Landscape Responses to Changes in Climate

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U.S. Geological Survey

AGCI August 4, 2015

Landscapes and Managed Lands

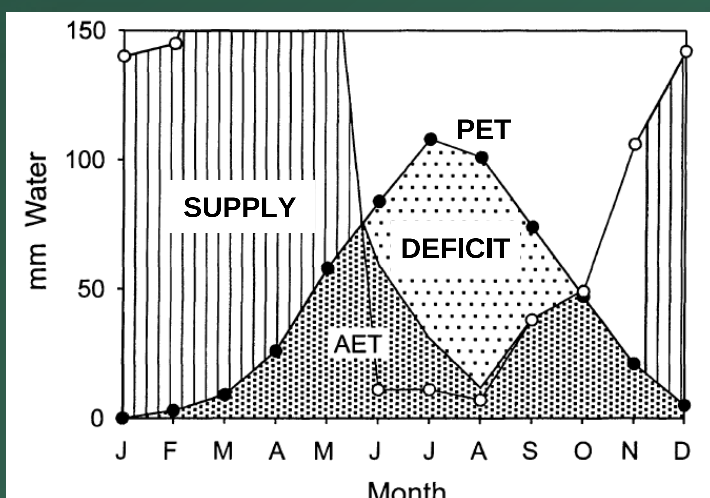
- Climatic water deficit
- Examples of fine scale applications
  - Agricultural demand
  - Management for soil health
  - Species distribution modeling
  - Wildfire risk
  - Wine grapes
  - Wolverines and fine scale snow modeling

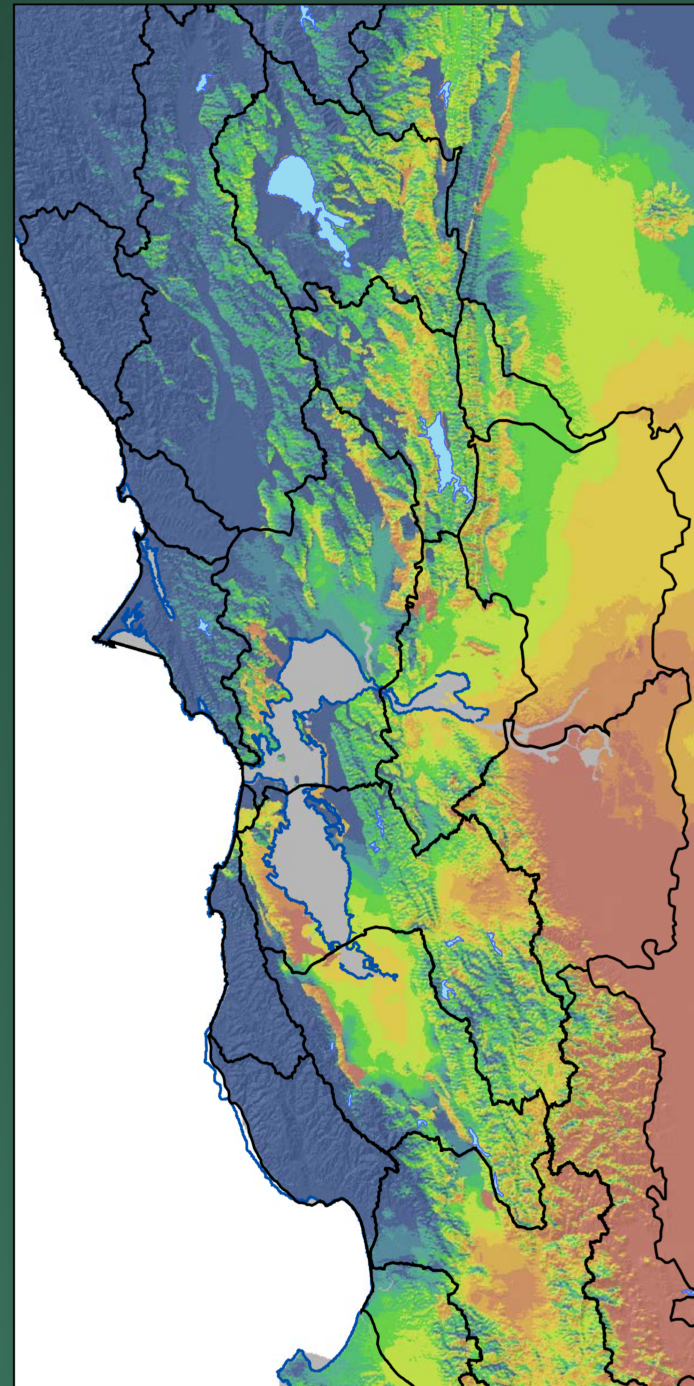
Climatic Water Deficit

Annual evaporative demand that exceeds available water

Potential – Actual Evapotranspiration

- Integrates climate, energy loading, drainage, and available soil moisture storage
- Address irrigation demand
- Generally increases with all future climate scenarios
- Defines level of stress on landscape

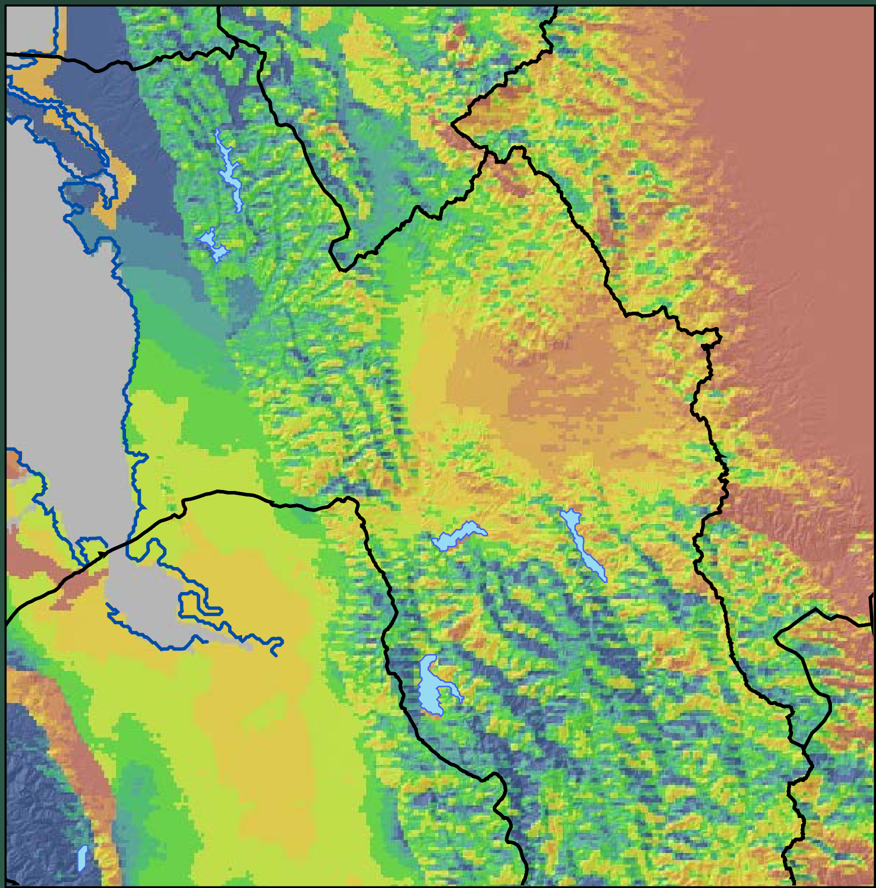




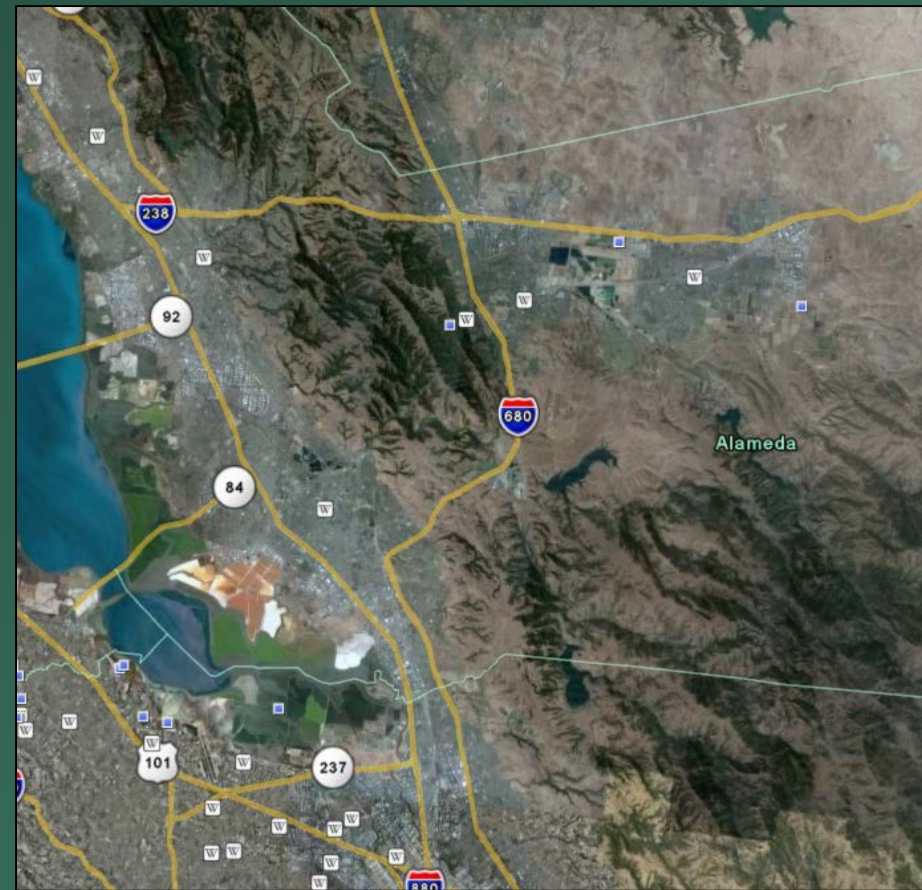
2001

mm/yr

- <775
- 775 - 800
- 800 - 825
- 825 - 850
- 850 - 875
- 875 - 900
- 900 - 925
- 925 - 950
- 950 - 975
- 975 - 1000

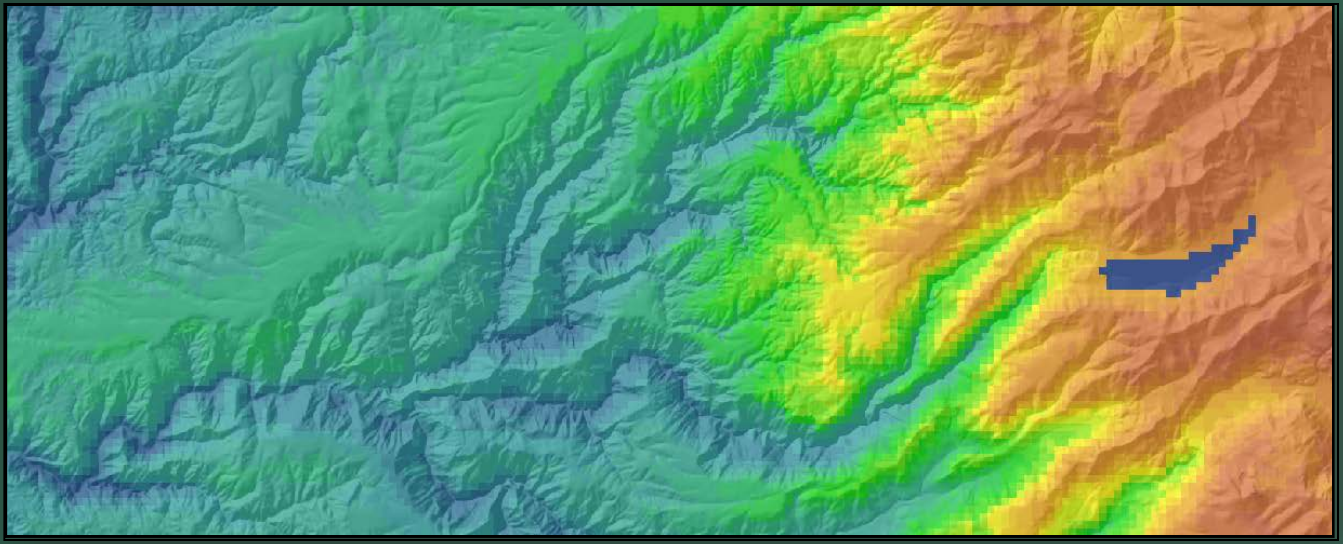


Climatic Water Deficit in South Bay



Google Earth Image of South Bay

Local to watershed application characterizes landscape resilience



Change in climatic water deficit (1981-2010) relative to (2070-2099)

(mm/year)

High : 500

Low : 120

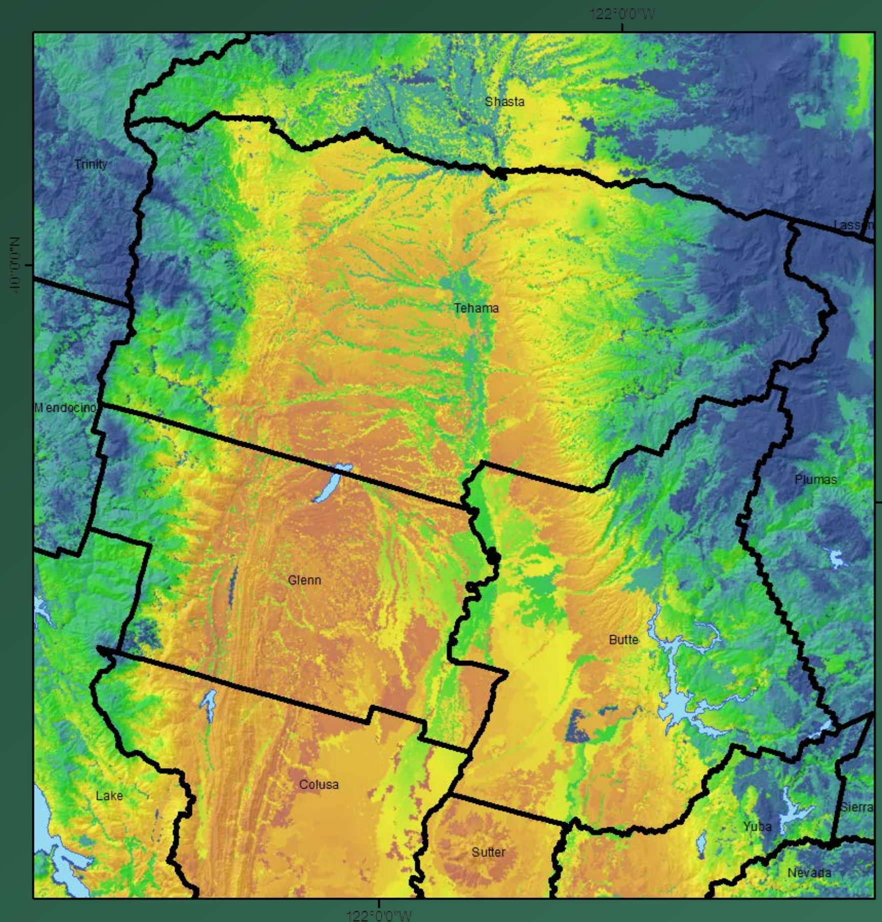
GFDL A2 climate scenario

Applications: Augmenting Soil Water Holding Capacity and Reducing CWD

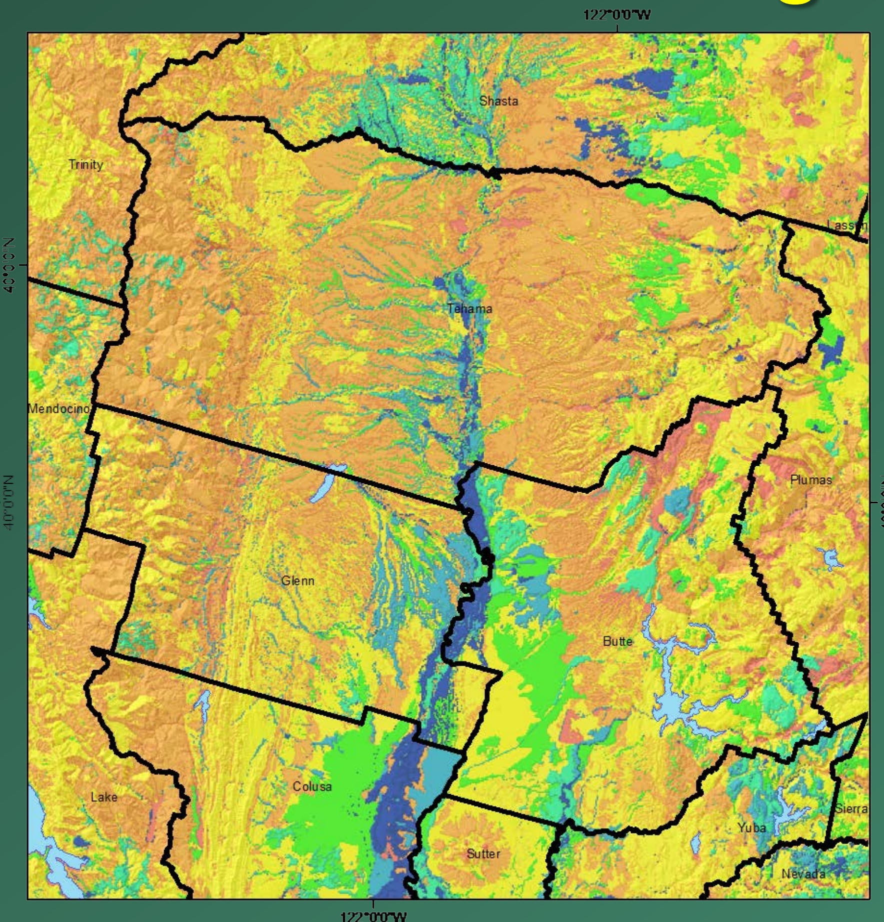
The Marin Carbon Project and Ryals and Silver, 2013, showed that increasing organic matter in soils could also increase field capacity.

That information was added to our hydrology model.

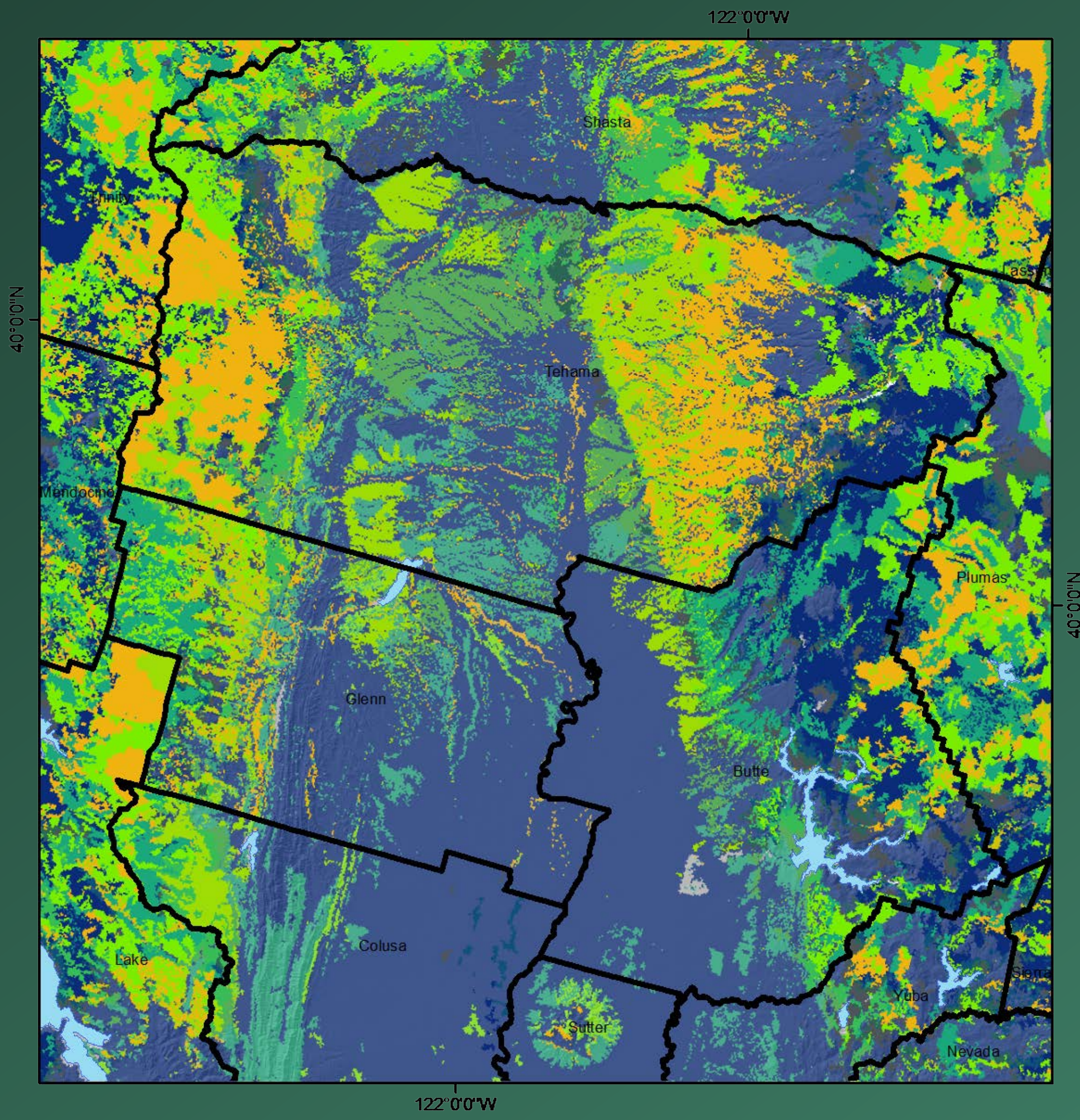
CWD



Soil water storage



Implications of Strategic Soil Management
Northern Sacramento Valley



WY1998
Decrease in CWD with soil amendments to increase WHC 25%

CWD Difference (mm/year)

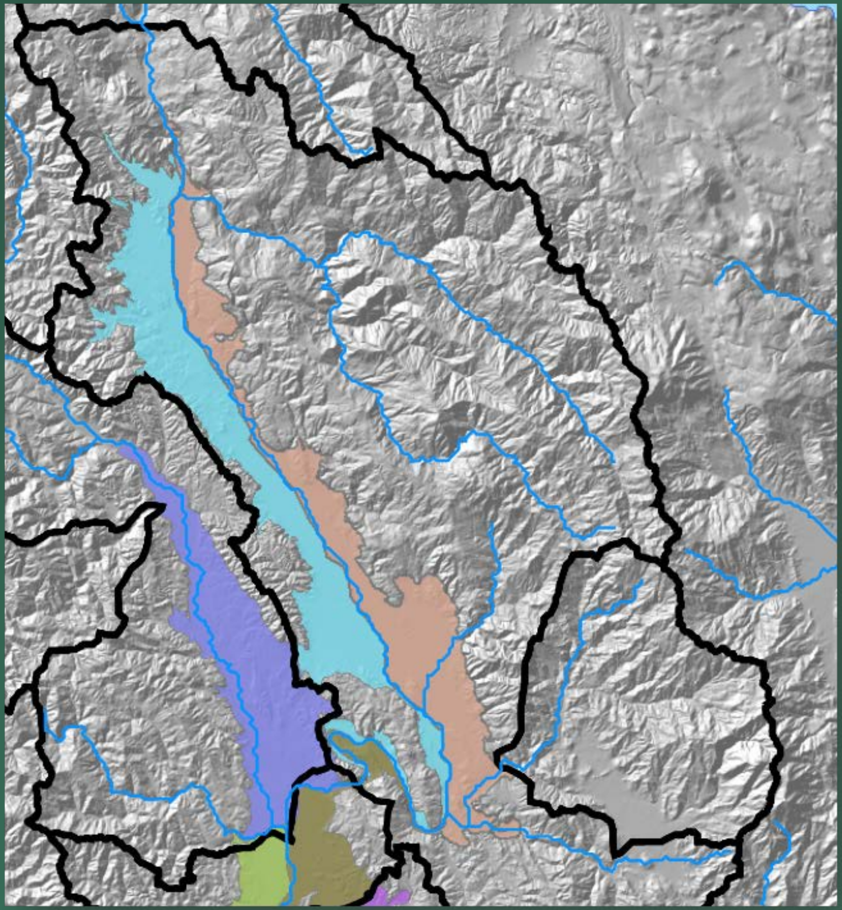
- 0 - 0.1
- 0. - 15
- 15 - 28
- 28 - 46
- 46 - 116

Applications: Estimate Agricultural Demand

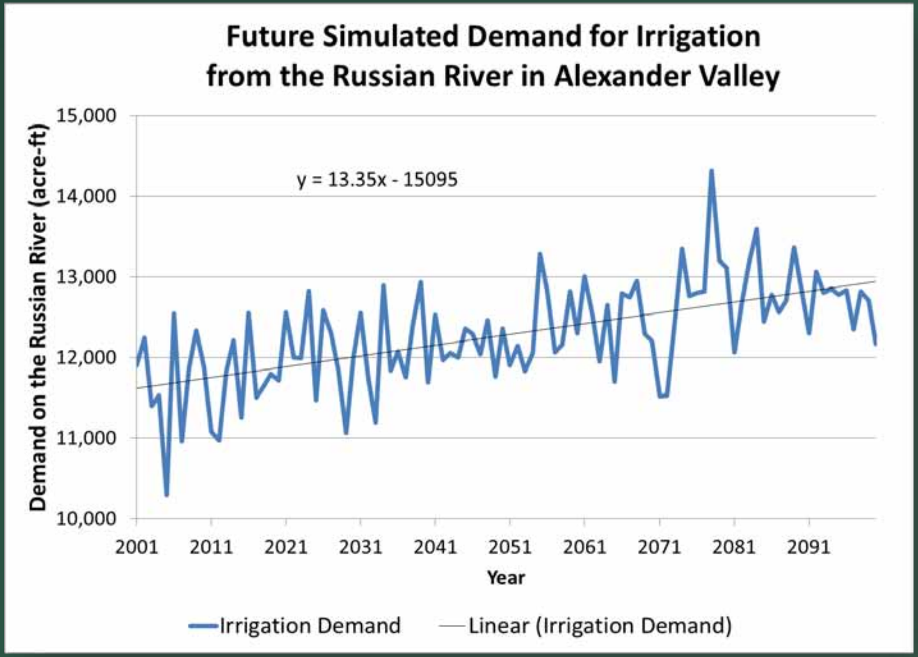
Climatic Water Deficit

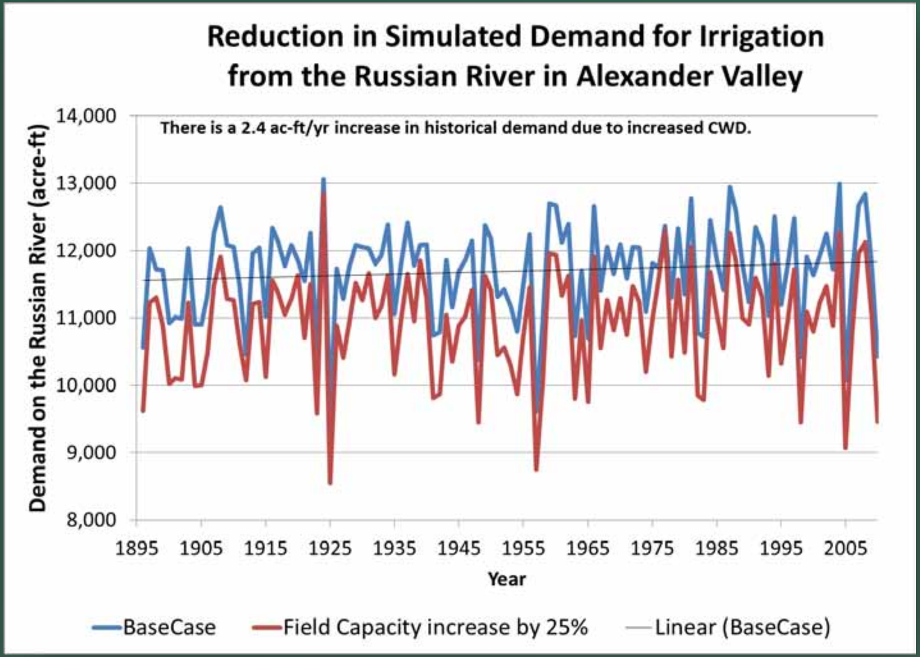
Potential – Actual Evapotranspiration

- Irrigation from wells near the Russian River can reduce flow from the Russian River and is an indicator of demand
- Agricultural land areas are mapped out to estimate irrigation needs to meet the water deficit
- Estimated from loss of stream flow between gages



Augmenting Soil Water Holding Capacity to reduce CWD



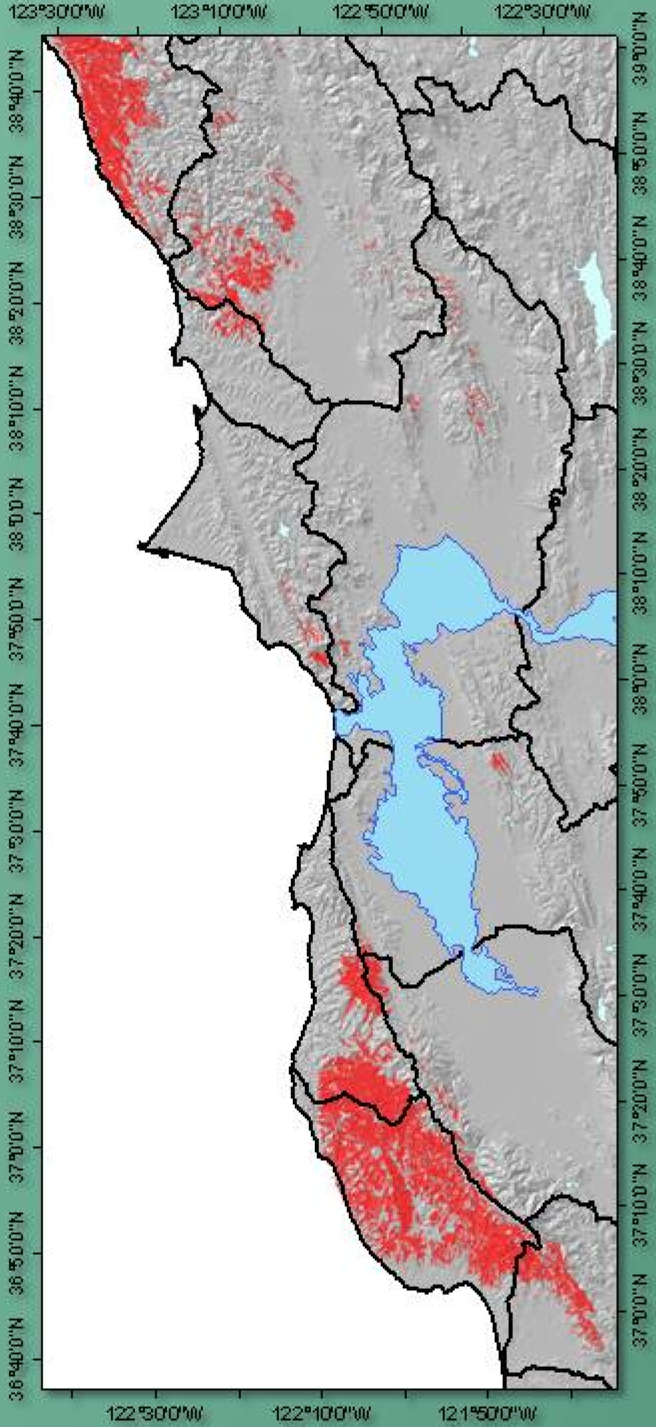


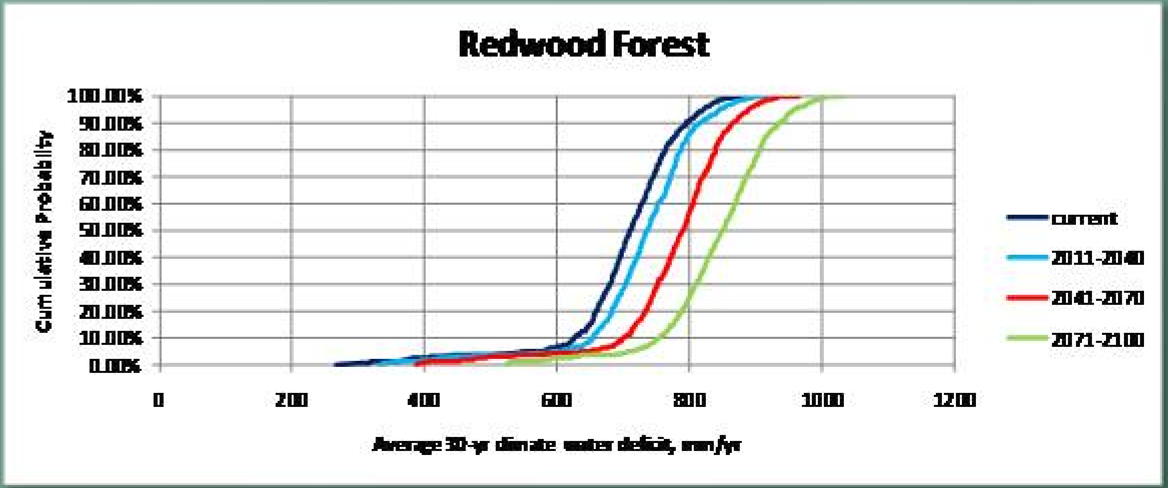
CWD has been shown to correlate to irrigation demand in the Russian River's Alexander Valley. Projections indicate a potential increase in demand of nearly 1,500 ac-ft by the end of the century.

If we increase water holding capacity of the soil by 25%, we reduce CWD and correlated losses due to demand from the Russian River by approximately 6.5%, or 776 ac-ft/year.

Application: Species distributions

Mapped Locations of Redwood Forest

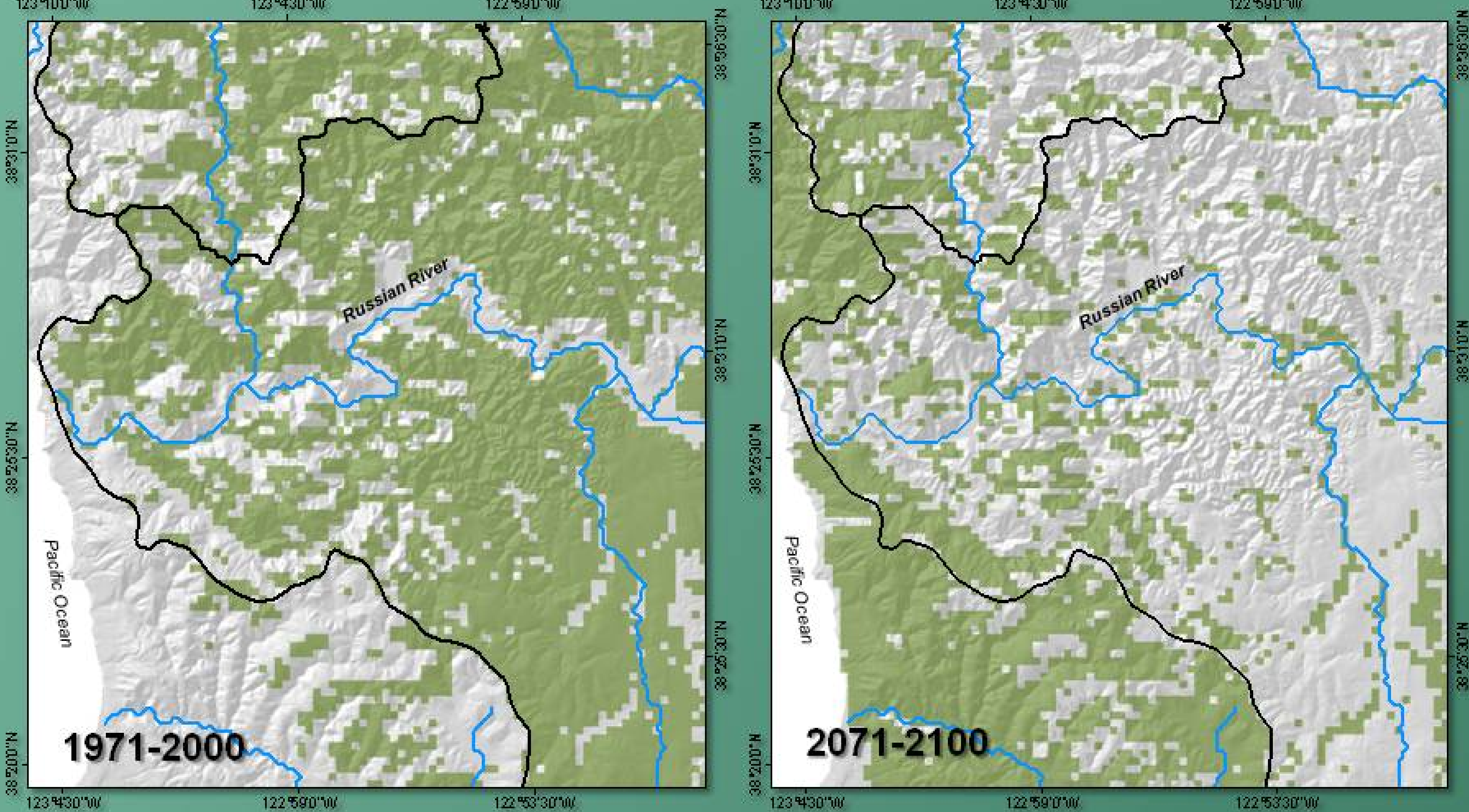




80% of cells for current conditions within 640-800 mm/yr

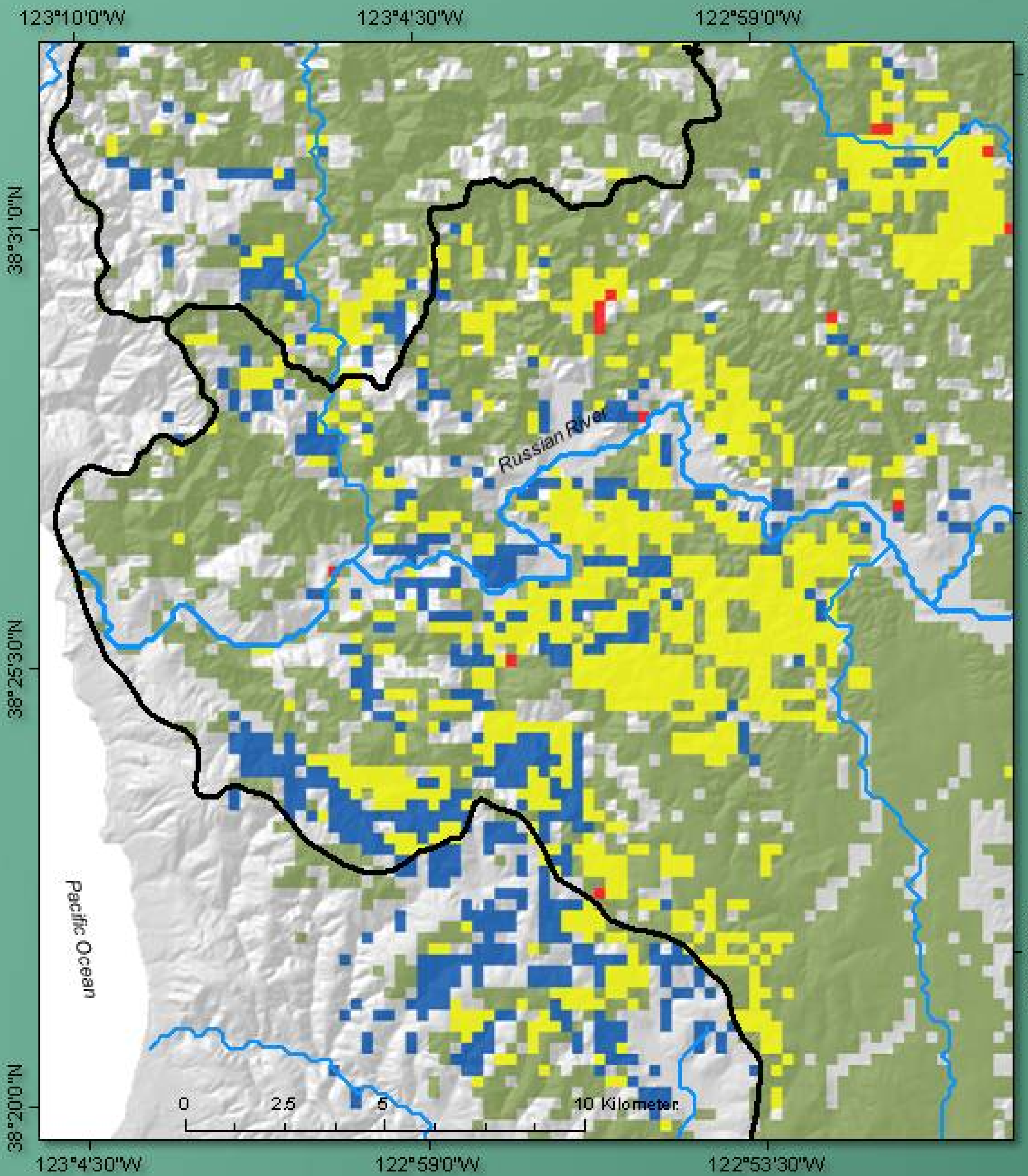
Map Courtesy of Bay Area Open Space Council

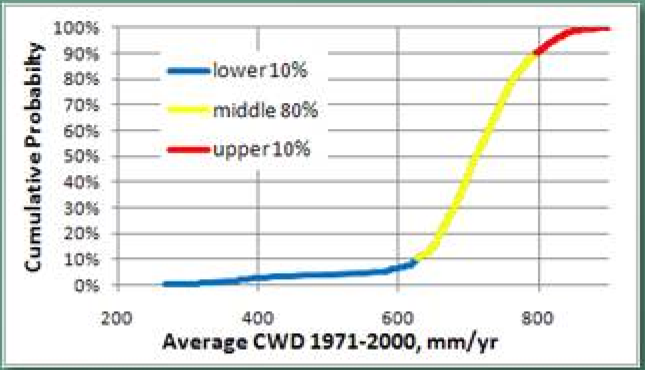
Russian River Valley Climatic Water Deficit



Suitable CWD

Russian River Valley Distribution of Redwoods





Suitable CWD

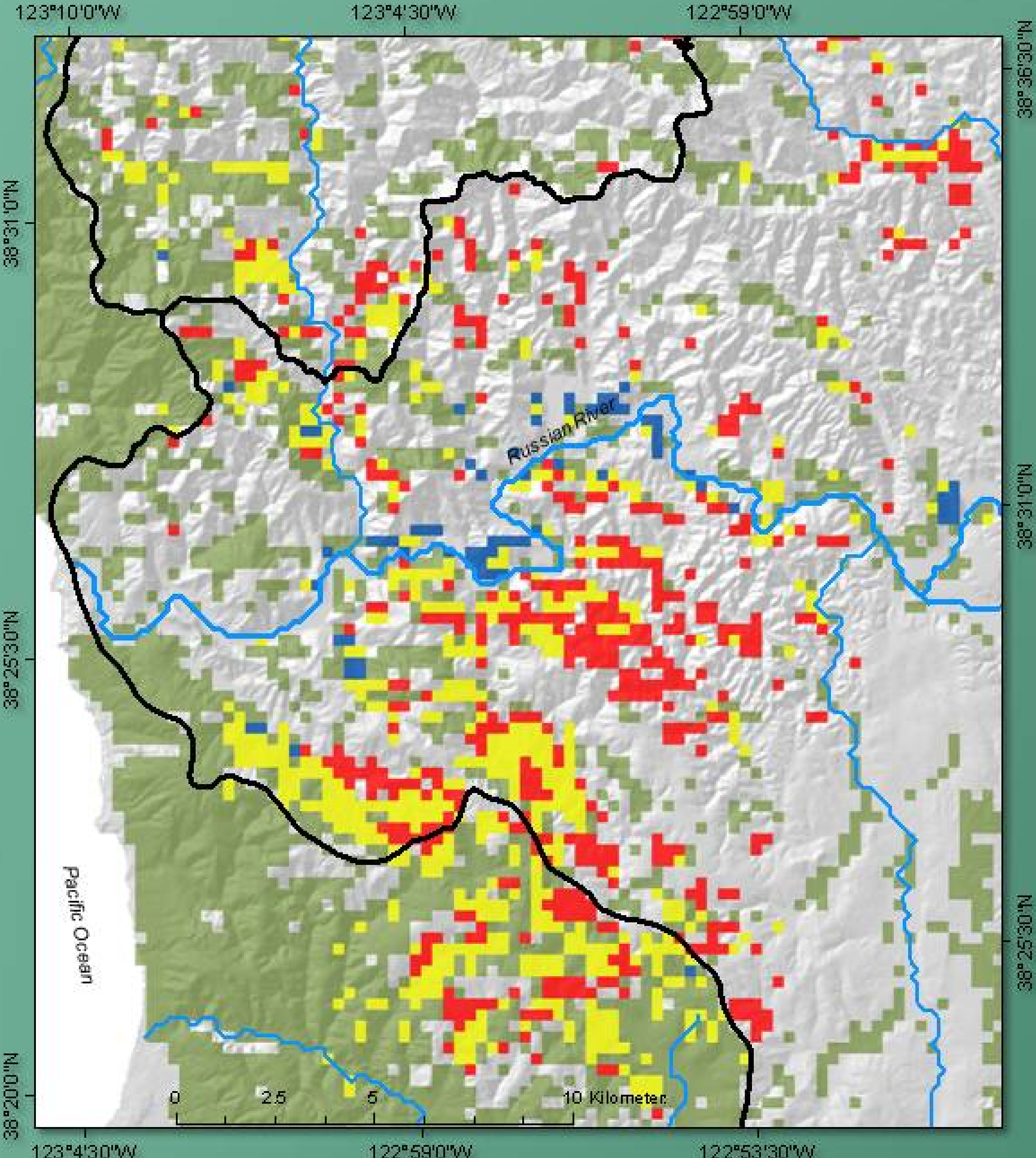
lower 10% (270-640 mm/yr)

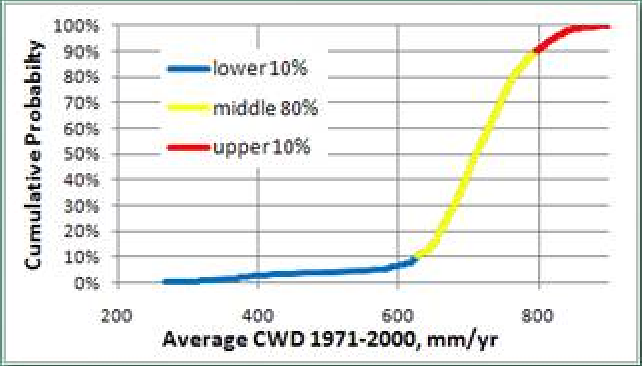
middle 80% (640-800 mm/yr)

upper 10% (800-900 mm/yr)

1971-2000

Russian River Valley and Distribution of Redwoods





Suitable CWD

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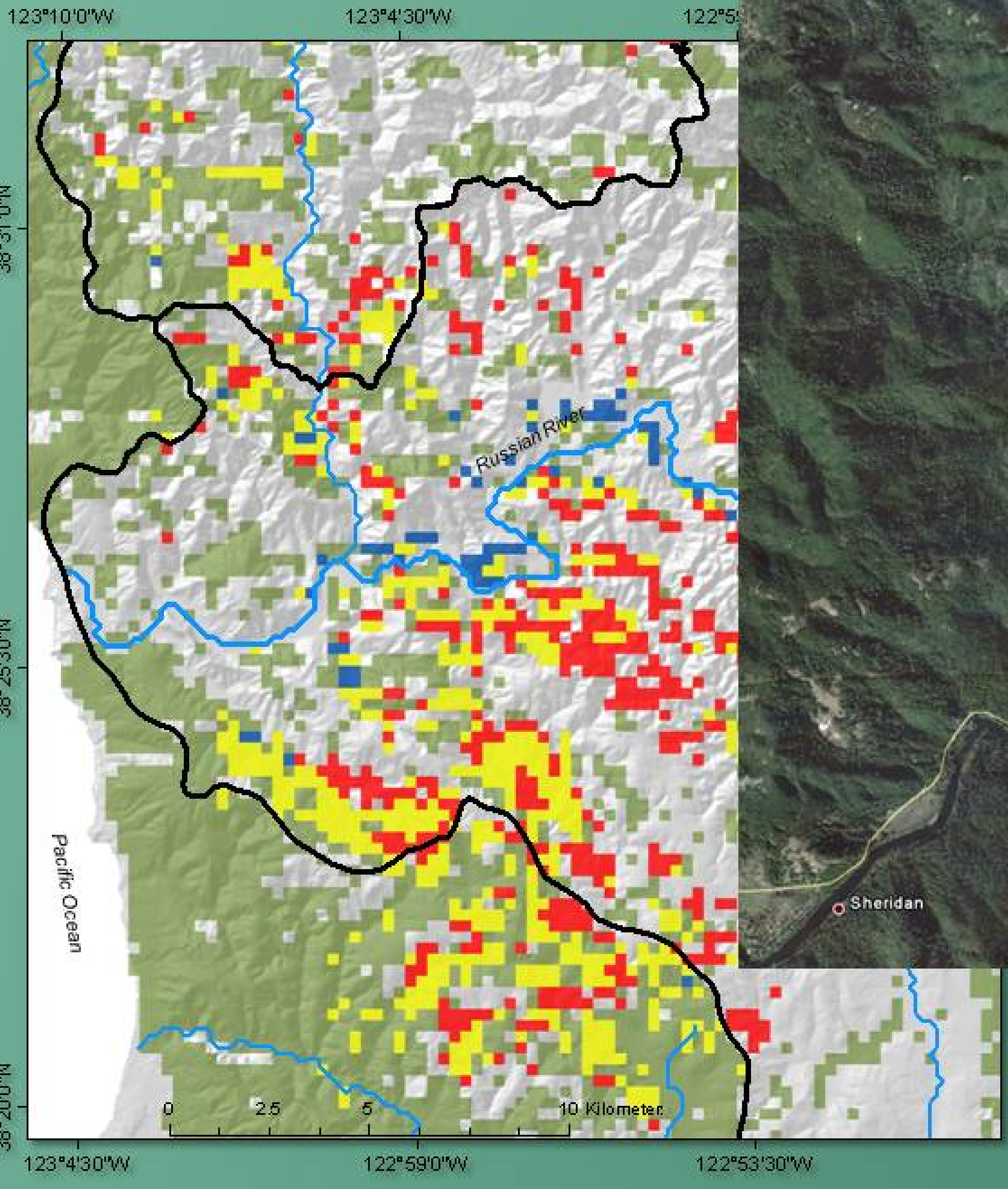
2071-2100
GFDL-A2

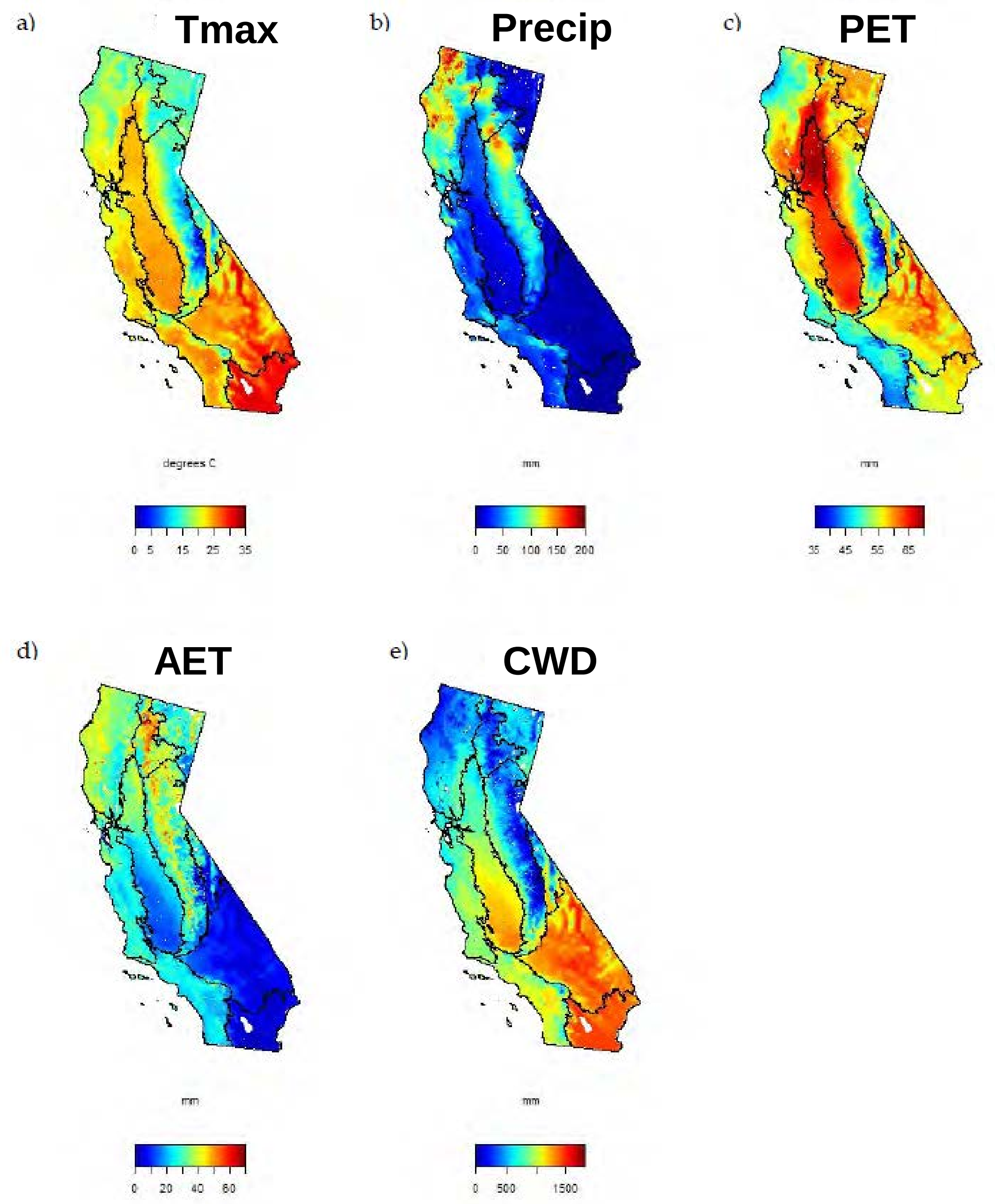
Russian River Valley and Distribution of Redwoods



2071-2100
GFDL-A2

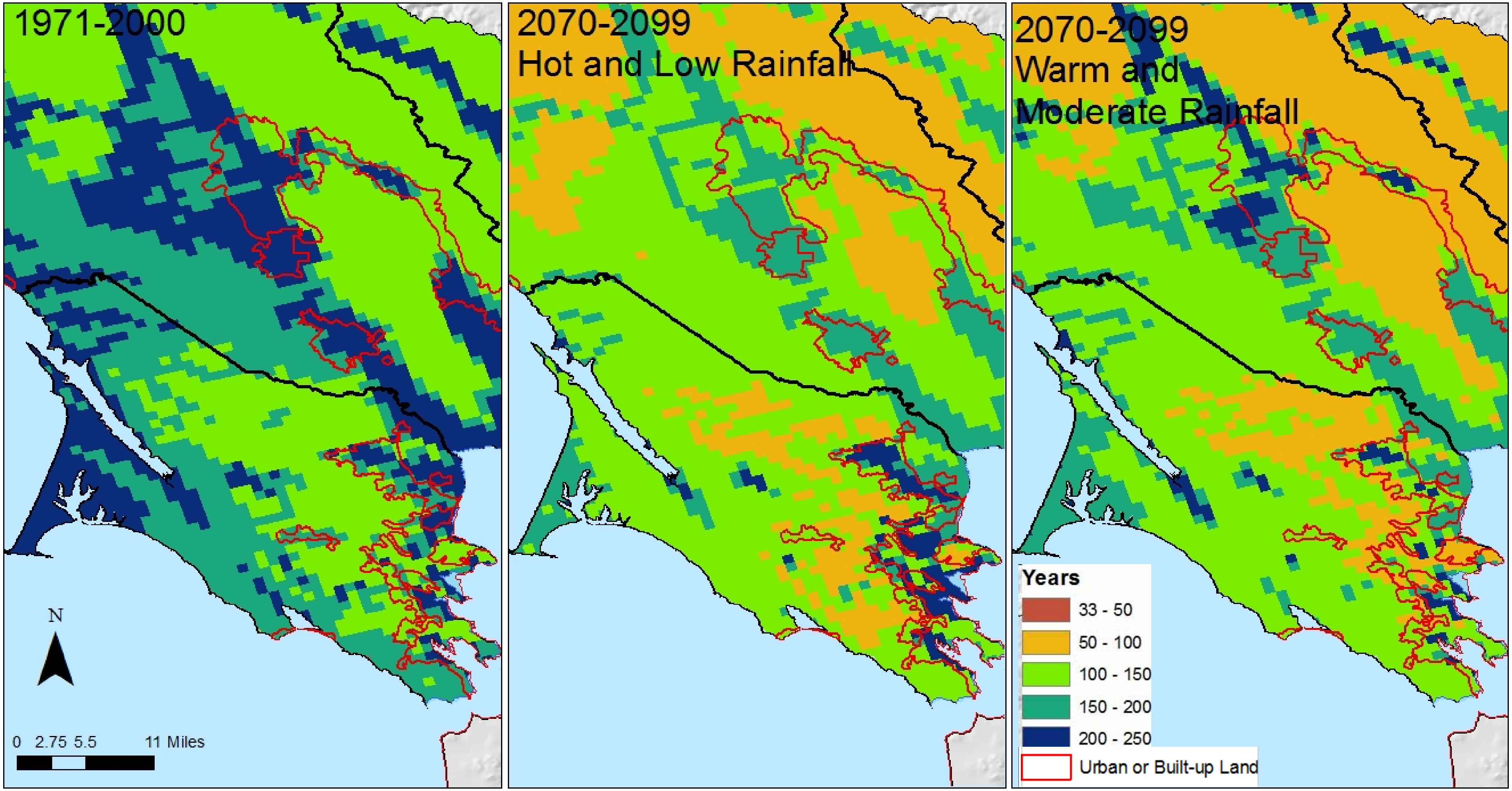
Applications: Projecting Wildfire

Spatial Patterns in Explanatory Climate Variables 1971–2000



Krawchuk and Moritz 2012 PIER report

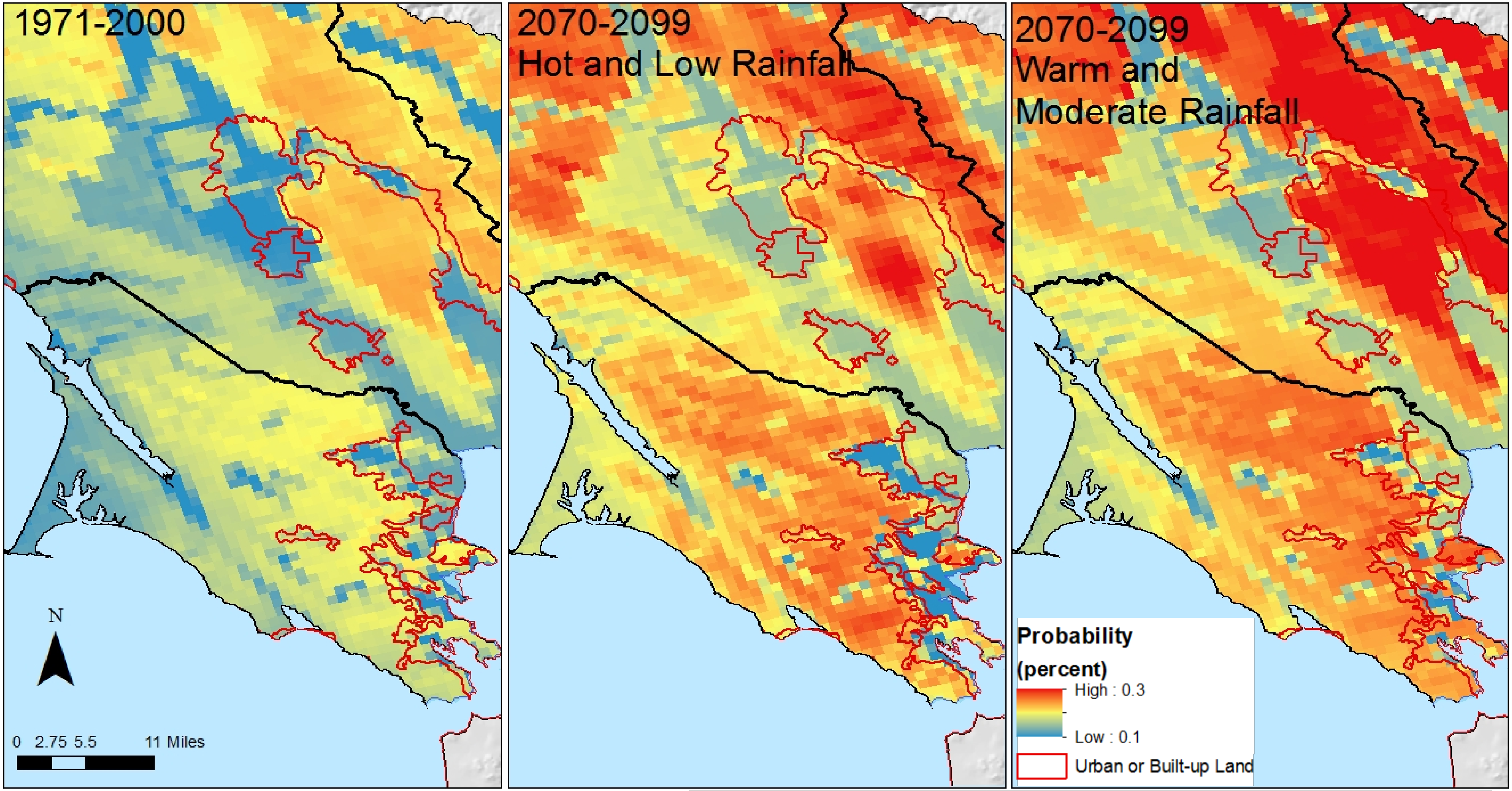
Change in Projected Fire Return Interval



Fire return intervals cut by approximately 25%

		Current	Hot, Low Rainfall	Moderate Rainfall
Variable	Units	1971-2000	2070-2099	2070-2099
Fire return interval	Years	175	152	127
	SD	42	145	35

Change in Projected Probability of Burning One or More Times



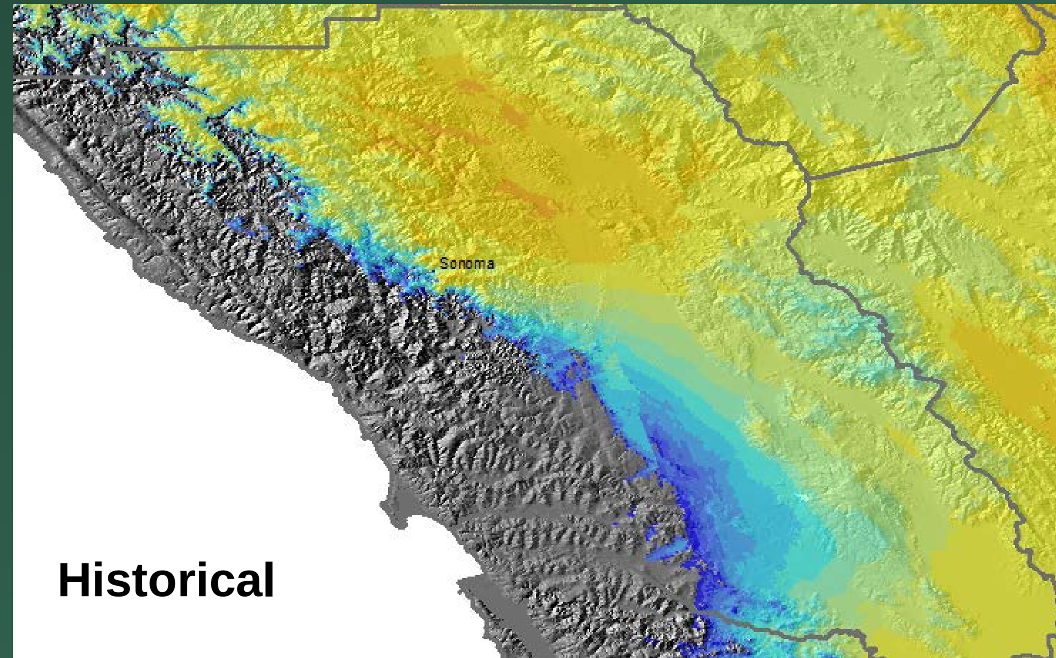
Probability of fire doubles in some locations

		Current	Hot, Low Rainfall	Moderate Rainfall
Variable	Units	1971-2000	2070-2099	2070-2099
Probability of burning 1	Percent	16%	21%	22%
or more times	SD	5%	7%	6%

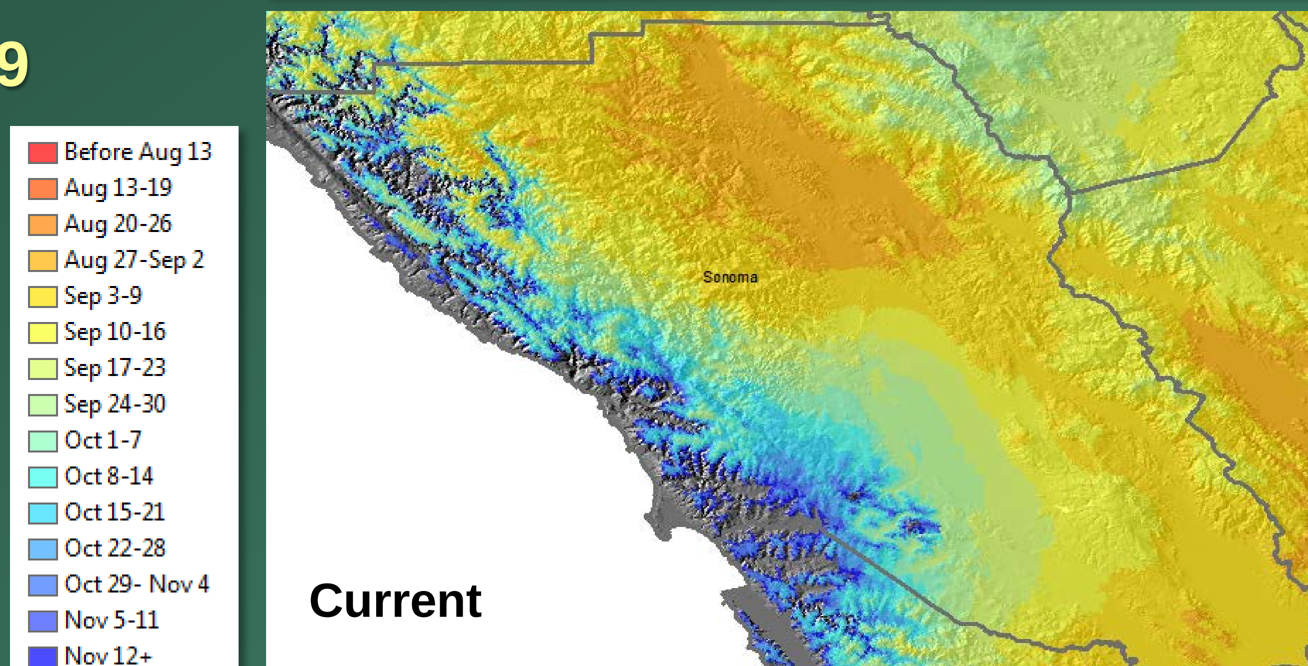
Mean Ripening Date

Group 5 1250 DD (Merlot, Sangiovese)

1971-2000



2000-2009



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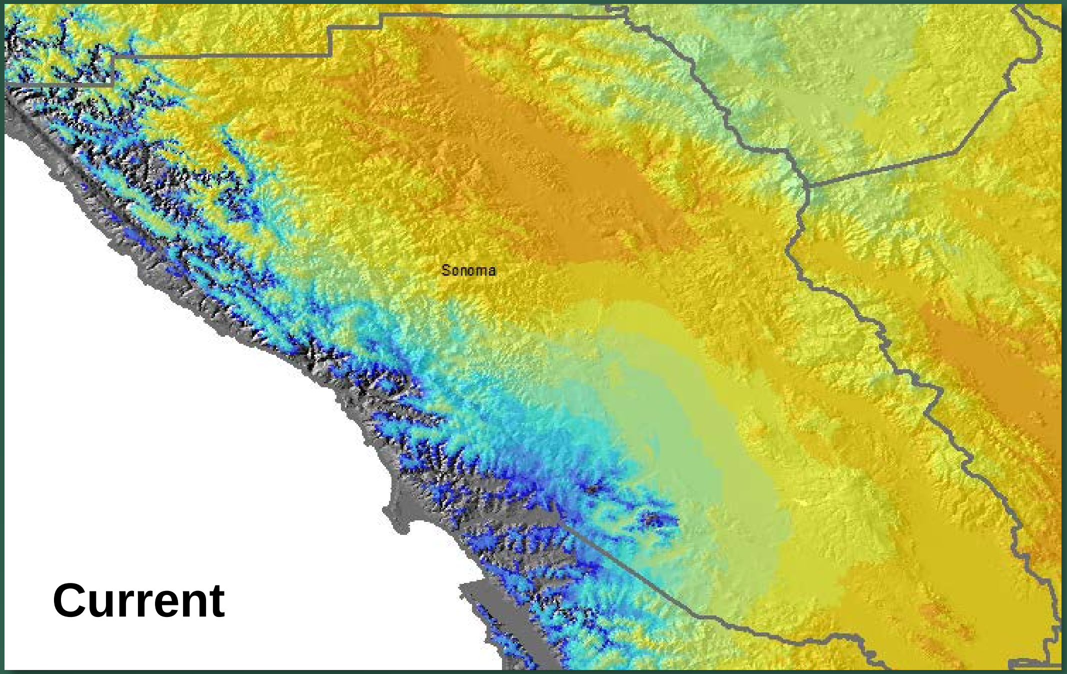
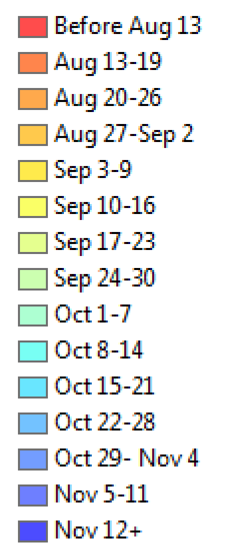
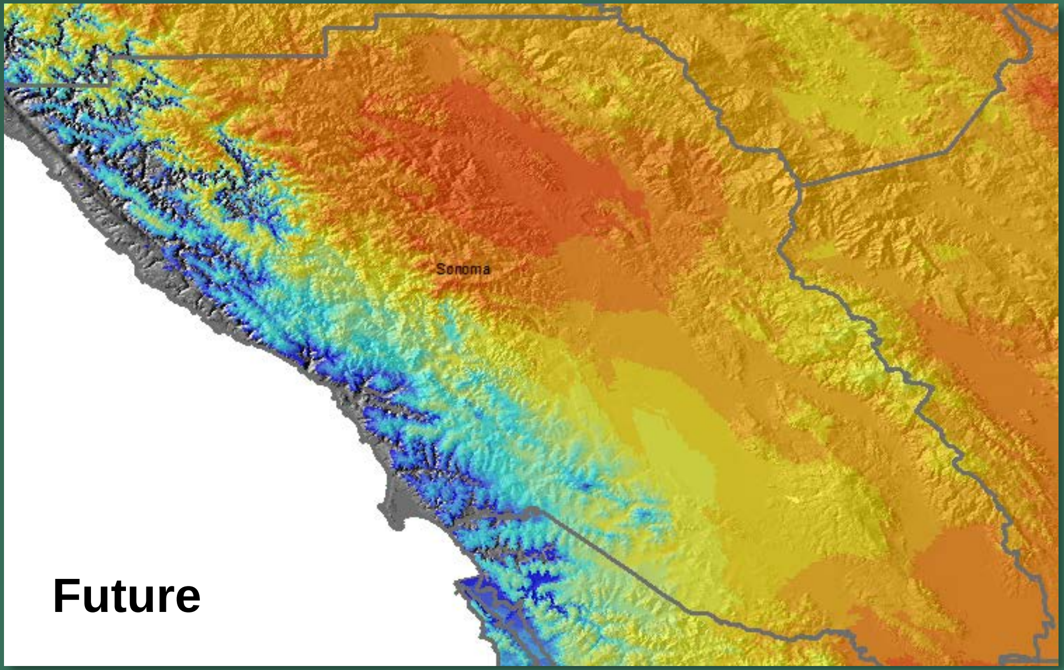
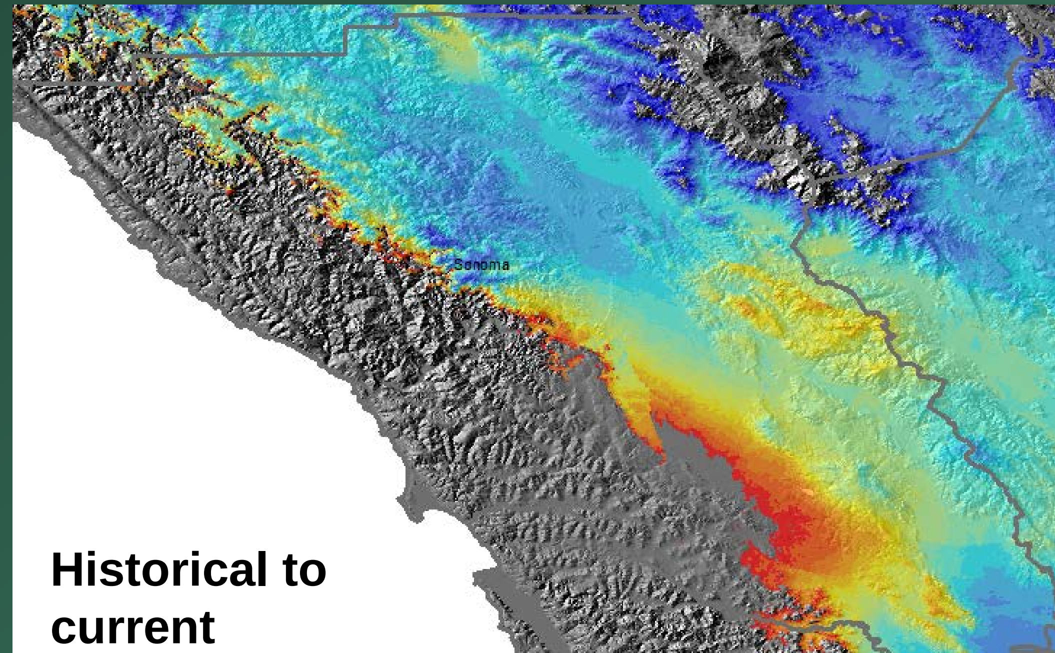


2025 GFDL-A2

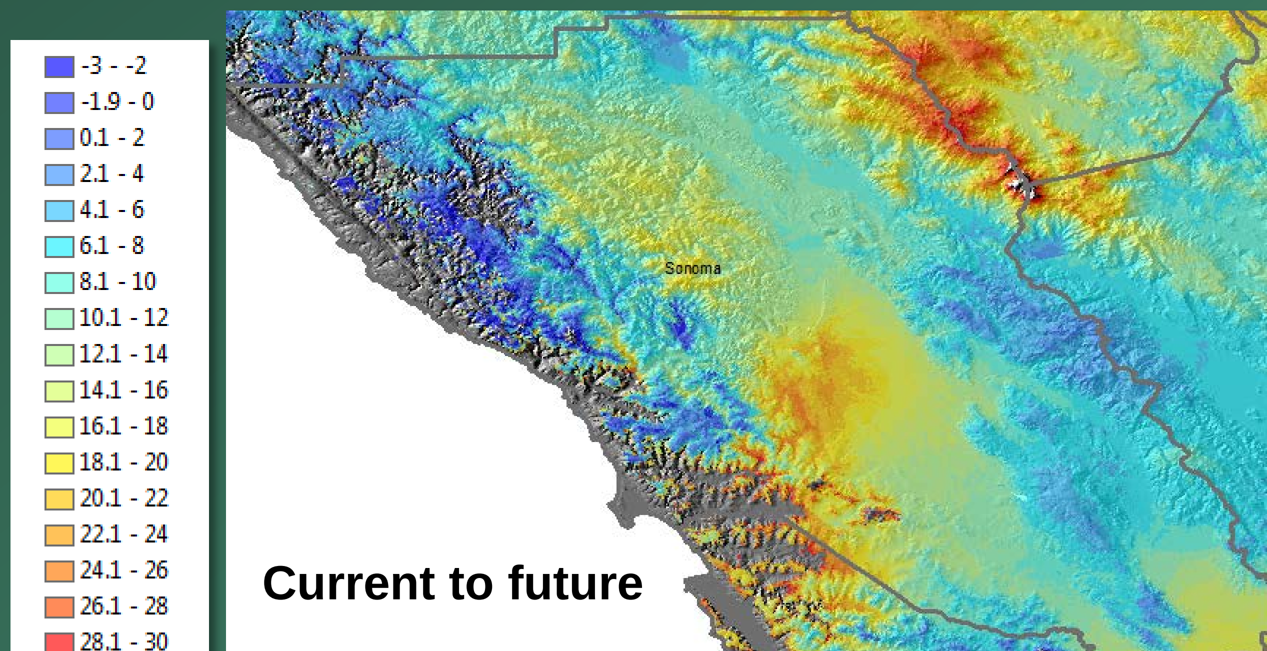




Group 5
Days Advancement
1971-2000 to 2000-2009

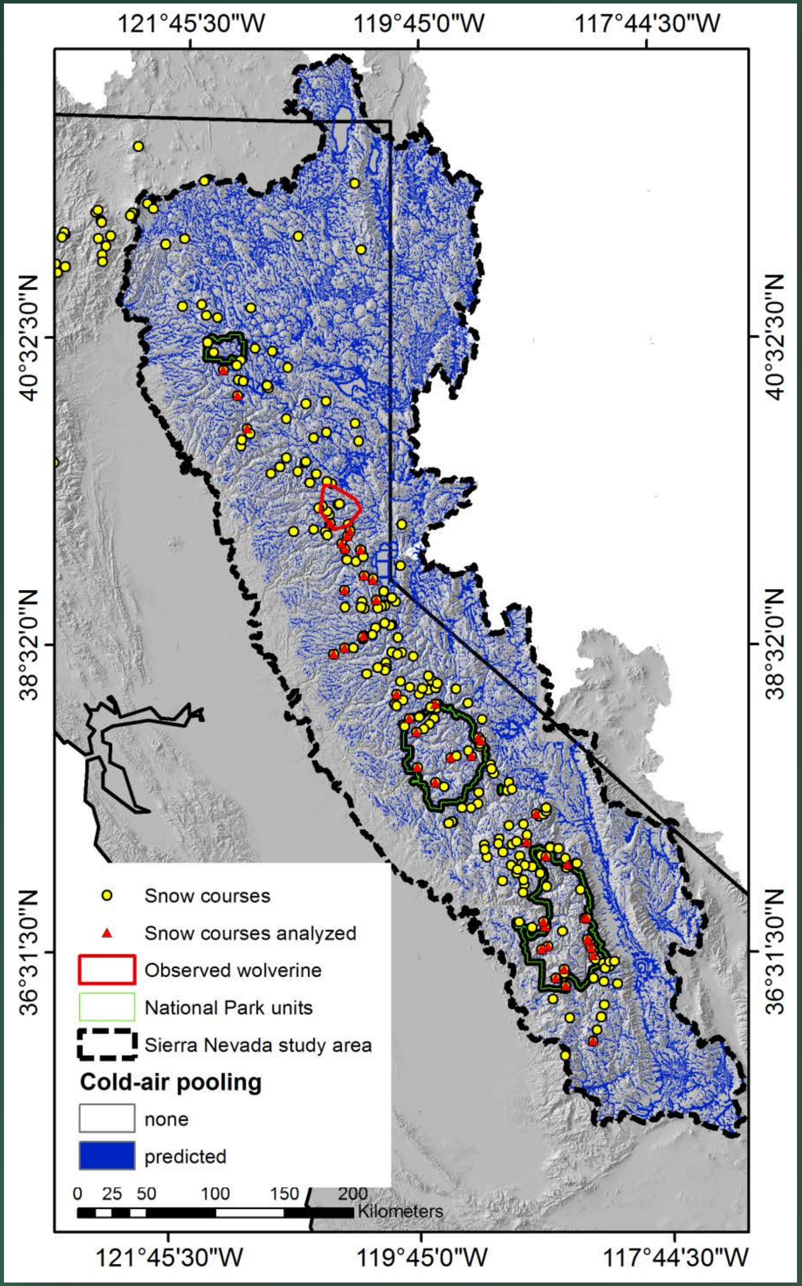


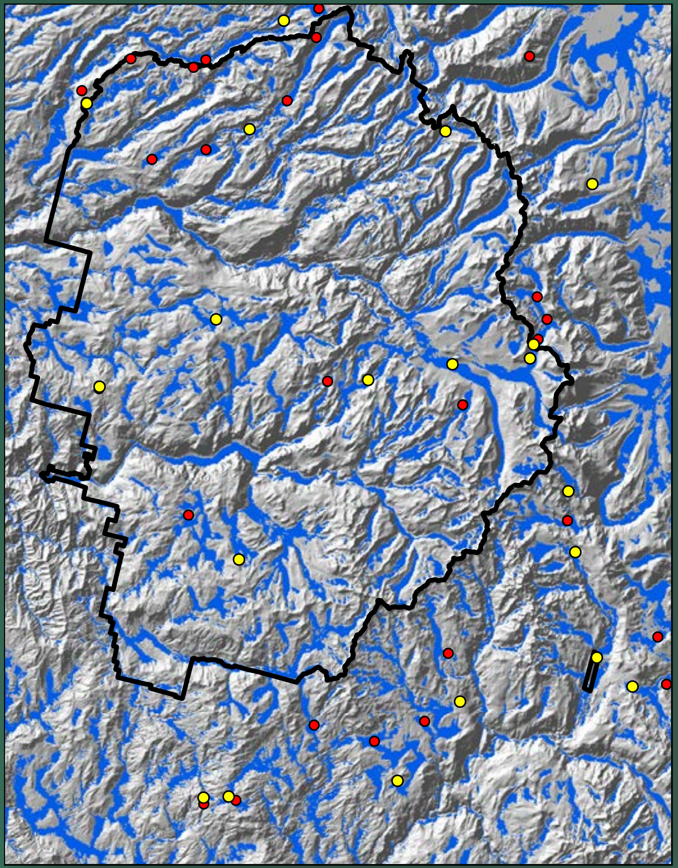
2000-2009 to 2025 GFDL-A2



Applications: Habitats and Refugia

Snow data to assess cold-air pooling

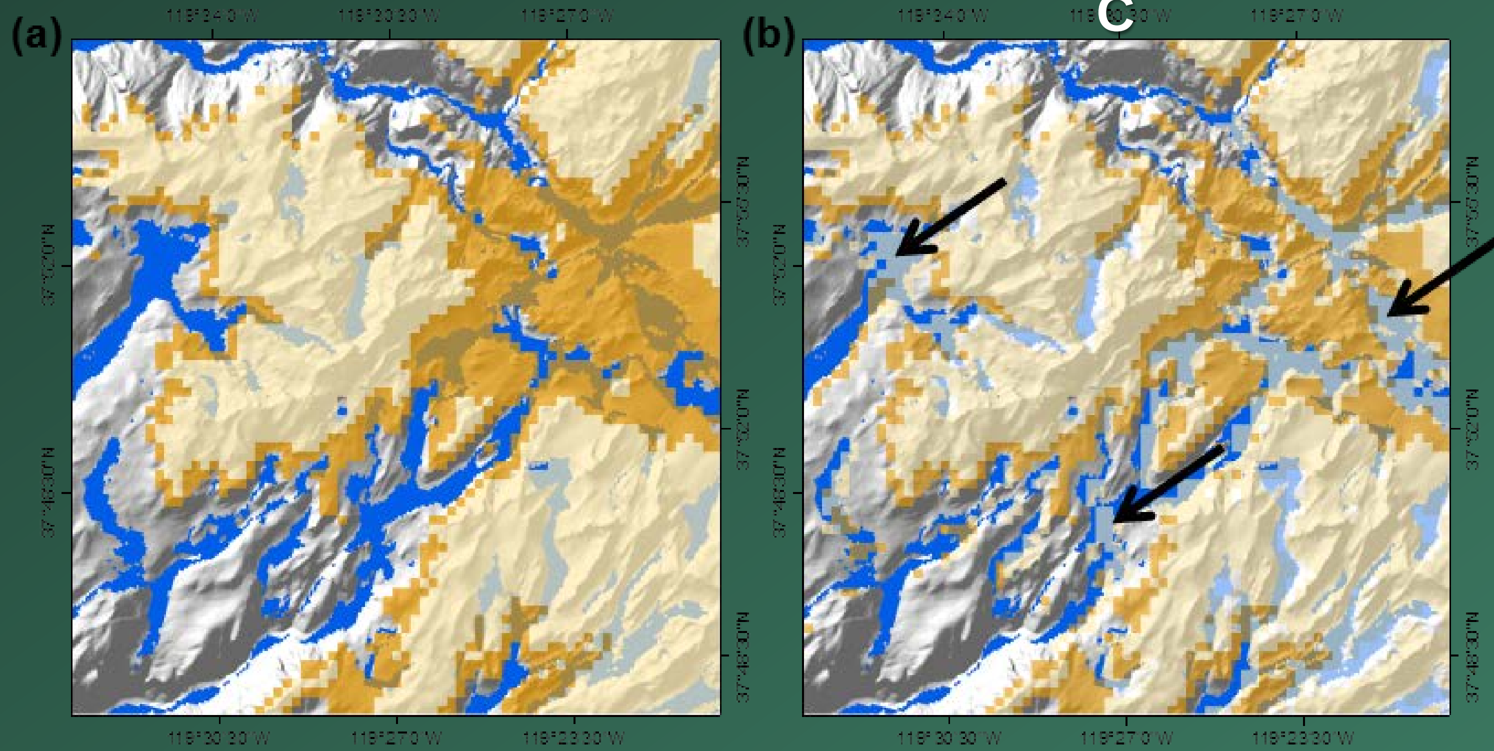




following Lundquist et al. 2008

No CAP

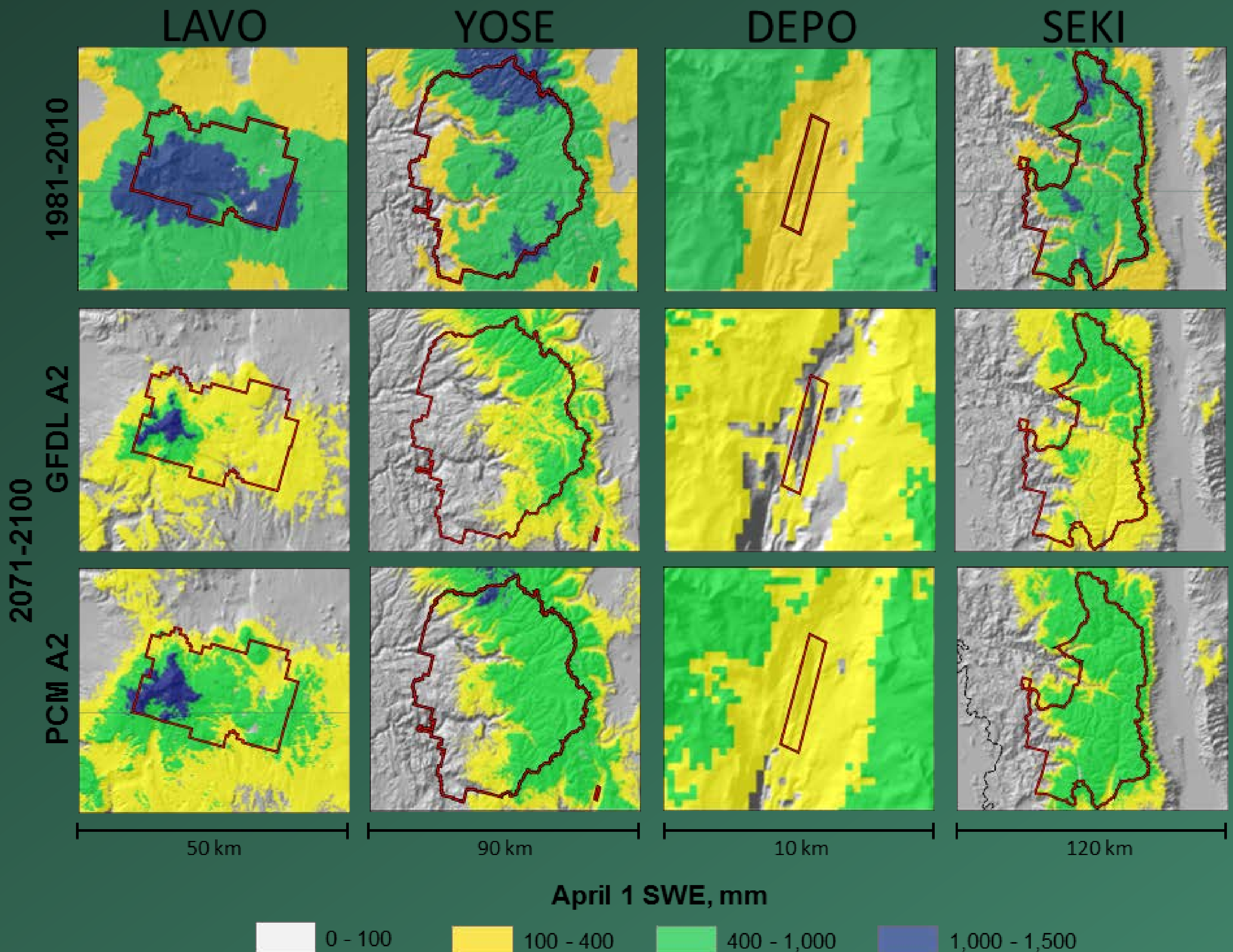
CAP simulated with temperature depression of 1.6 C



June 2001 GFDL A2

SWE (mm)

- 10 - 100
- 100 - 500
- 500 - 1,000
- Cold-air pooling


LAVO
YOSE
DEPO
SEKI
1981-2010
2071-2100
GFDL A2
PCM A2
50 km
90 km
10 km
120 km
April 1 SWE, mm
0 - 100
100 - 400
400 - 1,000
1,000 - 1,500

Even under the most pessimistic projections and restrictive population models sufficient habitat is expected to remain through the end of the 21st century to support a viable wolverine population following a successful reintroduction program.

Fine-Scale Applications for Landscapes

- Changes in tree diameter and density:
  - McIntyre et al. 2015 Proc. Nat. Acad. Sciences.
- Recruitment patterns of high elevation pines:
  - Millar et al., 2015 PACLIM
- Severity and distribution of Aspen die-off:
  - Anderegg et al., 2015 Nature GeoScience
- Magnitude and patterns of hydrologic change in CA:
  - Thorne et al., 2015 Ecosphere
- Geographic range limits of Pinus Coulteri:
  - Chardon et al. 2014 Ecography
- Climatic stress and forest fire severity western US:
  - van Mantgem et al., 2013 Ecology Letters
- Climate-related tree mortality:
  - Das et al., 2013 PLoS ONE
- Conservation of vegetation in urban environment:
  - Beltran et al., 2013 Geographical Info Sci
- Forest mortality in whitebark pine:
  - Millar et al 2012 Can J Forest Research
- Oak genetics and resilience for adaptation:
  - Sork et al. 2011 Molecular Ecology