Climate science for adaptation in the North Bay Region

Inter-tribal Climate Adaptation Leadership Summit

Graton Rancheria

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Lauren Casey, Regional Climate Protection Authority

Pepperwood PRESERVE
Inspiring conservation through science

rcpa
REGIONAL CLIMATE PROTECTION AUTHORITY

Outline

What is Pepperwood and what's our role in local climate adaptation and engaging TEK?

Where do climate projections come from?

Sample regional and local results, and applications to real world questions

Sonoma County's Regional Climate Protection Authority and community adaptation planning

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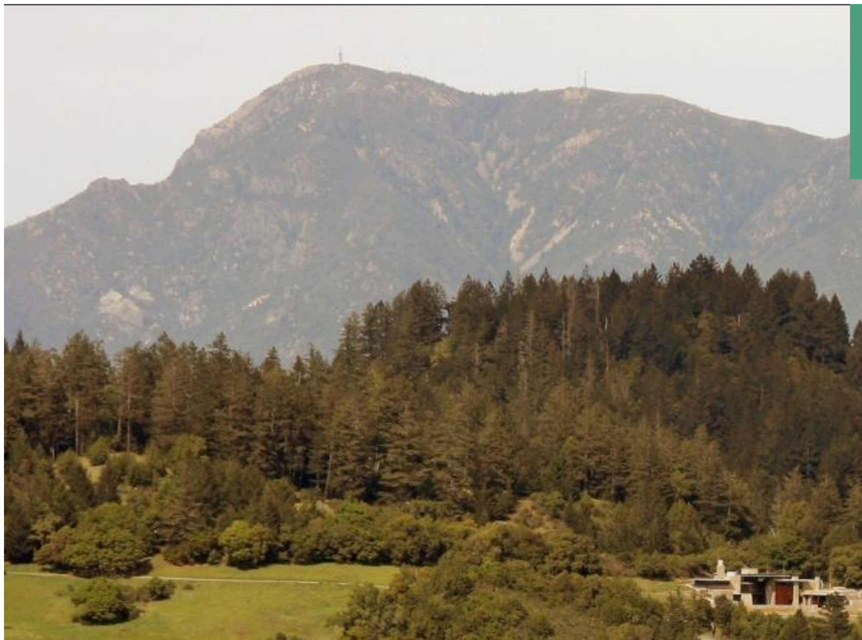
Pepperwood Mission: advance science-based conservation science across our region and beyond



3200-acre reserve in Mayacamas, partnered with CA Academy of Sciences

The new Dwight Center for Conservation Science

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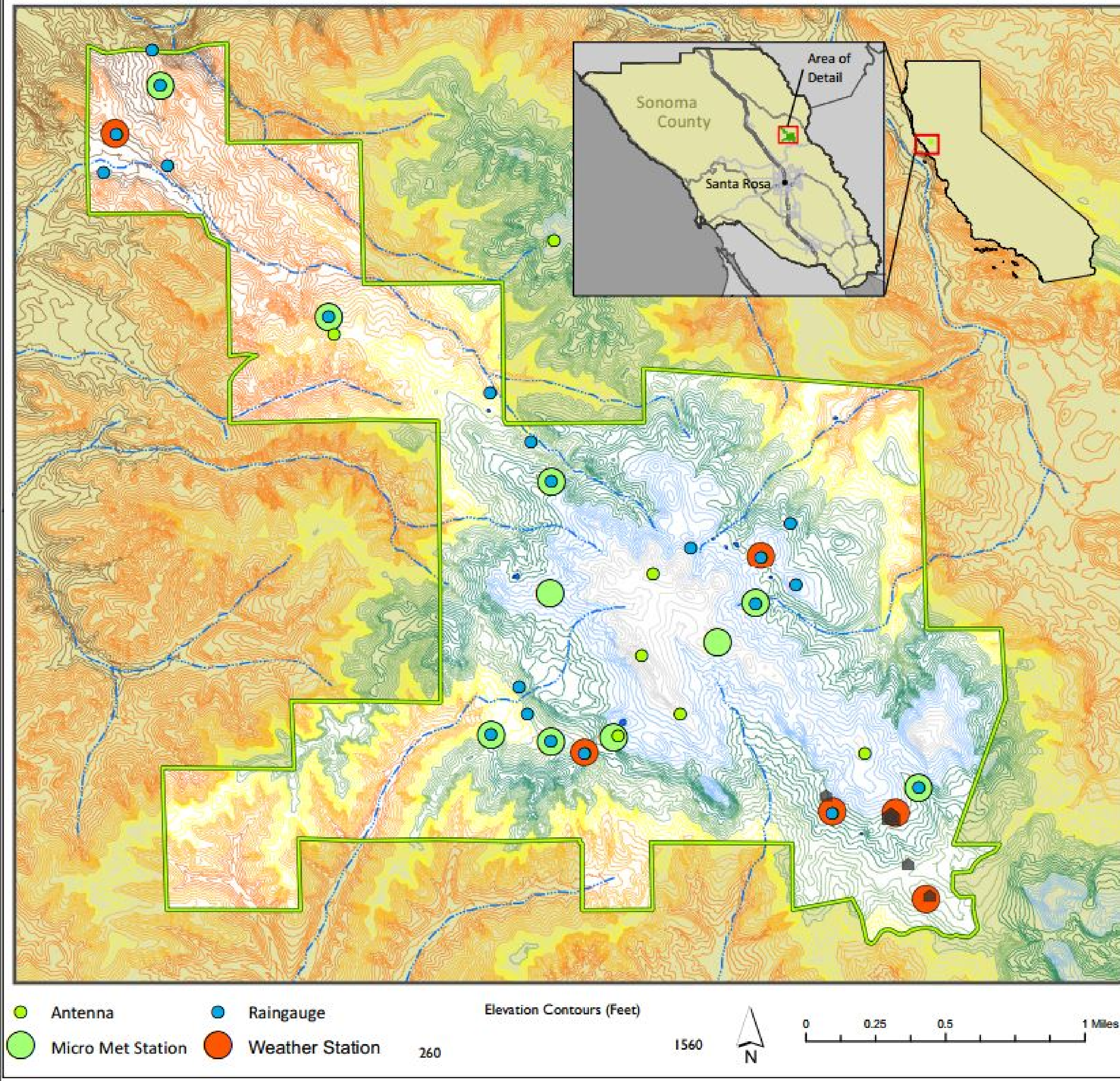
Topography and Climate Monitoring at Pepperwood, Sonoma County California



TBC3

Terrestrial Biodiversity Climate Change Collaborative

Pepperwood Preserve – Inspiring conservation through science

Berkeley – University of California

Bridging science and climate adaptation for natural resources

USGS – science for a changing world

CA.gov

The California Energy Commission

Gordon and Betty Moore Foundation

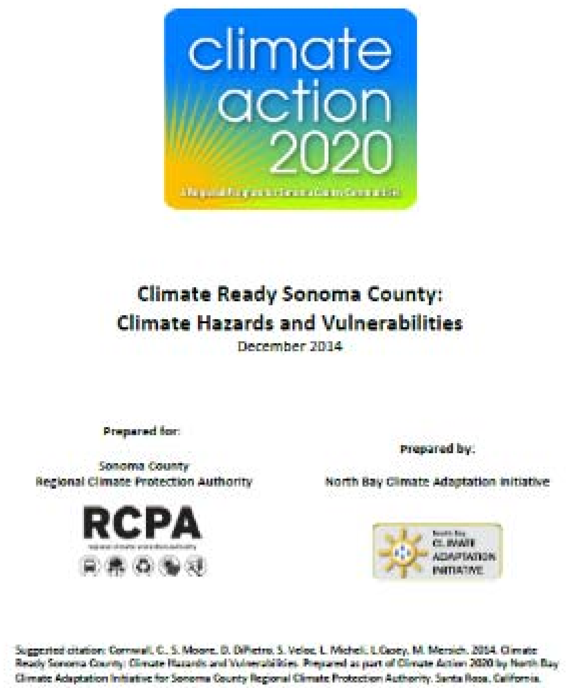
Bay Area Open Space Council

Creekside Center for Earth Observation

Point Blue Conservation Science

Pepperwood Native Advisory Council

Two sets of reports available on line summarizing data presented today


climate action 2020

Climate Ready Sonoma County:
Climate Hazards and Vulnerabilities
December 2014

Prepared for:
Sonoma County
Regional Climate Protection Authority

RCPA

Prepared by:
North Bay Climate Adaptation Initiative

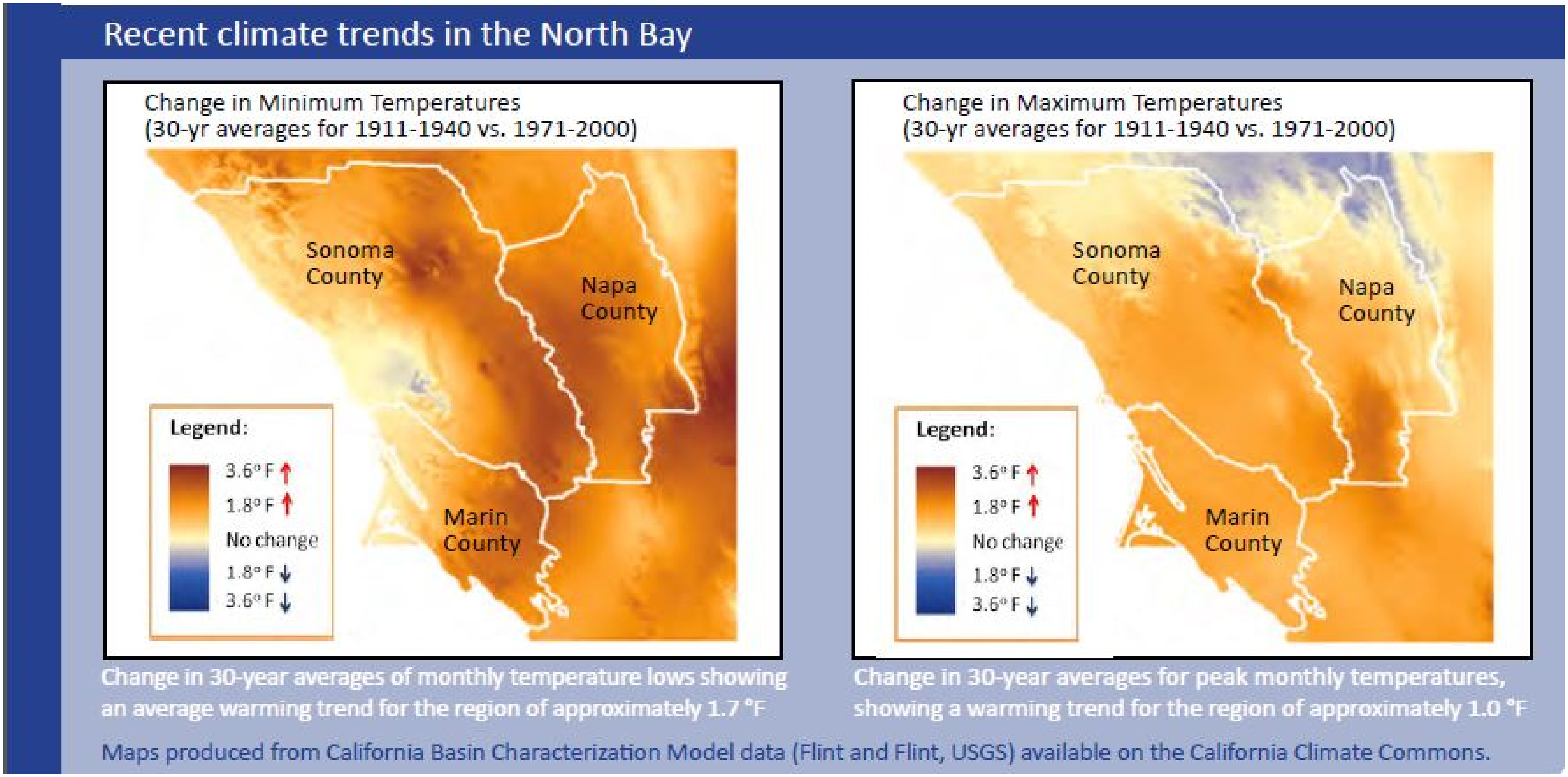
Suggested citation: Cornwall, C., S. Moore, D. DiPietro, S. Veloz, L. Micheli, L.Casey, M. Mersich. 2014. Climate Ready Sonoma County: Climate Hazards and Vulnerabilities. Prepared as part of Climate Action 2020 by North Bay Climate Adaptation Initiative for Sonoma County Regional Climate Protection Authority. Santa Rosa, California.

http://climate.calcommons.org/crnb/home

http://www.sctainfo.org/pdf/Climate%20Ready_Hazards_Vulnerabilities.pdf

Where do climate projections come from?

weather stations can already detect a warming trend in our local climate, especially in "minimum temperatures"



between 1911 and 2000, 1.0 degree F increase in summer temps and a 1.7 degree F increase in winter temps (averaged over 30 year periods)

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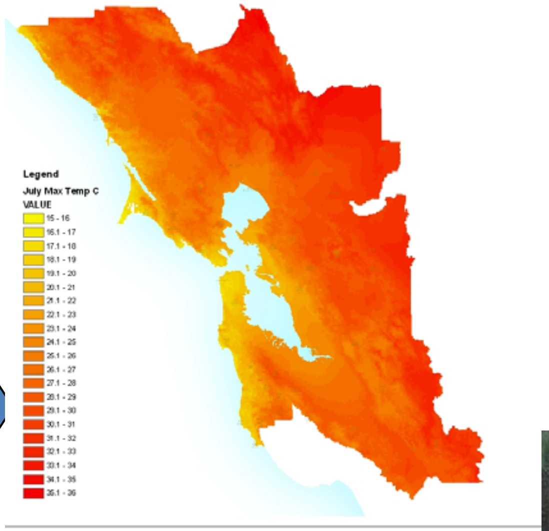
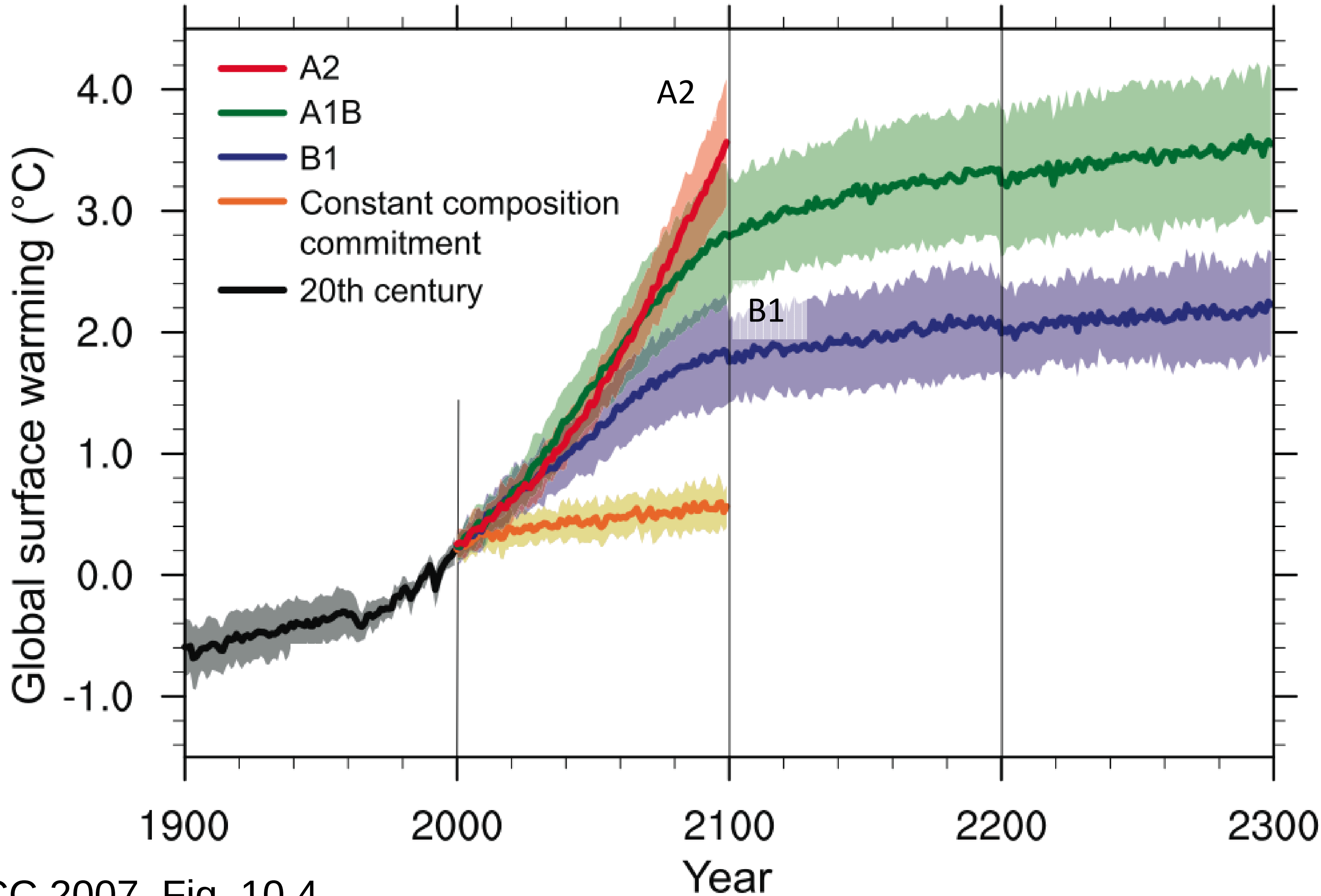
climate vulnerability



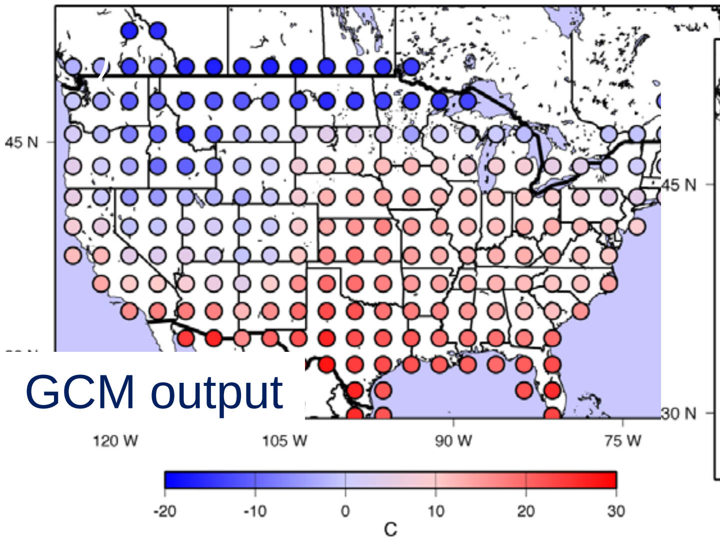
There is a consensus-based “library” of climate change models created by the Intergovernmental Panel on Climate Change (IPCC)--scientists from more than 200 United Nations’ member countries agreed!

Projections of future global temperature, IPCC assessment

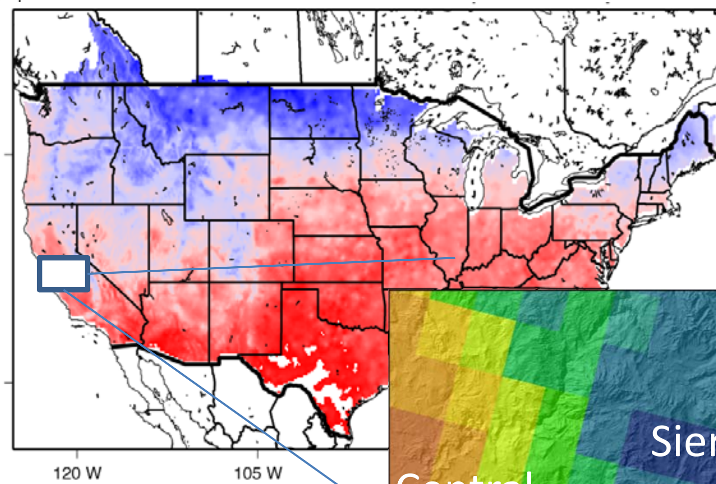


IPCC 2007, Fig. 10.4

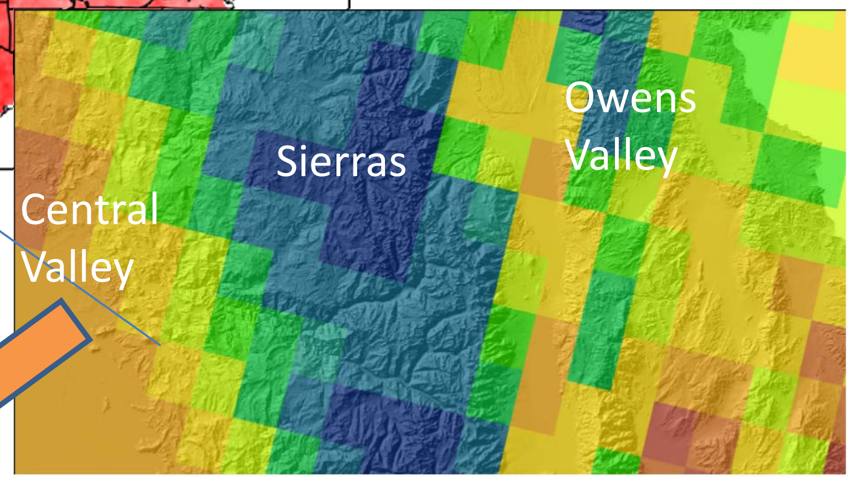
"downscaling" from Global Circulation Models (GCMs) to high resolution climate-hydro futures

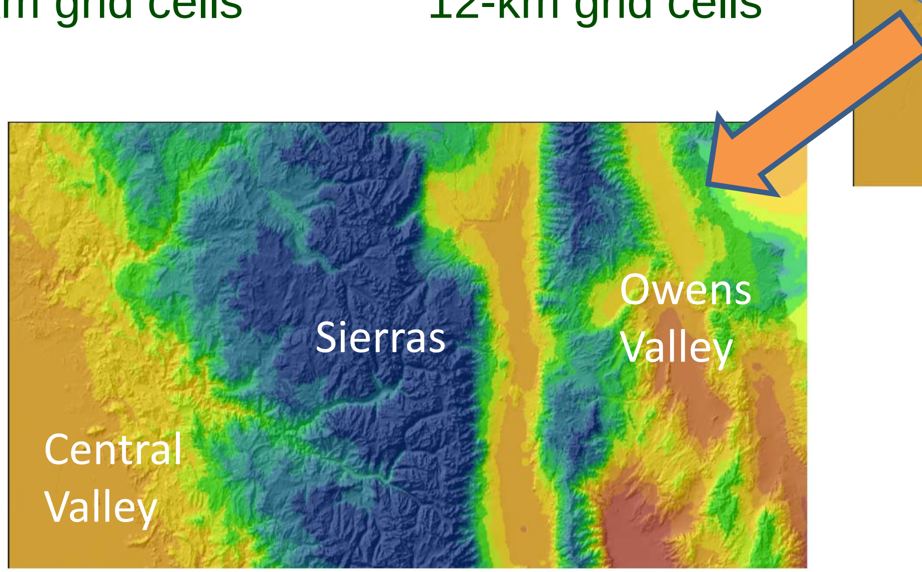


275 km grid cells



12-km grid cells





Downscaled to 270m grid cells

high-resolution data on watershed soils, geology and topography allow us to downscale to 18 acre "pixels" via the BCM

What kinds of questions can we answer with landscape-level data sets?

How much hotter is it going to get, and what will be the potential increase in frequency of heat and drought events?

What regions of the county will be most drought- or flood-prone?

How will stream flow and aquifer recharge be impacted?

Which floodplains and recharge areas should be protected to increase watershed resilience?

Where will fire risks be greatest, and how might fire frequency change?

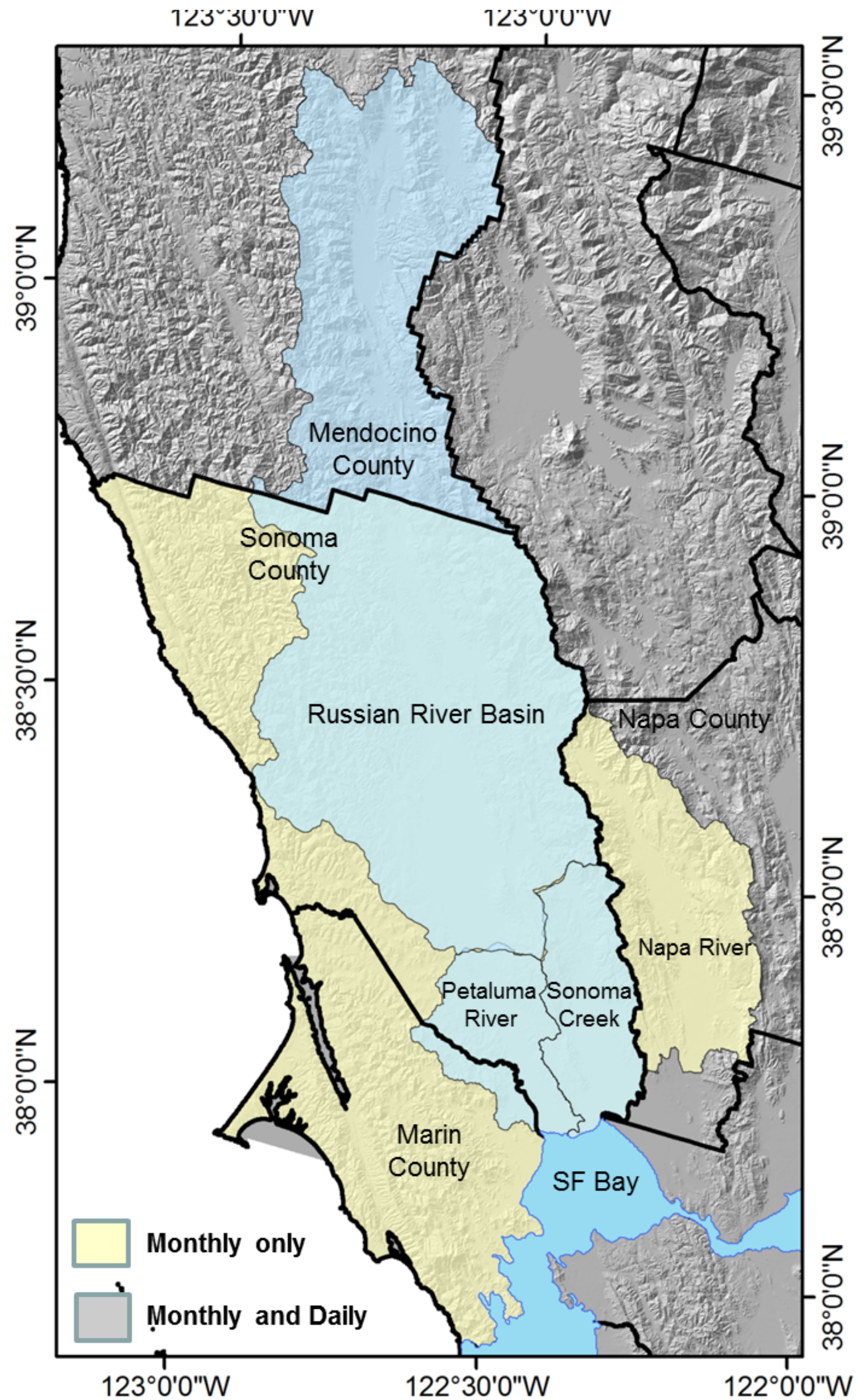
How will land suitability for agriculture, forestry or residential development be affected, and how much more water will be needed for irrigation due to higher temps?

North Bay CLIMATE ADAPTATION INITIATIVE

What do climate projections say about the future of Northern CA?

North Bay Climate Ready

assessed how climate impacts may play out across the North Bay landscape



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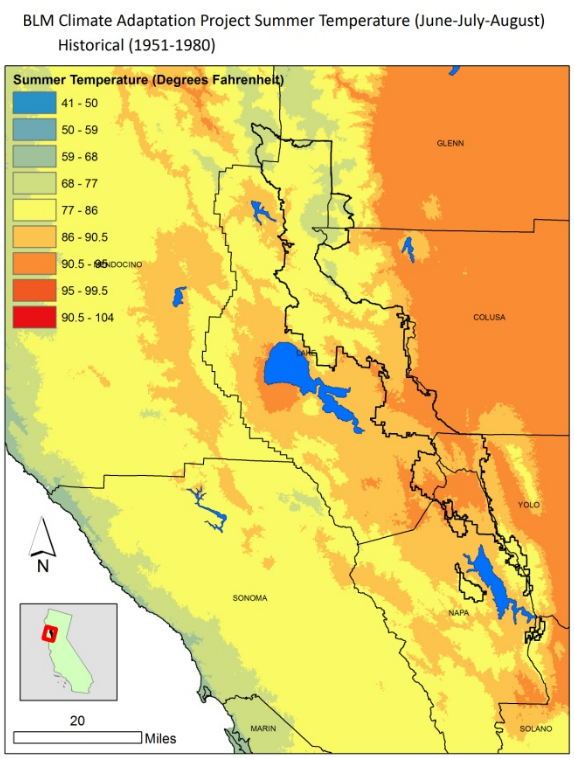
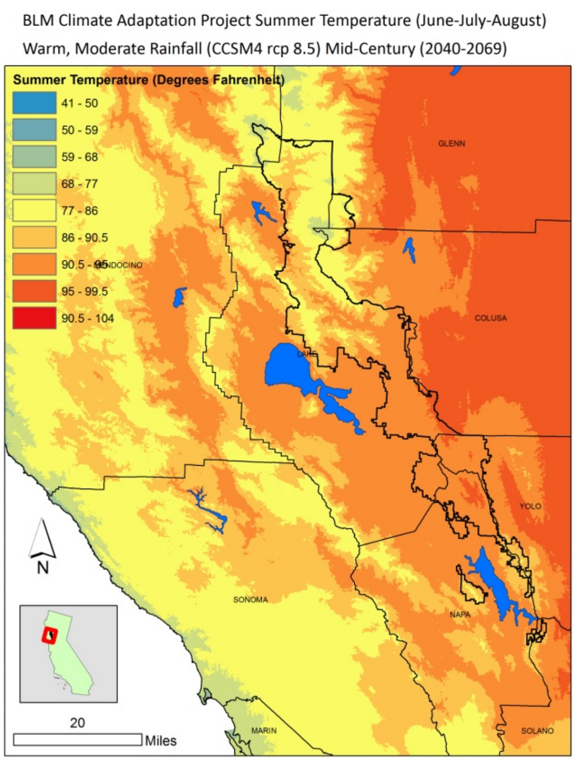
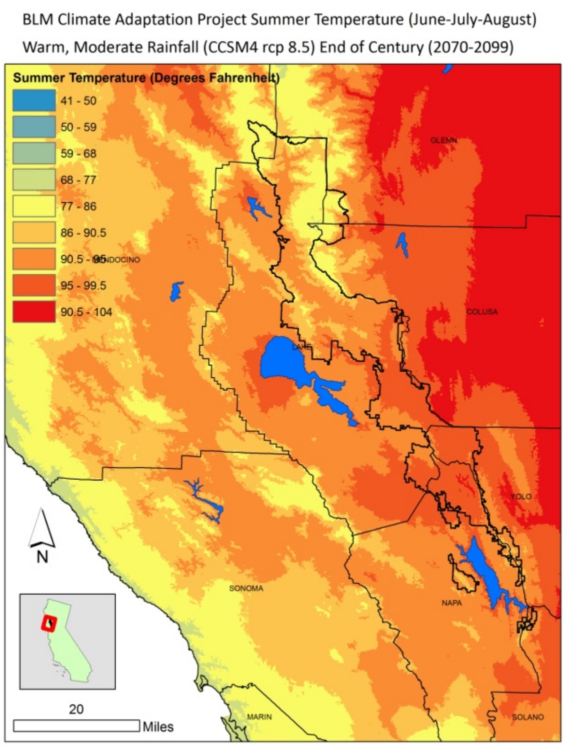
Temperatures are on the rise

increases on order of 4-7° by mid-century, 7-12°F by end (30 y)







1951-1980 2040-2069 2070-2099

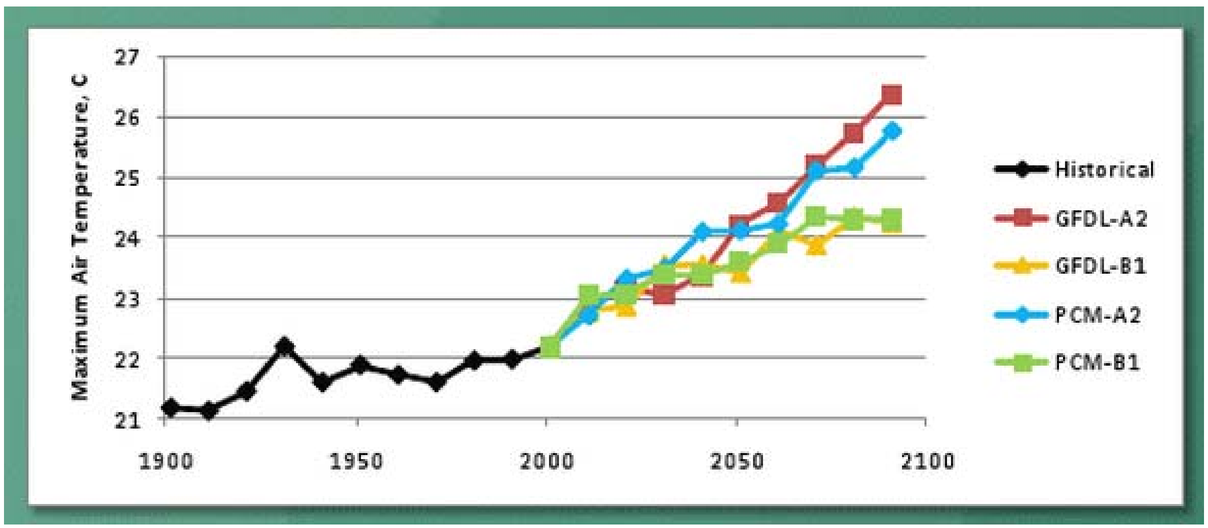
Confidence in direction of trend, uncertainty about how fast!

Local Climate

Warmer Environment

All of the climate models indicate warmer average temperatures across Sonoma County in the future

- Minimum temps rising faster than maximum temps
- Some areas are expected to cool slightly due to microclimates and other localized conditions

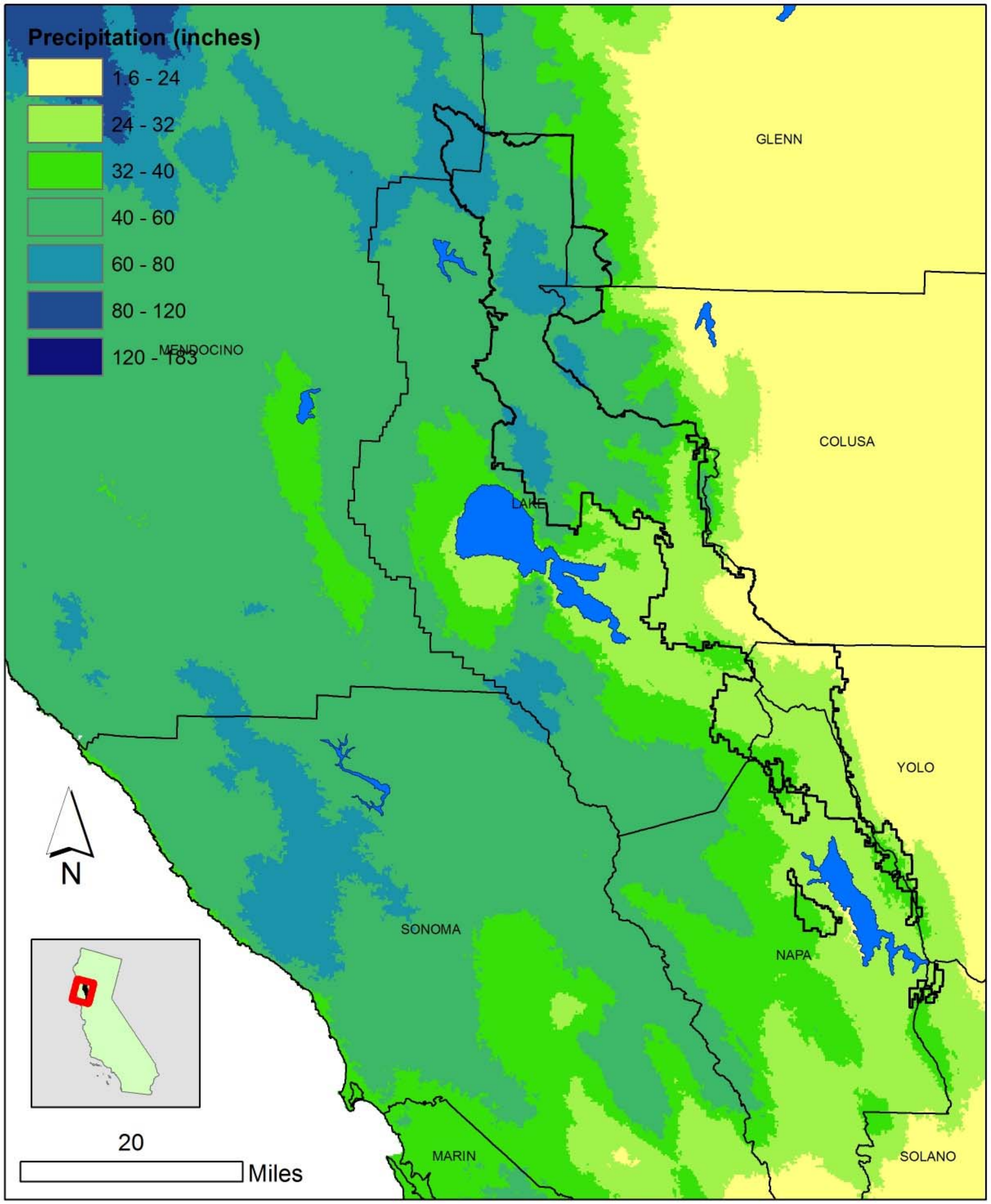


Model agreement on (4-7°F) warmer temps

Source: Alan and Lorraine Flint, USGS

BLM Climate Adaptation Project Precipitation

Historical (1951-1980)



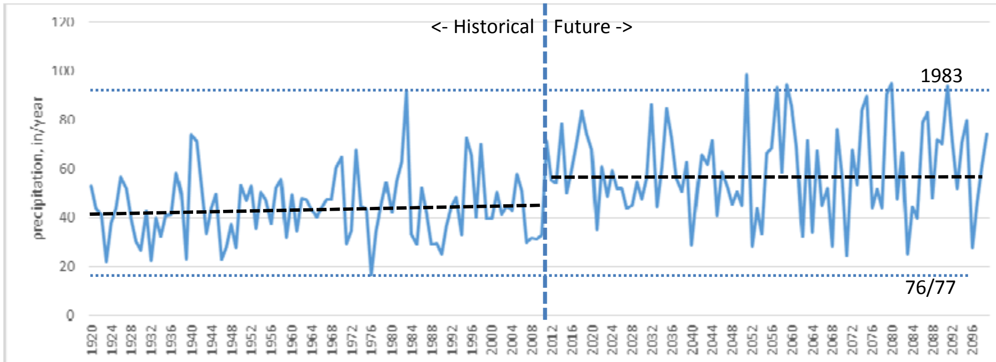
We don't know whether it's going to rain more or less....

+25% and -25% projected for 30 y averages ?

How might climate change impact the magnitude and frequency of water supply droughts?

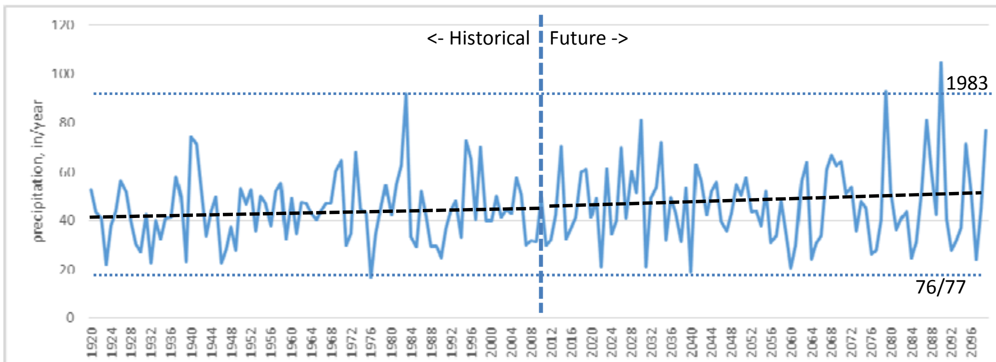
Average Historical
45 in/yr

Scenario 5
Warm &
High Rainfall



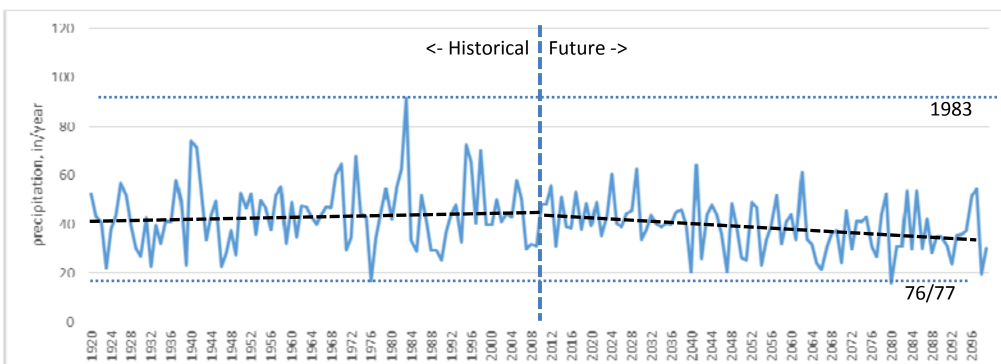
Warm & high rainfall future
Average 59 in/yr
5 yrs exceed historical max
3 yrs approach historical min

Scenario 3
Warm &
Moderate
Rainfall



Warm & mod rainfall future
Average 47 in/yr
2 yrs exceed historical max
4+ yrs approach historical min

Scenario 6
Hot &
Low Rainfall



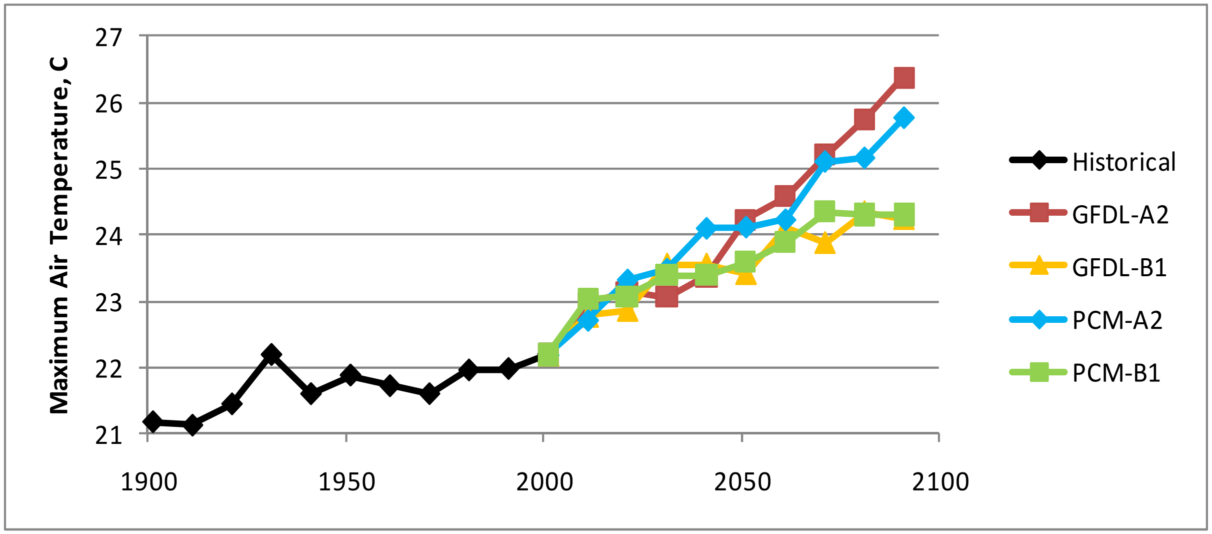
Hot and low rainfall future
Average 36 in/yr
No yrs approach historical max
5+ yrs approach historical min

Sonoma County Precipitation, 1920-2099

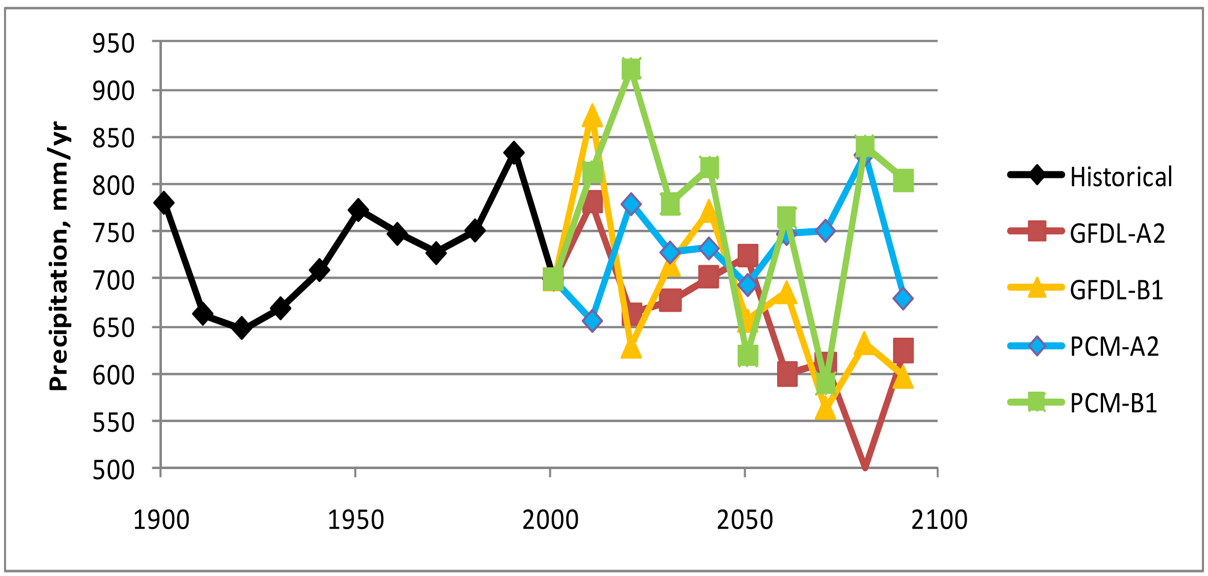
But rain is likely to be more variable year to year!

100% more flood years and 60% more drought years on average

Climate for Sonoma County
current and future conditions – 4 scenarios



average temperatures are projected to rise 3-6 degrees F by the close of this century

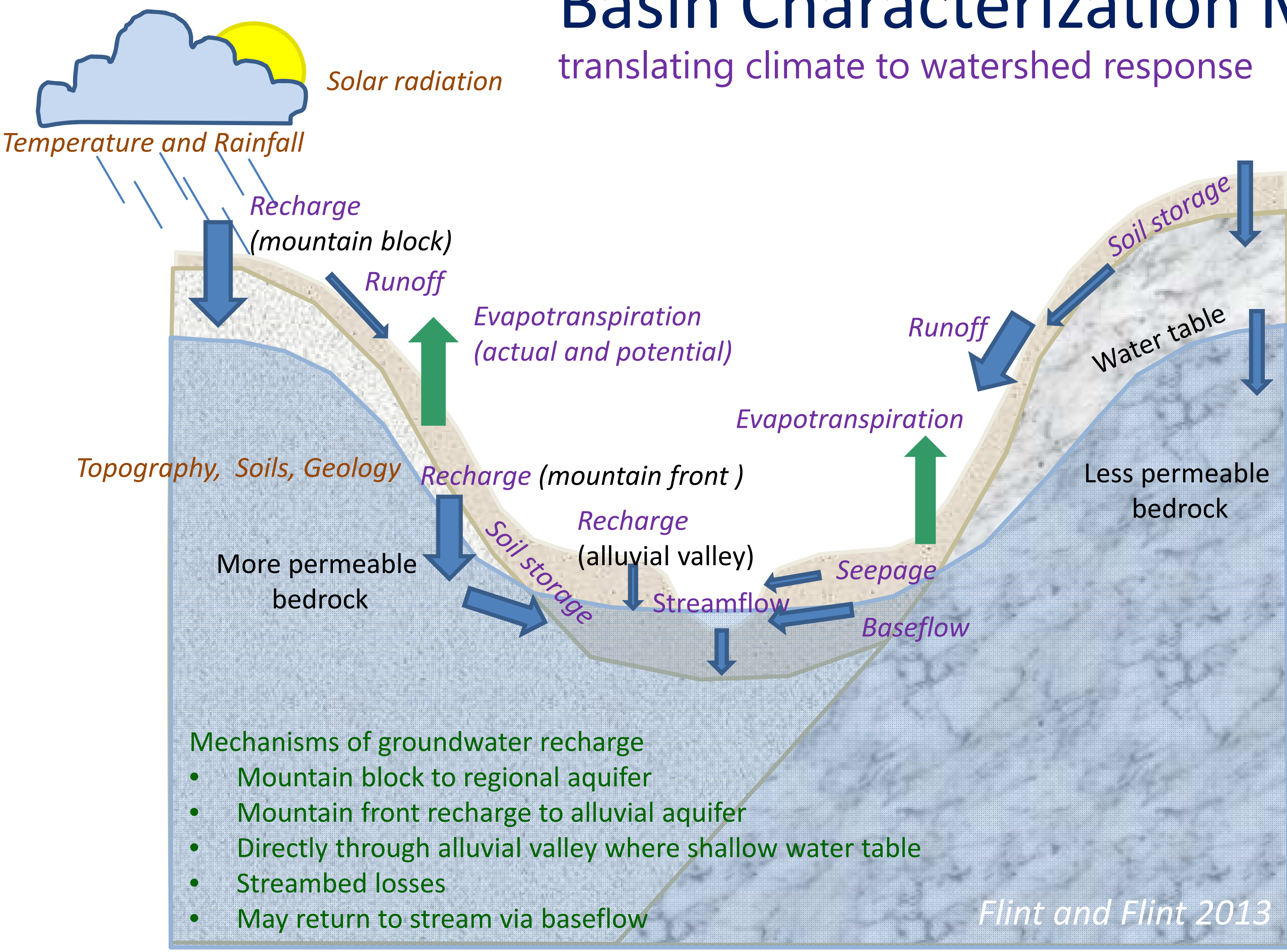


impacts on precipitation are uncertain, but rainfall patterns are likely to be more variable

How can we take rainfall and temperatures and project the future of watersheds in Northern CA?

Basin Characterization Model

translating climate to watershed response



Size of arrows reflect relative magnitude of water flow

USGS science for a changing world

Brown text is BCM input, Purple text is BCM output

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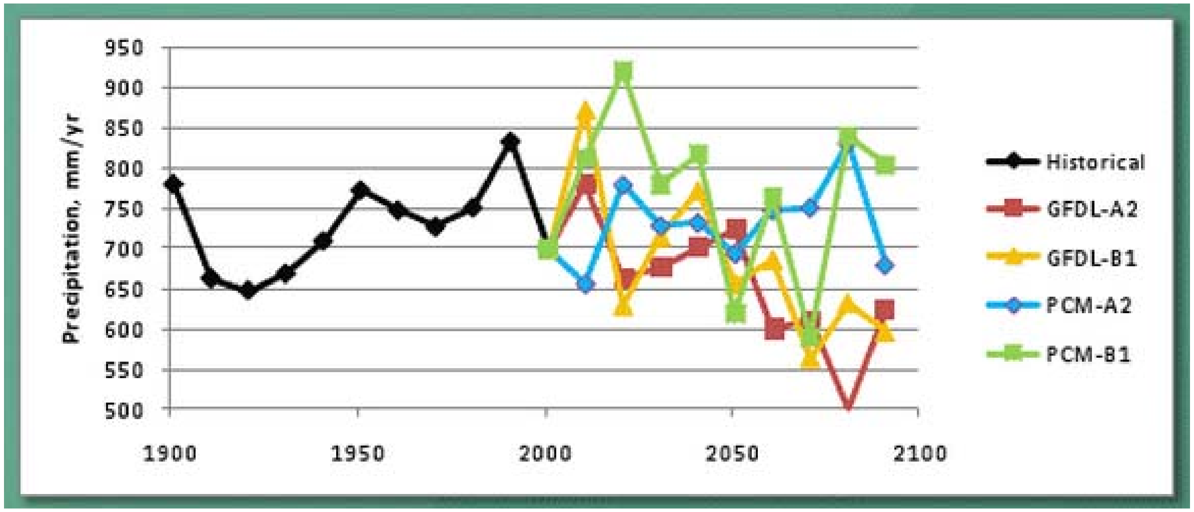
Local Climate

Drier Environment

Increased temperatures will dry out plants and soils, especially by end of summer

- This is true regardless of whether we receive more or less rain
- Expect more frequent and longer droughts
- Increased wildfire risk



Source: Alan and Lorraine Flint, USGS

Rainfall is uncertain, but more "arid" conditions likely under all scenarios

Climatic Water Deficit = drought stress

Potential – Actual Evapotranspiration

BCM methods

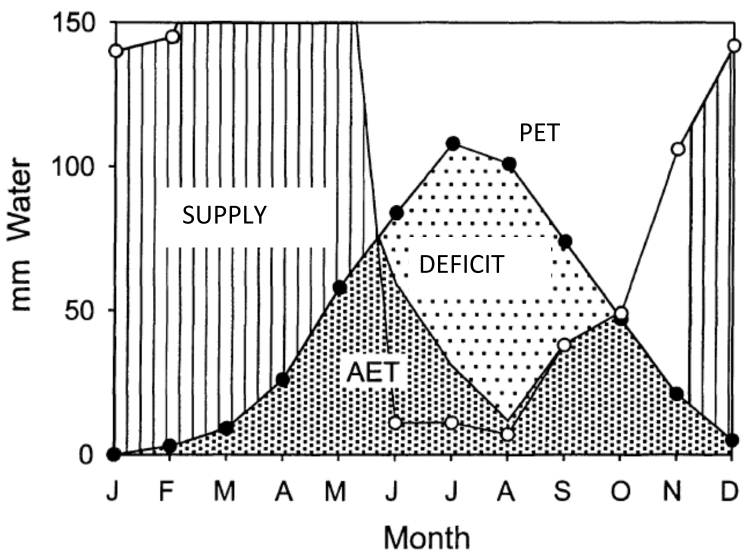
Integrates effects of temperature and rainfall on landscape in context of watershed structure

Surrogate for irrigation demand

Correlates with vegetation and fire risk

Potential drought-stress indicator

Increases with all future climate scenarios

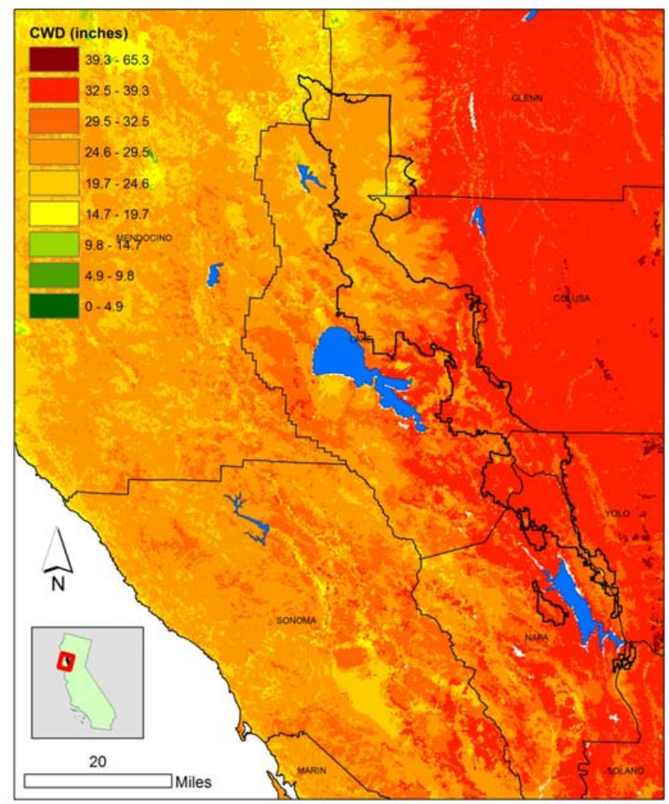


CWD mechanistically links energy loading, drainage, and available soil moisture

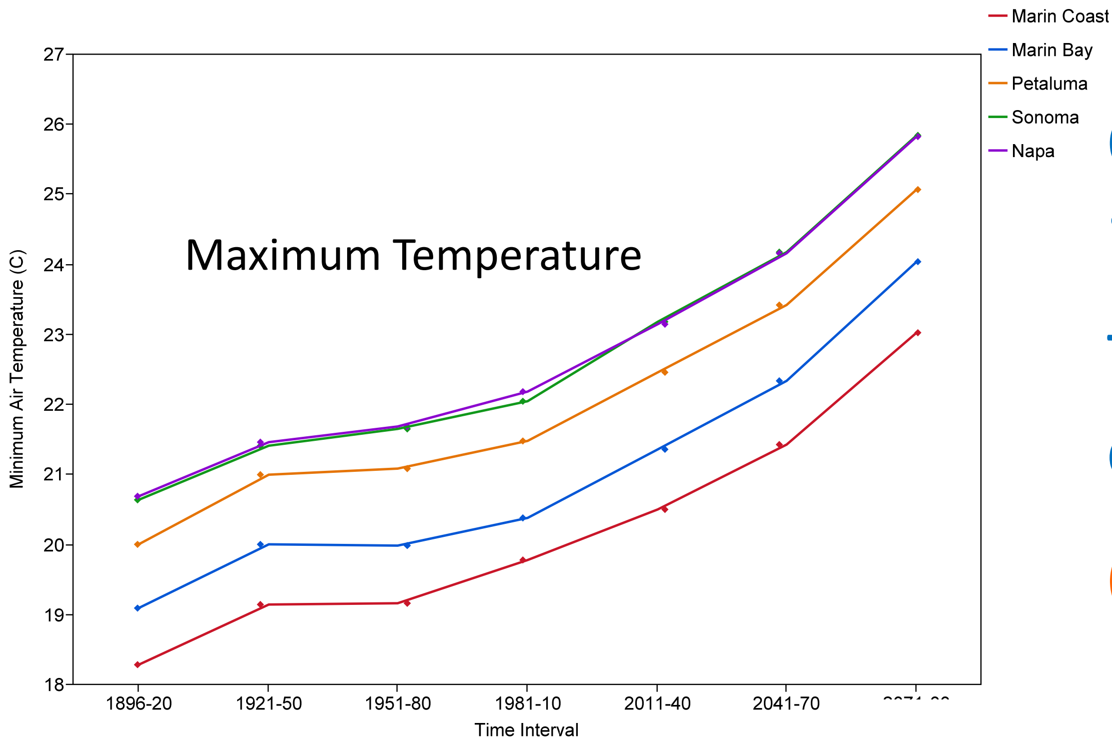
Climatic Water Deficit (CWD) of how dry the soils are at the end of the summer

BLM Climate Adaptation Project Climatic Water Deficit

Historical (1951-1980)



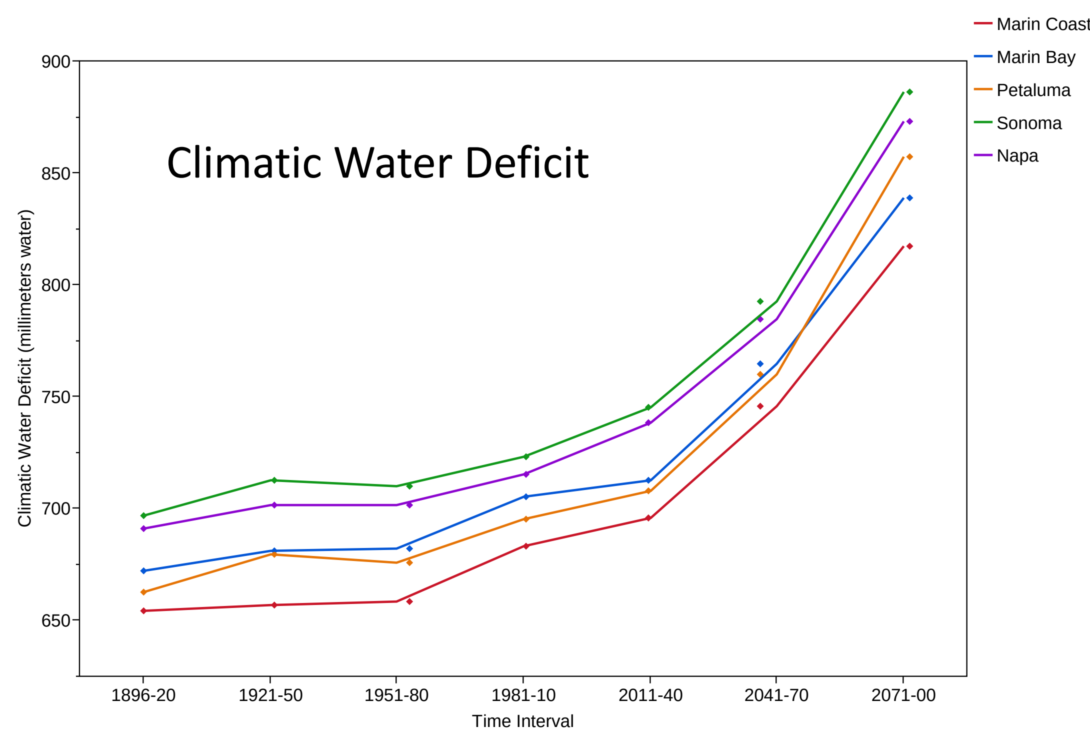
In North Bay on order of 10-20% drier, equivalent to 3-6" rainfall



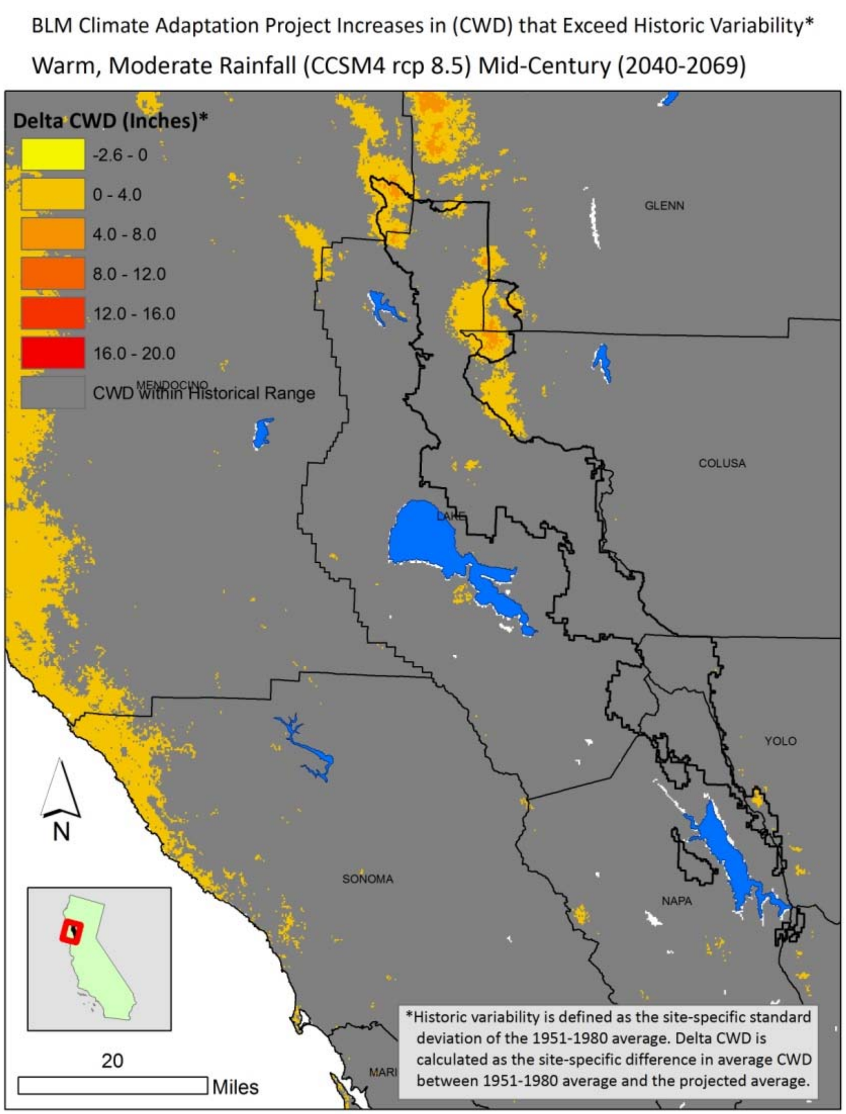
Climatic water deficits increase faster than temperature over time

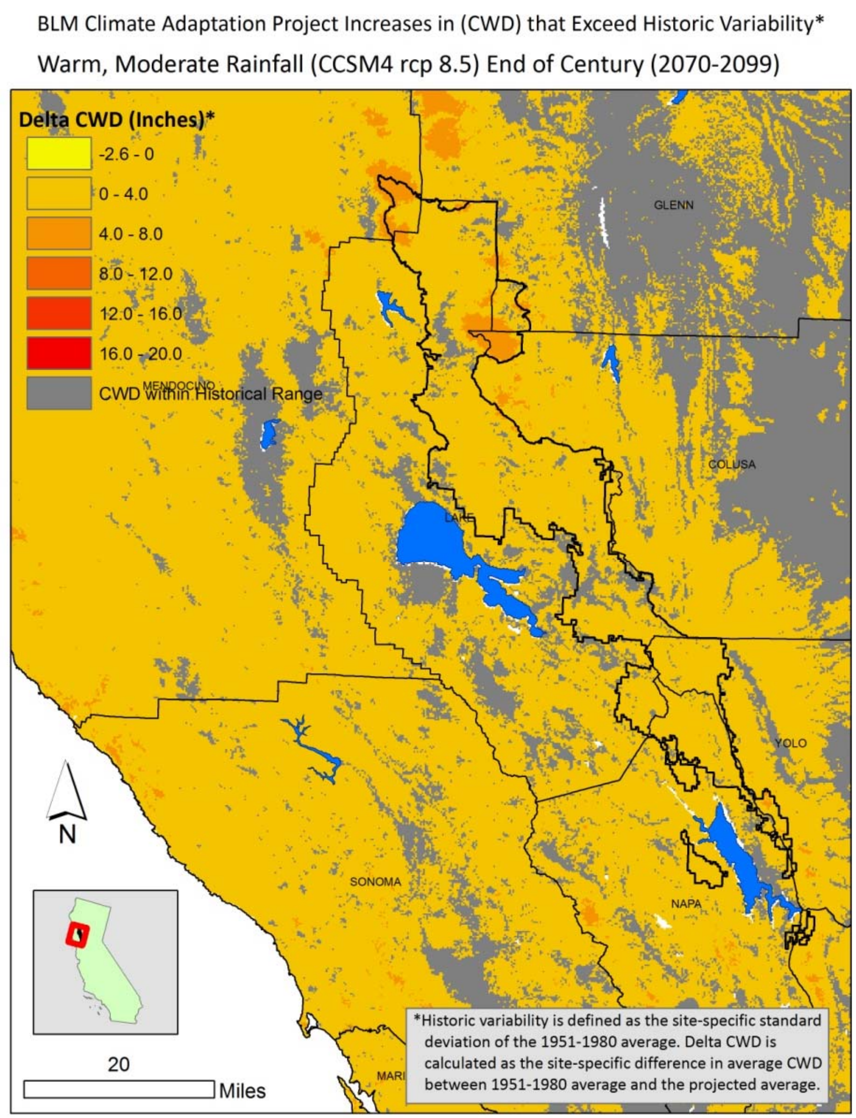
(Marin, Sonoma, Napa Basins)

Under both warmer drier and warmer wetter scenarios, climatic water deficit (AET-PET) increases on the order of 10-20%, or approx 75-150 mm additional water needed to maintain vegetation cover (natural or crop)

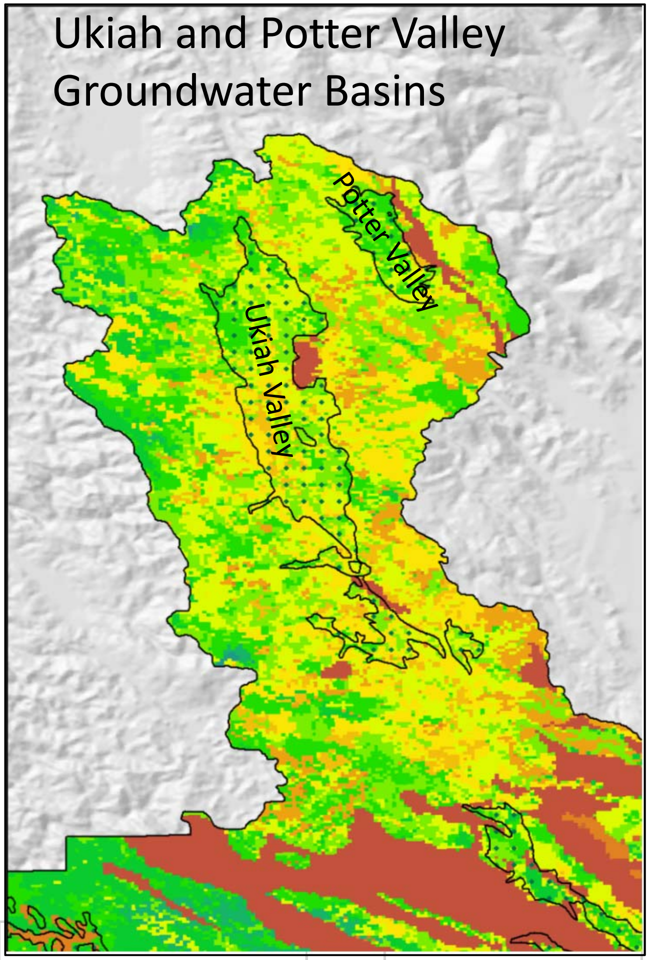


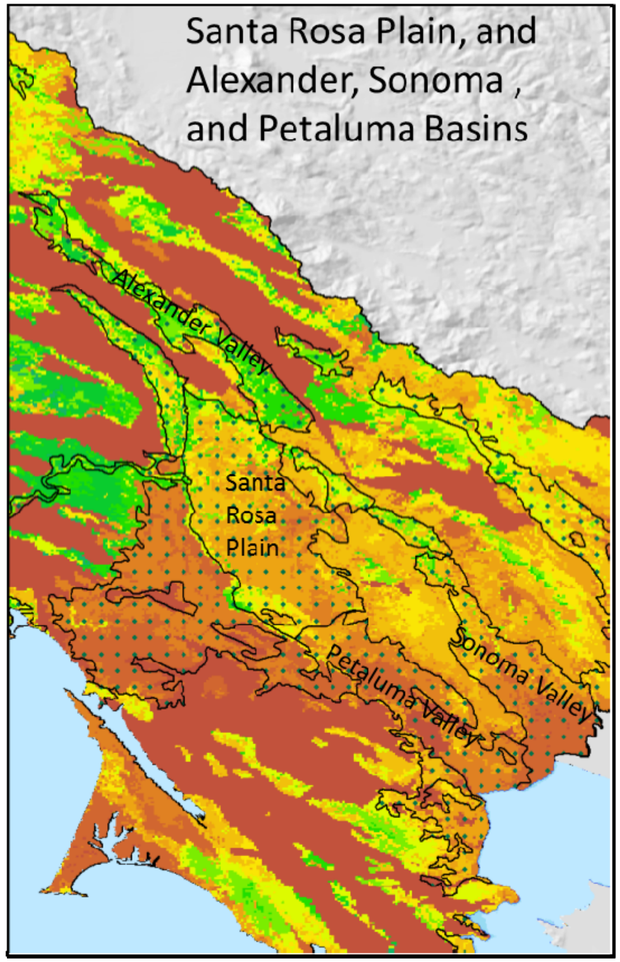
Where do projected increases in CWD exceed the historical range of variability?

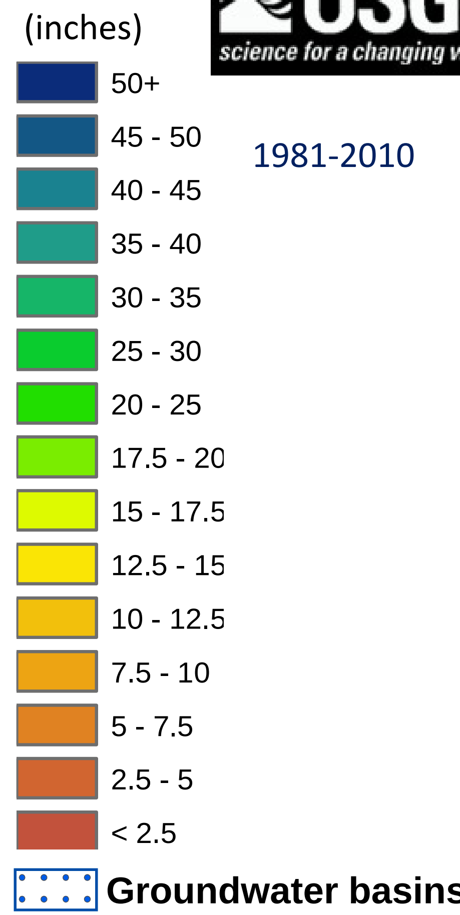




Recharge protection for drought resilience







1981-2010

		Current (1981-2010)	
Subbasin	Units	Recharge	Runoff
Ukiah Valley	in	36.1	18.9
East Fork Potter Valley	in	15.7	12.7

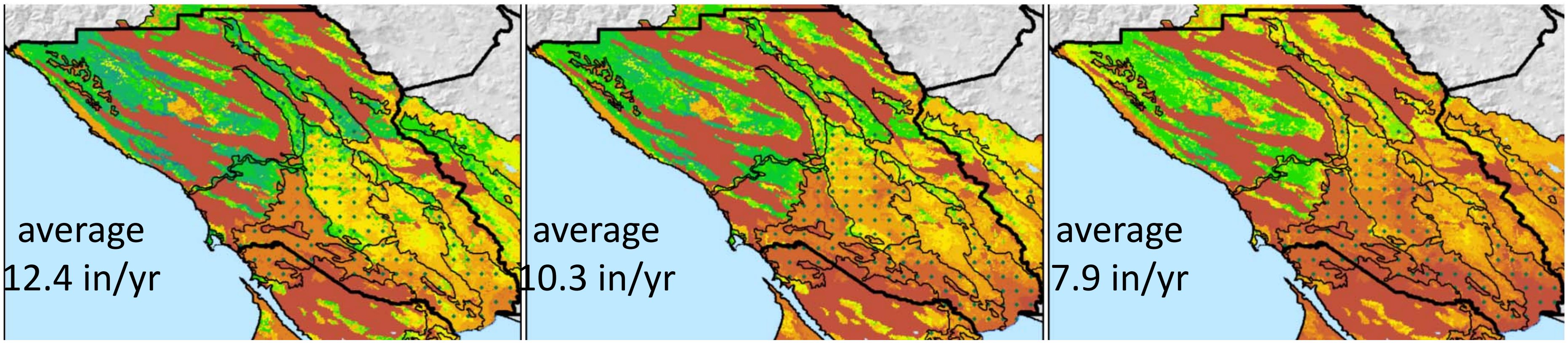
Recharge or Runoff for Groundwater Basin Watersheds

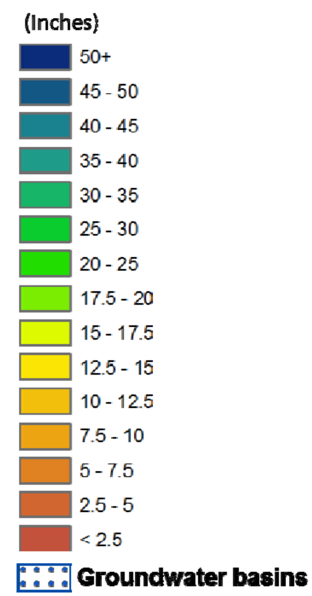
		Current (1981-2010)	
Subbasin	Units	Recharge	Runoff
Alexander Valley	in	9.1	19.4
Santa Rosa Plain	in	10.5	9.8
Petaluma Valley	in	10.6	8.5
Sonoma Valley	in	8.6	8.8

Given groundwater is more resilient than reservoir supplies, where are the most important groundwater recharge areas to protect?

Projected Groundwater Recharge 2040-2069

Warm & High Rainfall | Warm & Moderate Rainfall | Hot & Low Rainfall

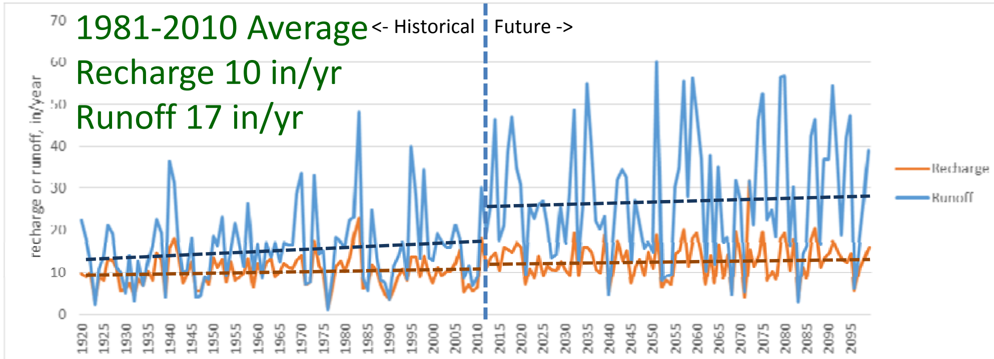




- Consider mapping priority recharge areas that target upper 75% of recharge
- Consider analyzing existing impermeable footprint, where could LID assist in conservation
- Consider analyzing developing areas for conservation of high recharge zones
- Can you use this to prioritize siting studies for injection wells?
- What % of recharge is currently used in each basin? How much area to protect to sustain in future?

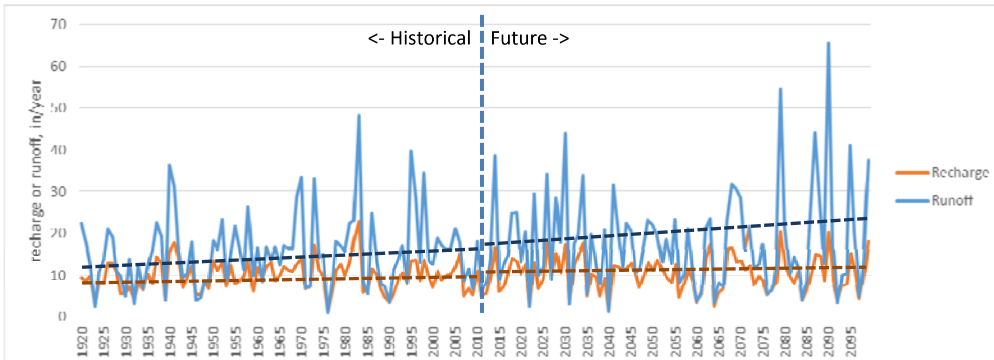
Sonoma County Annual Recharge and Runoff, 1920-2099

Scenario 5
Warm &
High Rainfall



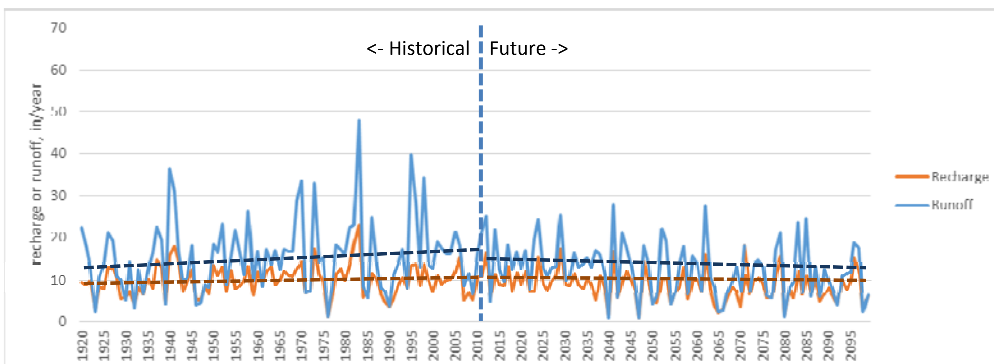
End century averages
Recharge 13 in/yr
Runoff 30 in/yr

Scenario 3
Warm &
Moderate
Rainfall



End century averages
Recharge 10.5 in/yr
Runoff 20 in/yr

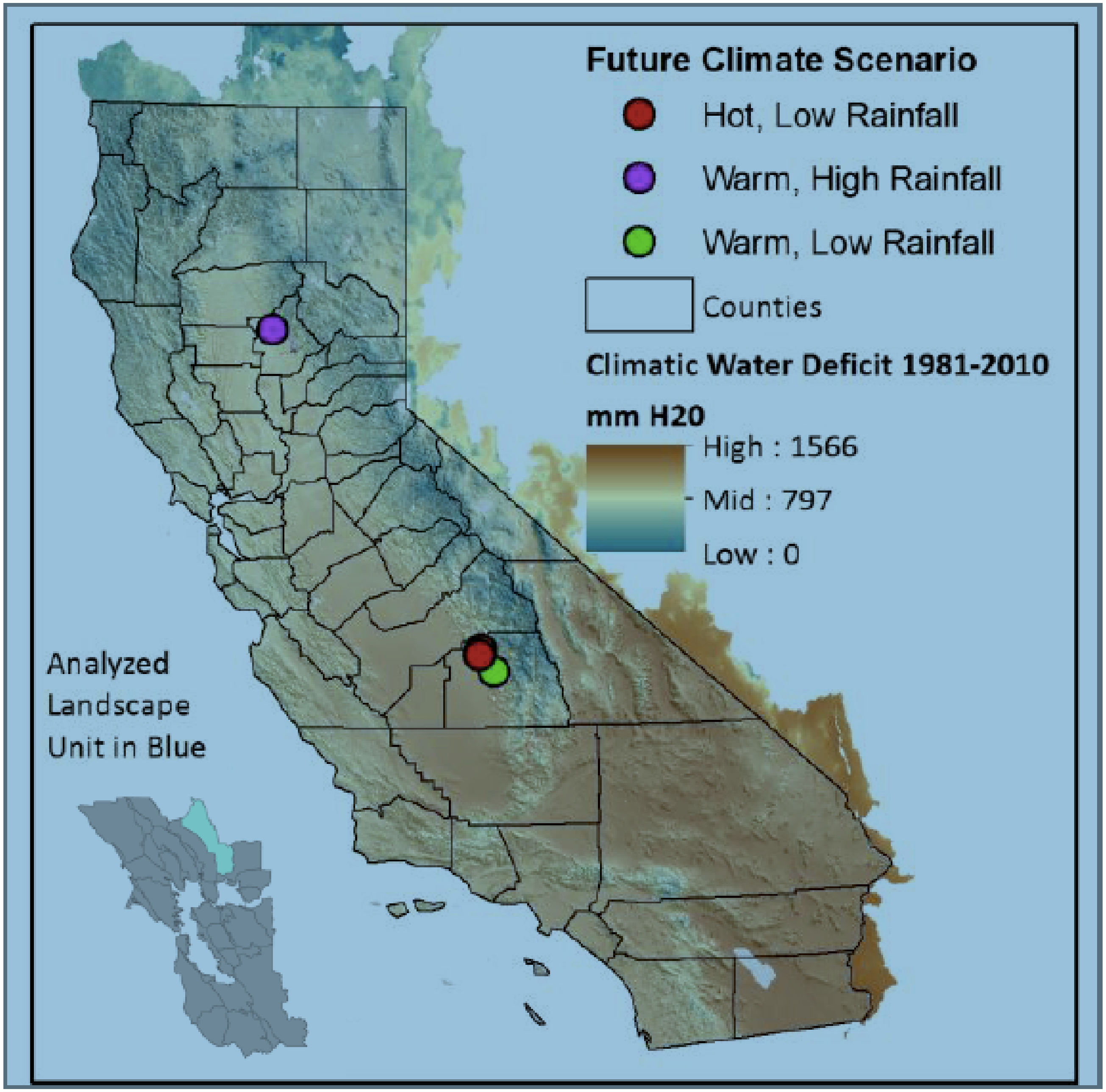
Scenario 6
Hot &
Low Rainfall



End century averages
Recharge 8 in/yr
Runoff 11 in/yr

Recharge is less variable than runoff across all futures

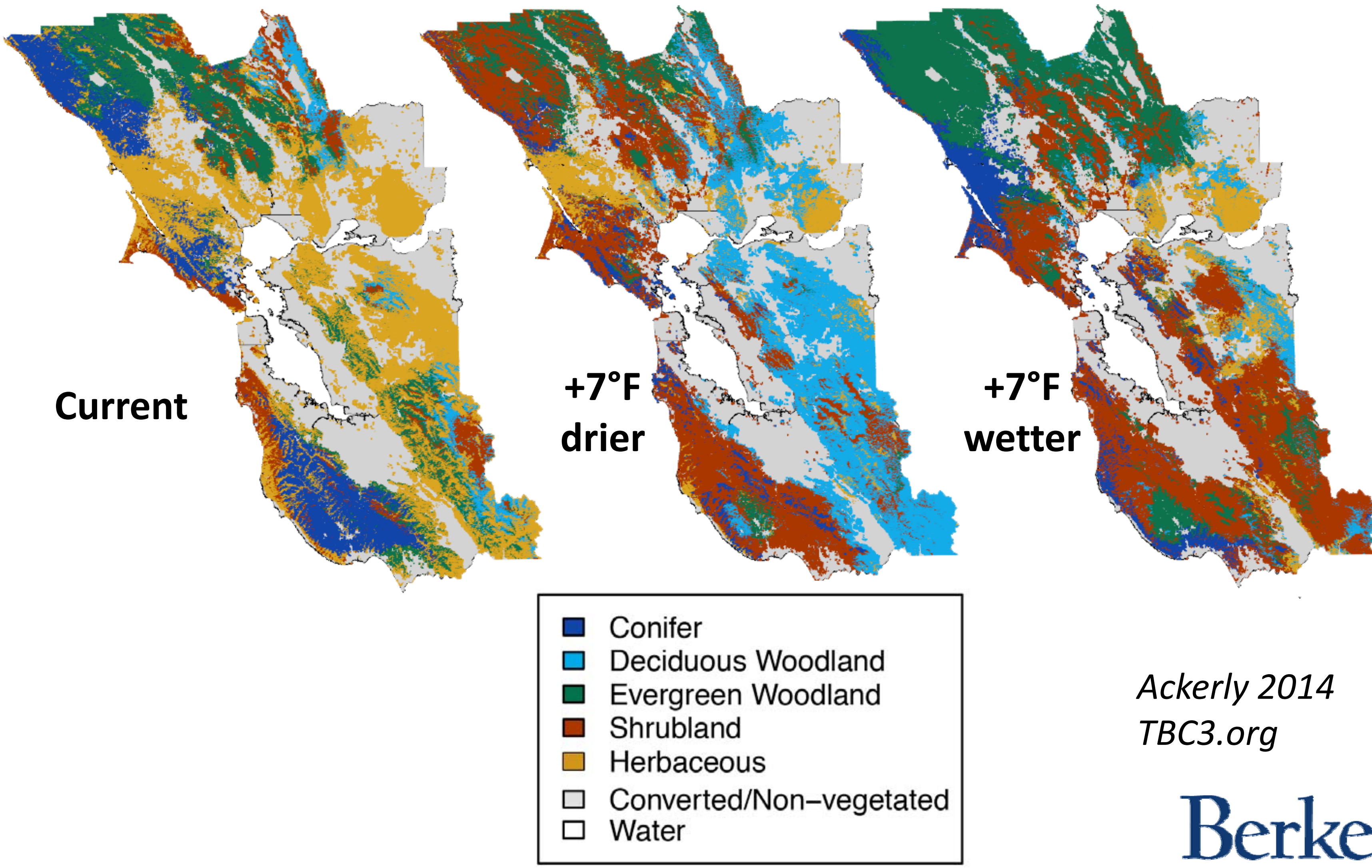
Landscape Analogs



Where in CA presently has climate projected for Blue Ridge-Berryessa Landscape Unit?

What does this mean for our forests and chaparral in Northern CA?

what might the Northern California vegetation of the future look like?

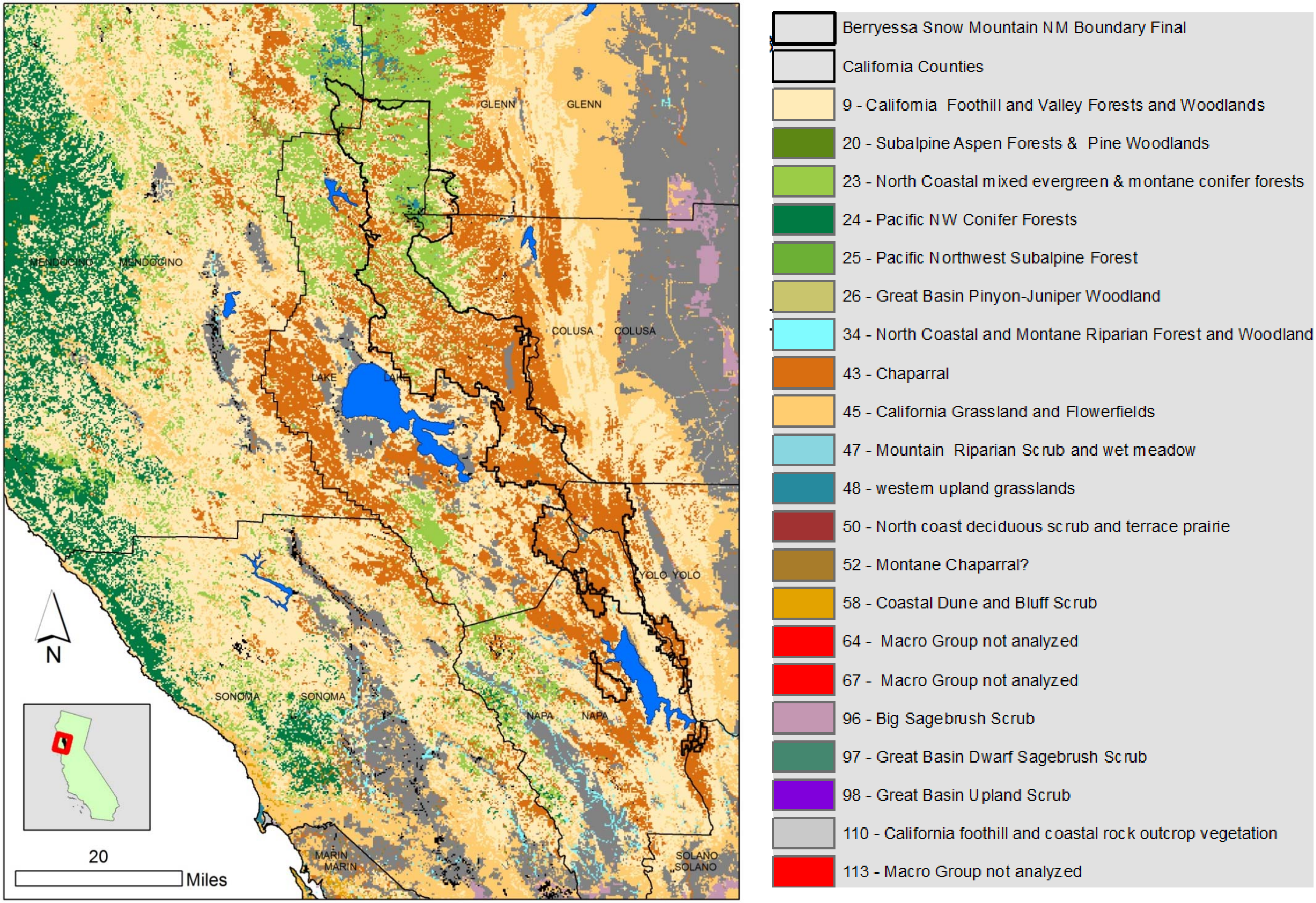


Ackerly 2014
TBC3.org

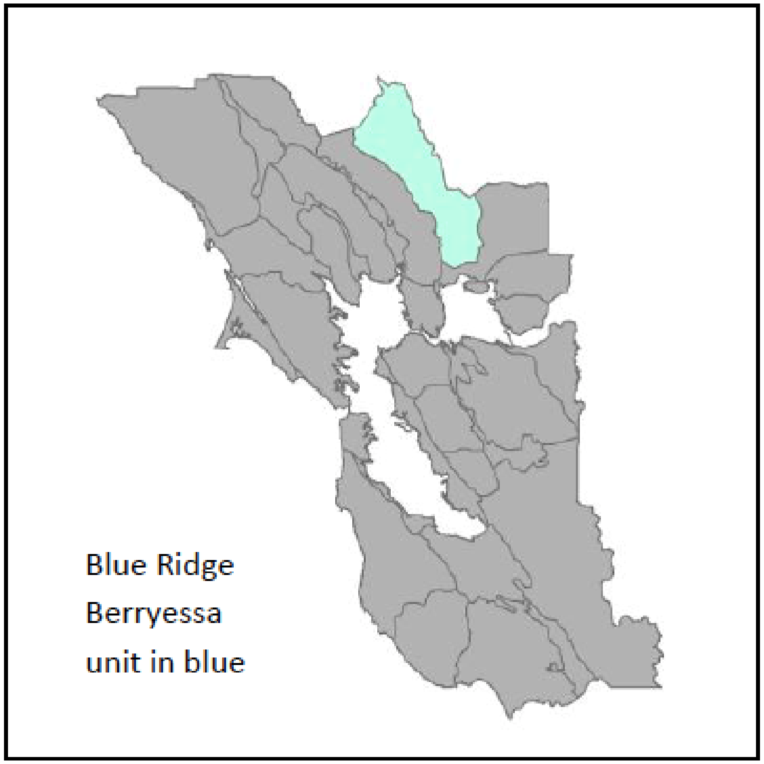
Berkeley
UNIVERSITY OF CALIFORNIA

BLM Climate Adaptation Project
Vegetation Macro Groups

North Bay/North Coast Region



Blue Ridge-Berryessa Vegetation



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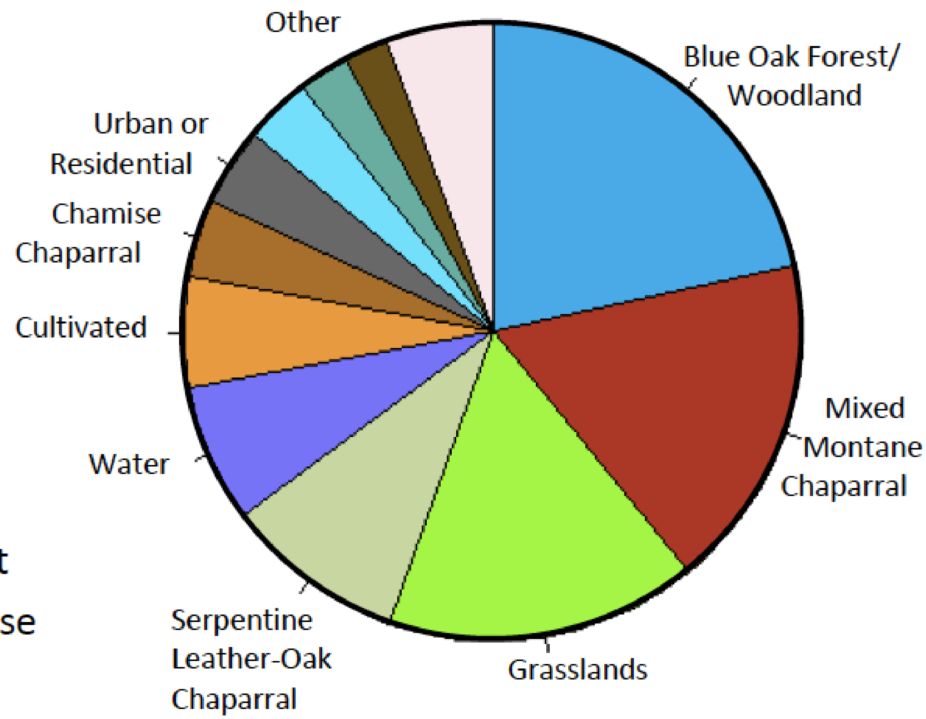
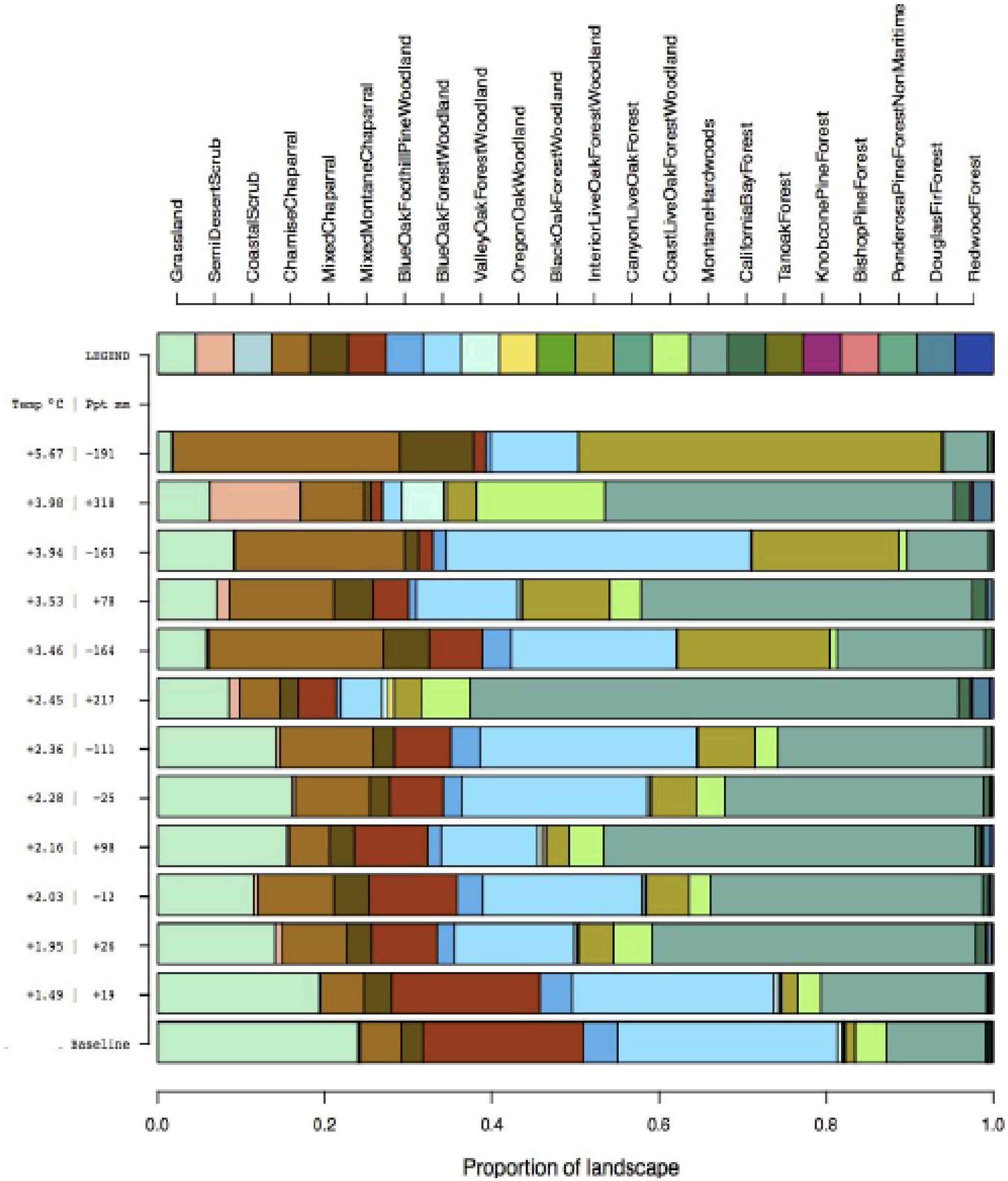


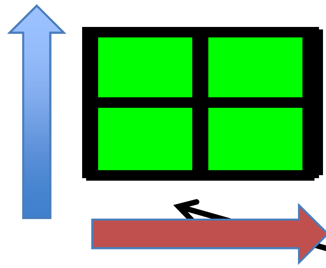
Blue Ridge-Berryessa Landscape unit-projected vegetation



What will be forest winners and losers under climate change?

Sonoma Coast Range Species Level Examples

Example: Coast Live Oak

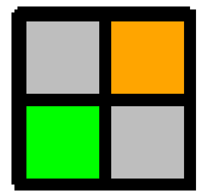


Identify potential "winners and losers" by landscape unit

does well in all future scenarios regardless of warming magnitude and rainfall

Example: California Bay is sensitive to rainfall in the Coast Ranges

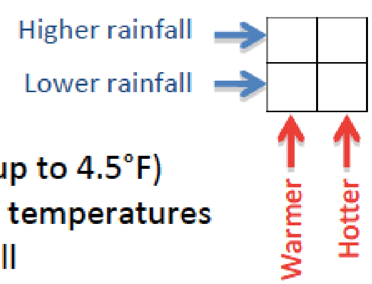
does well in moderate scenario, but declines in hot and low rainfall



Example: Tan Oak is sensitive to rainfall and temperature

shows declines in all scenarios

What are the potential native plant winners and losers for Blue Ridge Berryessa?

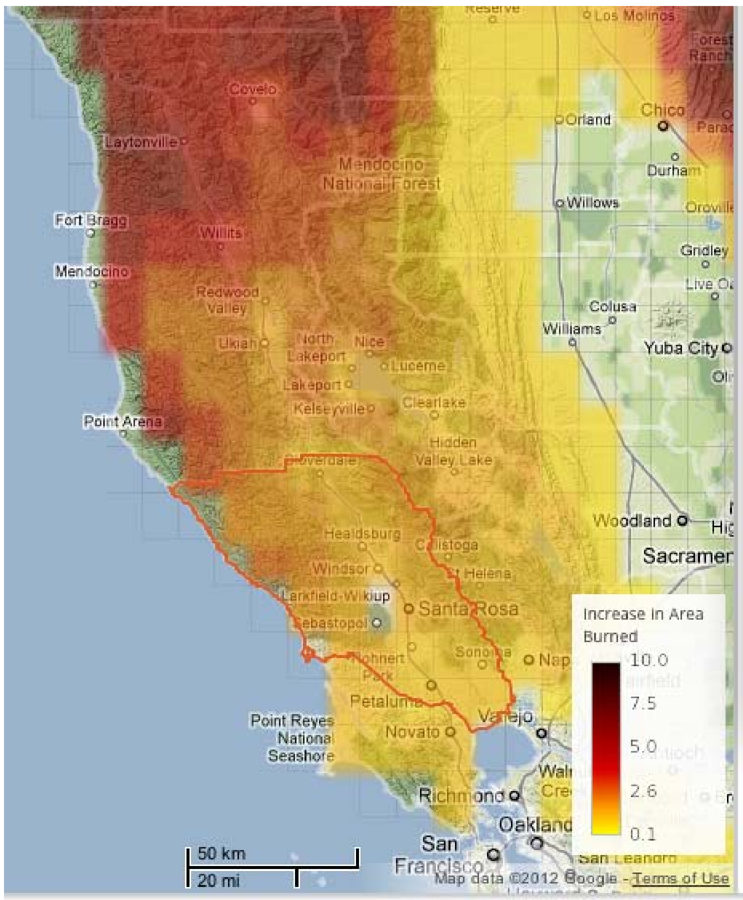
The color shows the projected response of vegetation to future climate. Red: Dramatic Decline - 25% less than current Orange: Moderate Decline - 25-75% less than current Gray: Relative Stability - 75-125% current Green: Increase - 125% more than current	The four squares represent different climate futures: combinations of warmer (up to 4.5°F) vs. hotter (+4.5°F or more) temperatures and lower vs. higher rainfall 

Impacts on plant phenology?

Earlier bud break in many species-complex reaction not just to earlier spring conditions, but also reduced winter temperatures/lack of chilling hours….

Local Climate

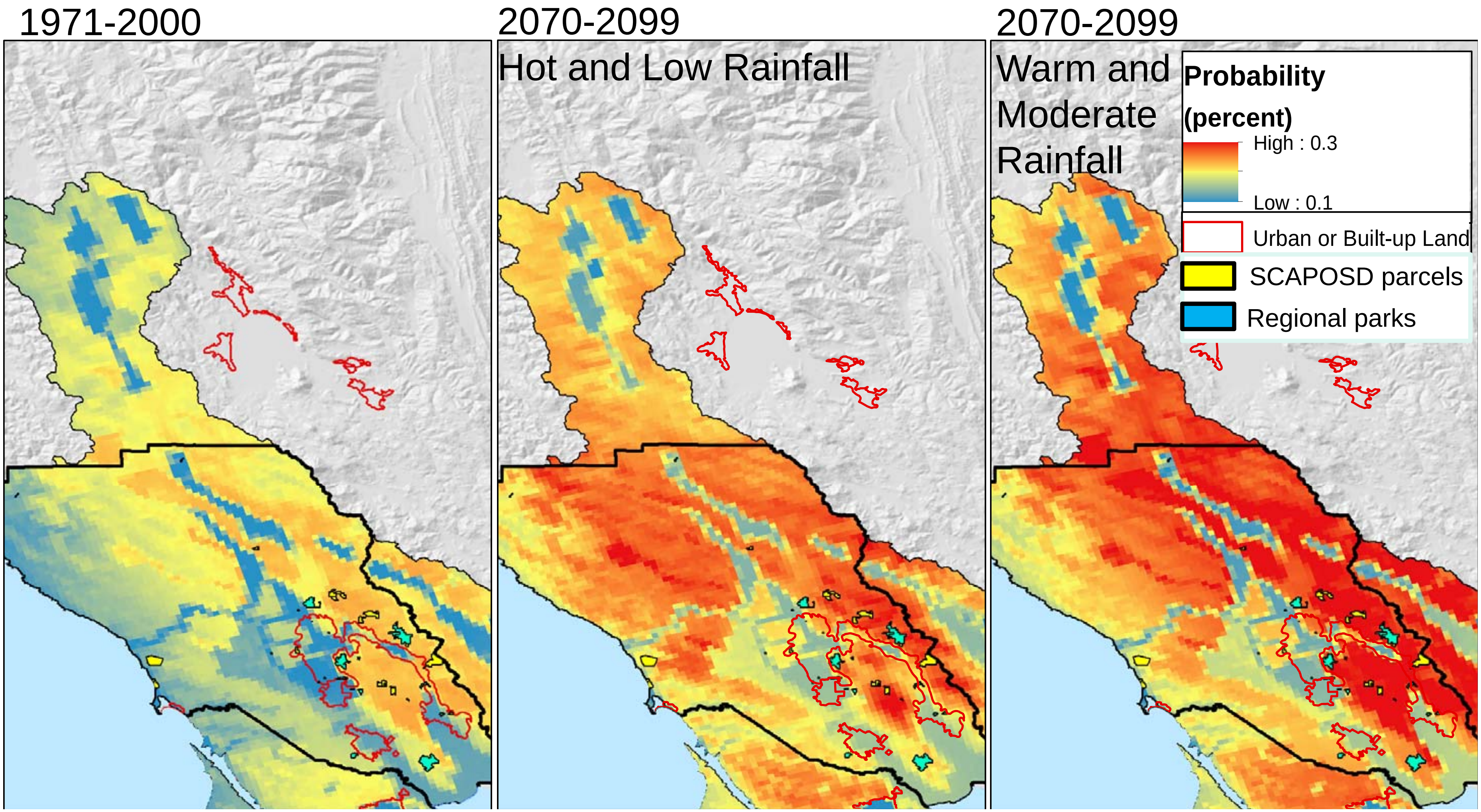
Projected vegetation change plus drier hotter weather



Moritz Lab: Source: Cal-Adapt.org Fire Risk Scenario – GFDL Model

A drier environment can lead to more frequent and more intense fires

Probability of a fire within next 30 years



What are the most fire-prone parts of the county?

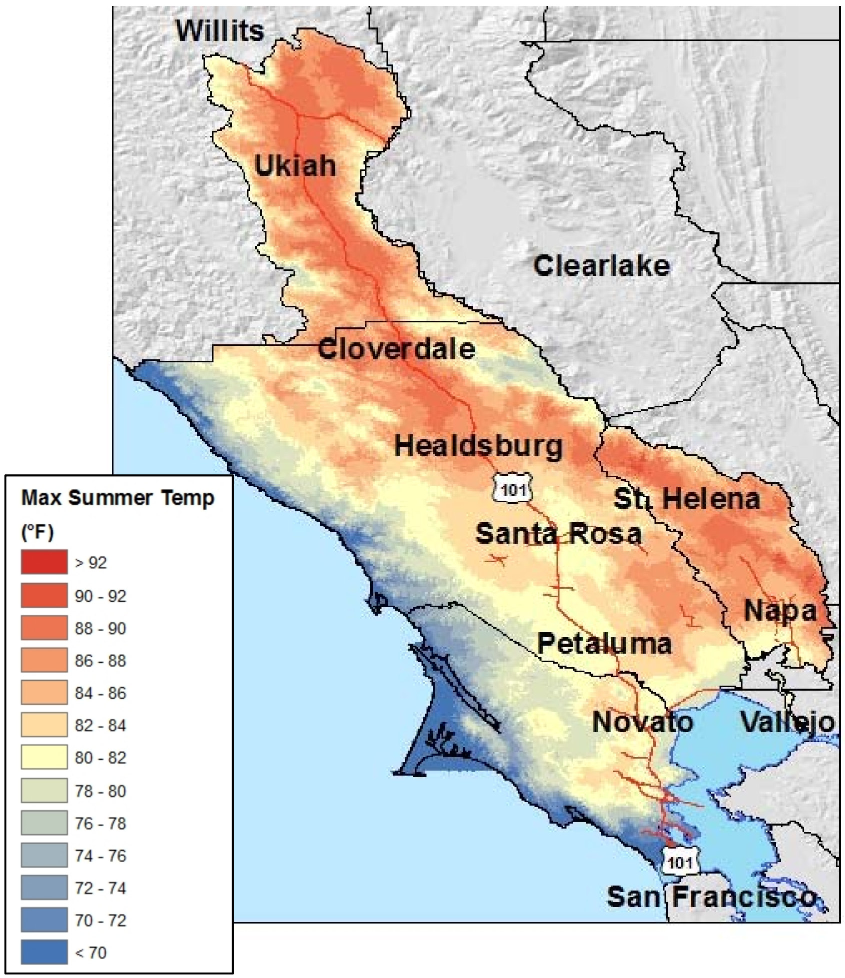
		Current	Hot, Low Rainfall		Warm, Moderate Rainfall	
Variable	Units	1971-2000	2040-2069	2070-2099	2040-2069	2070-2099
Probability of burning 1 or more times	Percent	0.17	0.21	0.23	0.20	0.23
	SD	0.05	0.06	0.05	0.05	0.06

Fire Mitigation and Forest Health Workshop
for the Mayacamas to Berryessa Coast Range Region

Workshop Proceedings
May 20, 2016

http://www.pepperwoodpreserve.org/what-we-do/conservation-initiatives/fire-and-forest-health/

Climate Ready North Bay:
translating a landscape-level climate-hydrology database into inputs for long-term planning



Source: Climate Ready North Bay 2015

- Warmer temperatures
- Greater rainfall variability
- Greater evapotranspiration
- Increased water demand
- Variable runoff and recharge
- Shifts in natural vegetation types
- Increased wildfire risk
- (Not sea level rise!)

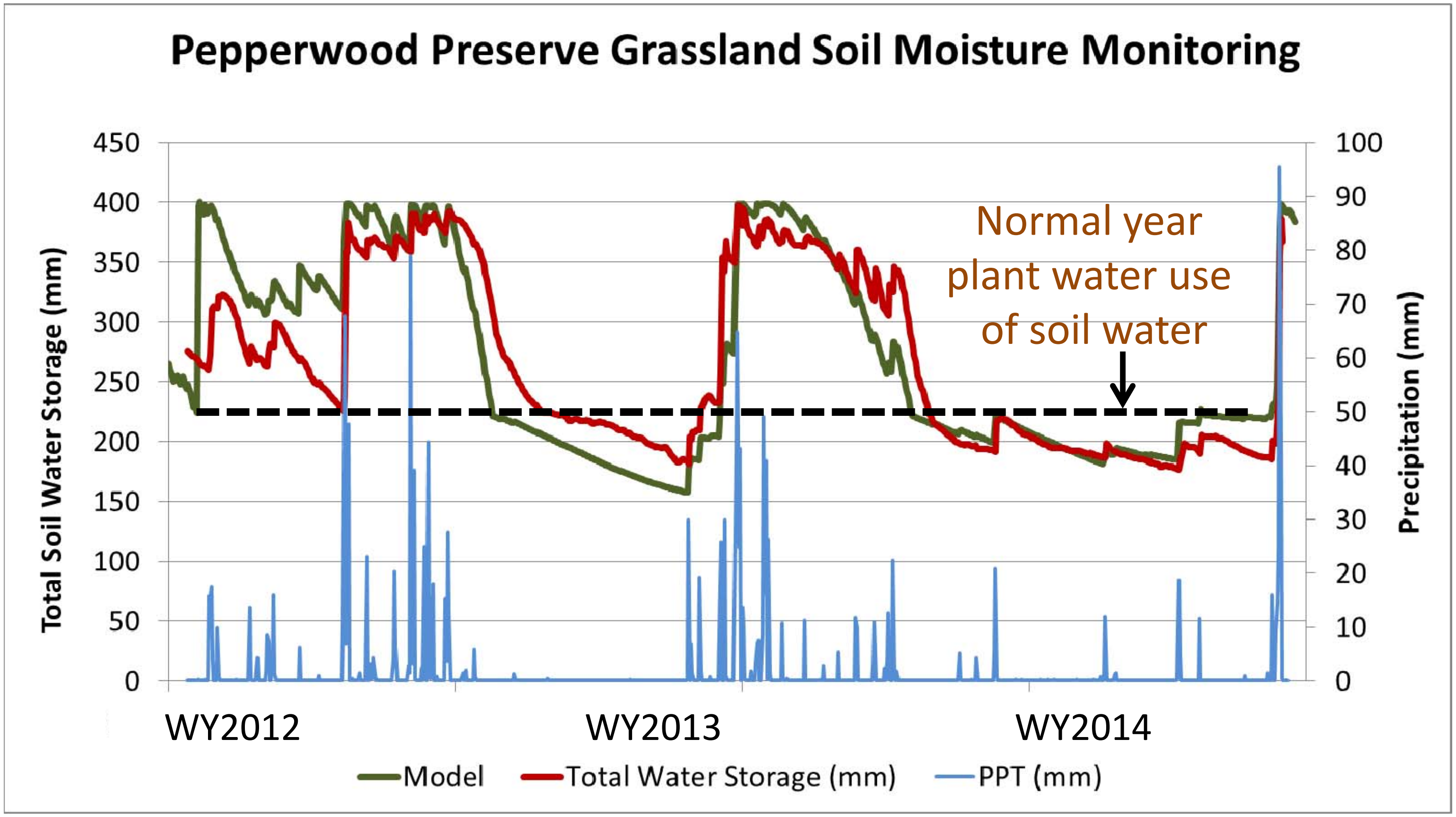
REGIONAL CLIMATE PROTECTION AUTHORITY

Pepperwood PRESERVE
Inspiring conservation through science

What are examples of practical applications?

Sentinel Site Soil Moisture Monitoring

(headwaters of Mark West Creek, Russian River)

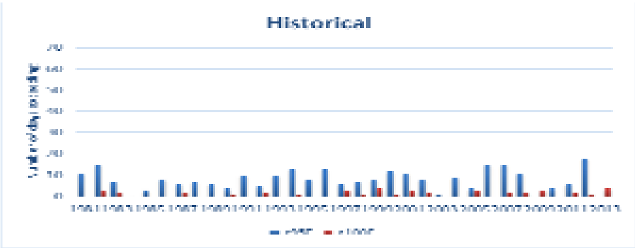


Soils dried out beyond wilting point!

USGS
science for a changing world

CRNB results

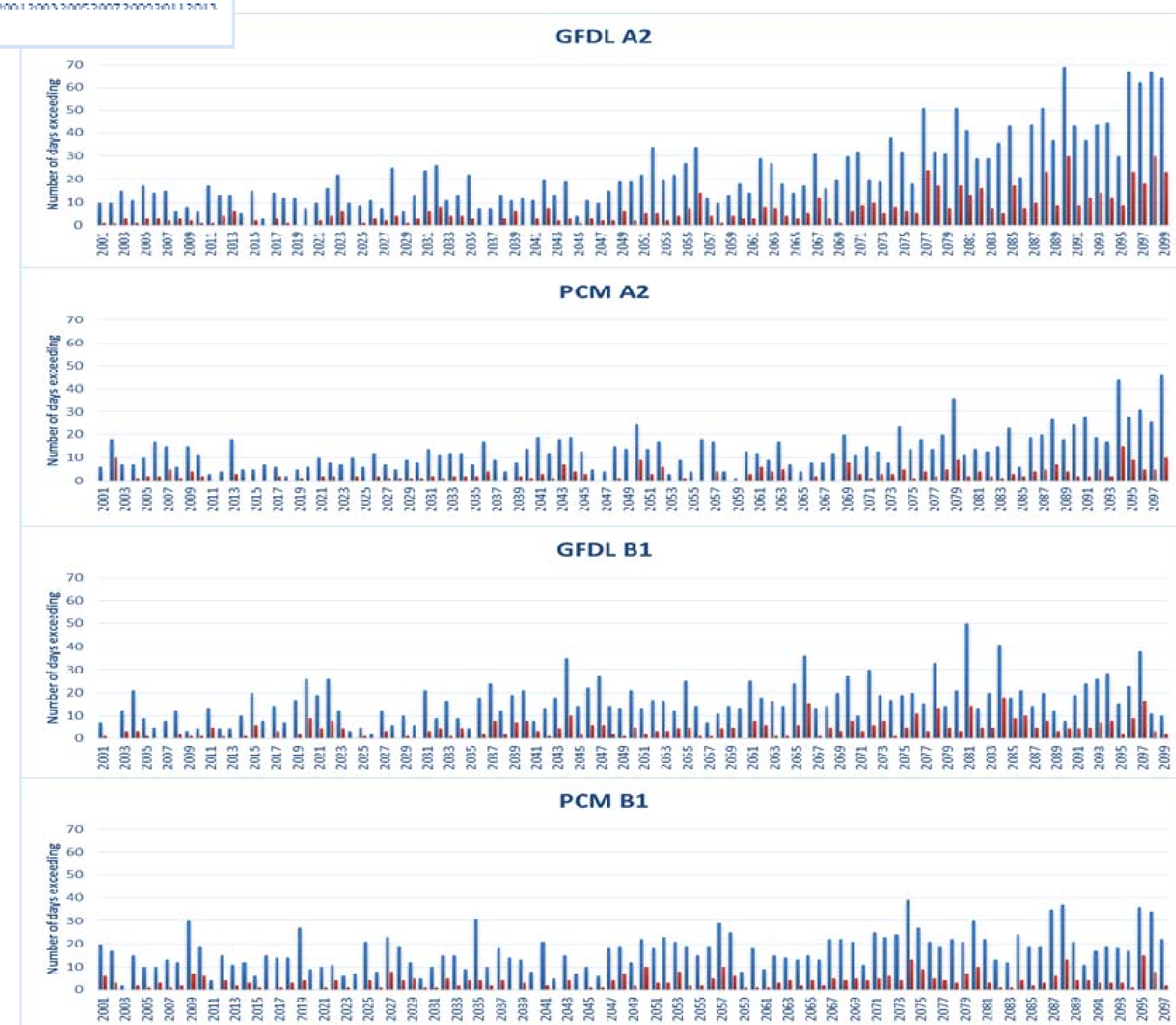
How might climate change impact the magnitude and frequency of heat waves impacting the health of vulnerable populations?



>95F

>100F

Extreme Heat Days for Santa Rosa Plain



3-day high flows for Upper River and Lower Russian River (modeled)

3-day flows exceedances of
99.9% threshold (per decade)

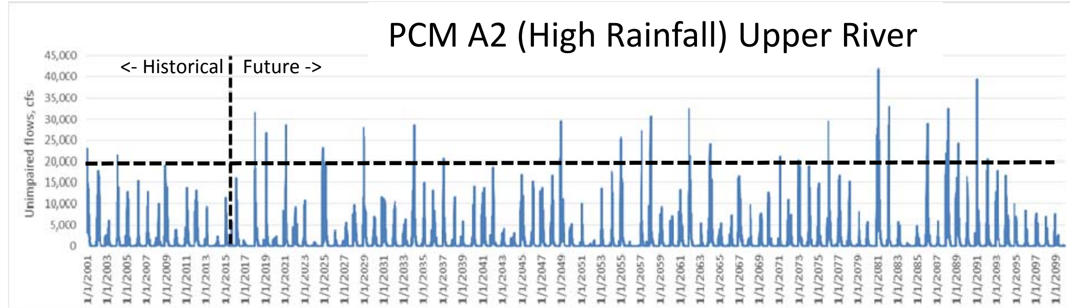
19,298 cfs threshold for upper river
38,902 cfs threshold for lower river

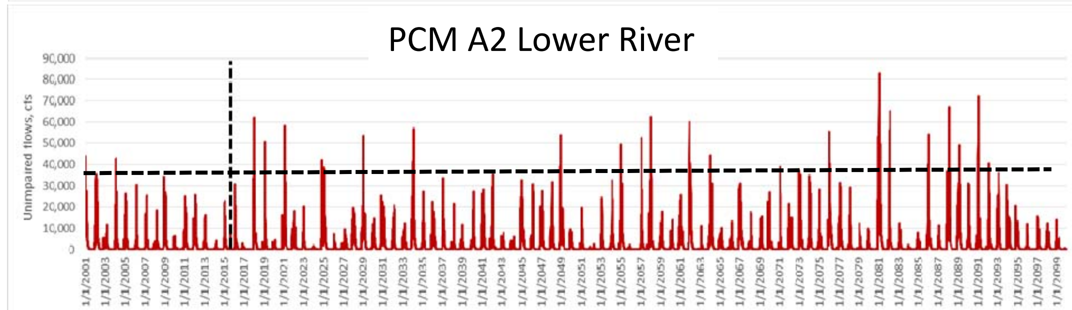
2001-2015 vs 2016-2099
(exceedances per decade)

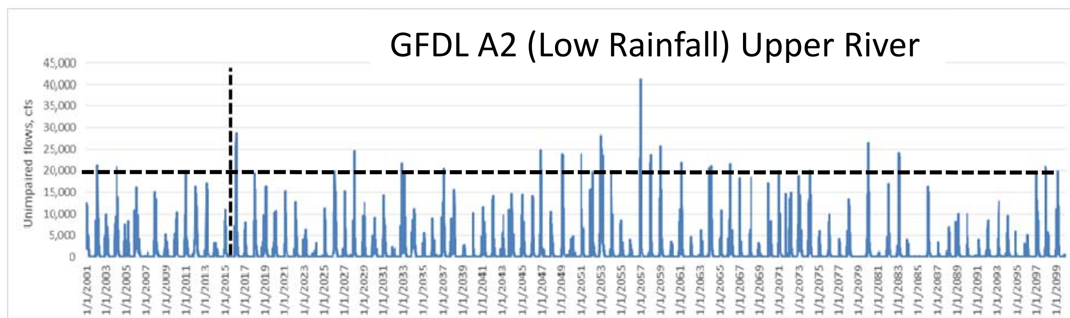
	Upper River: Healdsburg		Lower River: Guerneville	
	Current (2001-15)	Future (2016-99)	Current (2001-15)	Future (2016-99)
Business-as-usual				
PCM A2	1.3	3.9	1.3	3.6
GFDL A2	2.0	3.6	0.7	3.3
Mitigated				
PCM B1	4.0	4.8	3.3	4.6
GFDL B1	2.0	3.7	1.3	3.6

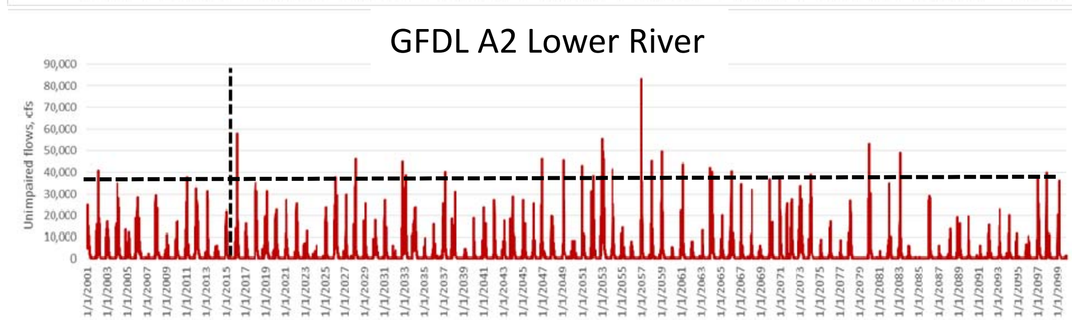
The frequency of 3-day "very high flow" events are up to 4 x more likely to occur than they do currently.

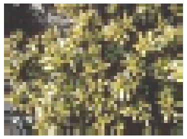
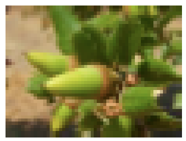
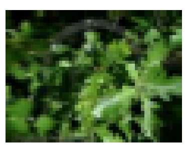
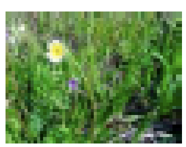
PCM wet model
GFDL dry model



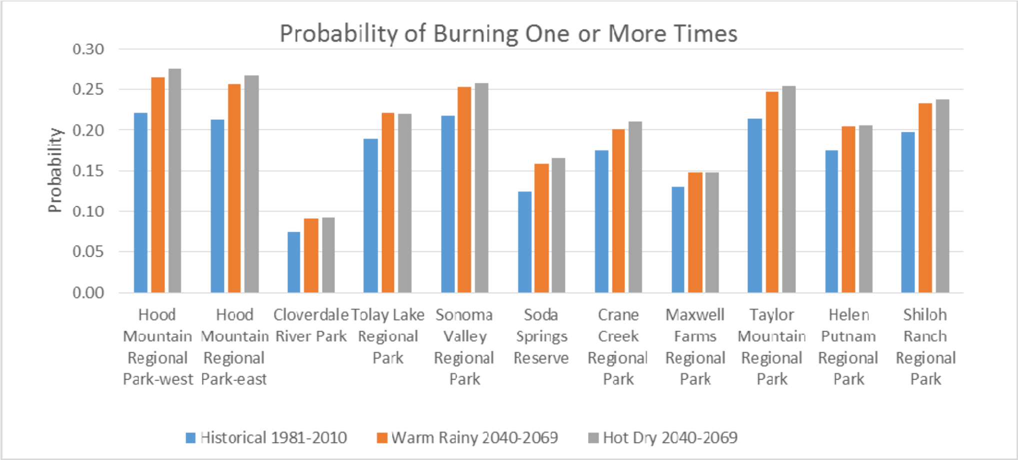




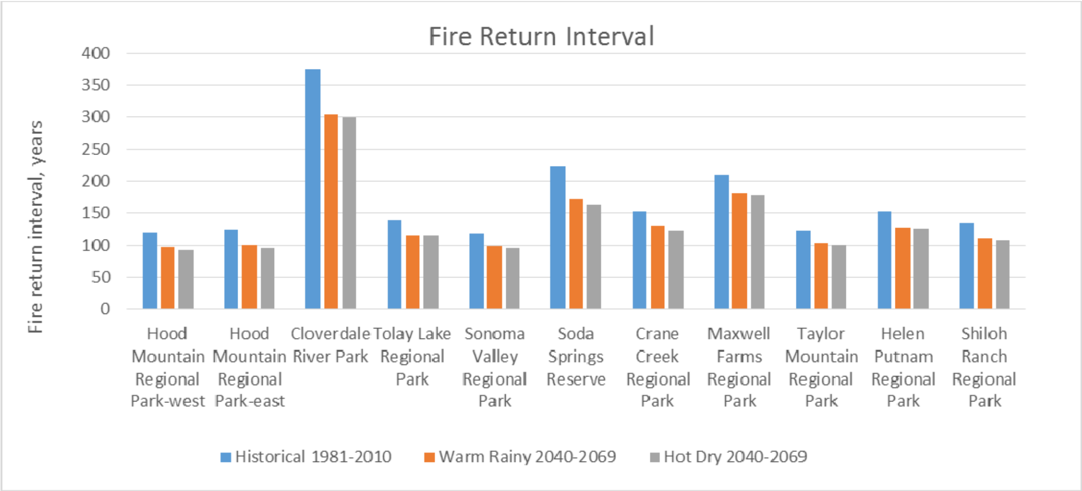


Possibly Expanding		Baccharis		Aggressive invader of grasslands in the absence of fire or grazing, and spreads rapidly in wet years. Models project expansion in interior regions of the Bay Area, especially under higher rainfall future scenarios.
		Toyon		Widespread in many different habitats and soil types, from coastal bluffs to interior chaparral and edges of woodland. Wide niche suggests it will be persistent in the face of climate change, but sensitivity of local populations is not known.
Likely Stable		Chamise Chaparral		Occupies hot, dry, steep slopes, and favorable conditions are projected to expand throughout the Bay Area under future climates. Seed dispersal and establishment may limit expansion. For existing chaparral stands, succession to oak woodland can happen over time in the absence of fire.
		Coast Live Oak		Reaches its northern range limit in the Bay Area, and may persist or even expand under warmer climates. While it is sensitive to warmer summers, it may be favored by increasing winter temperatures.
		Interior Live Oak		Models disagree on future projections for Interior Live Oak. It appears to be sensitive to warmer winter temperatures, and may decline in southern parts of the region, while staying stable or expanding in the north and in interior ranges.
Possibly Declining		Black Oak		Endemic to California and southern Oregon. Declines in climate suitability are predicted under all scenarios, due to warmer winters and drier summers. Native Americans promoted black oak for acorn harvesting.
		Blue Oak		Models disagree on the fate of Blue Oak. Native range includes very hot and dry locations, but it may be negatively impacted by warmer winters near the coast and loss of groundwater. Recruitment failure has been observed in parts of California, possibly due to competition with grasses and impacts of grazing.
		Grassland		Widespread across Bay Area climate gradients, usually maintained by grazing, mowing, and/or fire. Vulnerable to shrub invasion. Climate change and N-deposition are expected to alter species composition, but impacts on overall distribution and amount of grassland more likely depend on management strategies.

How might climate change impact the risk of fire on our regional parks?



Average probability of a burn within 30 years goes up 18% by mid-century



Average fire return interval goes down 18% by mid-century

See Table in “FireRisk.xls” spreadsheet

Coming soon-Mayacamas to Berryessa Habitat Connectivity for Climate Adaptation

Pepperwood plus UC Berkeley plus diverse land managers of the region-you are welcome to join us!

TEK inputs on Pepperwood's Adaptive Management Plan (2016)

- Acknowledge native land practices more adapted to surviving extremes!
- One of five preserve-wide strategies is to restore native stewardship practices, where appropriate, with our Council's guidance
- First prescribed burn achieved in 2016-8 acres of grassland-partnership between Pepperwood-NAC-CALFIRE
- Black Oak restoration project in development
- Basketry materials-locate and ID suitable restoration/collection sites
- Bay Nut and other traditional food source collecting
- Ongoing partnership with CIBA/Tending the Wild
- Site adoption by volunteer stewards

Creating multi-agency, multi-jurisdictional capacity to respond to climate change

REGIONAL CLIMATE PROTECTION AUTHORITY

Our members:

10 jurisdictions, ~490k people

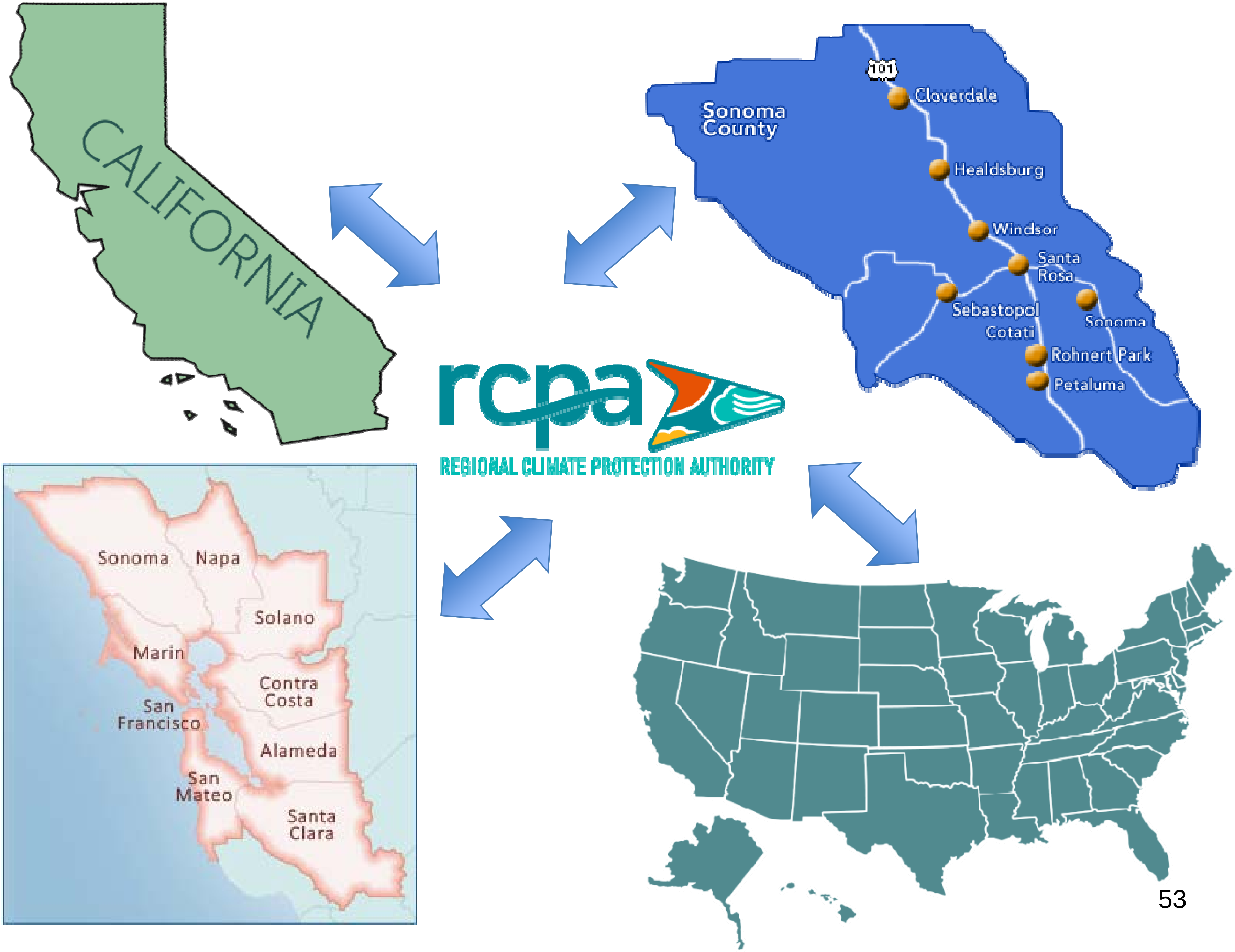
2 countywide agencies

Our goals:

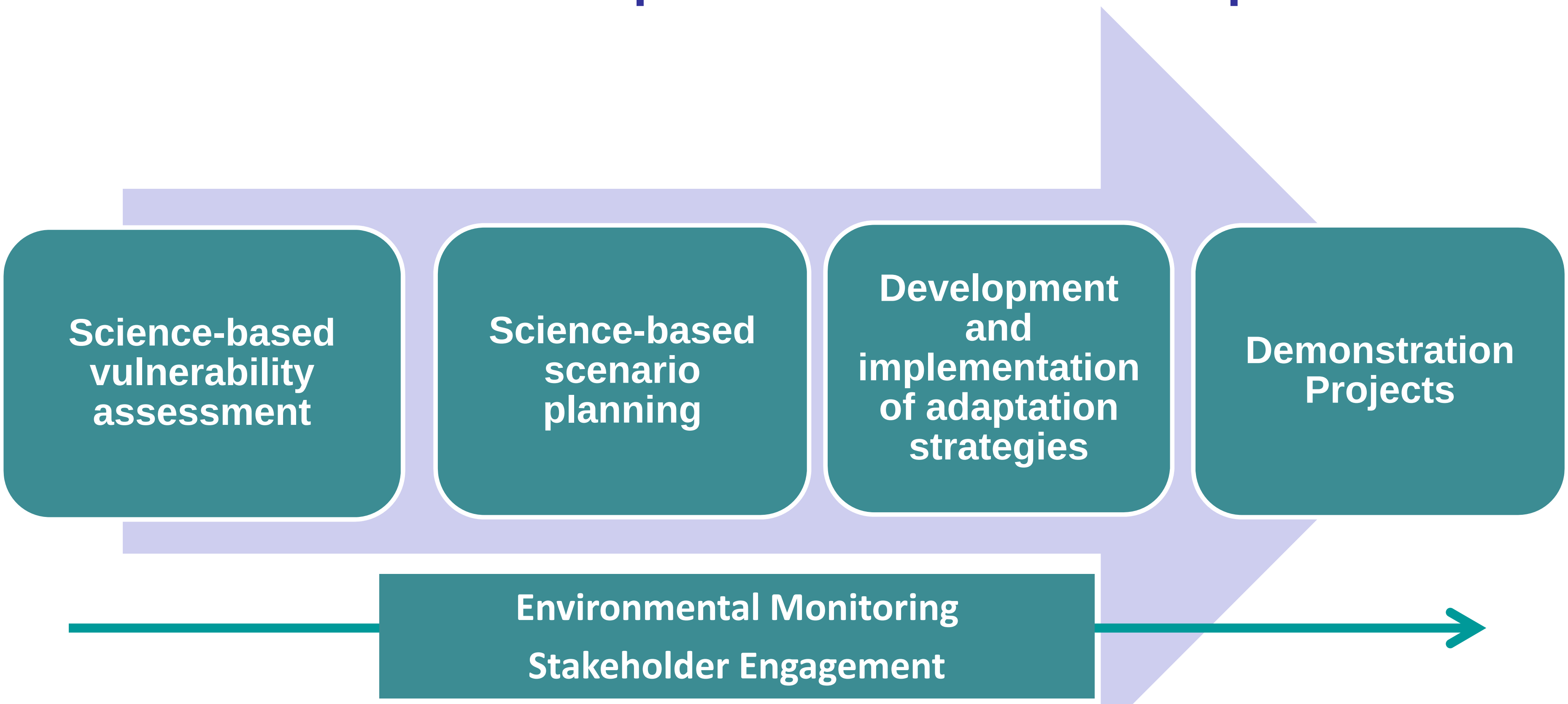
- Reduce GHGs by 25% from 1990 levels by 2020
- Reduce GHGs by 40% from 1990 levels by 2030
- Assess vulnerabilities and ID key adaptation strategies

Convening:

- Cities
- County Departments
- Sectors, Experts, Public
- Regional partners (CRNB)


CALIFORNIA
Sonoma County
101
Cloverdale
Healdsburg
Windsor
Santa Rosa
Sebastopol
Cotati
Sonoma
Rohnert Park
Petaluma
rcpa
REGIONAL CLIMATE PROTECTION AUTHORITY
Sonoma
Napa
Solano
Marin
Contra Costa
San Francisco
Alameda
San Mateo
Santa Clara

Climate Adaptation Road Map



Vulnerability assessments

These can help a community measure the risks it faces from climate change. A good vulnerability assessment uses the best available science to identify local impacts, determine the community's exposure and sensitivity to these impacts, and define where the community needs to improve its capacity to adapt to these impacts.

Climate adaptation plans

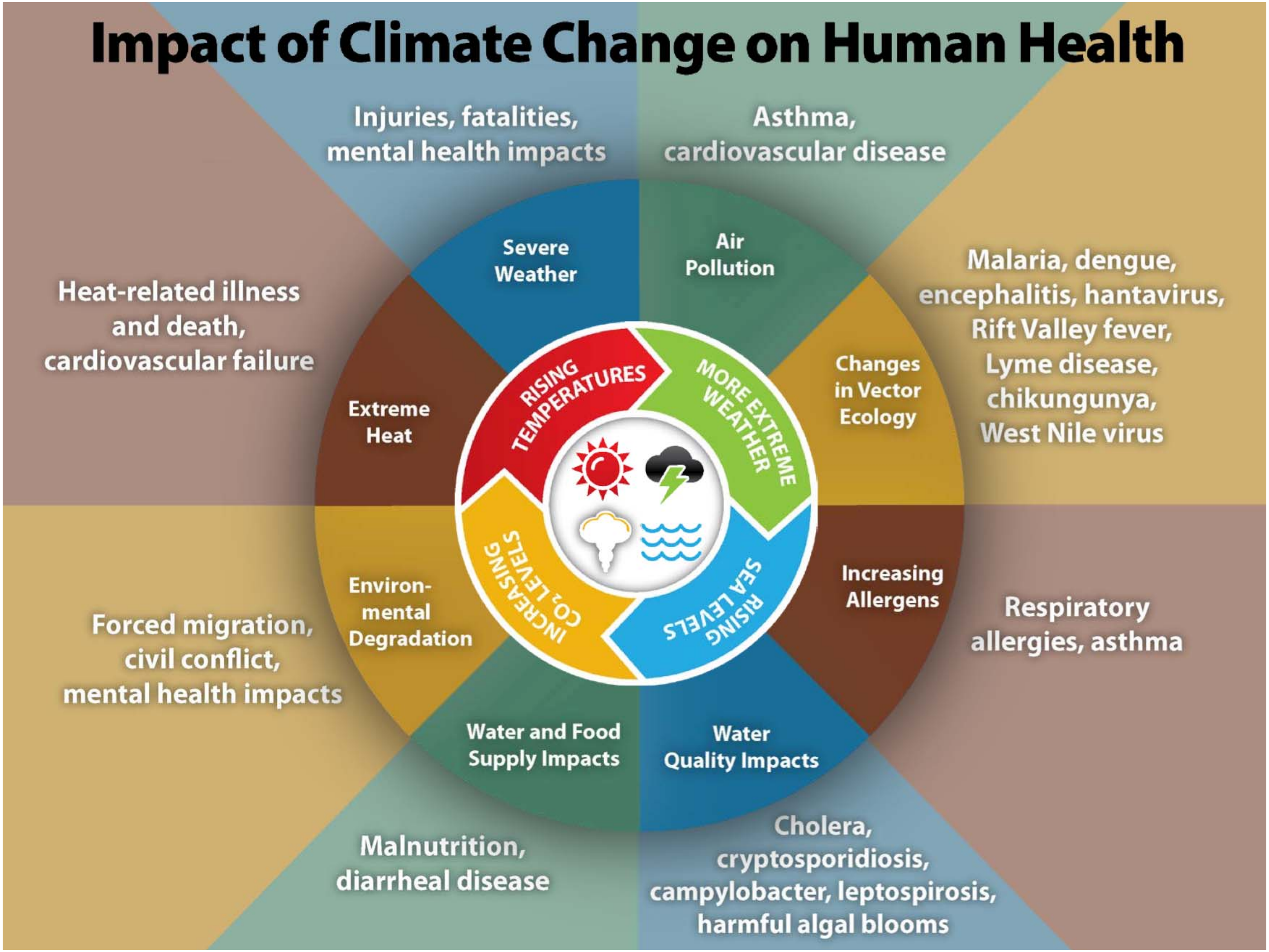
A comprehensive climate adaptation plan sets priorities for adaptation actions that respond to risks identified in a vulnerability assessment.

Climate Change & Health

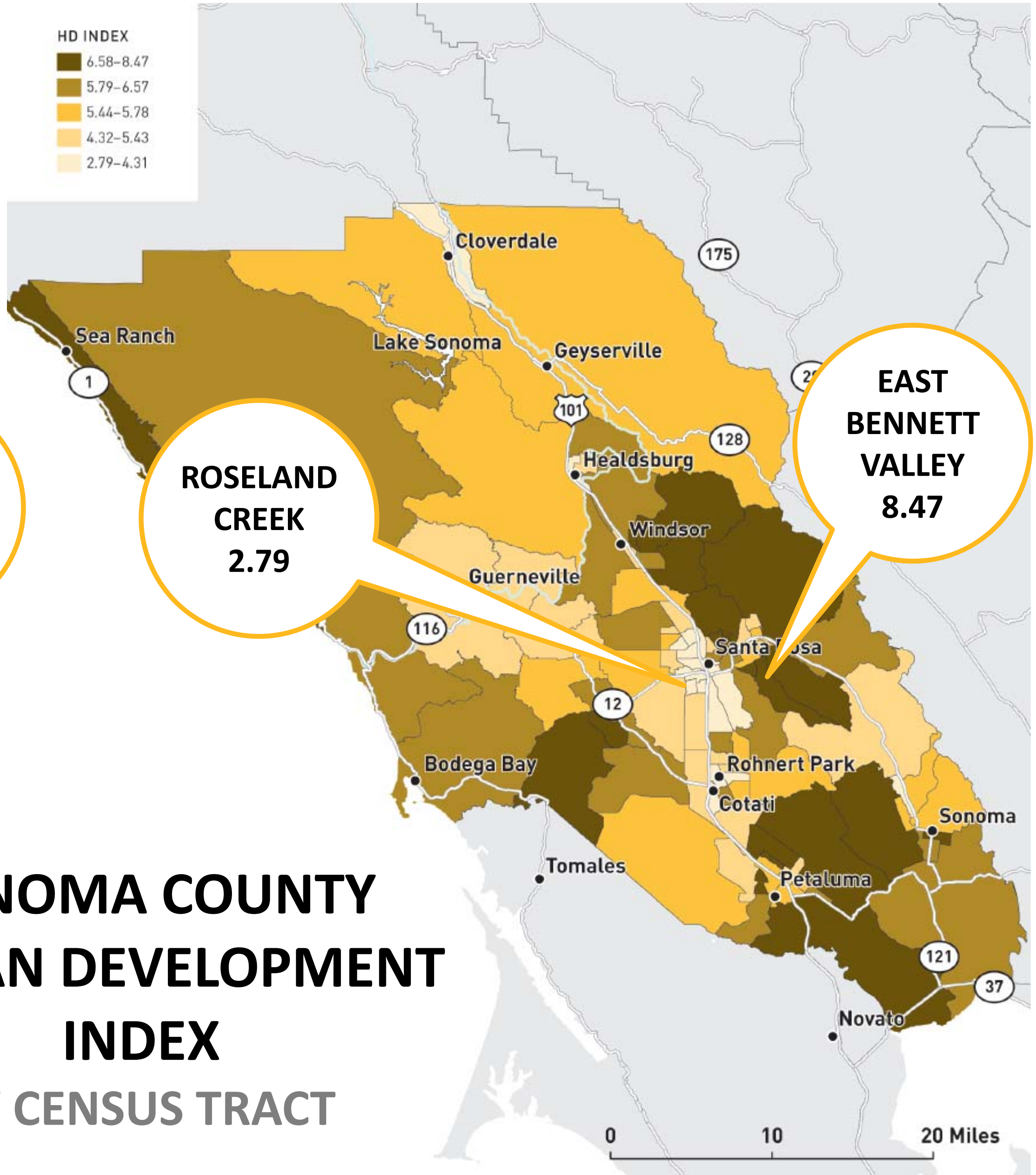
“Climate change is the biggest global health threat of the 21st century... The impacts will be felt all around the world – and not just in some distant future but in our lifetimes and those of our children.”

- The Lancet





Impact of Climate Change on Human Health
Injuries, fatalities, mental health impacts
Asthma, cardiovascular disease
Severe Weather
Air Pollution
Heat-related illness and death, cardiovascular failure
Malaria, dengue, encephalitis, hantavirus, Rift Valley fever, Lyme disease, chikungunya, West Nile virus
Extreme Heat
Changes in Vector Ecology
RISING TEMPERATURES
MORE EXTREME WEATHER
INCREASING CO_2 LEVELS
RISING SEA LEVELS
Environ-mental Degradation
Increasing Allergens
Forced migration, civil conflict, mental health impacts
Respiratory allergies, asthma
Water and Food Supply Impacts
Water Quality Impacts
Malnutrition, diarrheal disease
Cholera, cryptosporidiosis, campylobacter, leptospirosis, harmful algal blooms

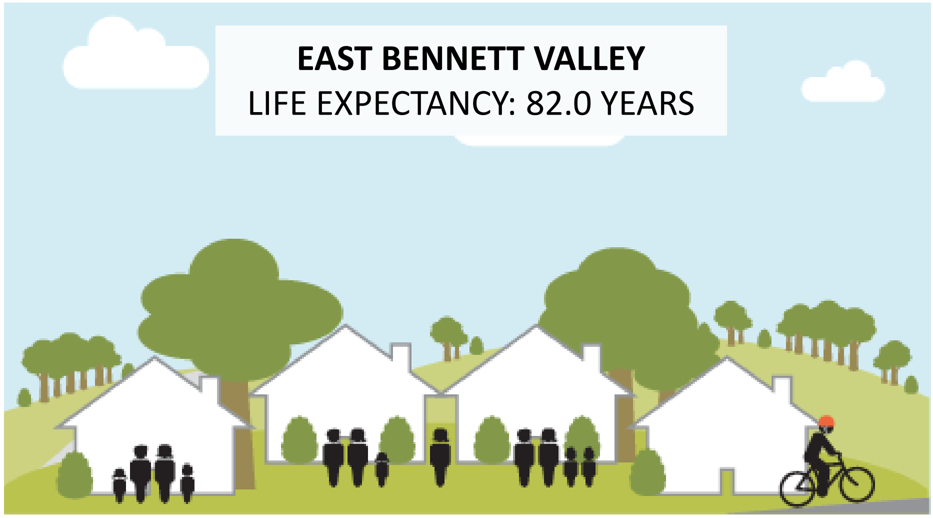


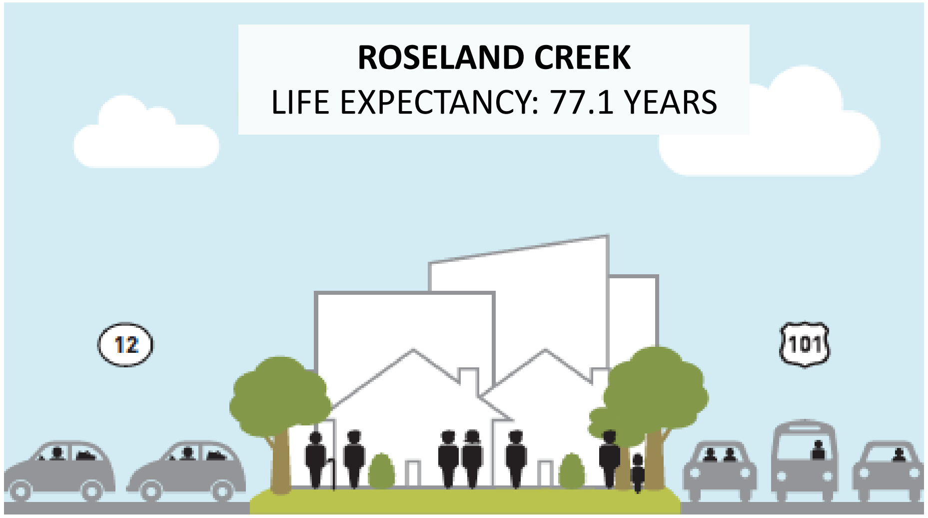
Sonoma County 5.42

SONOMA COUNTY HUMAN DEVELOPMENT INDEX

BY CENSUS TRACT

A TALE OF TWO NEIGHBORHOODS





- **1.2%** living in poverty
- **5%** Latino population
- **extensive** parks and green space
- **58.6%** at least bachelor's degree
- **61%** management occupations
- **$68,967** median personal earnings

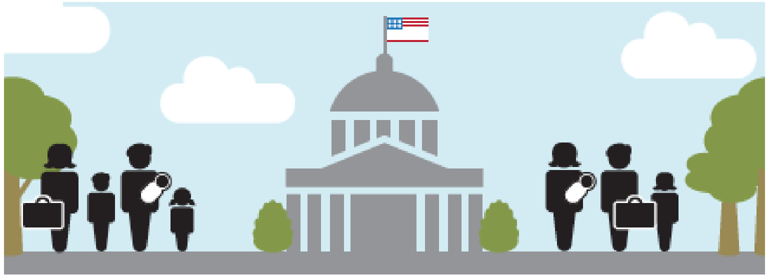
- **16.5%** living in poverty
- **59%** Latino population
- **limited** parks and green space
- **8.6%** at least bachelor's degree
- **11%** management occupations
- **$21,699** median personal earnings

ECOSYSTEM OF A HEALTHY COMMUNITY

- Green spaces
- Sidewalks and bike paths
- Affordable housing

- Jobs with decent wages
- Work/life balance
- A diverse economy

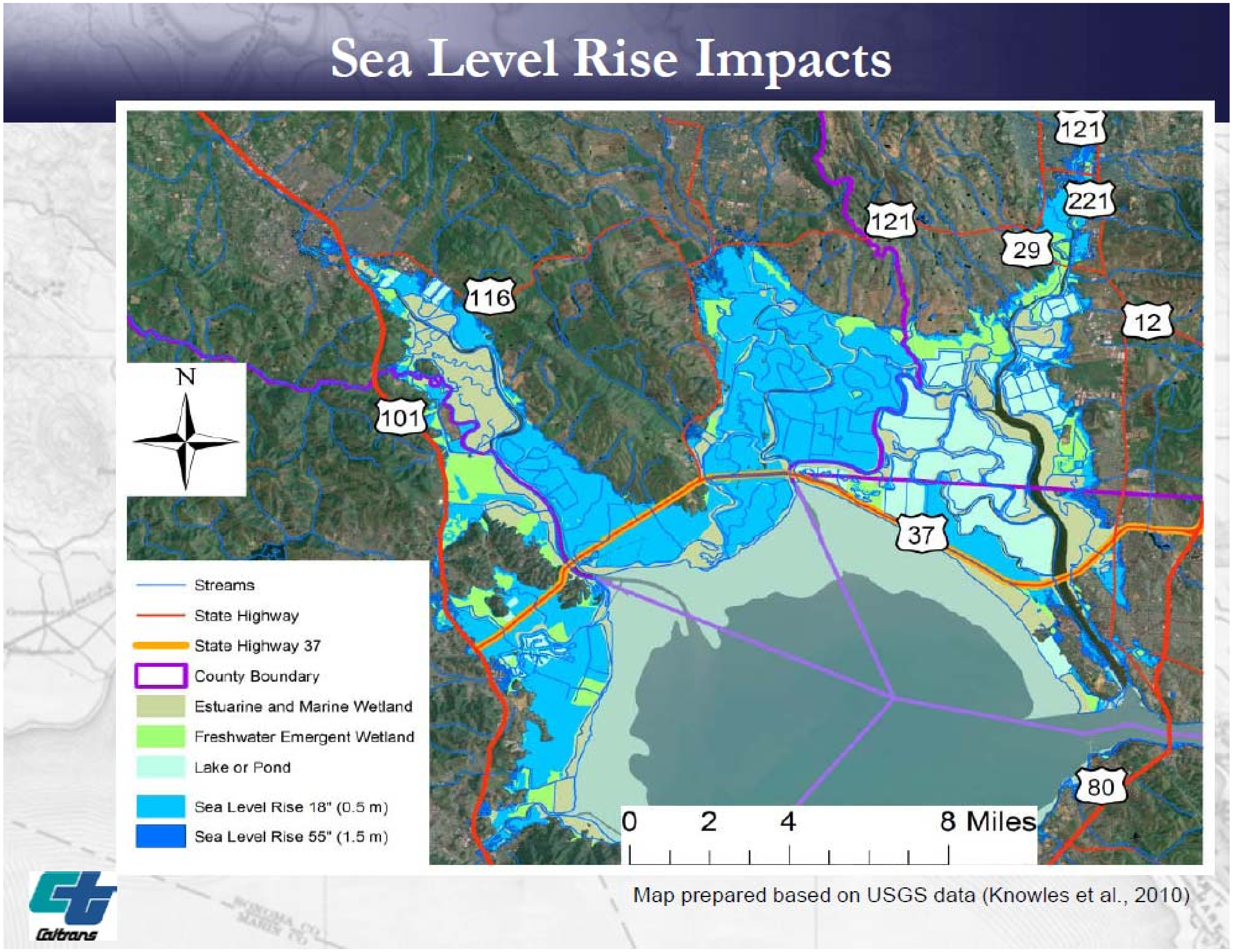
- Fresh produce stores
- High-quality schools
- Affordable health care
- Accessible public transportation



- Equality under the law
- Accountable government
- Affordable, safe childcare
- Safety and security

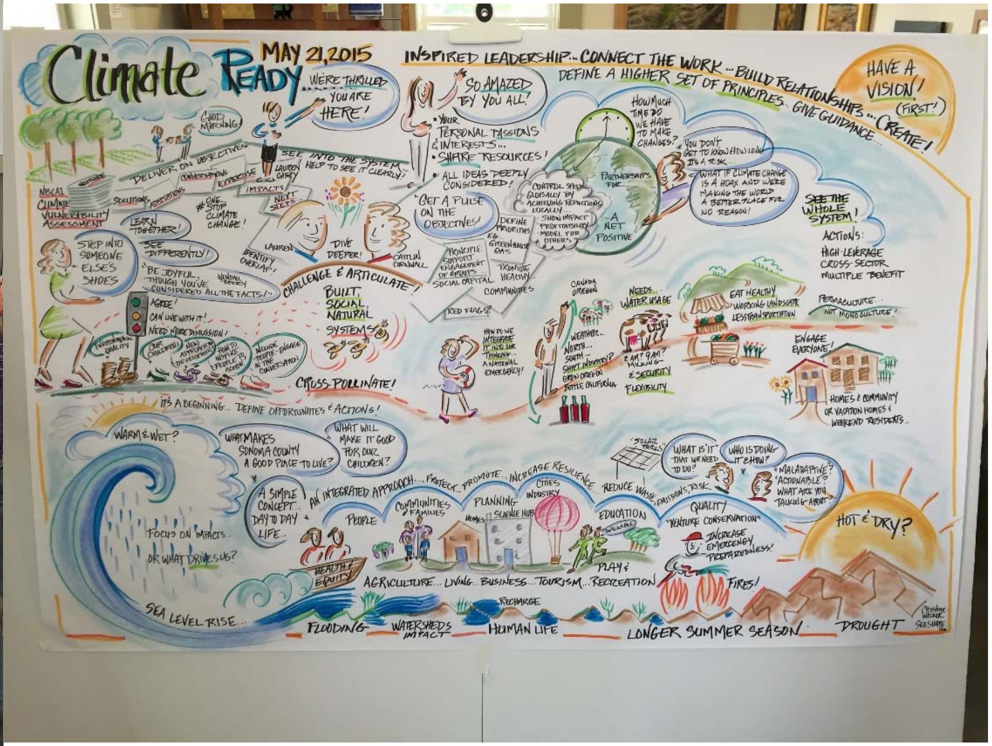
Pan Zoom
Draw Report
GIS File Report
Known Issues
Penngrove
El Verano
Sonoma
Sonoma
Napa
Napa Valley College
Petaluma
Petaluma
Institute of Noetic Sciences
Little Island
Russ Island
Napa River
Island No 2
Solano
Island Number 1
Island Number 1
Knight Island
Sonoma
Marin
Novato Creek
Novato
Nicasio
Mare Island
San Pablo Bay
San Pablo Bay
2 km
1 mi

Specific project example: Hwy 37



Source: Caltrans, State Route 37 Stewardship Study presentation, July, 2013

Community Adaptation Planning



RCPA Climate Readiness Goals

1	Promote healthy, safe communities
2	Protect water resources
3	Promote a sustainable, climate-resilient economy
4	Mainstream the use of climate projections (not just past patterns) in planning, design, and budgeting
5	Protect coastal, bayside, and inland buffer zones
6	Promote food system security and agricultural climate preparedness
7	Protect infrastructure: buildings, energy systems, communications systems, water infrastructure, and transportation systems
8	Increase emergency preparedness
9	Monitor the changing climate and its biophysical effects, in real time

Climate Action 2020 and Beyond

A REGIONAL PROGRAM FOR SONOMA COUNTY COMMUNITIES ~ HIGHLIGHTS AND SUMMARY

NBCAI

The Climate Resilience Roadmap Visual

A Climate-Resilient Vision for Sonoma County

6 CLIMATE HAZARDS ADDRESSED

- Extreme Heat
- Frequent Drought
- More Wildfires
- Warmer Winters
- More Floods
- Higher Seas

9 CLIMATE RESILIENCE GOALS

1. Promote healthy, safe communities
2. Protect water resources
3. Promote a sustainable, climate-resilient economy
4. Mainstream the use of climate projections
5. Manage buffer zones
6. Promote ag preparedness and food security
7. Protect infrastructure
8. Increase emergency preparedness and prevention
9. Monitor climate and its effects

Process

TOP 20 ACTIONS

Shown is a subset of 50 resilience actions that appear in the complete Roadmap, distilled from over 125 raw actions from dozens of contributors and vetted by NBCAI and other experts.

We must ALL participate for our community to be climate-resilient. Every person (and actor) has a part to play—school child, designer, official, tradesperson, farmer, retiree—to lead us to the resilient future we know is possible.

The Goals and Actions are numbered for convenience, not to indicate priority.
For the the full list of actions, see the Roadmap document at northbayclimate.org.

1. Vulnerable communities' reslience
2. Connect community
3. Use less water
4. Use less water
5. Manage water as one
6. Diversify agriculture
7. Be ready
8. Get specific advice
9. Quantify benefits
10. Make room for water
11. Align plans with hazards
12. Farm carbon, water & diverse crops
13. Subsidize local food
14. Know the risks
15. Reduce forest flammability
16. Prepare yourself
17. Invest in radical collaboration
18. Reality check
19. Align investments with values
20. Measure resilience

5 ACTORS

- WL – Working Lands Managers
- Bz – Businesses
- IH – Individuals Households
- Gv – Government
- NP – Nonprofits, Faith Community & Philanthropy, Academic Institutions

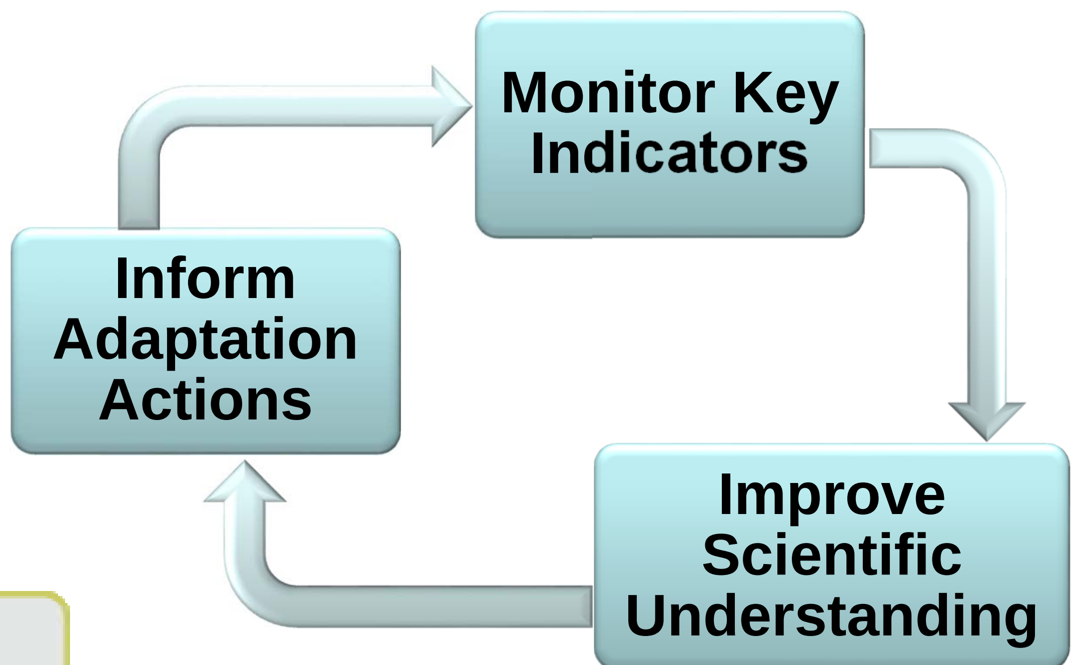
Local Adaptation

Proceeding with Climate-Safe Actions

Monitor starting now

Plan for extremes and wider range of variability

Adapt approaches to meet changing conditions

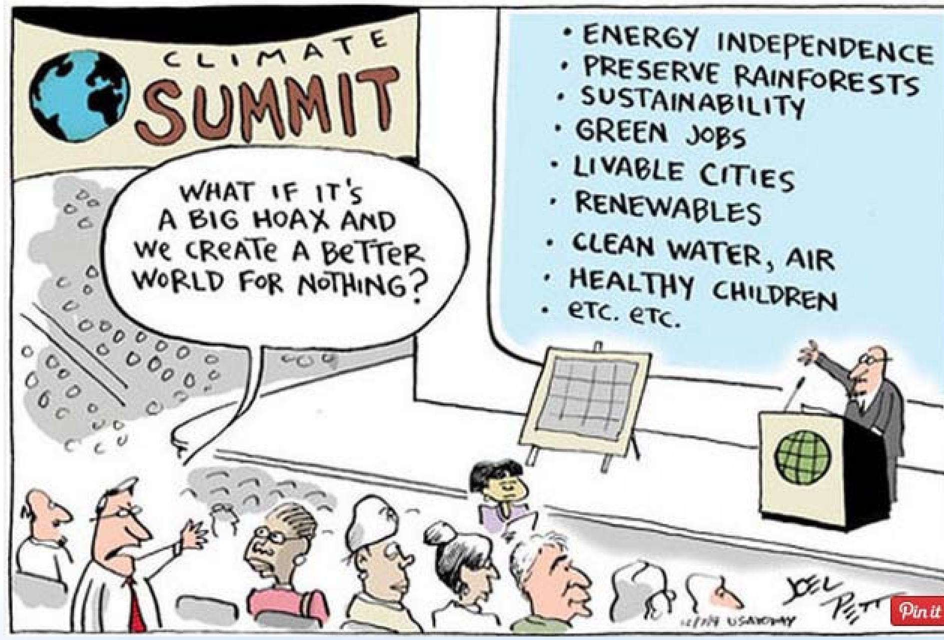


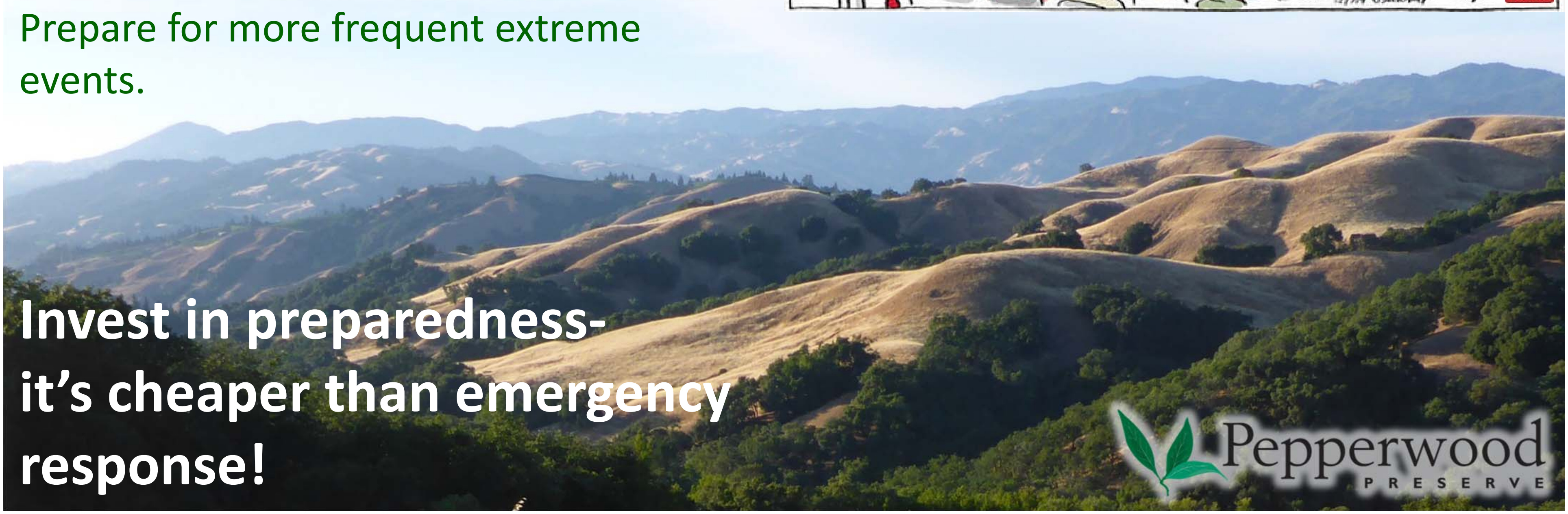
Sonoma County monitoring pilot underway (NBCAI, Pepperwood, SRJC, SCWA, TBC3, BAECCC)

North Bay CLIMATE ADAPTATION INITIATIVE

Win-win strategies for climate adaptation

Mitigate greenhouse gas emissions.
Protect key watershed functional areas: floodplains, recharge areas, wetlands.
Recycle and conserve water.
Increase soil moisture holding capacity.
Get serious about fuels management.
Identify native species that are likely to be climate “winners”- protect seed sources.
Keep the landscape connected-riparian and terrestrial habitat corridors.
Prepare for more frequent extreme events.





Invest in preparedness- it’s cheaper than emergency response!


Thank you!
lmicheli@pepperwoodpreserve.org
Lauren.casey@rcpa.ca.gov

TBC3 has built a climate adaptation knowledge base for application to CA Coast Range watersheds

Climate
+
Topography

⇨

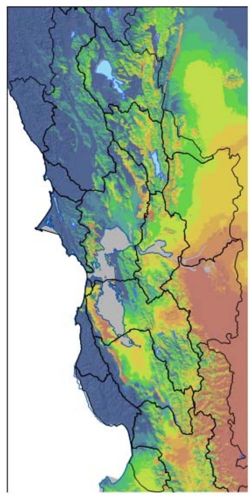
Watershed Hydrology
+
Topo-climate

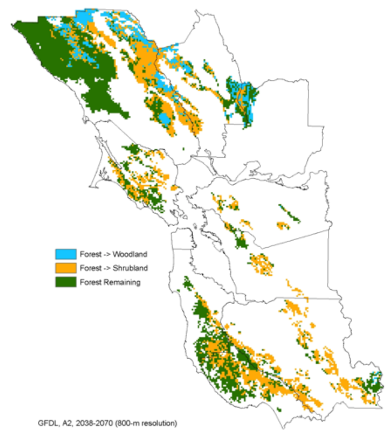
⇨

Vegetation Cover
+
Fire Risks

⇨

Species Distributions





generating an ensemble of projections for use in scenario planning

Pepperwood PRESERVE