Predicting effects of climate change on stream ecosystems in the conterminous United States: results from a pilot study in California

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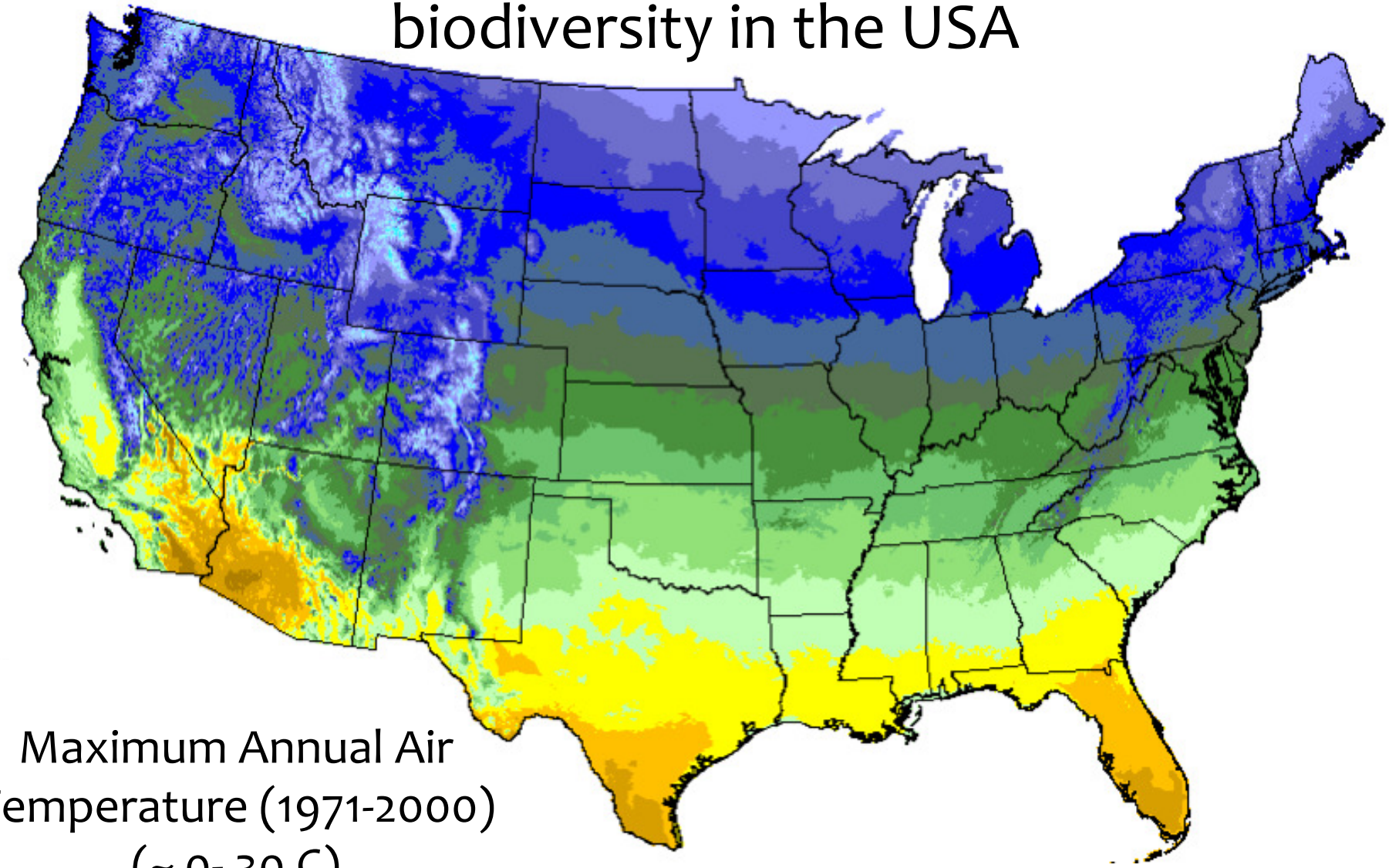
How will climate change affect stream invertebrate faunas across the continent?

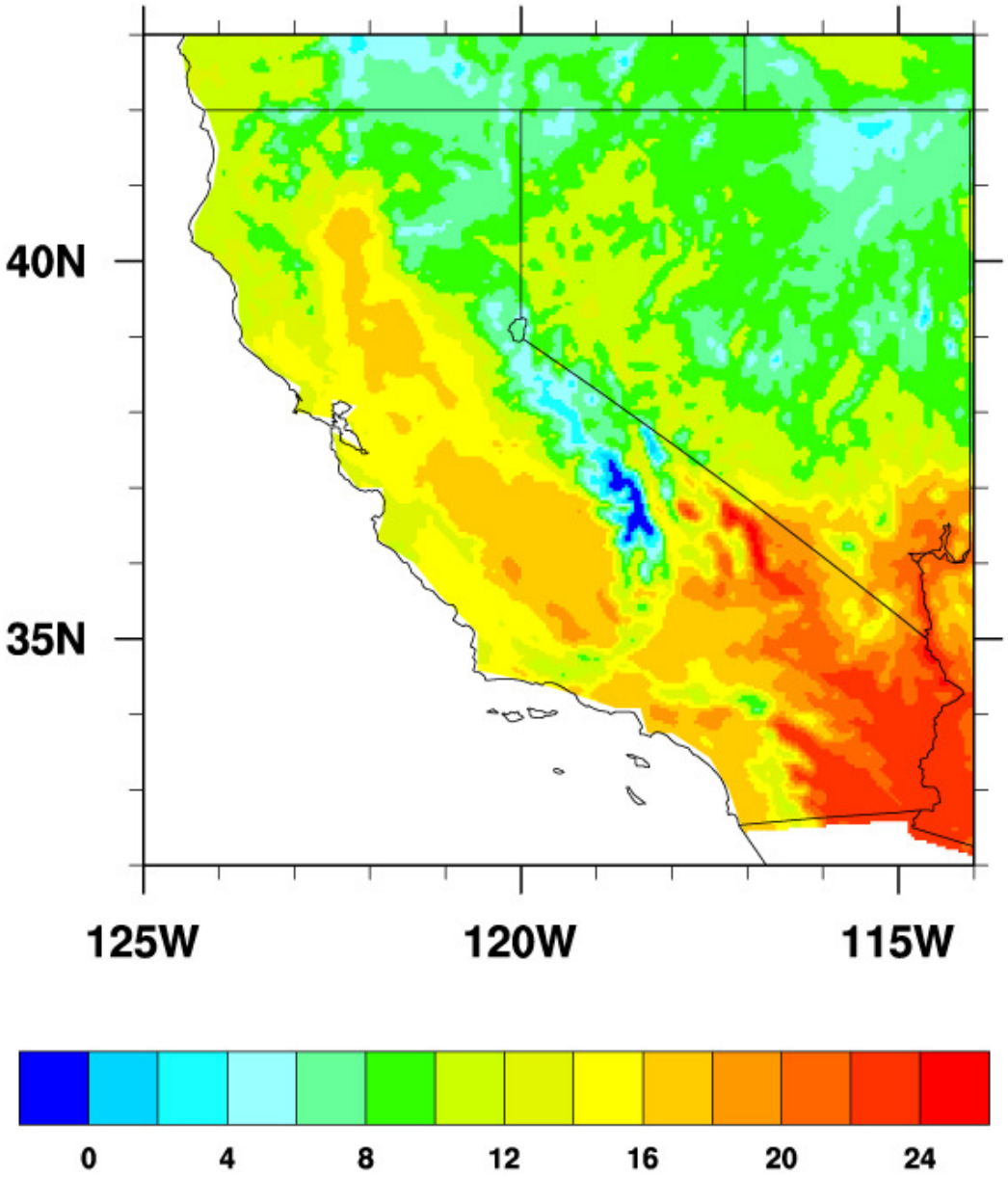
Are certain taxa and types of streams more vulnerable to climate change than others?

Will effects of climate change confound biological assessments?

USEPA-STAR funded project: Predicting effects of climate change on stream biodiversity in the USA



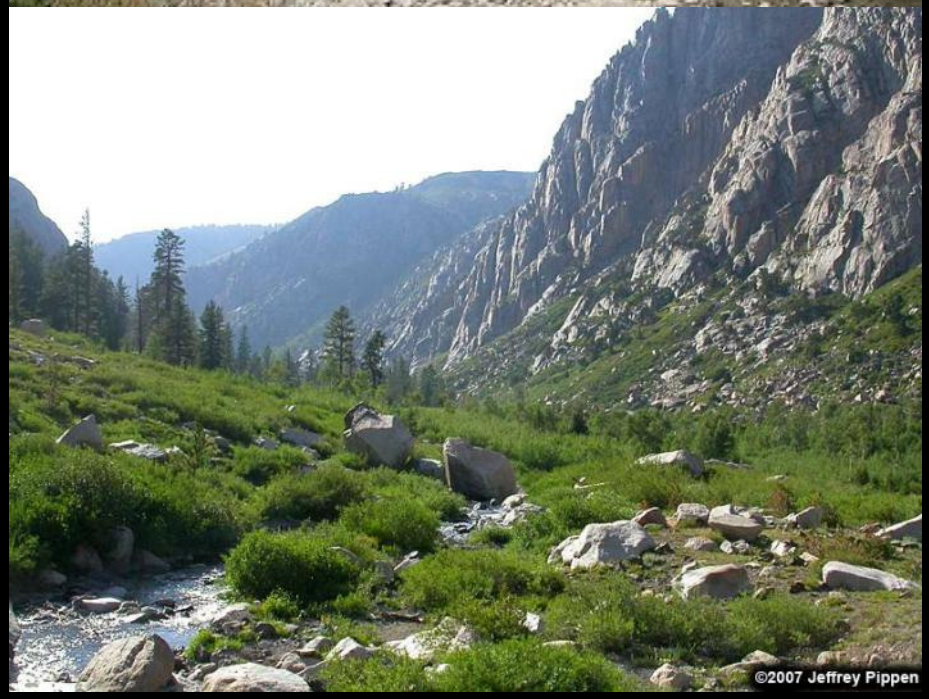
Maximum Annual Air Temperature (1971-2000) (~ 0- 30 C)



California as a pilot study

1999 variation in mean annual temperature (°C) (PRISM data)


walldesk.net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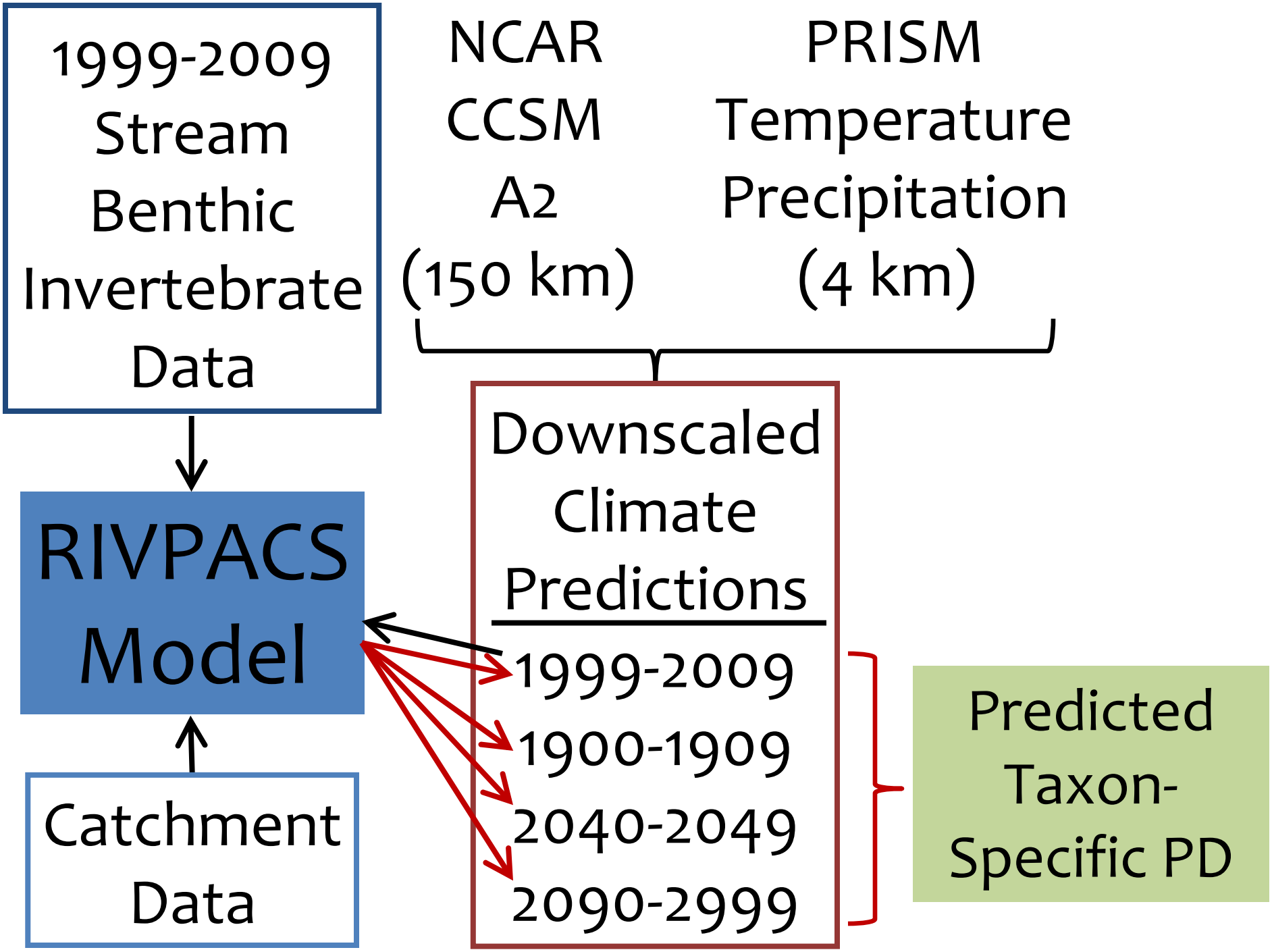
Probabilities of detection (PD): A foundation for estimating biodiversity and calculating biological indices

PD are associated with both abundance and richness metrics and indices:

- MMIs:
  - Abundance-based metrics
  - Richness metrics
- O/E = $\sum$O/$\sum$PD

Hypothetical Changes in PD & Taxa Richness

Taxon	1999	2090	2090-1999
A	0.87	0.22	-0.65
B	0.01	0.36	+0.35
C	0.92	0.58	-0.34
D	0.74	0.74	0.00
E	0.16	0.00	-0.16
etc.	0.60	0.31	-0.29
NTax	3.30	2.21	-1.09


1999-2009
Stream
Benthic
Invertebrate
Data
NCAR
CCSM
A2
(150 km)
PRISM
Temperature
Precipitation
(4 km)
Downscaled
Climate
Predictions
1999-2009
1900-1909
2040-2049
2090-2999
RIVPACS
Model
Catchment
Data
Predicted
Taxon-
Specific PD

Estimating O/E

1999 calibration:

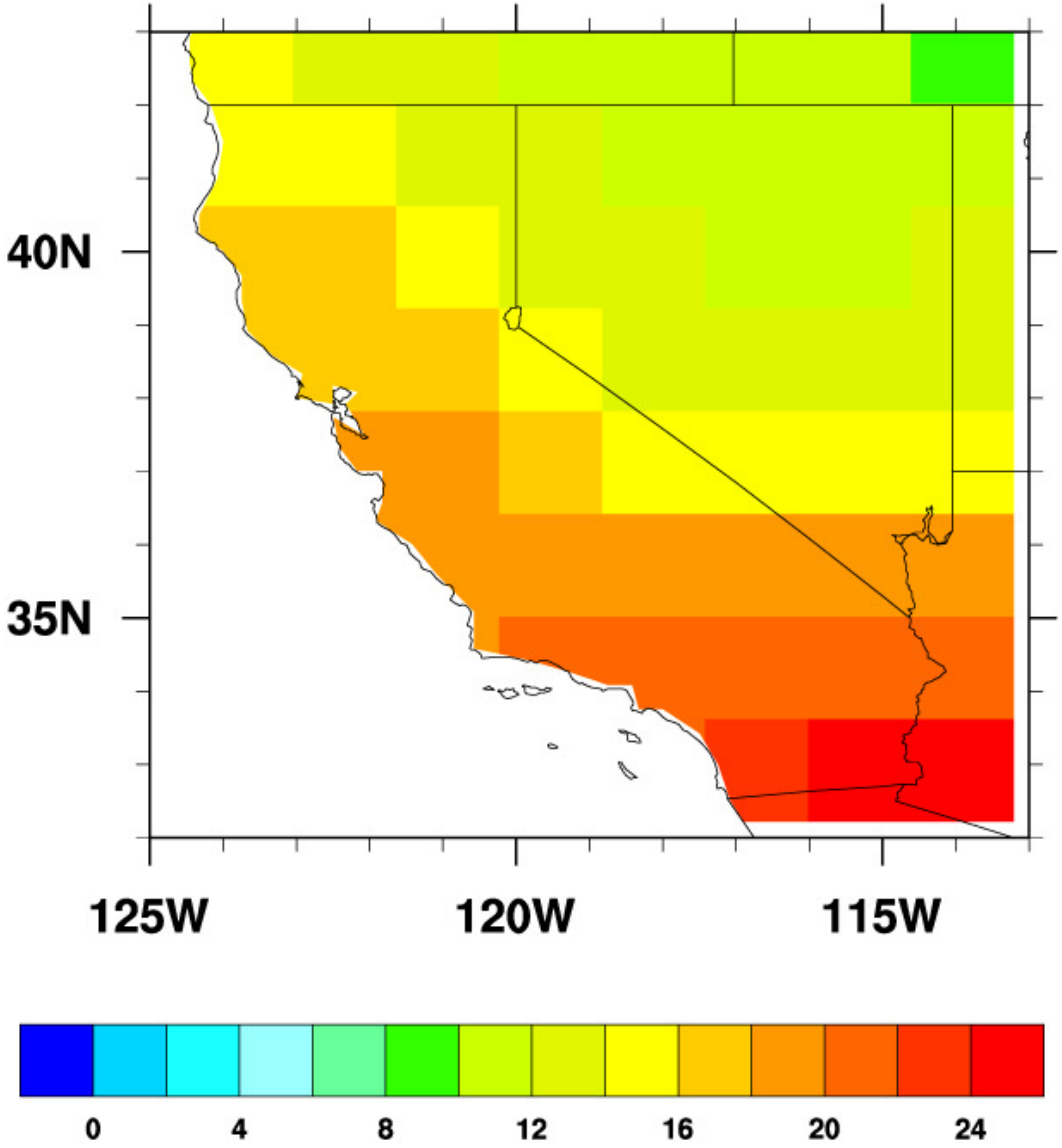
$\sum O / \sum pd$

1999, 1900, 2040, 2090 predictions:

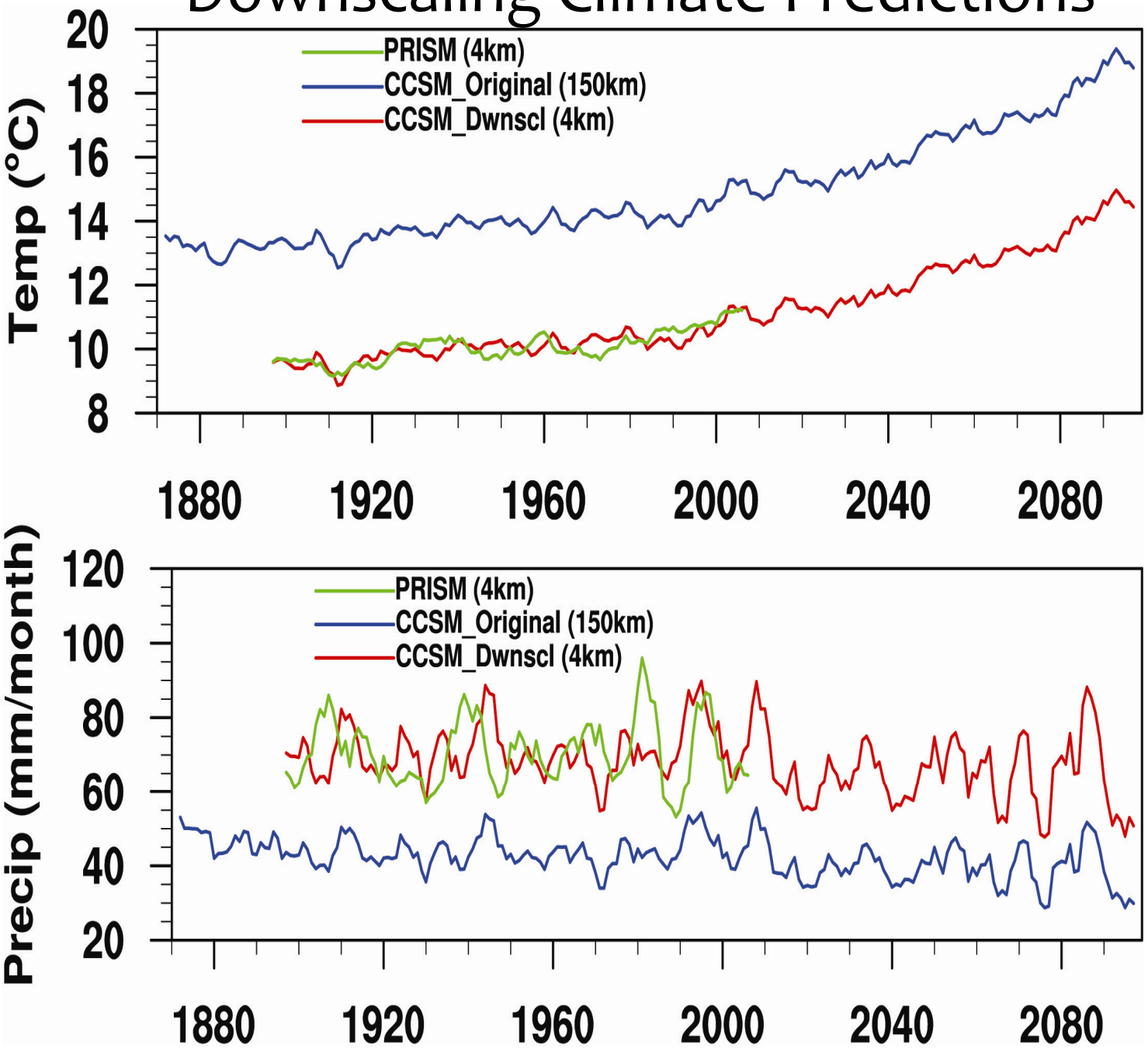
$\sum pd_{(year)} / \sum pd_{(1999)}$

A2 2090 Temperature (°C)

CCSM Original (150 km)

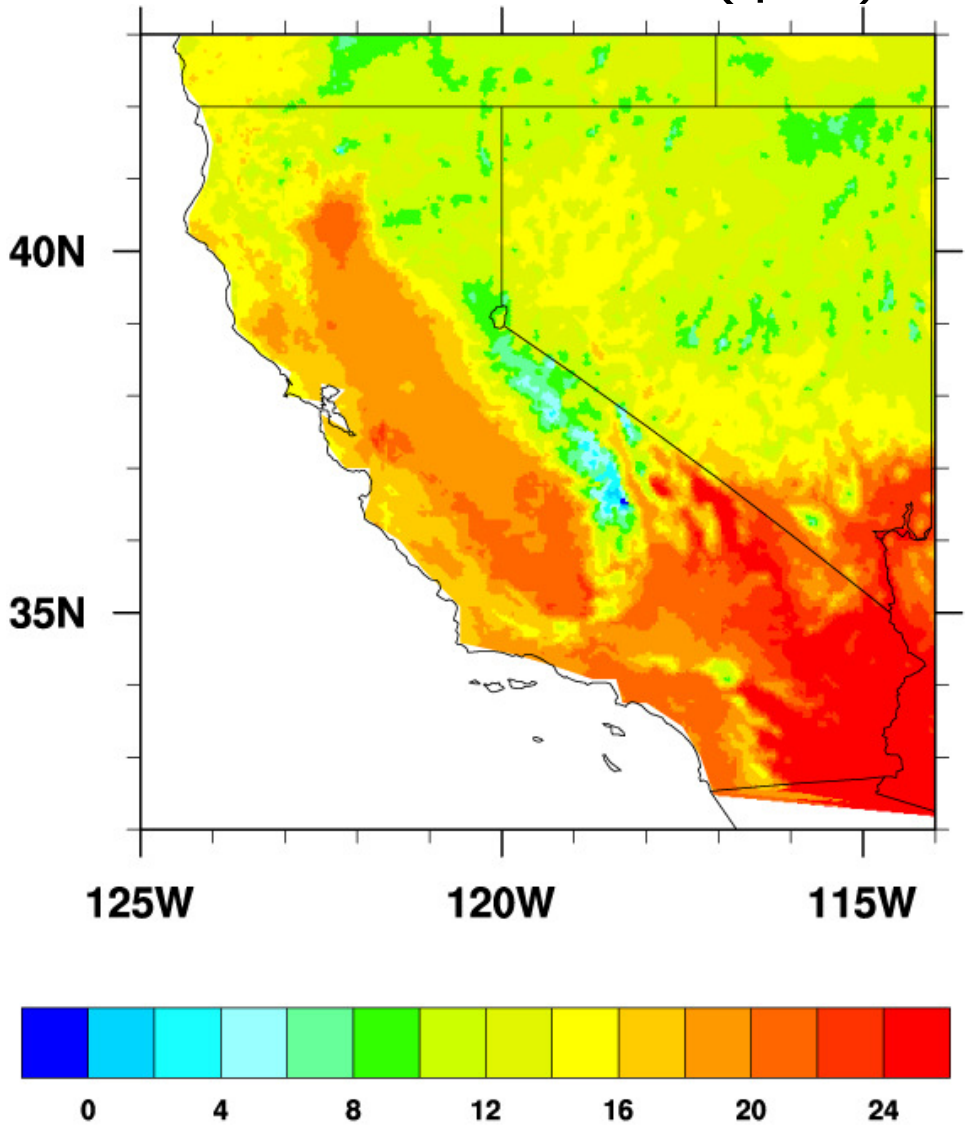


Downscaling Climate Predictions



A2 2090 Temperature (°C)

CCSM Downscaled (4km)

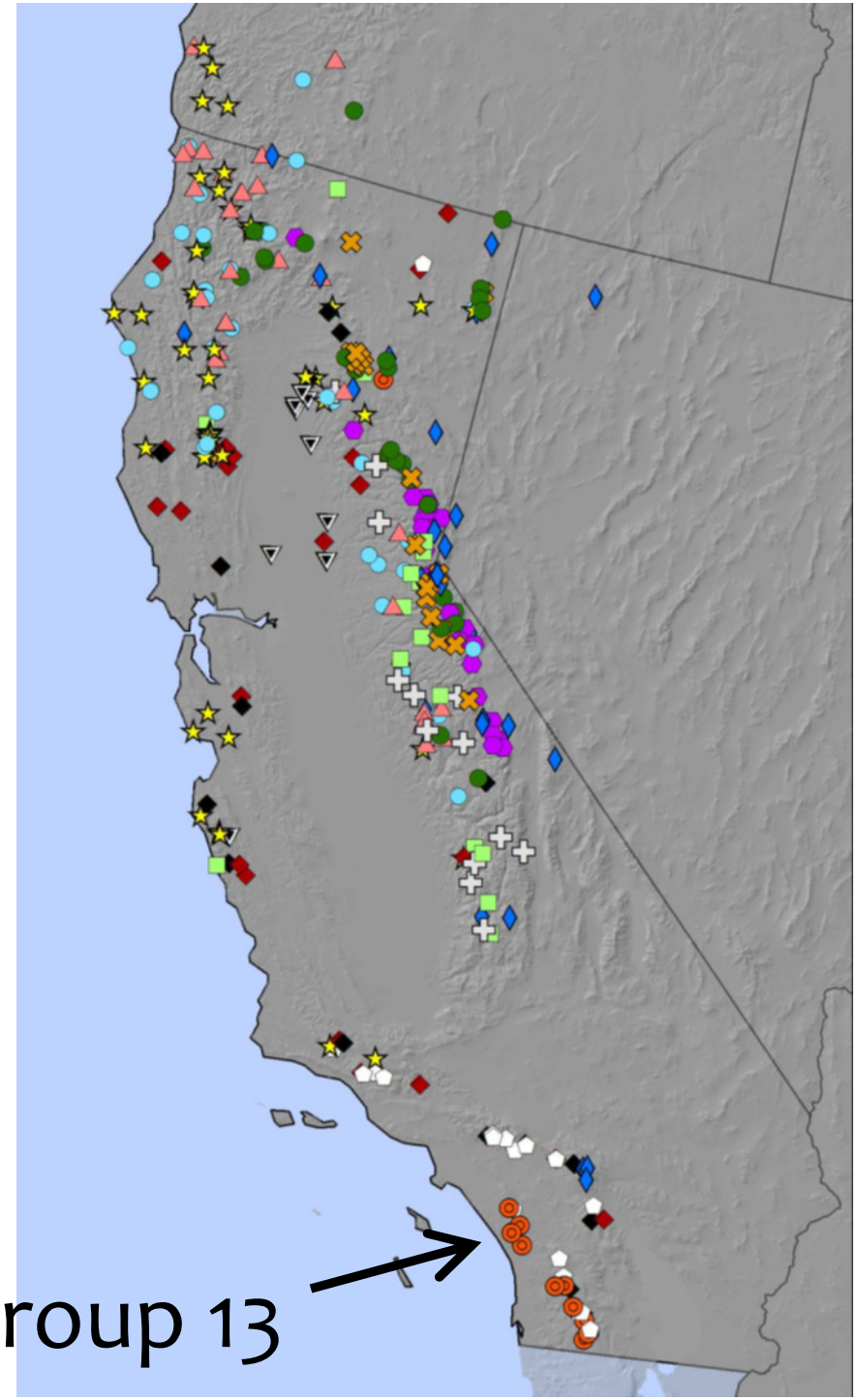


The California reference sites:

340 taxa.

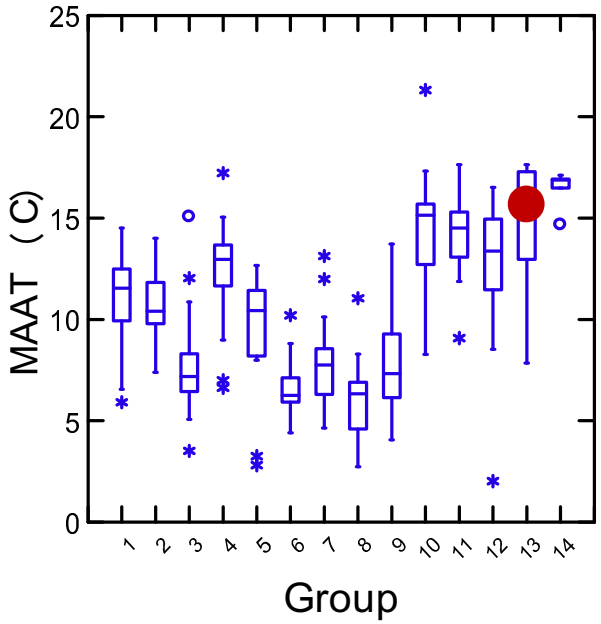
327 sites

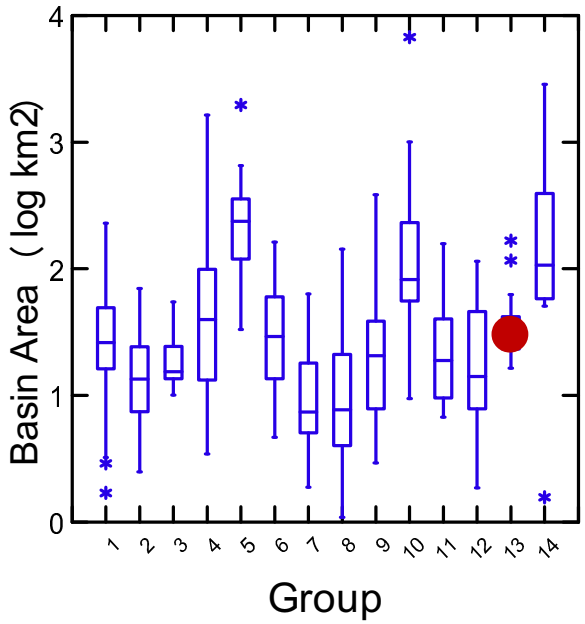
classified into 14 groups for model building.

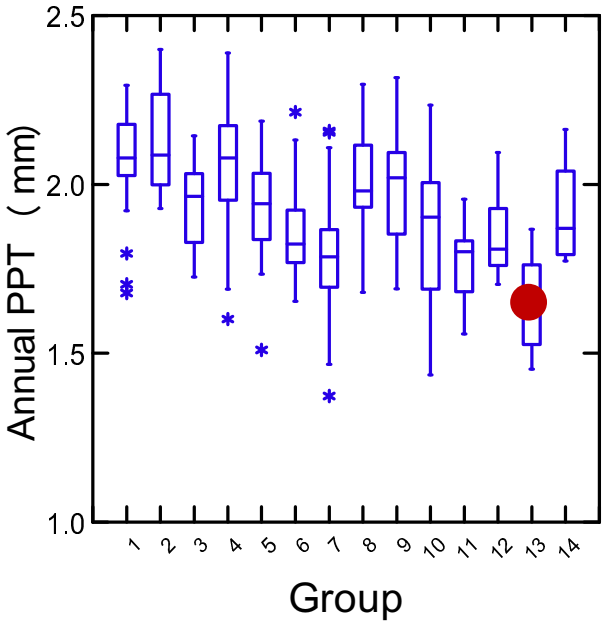


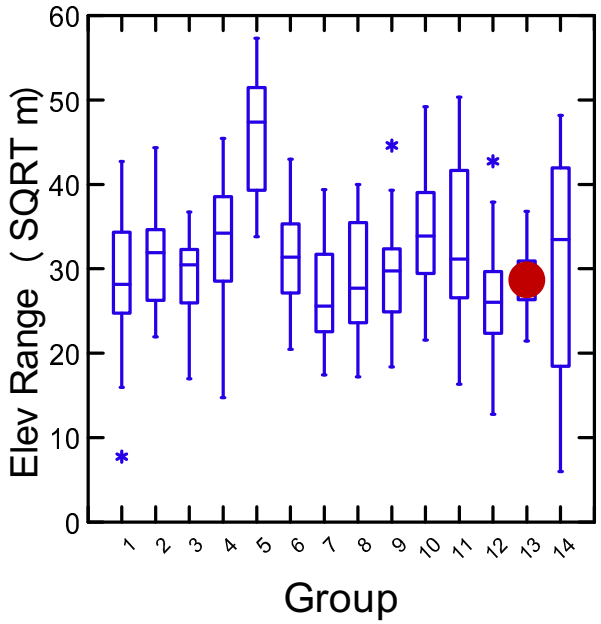
5 Predictors

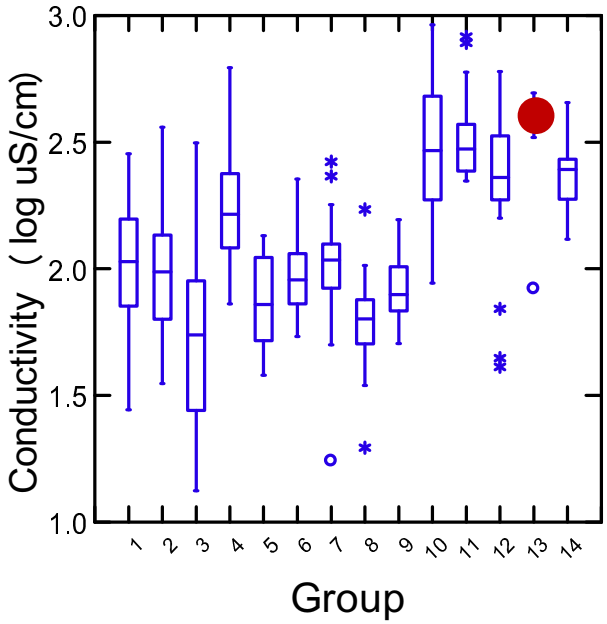
Group 13: warmest driest highest TDS



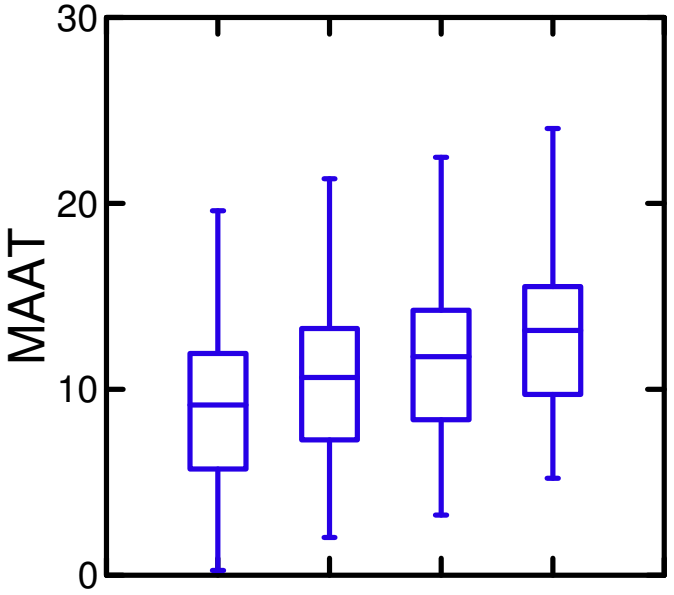


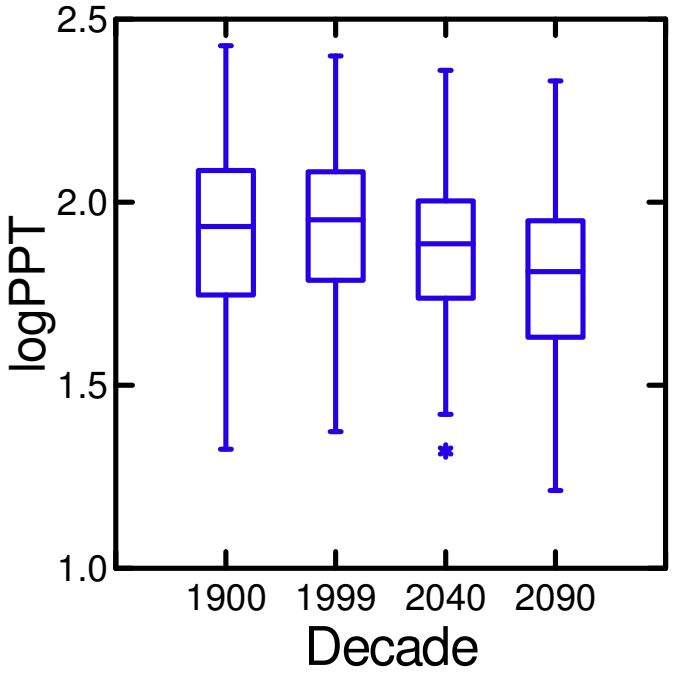


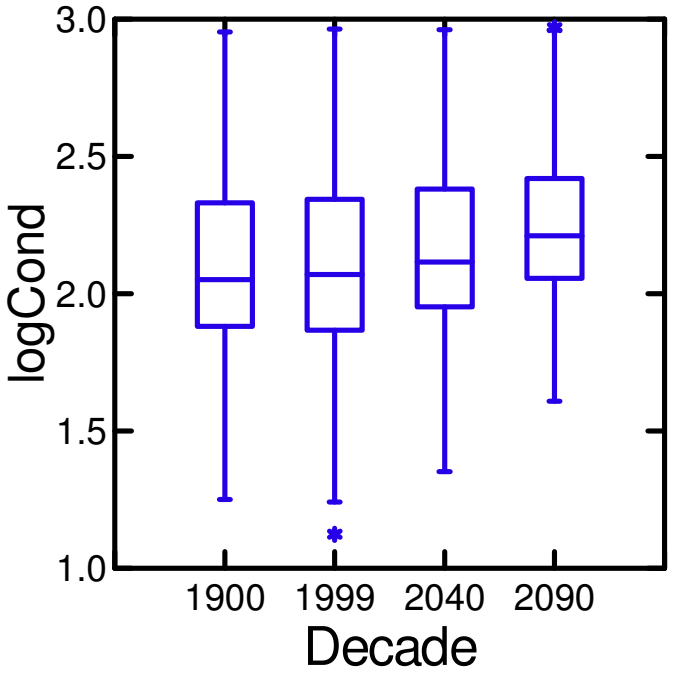




Predicted changes in climate-sensitive predictors







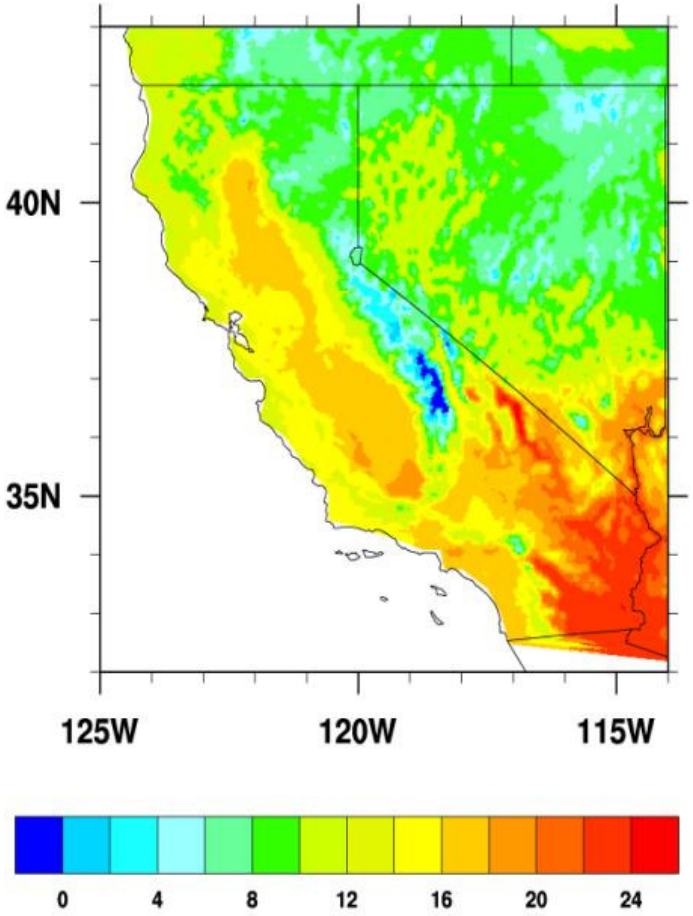
2090-1999 comparisons

A2 Climate Change Scenario

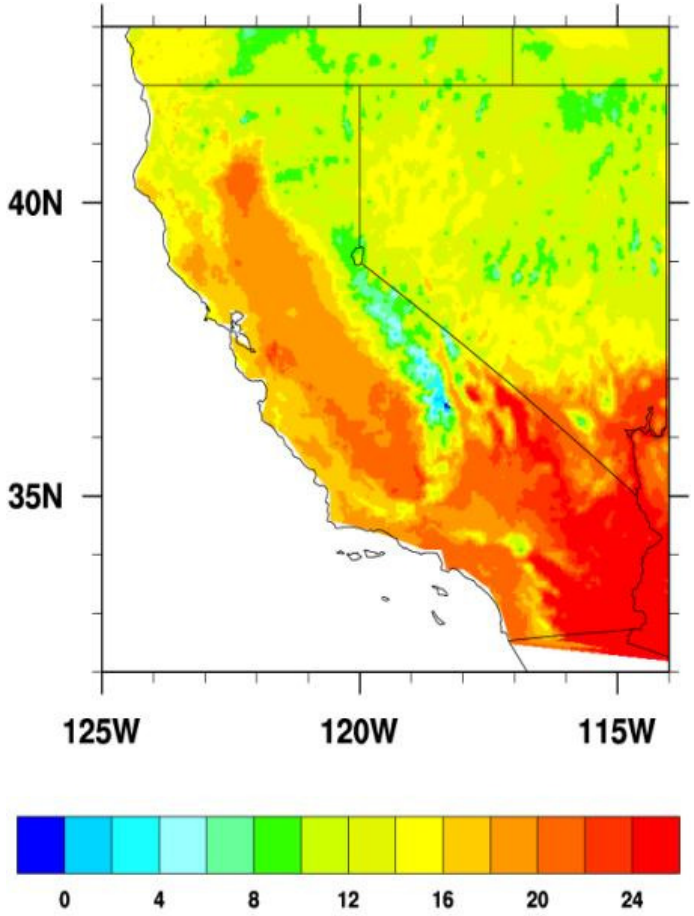
(CCSM 250 -> 4 km empirically downscaled predictions)

Mean Annual Temperature (°C)

1999 modeled



2090 forecast

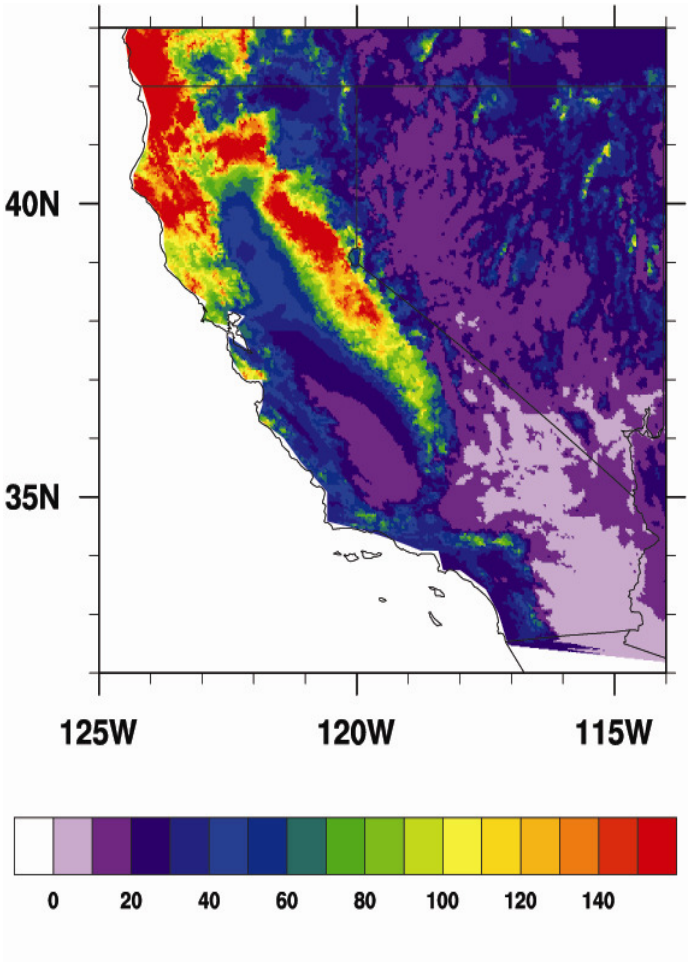


A2 Climate Change Scenario

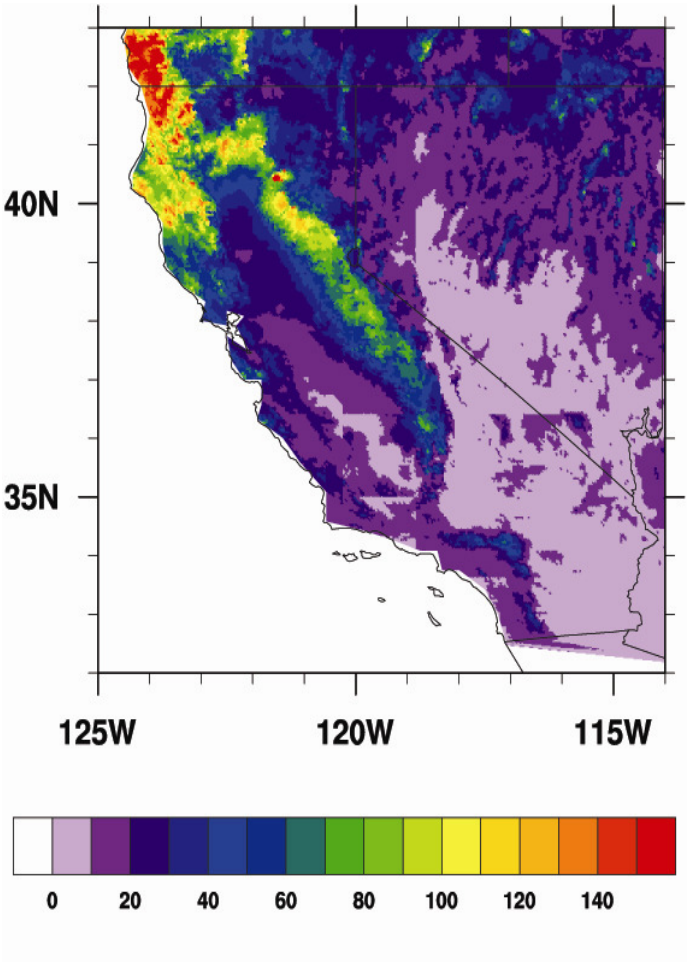
(CCSM 250 -> 4 km empirically downscaled predictions)

Mean Monthly Precipitation (mm)

1999 modeled

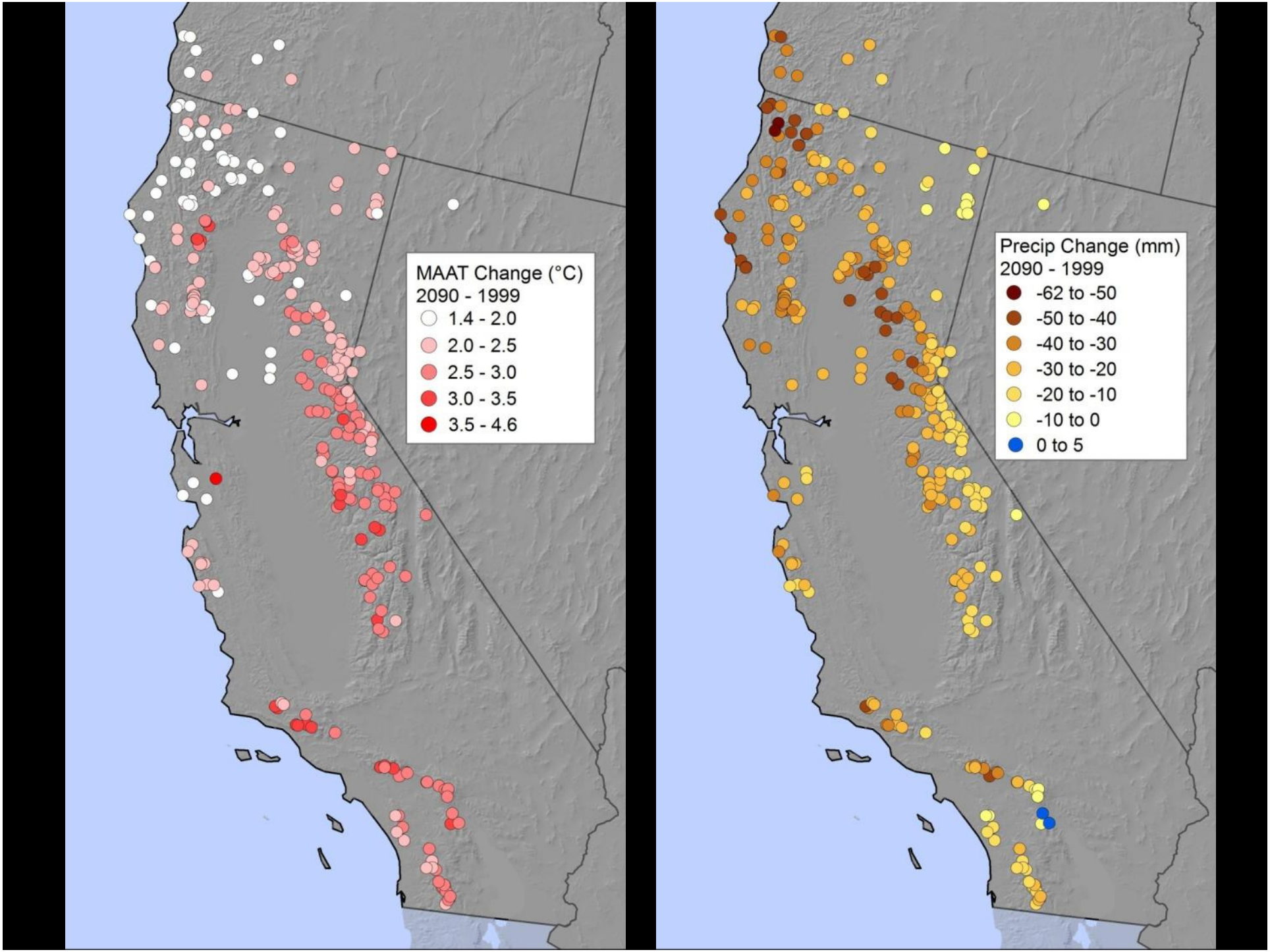


2090 forecast



Changes in climate-sensitive predictors (2090-1999) across 327 reference sites

Statistic	Precipitation (mm)	Temp (C)	Cond (µS/cm)
Mean	-26	2.4	48
Minimum	-61	1.4	-30
Maximum	+5	4.6	180


MAAT Change (°C)
2090 - 1999
1.4 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.6
Precip Change (mm)
2090 - 1999
-62 to -50
-50 to -40
-40 to -30
-30 to -20
-20 to -10
-10 to 0
0 to 5

Individual taxa

- Average changes in PD
  - 172 decreasers ($\delta \leq 0.1$)
  - 168 increasers ($\delta \geq 0.1$)
- Many predicted local extinctions (rare taxa).

Most Sensitive Taxa (mean ΔPD)

-0.16

+0.10

-0.14

+0.08

-0.13

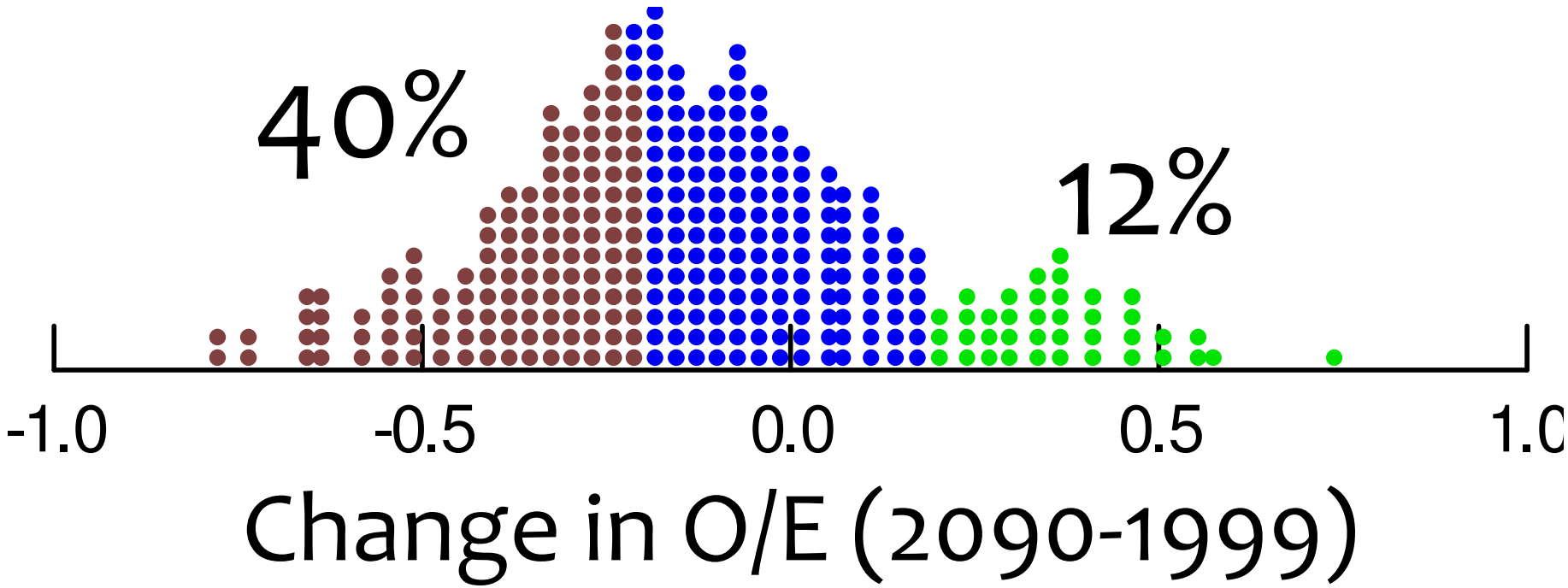
+0.07

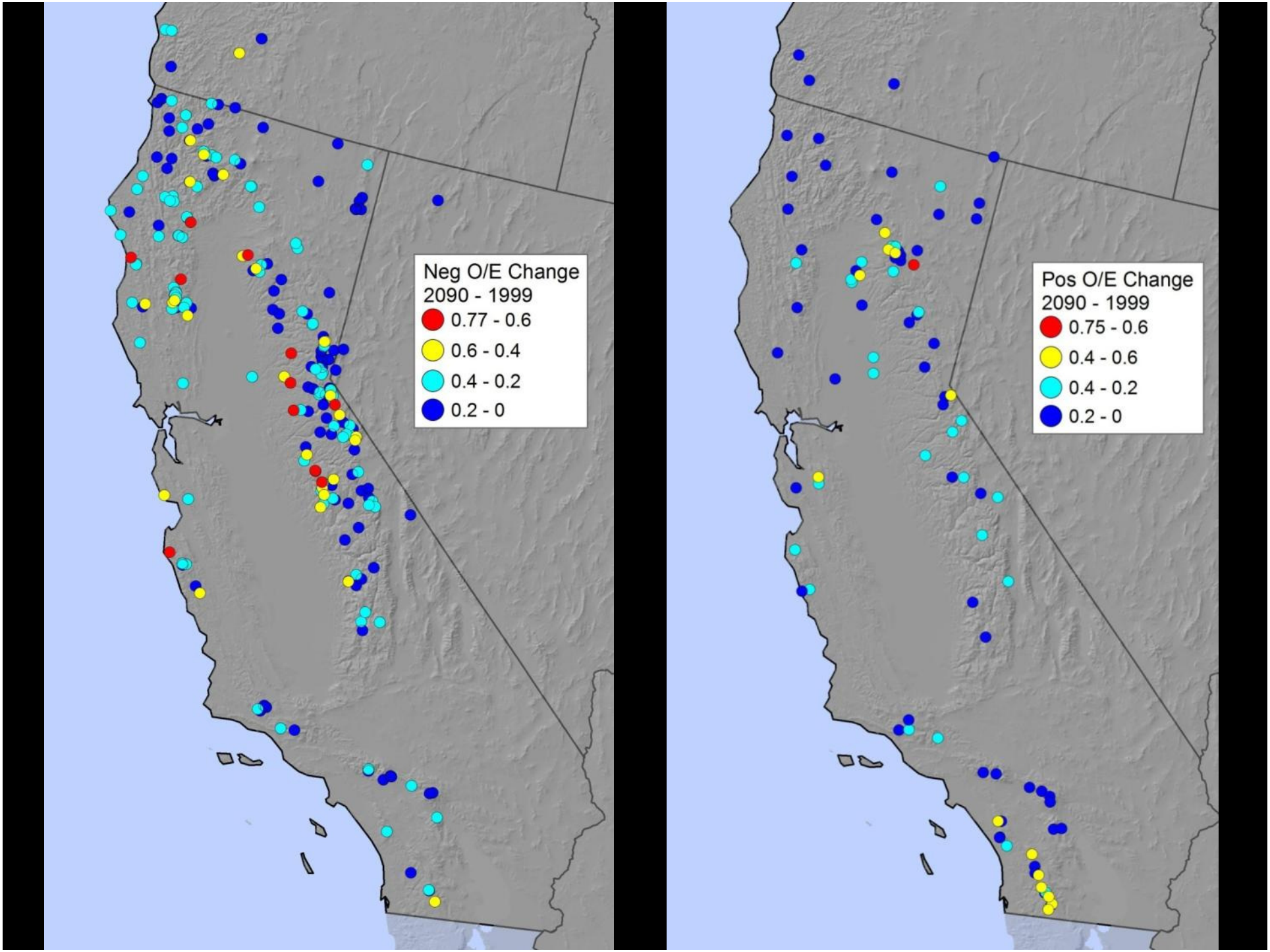
What is the consequence for reference site taxa richness and O/E?

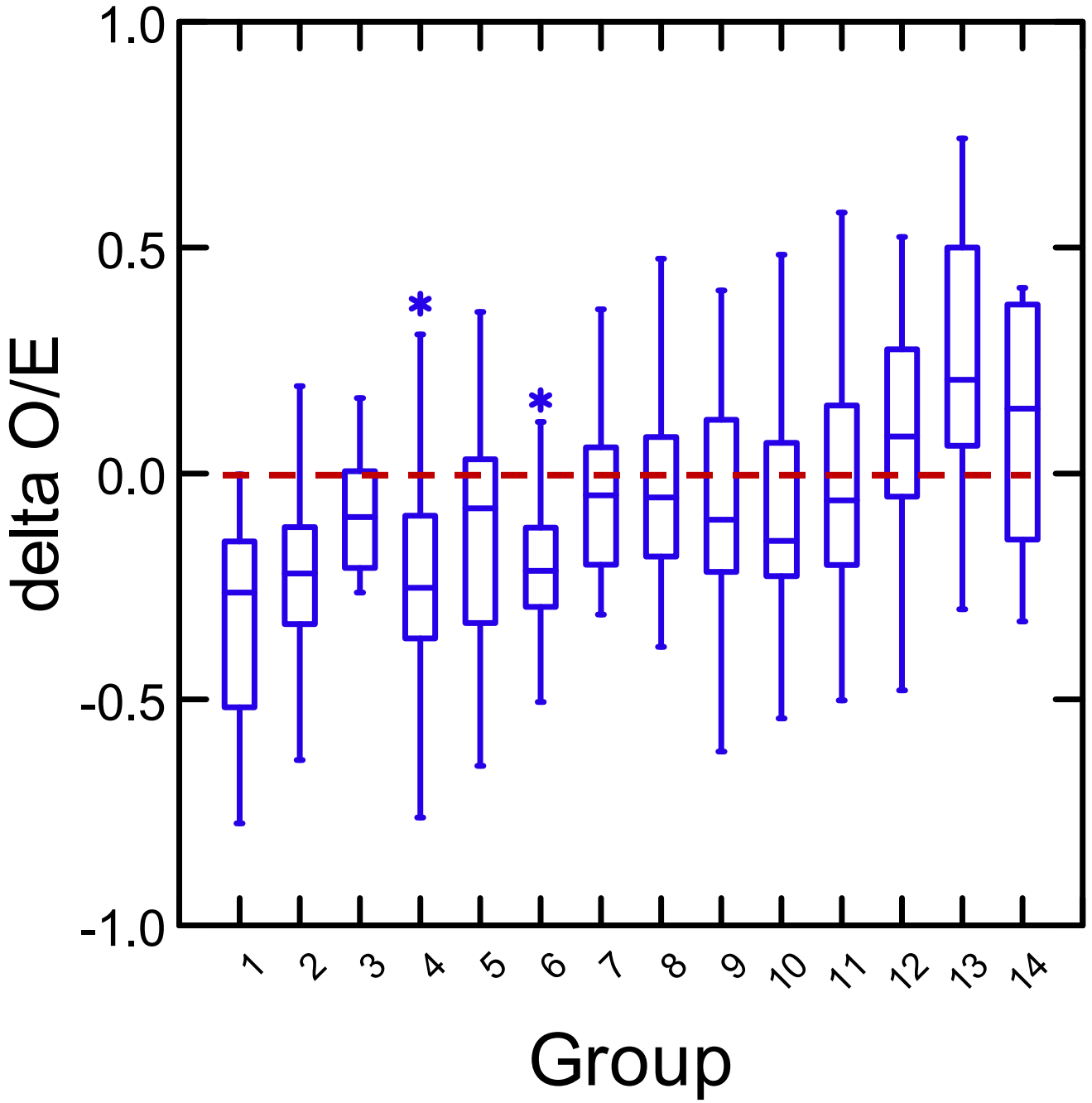
~10% loss in mean site richness by 2090

No loss in regional richness

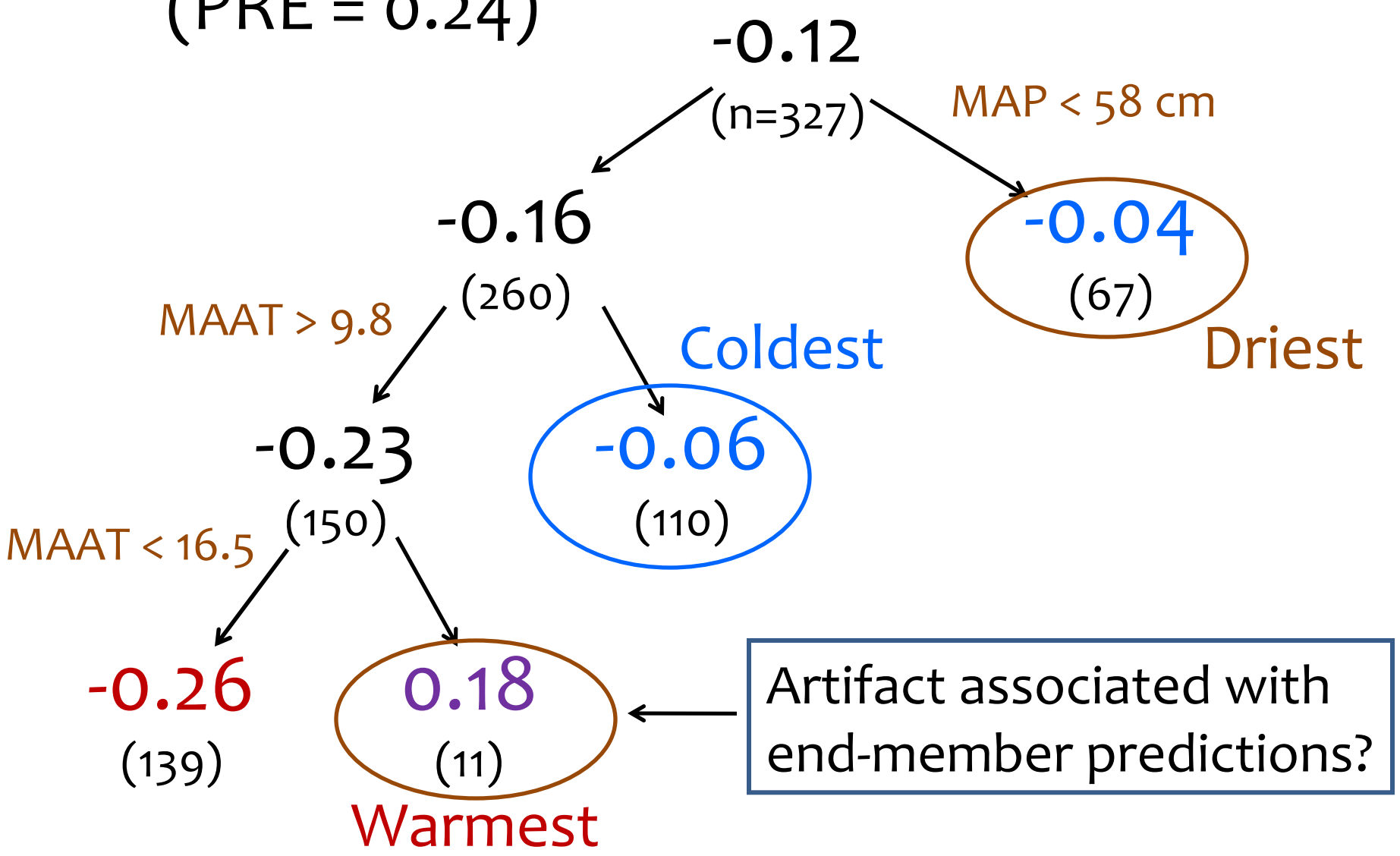
Mean ΔO/E = -0.12




Neg O/E Change
2090 - 1999
0.77 - 0.6
0.6 - 0.4
0.4 - 0.2
0.2 - 0
Pos O/E Change
2090 - 1999
0.75 - 0.6
0.4 - 0.6
0.4 - 0.2
0.2 - 0


1.0
0.5
0.0
-0.5
-1.0
delta O/E
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Group

Predictors of Site Vulnerability (Δ O/E) (PRE = 0.24)



How realistic are these predictions?

- Climate predictions?
  - Accuracy of CCSM?
  - Accuracy of downscaling?
- Biota predictions?
  - General accuracy of RIVPACS model?
  - End-member problem?

Implications?