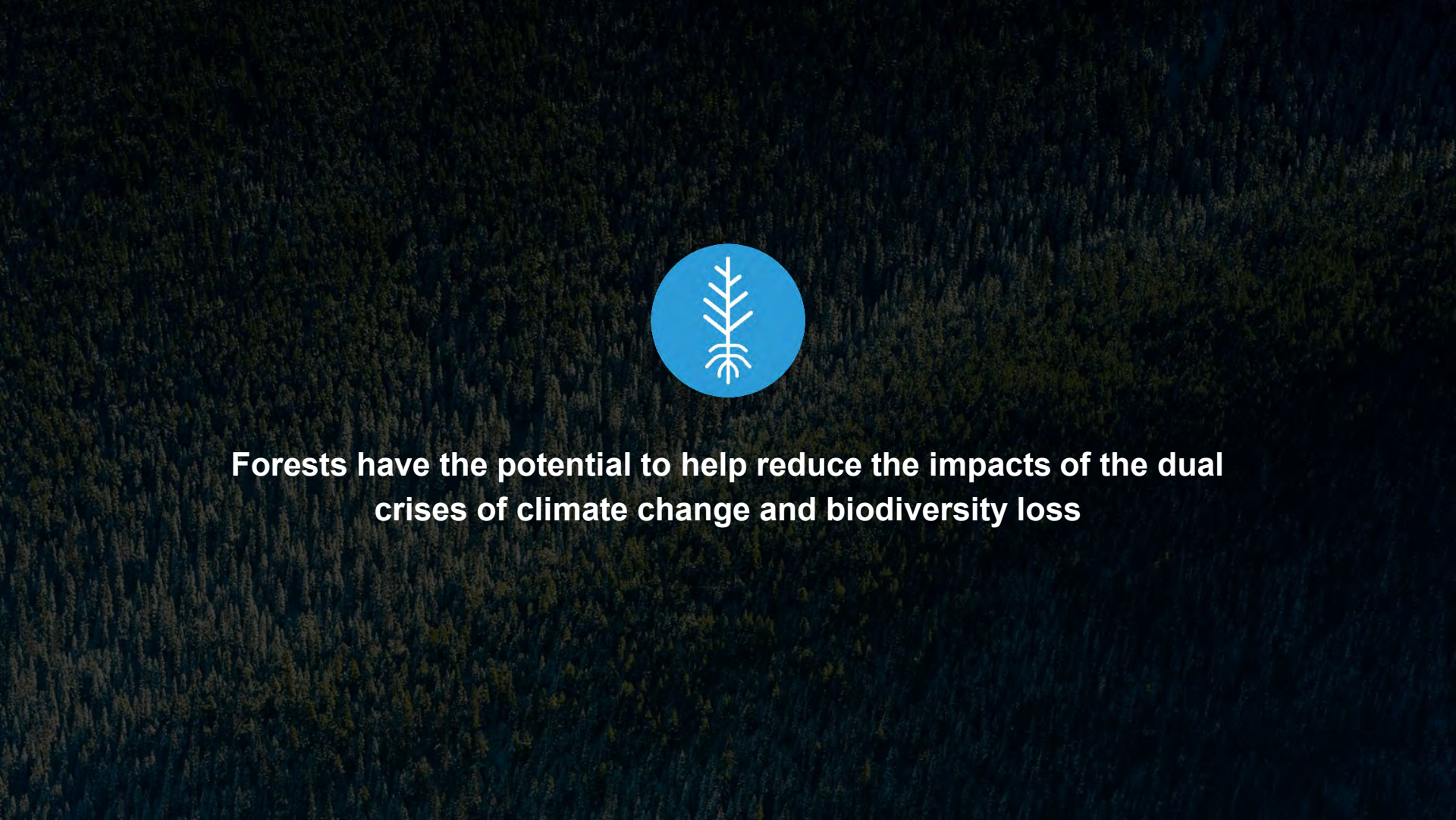
It All Starts With Seed: Strengthening the Reforestation Pipeline in the Western U.S

Olga Kildisheva
The Nature Conservancy

Shanna Hobbs
DroneSeed

Solomon Dobrowski
University of Montana

Matthew Aghai
DroneSeed & Silvaseed


Forests have the potential to help reduce the impacts of the dual crises of climate change and biodiversity loss

Context

Wildfire impacts are increasing

- Decades of fires suppression and management resulted in overstocked fire-prone forests
- US wildfire season burns more than 10 million ac annually
- Extent of western wildfires has doubled
- Wildfires are higher intensity and severity
  - In PNW 36% of wildfires are mod or high severity (6-9% historically)
- Climate change is exacerbating the problem
  - Higher summer temperatures have an exponential effect on fire through fuel drying and VPD

LEARN MORE & SOURCES

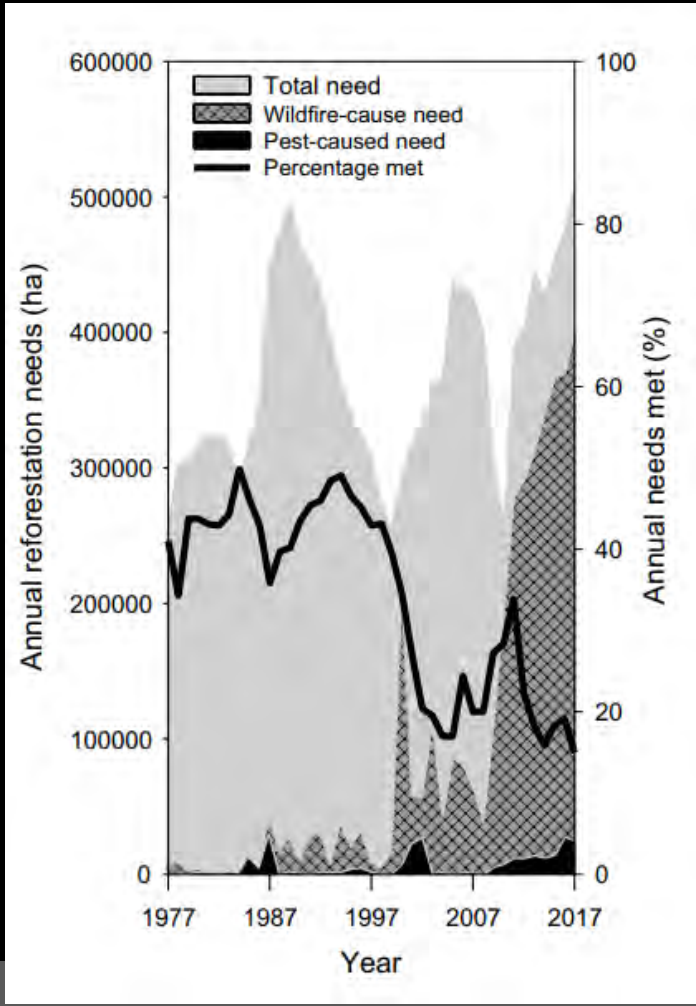
Journal of Forestry, Dumroese et al. (2005) | Earth's Future, Williams et al. 2019


High severity wildfires limit natural regeneration

Context

Reforestation backlog is increasing

- Fire, pests, and lack of funding over 3 decades contributed to a reforestation backlog
- USFS was only able to reforest 15-20% of national forest lands (only 6% of areas affected by fire) annually
  - Current backlog is four million ac
- Limited data on reforestation of non-federal, non-industrial lands, but picture is likely similar and state-specific



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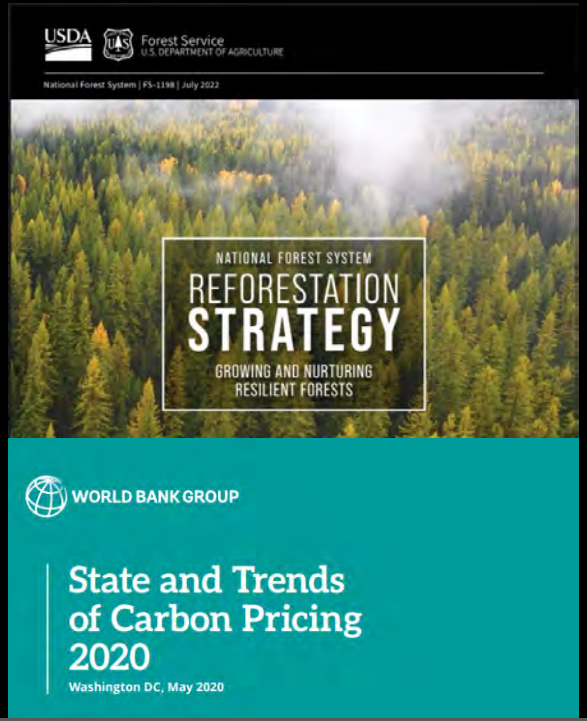
Journal of Forestry Dumroese et al., 2005 | New Forests Dumroese et al., 2019

Context

Increased interest and funding

- BIL (REPLANT Act) & IRA make more funding available to support reforestation and forest as a climate solution
- Increase interest in carbon sequestration & nature-based solutions in the private sector
  - 42% of global total offset credits attributed to forest carbon projects between 2015-2019
- Need to ensure that we can produce enough genetically appropriate seedlings to not only meet reforestation demand but to safeguard ecological integrity



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Bipartisan Infrastructure Law | The REPLANT Act of 2021 | State and Trends of Carbon Pricing 2020 | Nation Reforestation Strategy

Context

National and regional reforestation potential

- In the US, at least 64 million ac have the potential to be reforested
- To achieve this goal by 2040 would require planting 30 billion trees – 2x increase in annual seedling nursery production
- For the western US (which included 14 states in the study), the reforestation potential is 24 million ac and would require 7.5 billion trees
- Reforestation opportunity is approximately equal between private and public lands

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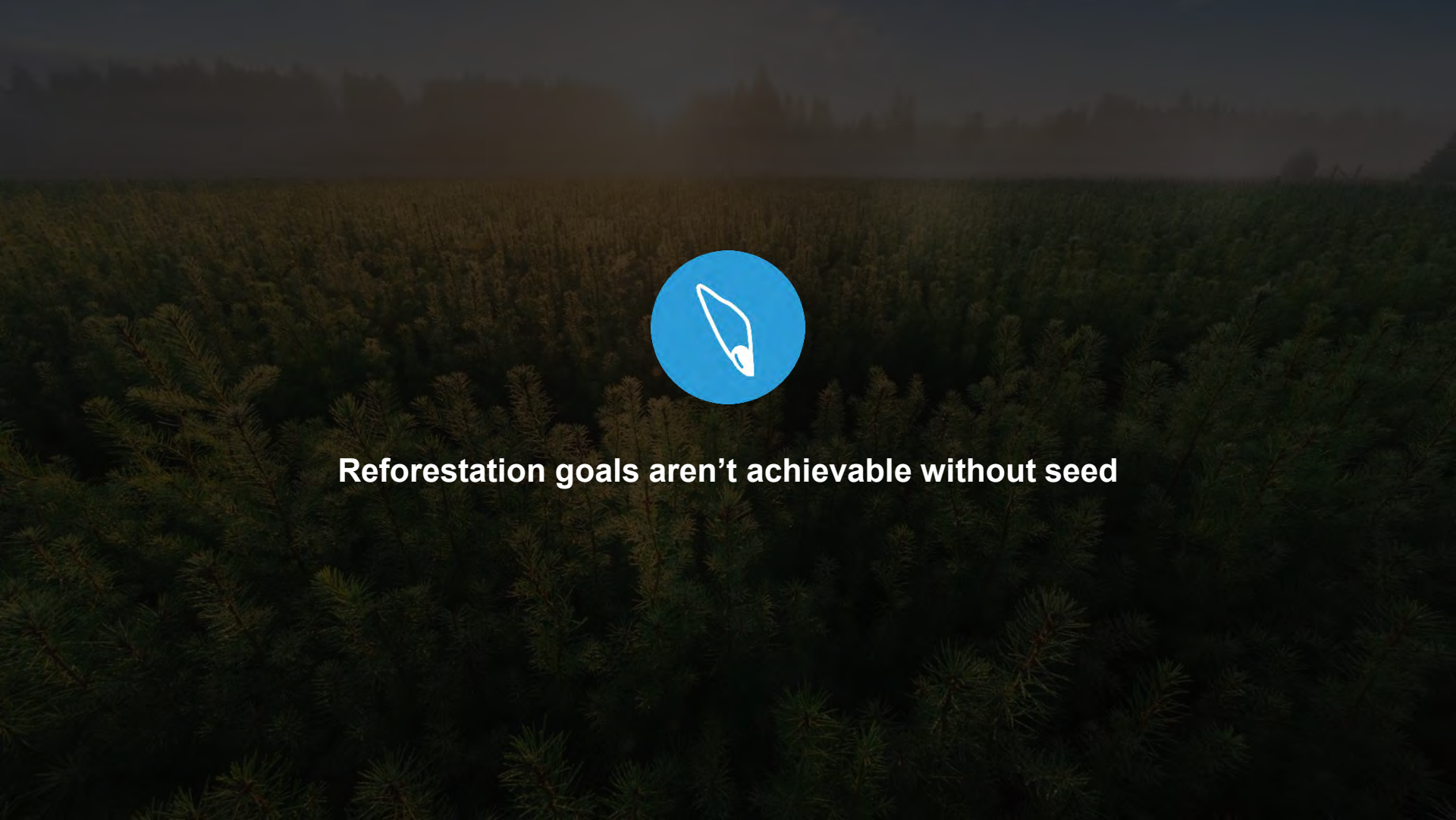
Frontiers in Forests and Global Change, Fargione et al. 2021 | Ramping Up Reforestation, American Forests


Reforestation goals aren’t achievable without seed

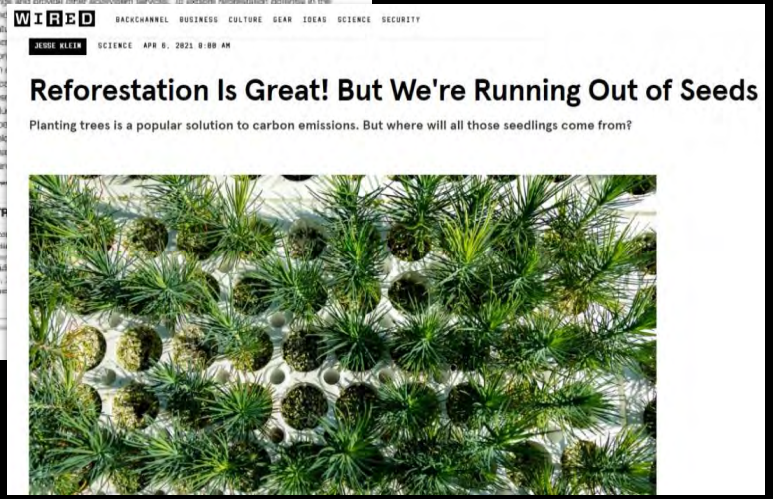
Context

Seed Supply

- In the western US, more seed is needed to meet reforestation goals
- Stored seed inventory could supply 5 and 2 years of conifer and hardwood seed at current production levels
- Insufficient to support a 2x increase in annual seedling production to meet the proposed 2040 goals


frontiers in Forests and Global Change

Challenges to the Reforestation Pipeline in the United States


WIRED BACKCHANNEL BUSINESS CULTURE GEAR IDEAS SCIENCE SECURITY

JESSE KLEIN SCIENCE APR 8, 2021 8:00 AM

Reforestation Is Great! But We're Running Out of Seeds

Planting trees is a popular solution to carbon emissions. But where will all those seedlings come from?

LEARN MORE & SOURCES

Frontiers in Forests and Global Change, Fargione et al., 2021 | Reforestation Is Great! But We're Running Out of Seeds, WIRED

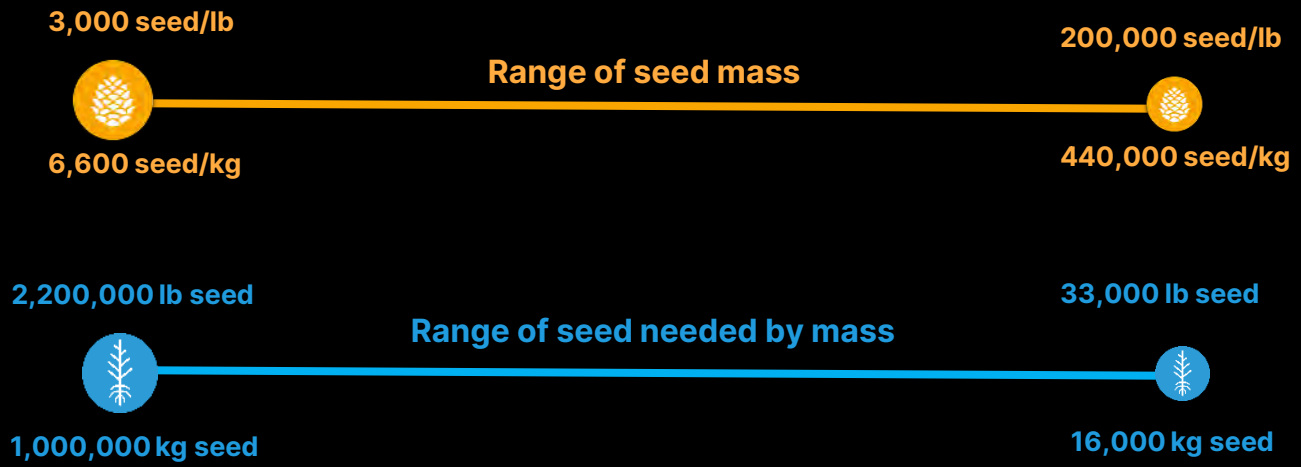
Exercise

How much do we need?

- For the western US, we would need 7.5 B seedlings by 2040
- 95% of western nursery production for reforestation focuses on conifers

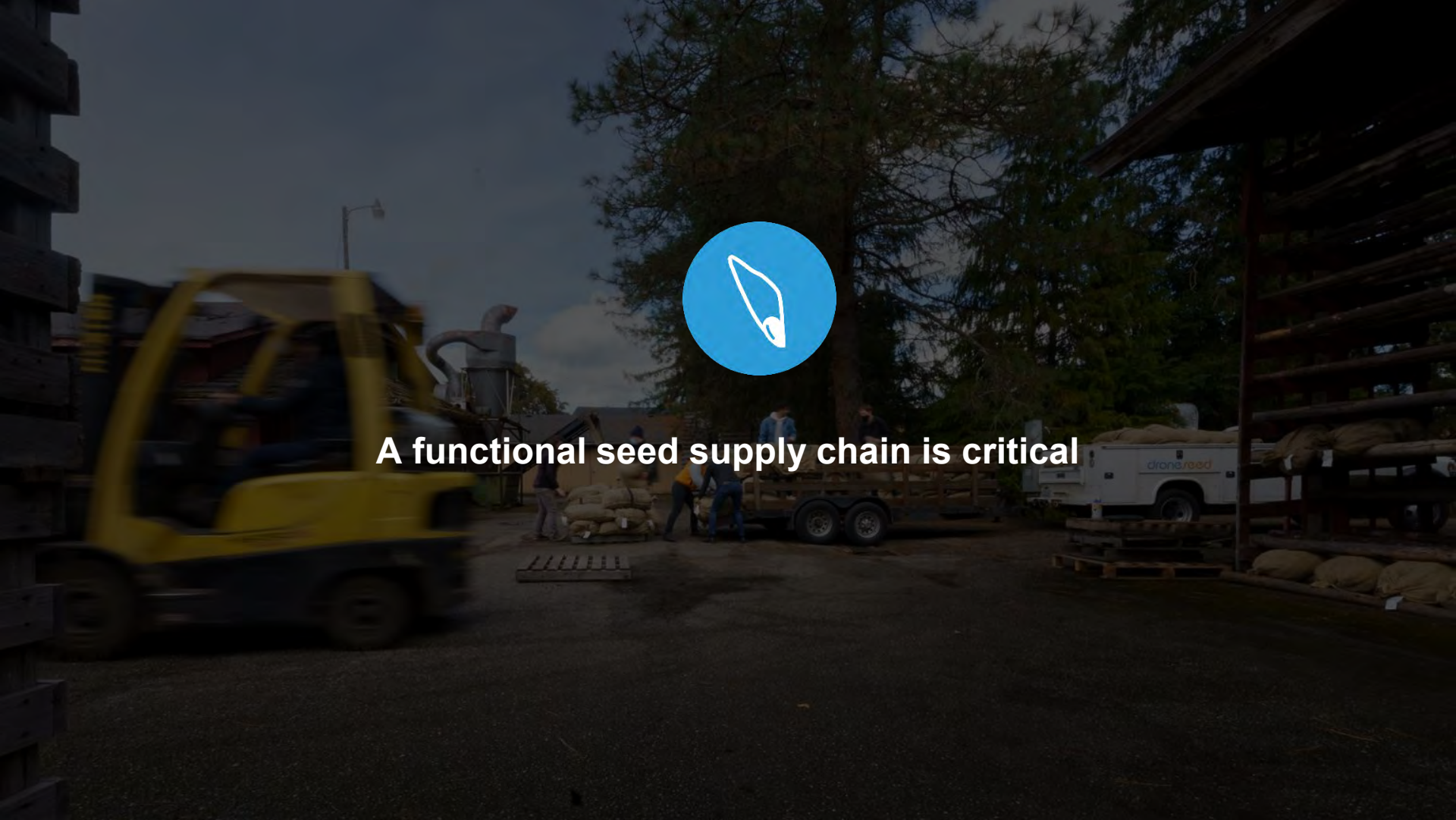
Assumptions:

- 1 seed = 1 seedling (never actually this simple)
- 90+ taxa of conifers with a range of seed mass



LEARN MORE & SOURCES

Frontiers in Forests and Global Change, Fargione et al., 2021 | The Woody Plant Seed Manual, Karrfalt & Bonner, 2008


A functional seed supply chain is critical

Key elements of the tree seed supply chain

1

Planning

Understanding and planning for seed needed to support production

2

Sourcing

Selecting genetically appropriate seed sources to meet reforestation goals

3

Collection & Procurement

Obtaining seed through collection

4

Handling, Cleaning & Storage

Moving from freshly collected cones or fruits to pure seed

5

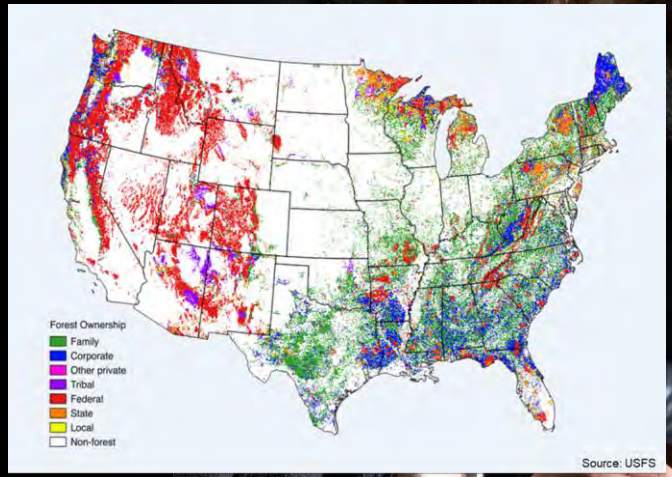
Testing & Certification

Ensuring quality and origin

1. Planning: Challenges

Planning for seed needs is paramount

- Planning collection need to consider seed ecology, biophysical factors, and human dimensions
- Seed procurement can take several years, in addition to 1+ years needed for seedling production
- Lack long-term planning and coordination - negative effects on reforestation outcomes:
  - species selection, genetics, seed quality, and cost
- Reforestation needs span federal, state, tribal and private lands - a complex mosaic of funding structures and management goals



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U.S. Land Ownership by Entity

1. Planning: Opportunities

Working together to understand and address inventory gaps

- Work together to better understand:
  - the current seed inventory across public, state, tribal, and private holdings
  - who has access to that seed
  - species- and seed zone-specific gaps for areas in need of reforestation across land ownerships

- Invest in decision-support tools that combine seed inventory information, across land ownerships with projections on where reforestation is most likely to be needed

2. Sourcing: Challenges

Seed sourcing in the face of climate change

- Climate change and fire will continue to reduce seed availability
- Forests cannot move fast enough to escape climate change by themselves
  - the average forest migrates 1,640 ft per yr, must move 10 x faster to outrun climate change
- Current seed zones and seed transfer guidelines may need to be adjusted to support survival within the lifetime of a tree
- More species will need to be considered for reforestation, for some of which seed transfer guidelines are not available

2. Sourcing: Opportunities

More research and management actions

- Increase support for and expand empirical field and modeling studies on:
  - Climate change impacts on seed production dynamics and natural regeneration
  - Assisted population migration and range expansion for a broad range of species

- Partnership between scientists and foresters to implement low-risk migration and expansion trials on sites in need of reforestation

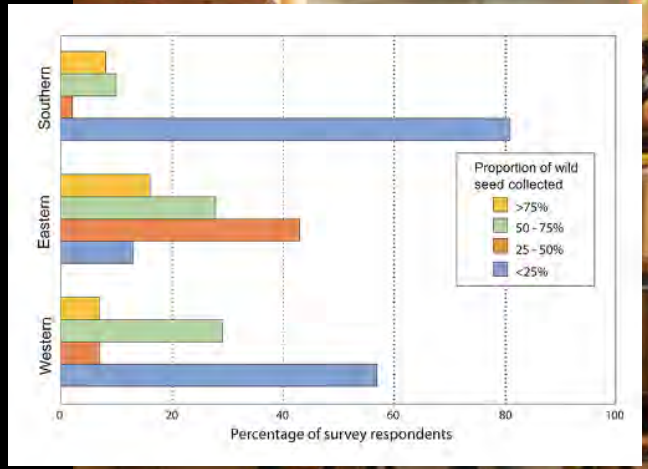
LEARN MORE & SOURCES

USFS Climate Change Resource Center | Can We Move Our Forests in Time to Save Them? Mother Jones

3. Collection & Procurement: Challenges

Increasing seed inventory requires seed collection

- Seed can be collected from seed orchards or from the wild
- In the western US, annual collections represent 45% of the current nursery seed needs
    - more than half (65%) of nurseries collect <50% of their seed from the wild
    - around a third (35%) of the nurseries collect >50% of their seed from the wild



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Frontiers in Forests and Global Change, Fargione et al. 2021

Challenges & Opportunities

Seed collection from orchards

- Efficient, systematic, high-quality seed, but:
  - Capacity reduced due to funding shortages over the past several decades
  - Limited by species, populations, and trait selection
  - New orchards will require ca. 15+ years to produce seed
- More investment in orchards is needed but approach should be adjusted to account for current reforestation objectives
- In the absence of adequate seed supply from orchards, particularly in the short-term, reliance on harvesting seeds from the wild may need to increase

LEARN MORE & SOURCES

Frontiers in Forests and Global Change, Fargione et al. 2021

3. Collection & Procurement: Challenges

Seed collection from wild stands

- High genetic diversity, wide range of species, broad geography, but logistically complex

View from inside a tree top.

Bucket and hand rake to pull cones off of branches, crossbow to get lines into a tree for rigging.

Crews travel in groups of 5-10 with half in trees and half as ground support

Ground crew making tags for bushels

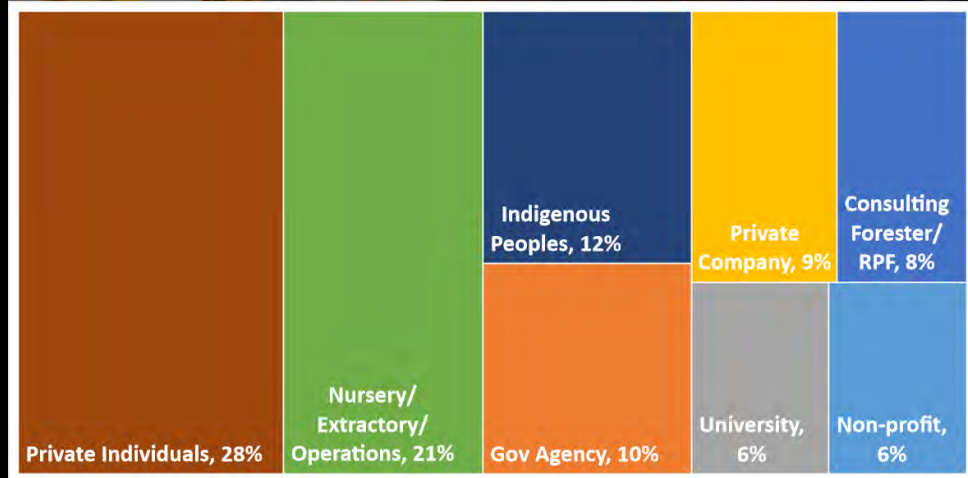
Climber in canopy

3. Collection & Procurement: Challenges

Understanding bottlenecks in scaling seed collection

- DroneSeed & Silvaseed hosted a Tree Seed Summit in March 2022 to bring together stakeholders from across the industry to identify challenges and opportunities in tree seed collection

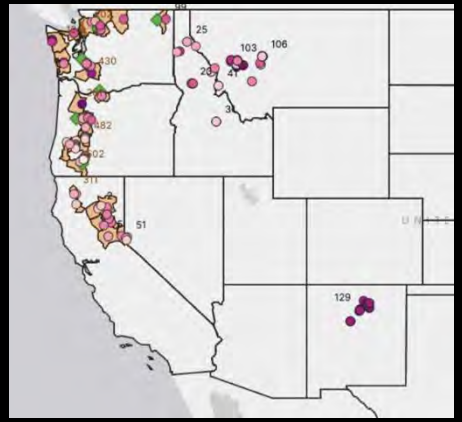
- Participants identified:
  1. a lack of advanced clarity around seed demand
  2. limited capacity for scouting of potential collection sites and predicting mast
  3. difficulty with permitting
  4. a limited professional labor pool
  5. need to streamline and increase communication across sector



3. Collection & Procurement: Opportunities

Communicating seed needs and improving cone scouting

- Better communication of anticipated seed needs between foresters and collectors
- Advanced identification of collection areas and regional mast events
- Scouting to ensure appropriate timing of collections can occur – this requires basic knowledge of seed biology and seed maturation



3. Collection & Procurement: Opportunities

Improving permitting and land access for collections

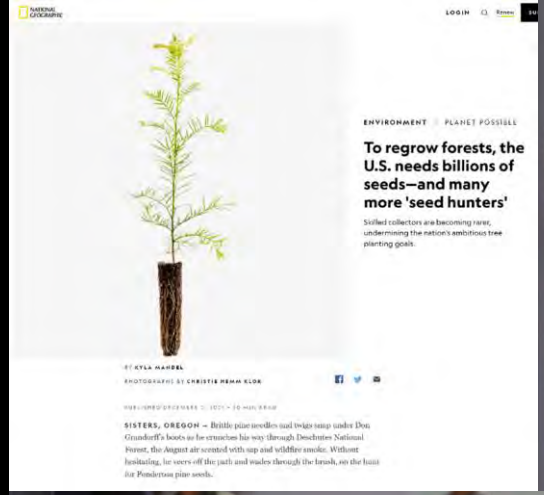
- Streamlining collection permitting across partner organizations through inclusive agreements
  - Memorandum of understanding
  - Good neighbor agreements
  - Multi-year contracts

- Enabling more targeted and systematic collections by trained collectors to address inventory gaps

3. Collection & Procurement: Opportunities

Improving training and workforce development

- Expand hands-on training programs to address knowledge gap and labor shortages:
  - university courses
  - continuing education (e.g. SAF, SER)
  - workforce development programs
  - citizen science (for scouting or small-scale collections)



Seed handling and transport

- Improper handling during and after collection can significantly decrease seed quality
- Critical that seed collectors are trained and can determine quality and know the appropriate storage requirements
- Advanced planning and frequent communication between the seed collector and seed purchaser to prevent costly mistakes

Conifer cones are often transported more than 300 mi, transport requires communication, timing, temperature management, and excellent record keeping for a quality crop to be delivered and staged the extractory

The Woody Plant Seed Manual, Karrfalt & Bonner, 2008

Seed extraction and cleaning is both an art and a science

After cones are delivered to the extractory, they undergo several stages that involve cone drying, tumbling, scalping, and cleaning.

Limitations in seed cleaning capacity

- Seed cleaning requires specialized equipment and expertise
- Expertise diminished with closing of nurseries and reduced opportunities for hands-on learning
  - Only 6 USFS nurseries (5 have cleaning capacity) and 2 seed cleaning facilities (extractories) remain nation-wide
  - Similar (less drastic) declines in state and private nurseries
  - Financial limitations have often made it difficult to hire permanent staff - higher long-term costs due to the need to hire and train new staff seasonally
  - Many college graduates do not know that this is a career option
- Strategic investment in seed infrastructure and training is needed

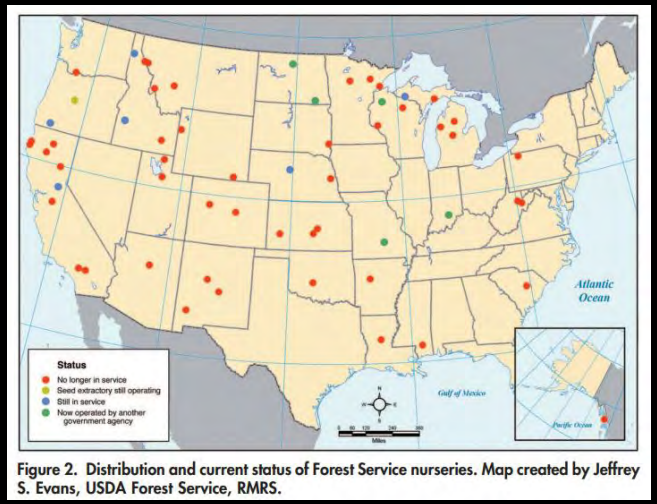
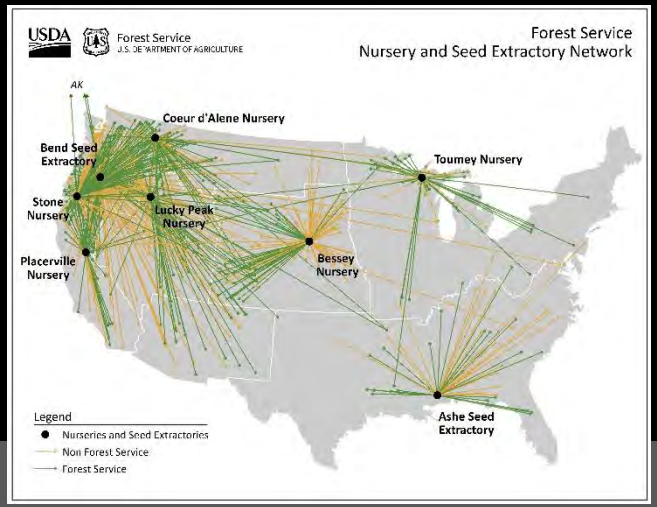


Figure 2. Distribution and current status of Forest Service nurseries. Map created by Jeffrey S. Evans, USDA Forest Service, RMRS.



LEARN MORE & SOURCES

Journal of Forestry, Dumroese et al. (2005)

4. Handling, cleaning, and **storage**:
Challenges & Opportunities

Seed Storage

- Most western species have orthodox storage behavior – can be stored long-term
- Seeds should be thoroughly cleaned, dried to 5-10% MC
- Storage in airtight polyethylene bags at -18°C
- Storing seed well is the biggest investment you can make in the longevity of your seed inventory
- Assessing regional storage capacity may be important in the long term

Seed quality testing

- Informs seed buyer of key seed parameters that are important for seedling production planning
- Seed quality is influenced by:
  - biotic and abiotic factors during seed set
  - handling during collection and cleaning
  - storage conditions and duration
- Testing is important and should be done using standardized approaches and trusted labs
  - Initial and periodic testing during storage
- Build a relationship and trust with a regional lab for long-term testing needs

Journal of Experimental Botany, Finch-Savage & Bassel, 2016 | Annual Review of Plant Biology, Rajjou et al., 2012 | Tree Planters' Notes, Rudolf, 1966

Seed certification

- Seed certification ensures that every seed lot is properly identified by species and collection origin and that it has been harvested, cleaned, stored, and sold in compliance with the official certification standards

- Improves seed source tracking for contracted collections
  - Primarily used for shipping seed overseas
  - Regulations usually state-specific but must meet basic federal guidelines

- Potential to modernize and use current geospatial tools to reduce cost of verification

The Woody Plant Seed Manual, Mangold & Bonner, 2008

Challenges

Access to seed

- Different agencies have different rules and restrictions guiding seed access
- All landowners should have access to seed to meet our reforestation challenges

Opportunities

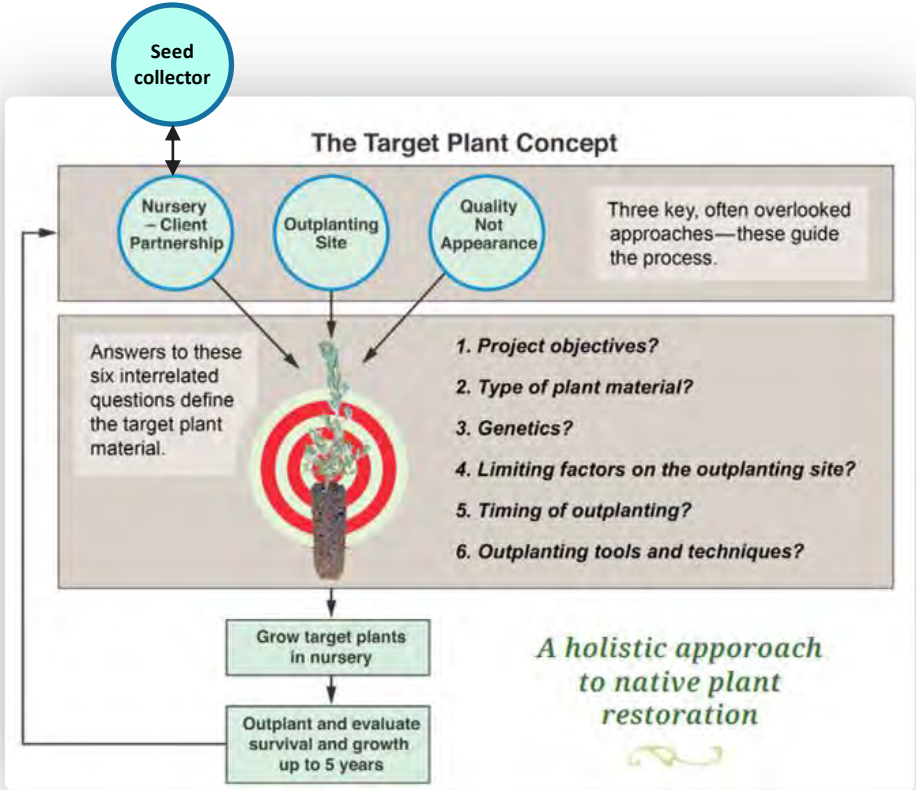
Funding and collaboration

- Understand and address funding and labor shortage - integrate how agencies and partners can work together
- Enable funding to be shared across land jurisdiction
- Find ways to structure funding to support the multi-year nature of seed sourcing/seedling production that is typically required
- Structure wildland seed (collection) contracts to increase public-private risk-sharing

Challenges & Opportunities

Continuous engagement across the reforestation pipeline is important

- The Target Plant Concept is used to define specific plant characteristics and guide nursery production based on project objectives and site conditions
- Emphasizes communication between elements of the reforestation pipeline and reinforce feedback loops
- This should include your seed collectors!



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Reforesta, Haase and Davis, 2017

Conclusions

1 Situation

- The need for reforestation is increasing
- To meet goals, more seed will be needed
- In the short-term, more seed will likely need to come from wildland collections

2 Opportunities

- Work together to assess collective inventory
- Identify gaps
- Focus on strategic collections with climate change and site vulnerability in mind
- Address bottlenecks to wildland seed collection
- Increase strategic investment into seed collection, cleaning, and storage infrastructure and training
- Find ways to share funding and increase access to seed
- Ensure a feedback loops

Acknowledgements

Thank you to the meeting organizers and to the Western Forestry & Conservation Association, and my co-authors

Support from:

Elemental Excelerator

Corinne Mock
Sr. Visual Designer, DroneSeed

Questions

State	Region	Reforestation on pasture and marginal cropland (1000s of ha)	Reforestation on natural lands (1000s of ha)	Total reforestation (1000s of ha)	Number of trees (millions)
Arizona	Western	4	522	525	389
California	Western	260	596	856	635
Colorado	Western	94	1,090	1,183	877
Idaho	Western	254	900	1,155	856
Kansas	Western	262	250	512	380
Montana	Western	175	993	1,168	866
Nebraska	Western	41	346	387	287
Nevada	Western	50	380	430	319
New Mexico	Western	10	819	828	614
North Dakota	Western	61	133	195	144
Oregon	Western	169	191	360	267
South Dakota	Western	86	568	655	485
Utah	Western	48	785	832	617
Washington	Western	134	104	239	177
Wyoming	Western	105	641	746	553
Total		**1,749**	**7,796**	**9,546**	**7,466**