# Climate Ready North Bay
## Napa County

# Project Overview and Sample Data Products

WICC September 24, 2015

prepared by TBC3.org members
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# Agenda

- introduce Pepperwood, TBC3 and Climate Ready
- climate ready project overview and approach
- sample data products for region and Napa Valley
- potential data applications
- questions!

# Mission: advance 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

Pepperwood
PRESERVE
Inspiring conservation through science

# TBC3

Terrestrial Biodiversity Climate Change Collaborative

Pepperwood Preserve
Inspiring conservation through science

Berkeley
University of California

An nationally-recognized climate science initiative

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

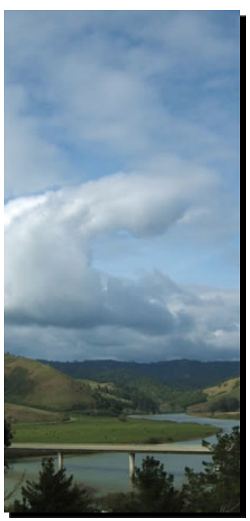
# TBC3 has built a climate adaptation knowledge base for application to regional conservation

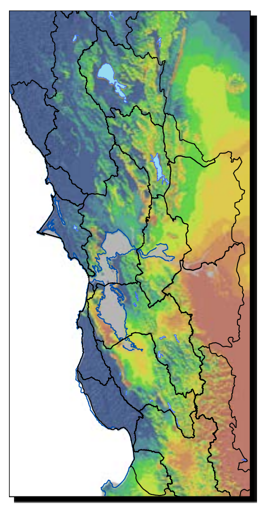
Climate
+
Topography

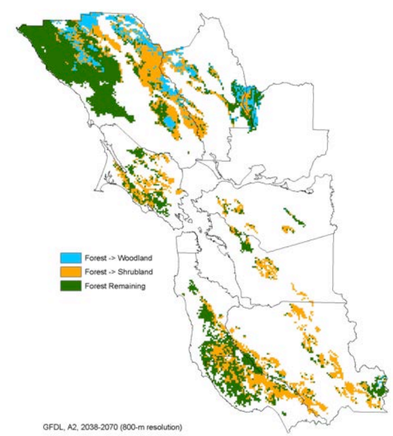
Watershed Hydrology
+
Topo-climate

Vegetation Cover
+
Fire Risks

Species Distributions








generating an ensemble of projections for use in scenario planning
NOT predictions

Pepperwood
PRESERVE

## the question

how will a shifting climate effect the lives and landscapes of Northern California?

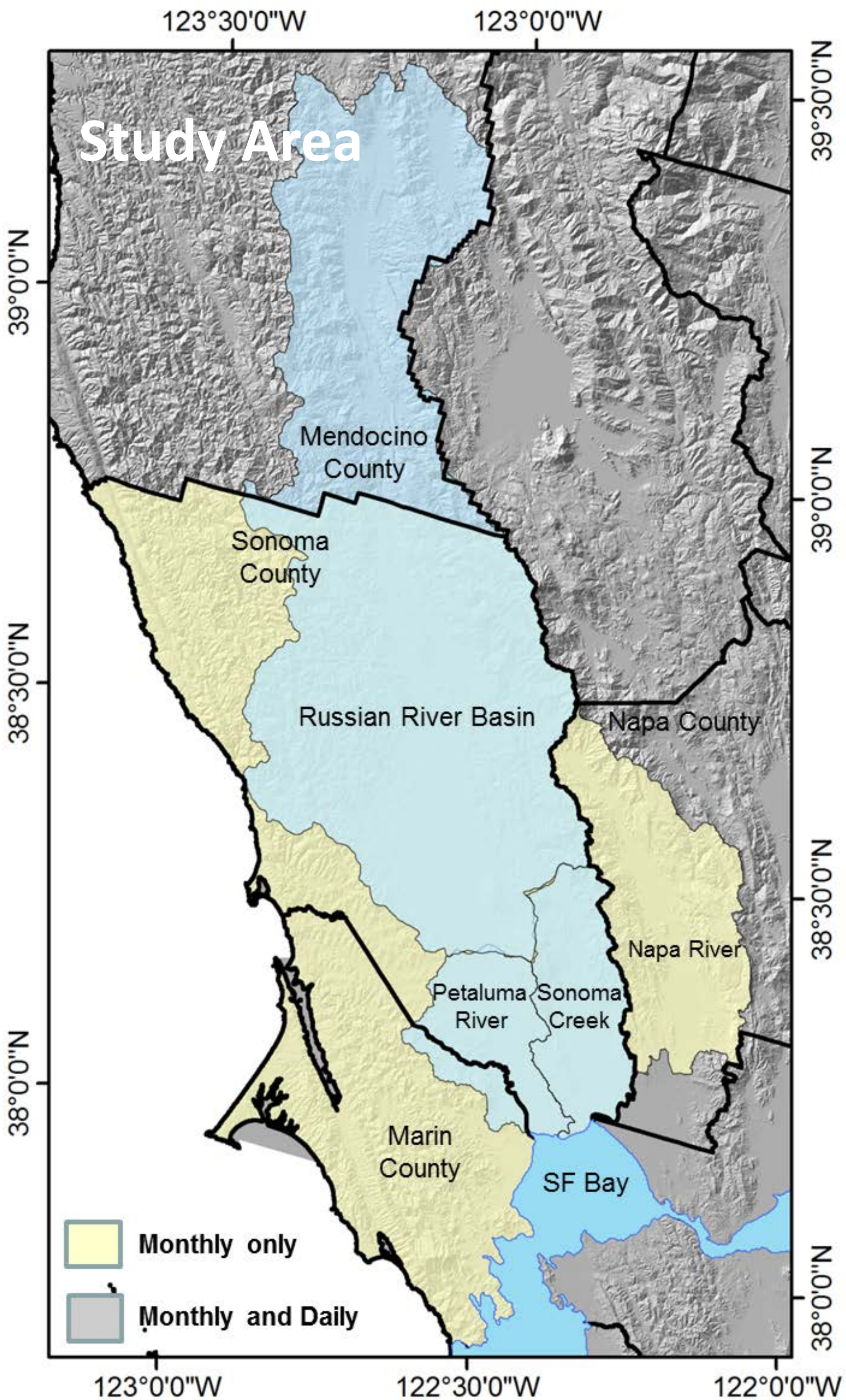
## take home message

our region is becoming more arid

## the challenge

so how can we make our watersheds more resilient?

# North Bay Climate Ready




## Serving natural resource agencies in Marin, Sonoma, Napa and Mendocino Counties

Funding: a *Climate Ready* Coastal Conservancy grant to Sonoma's Regional Climate Protection Authority plus match funds from partners

Pepperwood is the lead analyst on vulnerability assessment with TBC3 members from USGS, and Point Blue Conservation Science

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Inspiring conservation through science

# Climate Ready Process

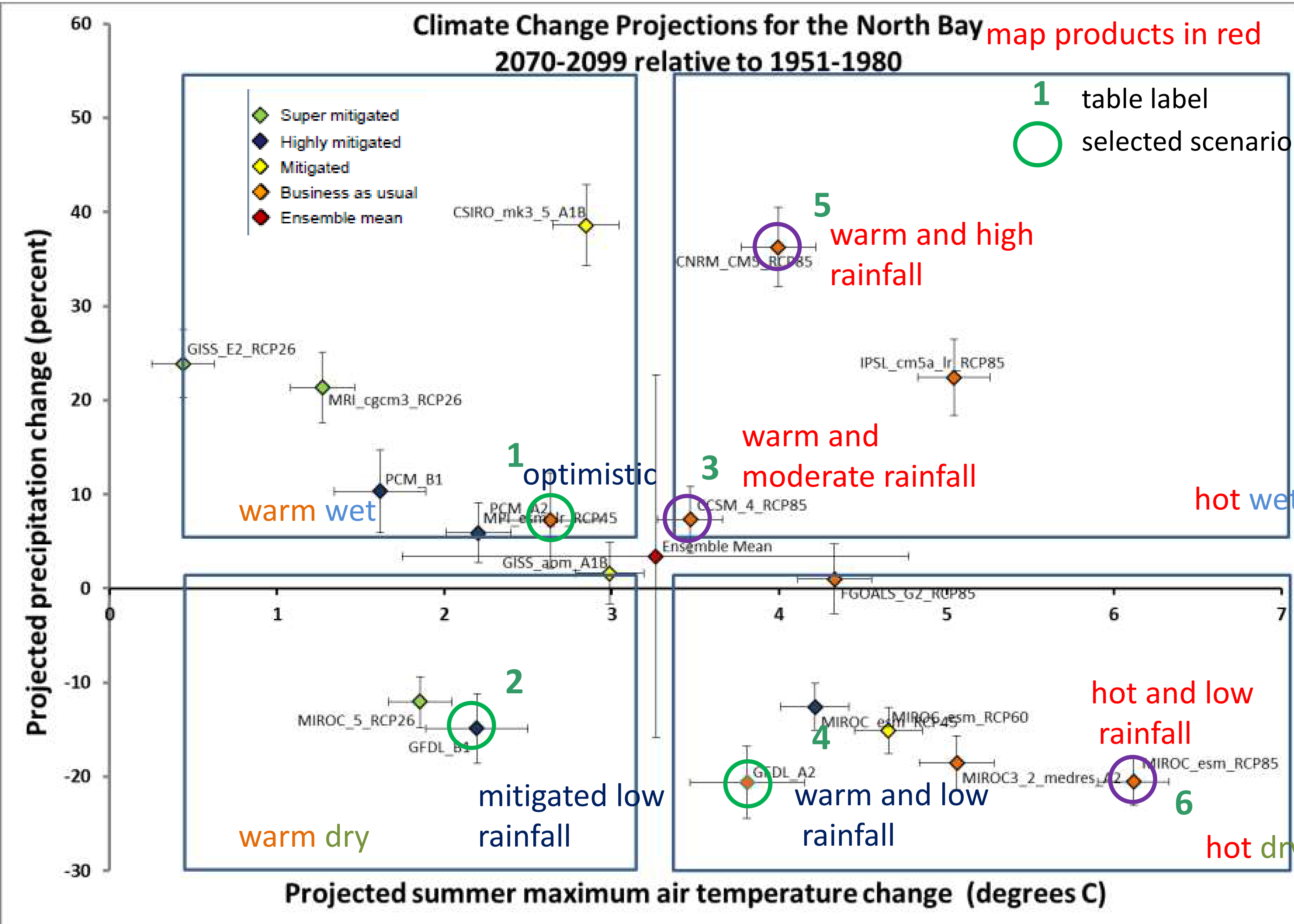
## Part 1

Engage managers at the outset: define key management questions for each jurisdiction, and then refine questions through process.

First meeting: based on their concerns, managers selected one set of climate "futures" based on concerns-focus on "worst case" with one "middle of road" and one "mitigated" for entire North Bay region.

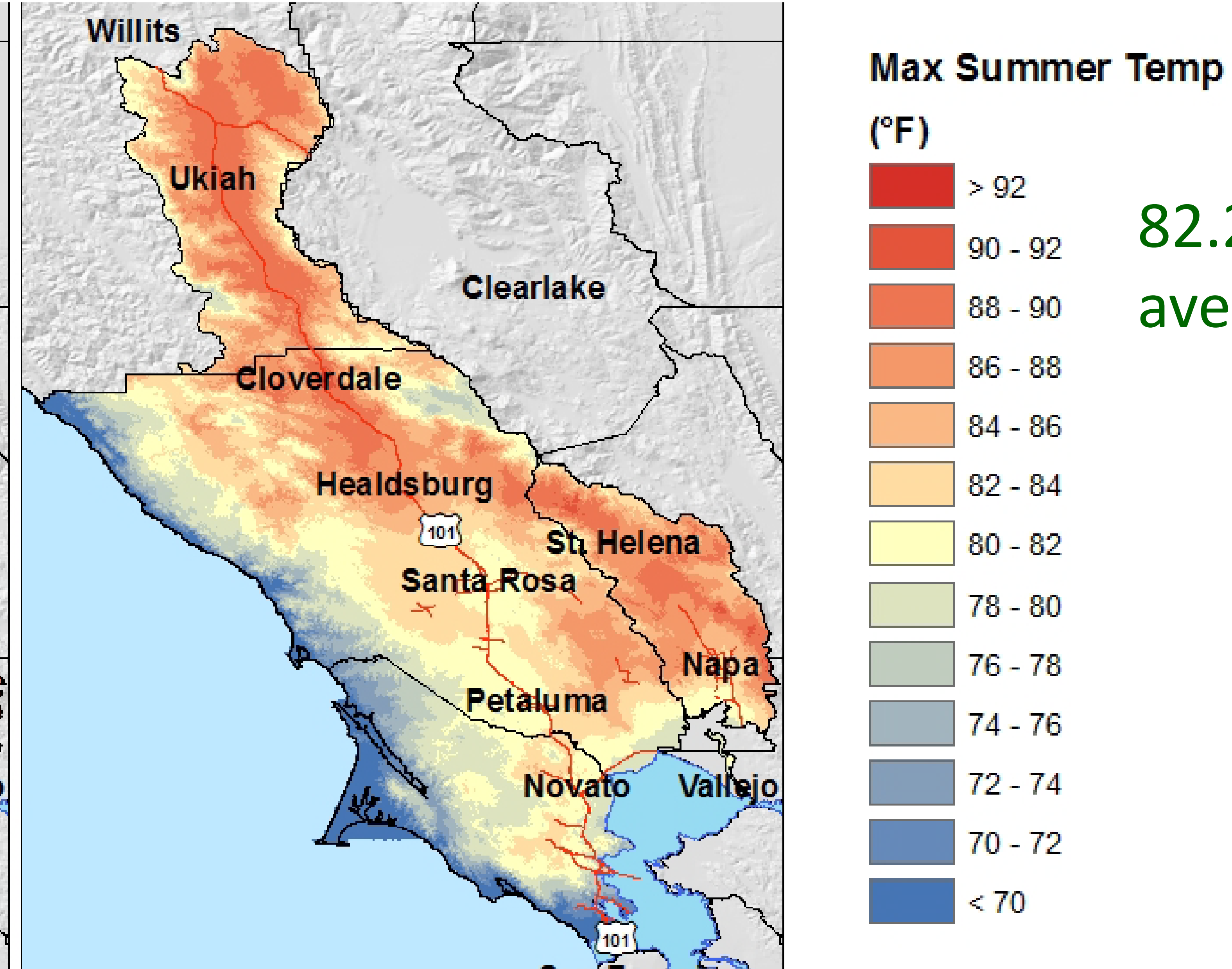
*climate model selection*

# North Bay Climate Ready: Selected Futures for Regional Vulnerability Assessment



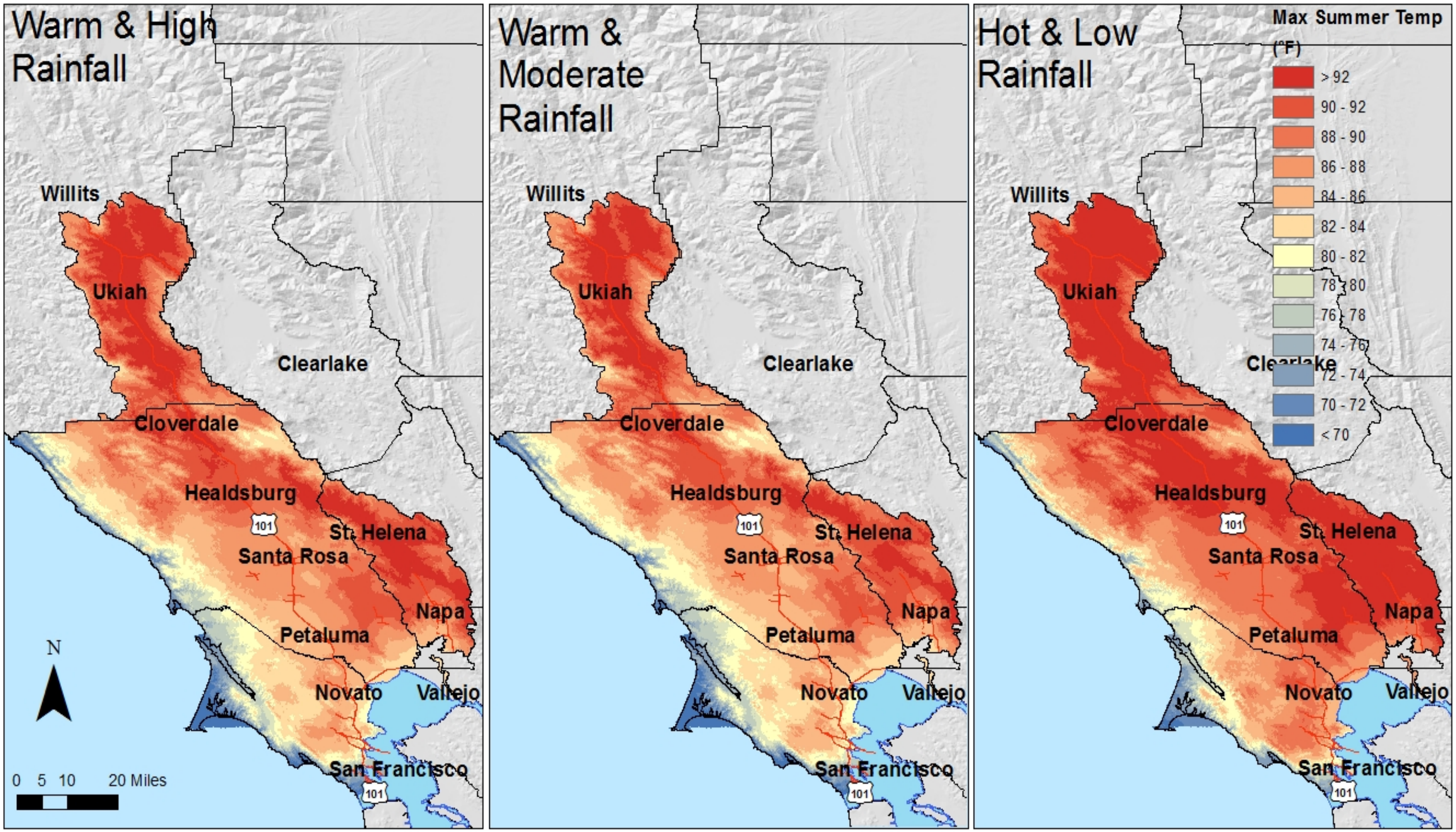
# Maximum summer temperature (monthly avg) (degF)

30-year average, current-1981-2010




82.2 deg F average

# Projected Maximum Summer Air Temperature, 2040-2069



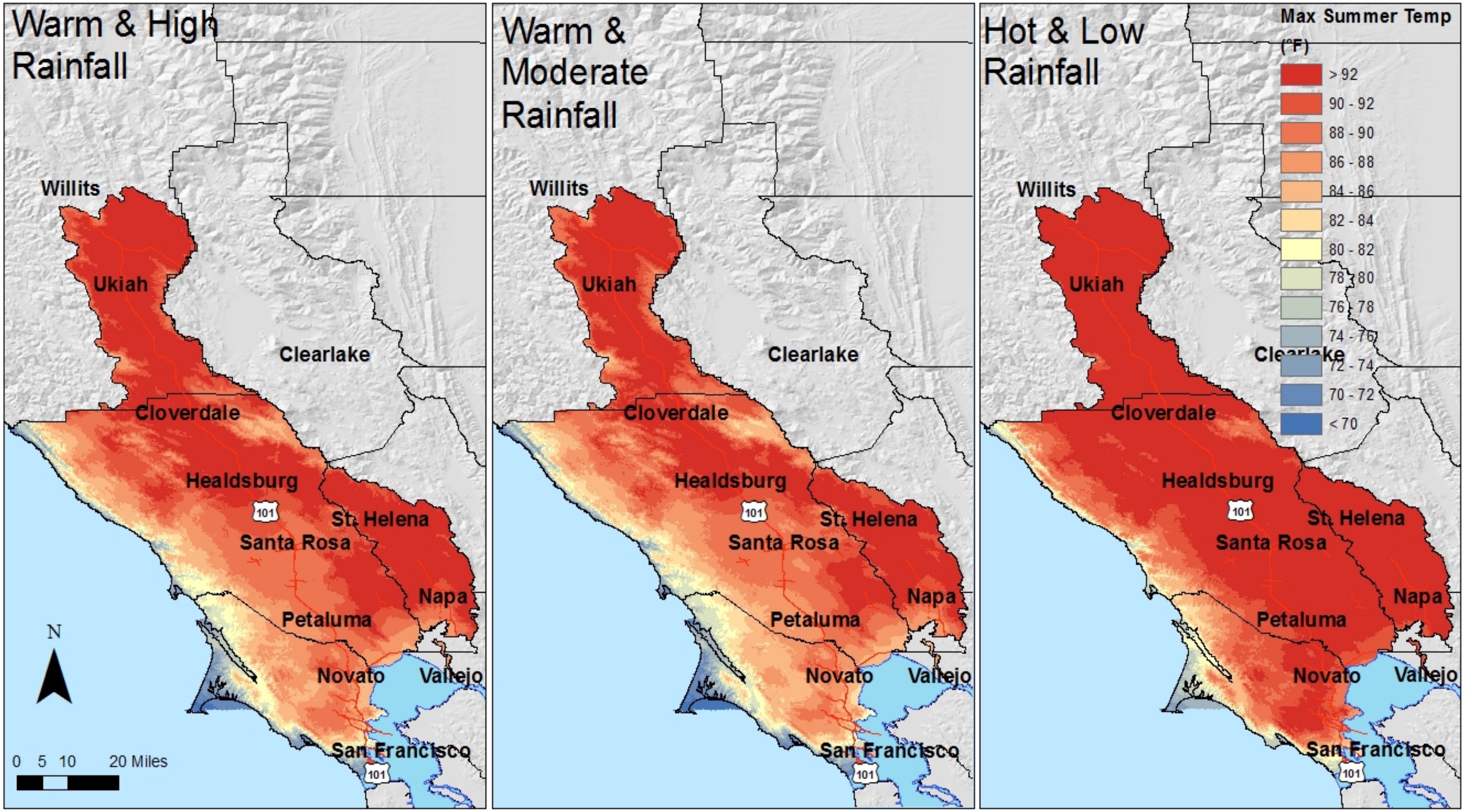

86.4 average
+4.2 deg F

86.0 average
+3.8 deg F

89.2 average
+7.0 deg F

“business as usual” mid-century temperatures-30 y average

# Projected Maximum Summer Air Temperature, 2070-2099




89.4 average
+7.2 deg F

88.45 average
+6.3 deg F

93.4 average
+11.2 deg F

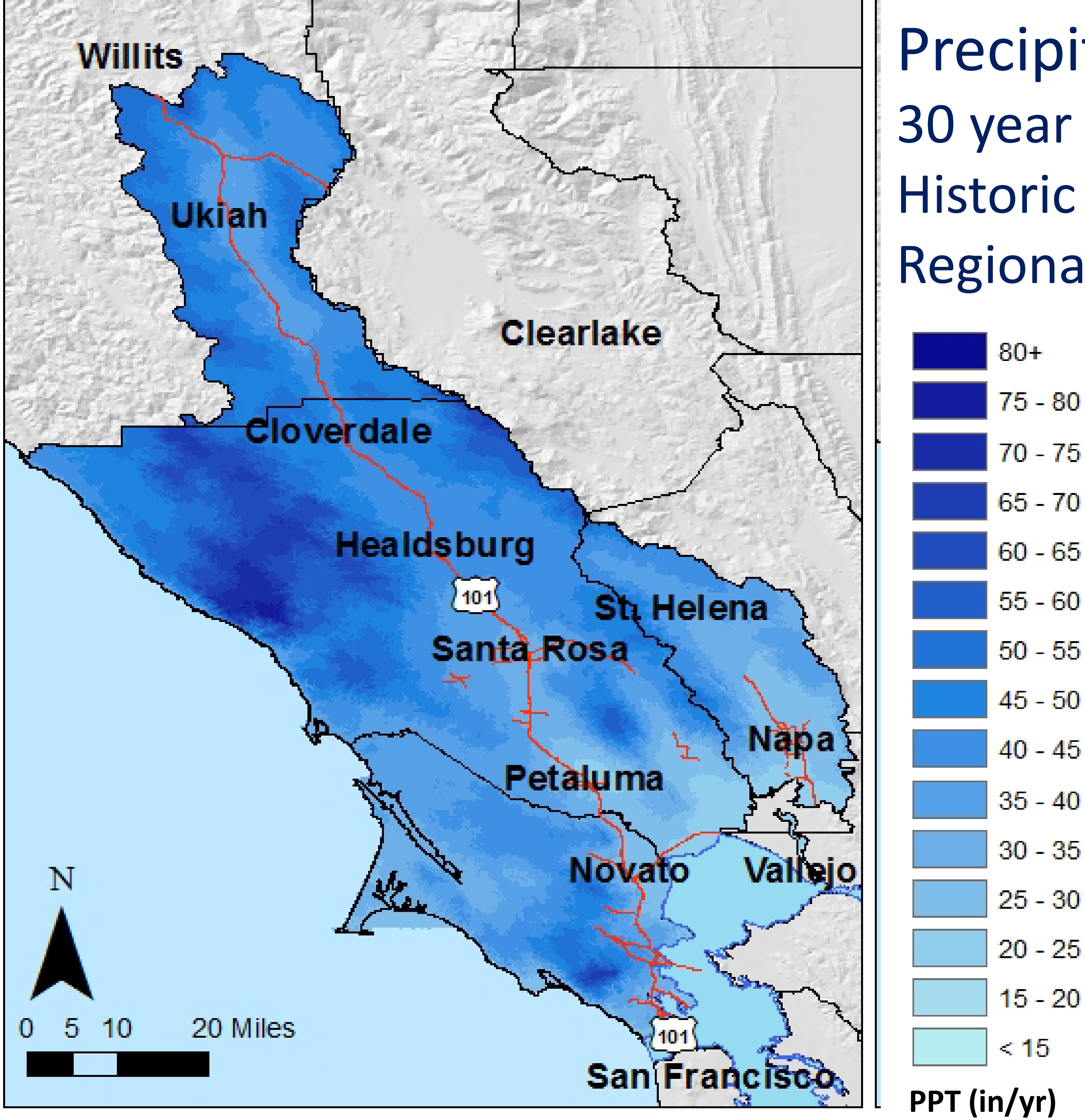
"business as usual" end of century temperatures-30 y average

# Precipitation (PPT)

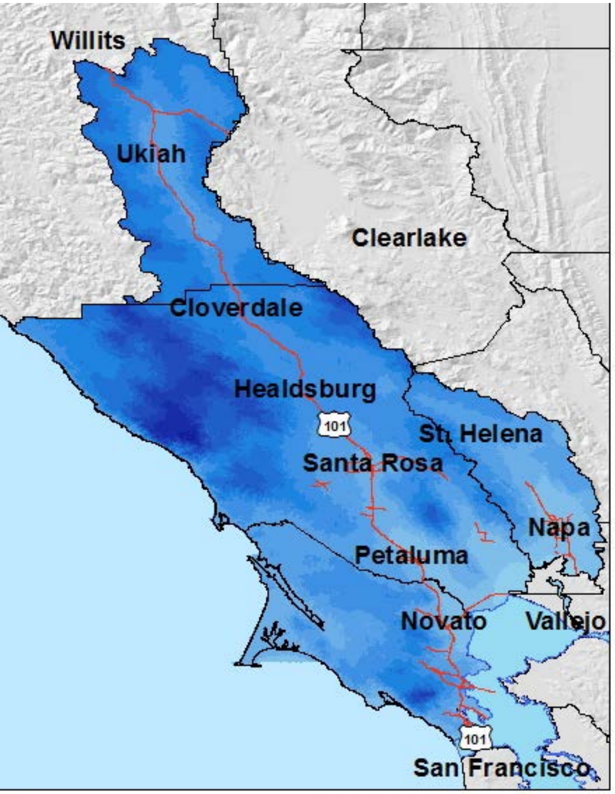
30 year average

Historic 1951-1980

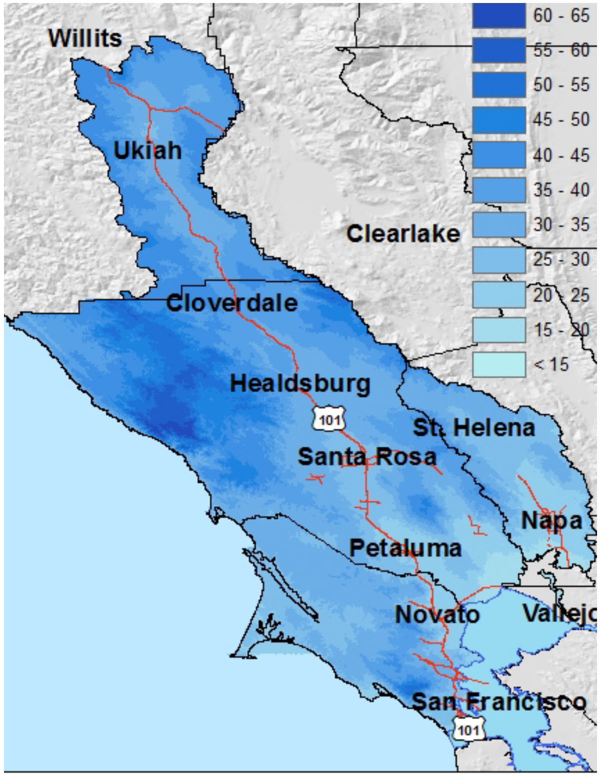
Regional average 43 in/y



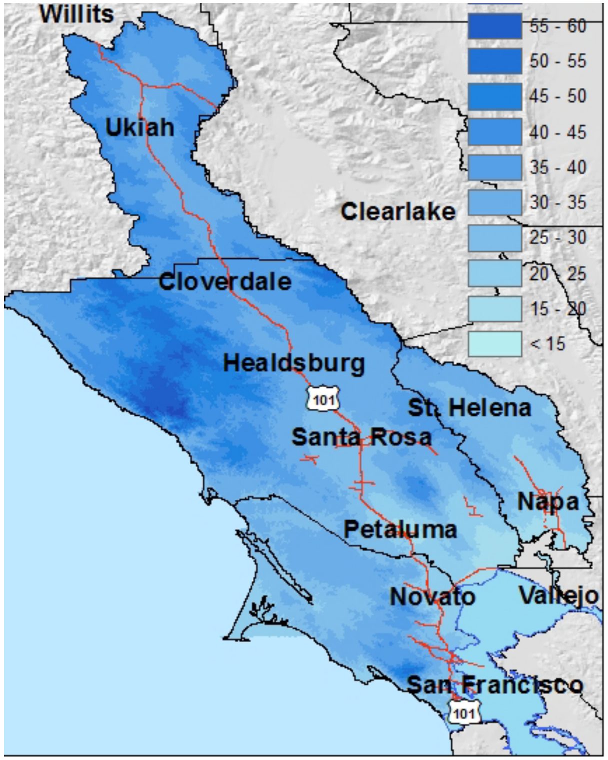
# Precipitation (PPT, annual in/y)
## 30-year average, current to projected-low rainfall, hot scenario




Current 1981-2010
43.0 average




Projected 2040-2069
35.0 average



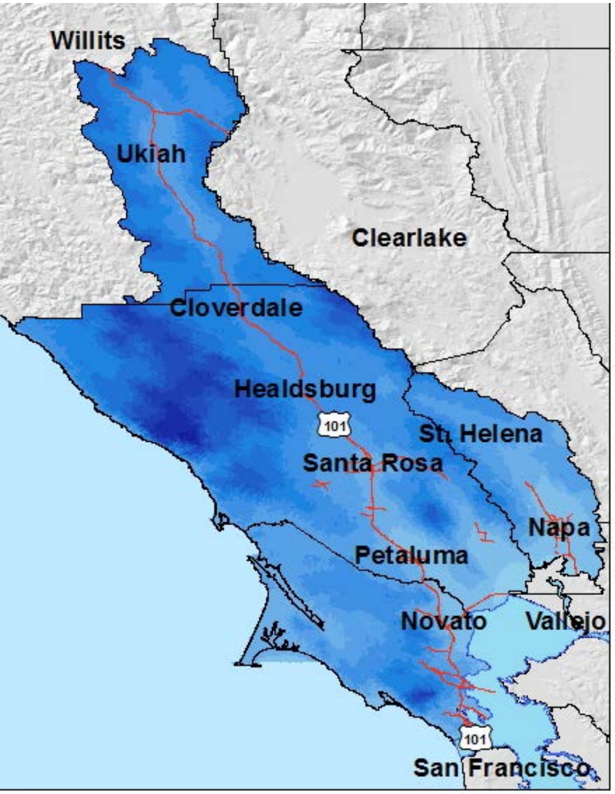

Projected 2070-2099
34.0 average

projecting 19-21% less rainfall than current

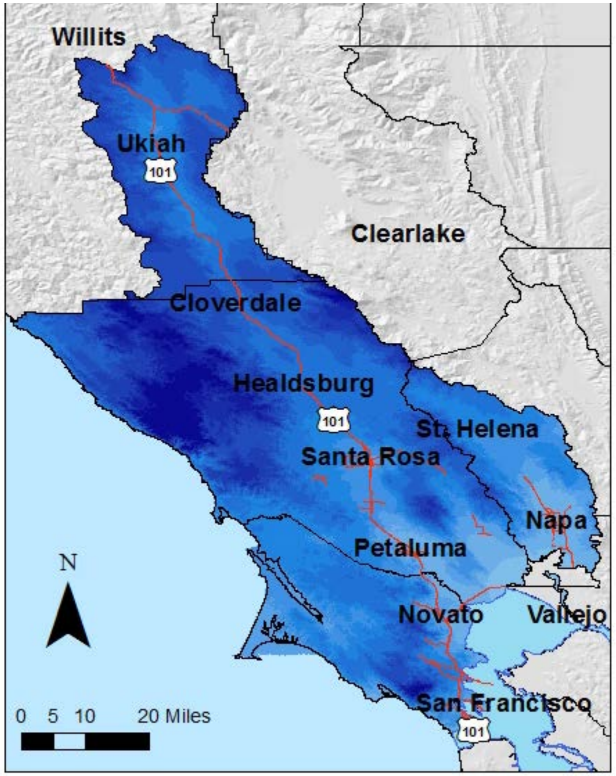
# Precipitation (PPT, annual in/y)

## 30-year average, current to projected-high rainfall

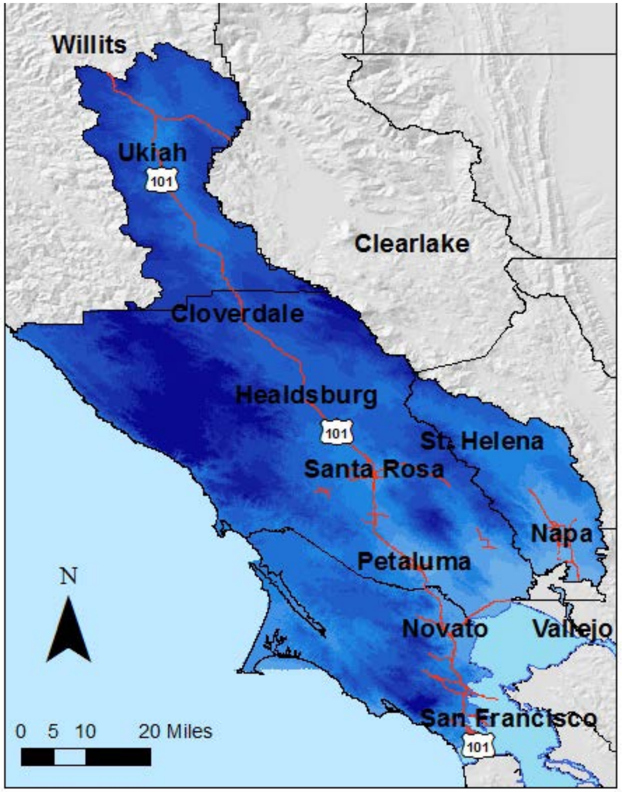
(warm scenario)




Current 1981-2010
43.0 average



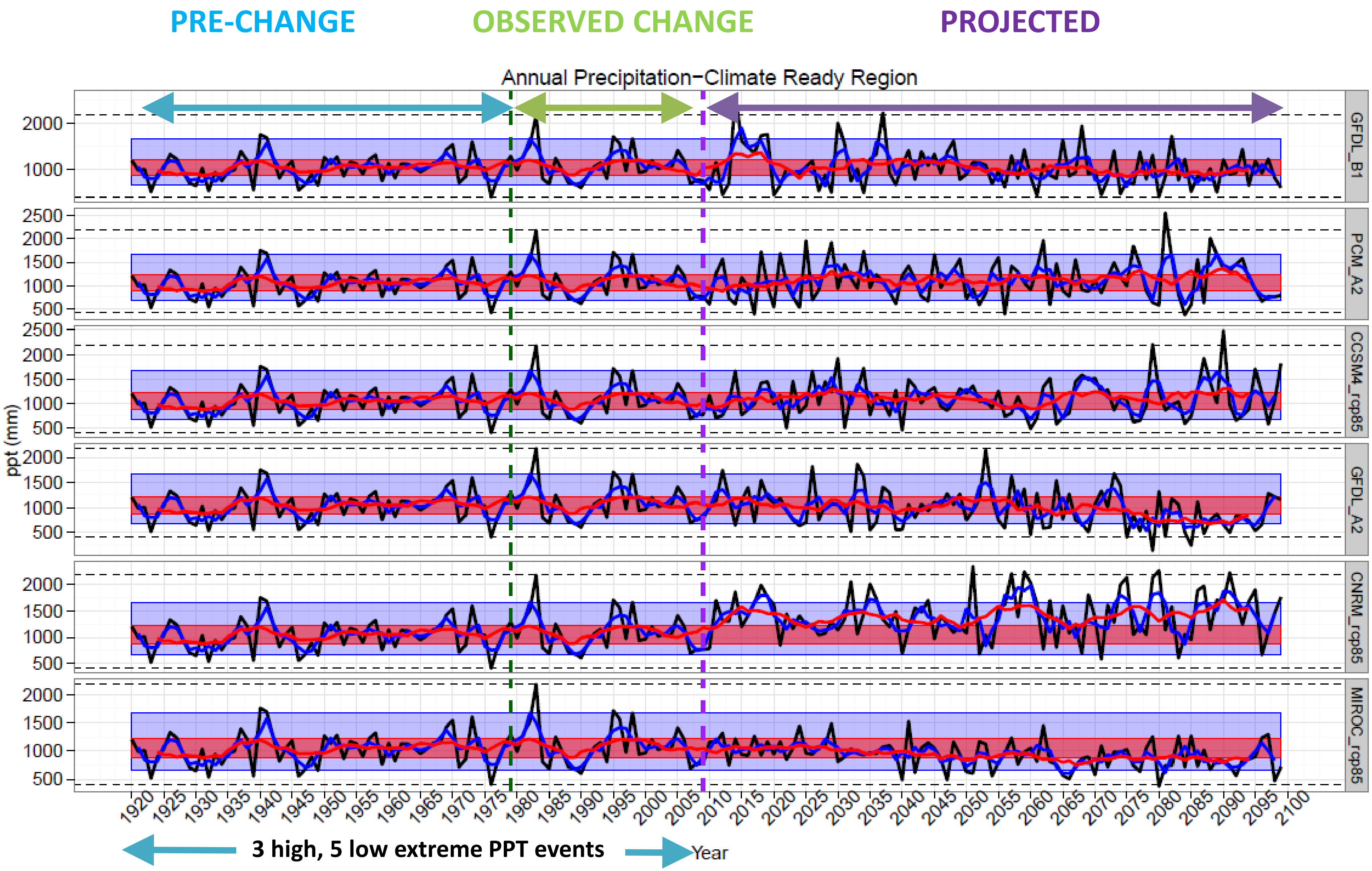

Projected 2040-2069
54.0 average




Projected 2070-2099
58.0 average

projecting 25-35% greater rainfall than current

# Annual Precipitation-North Bay Region




**PROJECTED EXTREMES**

6 highs
8 lows

8 highs
9 lows

8 highs
9 lows

5 highs
9 lows

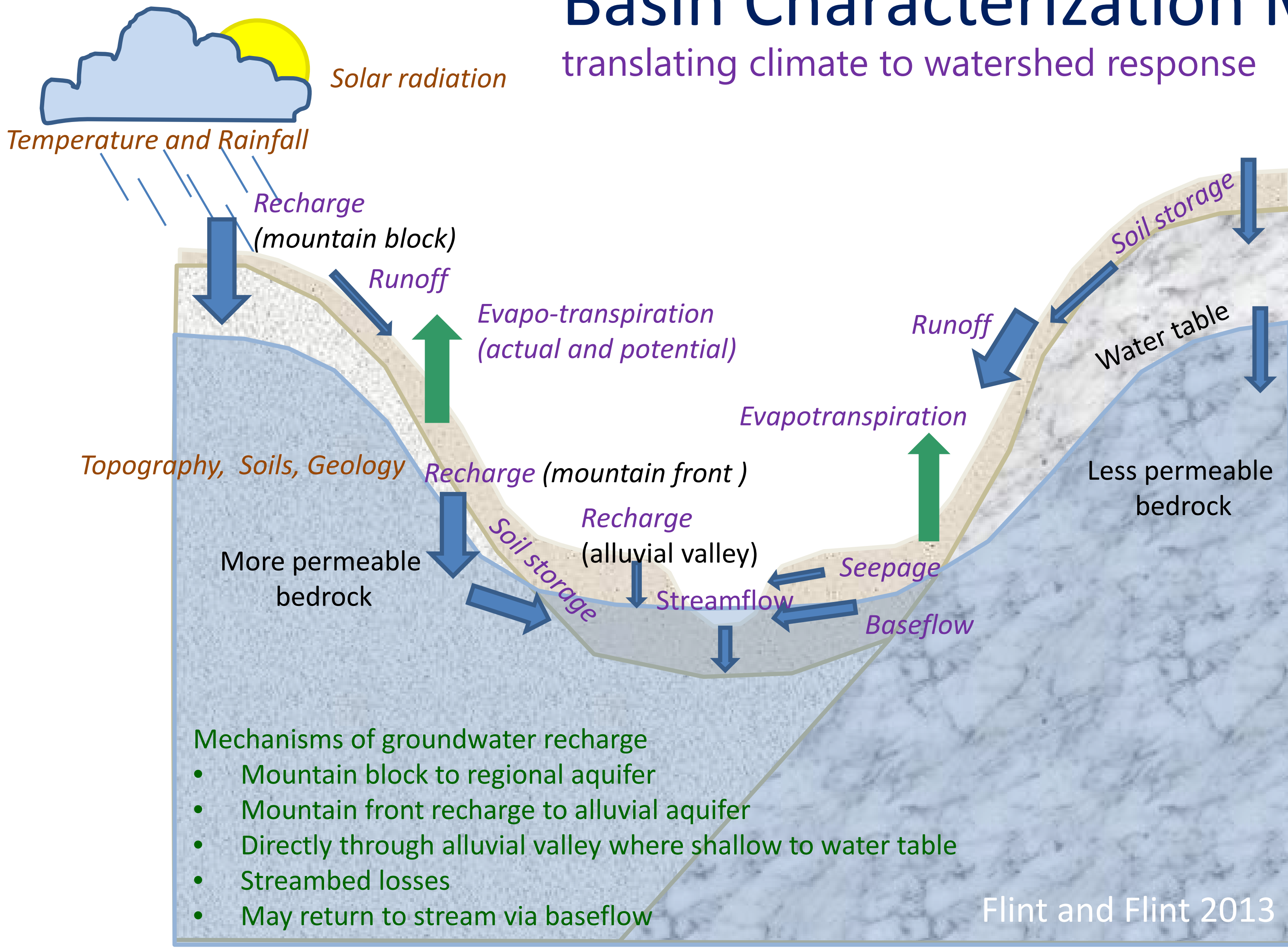
16 highs
6 lows

0 highs
12 lows

high and low extremes expected to approximately double frequencies in projections

# Basin Characterization Model

translating climate to watershed response



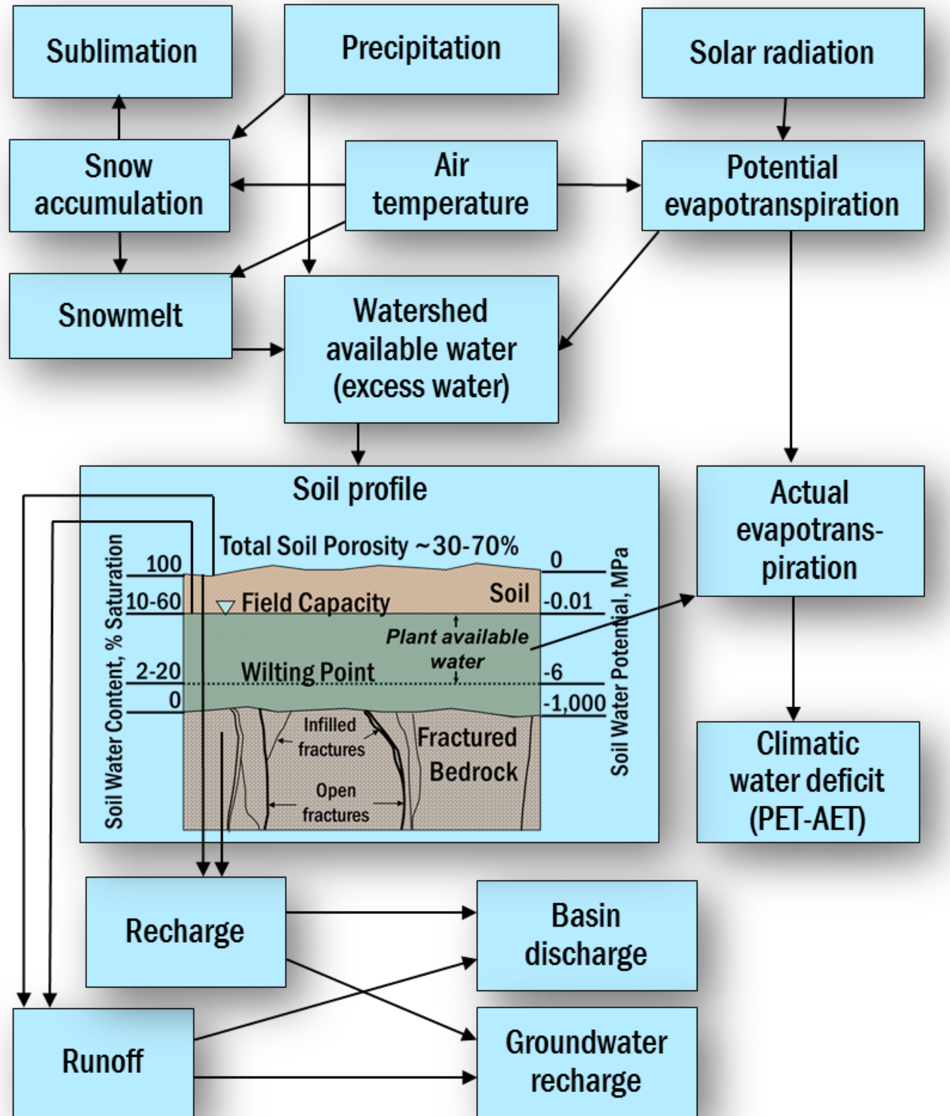

*Size of arrows reflect relative magnitude of water flow*

USGS science for a changing world

*Brown text is BCM input, Purple text is BCM output*

Pepperwood PRESERVE

# USGS California Basin Characterization Model:
## translating climate to watershed response




Flint and Flint 2013

*BCM methods*

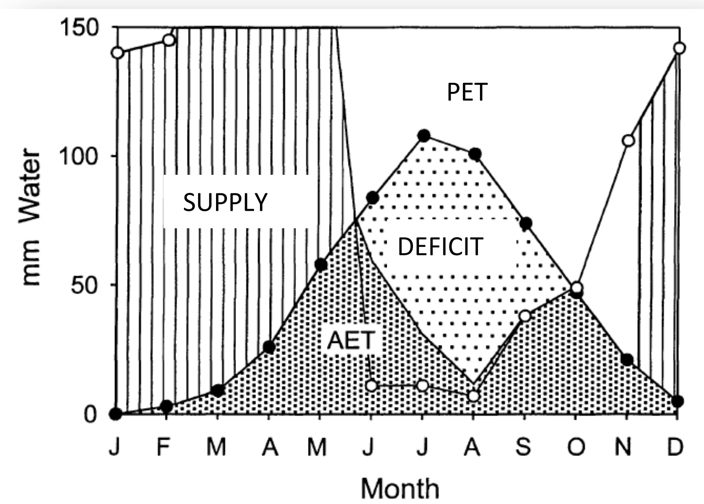
BCM output

# Climatic Water Deficit

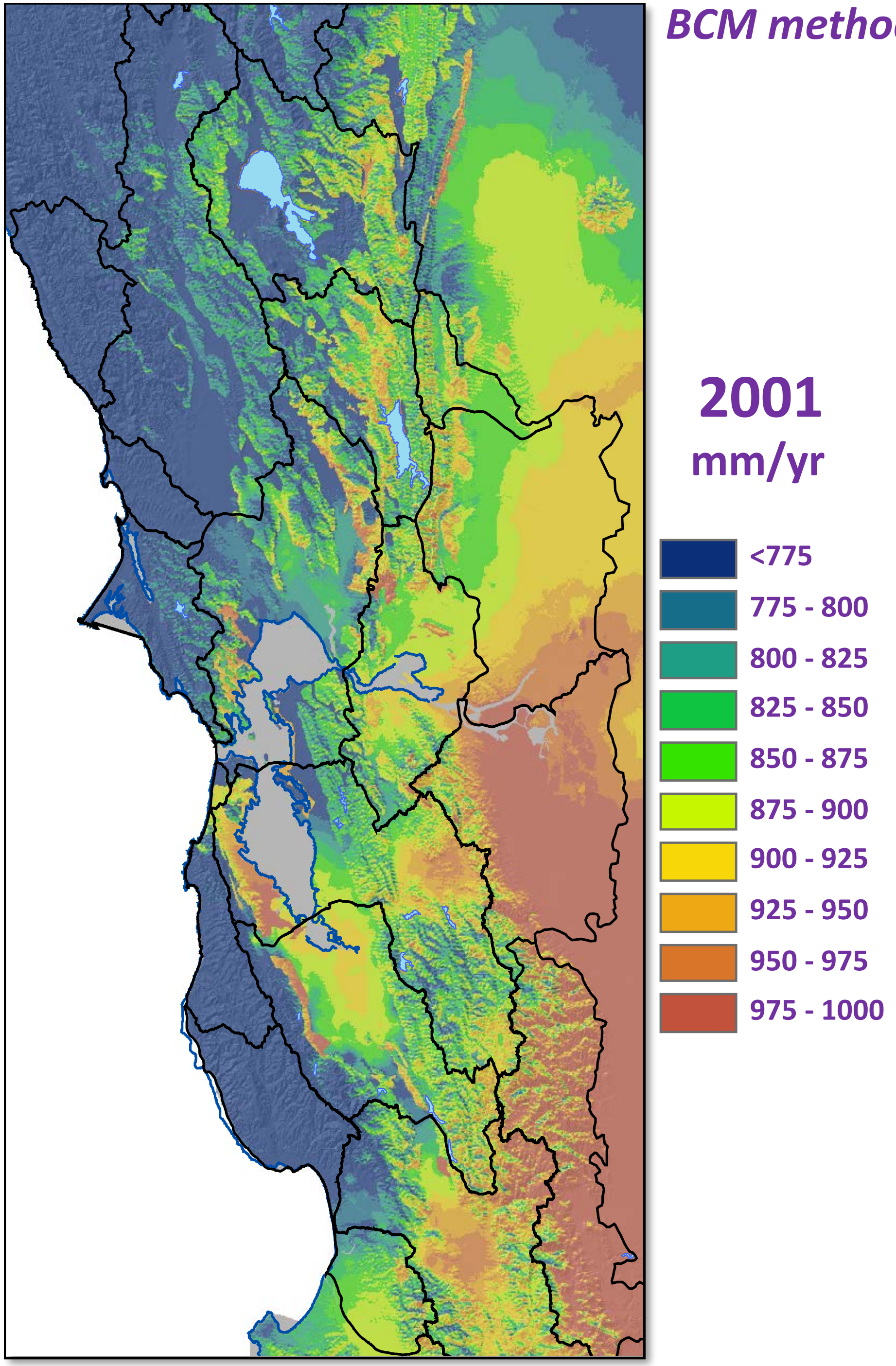
annual evaporative demand
that exceeds available water=
drought stress

Potential – Actual Evapotranspiration

- Integrates climate, energy loading, drainage, and available soil moisture
- Increases with all future climate scenarios
- Surrogate for irrigation demand
- Correlates with vegetation and fire risk




*BCM methods*



# Climate Ready Process

## Part 2

Managers survey: how does climate variability, including current drought, impact your operations today? What are your concerns for the future?

Agency-specific meetings to introduce our Basin Characterization Model, data menu and sample products, refine data queries based on management questions.

# Data menu

## Parameters that can be queried

Primary (BCM outputs):

- climate and hydology-temperature, rainfall, runoff, groundwater recharge, evapo-transpiration, soil moisture, climatic water deficit

Secondary:

- Fire frequency (either percent likelihood of burn or return interval)
- Potential native vegetation transitions

Time scales-historical (1910-2010) and projected (2010-2100)

- 30-y averages
- Annual data
- Monthly/Seasonal data


Spatial scales

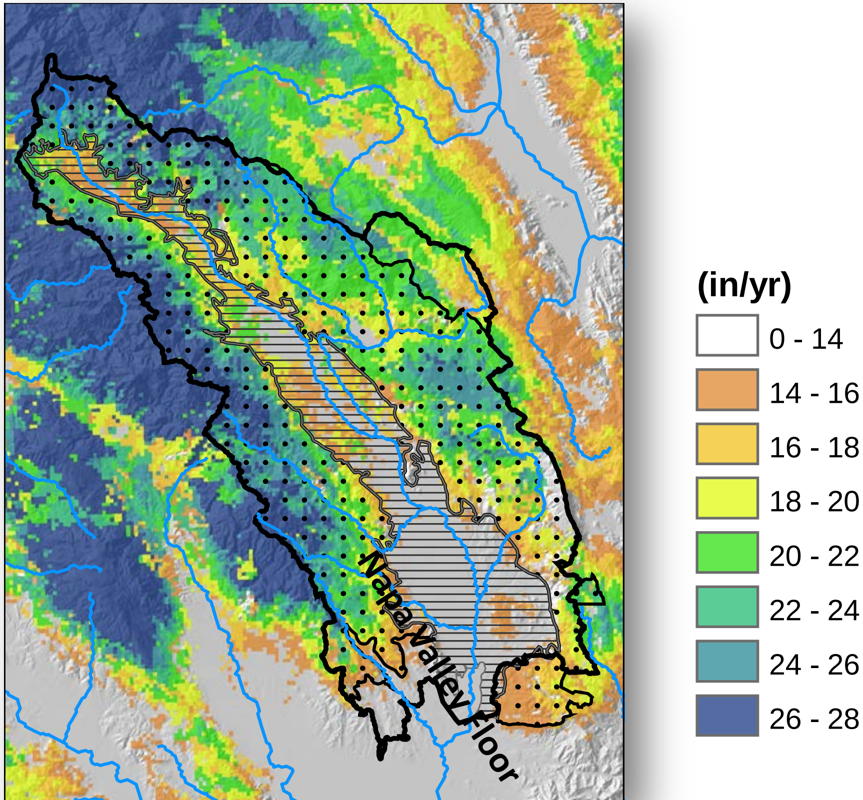
- Regional summaries-whole North Bay study area
- County Summaries
- Sub-regions-watershed, landscape unit, service area
- Large parcels

# Management Question

How will the valley's surface water supplies be potentially impacted by climate change?

What are the implications for reservoirs in the valley?

# Water Supply-Recharge + Runoff-projections




30 year averages capture potential trajectories depending on whether we receive more or less rainfall

We have also calculated these trends for every reservoir catchment in basin

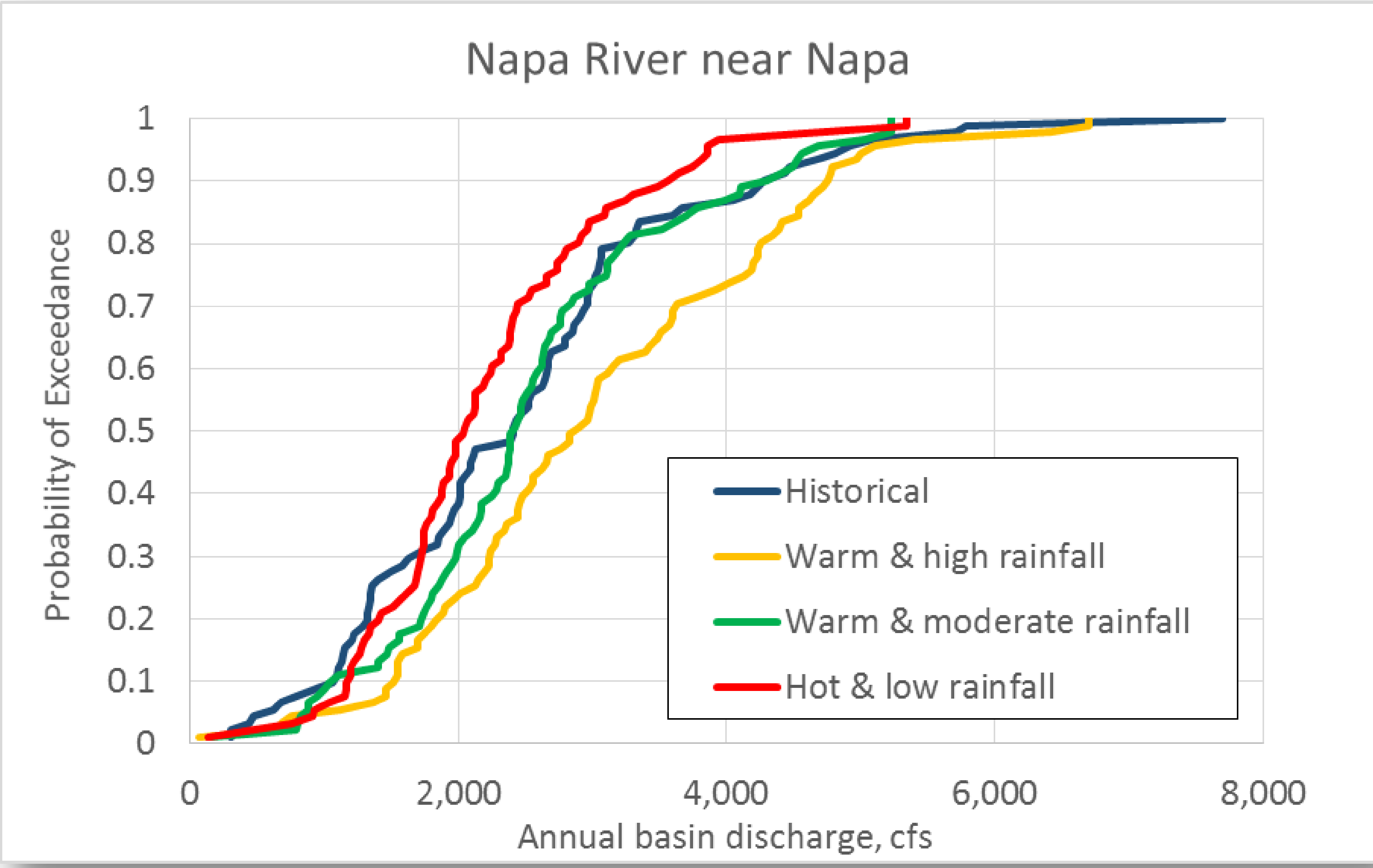
| | | | Current | Moderate Warming, High Rainfall | | Moderate Warming, Moderate Rainfall | | Hot, Low Rainfall | |
|---|---|---|---|---|---|---|---|---|---|
| Rch+Run (acre-ft) | | Area (acres) | 1981-2010 | 2040-2069 | 2070-2099 | 2040-2069 | 2070-2099 | 2040-2069 | 2070-2099 |
| Mountains | total | 452,476 | 243,131 | 344,656 | 392,444 | 233,723 | 272,710 | 163,522 | 160,806 |
| | SD | | 58,769 | 71,890 | 76,404 | 56,910 | 59,658 | 45,580 | 46,690 |
| | % change | | | 42% | 61% | -4% | 12% | -33% | -34% |
| Valley floor | total | 189,418 | 59,142 | 89,894 | 107,424 | 53,860 | 67,413 | 33,201 | 31,061 |
| | SD | | 21,889 | 28,335 | 30,616 | 22,300 | 23,755 | 17,066 | 17,567 |
| | % change | | | 52% | 82% | -9% | 14% | -44% | -47% |

# Management Question

How will the flow regime of the Napa River be potentially impacted by climate change?

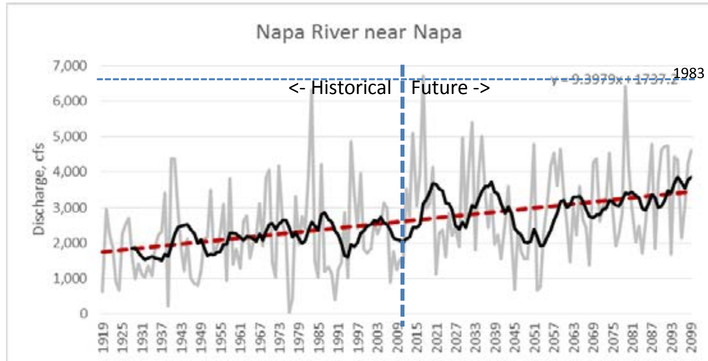
What are implications for fisheries and riparian zones, and tributaries prone to flooding?

# Runoff can be translated to annual or monthly in-river flows at a gage



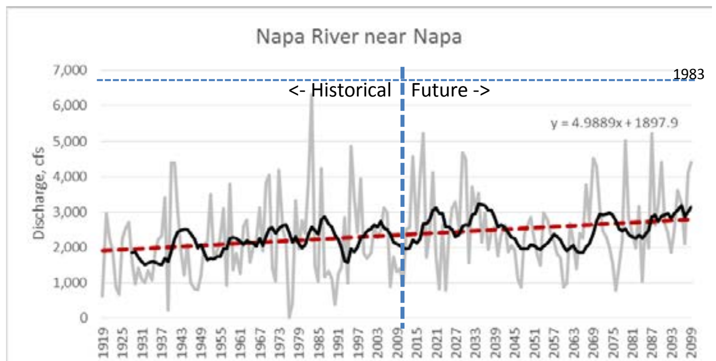
# Napa River near Napa: Annual Time Series

Warm & High Rainfall



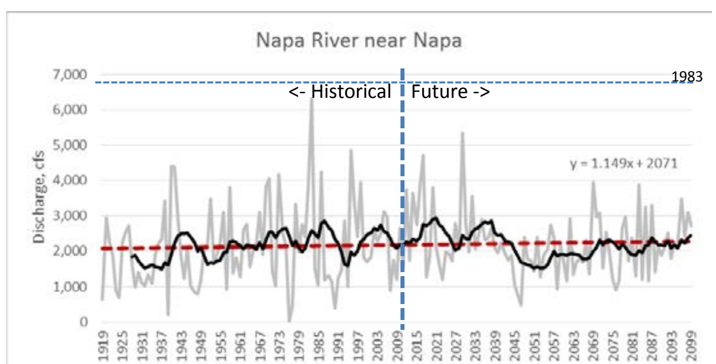

- As you move further downstream the alluvial valley widens, soils are deeper

Warm & Moderate Rainfall



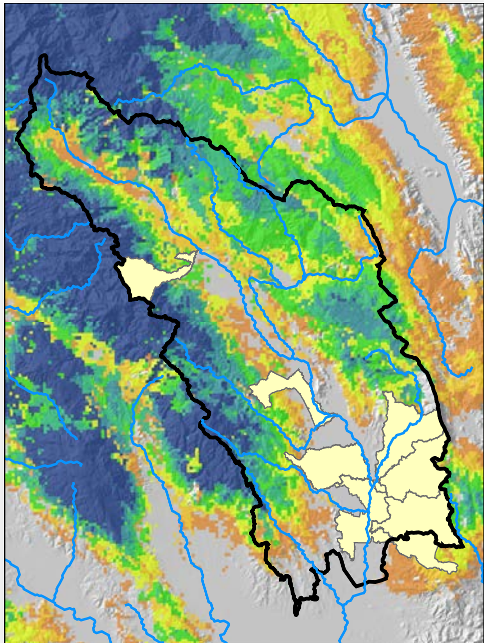

- With warming there is additional room in the soils to store rainfall, less runs off, higher fraction recharge

Hot & Low Rainfall

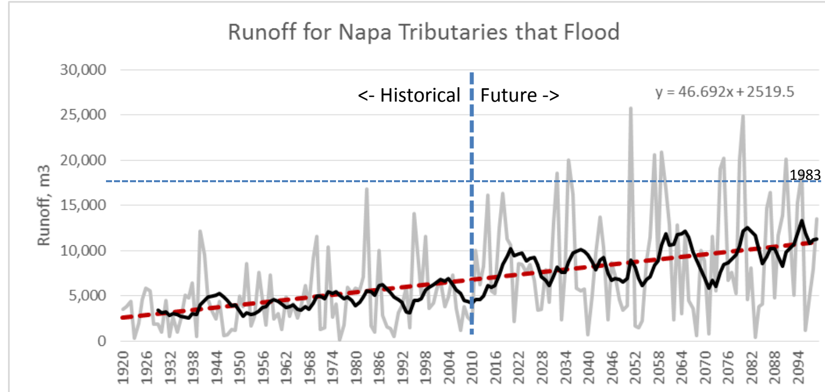



- This translates into dampened peak flows and a larger fraction of baseflow

# Napa Tributaries that Flood

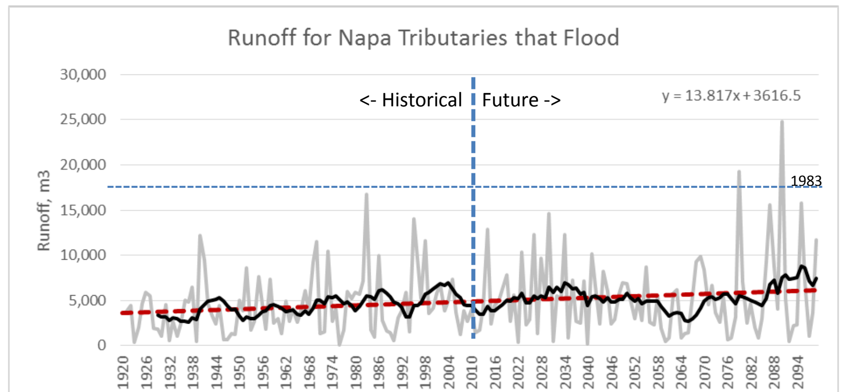


Warm & High Rainfall



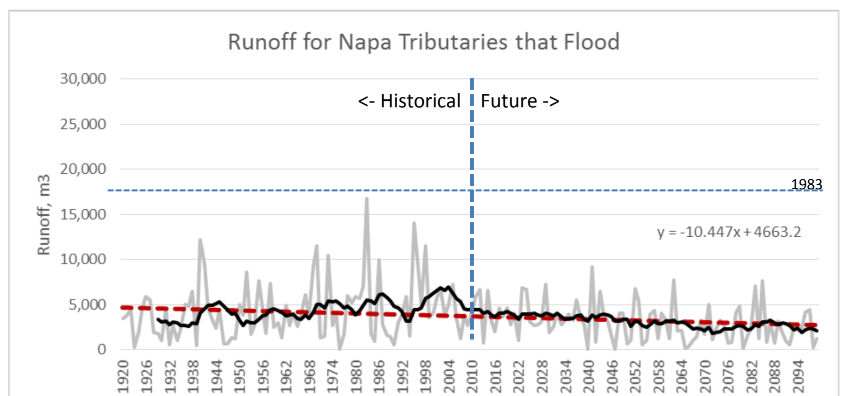

10 years exceeding historical peak threshold in future

Warm & Moderate Rainfall




2 years exceed threshold

Hot & Low Rainfall

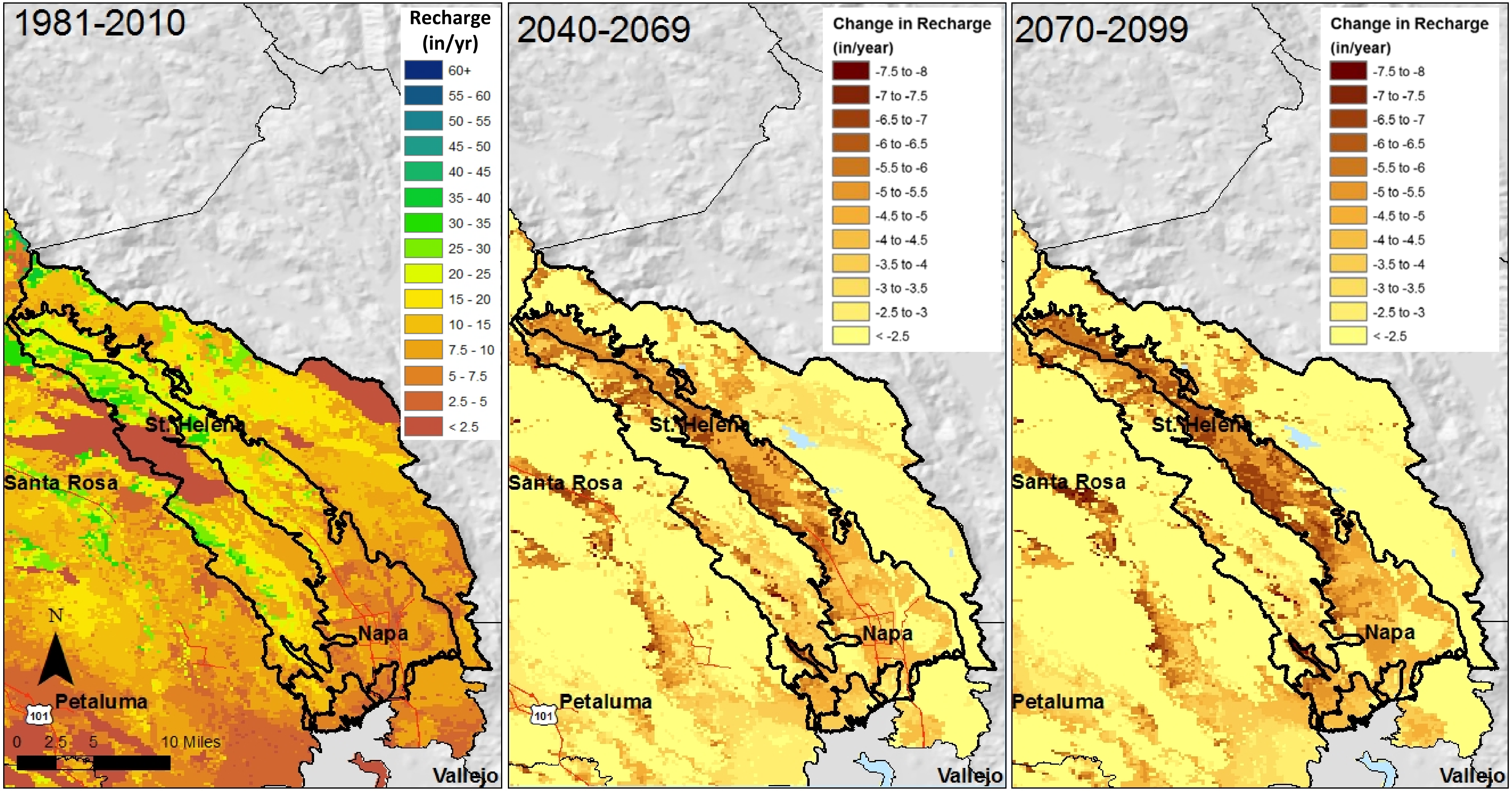



None exceed threshold

# Management Question

How will groundwater resources of the Napa River be potentially impacted by climate change?

# Projected Change in Recharge, Hot and Low Rainfall




11 in/y average for valley

29% reduction to 7.5 in/y average for valley

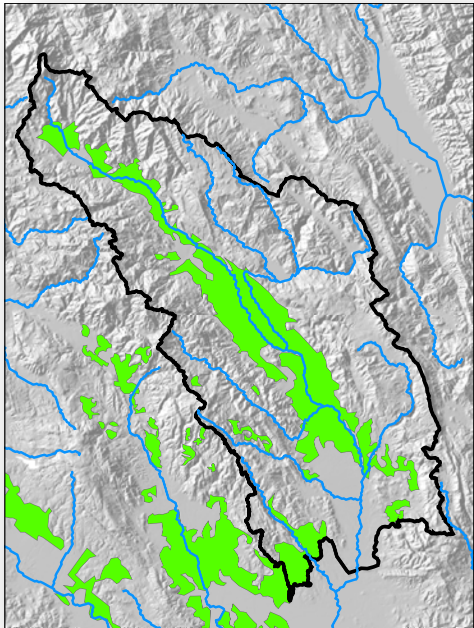
27% reduction to 7.8 in/y average for valley

Low rainfall scenario results in losses of 2.5 inches of groundwater recharge per unit area annually

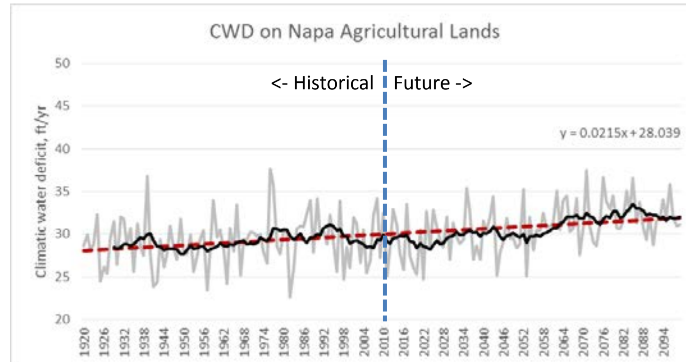
# Management Question

How will the agricultural lands of the Napa Valley be potentially impacted by climate change and what are the implications for irrigation demand and resultant pressures on groundwater?

# Climatic Water Deficit on Napa Agricultural Lands

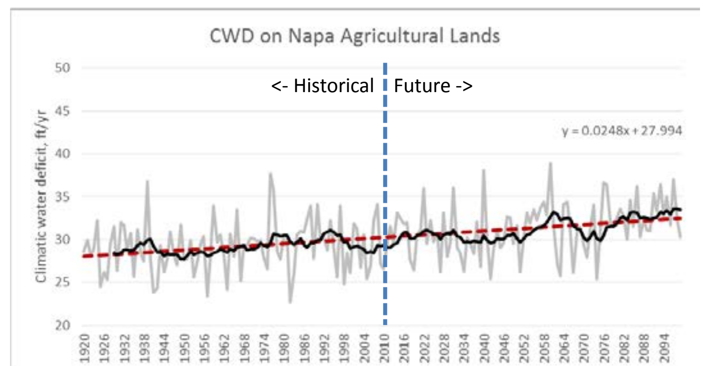


Warm &
High Rainfall



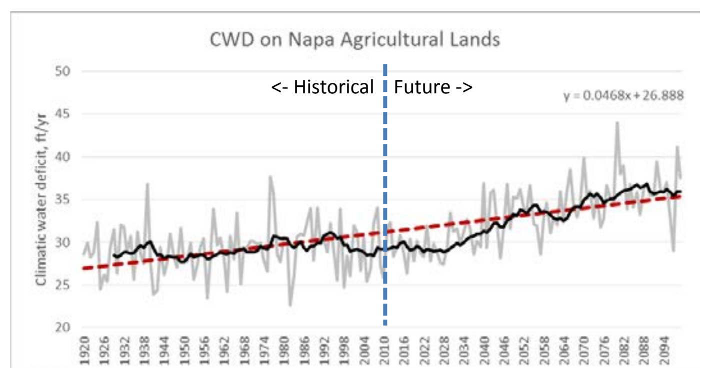

last 30 years 9 % greater deficit

Warm &
Moderate Rainfall




last 30 years 10 % greater deficit

Hot &
Low Rainfall




last 30 years 20 % greater deficit

Water deficits increase in all scenarios

# Basin Characterization Model: Napa Valley Watershed
# Trends in 30-year average values, historic-2099

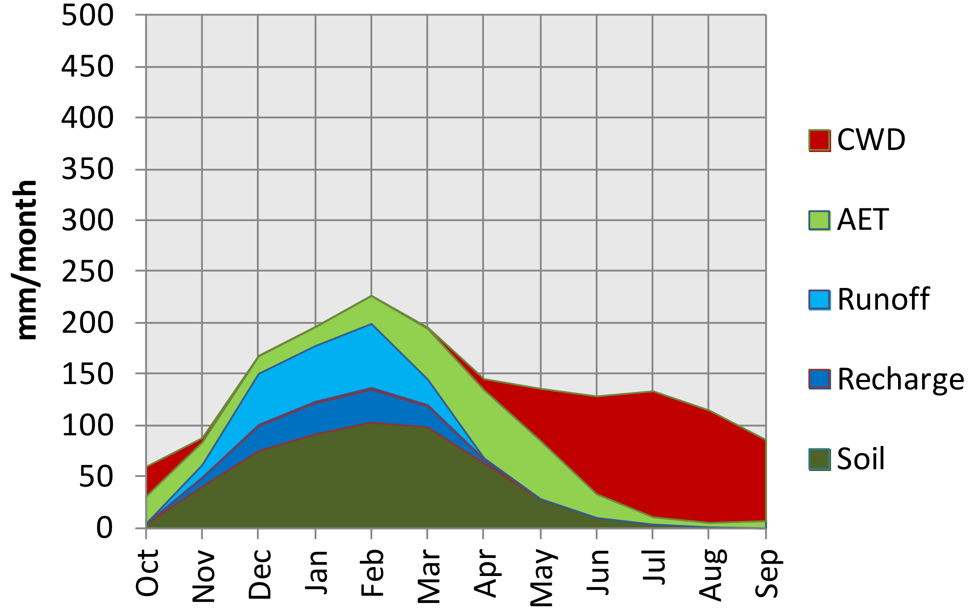
| | | | | *Projected change in temperature (Deg F) and hydrologic indicators (%)* | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **Units** | | **Current** | **Moderate Warming, High Rainfall** | | **Moderate Warming, Moderate Rainfall** | | **Hot, Low Rainfall** | |
| | | | ***1981-2010*** | ***2040-2069*** | ***2070-2099*** | ***2040-2069*** | ***2070-2099*** | ***2040-2069*** | ***2070-2099*** |
| **Ppt** | in | | 36.4 | +23% | +34% | -3% | +5% | -21% | -24% |
| **Tmn** | Deg F | | 39.4 | +3.4 | + 6.4 | + 2.1 | + 4.9 | +4.2 | + 7.3 |
| **Tmx** | Deg F | | 86.5 | +4.4 | +7.4 | + 4.0 | +6.6 | + 7.3 | + 11.5 |
| **CWD** | in | | 30.6 | +4% | + 9% | +6% | +10% | +12% | +20% |
| **Rch** | in | | 10.6 | +27% | + 27% | -1% | + 5% | -29% | -27% |
| **Run** | in | | 7.8 | +67% | +107% | -11% | + 22% | -44% | -51% |

VARIABLES: Ppt=precipitation, Tmn=winter minimum temperature, Tmx=summer maximum temperature, CWD=climatic water deficit, Rch=recharge, Run=runoff

*USGS, Point Blue, Pepperwood 2015*

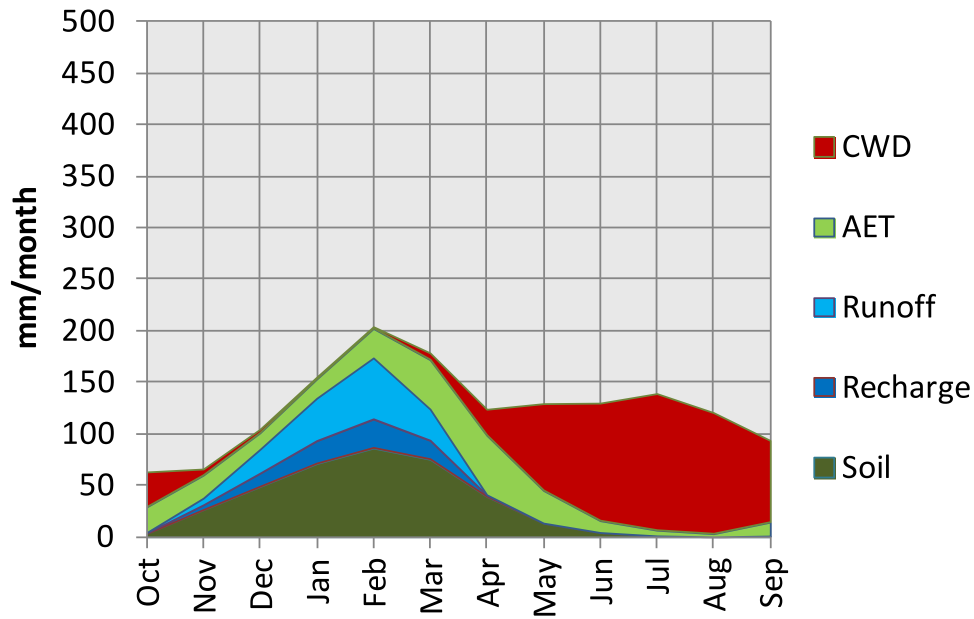
# Seasonality of Water Cycle

## Seasonal Water Diagram 1980-2009




| 1980-2009 | Annual Average | |
|---|---|---|
| | | |
| PPT | 25.9 | in |
| CWD | 19.8 | in |
| AET | 13.0 | in |
| Runoff | 8.2 | in |
| Recharge | 4.8 | in |
| Recharge/runoff | 0.58 | |
| Tmax | 59.2 | F |
| Tmin | 41.7 | F |

## Seasonal Water Diagram 2070-2099



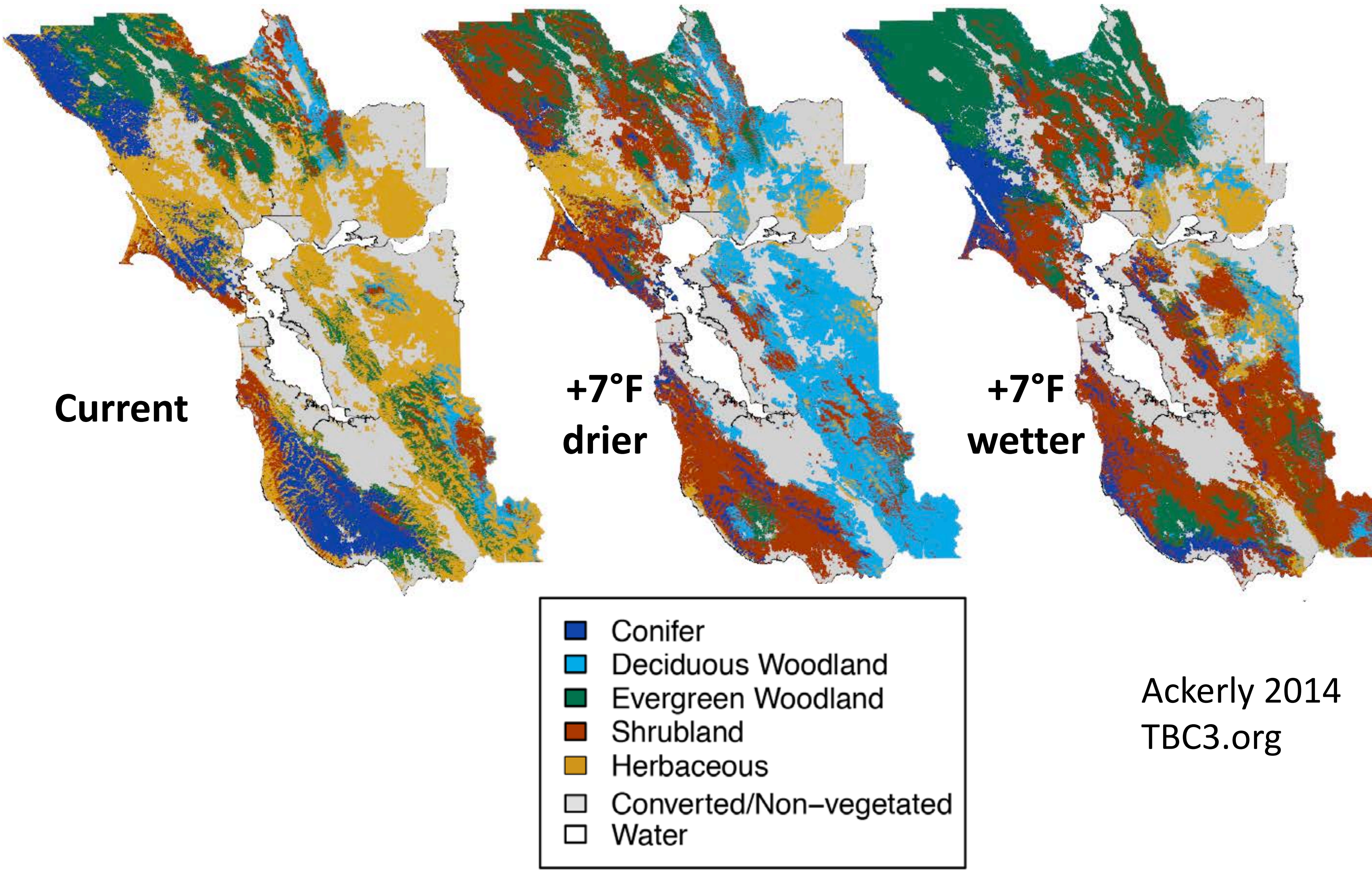

| 2070-2099 | Annual Average | |
|---|---|---|
| | | |
| PPT | 20.8 | in |
| CWD | 23.8 | in |
| AET | 11.1 | in |
| Runoff | 6.4 | in |
| Recharge | 3.4 | in |
| Recharge/runoff | 0.53 | |
| Tmax | 63.7 | F |
| Tmin | 45.5 | F |

Coming soon: Climate Smart Watershed Analyst ***climate.calcommons.org***

# Management Question

How will the natural vegetation of Napa County be potentially impacted by climate change?

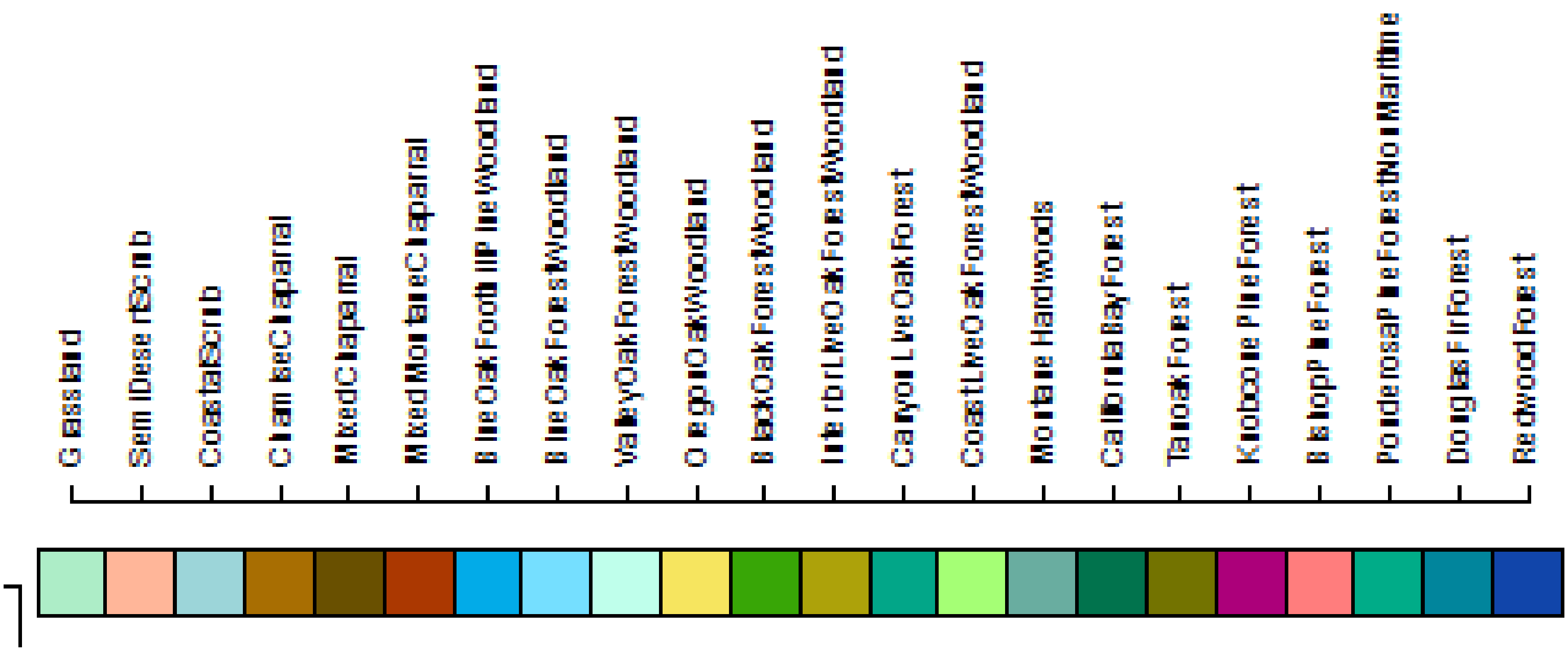
# what might the Bay Area vegetation of the future look like?




Ackerly 2014
TBC3.org

# Equilibrium vegetation response to climate change in Napa County

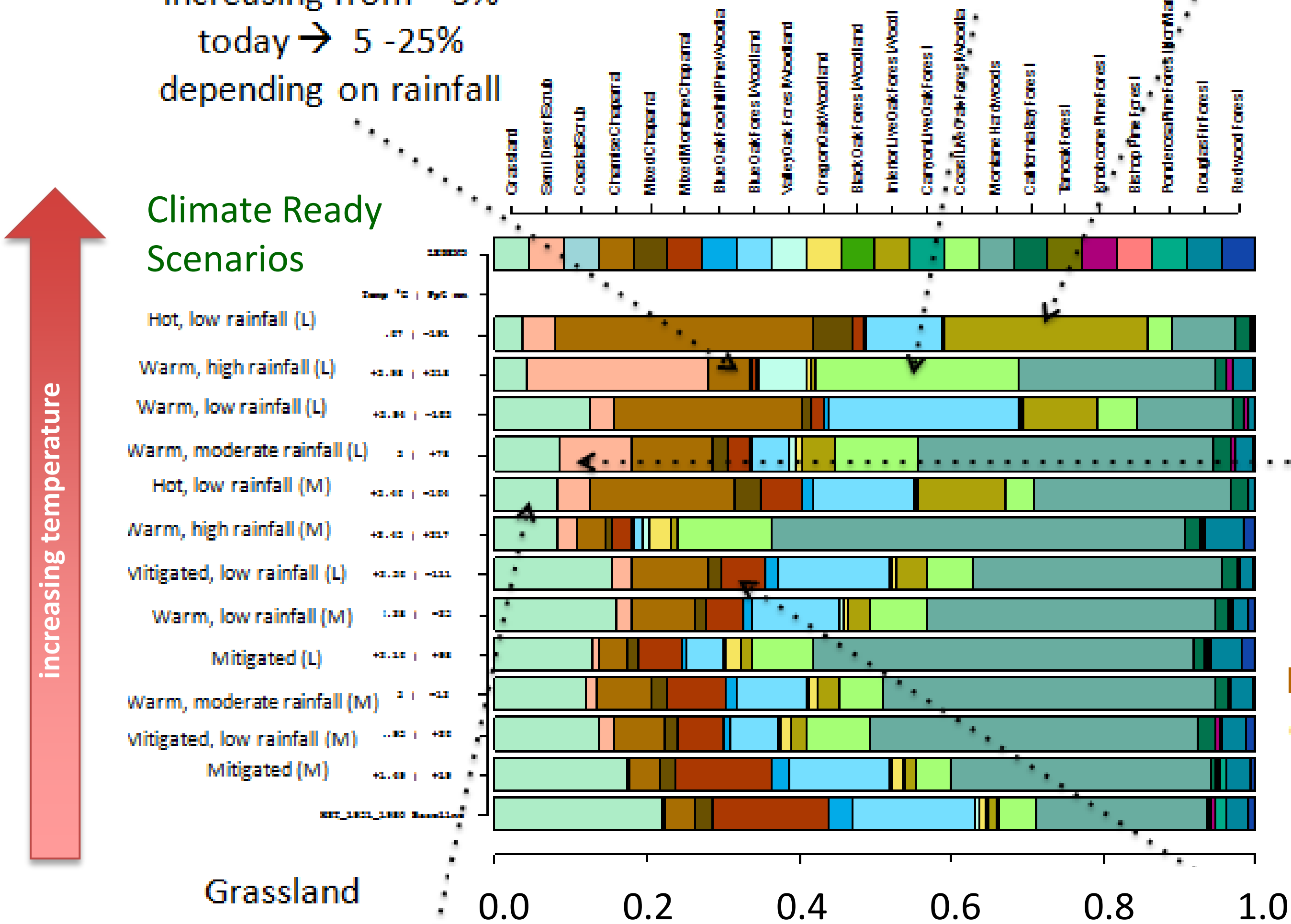
Projected proportional landscape cover of 22 vegetation types under both historical conditions and six future scenarios, organized from top to bottom by increasing temperature. This is an equilibrium model so this assumes vegetation has had time to adjust to climate conditions. In reality, vegetation turnover will take time. Fires and other disturbance can accelerate shifts. How land is managed will also affect rate of change. For example, grasslands may be maintained by active grazing, burning or mowing. Data from D.D. Ackerly 2015.



# Napa County Vegetation Report Summary

Coast Live Oak and Interior Live Oak increasing from ~ 5% today → 5 - 25% late century, depending on rainfall

Conditions for Chemise Chaparral increasing from ~ 5% today → 5 -25% depending on rainfall




Semi-desert Scrub emerges and becomes common

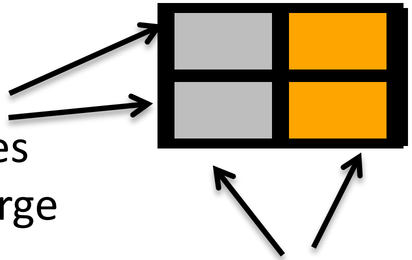
Grassland declining from 20% today → < 10% in late century

Mixed Montane Chaparral declining from ~10% → < 5% by mid century

# Another way to look at the vegetation data:

# Four-square diagrams

***Example:*** *Redwood Forest is sensitive to temperature in Northern Mayacamas*



Rainfall does not have large affect

Significant declines emerge at hotter temperatures.


The position in the square reflects the temperature and rainfall of a scenario

Rainfall

| | |
|---|---|
| warm < 4.5°F<br>more rain | hot > 4.5°F<br>more rain |
| warm <4.5°F<br>less rain | hot > 4.5°F<br>less rain |

Temperature

Color-coding the square quadrants shows the direction of change in percent cover in suitable climate for veg type (current to 2050)

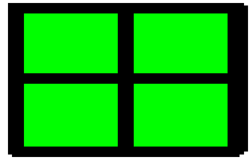
Red: Dramatic Decline (<25% of current)

Orange: Moderate Decline (25-75% of current)

Gray: Relative Stability (75-125% of current )

Green: Increase (>125% of current )

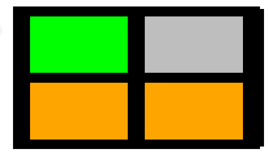

***Example: California Bay Forest is not sensitive to temperature or rainfall***



Does well in all future scenarios regardless of
Warming magnitude and rainfall

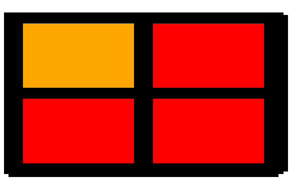
***Example: Oregon Oak is sensitive to rainfall in Northern Mayacamas***

Does well in high rainfall scenarios,
but declines in low rainfall



Does worse in hotter scenarios,
But impacts are not great.

***Example: Canyon Live Oak is sensitive to rainfall and temperature in Northern Mayacamas***

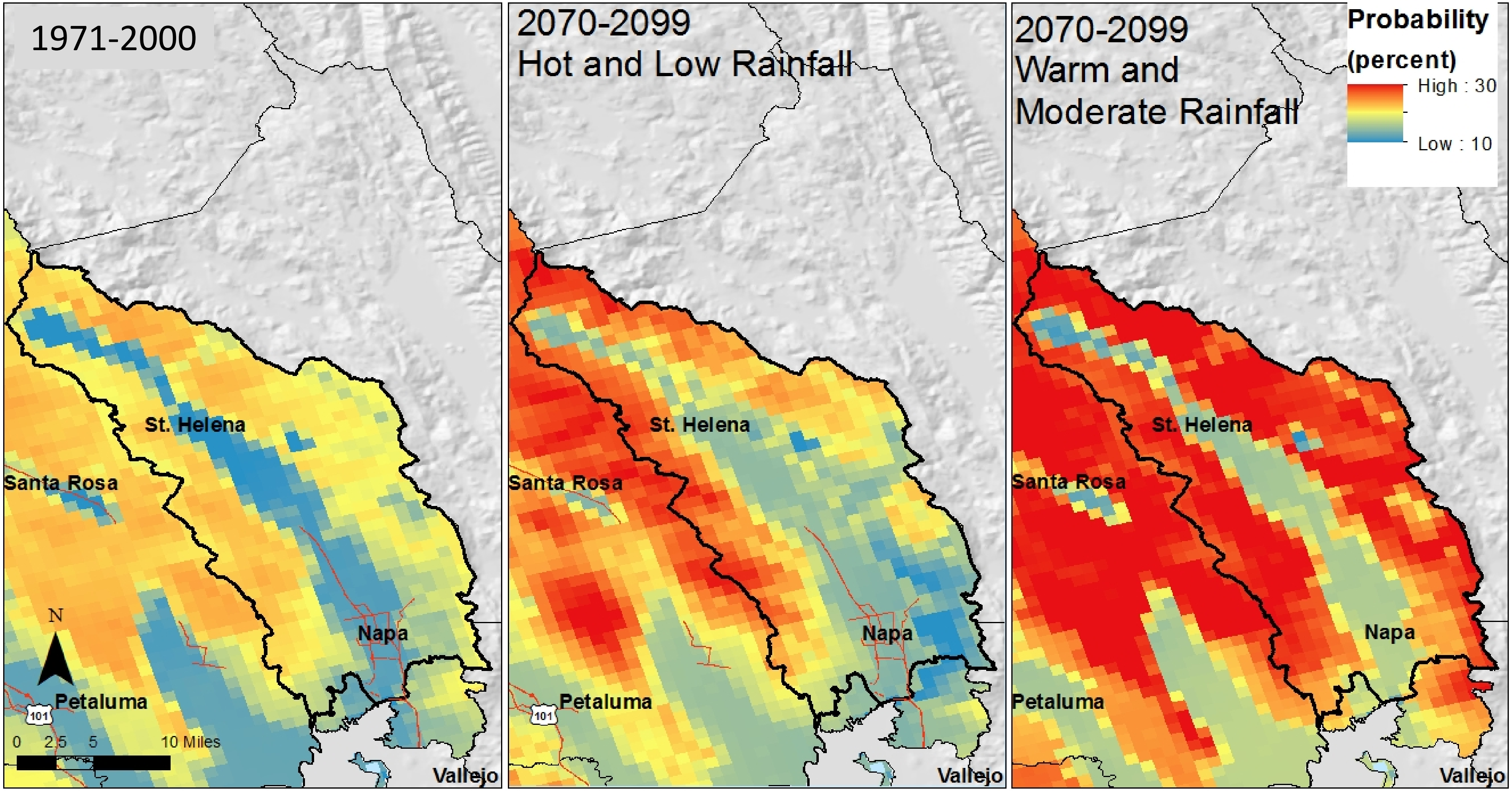


It shows declines in all scenarios

# Management Question

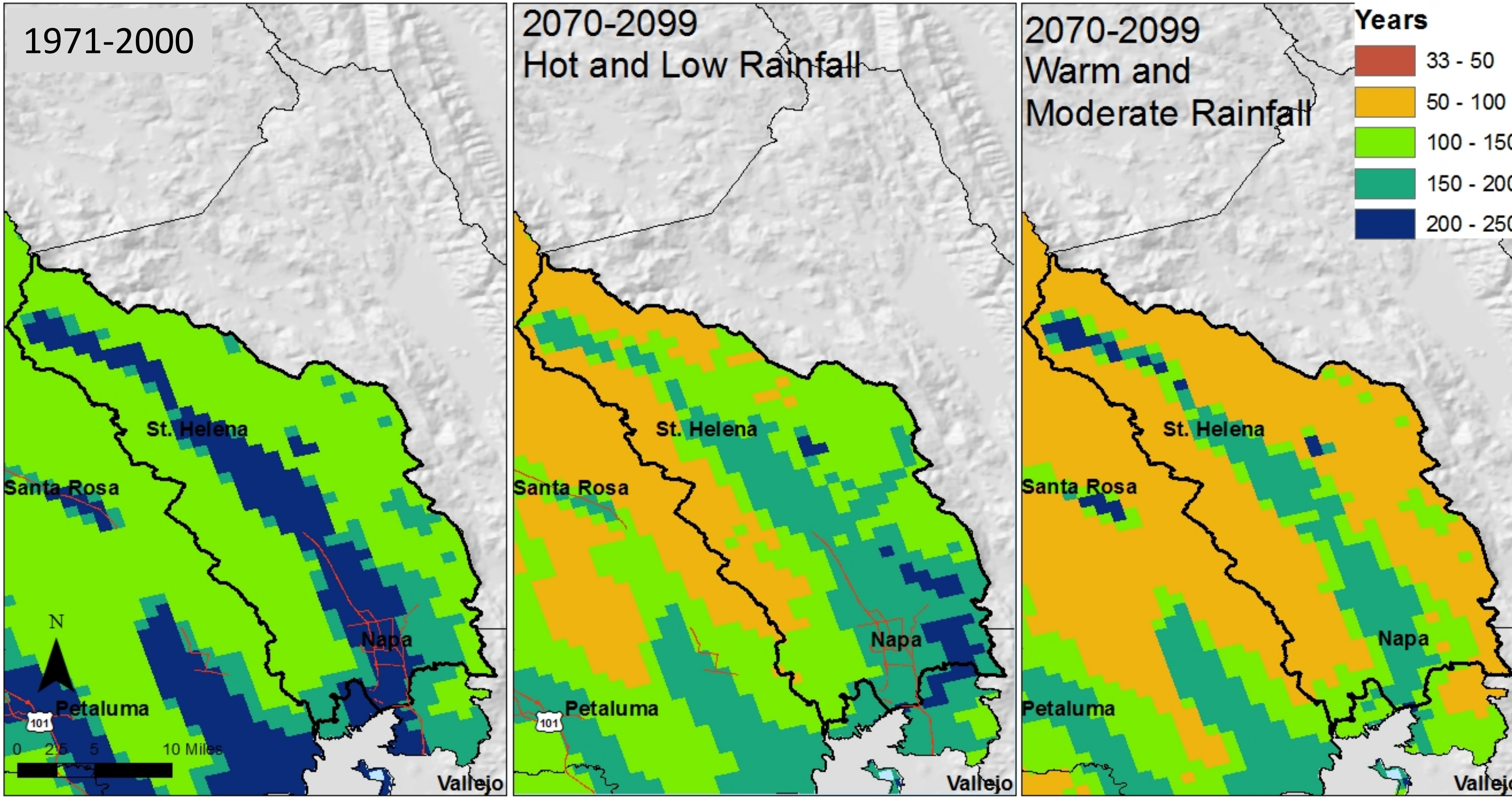
How will the risk of fire in the Napa Valley be potentially impacted by climate change?

# Change in Projected Probability of Burning One or More Times




Probability of a fire in a 30y period doubles in some locations

# Change in Projected Fire Return Interval




Fire return intervals cut approximately in half

# What kind of long-term plans can use this landscape-level data?

## In general:

human health energy demand watershed plans

surface water supply fire and hazard mitigation

sustainable groundwater management

agricultural sustainability ecological restoration

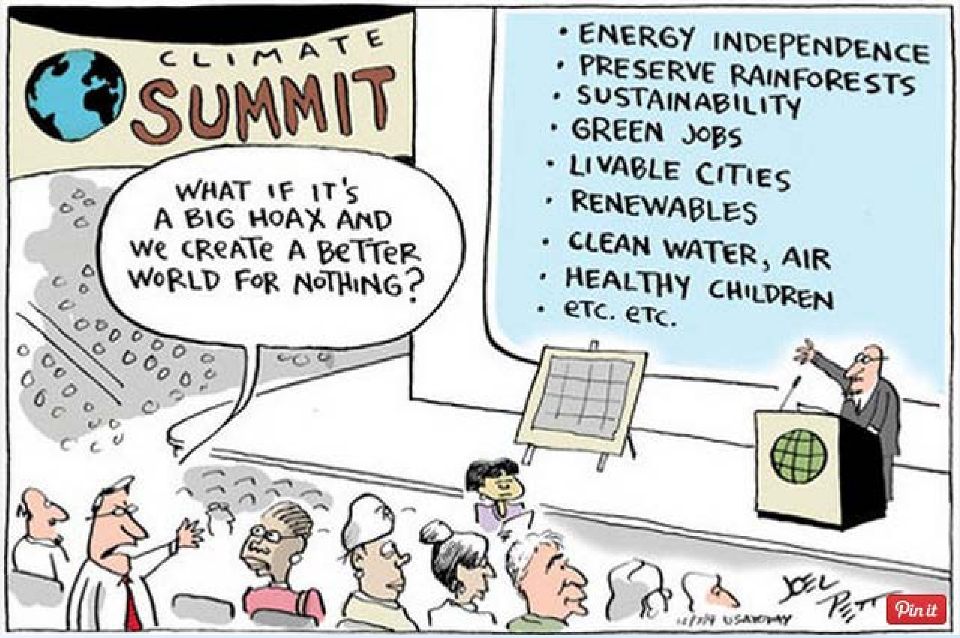
## In Napa:

CAP-Climate Action Plan-potential to use projections as local estimate of projected climate change. Increased heat could be used to project increase electrical use and emissions. Starting point for conversation about adaptation

Groundwater Plan: augment groundwater data with model recharge (current and projections). What area do you need to protect to achieve a target (% total?) recharge amount? Can Low Impact Development maintain recharge potential?

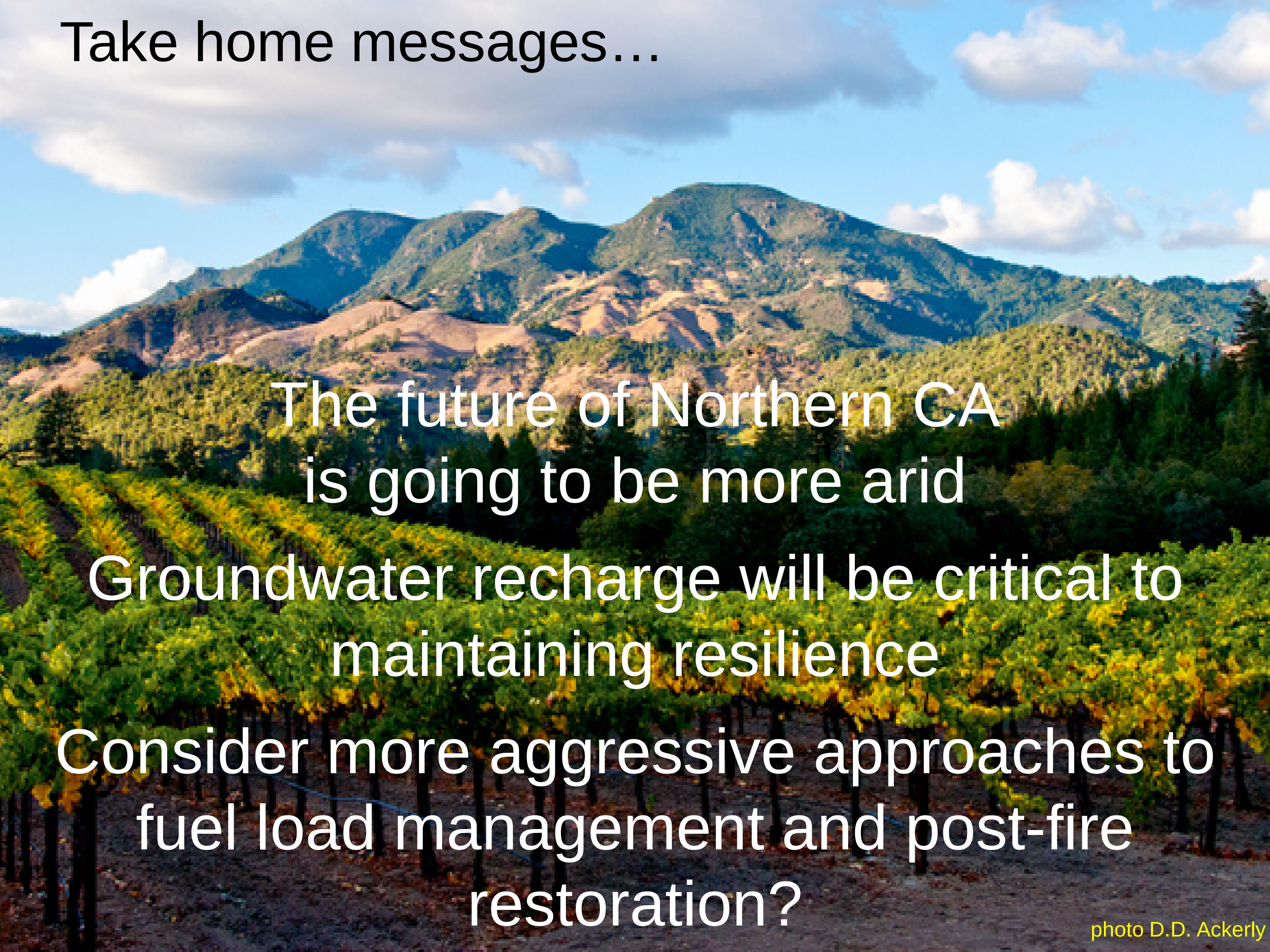
# Win-win strategies for climate adaptation

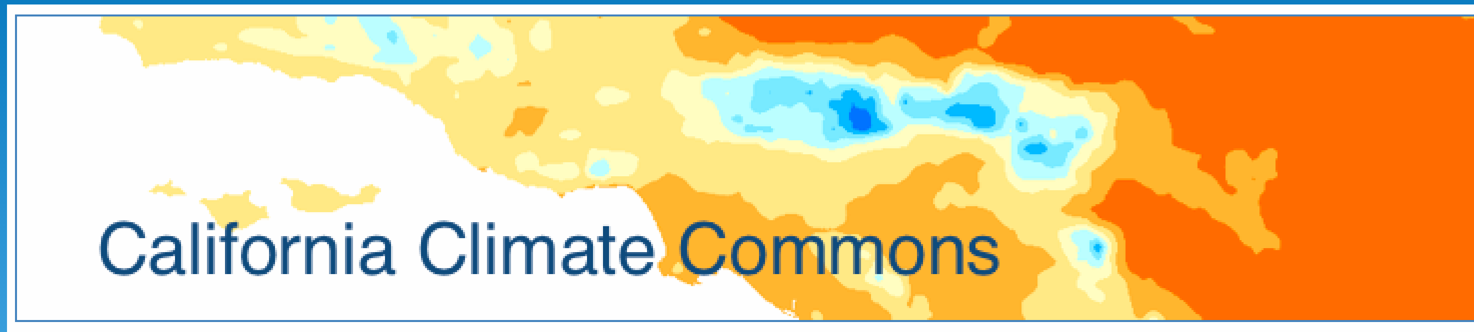
Mitigate greenhouse gas emissions.
Protect key watershed functional areas: floodplains, recharge areas, wetlands.
Recycle and conserve water.
Increase soil moisture holding capacity.
Get serious about fuels management.
Identify native species that are likely to be climate "winners"- protect seed sources.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




**Invest in preparedness-its cheaper than emergency response!**

Pepperwood PRESERVE


Take home messages…
The future of Northern CA is going to be more arid
Groundwater recharge will be critical to maintaining resilience
Consider more aggressive approaches to fuel load management and post-fire restoration?
photo D.D. Ackerly

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to learn more about the watershed model....

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Dataset

# California Basin Characterization Model (BCM) downscaled climate and hydrology

## Data Variables in this Dataset

- Actual evapotranspiration - Potential evapotranspiration calculated when soil water co wilting point
- Climatic Water Deficit - Potential minus Actual Evapotranspiration
- Excess water - Water remaining above evapotranspiration
- Maximum monthly temperature -
- Minimum monthly temperature -
- Potential Evapotranspiration - Water that could evaporate or transpire from plants if a

climate.calcommons.org

will host Climate Ready North Bay “Climate Smart Exchange”

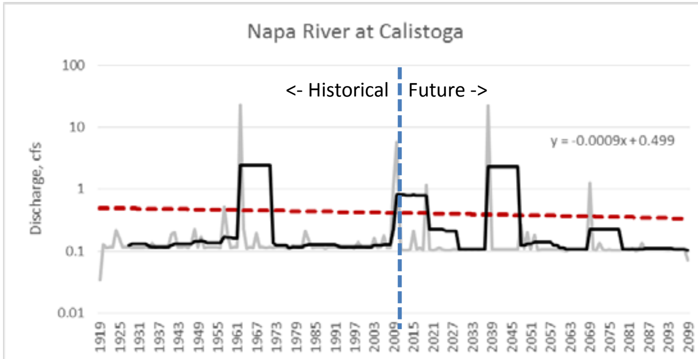
Thank you!
lmicheli@pepperwoodpreserve.org

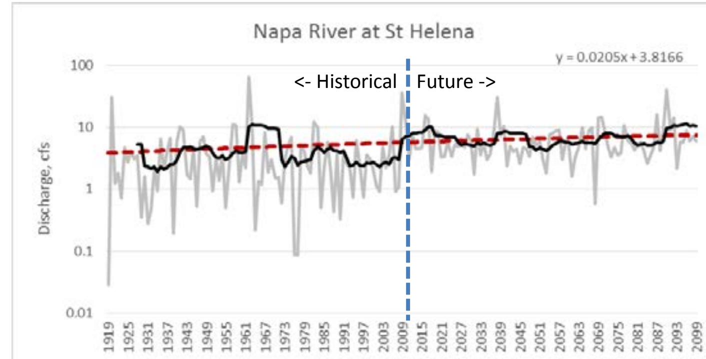
# EXTRAS

# Napa River Upstream

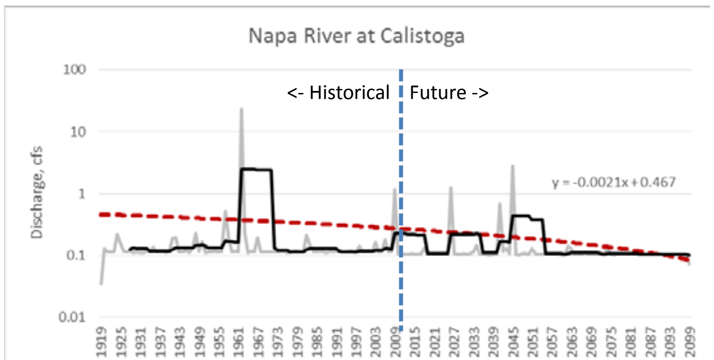
## Summer low flows (Aug-Sep-Oct)

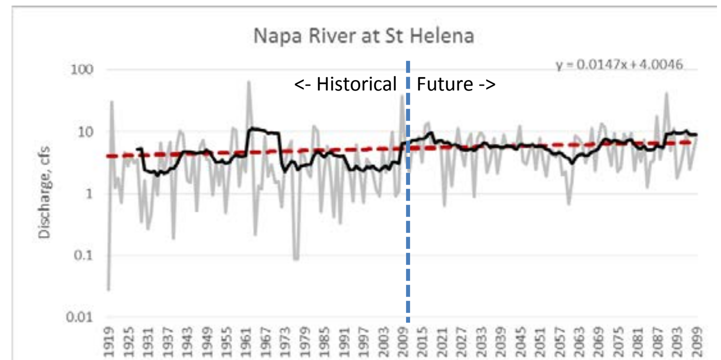
Warm &
High Rainfall



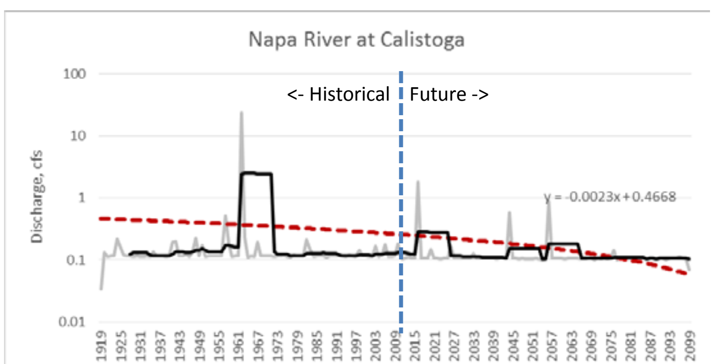



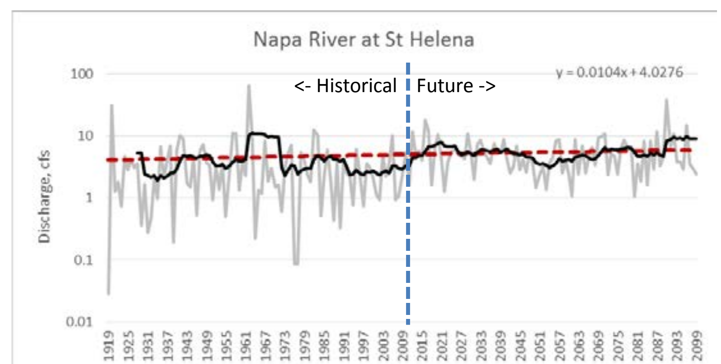

Warm &
Moderate
Rainfall




Hot &
Low Rainfall

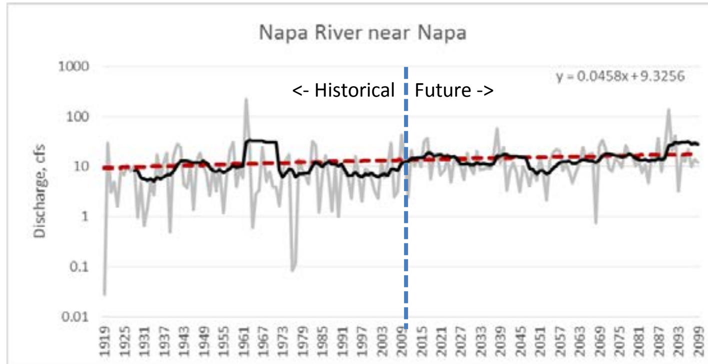


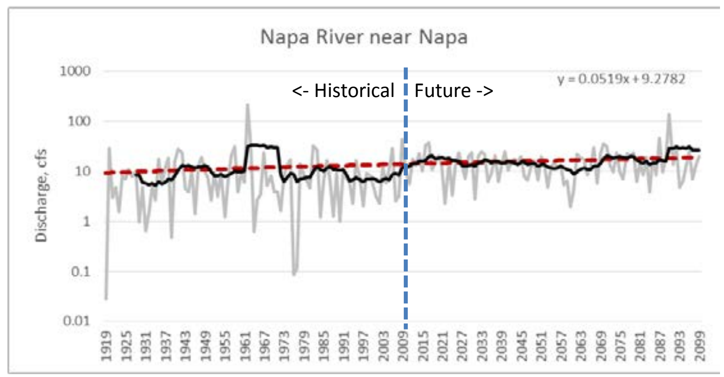
# Napa River near Napa

## Summer low flows (Aug-Sep-Oct)

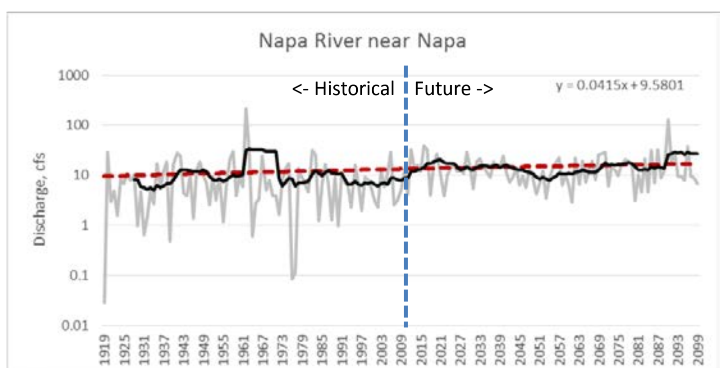
Warm &
High Rainfall




Warm &
Moderate
Rainfall



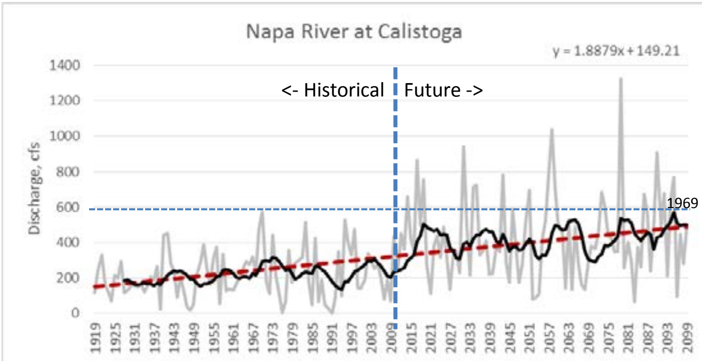

Hot &
Low Rainfall



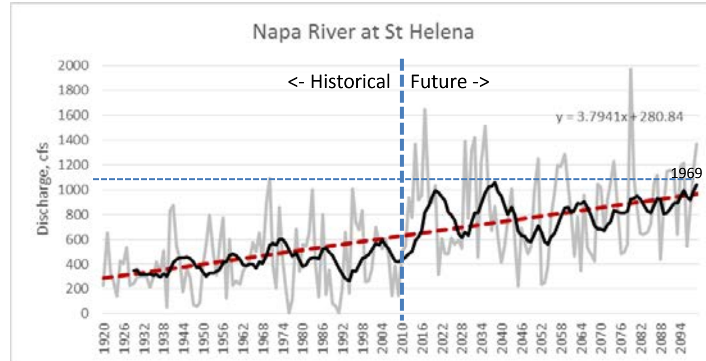
# Napa River Upstream

## Winter peaks (Dec-Jan-Feb)

Warm &
High Rainfall

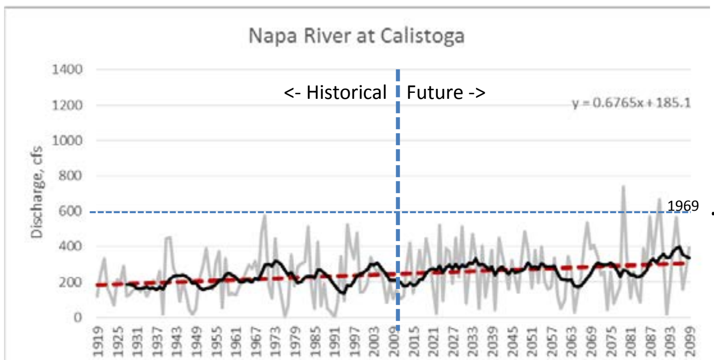



+17

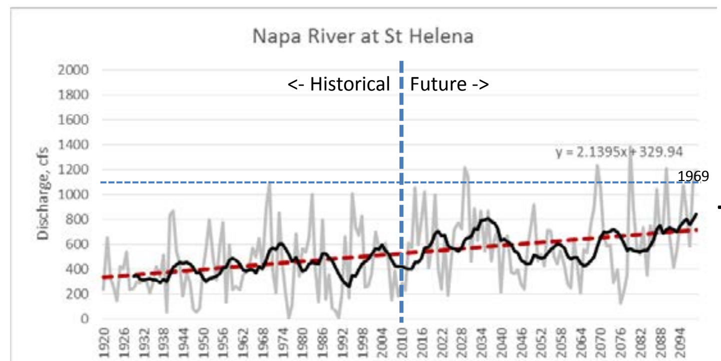



+19

Warm &
Moderate
Rainfall

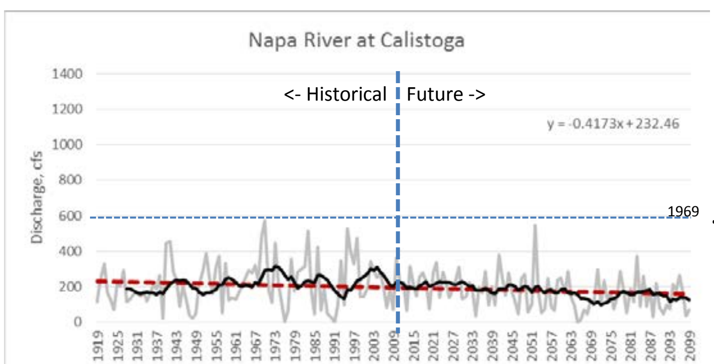



+2

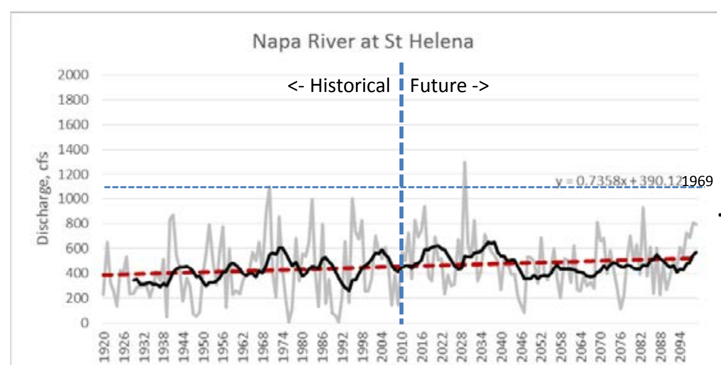



+7

Hot &
Low Rainfall




+0

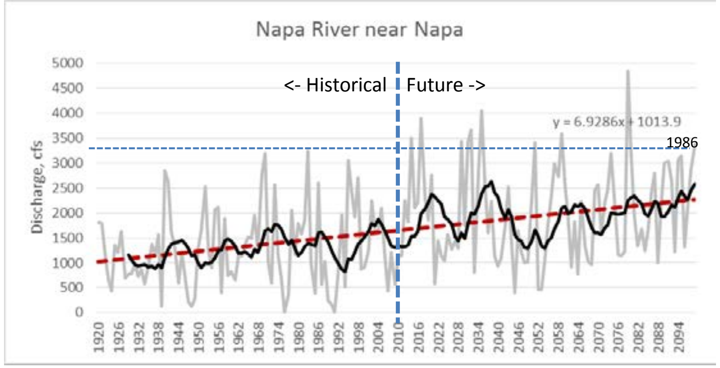



+1

# Napa River near Napa

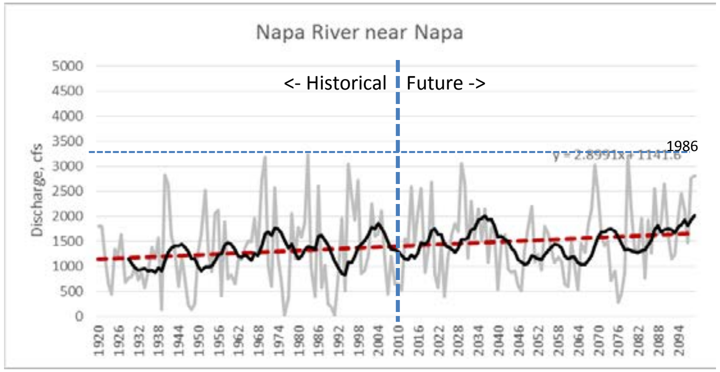
## Winter peaks (Dec-Jan-Feb)

Warm &
High Rainfall



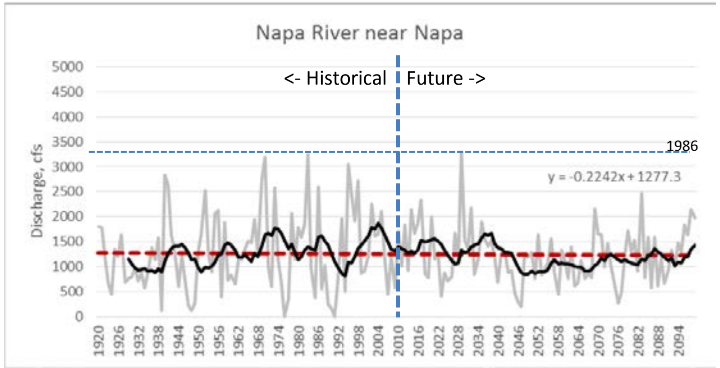

+10

Warm &
Moderate
Rainfall



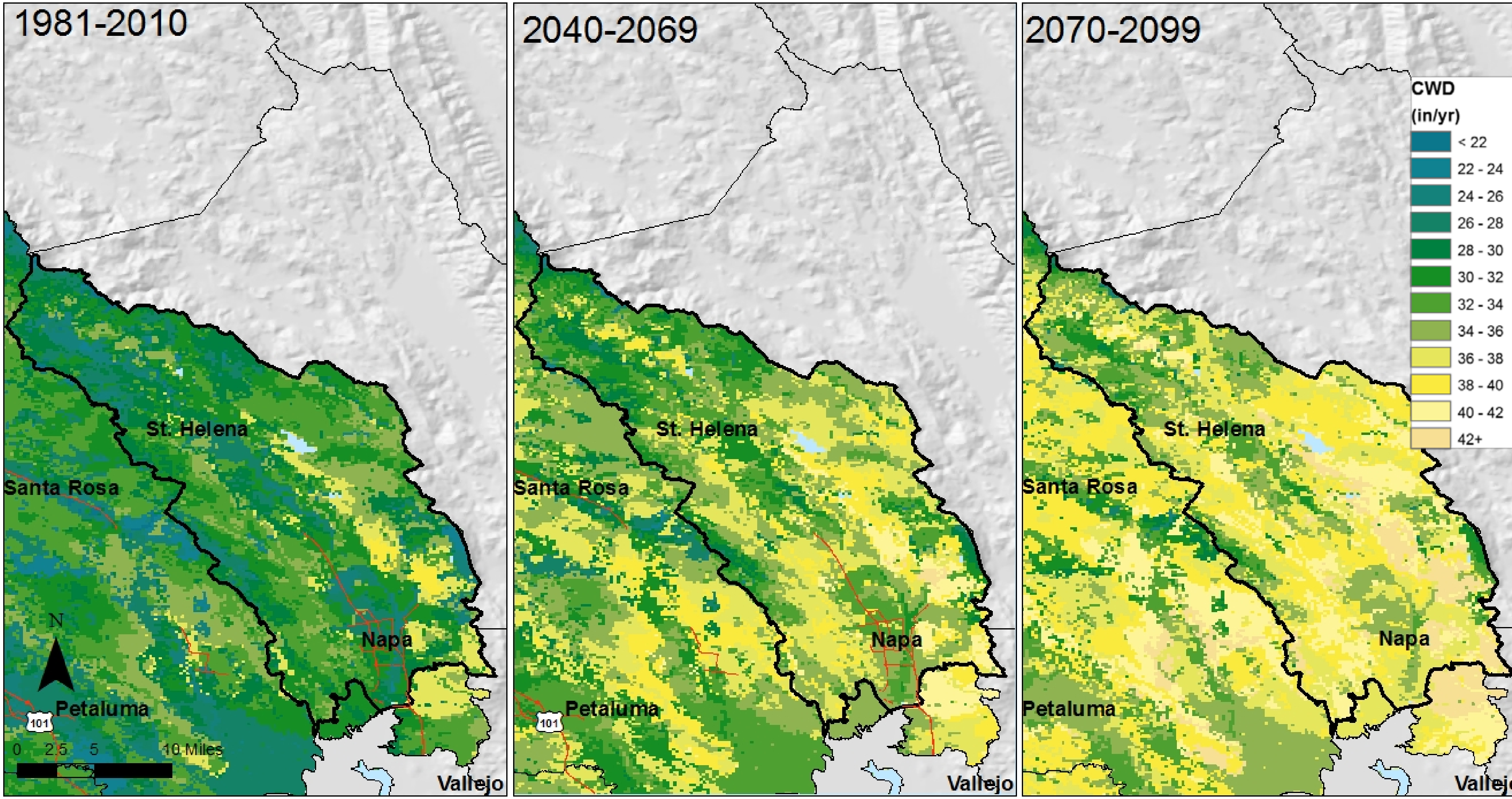

+0

Hot &
Low Rainfall




+0

# Climatic Water Deficit, Hot and Low Rainfall




31 in/y average
(36 in/y rainfall)

34 in/y average
(29 in/y rainfall)

37 in/y average
(28 in/y rainfall)