Applying the USGS Basin Characterization Model across multiple scales for conservation planning

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Terrestrial Biodiversity Climate Change Collaborative
(TBC3.org)

NRCS Webinar
August 31, 2016

Agenda

- introduce Pepperwood and TBC3 collaboration with USGS
- overview of USGS Basin Characterization Model
- region-scale: Climate Ready North Bay-vulnerability assessment highlights
- parcel-scale: adaptive management planning-Pepperwood AMP
- other projects in play
- questions!

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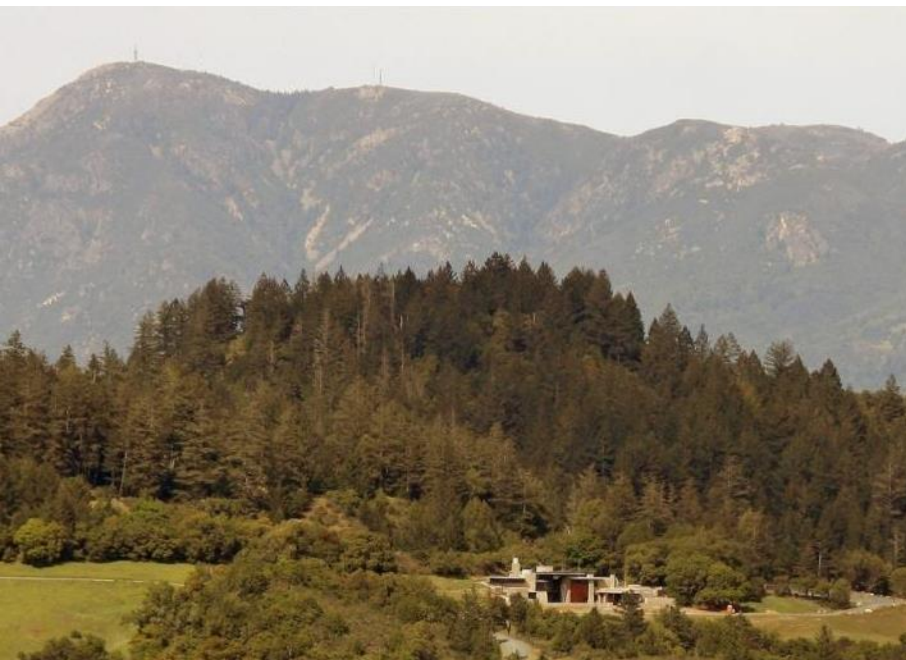
Inspiring conservation through science

Pepperwood Foundation

mission

to advance science-based conservation
throughout our region and beyond



3200-acre scientific preserve
in Sonoma County

The Dwight Center
for Conservation Science

a leader

in advancing the health of Northern California's land, water, and wildlife

advancing science-based conservation throughout our region and beyond

Pepperwood PRESERVE

Conservation Science Support

- Convene the region's best and the brightest in conservation science and planning to develop expert knowledge-bases and forge solutions
- Generate interdisciplinary applied science products for application to climate adaptation
- Utilize the preserve as a long-term monitoring Sentinel Site
- Serve as a learning and demonstration hub for the entire community
- Work directly with land and water managers to prioritize acquisitions and stewardship

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Terrestrial Biodiversity Climate Change Collaborative (Pepperwood's TBC3)

Berkeley
UNIVERSITY OF CALIFORNIA

USGS
science for a changing world

GORDON AND BETTY
MOORE
FOUNDATION

SONOMA COUNTY
AGRICULTURAL PRESERVATION
AND OPEN SPACE DISTRICT

BAY AREA | OPEN SPACE COUNCIL

Point Blue
Conservation
Science™

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Pepperwood's TBC3 knowledgebase

Gordon and Betty Moore Foundation investments in blue

How can we protect the value of this investment in the face of climate change?

Billions of dollars are being invested in securing over one million acres.

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 and working lands more resilient?

Methods

a watershed model provides the foundation for land and water assessments

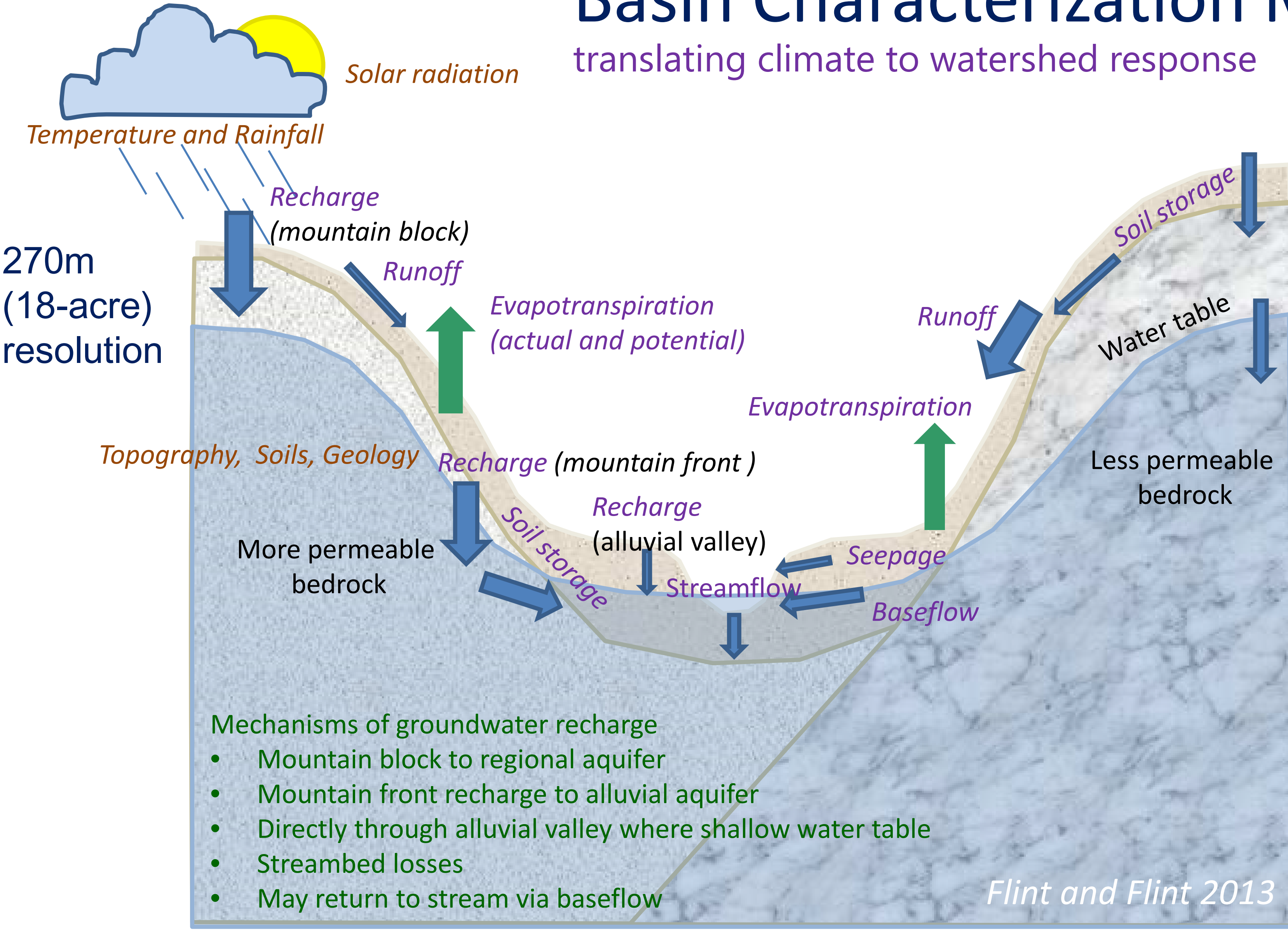
USGS California Basin Characterization Model

(L. Flint and A. Flint, USGS, California Water Resources Center, Sacramento, CA)

USGS science for a changing world

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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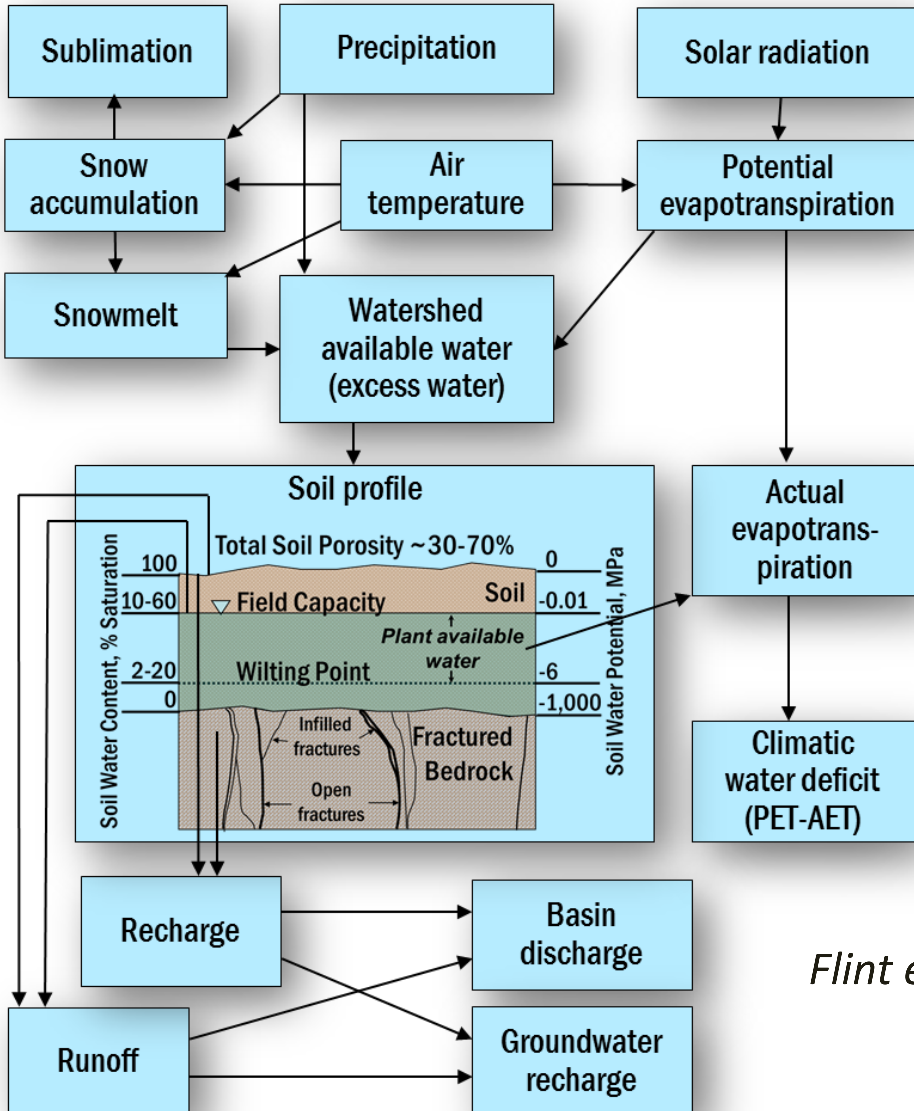
USGS California Basin Characterization Model: translating climate to watershed response



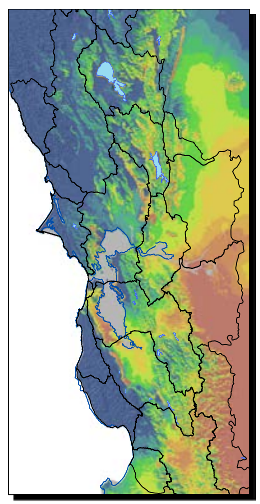
Flint et al 2013

BCM methods

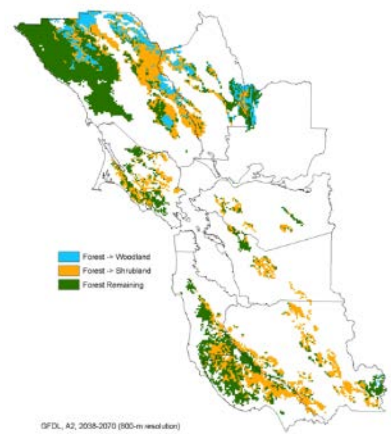
TBC3 has built a climate adaptation knowledge base for application to regional conservation

Climate
+
Topography

Watershed Hydrology
+
Topo-climate



Vegetation Cover
+
Fire Risks



Species Distributions

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

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BCM output: Climatic Water Deficit

Annual evaporative demand
that exceeds available water = drought stress

Potential – Actual Evapotranspiration

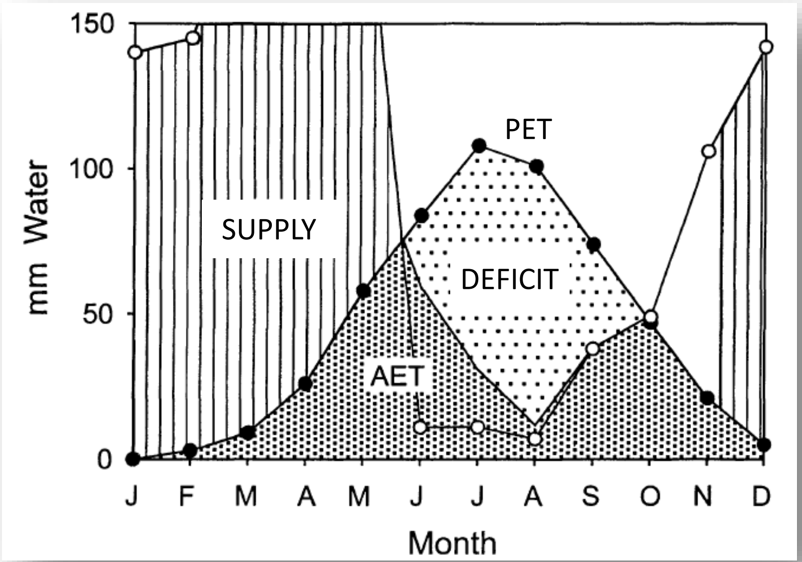
Integrates climate, energy loading, drainage, and available soil moisture storage

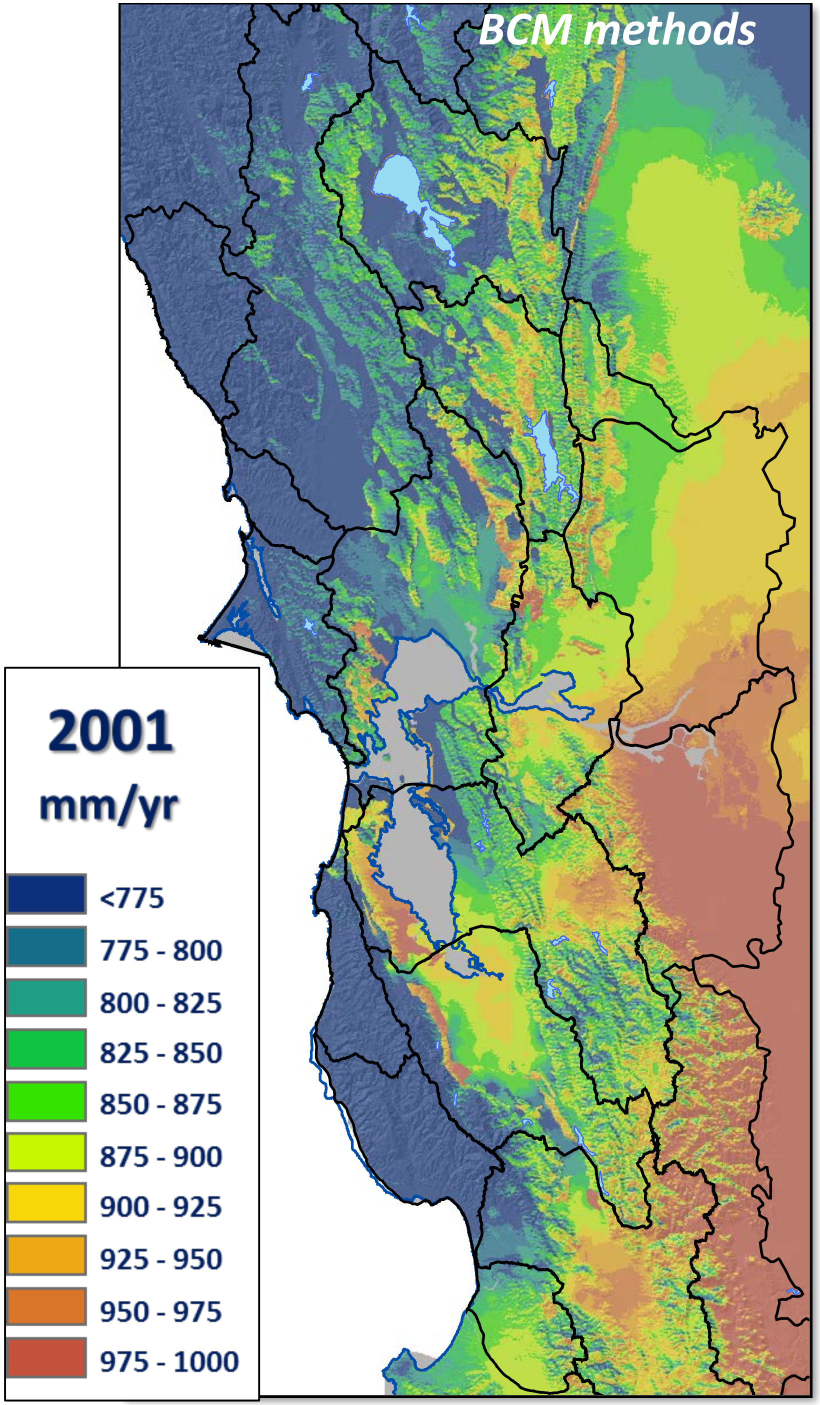
Vegetation independent (indicator)

Surrogate for irrigation demand

Generally increases with all future climate scenarios

Correlates with vegetation type and fire risk





Data menu

Primary (BCM outputs):

- climate and hydrology-temperature, rainfall, snowpack, runoff, recharge, evapo-transpiration, soil moisture, climatic water deficit

Secondary:

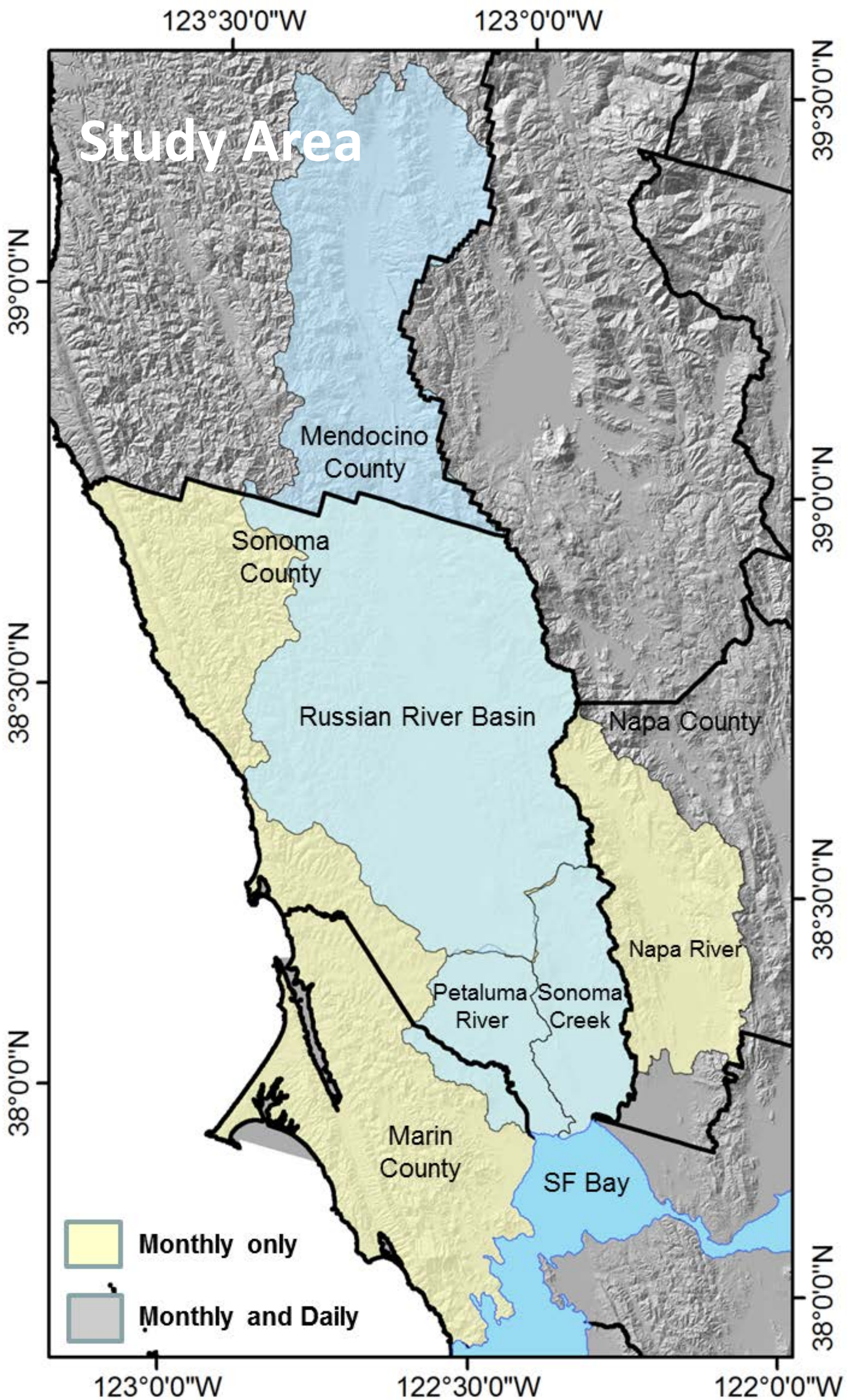
- Fire frequency (either percent likelihood of burn or return interval)
- Potential native vegetation transitions

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

- 30-y averages
- Annual data
- Monthly/Seasonal data
- Daily model for Russian River only

Spatial scales

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



Climate Ready North Bay

Serving natural resource agencies in Marin, Sonoma, Napa and Mendocino Counties (water agencies, park and open space districts, county, planners)

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

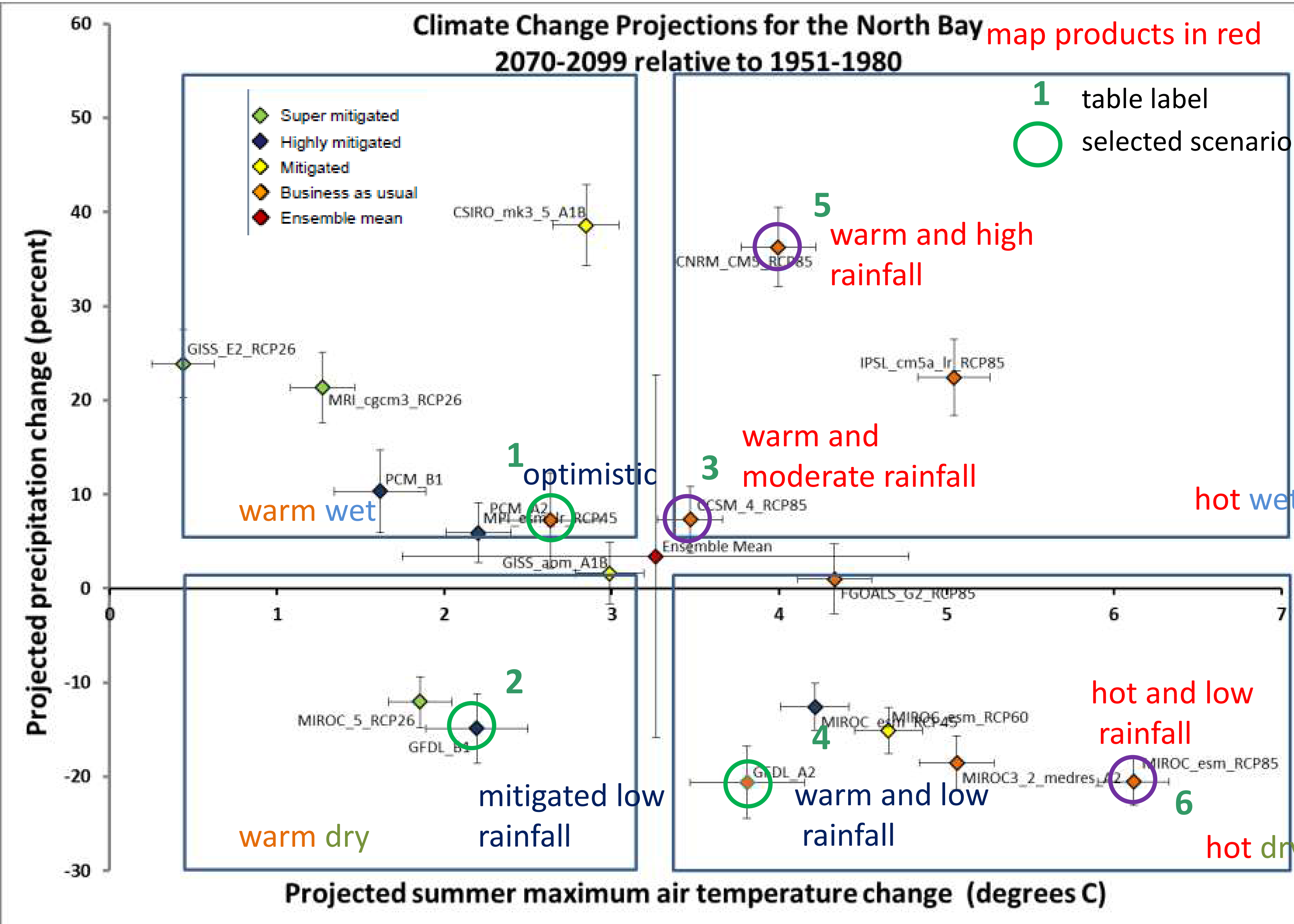


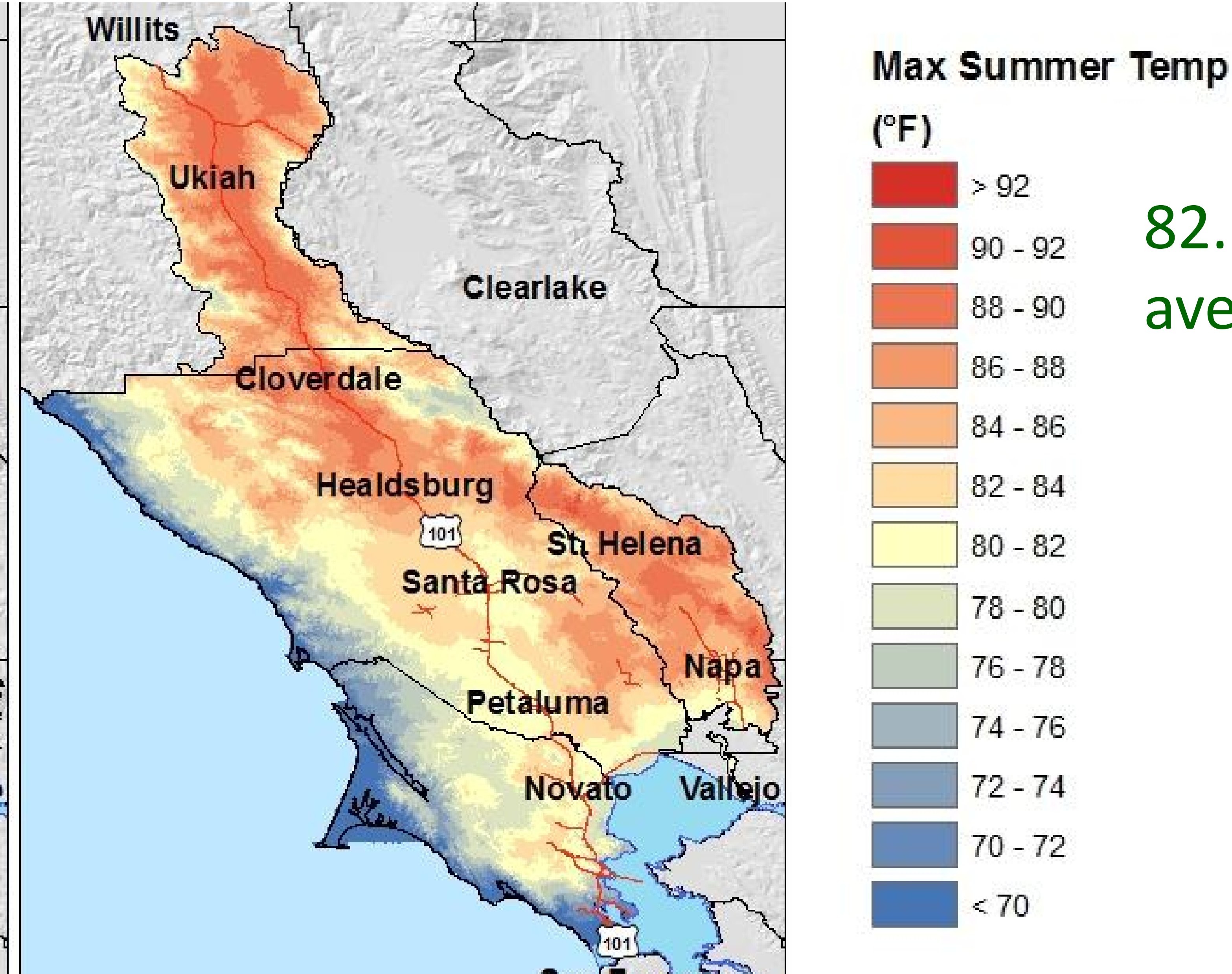
Table 2: Basin Characterization Model, North Bay Regional: Three "business as usual" models used for map products, 1951-2099, percent change from current.

Variable	Units	Historic	Current	Moderate Warming, High Rainfall		Moderate Warming, Moderate Rainfall		Hot, Low Rainfall	
		1951-1980	1981-2010	2040-2069	2070-2099	2040-2069	2070-2099	2040-2069	2070-2099
Ppt	in	42.6	43.0	25%	35%	-2%	6%	-19%	-21%
Tmn	Deg F	44.8	45.8	3.4	6.2	2.7	5.5	4.8	8.4
Tmx	Deg F	71.2	71.2	3.8	6.5	3.2	5.9	5.6	9.5
CWD	in	28.0	54.9	5%	10%	6%	10%	12%	22%
Rch	in	11.0	10.2	25%	29%	4%	6%	-20%	-17%
Run	in	14.0	14.2	61%	90%	-1%	22%	-32%	-34%

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

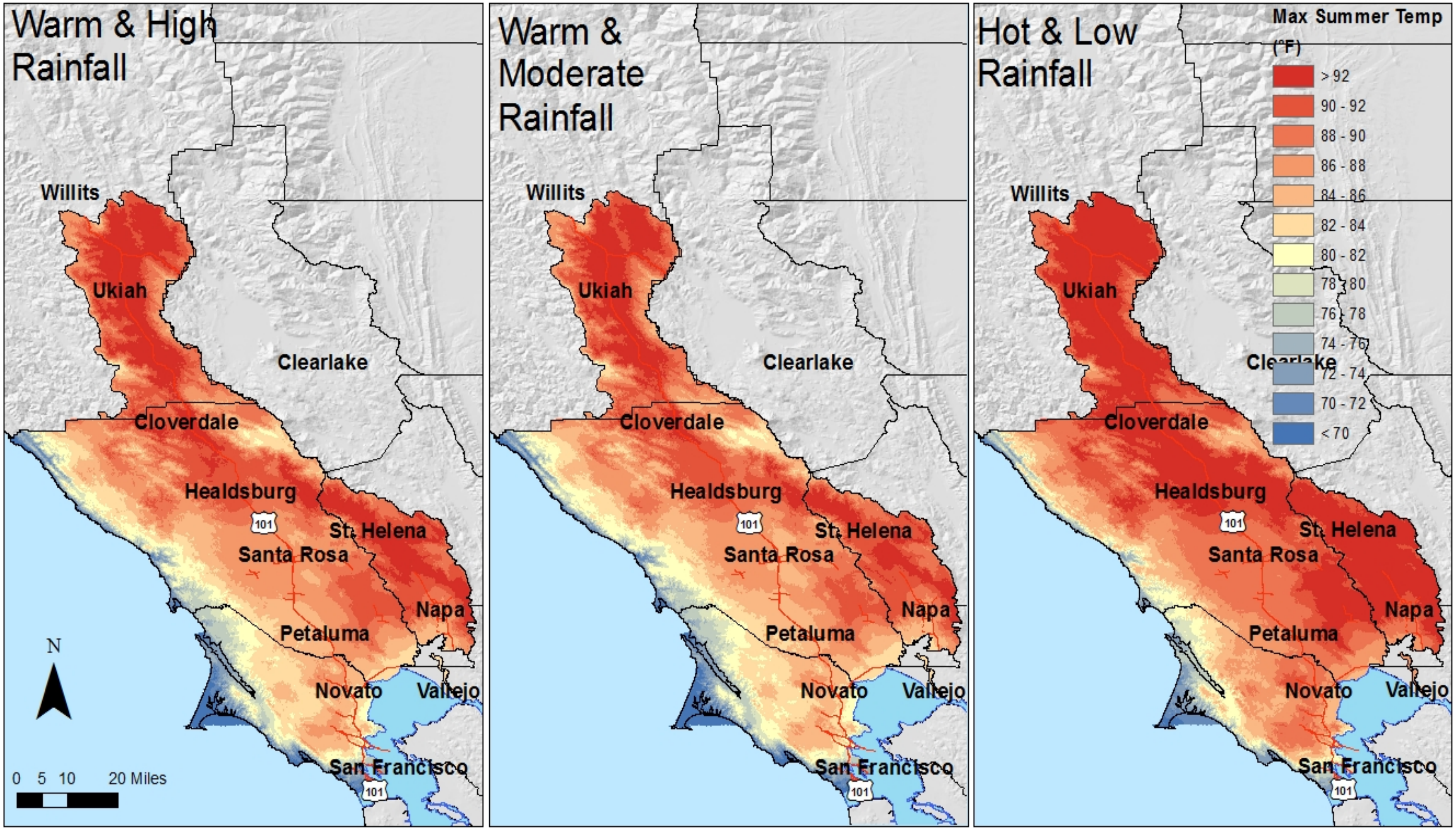
Maximum summer temperature (monthly avg) (degF)

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

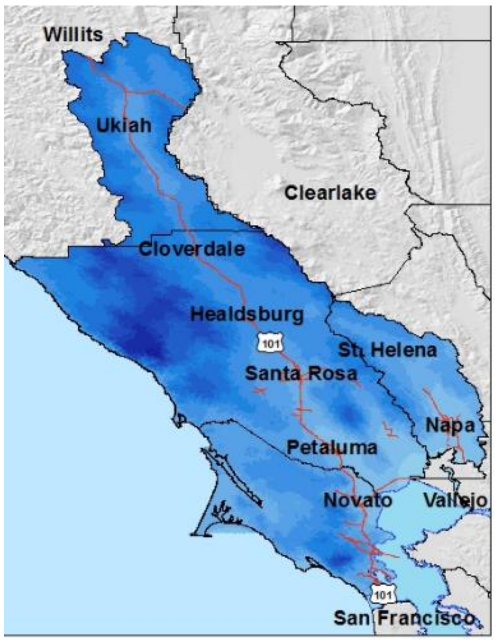
86.0 average
+3.8 deg F

89.2 average
+7.0 deg F

"business as usual" mid-century temperatures-30 y average

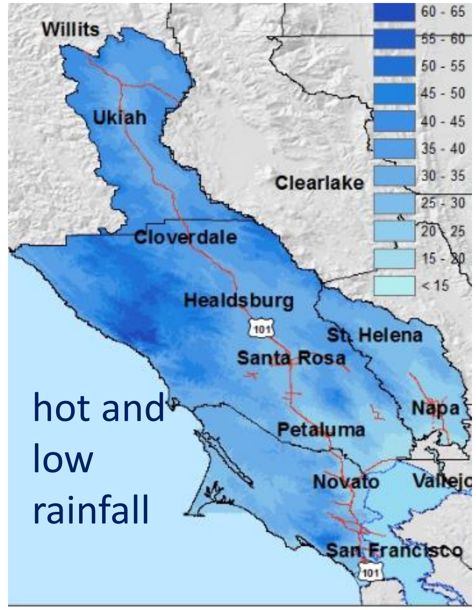
North Bay Precipitation (PPT in/y)

bounding extremes of IPCC range, 30-y average, current to mid-Century



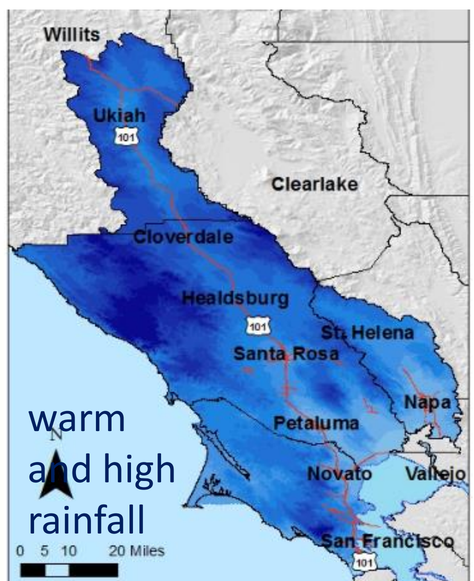
Current 1981-2010
43” average

?



Projected 2040-2069
35” average

projecting 19-21% less rainfall than 1981-2010



Projected 2040-2069
54” average

projecting 25-35% greater rainfall than 1981-2010

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Management Question

How is climate change projected to impact the variability of regional annual rainfall relative to the historic record?

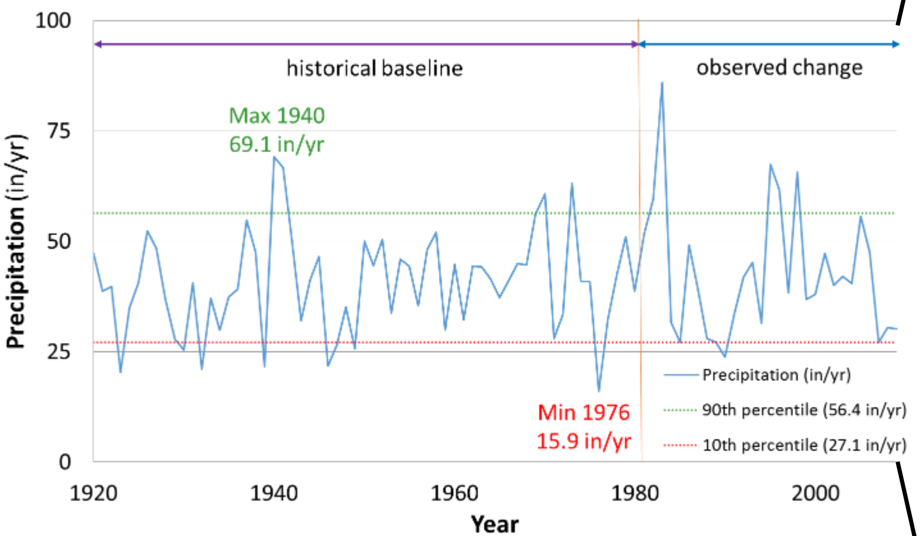
Lake Sonoma in drought

North Bay Climate Ready

Regional Annual Rainfall: Historical and Projected

(comparison of 90-year periods)

North Bay Annual Rainfall Record (1920-2009)



Extremes (1920-2009)

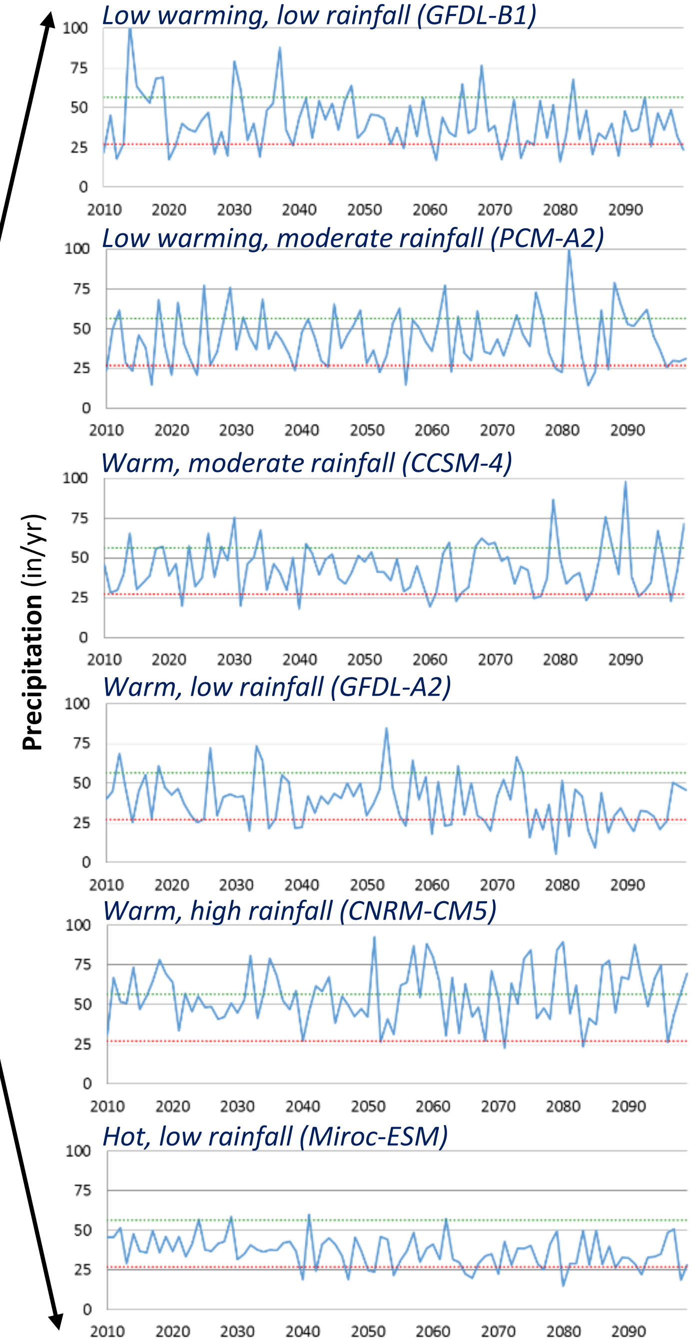
2 events >=1940

9 events >90th % (56.4in/y)*

1 events <=1976

9 events <10th % (27.1 in/y)*

North Bay Annual Rainfall Projections (2010-2099)



Scenario 1
5 events >=1940
13 events >90th %
0 events <=1976
18 events <10th %

Scenario 2
6 events >=1940
23 events >90th %
3 events <=1976
17 events <10th %

Scenario 3
5 events >=1940
19 events >90th %
0 events <=1976
10 events <10th %

Scenario 4
3 events >=1940
10 events >90th %
3 events <=1976
23 events <10th %

Scenario 5
19 events >=1940
41 events >90th %
0 events <=1976
6 events <10th %

Scenario 6
0 events >=1940
4 events >90th %
1 events <=1976
14 events <10th %

* 10th and 90th percentile benchmarks based on 1920-2009 record

Climate Ready North Bay

Annual Rainfall Extremes per Decade

Frequency of extreme annual events per decade

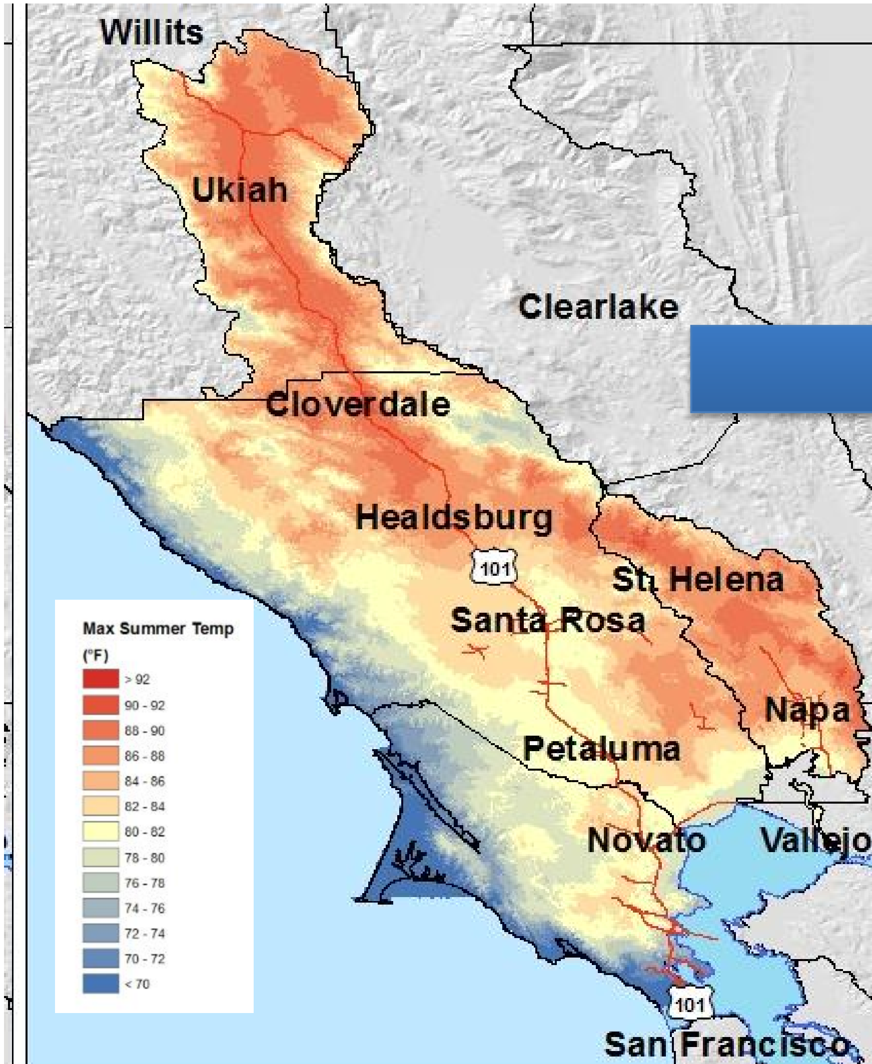
Scenario #	Model	Time Period	Name	Annual Peaks (floods) >=1940 (69.1 in/yr)	Annual Peaks (floods) >90th % (56.4 in/yr)	Annual Lows (droughts) <10th % (27.1 in/yr)	Annual Lows (droughts) <=1976 (15.9 in/yr)
	Historic & Observed Change	1920-2009		0.22	1.00	1.00	0.11
1	GFDL_B1	2010-2099	Low warming, Low rainfall	0.56	1.44	2.00	0.00
2	PCM_A2	2010-2099	Low warming, Mod rainfall	0.67	2.56	1.89	0.33
3	CCSM4_rcp85	2010-2099	Warm, Mod rainfall	0.56	2.11	1.11	0.00
4	GFDL_A2	2010-2099	Warm, Low rainfall	0.33	1.11	2.56	0.33
5	CNRM_rcp85	2010-2099	Warm, High rainfall	2.11	4.56	0.67	0.00
6	MIROC_rcp85	2010-2099	Hot, Low rainfall	0.00	0.44	1.56	0.11

Percent increase or decrease (projected relative to 1920-2009): Frequency extreme annual events per decade

Scenario #	Model	Time Period	Name	Annual Peaks (floods) >=1940 (69.1 in/yr)	Annual Peaks (floods) >90th % (56.4 in/yr)	Annual Lows (droughts) <10th % (27.1 in/yr)	Annual Lows (droughts) <=1976 (15.9 in/yr)
	Historic & Observed Change	1920-2009					
1	GFDL_B1	2010-2099	Low warming, Low rainfall	150%	44%	100%	-100%
2	PCM_A2	2010-2099	Low warming, Mod rainfall	200%	156%	89%	200%
3	CCSM4_rcp85	2010-2099	Warm, Mod rainfall	150%	111%	11%	-100%
4	GFDL_A2	2010-2099	Warm, Low rainfall	50%	11%	156%	200%
5	CNRM_rcp85	2010-2099	Warm, High rainfall	850%	356%	-33%	-100%
6	MIROC_rcp85	2010-2099	Hot, Low rainfall	-100%	-56%	56%	0%
			Average	***217%***	***104%***	***63%***	***17%***

* 10th and 90th percentile benchmarks based on 1920-2009 record

Climate Ready North Bay: translating TBC3's climate-hydrology database into inputs for long-term planning



Source: Climate Ready North Bay 2015

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

Engaged agencies: Regional Climate Protection Authority, Sonoma County Water Agency, SCAPOSD, Regional Parks; Marin Municipal Water District, Napa County

Case studies on CA Climate Commons
http://climate.calcommons.org/crnb/home

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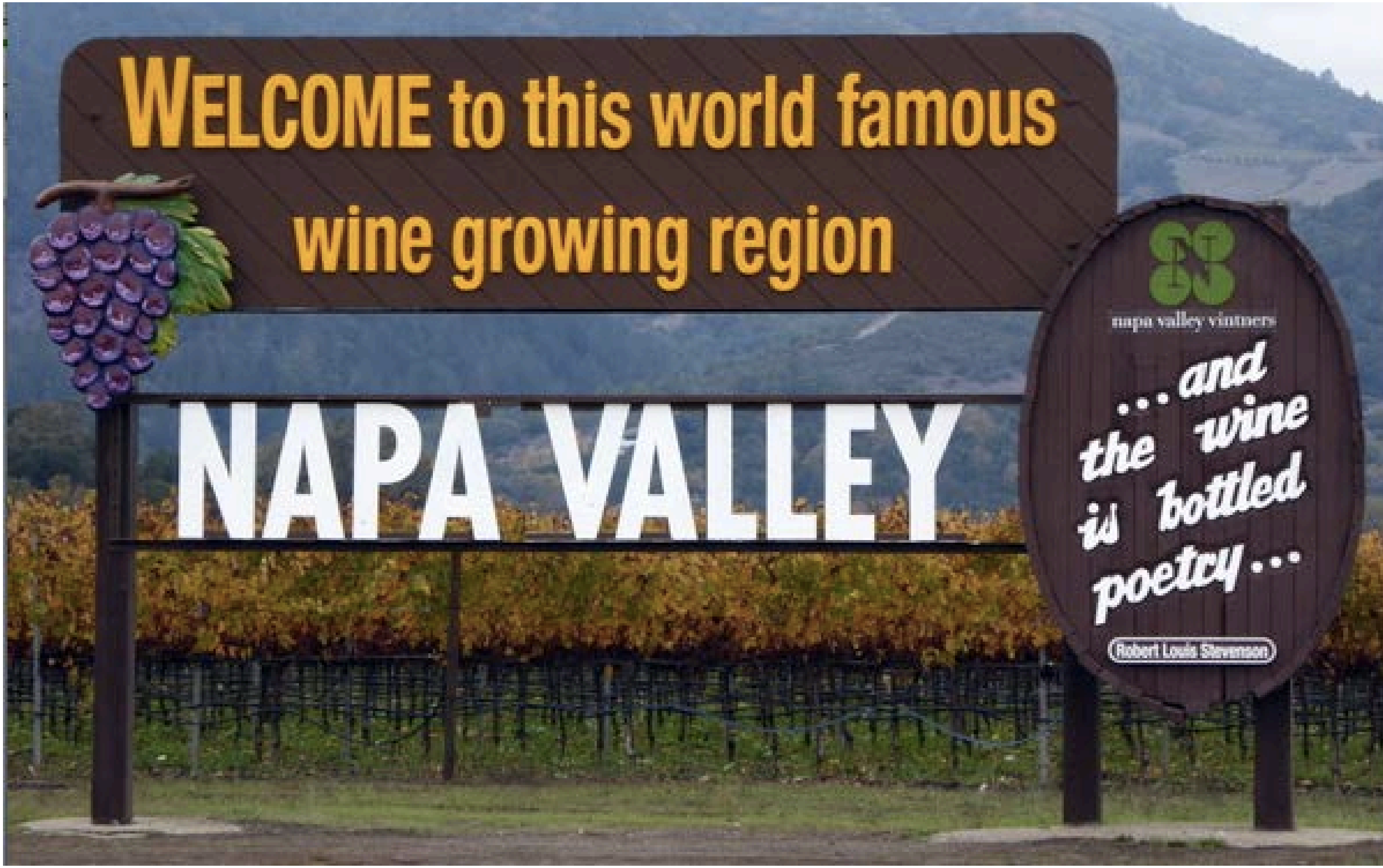

WELCOME to this world famous
wine growing region
NAPA VALLEY
napa valley vintners
...and the wine is bottled poetry...
Robert Louis Stevenson

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%

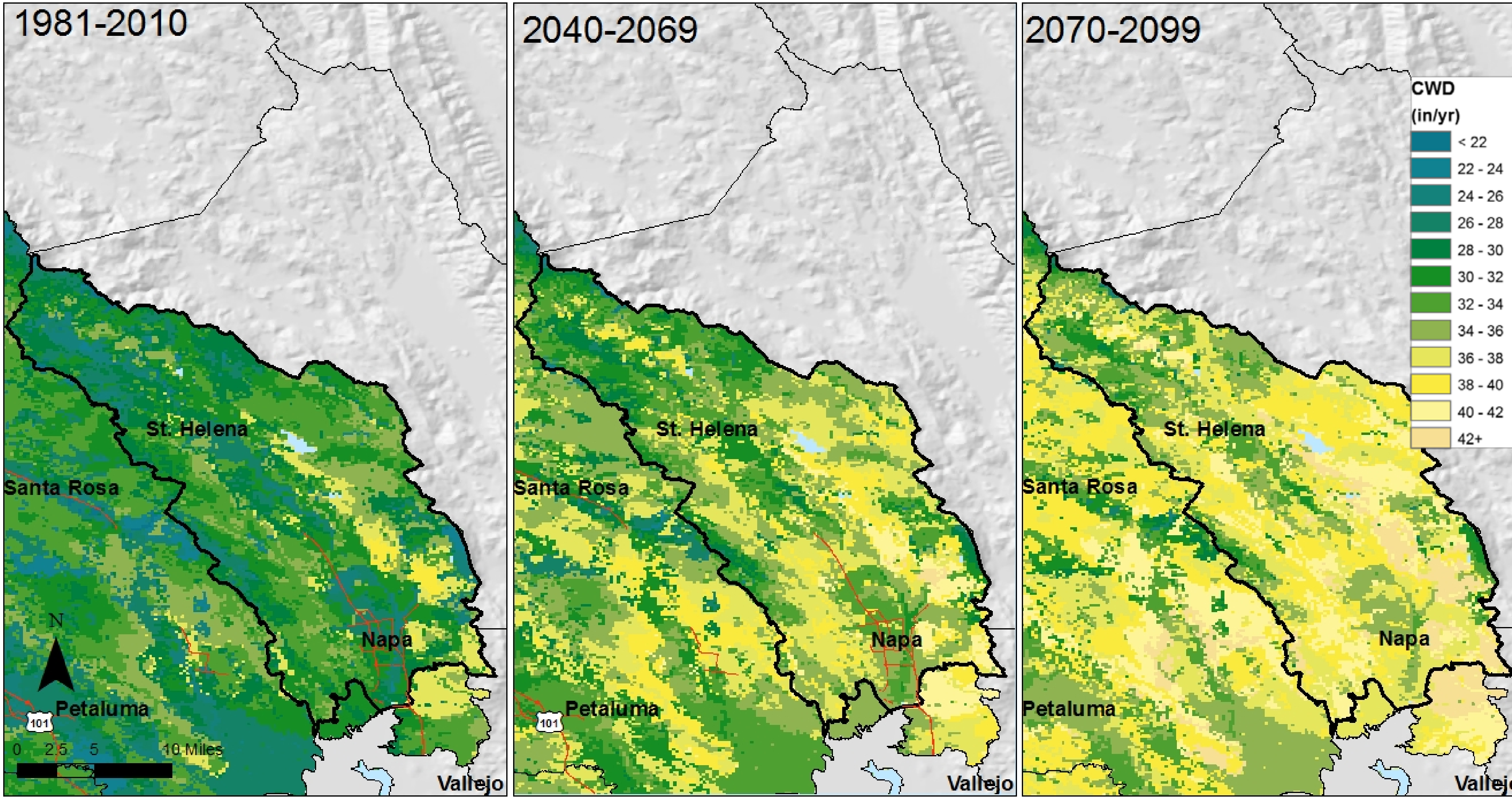
VARIABLES: Ppt=precipitation, Tmn=winter minimum temperature, Tmx=summer maximum temperature, CWD=climatic water deficit, Rch=recharge, Run=runoff

USGS, Point Blue, Pepperwood 2015

Management Question

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

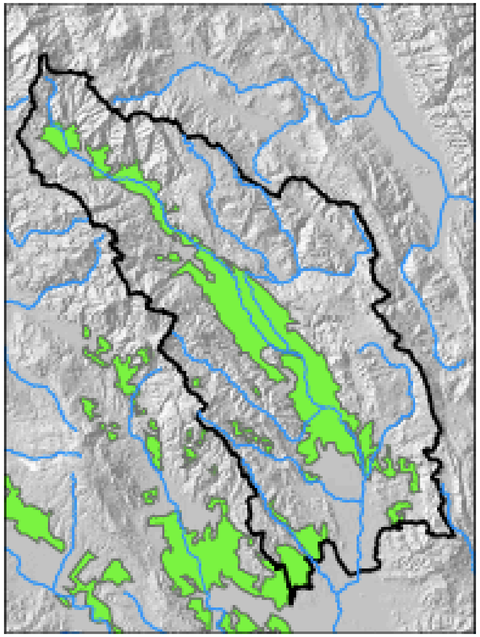
Climatic Water Deficit, Hot and Low Rainfall



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

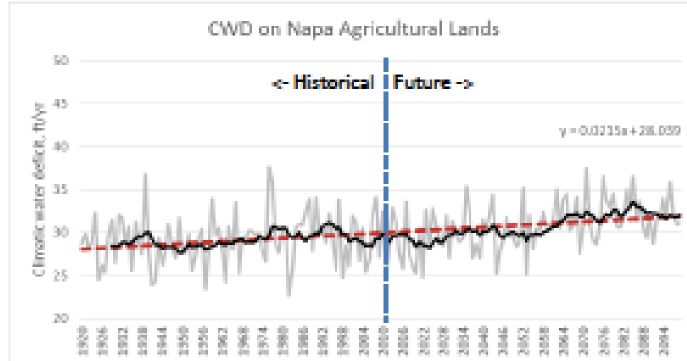
34 in/y average
(29 in/y rainfall)

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



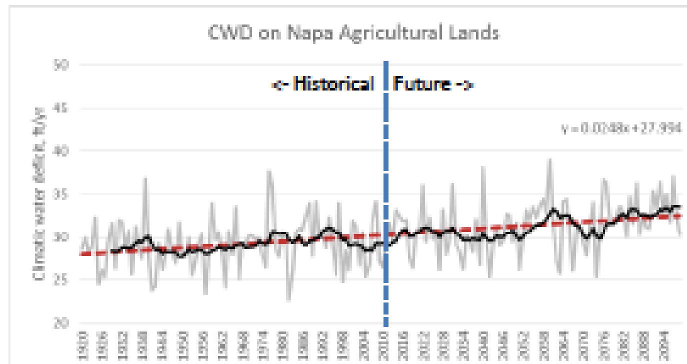
Climatic Water Deficit on Napa Agricultural Lands

Scenario 5
Warm &
High Rainfall



last 30 years 9 % greater deficit

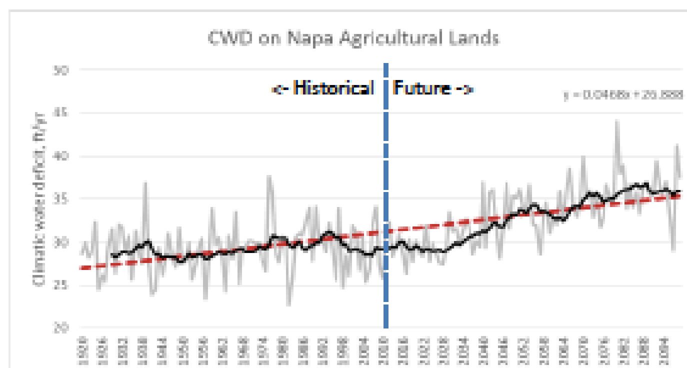
Scenario 3
Warm &
Moderate
Rainfall



last 30 years 10 % greater deficit

Water deficits increase in even high rainfall scenarios

Scenario 6
Hot &
Low Rainfall

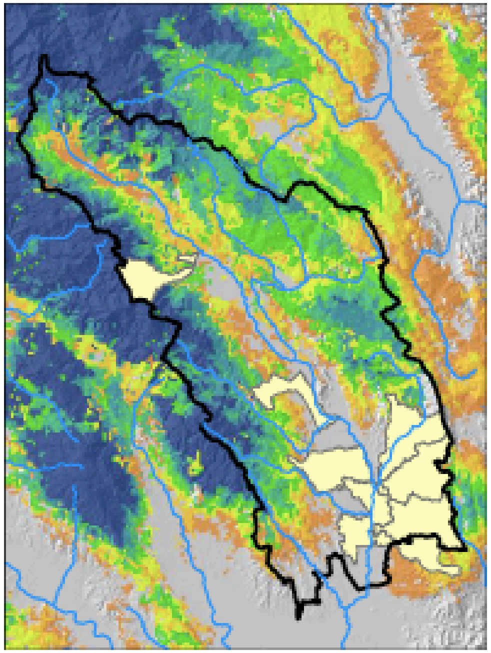


last 30 years 20 % greater deficit

Management Question

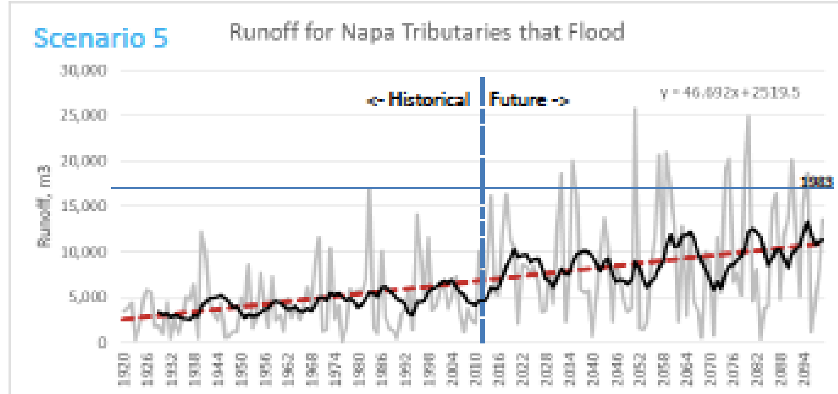
How will climate change impact Napa Valley tributaries prone to flooding?

Napa Tributaries that Flood



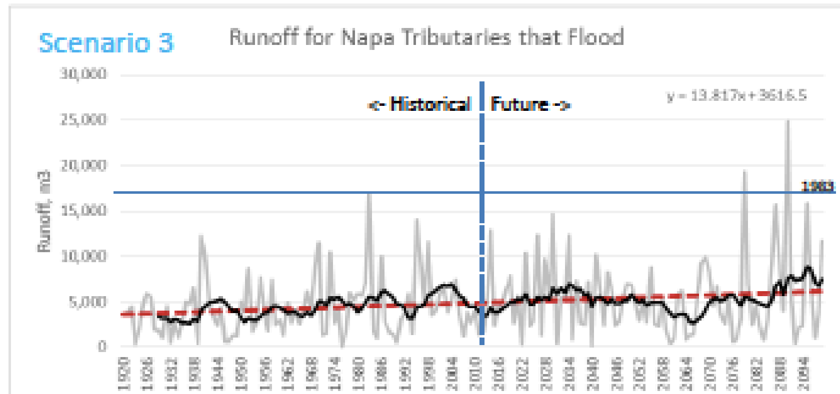
1983 is reference peak "year" of historical record

Warm &
High Rainfall



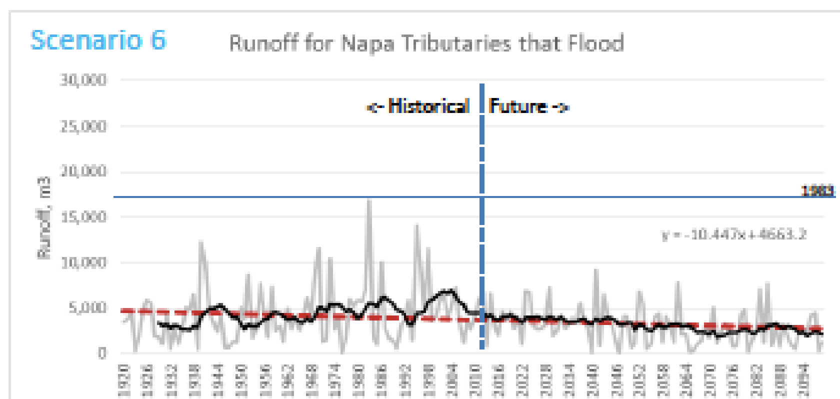
10 years exceeding historical peak threshold in future

Warm &
Moderate Rainfall



2 years exceed threshold

Hot &
Low Rainfall



None exceed threshold

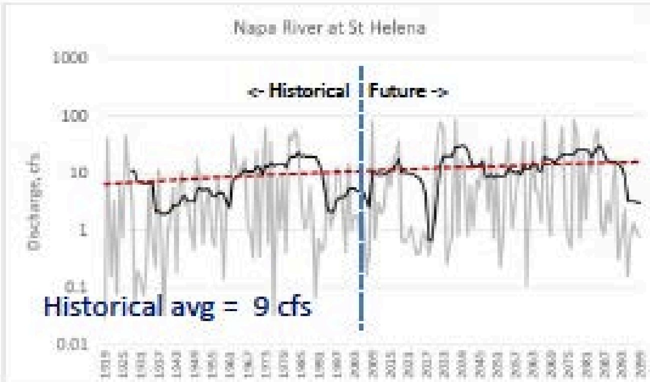
Management Question

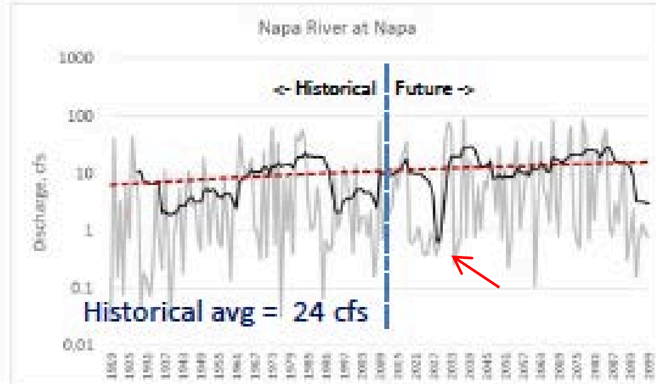
How will the low flow regime of the Napa River and its tributaries (critical to salmonid summer survival) be potentially impacted by climate change?

Napa River: Saint Helena and Napa Gages

Summer low flows (Aug-Sep-Oct)

Warm & High Rainfall

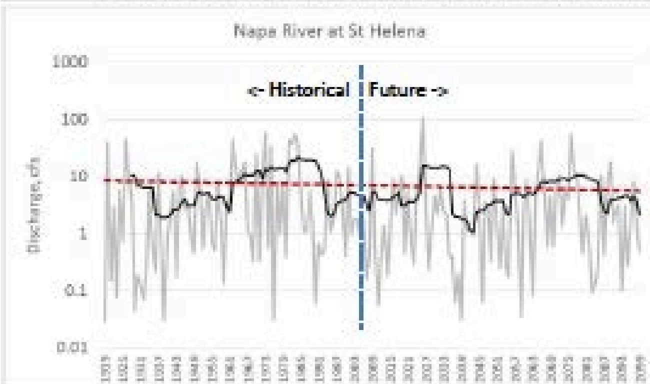


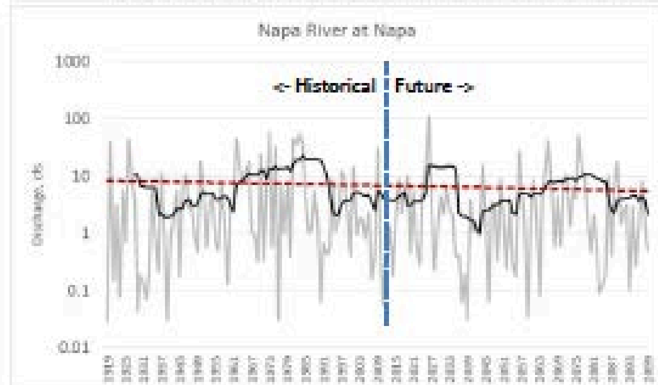


St Helena
Projected = 13 cfs

Napa
Projected = 36 cfs

Warm & Moderate Rainfall

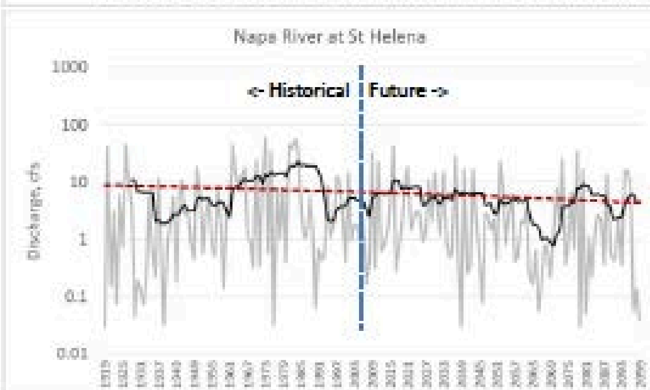


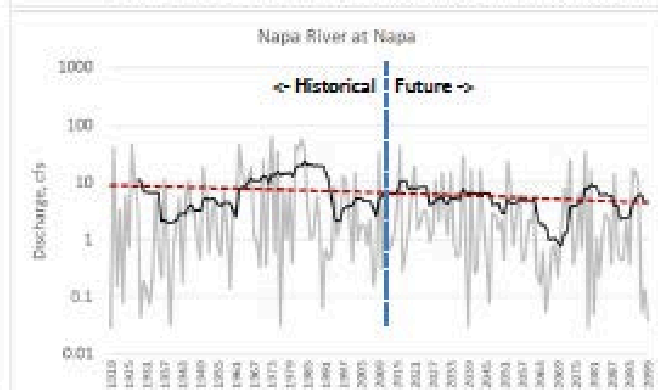


St Helena
Projected = 6 cfs

Napa
Projected= 15 cfs

Hot & Low Rainfall





St Helena
Projected = 5 cfs

Napa
Projected= 13 cfs

Management Question

How will the seasonality of the hydrologic cycle be potentially impacted by climate change?

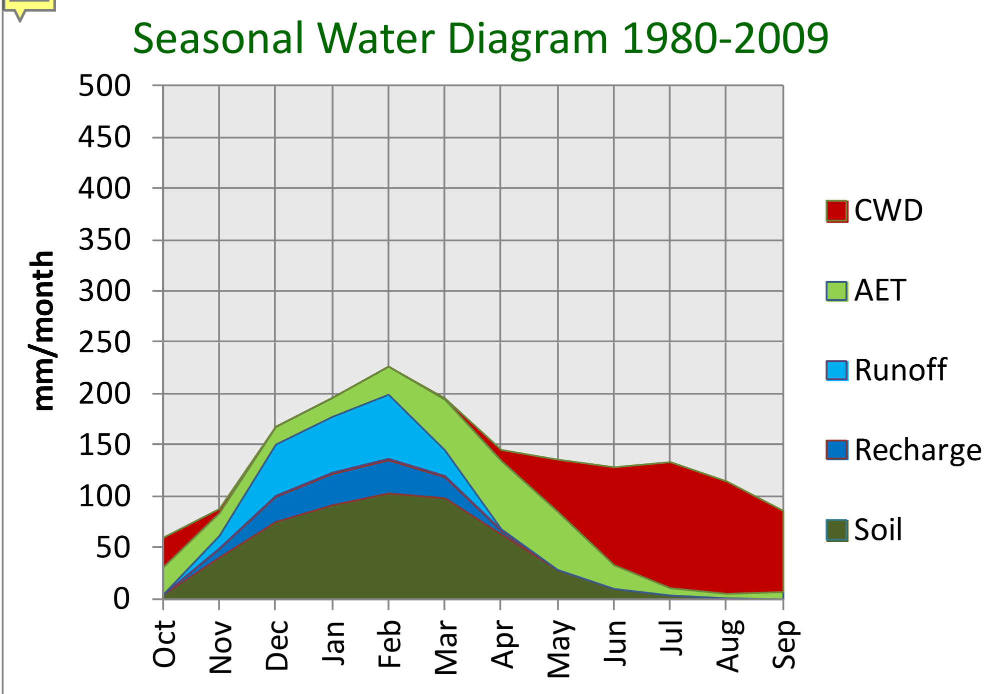
Bud Break in Napa Valley

Though it's easy to find reasons to visit Napa Valley at various times throughou
shining, the weather is mild and enjoyable, nature is waking up for another glor
buds in the 400+ vineyards across Napa Valley are beginning to break. Spring
harvest; it's a time of renewal and new beginnings. Clear signs that spring is w
carpets of mustard growing between the vines and the bud break now occurrin
your room at our romantic Bed and Breakfast this spring, and enjoy nature's re

Bud Break Comes Early

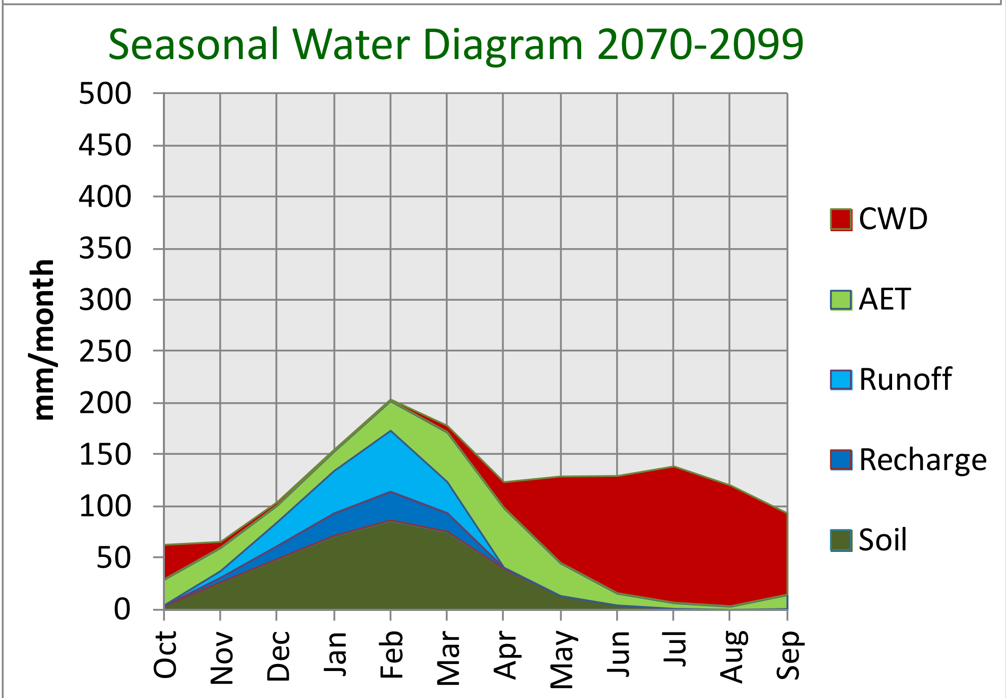
Bud break is an exciting time in Napa Valley, and it's ultimately where the grea
bud break, the vineyards that have been dormant throughout the winter month
tender buds of the growing season emerge in the early months of spring, growi
clusters of grapes begin to form. Though the Napa Valley is only 30 miles long, bud break and flowering can take up to two m
the differences in both elevation and temperature. The southern Carneros region near San Pablo Bay tends to be cooler whe

This year, bud break in Napa Valley seems to be happening earlier than ever before, thanks in large part to the warmer and



Seasonality of Water Cycle

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



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

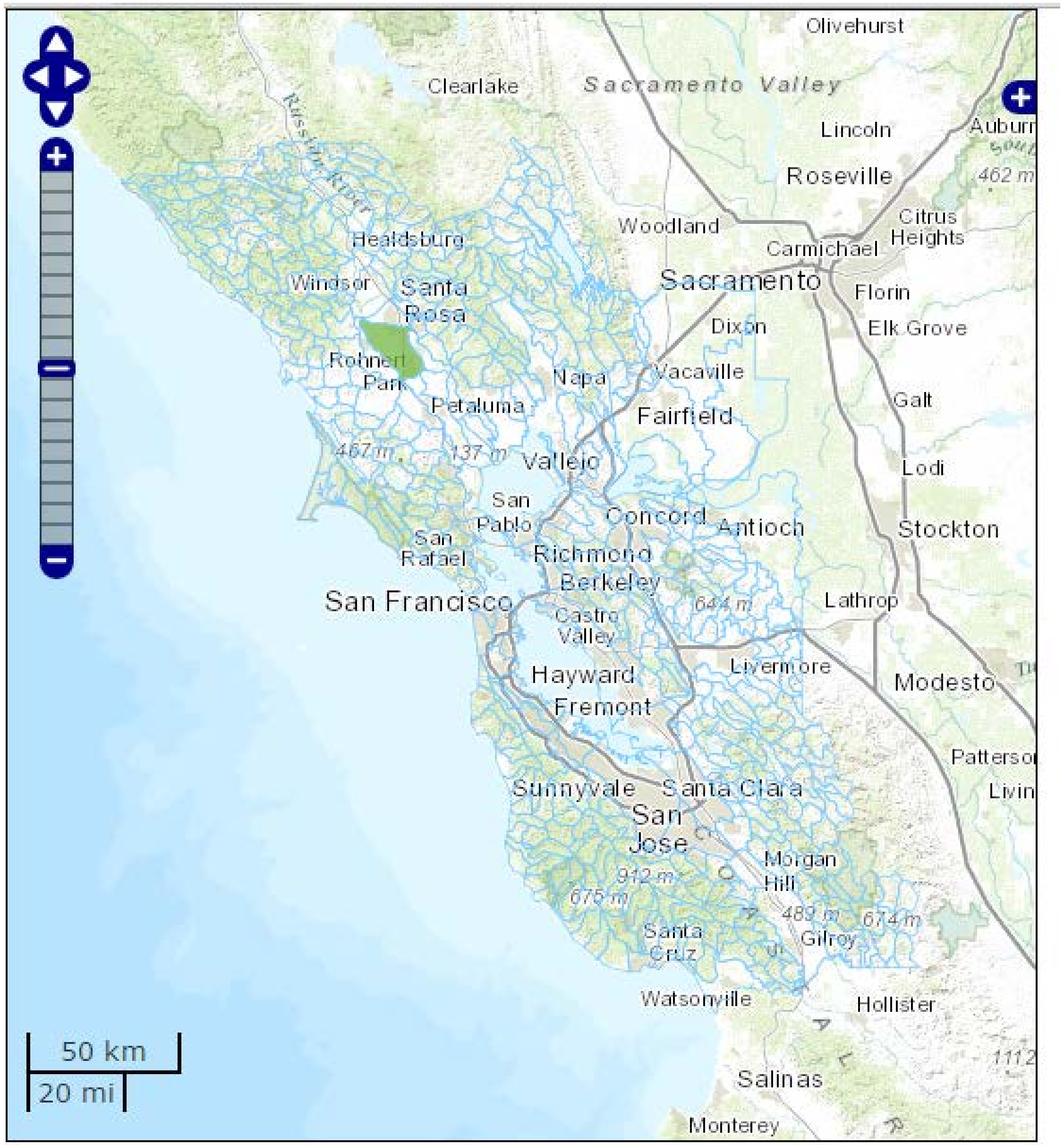
Management Question

How can I get this annual and seasonal time series BCM data for my Bay Area watershed?

BETA now available via the Climate Smart Watershed analyst on California Climate Commons!

calcommons.climate.org/tbc3/ sf-bay-watershed-analyst

On-line data manipulation



Watershed: Laguna de Santa Rosa (HUC 1114210002)

User selects a planning watershed

Watershed: Laguna de Santa Rosa (HUC 1114210002)

Data Variable: Precipitation

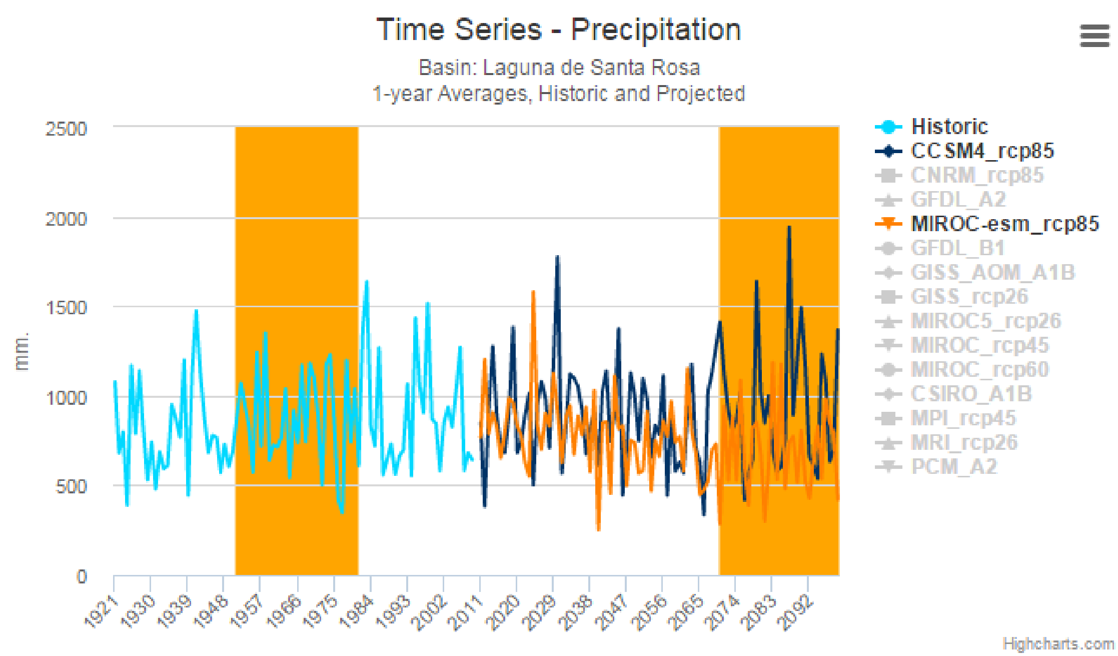
Future Scenario: MIROC-esm_rcp85

Historic Average Over: 30 Year Range: 1951 - 1980

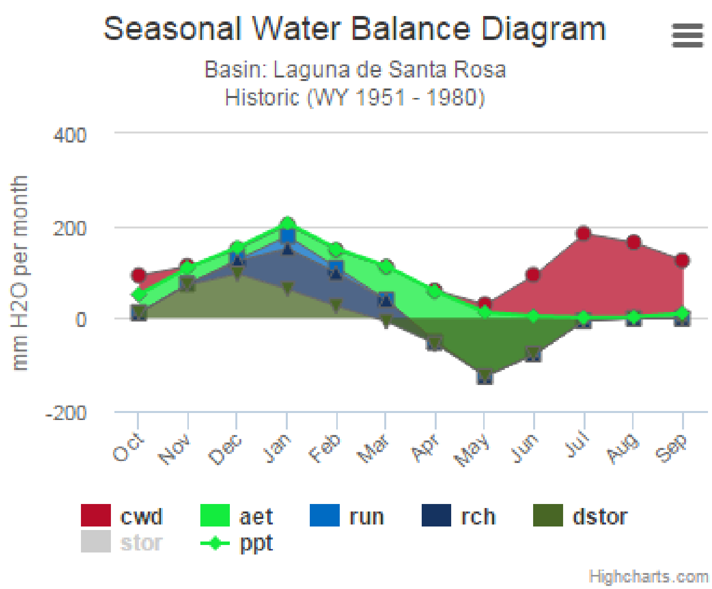
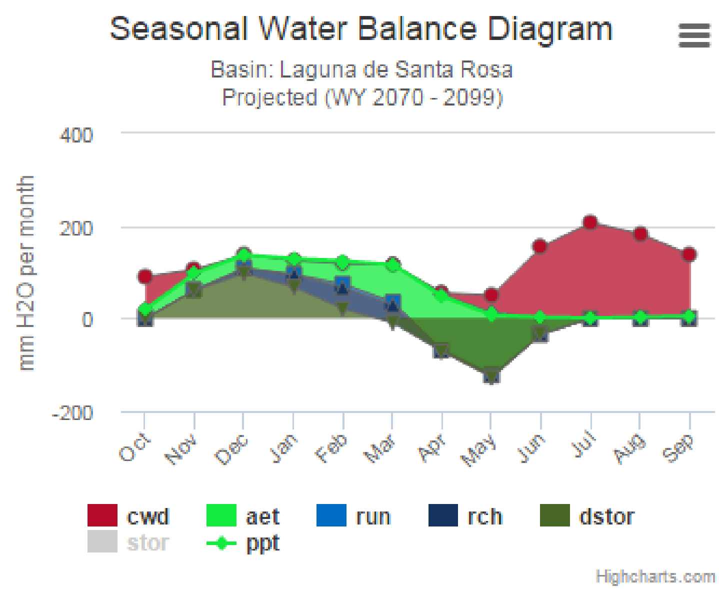
Projected Average Over: 30 Year Range: 2070 - 2099

Time Series

Running Average Window: 1 years

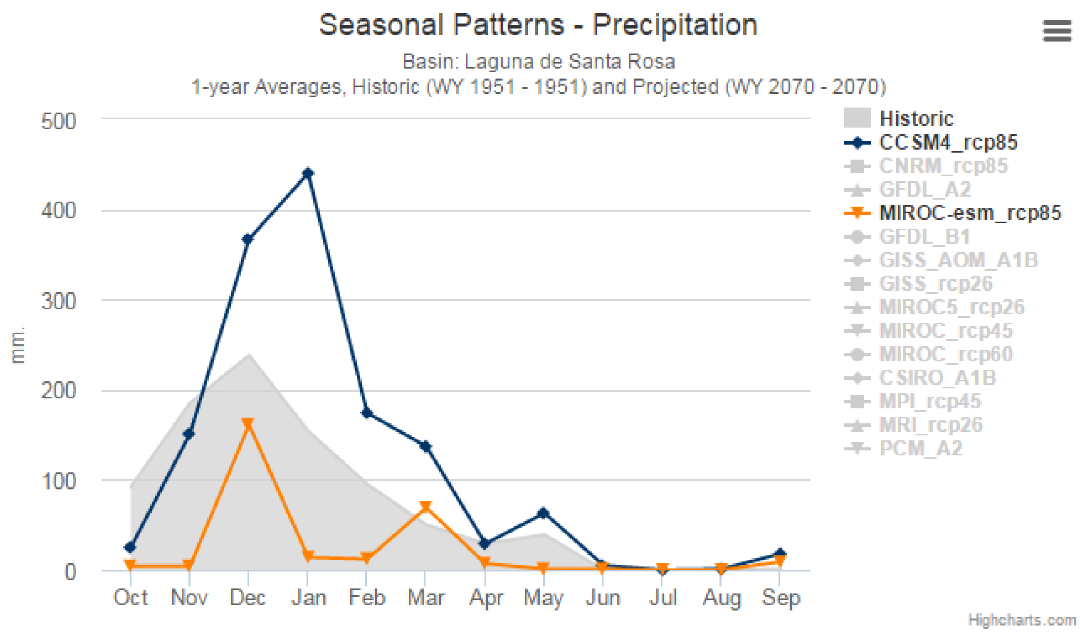


User selects a BCM variable, temporal resolution, running average option, “comparison” windows

Seasonal Water Balance Diagram	(Future Scenario and Year Ranges selected above)
	

Seasonal Water Balance generated for user-selected comparison windows

Seasonal Patterns	(Data Variable and Year Range selected above)



View Report for this Watershed

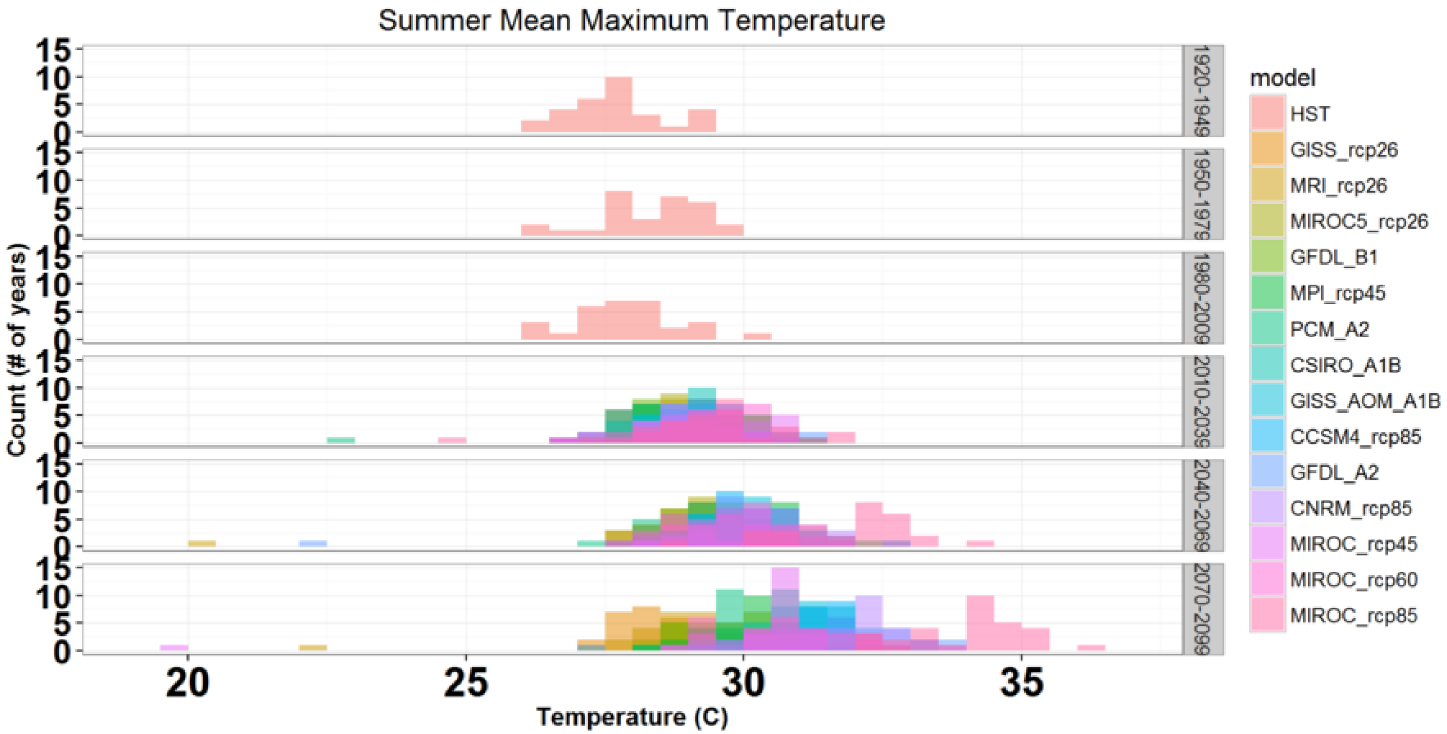
Download Data for this Watershed

Climate Scenario: Historic Download

Seasonality of selected parameter-one or multi-year records/projections versus reference period

Annual Extremes

Extreme climatic events can have great impacts on natural resources and human communities. Understanding how frequently climate models project extreme climatic events to occur in the future can help in the development of strategies to prepare and adapt. The graphs below show the number of years that the value of a given climate variable has occurred historically and within each of 14 future models projected into the future. Areas of light purple indicate where there is large overlap among the 14 models considered while individual colors indicate unique results for individual models.



The width of each bar is 0.5 degrees C.

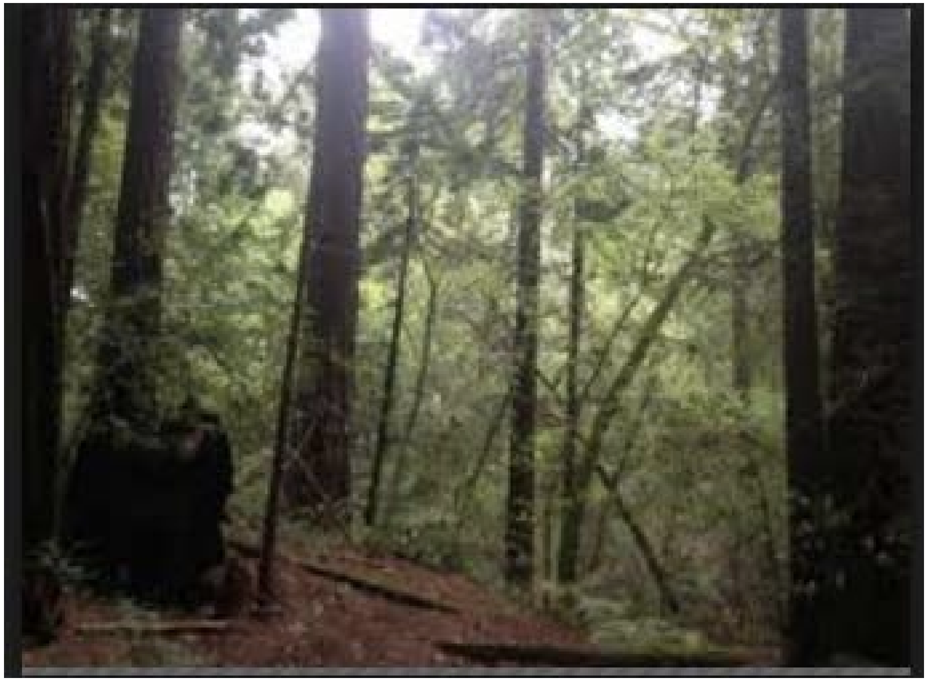
Annual value histograms-historic plus 14 futures

Report download



Management Question

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

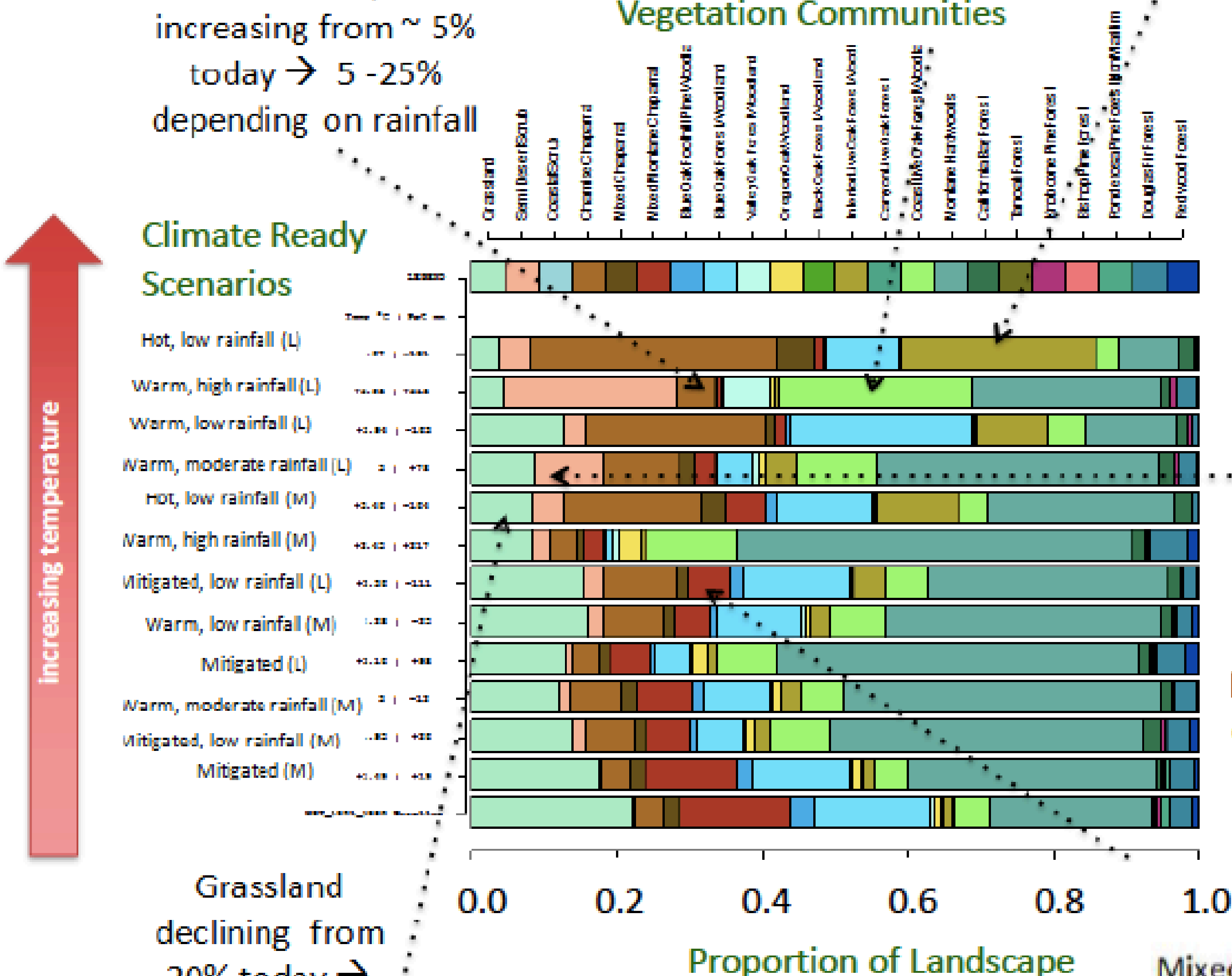


Ackerly et al 2015 - PloSOne

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

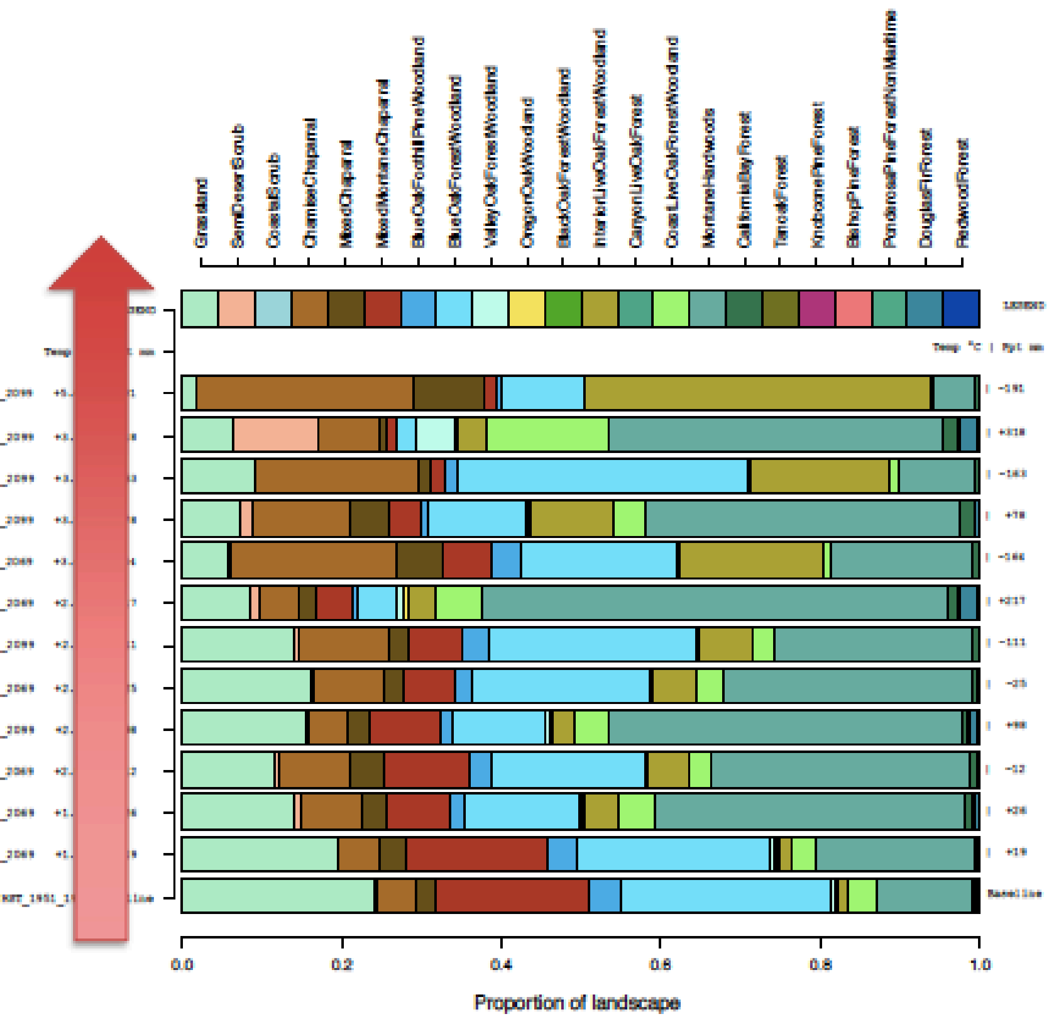


Semi-desert Scrub emerges and becomes common

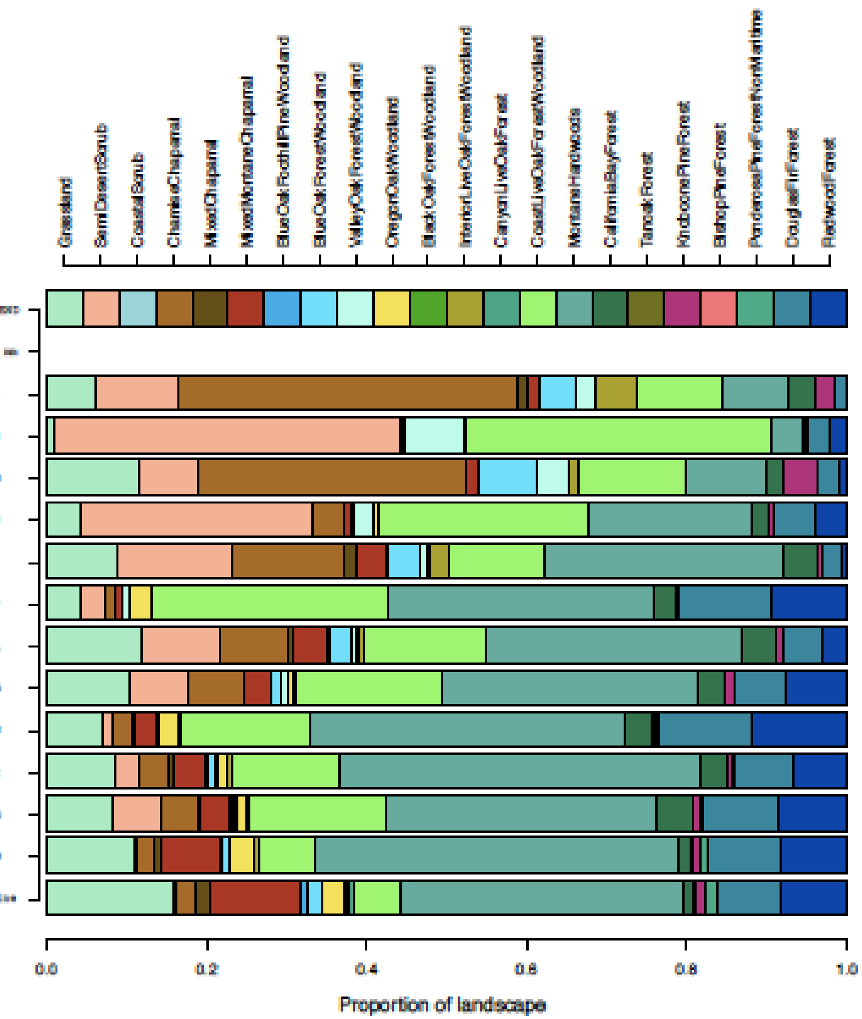
Grassland declining from 20% today → <10% in late century

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

Blue Ridge Berryessa



Southern Mayacamas Mountains

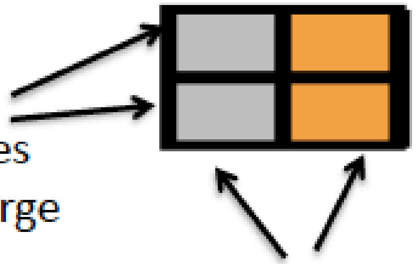


there can be significant differences between landscape units

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

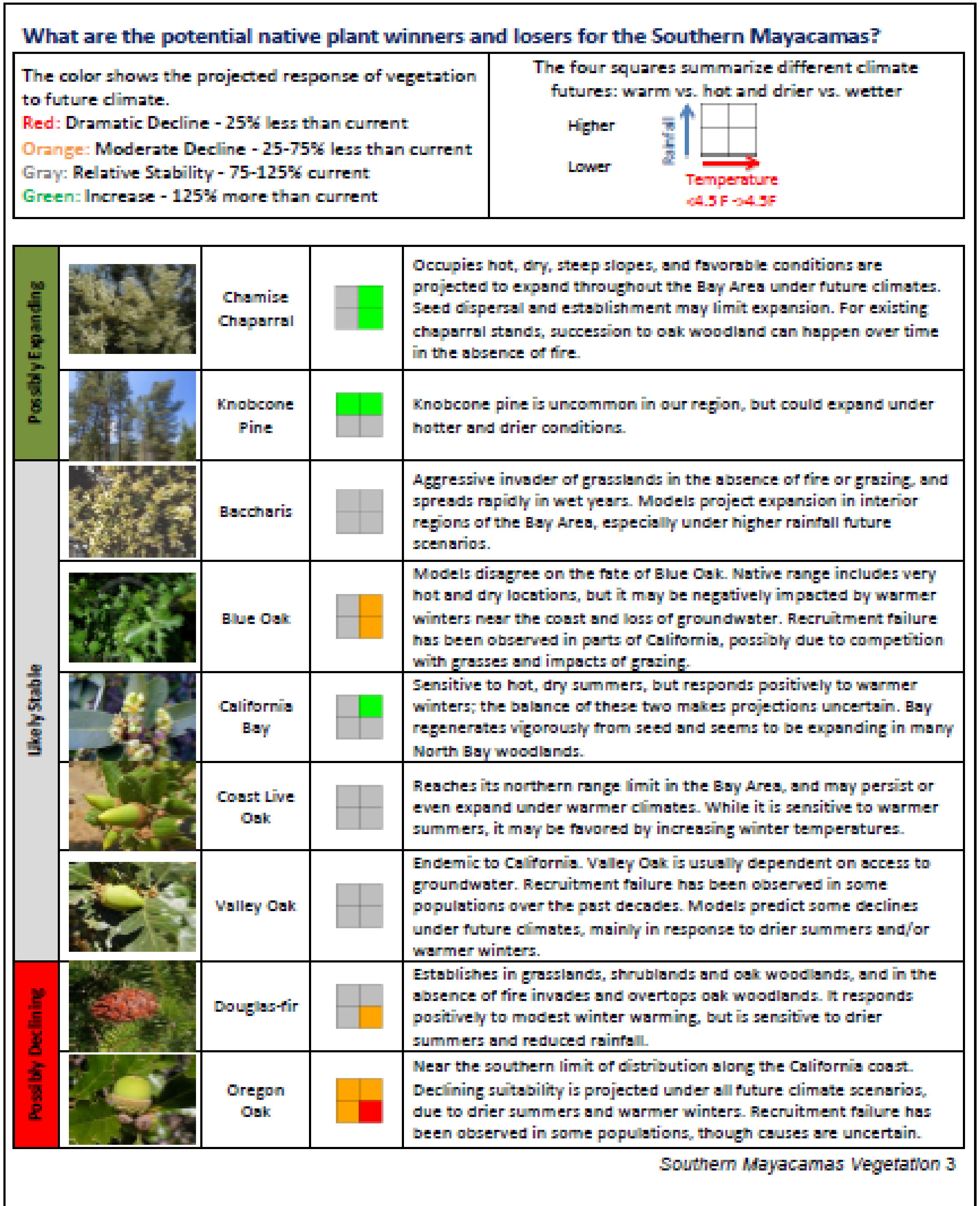
Rainfall ↑

warm < 4.5°F more rain	hot > 4.5°F more rain
warm <4.5°F less rain	hot > 4.5°F 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)



What are the potential native plant winners and losers for the Southern Mayacamas?

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 summarize different climate futures: warm vs. hot and drier vs. wetter Higher / Lower (Rainfall) Temperature <4.5 F - >4.5F

Possibly Expanding	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.
	Knobcone Pine	Knobcone pine is uncommon in our region, but could expand under hotter and drier conditions.
Likely Stable	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.
	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.
	California Bay	Sensitive to hot, dry summers, but responds positively to warmer winters; the balance of these two makes projections uncertain. Bay regenerates vigorously from seed and seems to be expanding in many North Bay woodlands.
	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.
	Valley Oak	Endemic to California. Valley Oak is usually dependent on access to groundwater. Recruitment failure has been observed in some populations over the past decades. Models predict some declines under future climates, mainly in response to drier summers and/or warmer winters.
Possibly Declining	Douglas-fir	Establishes in grasslands, shrublands and oak woodlands, and in the absence of fire invades and overtops oak woodlands. It responds positively to modest winter warming, but is sensitive to drier summers and reduced rainfall.
	Oregon Oak	Near the southern limit of distribution along the California coast. Declining suitability is projected under all future climate scenarios, due to drier summers and warmer winters. Recruitment failure has been observed in some populations, though causes are uncertain.

Southern Mayacamas Vegetation 3

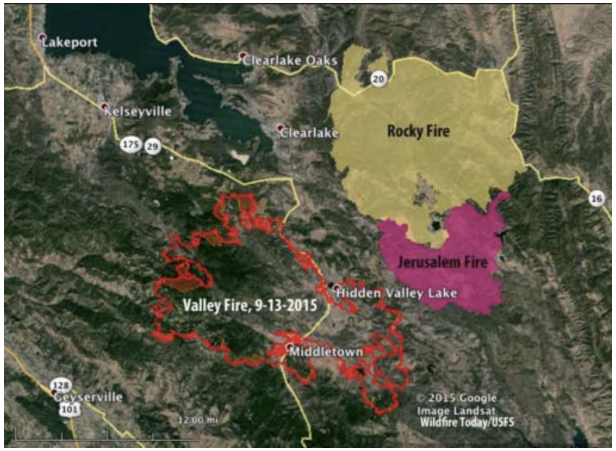
Projected Vegetation Model reports available for North Bay at

http://www.pepperwoodpreserve.org/tbc3/our-work/climate-ready/

Or shortcut to Tbc3.org

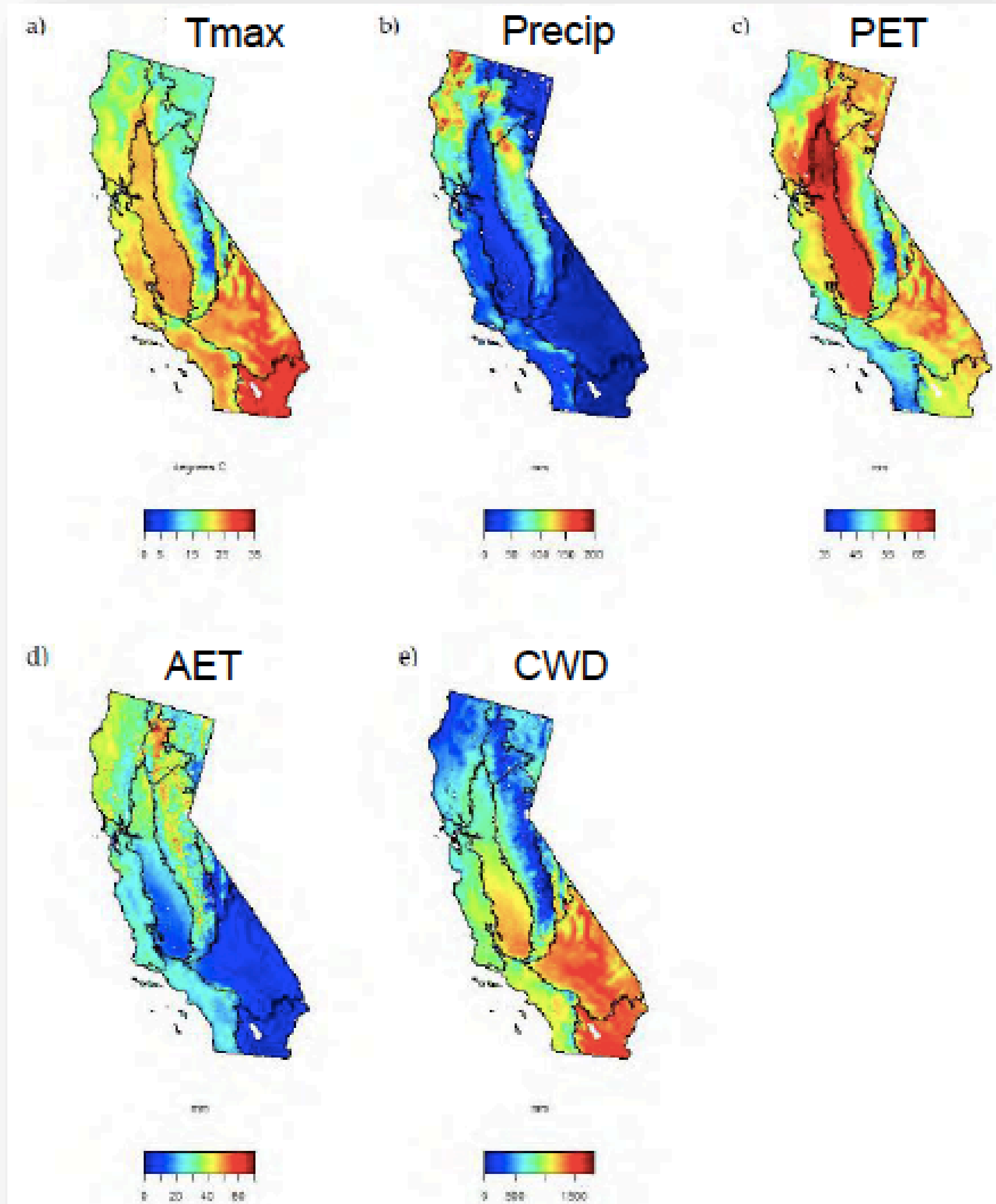
Management Question

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



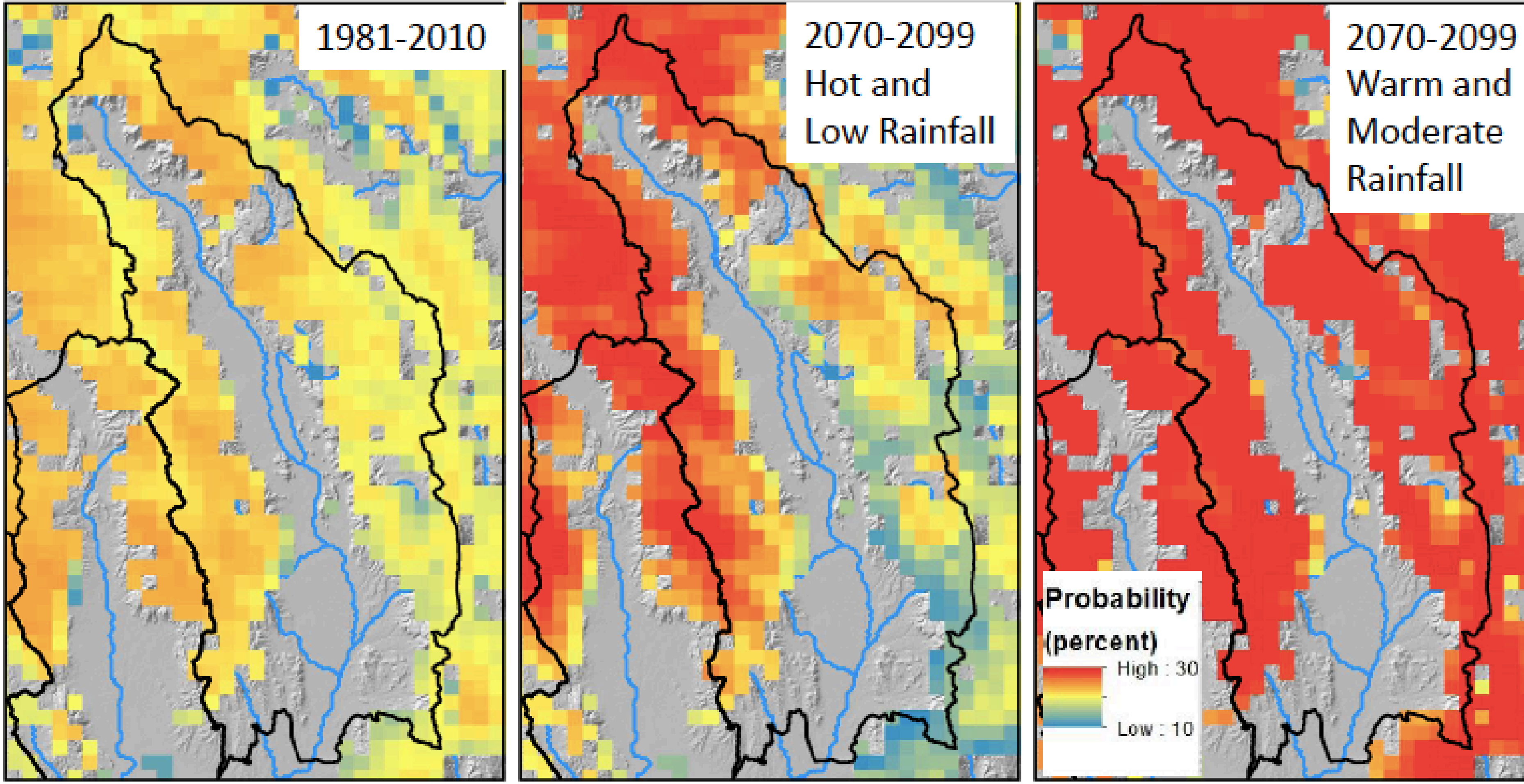
Statewide Fire Risk Model: BCM data inputs

Spatial Patterns in Explanatory Climate Variables 1971–2000



Krawchuk and Moritz 2012 PIER report

Change in Projected Probability of Burning One or More Times



Probability of fire doubles in some locations

Urban and agricultural areas masked out

		Current	Hot, Low Rainfall	Moderate Rainfall
Variable	Units	1971-2000	2070-2099	2070-2099
Probability of burning 1 or more times	Percent	21%	22%	29%
	SD	2%	5%	3%


FIND SWIMMING, FISHING,
CANOEING AND MORE
IN SONOMA COUNTY
EXPLORE REDWOODS AND RIVERS
DISCOVER MORE THAN
425 SONOMA COUNTY
WINERIES
FIND WINERIES
FIND YOUR
PASSION
IN SONOMA COUNTY
LEARN MORE
DISCOVER SONOMA COUNTY'S
NATURAL BEAUTY

Management Question

What is the spatial variability in recharge potential for Sonoma County/Russian River and where are high value recharge zones?

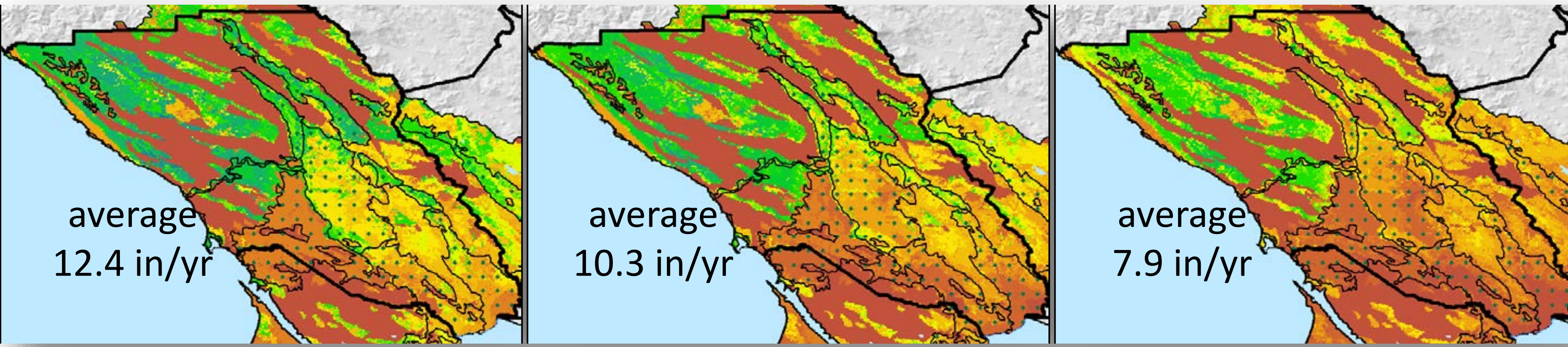
Sustainable Groundwater Management Act

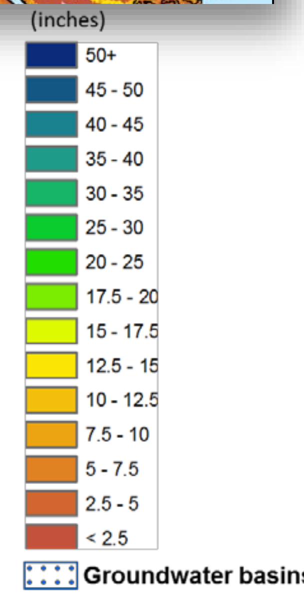
In September 2014, Governor Brown signed historic legislation requiring that California's critica groundwater resources be sustainably managed by local agencies. The Sustainable Groundwater Management Act (SGMA) gives local agencies (cities, counties and water districts) the powers needed to sustainably manage groundwater over the long-term, and requires Groundwater Sustainability Plans (GSPs) be developed for medium- and high-priority groundwater basins. In Sonoma County, three of the county's 14 basins and sub-basins are currently designated as medium-priority: Santa Rosa Plain, Sonoma Valley and Petaluma. No basins are currently designated as high-priority. The SGMA does not apply outside of mapped groundwater basins.

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





- What % of recharge is currently built out in each basin? How much area to protect to sustain groundwater into future?
- Prioritize conservation easements on high recharge zones?
- Analyze existing impermeable footprint and identify where could low impact development could help protect recharge?
- Siting studies for injection wells?

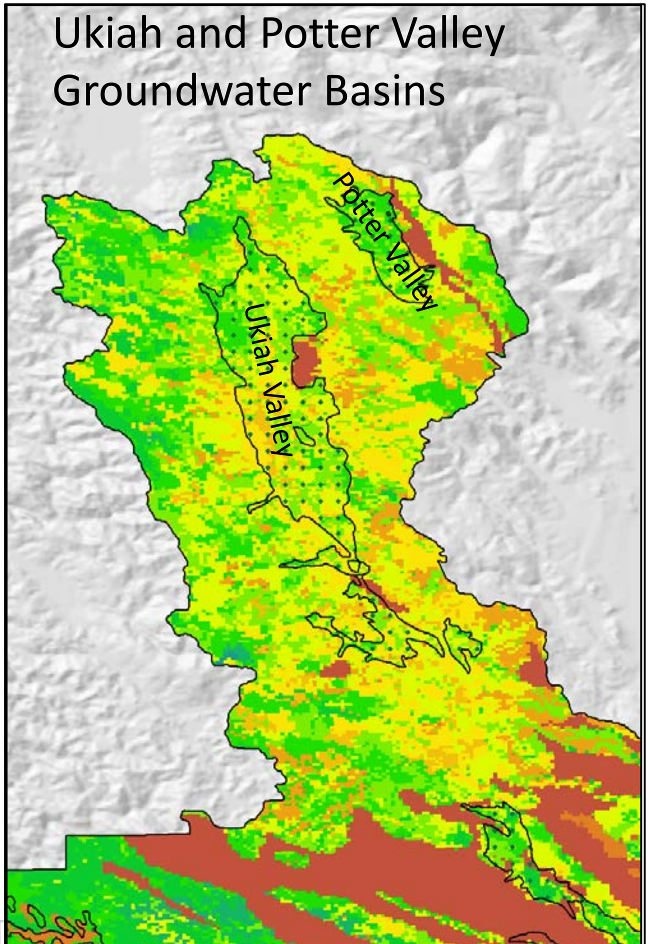
Recharge protection for drought resilience

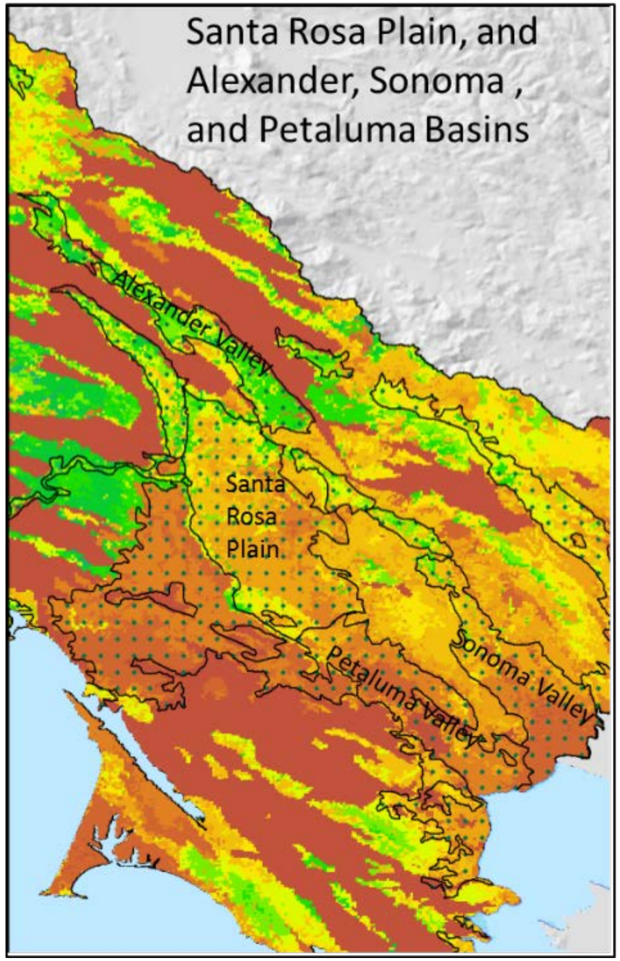
(inches)

1981-2010

< 2.5

Groundwater basins





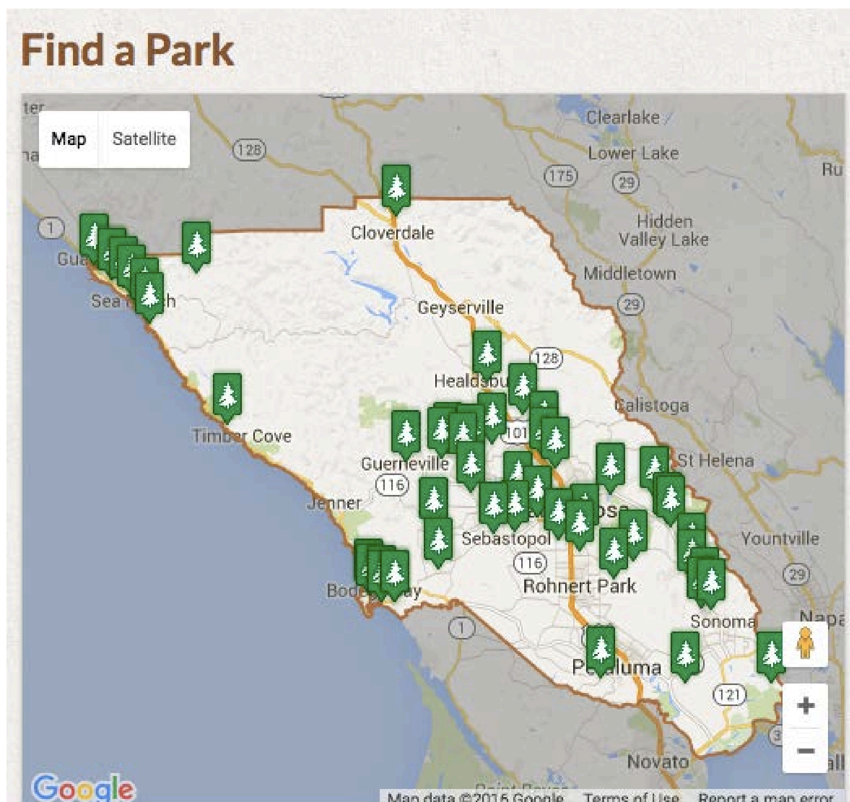
		Current (1981-2010)	
Subbasin	Units	Recharge	Runoff
Ukiah Valley	in	36.1	18.9
East Fork Potter Valley	in	15.7	12.7

Recharge or Runoff
for Groundwater
Basin Watersheds

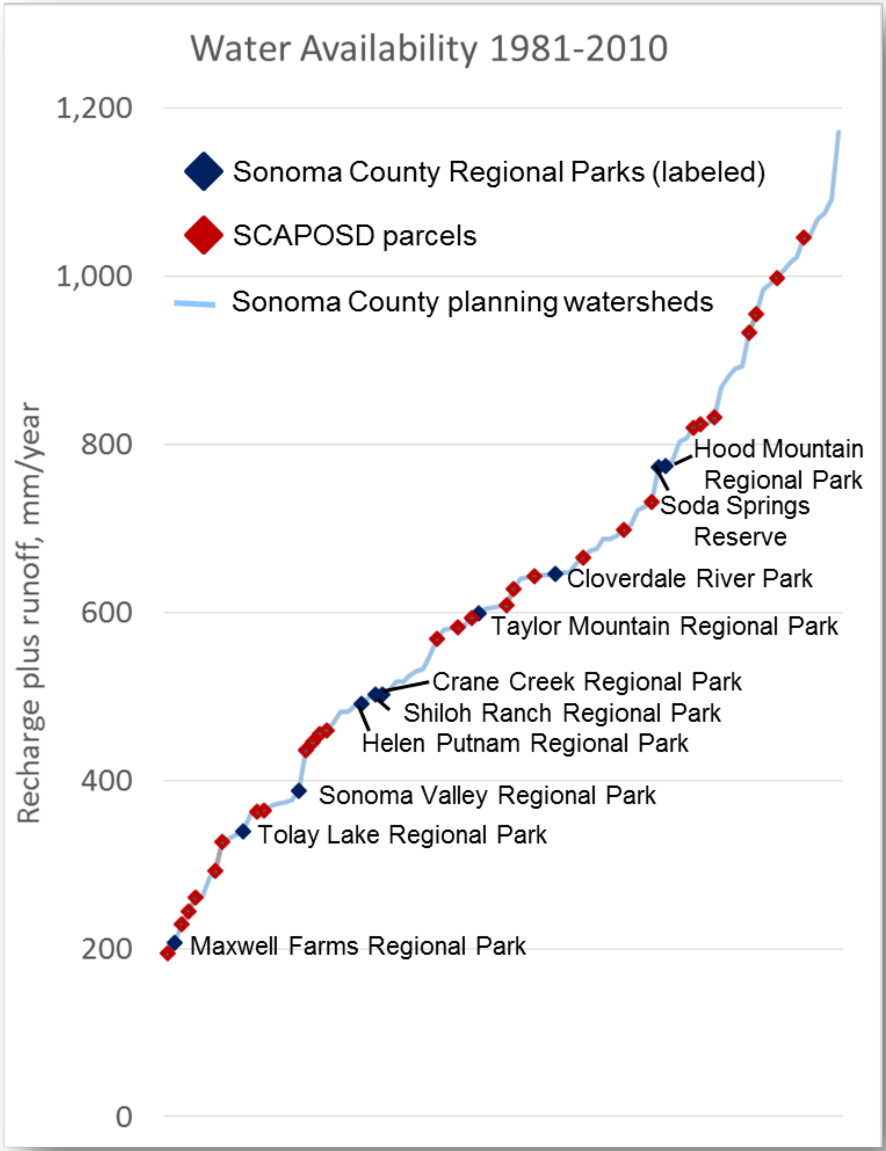
		Current (1981-2010)	
Subbasin	Units	Recharge	Runoff
Alexander Valley	in	9.1	19.4
Santa Rosa Plain	in	10.5	9.8
Petaluma Valley	in	10.6	8.5
Sonoma Valley	in	8.6	8.8

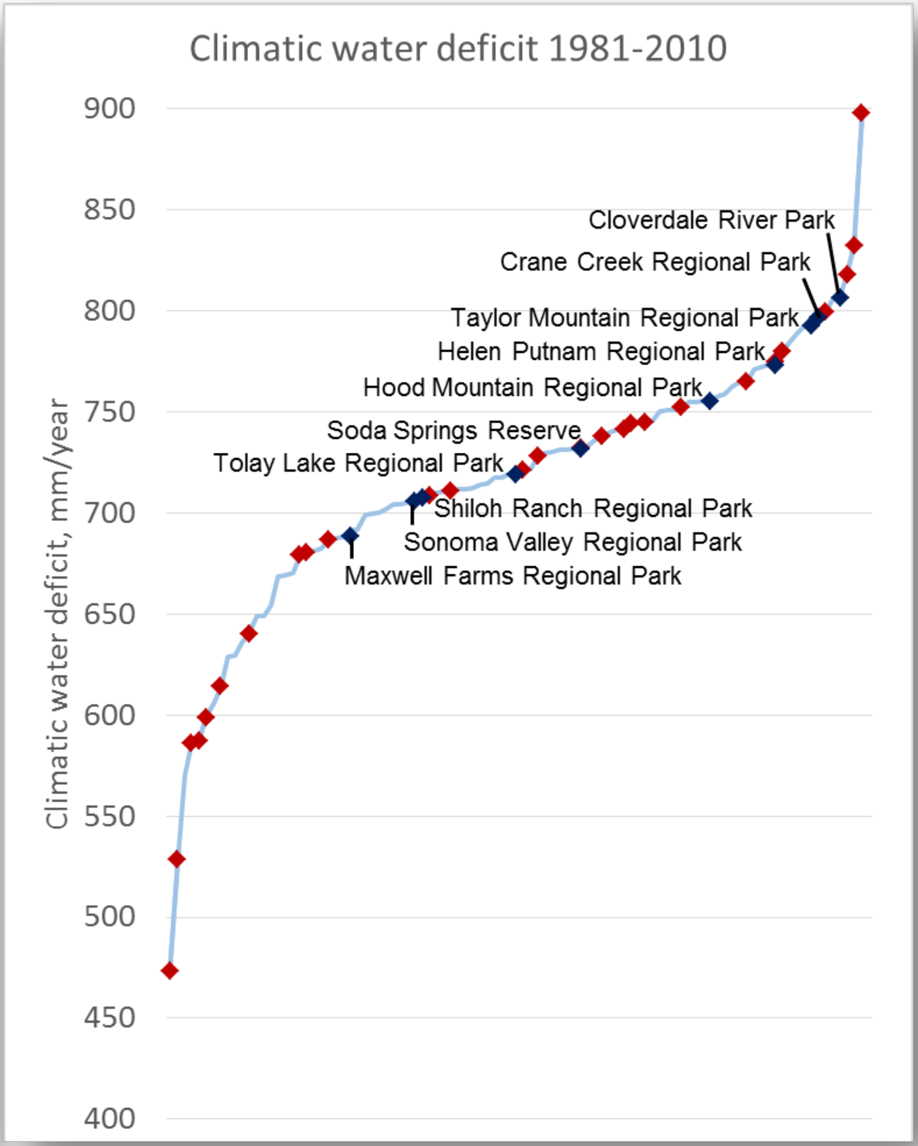
Management Question

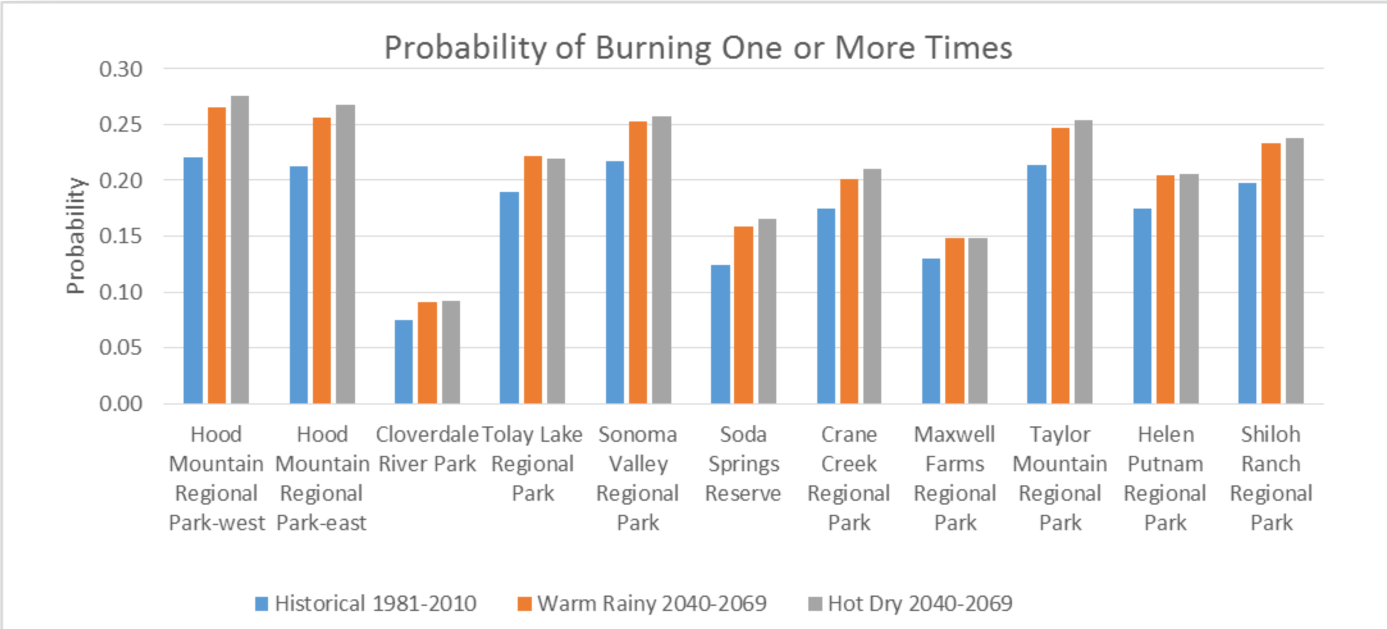
How can we compare parcel attributes of a county-wide park portfolio to prioritize management planning?



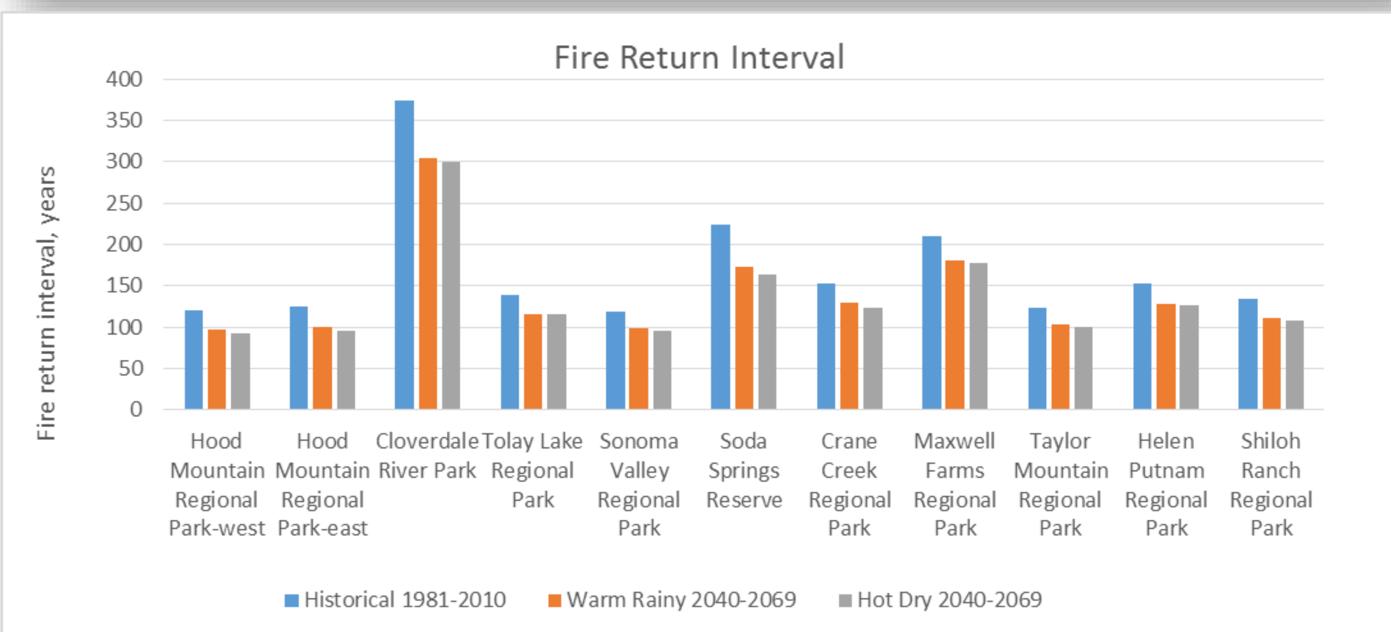
Comparing Regional Parks with conditions across all Sonoma County watersheds







Average probability goes up 18% by mid-century



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

See Table in "FireRisk.xls" spreadsheet

Management Question

How will the daily flows of the Russian River be potentially impacted by climate change?

3-day high flows for Upper and Lower Russian River

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

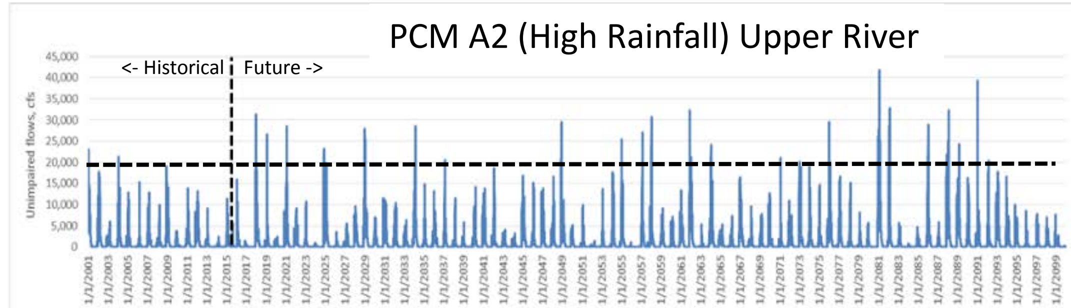
19,298 cfs threshold for upper river
38,902 cfs threshold for lower river

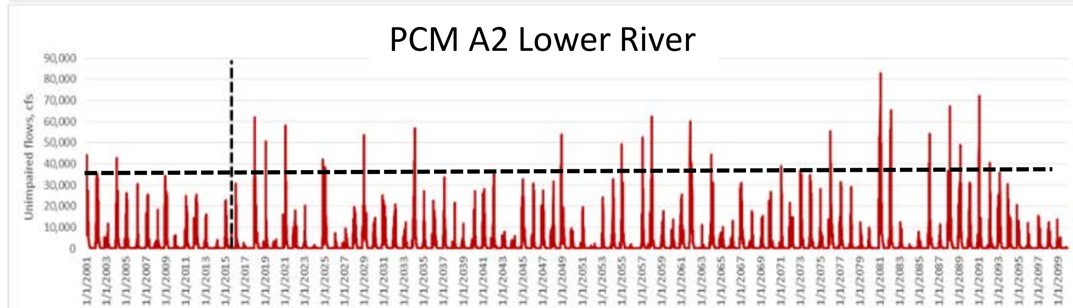
2001-2015 vs 2016-2099
(exceedances per decade)

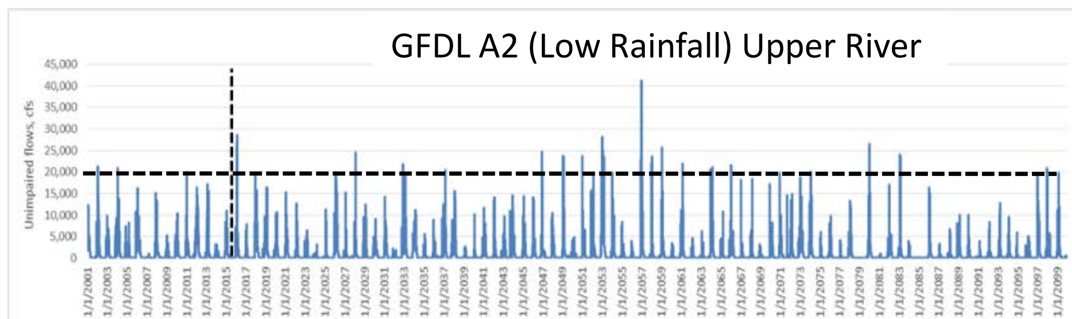
	Upper River: Healdsburg		Lower River: Guerneville	
	Current (2001-15)	Future (2016-99)	Current (2001-15)	Future (2016-99)
Business-as-usual				
PCM A2	1.3	3.9	1.3	3.6
GFDL A2	2.0	3.6	0.7	3.3
Mitigated				
PCM B1	4.0	4.8	3.3	4.6
GFDL B1	2.0	3.7	1.3	3.6

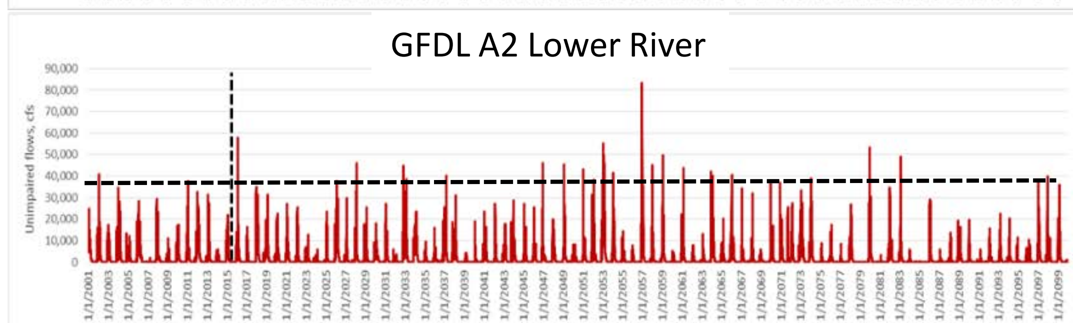
The frequency of 3-day "very high flow" events are up to 3 x more likely to occur than they do currently.

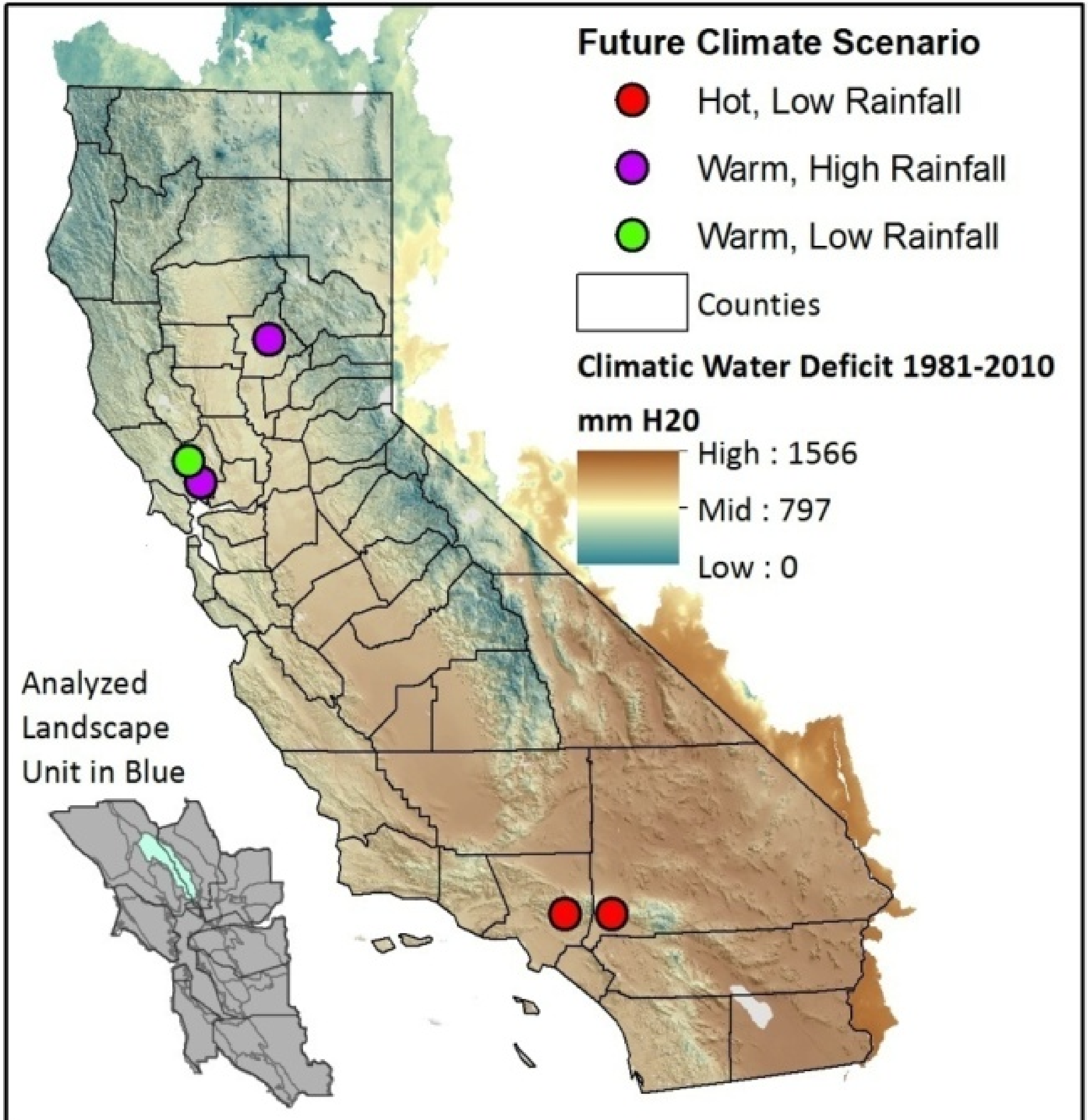
PCM wet model
GFDL dry model











Climate Analogs

Present day climate space analogs for end of century conditions projected for the Southern Mayacamas Mountains landscape unit shown in blue in the inset

Projected Vegetation Model reports available for North Bay
www.pepperwoodpreserve.org/tbc3/our-work/climate-ready/

Or shortcut to Tbc3.org

Habitat Connectivity for Climate Adaptation

Fall 2016 launch

- Continuous wildlife permeability surface e.g. Merenlender et al
- Ground-truthing with wildlife data
- Meaningful consideration of streams and riparian corridors
- Assessment of climate adaptation benefits

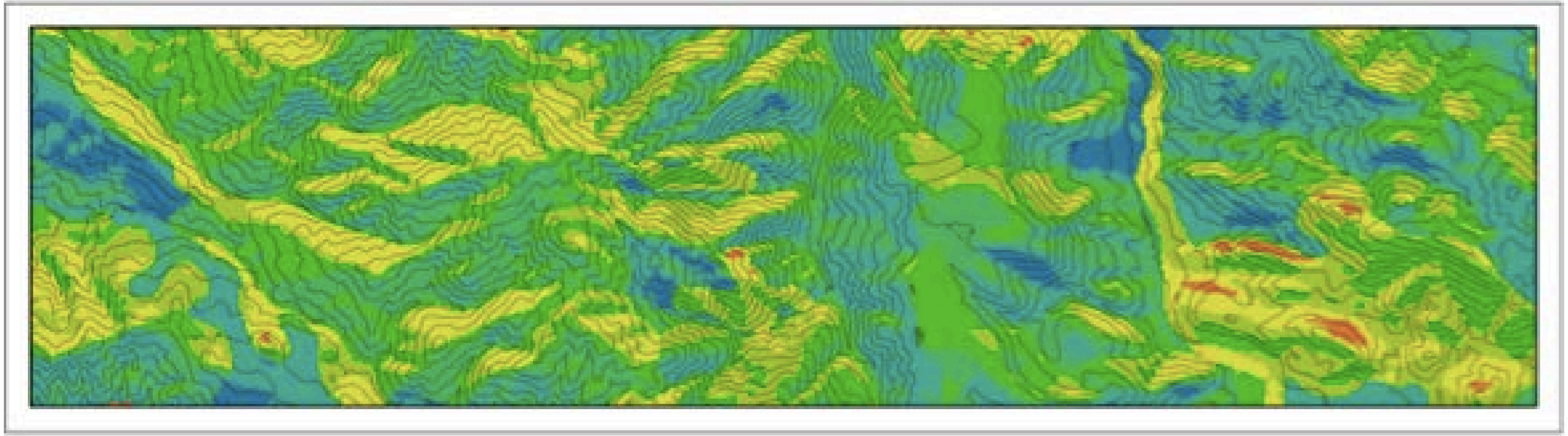
Pepperwood PRESERVE

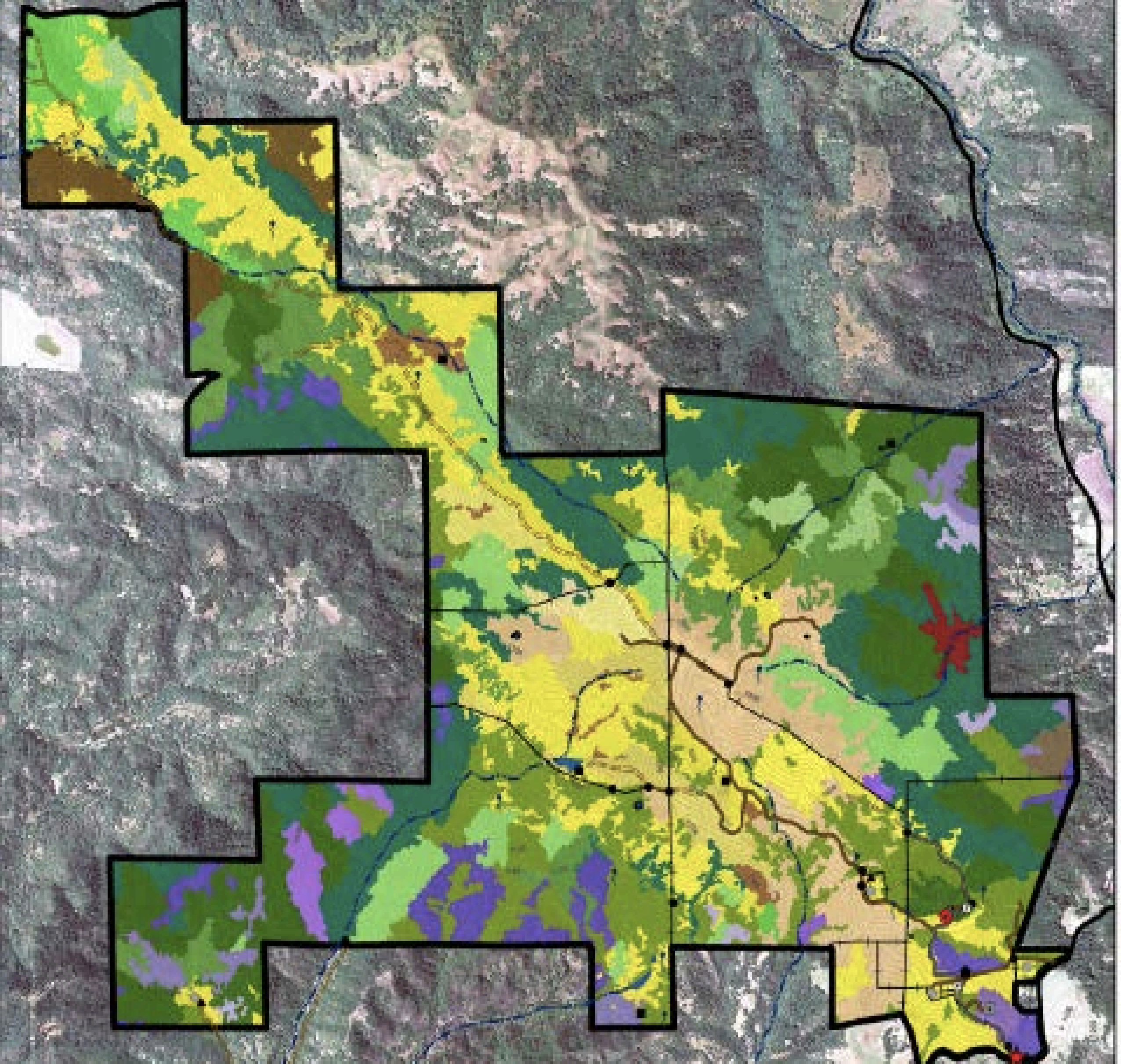
Pepperwood
PRESERVE
Inspiring conservation through science

An Adaptive Management Plan for Pepperwood Preserve

Sonoma County, CA

any day now of 2016





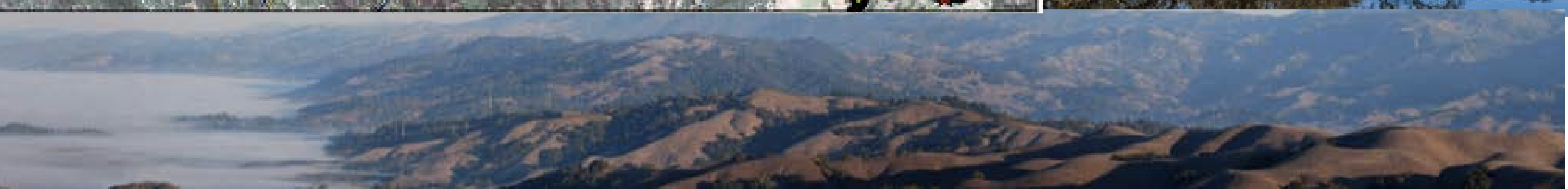
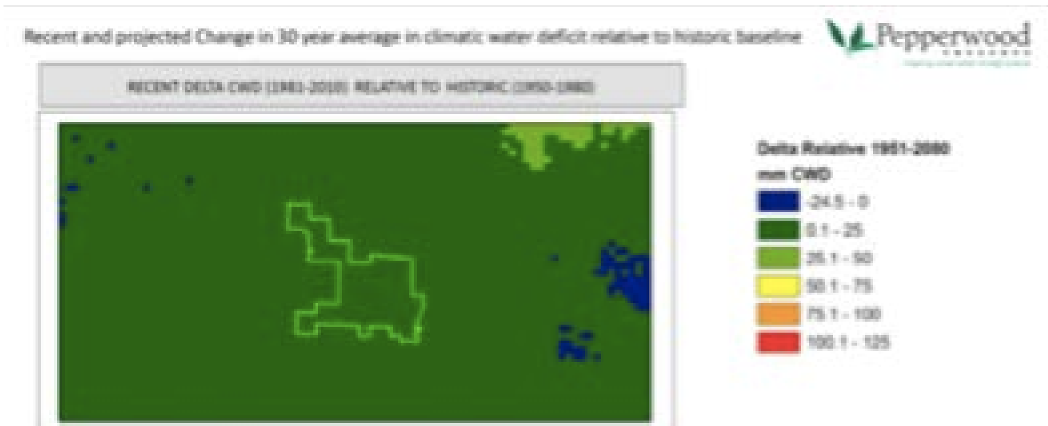
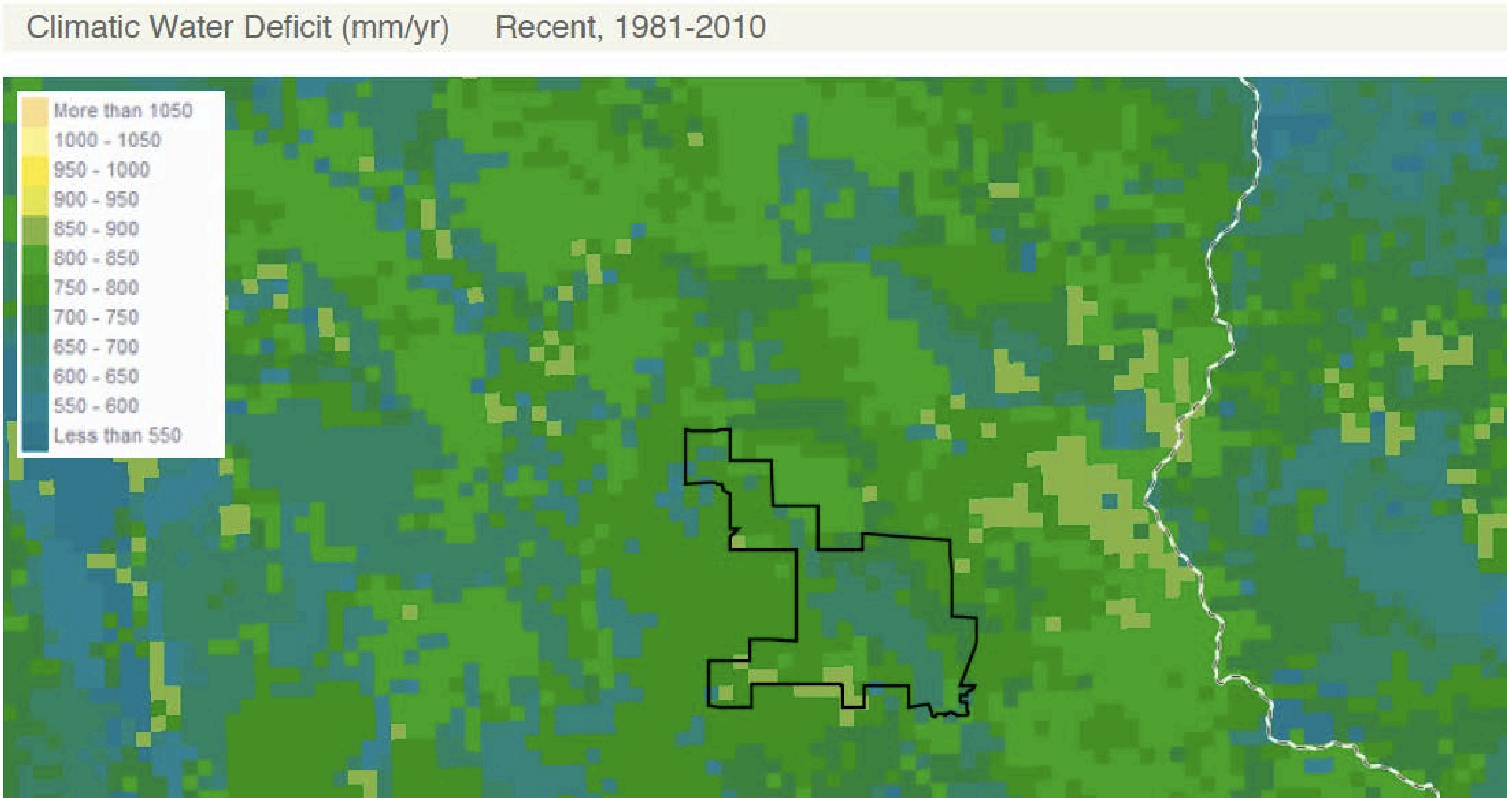



Table X. CLN Explorer Tool, Climate Portfolio Report, Pepperwood Boundary

Model	Period	Summer Tmax (F)	Summer Tmax Delta (F)	Winter Tmin (F)	Winter Tmin Delta (F)	Precip (in/yr)	Precip Delta (in/yr)	Precip Change (%)	CWD (in/yr)	CWD Delta (in/yr)	CWD Change (%)
Baseline	1951 - 1980	85.3	-	39.4	-	41.5		100	29.0	-	100
Recent	1981 - 2010	84.9	-0.4	40.5	1.1	41.2	-0.3	99	29.6	0.6	102
Low rainfall-BAU	2011 - 2039	87.6	2.3	41.9	2.5	41.3	-0.2	100	30.3	1.3	105
Low rainfall-MIT	2011 - 2039	87.4	2.2	42.4	3.1	44.2	2.6	106	31.3	2.3	108
High rainfall-BAU	2011 - 2039	86.7	1.4	40.5	1.1	41.8	0.2	101	29.4	0.4	102
High rainfall-MIT	2011 - 2039	86.5	1.3	41.4	2.0	50.7	9.2	122	29.9	0.9	104
Low rainfall-BAU	2040 - 2069	89.4	4.1	44.2	4.9	39.0	-2.5	94	32.5	3.5	113
Low rainfall-MIT	2040 - 2069	88.3	3.1	43.7	4.3	41.8	0.3	101	30.8	1.9	107
High rainfall-BAU	2040 - 2069	87.8	2.5	42.1	2.7	43.1	1.5	104	30.9	1.9	107
High rainfall-MIT	2040 - 2069	87.3	2.0	40.8	1.4	43.1	1.5	104	29.8	0.9	103
Low rainfall-BAU	2070 - 2099	91.6	6.3	47.1	7.7	32.6	-8.9	78	34.8	5.9	121
Low rainfall-MIT	2070 - 2099	89.2	4.0	44.1	4.7	35.4	-6.1	85	32.0	3.0	111
High rainfall-BAU	2070 - 2099	89.8	4.5	44.4	5.0	45.4	3.9	109	32.2	3.2	111
High rainfall-MIT	2070 - 2099	88.2	2.9	43.0	3.6	46.8	5.2	113	30.5	1.5	106

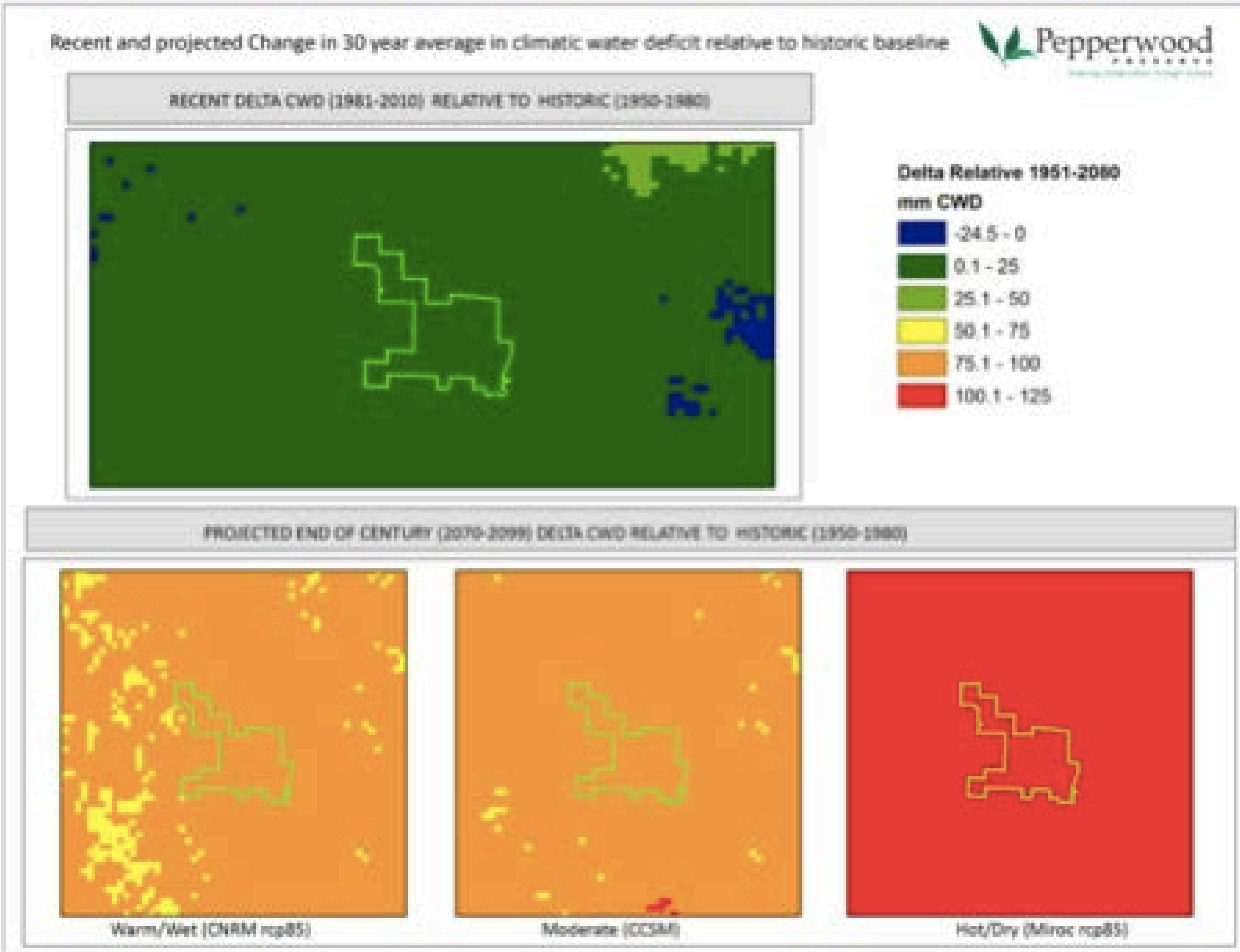
Bay Area Open Space Council's
www.bayarealands.org
"the CLN Explorer Tool"



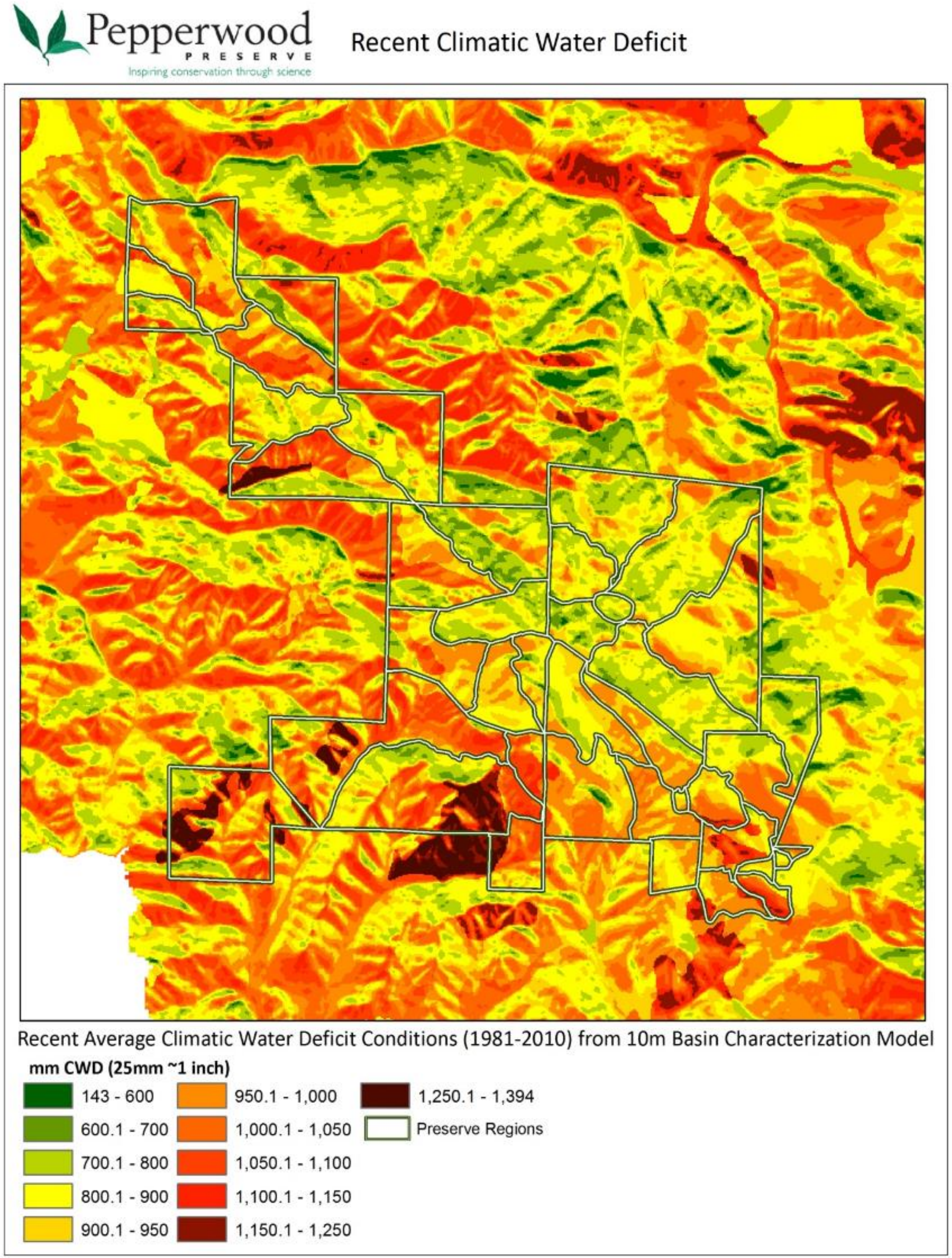


Explorer tool output: 270 m resolution model

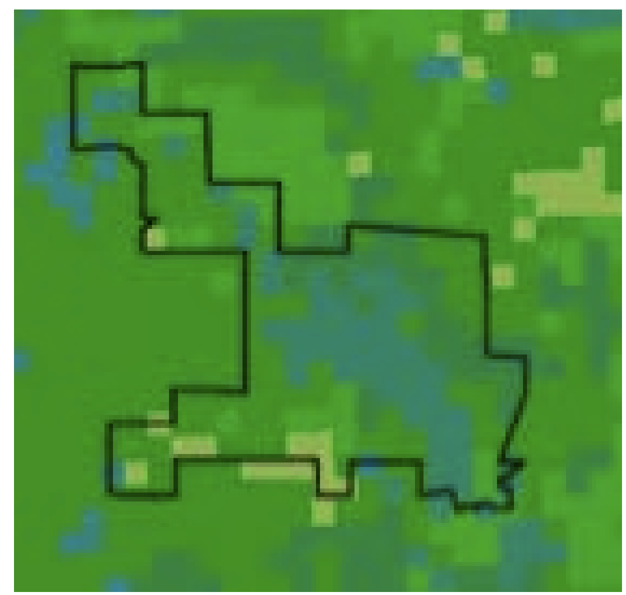
Figure X. Projected change in climatic water deficit for Pepperwood, 1981–2099, 270 meter resolution



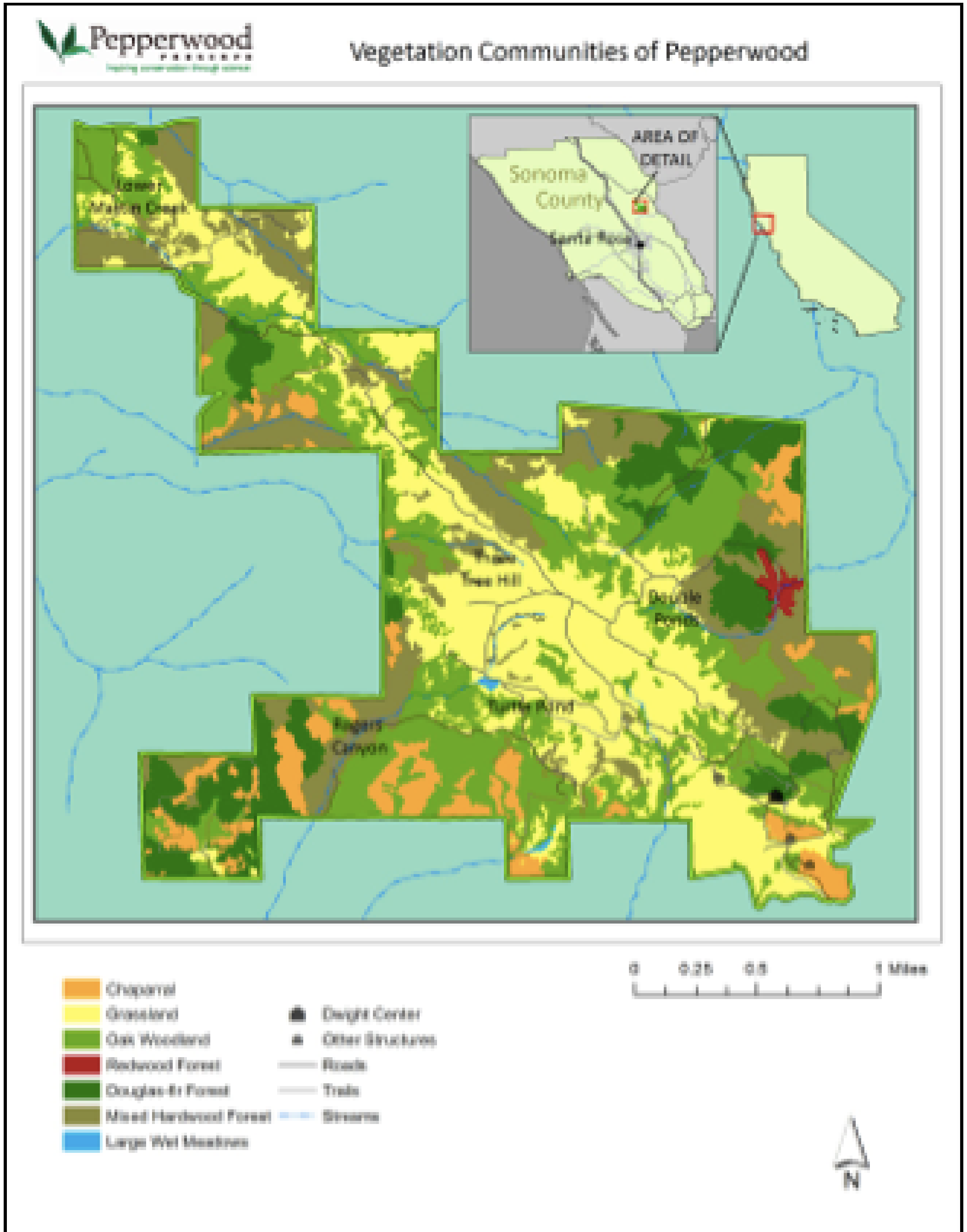
Water deficits are expected to increase by 3” to 5” per year across the preserve by end-of-century



Custom 10m BCM CWD output



270 m for comparison



Map 4 Vegetation Communities of Pepperwood

We intersected our vegetation map with our high resolution CWD map

Figure xxB. Distribution of CWD at Pepperwood by Vegetation Community

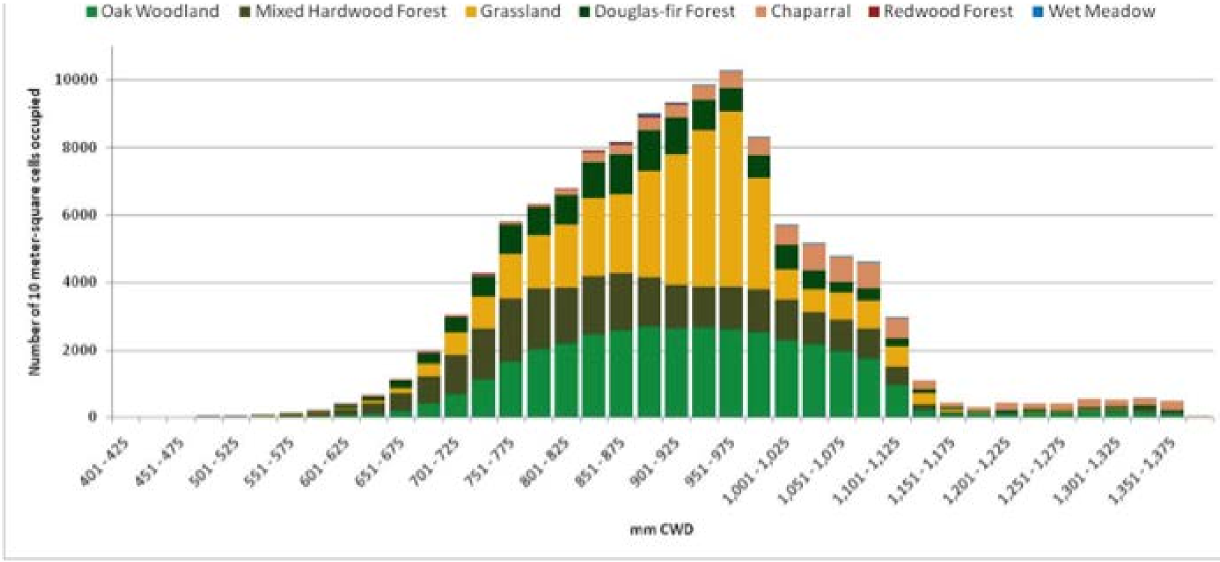
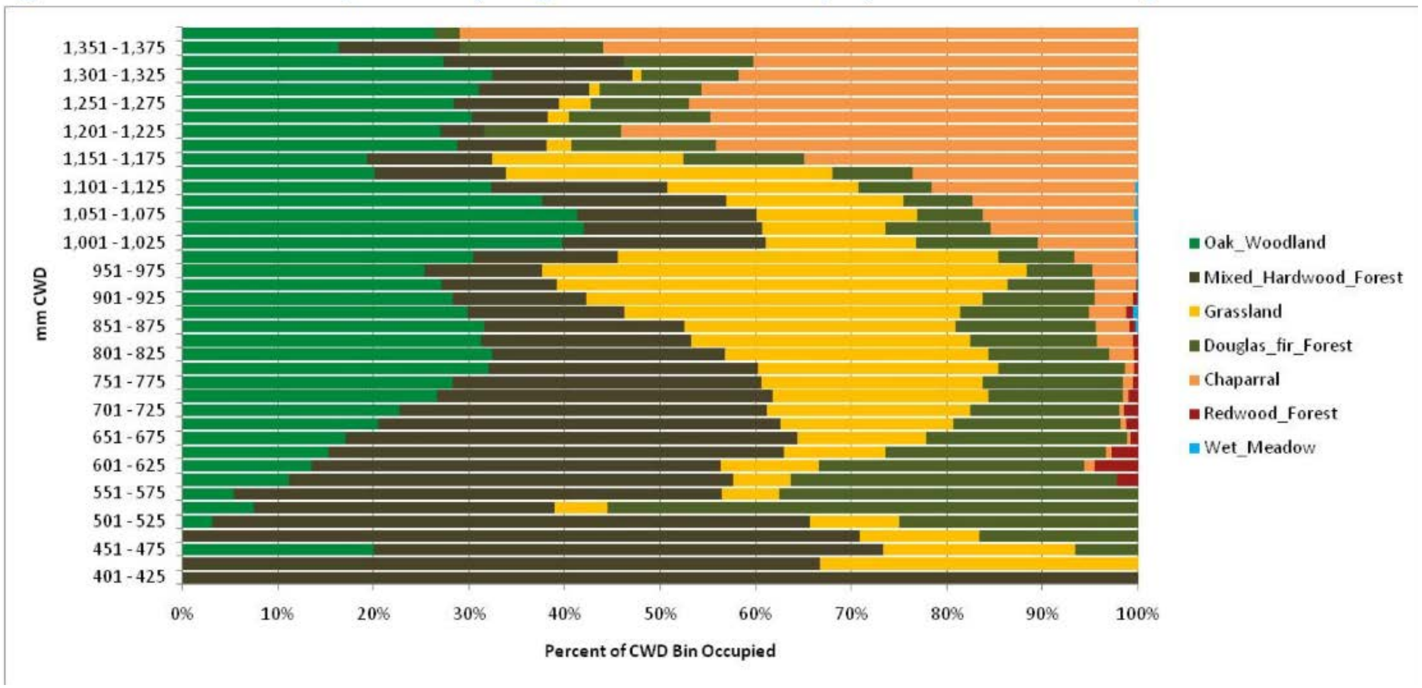
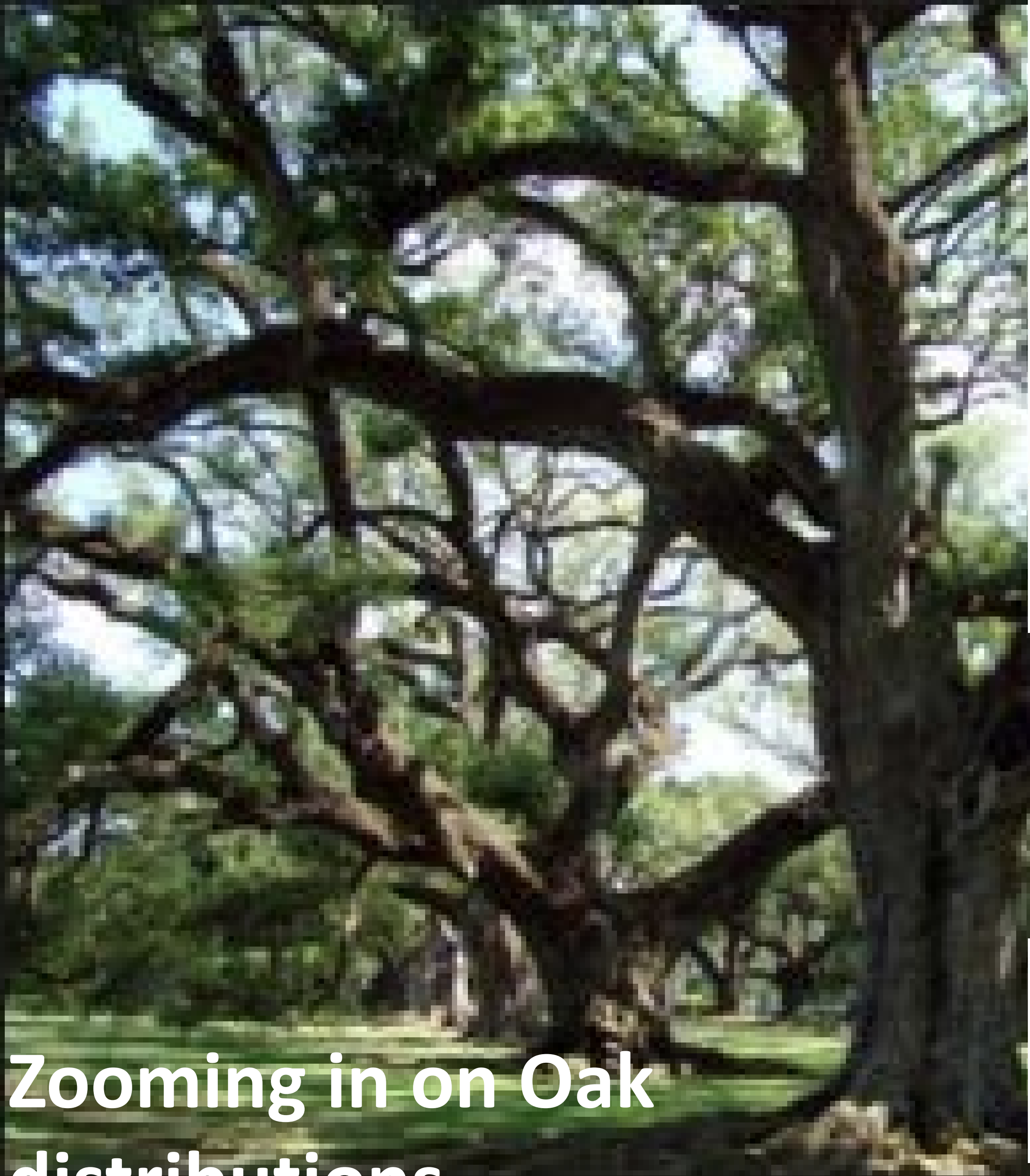


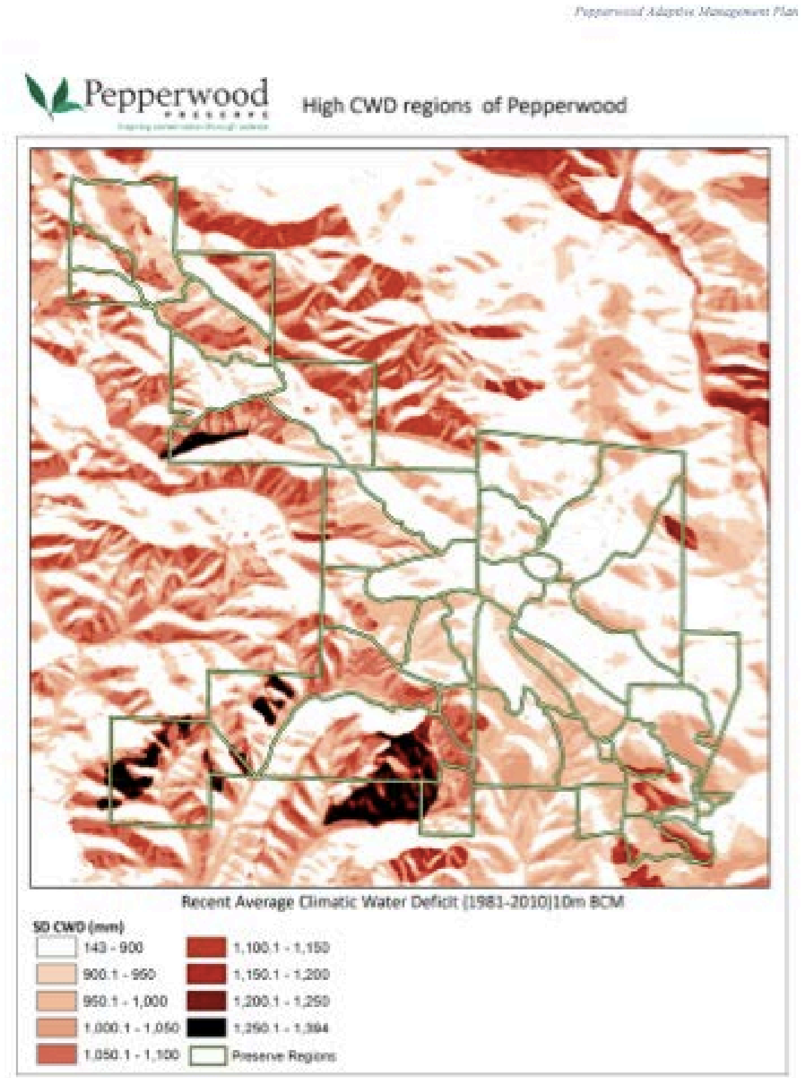
Figure xxA. Relative Proportion of Vegetation Community by Climate Water Deficit Value.



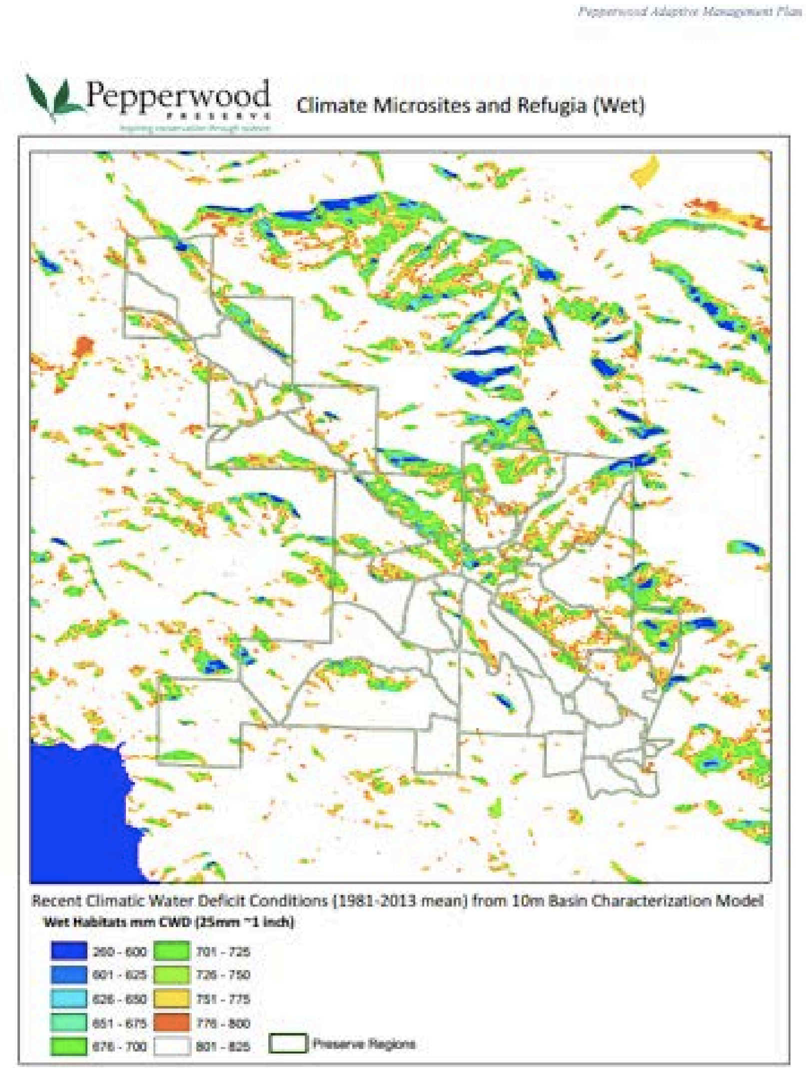


Zooming in on Oak distributions……

Drier places



Wetter places



Pepperwood PRESERVE
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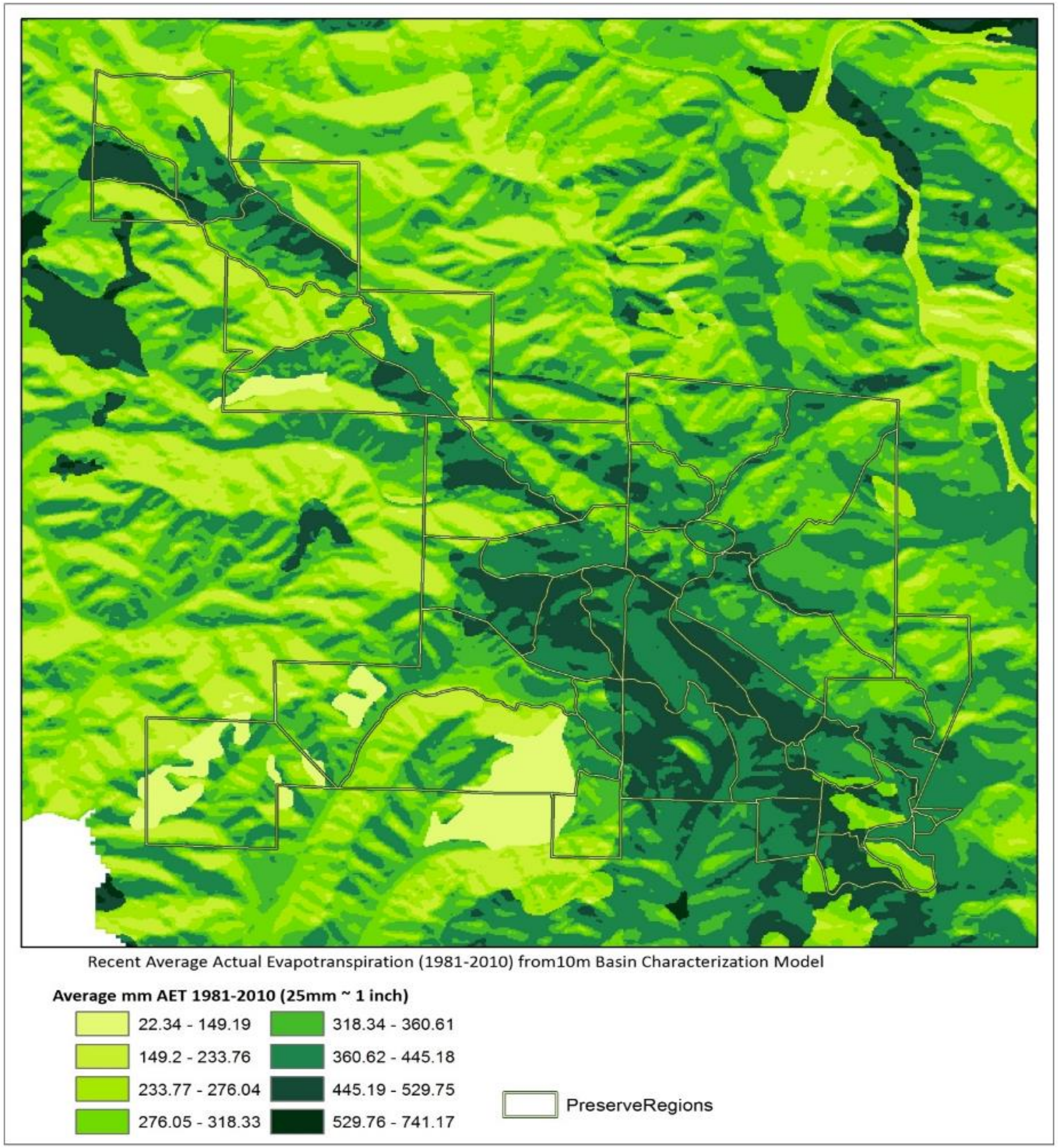
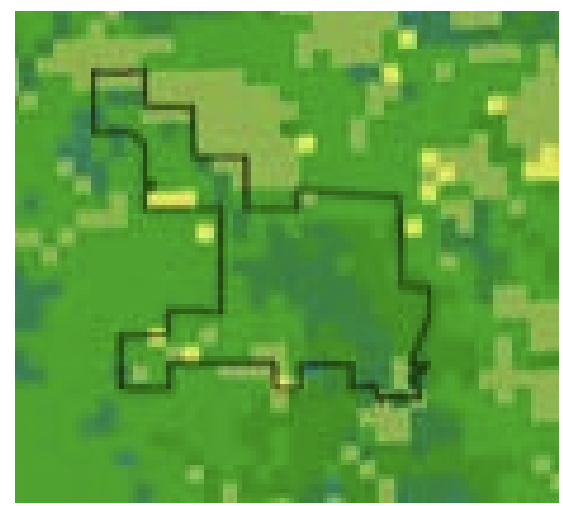
Recent (1981-2010) Actual Evapotranspiration

Custom 10m BCM AET output





270 m for comparison

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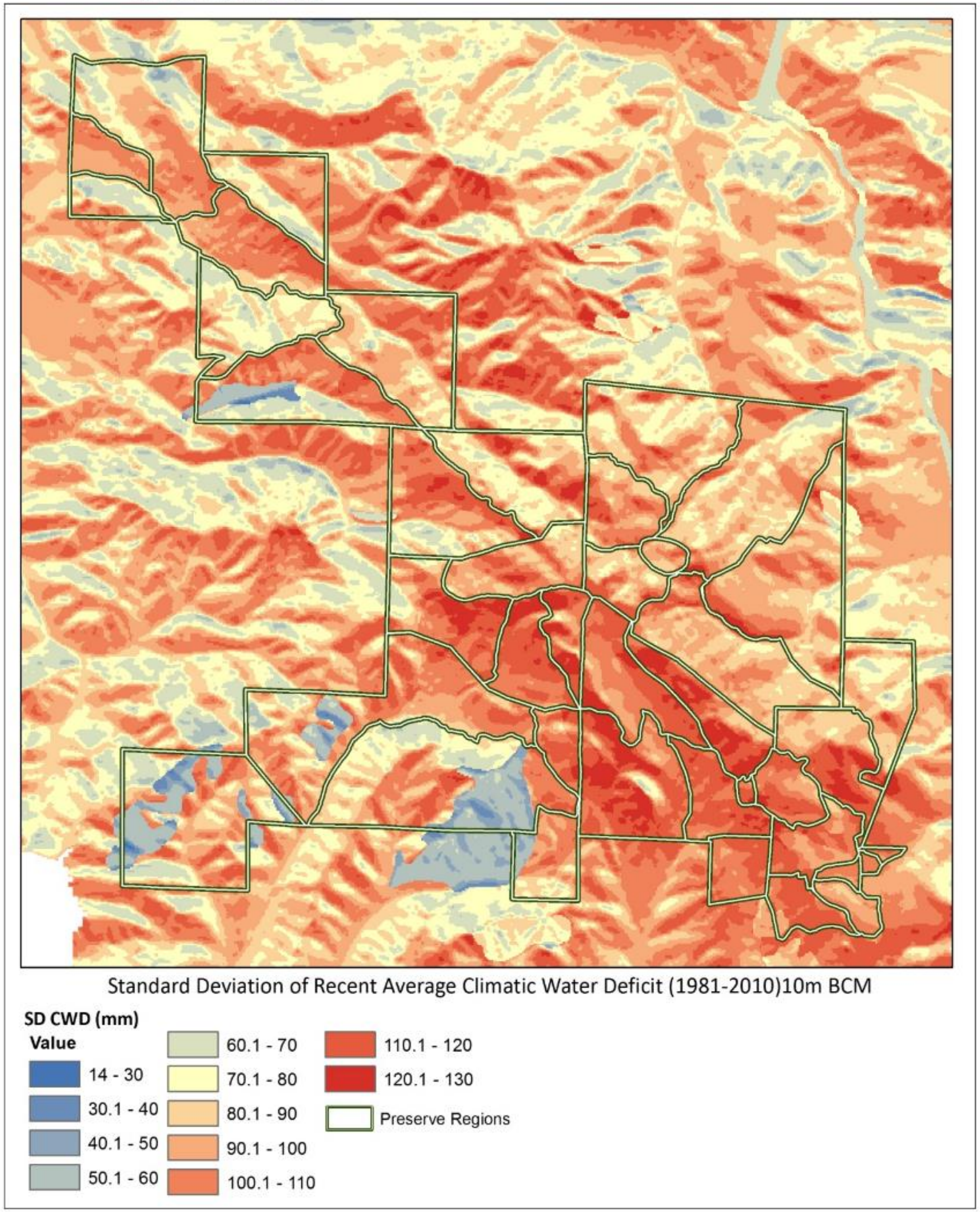
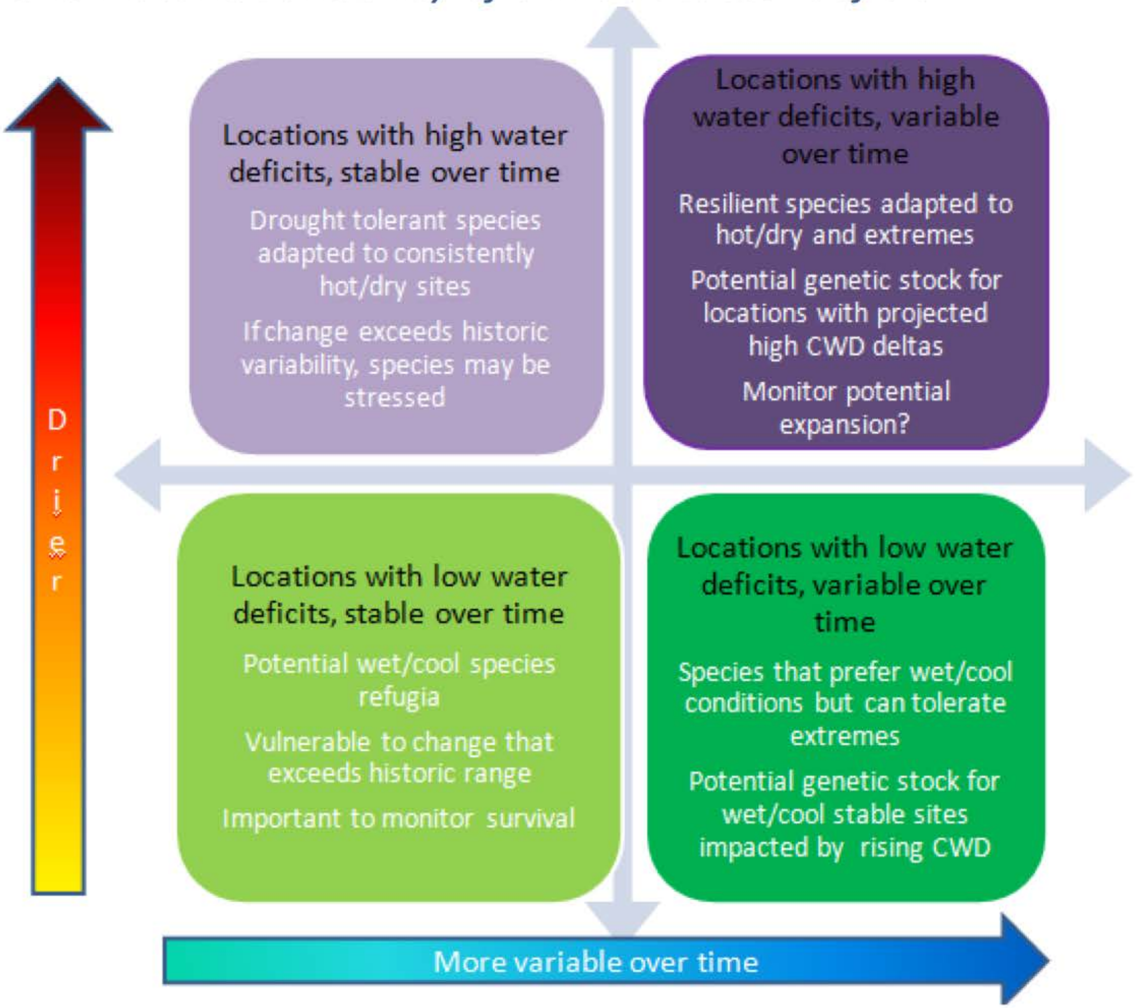
Variability of Recent Climatic Water Deficit

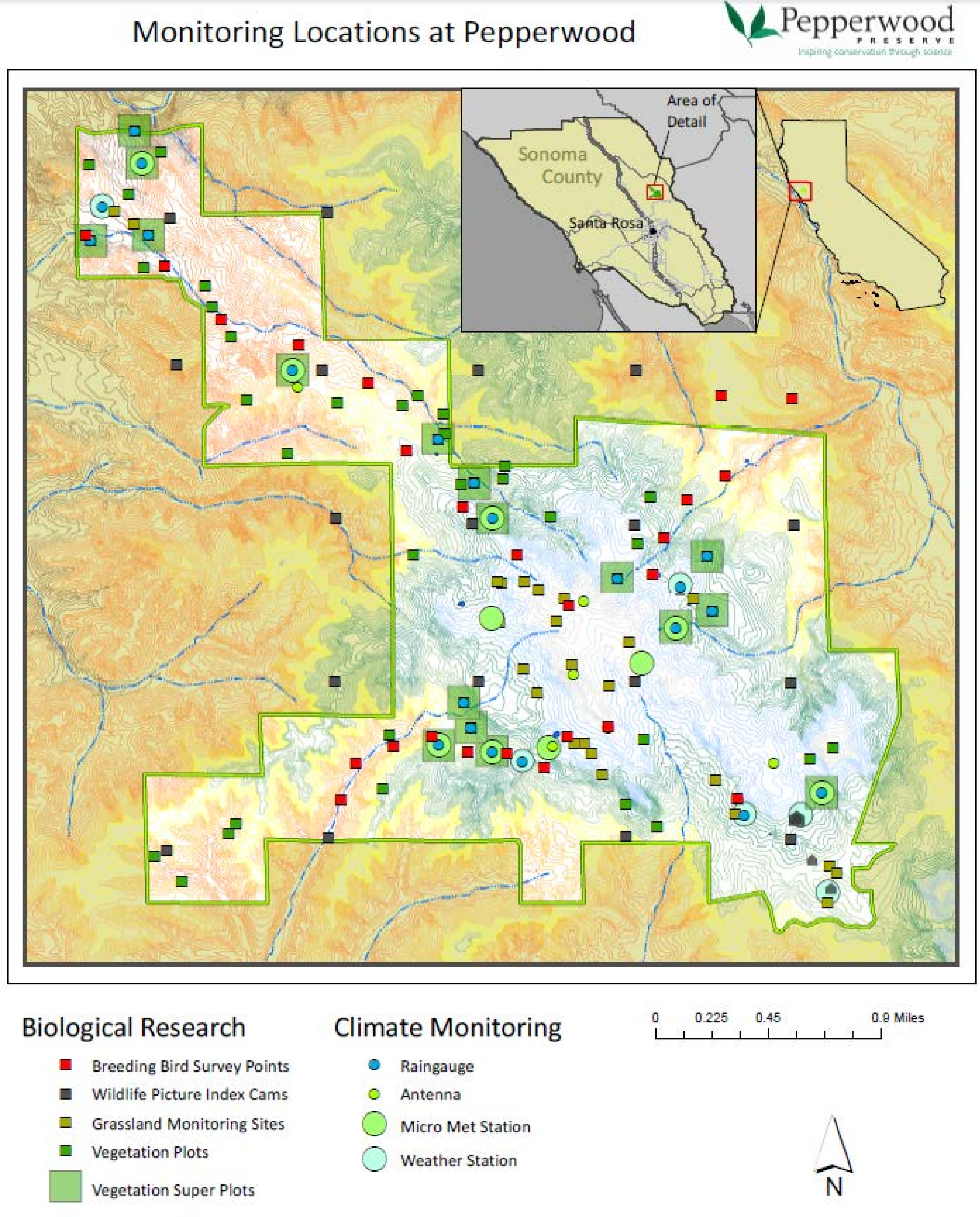


Standard Deviation of Recent Average Climatic Water Deficit (1981-2010)10m BCM

We can evaluate zones of high and low variability

Figure X. Conceptual framework for classifying portions of the preserve relative to absolute value and historic variability of climatic water deficit





got data?

Topo-climate-variability of temp, rainfall and humidity across preserve, an interface of coastal-inland meteorology

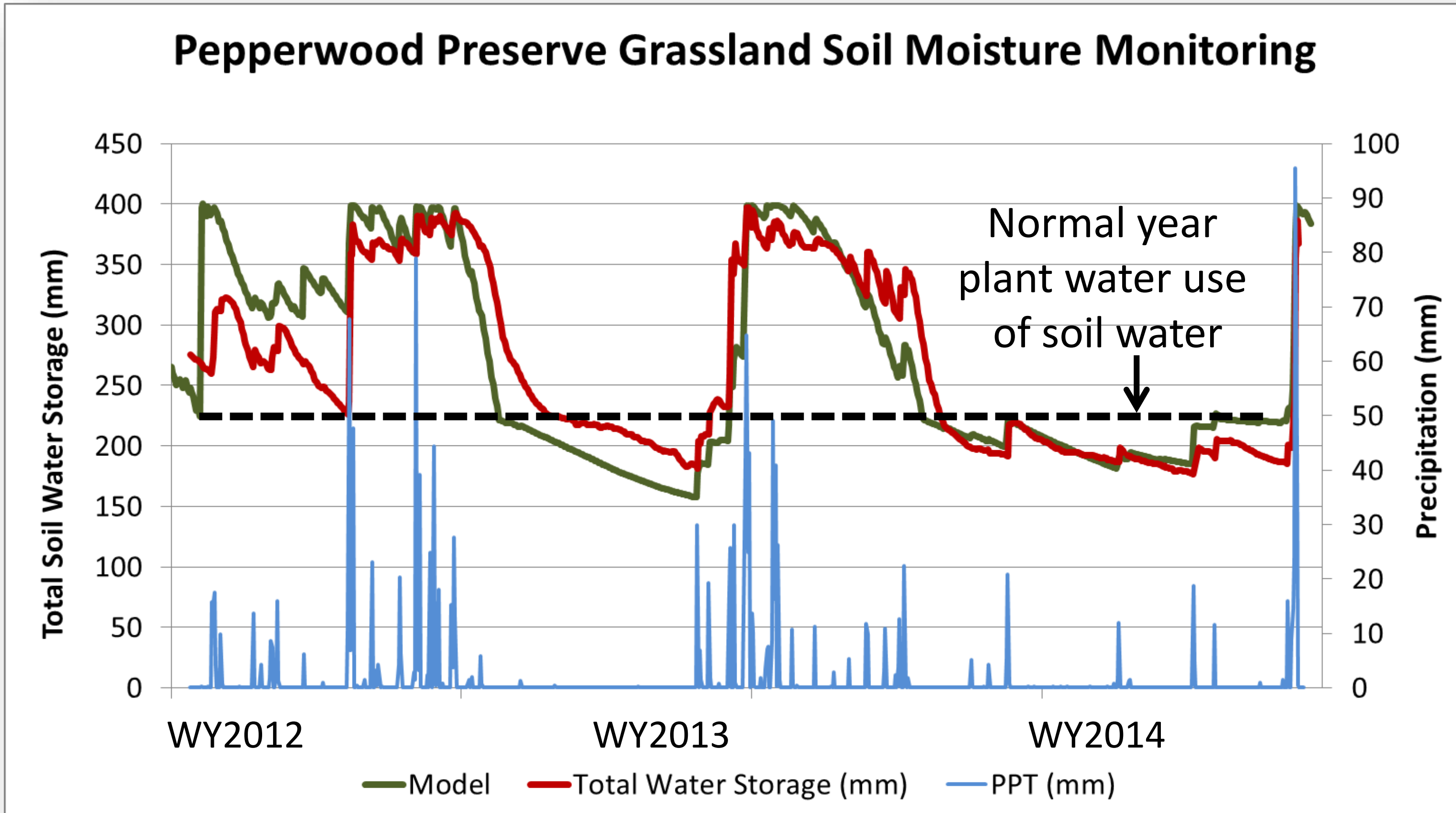
Full hydrologic cycle monitoring-fog drip, precipitation, soil moisture, stream flow

Dominant plant communities-forest and grassland long-term stations and plant phenology transect

Wildlife occupancy-complemented by bird, herpetofauna, invertebrate surveys

Soil Moisture Monitoring

(headwaters of Mark West Creek)



TBC3

Data US Geological Survey

Managing Natural and Working Lands

Other Related Projects

- Advising BLM Ukiah Field Office on Climate Adaptation and Monitoring: just held science-management workshop on fire mitigation and forest health
- Advisors to USFS-BLM Northern California Vulnerability Assessment with EcoAdapt
- Working directly with land and water managers to prioritize acquisitions and stewardship, including Sonoma's Venture Conservation (RCPP) grant
- Technical advisors with USGS to the North Coast Resource Partnership on climate, groundwater protection, and ecosystem impacts
- Creating a model Adaptive Management Plan for our 3200-acre reserve, including conservation grazing and forest management
- Serving as a learning and demonstration hub on-site and providing outreach for the entire community

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Thank you!

www.pepperwoodpreserve.org