Adapting Forests to Climate Change via Climate-Adapted Seed Transfer

Joe Stewart

stewartecology.shinyapps.io/CAST_dev_version/

Climate-Adapted Seed Tool | Climate-Adapted Seed Finder | Climate Tracker | About

Planting Location:

Specify planting location by: Coord

Map seed sources as: Raster

Longitude

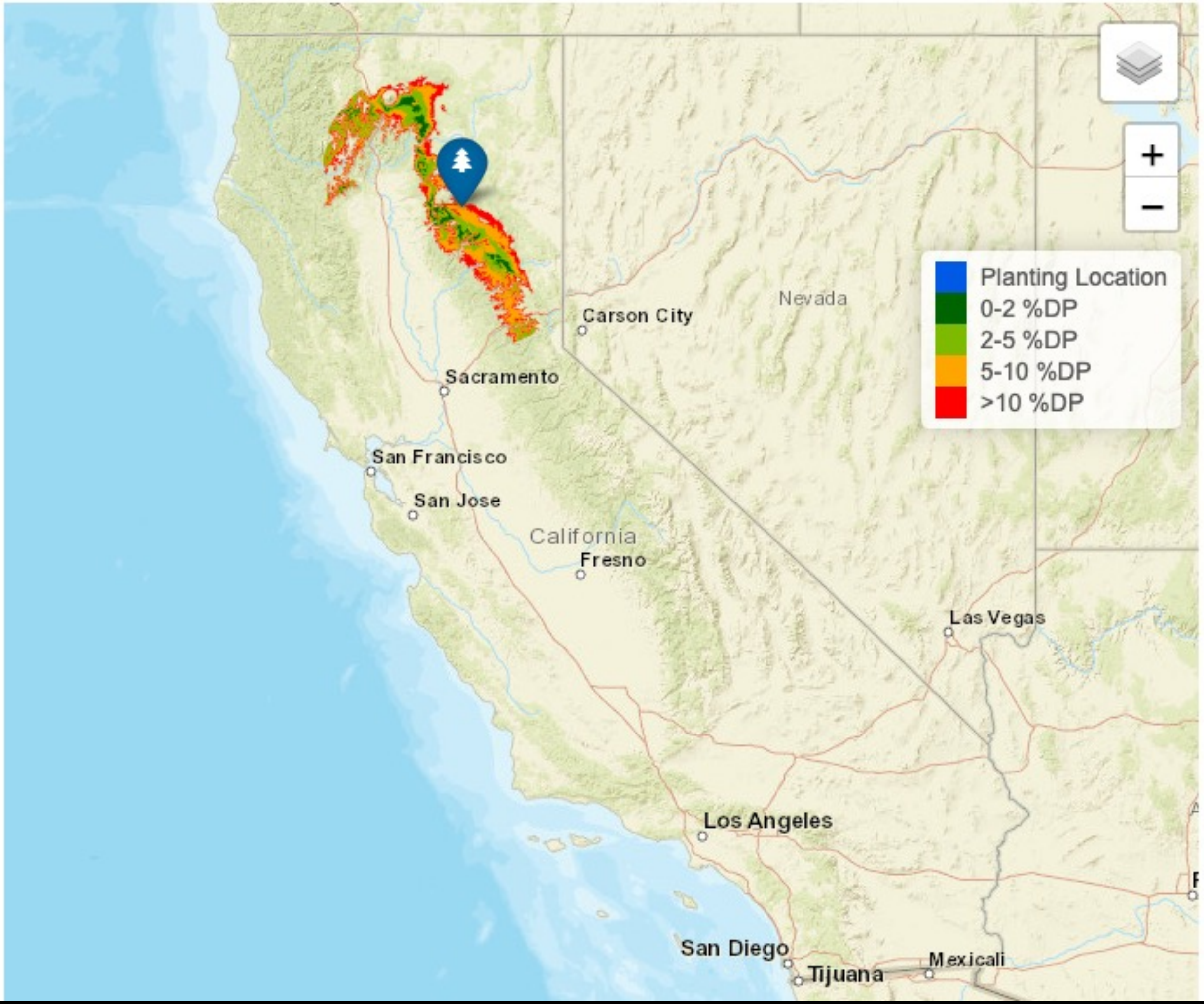
-121.29136

Latitude

40.40304

Species

Pinus ponderosa



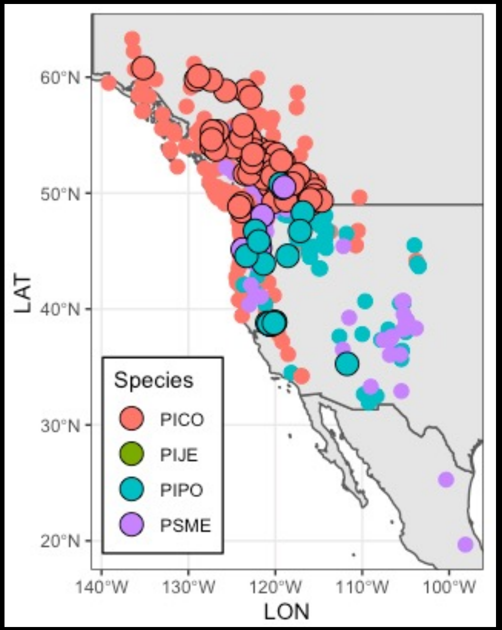
Examine Match | Table | Raster

Seed Zone	Elevation	% Decline in Productivity			CO2 Seq.
		Expected	Lower	Upper	
522	6000 - 6500ft	14.41%	10.75%	19.52%	105.63
332	5000 - 5500ft	2.37%	1.24%	3.85%	142.20
521	5000 - 5500ft	2.40%	0.52%	4.13%	136.75
331	5000 - 5500ft	2.90%	1.31%	4.05%	135.32
331	4500 - 5000ft	3.01%	1.56%	4.76%	142.05
332	5500 - 6000ft	3.33%	1.33%	5.24%	134.88
521	4500 - 5000ft	3.56%	0.84%	10.86%	143.15
332	4500 - 5000ft	3.66%	2.25%	6.45%	144.86
521	5500 - 6000ft	4.90%	1.08%	8.70%	125.32
522	5000 - 5500ft	4.97%	1.35%	12.46%	127.82

Showing 1 to 10 of 47 entries

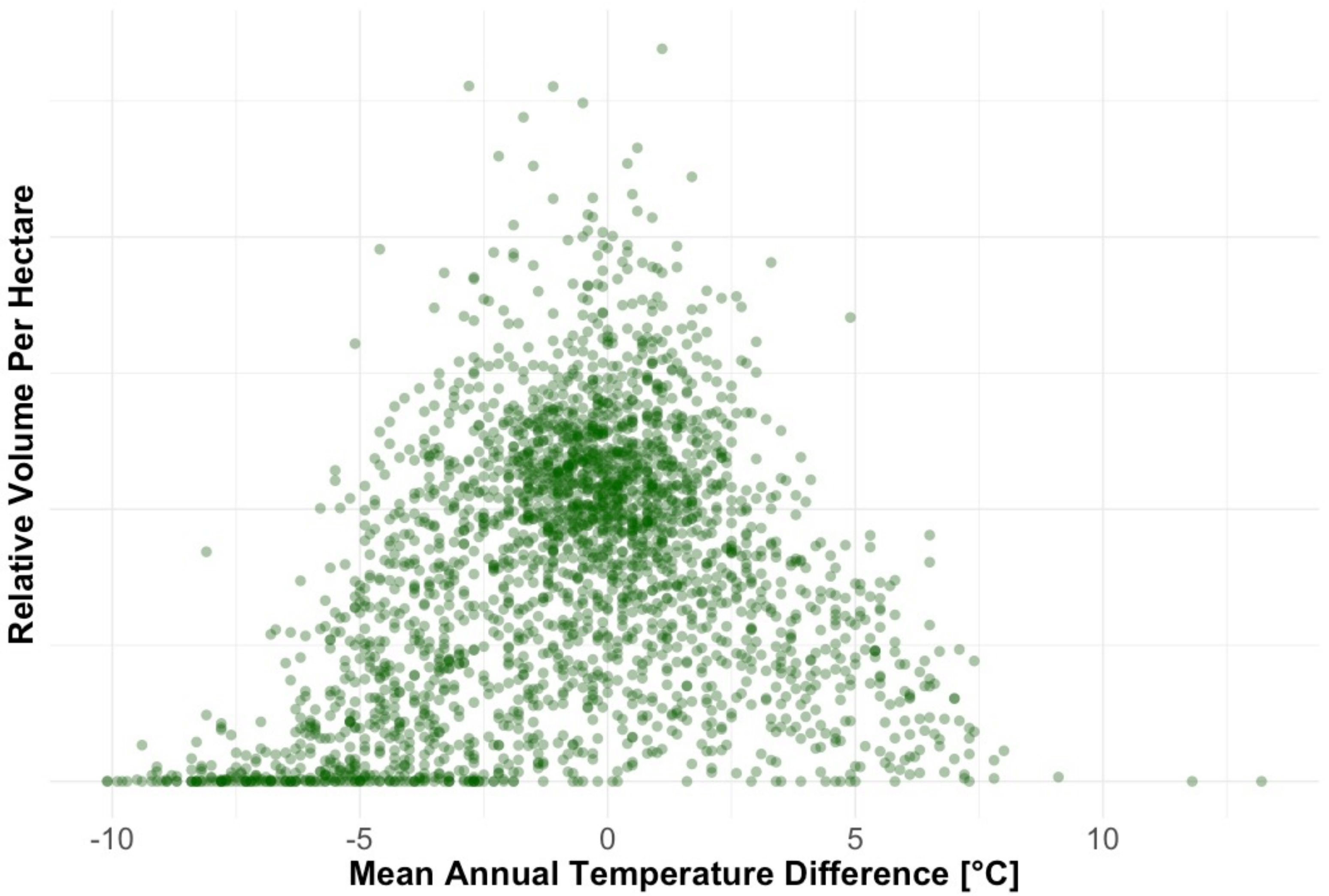
Previous 1 2 3 4 5 Next

Provenance Test Data Sets



Species	abco	abma	acma	alru	pico	pije	pimo	pien	pipo	pisi	potr	psme	qulo	thpl	tshe
N. Provenances	14	9	42	47	184	3	145	182	42	30	180	77	95	10	57
N. Sites	5	5	3	2	60	3	7	26	10	9	3	6	2	6	5
N. Trees	9.1k	3.3k	13.8k	4.1k	70.7k	4.6k	22.1k	110k	10k	31.9k	9k	25.3k	7k	4.1k	42.7k
Last Meas. Age [yrs]	18-26	18-26	10	10	20-35	41	16	10-15	8-80	10-15	3	17-100	6	15	5-25
Planting Yr(s)	1976-1979	1976-1979	2008-2009	1995	1974	1973	1988	2000-2005	1910 - 1992	2000	2000-2007	1915-1975	2014-2015	1991	1993-2005

Shape of Response Functions



Growing in colder climate than seed origin

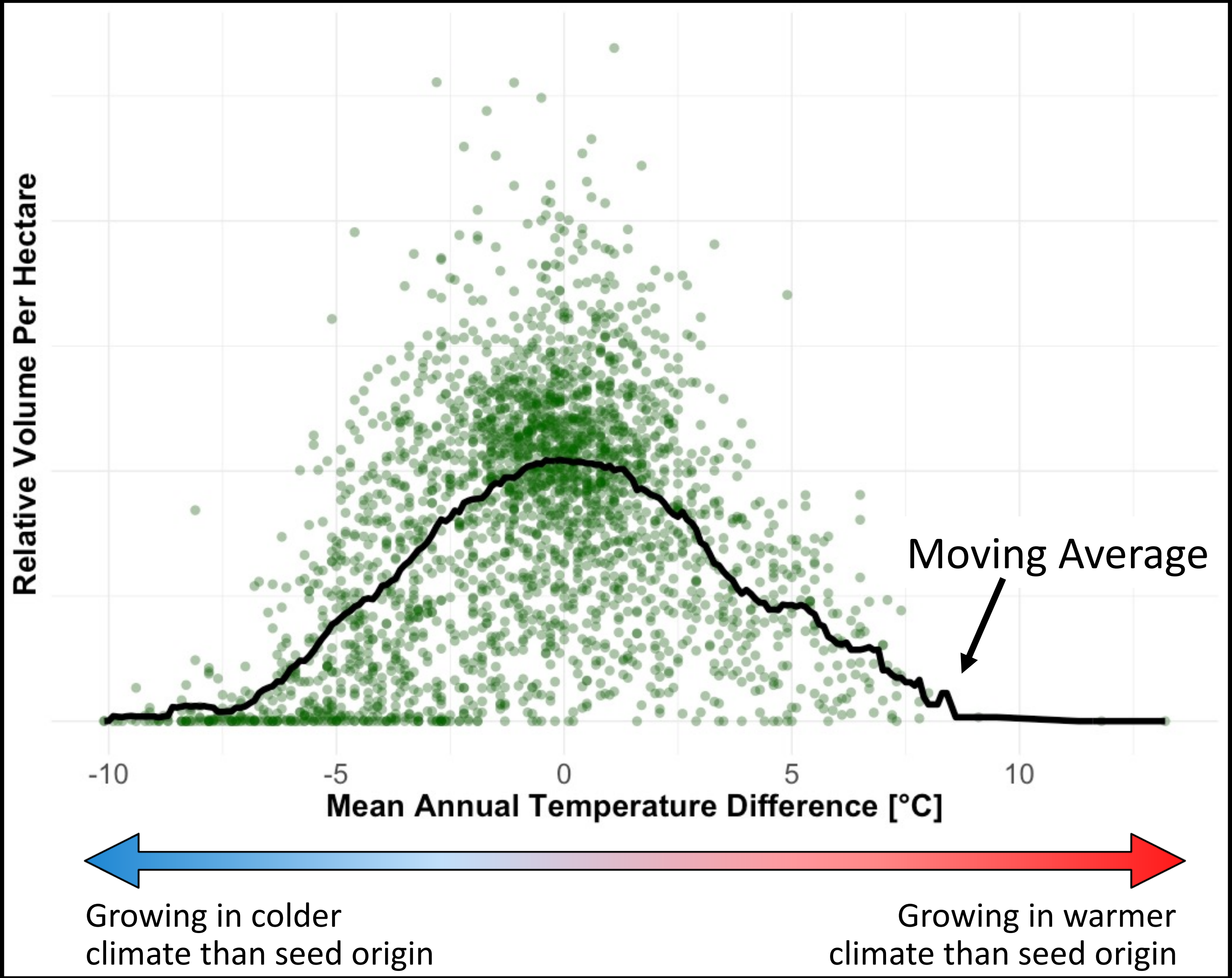
Growing in warmer climate than seed origin

Age 32 lodgepole pine data (Illingworth+)

- 44 sites
- 182 Provenances
- ~50,000 trees

Photo Courtesy Greg O'Neill

Shape of Response Functions



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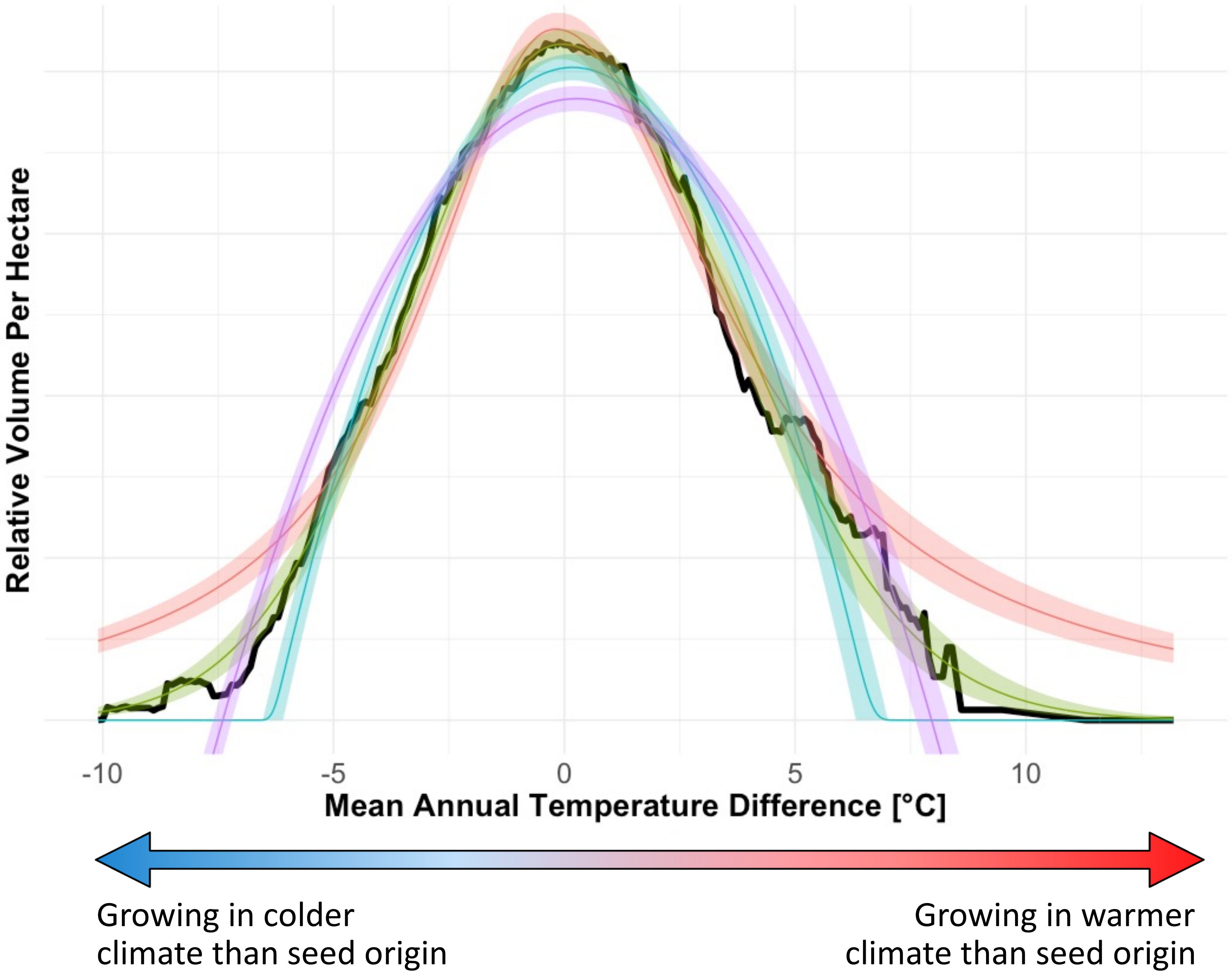
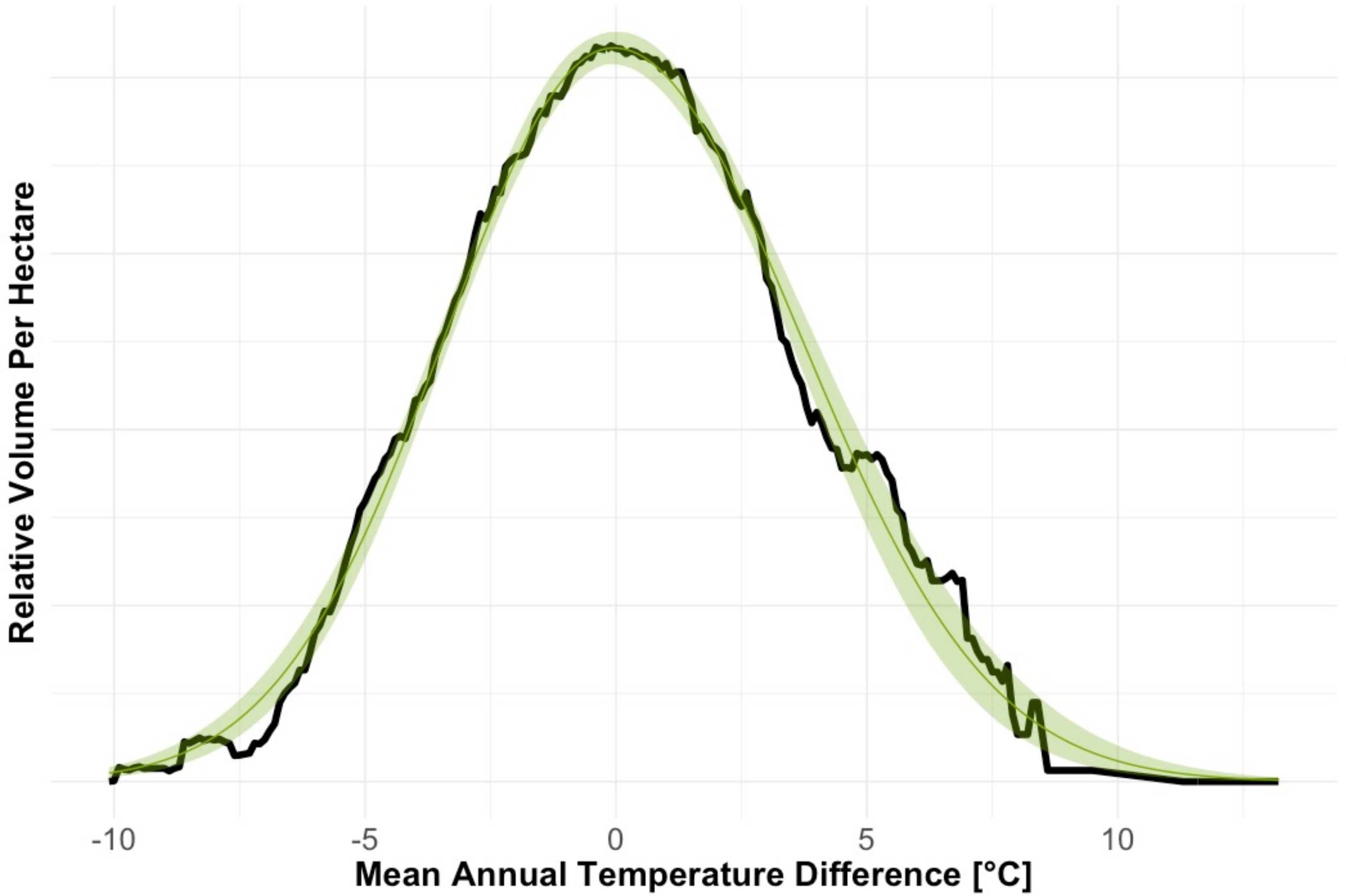


Model	Δ LOO IC
Asymetric Gaussian	0
Asymetric Cauchy	28.3
Non-negative Quadratic	40.9
Quadratic	97.1

Shape of Response Functions



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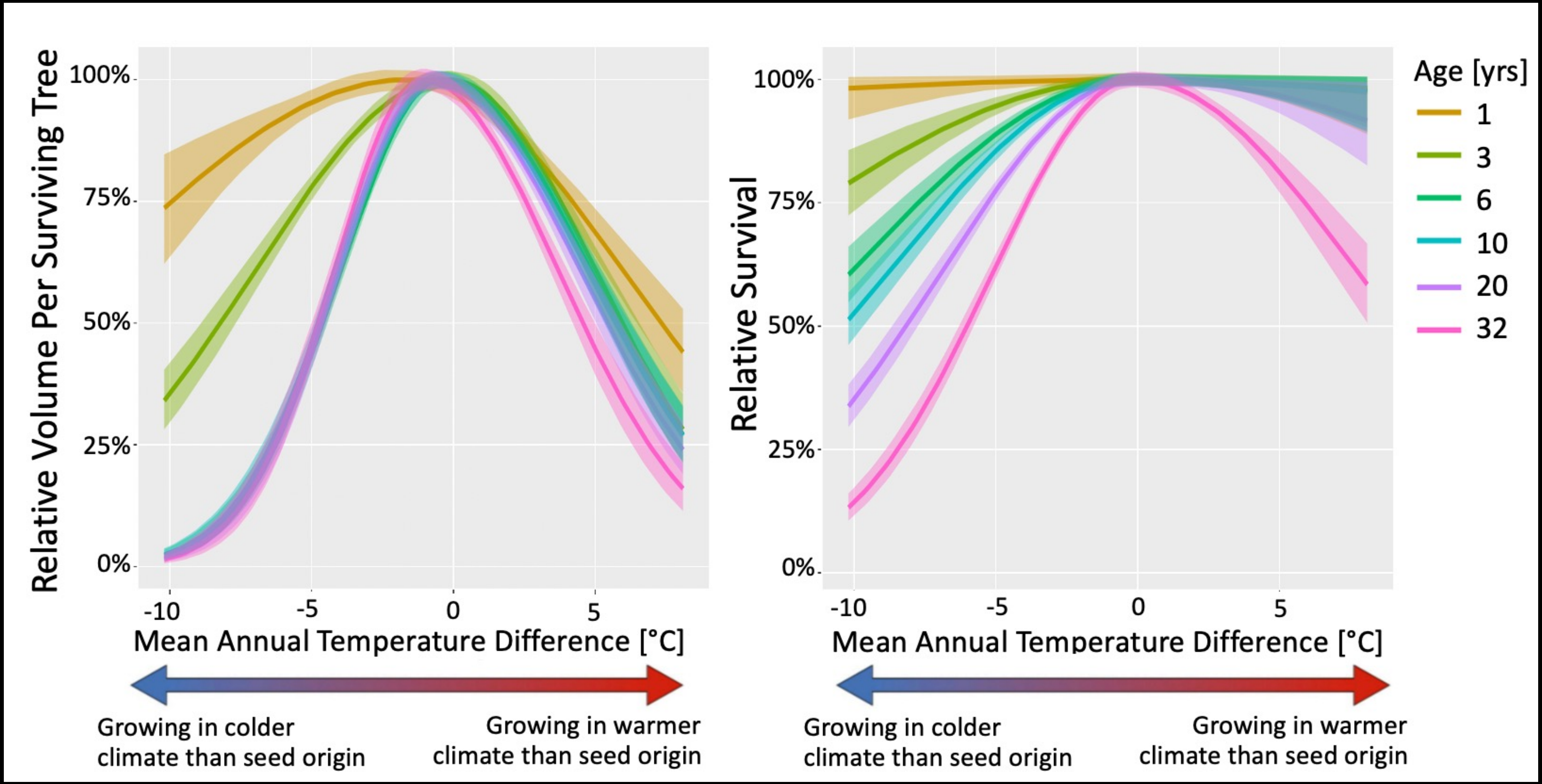
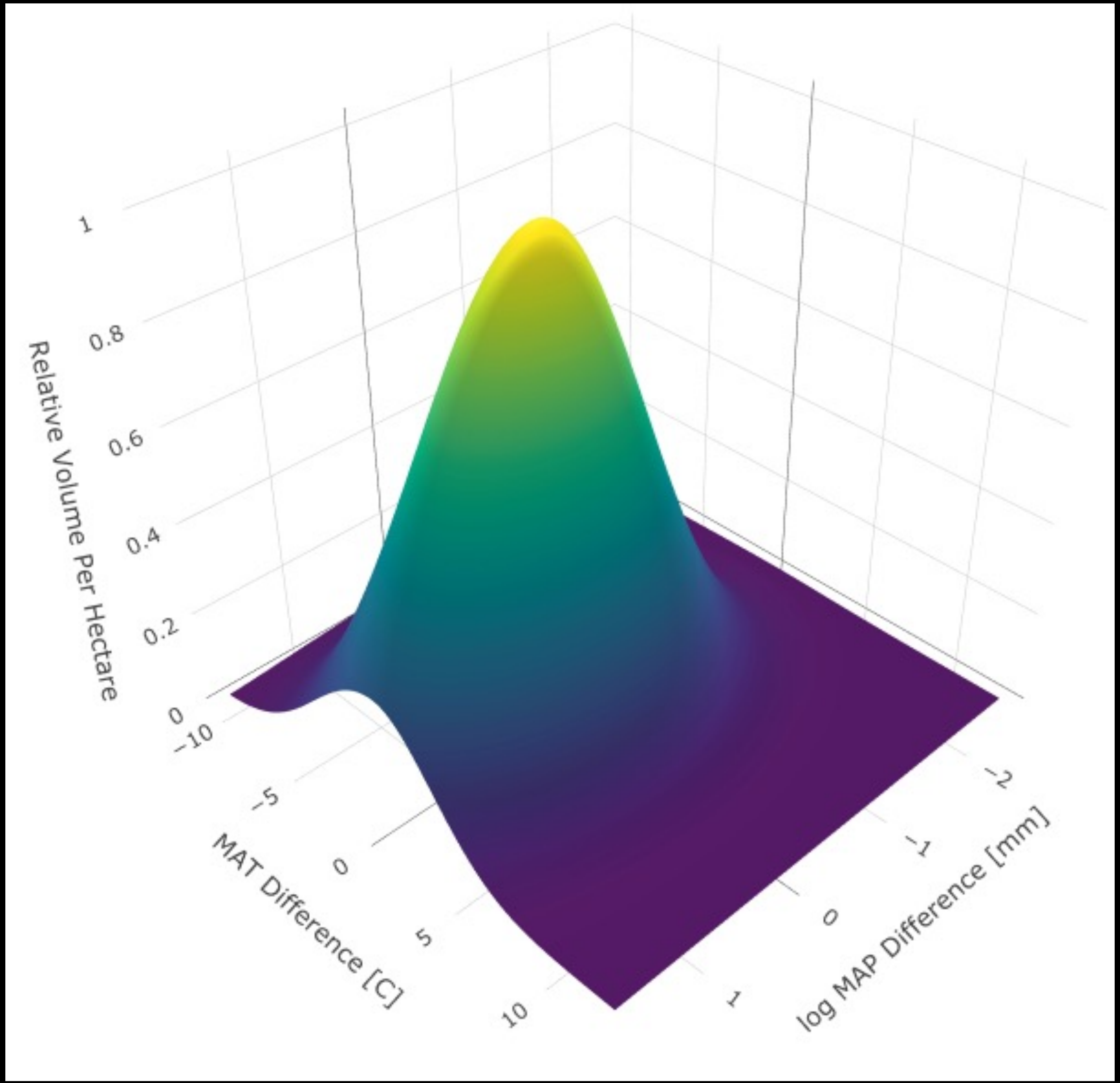
Effects of tree age on transfer functions



3-Dimension Ensemble Transfer Functions

Model	Bayesian Stacking Weight (LOO)	Δ LOO IC	LOO R2
MAT & MAP	0.319	111.71	0.369
MCMT & MAP	0.195	0	0.400
TD & MAP	0.470	34.31	0.388
MWMT & MAP	0.016	495.77	0.266

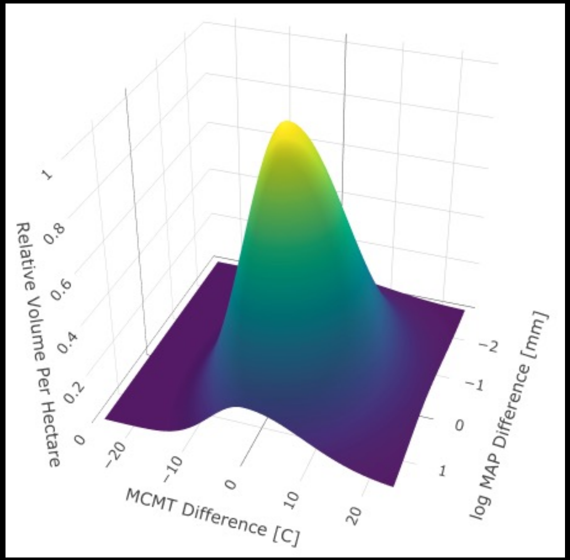


MAT: Mean Annual Temperature

MCMT: Mean Cold-Month Temperature

MAP: Mean Annual Precipitation

MWMT: Mean Warm-Month Temperature



Yao et al. 2018. Bayesian Analysis: 13:917–1007.

Multi-Dimension Ensemble Transfer Functions

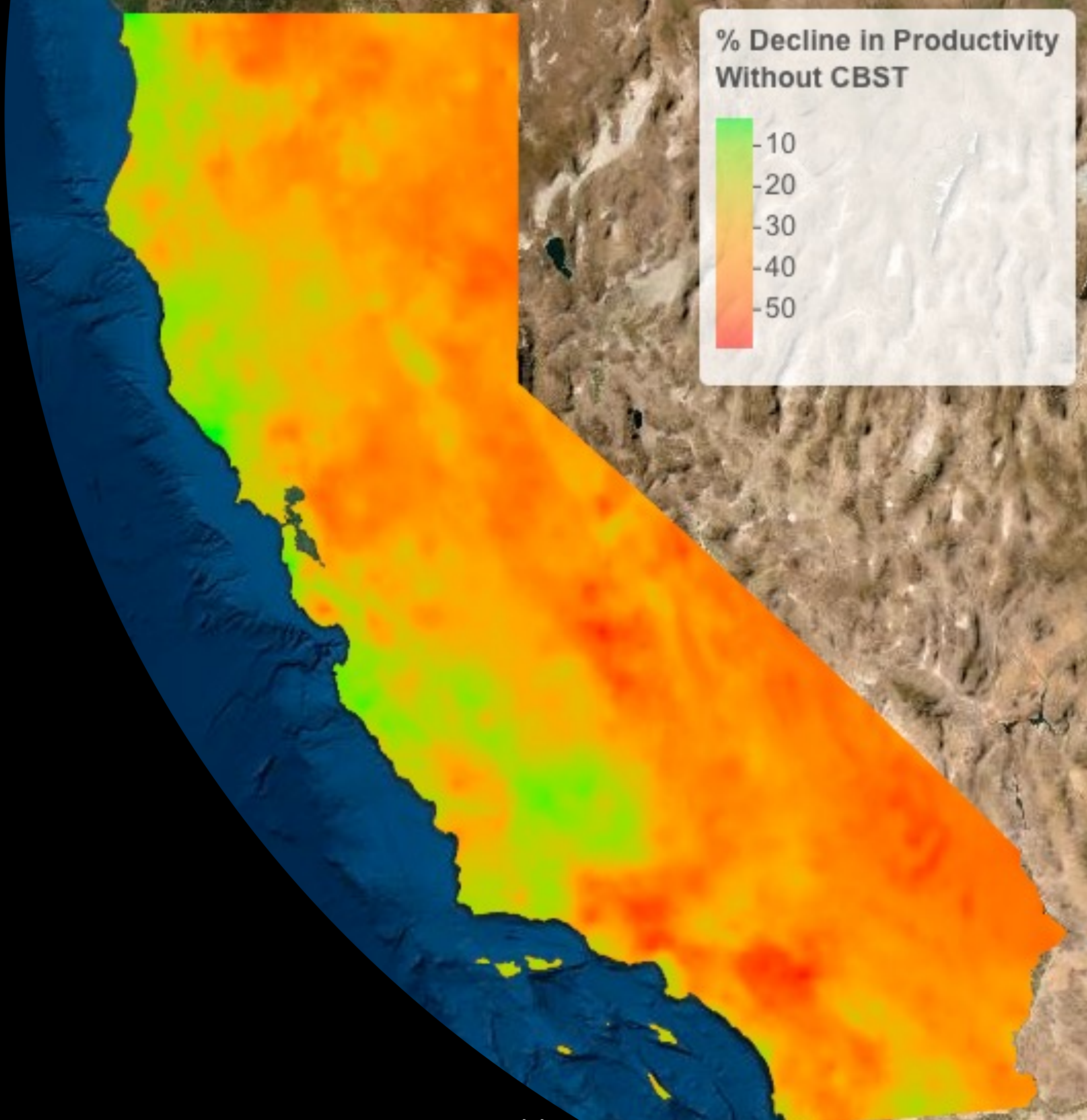
Independent Variables	Bayesian Stacking Weight (LOO)	Δ LOO IC	LOO R^2
PC(MAT, MCMT, TD, MAP)[1:4]	0.514	0	0.550
PC(MAT, MCMT, MWMT, TD, MAP, MSP, AHM, SHM)[1:6]	0.471	88.51	0.534
PC(MAT, MCMT, MWMT, TD, MAP, MSP, AHM, SHM)[1:5]	0.000	350.97	0.483
PC(MAT, MCMT, TD, MAP)[1:3]	0.000	382.60	0.476
MAT & MAP	0.000	857.26	0.369
MCMT & MAP	0.000	745.55	0.400
TD & MAP	0.000	779.86	0.388
MWMT & MAP	0.015	1241.33	0.266

MAT: Mean Annual Temperature
MCMT: Mean Cold-Month Temperature
MAP: Mean Annual Precipitation
MSP: Mean Summer Precipitation
MWMT: Mean Warm-Month Temperature
TD: Temperature Differential
AHM: Annual Heat-Moisture Index
SHM: Summer Heat Moisture Index

Yao et al. 2018. Bayesian Analysis: 13:917–1007.

Crisis and Opportunity

- California forests are not adapted to rapidly changing climate conditions.
- With climate-based seed transfer (CBST) we can take proactive steps to adapt forests to climate change.
- CBST can make a huge positive impact on forest health and net CO_2 emissions.

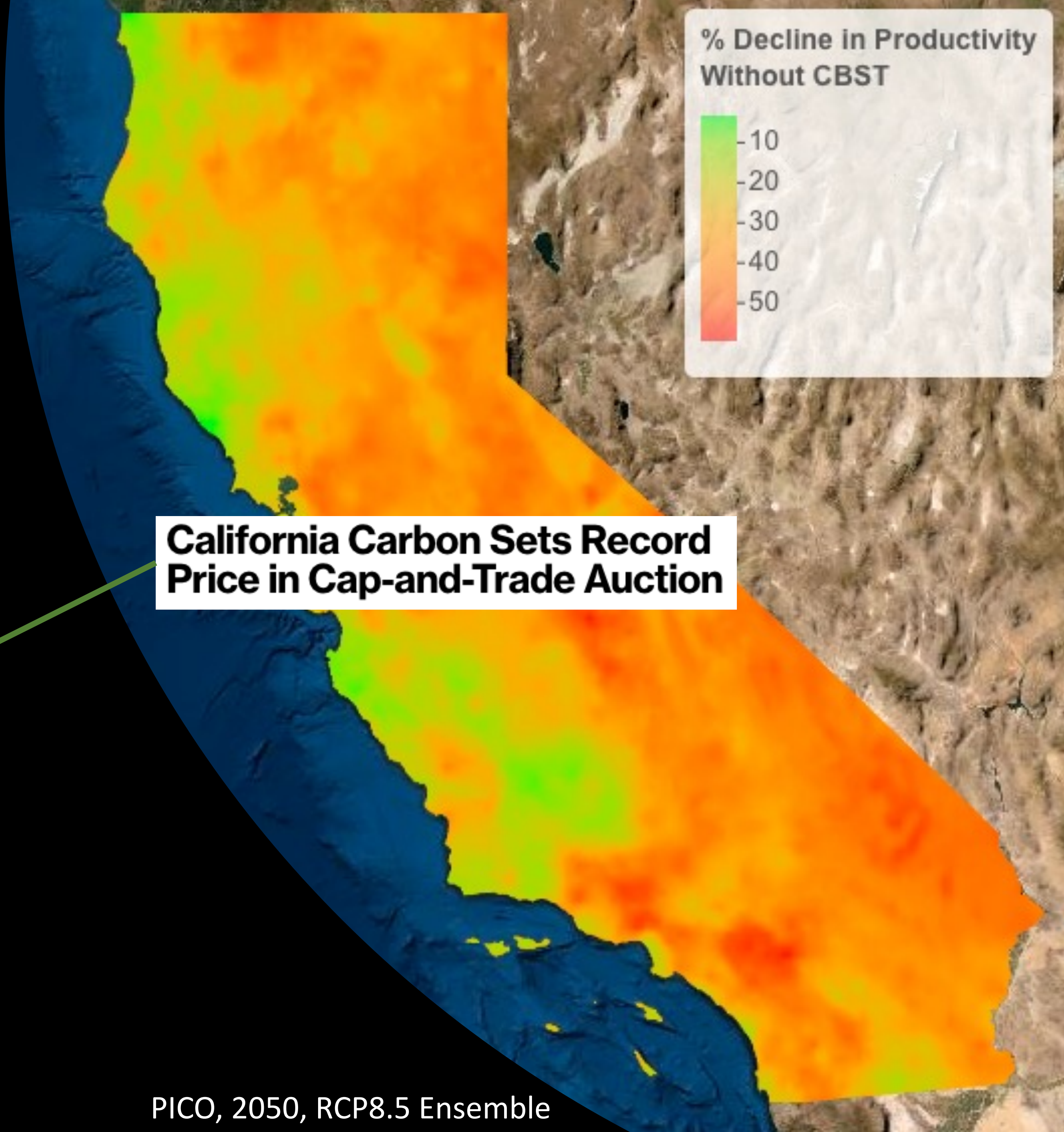


PICO, 2050, RCP8.5 Ensemble

Conservative Estimates of CBST Impact

If deployed across private land in CA starting in 2021:

	By 2050	By 2060
Additional CO2 Sequestered [*million* tonnes/yr]	2.3	4.1
Market Value of Additional CO2 Sequestered [*million* USD/yr]	$77	$138
Percent of net 2018 CA GHG Emissions [%/yr]	.5%	1%
Additional Timber Production [*million* board-ft/yr]	142	256



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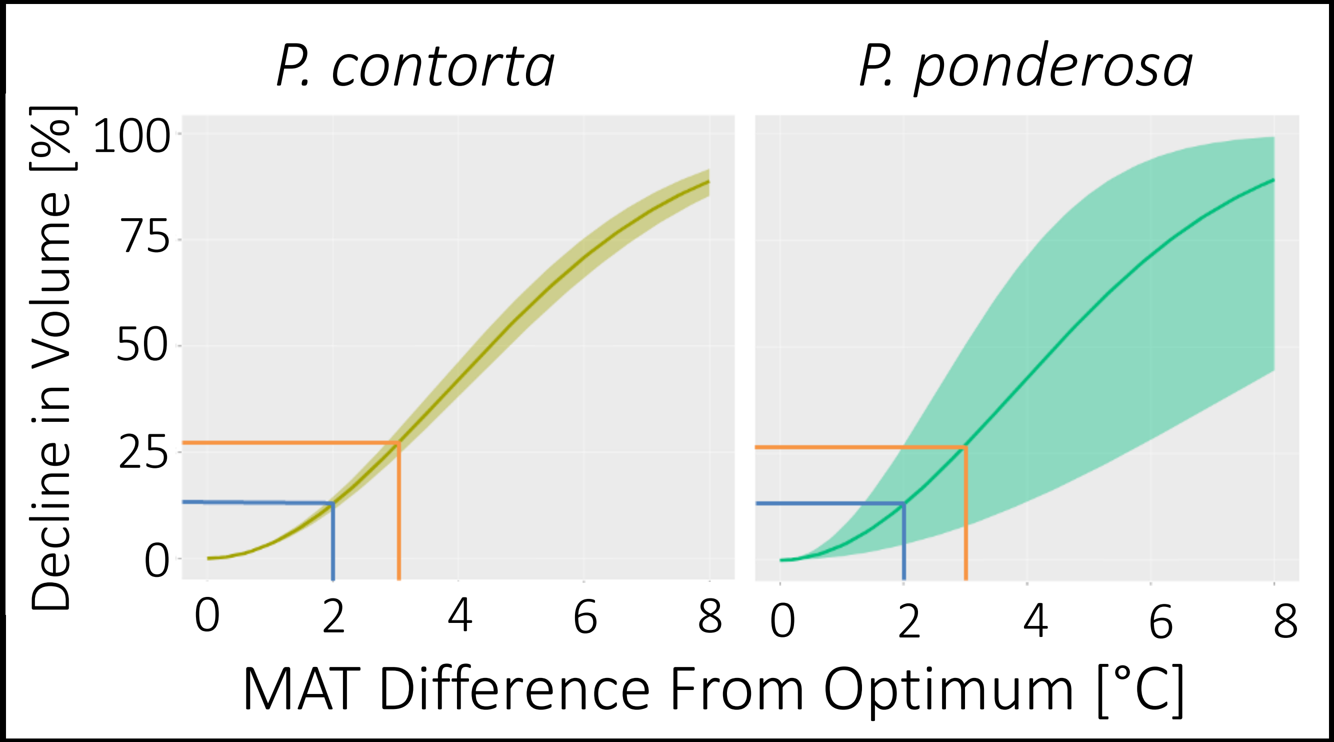
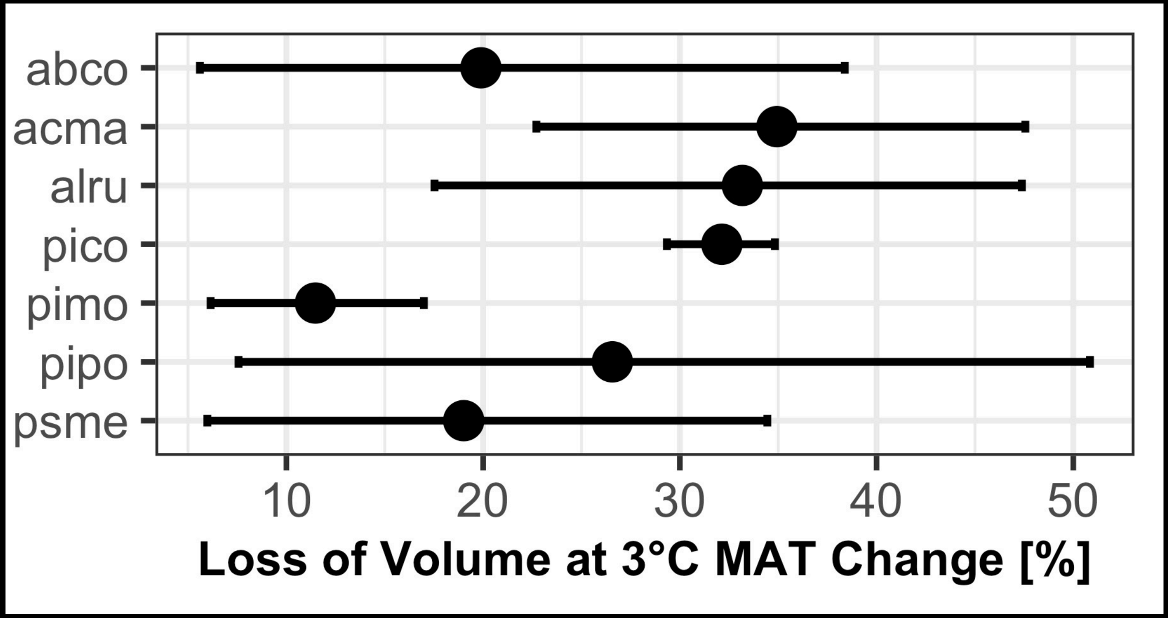
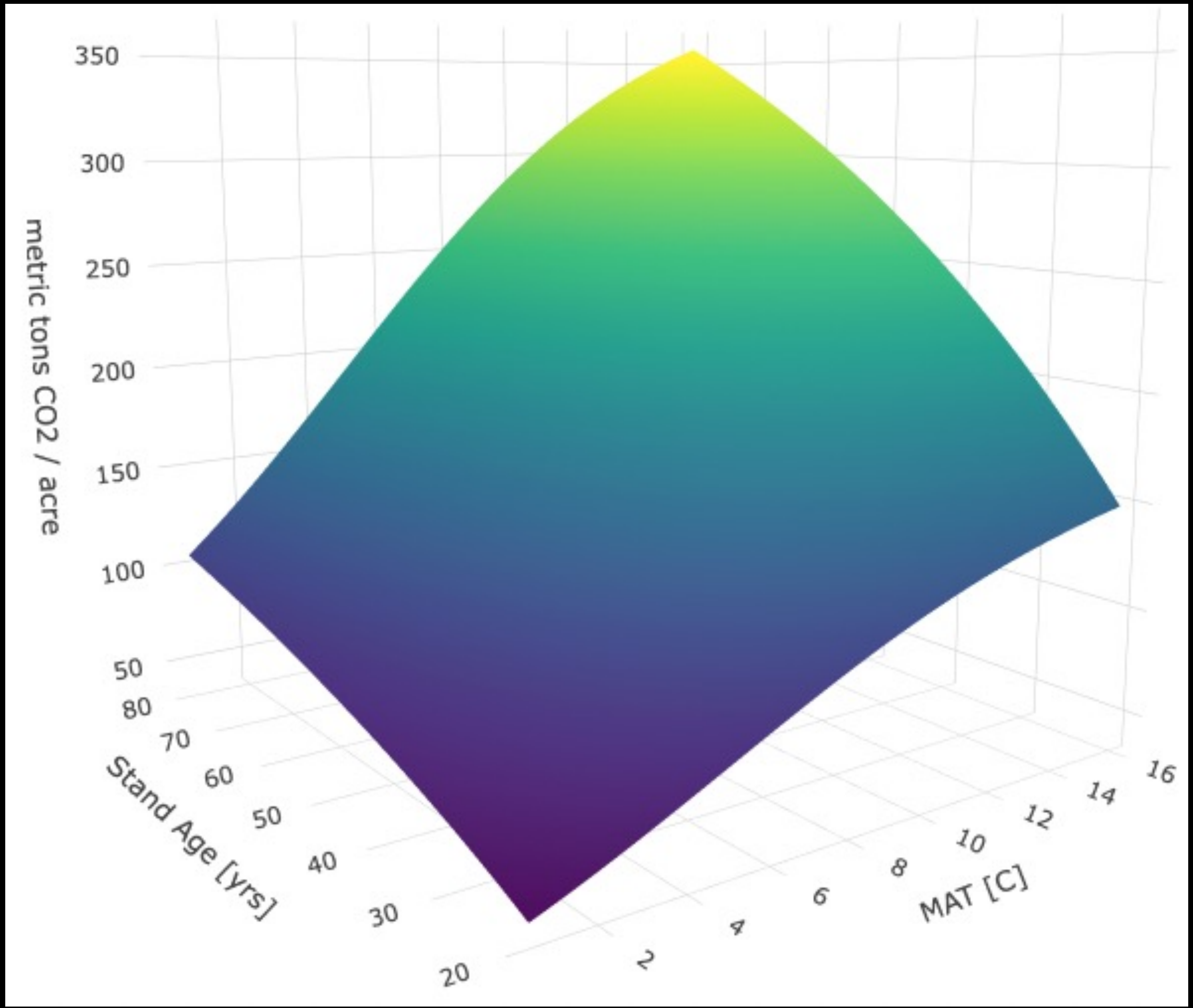
Differences between species (provisional analyses)

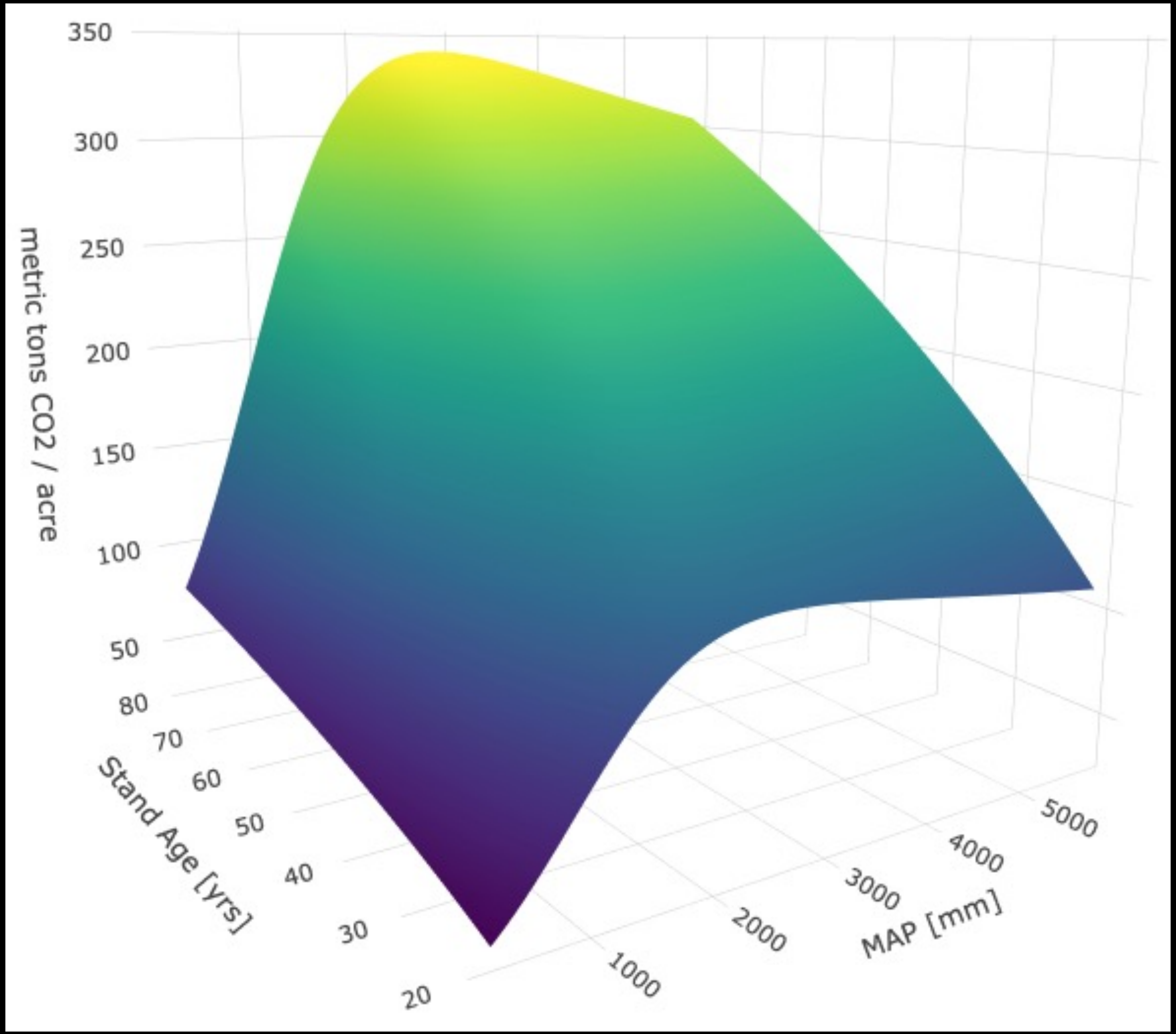




Growth and Yield Functions

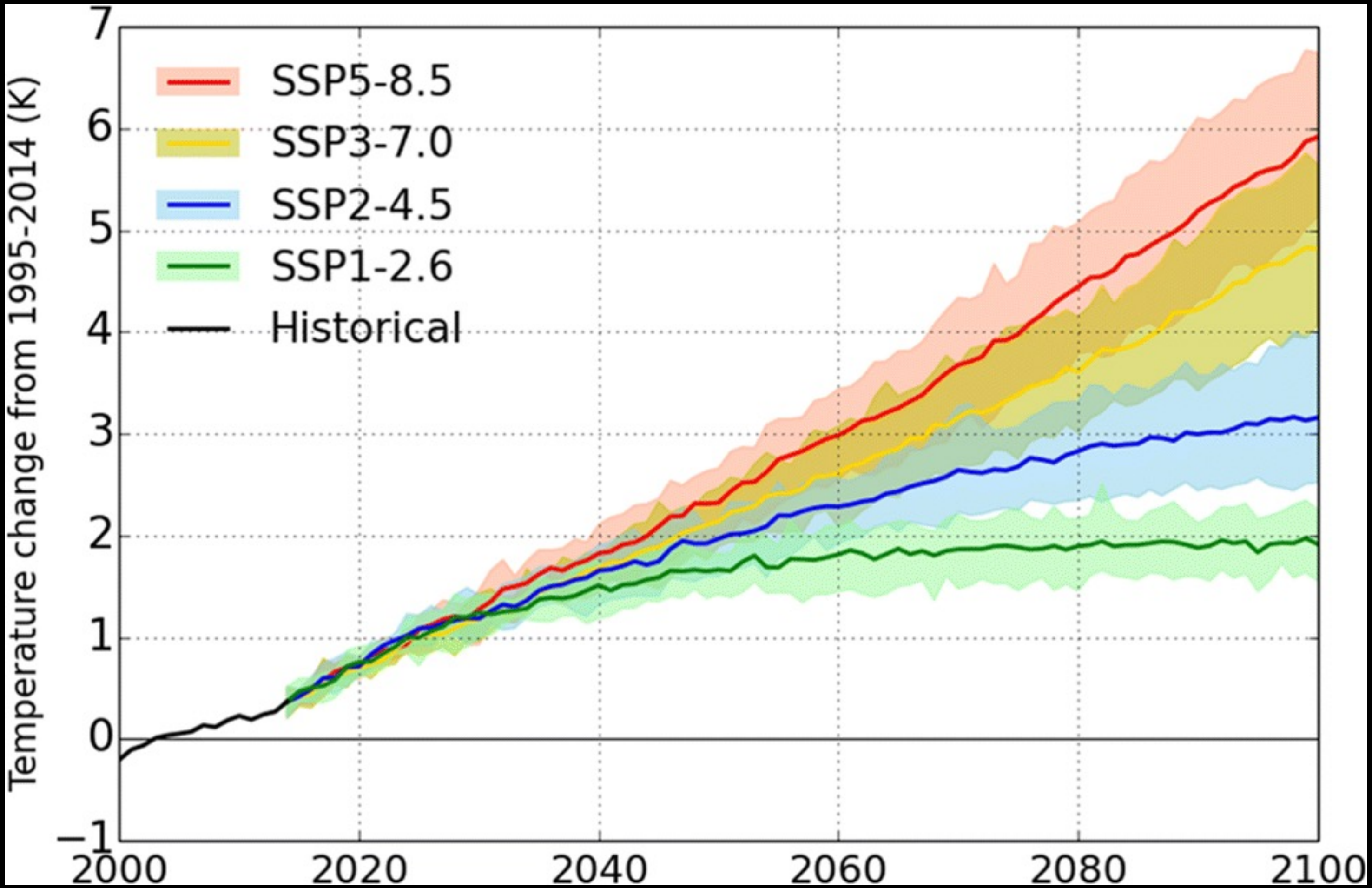
- Fit to FIA data from 5 most western US states
- Monod-type function





Optimizing Seed Selection for Growth and Survival Over the Long Run

- Climate is a moving and uncertain target.
- Tradeoff between short- and long-term growth and survival.
- Age-specific sensitivity to climate adaptation mismatch.
- Better quantitative approach for optimizing seed selection for long-term growth and survival.



Sung et al 2021

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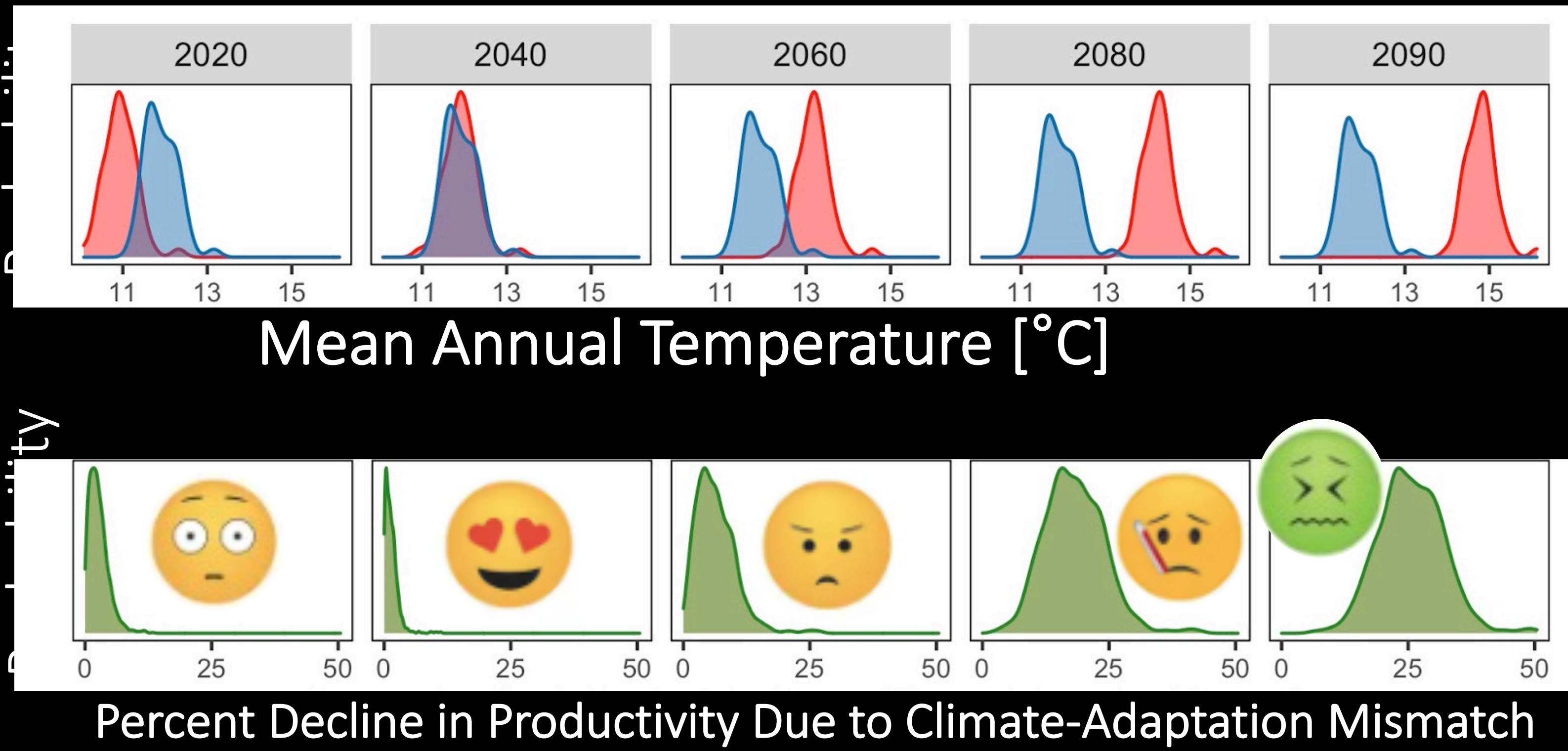

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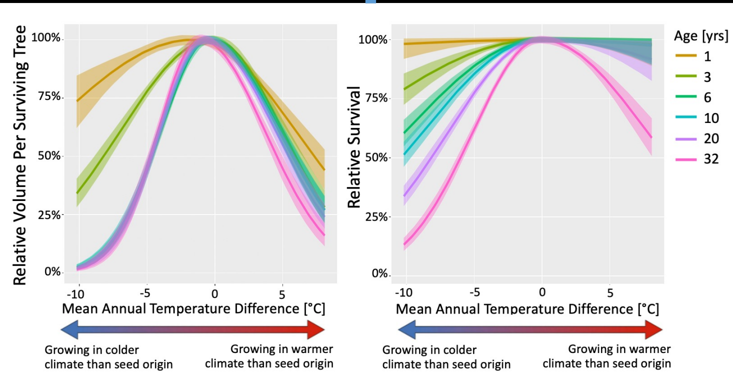
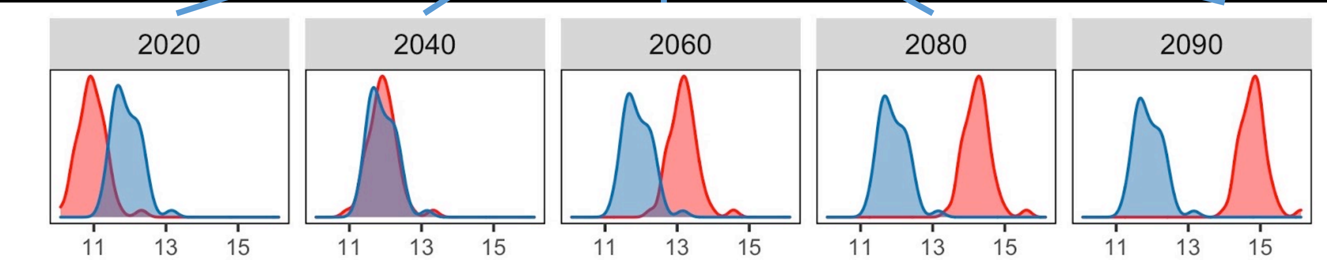
Long-term Growth and Survival



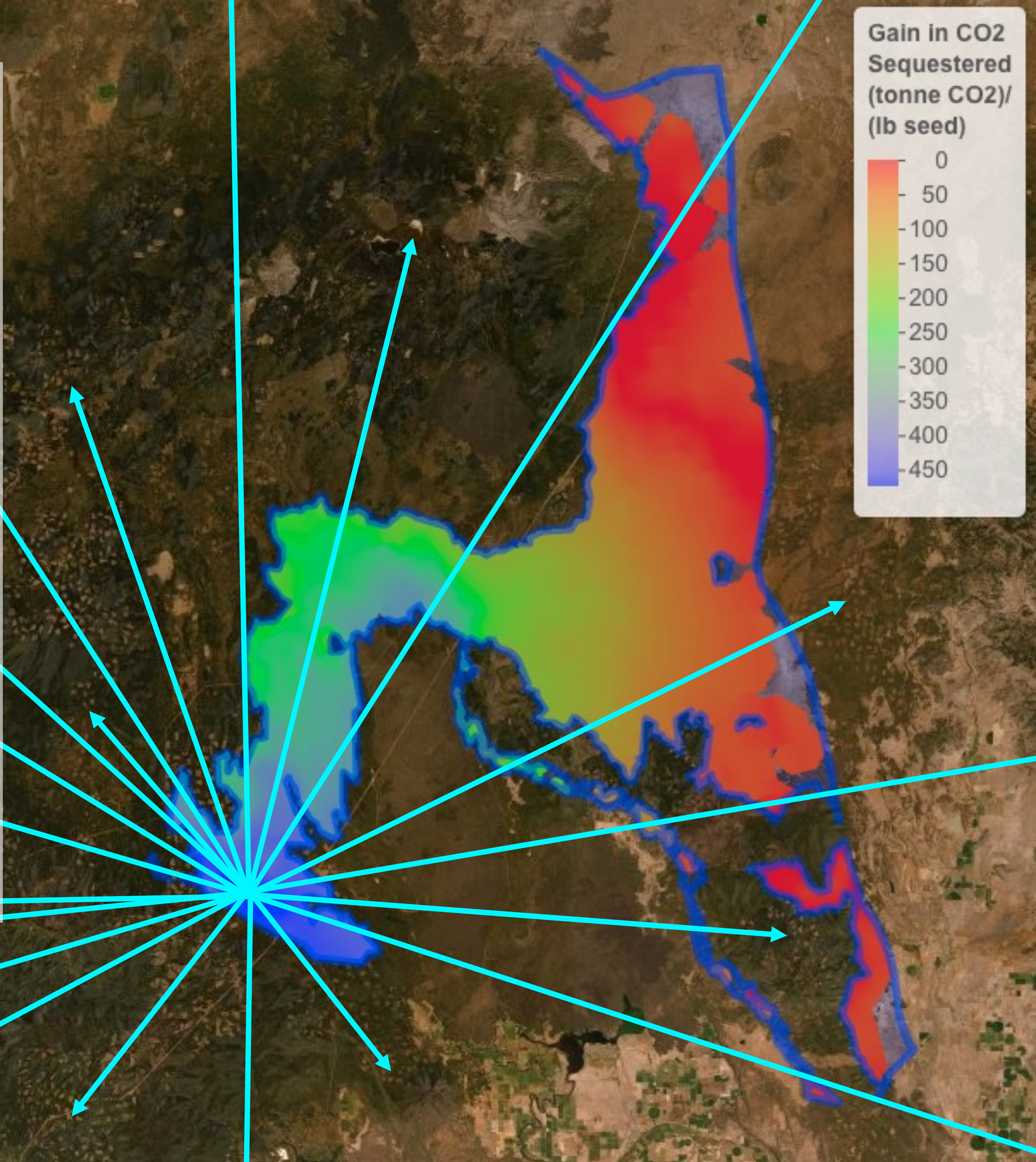
Age-Specific (Multidimensional) Transfer Functions



(Multiple) Climate Variables Over Time (with uncertainty)

Seed Collection Prioritization

- Big differences in benefit of seed collection within seed zone elevation bands.
- Optimize collection for deployment to full range of potential planting locations (probabilistic).
- Prioritize collection locations with metrics that are directly relevant to management (CO_2 sequestered, timber produced).



Thanks!

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CAL FIRE

Jessica Wright
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UC Davis

Ryan Boynton
UC Davis