Historical and future impacts of climate change to the vegetation of California

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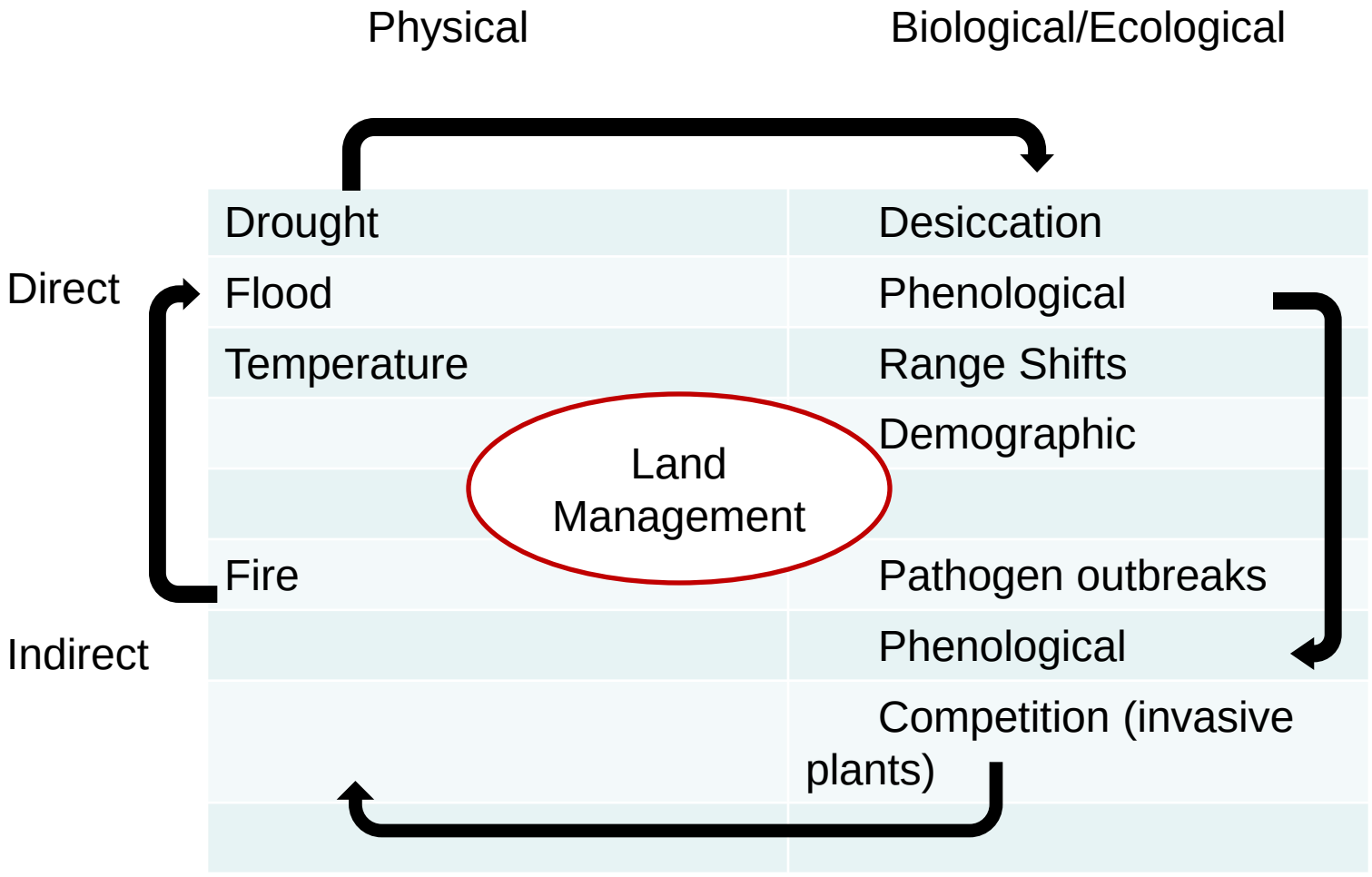
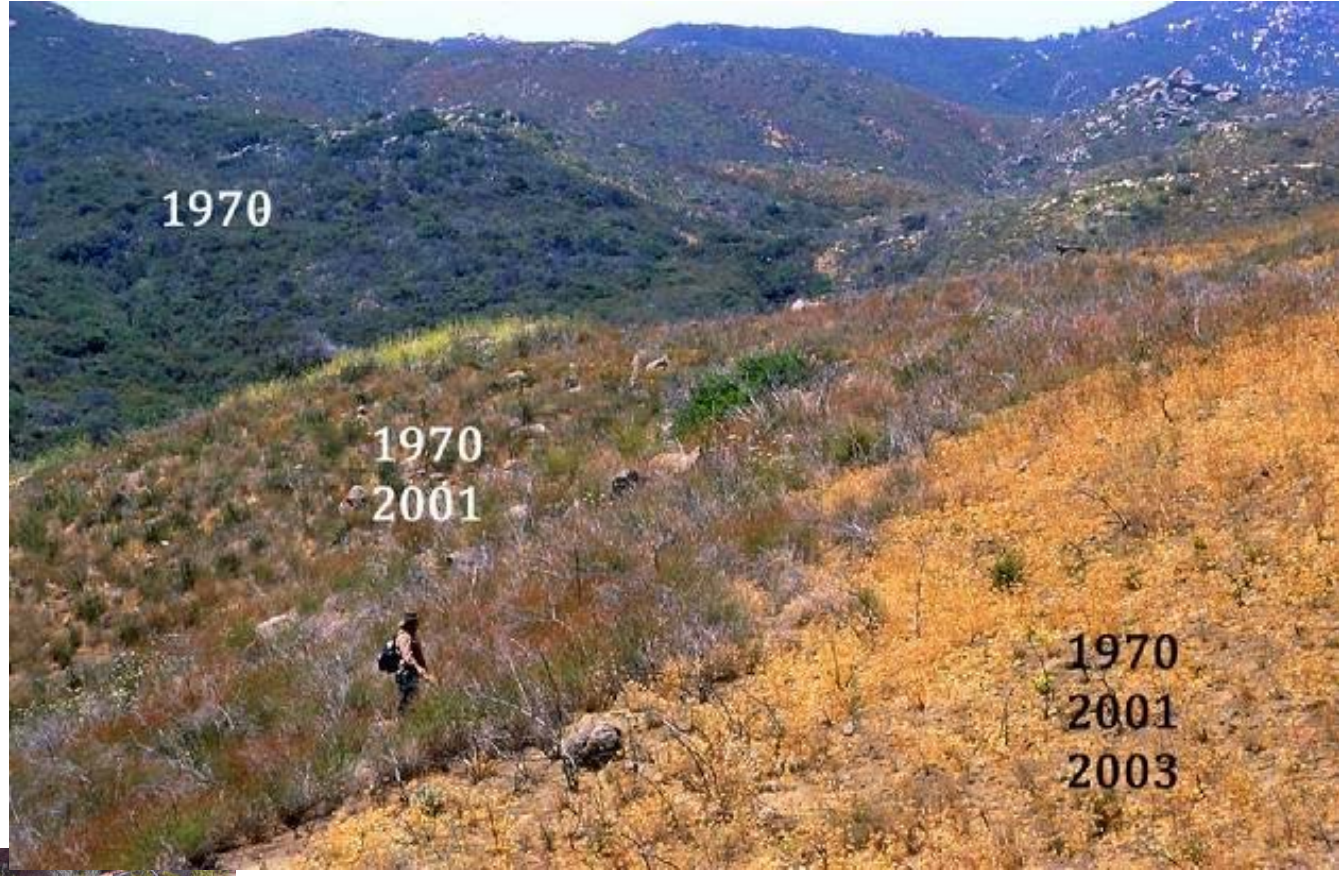
Photo credit: Annie Esperanza

Interactions of Climate with Plants/Vegetation

	Physical	Biological/Ecological
Direct	Drought	Desiccation
	Flood	Phenological
	Heat	Range Shifts
		Demographic
Indirect	Fire	Pathogen outbreaks
		Phenological
		Competition (invasive plants)

Interactions of Climate with Plants/Vegetation

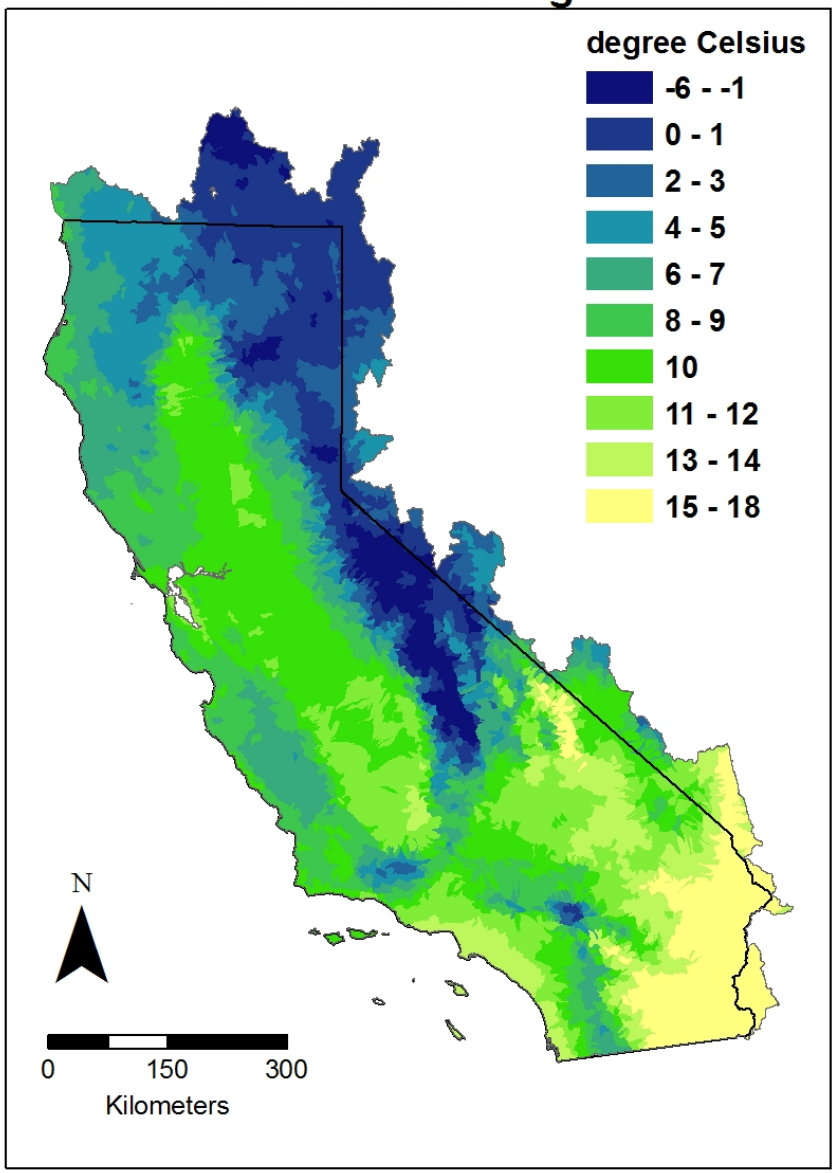


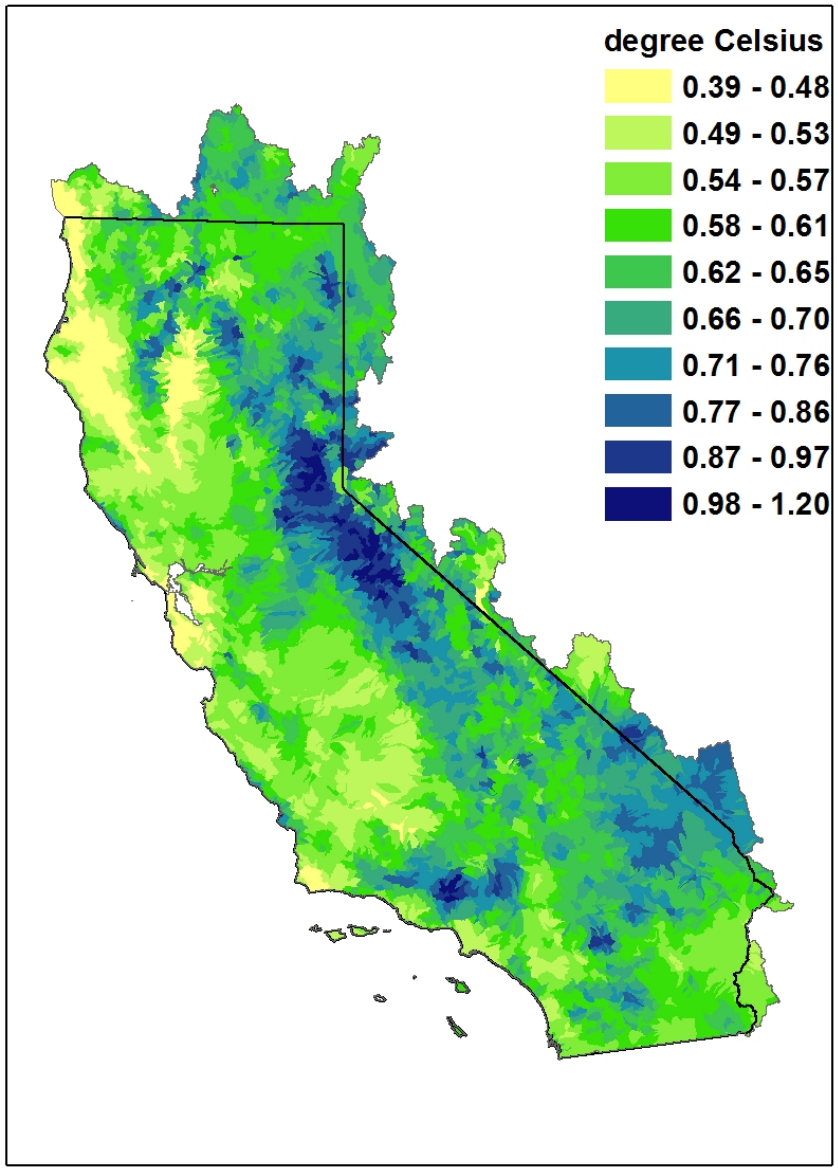


http://californiachaparral.blogspot.com/

Photo by Stan Shebs, used under a Creative Commons License.

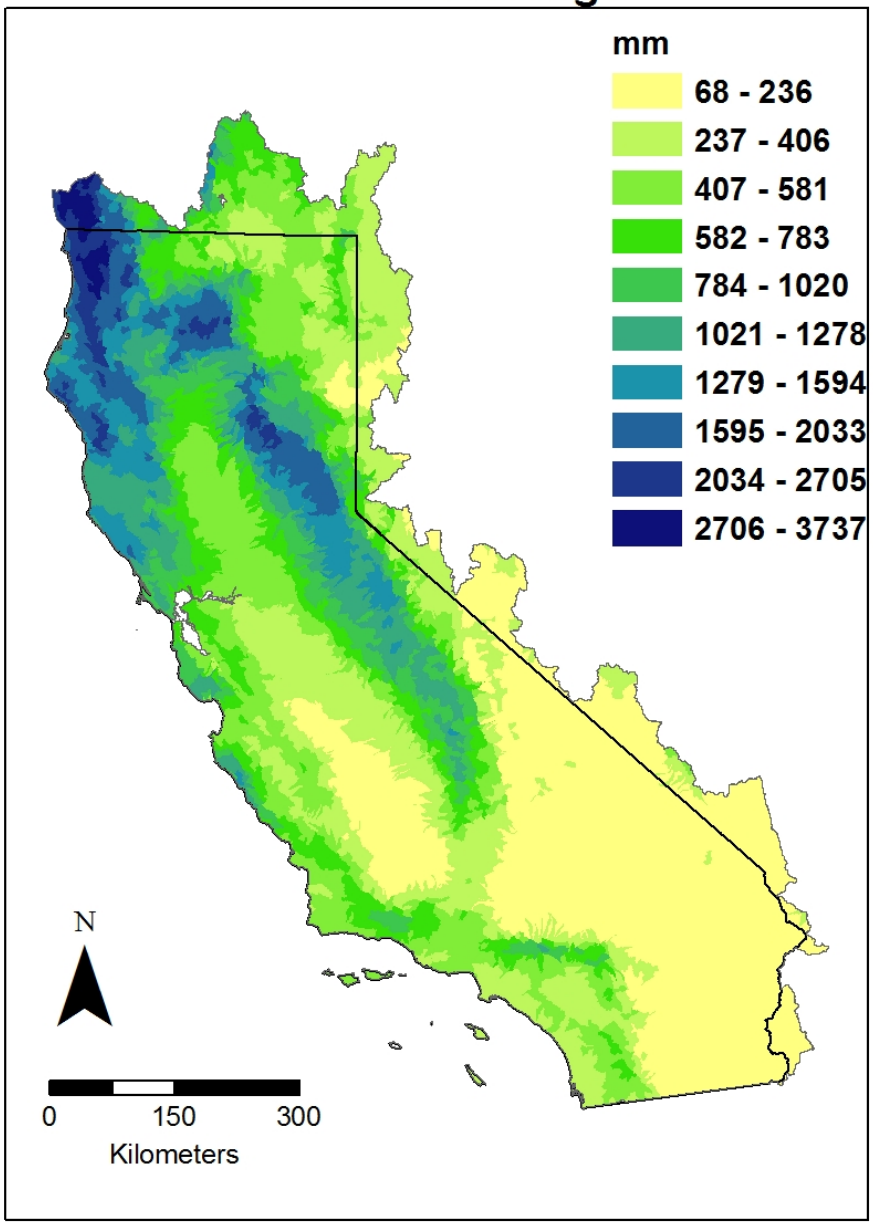
Minimum Temperature

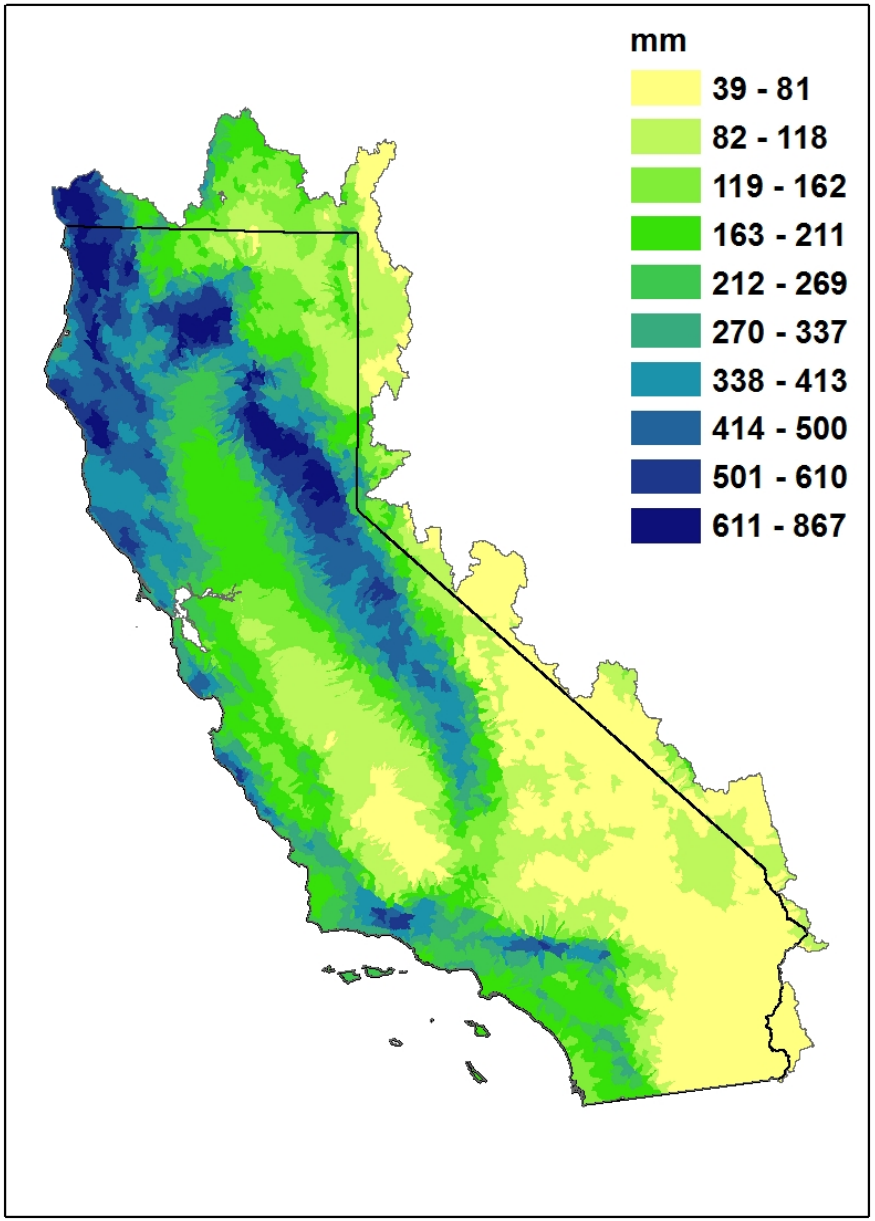




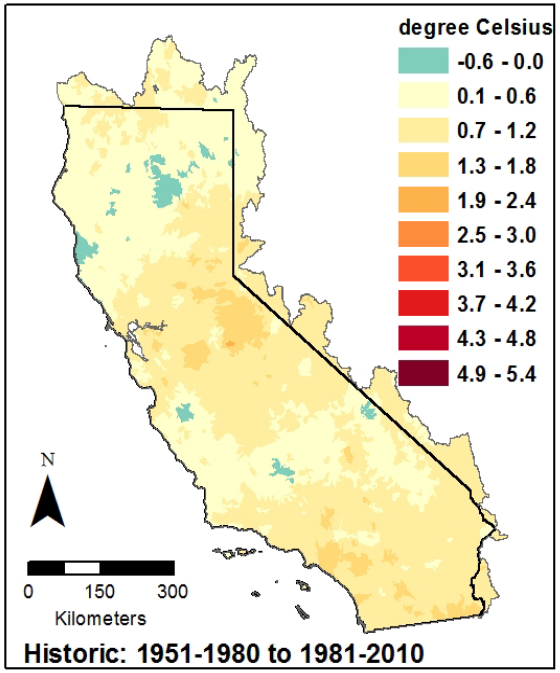
Thorne et al. 2015; Flint et al. 2012, 2013

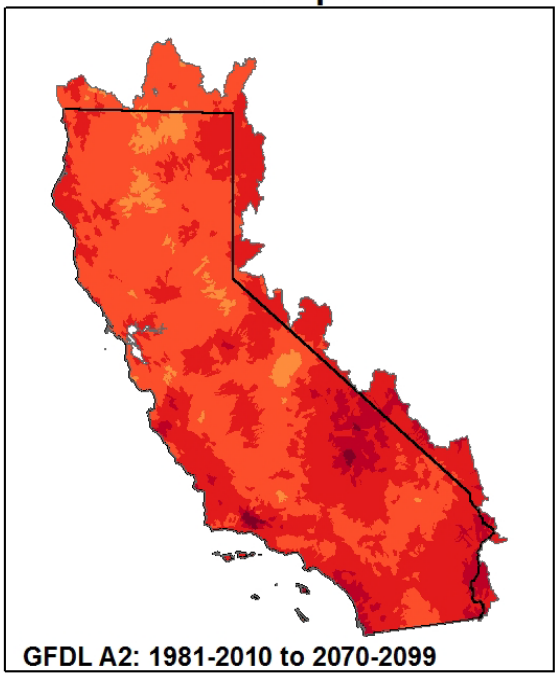
Precipitation

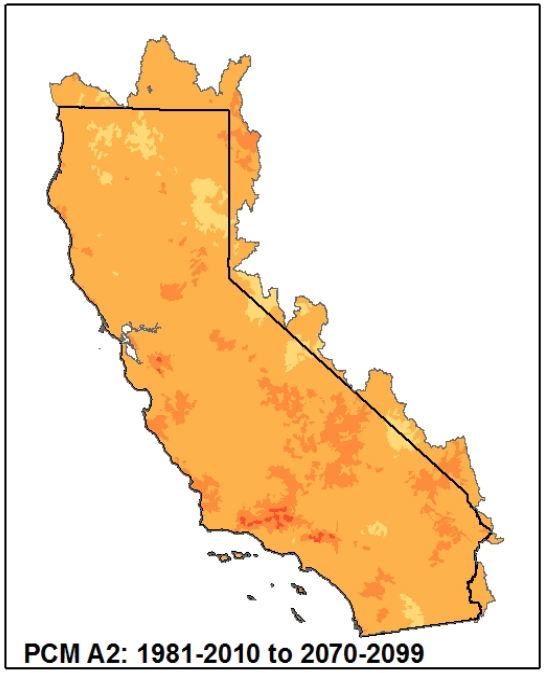




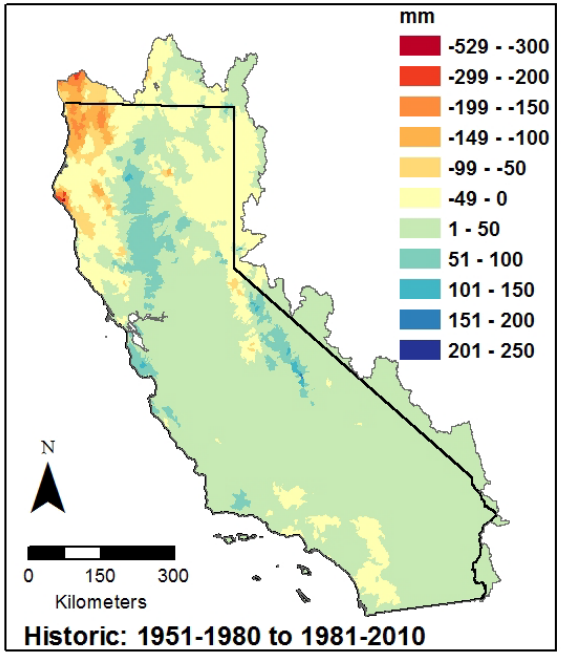
Minimum Temperature

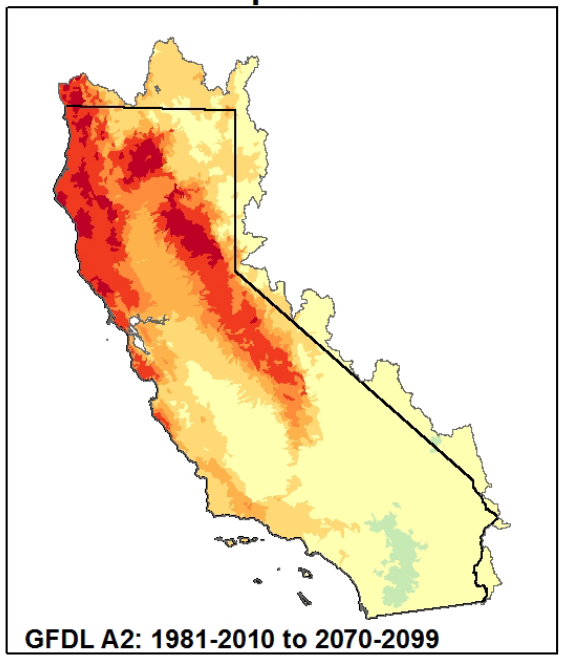


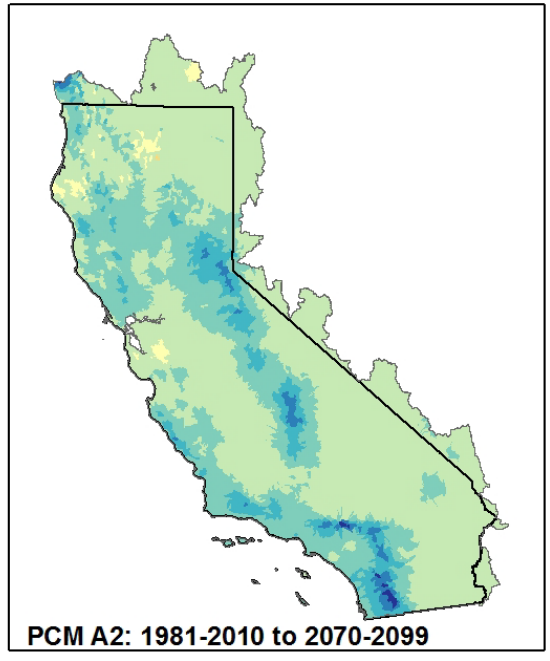




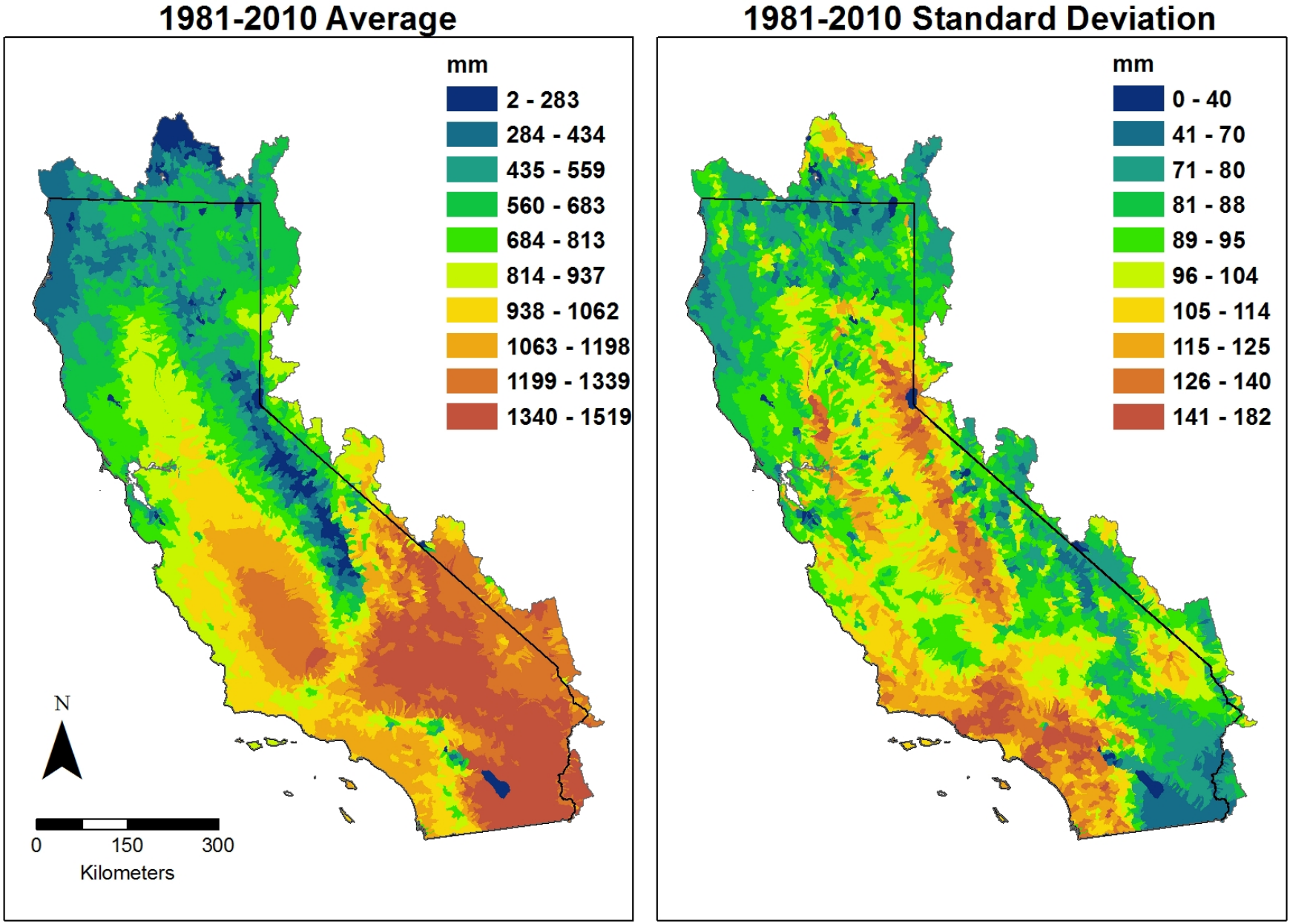
Precipitation



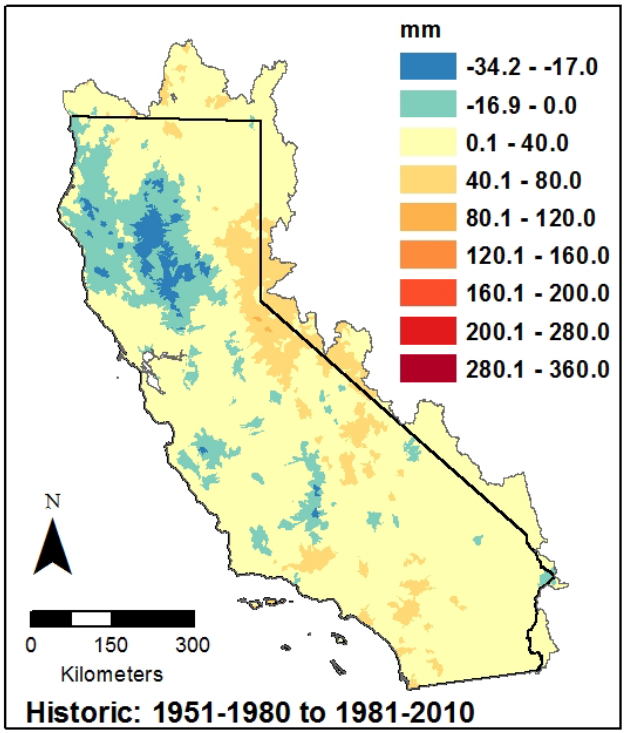




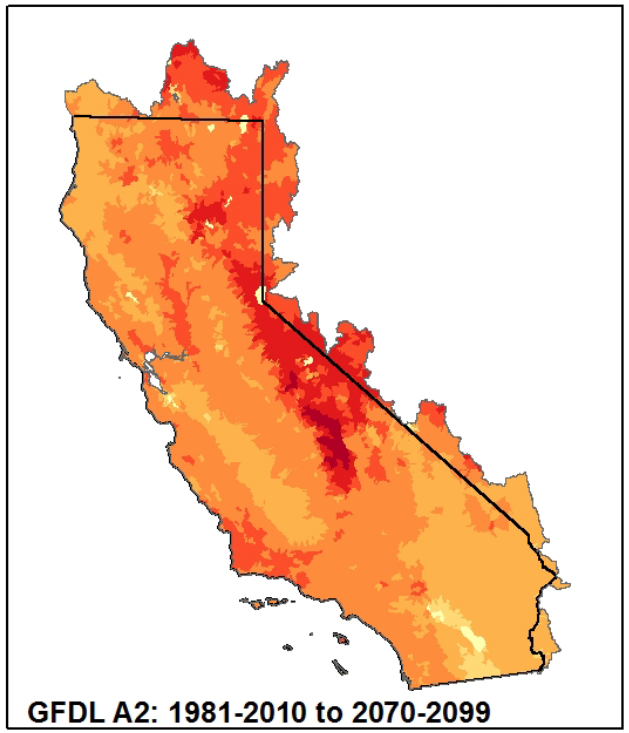
Climatic Water Deficit

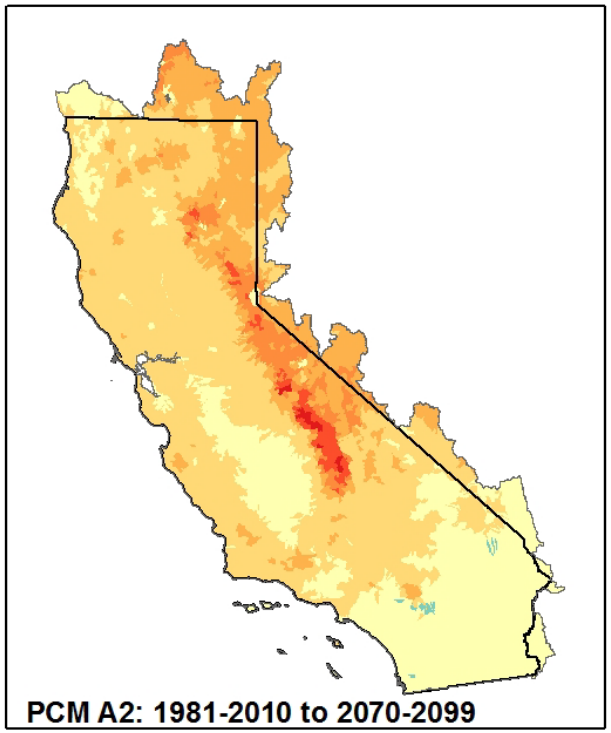


Climatic Water Deficit

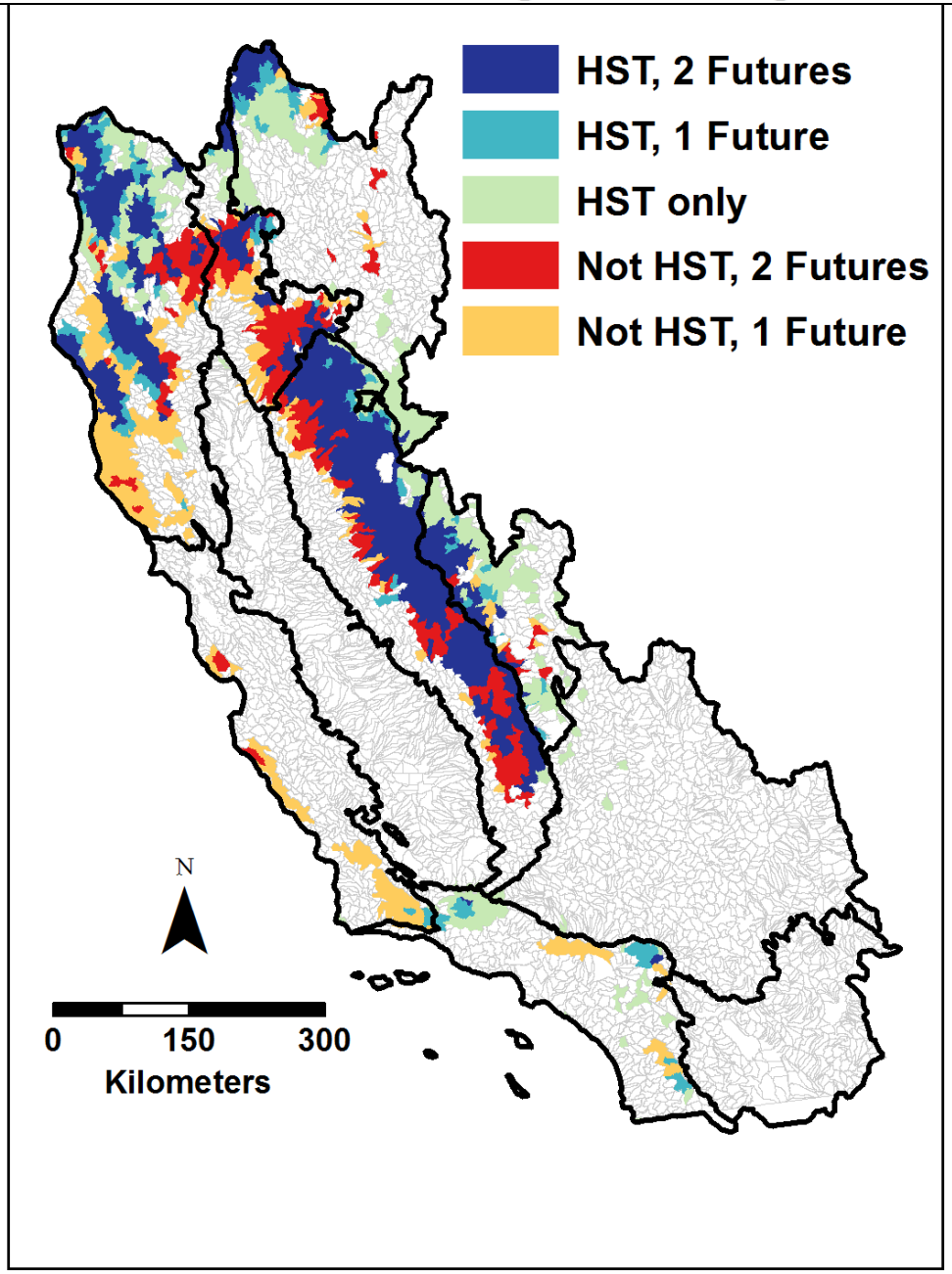


Historic: 1951-1980 to 1981-2010


GFDL A2: 1981-2010 to 2070-2099


PCM A2: 1981-2010 to 2070-2099

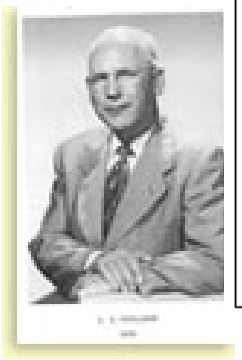
Watersheds with the Highest Change Index

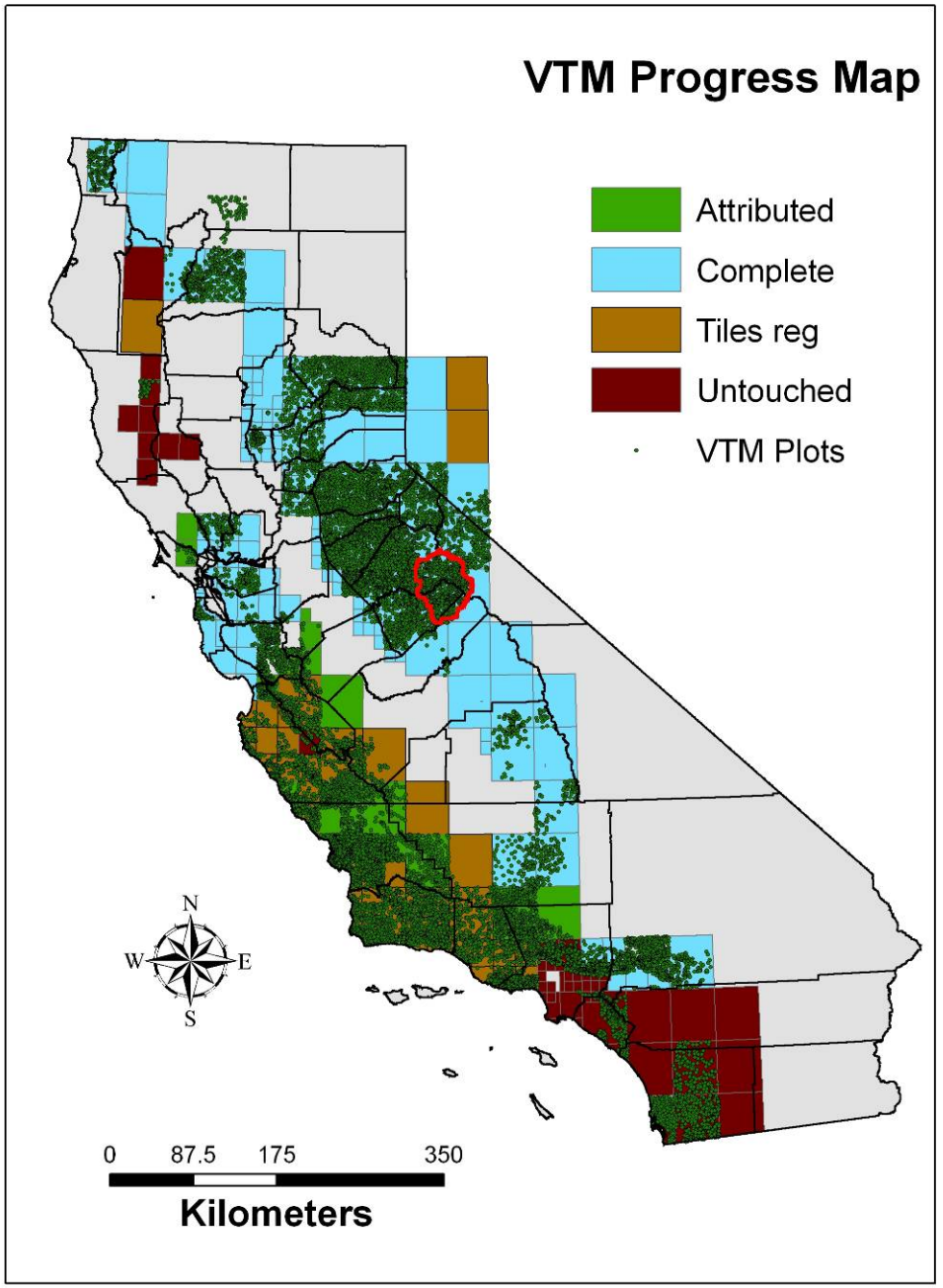


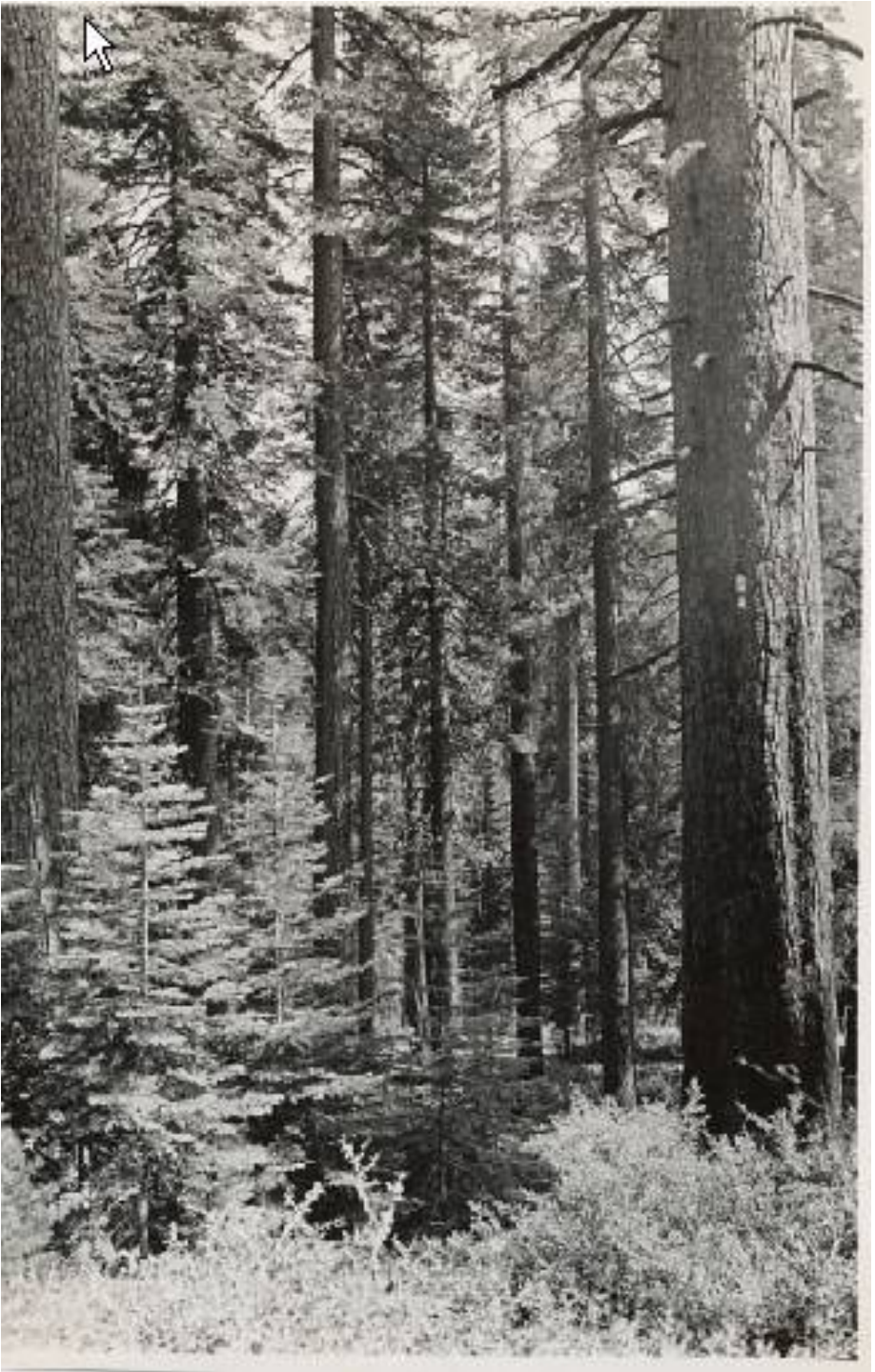
The PAST

The Wieslander VTM Project

- Conducted in the 1930s
- Basis for much of current understanding of California Vegetation
- Mapped 1/3 of the state
- 16,000 vegetation plots
- Over 3000 photographs





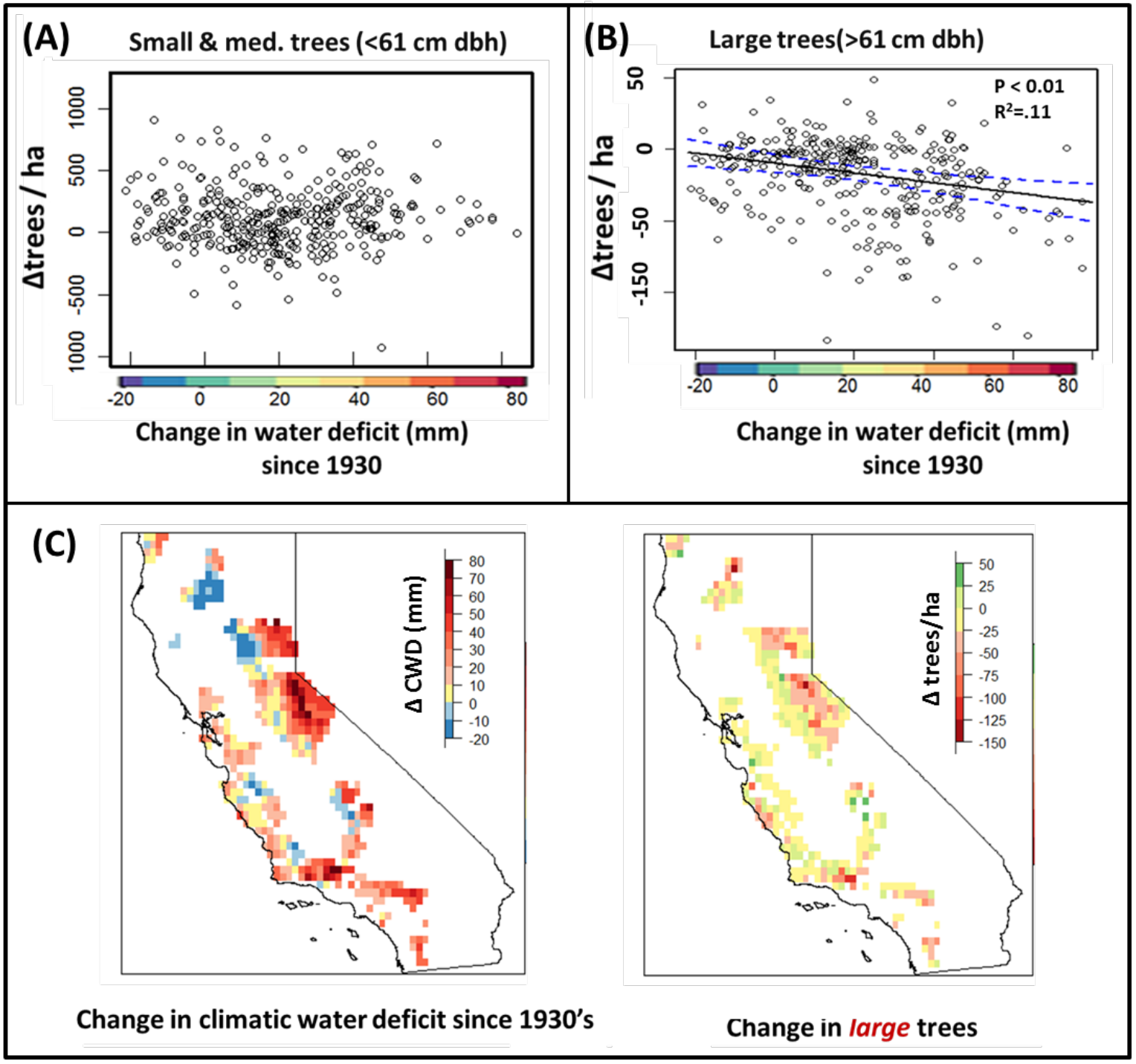


VTM-FIA data have been used for:

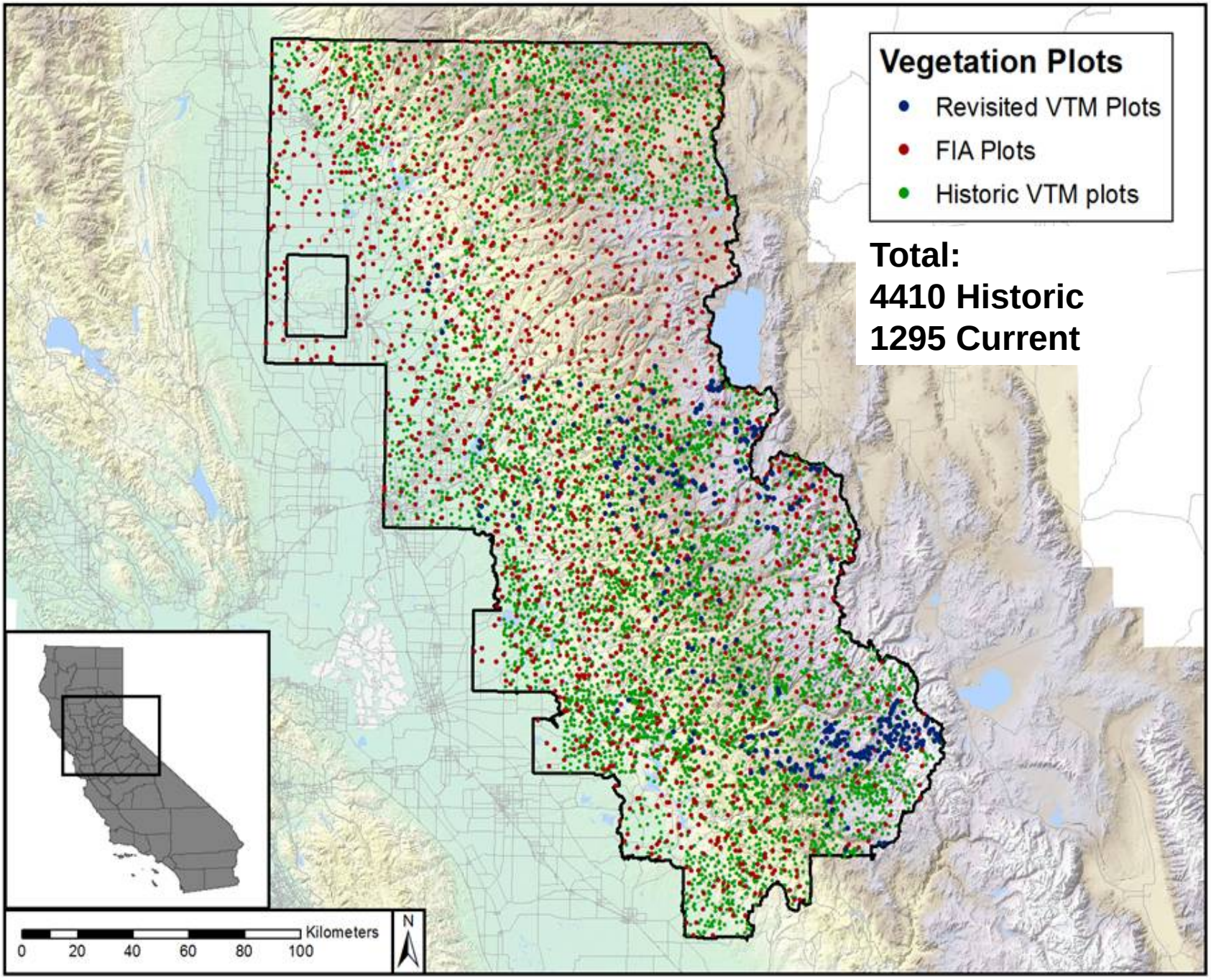
Assessing changes in composition and structure

Exploring environmental drivers of change

Exploring integration of plots and maps

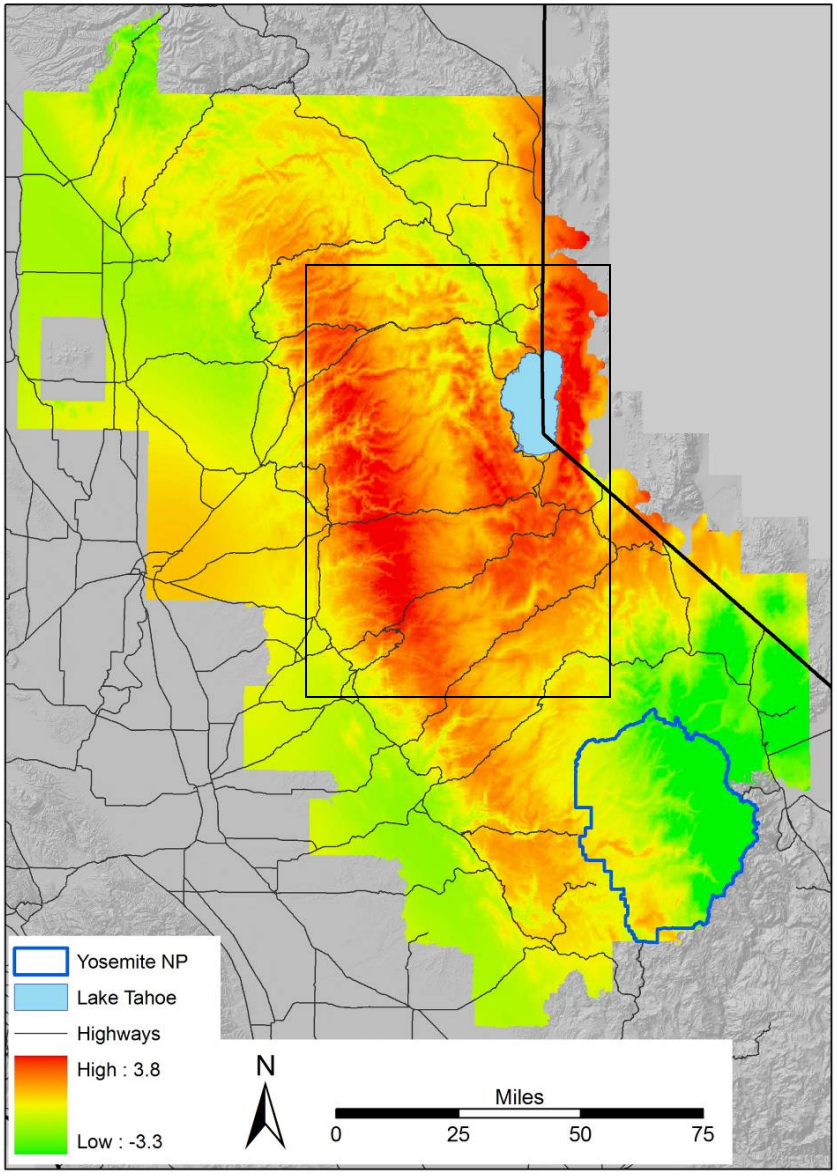


McIntyre et al. 2015 PNAS


Vegetation Plots
Revisited VTM Plots
FIA Plots
Historic VTM plots
Total:
4410 Historic
1295 Current
Kilometers
0
20
40
60
80
100
N

Winter Minimum Temperature Difference - Dec, Jan, F

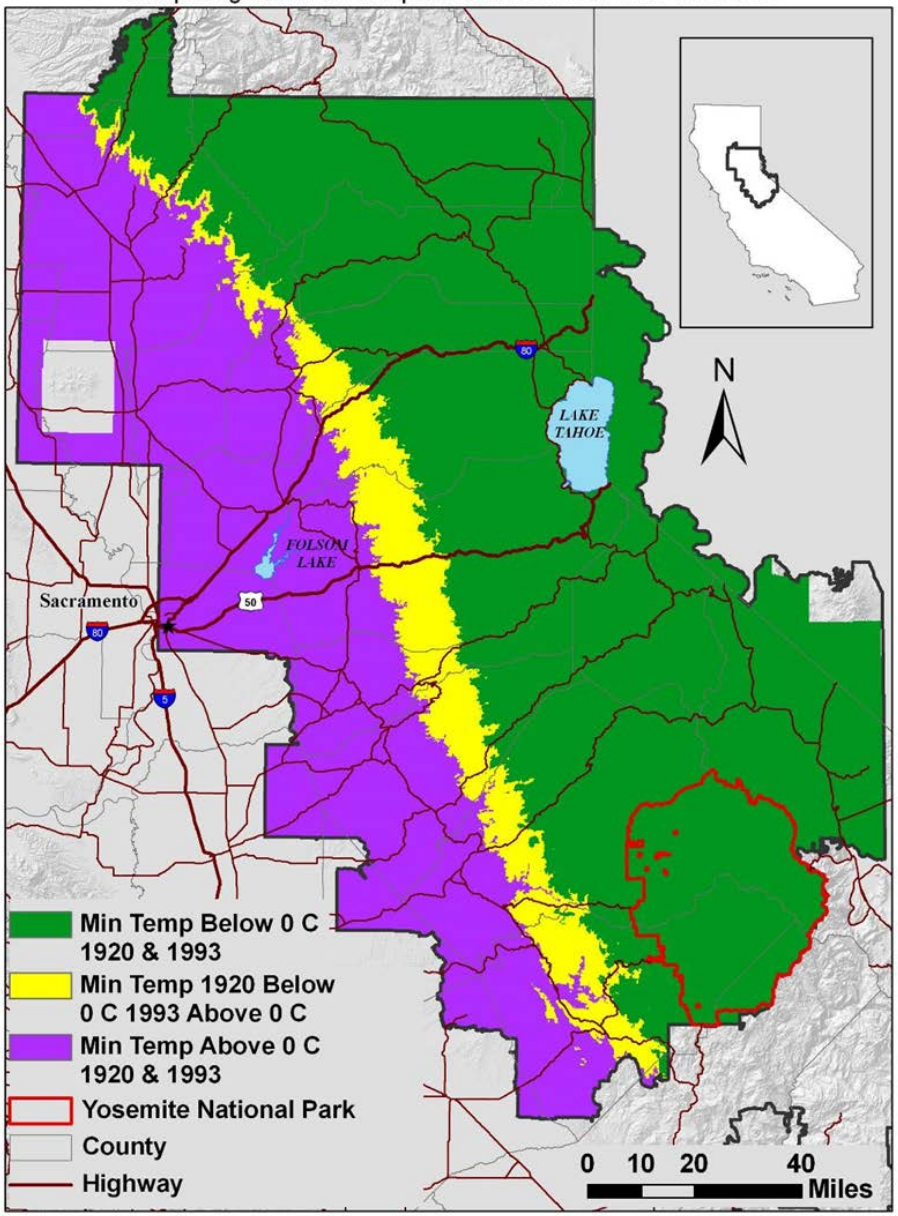
Difference = Tmin 1993 - Tmin 1920*



*1920 data is the average between 1900-1940; 1993 data is the average between 1980-2006

Winter Freeze Line - Dec, Jan and Feb

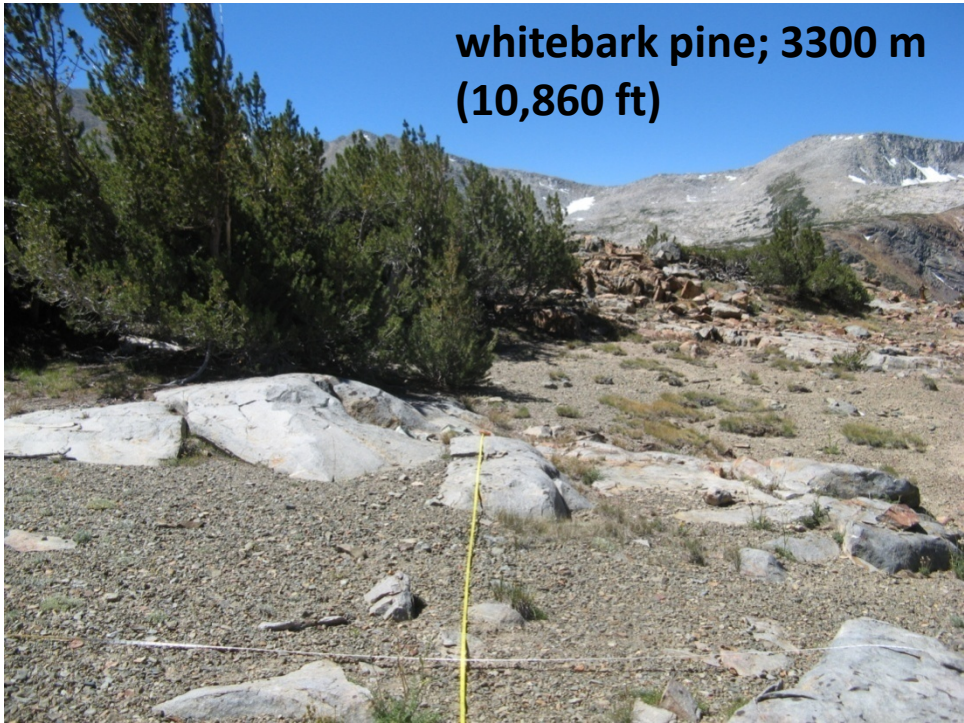
Comparing Minimum Temperatures Between 1920 and 1993

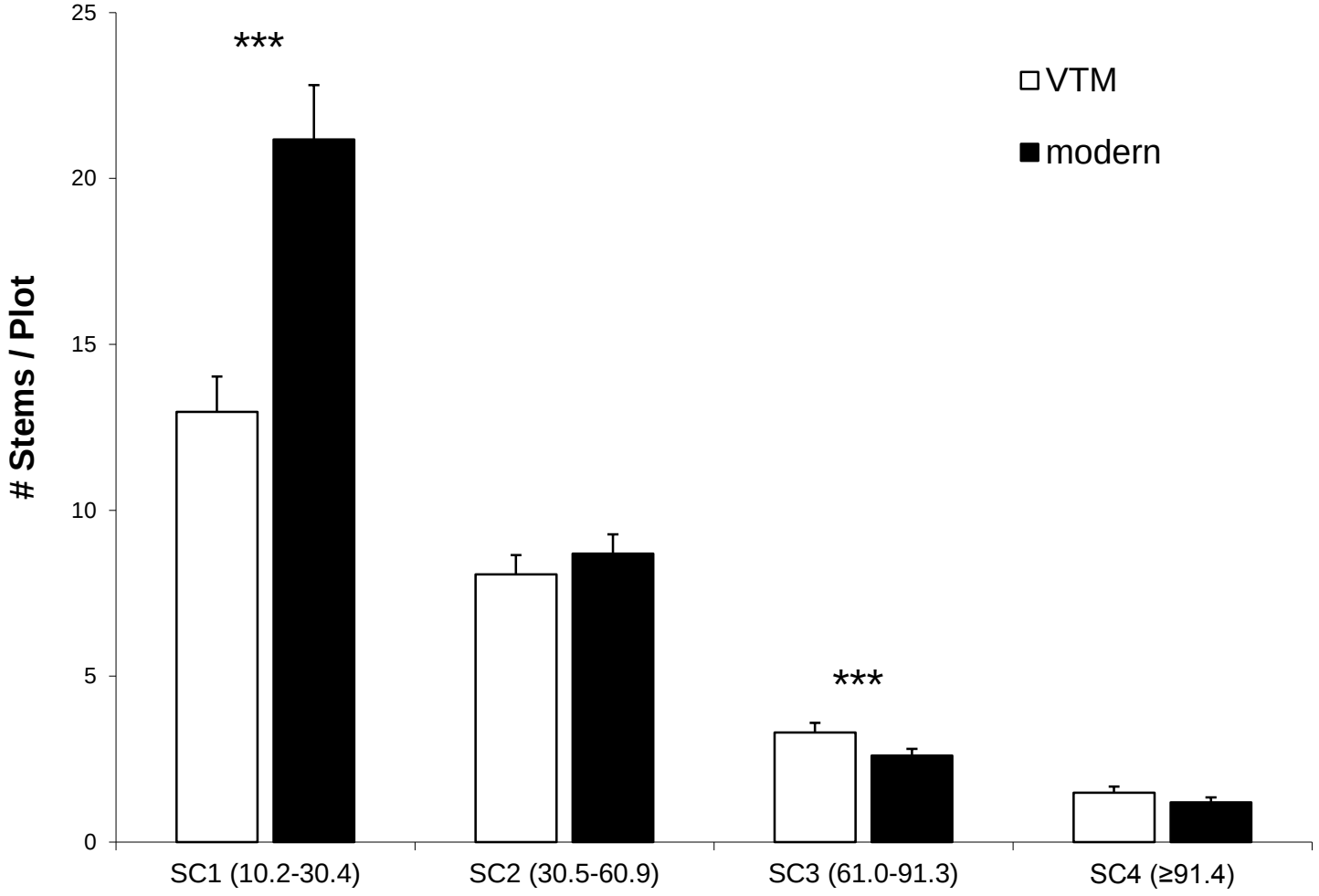



jeffrey pine/ white fir/ juniper; 2520 m (8270 ft)


mtn hemlock/ red fir/ western white pine lodgepole; 2650 m (8780 ft)


lodgepole/whitebark pine; 3000 m (9,820 ft)

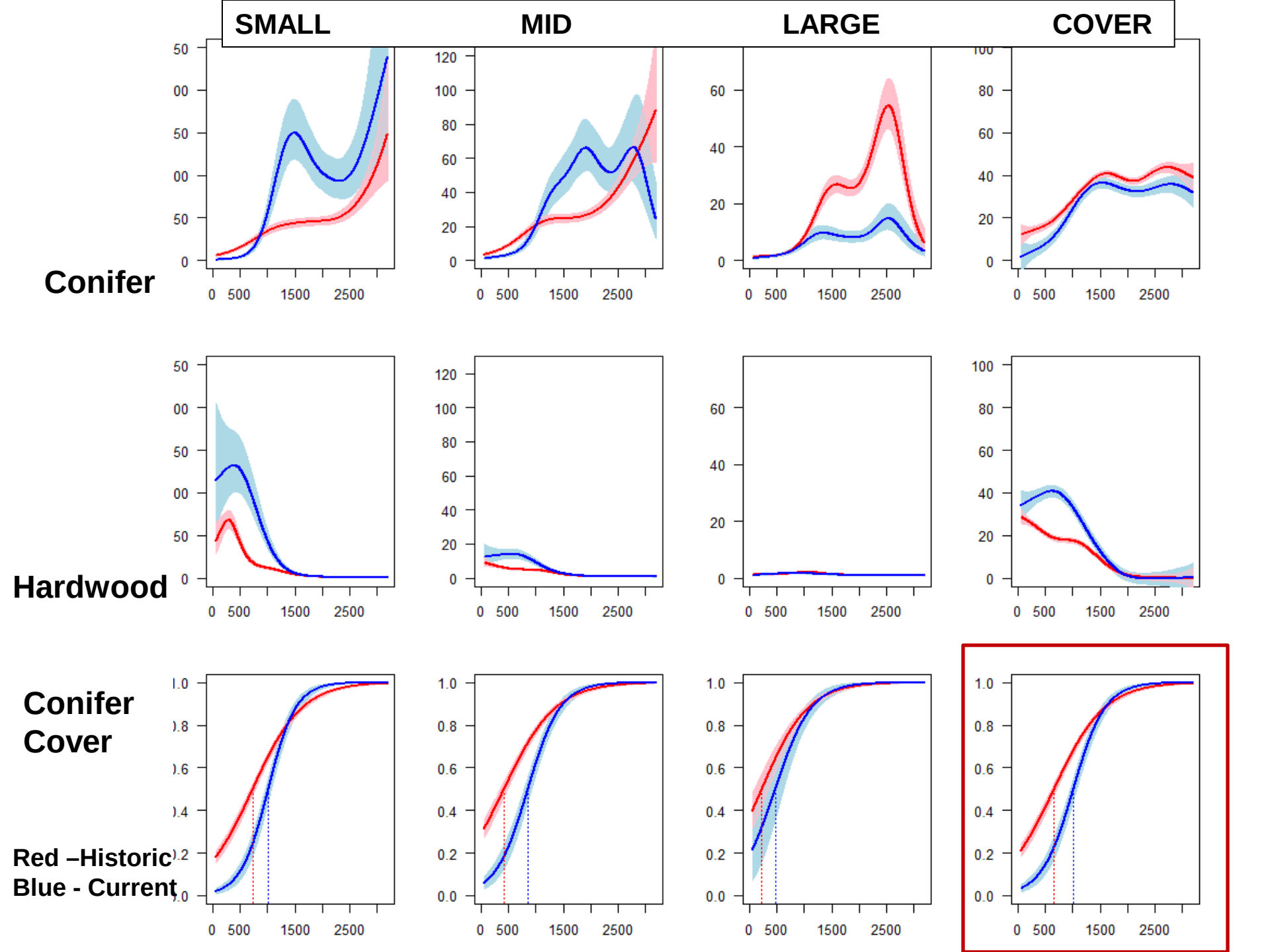

whitebark pine; 3300 m (10,860 ft)

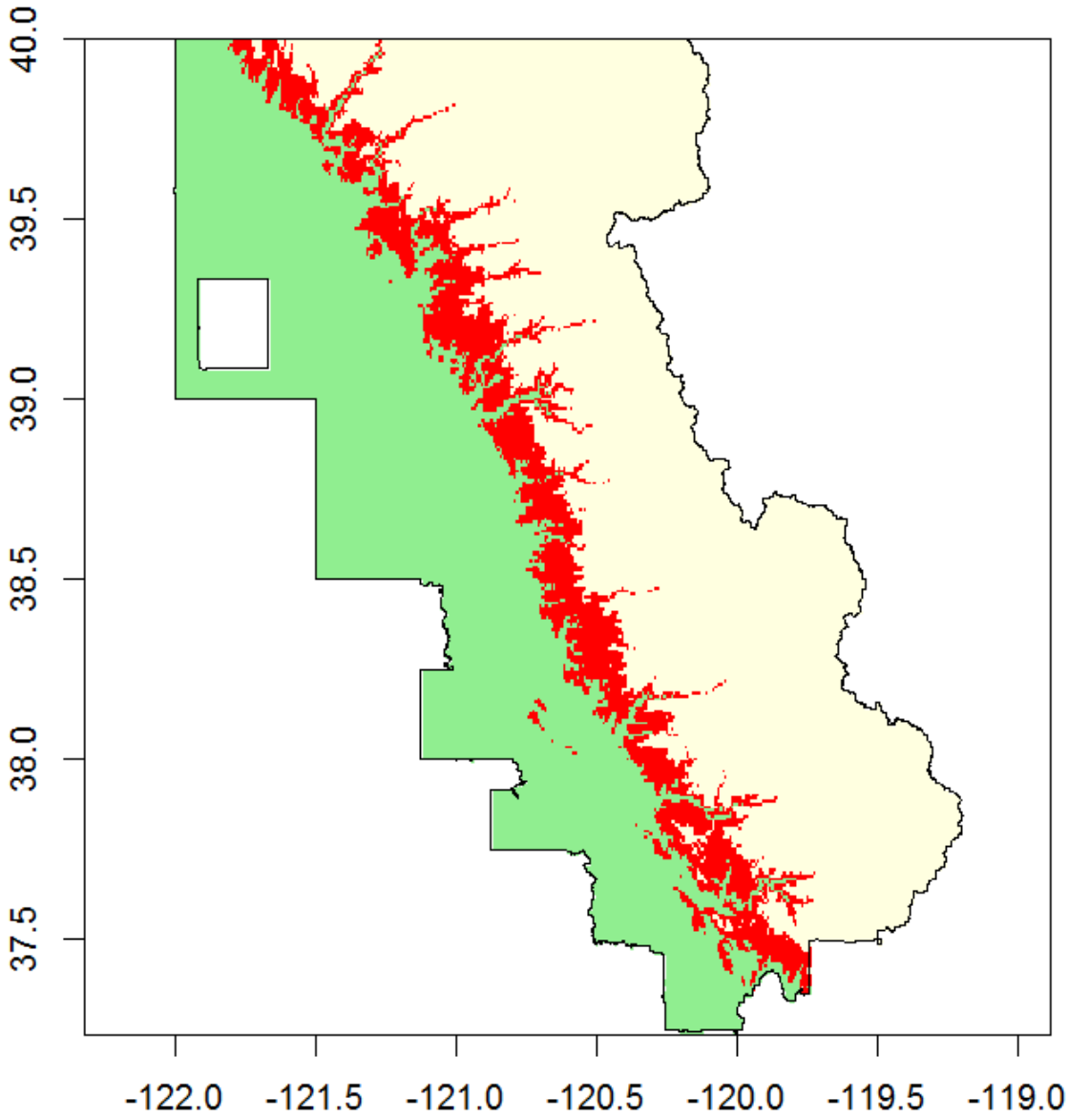


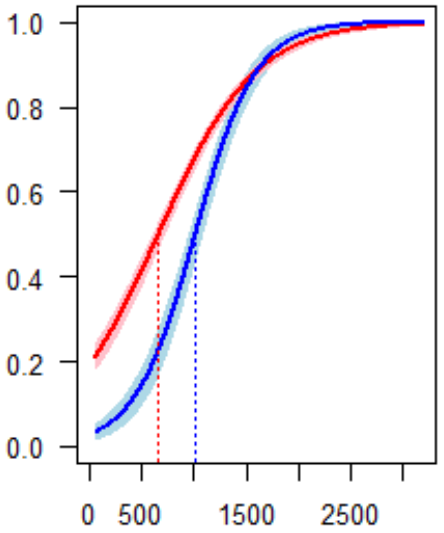
(Dolanc *et al*. 2013 Global Ecology and Biogeography)

Change in stand structure of subalpine forests (1934 to 2007) for all species, all plots (n = 139):

Many more small trees; fewer large trees


SMALL
MID
LARGE
COVER
Conifer
Hardwood
Conifer Cover
Red –Historic
Blue - Current

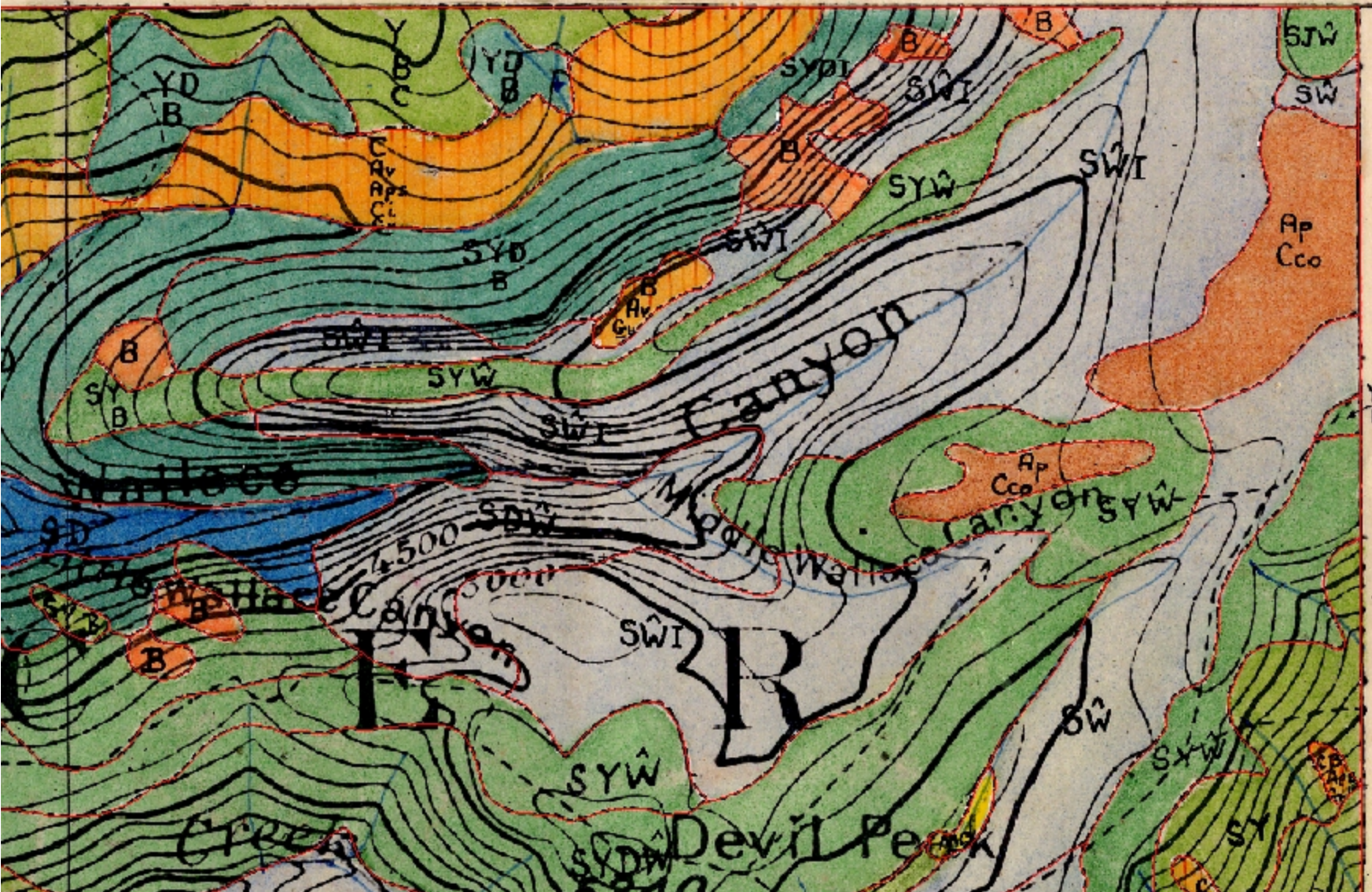


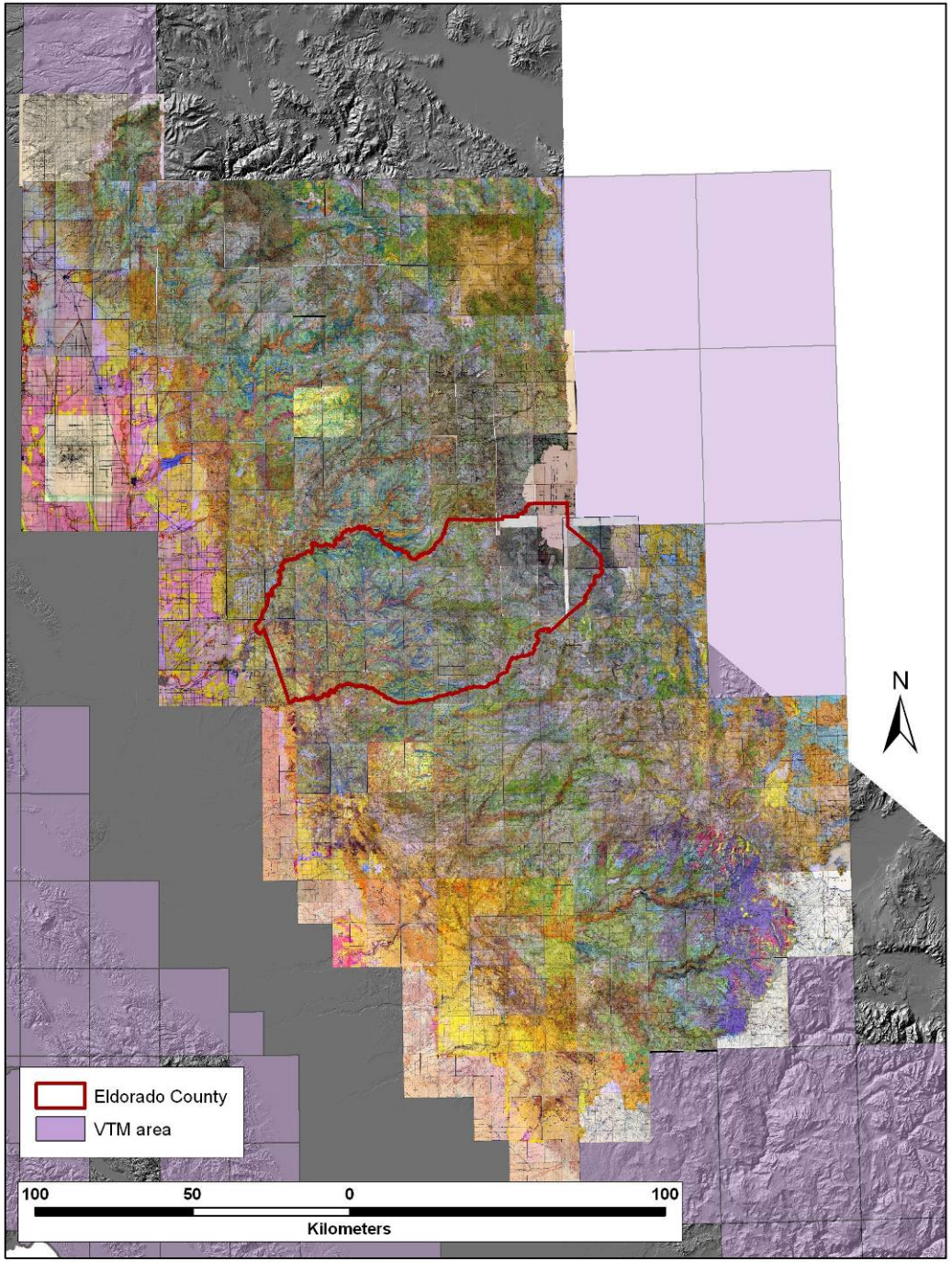


Conifer Canopy

Modeled Change in 50% cover converting to hardwoods

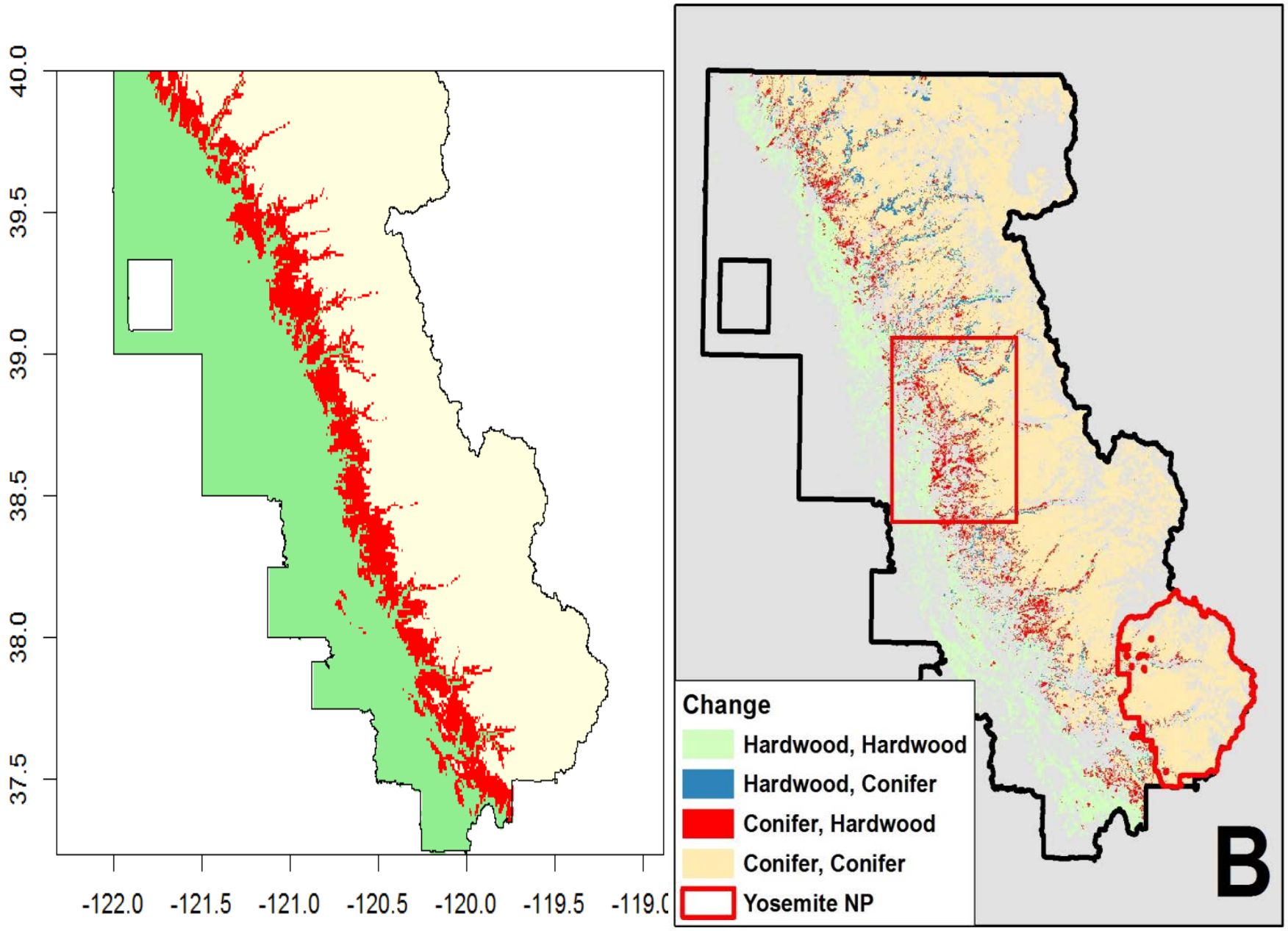
CALIFORNIA
PLACERVILLE SHEET



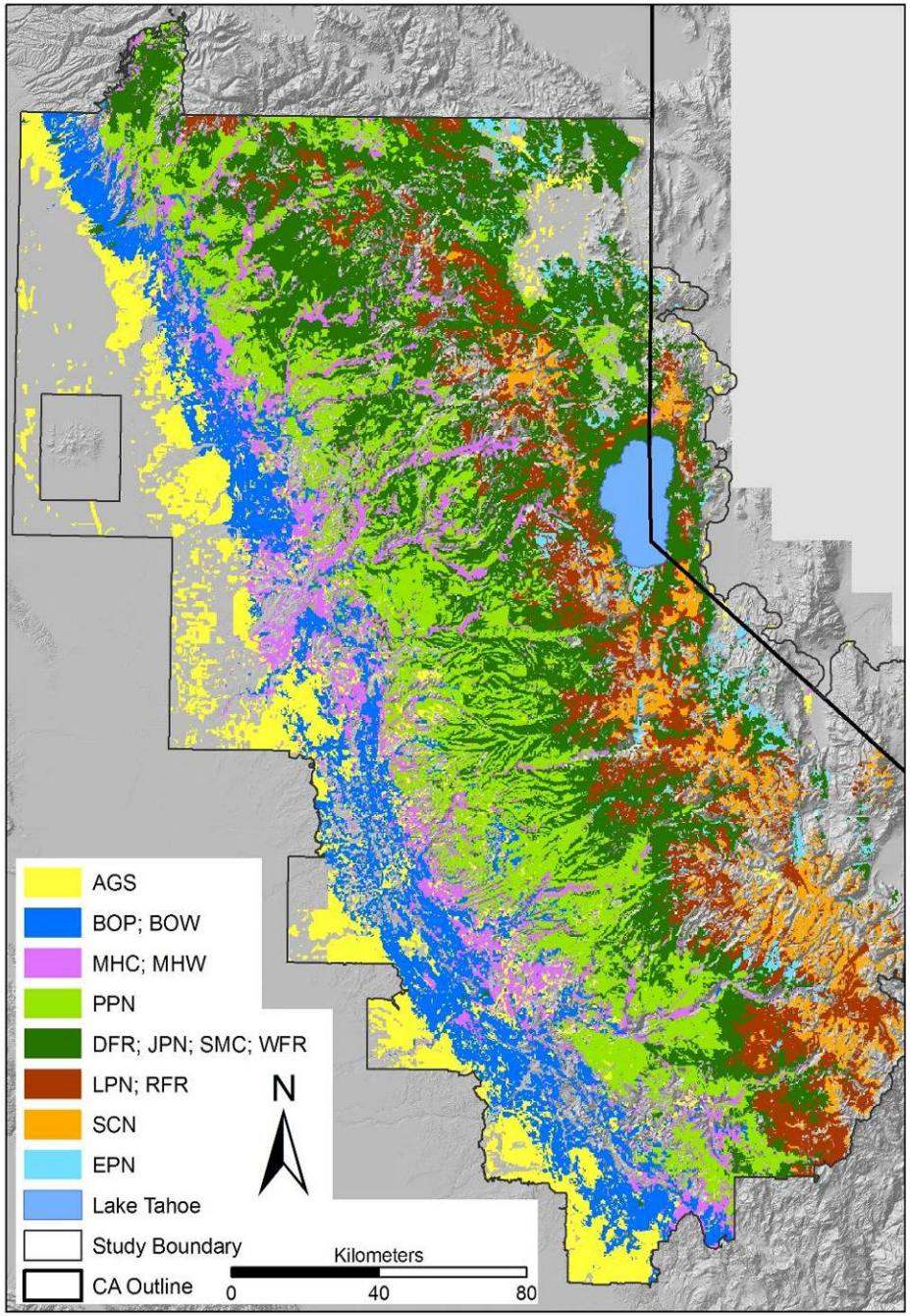


Study Area
Central & Northern Sierra

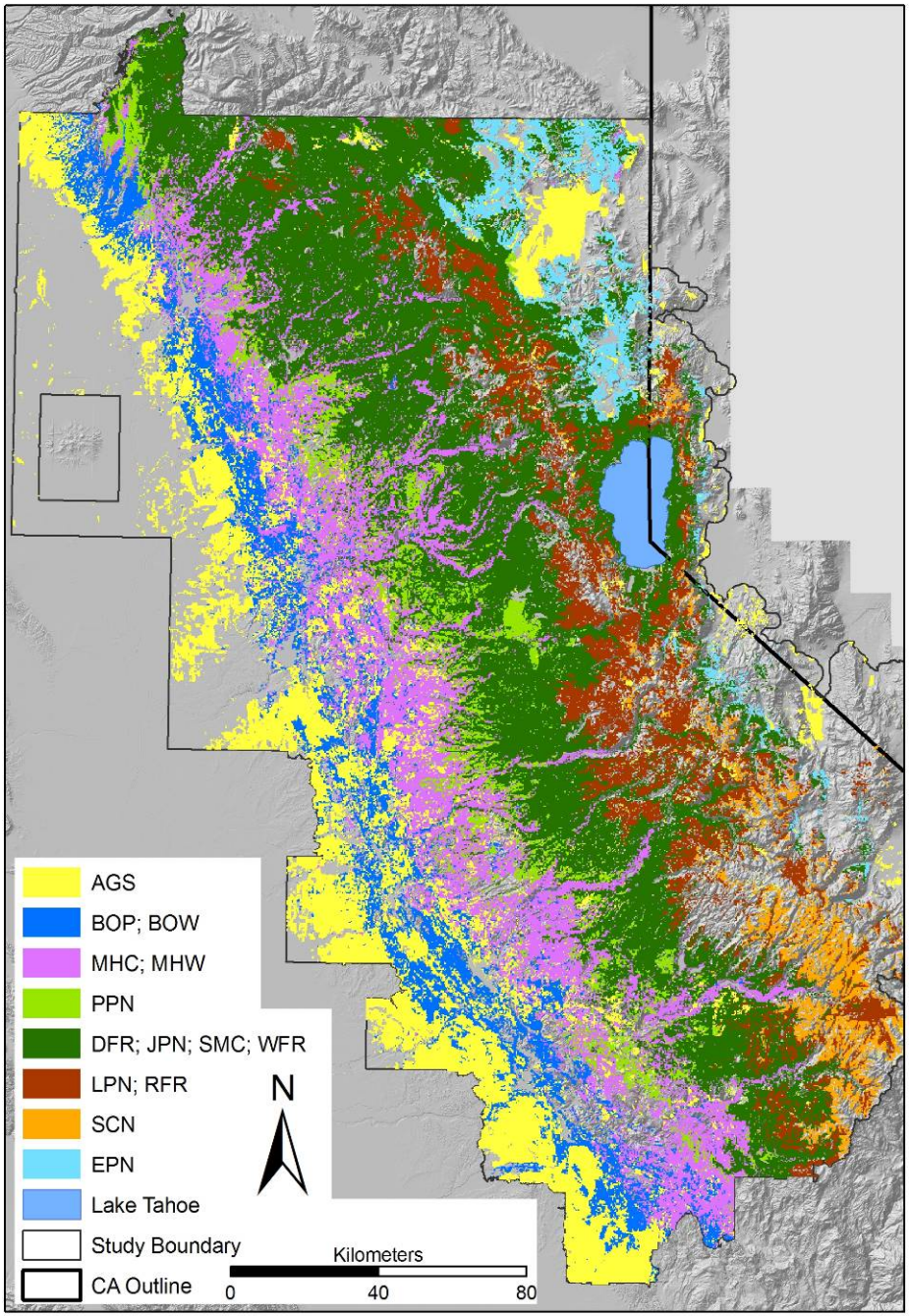
Analytical framework development

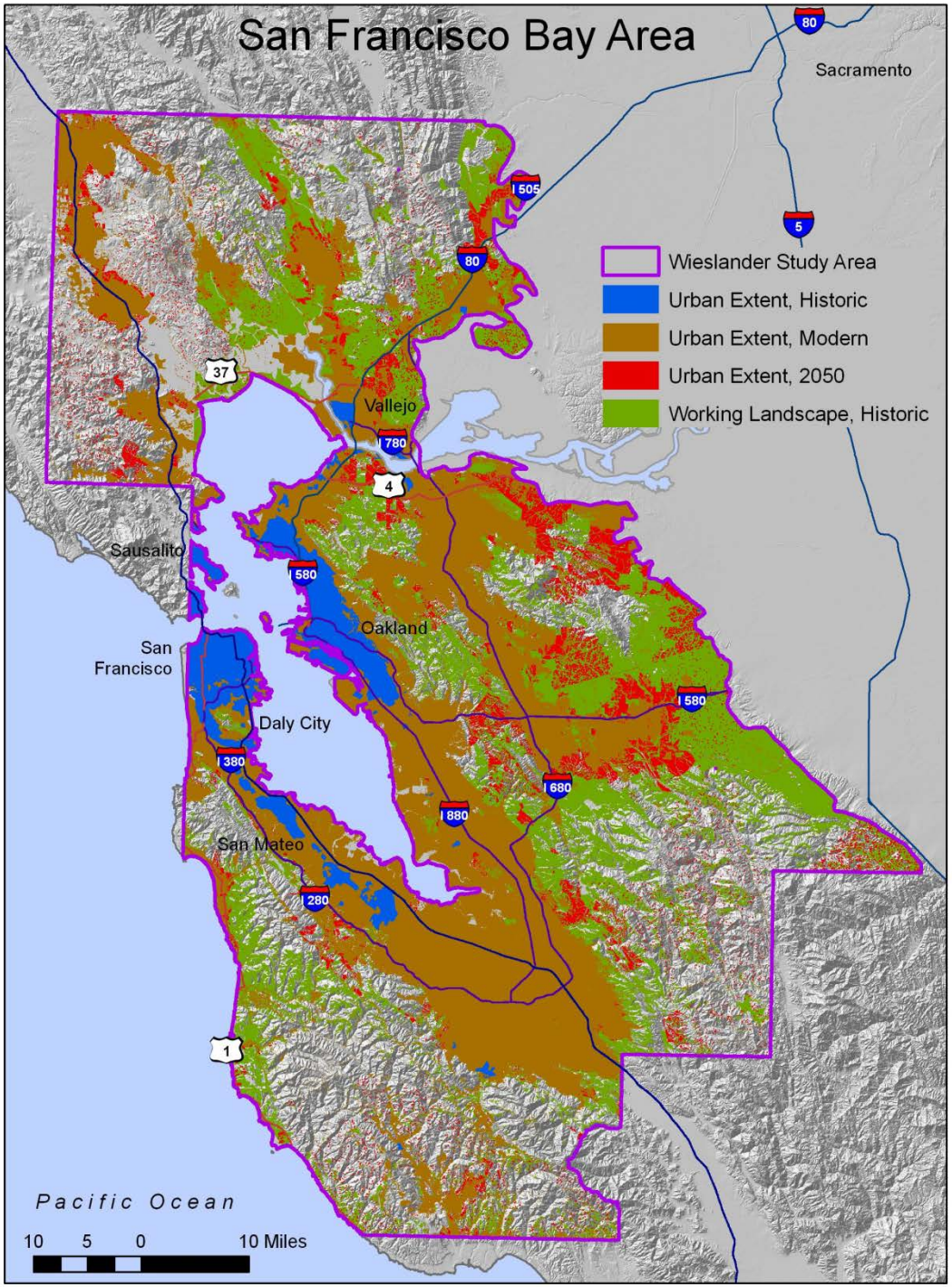

40.0
39.5
39.0
38.5
38.0
37.5
-122.0
-121.5
-121.0
-120.5
-120.0
-119.5
-119.0
Change
Hardwood, Hardwood
Hardwood, Conifer
Conifer, Hardwood
Conifer, Conifer
Yosemite NP
B

Historic WHR Types



Current WHR Types





Historic Extents

Urban 392 km^2
Working Landscapes 4771 km^2

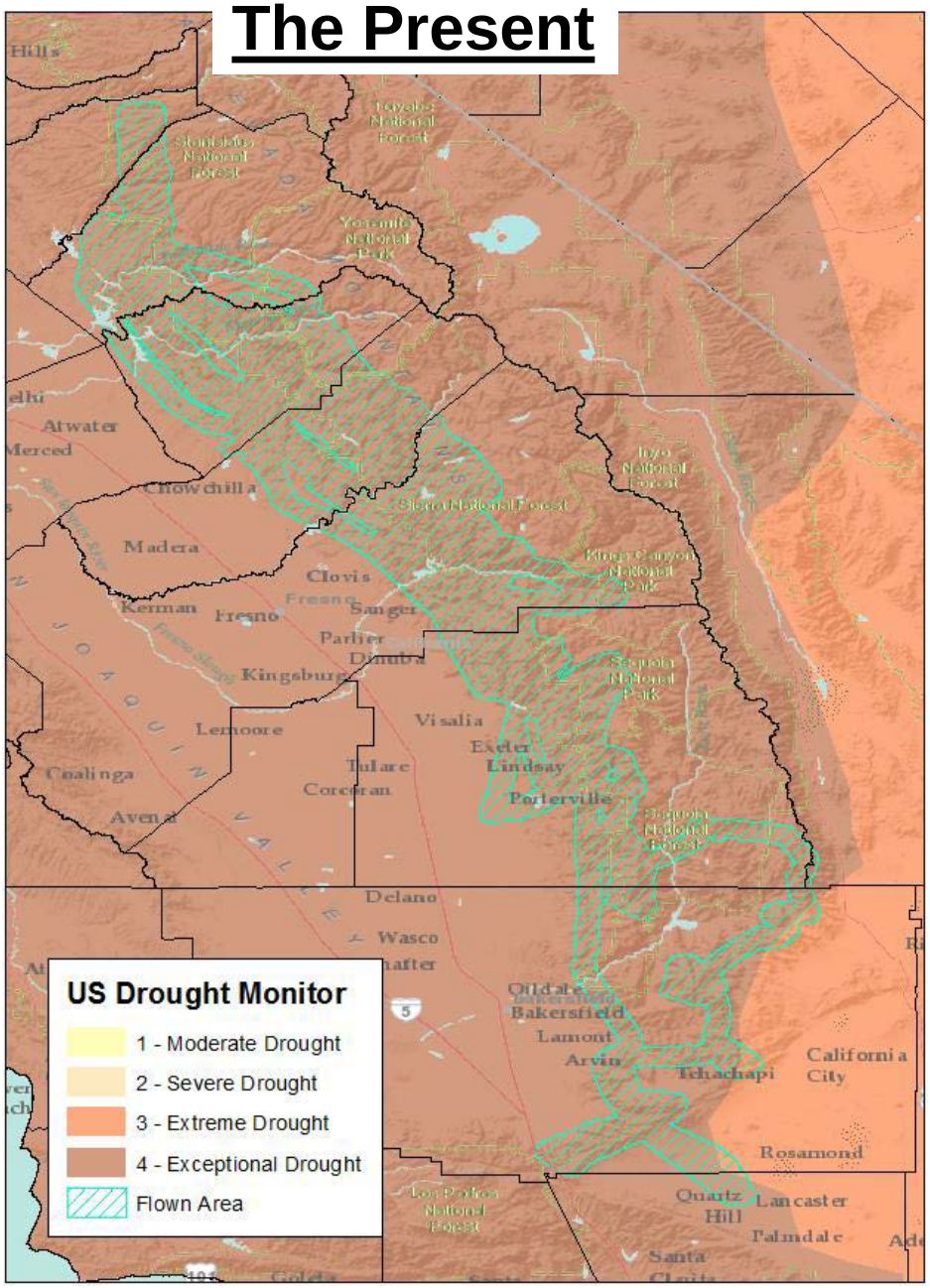
Current Extents

Urban 2258 km^2
Working Landscapes 2981 km^2

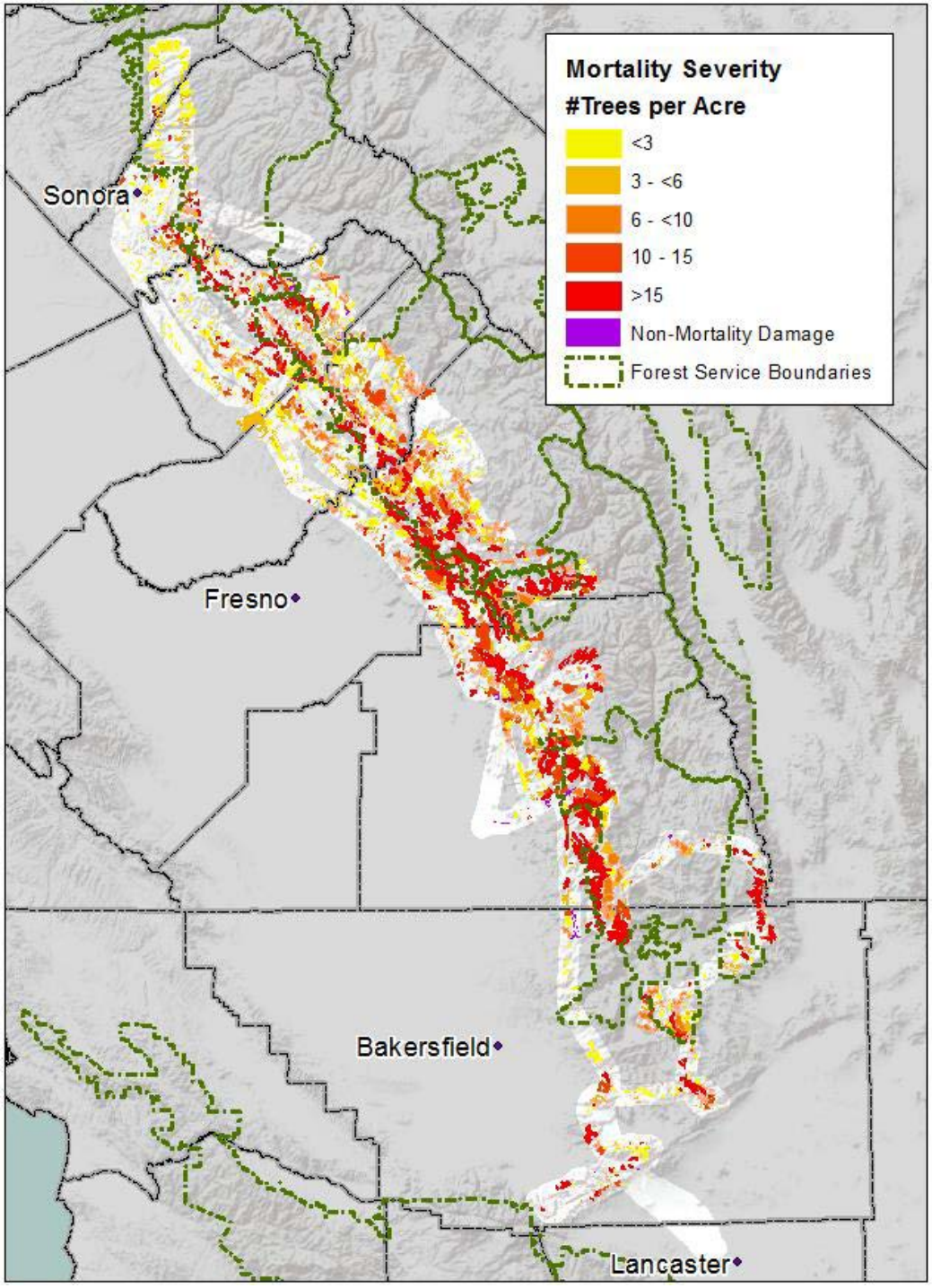
Future Extents

Urban + 61 km^2
Working Landscapes -36 km^2

The Present



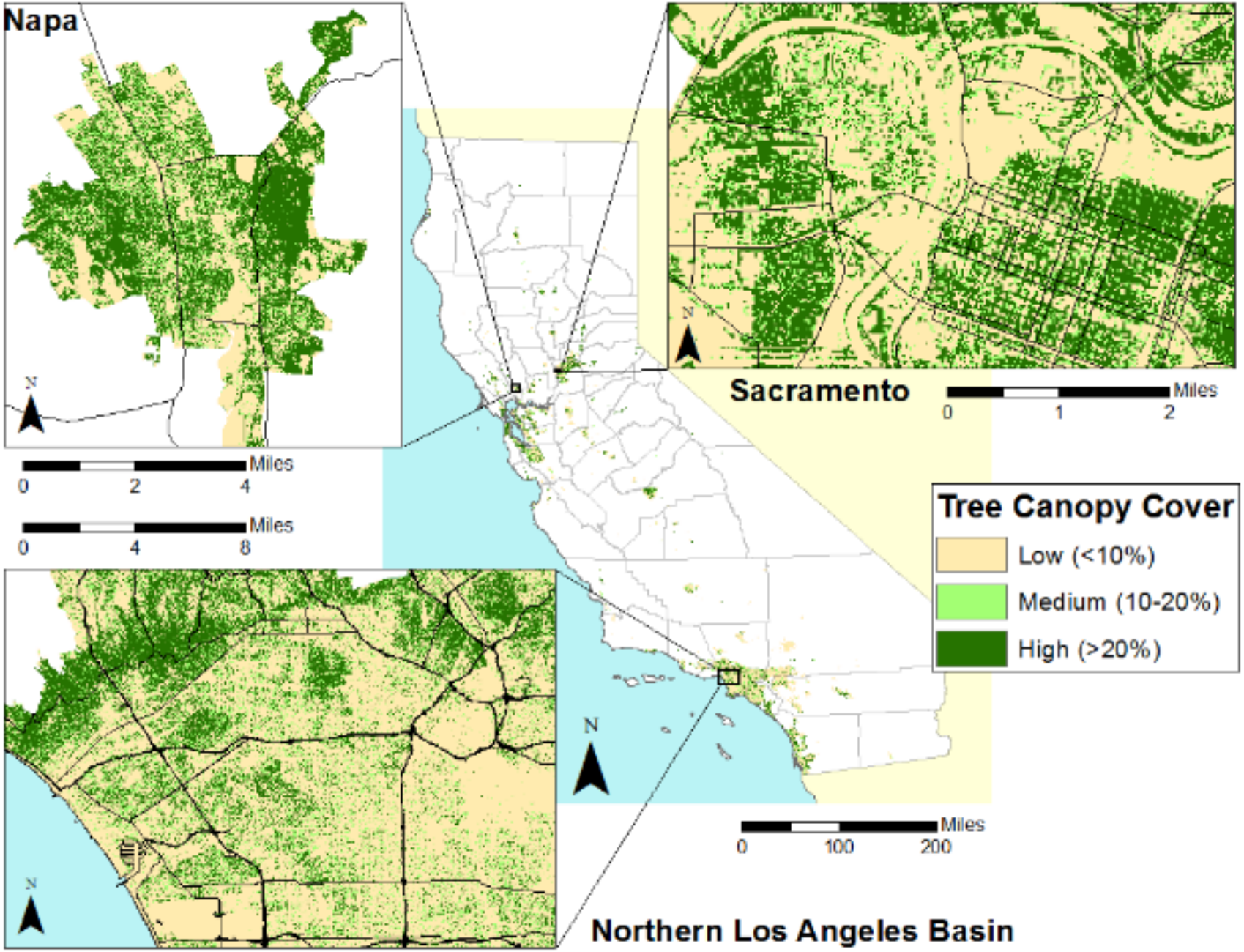
Summary USFS April 21 2015 Aerial Survey



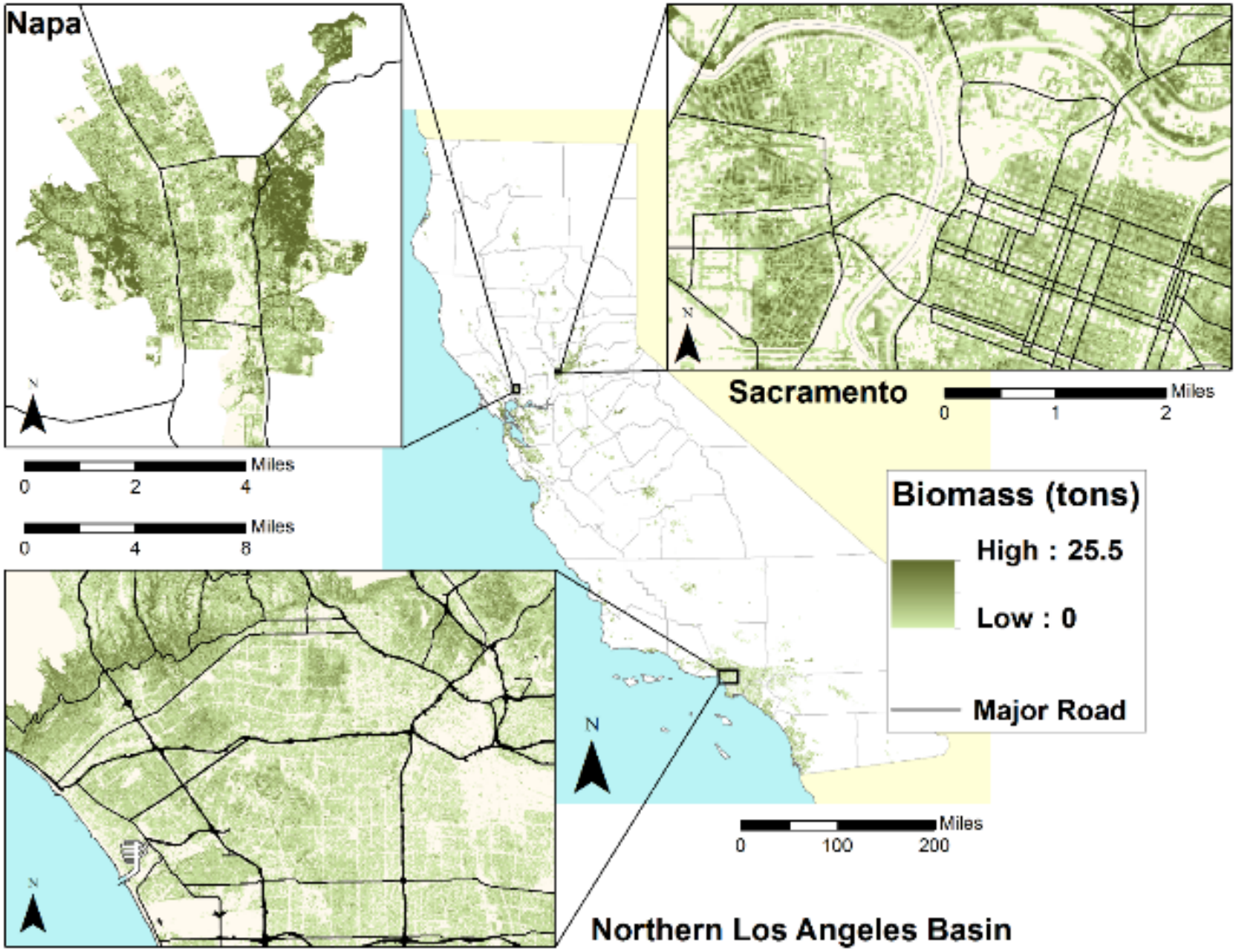
Area surveyed: 4.1 million acres
Areas with mortality: 835,000 acres
Estimated number of trees killed: 10,450,000

Overview of flown area and mapped tree mortality and damage.

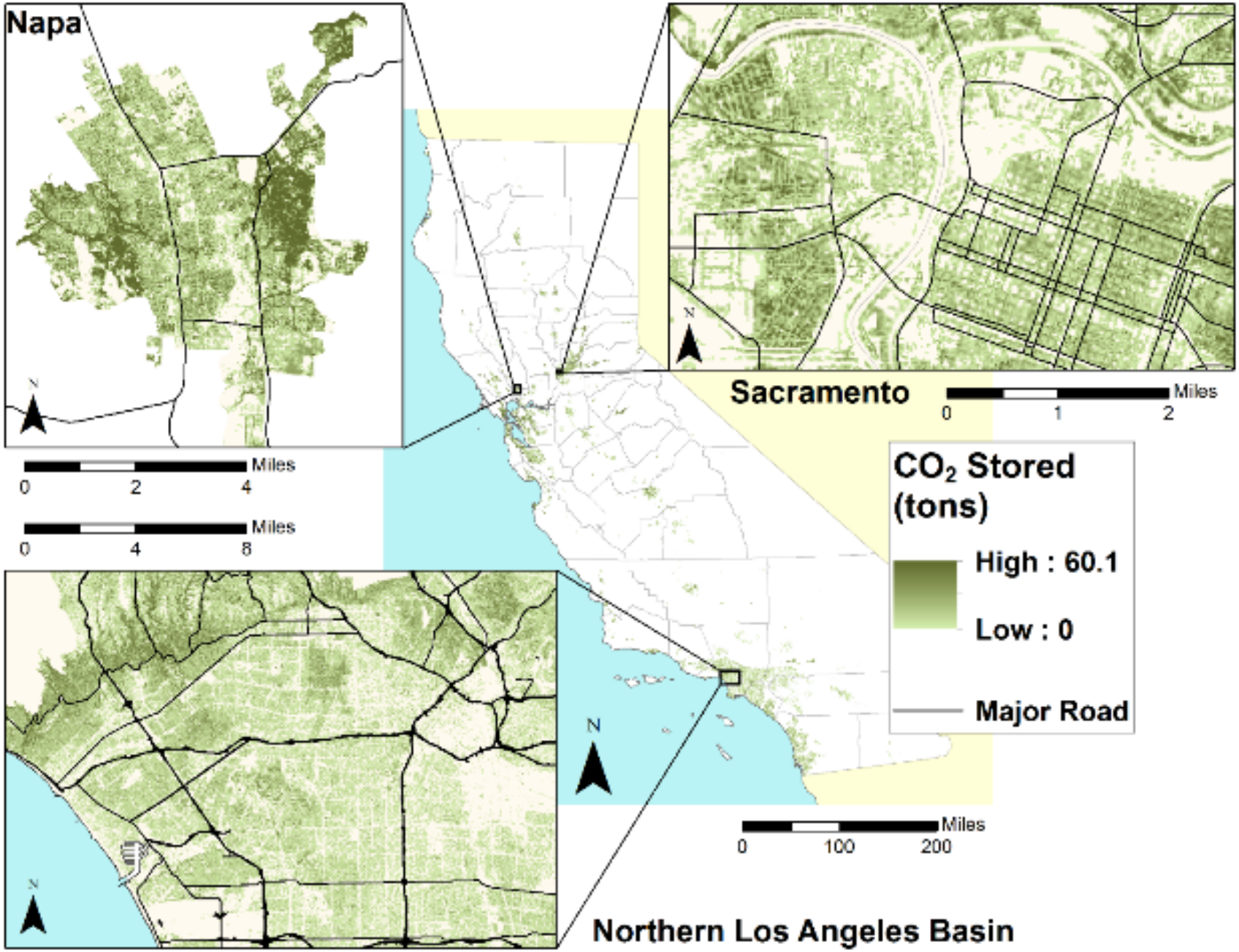
Jeffrey Moore (email: jwmoore02@fs.fed.us phone: 530-759-1753)



Percent tree canopy cover within California urban areas (map).



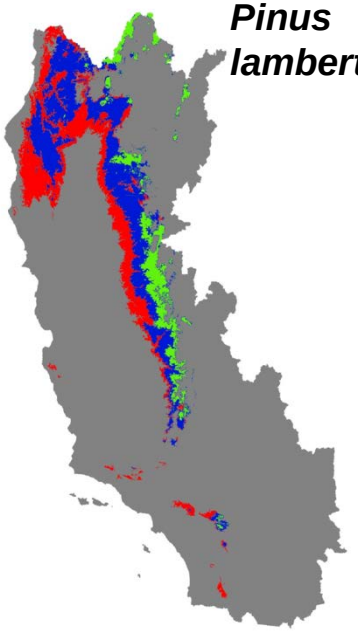
Estimated biomass (tons/grid cell) within California urban areas (map).



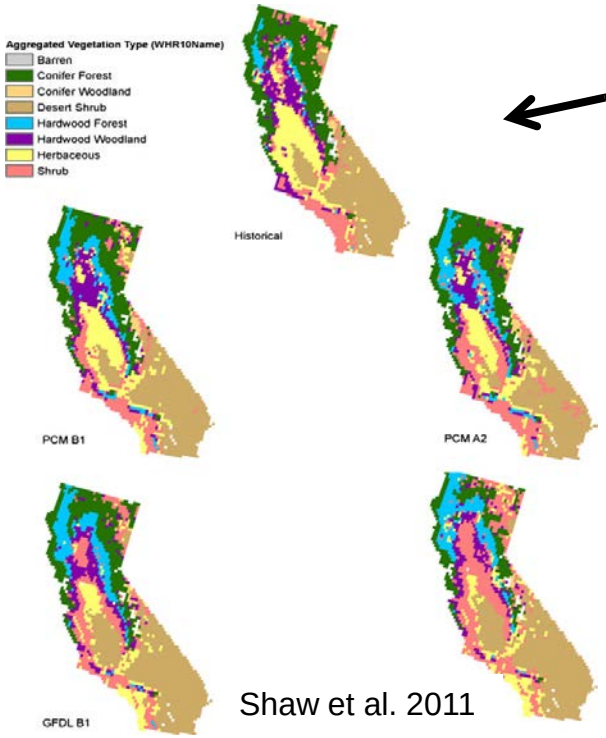
Estimated CO_2 stored (tons/grid cell) within California urban areas (map).

The Future

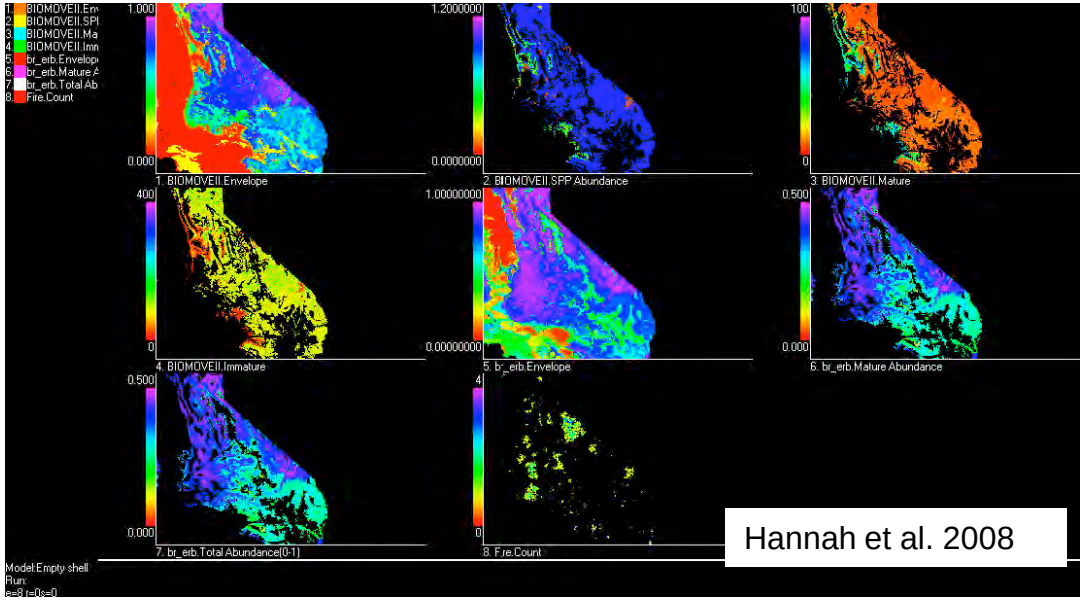
Species Distribution Models (Range Dynamics)
Species Demographic Dispersal Models (BioMove)
Dynamic Vegetation Models (MCII)
Site-based Exposure Assessments
Vulnerability Models
- Sensitivity
- Adaptive Capacity
- Exposure
- Range Dynamics



Pinus lambertiana

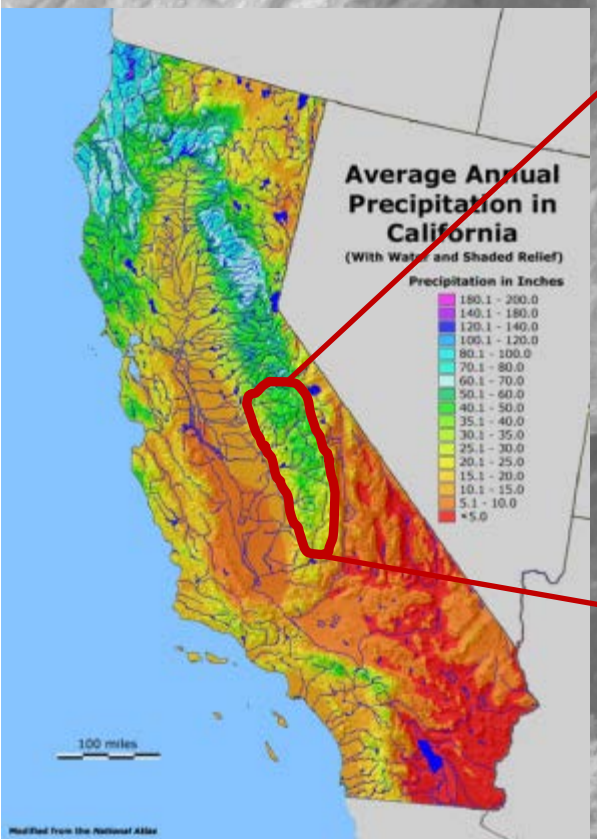


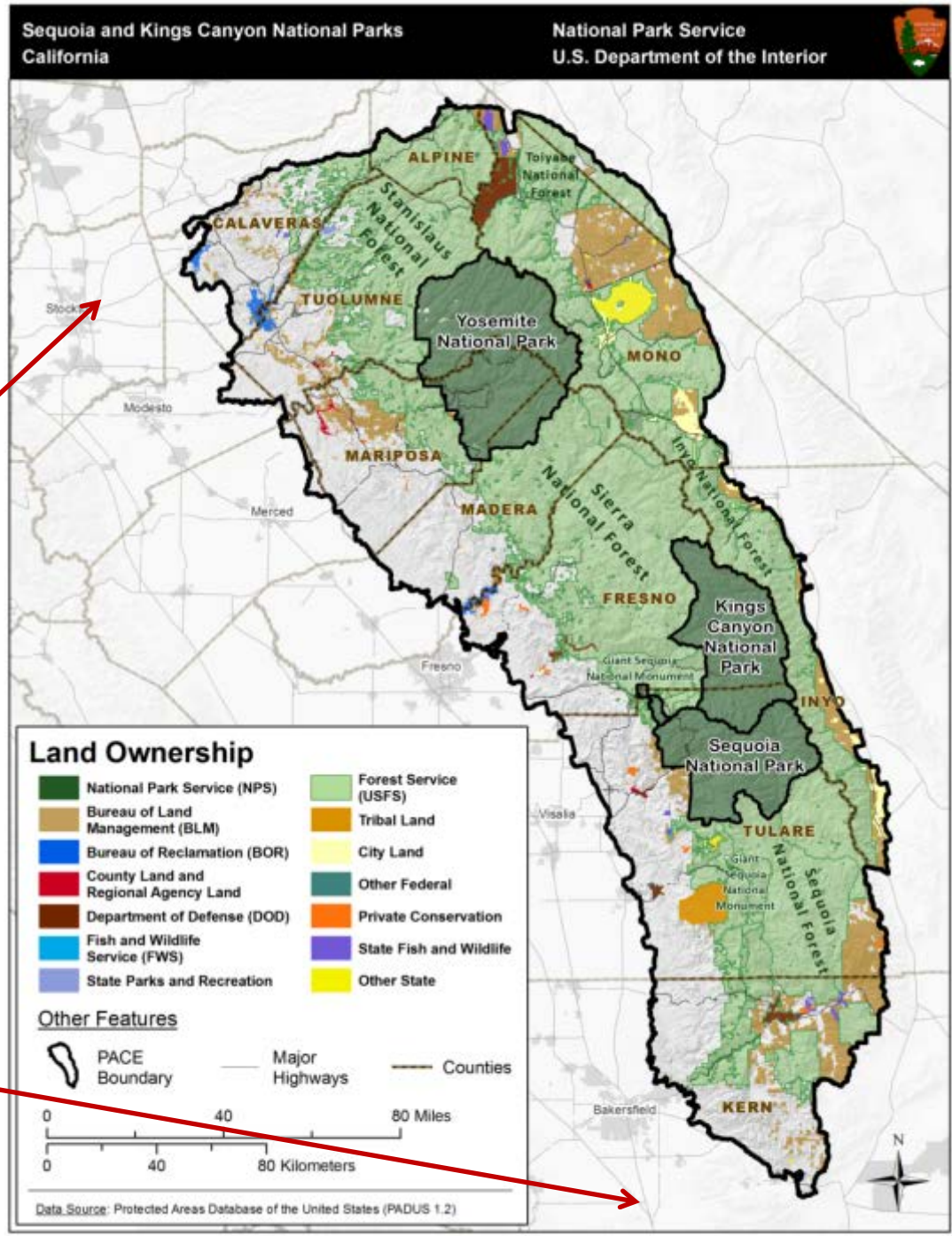
Shaw et al. 2011



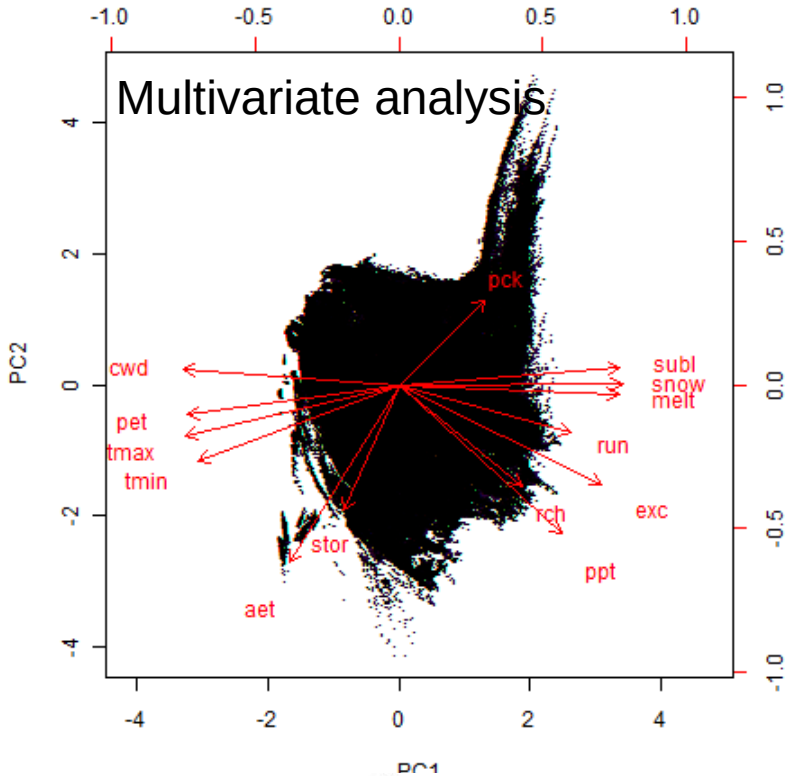
Hannah et al. 2008

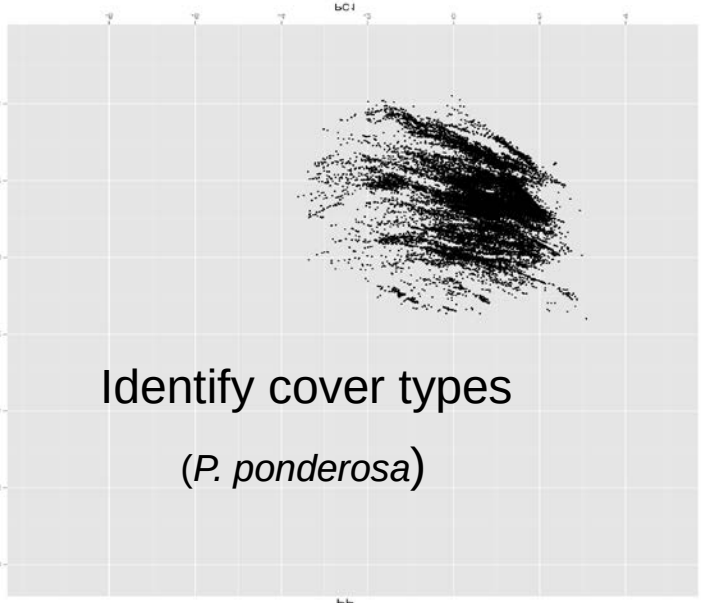
Climate Change Macrovegetation Vulnerability Assessment



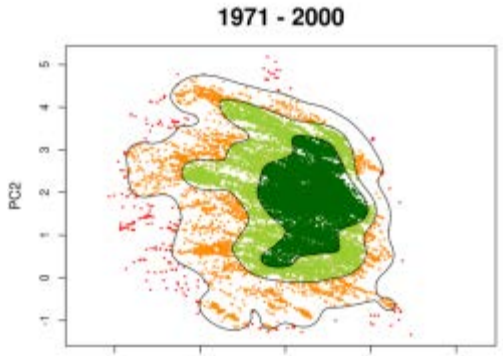


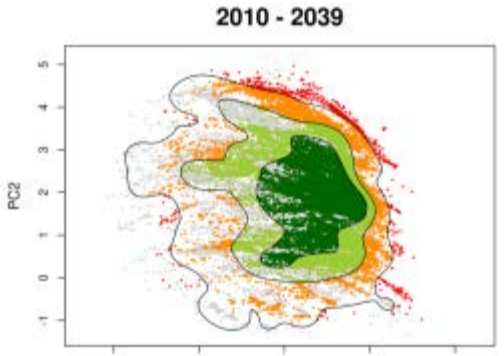
Vegetation Exposure to Climate Change



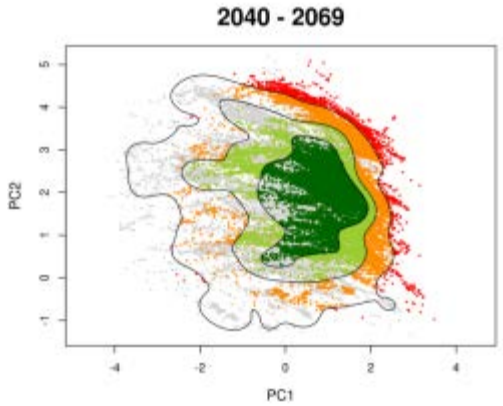


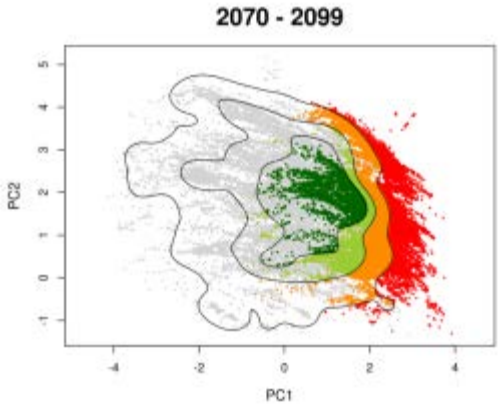
Central (<66%);
Marginal 67-90th,
Highly marginal (90-99th%), and
Outside (>99th%



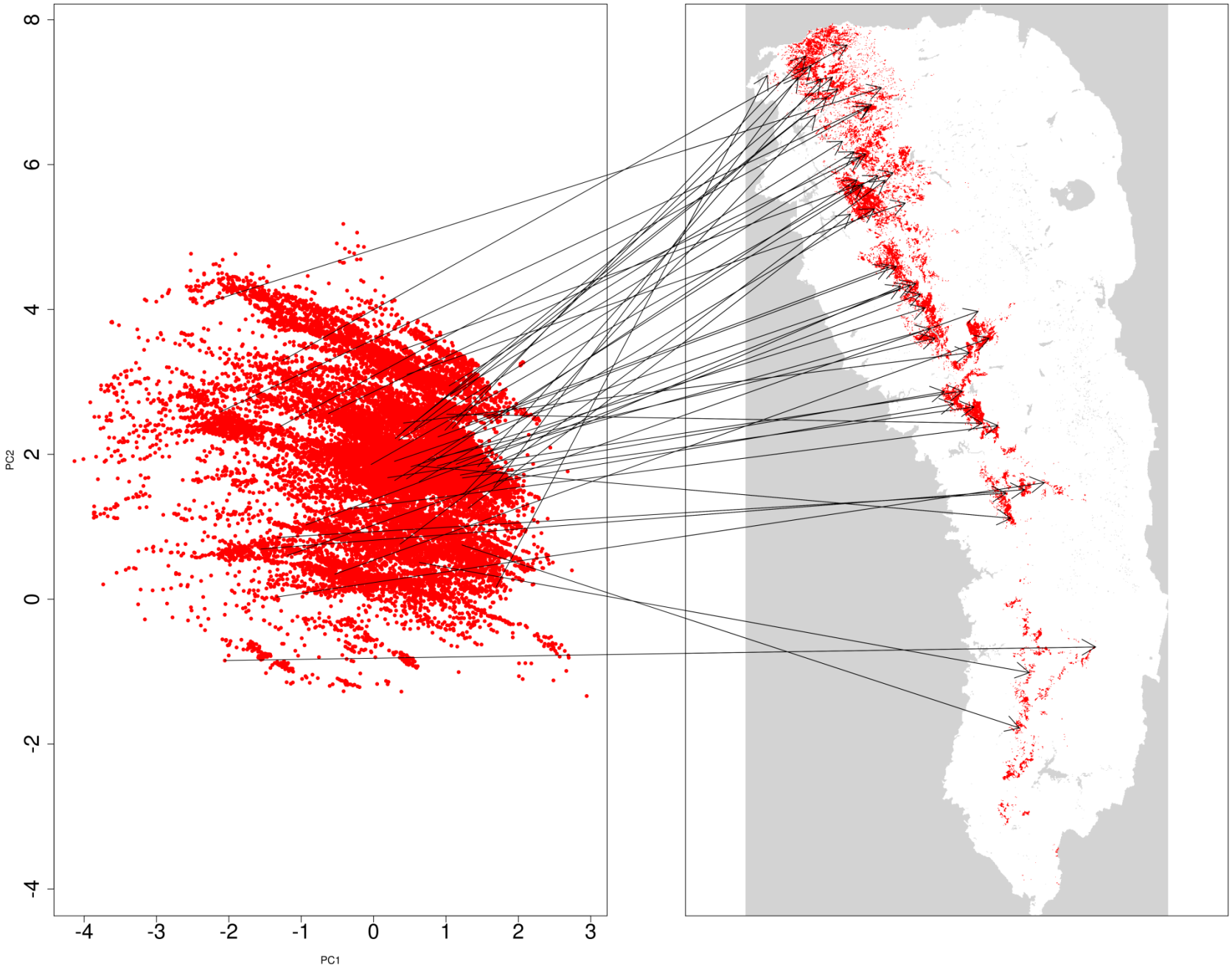


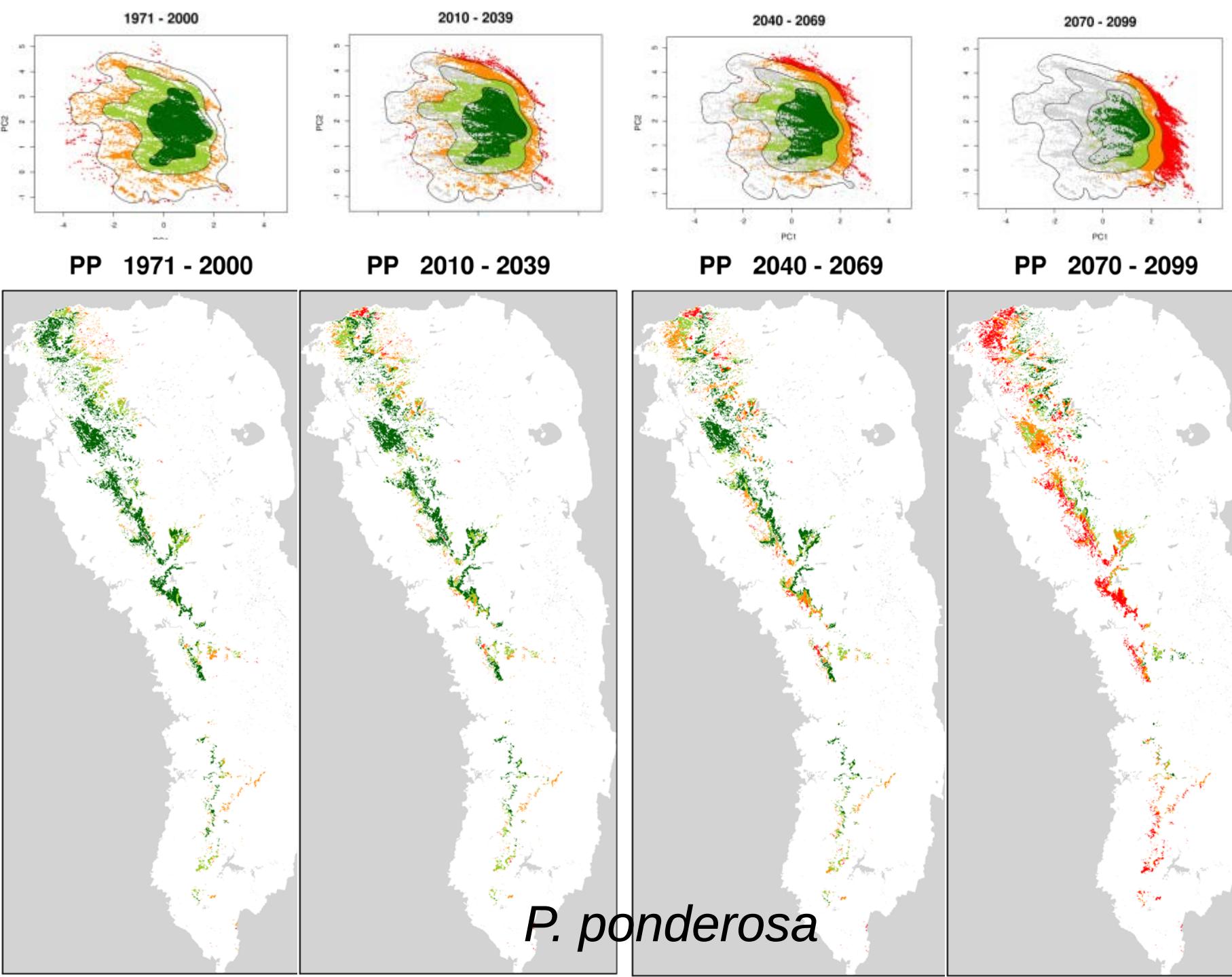
D. Assess exposure under future climate

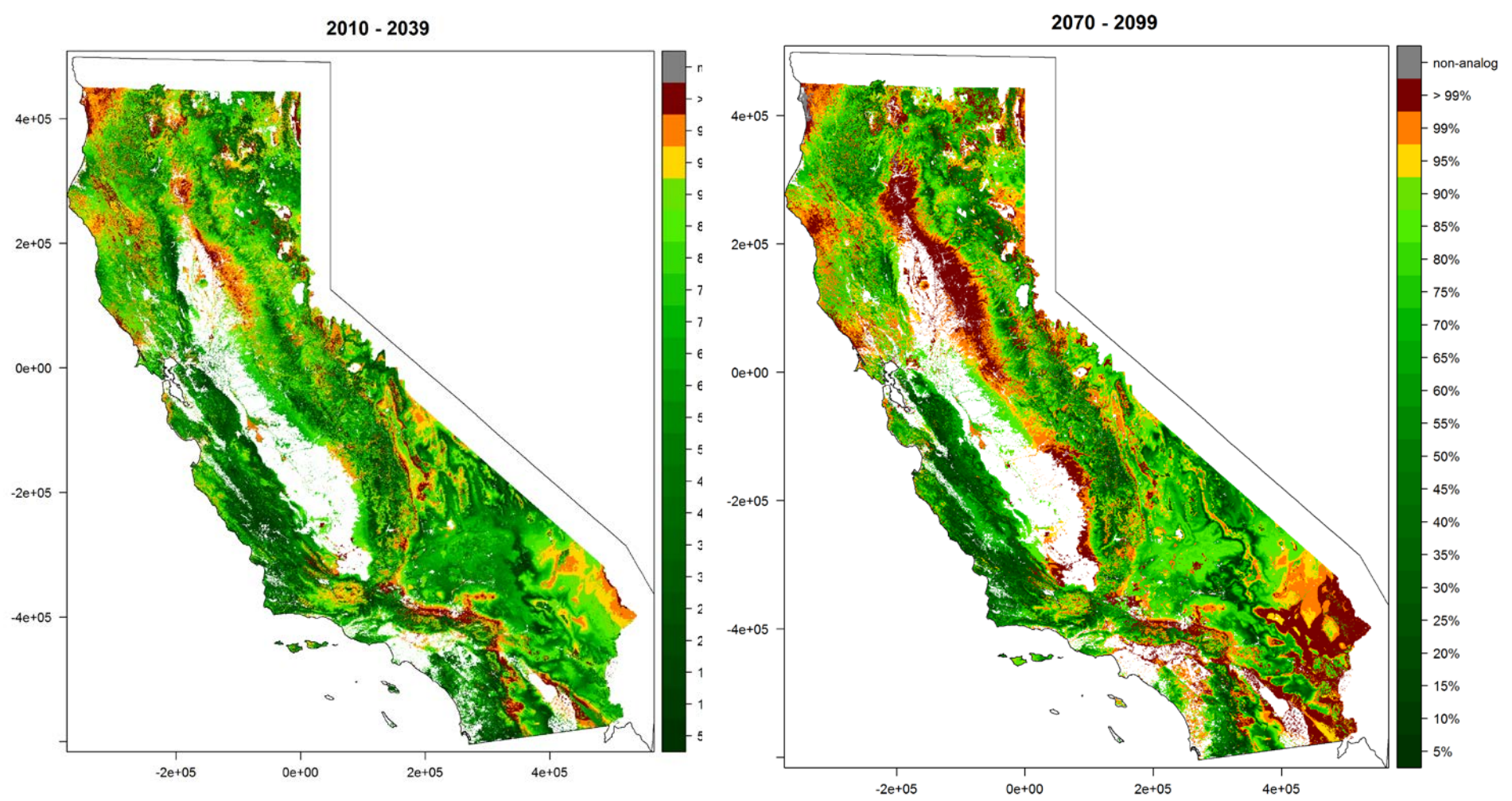




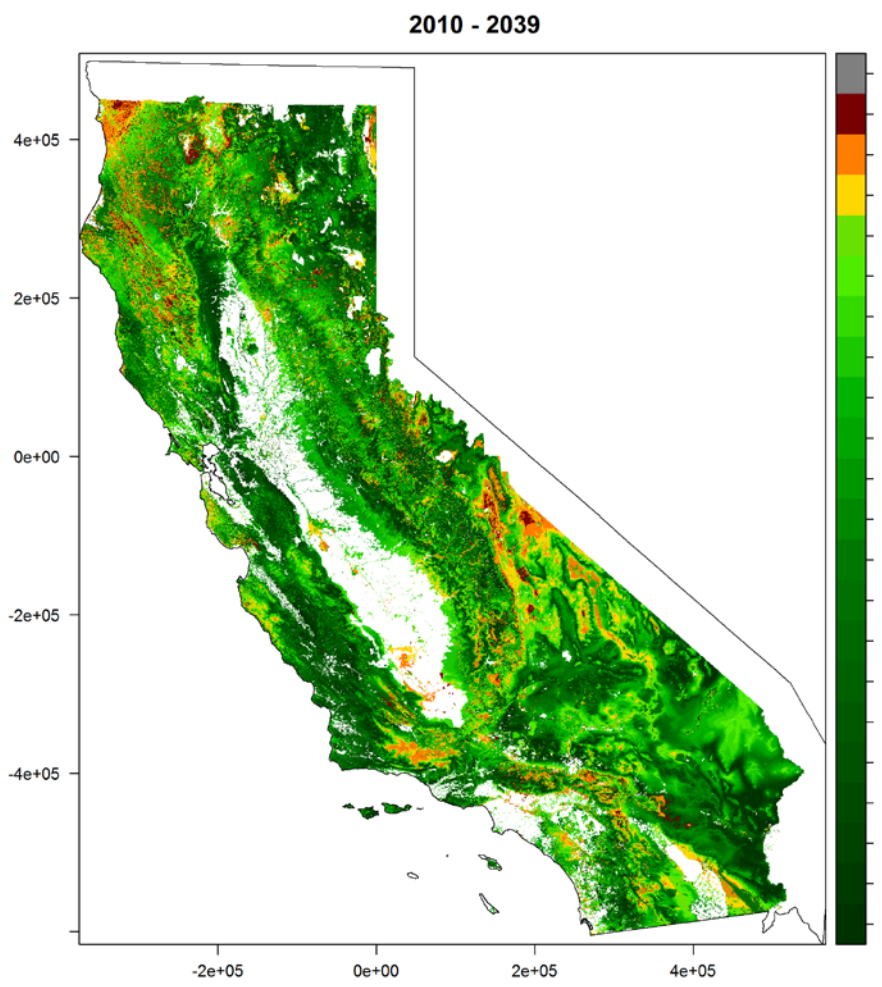
Ponderosa Pine

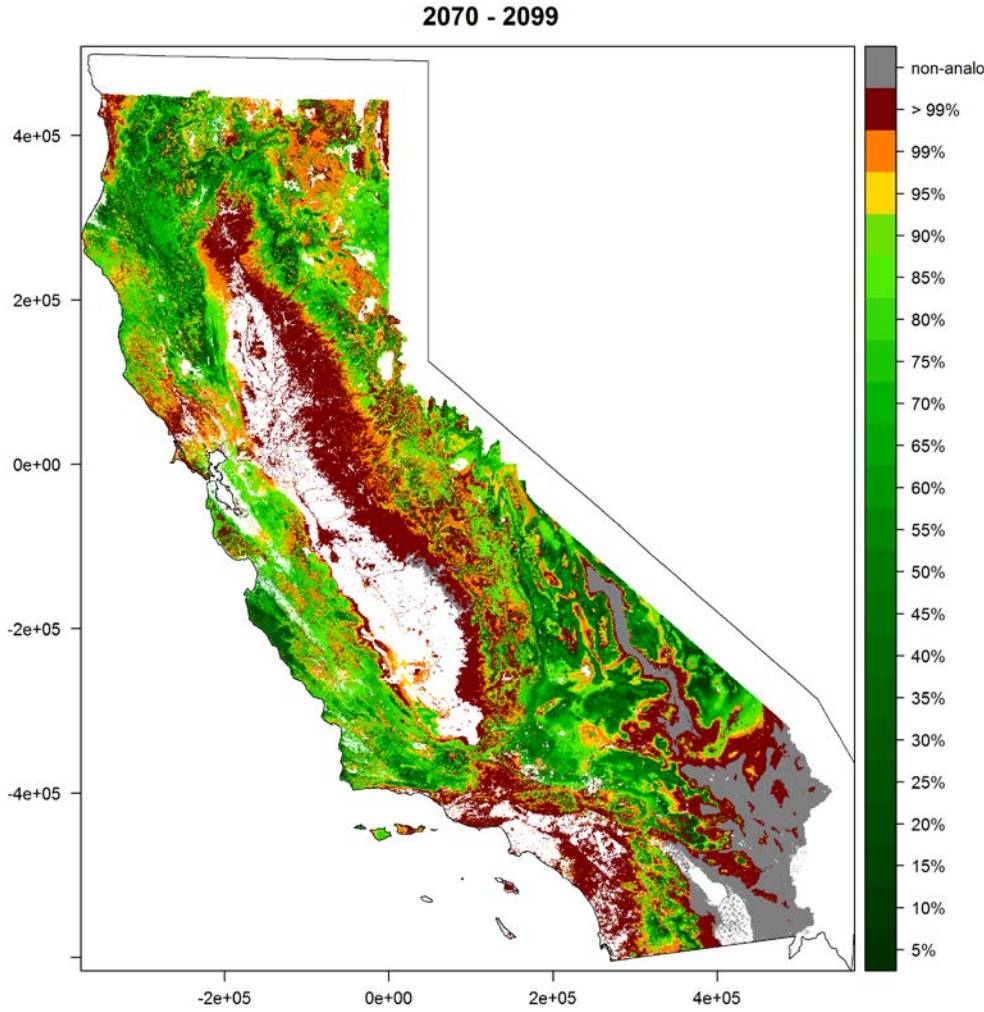



1971 - 2000
2010 - 2039
2040 - 2069
2070 - 2099
PC1
PC2
PP 1971 - 2000
PP 2010 - 2039
PP 2040 - 2069
PP 2070 - 2099
P. ponderosa

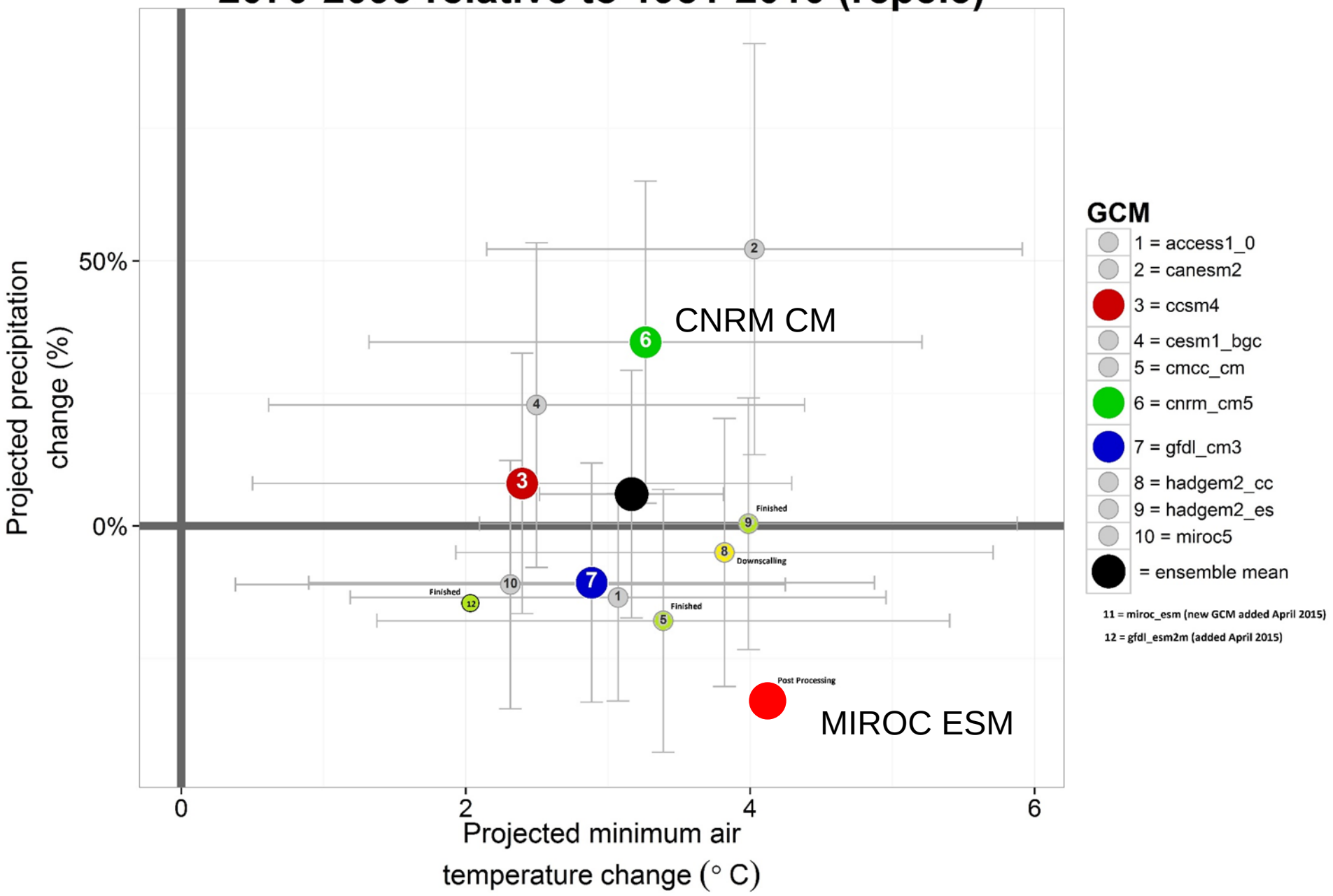

2010 - 2039
2070 - 2099
4e+05
2e+05
0e+00
-2e+05
-4e+05
-2e+05
0e+00
2e+05
4e+05
non-analog
> 99%
99%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%

CNRM RCP4.5

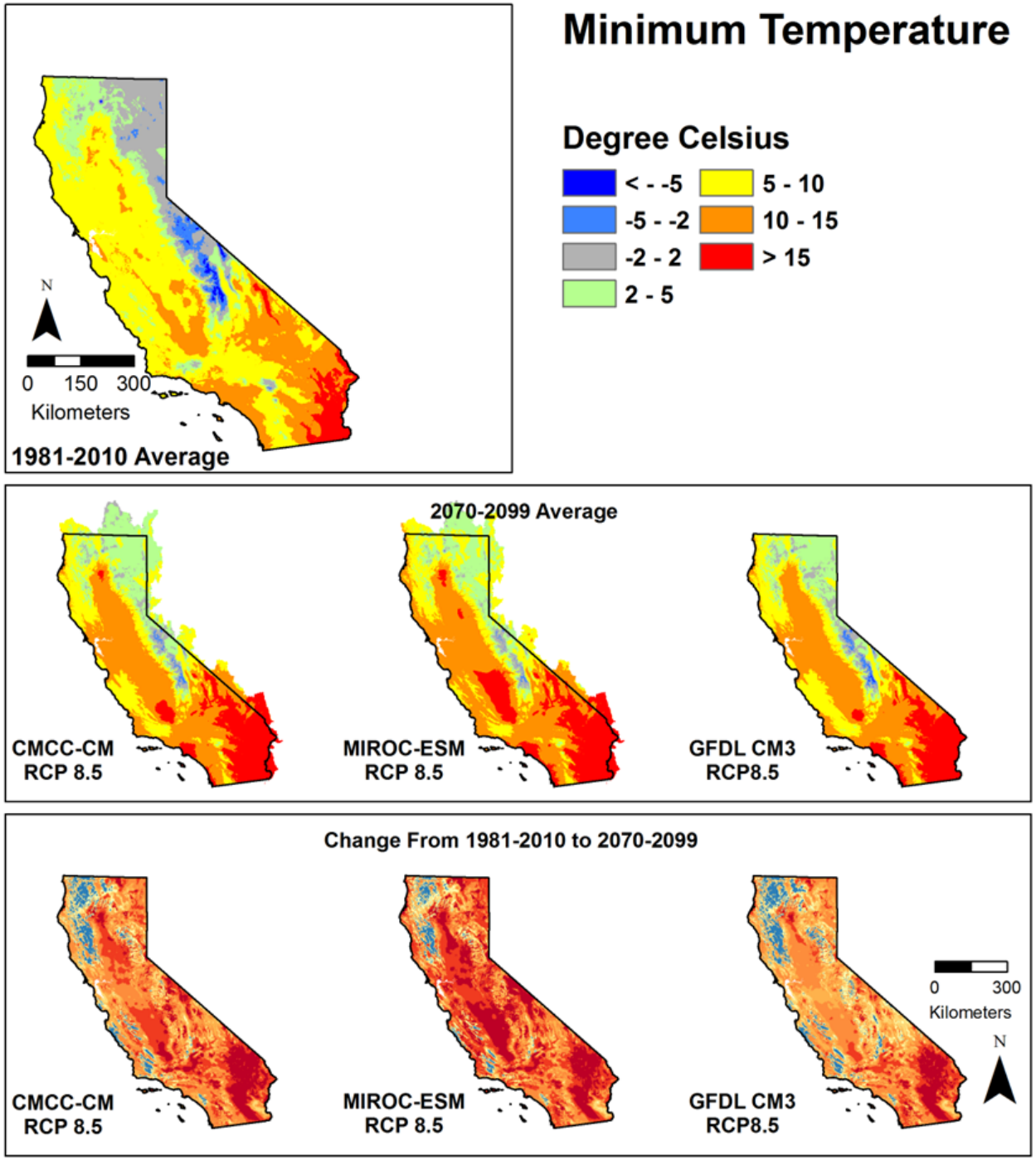

2010 - 2039
4e+05
2e+05
0e+00
-2e+05
-4e+05
-2e+05
0e+00
2e+05
4e+05

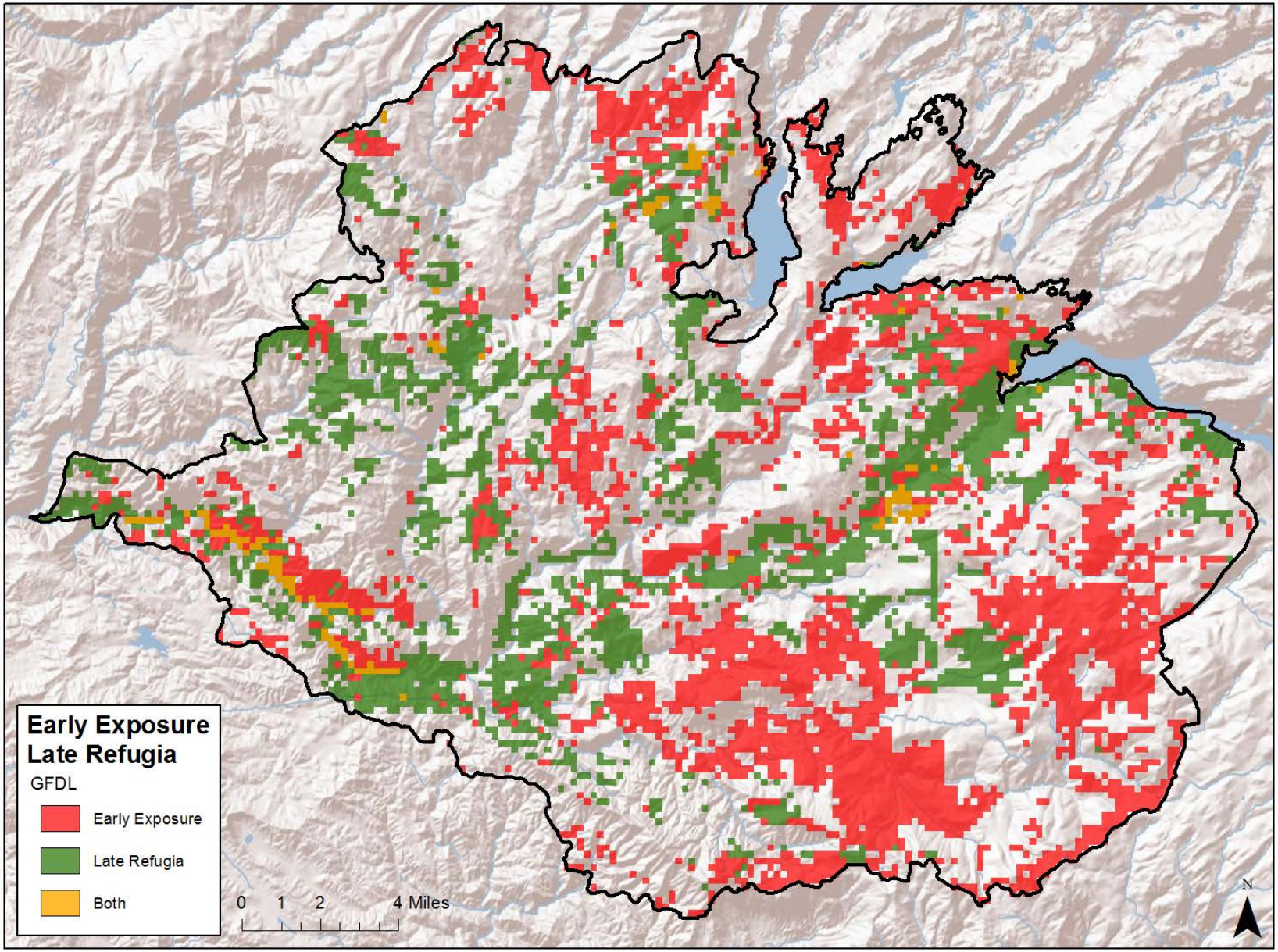

2070 - 2099
4e+05
2e+05
0e+00
-2e+05
-4e+05
-2e+05
0e+00
2e+05
4e+05
non-analo
> 99%
99%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%

MIROC RCP 8.5


Climate Change Projections for California
2070-2099 relative to 1981-2010 (rcp8.5)
Projected precipitation change (%)
50%
0%
0
2
4
6
Projected minimum air temperature change (° C)
CNRM CM
MIROC ESM
Finished
Downscalling
Finished
Finished
Post Processing
GCM
1 = access1_0
2 = canesm2
3 = ccsm4
4 = cesm1_bgc
5 = cmcc_cm
6 = cnrm_cm5
7 = gfdl_cm3
8 = hadgem2_cc
9 = hadgem2_es
10 = miroc5
= ensemble mean
11 = miroc_esm (new GCM added April 2015)
12 = gfdl_esm2m (added April 2015)

Minimum Temperature

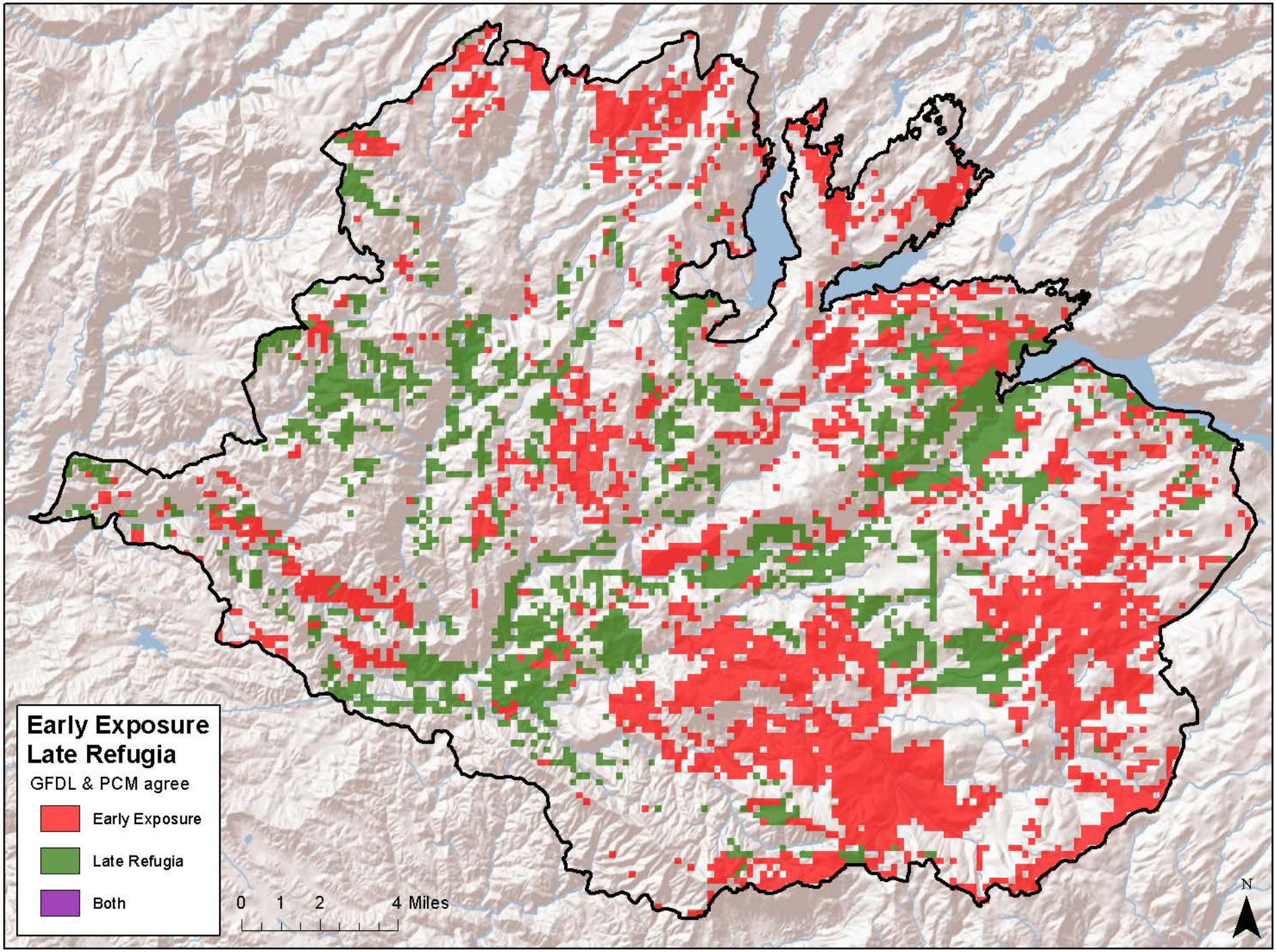


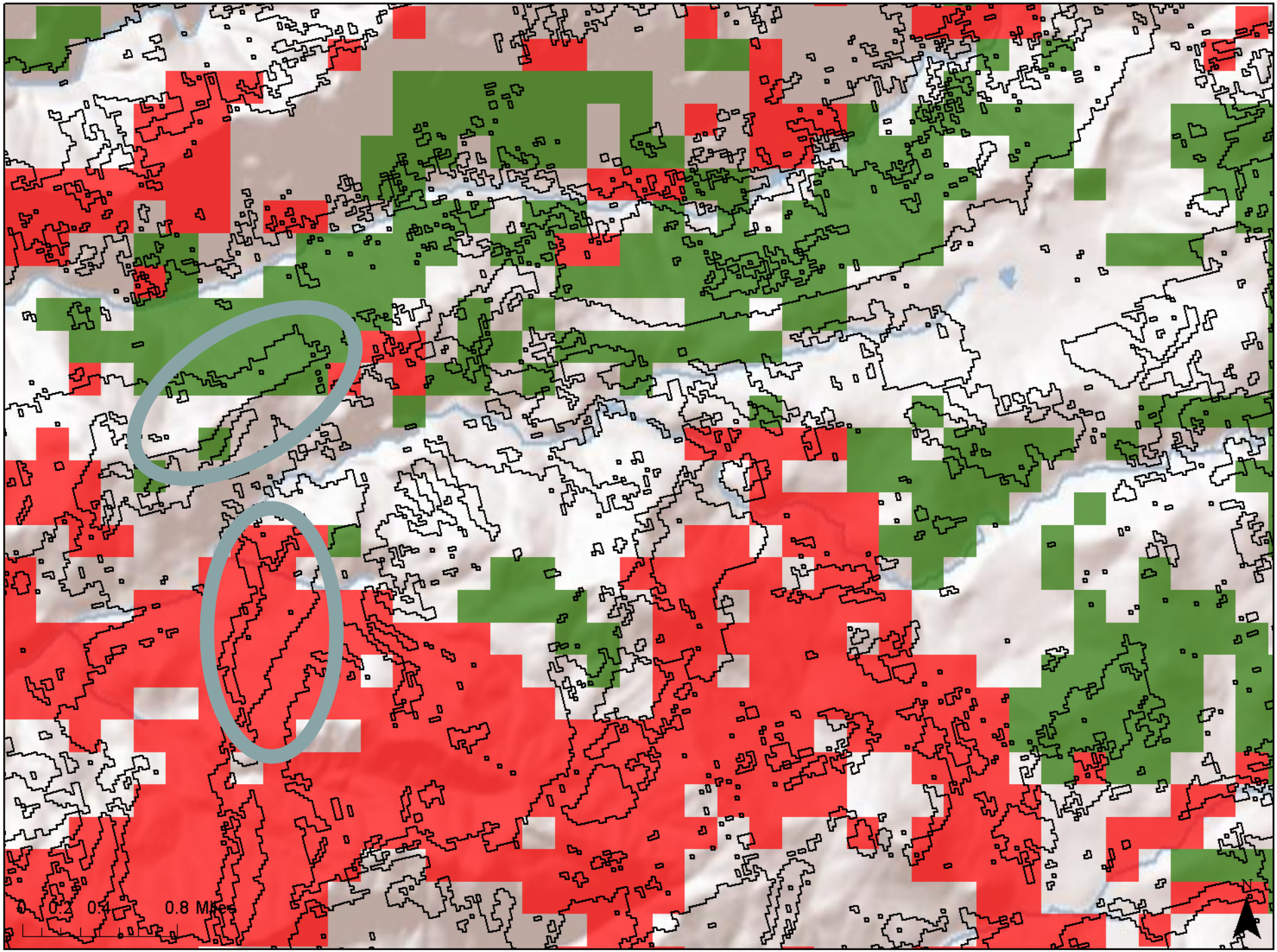


Rim Fire Boundary.

Green – places that remain within bioclimatic envelope at end of century.

Red: places that fall outside of bioclimatic envelope by 2040


Early Exposure
Late Refugia
GFDL & PCM agree
Early Exposure
Late Refugia
Both
0 1 2 4 Miles
N


0 0.2 0.4 0.8 Miles
N

A few comments on indicators for plants & vegetation

Active management of natural lands means there are few areas in which observed landscape-level dynamics will be purely due to climate.

Active management can represent experimental treatments that could be evaluated from a climate change perspective.

Differences in carbon sequestration and retention potential on natural lands is already driving different practices in various places around California.

As downscaled CMIP5 GCMs apparently have more complex spatial patterns for California, it is critical to be explicit about those, and to use consistent models for future forecasts across fields.

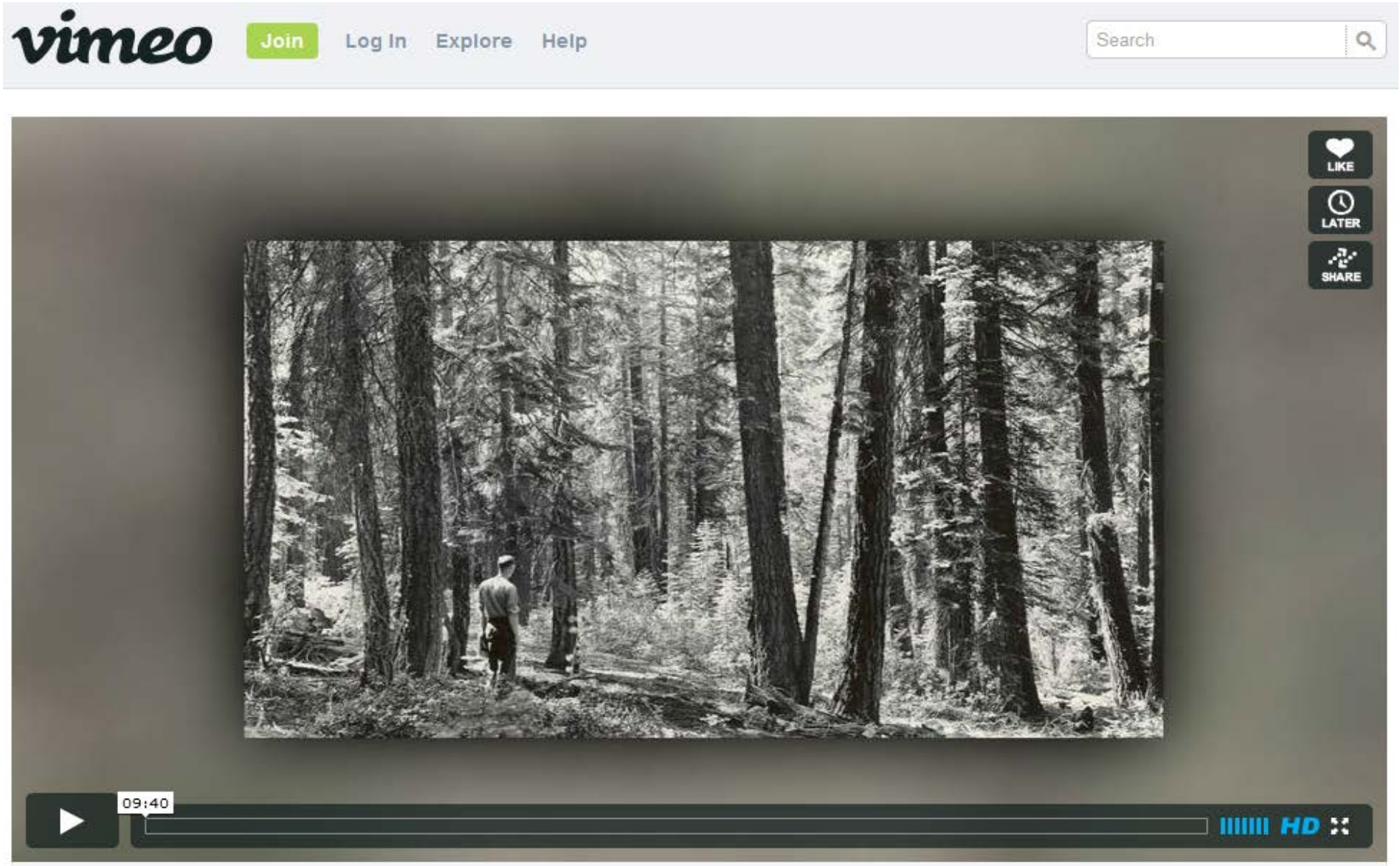
Integration of remote sensing with spatially explicit models and ground data is a promising prospect for better understanding vegetation response to climate change.

Ecotone Dynamics; Species Turnover; Demographics; Composition; and Phenology!

VIDEO: Mapping Change in Sierra Nevada Forests

2D on vimeo: http://vimeo.com/41524838

3D on youtube: http://www.youtube.com/watch?v=ZGo-vI4Ey44



Thank You

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