Assisted Migration and Climate Adaptation

Maintaining ecosystem, function, and diversity in a changing climate

January 29, 2025 – Pull Together

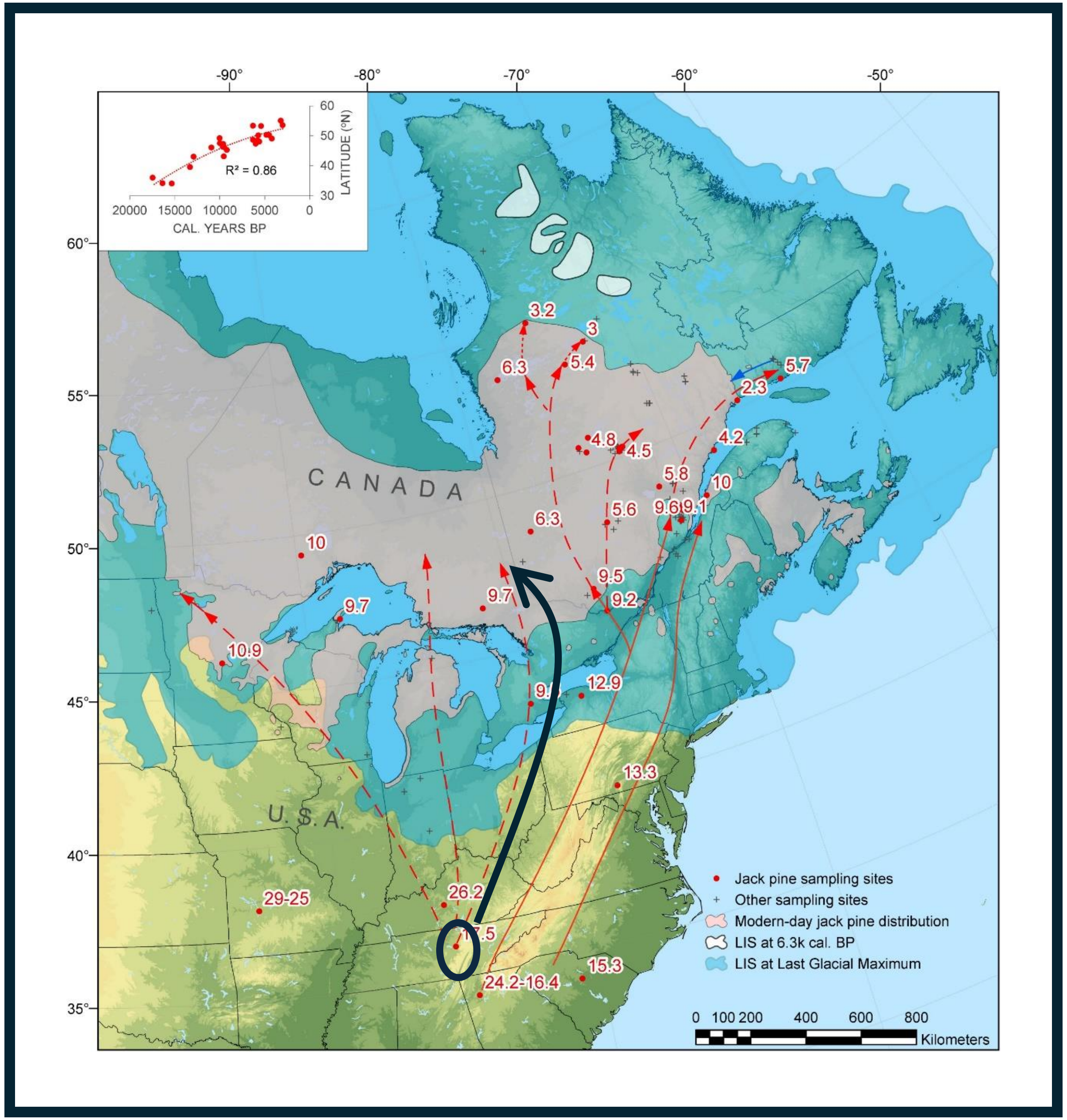
Adrienne St Clair, Mike Conroy and Jess Nettle Shamek

Climate is changing…
faster than natural migration

After the last ice age

- Jack pine moved about
  19 km per 100 years

- Blue spruce moved about
  25 km per 100 years



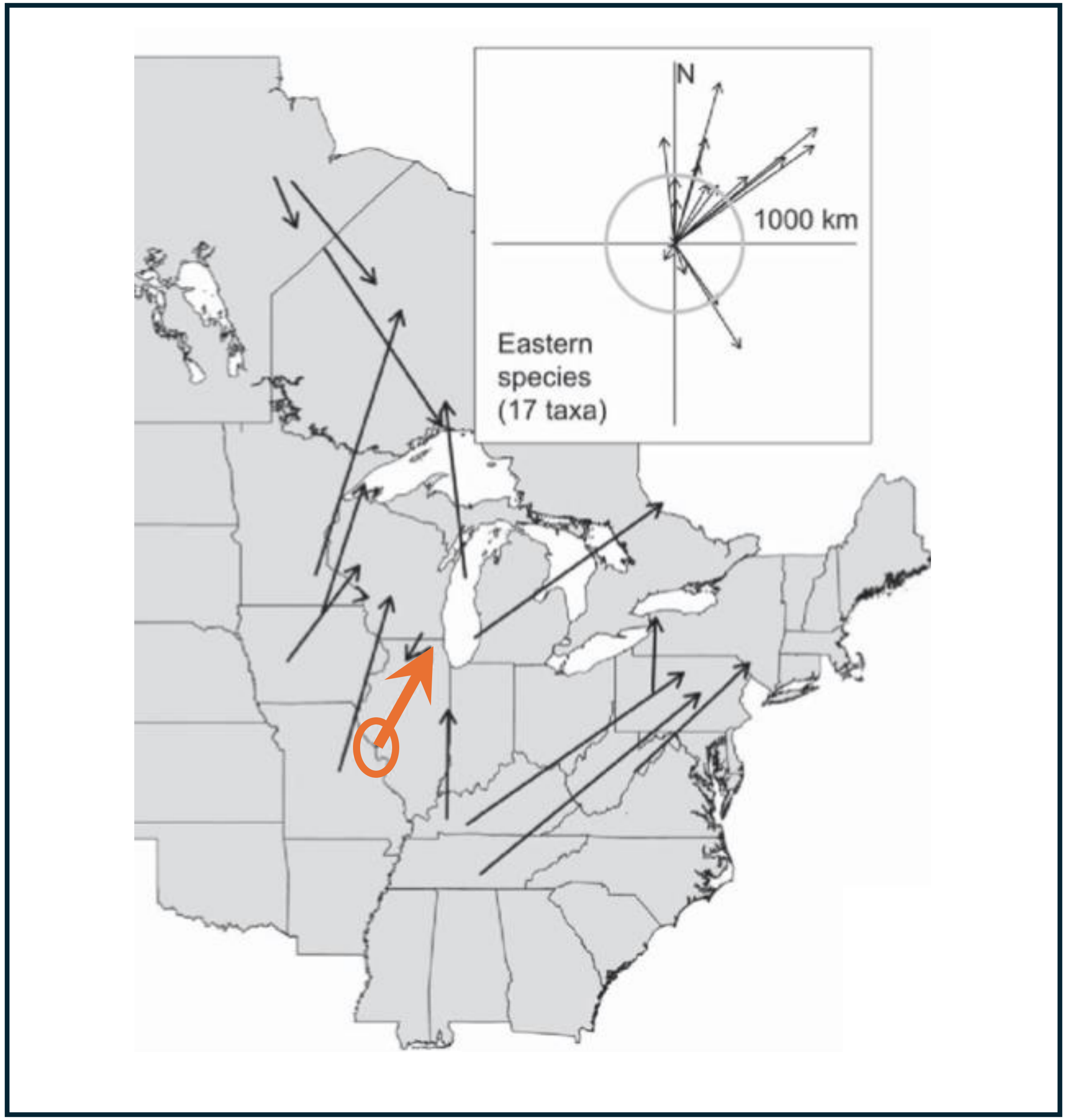
Peyette et al. 2022

Climate is changing…
faster than natural migration

Climate change isn't measured in km per century

Niches of rare species is predicted to shift, on average

500 kilometers in the next 100 years



Havens et al. 2015

What happens when climates shift that fast?

Local adaptation,

mycorrhiza

Soil type

which is driven by → climate

pathogens

pollinators

...may no longer be local

Baughman et al. 2019

We see evidence of this already

We see this anecdotally,

ENVIRONMENT

Massive die-off hits fir trees across the Northwest

Labeled "Firmageddon," by researchers, the drought-driven "mortality event" is the largest ever recorded in the region

BY: **NATHAN GILLES** - FEBRUARY 14, 2023 5:30 AM

The Pacific Northwest Region Aerial Survey is cataloging tree decline. (Daniel DePinte/U.S. Forest Service)

Columbia Insight

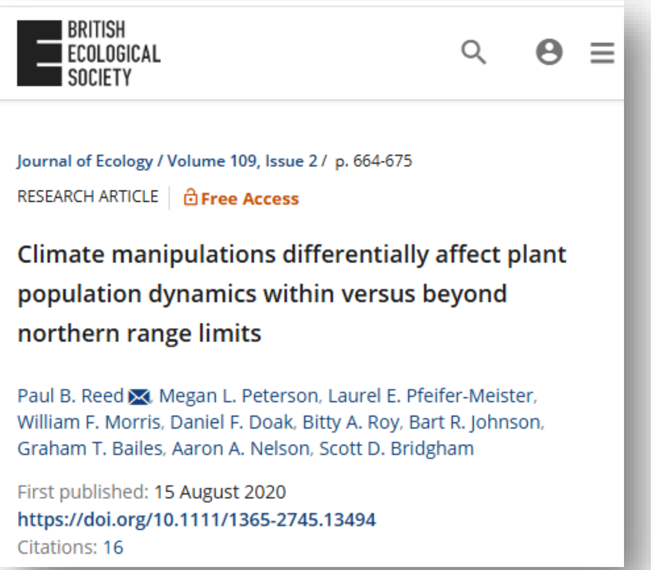
But we can also study this empirically

Rainout shelters mimic drought

Heating arrays mimic mean temp increase

Hoover et al. 2018, Kimball et al 2018, Duan et al 2022

Local results



BRITISH ECOLOGICAL SOCIETY

Journal of Ecology / Volume 109, Issue 2 / p. 664-675

RESEARCH ARTICLE | Free Access

Climate manipulations differentially affect plant population dynamics within versus beyond northern range limits

Paul B. Reed, Megan L. Peterson, Laurel E. Pfeifer-Meister, William F. Morris, Daniel F. Doak, Bitty A. Roy, Bart R. Johnson, Graham T. Bailes, Aaron A. Nelson, Scott D. Bridgham

First published: 15 August 2020
https://doi.org/10.1111/1365-2745.13494
Citations: 16

Idaho fescue shows declining germination and seed set with warming

esa

Journal | Articles

Ecology / Volume 94, Issue 10 / p. 2131-2137

Report | Free Access

Pushing the limit: experimental evidence of climate effects on plant range distributions

Laurel Pfeifer-Meister, Scott D. Bridgham, Chelsea J. Little, Lorien L. Reynolds, Maya E. Goklany, Bart R. Johnson

First published: 01 October 2013
https://doi.org/10.1890/13-0284.1
Citations: 23

Corresponding Editor: M. C. Wimberly.

Prairie species will have limited persistence due to reduced seed germination and establishment

More data here

There are limited empirical studies done on local species. More needed!

Changing climate = changing phenology

- Later-season
- Higher elevation
- Inland

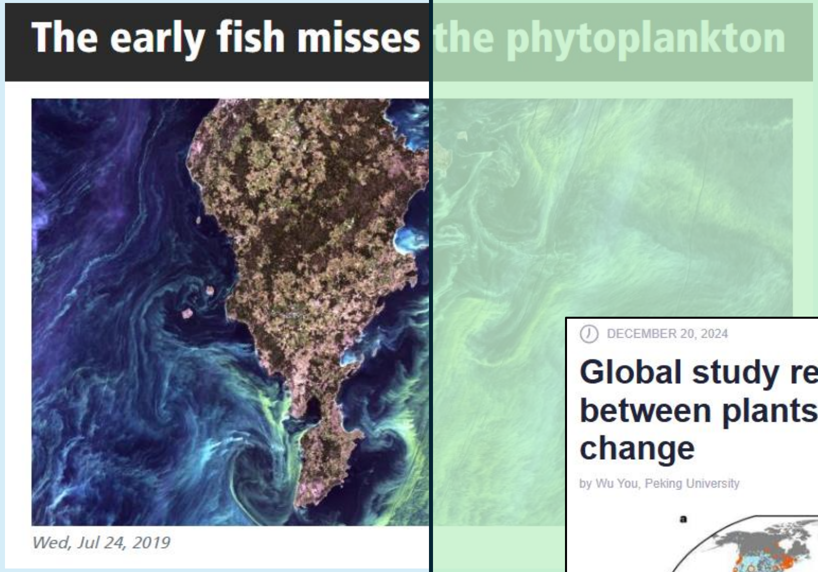
Flowering earlier

- Early season
- Lower elevation
- Maritime

Flowering EVEN EARLIER

Average change of 4.4 days earlier per 1° C change

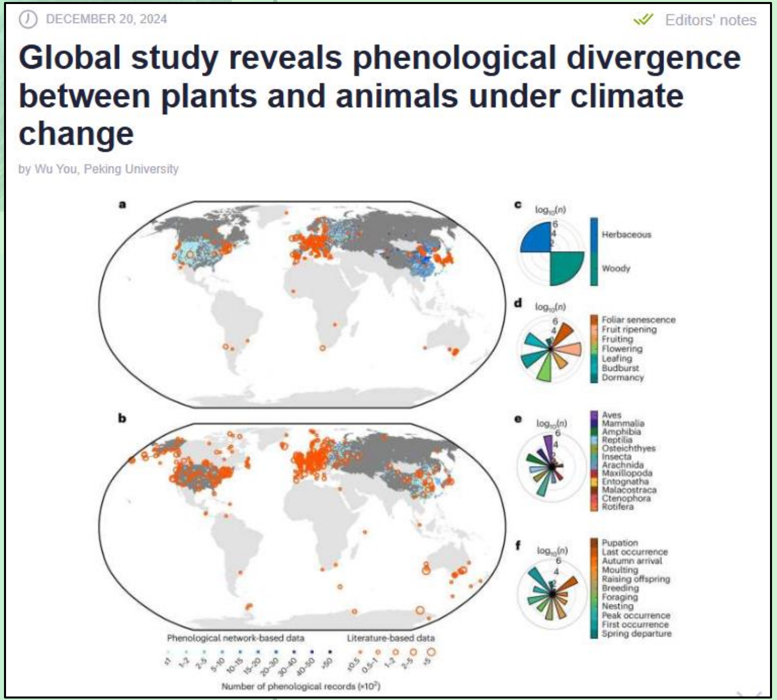
Kopp 2020 (photo credits Metro, Barbara Wilson)



Fish spawning may no longer match food source

Asch 2019

Globally, plant phenophases change more than animal phenophases



DECEMBER 20, 2024

Editors' notes

Global study reveals phenological divergence between plants and animals under climate change

by Wu You, Peking University

Lang et al. 2024

If locally adapted plants are no longer locally adapted, a next progression of thought might be, perhaps we should move plants up to this region from an area currently experiencing our projected future climate, so they are "already adapted" to these warmer conditions.

Managed relocation

Movement of:

species or individuals

within or outside
of their ‘current’ range

In order to:

- Maintain ecosystem function
- Encourage genetic diversity
- Protect a species from extinction

Managed relocation

Assisted species migration

Assisted range expansion

Rewilding

Translocation

Assisted gene flow

Assisted migration

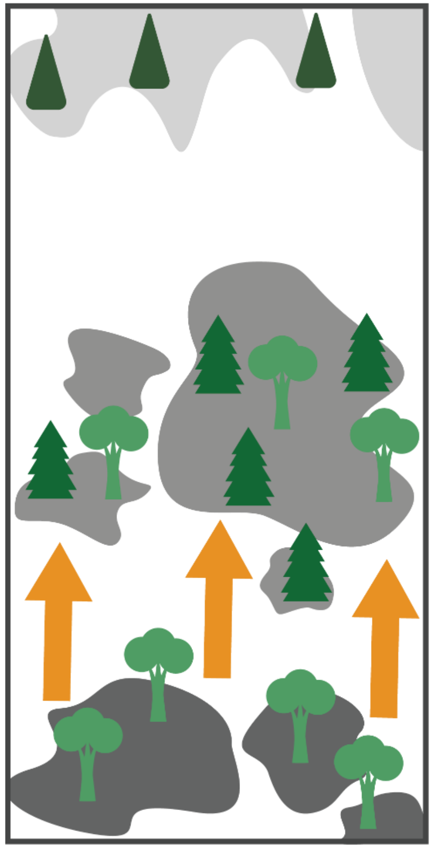
Assisted population migration

Just as with any emerging technology, the terminology is not well defined and depends on who you're speaking with. It's important to define your terms in any conversation about topics such as these

Managed relocation

For the purposes of this talk, we'll trim it down to two main actions:

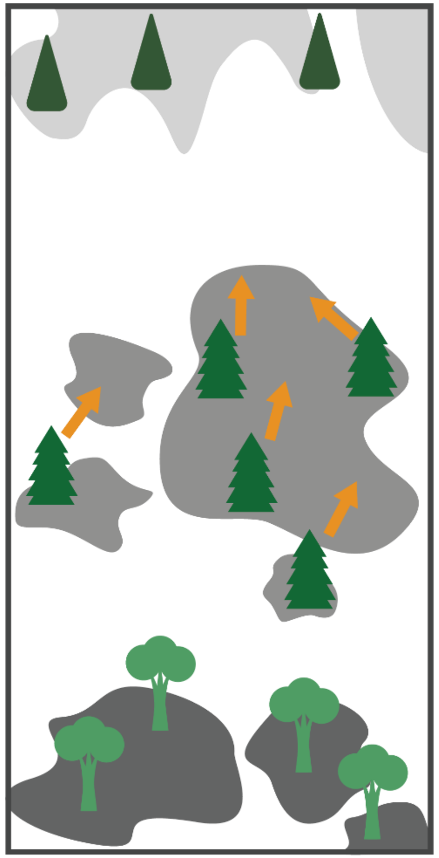
Assisted Migration



Movement of **species outside** of their current geographic range

Assisted Gene Flow

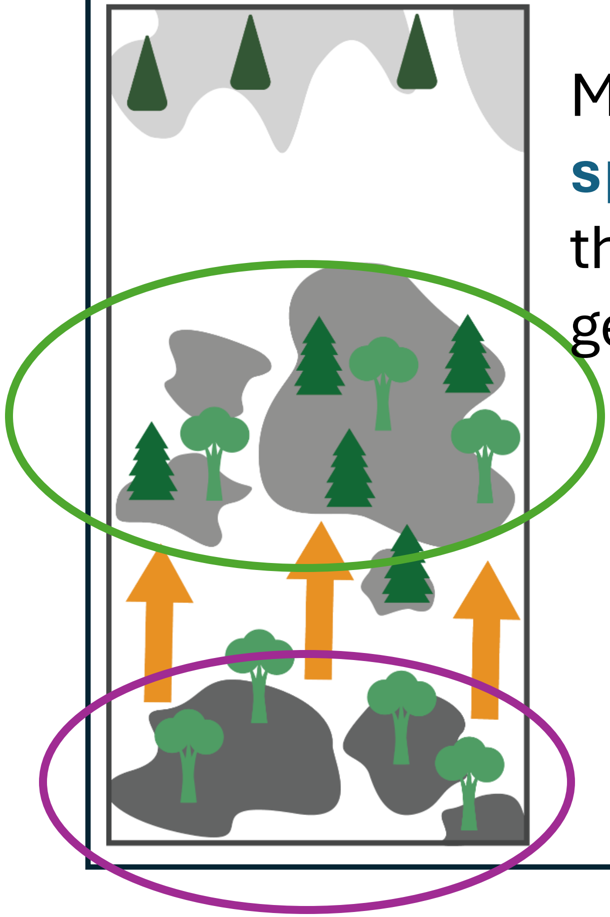
Movement of **individuals** (genotypes) **within** their current geographic range



Modified from USDA Climate Hubs

Managed relocation

Assisted Migration



Movement of **species outside** of their current geographic range

Driven by a need in the final translocation region

- e.g., filling a **niche** left by a species in decline

or

Driven by the target **species** we're moving

- e.g., moving a species that is losing habitat due to climate change

Modified from USDA Climate Hubs

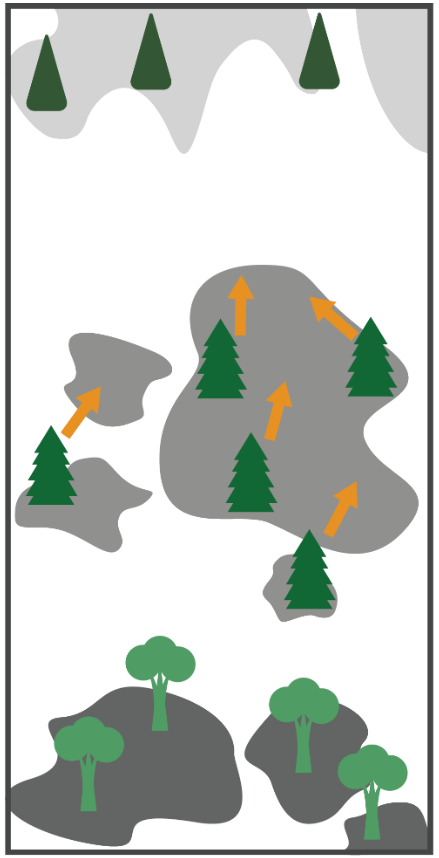
Managed relocation

Assisted Gene Flow

Goals:

- Mitigate isolation by human interference
  - Mimic historic gene flow
  - Combat inbreeding depression
- Intentionally place populations in more suitable microclimates

Movement of **individuals** (genotypes) **within** their current geographic range



Modified from USDA Climate Hubs

How do we make choices moving forward?

Species on the landscape define people's personal and cultural relation to the land.

While we don't have time for long-term studies before action,
we can move forward with intention and following the best available science.

#itscomplicated

Collecting cottonwood buds

What is our projected climate analog?

Many aspects of climate affect plants' and animals' life cycles…

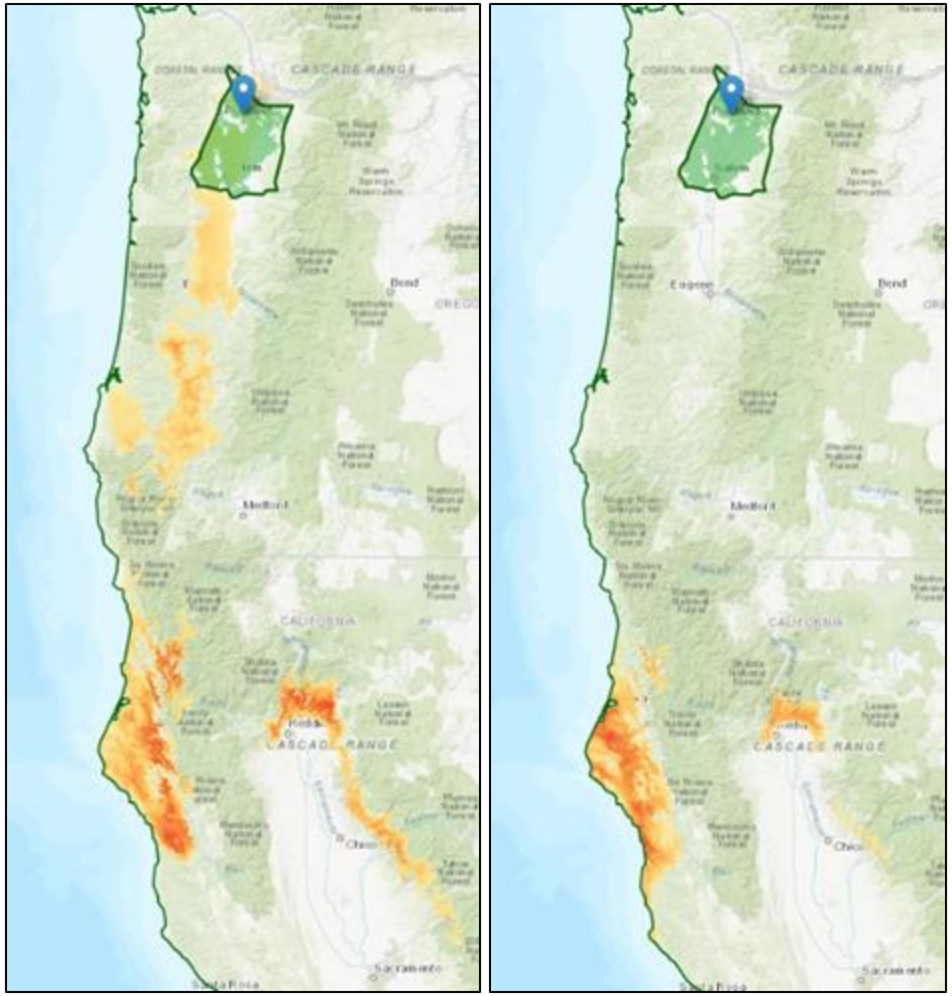
Temperature
- Annual temperature
- Warmest or Coldest month temperatures

Precipitation
- Annual precipitation
- Summer precipitation

Heat moisture index – summer or annual

Etc., etc.

All models are wrong, but some are useful. These models were built off of fairly large-scale climate data. They do not take into account microclimates or microsites which will be important refugia for individuals



2041-2070 2071-2100

Tom Kaye, 2020. Report to TSWCD.

Models: useful and incomplete

Phenotypic plasticity

Spring Summer

Adaptive potential

Cryptic diversity

2n 4n 6n 8n

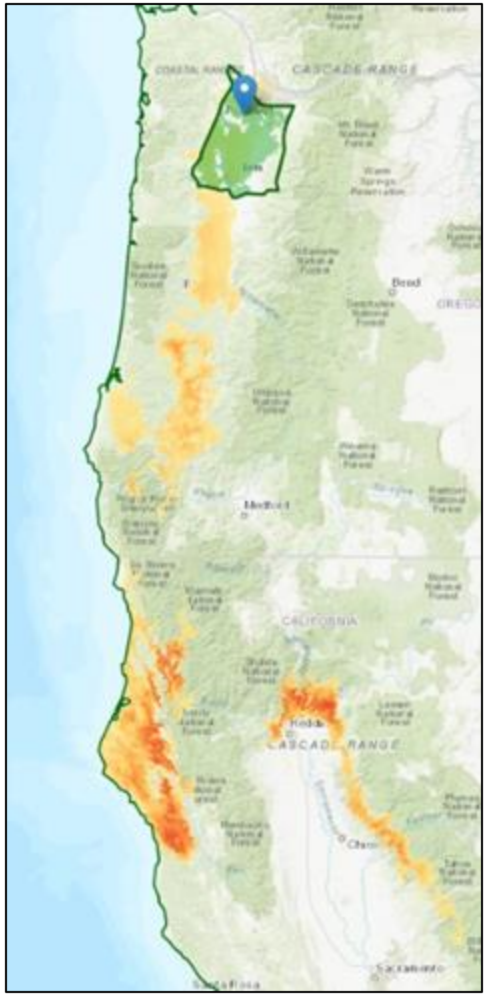
Species or population genetic diversity

- Adaptation can occur in as little as 1 generation
- Adaptation only arises from genetic diversity

Biological concepts such as phenotypic plasticity, species diversity and cryptic diversity, among other things, combine to define a species' adaptive potential. This potential is not captured in climate change models.

Photos: Luis Navarro, Metro,

What is our projected climate analog?



2041-2070

2071-2100

Tom Kaye, 2020. Report to TSWCD.

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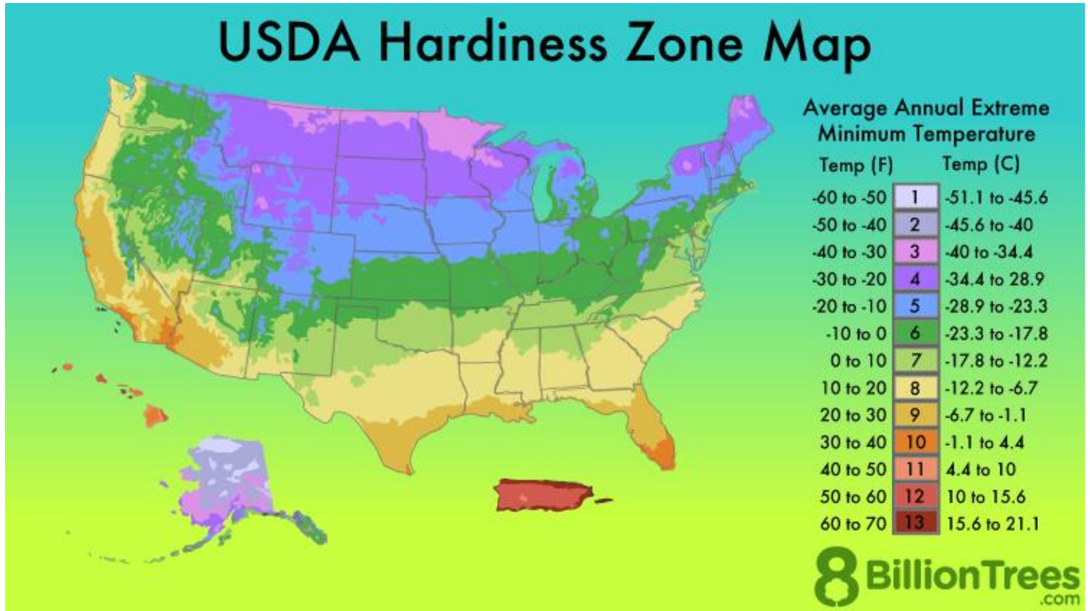


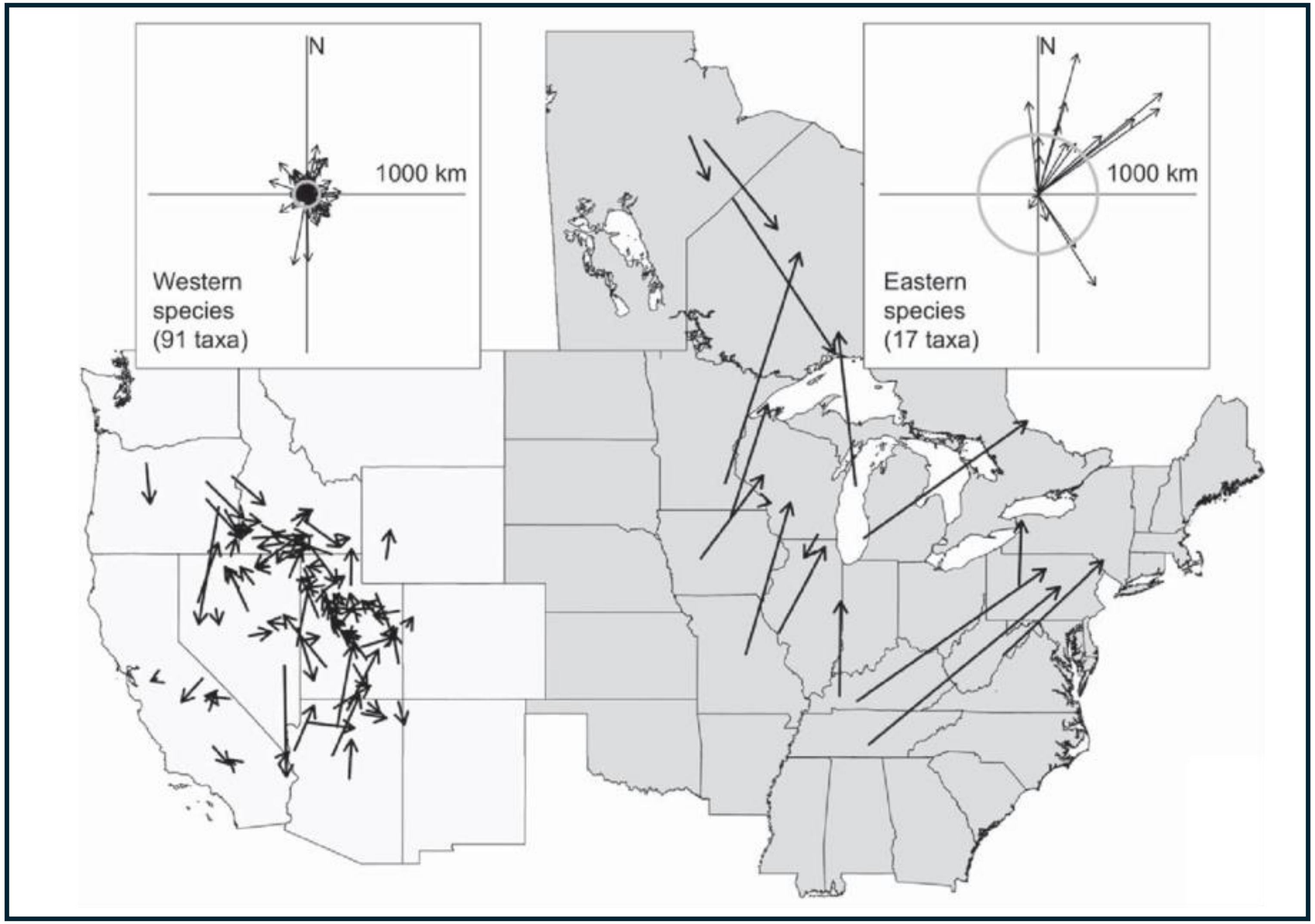
The climate analogs for the future climate of the Pacific Northwest currently lie from Eureka to Ukiah and on the south slope of the Cascade range near Redding.
Why do these maps not look like the old fashioned USDA Hardiness Zone maps? The answer has to do with elevation and microclimates.

Microclimates are complex

Microclimates interact with elevation

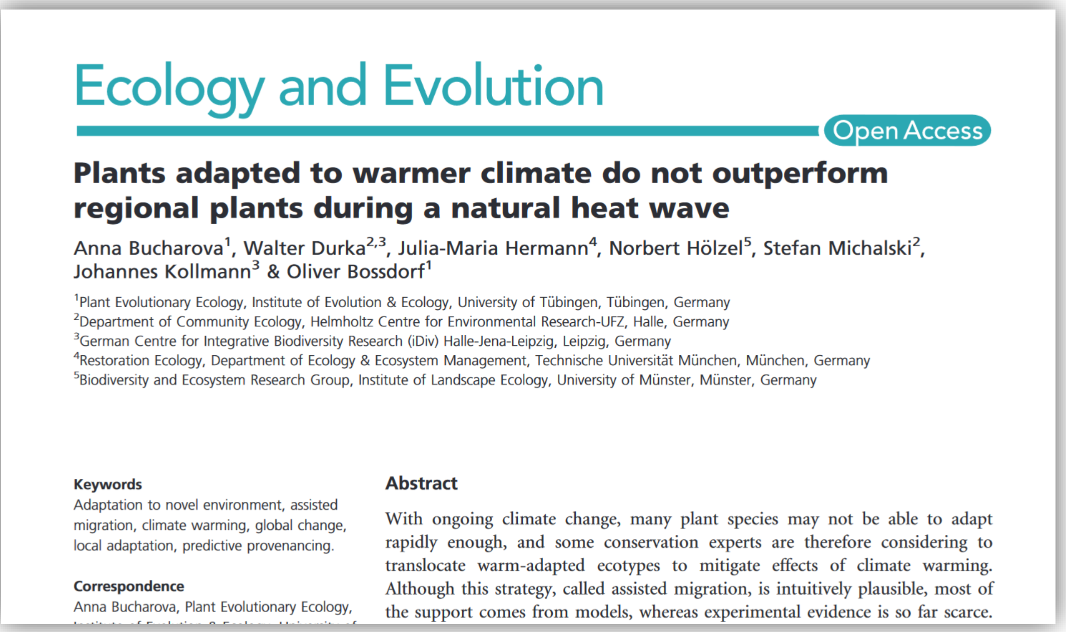
A simple movement of plants or species from south to north may not be the full picture

As you get west into the Rockies, everything changes. Now climates are moving up or down slopes, from the south side of a mountain to the north, or from the west slopes to the east.



Havens et al. 2015

Sometimes local may still outperform



Ecology and Evolution

Open Access

Plants adapted to warmer climate do not outperform regional plants during a natural heat wave

Anna Bucharova[1], Walter Durka[2,3], Julia-Maria Hermann[4], Norbert Hölzel[5], Stefan Michalski[2], Johannes Kollmann[3] & Oliver Bossdorf[1]

[1]Plant Evolutionary Ecology, Institute of Evolution & Ecology, University of Tübingen, Tübingen, Germany
[2]Department of Community Ecology, Helmholtz Centre for Environmental Research-UFZ, Halle, Germany
[3]German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, Germany
[4]Restoration Ecology, Department of Ecology & Ecosystem Management, Technische Universität München, München, Germany
[5]Biodiversity and Ecosystem Research Group, Institute of Landscape Ecology, University of Münster, Münster, Germany

Keywords
Adaptation to novel environment, assisted migration, climate warming, global change, local adaptation, predictive provenancing.

Correspondence
Anna Bucharova, Plant Evolutionary Ecology,

Abstract

With ongoing climate change, many plant species may not be able to adapt rapidly enough, and some conservation experts are therefore considering to translocate warm-adapted ecotypes to mitigate effects of climate warming. Although this strategy, called assisted migration, is intuitively plausible, most of the support comes from models, whereas experimental evidence is so far scarce.

Common garden study followed

- 6 grassland species
- Grown in 4 regional locations
- Experienced a natural heat wave

- In 4 of the species there was no difference in performance
- In 2 species the local ecotypes outperformed the warmer-adapted ecotypes

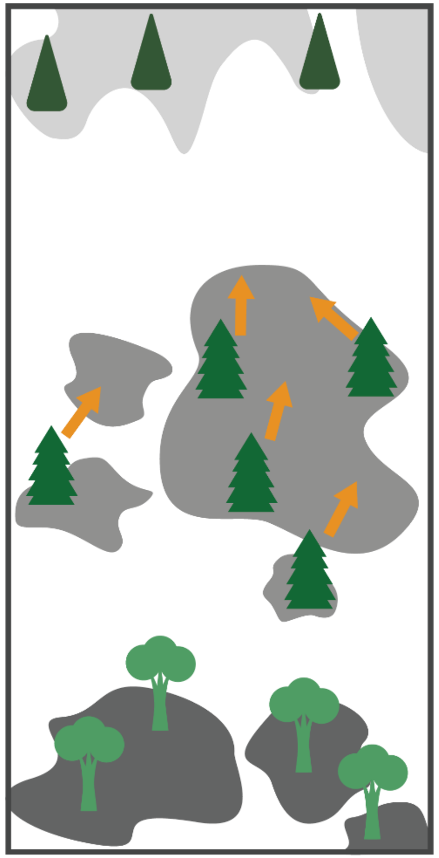
The 2 species who's local populations outperformed likely had some factor other than climate to thank. For instance, they could have had a mychorrizal association that allowed them to persist.

Bucharova et al. 2016

For climate-forward restoration, genetic diversity is key

- Plants can have high adaptive capacity but only if they have the genetic information to work from.
- Urbanization has isolated populations, but we move a LOT of material around for restoration, how can we optimize this resource for genetic diversity?
- Intentional gene flow from areas with varying climactic conditions could improve response to climate change.

Assisted Gene Flow



Modified from USDA Climate Hubs

Climate Adapted Plant Materials Project

Preparing for an Uncertain Future

Tualatin River Watershed

Tualatin Soil and Water
CONSERVATION DISTRICT

Clean Water Services

Institute for Applied Ecology

Provision of Ecosystem Services– Riparian Reforestation

- Plantings generate shade credit to meet regulatory requirements
- Maintain function to maintain credit
- Trees and shrubs are Green Infrastructure

Tualatin Basin Story
https://www.jointreeforall.org/

Climate Change Locally

Western redcedar dieback Photo by Joey Hulbert

Climate Change – Felt and Forecast

- Annual temps increasing, extreme heat events more frequent
- Annual precip roughly the same, but decrease during summer

Impacts for Riparian Restoration

- Decline in iconic PNW species like Douglas-fir and Western redcedar
- Increased drought mortality of planted seedlings
- Land managers altering species selections without guidance
- Overlap with Oregon ash replacement

CAPM Common Garden Project

Project Timeline

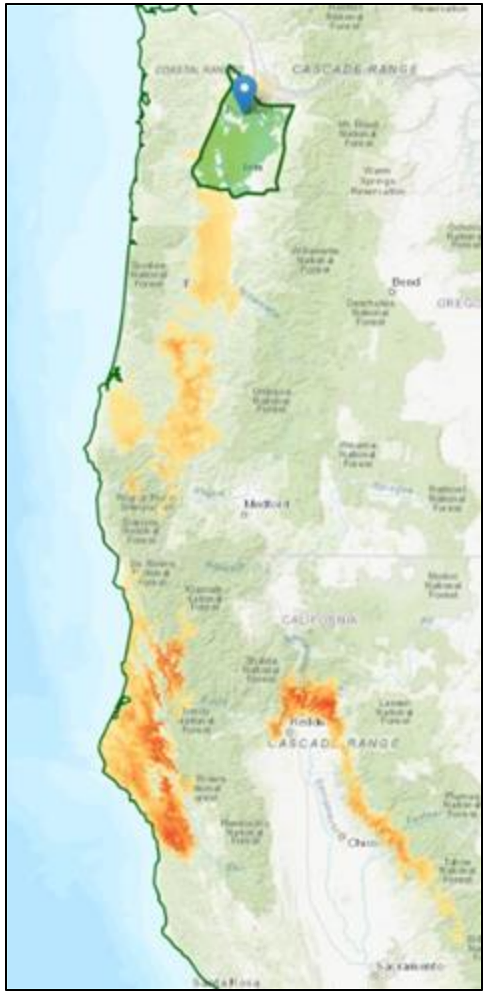
Phase	Name	Fiscal Years	Status
1	Scope Development	2020	Complete
2	Analog Surveys	2021	Complete
3	Synthesize Analog Survey Data	2022	Complete
4	Experimental Design and Developing Guidance	2022-2024	Complete
5	Seed Collection	2023-2025	Complete*
6	Plant Material Grow Out	2023-2026	In Progress
7	Establish Common Garden	2024-2026	In Progress
8	Monitor and Refine Guidance	2024-	In Progress

*Potential to recollect Oregon White Oak in 2025 due to grow out problems

Phase 1 – Scope Development (SST)

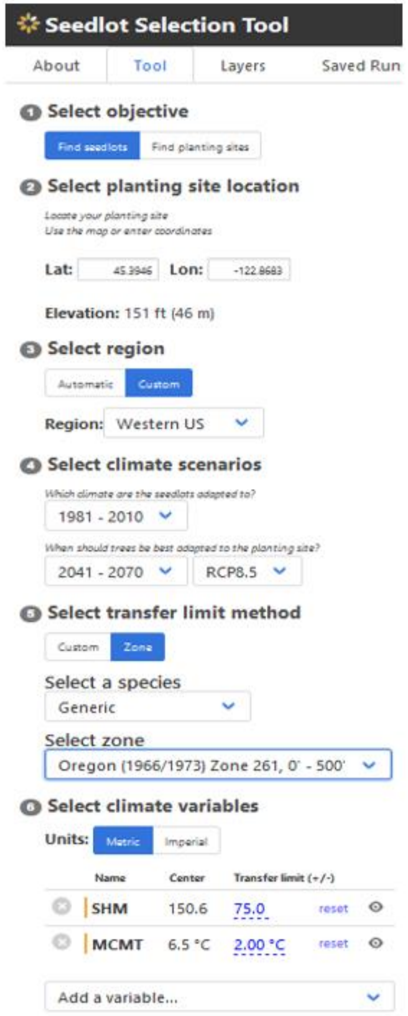
Completed in 2020

Tom Kaye, 2020. Report to TSWCD.



2041-
2070

2071-
2100



Key Variables

- Mean Coldest Month Temperature (MCMT)
- Summer Heat-Moisture Index (SHM)

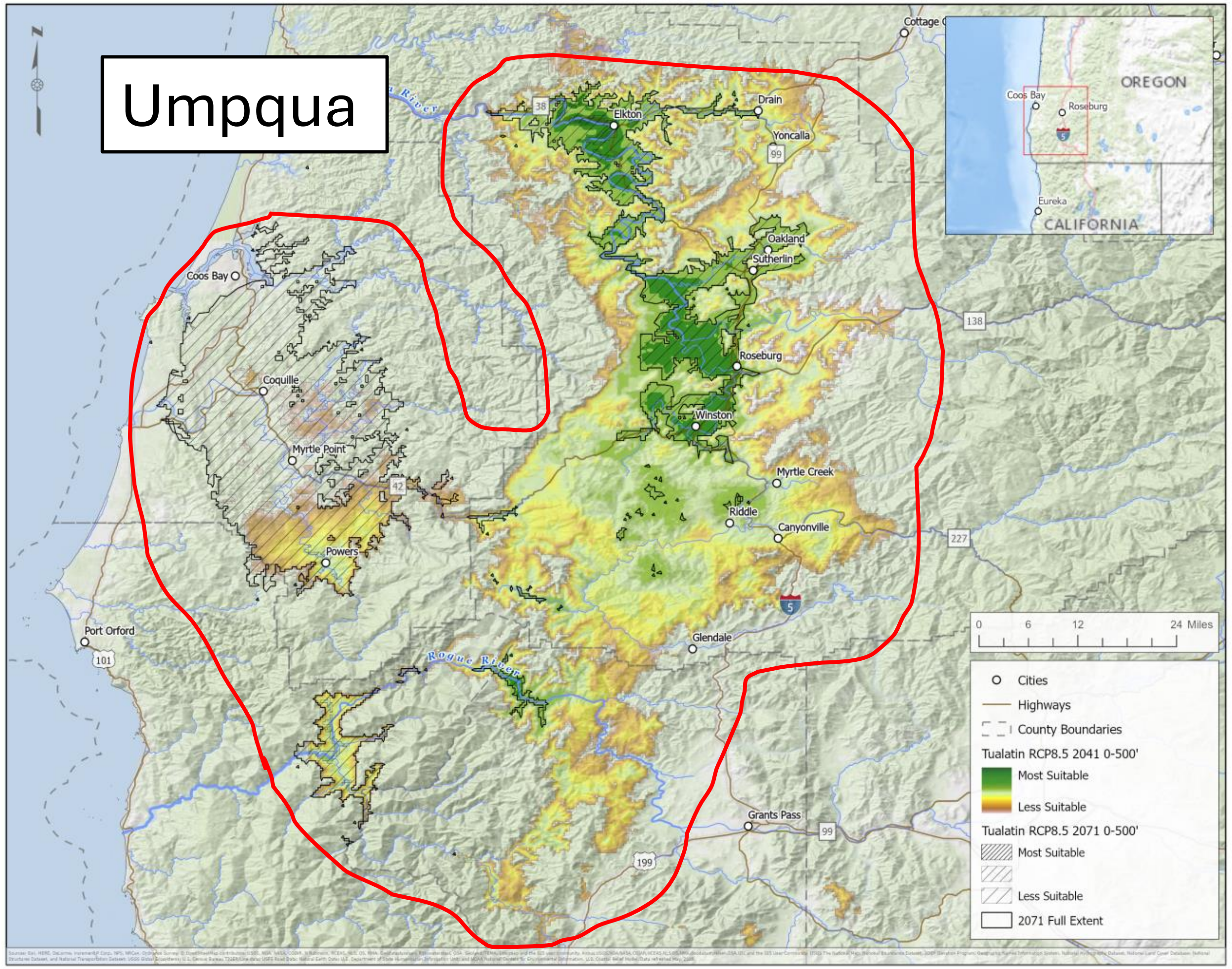
Recommendations From

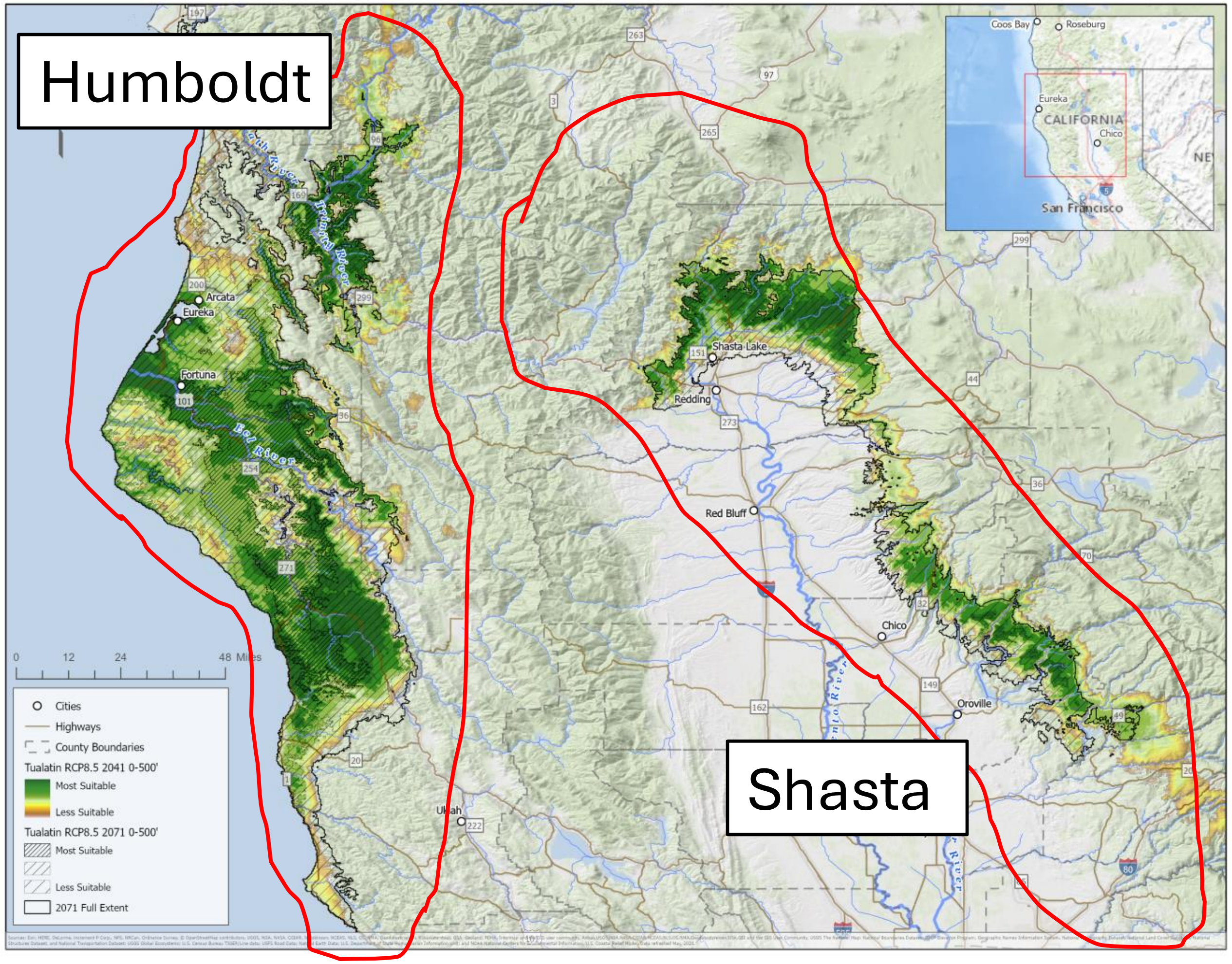
https://rb.gy/qdthat

Seedlot Selection Tool and Climate-Smart Restoration Tool: Web-based tools for sourcing seed adapted to future climates

John Bradley St.Clair[1] | Bryce A. Richardson[2] | Nikolas Stevenson-Molnar[3] | Glenn T. Howe[4] | Andrew D. Bower[5] | Vicky J. Erickson[6] | Brendan Ward[3] | Dominique Bachelet[3] | Francis F. Kilkenny[7] | Tongli Wang[8]

Phase 1 – Scope Development (SST)





Maps by Ben Protzman, CWS

Phase 2 – Climate Analog Surveys

Completed in 2021

Limitations

- Public access, landscape position
- Fine grained soils elusive
- Northern California Fog Belt

Excluded

- Serpentine Soils
- Gravels and cobbles
- Human Disturbance

Surveyor on Klamath River – Stillwater Sciences

Phase 3 – Synthesize Analog Survey Data

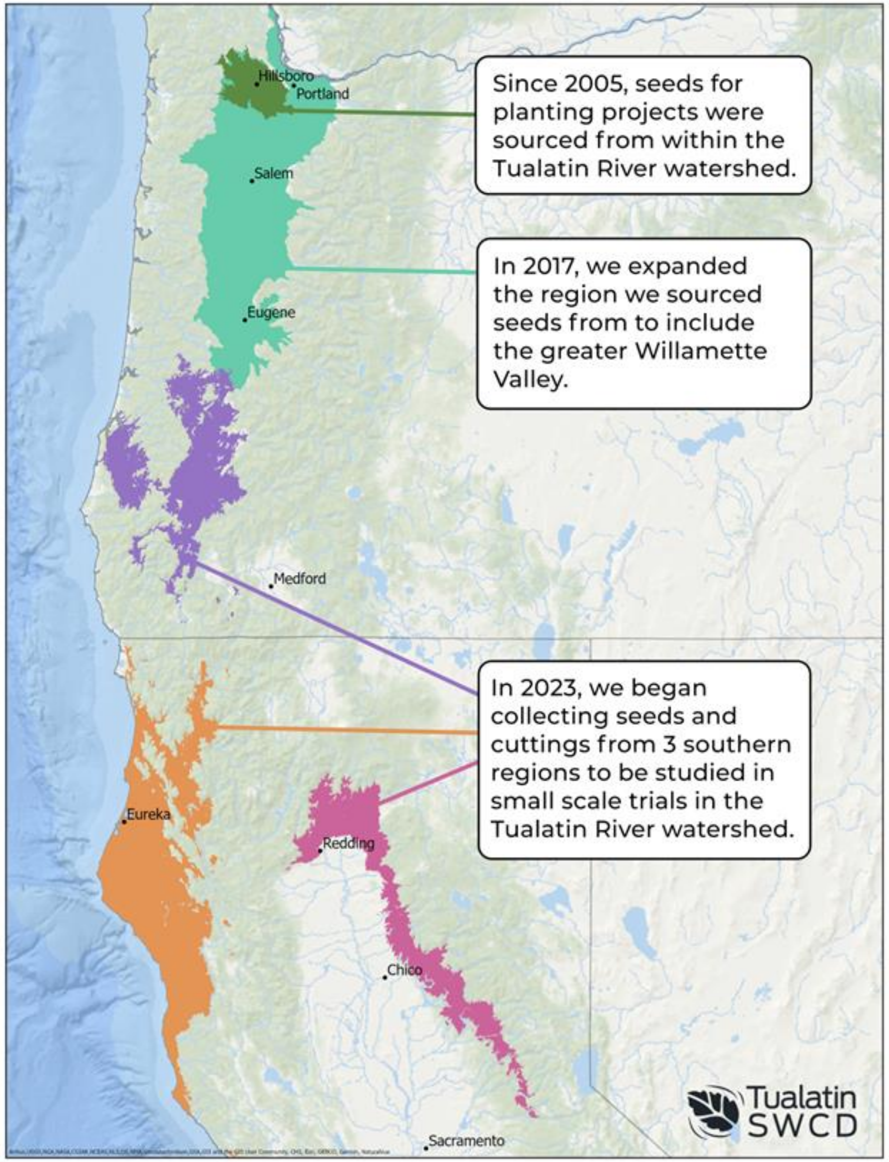
Completed in 2022

Common Name	Species
Bigleaf maple	Acer macrophyllum
Blackfruit dogwood	Cornus sessilis
California bay laurel	Umbellularia californica
California black oak	Quercus kelloggii
Cascara	Rhamnus purshiana
Douglas fir	Pseudotsuga menziesii
Douglas spiraea	Spiraea douglasii
Hooker's willow	Salix hookeriana
Incense cedar	Calocedrus decurrens
Oregon ash	Oregon ash
Oregon grape	Mahonia aquifolium
Oregon white oak	Quercus garryana
Osoberry	Oemleria cerasiformis
Pacific ninebark	Physocarpus capitatus
Pacific willow	Salix lasiandra
Ponderosa pine	Pinus ponderosa
Red alder	Alnus rubra
Red osier dogwood	Cornus sericea
Salmonberry	Rubus spectabilis
Snowberry	Symphoricarpos albus
Swamp rose	Rosa pisocarpa
Thimbleberry	Rubus parviflorus
White alder	Alnus rhombifolia

Criteria for species to test

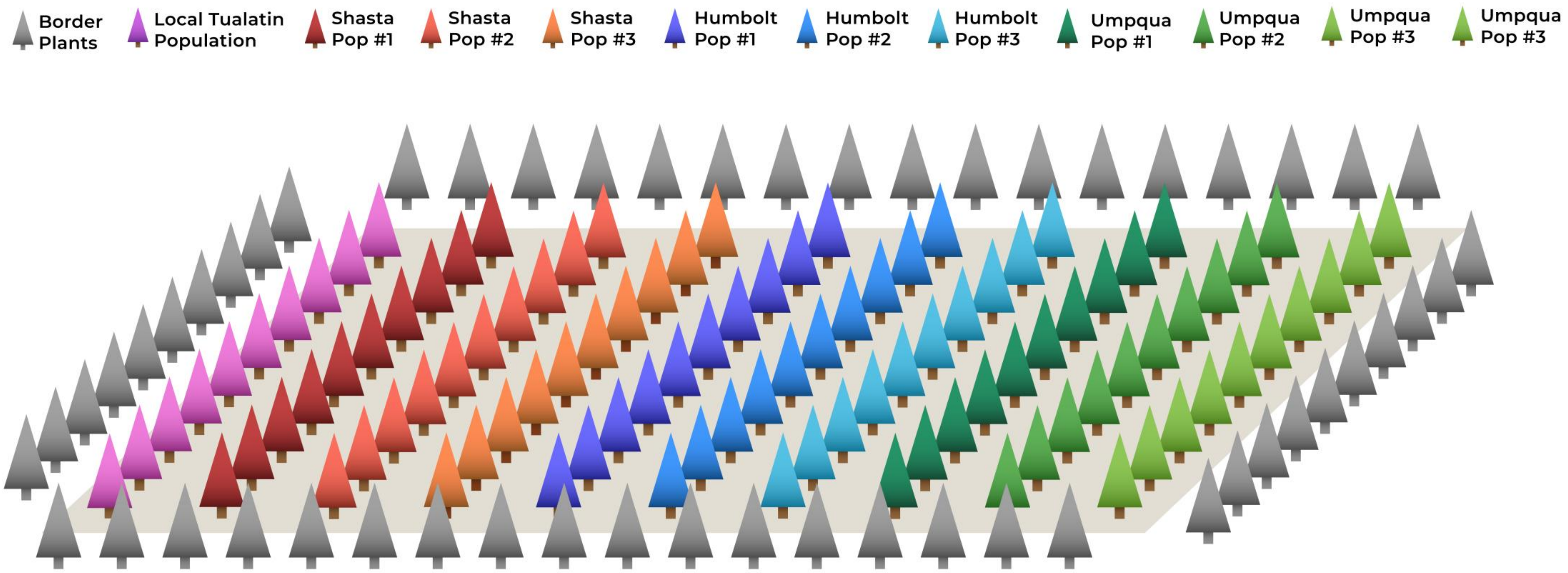
- Cover and frequency local and in analog regions
- Risk
- Ease of establishment

3 of the target species could be considered range expansion, only one of the species is true Assisted Migration (Cornus sessilis).



Phase 4 – Common Garden Design and Interim Guidance

Garden Design is Complete



While this illustration shows them in rows for simplicity, in the field plots they are randomly assigned location

Phase 5 – Seed and Cutting Collection

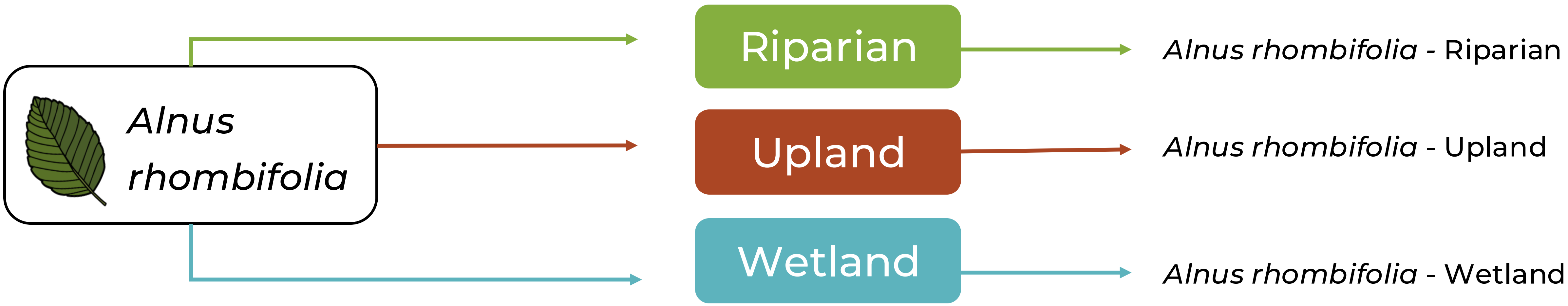
Started February 2023, Finishing in 2025

49 Species-Community Units (SCU)

SPECIES (24)

COMMUNITIES (1 to 3)

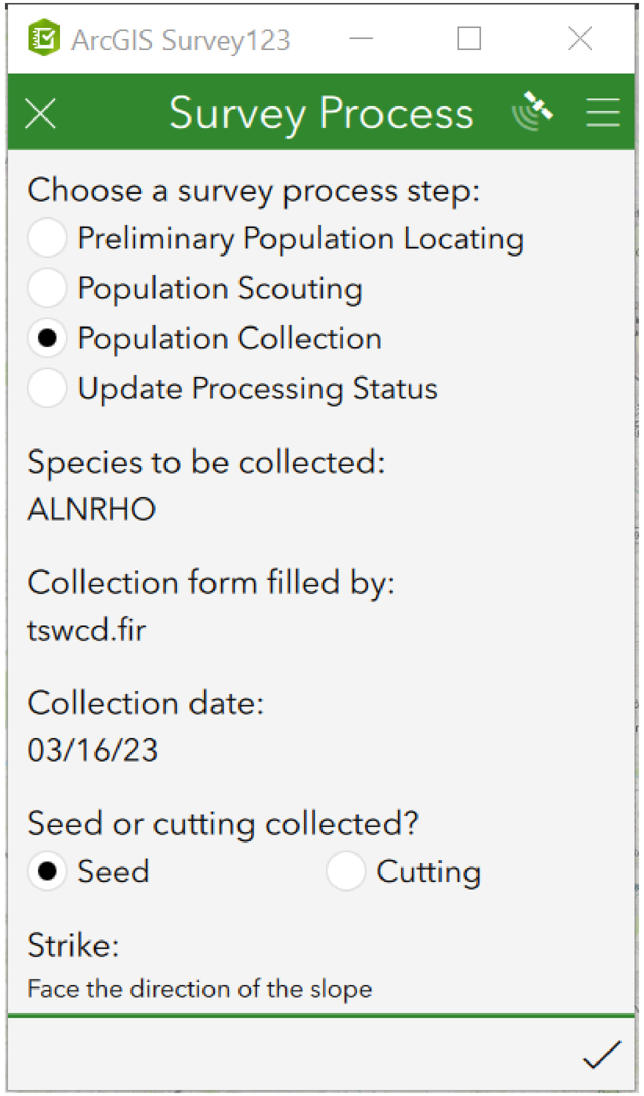
SPECIES COMMUNITY UNIT



Phase 5 – Seed and Cutting Collection

Started February 2023, Finishing in 2025

Jonny Native Seeds



Phase 6 – Plant Material Grow Out

In progress, finish in 2026

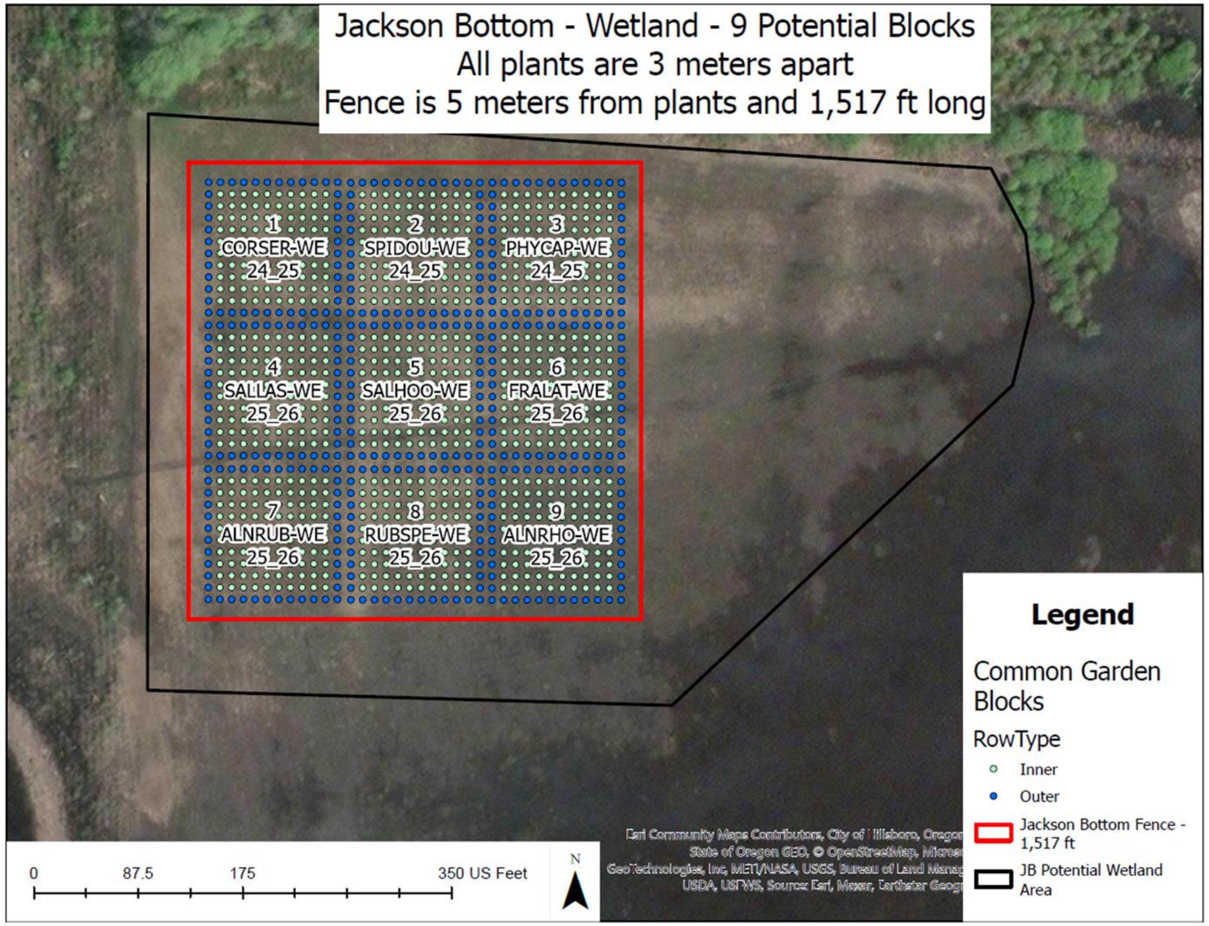
Sort → Sanitize → Rinse → Root hormone → Pot

Isolated Clean Nursery

Lots of care was taken to assure we weren't transporting pathogens.

Phase 7 – Establish Common Garden

In progress, finish in 2026



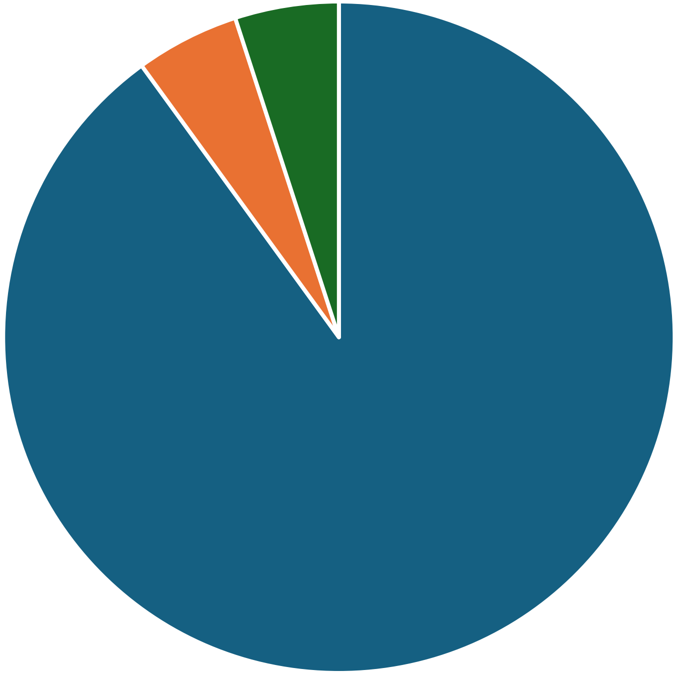
Phase 8 – Monitor and Refine Guidance

Performance objective	Category	Measure	Priority	Year 0	1	2	3	5	10	15	20
Function	Morphology	Height	1		x	x	x	x	x	x	x
		Length & width	1				x	x	x	x	x
		Leaf area	3				Upon reaching leaf area threshold				
		LMA & SMA	3								
Adaptation	Phenology	Leaf budburst	2				x	x			
		First flower	2				x	x			
	Fitness	Germination	1	x	x						
		Bud mortality	2			x	x	x	x	x	x
		Stem mortality	1			x	x	x	x	x	x
		Plant mortality	1			x	x	x	x	x	x
		Flower/fruit numbers	1			x	x	x	x	x	x
		Filled seed production	2					x	x	x	x
Resilience		Vigor	1					x	x	x	x
		Herbivory	1			x	x	x	x	x	x
		Disease & pathogens	1			x	x	x	x	x	x
	Physiology	Photosynthetic rate	3					x	x	x	x
	Site	Soil moisture	2		Continuous logger at 1-hr interval						
		Soil temperature	2		Continuous logger at 1-hr interval						

Measurements for the common garden experiment (IAE)

Phase 8 – Monitor and Refine Guidance

Assisted Migration is one of several strategies for sourcing seed for restoring resilient native plant communities



Native Seed Sourcing Strategies

90% Local and Commercial

5% Local and Harsh Sites

5% Climate Adapted

- **Assisted Gene Flow**
- **Assisted Range Expansion**

Climate Adapted Plant Materials Project

For more information and project updates visit:

www.tualatinswcd.org/projects/climate-adapted-plants-study

Thank You

Mike Conroy, Habitat Conservation Specialist

mike.conroy@tualatinswcd.org

Tualatin Soil and Water Conservation District

Institute for Applied Ecology

Clean Water Services

Source: Jonny Native Seeds

Navigating Assisted Migration

Risks, Responsibilities, and Alternatives in Climate Adaptation

Outline

1. Risk and Benefits of Assisted Migration (AM)
2. Responsibility and Risk Assessments.
3. Metro and Climate Adapted Plant Materials
4. Moving Forward with Cooperation and Caution

Jess Nettle Shamek, Ph.D., Associate Natural Resource Scientist at Metro and Golden Paintbrush (*Castilleja levisecta*) at Howell Territorial Park in 2019.

<u>We're</u> talking to <u>you</u> about assisted migration today…

but this group of people is arguably more familiar with the unintended consequences of assisted migration than anyone else.

Arum italicum, Taeniatherum caput-medusae, and Crataegous monogyna. Photos are CC from Wikipedia.

We see three general trends of how people use Assisted Migration

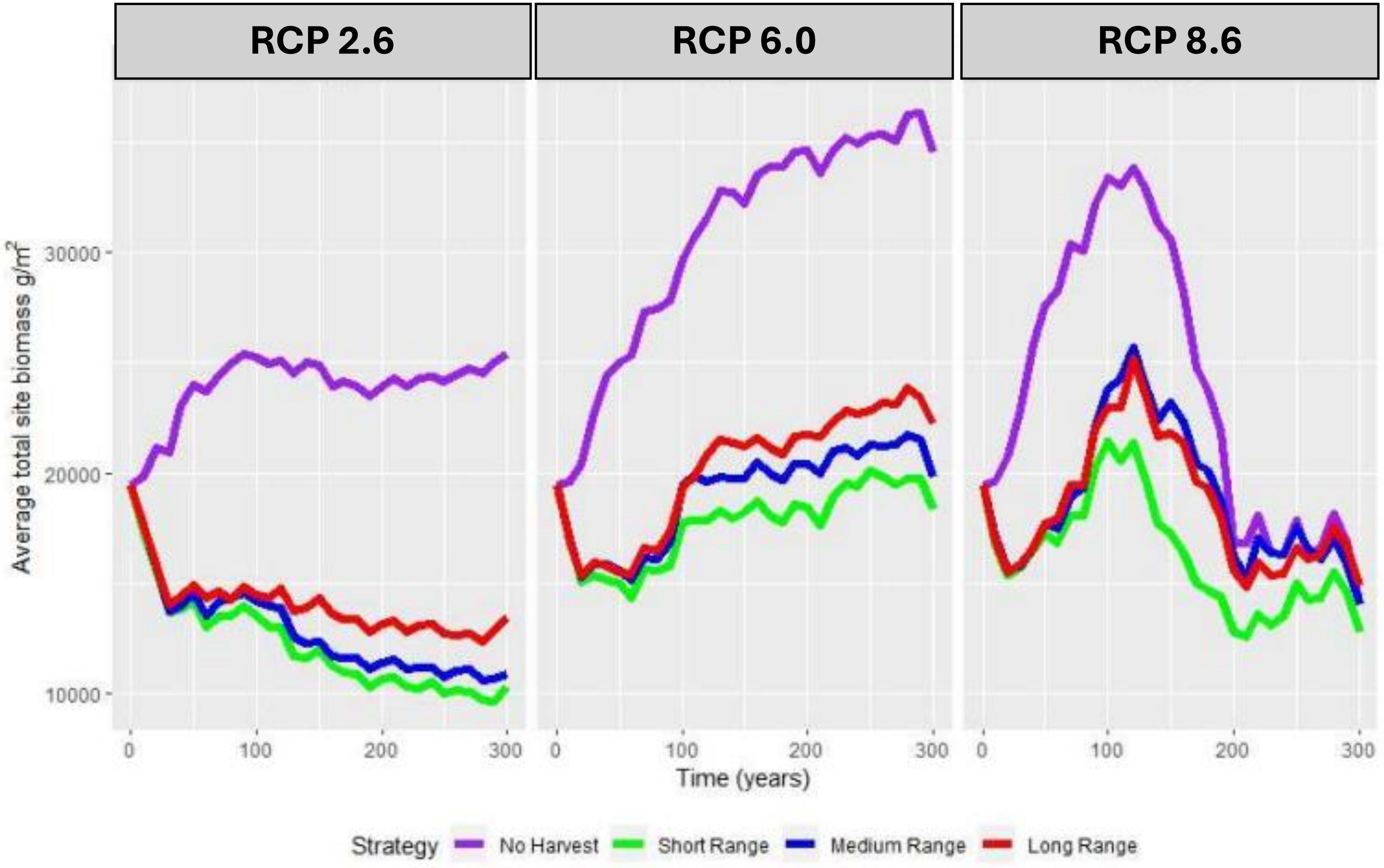
The feds use it in response to the ESA to reintroduce species.

The forestry industry and government in Canada use it maintain forest products.

And now in the United States local organizations and land managers are utilizing it primarily for conservation.

Golden Paintbrush (*Castilleja levisecta*) at Cooper Mountain Nature Park in 2019.

AM is becoming a normalized conservation practice...



(Gustafason et al., 2022)

But will it work?

The **consequences and success of Assisted Migration remain an open question** (Bucharova 2016; Hewitt et al., 2011).

The ability of assisted migration to maintain ecosystem function and biodiversity remains an open question. While most models agree that it can protect or enhance species diversity in mild and moderate scenarios, they also show that it alone cannot maintain ecosystem function or diversity through the most extreme climate scenarios AND the moral justification is still hotly debated.

What do we know about the risks of assisted migration?

Ensemble modeling suggest that **if assisted migration is successful, it is likely to drive more species to extinction than it saves**.

Conservation Biology

Contributed Paper

Using ensemble modeling to predict the impacts of assisted migration on recipient ecosystems

Katie Peterson [1*,†] and Michael Bode [2]

[1]ARC Centre of Excellence for Coral Reef Studies, Sir George Fisher Research Building, James Cook University, 1 James Cook Drive, Douglas, QLD 4814, Australia
[2]School of Mathematical Sciences, Queensland University of Technology, 2 George Street, Brisbane, QLD 4000, Australia

"Using an ensemble of simulated 15-species recipient ecosystems, we estimated that translocated species will successfully establish in 83% of cases if introduced to stable, high-quality habitats. However, assisted migration projects were estimated to cause an average of 0.6 extinctions and 5% of successful translocations triggered 4 or more local extinctions."

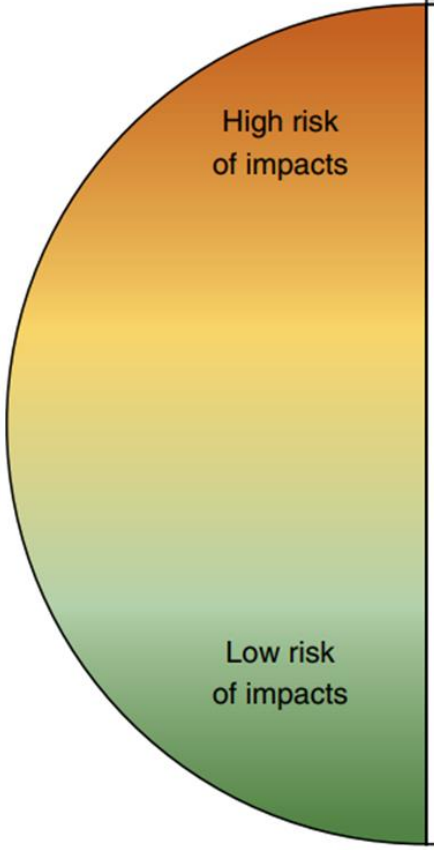
What do we know about the risks of assisted migration?

Information from past species introductions show us:

- The **potential for species used in AM to become invasive is small** but not zero.

- **Species that do become invasive could have significant negative effects** (Mueller & Hellmann, 2008).

Refresher: What makes a species invasive?



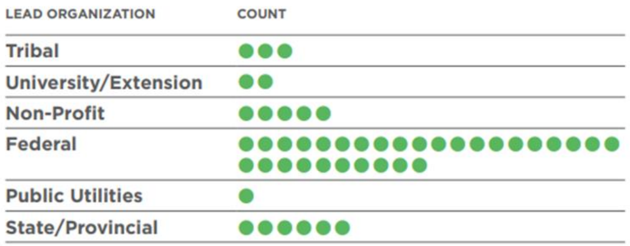
Propagule or dispersal pressure (species)	Abiotic effects (community)	Biotic characteristics Species	 Community
High fecundity **Wide dispersal** **Continuous propagules** **High genetic diversity**	**History of disturbance** **Increasing environmental stress** **Breach of biogeographic barriers**	**Invasive elsewhere** **Abundant in home range** **Fast growth** **Generalists** **Foundation species or ecosystem engineers** **Pathogen carriers**	**Rare community** **Naïve prey** **Enemy release**
Low fecundity Limited dispersal	Resilient or resistant to disturbance Similar environmental conditions	Threatened or endangered Endemic Obligate mutualist Specialists	Shared evolutionary history Biotic resistance

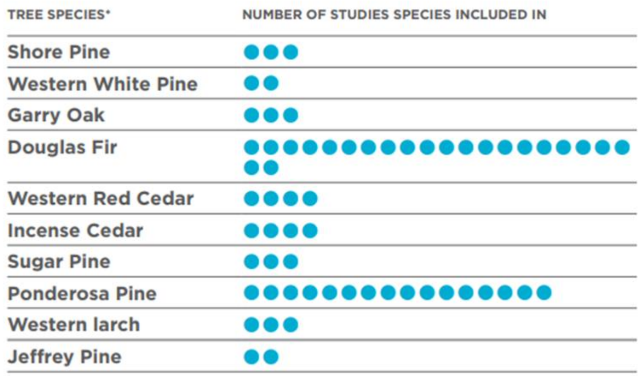
(Wallingford et al., 2020)

Who's responsible for assessing the risk?

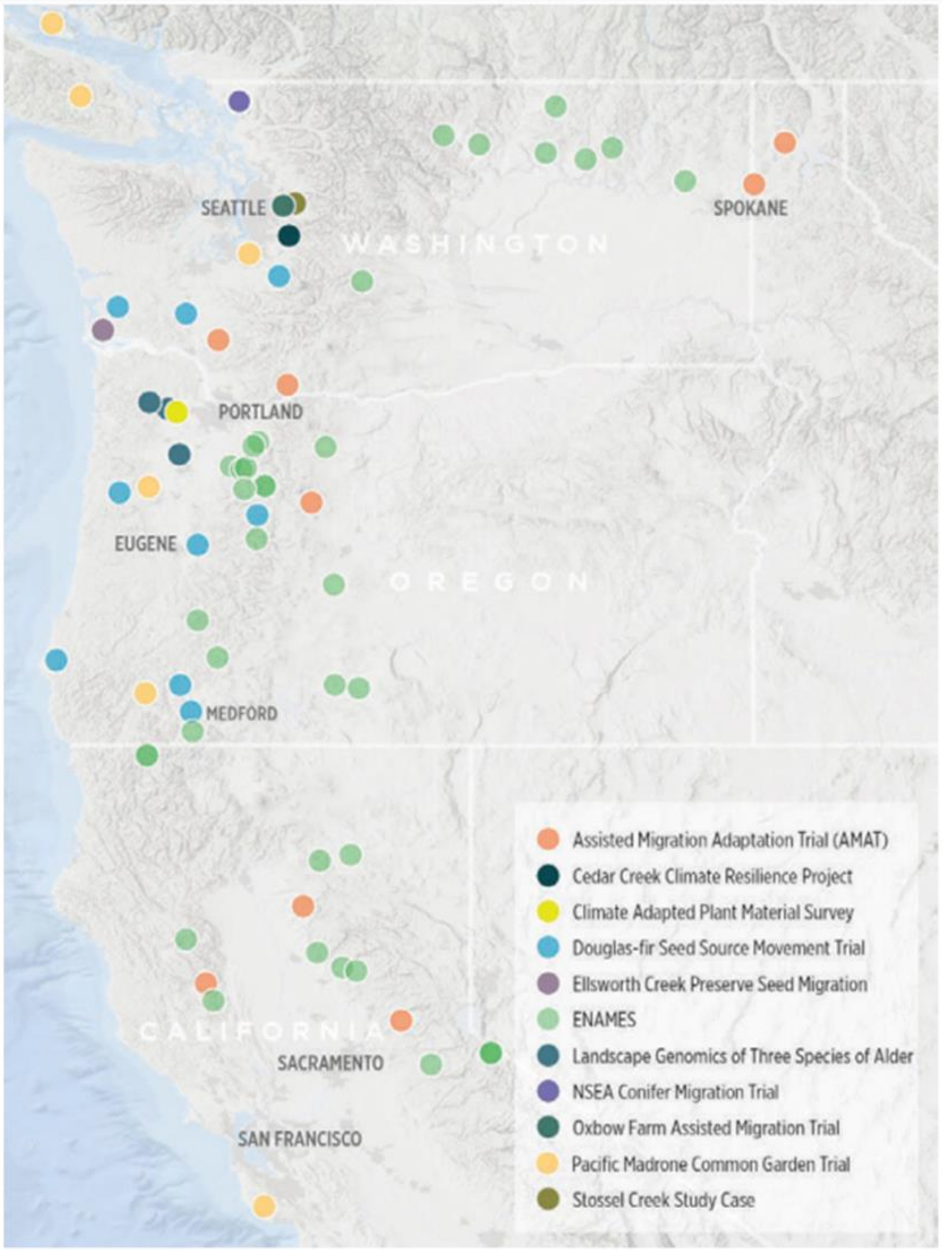
Across the pacific northwest, **AM of forest trees is happening without consensus** and **in the absence of risk assessments.**

No official entity is tasked with tracking Assisted Migration experiments, but our region is lucky to have Bonneville Environmental Foundation who took their own initiative to begin tracking the work.





*Species included in just one study are not depicted, but include the following: giant sequoia, coast redwood, Alaskan yellow cedar, Western hemlock, bigleaf maple, grand fir, white alder, red alder, gray alder, and Pacific madrone.



Assisted migration trial map created for the Treeline newsletter by Bonneville Environmental Foundation. https://www.treeline-pnw.org/wp-content/uploads/2024/04/2023-Assisted-Migration-Trial-Map.pdf

How do we assess risk?

Ecological Risk Assessment of Managed Relocation as a Climate Change Adaptation Strategy:

A multi-step framework that ranks quality of data and requires input from experts.

Climate Adapted Plant Materials at Metro

Assisted migration is ONE tool in the Toolbox.

Risk Level	Low Risk	Medium Risk	Medium/High Risk	High Risk
Action	Shift Willamette Valley (WV) planting palette. Short Distance Assisted Gene Flow Within the WV.	Long Distance Assisted Gene Flow Outside of the WV.	Do nothing and accept change. Resist change by continuing to use the same planting guidelines. Assisted Migration of species that don't have known pathogen/pest risks.	Assisted Migration of species that could have pathogen/pest risk.
Discussion Partners	Work team	Work team and regional partners	Work team and regional partners	Work team, regional partners, and regional experts.

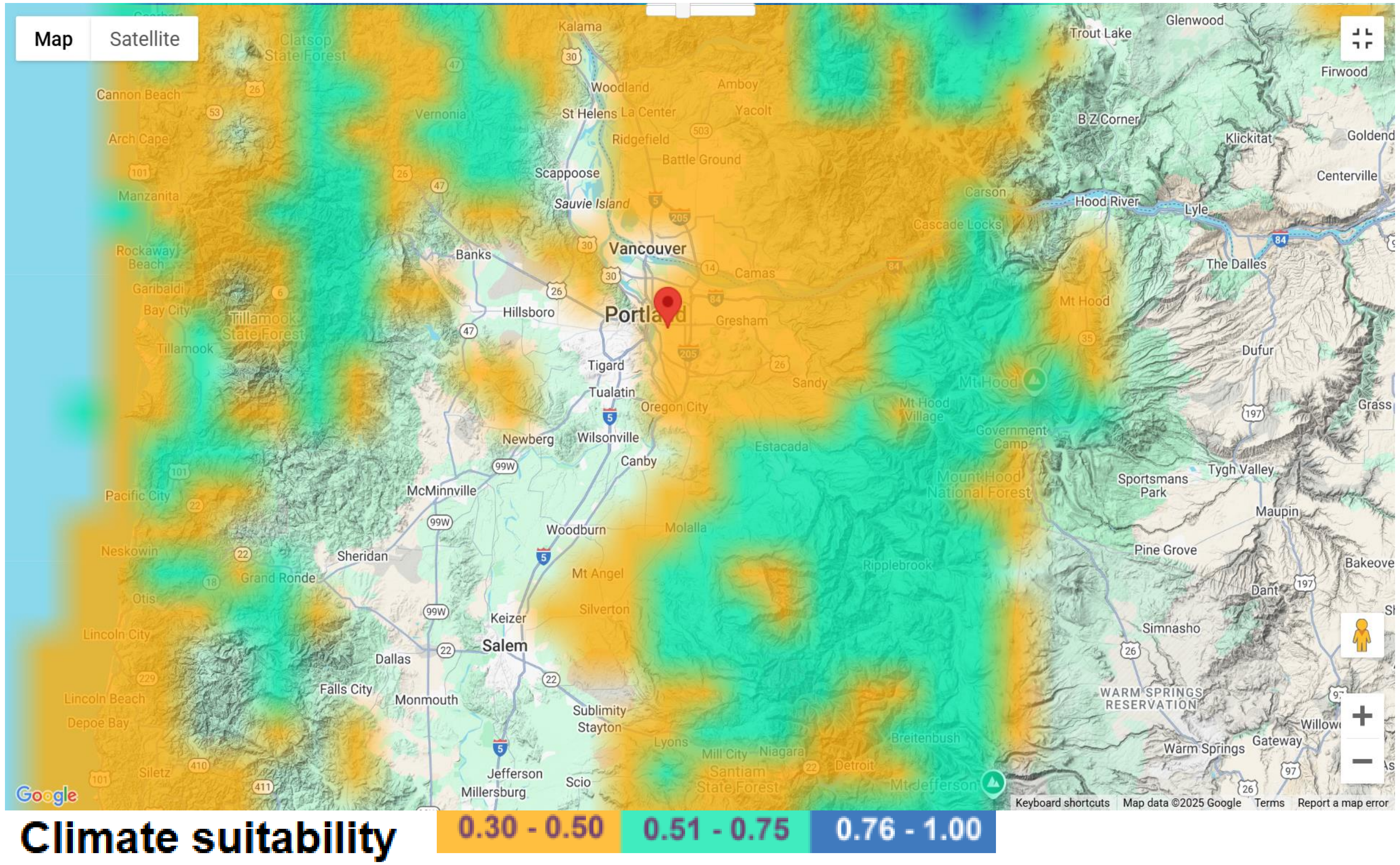
We emphasize the importance of **integrating biological, cultural, and Indigenous Traditional Ecological and Cultural Knowledge (ITECK)** into restoration decisions, recognizing the interconnected consequences of these choices. If someone were to conduct assisted migration, a risk assessment and community conversation would need to take place.

Climate Adapted Plant Materials at Metro

Key Decisions:

- Assisted Migration?
- Assisted Gene Flow?
- Transitioning Ecosystems and Choosing Species?
- Identifying Climate Refugia for Vulnerable Species?

Predicted Climate Suitability for Western Red Cedar, 2071-2100



Climate suitability overlay of Western Red Cedar (*Thuja* plicata) predicted using a moderate emissions scenario (SSP245). Overlay and screenshots gathered from the Center for Forest Conservation Genetics Climate NA web map (https://climatena.ca/mapVersion).

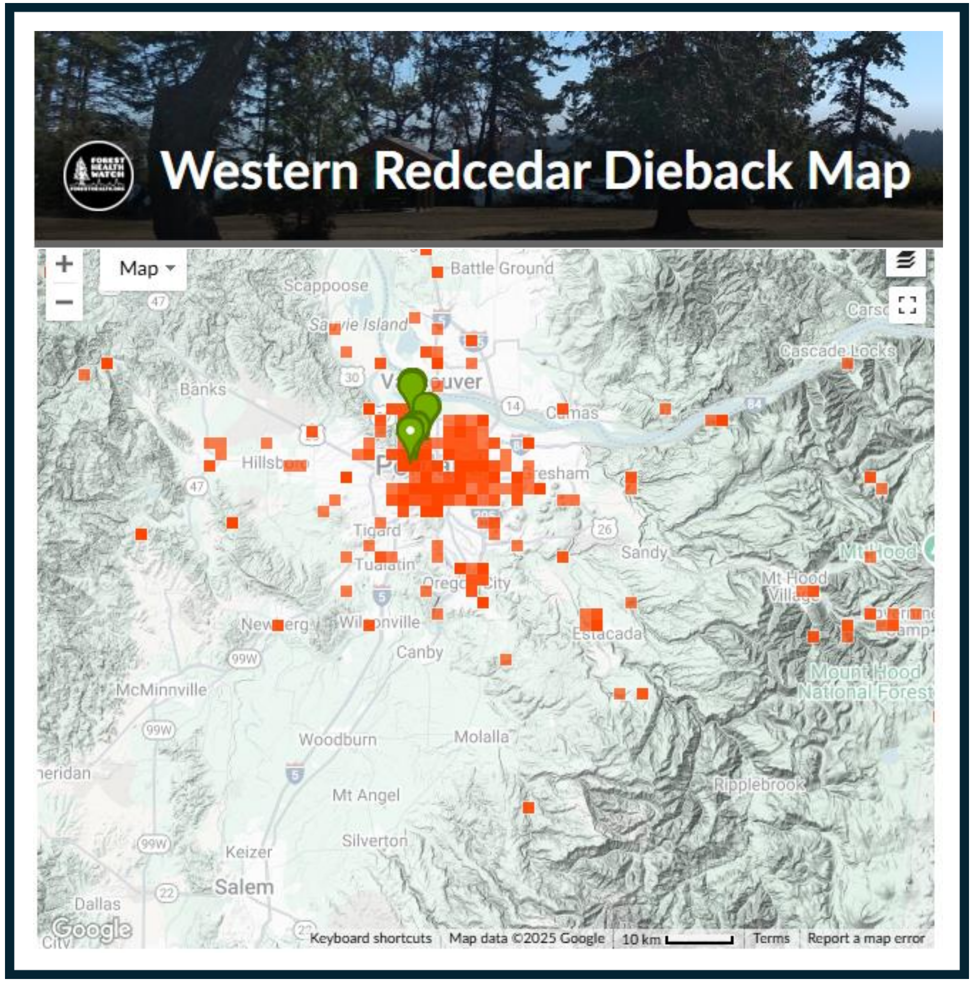
Assessing Species for AM – Incense Cedar and W. Red Cedar

<u>Western Red Cedar (*Thuja plicata*):</u>

- **Experiencing significant die off**.
- Reliant on year-round moisture that is specific to microsites.

<u>Incense Cedar (*Calocedrus decurrens*):</u>

- **Identified as a suitable candidate for assisted migration** to partially fulfill the ecological role of Western Red Cedar (Young et al., 2020; Cox et al., 2022; Zou et al., 2024).



The Western Cedar Dieback project is a program with an iNaturalist project created and maintained by Forest Health Watch.

Assessing Species for AM – Incense Cedar and W. Red Cedar

- <u>**What are the risks?**</u>
  - There is **low potential for competition** because they occupy significantly different hydrological niches (Cox et al., 2022).
  - Host to Cedar Broom Rust that can jump to fruit trees. Susceptible to Pocket Dry Rot (USFS 2023).
- However, it **cannot completely replace** the ecological functions of **Western Red Cedar**.
- **Additionally, what are the cultural implications of replacing it?**

Eco-Cultural Implications of Assisted Migration

Tribal governments and Indigenous People need to be included early and often in these conversations.

ITECK (by Indigenous People) is a climate adaptation practice and makes ecosystems more resilient.

Alternatives to Assisted Migration

Assisted migration is one tool we can use but **it comes with risks** and **we need to seek consensus** and **take a cautious approach.**

So, What Can We Do?!

(Ellis et al., 2024)

Alternatives to Assisted Migration

Western Red Cedar

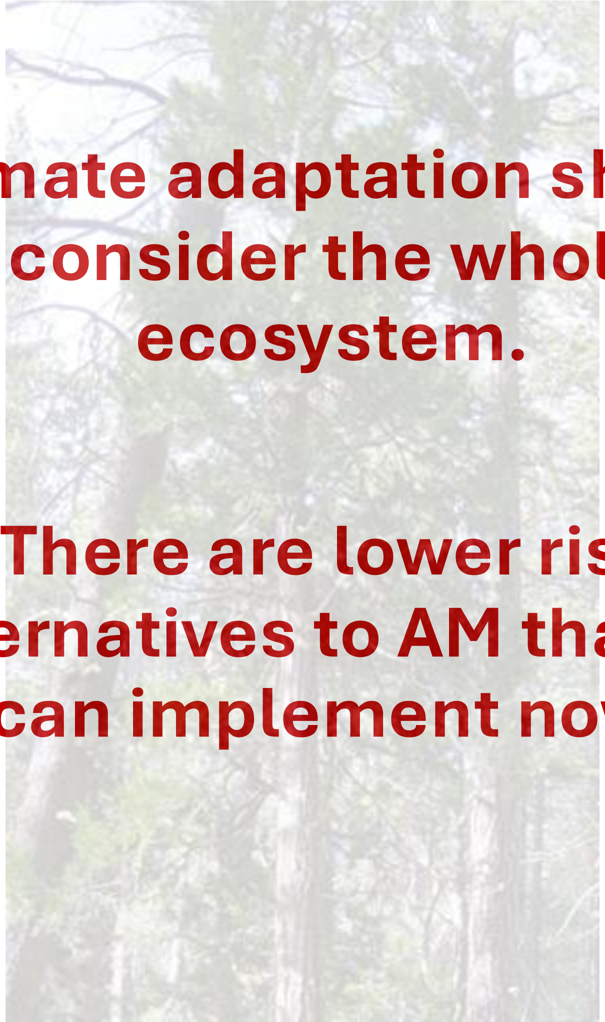
Replace with drought tolerant conifer species from nearby

Thin stands to reduce competition for water

Increase habitat connectivity

Select seed from droughty sites or farther south

Find mitigation sites for cedar



Climate adaptation should consider the whole ecosystem.

There are lower risk alternatives to AM that we can implement now.

Assisted migration policy in the United States

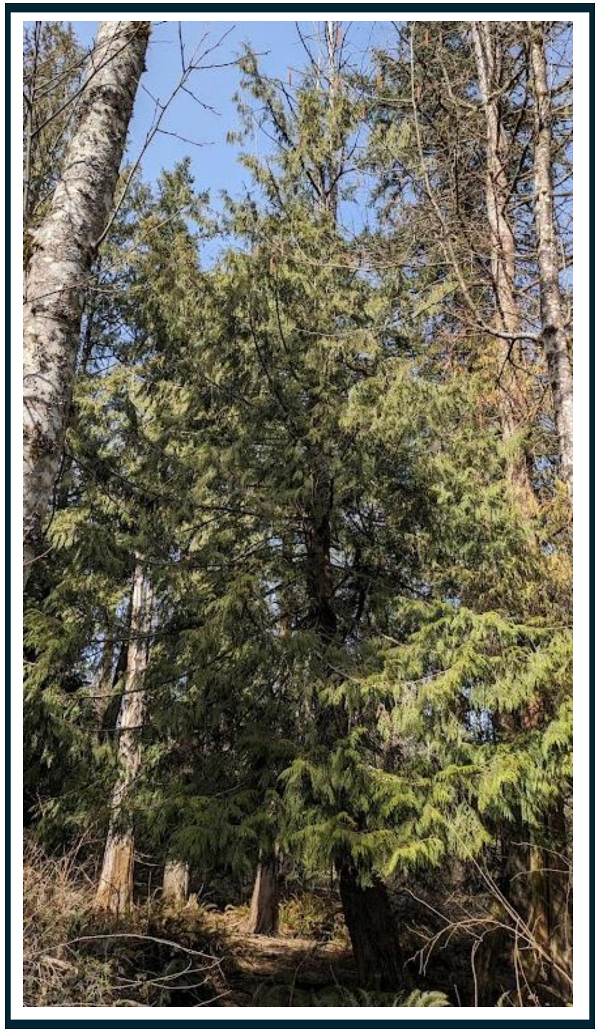
It's the wild, wild west…

Federal policies as well as international treaties carry legal authority that could either support or complicate assisted migration efforts

But no legal precedent has been set…

(Jolly & Fuller, 2009)

Not Just Assisted Migration...



- No ecological assessment of benefits and trade offs can solve the inherent values-based challenges of assisted migration (Hewitt et al., 2011).
- Solutions will be species, ecosystem, and site dependent.
- Limited input from Indigenous Peoples and local practitioners is a serious concern and vital for climate adaptation success (Pelai et al., 2021).

Not Just Assisted Migration…

Moving Forward:

- More empirical studies such as at TSWCD
- More collaboration on genetic diversity
- Regional discussions (meeting in April)
- Metro white pages for project managers

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Adrienne St Clair – adrienne.stclair@oregonmetro.gov

Jess Nettle Shamek – jess.shamek@oregonmetro.gov

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