind as much as possible.

During planting, selecting favorable microsite conditions can reduce stress at the planting site and increase seedling survival, leading to more successful outplanting outcomes. For example, managers may opt to plant on the north side of nurse objects or incorporate protective barriers (e.g., shelters) against ungulate browsing. In addition, it is important to match the planting tool to site conditions and minimizing soil disturbance when planting to encourage more favorable outcomes. While planting, and in the seasons post-planting, it's important to inspect for common problems related to planting density, microsite conditions, planting quality, and shelter quality. After planting, monitoring after the first growing season, and as often as possible after that, provides useful statistical information to improve the outplanting process in the future.

Knowledge Gaps and Next Steps

Workshop participants identified several knowledge gaps during and after the workshop for reforestation work in the Southwest. Workshop organizers will try to address these knowledge gaps in the future with additional workshops, knowledge summaries or research studies as capacity allows.

General

- Need for more in-person field experience and training
- Apply and adapt reforestation pipeline components for private landowners

- Better incorporate Traditional Ecological Knowledge into all reforestation practices

Seed

- Improve understanding of length of storage for germination by species
- Guidelines for judging when to collect seed and determine maturity
- Translate seed plans into actionable scouting, monitoring, and collection operations to meet current and future reforestation needs
- Improve prediction of cone crops and assessing reproductive buds
- Proper post collection handling and storage
- Contractor selection and contract language
- How to plan thinning and harvests around cone collection operations

Nursery Production and Seedling Quality

- Stock type selection
- Cost analysis of seedling attributes and tradeoffs
- Articulate how nursery culture and production influence seedling quality
- Best practices for seedling hardening
- Best practices for seedling shipping and delivery
- Selecting optimal media
- Nursery communication and coordination

Outplanting and Post-planting

- More information on when and how to implement adaptive management/assisted migration, particularly based on individual agency policies
- Post-planting monitoring techniques - plot design and best practices
- How to utilize volunteer help
- Additional microsite techniques
- Outplanting labor challenges

Tools

- Seedlot selection tool
- Seed scouting application

Figure 6: Developing ponderosa pine cones. Photo credit: Rachael Foe, American Forests.

RESOURCES

- Reforestation Pipeline Virtual Workshop to Improve Operational Outcomes in the Southwestern US (All of the workshop presentation recordings)
- Reforestation, Nurseries, and Genetics Resources website
- Ponderosa Pine Cone and Seed Collection: Frequently Asked Questions and Answers
- Woody Plant Seed Manual
- Nurseries and Seed Extractories
- NMRC x American Forests Seed Scouting App for USFS R3 (2025 version)
- Seedlot Selection Tool
- The Container Tree Nursery Manual, Volume 7: Seeding Processing, Storage, and Outplanting

Citations

Dumroese RK, Landis TD, Pinto JR, Haase D, Wilkinson KW, Davis AS. (2016). Meeting forest restoration challenges: using the Target Plant Concept. Reforesta 1:37-52.

Fargione, J., Haase, D. L., Burney, O. T., Kildisheva, O. A., Edge, G., Cook-Patton, S. C.,... & Guldin, R. W. (2021). Challenges to the reforestation pipeline in the United States. Frontiers in Forests and Global Change, 4, 629198.

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