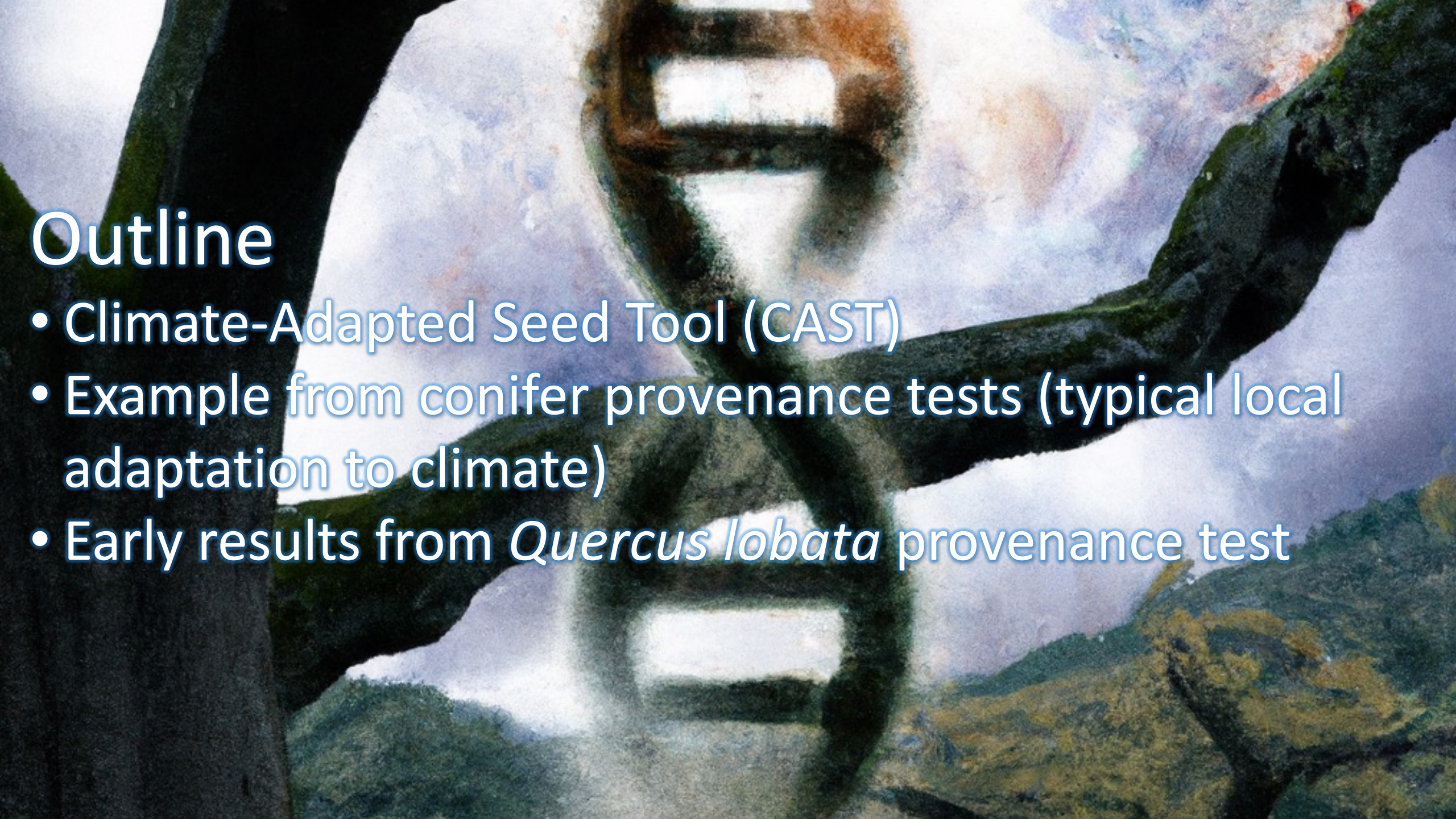
The Climate-Adapted Seed Tool: Using Provenance Tests to Inform Oak Seed Transfer in a Changing Climate

Joe Stewart
Postdoc, UC Davis



Outline

- Climate-Adapted Seed Tool (CAST)
- Example from conifer provenance tests (typical local adaptation to climate)
- Early results from *Quercus lobata* provenance test

reforestationtools.org/climate-adapted-seed-tool/cast-v-0-023/

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

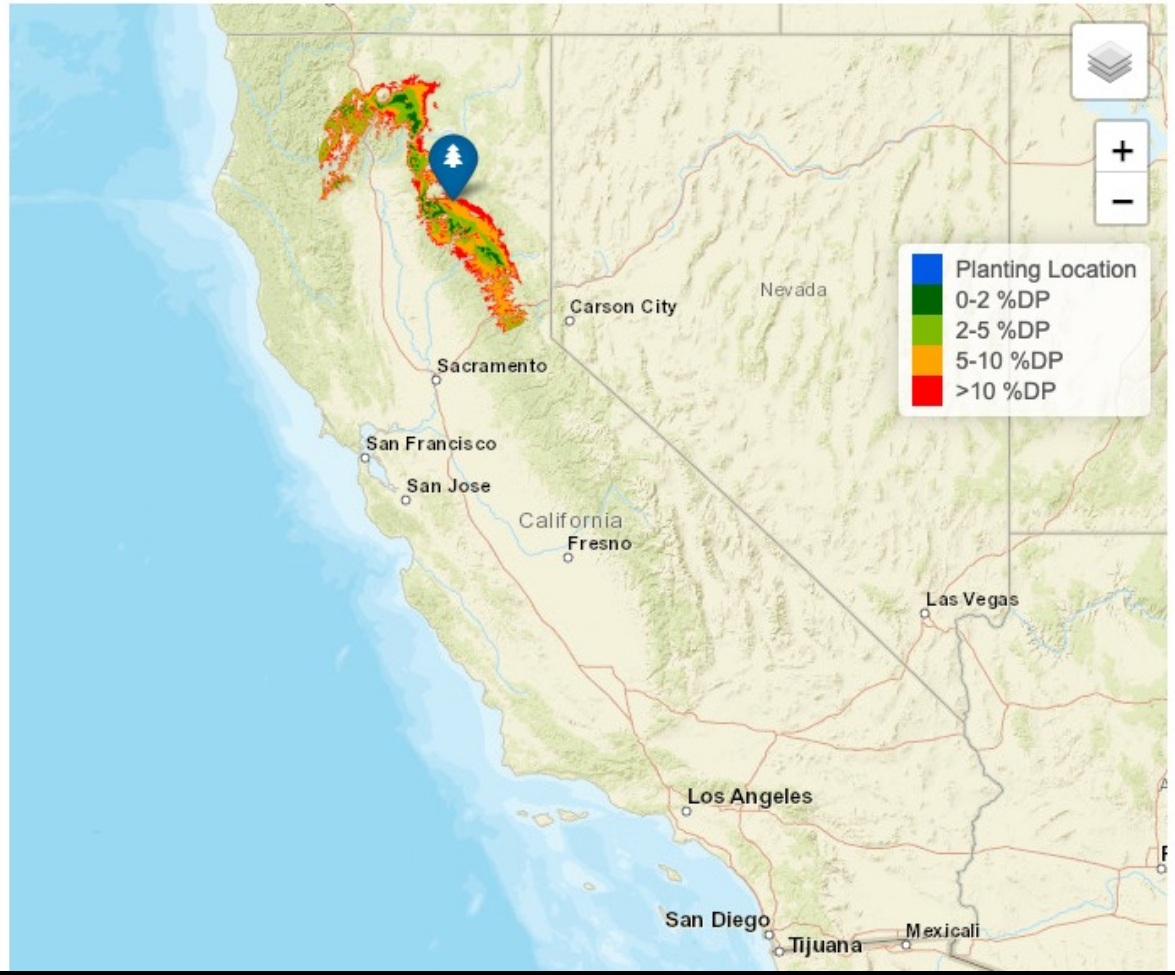
Planting Location: Specify planting location by: Coord

Map seed sources as: Raster

Longitude: -121.29136

Latitude: 40.40304

Species: Pinus ponderosa



Examine Match | Table | Raster

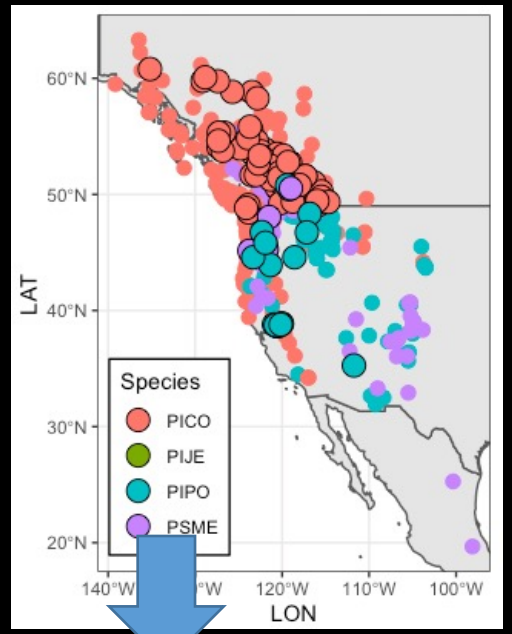
Seed Zone	Elevation	% Decline in Productivity			CO2 Seq.
		Expected	Lower	Upper	
522	6000 - 6500ft	14.41%	10.75%	19.52%	105.63
332	5000 - 5500ft	2.37%	1.24%	3.85%	142.20
521	5000 - 5500ft	2.40%	0.52%	4.13%	136.75
331	5000 - 5500ft	2.90%	1.31%	4.05%	135.32
331	4500 - 5000ft	3.01%	1.56%	4.76%	142.05
332	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

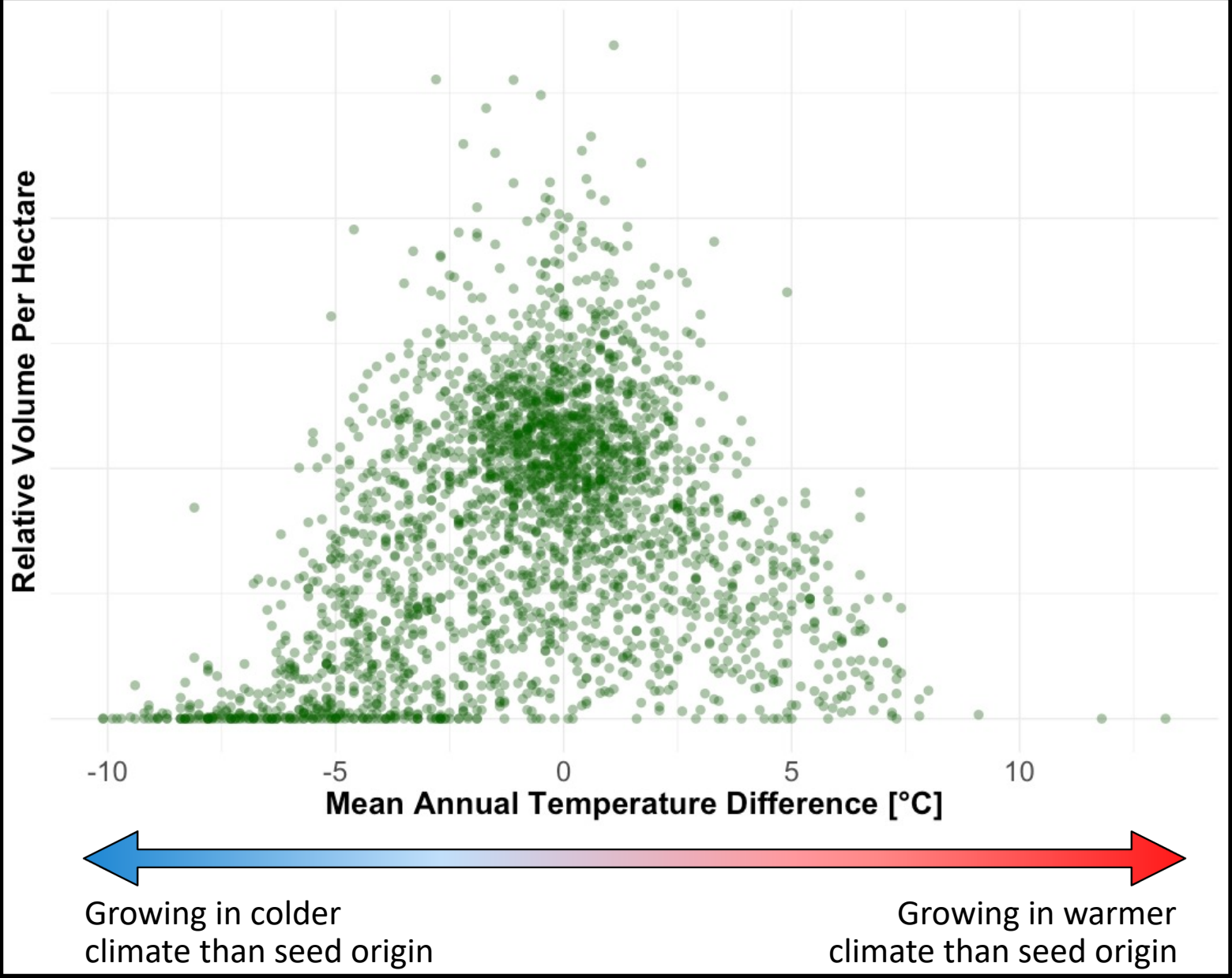
CAST

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 [field-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

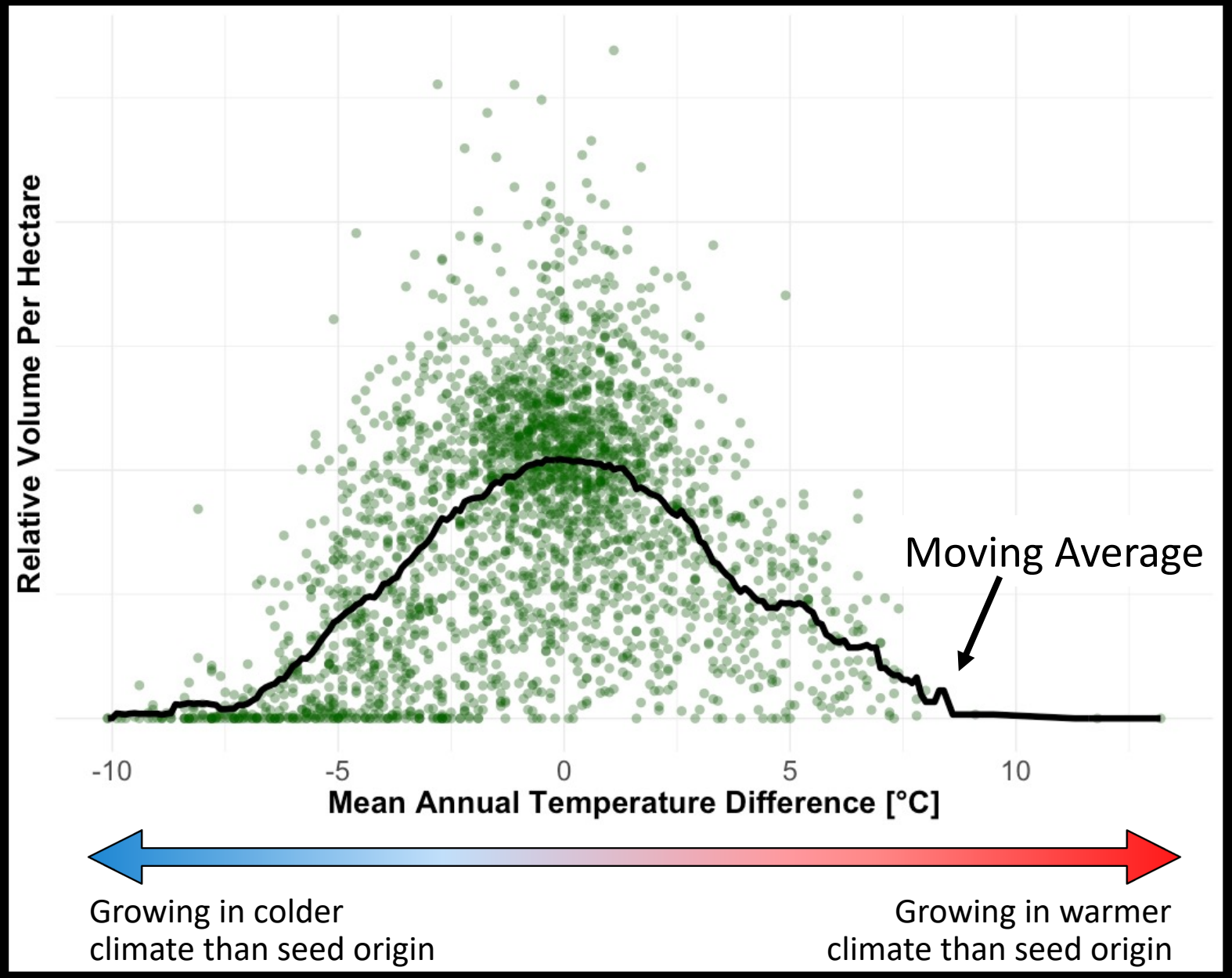


Age 32 lodgepole pine data (Illingworth+)

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

Photo Courtesy Greg O'Neill

Shape of Response Functions

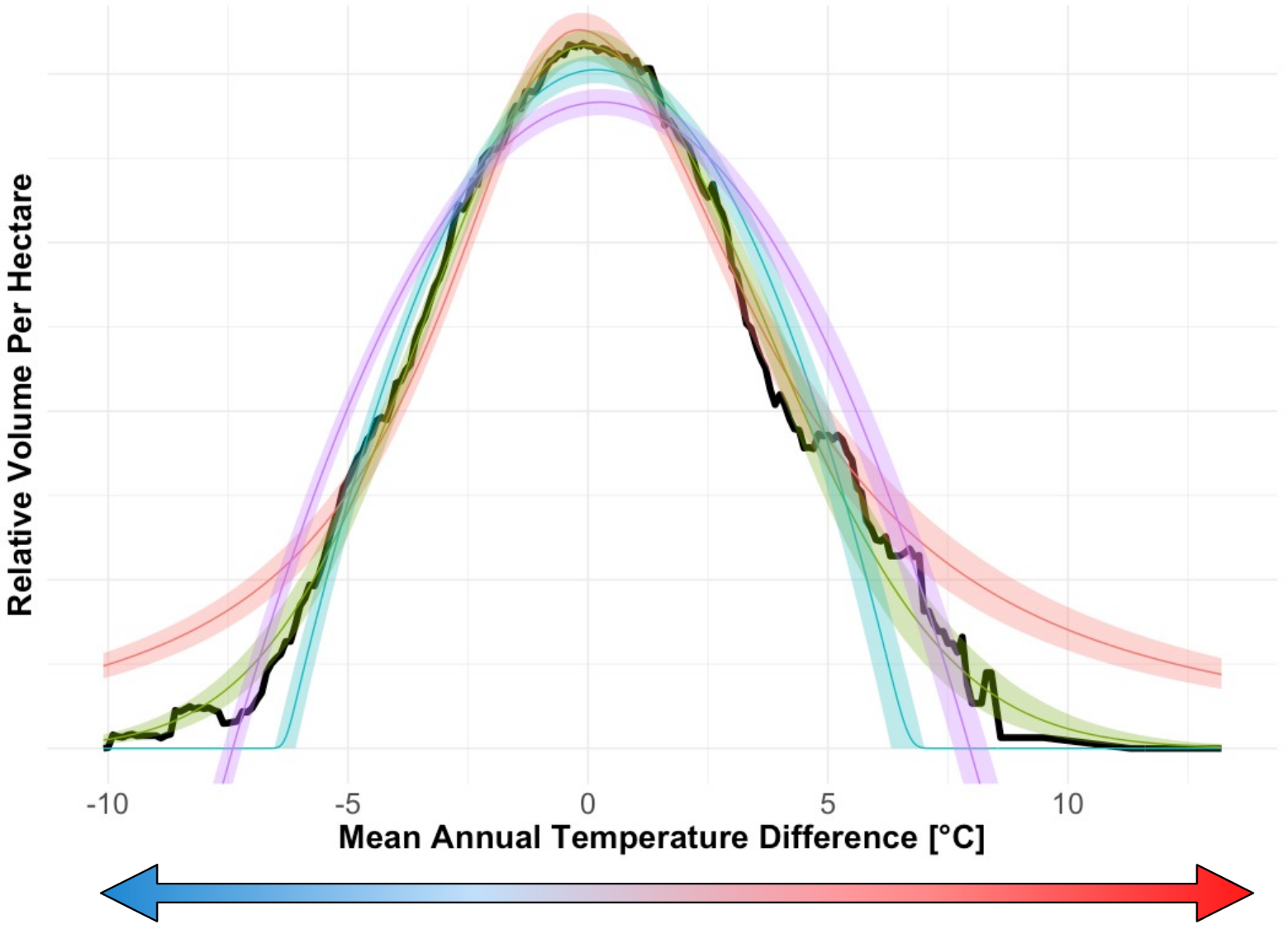


Age 32 lodgepole pine data (Illingworth+)

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

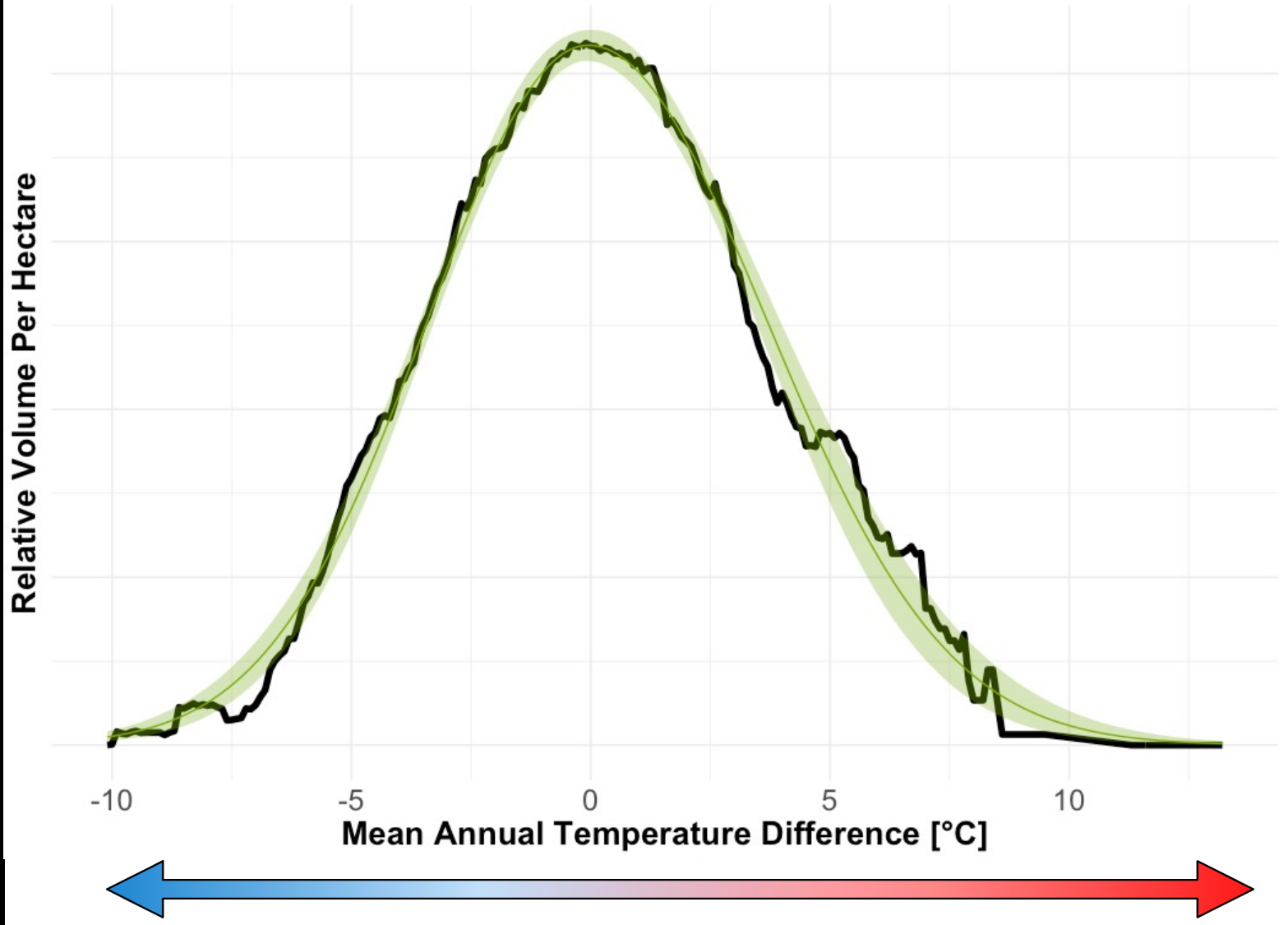
Photo Courtesy Greg O'Neill

Shape of Response Functions



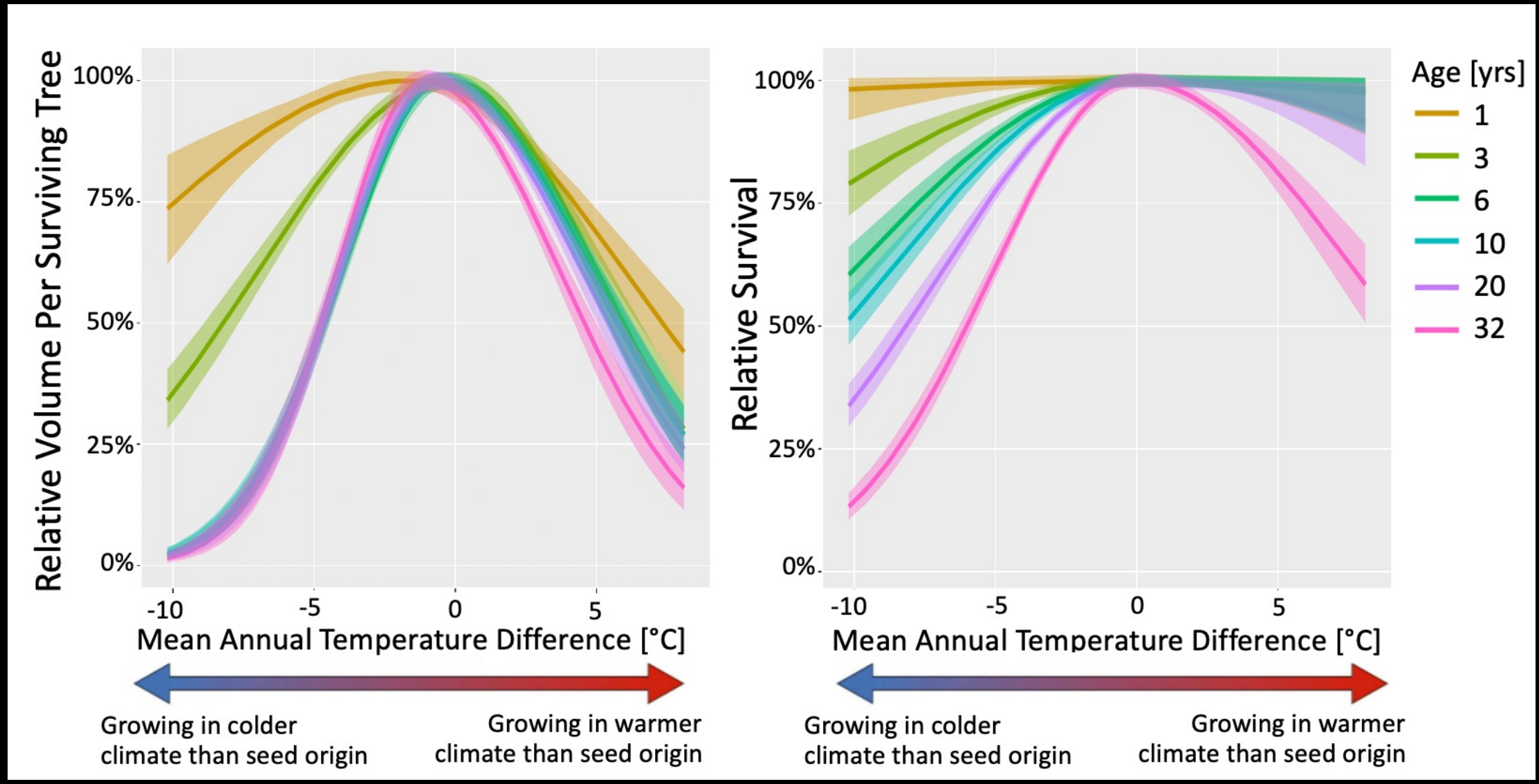
Model	Δ LOO IC
Asymetric Gaussian	0
Asymetric Cauchy	28.3
Non-negative Quadratic	40.9
Quadratic	97.1

Shape of Response Functions



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

Effects of tree age on transfer functions



3-Dimension Ensemble Transfer Functions

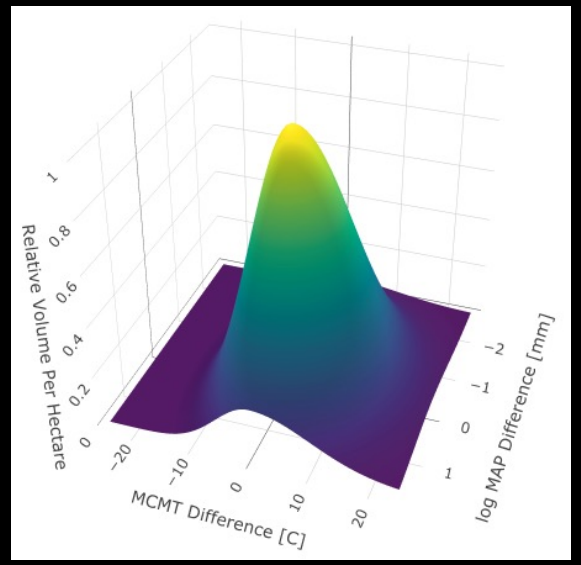
Model	Bayesian Stacking Weight (LOO)	Δ LOO IC	LOO R2
MAT & MAP	0.319	111.71	0.369
MCMT & MAP	0.195	0	0.400
TD & MAP	0.470	34.31	0.388
MWMT & MAP	0.016	495.77	0.266

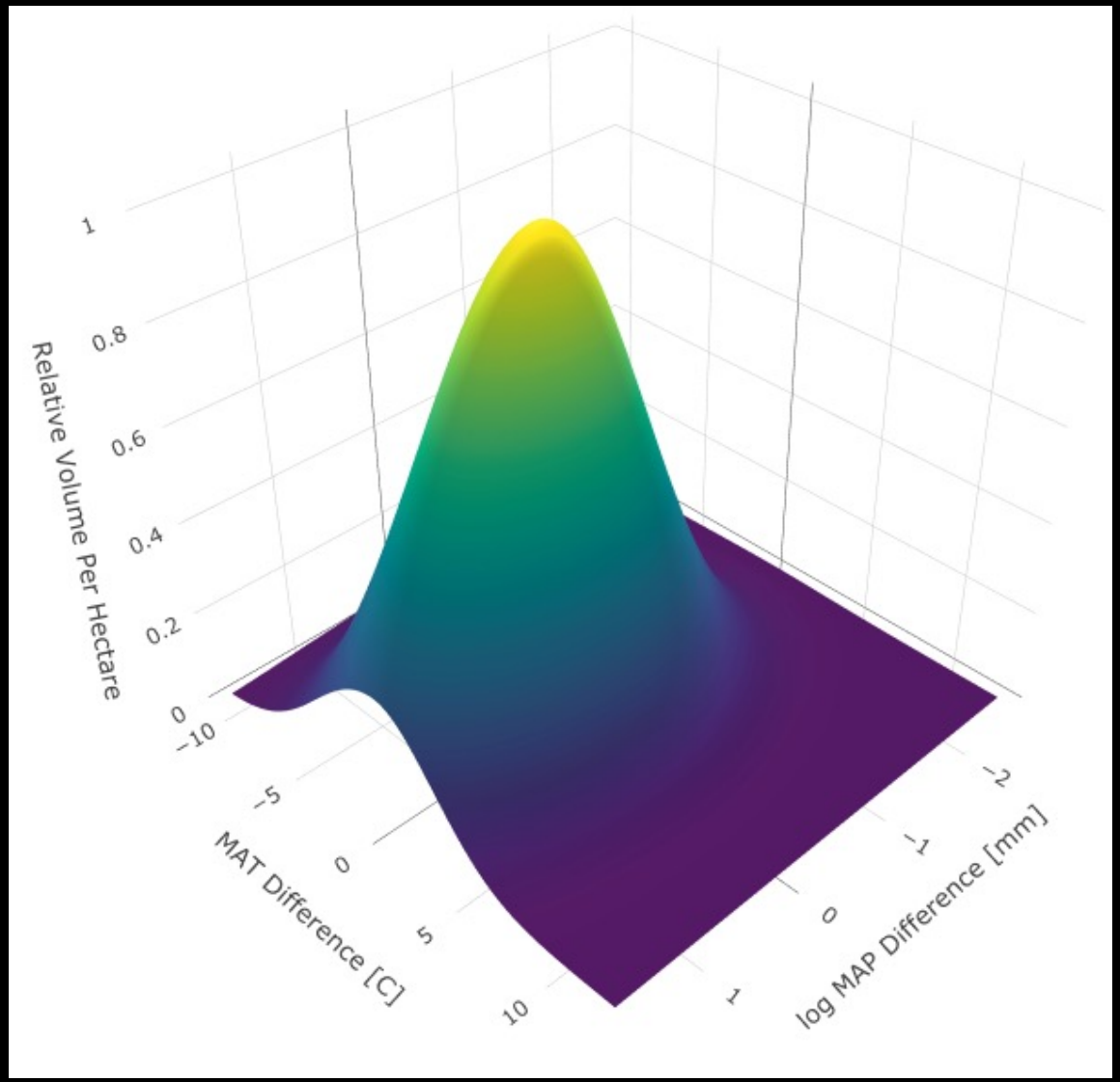
MAT: Mean Annual Temperature

MCMT: Mean Cold-Month Temperature

MAP: Mean Annual Precipitation

MWMT: Mean Warm-Month Temperature

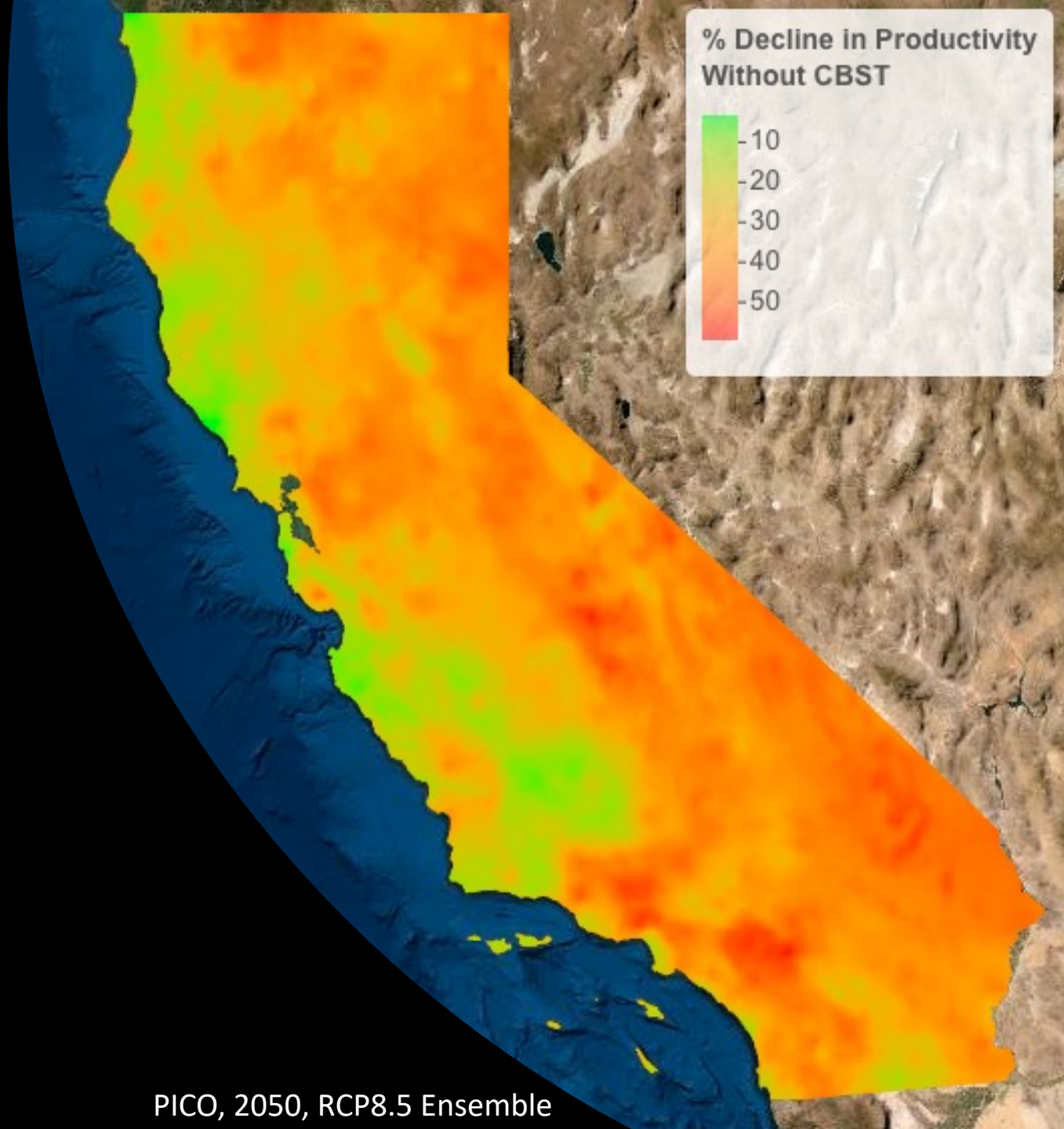




Yao et al. 2018. Bayesian Analysis: 13:917–1007.

Crisis and Opportunity

- California forests are not adapted to rapidly changing climate conditions.
- With climate-adapted seed transfer (CAST) we can take proactive steps to adapt forests to climate change.
- CAST can make a huge positive impact on forest health and net CO2 emissions.

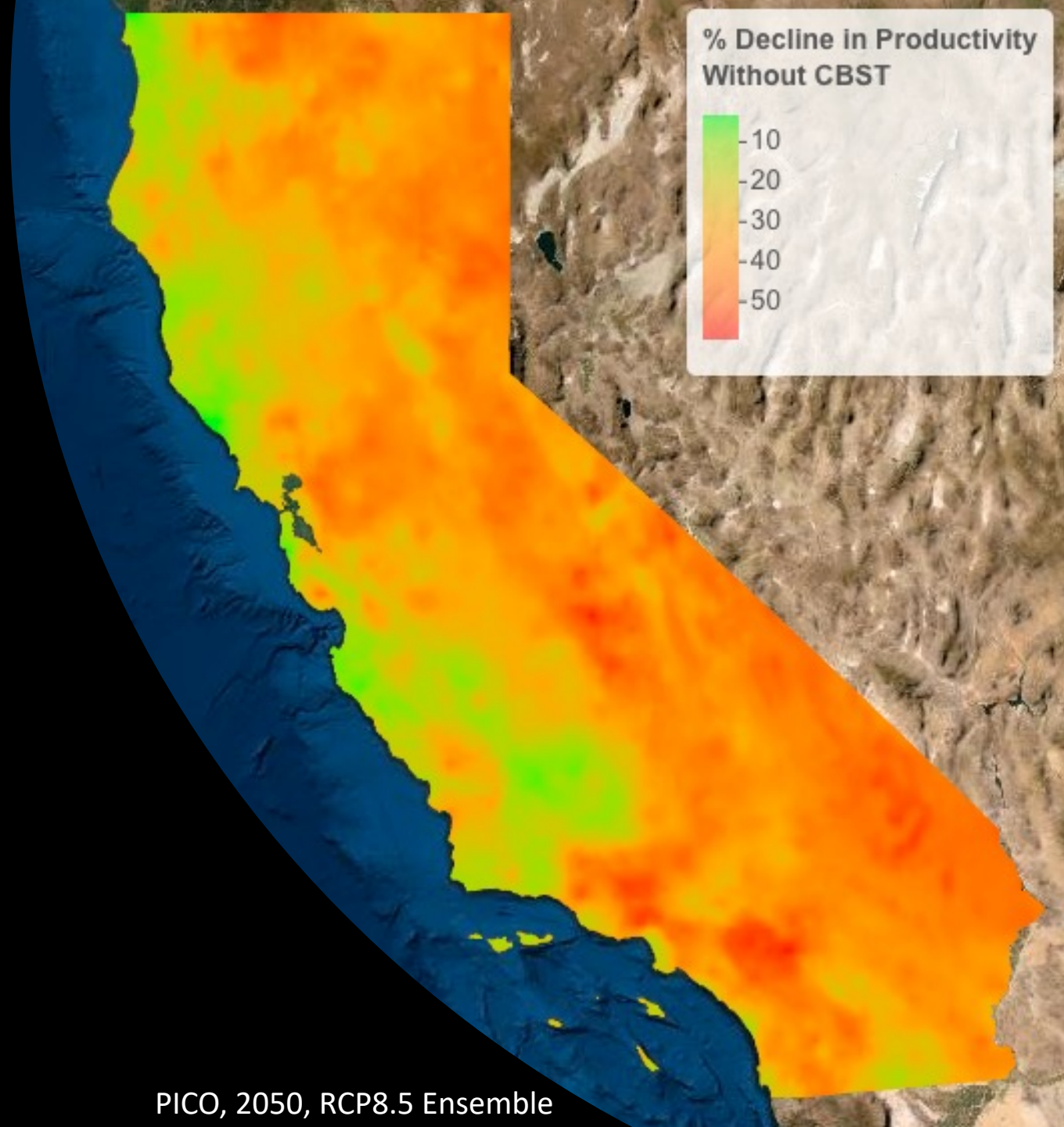


PICO, 2050, RCP8.5 Ensemble

Conservative Estimates of Impact of Climate Adapted Seed Transfer

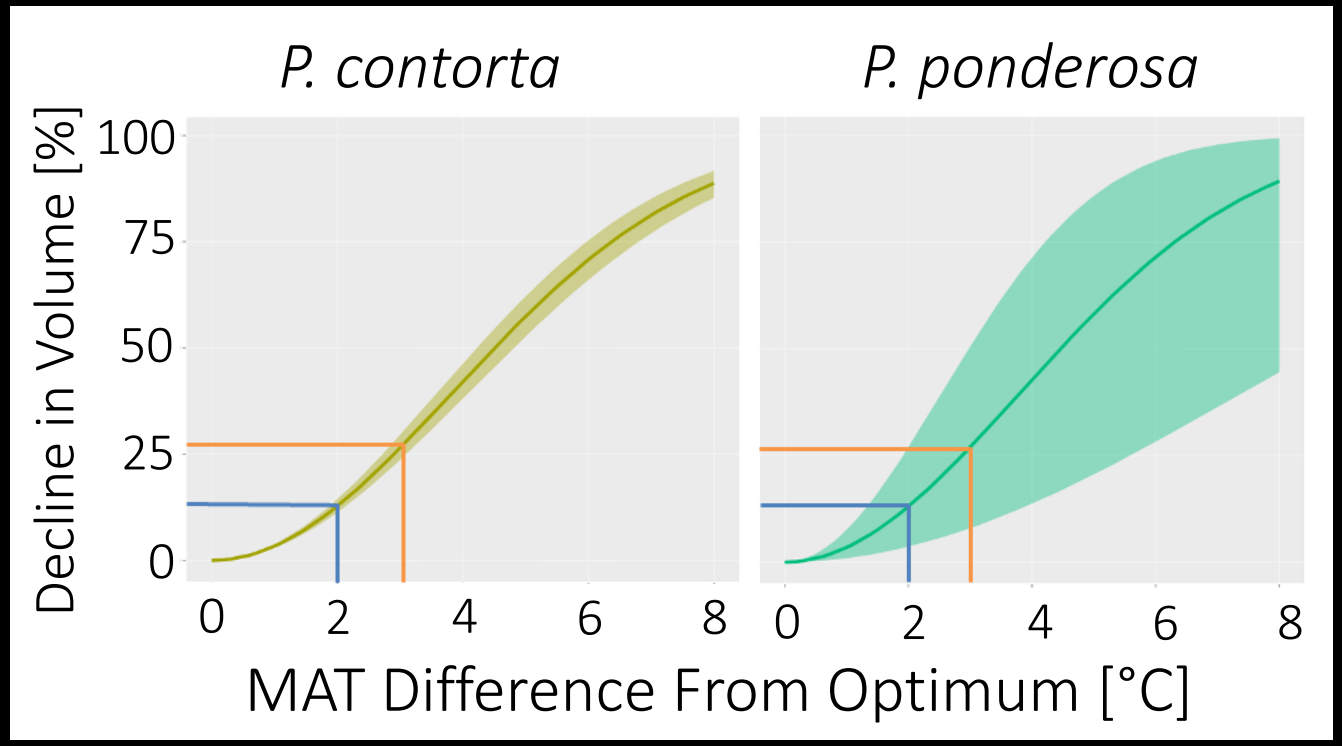
If deployed across private land in CA starting in 2021:

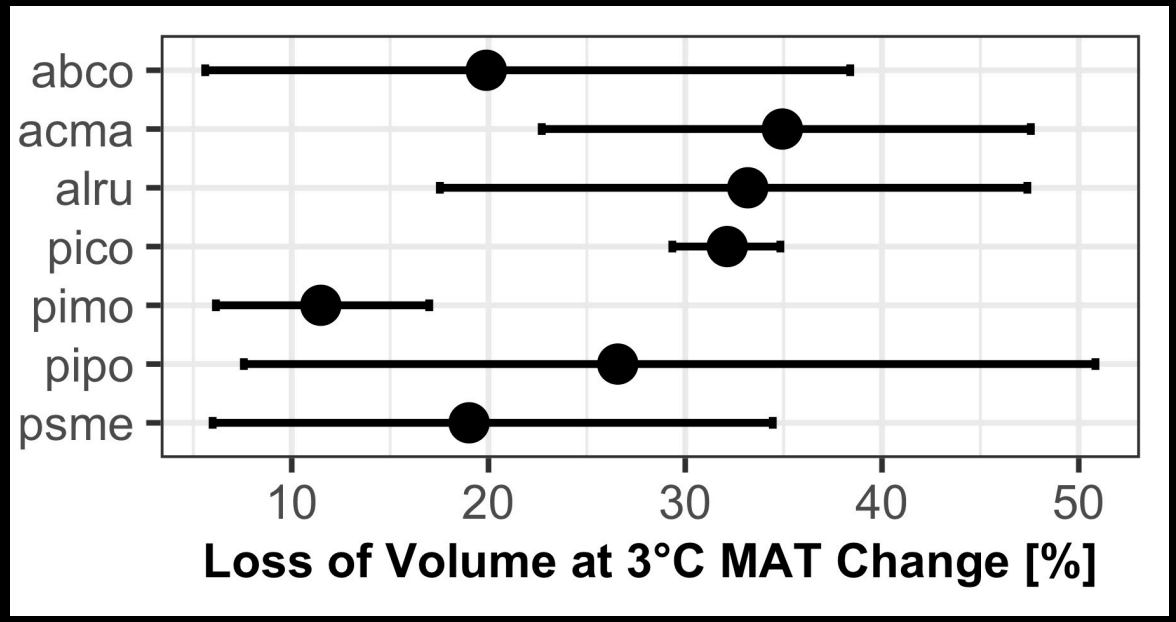
	By 2050	By 2060
Additional CO2 Sequestered [*million* tonnes/yr]	2.3	4.1
Market Value of Additional CO2 Sequestered [*million* USD/yr]	$77	$138
Percent of net 2018 CA GHG Emissions [%/yr]	.5%	1%
Additional Timber Production [*million* board-ft/yr]	142	256



PICO, 2050, RCP8.5 Ensemble

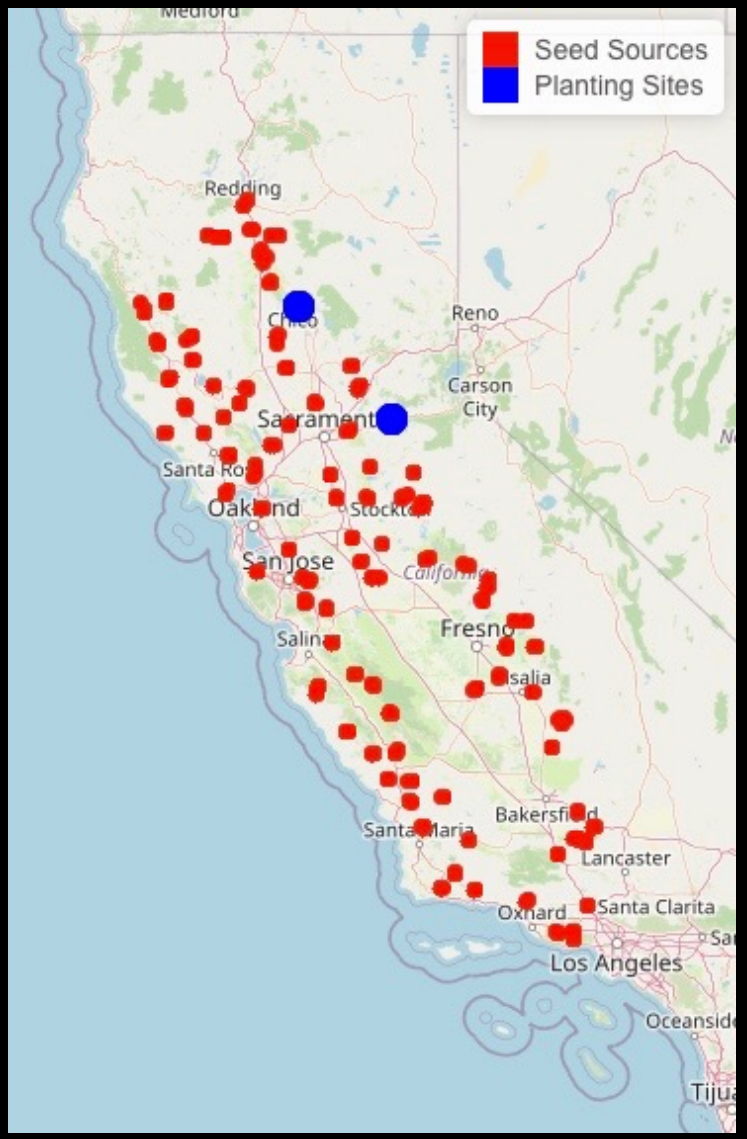
Differences between species (provisional analyses)





Quercus lobata Provenance Test

- ~ 7,000 trees planted
- 95 provinces (670 precise seed source locations)
- 2 planting locations
  - Institute for Forest Genetics (IFG), Placerville, CA
    - Out-Planted Dec 2014
  - Chico Seed Orchard
    - Out-Planted Jan 2015
- Analyses focus on fall 2021 measurements

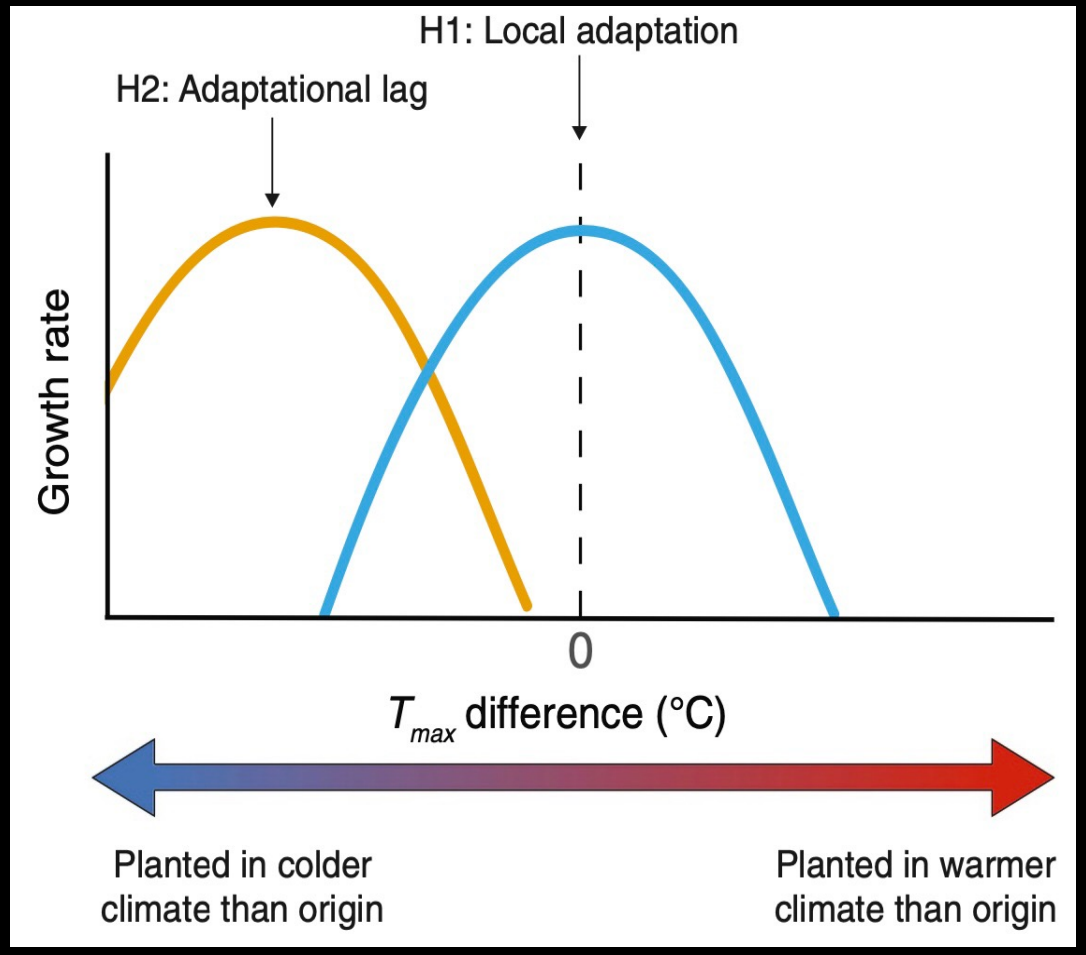


Current limitations:

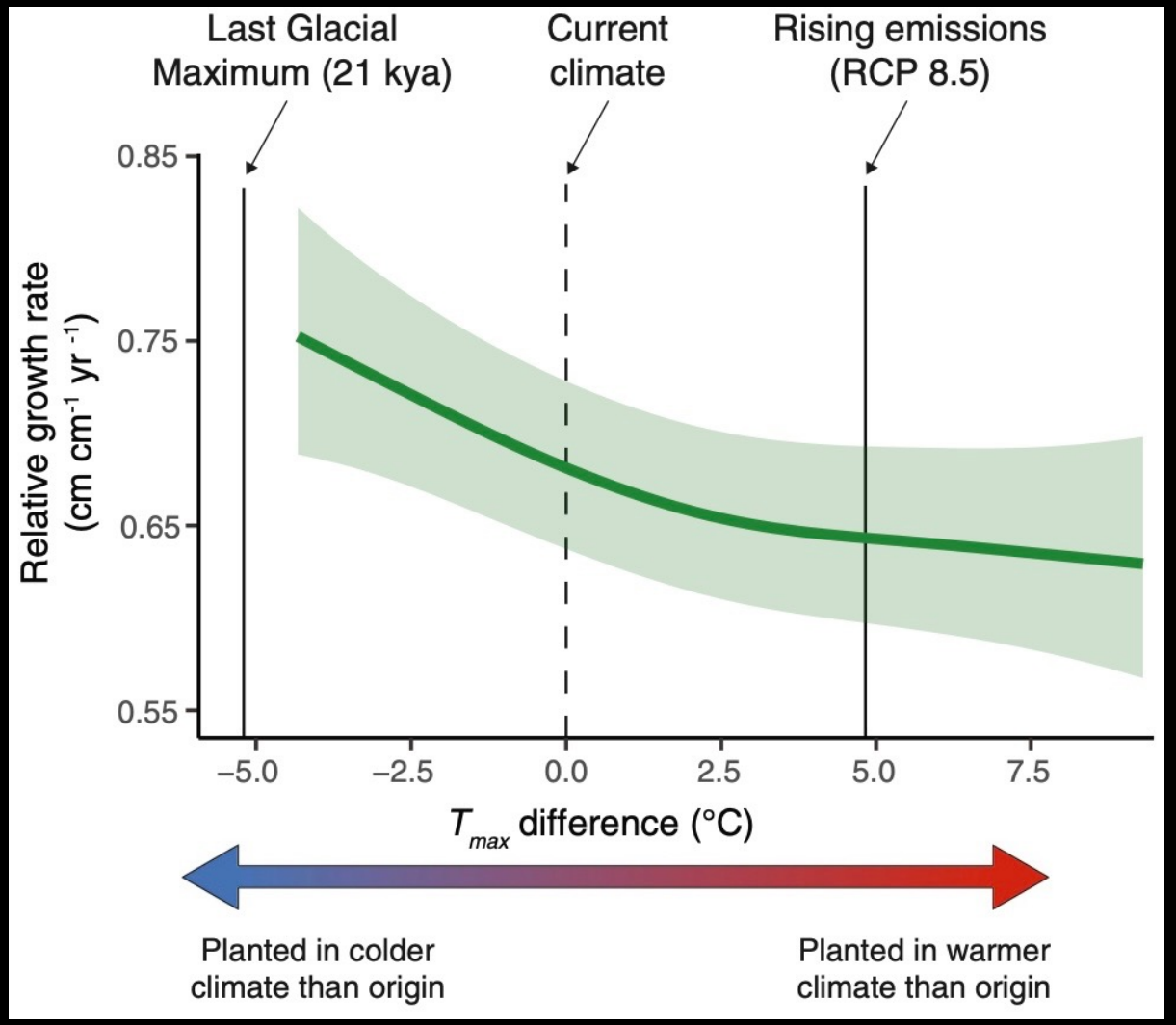
- I do not yet have seed source IDs for trees that died prior to 2017, thus cannot yet look at mortality as function of climate transfer.
- Heights were not measured for trees over 2.5 m tall, so I had to estimate them from allometric relationship with DBH.

Results from Browne et al. 2019 —
Based on 2017 measurements after 3 field-years in the ground.

Hypothesized:

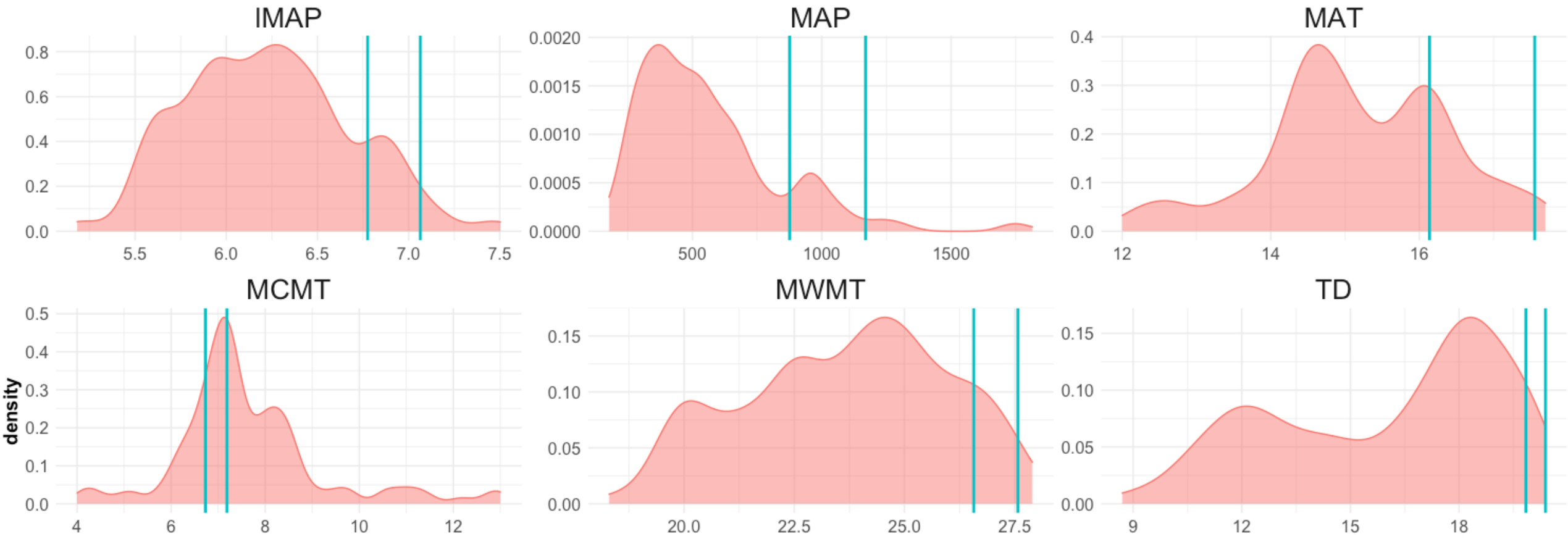


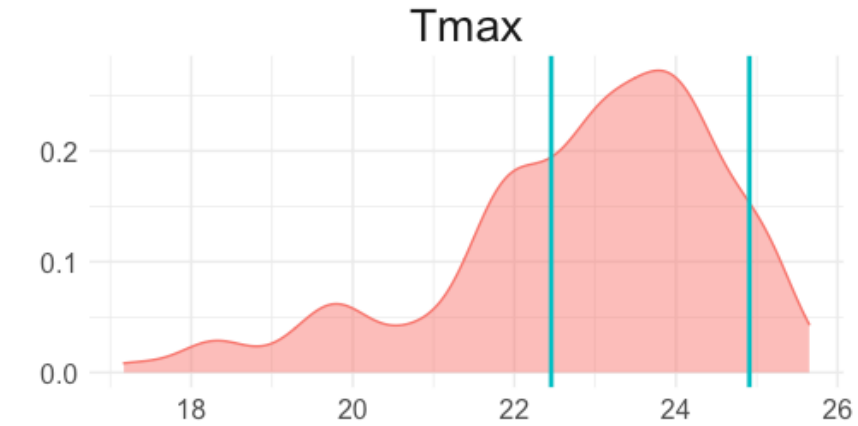
Observed:



Seed Source Climates (N = 670; 1950-1980)

Planting Site Climates (N= 2; 2015-2021)



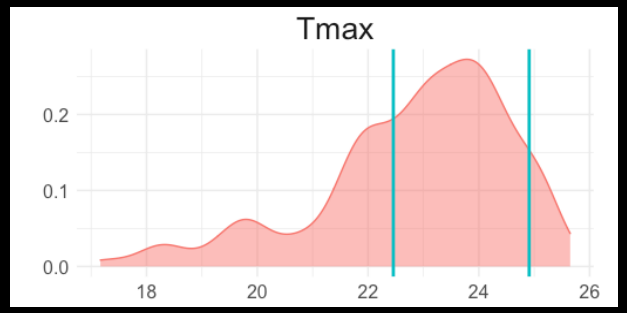


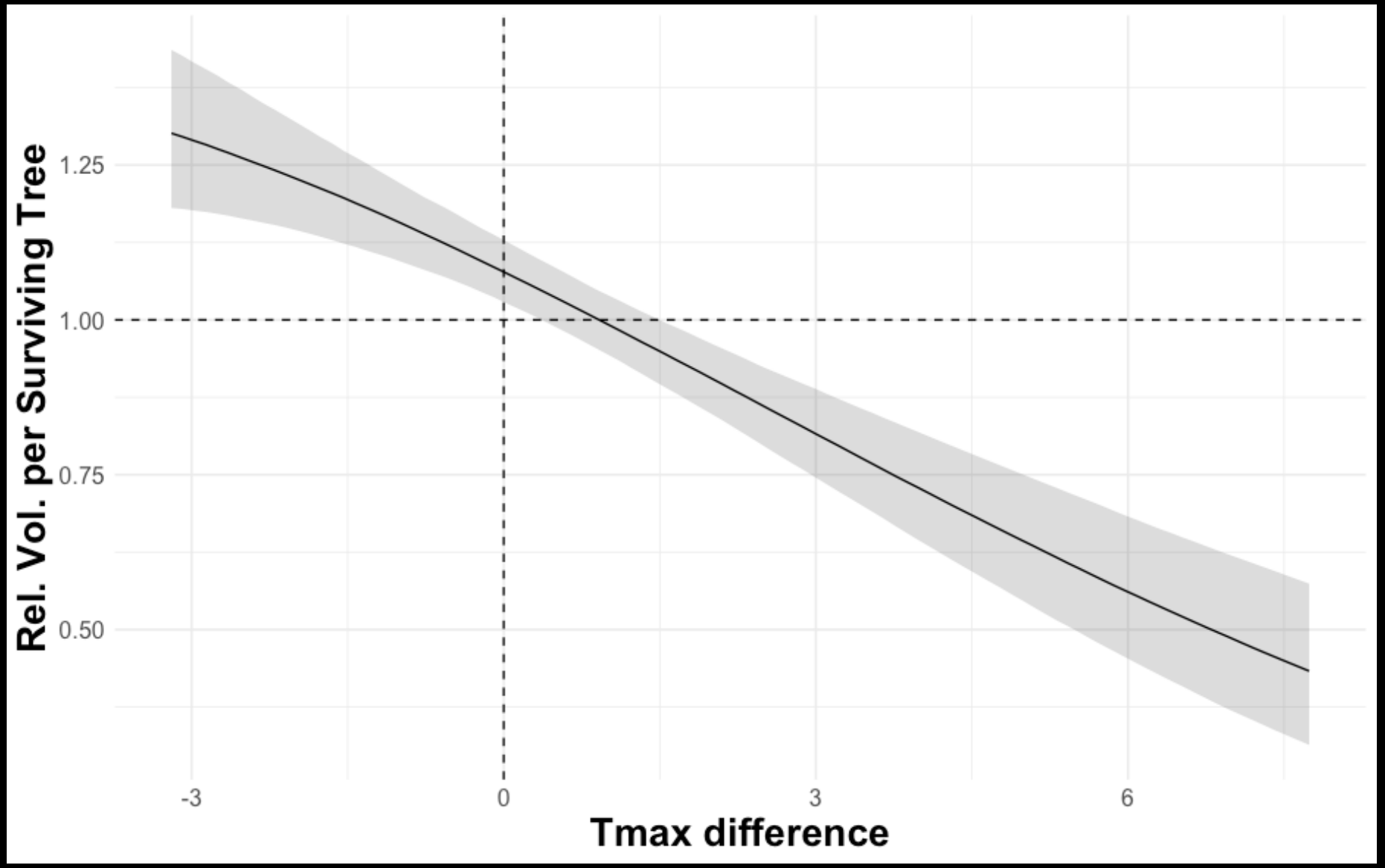
lMAP = log(Mean Ann. Precipitation)
MAP = Mean Ann. Precipitation
MAT = Mean Ann. Temperature
MCMT = Mean Cold-Month Temperature
MWMT = Mean Warm-Month Temperature
TD = Temperature Differential, aka seasonality (MWMT – MCMT)
Tmax = Mean Ann. Daily Maximum Temperature (Browne et al 2019)

Tmax

6 Field-Years

Similar result to Browne et al (2019) for RGR at 3 field-years.



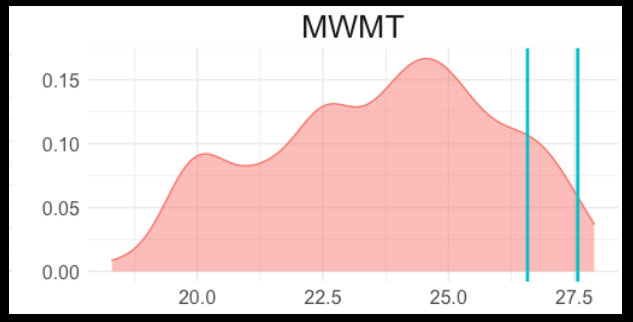


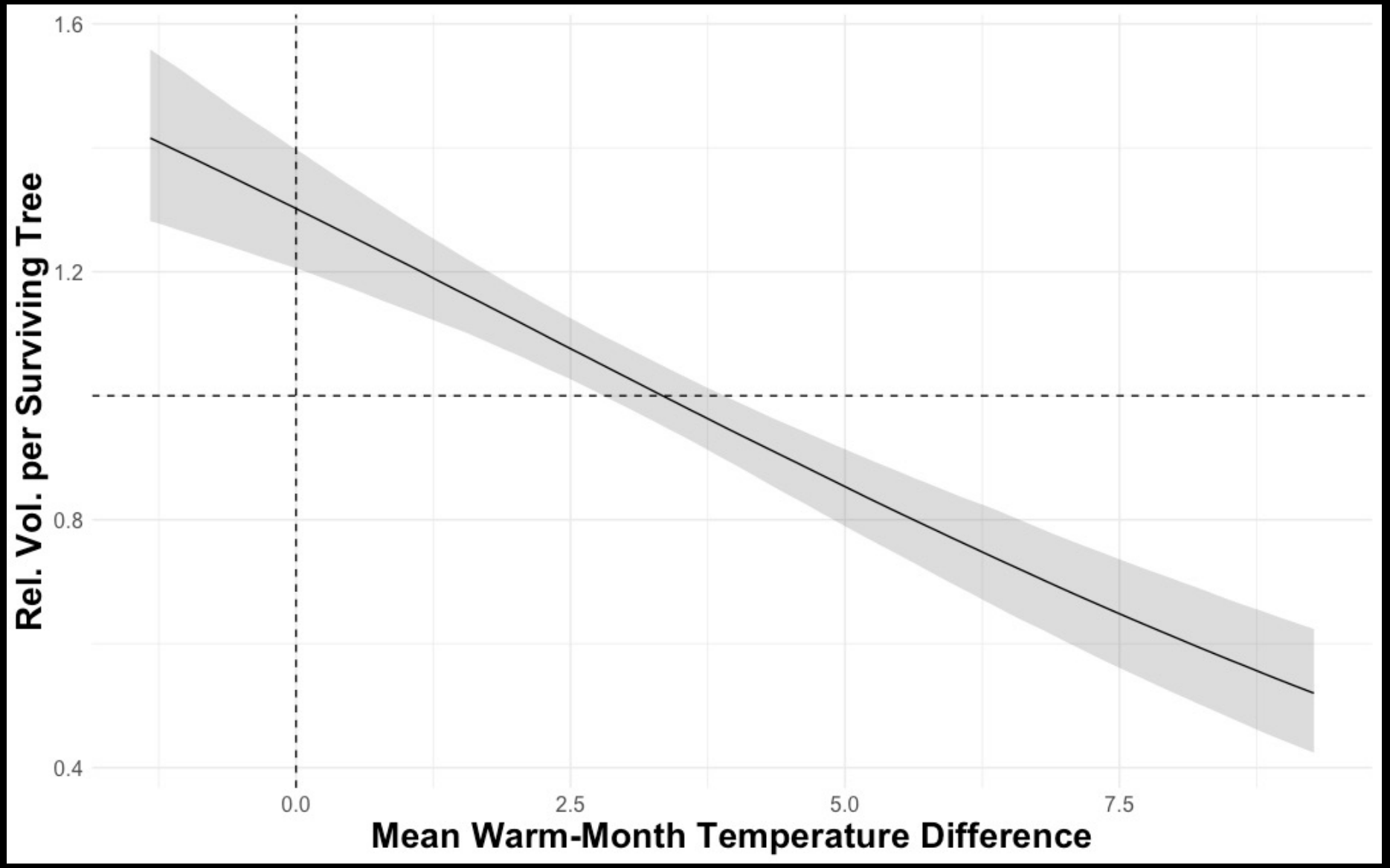
Growing in colder climate than seed origin

Growing in warmer climate than seed origin

Mean Warm-Month Temp.

6 Field-Years





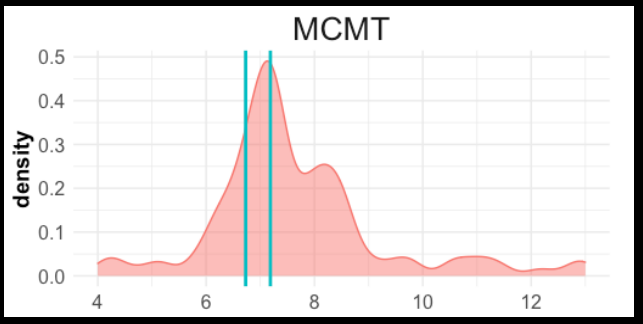
Growing in colder climate than seed origin

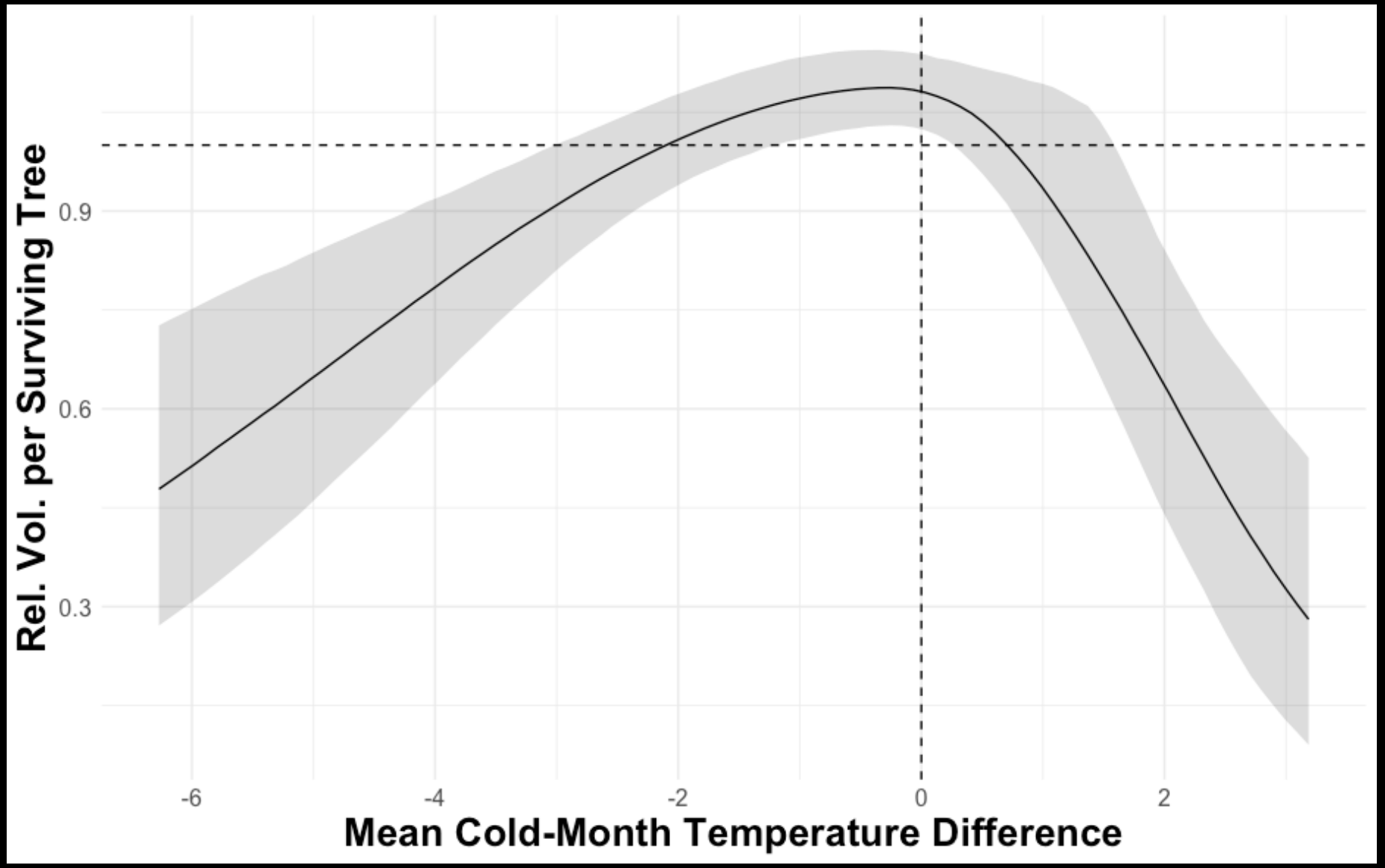
Growing in warmer climate than seed origin

Mean Cold-Month Temp.

6 Field-Years

Local Adaptation:
Aligns with typical pattern of provenance tests.





Growing in colder climate than seed origin

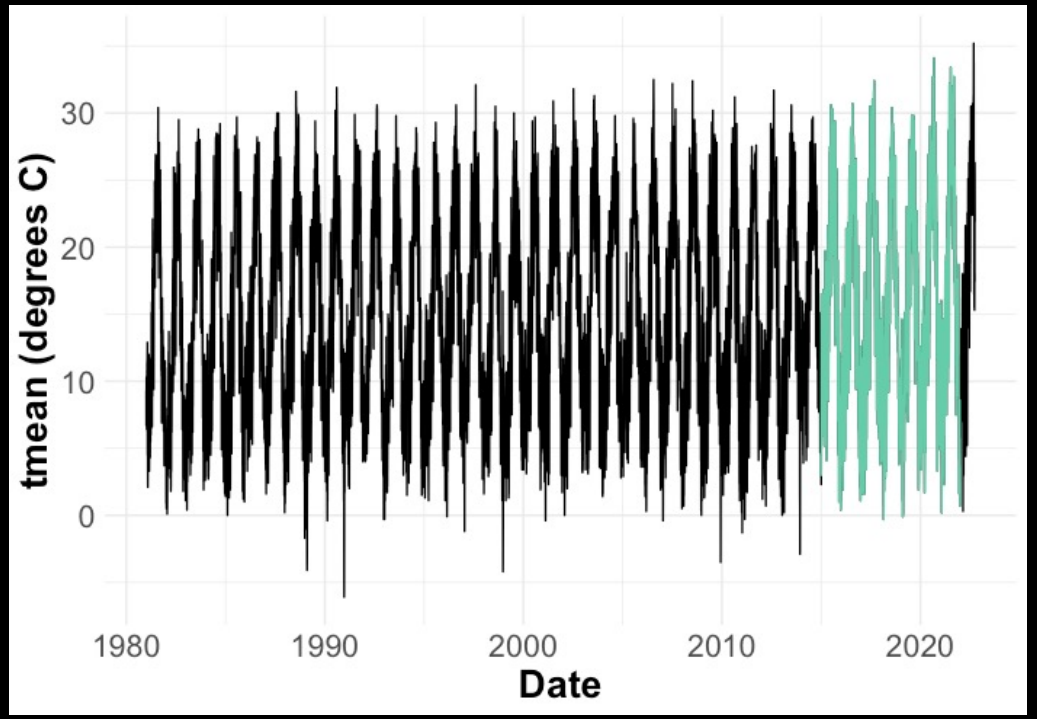
Growing in warmer climate than seed origin

QULO 2-Dimension Ensemble Transfer Functions w/ adaptation lag

Model	Bayesian Stacking Weight (LOO)	Shape
MWMT	0.585	Monotonic
MCMT	0.239	Non-monotonic (adapted to recent environment)
Tmax	0.131	Monotonic
MAT	0.045	Monotonic
TD	0	Monotonic
lMAP	0	Monotonic

MCMT = Mean Cold-Month Temperature
MWMT = Mean Warm-Month Temperature
Tmax = Mean Ann. Daily Maximum Temperature (Browne et al. 2019)
MAT = Mean Ann. Temperature
TD = Temperature Differential, aka seasonality (MWMT – MCMT)
lMAP = log(Mean Ann. Precipitation)

IFG Planting Site Daily Mean Temperature



Thanks!

LA Moran
Reforestation Center

Jessica Wright
US Forest Service

Victoria Sork
UCLA

Marissa Ochoa
UCLA

Courtney Canning
USFS

Greg O'Neill
BC Forest Service

Jimi Scheid
CALFIRE

Stewart McMorrow
CAL FIRE

For species with adaptation-lag, should we:

(A) Select seeds to optimize growth, survival, fitness (remove adaptation lag)?

(B) Select seeds to match historical climate of the seed source to the climate they will grow in (maintain historical level of adaptation lag)?

(C) Both/somewhere in between/bet hedging?