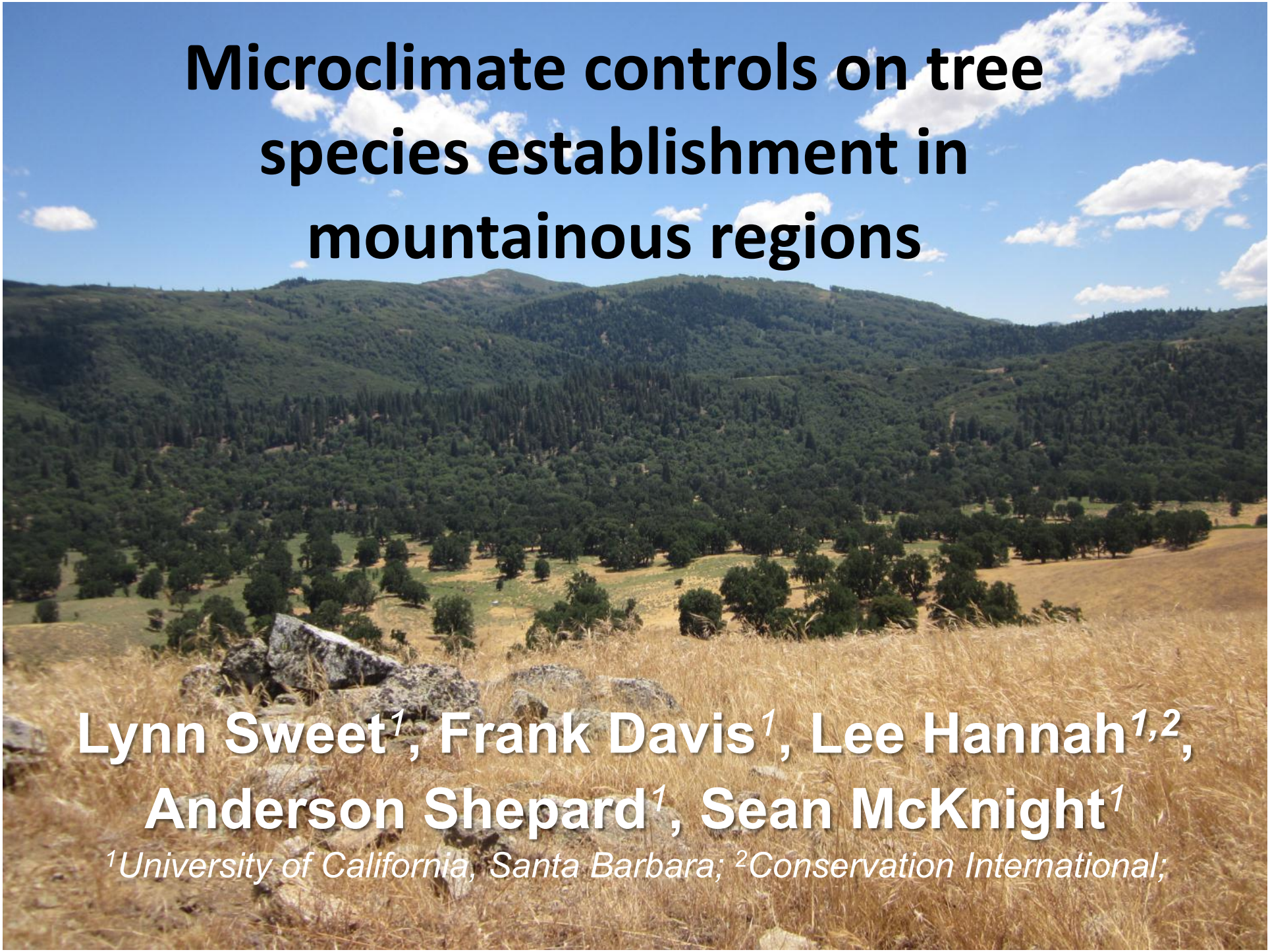


Microclimate controls on tree species establishment in mountainous regions

Lynn Sweet[1], Frank Davis[1], Lee Hannah[1,2], Anderson Shepard[1], Sean McKnight[1]

[1]University of California, Santa Barbara; [2]Conservation International;

How do microenvironments play into species distribution?

- Climate→ Plant distributions
  - Observed at macroecological scales
  - Influences *individual* plants (phenomena on scales of meters)

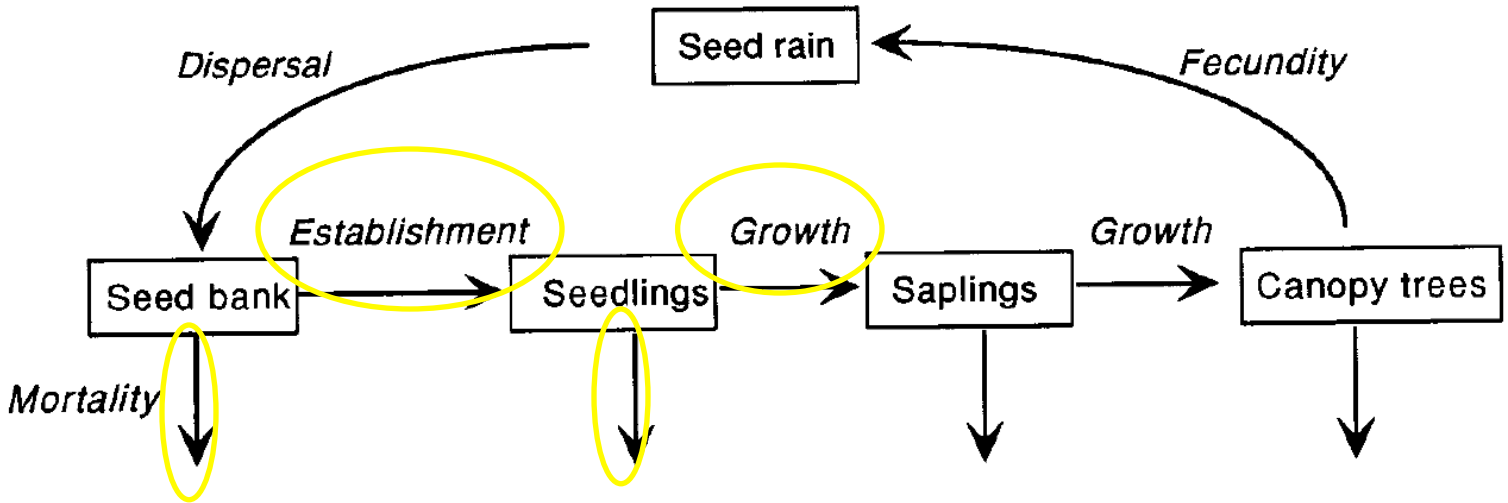
- Are fine-scale phenomena adequately predicted by coarse-scale correlations?

- Microrefugia- mediate long-distance migration of core populations

- ***Fine-scale environmental heterogeneity determines emergent macro-scale properties of species ranges***

Tree species establishment: The regeneration niche

- How, where and when do long-lived plant species (e.g. trees) establish in semi-arid environments?



Clark et al 1999, Am J Bot

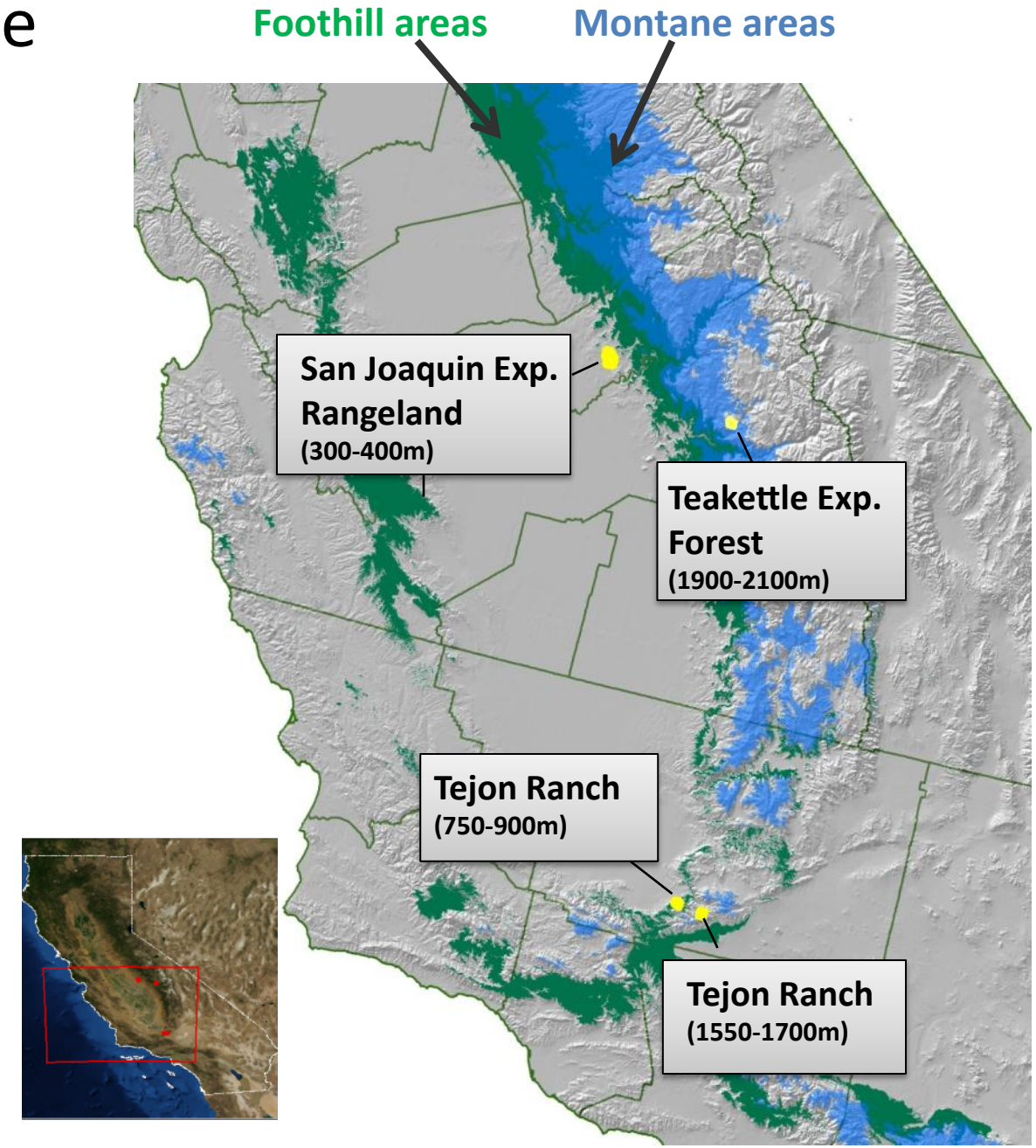
Our Research Questions

- What are the topoclimatic ("microclimate") factors influencing tree seedling establishment and growth?

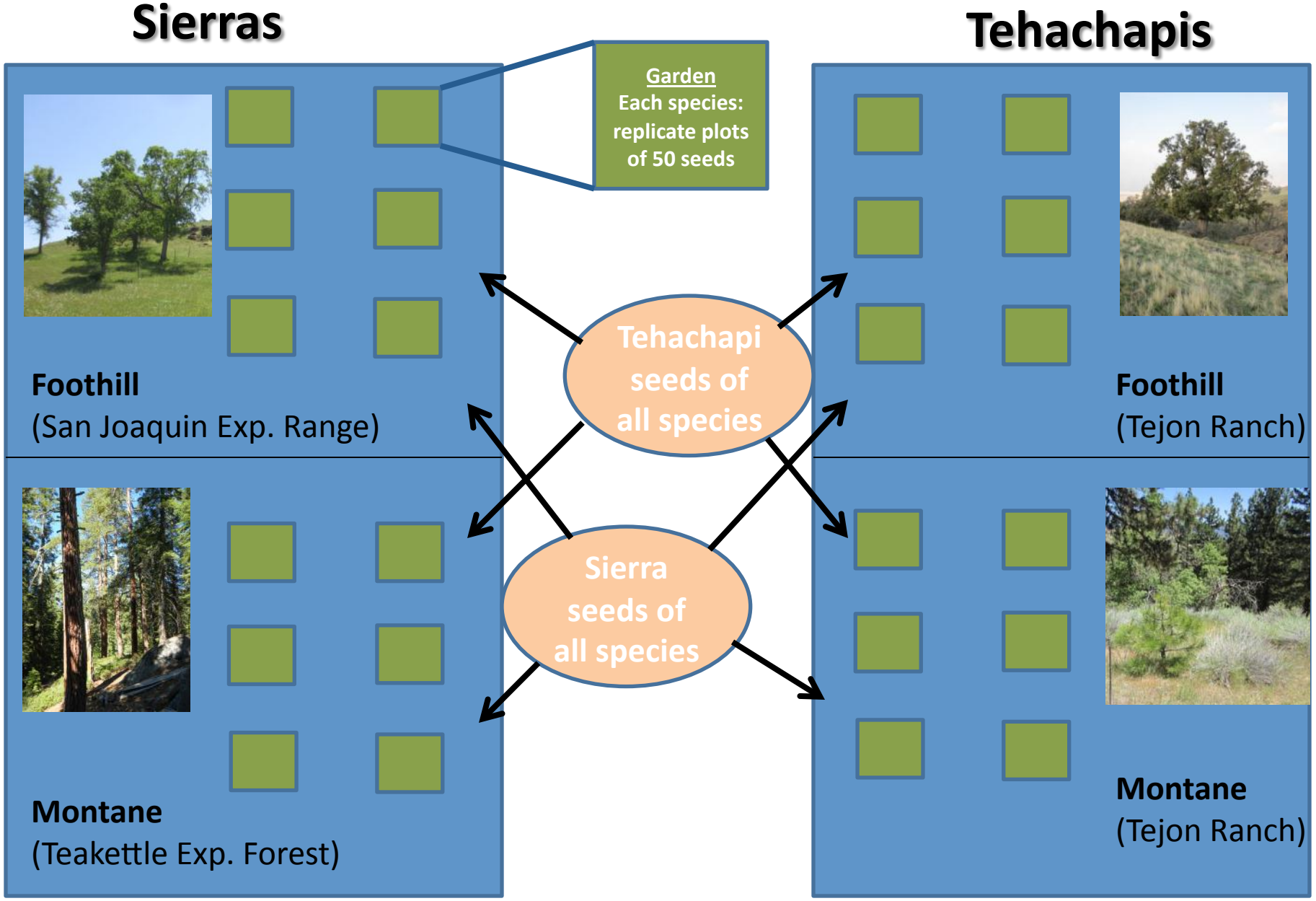
- What is the distribution of microenvironments in the landscape under current climate conditions?

Representative California Foothill and Montane Species Distribution

- *Montane:*
  - *Pinus jeffreyi* (Jeffrey pine)
  - *Pinus ponderosa* (ponderosa pine)
  - *Quercus kelloggii* (black oak)
- Foothill:
  - *Pinus sabiniana* (gray pine)
  - *Quercus douglasii* (blue oak)



Reciprocal Seeding in Common Gardens



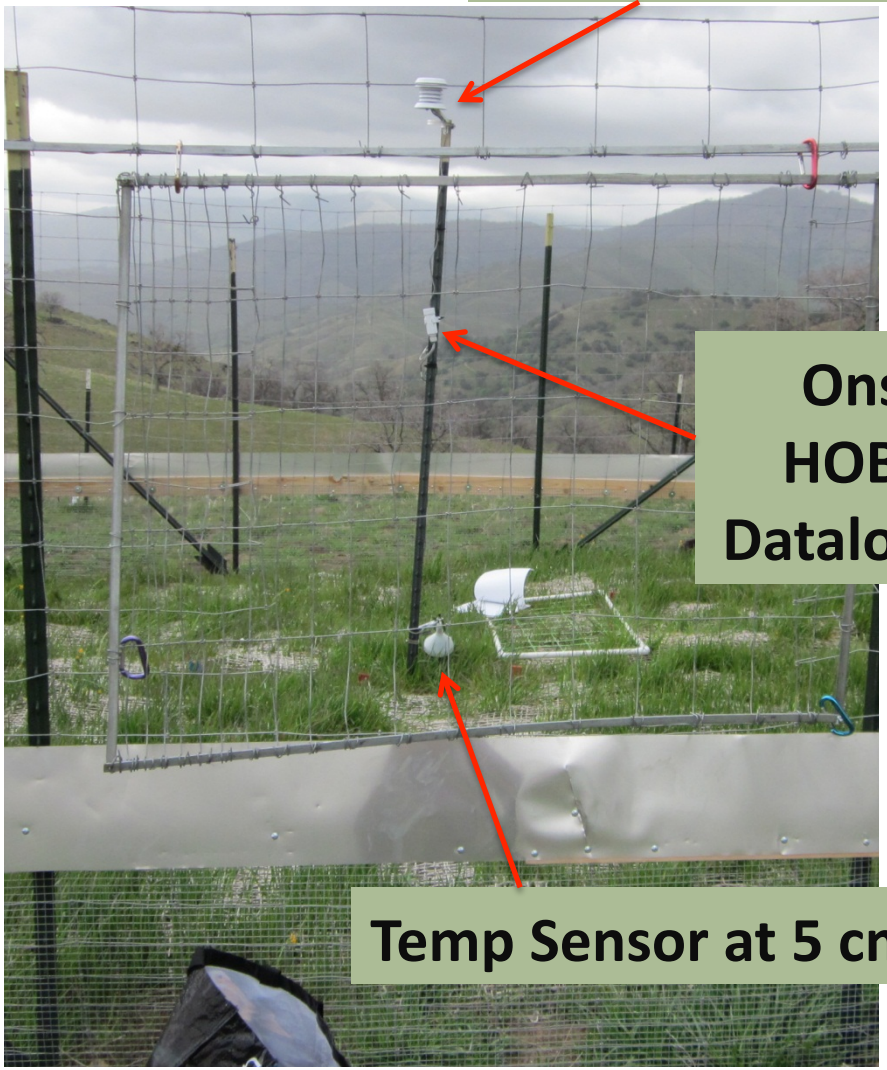
Installation and Measurements

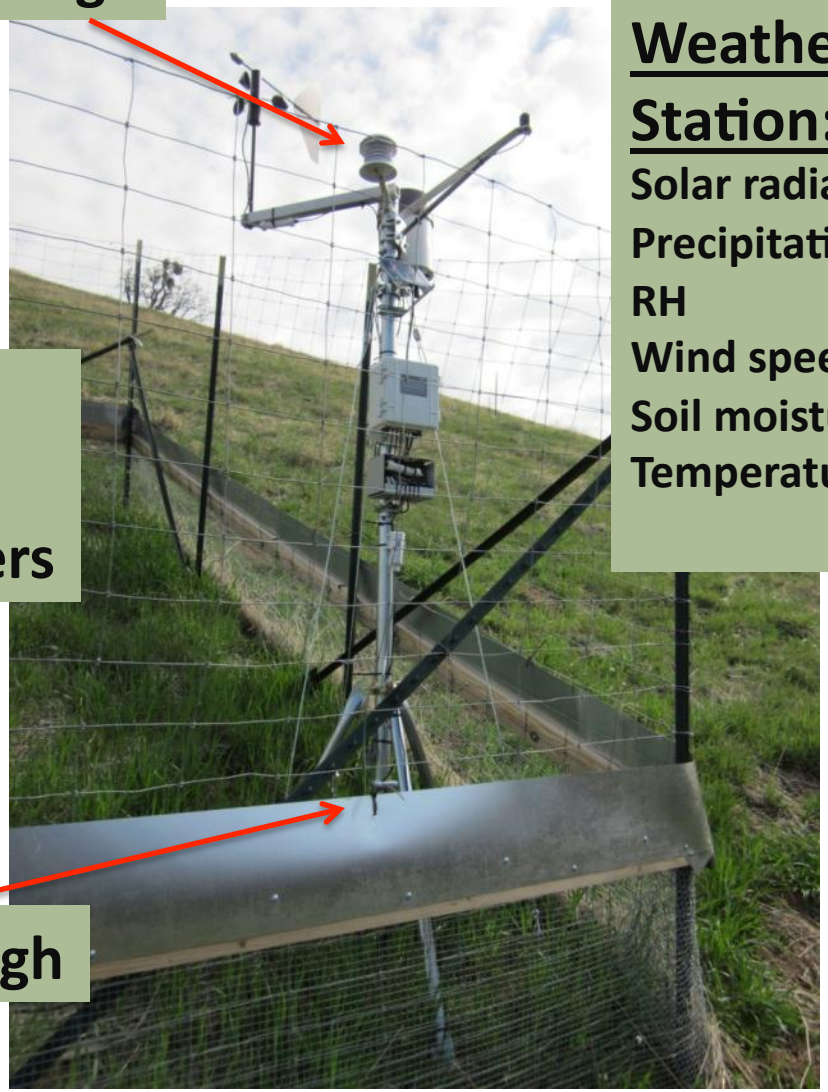
- Annual fall seed collection and planting over 3 years (2011-2013)

- Spring-summer monitoring over 5 years:
  - Measurement of emergence, growth, survival
    - 5 species
    - 50 seeds per replicate plot
    - 2 replicates per garden
    - 6 gardens per site
    - 4 sites

- Microclimate sensor measurements at 10-minute intervals, 5 years

Microclimate Sensing Equipment



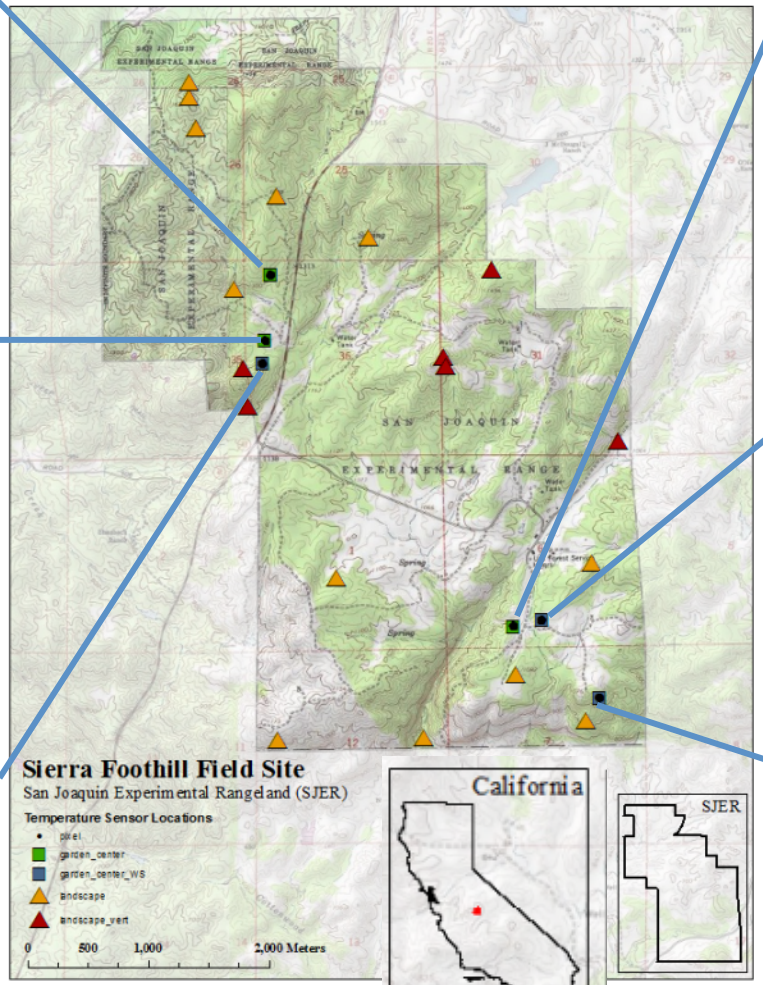


Onset Weather Station:

- Solar radiation
- Precipitation
- RH
- Wind speed
- Soil moisture
- Temperature

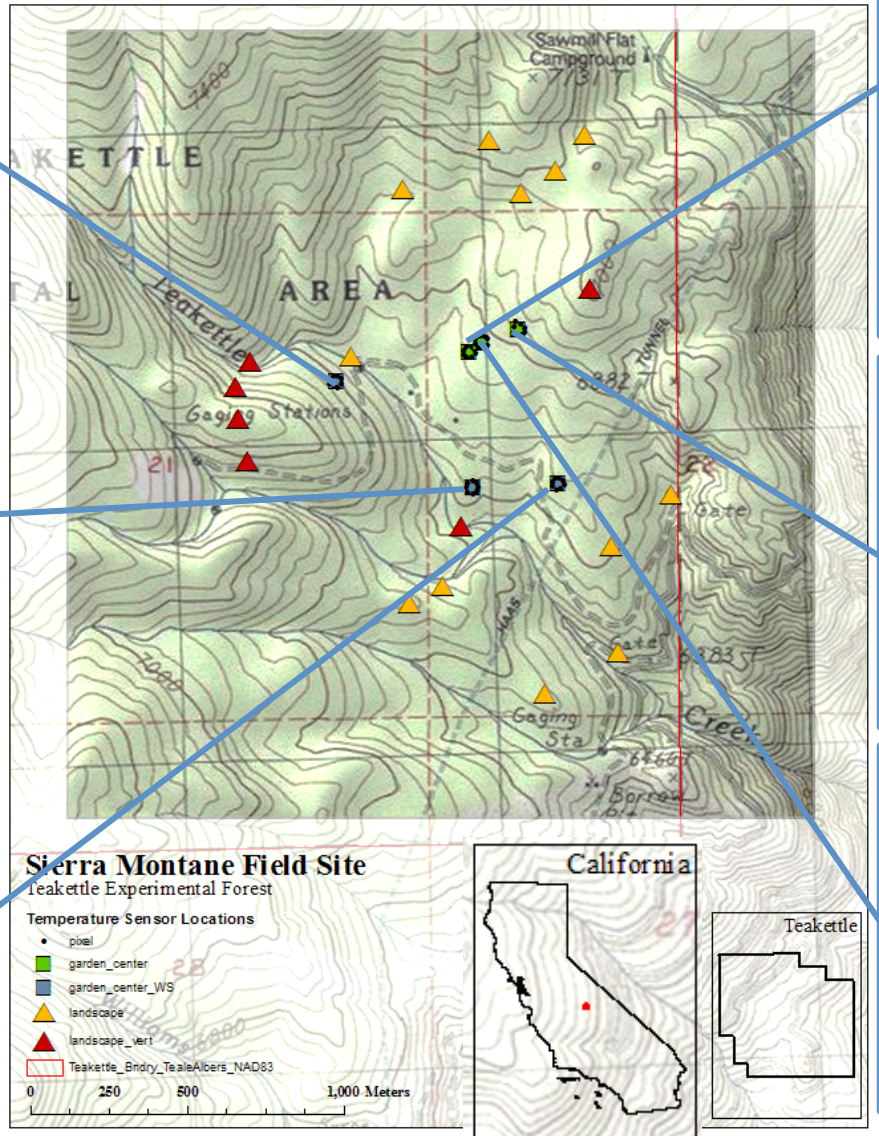
Sierra Foothill Field Site

(USFS San Joaquin Experimental Rangeland, 300-400m Elevation)



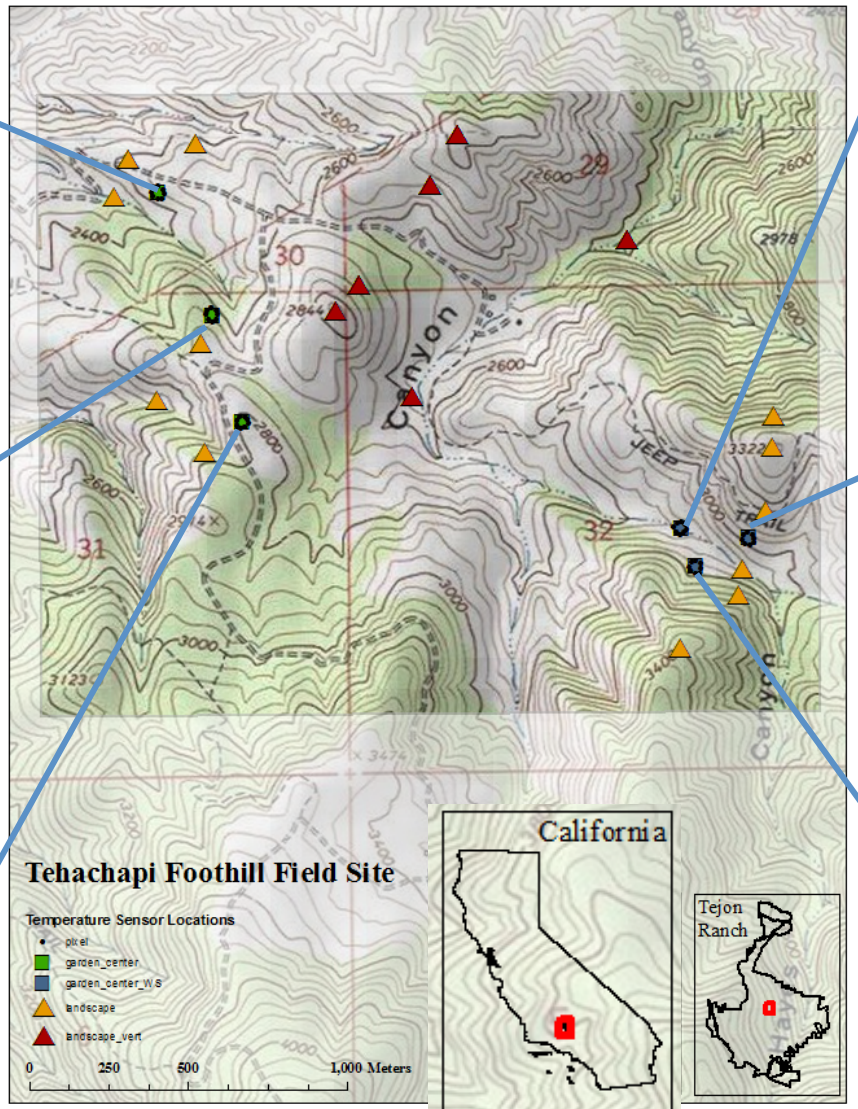
Sierra Montane Field Site

(USFS Teakettle Experimental Forest,
1900-2100m elevation)



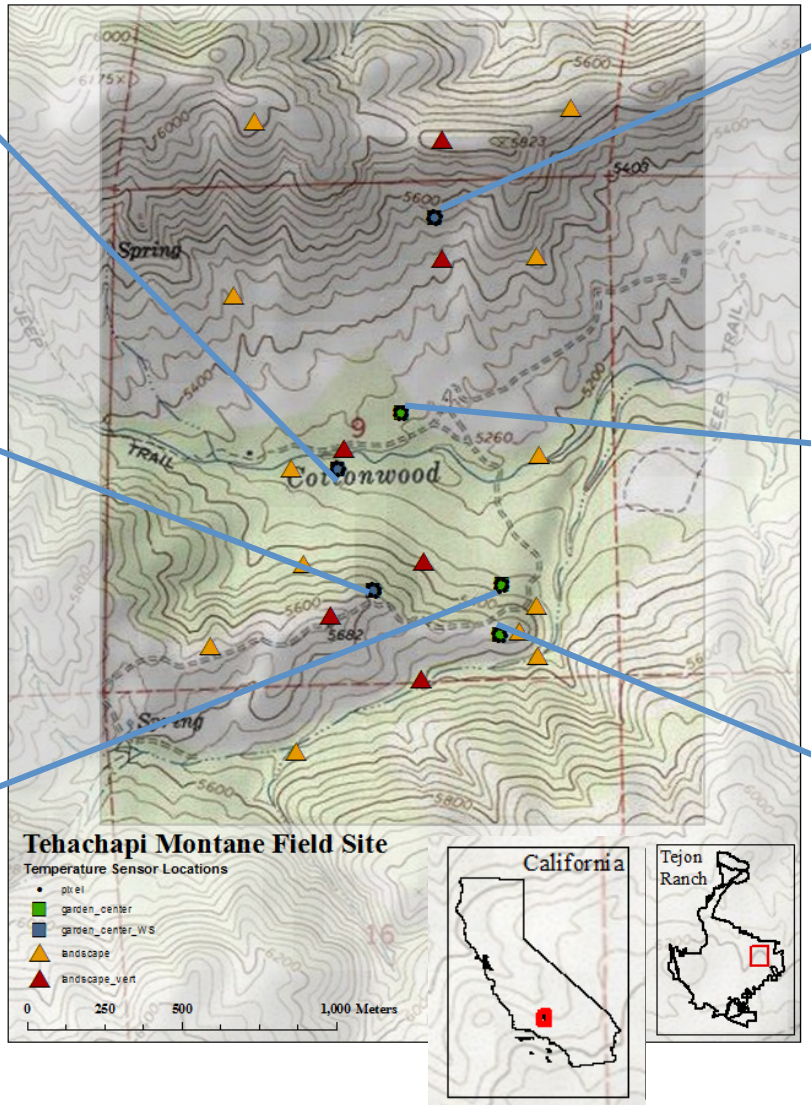
Tehachapi Foothill Field Site

(Tejon Ranch,
750-900m elevation)

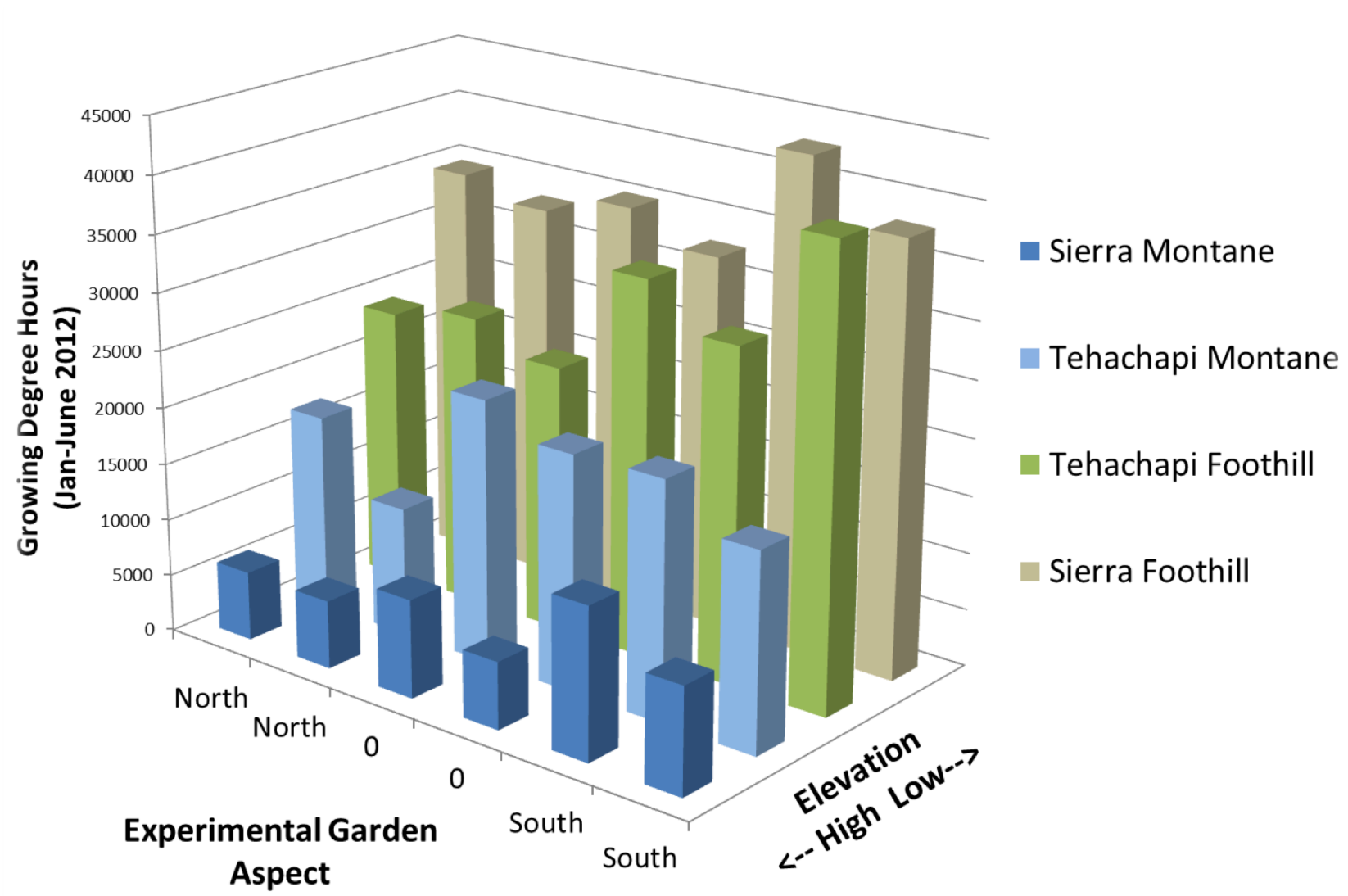


Tehachapi Montane Field Site

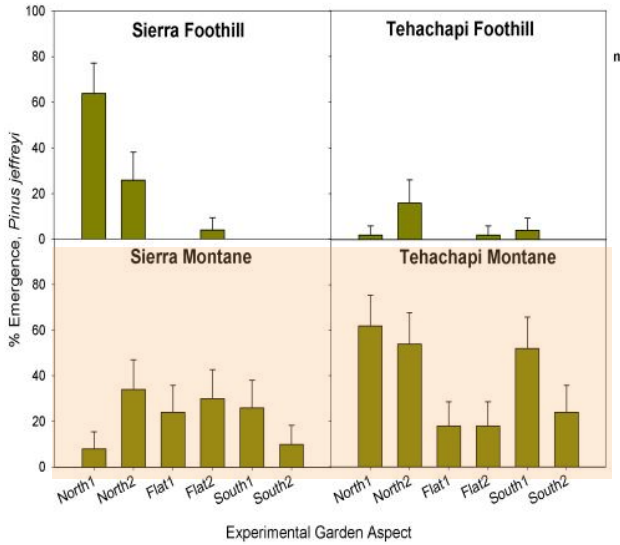
(Tejon Ranch,
1550-1900m elevation)

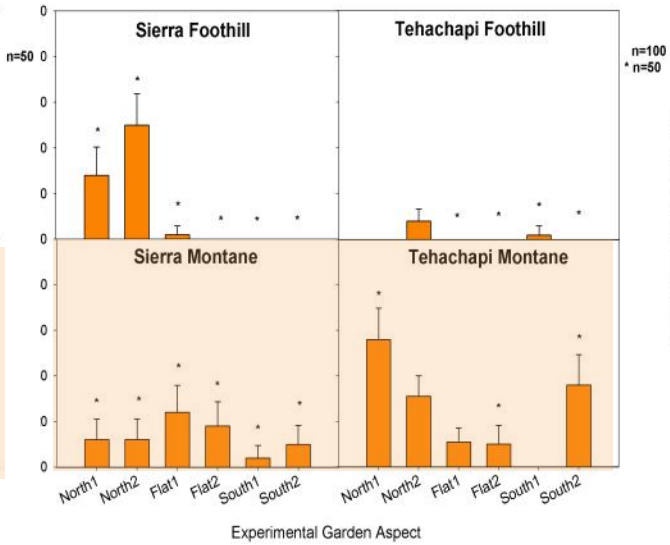


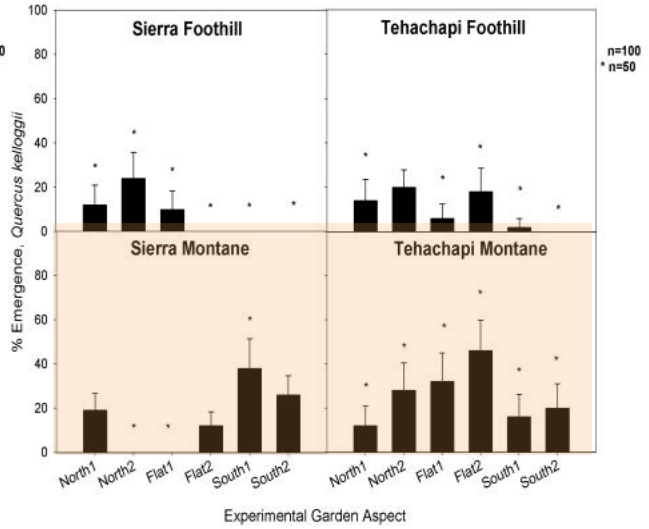
Jan-June Accumulated Growing Degree Hours at Garden Locations *(10°C threshold)*



Results: Emergence of Montane Species





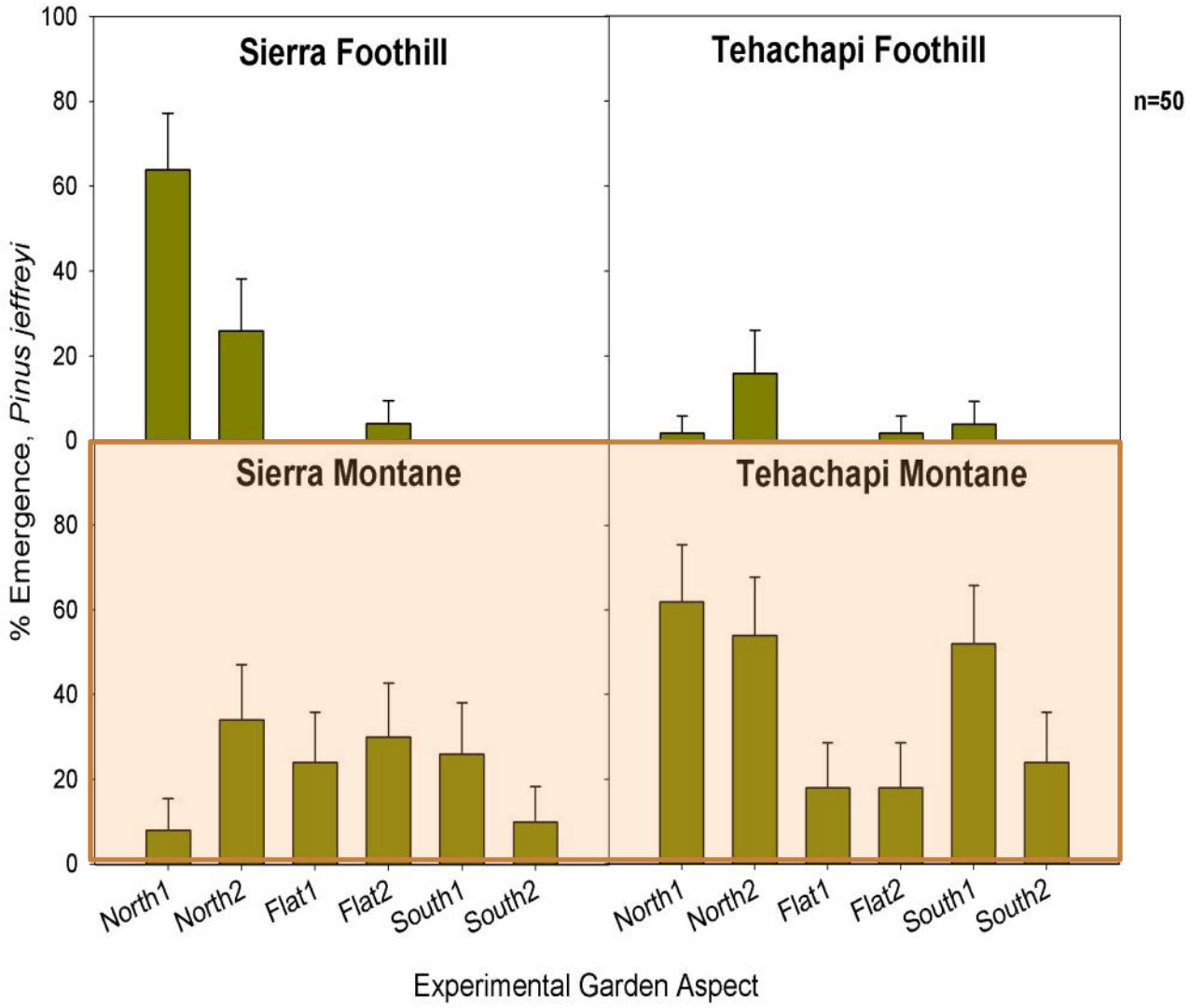


Jeffrey Pine

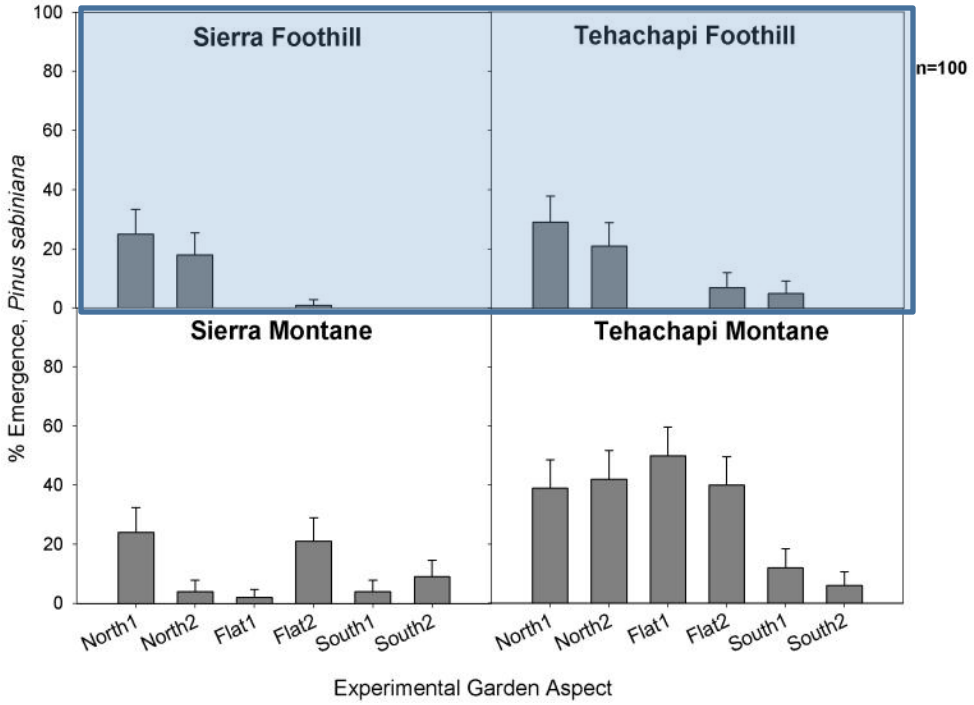
Ponderosa Pine

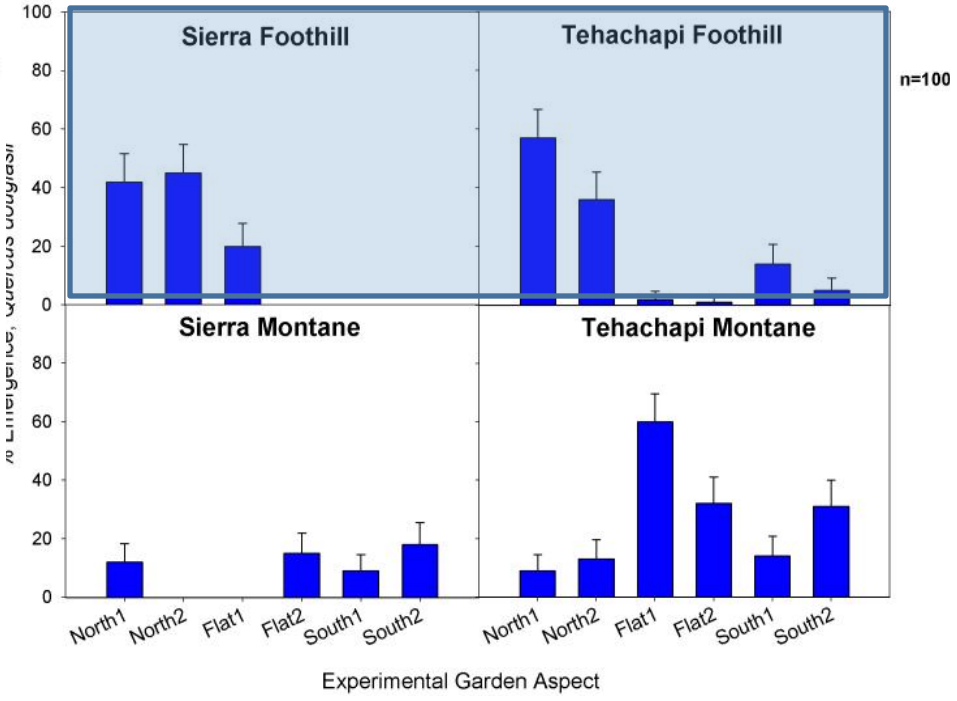
Black Oak

Jeffrey Pine



Results: Emergence of Foothill Species

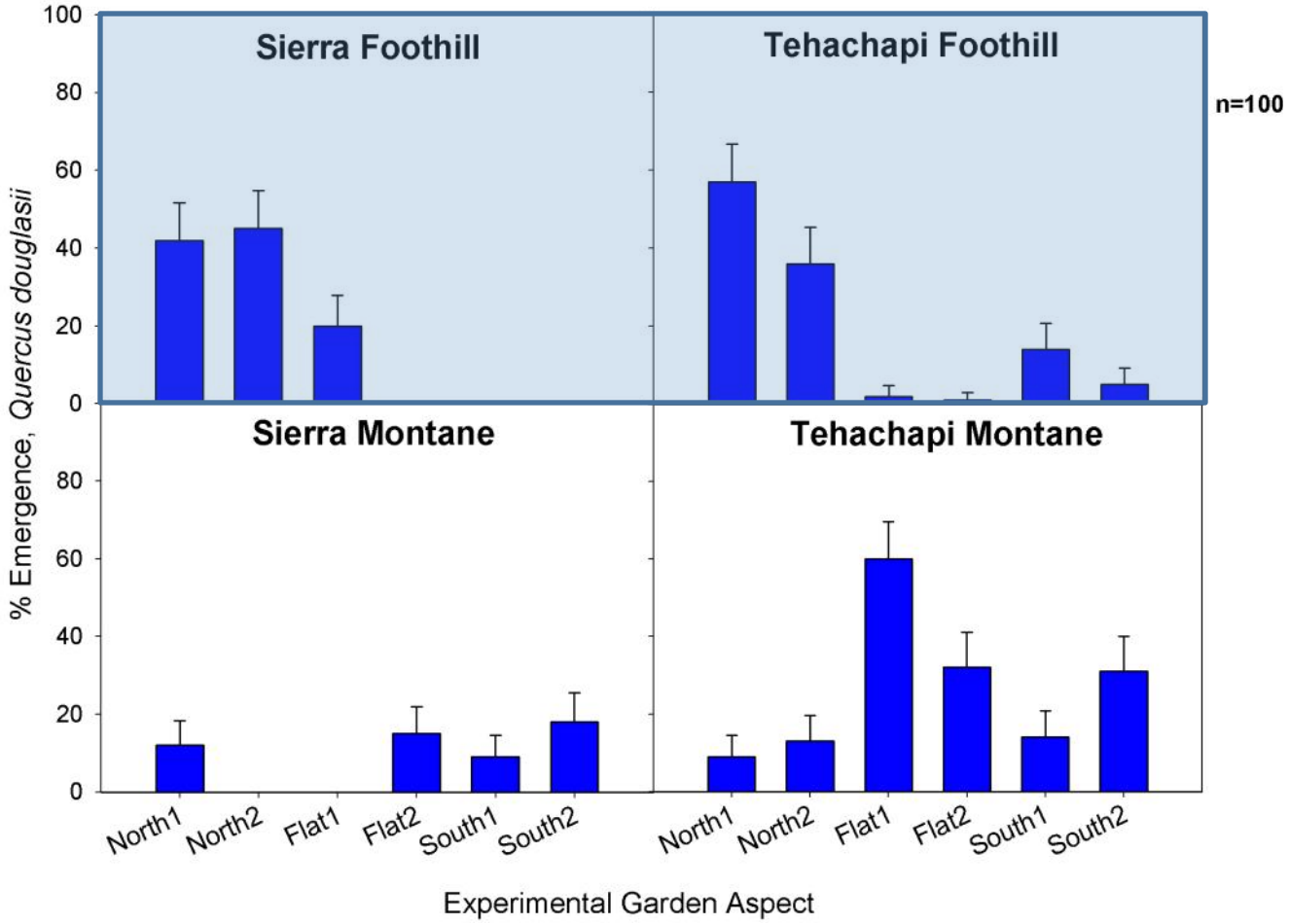




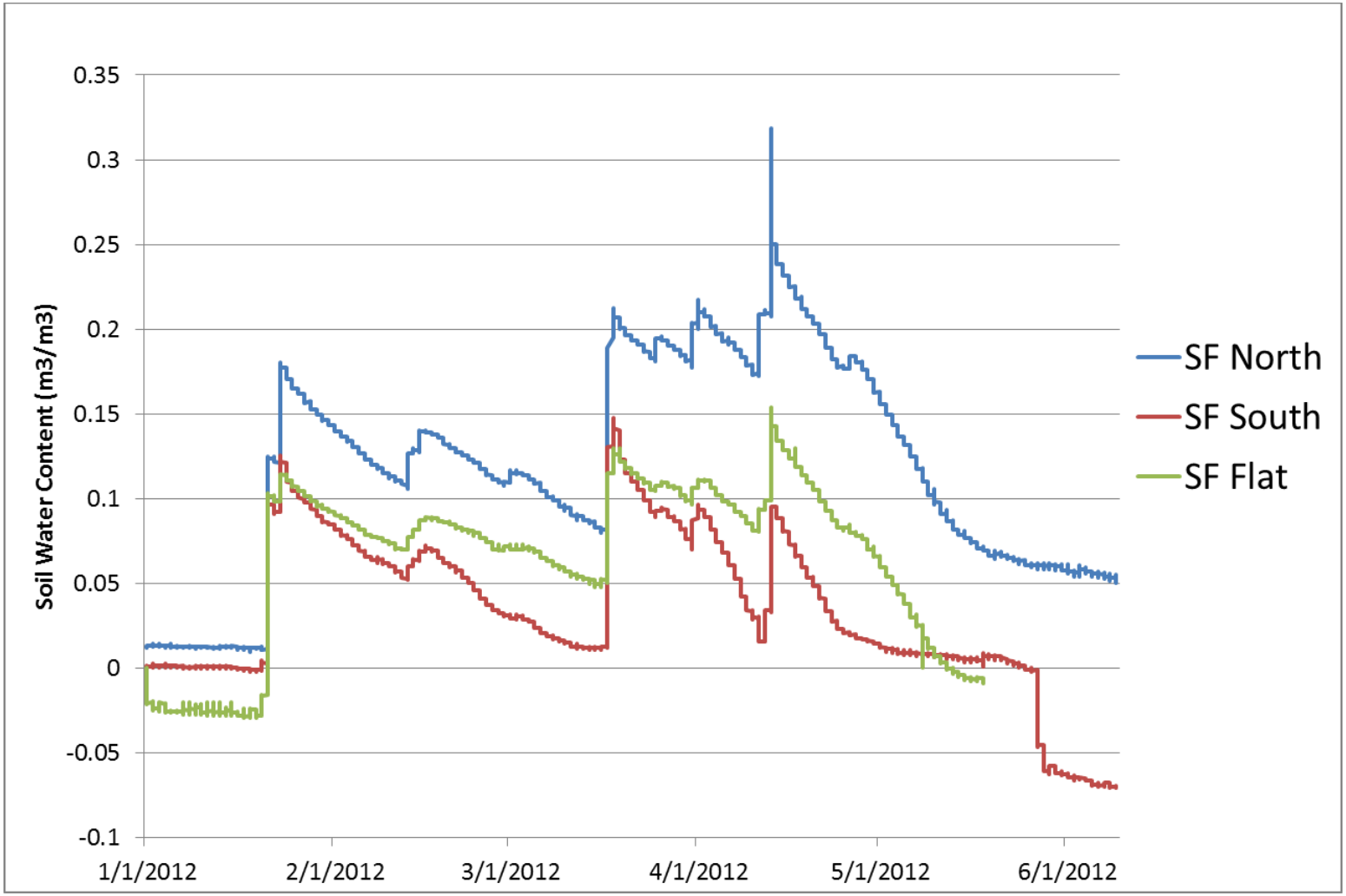
Gray Pine

Blue Oak

Blue Oak


Sierra Foothill
Tehachapi Foothill
Sierra Montane
Tehachapi Montane
n=100
% Emergence, Quercus douglasii
100
80
60
40
20
0
North1
North2
Flat1
Flat2
South1
South2
Experimental Garden Aspect

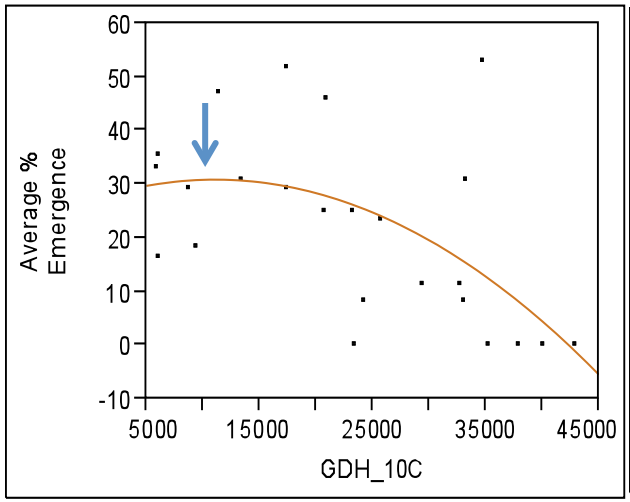
Growing Season Soil Moisture



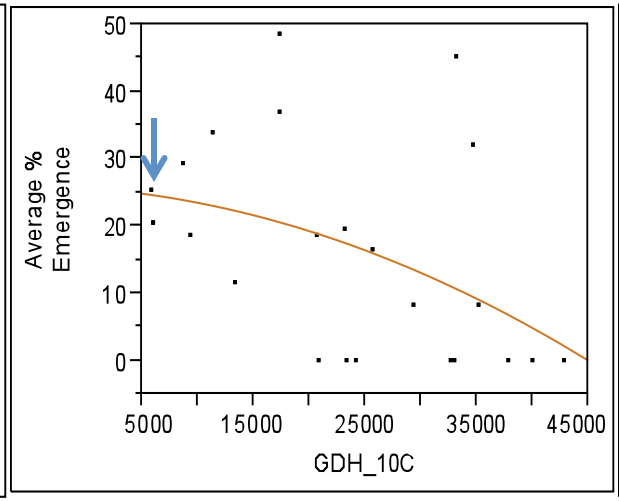
Species Emergence and Growing Degree Hours

MONTANE SPECIES

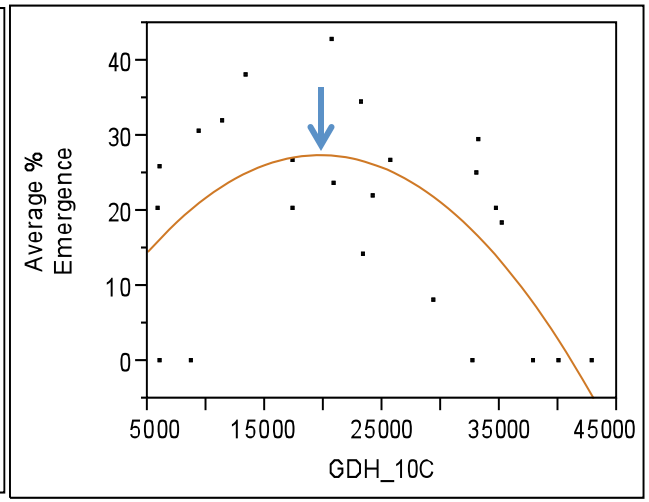
Jeffrey pine (r^2=0.304)



Ponderosa pine (r^2=0.198)

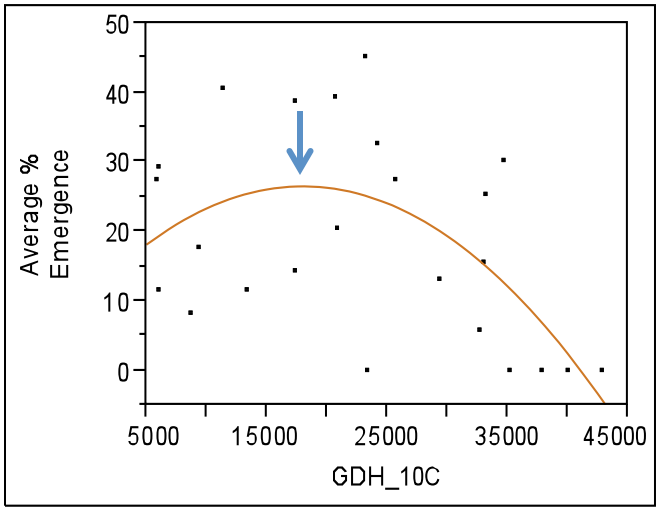


Black oak (r^2=0.386)

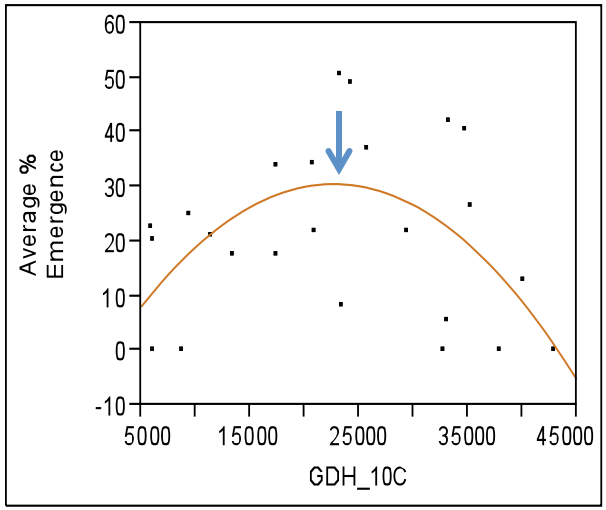


FOOTHILL SPECIES

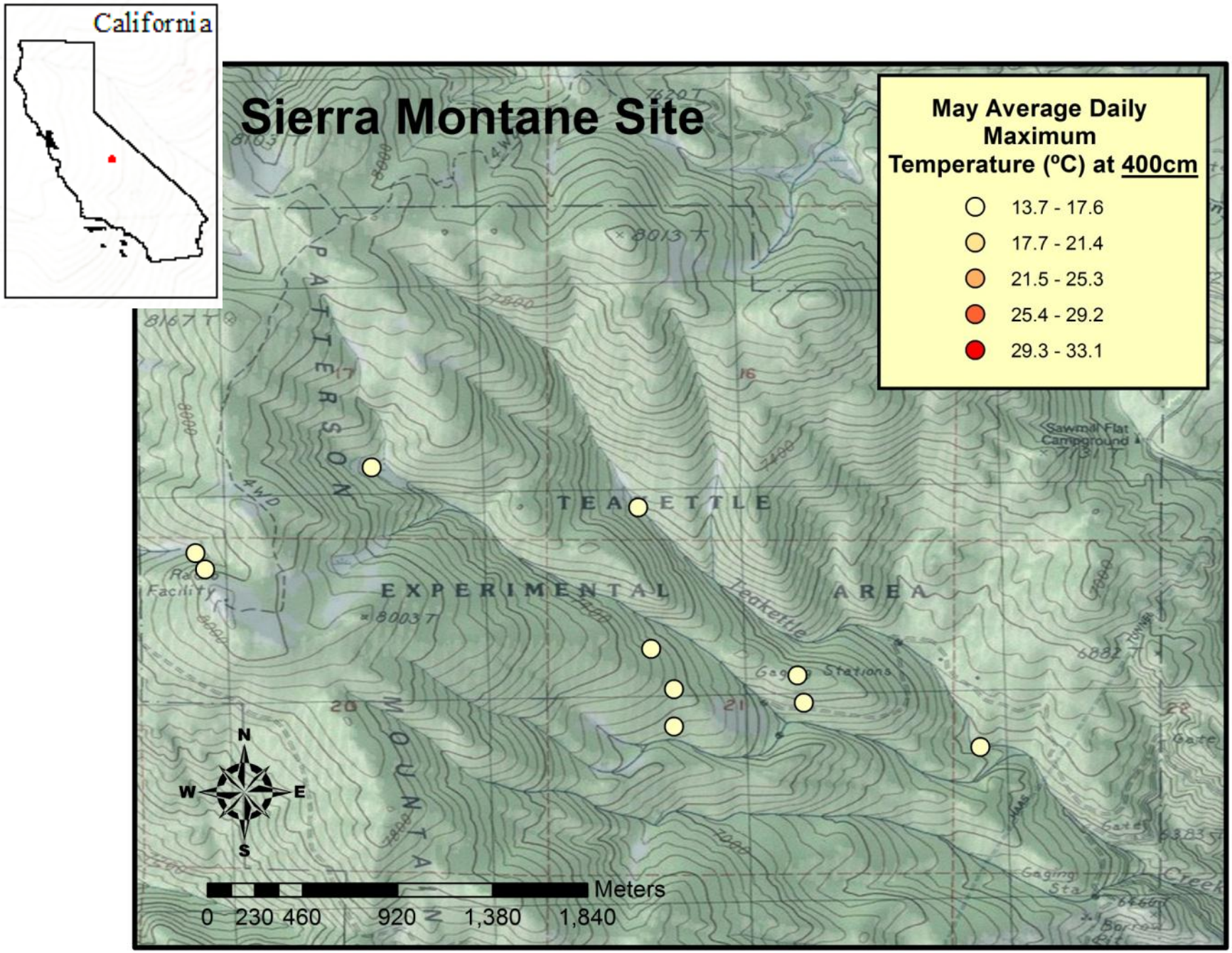
Gray pine (r^2=0.318)

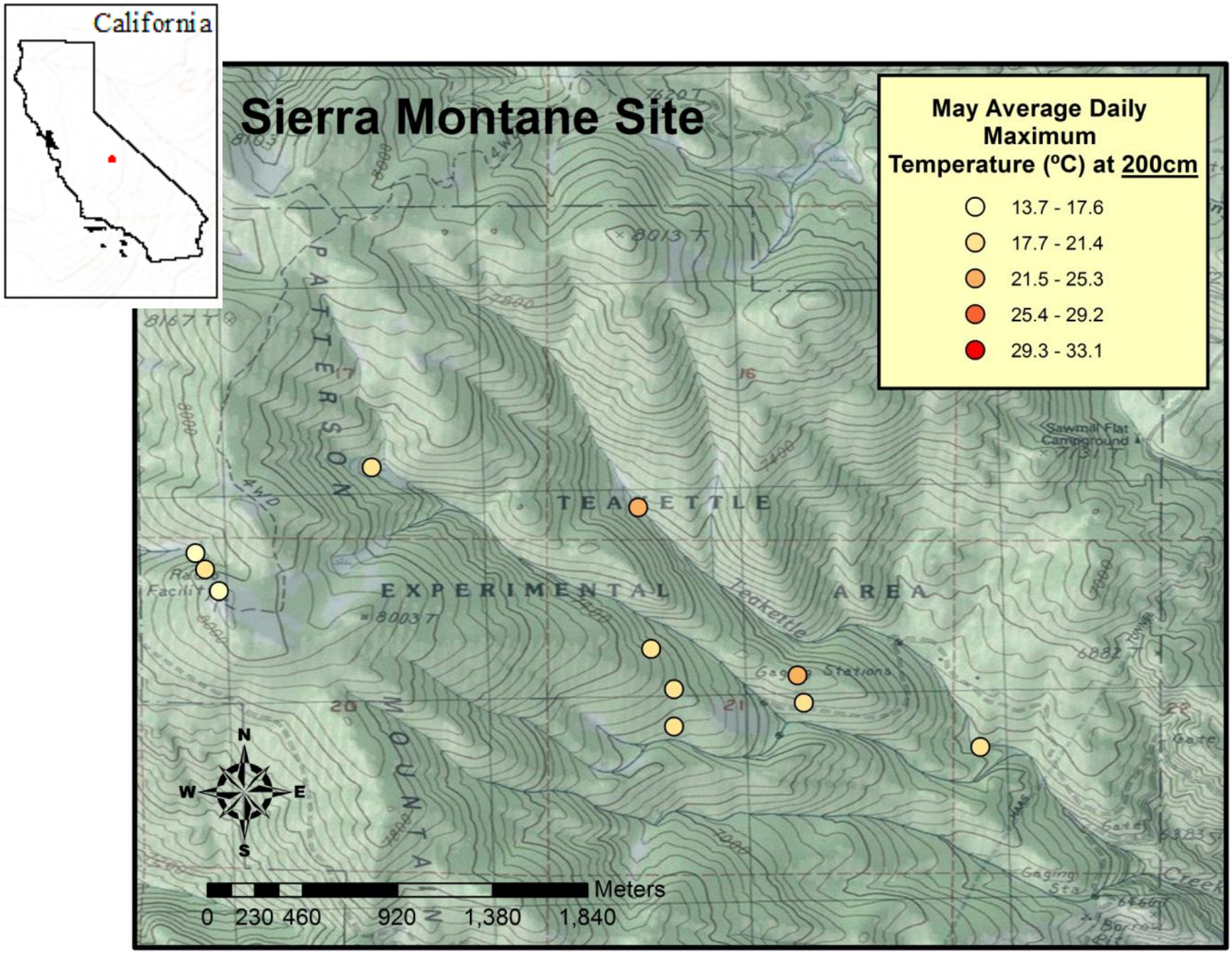


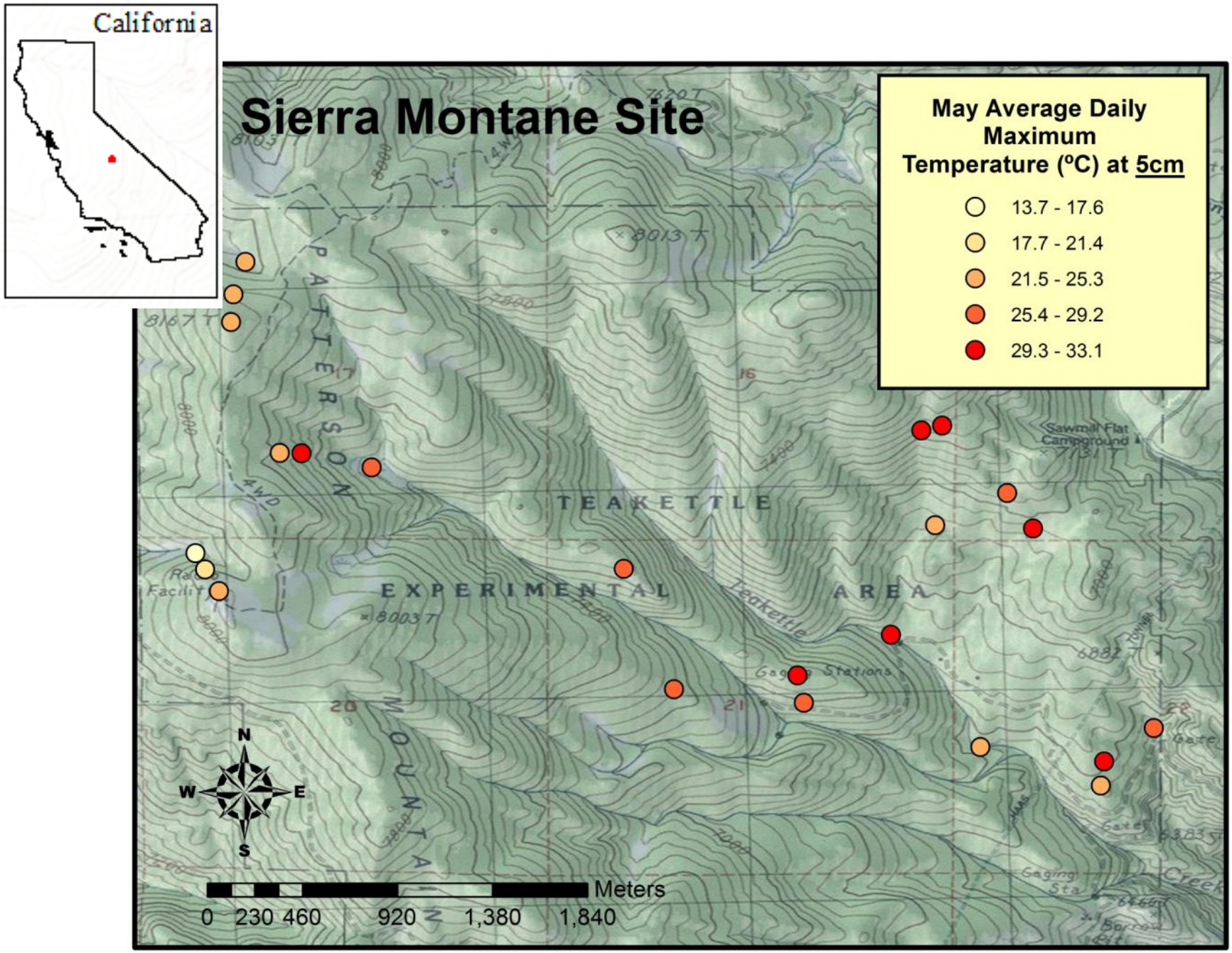
Blue oak (r^2=0.282)



Sampling Landscape Microclimates


California
Sierra Montane Site
May Average Daily Maximum Temperature (ºC) at 400cm
13.7 - 17.6
17.7 - 21.4
21.5 - 25.3
25.4 - 29.2
29.3 - 33.1
PATTERSON MOUNTAIN
TEAKETTLE EXPERIMENTAL AREA
Sawmill Flat Campground
Teakettle
Gaging Stations
Gaging Sta
Gate
Creek
Meters
0 230 460 920 1,380 1,840
N
S
E
W


California
Sierra Montane Site
May Average Daily Maximum Temperature (ºC) at 200cm
13.7 - 17.6
17.7 - 21.4
21.5 - 25.3
25.4 - 29.2
29.3 - 33.1
PATTERSON MOUNTAIN
TEAKETTLE EXPERIMENTAL AREA
Sawmill Flat Campground
Teakettle
Gaging Stations
N
S
E
W
Meters
0 230 460 920 1,380 1,840


California
Sierra Montane Site
May Average Daily Maximum Temperature (ºC) at 5cm
13.7 - 17.6
17.7 - 21.4
21.5 - 25.3
25.4 - 29.2
29.3 - 33.1
PATTERSON
TEAKETTLE
EXPERIMENTAL
AREA
MOUNTA
Sawmill Flat Campground
Teakettle
Gaging Stations
N
W
E
S
Meters
0 230 460 920 1,380 1,840

Importance of Microclimates

- Microclimate at ground level, especially temperature, varies across the landscape
- Early emergence of tree seedlings is also variable across the landscape
- Favorable microsites for establishment at/ beyond range edges
- Microclimate variables→ model species responses

Implications for Studying Climate Change

- Tree species range shifts with climate change (e.g. Lenoir 2009)
  - Range shifts, changes in community composition and ecosystem function (Purves et al. 2008)

- Microenvironments may allow species to persist where coarse-scale models show no suitable future climate (Dobrowski 2010)

- Establishment-phase responses of species to microclimate are key to understanding future range dynamics with climate change

Future Work: Scaling it Up

- Emergence, survival and growth data (ongoing)

  → Model current species distributions and population dynamics

- Measured microclimate data (ongoing)

  →Compare with downscaled climate data

- How will climate change scenarios affect species occupancy of microenvironments?

Acknowledgments

- Janet Franklin, Malcolm North, Peter Slaughter, Patrick Roehrdanz, Oliver Soong, Claudia Tyler, Kate McCurdy

- Tejon Ranch and Tejon Ranch Conservancy

- USFS Teakettle and San Joaquin staff

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  - Jason McLure, Phoebe Prather, Eric Hopkins, John Dingman, Andy McDonald, Aubrey Duggar, Whitney Wilkerson, Lauren di Scipio, Stephanie Dashiell, Ethan Peck, Erin Conlisk, Katy Maher, Rebecca Swab

NSF Macrosystems Biology: *Do microenvironments govern macroecology?*

Frank W. Davis[1], John Dingman[3], Alan Flint[3], Lorrie Flint[3], Janet Franklin[4], Alex Hall[5], Lee Hannah[6], Sean McKnight[2], Max Moritz[7], Malcolm North[8], Kelly Redmond[9], Helen Regan[10], Peter Slaughter[2], Anderson Shepard[2], Lynn Sweet[2] and Alexandra Syphard[11]

[1]University of California, Santa Barbara; [2]Earth Research Institute, University of California, Santa Barbara; [3]US Geological Survey, California Water Science Center; [4]School of Geographic Sciences, Arizona State University; [5]Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles; [6]Conservation International; [7]Department of Environmental Science Policy and Management, University of California, Berkeley; [8]USDA Forest Service, Pacific Southwest Research Station; [9]Western Regional Climate Center, Desert Research Institute, University of Nevada, Reno; [10]University of California, Riverside; [11]Conservation Biology Institute