

The future of Douglas-fir in southwest Oregon

Genetic and climate change considerations



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Oregon State
University



Climate change effects on forests

Altered tree reproduction,
survival, and growth

Increased disturbances from
fire, insects, pathogens

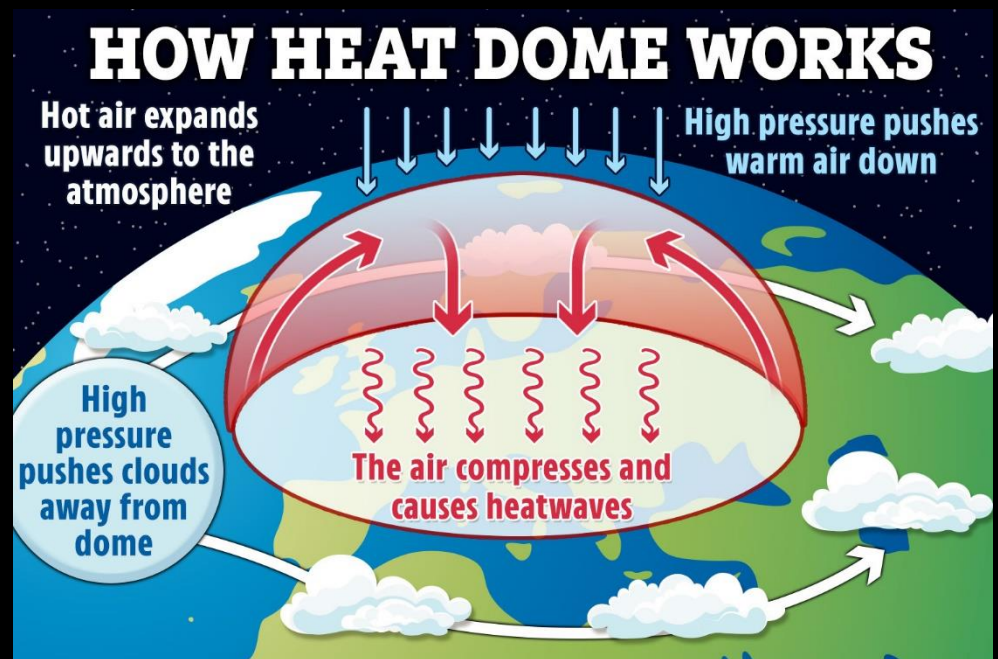
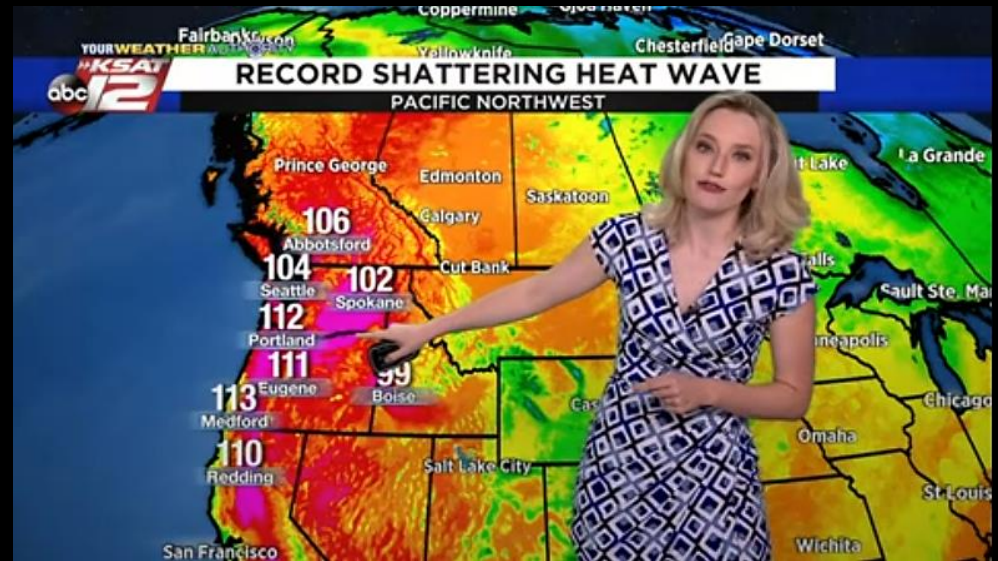
Changes in species habitats,
distributions, and overall forest
composition



PNW Heat Dome June 2021

“Records were broken across the region in June of 2021, as temperatures soared as high as 118 degrees Fahrenheit. Portland saw a record high temperature of 116 degrees, while cities including Salem, Hillsboro and the Columbia River Gorge also broke their all-time records”

McKinnon and Simpson (2022)
Geophysical Research Letters 49(18): 1-9

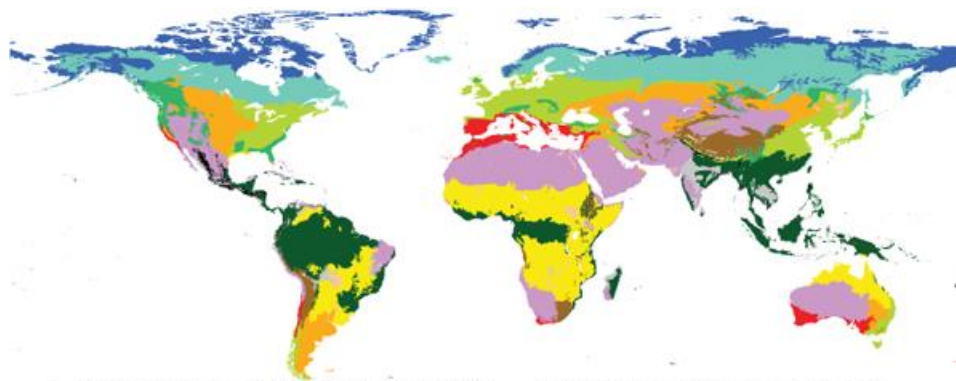


How fast will trees need to migrate?

Speed of temperature change within each biome. Histograms are ordered by increasing velocity according to their geometric means.

Forest examples

Temperate conifers	110 m/yr
Boreal and taiga	430 m/yr
Temperate broadleaf/mixed	350 m/yr



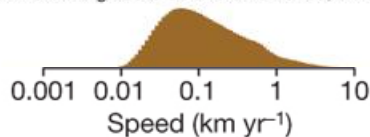
1. Tropical and subtropical coniferous forests, 0.08



2. Temperate coniferous forests, 0.11



3. Montane grasslands and shrublands, 0.11



8. Tropical and subtropical dry broadleaf forests, 0.42



9. Boreal forests/taiga, 0.43



10. Temperate grasslands, savannas and shrublands, 0.59



4. Mediterranean forests, woodlands and scrub, 0.26



5. Tundra, 0.29



6. Tropical and subtropical moist broadleaf forests, 0.33



7. Temperate broadleaf and mixed forests, 0.35



11. Tropical and subtropical grasslands, savannas, shrublands, 0.67



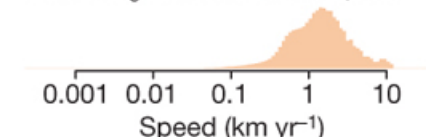
12. Deserts and xeric shrublands, 0.71



13. Mangroves, 0.95



14. Flooded grasslands and savannas, 1.26



Loarie et al (2009) *The velocity of climate change*. *Nature* 462:1052-1055

CA conifers not keeping pace with climate change



PNAS Nexus, 2023, 2, 1-9
<https://doi.org/10.1093/pnasnexus/pgad004>
Advance access publication 28 February 2023
Research Report

Low-elevation conifers in California's Sierra Nevada are out of equilibrium with climate

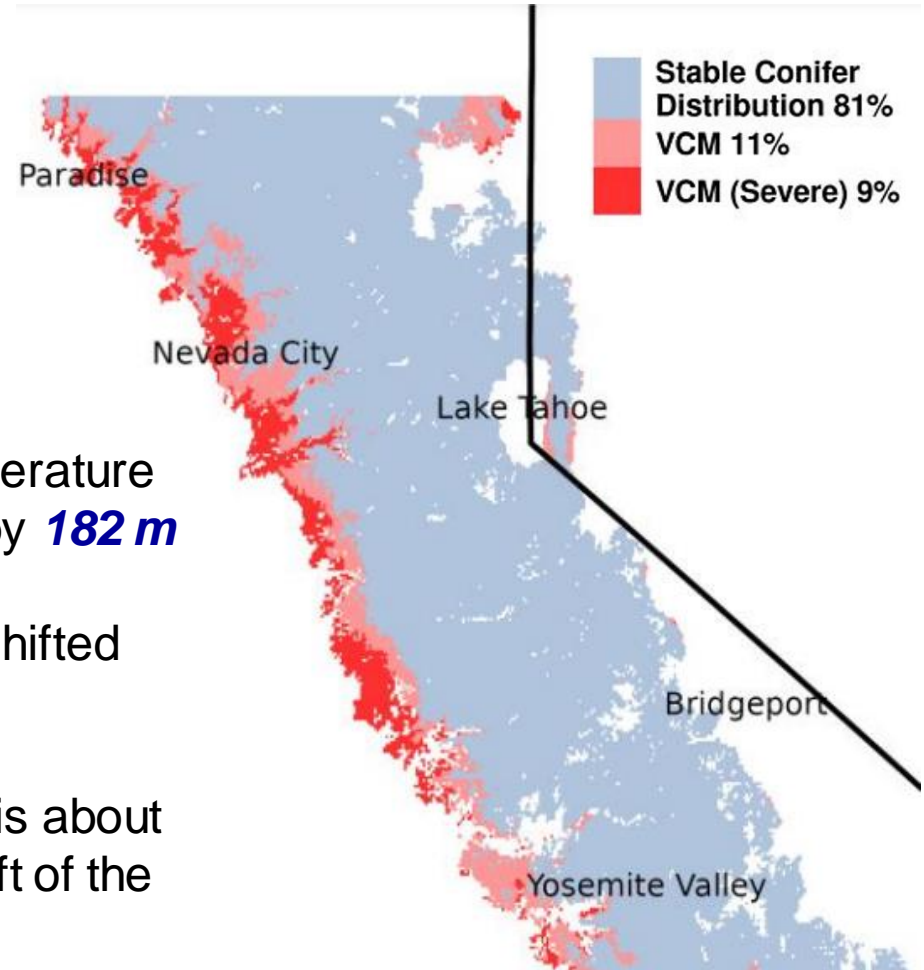
Avery P. Hill¹, Connor J. Nolan¹, Kyle S. Hemes¹, Trevor W. Cambron¹ and Christopher B. Field^{1,2,3,4}

Since the 1930s, the characteristic temperature range for conifers has shifted up-slope by **182 m**

But the mean elevation of conifers has shifted up-slope by only **34 m**

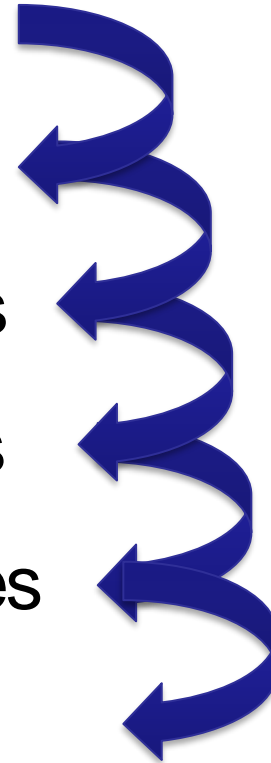
The magnitude of this temperature shift is about **three to five times greater** than the shift of the conifers

Result = vegetation-climate mismatch (VCM)



Uncertainty of forest responses

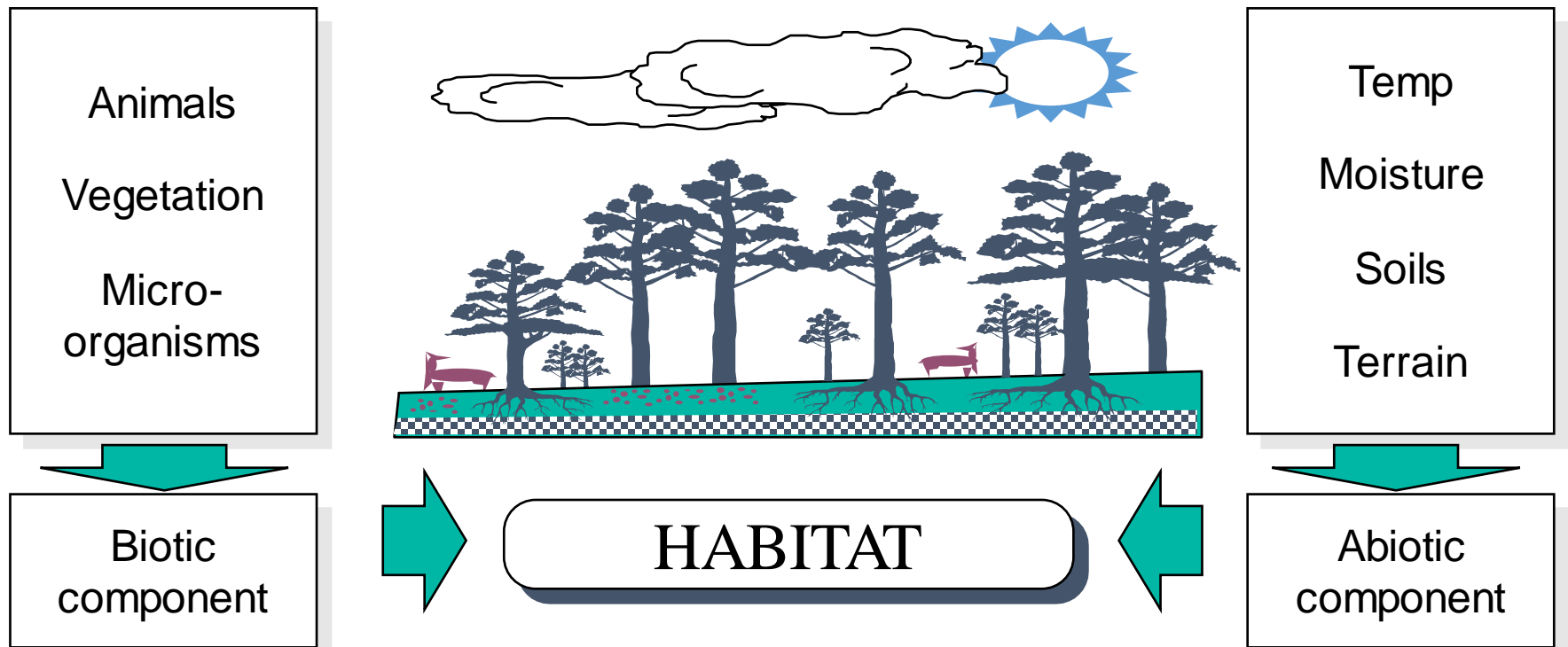
- Human behavior
- Greenhouse gases
- Global climate models
- Downscaling methods
- Direct forest responses
- Interacting stressors



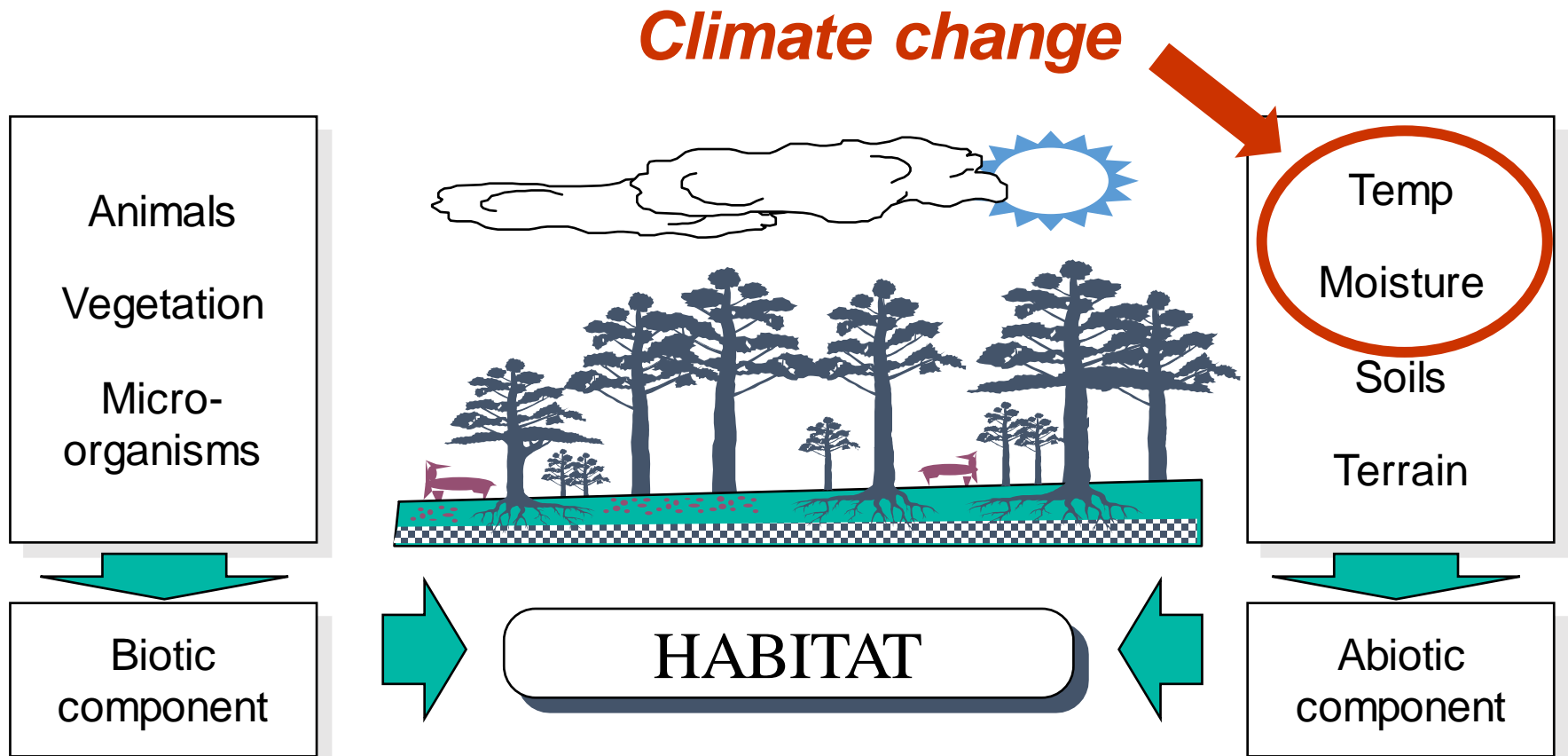
Many levels of uncertainty!!

Modified from Dave Peterson, USFS PNWRS

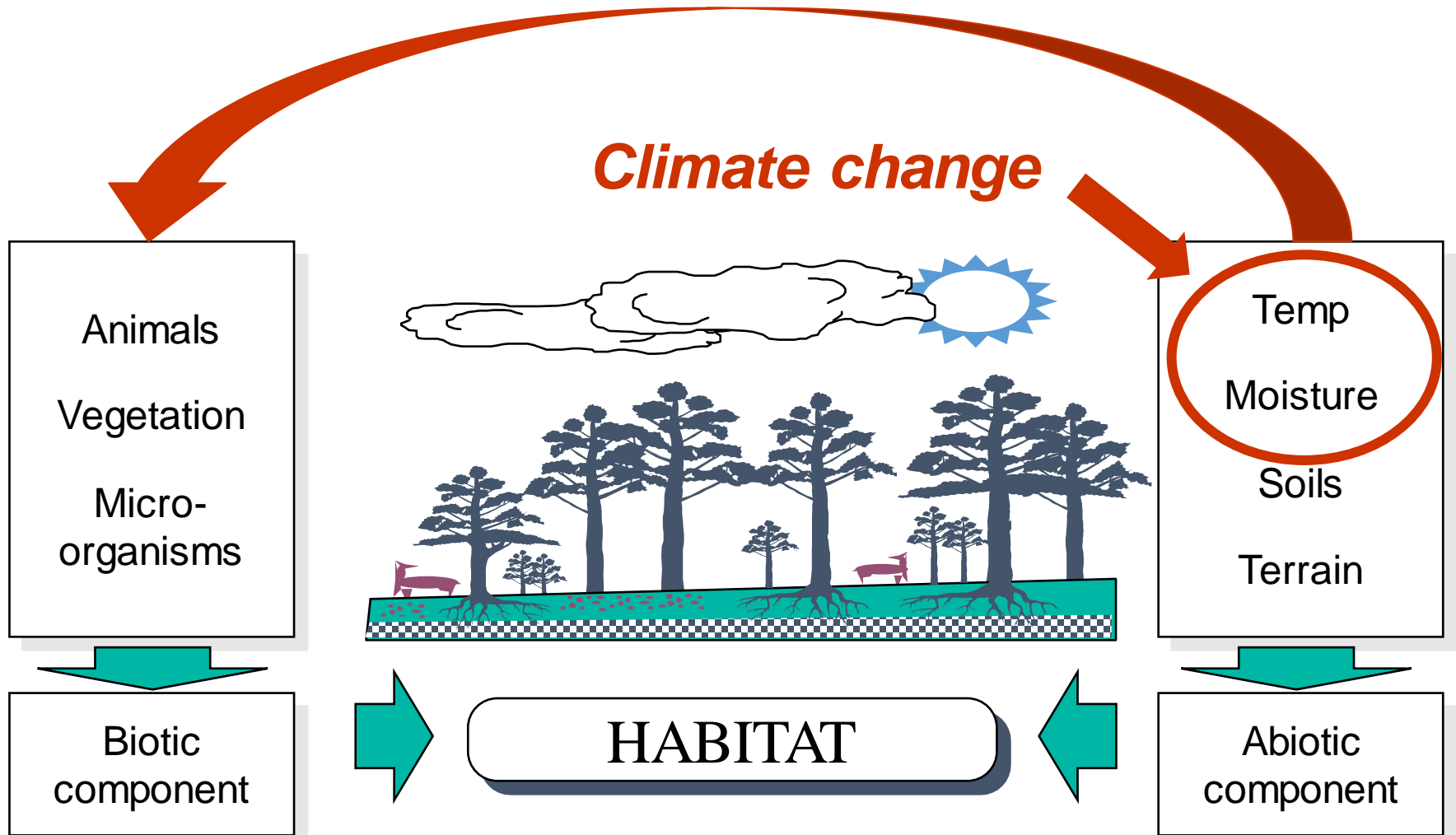
Which factors influence habitat?



Which factors influence habitat?

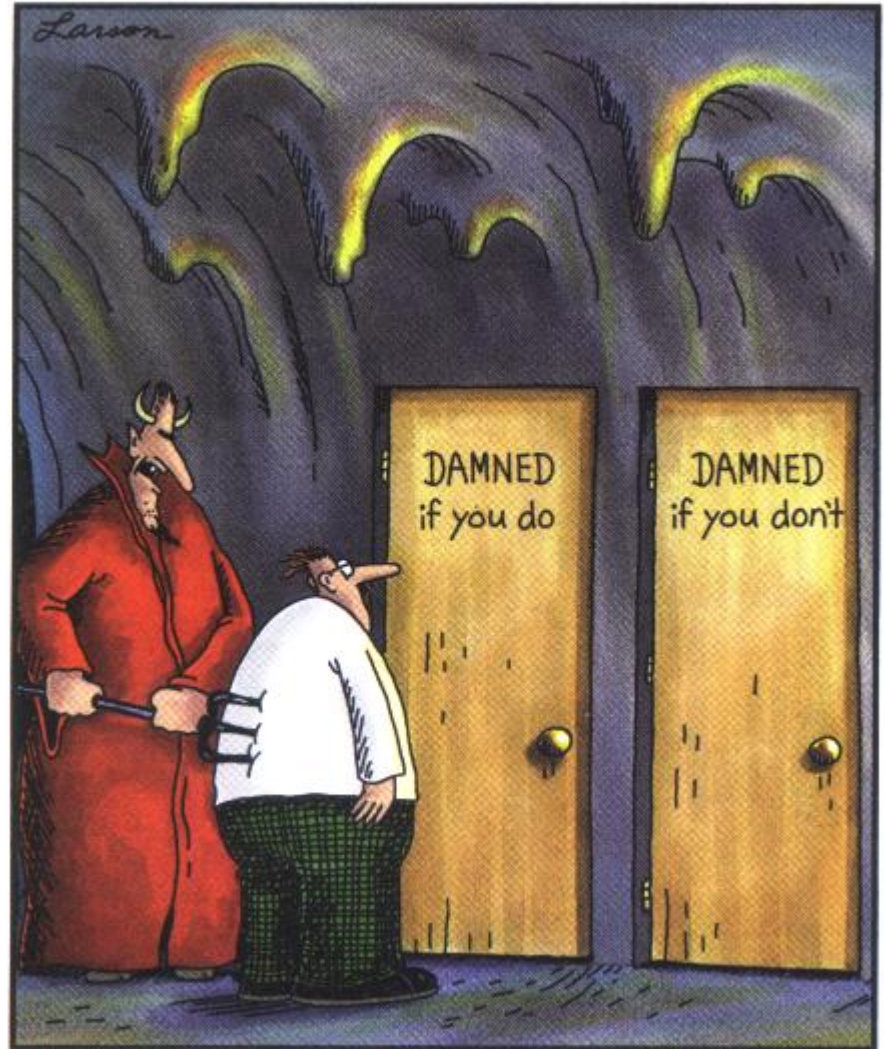


Which factors influence habitat?



Avoid analysis paralysis

“Not to decide is to decide”



“C’mon, c’mon—it’s either one or the other”

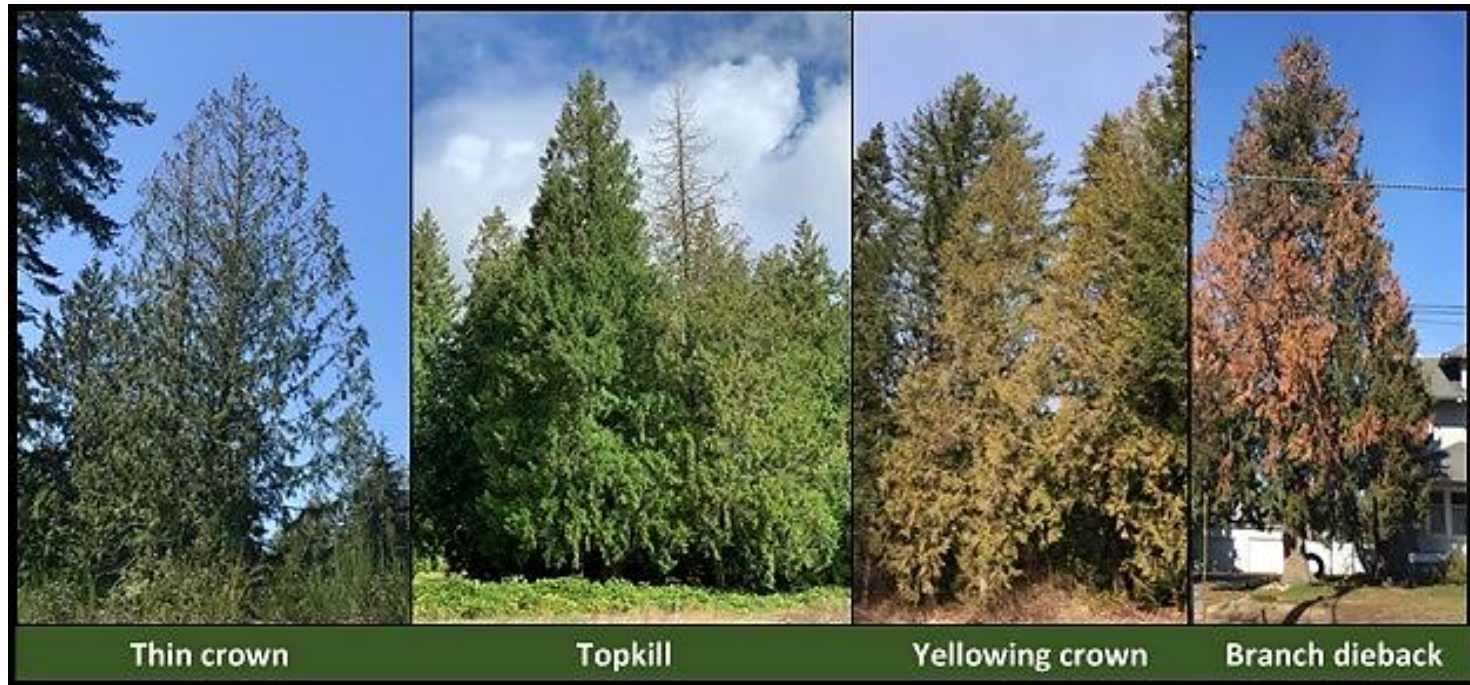
How to respond?

The view from 30,000 feet

Transition versus resistance/resilience

Local forest health problem?

Western redcedar dieback monitoring in the PNW – Help Wanted
Posted on [April 20, 2021](#) by [withrowb](#)



<https://blogs.oregonstate.edu/treetopics/2021/04/20/western-redcedar-dieback-monitoring-in-the-pacific-northwest-help-wanted/>

Local forest health problem?

Oregon Capital Chronicle

POLITICS ENVIRONMENT EDUCATION ECONOMY HEALTH OREGON'S PEOPLE


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 9:00 AM

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


This story was originally published by Columbia Insight.

Local forest health problem?

Journal of Forestry, 2023, XX, 1–16
<https://doi.org/10.1093/jofore/fvad007>
Advance access publication 7 March 2023
Research Article - forest threats

OXFORD

Recent Douglas-fir Mortality in the Klamath Mountains Ecoregion of Oregon: Evidence for a Decline Spiral

Max Bennett,^{1,*}  David C. Shaw,² and Laura Lowrey³





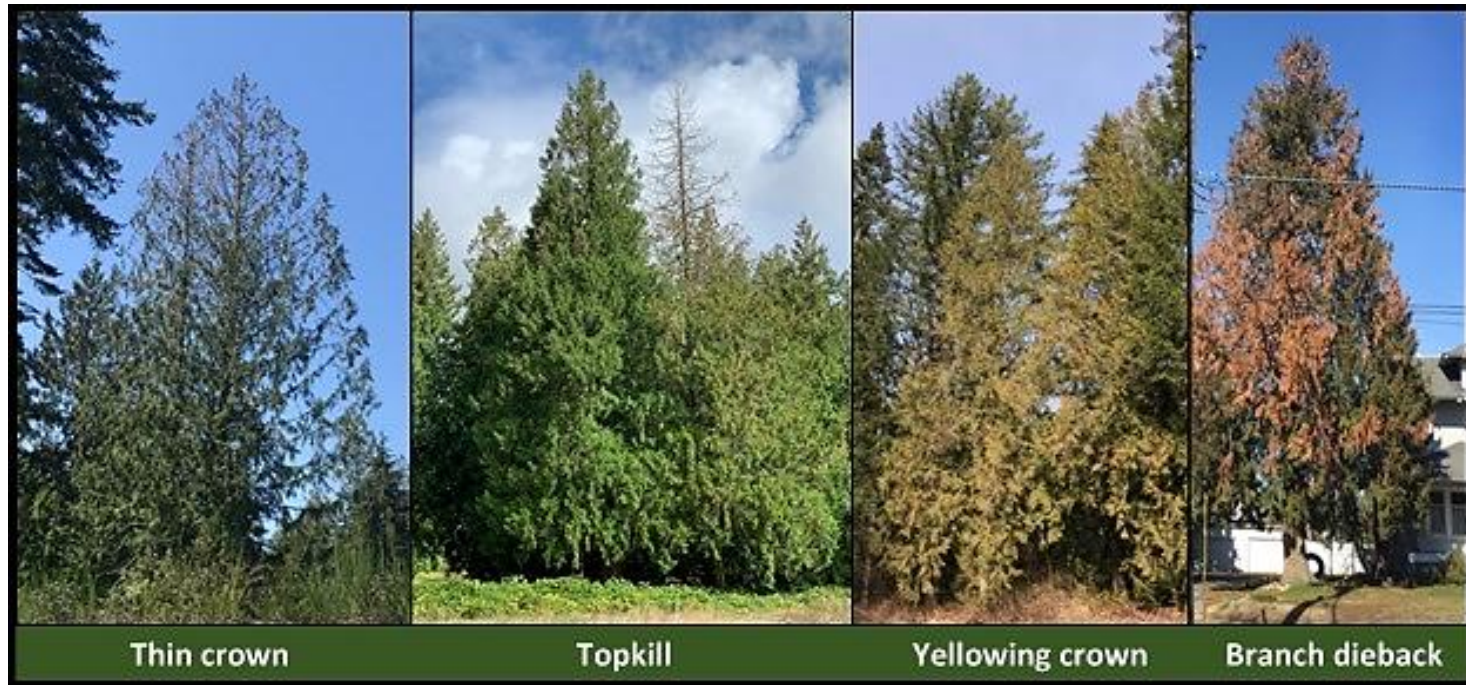
The view from 30,000 feet

Douglas-fir distribution



Changes in species habitat?

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Posted on [April 20, 2021](#) by [withrowb](#)



<https://blogs.oregonstate.edu/treetopics/2021/04/20/western-redcedar-dieback-monitoring-in-the-pacific-northwest-help-wanted/>

Changes in species habitat?

Oregon Capital Chronicle

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

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


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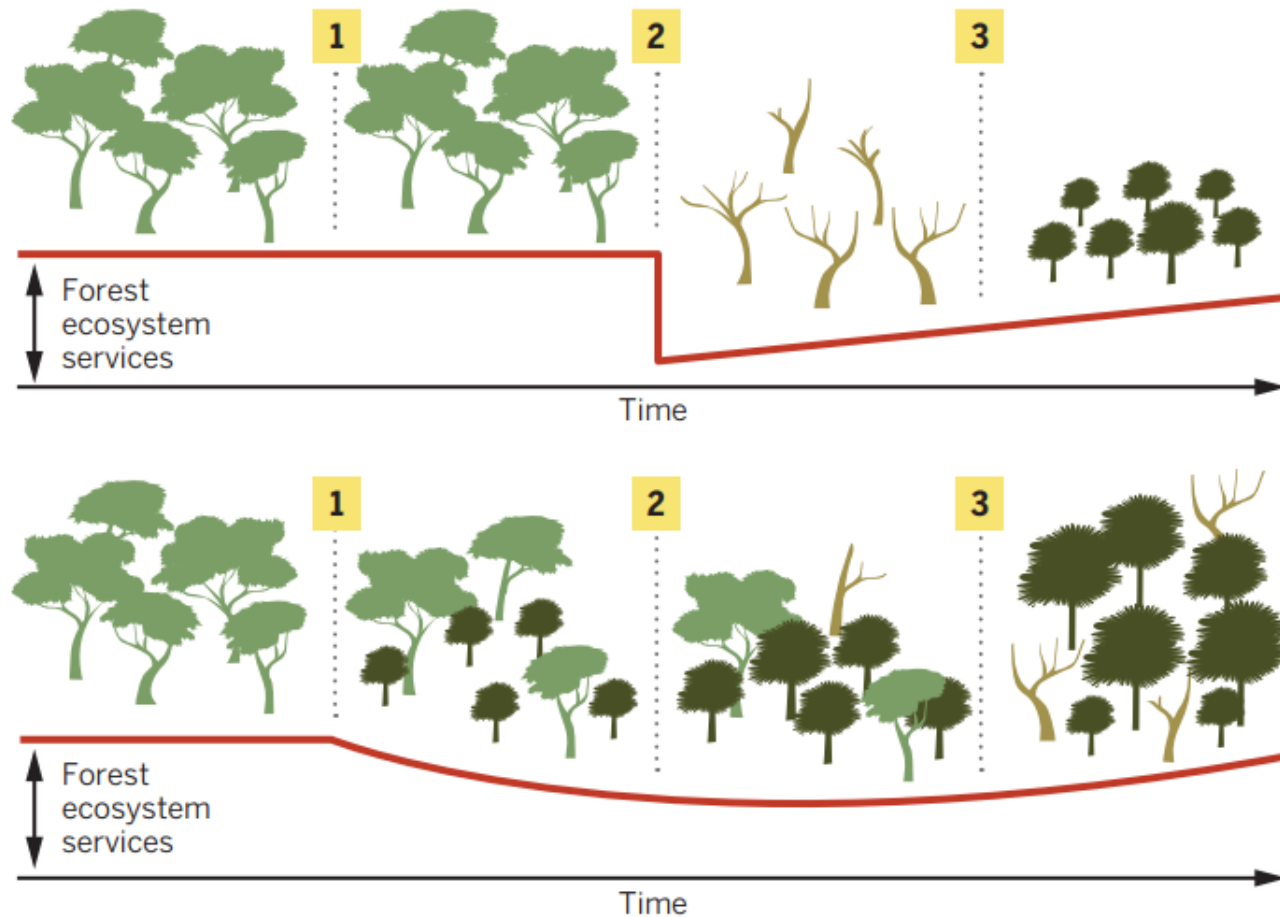
OXFORD

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Max Bennett,^{1,*}  David C. Shaw,² and Laura Lowrey³



Transition versus resistance/resilience



Millar, C.I. and Stephenson, N.L. (2015). *Science* 349(6250): 823-826

How can forest managers respond?

Choose appropriate species

Choose appropriate seedlots

How do we project where species can occur in the future?

Species distribution models

Bioclimatic models

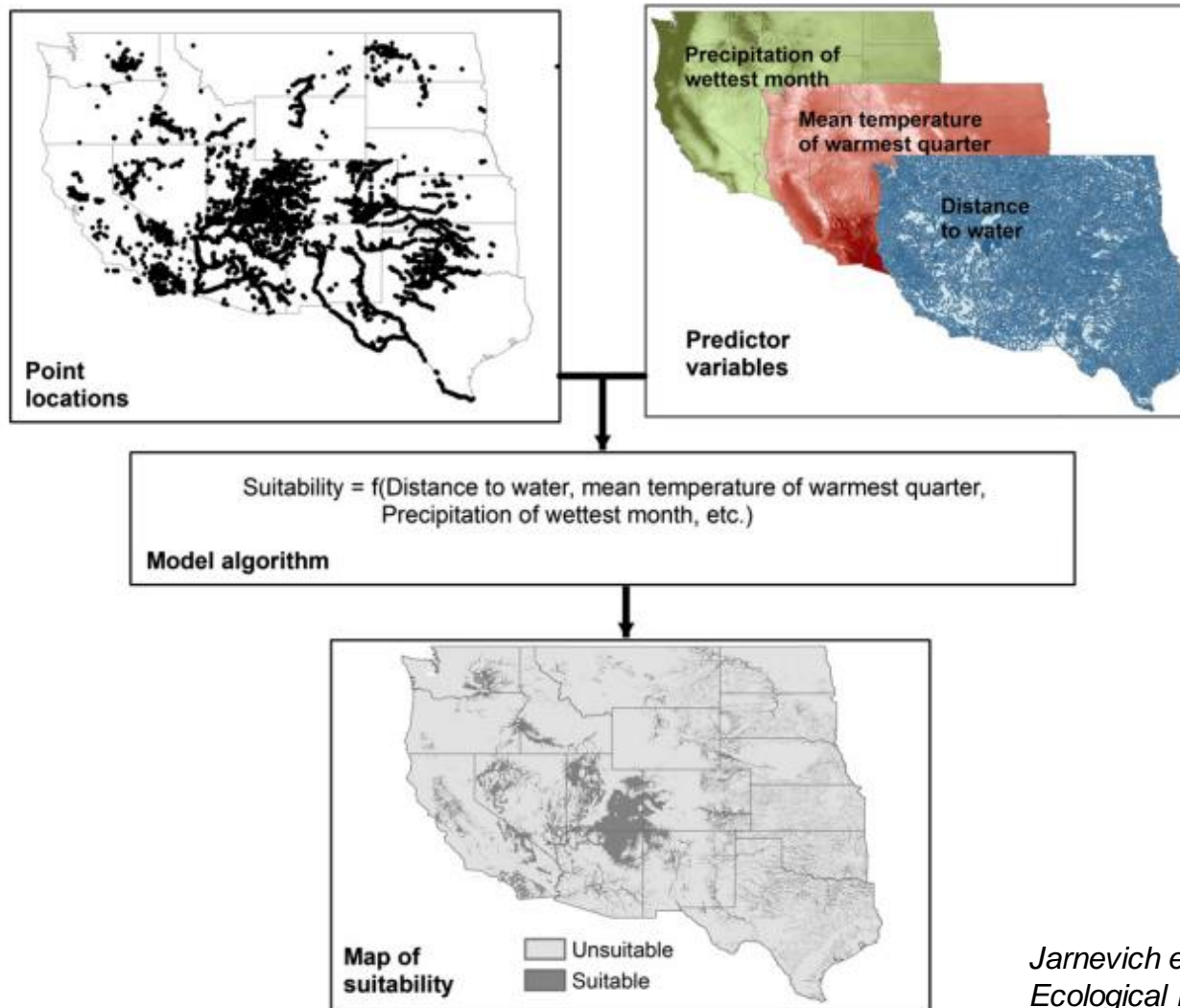
Climate envelope models

Ecological niche models

Resource selection functions

Habitat models

Habitat modeling – Approach



Jarnevich et al. (2015)
Ecological Informatics 29:6-15

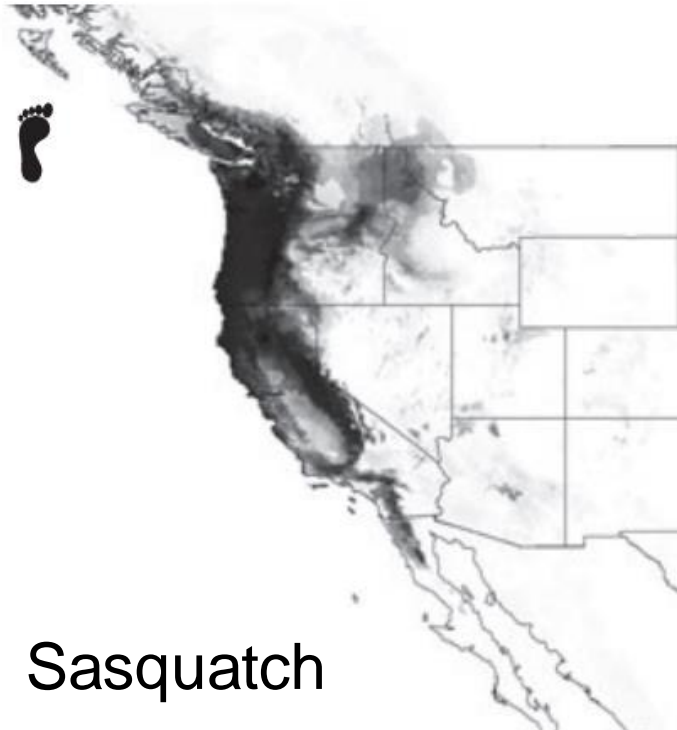
Issues?

Journal of Biogeography (J. Biogeogr.) (2009)

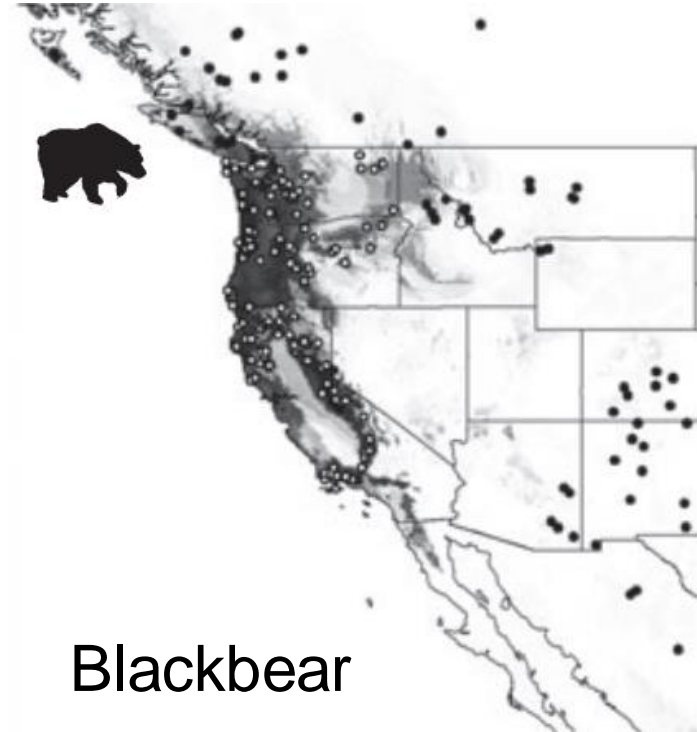


Predicting the distribution of Sasquatch in western North America: anything goes with ecological niche modelling

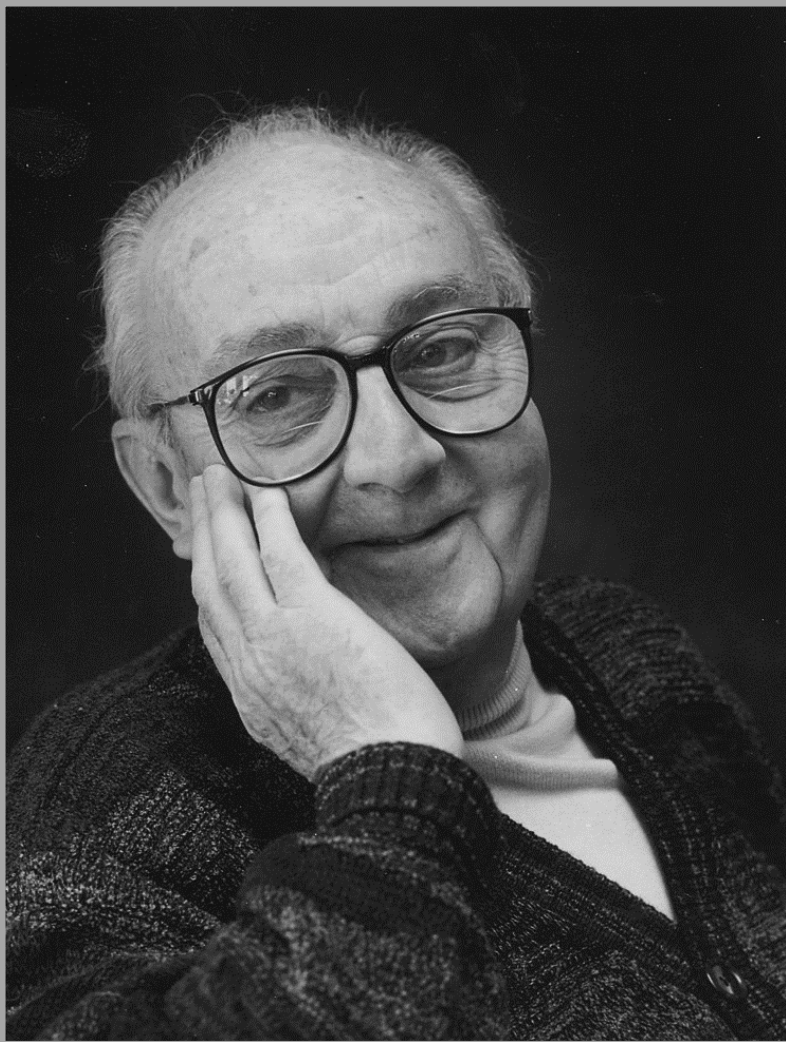
J. D. Lozier^{1*}, P. Aniello² and M. J. Hickerson³



Sasquatch



Blackbear

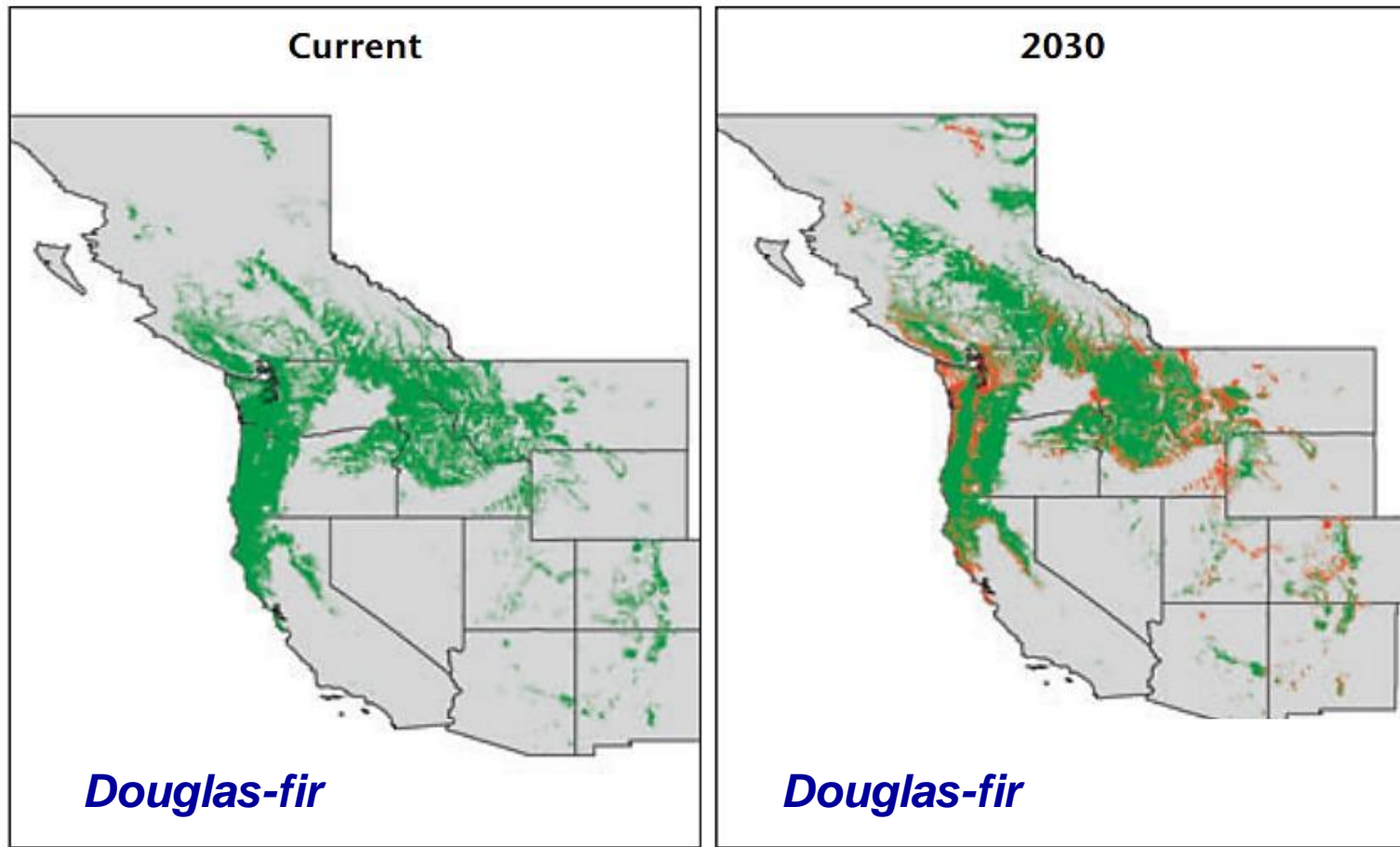


*All models are wrong...
but some are useful*

— George E. P. Box —

Choose appropriate species

Be careful about planting near the margins of a species distributions



Weiskittel et al. (2012) Weis Schweiz Z Forstwes 163 (3):70–78

Assisted migration

The intentional movement of species, populations, or genotypes outside of their known historical distributions in response to anticipated climate change

a.k.a. “managed relocation,” “assisted colonization,” “managed translocation”...



Assisted migration

Species-level

Population-level

Exotic species translocation

Range expansion

Seed transfer

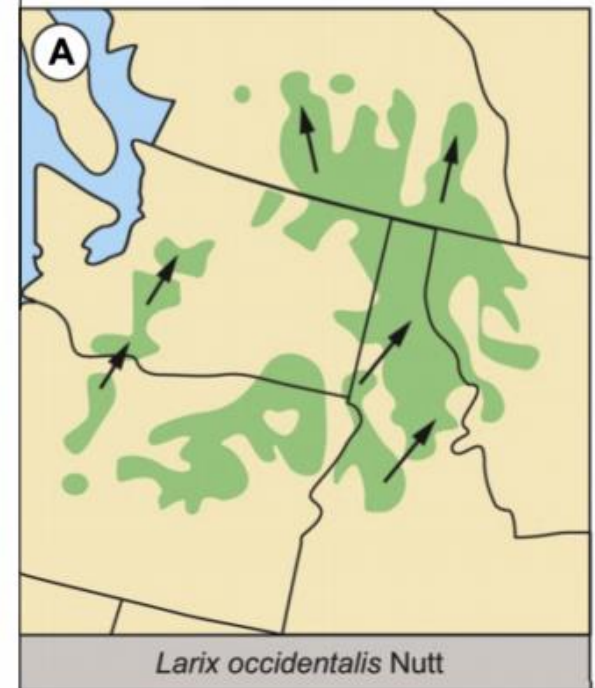
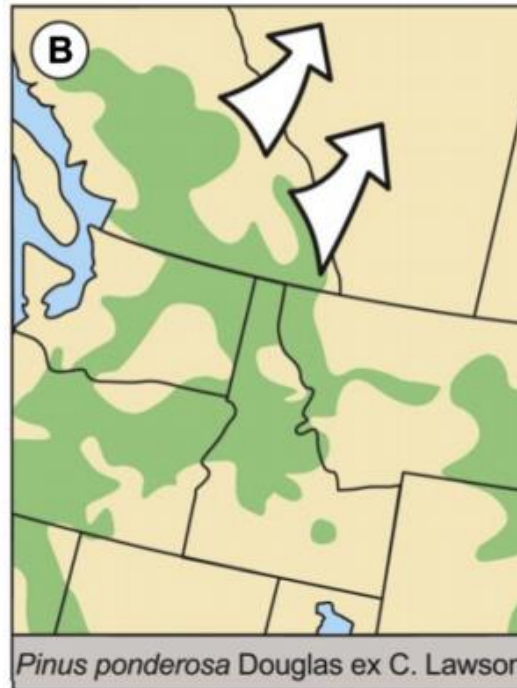


Figure modified from Williams and Dumroese (2014) *Tree Planters' Notes* 57(1):21-26

Species-level assisted migration

Species Potential Habitat Tool (SPHT)

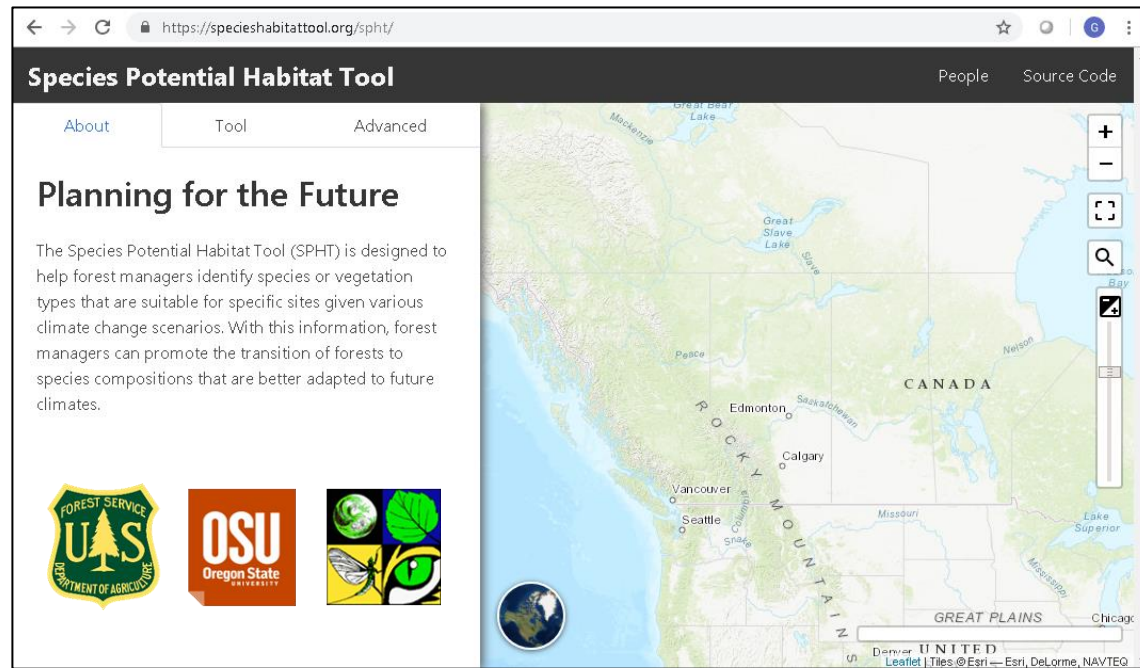
<https://specieshabitattool.org/spht/>



Species Potential Habitat Tool (SPHT)

A mapping tool to help forest managers match **species** with planting sites based on climate information

Check it out at: <https://specieshabitattool.org/spht/>



Species Potential Habitat Tool

Species Potential Habitat Tool

People Source Code

About Tool Advanced

1 Select Species

Sitka spruce

2 Select Species Distribution Record

1961 - 1990

3 Select Modeling Conditions

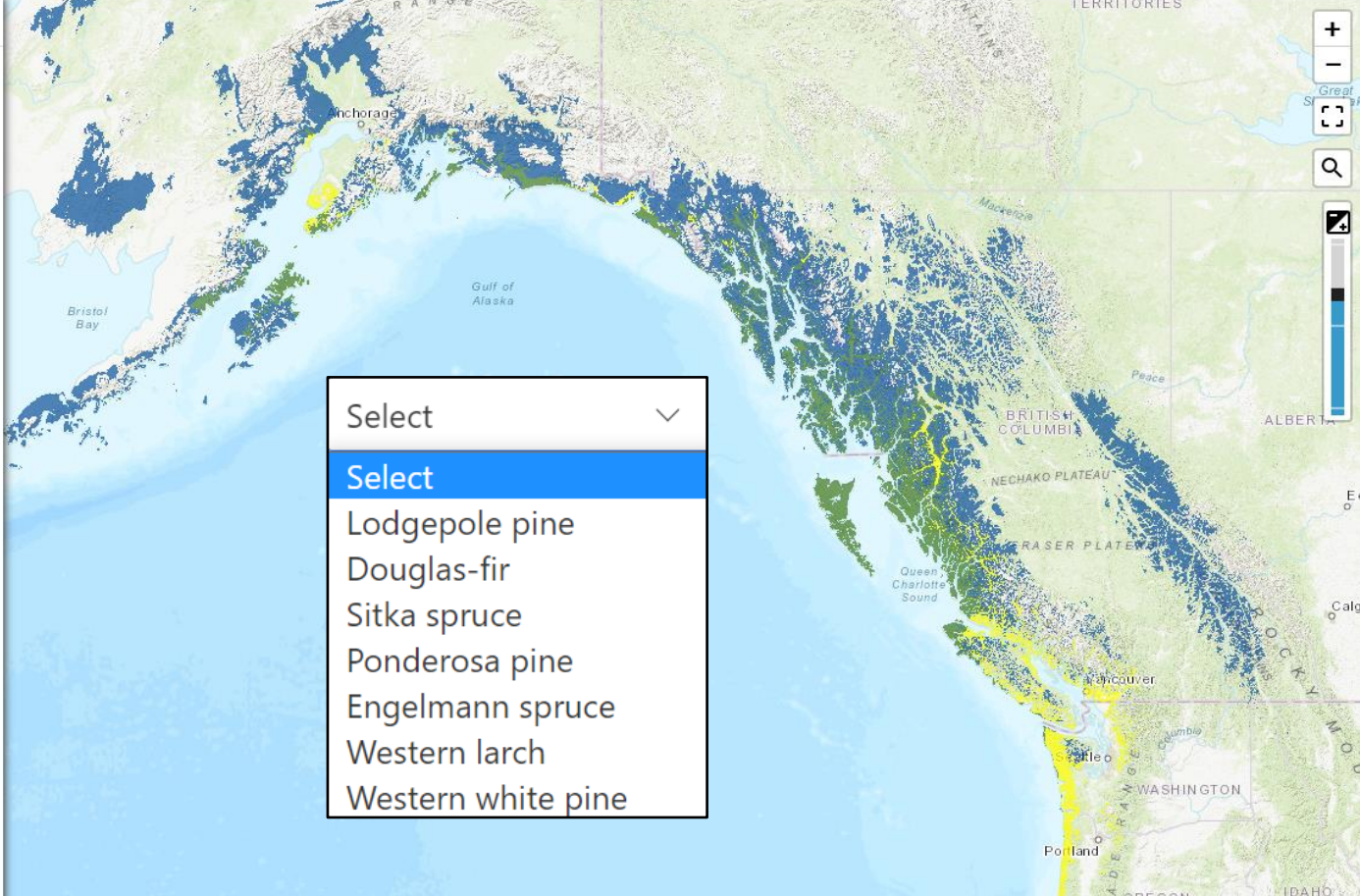
Select a future time range and a model

	RCP 4.5	RCP 8.5
2011 - 2040	<input type="checkbox"/>	<input type="checkbox"/>
2041 - 2070	<input type="checkbox"/>	<input type="checkbox"/>
2071 - 2100	<input type="checkbox"/>	<input checked="" type="checkbox"/>

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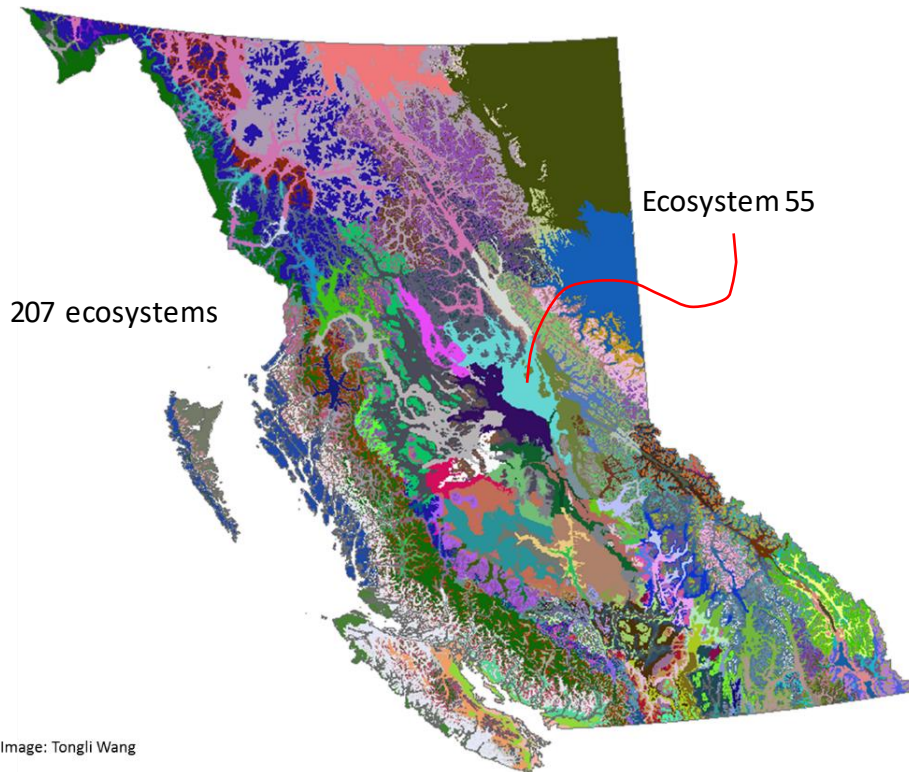
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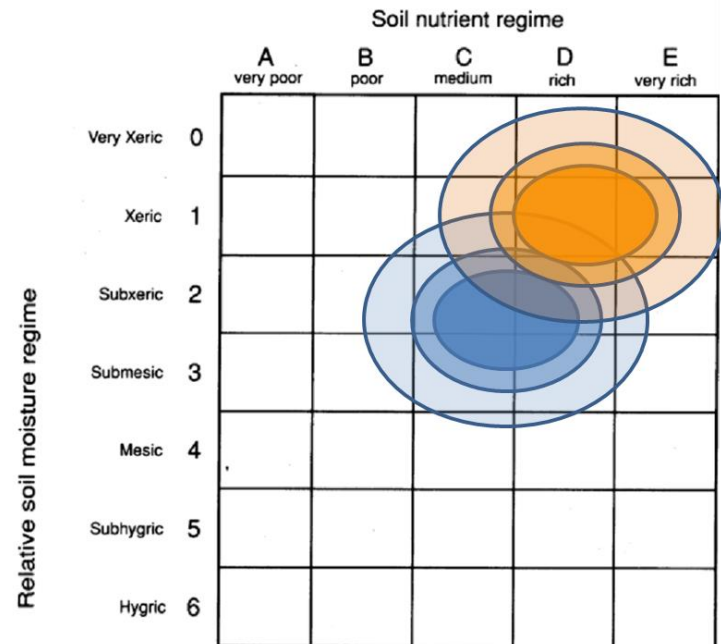
<https://specieshabitatool.org/spht/>


Habitats

Ponderosa pine and Douglas-fir



Edatopic grid for ecosystem 55



 *Pinus ponderosa*

 *Pseudotsuga menziesii*

Douglas-fir | 1975

Species Potential Habitat Tool People Source Code

About Tool Advanced

- Select Species**
Douglas-fir
- Select Species Distribution Record**
1961 - 1990
- Select Modeling Conditions**
Select a future time range and a model

	RCP 4.5	RCP 8.5
2011 - 2040	<input type="checkbox"/>	<input type="checkbox"/>
2041 - 2070	<input type="checkbox"/>	<input type="checkbox"/>
2071 - 2100	<input type="checkbox"/>	<input type="checkbox"/>
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4/19/2021

<https://specieshabitatool.org/spht/>

Douglas-fir | 2025

Species Potential Habitat Tool People Source Code

About Tool Advanced

1 Select Species
Douglas-fir

2 Select Species Distribution Record
1961 - 1990

3 Select Modeling Conditions
Select a future time range and a model

	RCP 4.5	RCP 8.5
2011 - 2040	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2041 - 2070	<input type="checkbox"/>	<input type="checkbox"/>
2071 - 2100	<input type="checkbox"/>	<input type="checkbox"/>

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<https://specieshabitattool.org/spht/#>

Legend: Douglas-fir

- Habitat lost
- Habitat kept (1 scenario)
- Habitat kept (2 scenarios)
- Habitat gained (1 scenario)
- Habitat gained (2 scenarios)

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<https://specieshabitattool.org/spht/>

Douglas-fir | 2055

Species Potential Habitat Tool People Source Code

About Tool Advanced

- Select Species**
Douglas-fir
- Select Species Distribution Record**
1961 - 1990
- Select Modeling Conditions**
Select a future time range and a model

	RCP 4.5	RCP 8.5
2011 - 2040	<input type="checkbox"/>	<input type="checkbox"/>
2041 - 2070	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2071 - 2100	<input type="checkbox"/>	<input type="checkbox"/>
- Download**
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Legend: Douglas-fir

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Douglas-fir | 2085

Species Potential Habitat Tool People Source Code

About Tool Advanced

- Select Species**
Douglas-fir
- Select Species Distribution Record**
1961 - 1990
- Select Modeling Conditions**
Select a future time range and a model

	RCP 4.5	RCP 8.5
2011 - 2040	<input type="checkbox"/>	<input type="checkbox"/>
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2071 - 2100	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
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Douglas-fir consensus

Species Potential Habitat Tool People Source Code

About Tool Advanced

1 Select Species
Douglas-fir

2 Select Species Distribution Record
1961 - 1990

3 Select Modeling Conditions
Select a future time range and a model

	RCP 4.5	RCP 8.5
2011 - 2040	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2041 - 2070	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2071 - 2100	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

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▼ Douglas-fir

- Habitat lost
- Habitat kept (1 scenario)
- Habitat kept (2 scenarios)
- Habitat kept (3 scenarios)
- Habitat kept (4 scenarios)
- Habitat kept (5 scenarios)
- Habitat kept (6 scenarios)
- Habitat gained (1 scenario)
- Habitat gained (2 scenarios)
- Habitat gained (3 scenarios)
- Habitat gained (4 scenarios)
- Habitat gained (5 scenarios)
- Habitat gained (6 scenarios)

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Ponderosa pine | 1975

Species Potential Habitat Tool People Source Code

About Tool Advanced

- Select Species**
Ponderosa pine
- Select Species Distribution Record**
1961 - 1990
- Select Modeling Conditions**
Select a future time range and a model

	RCP 4.5	RCP 8.5
2011 - 2040	<input type="checkbox"/>	<input type="checkbox"/>
2041 - 2070	<input type="checkbox"/>	<input type="checkbox"/>
2071 - 2100	<input type="checkbox"/>	<input type="checkbox"/>
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Download results to a pdf

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Ponderosa pine | 2025

Species Potential Habitat Tool People Source Code

About Tool Advanced

- Select Species**
Ponderosa pine
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1961 - 1990
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Select a future time range and a model

	RCP 4.5	RCP 8.5
2011 - 2040	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2041 - 2070	<input type="checkbox"/>	<input type="checkbox"/>
2071 - 2100	<input type="checkbox"/>	<input type="checkbox"/>
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▼ Ponderosa Pine

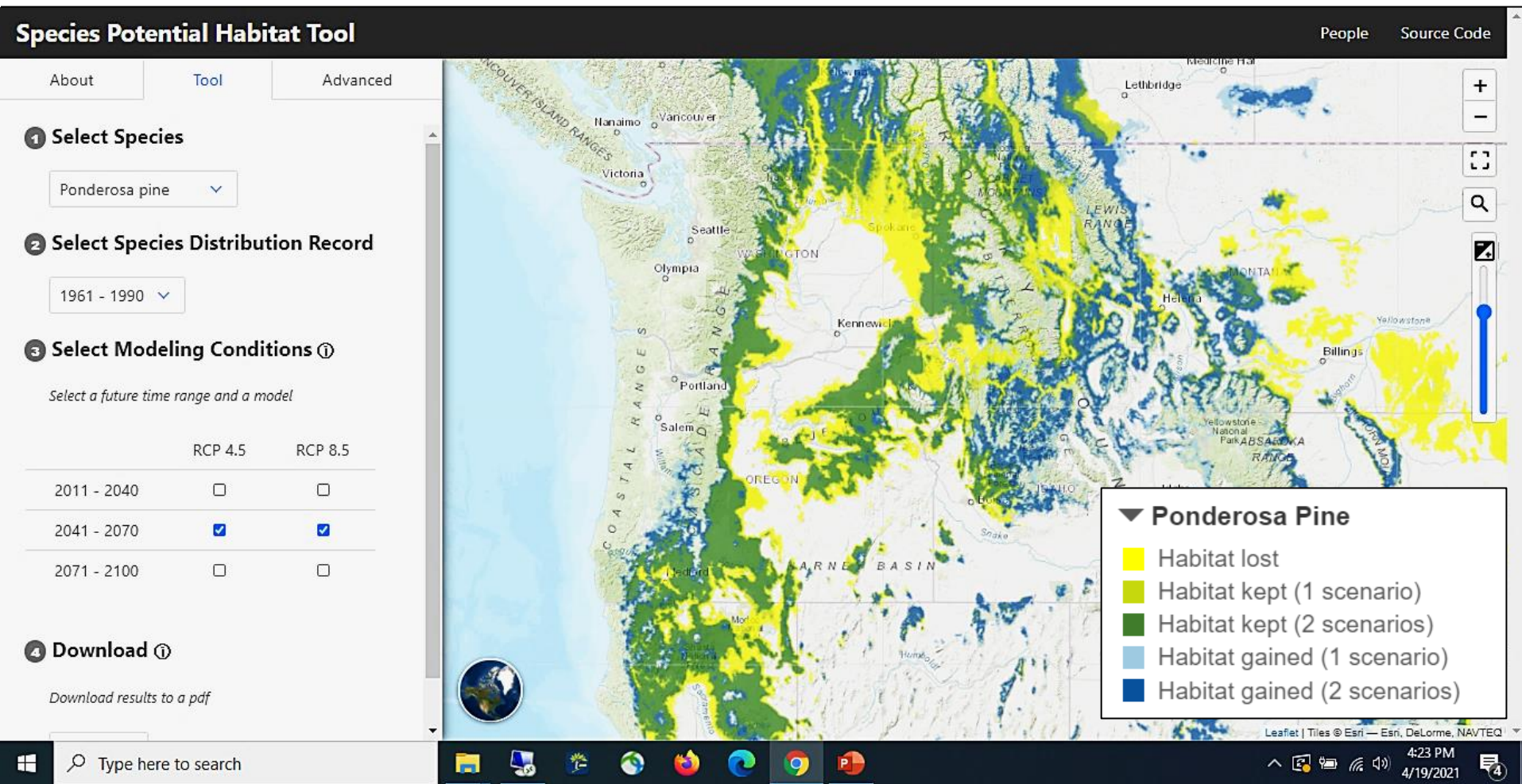
- Habitat lost
- Habitat kept (1 scenario)
- Habitat kept (2 scenarios)
- Habitat gained (1 scenario)
- Habitat gained (2 scenarios)

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<https://specieshabitatool.org/spht/>

Ponderosa pine | 2055



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Ponderosa pine | 2085

Species Potential Habitat Tool People Source Code

About Tool Advanced

1 Select Species
Ponderosa pine

2 Select Species Distribution Record
1961 - 1990

3 Select Modeling Conditions
Select a future time range and a model

	RCP 4.5	RCP 8.5
2011 - 2040	<input type="checkbox"/>	<input type="checkbox"/>
2041 - 2070	<input type="checkbox"/>	<input type="checkbox"/>
2071 - 2100	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

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▼ Ponderosa Pine

- Habitat lost
- Habitat kept (1 scenario)
- Habitat kept (2 scenarios)
- Habitat gained (1 scenario)
- Habitat gained (2 scenarios)

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Ponderosa pine consensus

Species Potential Habitat Tool People Source Code

About Tool Advanced

1 Select Species
Ponderosa pine

2 Select Species Distribution Record
1961 - 1990

3 Select Modeling Conditions
Select a future time range and a model

	RCP 4.5	RCP 8.5
2011 - 2040	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2041 - 2070	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2071 - 2100	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

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▼ Ponderosa Pine

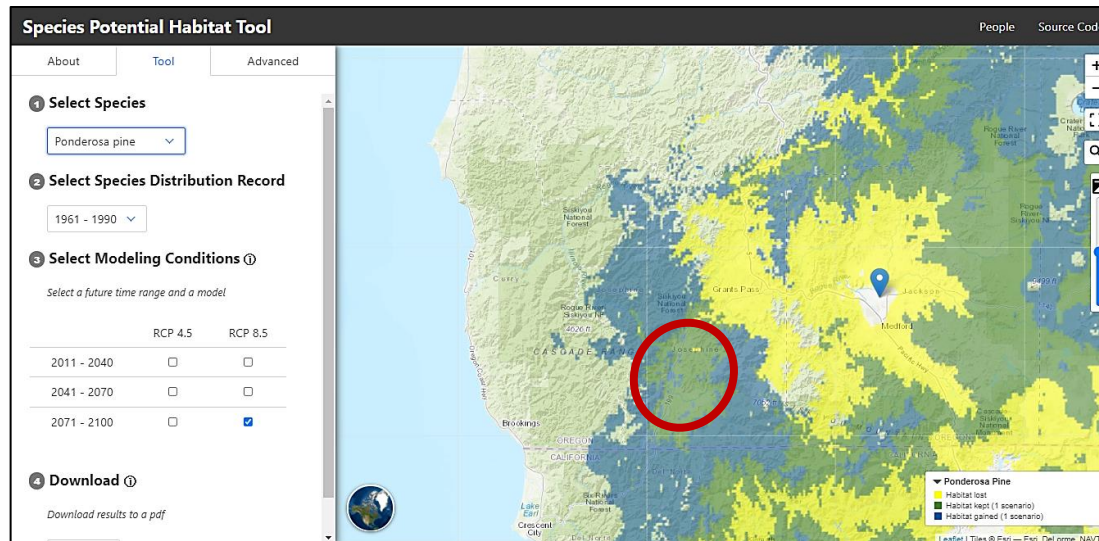
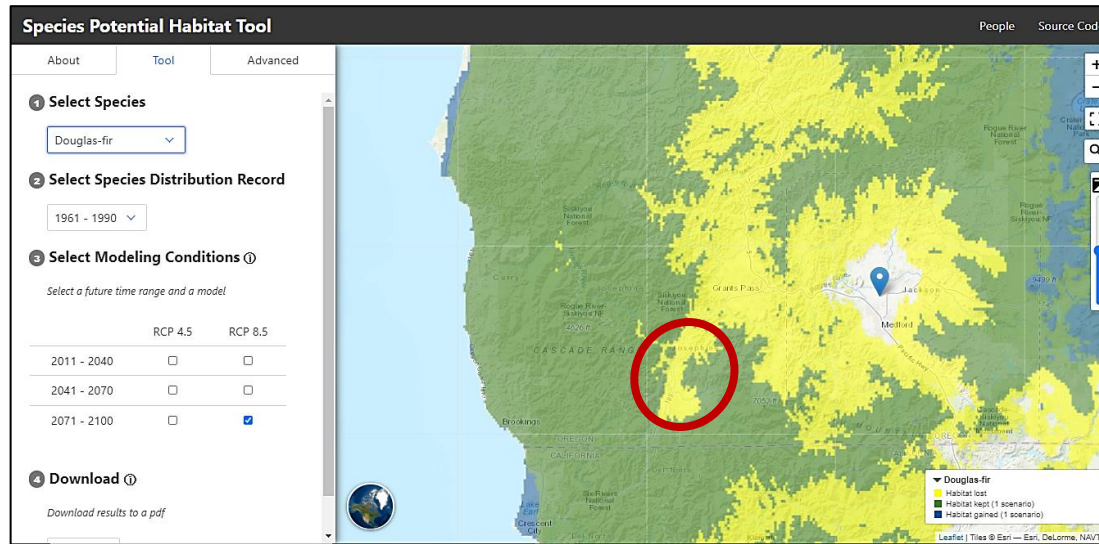
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- Habitat kept (3 scenarios)
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- Habitat gained (3 scenarios)
- Habitat gained (4 scenarios)
- Habitat gained (5 scenarios)
- Habitat gained (6 scenarios)

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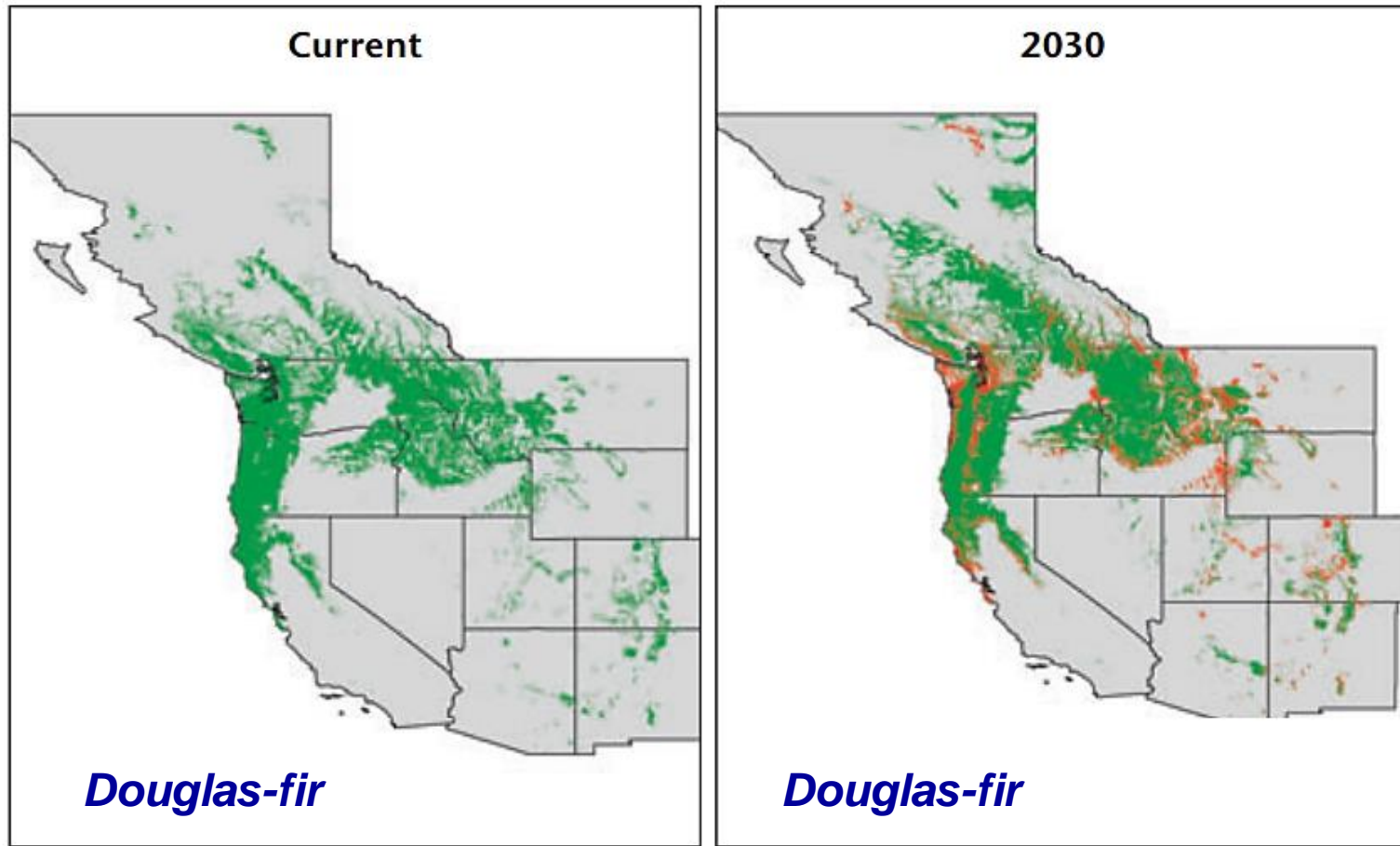
<https://specieshabitattool.org/spht/>

Douglas-fir vs ponderosa pine



Choose appropriate species

Be careful about planting near the margins of a species distributions



Weiskittel et al. (2012) Weis Schweiz Z Forstwes 163 (3):70–78

Where to get species information?

Natl. Individual Tree Species Atlas



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- Data and Application Development
- National Insect & Disease Risk Maps

Mapping & Reporting


Individual Tree Species Parameter Maps

The Individual Tree Species Parameter Maps (ITSP) were developed to support the [National Insect and Disease Risk Map](#) (NIDRM) since insect and disease risk is often driven by the density of a given species. While similar to the Tree Atlas, the ITSP project mapped basal area and stand density index for each individual tree species. The parameter products are based on 30-meter Landsat satellite data, climate, terrain, and soil predictor layers and ground samples from the USFS Forest Inventory and Analysis plot data. Many other applications and analyses requiring tree-species density could benefit from this spatially refined dataset.

These data are available in View-Only mode from the [ITSP web map viewer](#). The map services that drive the ITSP web map viewer are accessible from the Hosts folder at the ArcGIS Server connection <https://apps.fs.usda.gov/fsqjx05/rest/services>. Image services at a finer 30-meter pixel resolution area available in the 'RDW_FHP_TreeSpeciesMetrics' folder at the <https://apps.fs.usda.gov/fsqjx01/rest/services> Server connection.

The ITSP rasters used in NIDRM models are available for download from the following GIS Data Downloads.

National Individual Tree Species Atlas



USDA United States Department of Agriculture

NATIONAL INDIVIDUAL TREE SPECIES ATLAS

James R. Ellenswood
Frank J. Krist Jr.
Sheryl A. Romero

Forest Service Forest Health Technology Enterprise Team FHTET-15-01 February 2015

Natl. Individual Tree Species Atlas



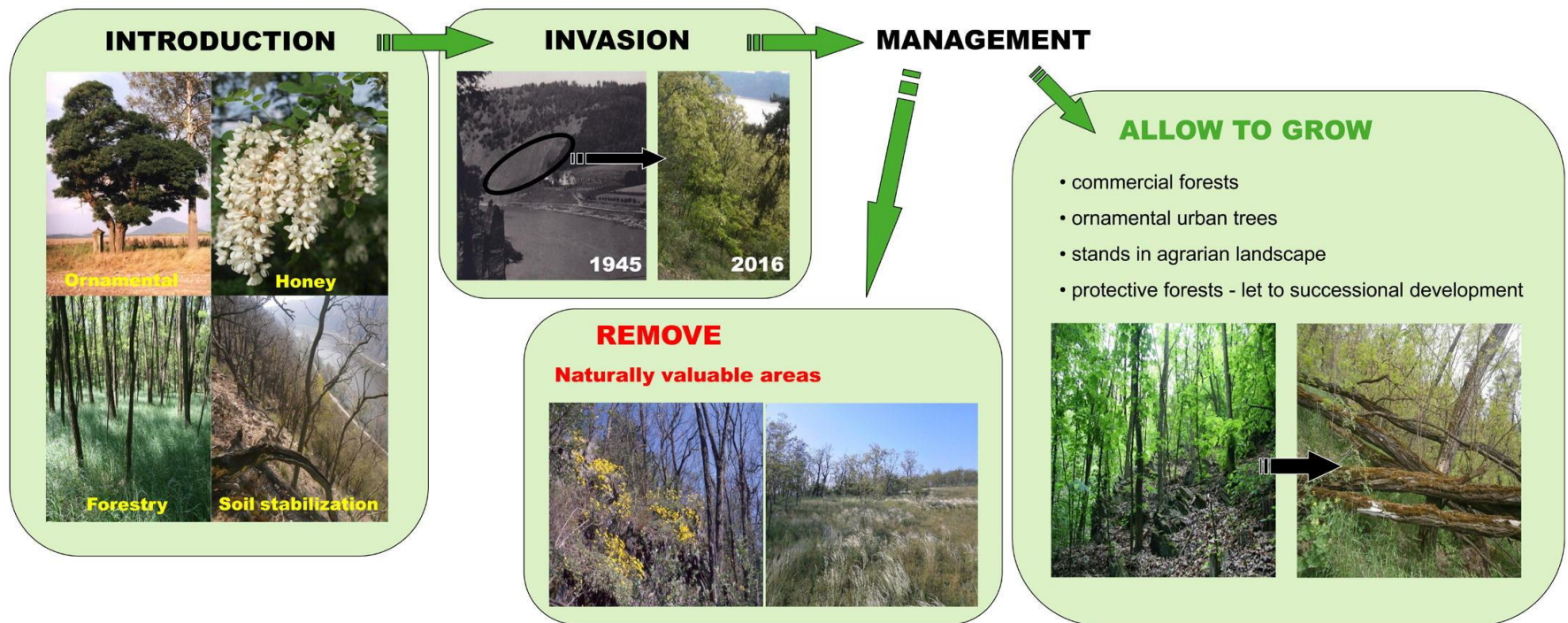
Douglas-fir



Ponderosa pine

Species AM - Concerns

May lead to species invasions



Slide from Greg O'Neill

Species AM - Concerns

Insects and pathogens may hitchhike



Slide from Greg O'Neill

I've chosen a suitable species...
Which seedlot should I use?

Assisted migration

Species-level

Population-level

Exotic species translocation

Range expansion

Seed transfer

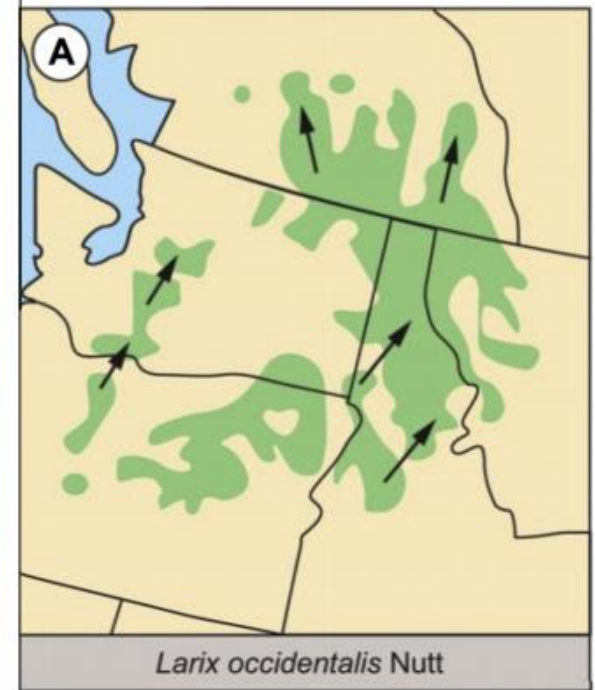
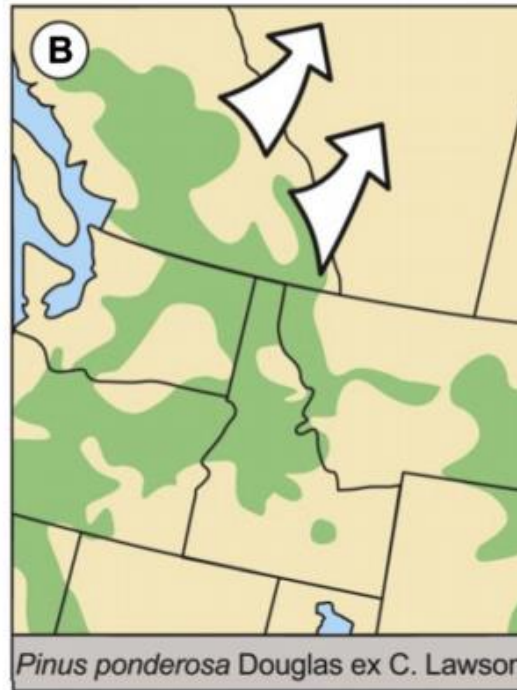


Figure modified from Williams and Dumroese (2014) *Tree Planters' Notes* 57(1):21-26

Population-level assisted migration

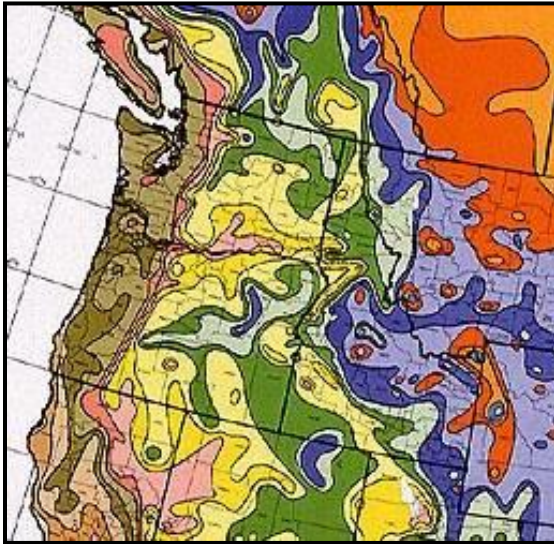
Zone Matcher

https://pnw-focal-zones.shinyapps.io/ZM_CMIP6_v5/



NORTHWEST
Climate Adaptation
Science Center

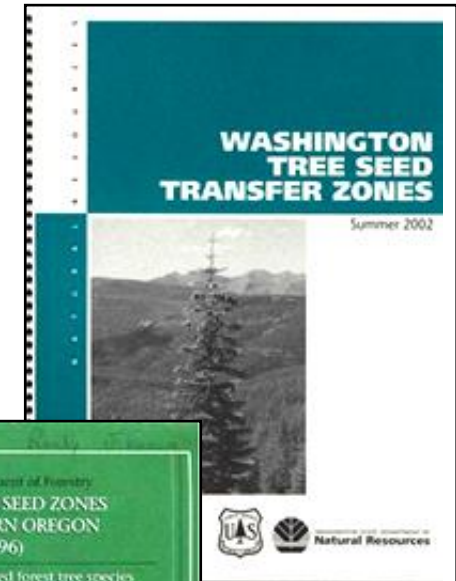
What to plant - Seed zones and breeding zones



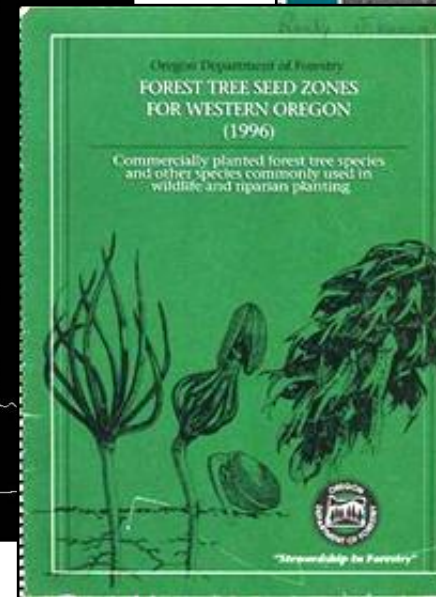
Seed zones and breeding zones are largely delineated based on climate



Randall (1996) OR Dept of Forestry

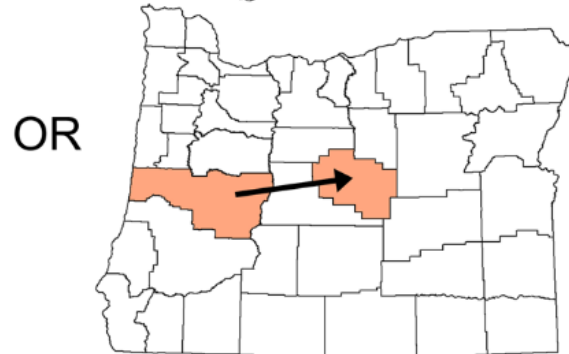


Randall and Berrang (2002) WA Dept Nat Resources

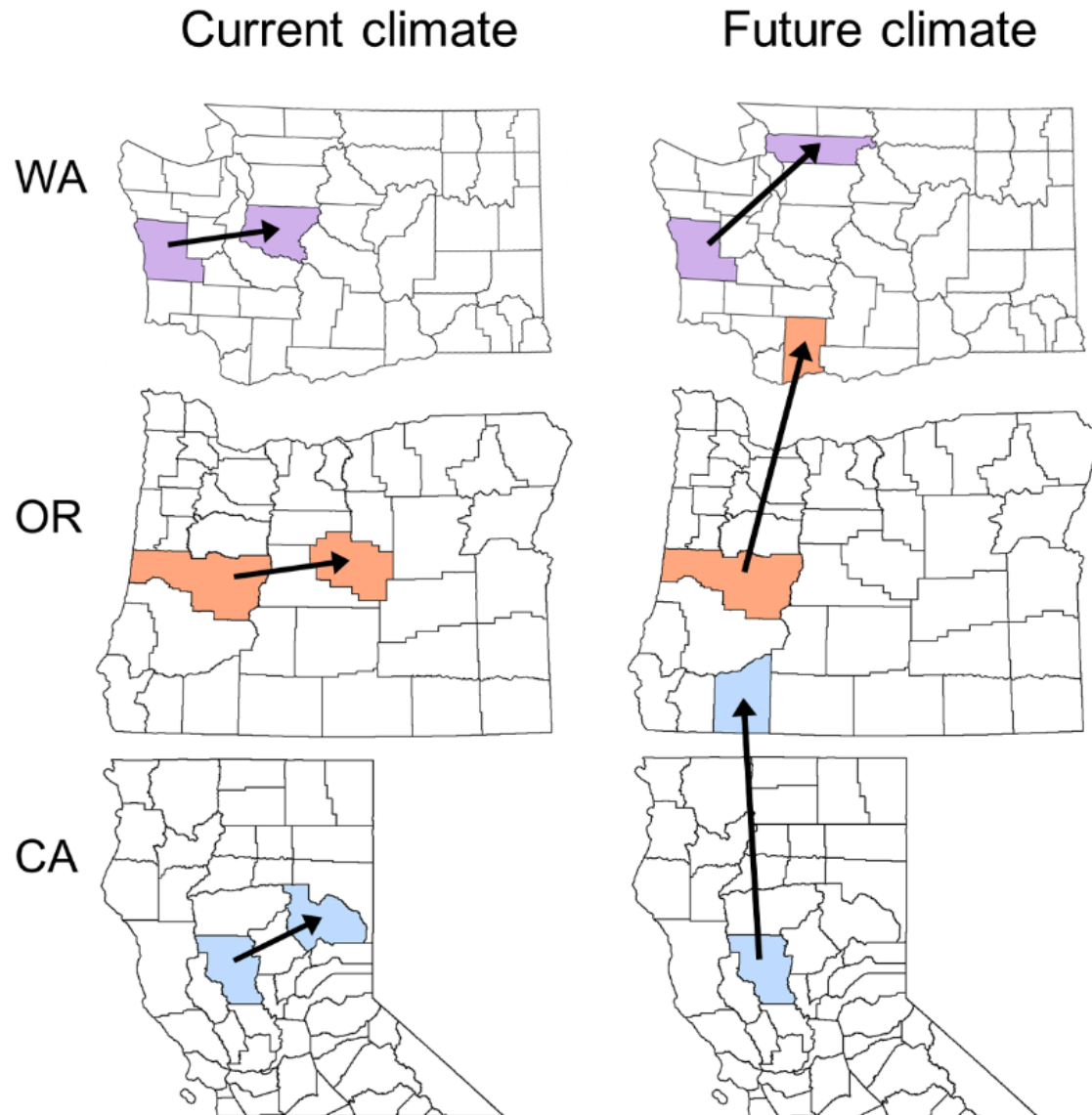


Zone matching – Current climates

Current climate



Zone matching – Future climates



Zone Matcher web application

Zone Matcher

Match Instructions Transfer limits

[Download](#)

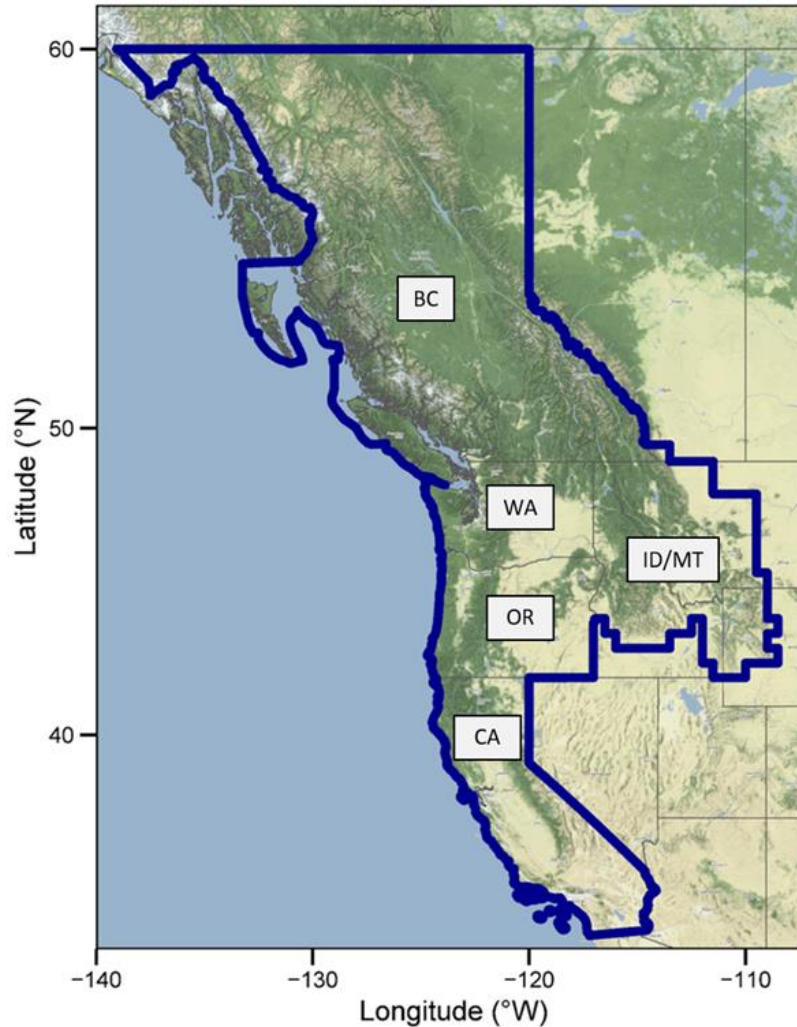
Focal climate is 1995 | Historic
Match climate is 1995 | Historic

Distance between focal and comparison zone = 518

Zone	AHM	CMD	DD_0	DD5	EMT	EREF	EXT	FFP
ORWA66_generic_11_0_499	9.1	117.0	83.5	1813.0	-12.2	600.8	32.9	237.8
ORWA66_generic_51_0_499	8.3	154.5	67.5	2090.2	-13.6	739.0	34.8	225.3

The screenshot shows a web application interface for a 'Zone Matcher'. On the left, there are input fields for 'Focal zone' (1000), 'Zone set' (WA66), 'Zone unit' (11), 'Transfer limit' (1000), 'Species' (GENERIC), and 'Elevation' (0 - 499). Below these is a 'Zone name' field containing 'ORWA66_generic_11_0_499' and an 'Update zone' button. At the bottom left, there are labels for 'Focal zone climate' and 'Match zone climate'. On the right, there are tabs for 'Match', 'Instructions', and 'Transfer limits'. A 'Download' button is present. The status shows 'Focal climate is 1995 | Historic' and 'Match climate is 1995 | Historic'. A message states 'Distance between focal and comparison zone = 518'. Below this is a table with 9 columns: Zone, AHM, CMD, DD_0, DD5, EMT, EREF, EXT, and FFP. Two rows of data are shown, corresponding to the zone names in the input fields.

Zone Matcher region



South of Grant's Pass, OR

Ferris Gulch (42.24°N, -123.21°W, 2500 feet)

**Oregon 1966
Seed Zone #511**



A reasonable climate match

Zone Matcher

Ferris Gulch
42.24°N, -123.21°W
2500 feet

Match Instructions Transfer limits

Download

Focal climate is 2085 | SSP2: 4.5

Comparison climate is 1975 | Historic

No. of matches (scaled distance <= 1.0) = 279

No. of searches = 2041

Percent matching (scaled distance <= 1.0) = 13.7

Scaled distance between focal and comparison zone = 0.744

Zone	ELEV_M	ELEV_FT	LAT	LONG	PHOTO	EMT	EREF	FFP	MAP	MAT
OR66_generic_511_2503_2999	836.4	2744.1	42.26	-123.12	14.2	-14.5	1096	230	859	13.6
CA_generic_524_4003_4498	1293.6	4244.2	39.97	-121.45	14.1	-19.4	1021	184	1850	11.2

Match	Dist	Scaled	Set	Species	Unit	Elevation
OR66_generic_512_3501_3999	0.204	0.438	OR66	GENERIC	512	3500 - 4000
OR66_generic_491_2001_2500	0.214	0.460	OR66	GENERIC	491	2000 - 2500
OR66_generic_462_955_981	0.215	0.461	OR66	GENERIC	462	750 - 1000
CA_generic_301_4003_4498	0.215	0.461	CA	GENERIC	301	4000 - 4500
OR66_generic_491_2503_2999	0.216	0.463	OR66	GENERIC	491	2500 - 3000
OR66_generic_512_3002_3497	0.217	0.466	OR66	GENERIC	512	3000 - 3500
OR66_generic_481_2503_2999	0.220	0.473	OR66	GENERIC	481	2500 - 3000
OR66_generic_472_1001_1499	0.223	0.479	OR66	GENERIC	472	1000 - 1500

Focal zone

Zone set

Zone unit

Zone name

Focal zone climate

Match zone climate

Choose zone sets to search for matches

BEC CA EPA4 ID/MT OR66

OR96 R61 WA66 WA02

Transfer limit

Species

Elevation

Comparison zone

Zone set

Zone unit

Species

Elevation

A reasonable climate match

Zone Matcher

Ferris Gulch
42.24°N, -123.21°W
2500 feet

Focal zone: 0.466

Zone set: OR66

Zone unit: []

Transfer limit: 0.466

Species: GENERIC

Elevation: []

Match Instructions Transfer limits

Download

Focal climate is 2085 | SSP2: 4.5
Comparison climate is 1975 | Historic
No. of matches (scaled distance <= 1.0) = 279
No. of searches = 2041

Zone	ELEV_M	ELEV_FT	LAT	LONG	PHOTO	EMT	EREF	FFP	MAP	MAT	MCMT	MSP	MWMT	TD
OR66_generic_511_2503_2999	836.4	2744.1	42.26	-123.12	14.2	-14.5	1096	230	859	13.6	5.5	109	23.5	18.0
CA_generic_524_4003_4498	1293.6	4244.2	39.97	-121.45	14.1	-19.4	1021	184	1850	11.2	3.6	148	20.9	17.3

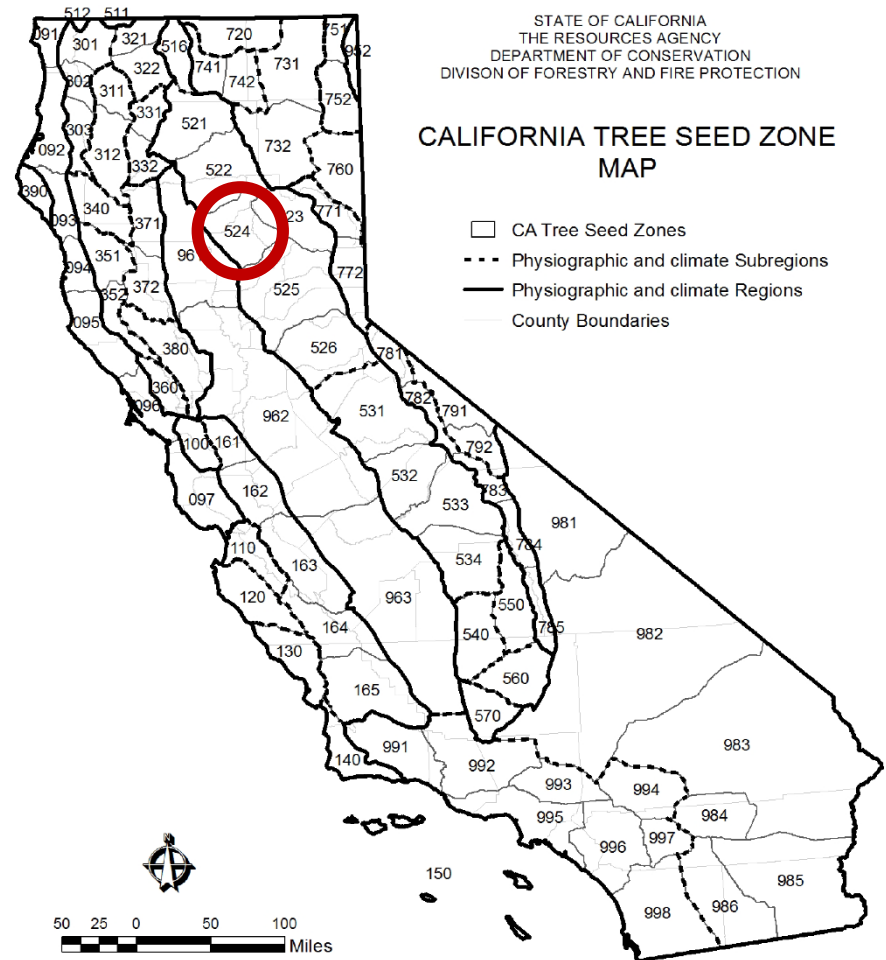
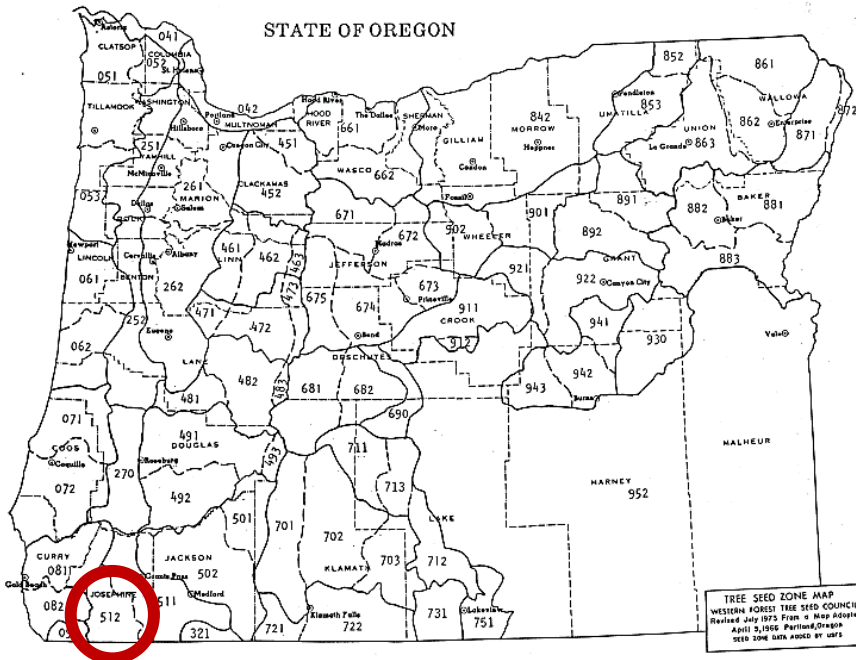
Match	Dist	Scaled	Set	Species	Unit	Elevation
OR66_generic_512_3501_3999	0.204	0.438	OR66	GENERIC	512	3500 - 4000
OR66_generic_491_2001_2500	0.214	0.460	OR66	GENERIC	491	2000 - 2500
OR66_generic_462_955_981	0.215	0.461	OR66	GENERIC	462	750 - 1000
CA_generic_301_4003_4498	0.215	0.461	CA	GENERIC	301	4000 - 4500
OR66_generic_491_2503_2999	0.216	0.463	OR66	GENERIC	491	2500 - 3000

Zone unit	Elevation	Match	Dist	Scaled	Set	Species	Unit	Elevation
524	4003 - 4498	OR66_generic_481_2503_2999	0.220	0.473	OR66	GENERIC	481	2500 - 3000
		OR66_generic_472_1001_1499	0.223	0.479	OR66	GENERIC	472	1000 - 1500

CA Seed Zone
#524
4250 feet

Redwood location in N. California

CA Seed Zone
#524
4250 feet



Questions?

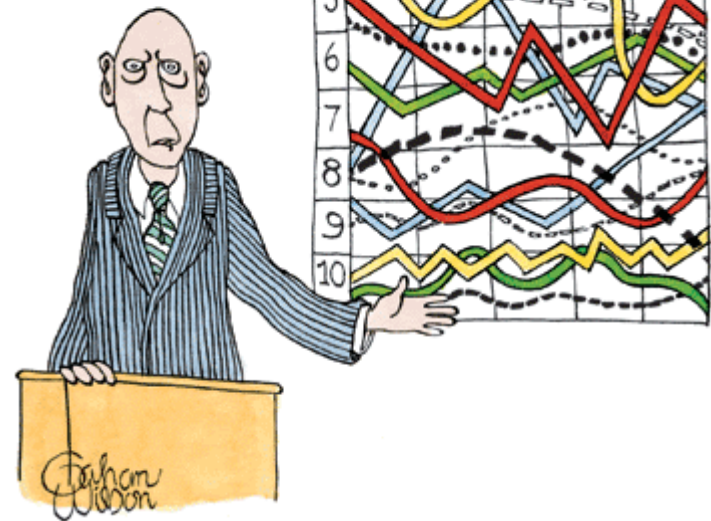
Climate change - think in terms of changing habitats

Use assisted migration (AM)

Species AM – Maybe

Population / seed source AM – Definitely

"I'll stop here so you
can let this information
sink in"



Questions?

Glenn Howe

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