Considerations for Outplanting Practices in the Western U.S.: An Account of its Past, Present, and Future

Rebecca Downer

Specialist, Biological Research & Development

Gabriel Altieri

Specialist, Biological Research & Development

Matthew Aghai

VP, Research & Development, Mast | General Manager, Silvaseed & Cal Forest Nurseries

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Outplanting in the Western U.S.

Team

Objective

Understanding historical and current practices associated with outplanting practices across the western U.S.

The team empowered to solve these problems:

- 2 x Biological R&D Lead(s) & Project Coordinator(s)
  - Vendor communications
  - Coordinating site visits and project critical discussions (within team and external)
  - Support literature review of outplanting practices
  - Developed tools for analysis of key data metrics from interviews and site visits
- 1x Engineer
  - Supply chain / relationship management
  - Process development

Contact us about contributing to the ongoing research, or just to connect: Matthew@mastreforest.com

Gabriel Altieri

Specialist, Biological Research & Development

E-mail: gabriel.altieri@mastreforest.com

Rebecca Downer

Specialist, Biological Research & Development

E-mail: rebecca.downer@mastreforest.com

John Thomson

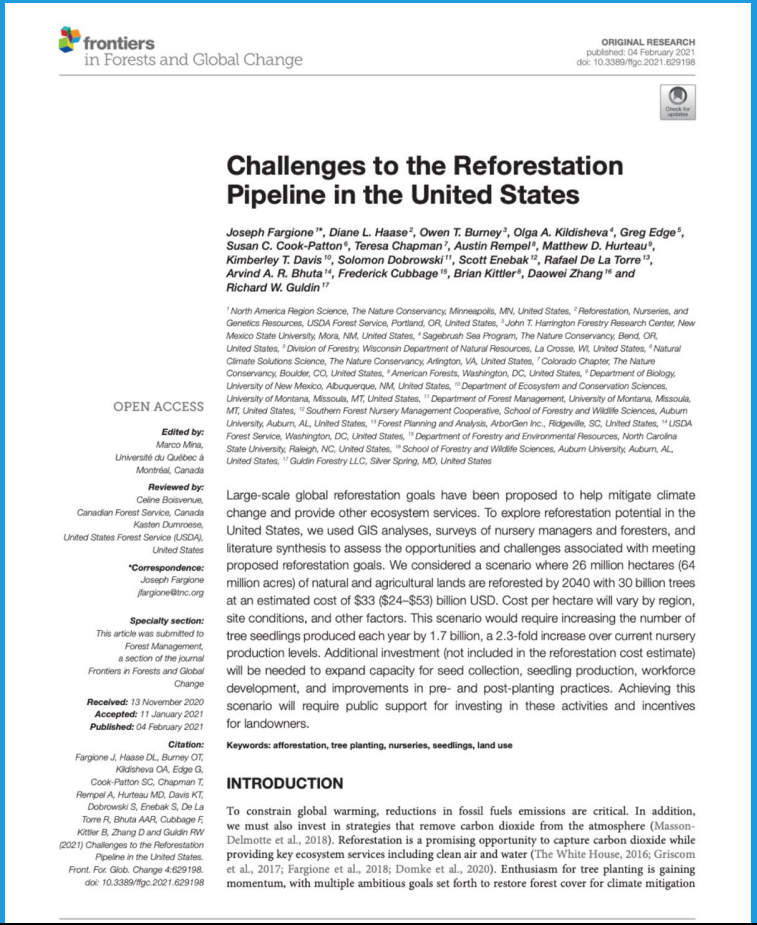
Sr Systems Engineer, Last Mile

E-mail: john@mastreforest.com

Scaling reforestation

Proposed targets

- Trillions of trees!?
- Recent analysis suggested that 64M acres of natural lands have the potential for artificial regeneration investment →
  - Achievement by 2040 will require 30 billion trees to be produced and planted nationally
  - An est. 3B trees per year nationally
- Est. annual production in the Western US is ~200M seedlings - 166M as of 2019
  - Proposed target achieve 7B trees planted by 2040
  - so..400M annually produced and planted?



frontiers in Forests and Global Change

ORIGINAL RESEARCH
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Challenges to the Reforestation Pipeline in the United States

Joseph Fargione[1], Diane L. Haase[2], Owen T. Burney[3], Olga A. Kildisheva[4], Greg Edge[5], Susan C. Cook-Patton[6], Teresa Chapman[7], Austin Rempel[8], Matthew D. Hurteau[9], Kimberley T. Davis[10], Solomon Dobrowski[11], Scott Enebak[12], Rafael De La Torre[13], Arvind A. R. Bhuta[14], Frederick Cubbage[15], Brian Kittler[8], Daowei Zhang[16] and Richard W. Guldin[17]*

[1] North America Region Science, The Nature Conservancy, Minneapolis, MN, United States, [2] Reforestation, Nurseries, and Genetics Resources, USDA Forest Service, Portland, OR, United States, [3] John T. Harrington Forestry Research Center, New Mexico State University, Mora, NM, United States, [4] Sagebrush Sea Program, The Nature Conservancy, Bend, OR, United States, [5] Division of Forestry, Wisconsin Department of Natural Resources, La Crosse, WI, United States, [6] Natural Climate Solutions Science, The Nature Conservancy, Arlington, VA, United States, [7] Colorado Chapter, The Nature Conservancy, Boulder, CO, United States, [8] American Forests, Washington, DC, United States, [9] Department of Biology, University of New Mexico, Albuquerque, NM, United States, [10] Department of Ecosystem and Conservation Sciences, University of Montana, Missoula, MT, United States, [11] Department of Forest Management, University of Montana, Missoula, MT, United States, [12] Southern Forest Nursery Management Cooperative, School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL, United States, [13] Forest Planning and Analysis, ArborGen Inc., Ridgeville, SC, United States, [14] USDA Forest Service, Washington, DC, United States, [15] Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC, United States, [16] School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL, United States, [17] Guldin Forestry LLC, Silver Spring, MD, United States

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Edited by:
Marco Mina,
Université du Québec à Montréal, Canada

Reviewed by:
Celine Boisvenue,
Canadian Forest Service, Canada
Kasten Dumroese,
United States Forest Service (USDA), United States

****Correspondence:***
Joseph Fargione
jfargione@tnc.org

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Large-scale global reforestation goals have been proposed to help mitigate climate change and provide other ecosystem services. To explore reforestation potential in the United States, we used GIS analyses, surveys of nursery managers and foresters, and literature synthesis to assess the opportunities and challenges associated with meeting proposed reforestation goals. We considered a scenario where 26 million hectares (64 million acres) of natural and agricultural lands are reforested by 2040 with 30 billion trees at an estimated cost of $33 ($24–$53) billion USD. Cost per hectare will vary by region, site conditions, and other factors. This scenario would require increasing the number of tree seedlings produced each year by 1.7 billion, a 2.3-fold increase over current nursery production levels. Additional investment (not included in the reforestation cost estimate) will be needed to expand capacity for seed collection, seedling production, workforce development, and improvements in pre- and post-planting practices. Achieving this scenario will require public support for investing in these activities and incentives for landowners.

Keywords: afforestation, tree planting, nurseries, seedlings, land use

INTRODUCTION

To constrain global warming, reductions in fossil fuels emissions are critical. In addition, we must also invest in strategies that remove carbon dioxide from the atmosphere (Masson-Delmotte et al., 2018). Reforestation is a promising opportunity to capture carbon dioxide while providing key ecosystem services including clean air and water (The White House, 2016; Griscom et al., 2017; Fargione et al., 2018; Domke et al., 2020). Enthusiasm for tree planting is gaining momentum, with multiple ambitious goals set forth to restore forest cover for climate mitigation

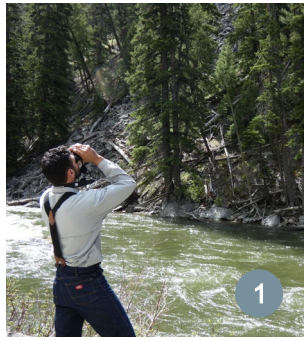
LEARN MORE & SOURCES

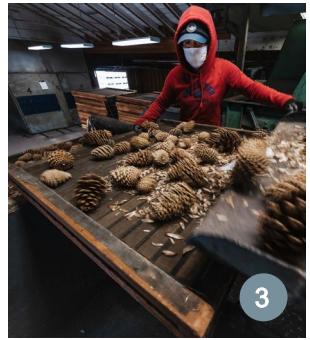
Haase, Diane L., et al. "Forest nursery seedling production in the United States—fiscal year 2018." *Tree Plant. Notes* 62.1/2 (2019): 20-24.

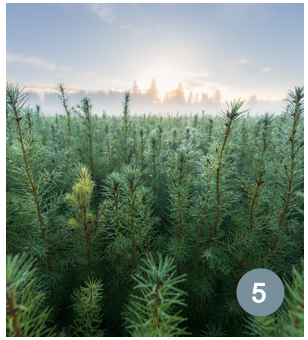
Supply chain

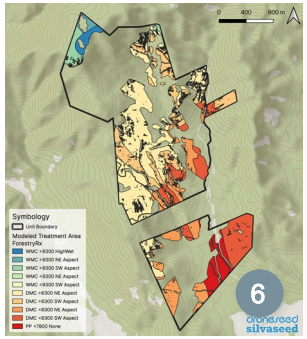
Reforestation pipeline

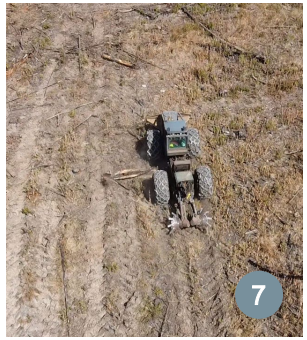
1. Seed planning
2. Seed collection
3. Extractory and lab
4. Nursery planning
5. Seedling production
6. Reforestation Rx
7. Site preparation
8. Seedling packing, cold storage, and transport to site
9. Outplanting











Supply chain

Is the pipeline balanced?

1. Seed planning
2. Seed collection
3. Extractory and lab
4. Nursery planning
5. Seedling production
6. Reforestation Rx
7. Site preparation
8. Seedling packing, cold storage, and transport to site
9. Outplanting
10. Reforestation project success?

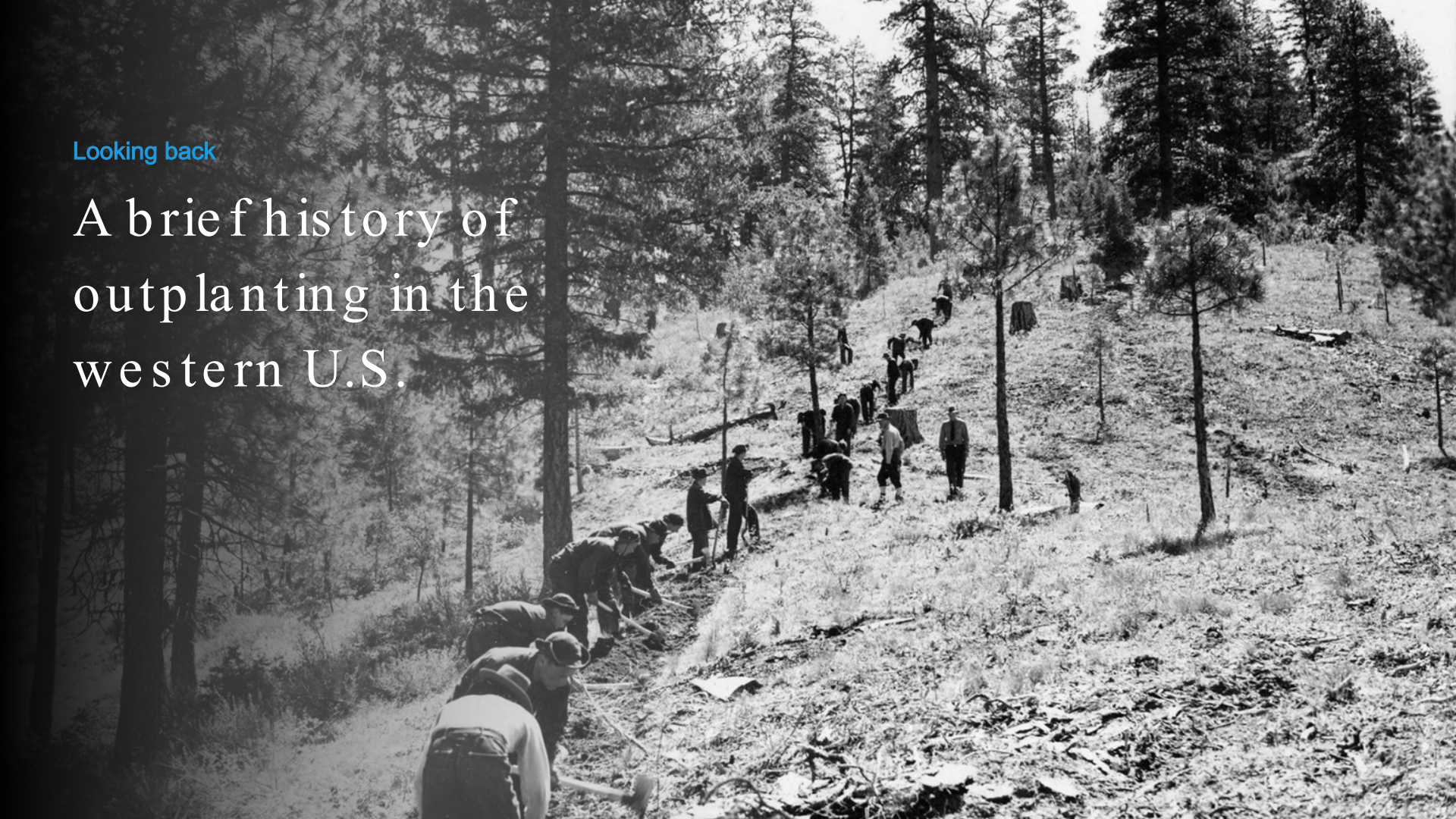
~400M seedlings planted per year in the Western US

- Assess current capacity
- Identify limiting factors
- Set targets for improvement
- Identify areas for innovation

Proposed tree planting goals are not achievable unless we scale our outplanting capacity.

Looking back

A brief history of outplanting in the western U.S.



Past

20th Century origins

- Early 1900's
  - Demand for forest restoration was paramount due to large wildfires, indiscriminate harvesting, and soil erosion endangering watersheds
  - Investment in exploring artificial regeneration as a strategy to compensate for limitations from natural regeneration
- Private nurseries largely serving agricultural or horticultural needs
- Federal government the logical actor to make improvements where industry had no incentive to invest

LEARN MORE & SOURCES

Taylor, W. M. 1948. Natural versus artificial regeneration in Benton County, Oregon. *Oregon State University.* pp. 1-5.

Curtis, R. O.; DeBell, D.S.; Miller, R.E. 2007. Silvicultural research and the evolution of forest practices in the Douglas-fir region. *U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station* . pp. 16-29.

Past

20th Century origins

- The Civilian Conservation Corp was formed in 1933
  - Roosevelt's Emergency Conservation Work Act enlisted unemployed men …"to mitigate the effects of soil erosion and widespread decline of timber resources"...
  - Records suggest they planted 3 billion trees between 1933 and 1942 throughout the US, with 3 million men
- Creation of federal nurseries
  - Including the Wind River Nursery (Washington), Monument Nursery (Colorado), and Savenac Nursery (Montana) in the western United States
  - Many federal facilities were later converted to state facilities and maintained through the later century.

LEARN MORE & SOURCES

Dumroese, R. K., Landis, T. D., Barnett, J. P., & Burch, F. 2005. Forest Service nurseries: 100 years of ecosystem restoration. *Journal of forestry* , pp. 241-247.
US National Archives 95-G-152502

Past

20th Century efforts

- Who were the tree planters of that time?
  - …"unmarried men generally between 18-25 years old who were United States citizens"
  - Reflective of military chain of command and organizational structure
- Incentives
  - Work in a time of need, with transferable skills and discipline to enrich workers for return to civil society
  - A CCC worker's salary was $30-45 a month ($500-800 equivalent today), most of which the men sent home to their families
  - Meals, lodging, clothing, medical, and dental care were all free for enrollees

LEARN MORE & SOURCES

Paige, J. C. 1985. The Civilian Conservation Corps and the National Park Service, 1933-1942: An Administrative History. *National Park Service, US Department of the Interior* . p. 11.
https://www.nps.gov/

Past

20th Century efforts

- How did they accomplish the outplanting?
  - "labor at a minimum cost for materials and equipment"
  - "...strong backs, shovels, and picks, the CCC built roads, trails, culverts, and structures"
  - "..the CCC utilized native materials, such as the local sandstone, which they quarried themselves with star drills, sledge hammers, muscle, and sweat"

LEARN MORE & SOURCES

Paige, J. C. 1985. The Civilian Conservation Corps and the National Park Service, 1933-1942: An Administrative History. *National Park Service, US Department of the Interior* . p. 11.
https://www.nps.gov/

Past

20th Century efforts

- Support infrastructure was critical
  - Camps included a full complement of buildings
  - Primarily: barracks, mess hall, recreational hall, bath house, latrine, supply, garage, and headquarters
  - More developed areas: classrooms, hospital, barber shop, post office, canteen, and sometimes a theater

LEARN MORE & SOURCES

Paige, J. C. 1985. The Civilian Conservation Corps and the National Park Service, 1933-1942: An Administrative History. *National Park Service, US Department of the Interior* . p. 11.
https://www.nps.gov/

Past

20th Century origins

- A few records of private seed and nursery operations in the NW until mid-century (post-war)
  - Weyerhaeuser started a tree nursery in 1938 in Snoqualmie Falls, WA
  - Silvaseed Co was previously Manning Seed Company and was operating cone collection stations and seed extractories in OR and WA since 1870
  - Eventually as Private timber operations (TIMOs, REITs, others) flourished, they supported regeneration and outplanting programs that were both internal and external

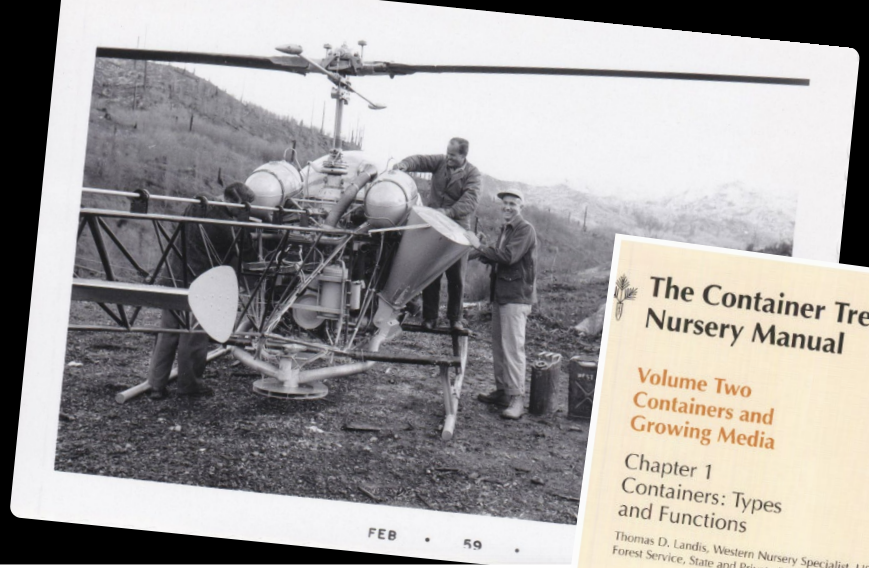
LEARN MORE & SOURCES

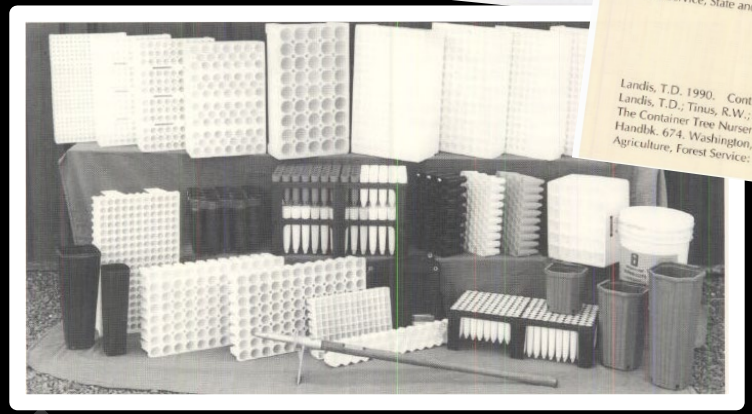
Lewis, R. 1981. Tree Farming: A Voluntary Conservation Program. *Journal of Forest History.* pp. 166-169.
Weyerhaeuser dedicates the nation's first tree farm near Montesano on June 21, 1941

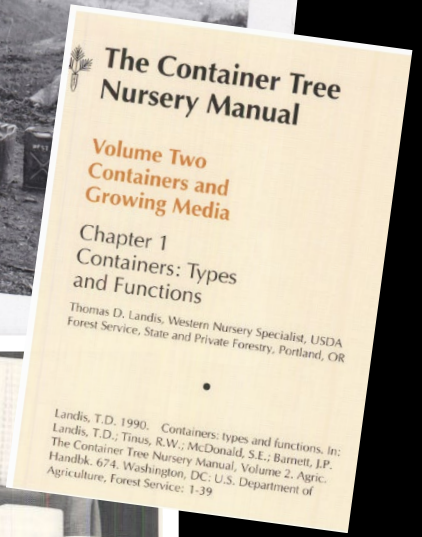
Past

20th Century innovation

- Fast forward through the 1950s-2000
- Myriad research on stocktypes evolved to meet outplanting site conditions and improved timber crop establishment
- Seedling crop science and site prep technology
- Aerial seeding as a rapid response tool
- Standardized products and processes were the means to efficiency: stocktype, tools, spacing, etc.
- Innovation limited by economic incentives
  - Some tool innovations
  - Cold storage or transportation solutions
  - Focus was cost savings and plantation survival
- Shut down extraction of old growth on federal land, impacted rural economies and forestry workforce







LEARN MORE & SOURCES

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Lott, J.R. 1984. Forest Service Equipment Development Reforestation Program. National Nursery Proceedings-1984. p. 21.

Observations

The current state of outplanting practices in the Western U.S.

Macro challenge

Considering capacity

- Current capacity is limited
  - Timber/fiber production relies on an active workforce post-harvest
  - Commodities markets are essential
  - Will the required planting strain the workforce or create more competition over few planting crews?

- Wildfire are increasing in size and intensity
  - Increased urgency for reforestation, need to act quickly before site preparation becomes more expensive
  - Drain of laborers that are supporting firefighting instead of fall planting, or altogether shifting to firefighting for better income
  - Increased backlog of reforested acres

Macro challenge

Considering timelines

- Assuming we want to keep up with forest loss
  - Speed and flexibility are required
  - Nature loves a vacuum
  - Cost of site preparation increases with every year of inactivity

Problem

Considering workforce

- Today, forestry workers in the western US are largely comprised of H-2B guest workers and other immigrant workers from Latin America
- Program is critical..but many drawbacks to H-2B
  - National cap around 66k, with additional allocation of 35k recently
  - Shortage of visas allocated to forestry sector
  - In 2004 - 24,650 available
  - In 2020 - 11,117 available
  - According to Office of Foreign Labor Certification, 82% of forestry labor was accounted for by H-2B visas
- Some landowners have requirements to hire locally (e.g. tribal lands)
- State and federal agencies have more rigid hiring

Macro challenge

Considering incentives & infrastructure

- Professional crews driven by earnings
  - Per tree or per project/acre
  - Hourly wages less common
- "Boutique" planting operations
  - "CCCs," "WCC," "ACE"...Americorp, volunteers, etc.
  - Priorities vary from tree planting to other needs
  - Prison crews, or "adults in custody"
  - Work with low or no incentive to meet volume needs, lack of accountability
  - Switching between other critical needs for land management
  - High turnover/attrition
- Custom supply chains and infrastructure do not exist for accommodating tree planting labor force
- Supply lines need modernization

Problem

Considering logistics

- Materials logistics from the nursery to the site
- Cold storage
- Packing and transport on site are cumbersome
- Mixture of tools and equipment
- Crews create efficiencies
  - Runners with seedlings supplying planters
  - Staging on roads
- Post-planting materials processing
  - Returning to nursery
  - “Recycling”

Problem

Considering strain

- Energy inputs are high
  - A marathon takes ~2,300 – 2,400 kCal, and 1-2x that for tree planting/day
  - Planters carry loads of 40+ lbs and can travel 10+ miles at 60-70% of maximal heart rate
  - “Physical exertion and working efficiency of reforestation workers”
- Work days are long and sustained
  - Start at cooler at 5am, done at 4pm
  - Average 8-14 hours of work
  - 30-45 day sprints per crew
  - Limited breaks due to the nature of work and earning structure

LEARN MORE & SOURCES

Hodges, A. N., & Kennedy, M. D. (2011). Physical exertion and working efficiency of reforestation workers. *Journal of Occupational Medicine and Toxicology* , *6*(1), 1-7.

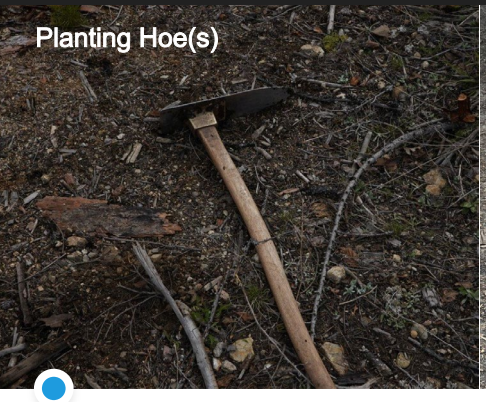
Problem

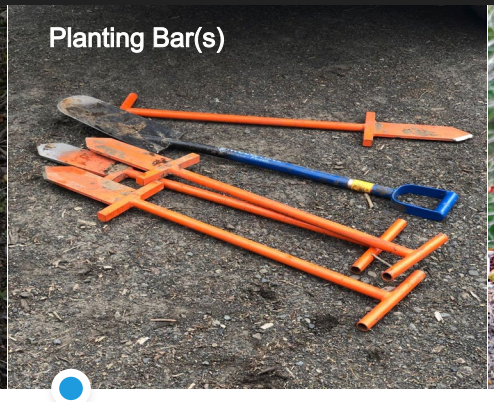
Considering longevity

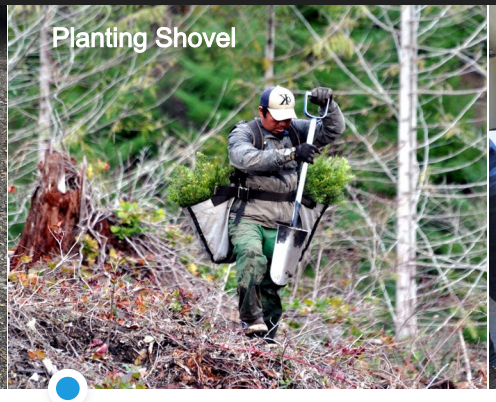
- Injuries, wear and tear…
  - Forestry laborers need to be healthy to earn income
    - Limited support on site for crew
    - Usually no healthcare coverage
  - Repetitive work leads to chronic injuries
  - 35% of all nonfatal workplace injuries were caused due to musculoskeletal disorders (MSDs), of which the Agricultural, Fishery, and Forestry (AFF) industries accounted for the highest rate (0.39% per 10,000)
  - Safety has improved, but the difficulty and danger of terrain and site conditions provide unquantified risks

Granzow, R., Schall Jr, M. C., Smidt, M., Davis, J., Sesek, R., & Gallagher, S. (2019, November). Measuring the effect of tool design on exposure to physical risk factors among novice hand planters. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 63, No. 1, pp. 1013-1017).

Types of outplanting tools







Planting Hoe

Aka: *Hoedad, Rindt hoe, Mattock, Narrow blade hoe/Plughoe, Swedish planting hoe, Wifsta hoe*

Bareroot & Container

3.0 lbs - 7.5 lbs

- Utilized for scalping and creating planting holes
- Lightweight, tough, easy to handle
- Versatile & inexpensive
- Most effective in steep terrain, rocky or clay soils, heavy brush, or slash

Planting Bar

Aka: *OST Bar, KBC Bar, Planting Spear*

Bareroot & Container

8.0 lbs - 10.0 lbs

- Common tool for planting in hard, rocky soils with roots
- Simple, inexpensive & versatile
- Utilized in confined spaces, on steep slopes or rocky ground
- Less fatigue on operators

Planting Shovel

Aka: *Round-point Shovel, Garden Shovel*

Bareroot & Container (Larger Seedlings)

~2.0 - 7.0 lbs

- Produces large planting holes
- Primarily used for seedlings with large root systems
- Easy use for inexperienced planters
- Well suited for planting in areas where high survival rates are crucial
- Most effective in deep, loose soils

Dibble

Aka: *Dibble Bar*

Bareroot & Container (Smaller Seedlings)

~8.0 lbs

- Fastest hand tool
- Creates small holes
- Effective in loose soils

LEARN MORE & SOURCES

USDA Forest Service, Technology and Development. 2013. *Reforestation Toolbox Planting Tools and Techniques.*

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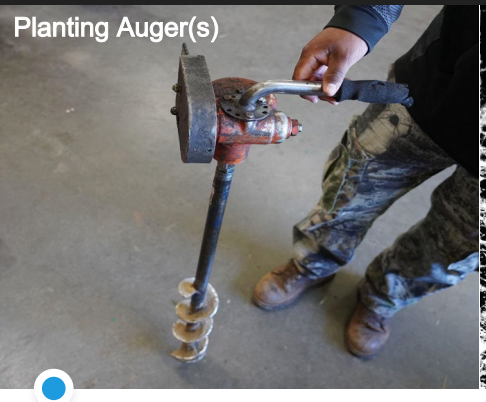
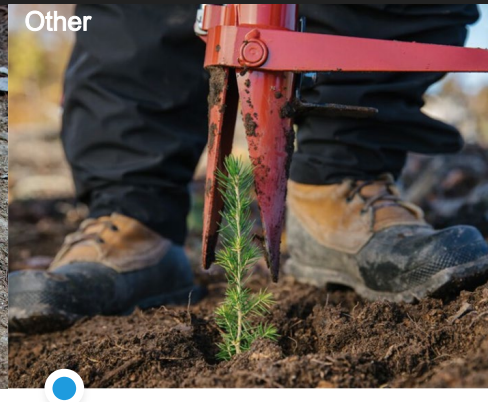
Types of outplanting tools





Auger

Aka: *Hand Auger, Power Auger*

Bareroot & Container (Larger Seedlings)

~7.0 lbs - 14.0 lbs

- Easy to use in confined areas
- Beneficial for cutting thick roots (~⅜ inch)
- Creates holes quickly, consistently, & without compression
- Best for shallow soil, or sites with harsh conditions
- Primarily used in loamy, sandy, or pumice soils

Hammer -Action Planter

Aka: *Hammer -Action Hand Planter*

Bareroot & Container

11.0 lbs - 22.0 lbs

- Designed for rocky soils
- Able to withstand significant wear and tear

Scalper

Aka: *Adze hoe, Duty scalping tool, American eye hoe, Pulaski, McLeod, Pickmattock*

Container (Large)

3.0 lbs - 7.5 lbs

- Removes forest litter and competitive vegetation
- Lightweight and simple to use
- Quick and effective for site preparation in real time

Other

Aka: *Pottiputki, etc.*

Container

~5.5 lbs - 8.0 lbs

- Ergonomic benefits
- Increases planting efficiency and productivity
- Provides better depth and angle precision

LEARN MORE & SOURCES

USDA Forest Service, Technology and Development. 2013. *Reforestation Toolbox Planting Tools and Techniques.*

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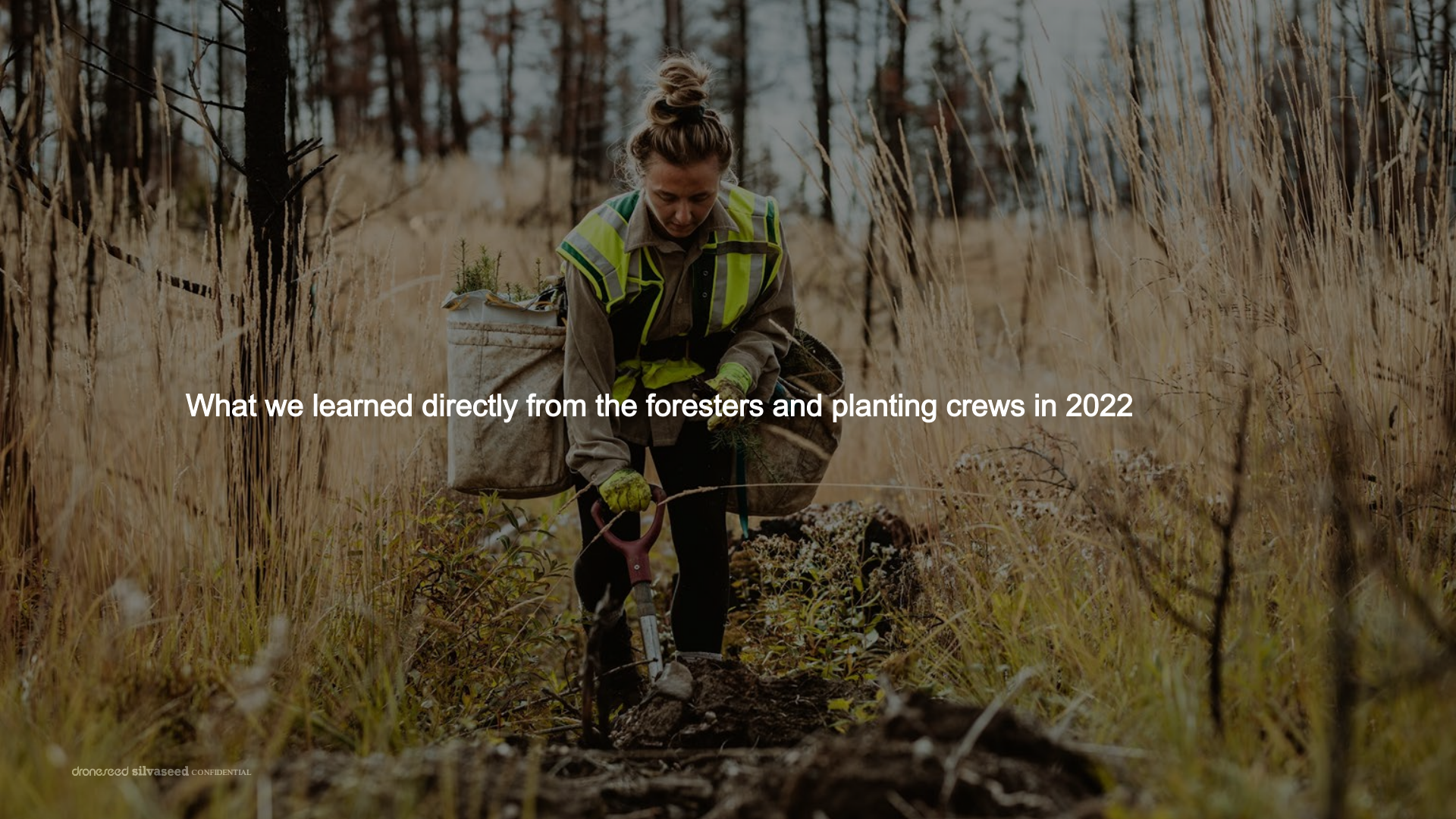


What we learned directly from the foresters and planting crews in 2022

Building an understanding

Methodology

What we wanted to learn

- In person &remote surveys of planting crews across the western U.S. discussing outplanting operations
- Topics included:
    - Project Objectives
    - Species &Stocktype(s)
    - Pre-Planting Logistics
    - Planting Process
    - Overall Satisfaction

Who did we survey?

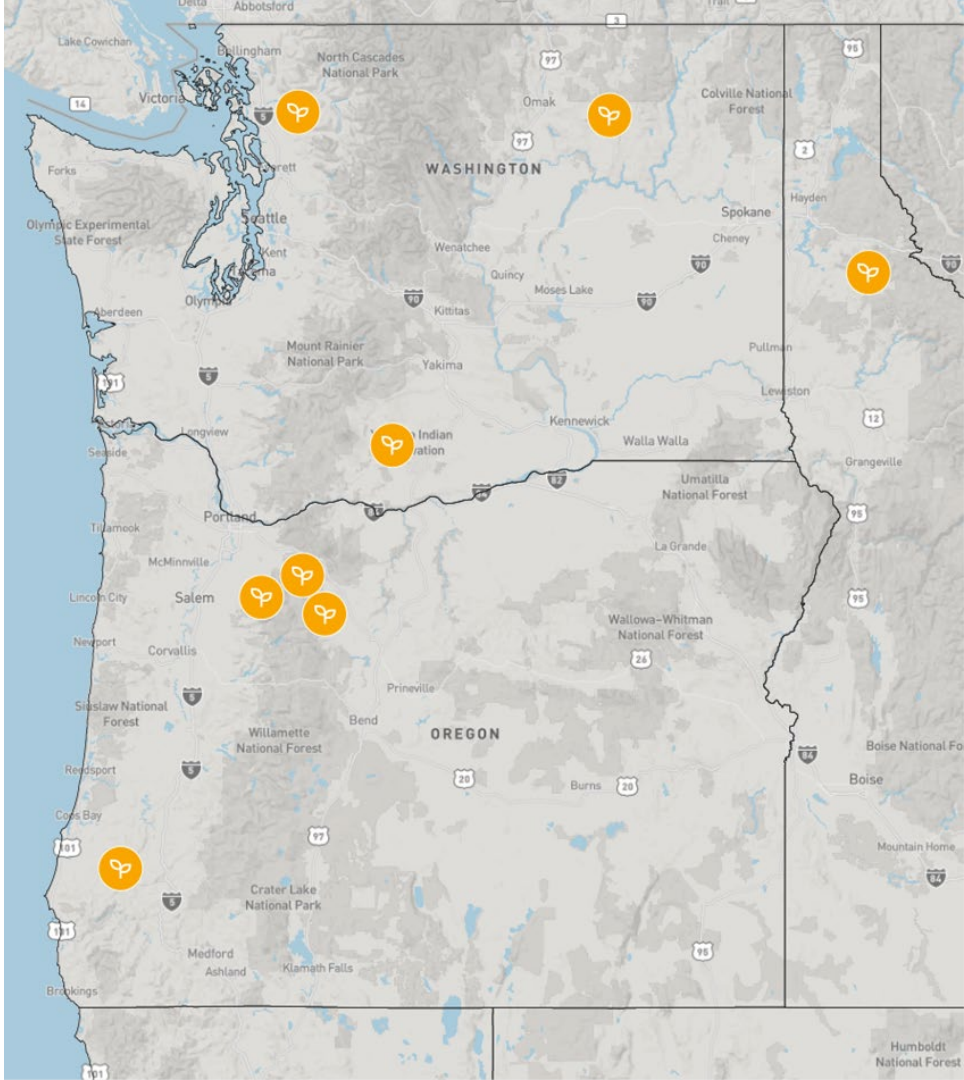
- 9 organizations involved in outplanting operations
    - Federal (3)
    - Private (4)
    - Tribal (2)
    - Washington, Oregon, and Idaho
- Including
    - Foresters
    - Foremen
    - Crew members
- Please reach out if you would like to participate
    - gabriel.altieri@mastreforest.com

Building an understanding

Methodology

Caveats and considerations

- After remote and in-person interviews were completed, follow-up questions were supplied to each organization, resulting in complete datasets from 8 groups.
- Surveys were conducted between March 2022 and August 2022
- Observations geographically constrained to the Pacific Northwest, spring planting efforts
- Note/caveats, seasonality is critical in planning
    - Spring has historically been when seedlings are planted in the PNW, but shifts toward incorporating autumn-based plantings is increasingly common
    - Outplanting seasons is geographically dependent, some states use monsoonal rain patterns, while others have more reliable seasonal moisture



Building an Understanding

The Act of Planting

Observations

1

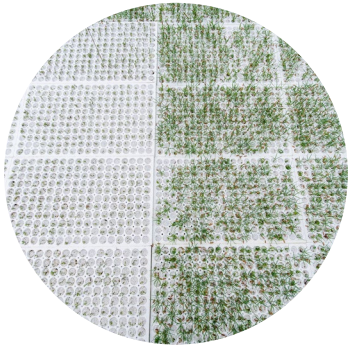
Project Objectives

- Reforestation Post-Wildfire
- Reforestation Post-Harvest

2

Species

- *Douglas fir (P. menziesii)*
- *Ponderosa pine (P. ponderosa)*
- *Western white pine (P. monticola)*
- *Western larch (L. occidentalis)*
- *etc.*
- *15+ conifers species*
- *~5 broadleaved species*



3

Stocktype(s)

- Bareroot
- Plugs and Plug+1
- Styroblock most common

4

Tool(s)

- Planting Bag
- Planting Shovel
- Hoedad

5

Planting Spacing (Feet)

- Min: 6’x 6’
- Max: 15’x 15’
- Mean: 10.32’x 10.32’

6

Elevational Range (Feet)

- Min: 400’
- Max: 9,400’
- Mean: 3,068.5’

7

Trees per Acre (TPA)

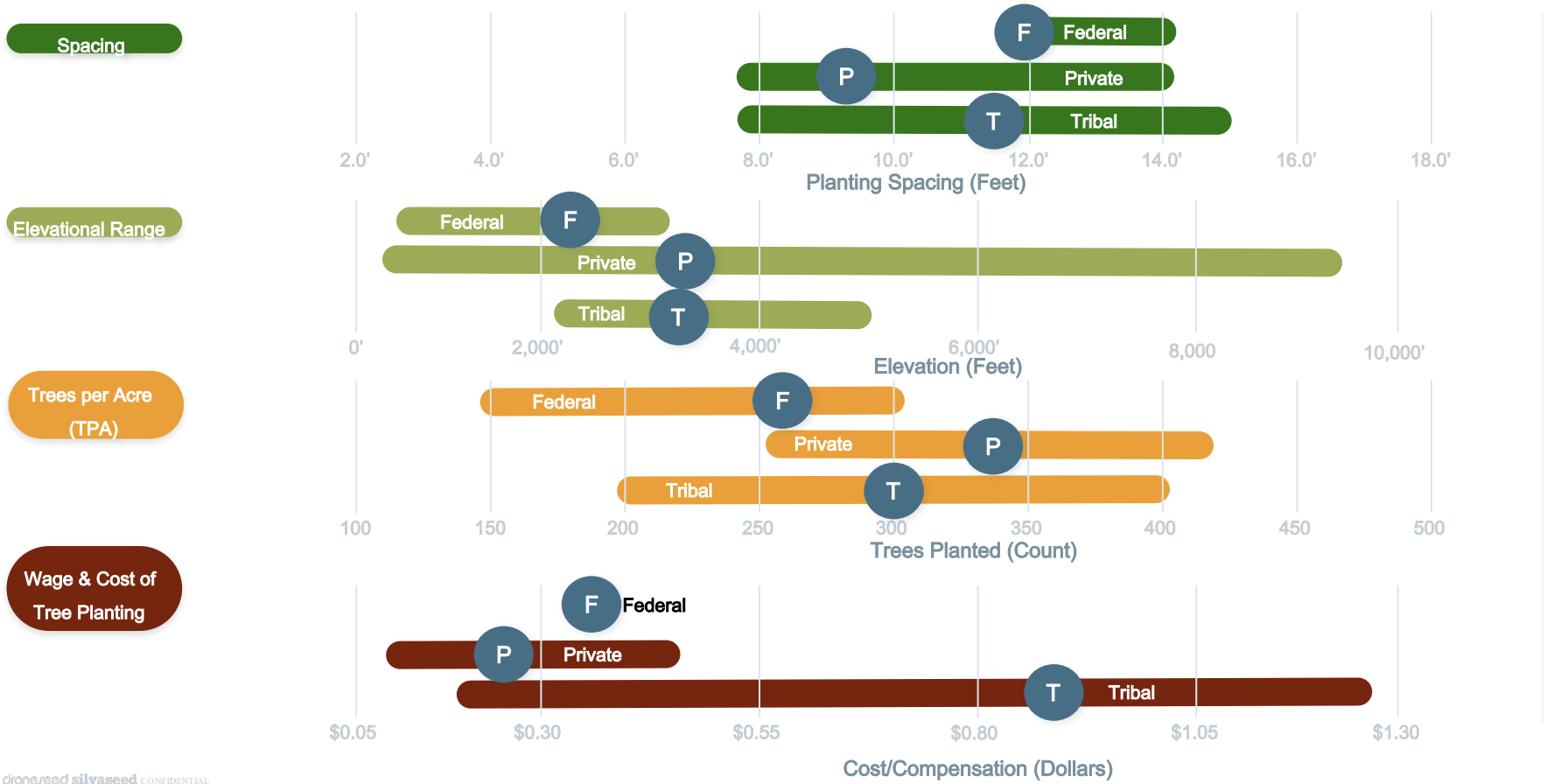
- Min: 150 TPA
- Max: 412.5 TPA
- Mean: 297 TPA

8

Trees per Day (TPD)

- Min: 278 TPD
- Max: 2,000 TPD
- Mean: 1,054 TPD

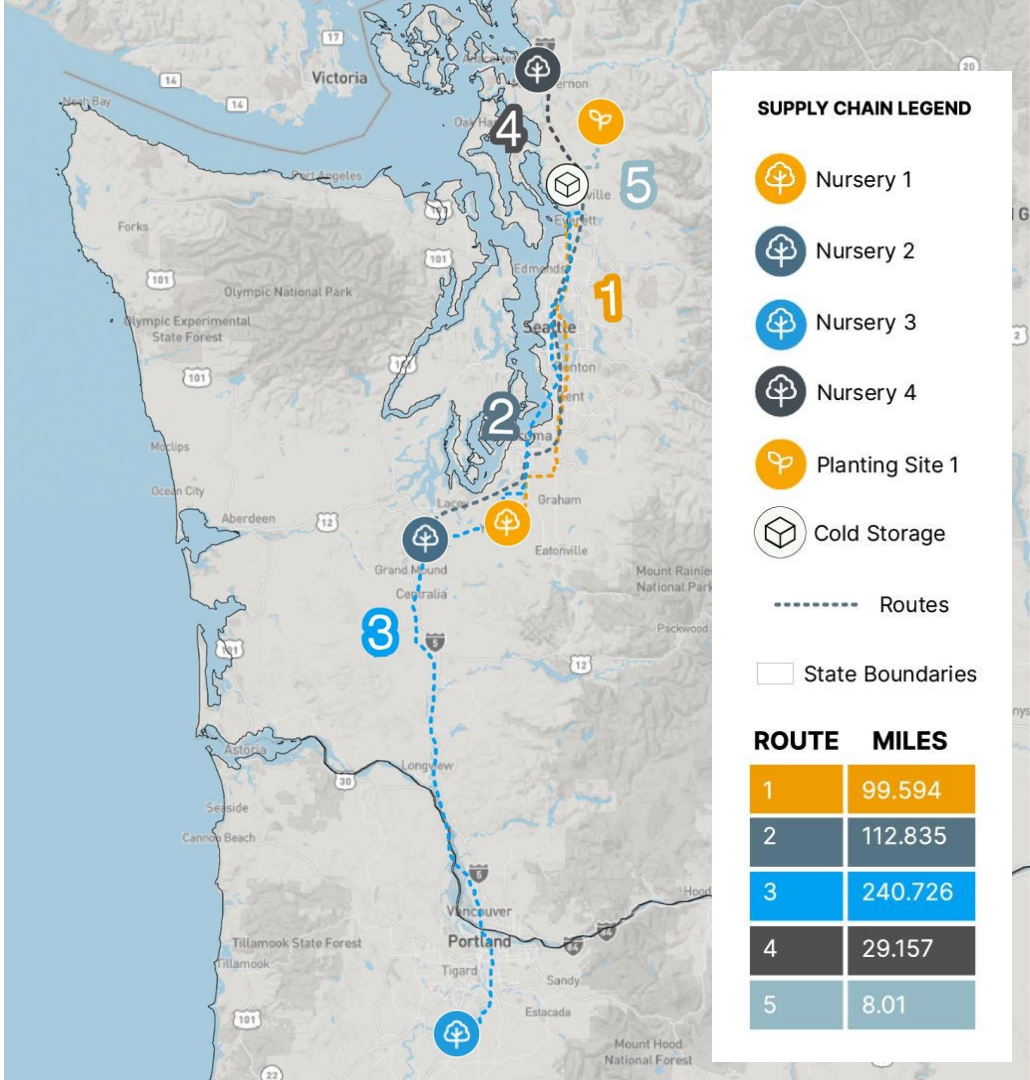
Quantitative Averages
(Federal, Private, Tribal)



Results

Transportation woes

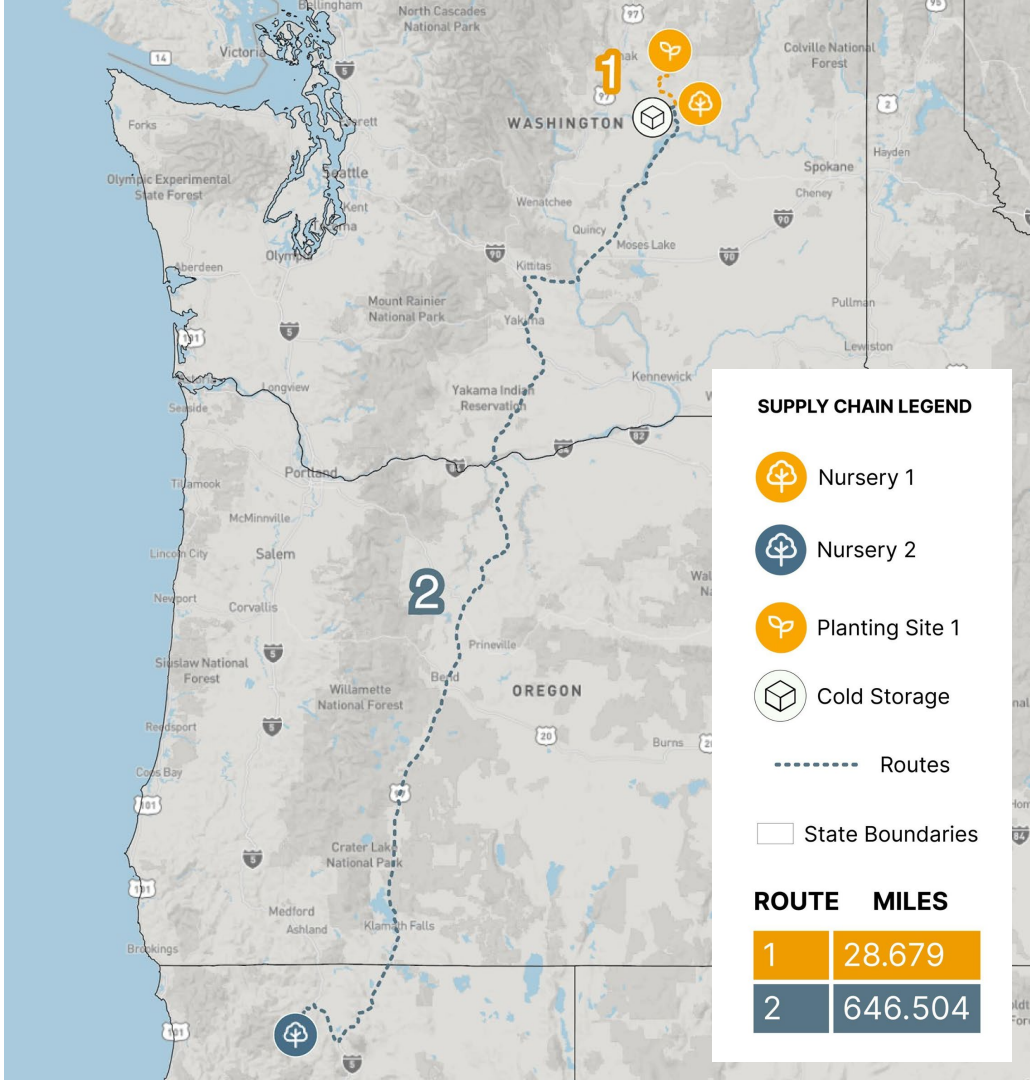
- Private landowner (15,000 acre tree farm)
- Managing for timber in WA
- Route between nurseries, cold storage, and planting site(s) in spring 2022
- Seedlings were sourced from four (4) different nurseries across Washington & Oregon
- The distance from nursery source to cold storage site ranged from **29 miles - 241 miles**



Results

Transportation woes

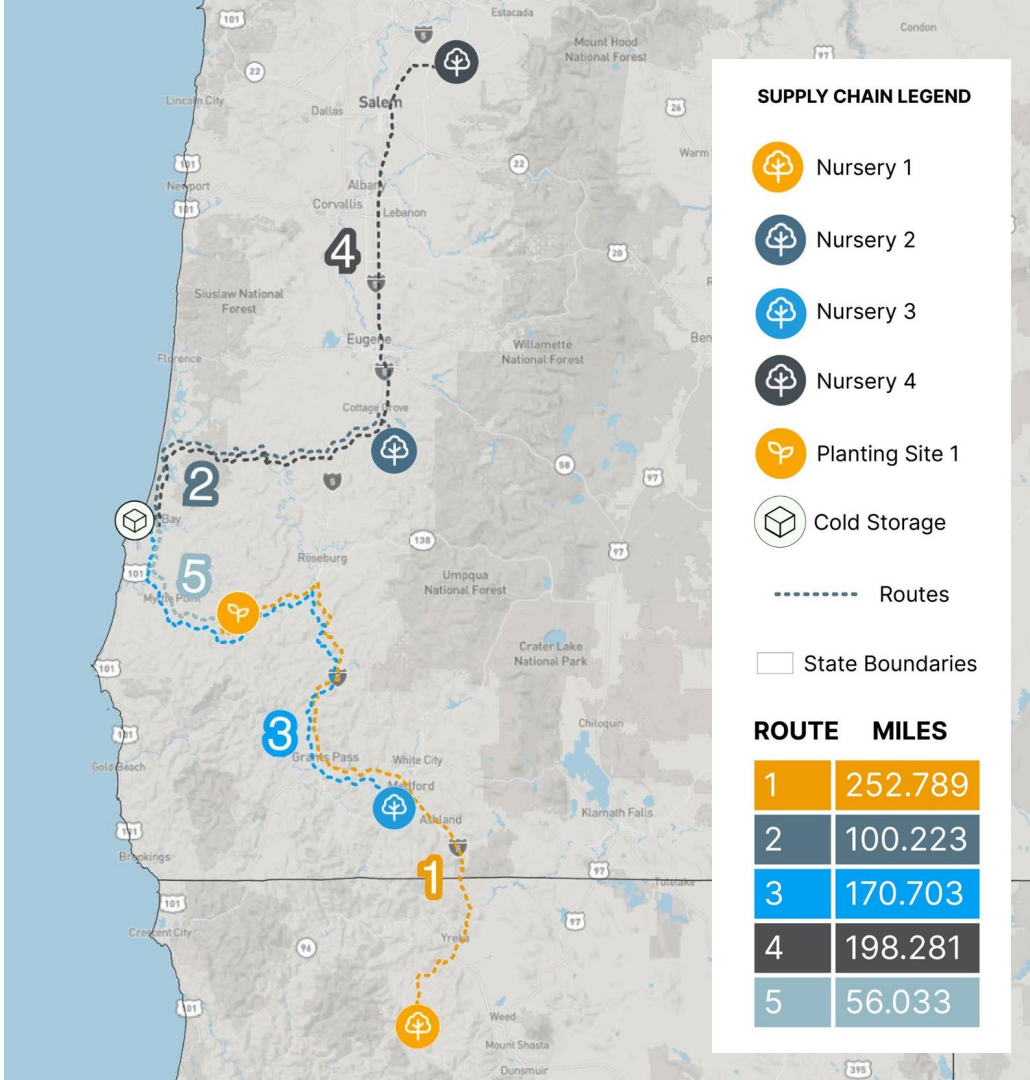
- Tribal Lands
- Managing for timber and post-fire restoration
- Route between nurseries, cold storage, and planting site spring 2022
- Seedlings were sourced from two (2) different nurseries across Washington &northern California
- The distance from nursery source to cold storage site ranged from **29 miles - 647 miles**



Results

Transportation woes

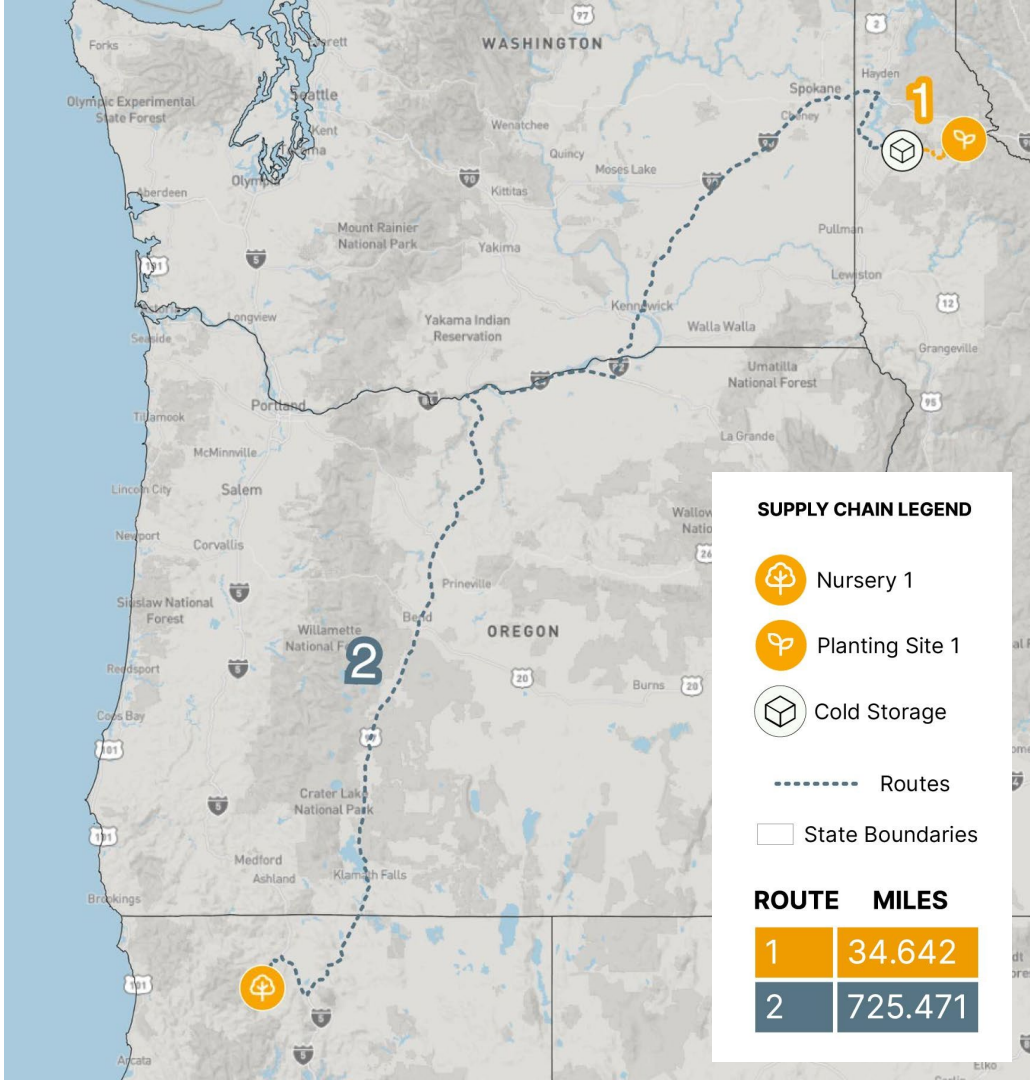
- Government Agency
- Route between nurseries, cold storage, and planting site spring 2022
- Seedlings were sourced from four (4) different nurseries across northern &southern Oregon, as well as northern California
- The distance from nursery source to cold storage site ranged from **56 miles - 253 miles**



Results

Transportation woes

- Private Landowner (Large REIT)
- Route between nurseries, cold storage, and planting site as part of the outplanting pipeline of an organization in Northern Idaho performing planting operations in spring 2022
- Seedlings were sourced from one (1) nursery in northern California
- The distance from nursery source to cold storage site ranged from **35 miles - 725 miles**



Results

Major bottlenecks

Primary challenges identified by survey	Dissatisfaction %	Detailed observations
Seedling planting quality and handling	78%	Poor planting techniques are common (e.g. J-rooting, L-rooting, tree wasting)
Terrain and site conditions	67%	Lack of resources available for site preparation
Nursery supply chain limitations (e.g. seedling availability, quantity, species)	56%	Nursery timeline may require seasonal shift
Adverse weather impacts on planting timing(s) and windows (e.g. seasonality, climate, weather)	56%	Constricted and changing planting window
Lack of readily available labor force (e.g. crew members, inspectors)	56%	Shortage of available and trained planting crew members

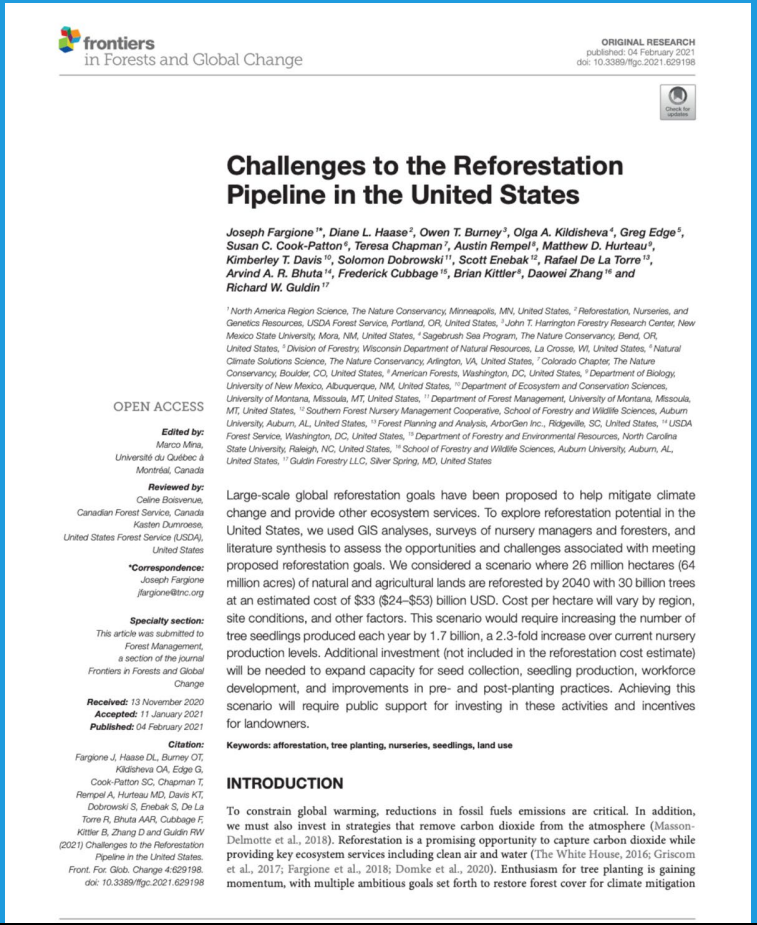
Future of outplanting

What's on the horizon for outplanting operations?

Scaling reforestation

Proposed targets

- Nationally - targeting 3B seedlings planted annually
- Western states - targeting 400M seedlings planted annually
- Assuming we want to hit the national target, at a moderate pace of planting in line with our median research findings and median spacing
    - Assuming ave of 1200 seedlings/day/planter
    - 3,000+ crews of 12
    - Total estimated 35,000+ planters
  - Western regions target
    - 400+ crew of 12
    - 4,800+ planters
  - What new avenues do we need to explore to satisfy demand?



frontiers in Forests and Global Change

ORIGINAL RESEARCH
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Challenges to the Reforestation Pipeline in the United States

Joseph Fargione[1], Diane L. Haase[2], Owen T. Burney[3], Olga A. Kildisheva[4], Greg Edge[5], Susan C. Cook-Patton[6], Teresa Chapman[7], Austin Rempel[8], Matthew D. Hurteau[9], Kimberley T. Davis[10], Solomon Dobrowski[11], Scott Enebak[12], Rafael De La Torre[13], Arvind A. R. Bhuta[14], Frederick Cubbage[15], Brian Kittler[6], Daowei Zhang[16] and Richard W. Guldin[17]*

[1] North America Region Science, The Nature Conservancy, Minneapolis, MN, United States, [2] Reforestation, Nurseries, and Genetics Resources, USDA Forest Service, Portland, OR, United States, [3] John T. Harrington Forestry Research Center, New Mexico State University, Mora, NM, United States, [4] Sagebrush Sea Program, The Nature Conservancy, Bend, OR, United States, [5] Division of Forestry, Wisconsin Department of Natural Resources, La Crosse, WI, United States, [6] Natural Climate Solutions Science, The Nature Conservancy, Arlington, VA, United States, [7] Colorado Chapter, The Nature Conservancy, Boulder, CO, United States, [8] American Forests, Washington, DC, United States, [9] Department of Biology, University of New Mexico, Albuquerque, NM, United States, [10] Department of Ecosystem and Conservation Sciences, University of Montana, Missoula, MT, United States, [11] Department of Forest Management, University of Montana, Missoula, MT, United States, [12] Southern Forest Nursery Management Cooperative, School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL, United States, [13] Forest Planning and Analysis, ArborGen Inc., Ridgeville, SC, United States, [14] USDA Forest Service, Washington, DC, United States, [15] Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC, United States, [16] School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL, United States, [17] Guldin Forestry LLC, Silver Spring, MD, United States

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Marco Mina,
Université du Québec à Montréal, Canada

Reviewed by:
Celine Boisvenue,
Canadian Forest Service, Canada
Kasten Dumroese,
United States Forest Service (USDA), United States

***Correspondence:**
Joseph Fargione
jfargione@tnc.org

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Large-scale global reforestation goals have been proposed to help mitigate climate change and provide other ecosystem services. To explore reforestation potential in the United States, we used GIS analyses, surveys of nursery managers and foresters, and literature synthesis to assess the opportunities and challenges associated with meeting proposed reforestation goals. We considered a scenario where 26 million hectares (64 million acres) of natural and agricultural lands are reforested by 2040 with 30 billion trees at an estimated cost of $33 ($24–$53) billion USD. Cost per hectare will vary by region, site conditions, and other factors. This scenario would require increasing the number of tree seedlings produced each year by 1.7 billion, a 2.3-fold increase over current nursery production levels. Additional investment (not included in the reforestation cost estimate) will be needed to expand capacity for seed collection, seedling production, workforce development, and improvements in pre- and post-planting practices. Achieving this scenario will require public support for investing in these activities and incentives for landowners.

Keywords: afforestation, tree planting, nurseries, seedlings, land use

INTRODUCTION

To constrain global warming, reductions in fossil fuels emissions are critical. In addition, we must also invest in strategies that remove carbon dioxide from the atmosphere (Masson-Delmotte et al., 2018). Reforestation is a promising opportunity to capture carbon dioxide while providing key ecosystem services including clean air and water (The White House, 2016; Griscom et al., 2017; Fargione et al., 2018; Domke et al., 2020). Enthusiasm for tree planting is gaining momentum, with multiple ambitious goals set forth to restore forest cover for climate mitigation

LEARN MORE & SOURCES

Haase, Diane L., et al. "Forest nursery seedling production in the United States—fiscal year 2018." *Tree Plant. Notes* 62.1/2 (2019): 20-24.

Future of outplanting

Incentives

- Human dimensions
- Wage increases to reflect value chain
  - Influx of capital from various government initiatives and market trends, like carbon, should be directed to wage labor across the pipeline
  - Advocacy from experts and practitioners, including us!
  - **Tree planters are the front lines!**
- Support infrastructure improvements
  - Near site lodging
  - Diversify transportation options or reduce burden of daily commute
  - Process and safety improvements
  - General health and well being
  - Recall why the CCC was effective!

Future of outplanting

Pathways

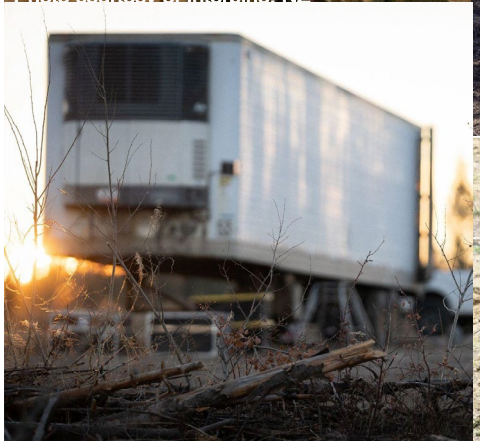
- Visas and streamlining the migrant labor pool
  - Collaborating/lobbying with agriculture and other industries relying on migrant labor to improve quality of H2-B visas
  - Creating contracting standards to protect the workers
- What about other demographics?
  - Canada's tree planters are often college aged and incentivized to take on seasonal work and sometimes stay on for 10 years
  - Culture, infrastructure, wages
  - Where else do we source for labor intensive roles?
  - Does the mission of climate change and reforestation resonate better than timber?

Future of outplanting

Innovation

- Near- or on-site storage of seedlings for scale
  - Daily transport reduction
  - Flexibility for planting conditions
  - Improving transport and storage may also mean packing and storage solutions in collaboration with nurseries
  - Testing this with planting groups directly
- Technology improvements to transport seedlings to site, then on site
  - Moving seedlings across large areas on site is time lost planting
  - UAVs, helicopters, cable systems, or terrestrial solutions


Photo courtesy of Interpine, NZ



Future of outplanting

Innovation

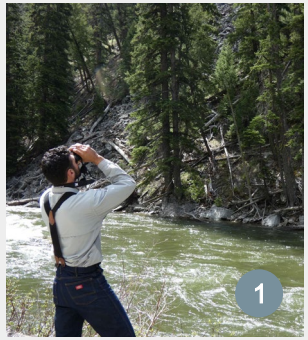
- Tool development to increase planting efficiency and ergonomic value
  - Evidence of planters integrating key components of broken tools to develop a ‘Frankenstein Tool’
- Automation
  - Planting machines - overcoming terrain limitations
  - Aerial seeding - seed use efficiency and scale of operations
- Wage labor vs automation
  - To scale, we need a multiplicative increase in cost of labor (probably won’t happen in the U.S.)
  - Automation must cost equivalent to labor based approach (won’t be in the near term)
  - What’s the balance between the two?

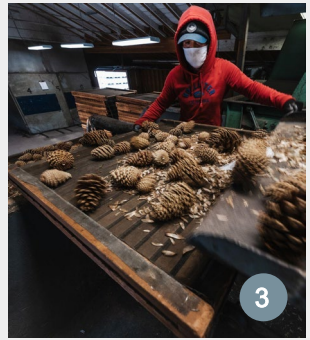
Photo courtesy of Plantma Forestry

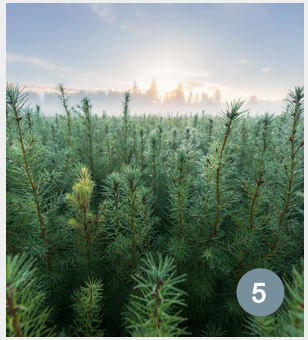
Future of outplanting

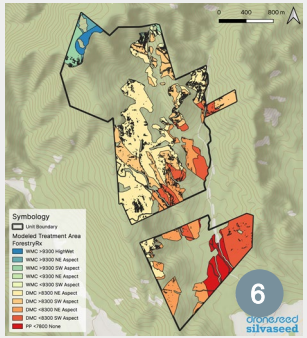
Data and communication

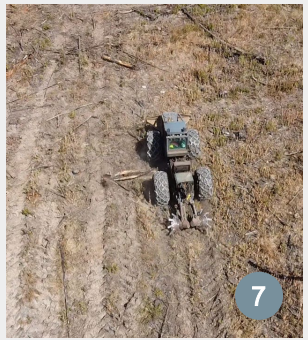
- Feedback loops - Target Plant Concept
  - Data and information age should inform more rapid development of solutions
- Land management objectives beyond timber
- Changes to nursery production processes and infrastructure
- Land managers → Foresters -> nurseries → Planting crews require:
  - Complex planning, mapping, design, Rx
  - Communication
  - Materials transport
- Can software solutions be designed to streamline across the stakeholder group and supply chain?











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- U.S. Forest Service
- As well as others!

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Thank you!

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Past

20th Century origins

- Demand for artificial forest regeneration was paramount due to wildfires, indiscriminate harvesting, and soil erosion endangering watersheds
- Private sector
  - Private nurseries largely serving agricultural or horticultural needs
  - A few records of private seed and nursery operations in the NW until mid-century (post-war)
    - 1938: Weyerhaeuser started a tree nursery in WA
    - 1870: Manning Seed Co (now Silvaseed Co) operated cone collection stations and seed extractories in OR and WA
- Public sector
  - Federal government the logical actor to make improvements where industry had no incentive to invest
  - Creation of federal nurseries (e.g. Wind River, Monument, and

LEARN MORE & SOURCES

Dumroese, R. K., Landis, T. D., Barnett, J. P., & Burch, F. 2005. Forest Service nurseries: 100 years of ecosystem restoration. Journal of forestry, pp. 241-247.
US National Archives 95-G-152502
Lewis, R. 1981. Tree Farming: A Voluntary Conservation Program. Journal of Forest History. pp. 166-169.
Weyerhaeuser dedicates the nation's first tree farm near Montesano on June 21, 1941

Past

20th Century efforts

- Roosevelt's Emergency Conservation Work Act created the Civilian Conservation Corps in 1933 …"to mitigate the effects of soil erosion and widespread decline of timber resources"...
  - Records suggest they planted 3 billion trees in the U.S. from 1933-1942, with 3 million men
  - Used unemployed men between 18-25 years old
- How did they accomplish the outplanting?
  - Was reflective of military chain of command and organizational structure
  - "labor at a minimum cost for materials and equipment"
- Support infrastructure was critical
  - A CCC worker's salary was $30-45 a month ($500-800 equivalent today), most of which was sent home to family
  - Camps included barracks, mess hall, recreational hall, latrine, classrooms, post office, hospital, etc

LEARN MORE & SOURCES

Paige, J. C. 1985. The Civilian Conservation Corps and the National Park Service, 1933-1942: An Administrative History. National Park Service, US Department of the Interior. p. 11.
https://www.nps.gov/

Macro challenge

Considering capacity and timelines

- Current capacity is limited as wildfires are increasing in size and intensity
  - Timber/fiber production relies on an active workforce post-harvest
  - Commodities markets are essential
  - Will the required planting strain the workforce or create more competition over few planting crews?
  - Increased backlog of reforested acres due to laborers supporting firefighting instead of planting for an increased income
- Assuming we want to keep up with forest loss
  - Speed and flexibility are required as costs of site preparation increase with every year of inactivity

LEARN MORE & SOURCES | Read (3 min) Newspaper Article | FAST COMPANY Read (5 min) | The Nature Conservancy Read (5 min)

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Results

Transportation woes

- Private landowner - 15,000 ac tree farm (Left), Government Agency (Right)
- Route between nurseries, cold storage, and planting site(s) in spring 2022
- Seedlings were sourced from four (4) different nurseries across Washington, Oregon, and northern California
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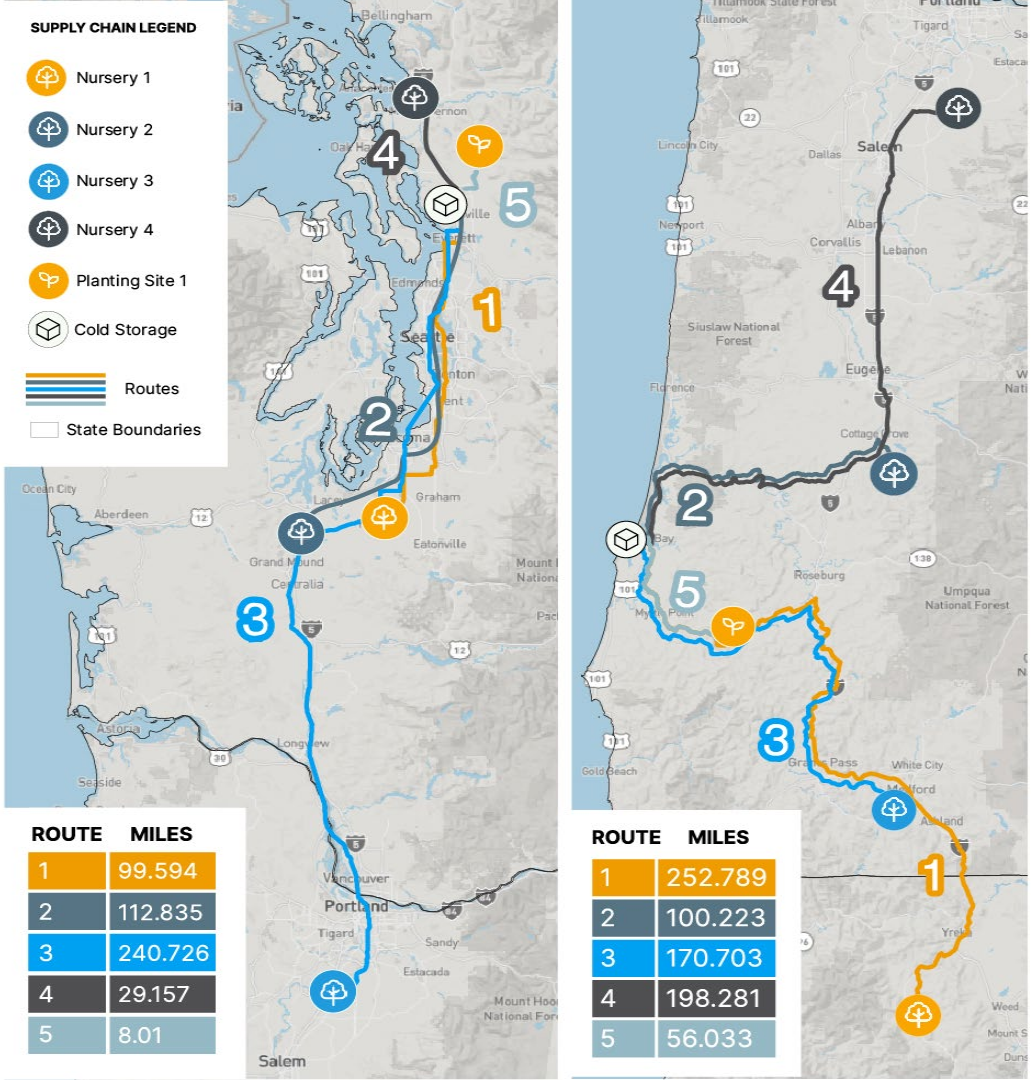

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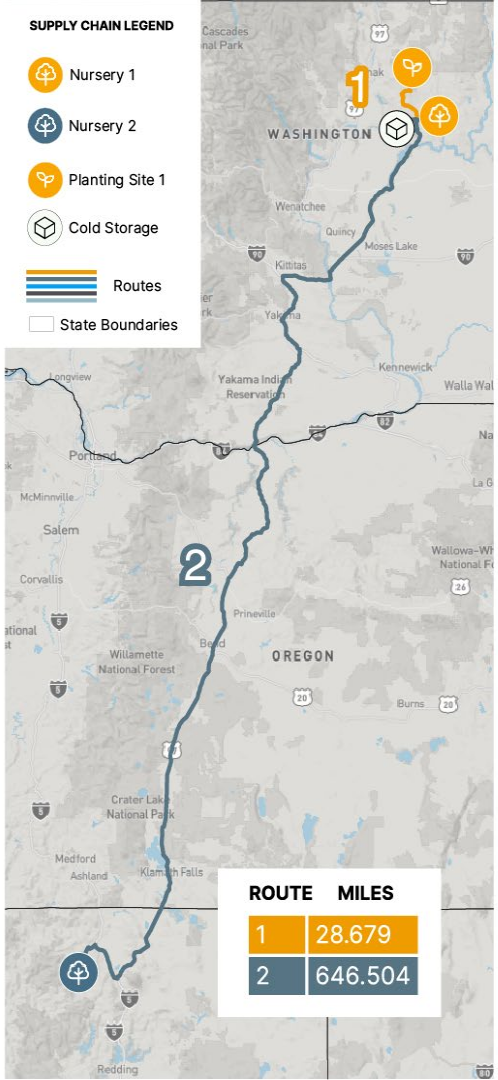

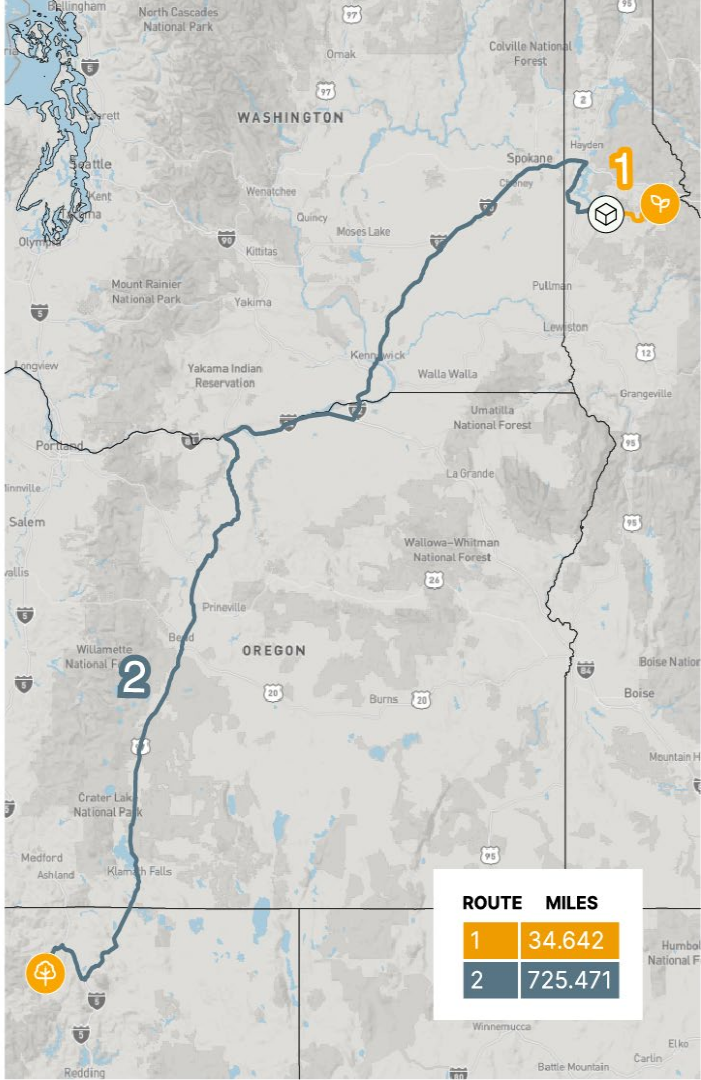

Future of outplanting

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  - Improving transport and storage may result in nursery packing and storage solutions
- Innovations to transport seedlings to site, increase planting efficiency, and improve ergonomic value
  - UAVs, helicopters, cable systems, or terrestrial solutions to increase seed use efficiency and scale
  - Tool development - evidence of planters integrating key components of broken tools to develop a 'Frankenstein Tool'
- Wage labor vs Automation
  - Scaling planting machines and aerial seeding – overcoming terrain limitations and scale
  - Automation cost equivalent to labor? What's the balance between the two?

Photo courtesy of Interpine, NZ