Climate Ready North Bay

Sonoma County Regional Parks and Sonoma County Agricultural Protection and Open Space District

Project Overview and Sample Data Products

January 2016

prepared by TBC3.org members
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RCPA regional climate protection authority

Point Blue Conservation Science

USGS science for a changing world

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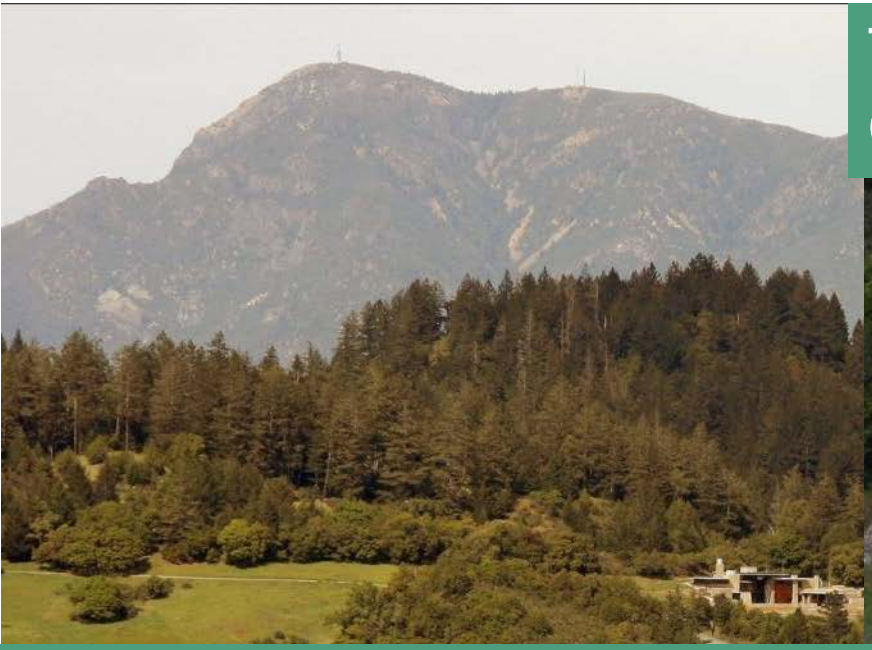
Pepperwood Mission: to advance science-based conservation across our region and beyond

Pepperwood served as project manager of the Climate Ready North Bay vulnerability assessment with TBC3 partners including USGS, Point Blue Conservation Science, and University of California at Berkeley.



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

The new Dwight Center for Conservation Science

USGS science for a changing world

Berkeley UNIVERSITY OF CALIFORNIA

Point Blue Conservation Science

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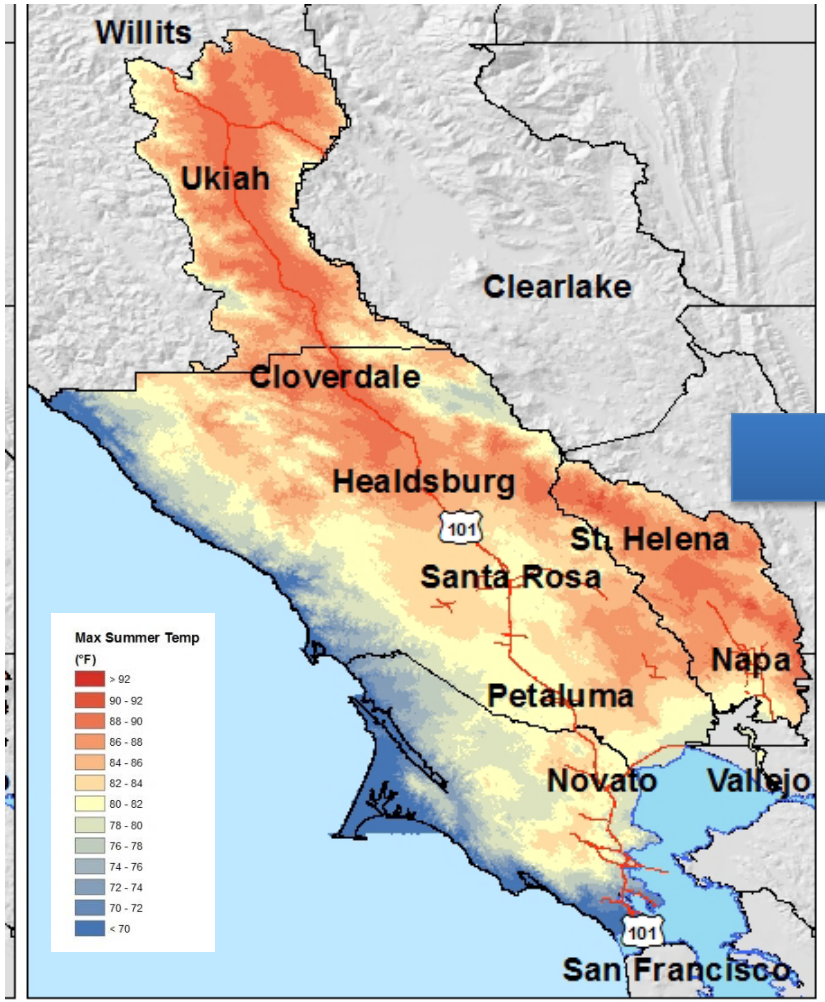
Climate Ready North Bay: translating a landscape-level climate-hydrology database into inputs for long-term planning



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

Source: North Bay Climate Ready 2015

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North Bay Climate Ready

User Groups and Partners

User Group 1: Sonoma County Water Agency with Mendocino County Water Conservation and Flood District

Domain: Sonoma County plus Russian River Basin of Mendocino County

User Group 2: Sonoma County Agricultural Protection and Open Space District and Sonoma County Regional Parks

Domain: Sonoma County

User Group 3: Napa County, Departments of Planning and Public Works plus the Watershed Protection District

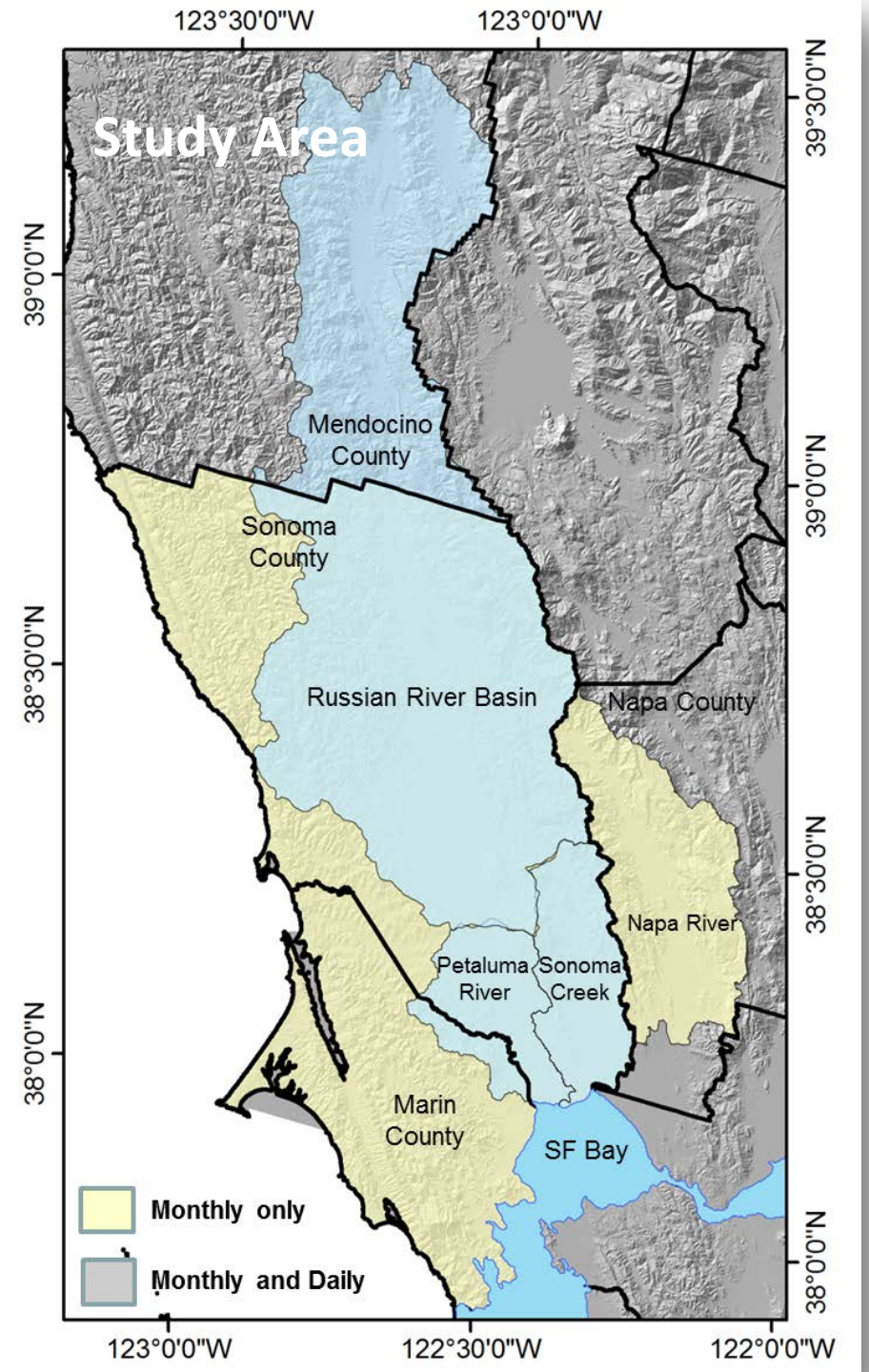
Domain: Napa Valley

User Group 4: Marin Municipal Water District (MMWD)

Domain: Marin County

User Group 5: Regional Climate Protection Authority (RCPA) Municipal Users Group: all nine cities of Sonoma County-public works and planning officers

Domain: Sonoma County and sub-watersheds



project overview

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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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 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.

Climate model selection

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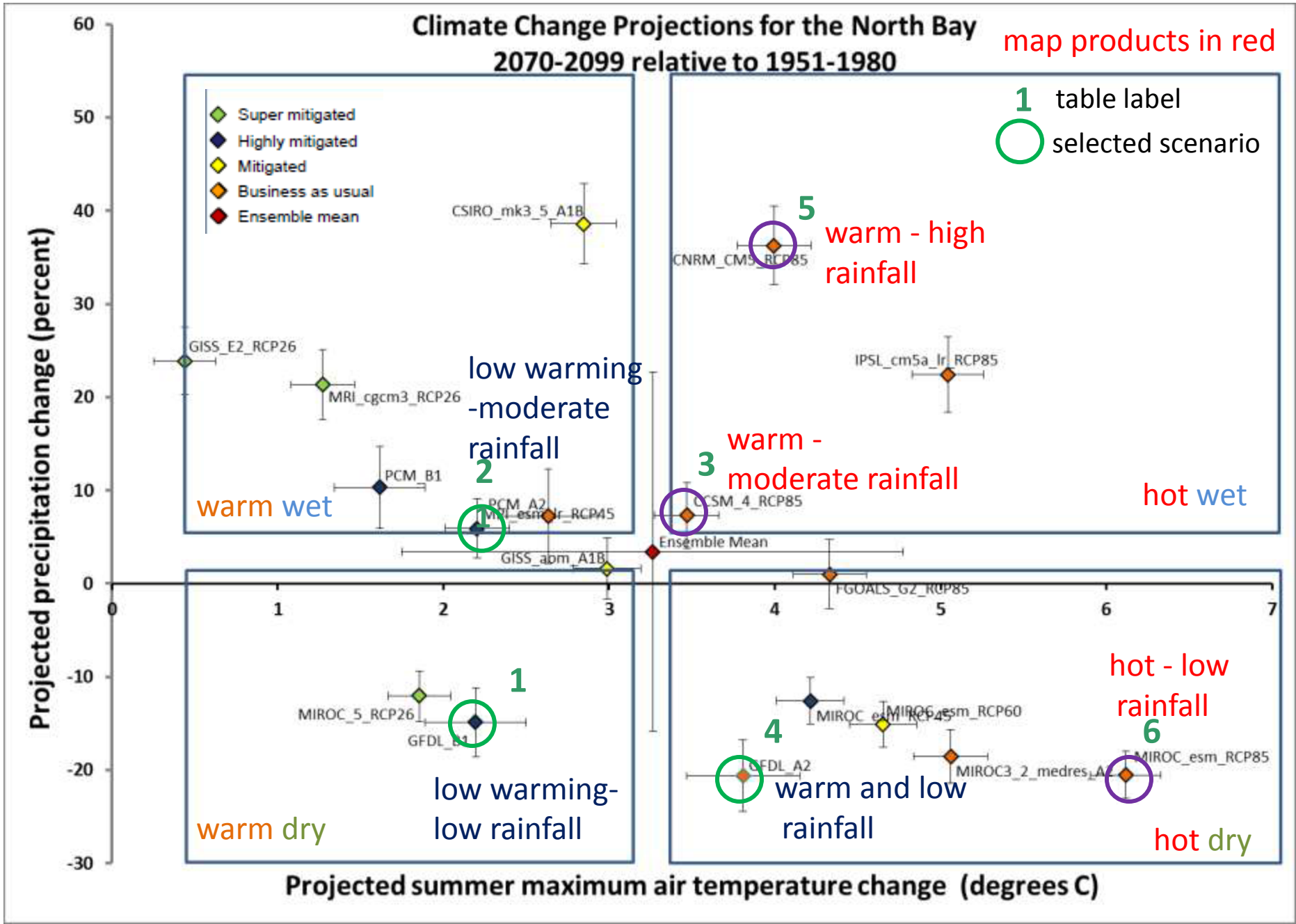
North Bay Climate Ready: Selected Futures for Regional Vulnerability Assessment



Selected Futures for North Bay Regional Vulnerability Assessment (in yellow)

Scenario #	Model	Emissions Scenario	Assessment Report Vintage	Time Period	Summer Tmax °C	Summer Tmax Increase	Winter Tmin °C	Winter Tmin Increase °C	Annual Precipitation (mm)	% Change Precipitation	% Change Water Deficit
	historic (hst)	N/A	N/A	1951-1980	27.9		3.9		1087		
	current	N/A	N/A	1981-2010	27.9		4.3	0.4	1095	1%	1%
	Assumption: Business as Usual										
6	miroc-esm	rcp85	AR5	2070-2099	34.0	6.1	8.4	4.6	865	-20%	24%
	miroc3_2_mr	A2	AR4	2070-2099	33.0	5.1	7.1	3.2	887	-18%	20%
	ipsl-cm5a-lr	rcp85	AR5	2070-2099	33.0	5.0	9.6	5.7	1325	22%	16%
	fgoals-g2	rcp85	AR5	2070-2099	32.3	4.3	7.1	3.2	1099	1%	22%
5	cnrm-cm5	rcp85	AR5	2070-2099	31.9	4.0	7.7	3.9	1477	36%	12%
4	GFDL	A2	AR4	2070-2099	31.7	3.8	7.7	3.9	861	-21%	21%
3	ccsm4	rcp85	AR5	2070-2099	31.4	3.5	7.1	3.2	1163	7%	12%
2	PCM	A2	AR4	2070-2099	30.6	2.6	6.3	2.4	1159	7%	11%
			Business as Usual Average		**32.2**	**4.3**	**7.6**	**3.7**	**1104**	**2%**	**17%**
	Assumption: Mitigated										
	miroc-esm	rcp60	AR5	2070-2099	32.6	4.7	7.1	3.2	922	-15%	14%
	giss_aom	A1B	AR4	2070-2099	30.9	3.0	6.4	2.5	1104	2%	11%
	csiro_mk3_5	A1B	AR4	2070-2099	30.8	2.8	6.5	2.6	1506	38%	4%
			Mitigated Average		**31.4**	**3.5**	**6.6**	**2.8**	**1177**	**8%**	**10%**
	Assumption: Highly Mitigated										
	mpi-esm-lr	rcp45	AR5	2070-2099	30.1	2.2	5.8	1.9	1148	6%	5%
	miroc-esm	rcp45	AR5	2070-2099	30.1	2.2	6.9	3.0	949	-13%	14%
1	GFDL	B1	AR4	2070-2099	30.1	2.2	6.1	2.2	923	-15%	10%
	PCM	B1	AR4	2070-2099	29.5	1.6	5.5	1.7	1197	10%	5%
			Highly Mitigated Average		**30.0**	**2.1**	**6.1**	**2.2**	**1055**	**-3%**	**8%**
	Assumption: Super Mitigated										
	miroc5	rcp26	AR5	2070-2099	29.8	1.9	5.2	1.3	953	-12%	9%
	mri-cgcm3	rcp26	AR5	2070-2099	29.2	1.3	4.8	0.9	1315	21%	2%
	giss-e2-r	rcp26	AR5	2070-2099	28.4	0.4	4.6	0.7	1344	24%	-4%
			Super Mitigated Average		**29.1**	**1.2**	**4.8**	**1.0**	**1204**	**11%**	**2%**
			ALL Scenarios Average		**31.1**	**3.2**	**6.7**	**2.8**	**1122**	**3%**	**11%**

TBC3 downscaled 18 global climate models selected to represent the full range of IPCC projections. 6 were selected by a consensus of all the managers engaged in Climate Ready. Scenario numbers correlate to chart version of the North Bay TBC3 ensemble.

Climate Ready North Bay Scenarios

6 selected futures: monthly values, observed vs mid-century

	Model	Emissions Scenario	IPCC Assessment	Short-hand name	Time Period	Summer Tmax °F	Summer Tmax Increase °F	Winter Tmin °F	Winter Tmin Increase °F	Annual Precipitation (in)	% Change Precipitation	% Change Water Deficit
Observed	historical baseline	N/A	N/A		1951-1980	82.2		39.0		42.8		
	current	N/A	N/A		1981-2010	82.2		39.7	0.7	43.1	1%	1%
Projections												
1	GFDL	B1	AR4	low warming-low rainfall	2040-2069	85.2	2.9	42.7	3.7	42.6	-1%	6%
2	PCM	A2	AR4	low warming-mod rainfal	2040-2069	85.0	2.7	41.1	2.1	43.8	2%	7%
3	CCSM-4	rcp85	AR5	warm-mod rainfall	2040-2069	86.0	3.7	42.0	3.0	42.2	-1%	8%
4	GFDL	A2	AR4	warm-low rainfall	2040-2069	86.3	4.0	43.2	4.2	39.8	-7%	12%
5	CNRM-CM5	rcp85	AR5	warm-high rainfall	2040-2069	86.5	4.2	43.0	4.0	53.8	26%	6%
6	MIROC-ESM	rcp85	AR5	hot-low rainfall	2040-2069	89.2	6.9	41.4	2.4	35.0	-18%	14%
Average						**86.3**	**4.1**	**42.2**	**3.2**	**42.9**	**0%**	**9%**

Climate Ready North Bay Scenarios

6 selected futures: monthly values, observed vs end-century

	Model	Emissions Scenario	IPCC Assessment	Short-hand name	Time Period	Summer Tmax °F	Summer Tmax Increase °F	Winter Tmin °F	Winter Tmin Increase °F	Annual Precipitation (in)	% Change Precipitation	% Change Water Deficit
Observed	historical baseline	N/A	N/A		1951-1980	82.2		3.9		42.8		
	current	N/A	N/A		1981-2010	82.2		4.3	0.4	43.1	1%	1%
Scenario # Projections												
1	GFDL	B1	AR4	low warming-low rainfall	2070-2099	86.2	4.0	6.1	2.2	36.3	-15%	10%
2	PCM	A2	AR4	low warming-mod rainfal	2070-2099	87.0	4.7	6.3	2.4	45.6	7%	11%
3	CCSM-4	rcp85	AR5	warm-mod rainfall	2070-2099	88.5	6.2	7.1	3.2	45.8	7%	12%
4	GFDL	A2	AR4	warm-low rainfall	2070-2099	89.1	6.9	7.7	3.9	33.9	-21%	21%
5	CNRM-CM5	rcp85	AR5	warm-high rainfall	2070-2099	89.5	7.2	7.7	3.9	58.1	36%	12%
6	MIROC-ESM	rcp85	AR5	hot-low rainfall	2070-2099	93.3	11.0	8.4	4.6	34.0	-20%	24%
Average						88.9	**6.7**	**7.2**	**3.3**	**42**	**0.0**	**15%**

BCM methods

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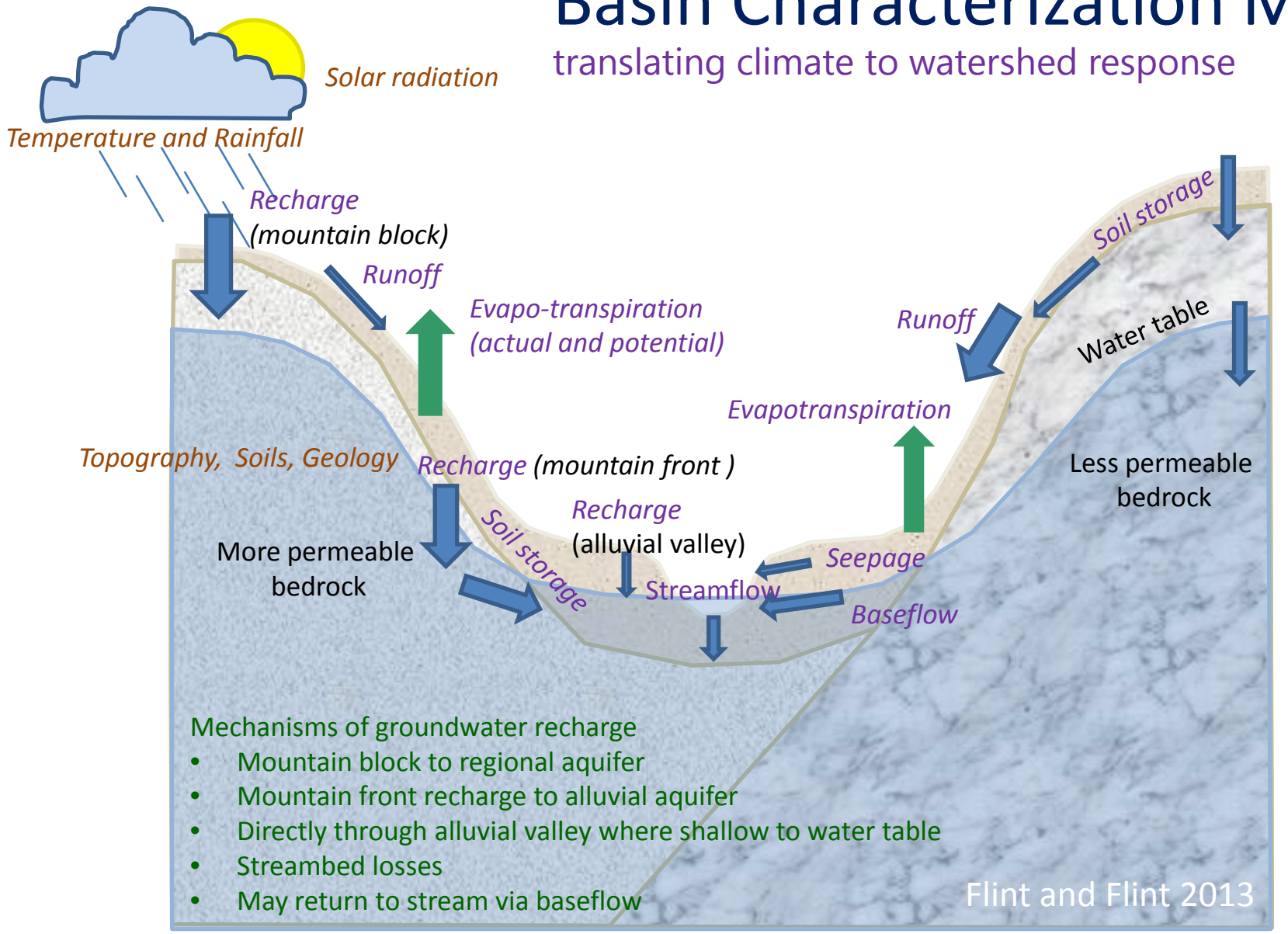
Basin Characterization Model

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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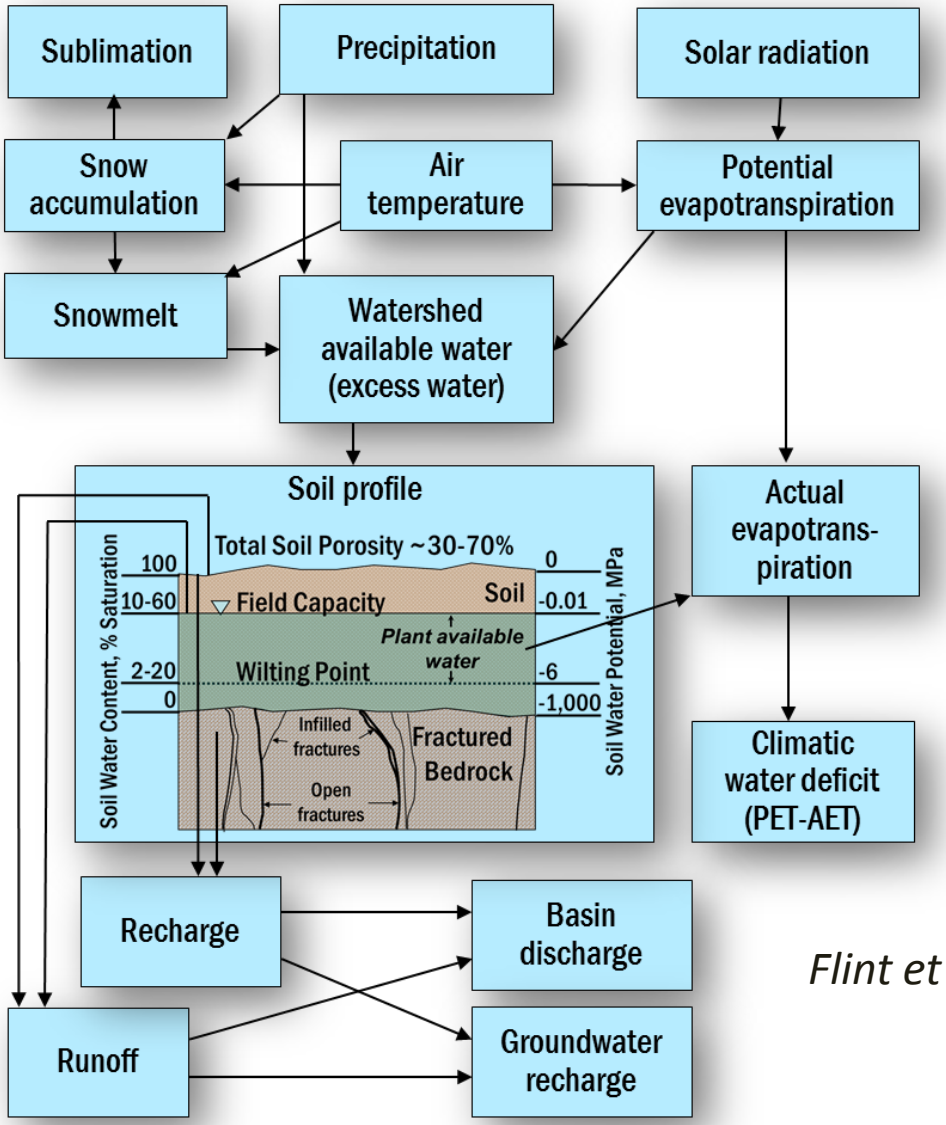
USGS California Basin Characterization Model: translating climate to watershed response



Flint et al 2013

BCM methods

USGS science for a changing world

BCM output: Climatic Water Deficit

Annual evaporative demand
that exceeds available water = drought stress

Potential – Actual Evapotranspiration

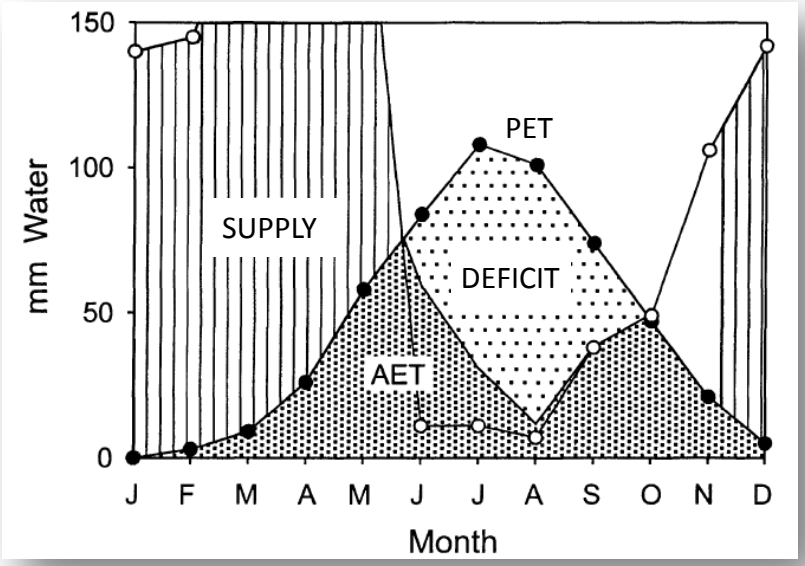
Integrates climate, energy loading, drainage, and available soil moisture storage

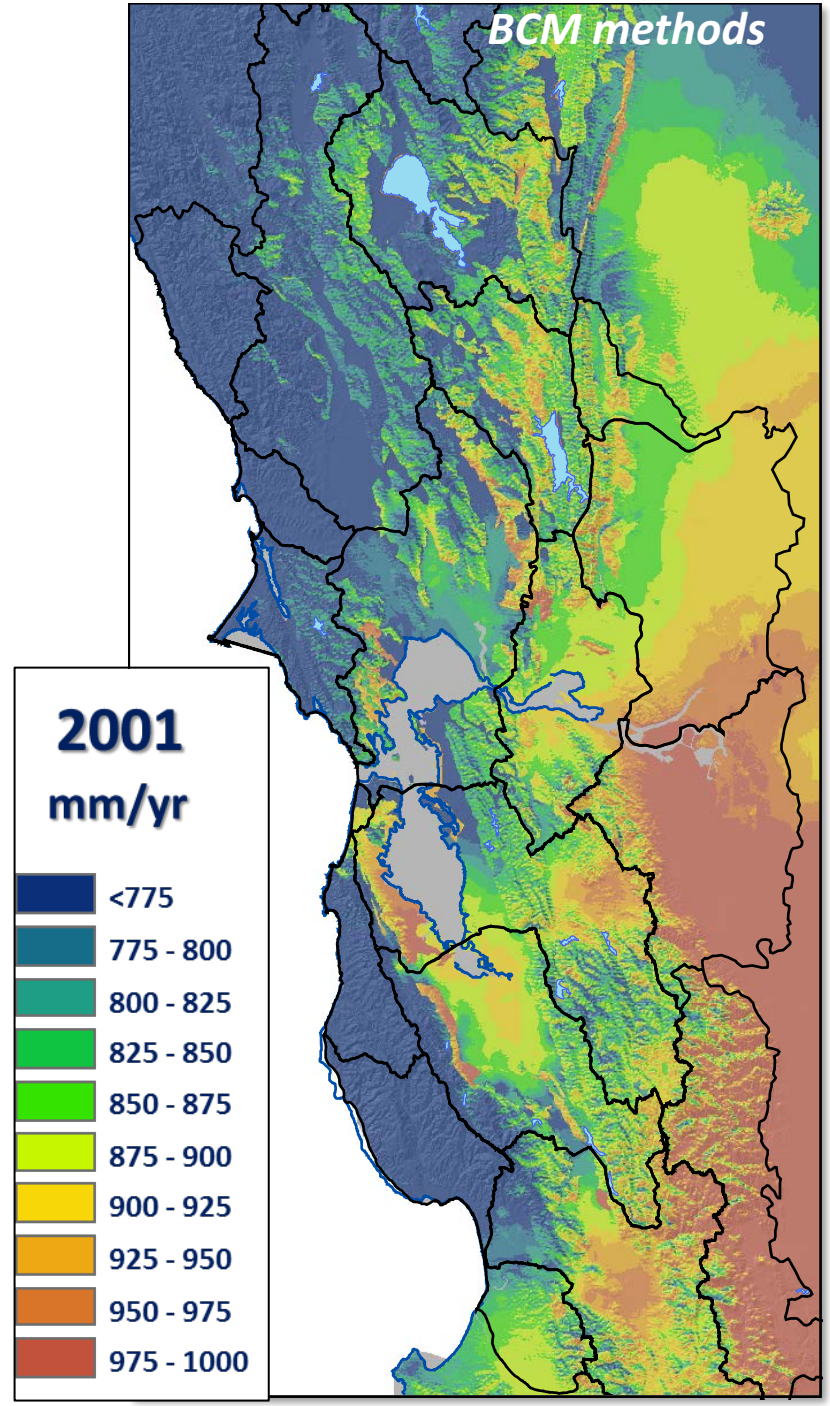
Vegetation independent (indicator)

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 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

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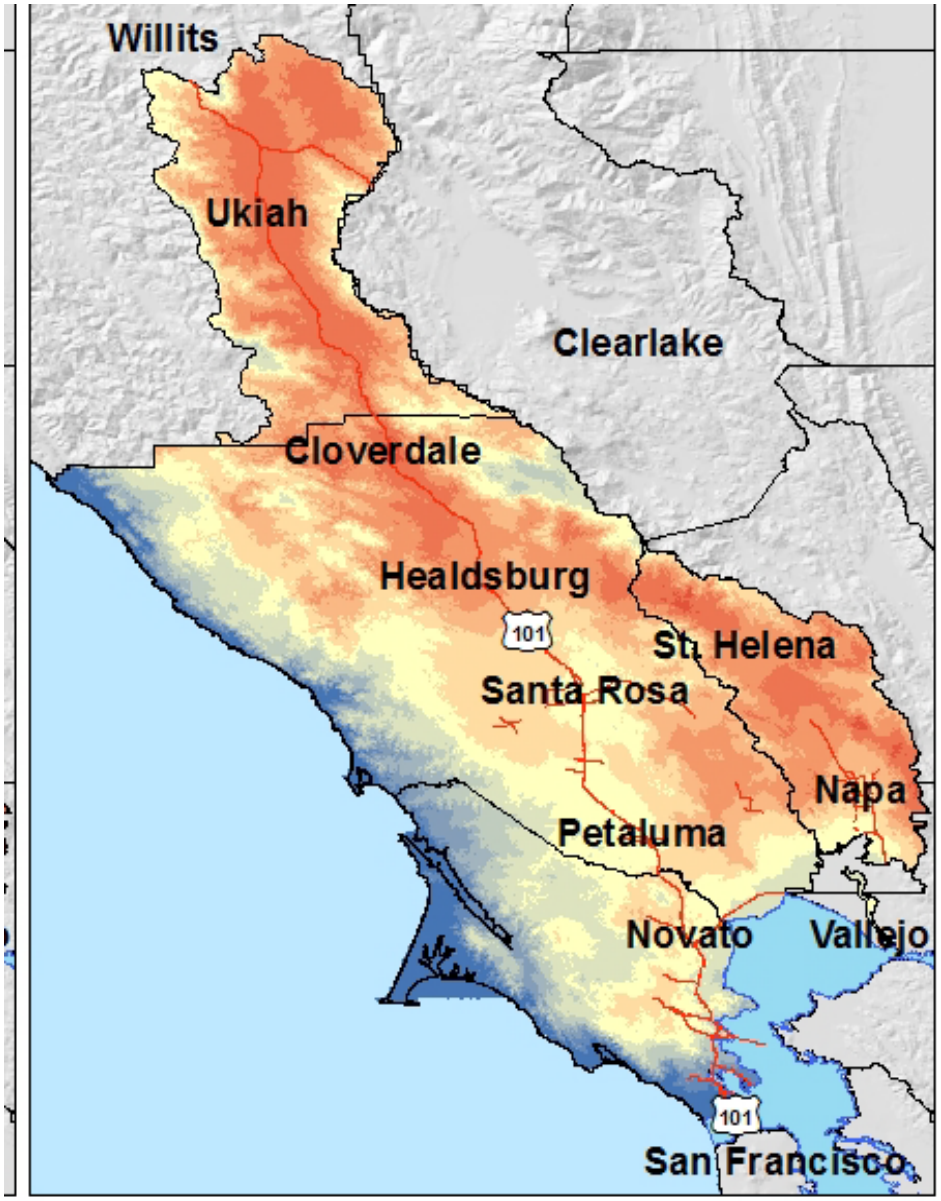
Regional data samples

- Cover entire North Bay Climate Ready Study Area (Russian River basin, Sonoma County, Marin County, Napa Valley)
- Showing primary temperature and rainfall outputs from CA Basin Characterization Model (USGS)
- Put local results in regional context and facilitates regional planning

Maximum summer temperature (monthly avg) (degF)

30-year average, current-1981-2010



Max Summer Temp

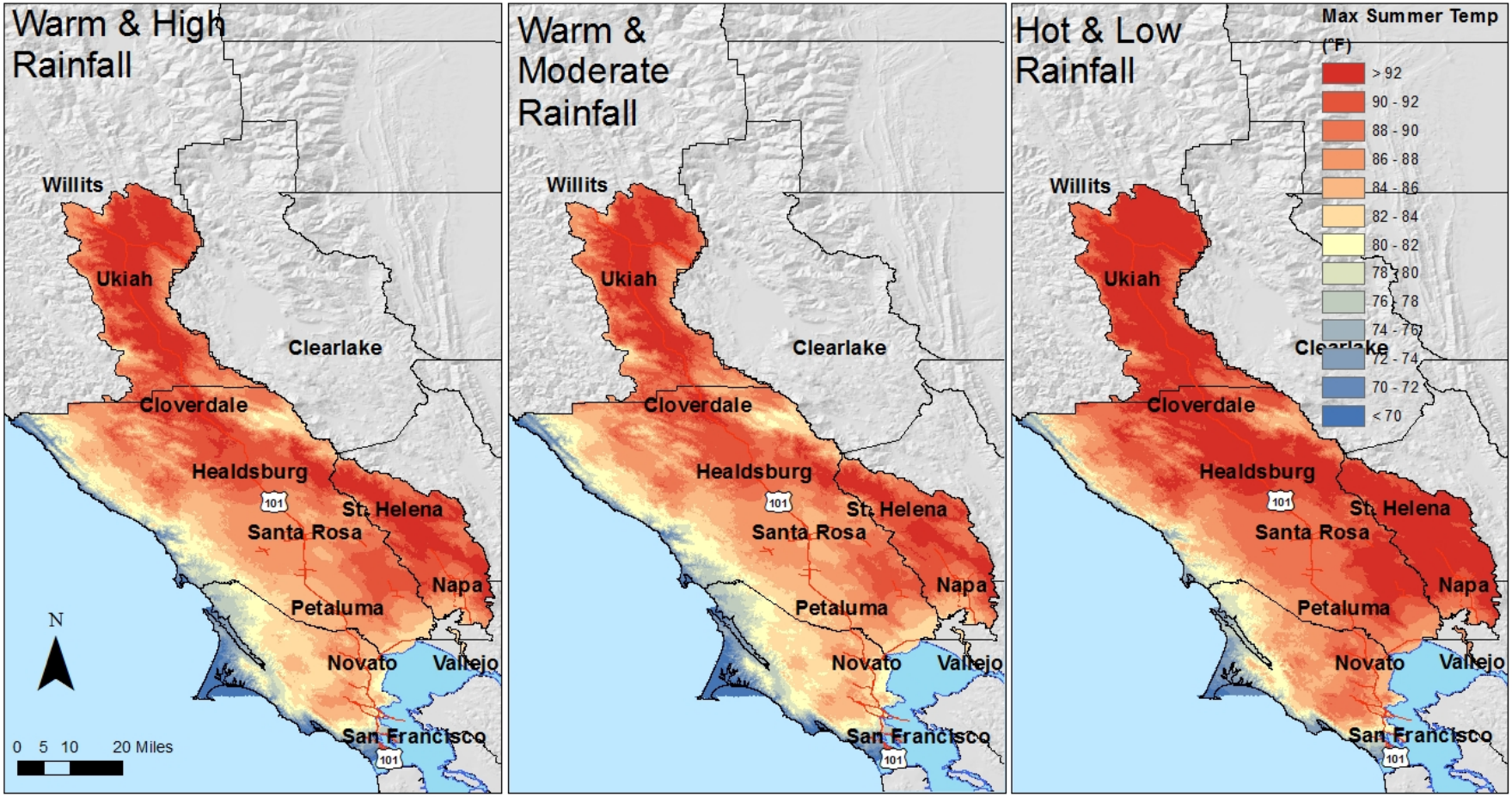
(°F)

- > 92
- 90 - 92
- 88 - 90
- 86 - 88
- 84 - 86
- 82 - 84
- 80 - 82
- 78 - 80
- 76 - 78
- 74 - 76
- 72 - 74
- 70 - 72
- < 70

82.2 deg F average

Regional data

Projected Maximum Summer Air Temperature, 2040-2069



86.4 average
+4.2 deg F

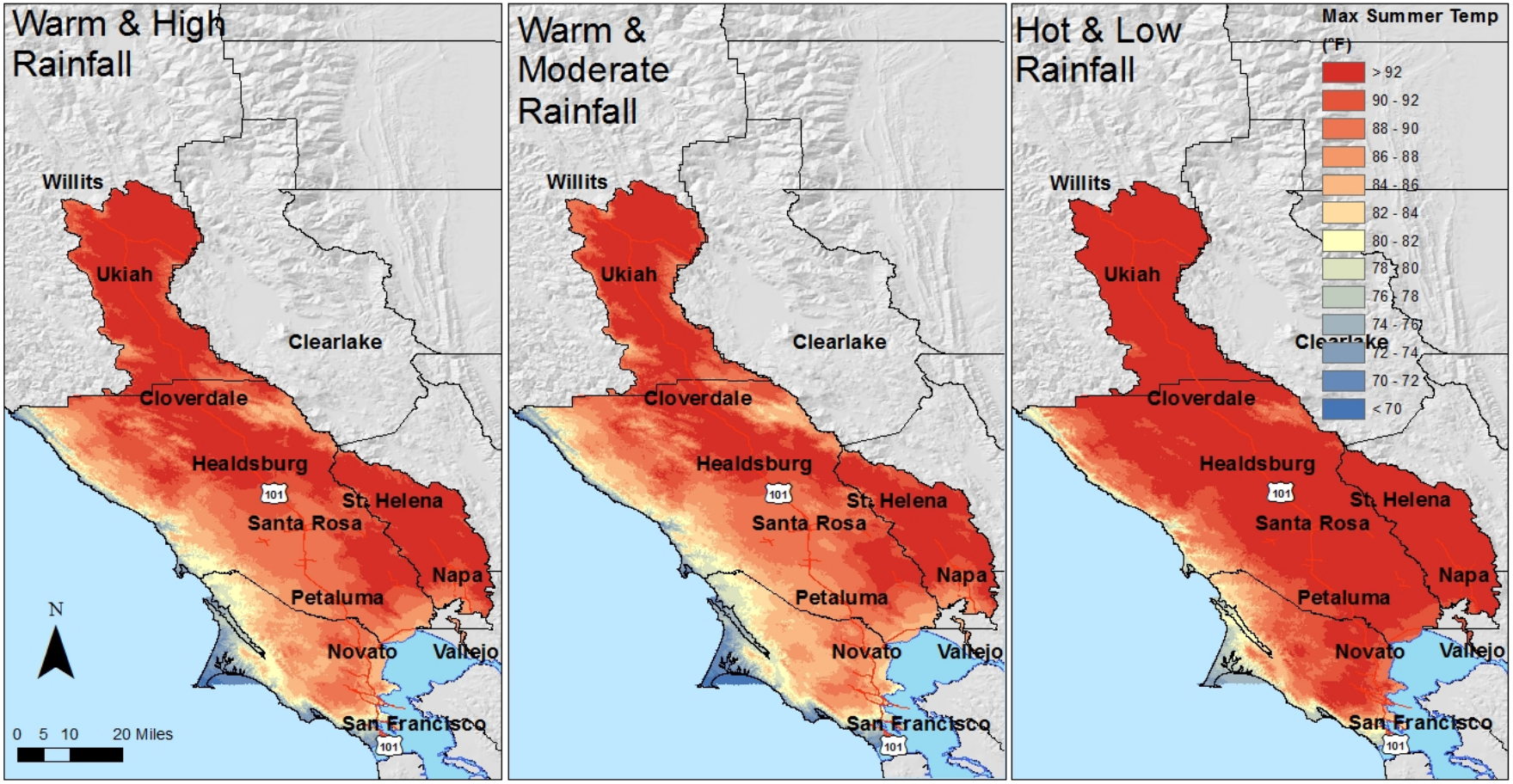
86.0 average
+3.8 deg F

89.2 average
+7.0 deg F

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

Regional data

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

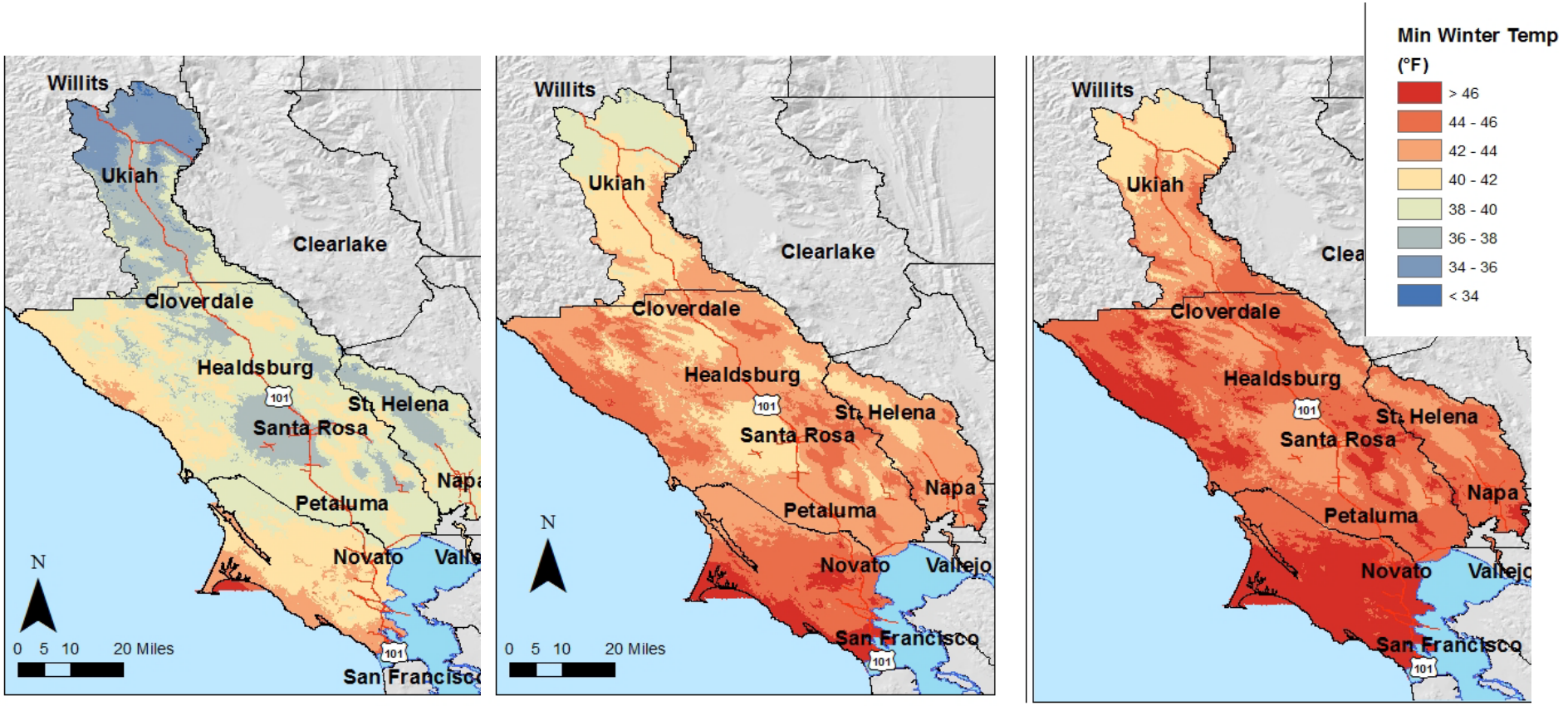
"business as usual" end of century temperatures-30 y monthly average

Minimum winter temperature (monthly) (degF)

Regional data

30-year average, current-moderate warming (projected)

(mod rainfall scenario)



Current 1981-2010
39.7 average

Projected 2040-2069
43.0 average

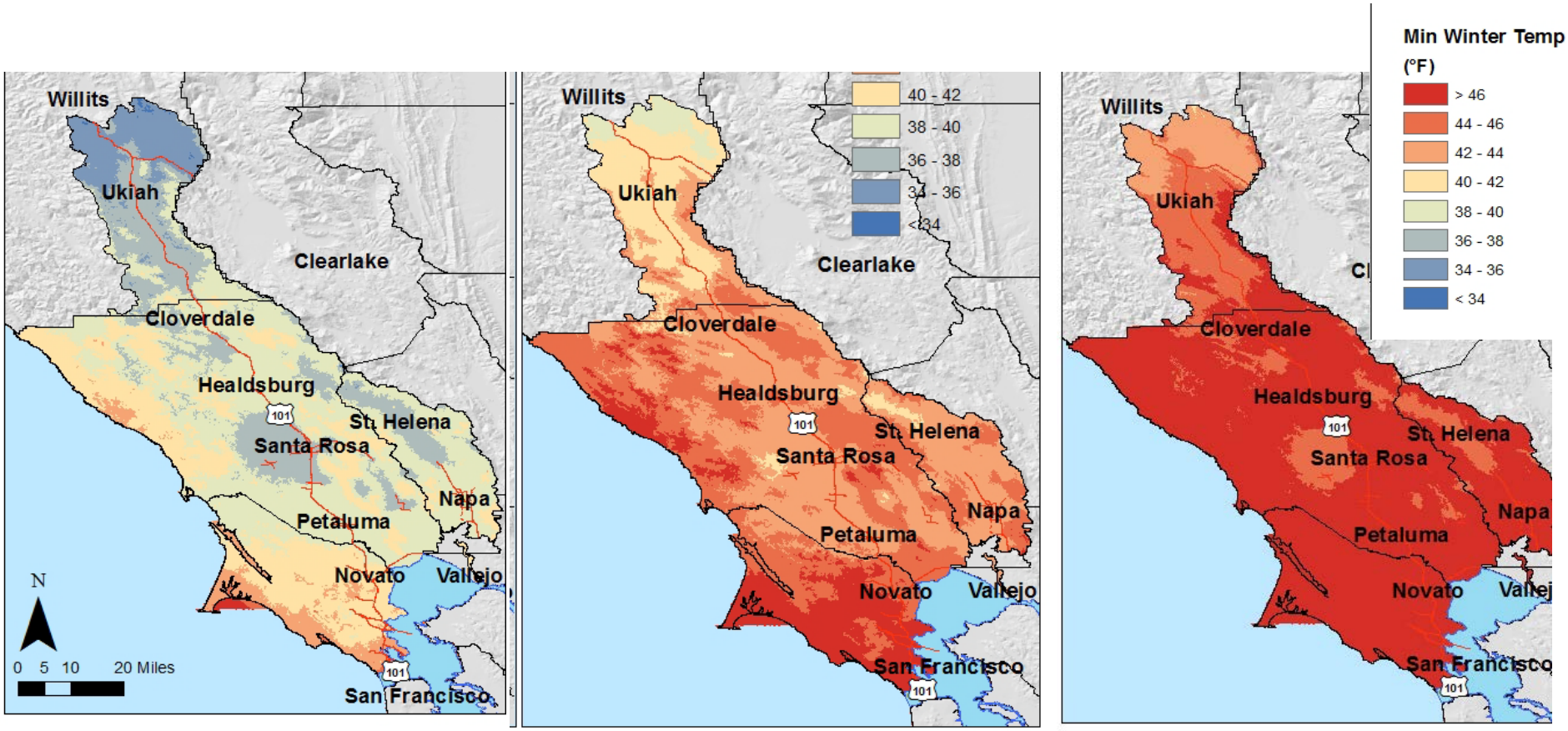
Projected 2070-2099
44.8 average

5.1 degF increase by end of century

Minimum winter temperature (monthly) (degF)

Regional data

30-year average, current-high warming (projected)

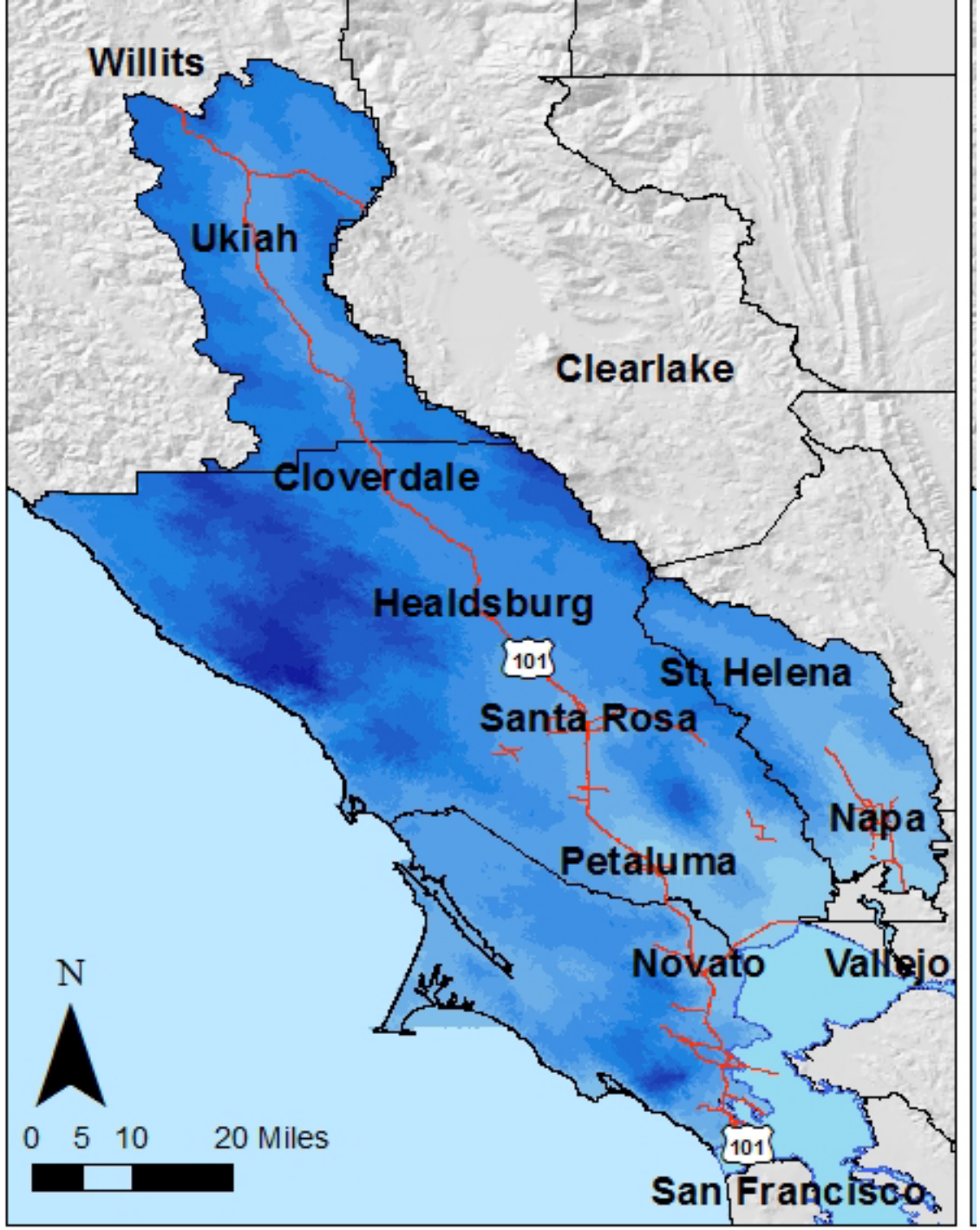


Current 1981-2010
39.7 average

Projected 2040-2069
44.1 average

Projected 2070-2099
47.3 average

8.6degF greater by end of C than current, 2.5 degF greater than moderate warming scenario



Precipitation (PPT)

30 year average

Historic 1951-1980

Regional average 43 in/y

80+
75 - 80
70 - 75
65 - 70
60 - 65
55 - 60
50 - 55
45 - 50
40 - 45
35 - 40
30 - 35
25 - 30
20 - 25
15 - 20
< 15

PPT (in/yr)

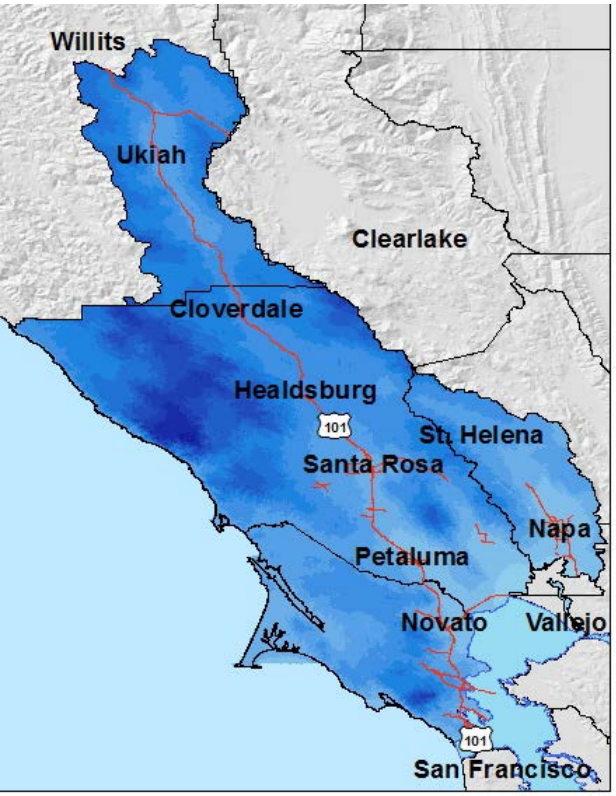
Regional data

Regional data

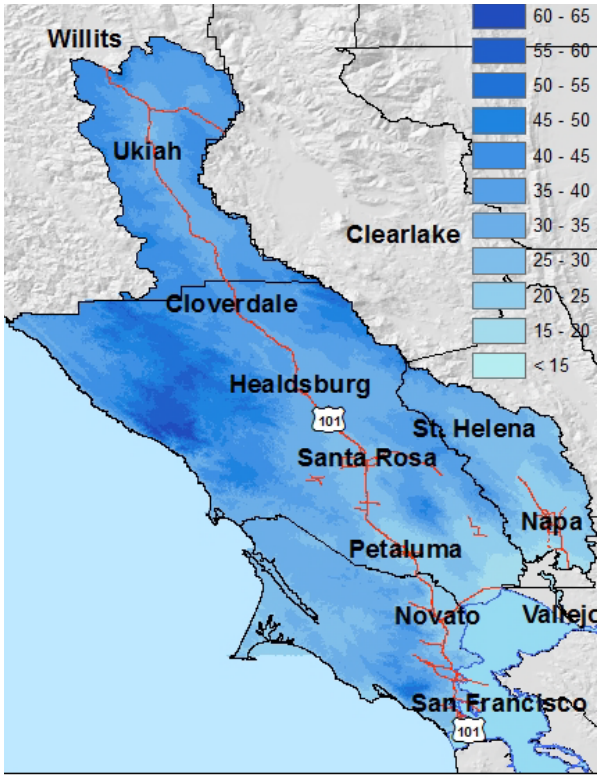
Precipitation (PPT, annual in/y)

30-year average, current to projected-low rainfall

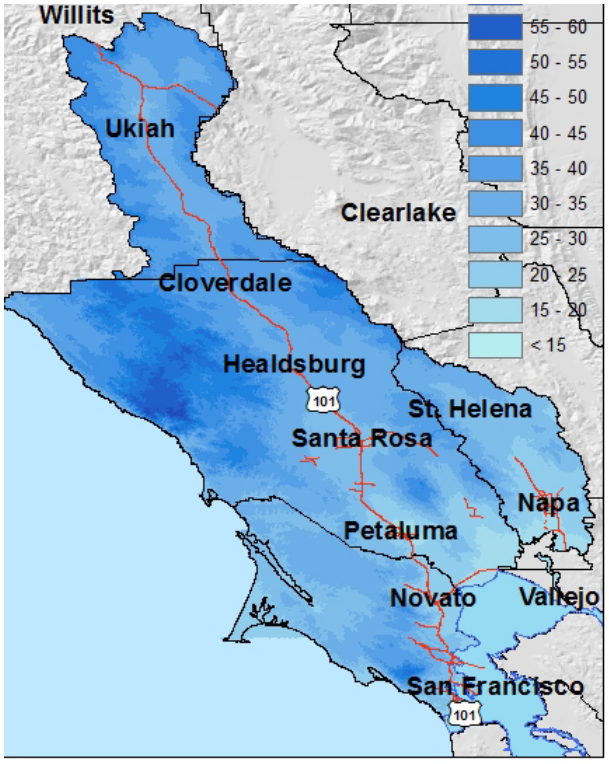
(hot scenario)



Current 1981-2010
43.0 average



Projected 2040-2069
35.0 average



Projected 2070-2099
34.0 average

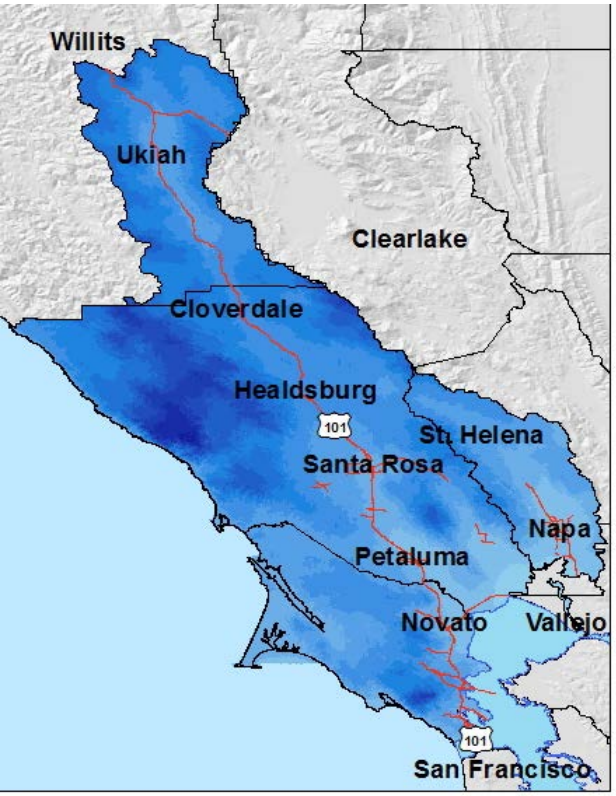
projecting 19-21% less rainfall than current

Precipitation (PPT, annual in/y)

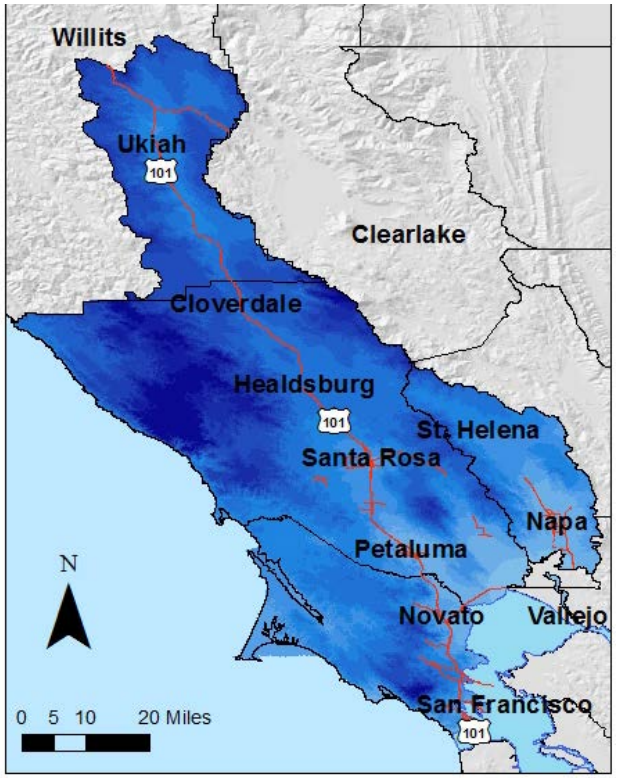
Regional data

30-year average, current to projected-high rainfall

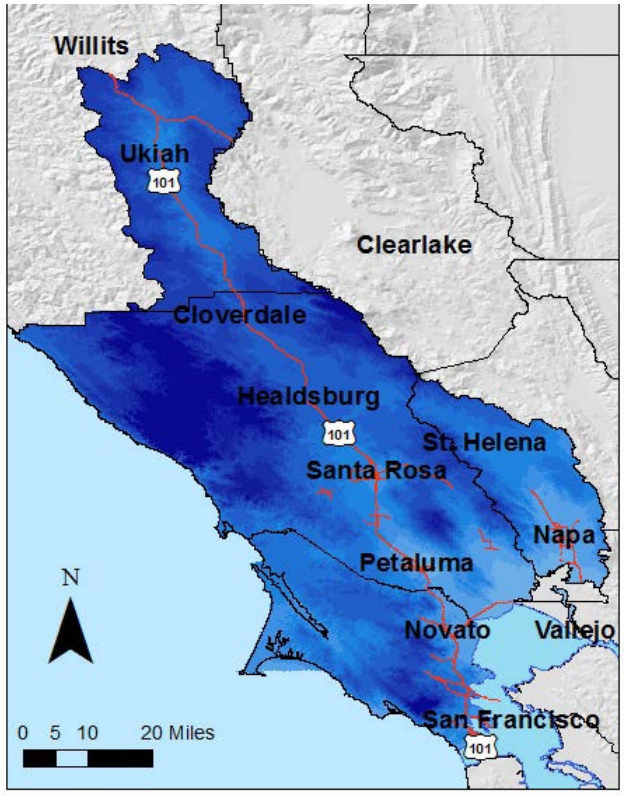
(warm scenario)



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

Basin Characterization Model: North Bay Region
Trends in 30-year average values, historic-2099

		Historical	Current	Moderate Warming, High Rainfall		Moderate Warming, Moderate Rainfall		Hot, Low Rainfall	
Variable	Units	1951-1980	1981-2010	2040-2069	2070-2099	2040-2069	2070-2099	2040-2069	2070-2099
Ppt	in	42.6	43.0	53.6	57.9	42.1	45.6	34.8	33.9
Tmn	Deg F	38.8	39.7	43.0	45.9	41.9	44.8	44.1	47.3
Tmx	Deg F	82.2	82.2	86.4	89.4	86.0	88.5	89.2	93.4
CWD	in	28.0	28.4	29.8	31.3	30.3	31.4	32.0	34.6
Rch	in	11.0	10.2	12.8	13.2	10.7	10.8	8.2	8.5
Run	in	14.0	14.2	22.8	26.9	14.0	17.3	9.7	9.3
Regional Statistics				Percent Change from Current or Change in Temperature					
			Current	Moderate Warming, High Rainfall		Moderate Warming, Moderate Rainfall		Hot, Low Rainfall	
Variable	Units		1981-2010	2040-2069	2070-2099	2040-2069	2070-2099	2040-2069	2070-2099
Ppt	in		43.0	25%	35%	-2%	6%	-19%	-21%
Tmn	Deg F		39.7	3.2	6.1	2.2	5.0	4.3	7.6
Tmx	Deg F		82.2	4.1	7.2	3.8	6.3	7.0	11.2
CWD	in		28.4	5%	10%	7%	11%	12%	22%
Rch	in		10.2	25%	29%	4%	6%	-20%	-17%
Run	in		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

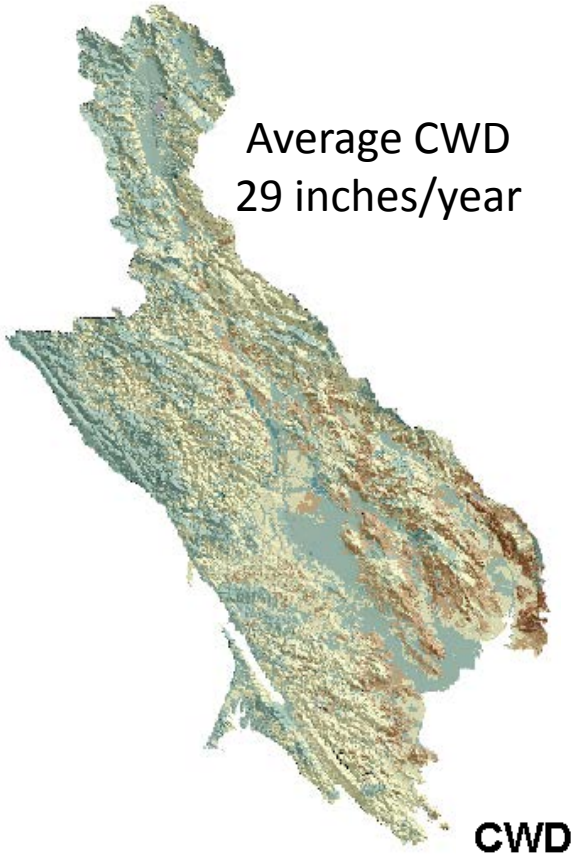
USGS, Point Blue, Pepperwood 2015

North Bay Region Climatic Water Deficit

Hot & Low Rainfall

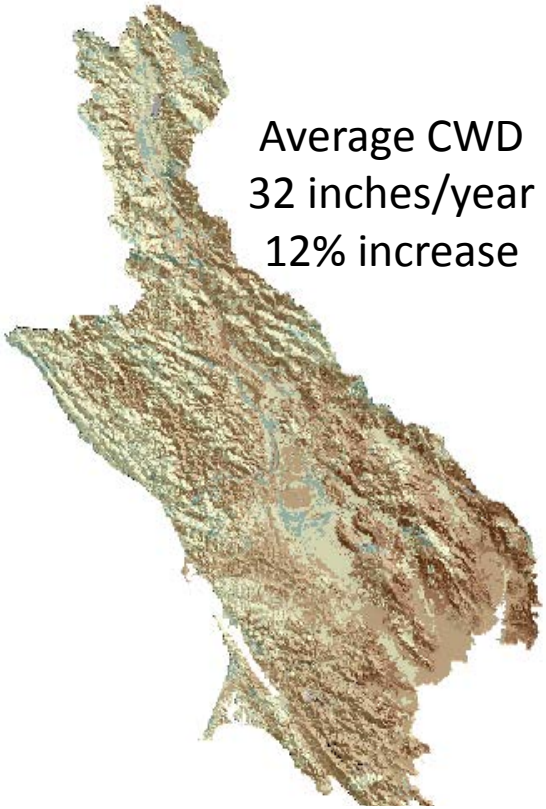
1981-2010

Average CWD
29 inches/year



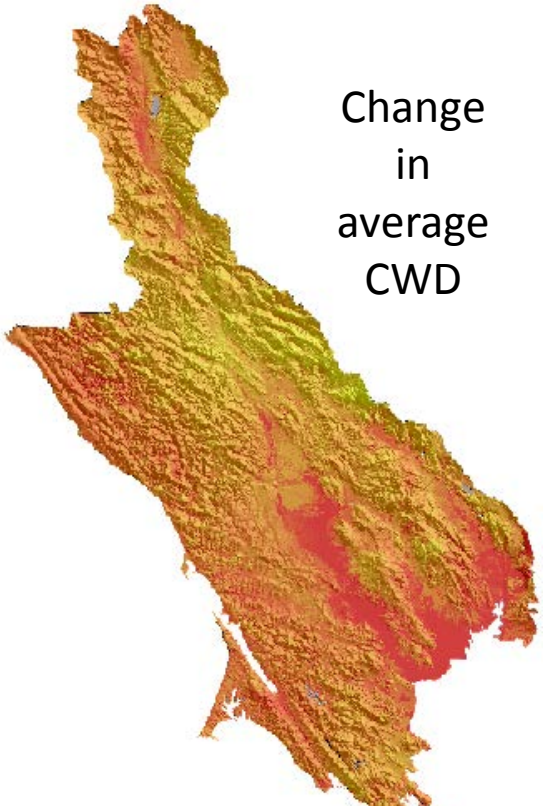
2040-2069

Average CWD
32 inches/year
12% increase



2040-2069

Change
in
average
CWD



CWD (in/year)

20 28 32 36 41

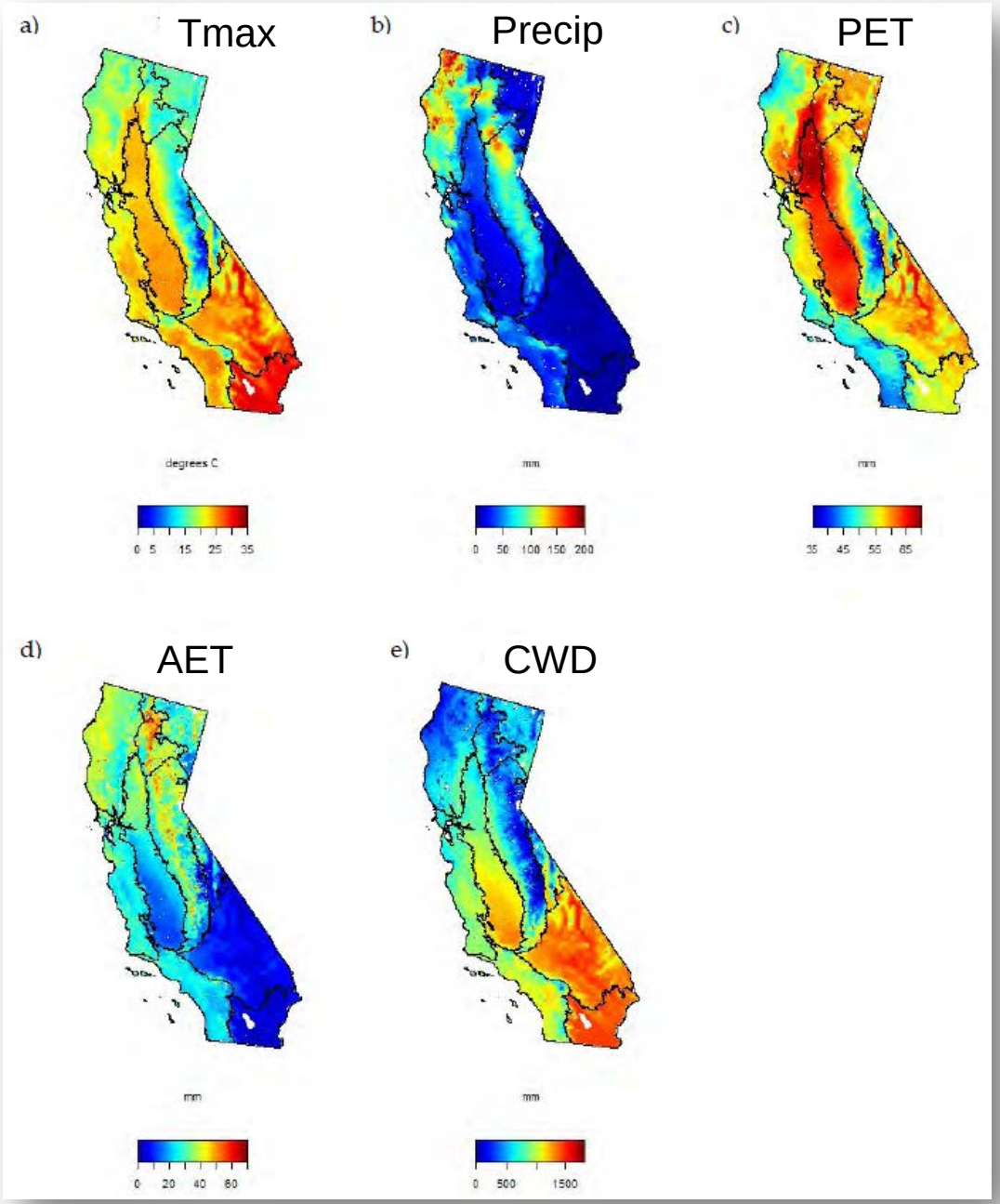
Delta CWD

High : 9 in/year

Low : 1 in/year

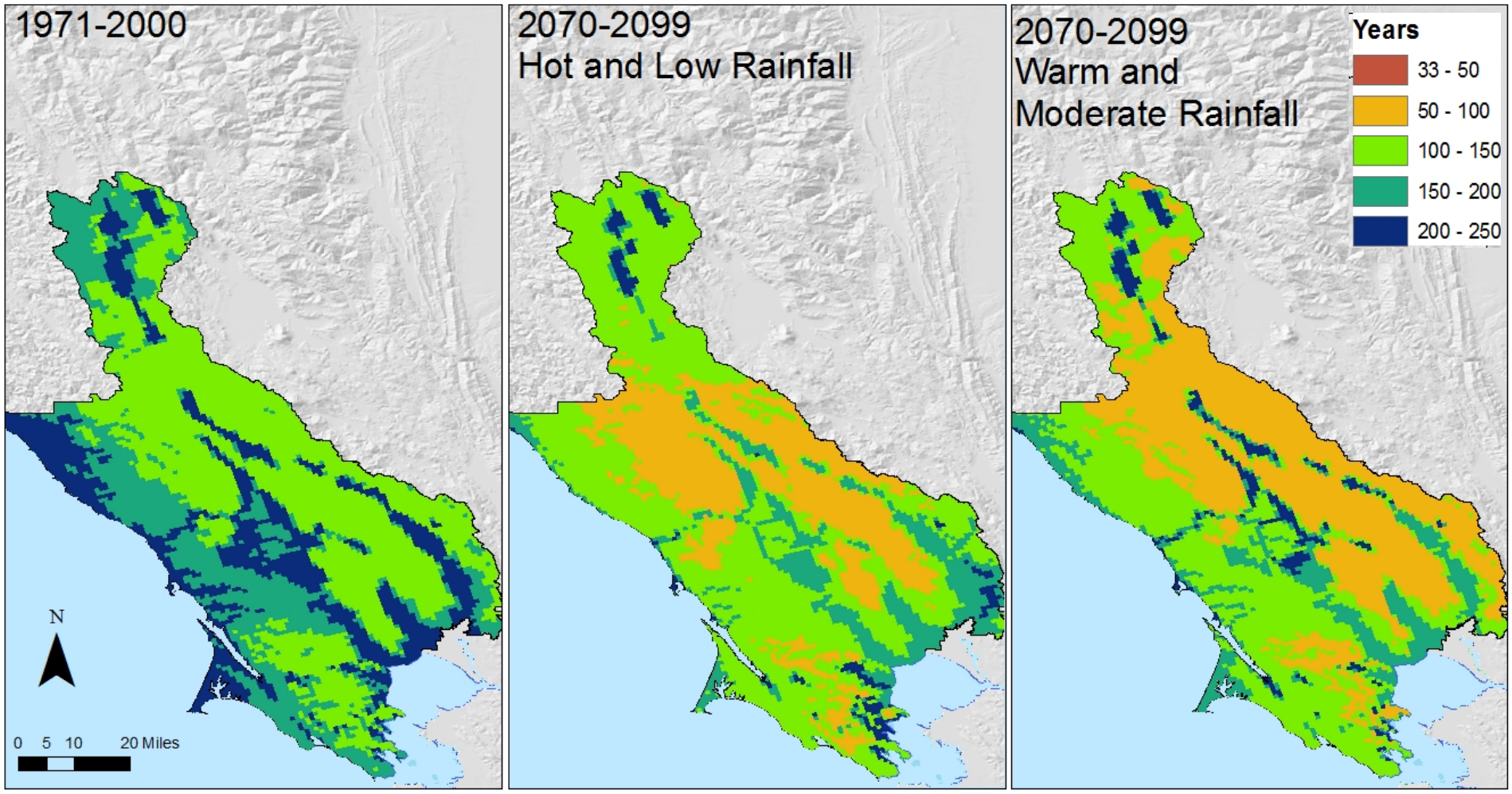
Statewide Fire Risk Model: BCM data inputs

Spatial patterns of statewide input climate variables 1971–2000



Krawchuk and Moritz 2012 PIER report

Change in Projected Fire Return Interval



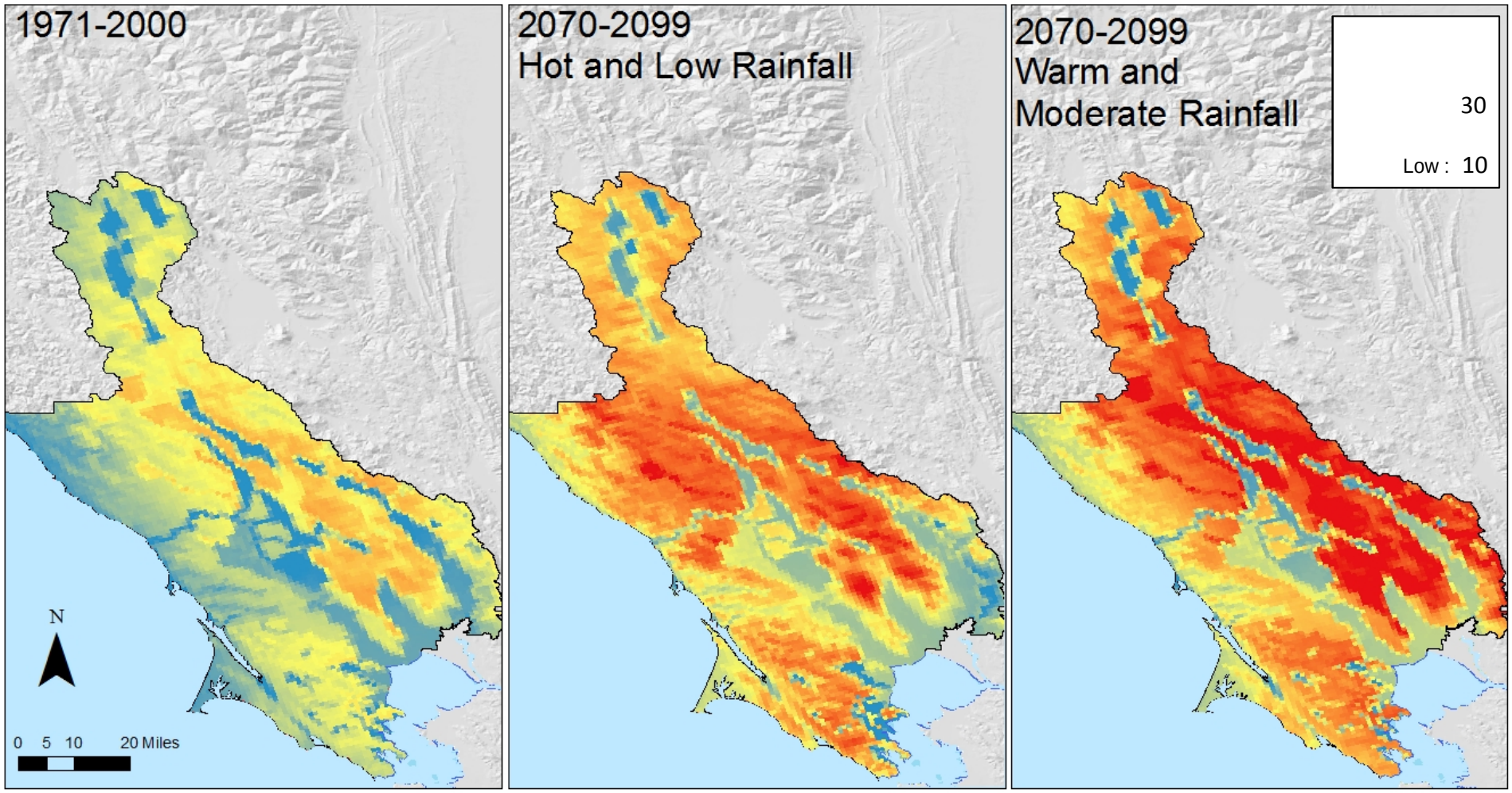
172 yr average historic return interval

117 yr average projected return interval

120 yr average projected return interval

Average regional fire return intervals reduced by approximately 30%

Change in Projected Fire Probability



Historic average probability of 17%

Projected: 23% average

Projected: 23% average

Probability of burning one or more times within 30 years increases by an average of 35%, extremes are worse in increased rainfall locations due to additional fuels

SCAPOSD and
Sonoma County Regional Parks

Sample Data Output Products

Basin Characterization Model: Sonoma County
Trends in 30-year average values, historic-2099

		Historical	Current	Moderate Warming, High Rainfall		Moderate Warming, Moderate Rainfall		Hot, Low Rainfall	
Variable	Units	1951-1980	1981-2010	2040-2069	2070-2099	2040-2069	2070-2099	2040-2069	2070-2099
Ppt	in	42.6	43.0	53.6	57.9	42.1	45.6	34.8	33.9
Tmn	Deg F	44.8	45.8	49.2	52.0	48.5	51.3	50.6	54.3
Tmx	Deg F	71.2	71.2	75.0	77.7	74.4	77.1	76.8	80.7
CWD	in	28.0	54.9	57.4	60.1	58.3	60.3	61.5	66.7
Rch	in	11.0	10.2	12.8	13.2	10.7	10.8	8.2	8.5
Run	in	14.0	14.2	22.8	26.9	14.0	17.3	9.7	9.3

			Percent Change from Current or Change in Temperature					
		Current	Moderate Warming, High Rainfall		Moderate Warming, Moderate Rainfall		Hot, Low Rainfall	
Variable	Units	1981-2010	2040-2069	2070-2099	2040-2069	2070-2099	2040-2069	2070-2099
Ppt	in	43.0	25%	35%	-2%	6%	-19%	-21%
Tmn	Deg F	45.8	3.4	6.2	2.7	5.5	4.8	8.4
Tmx	Deg F	71.2	3.8	6.5	3.2	5.9	5.6	9.5
CWD	in	54.9	5%	10%	6%	10%	12%	22%
Rch	in	10.2	25%	29%	4%	6%	-20%	-17%
Run	in	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

USGS, Point Blue, Pepperwood 2015

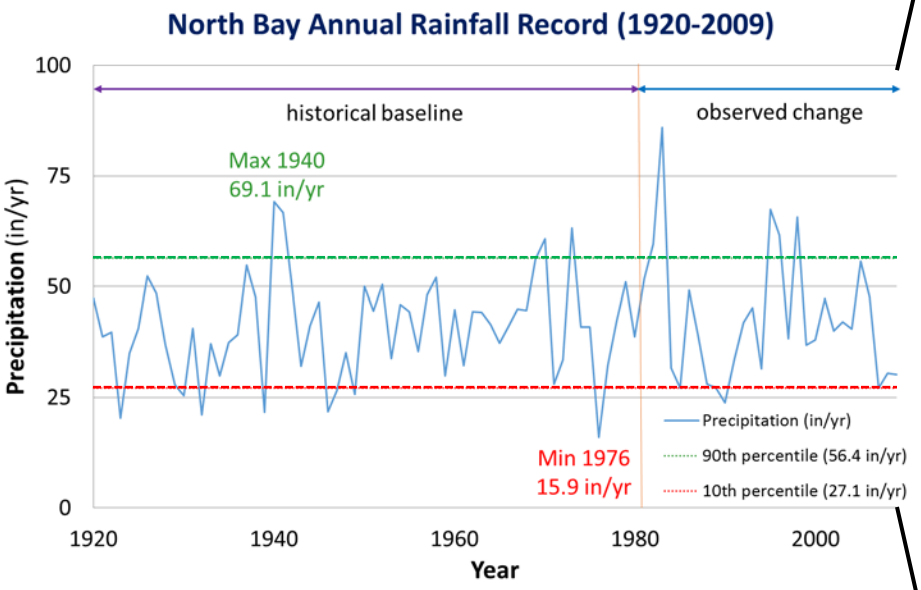
Management Question

How may climate change impact the inter-annual variability of rainfall in the region as a whole and Sonoma County?

North Bay Climate Ready

Regional Annual Rainfall: Historical and Projected

(comparison of 90-year periods)



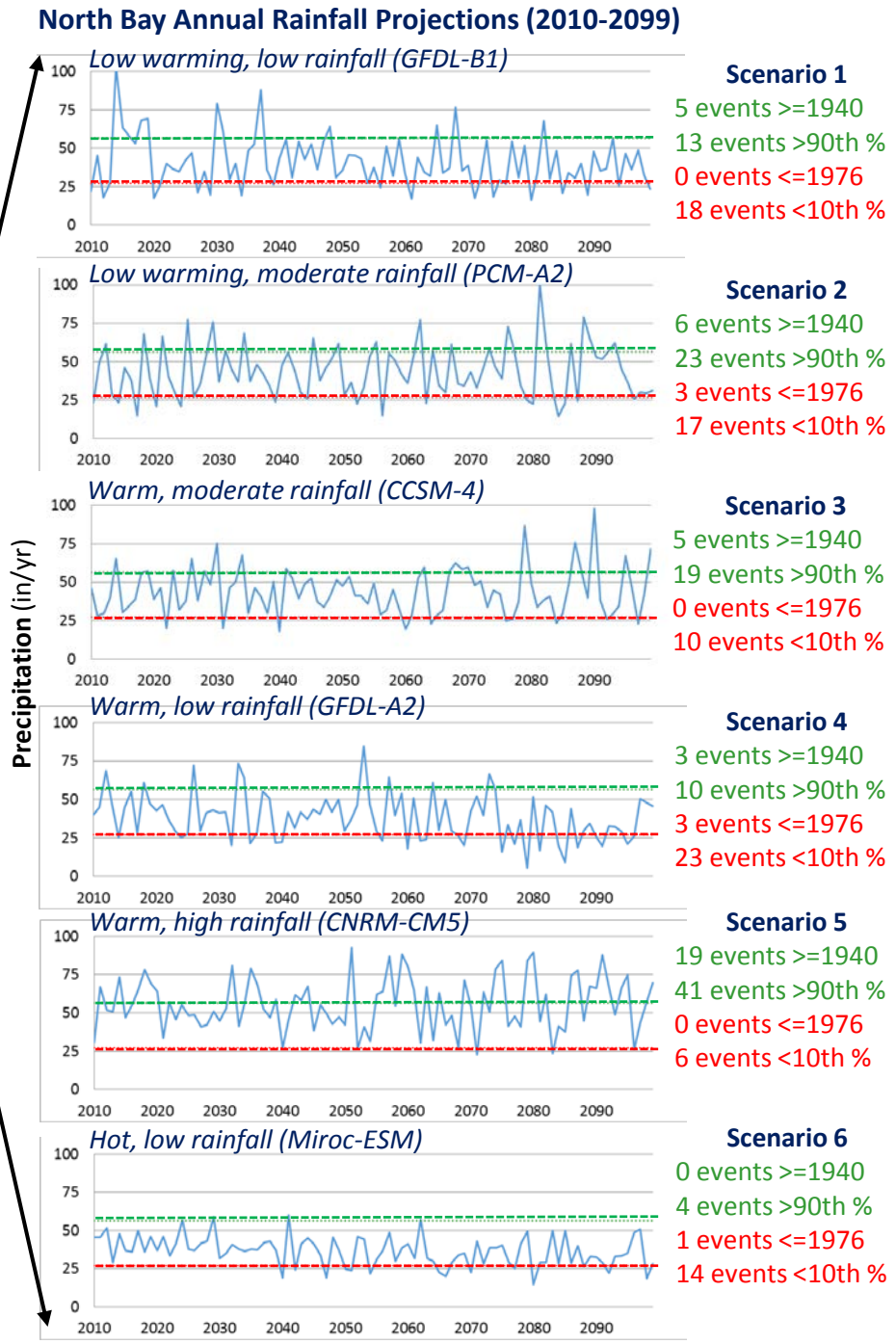
Extremes (1920-2009)

2 events >=1940

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

1 events <=1976

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



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

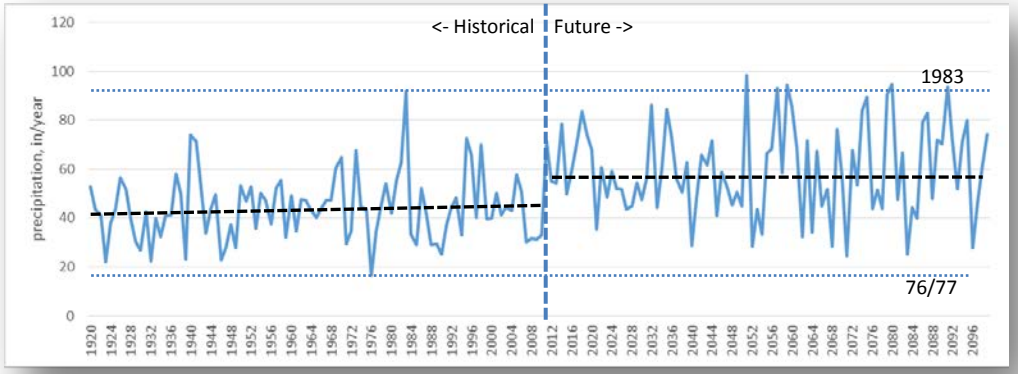
Scenario #	Model	Time Period	Name	Annual Peaks (floods) >=1940 (69.1 in/yr)	Annual Peaks (floods) >90th % (56.4 in/yr)	Annual Lows (droughts) <10th % (27.1 in/yr)	Annual Lows (droughts) <=1976 (15.9 in/yr)
	Historic & Observed Change	1920-2009					
1	GFDL_B1	2010-2099	Low warming, Low rainfall	150%	44%	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

Sonoma County Precipitation, 1920-2099

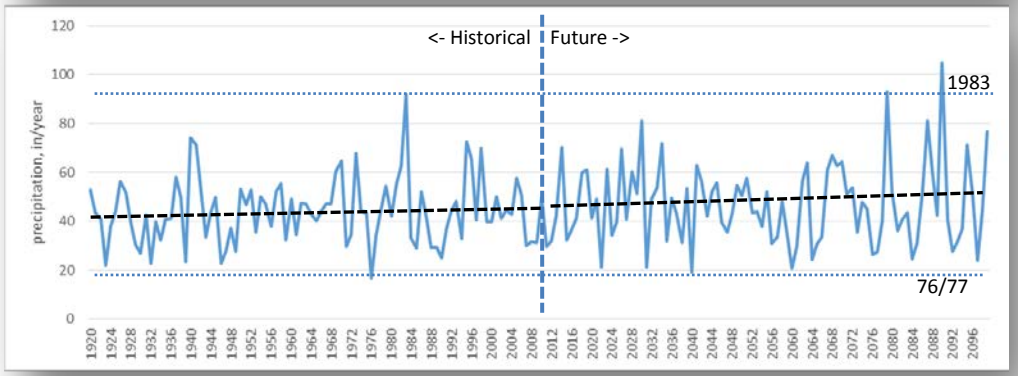
Average Historical
45 in/yr

Scenario 5
Warm &
High Rainfall



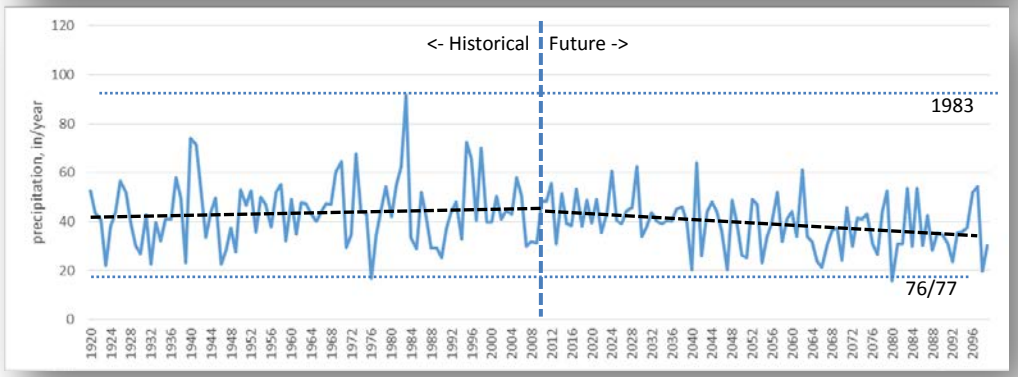
Warm & high rainfall future
Average 59 in/yr
5 yrs exceed historical max

Scenario 3
Warm &
Moderate
Rainfall



Warm & mod rainfall future
Average 47 in/yr
2 yrs exceed historical max

Scenario 6
Hot &
Low Rainfall



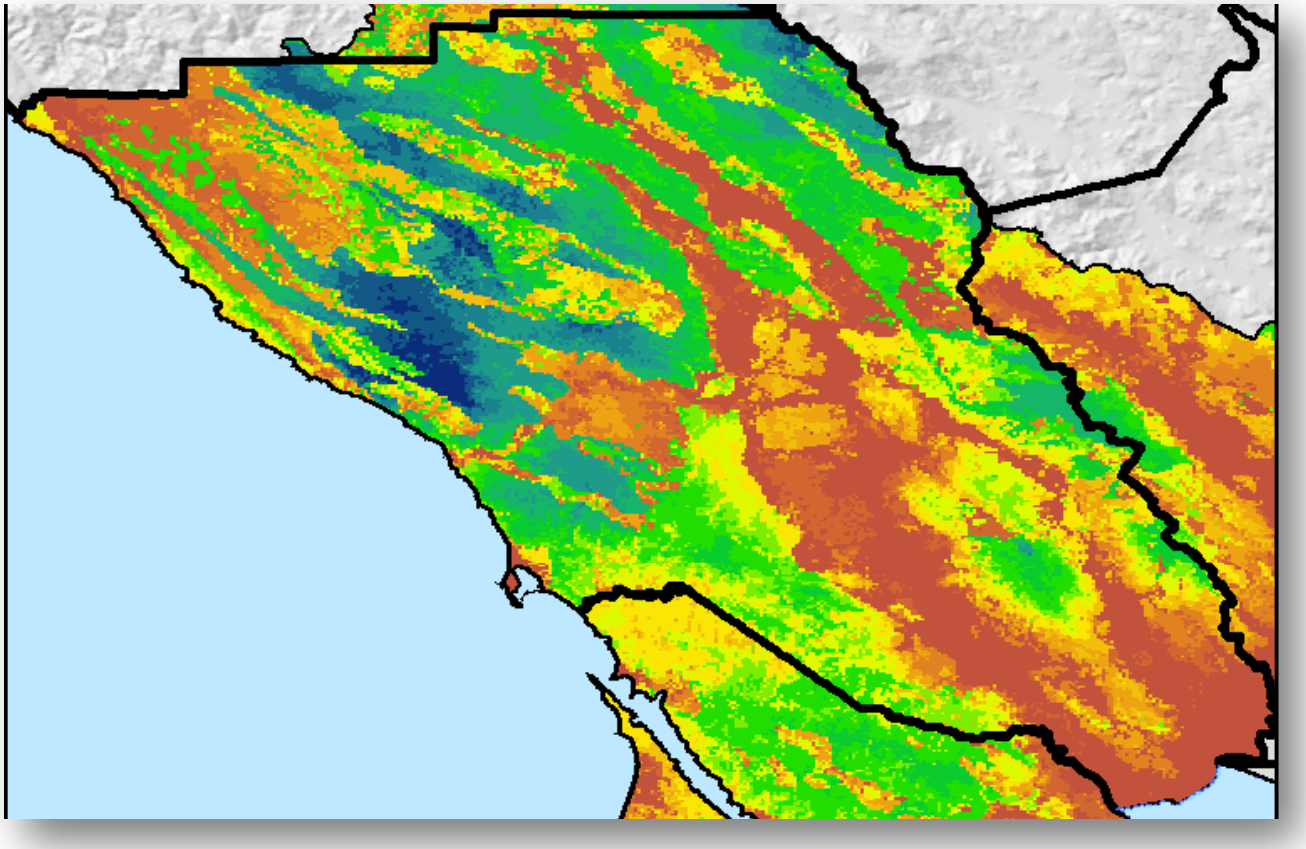
Hot and low rainfall future
Average 36 in/yr
No yrs approach historical max

Management Question

Which parcels in the combined parks and open space portfolio provide key water supply benefits?

County average
17 in/yr

Sonoma County Historical Runoff
1981-2010



Average annual runoff
(inches)

- 50+
- 45 - 50
- 40 - 45
- 35 - 40
- 30 - 35
- 25 - 30
- 20 - 25
- 17.5 - 20
- 15 - 17.5
- 12.5 - 15
- 10 - 12.5
- 7.5 - 10
- 5 - 7.5
- 2.5 - 5
- < 2.5

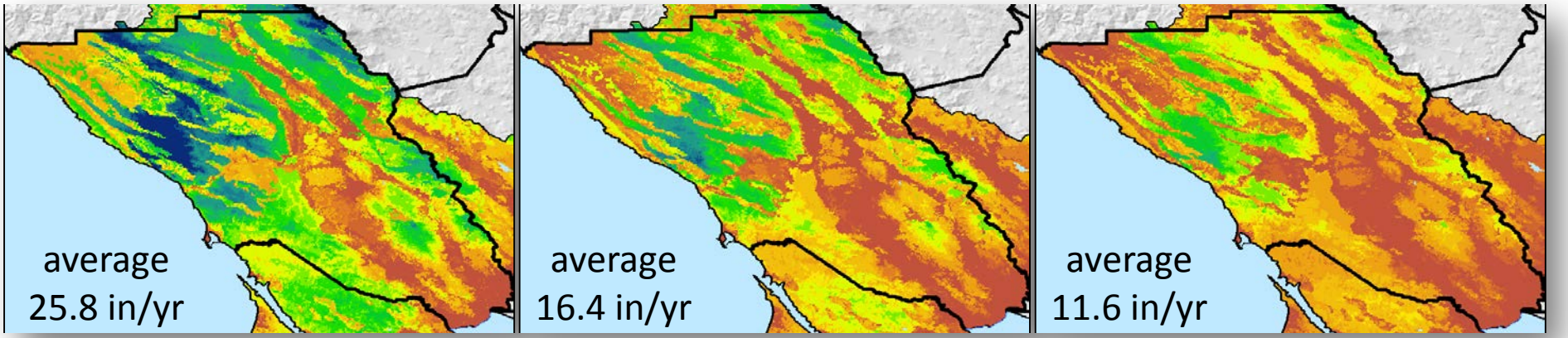
Runoff is primarily controlled by soil water holding capacity and geology. The high runoff values in blue and green are primarily in the mountains where the soils are relatively thin. The low runoff values are in the valleys where the soils are thick or in mountain locations where the bedrock is permeable.

Sonoma County Projected Runoff 2040-2069

Warm & High Rainfall

Warm & Moderate Rainfall

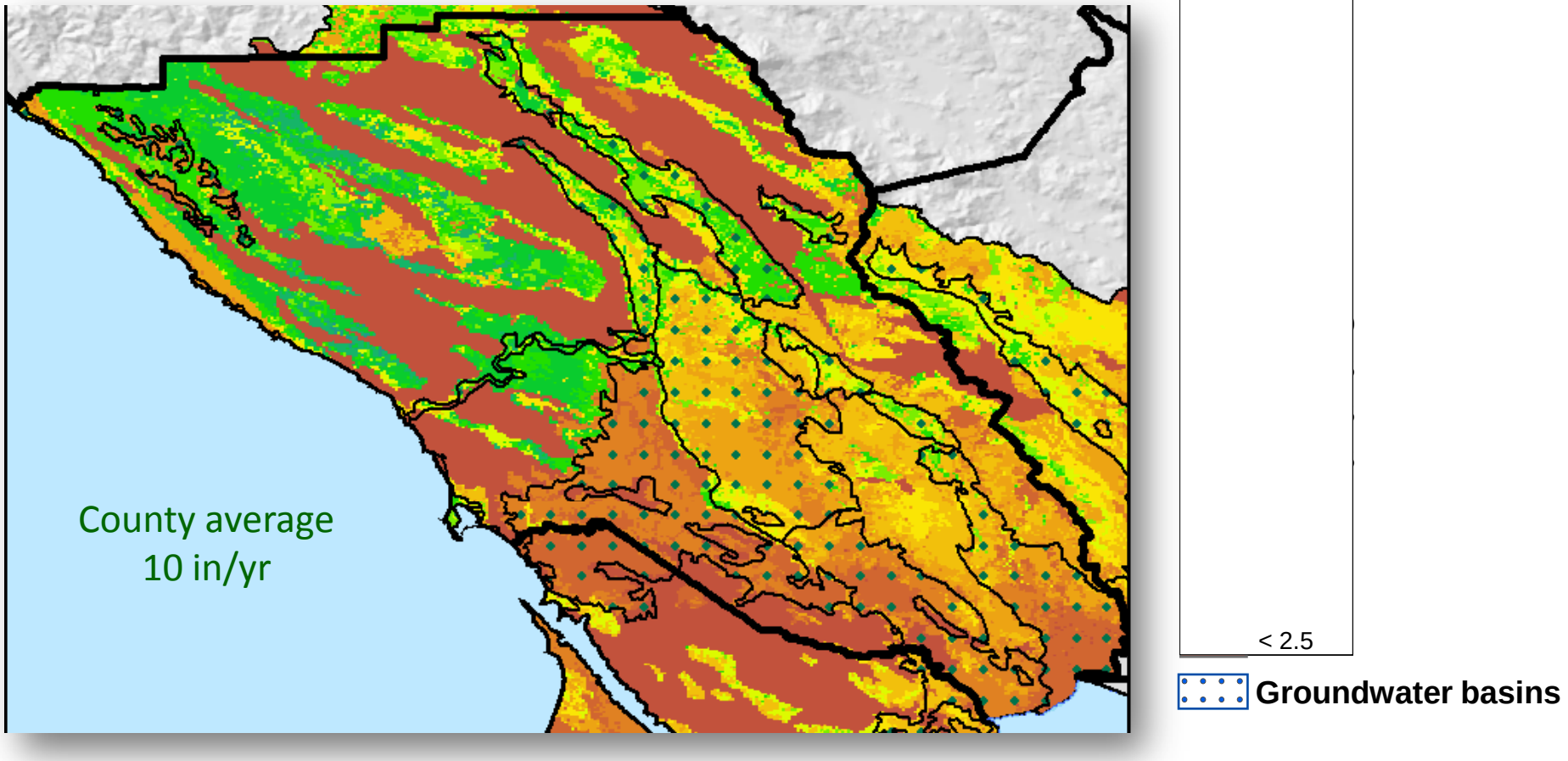
Hot & Low Rainfall



- Most of the runoff is in the high elevation locations where there are shallow soils and higher precipitation
- High runoff areas range from providing 75% of total county runoff in wet scenarios to just 25% in low rainfall scenarios by mid-century
- Historical range of runoff is very similar to the moderate rainfall scenario by mid-century

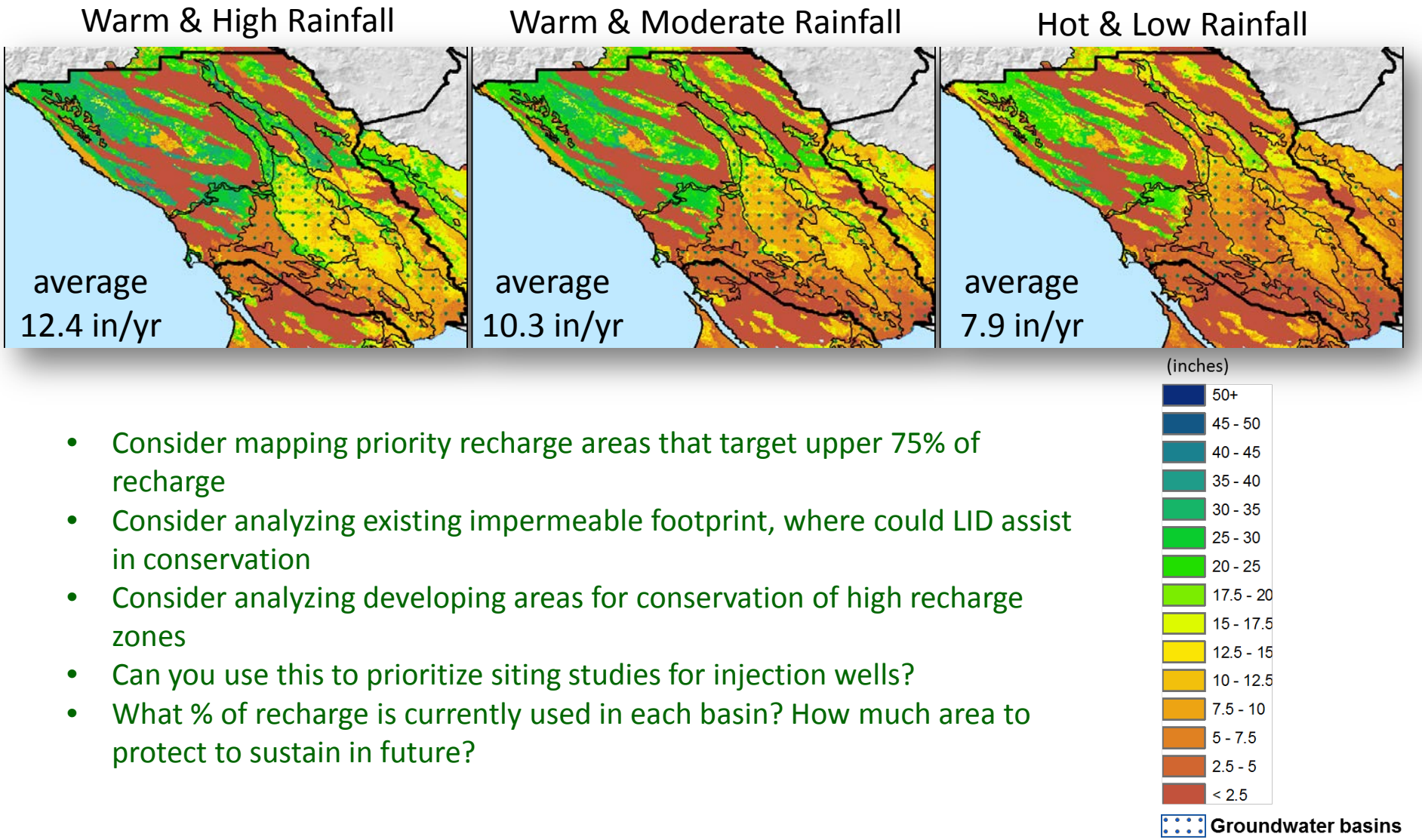
Sonoma County Historical Groundwater Recharge

1981-2010



Recharge is dominant where soils are thin and bedrock permeability is high, or where the water can penetrate below plant roots in deeper valley soils. The boundaries of the groundwater basins are shown, but most of the recharge occurs in the higher precipitation mountains surrounding the valleys.

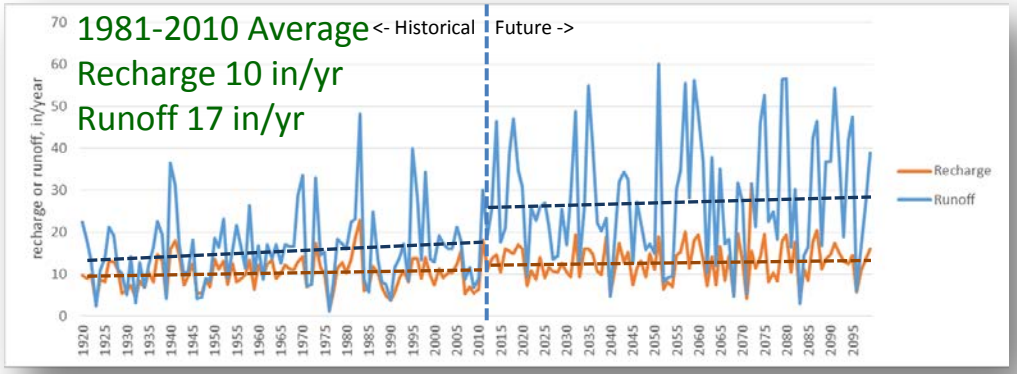
Projected Groundwater Recharge 2040-2069



- 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?

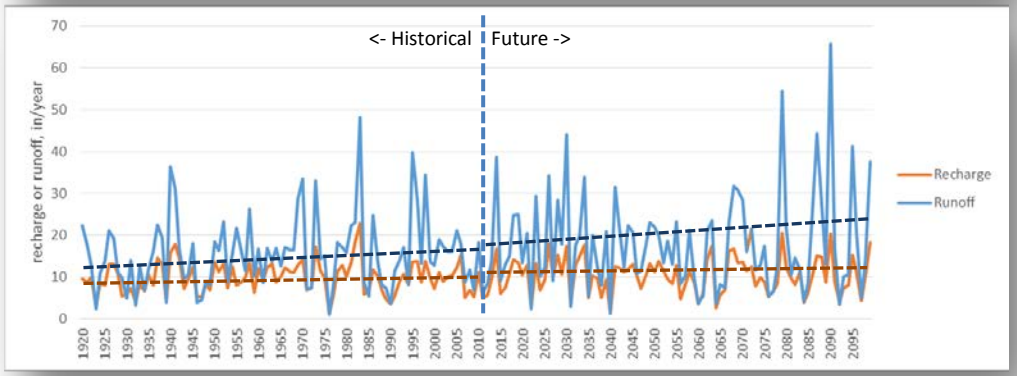
Sonoma County Annual Recharge and Runoff, 1920-2099

Scenario 5
Warm &
High Rainfall



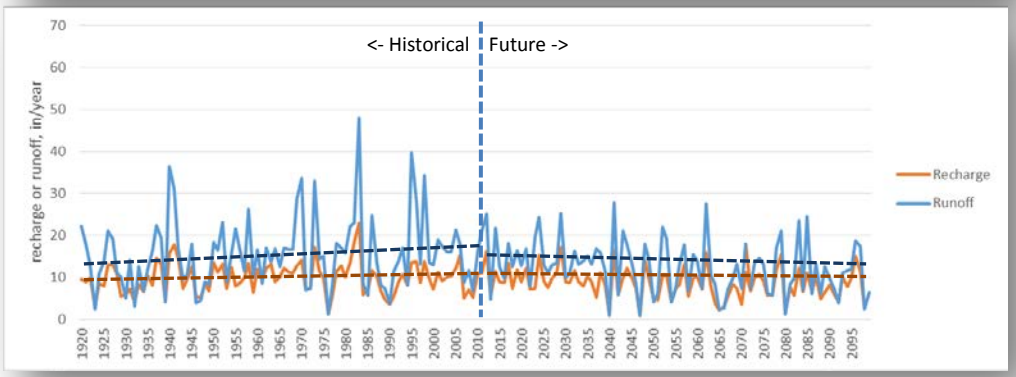
End century averages
Recharge 13 in/yr
Runoff 30 in/yr

Scenario 3
Warm &
Moderate
Rainfall



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

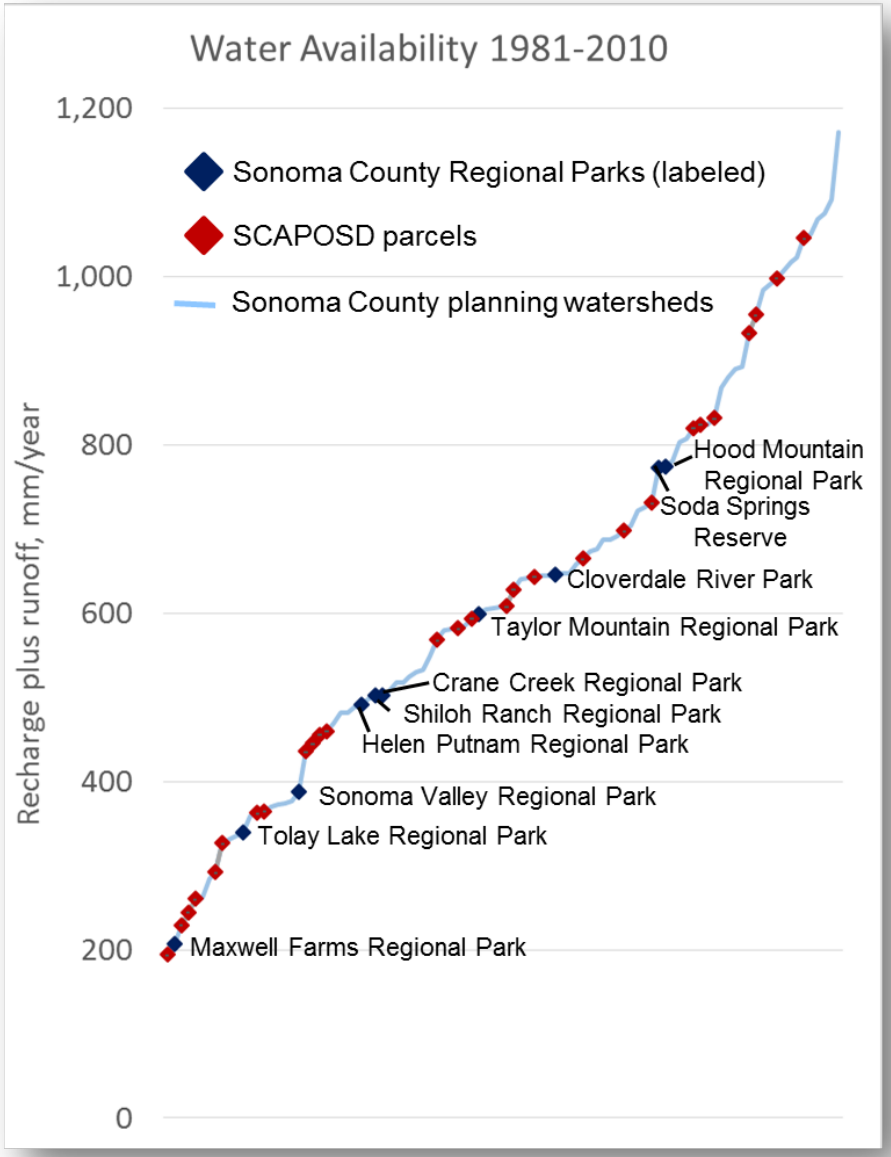
Scenario 6
Hot &
Low Rainfall



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

Recharge is less variable than runoff across all futures

How do the Regional Parks and District parcel water availability values compare with the distribution for all Sonoma County watersheds?



- When compared to all Sonoma County watersheds, the parks span most of the range of all watersheds for water availability, and District parcels span the entire range.
- Some parks and District parcels are clustered together, suggesting similar conditions for water availability
- Maxwell Farms, Tolay Lake and Sonoma Valley display the lowest water availability
- Hood Mtn and Soda Springs display the highest water availability

What is the historical and projected range in available water (runoff plus recharge) for Regional Parks parcels?

	1981-2010	2040-2069			2070-2099		
Water availability (Recharge + Runoff)	Current	Warm & high rainfall	Warm & moderate rainfall	Hot & low rainfall	Warm & high rainfall	Warm & moderate rainfall	Hot & low rainfall
Regional Parks	(in/yr)	% chg	% chg	% chg	% chg	% chg	% chg
Maxwell Farms Regional Park	8.2	82%	-5%	-48%	127%	31%	-55%
Tolay Lake Regional Park	13.3	56%	-5%	-41%	88%	20%	-44%
Sonoma Valley Regional Park	15.3	60%	0%	-36%	90%	23%	-39%
Helen Putnam Regional Park	19.3	41%	-6%	-35%	65%	14%	-36%
Shiloh Ranch Regional Park	19.8	52%	2%	-30%	74%	18%	-30%
Taylor Mountain Regional Park	23.6	41%	-1%	-28%	59%	14%	-28%
Hood Mountain Regional Park	30.5	41%	0%	-26%	58%	14%	-27%
Soda Springs Reserve	30.4	39%	-1%	-27%	55%	10%	-26%
Crane Creek Regional Park	19.8	56%	6%	-24%	79%	25%	-25%
Cloverdale River Park	25.4	46%	2%	-25%	63%	14%	-24%
Average	*20.6*	*51%*	*-1%*	*-32%*	*76%*	*18%*	*-33%*

See Parks and OSD tables.xlsx

Parks sorted by last column

What is the historical and projected range in available water (runoff plus recharge) for District parcels?

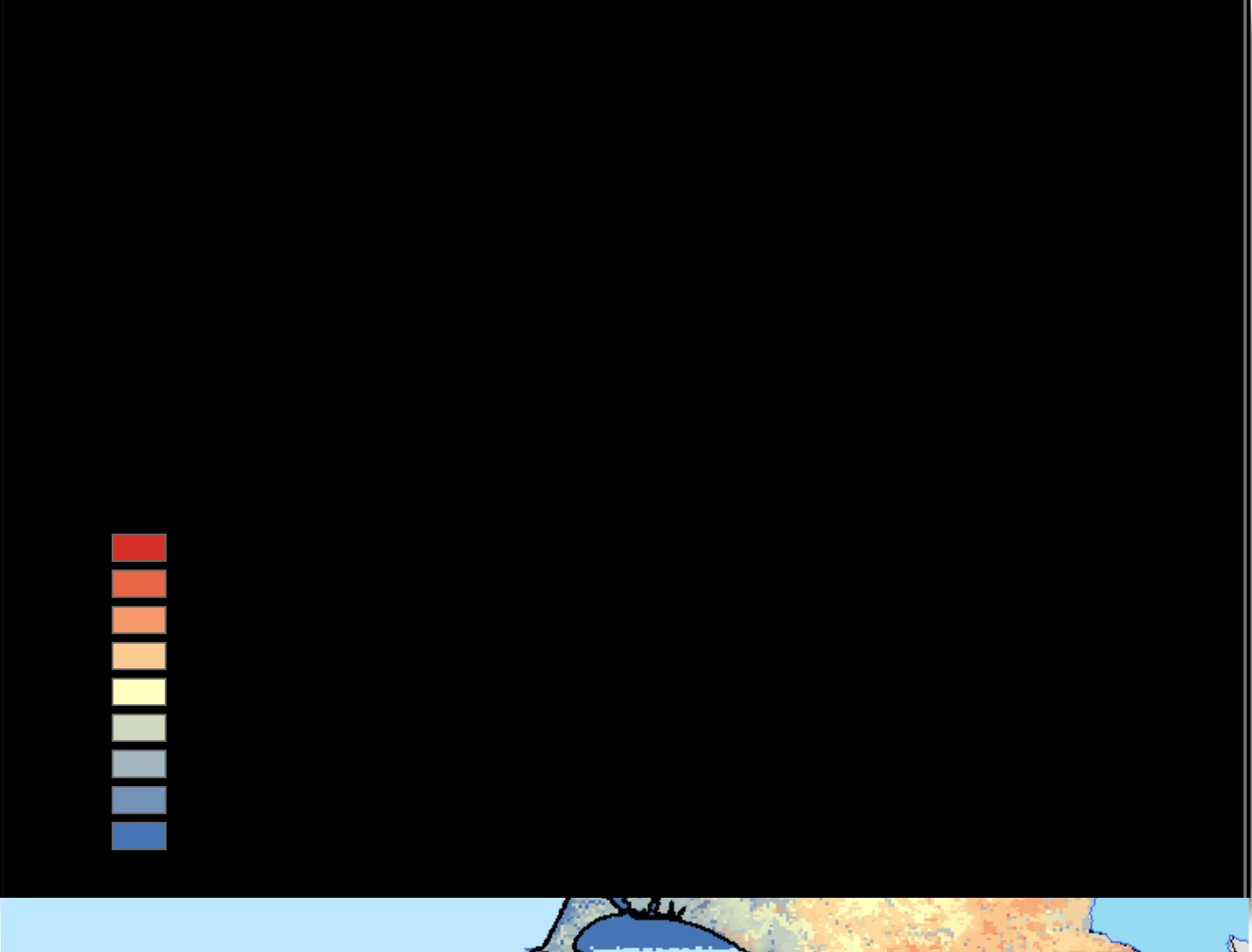
	1981-2010	2040-2069			2070-2099		
Water availability (Recharge + Runoff)	Current	Warm & high rainfall	Warm & moderate rainfall	Hot & low rainfall	Warm & high rainfall	Warm & moderate rainfall	Hot & low rainfall
SCAPOSD parcels	(in/yr)	% chg	% chg	% chg	% chg	% chg	% chg
Dogbane Preserve	7.0	115%	-1%	-50%	170%	39%	-61%
Haroutunian - North	7.7	113%	1%	-47%	167%	40%	-57%
Haroutunian - South	9.6	74%	-9%	-47%	115%	24%	-54%
San Francisco Archdiocese	10.2	75%	-8%	-46%	115%	26%	-53%
Occidental Road Wetland Transfer	11.5	72%	-9%	-45%	110%	24%	-52%
Ho	9.0	97%	6%	-42%	144%	42%	-49%
Wright Preservation Bank	12.9	60%	-9%	-43%	93%	18%	-48%
Oken	14.3	60%	-2%	-38%	90%	21%	-41%
Young/Armos	14.4	60%	1%	-32%	88%	24%	-35%
Calabasas Creek Open Space Preserve	22.9	47%	-1%	-33%	68%	15%	-34%
Healdsburg Ridge Open Space Preserve - Sonoma Land Trust	22.4	45%	-4%	-33%	64%	11%	-33%
Healdsburg Ridge Open Space Preserve	23.4	42%	-4%	-32%	61%	10%	-32%
Paulin Creek Preserve	17.9	43%	-3%	-32%	65%	14%	-32%
McCullough	23.9	43%	-2%	-31%	62%	12%	-31%
Cresta	24.7	41%	-2%	-30%	59%	11%	-30%
Auberge	26.2	44%	0%	-29%	62%	15%	-29%
Carrington Ranch	17.6	60%	6%	-28%	87%	25%	-29%
Keegan and Coppin	25.3	37%	-3%	-29%	55%	11%	-29%
McCrea Fee	36.7	33%	-3%	-27%	49%	9%	-28%
Montini Open Space Preserve	18.1	48%	1%	-28%	70%	21%	-28%
Cresta II	27.5	36%	-3%	-28%	52%	10%	-28%
Coopers Grove	32.4	39%	0%	-25%	56%	13%	-26%
Sonoma Mountain Trail Corridor - Skiles	39.3	34%	-1%	-25%	49%	11%	-26%
Saddle Mountain Open Space Preserve	28.8	42%	1%	-25%	58%	14%	-26%
Sonoma Mountain Trail Corridor - Wilroth Donation	37.6	36%	-1%	-25%	51%	11%	-26%
Sonoma Mountain Ranch	41.2	36%	0%	-24%	51%	12%	-25%
Jacobs Ranch	32.3	41%	1%	-24%	58%	15%	-25%
Wright Hill Ranch	32.8	44%	3%	-23%	62%	17%	-23%
Average	32.7	39%	0%	-25%	56%	13%	-26%

See CRNB SCPAOSD and Parks parcels-water supply and deficits.xlsx

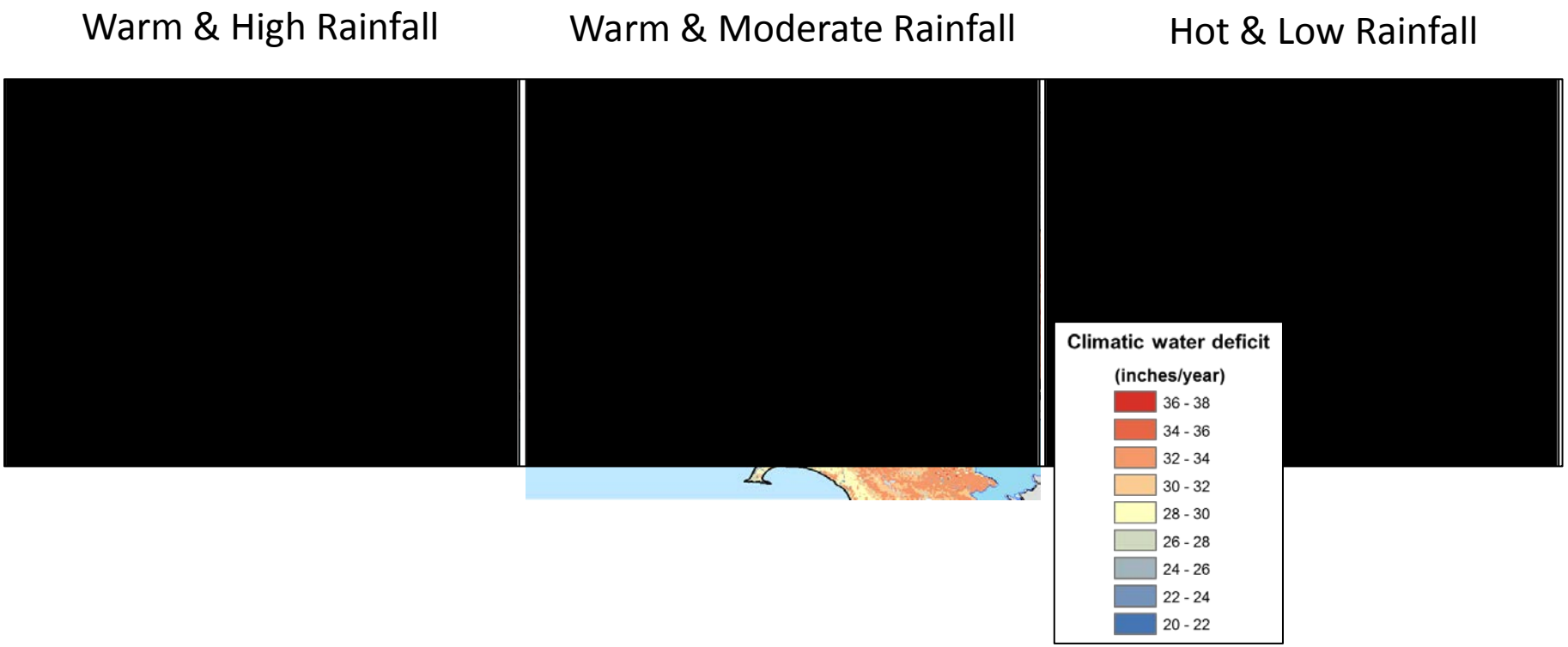
Parcels sorted by last column

Management Question

Which parcels in the combined portfolio are prone to extreme drought stress?

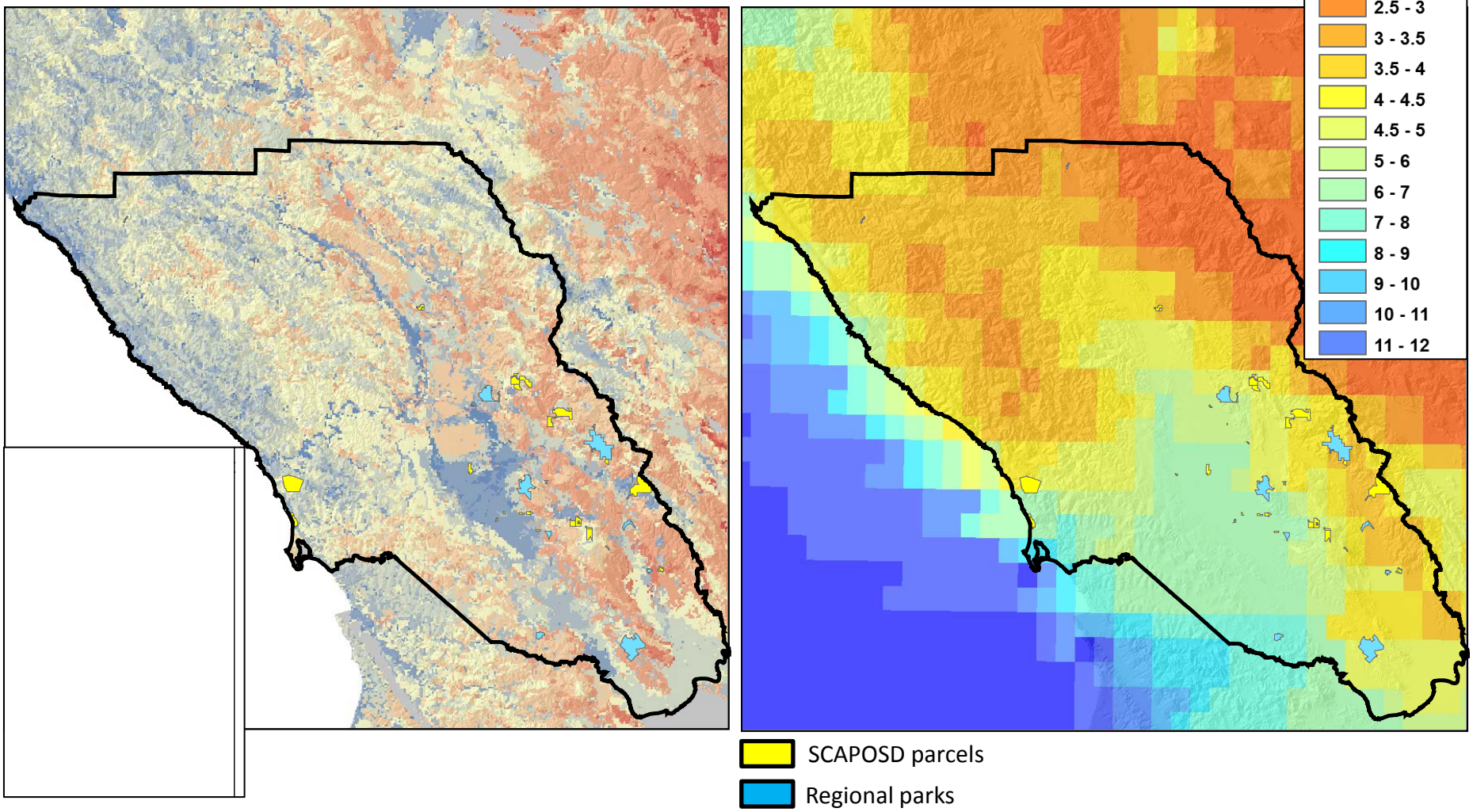


Projected Climatic Water Deficit 2040-2069

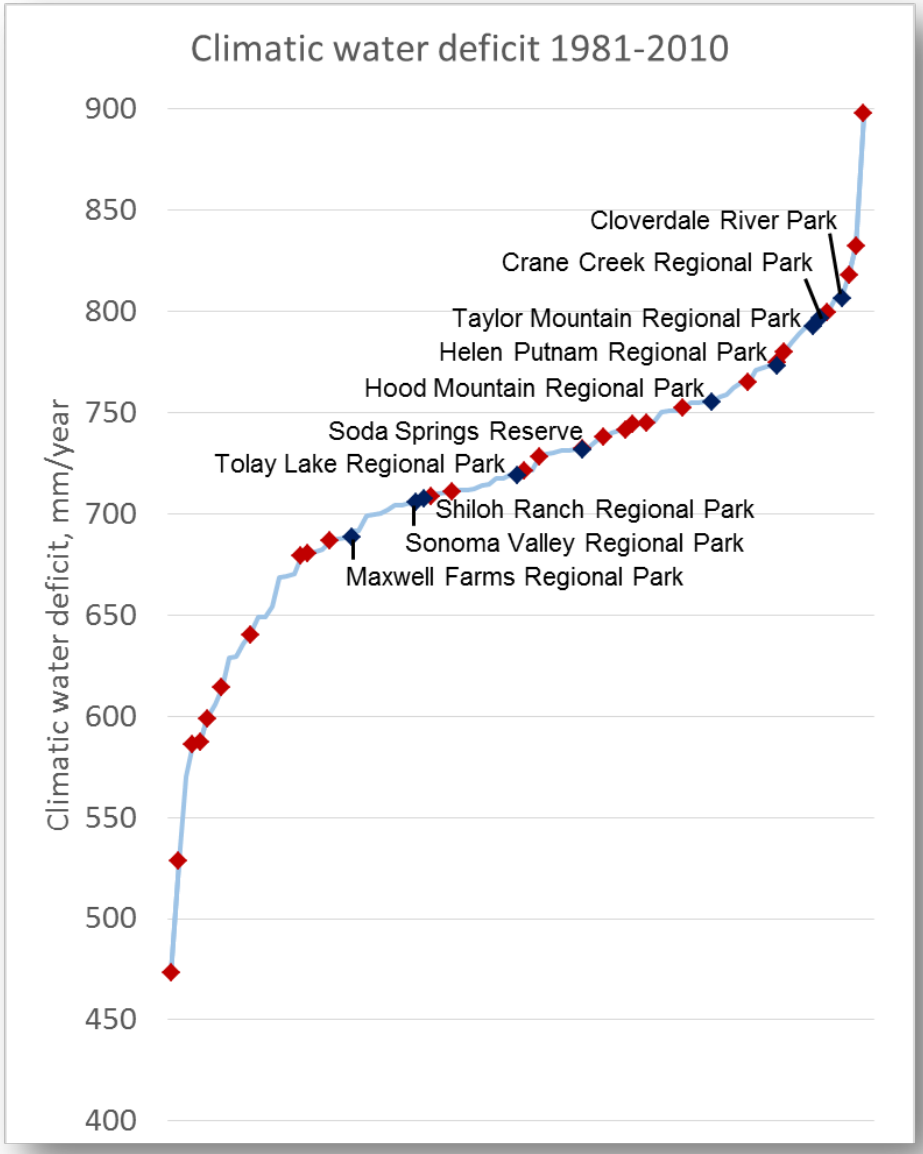


- CWD increases by mid-century due to increases in air temperature and evapotranspiration for all scenarios
- The largest increases are projected for lower elevation locations in the southern-most parts of Sonoma County
- CWD correlates to irrigation demand, landscape stress, vegetation distributions, and fire risks

Will fog help offset rises in CWD in Sonoma County?
Future patterns of fog are uncertain



How do the Regional Parks and District parcel CWD values compare with the distribution for all Sonoma County watersheds?



- Represented in the context of all Sonoma County watersheds parks tend to be located in the drier watersheds with the highest deficits
- OSD parcels span the entire range of CWD for all watersheds
- Maxwell Farms, Sonoma Valley, and Shiloh Ranch are the parks with the lowest deficits
- Cloverdale River, Crane Creek and Taylor Mtn are the parks with the highest deficits

What is the historical and projected range in landscape drought stress (CWD) for Regional Parks parcels?

	1981-2010	2040-2069			2070-2099		
Landscape Stress (CWD)	Current	Warm & high rainfall	Warm & moderate rainfall	Hot & low rainfall	Warm & high rainfall	Warm & moderate rainfall	Hot & low rainfall
Regional Parks	(in/yr)	% chg	% chg	% chg	% chg	% chg	% chg
Maxwell Farms Regional Park	27.1	5%	7%	18%	11%	12%	26%
Soda Springs Reserve	28.8	8%	10%	14%	13%	13%	25%
Tolay Lake Regional Park	28.3	5%	7%	15%	11%	11%	23%
Sonoma Valley Regional Park	27.8	5%	6%	14%	10%	10%	23%
Shiloh Ranch Regional Park	27.9	4%	6%	12%	9%	10%	21%
Helen Putnam Regional Park	30.4	5%	6%	12%	10%	11%	21%
Hood Mountain Regional Park	29.7	4%	5%	11%	9%	9%	20%
Taylor Mountain Regional Park	31.2	5%	6%	11%	9%	10%	20%
Crane Creek Regional Park	31.4	4%	5%	10%	8%	9%	19%
Cloverdale River Park	31.7	3%	4%	8%	7%	7%	17%
Average	*29.4*	*5%*	*6%*	*12%*	*10%*	*10%*	*21%*

See Parks and OSD tables.xlsx

Parks sorted by last column

What is the historical and projected range in landscape drought stress (CWD) for SCAPOSD parcels?

	1981-2010	2040-2069			2070-2099		
Landscape Stress (CWD)	Current	Warm & high rainfall	Warm & moderate rainfall	Hot & low rainfall	Warm & high rainfall	Warm & moderate rainfall	Hot & low rainfall
SCAPOSD parcels	(in/yr)	% chg	% chg	% chg	% chg	% chg	% chg
Dogbane Preserve	18.9	5%	12%	31%	13%	16%	41%
Haroutunian - North	18.6	4%	11%	30%	12%	16%	40%
Occidental Road Wetland Transfer	20.8	6%	10%	23%	14%	15%	33%
San Francisco Archdiocese	23.1	6%	10%	22%	14%	15%	32%
Haroutunian - South	23.6	7%	10%	22%	14%	15%	31%
Ho	23.1	5%	9%	21%	13%	14%	31%
Wright Preservation Bank	24.2	6%	9%	19%	13%	14%	28%
Carrington Ranch	25.2	6%	8%	15%	12%	12%	26%
Oken	26.7	5%	8%	15%	11%	12%	25%
Wright Hill Ranch	27.0	6%	7%	12%	11%	10%	23%
Calabasas Creek Open Space Preserve	26.8	5%	6%	13%	10%	10%	23%
Young/Armos	28.8	5%	6%	14%	10%	11%	22%
McCullough	27.9	5%	6%	12%	10%	10%	22%
Healdsburg Ridge Open Space Preserve - Sonoma Land Trust	28.0	4%	6%	12%	9%	10%	21%
McCrea Fee	30.1	5%	6%	11%	10%	10%	21%
Sonoma Mountain Trail Corridor - Skiles	29.0	5%	6%	11%	10%	9%	21%
Sonoma Mountain Ranch	29.3	5%	5%	10%	9%	9%	20%
Cresta	28.4	4%	6%	11%	9%	9%	20%
Coopers Grove	29.2	5%	6%	11%	9%	9%	20%
Sonoma Mountain Trail Corridor - Wilroth Donation	29.3	5%	5%	11%	9%	9%	20%
Auberge	30.5	4%	5%	10%	9%	9%	20%
Healdsburg Ridge Open Space Preserve	28.7	4%	6%	11%	9%	10%	20%
Jacobs Ranch	29.6	5%	5%	10%	9%	9%	20%
Keegan and Coppin	32.8	5%	6%	11%	9%	10%	19%
Paulin Creek Preserve	32.2	4%	6%	11%	9%	10%	19%
Saddle Mountain Open Space Preserve	30.7	4%	5%	10%	8%	9%	19%
Cresta II	31.5	4%	5%	10%	8%	9%	18%
Montini Open Space Preserve	35.4	4%	4%	9%	8%	9%	17%
Average	*31.0*	*4%*	*5%*	*10%*	*9%*	*9%*	*19%*

See Parks and OSD tables.xlsx

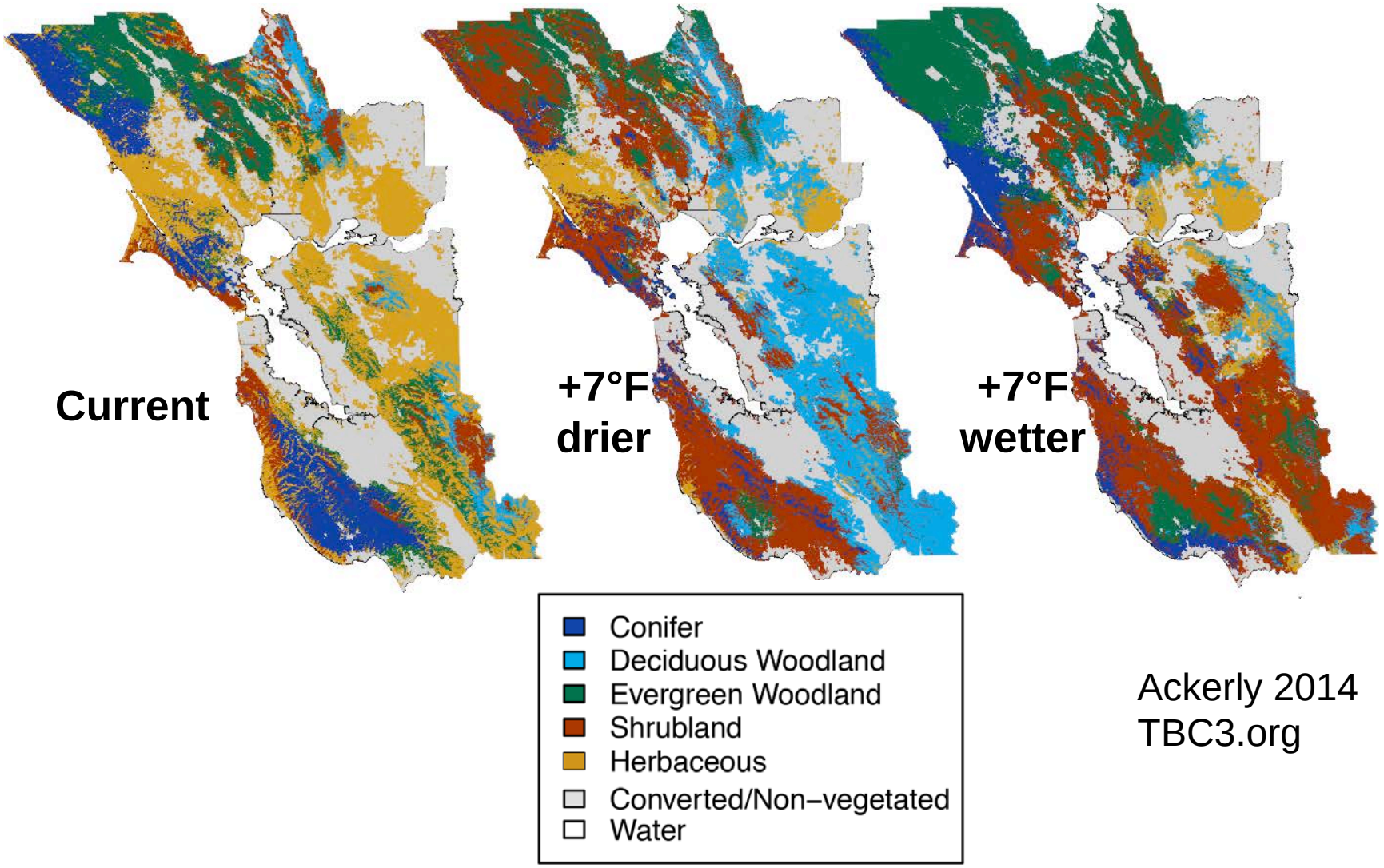
Parcels sorted by last column

Potential native vegetation responses to changing climate

Management Question

What kind of transitions in climate suitability for native vegetation may occur on parks and open space lands?

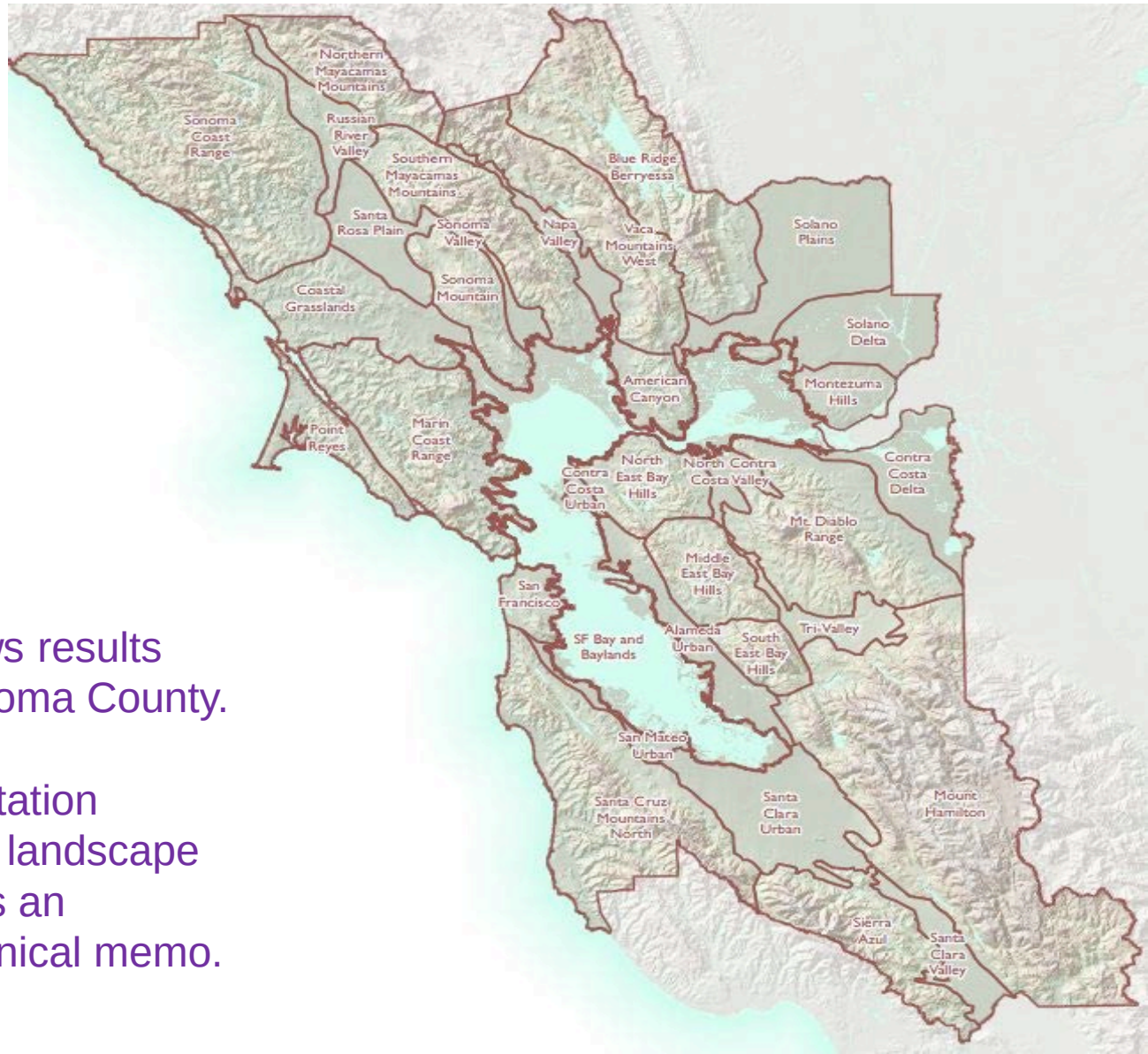
what might the Bay Area vegetation of the future look like?



Ackerly 2014
TBC3.org

Climate Ready Vegetation Reports are available for Landscape Units defined by Bay Area Upland Habitat Goals/Conservation Lands Network (2011)

There are 8 Sonoma County Landscape Units

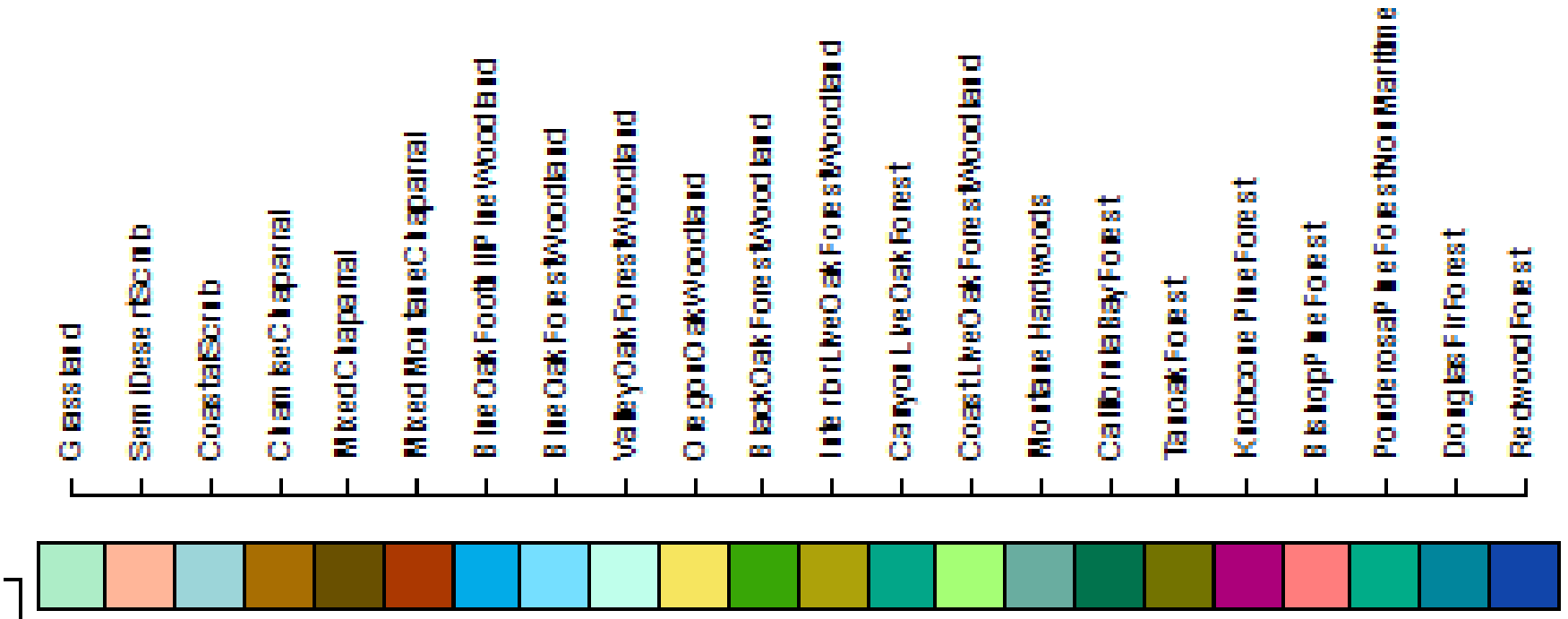


This slide deck shows results summarized for Sonoma County.

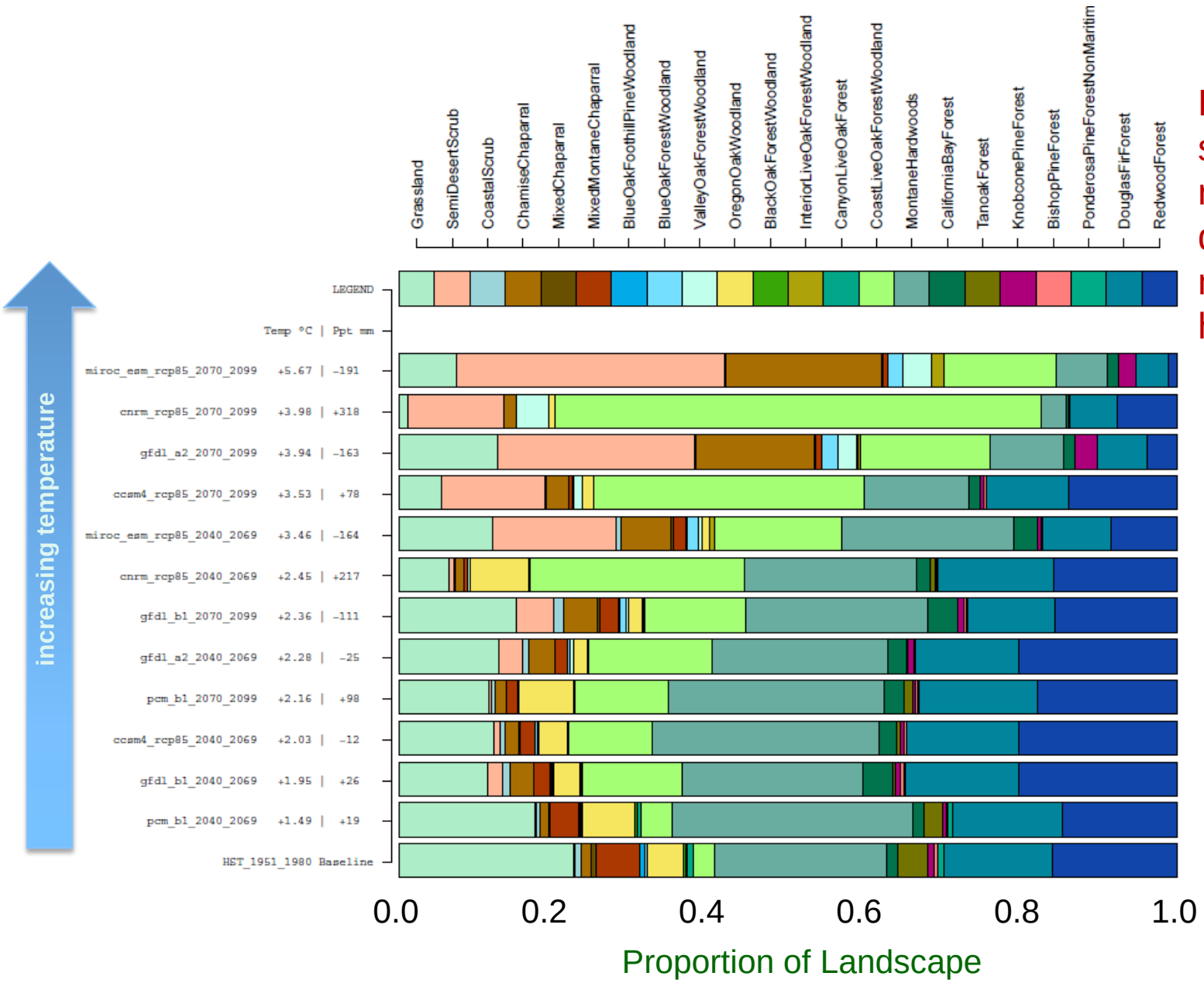
Climate Ready vegetation reports for individual landscape units are provided as an appendix to the technical memo.

Equilibrium vegetation response to climate change in Sonoma 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.



Sonoma County Vegetation Report Summary



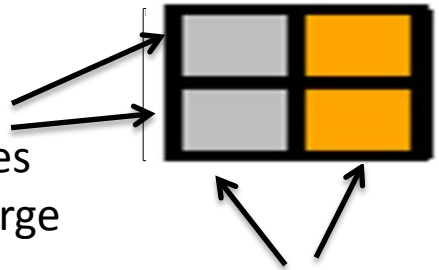
Reduced suitability for redwood, doug-fir, and montane hardwoods,

Increased suitability for coast live oak, semi-desert scrub, chamise chaparral

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

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

Rainfall

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)

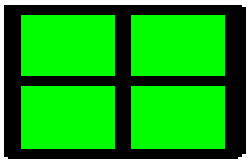
Orange: Moderate Decline (25-75% of current)

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

Green: Increase (>125% of current)

Sonoma Coast Range Species Level Examples

Example: Coast Live Oak



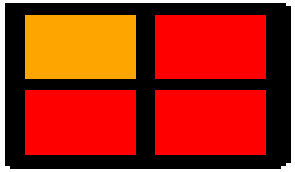
does well in all future scenarios regardless of warming magnitude and rainfall

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

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

Identify potential "winners and losers" by landscape unit

Example: Tan Oak is sensitive to rainfall and temperature



shows declines in all scenarios

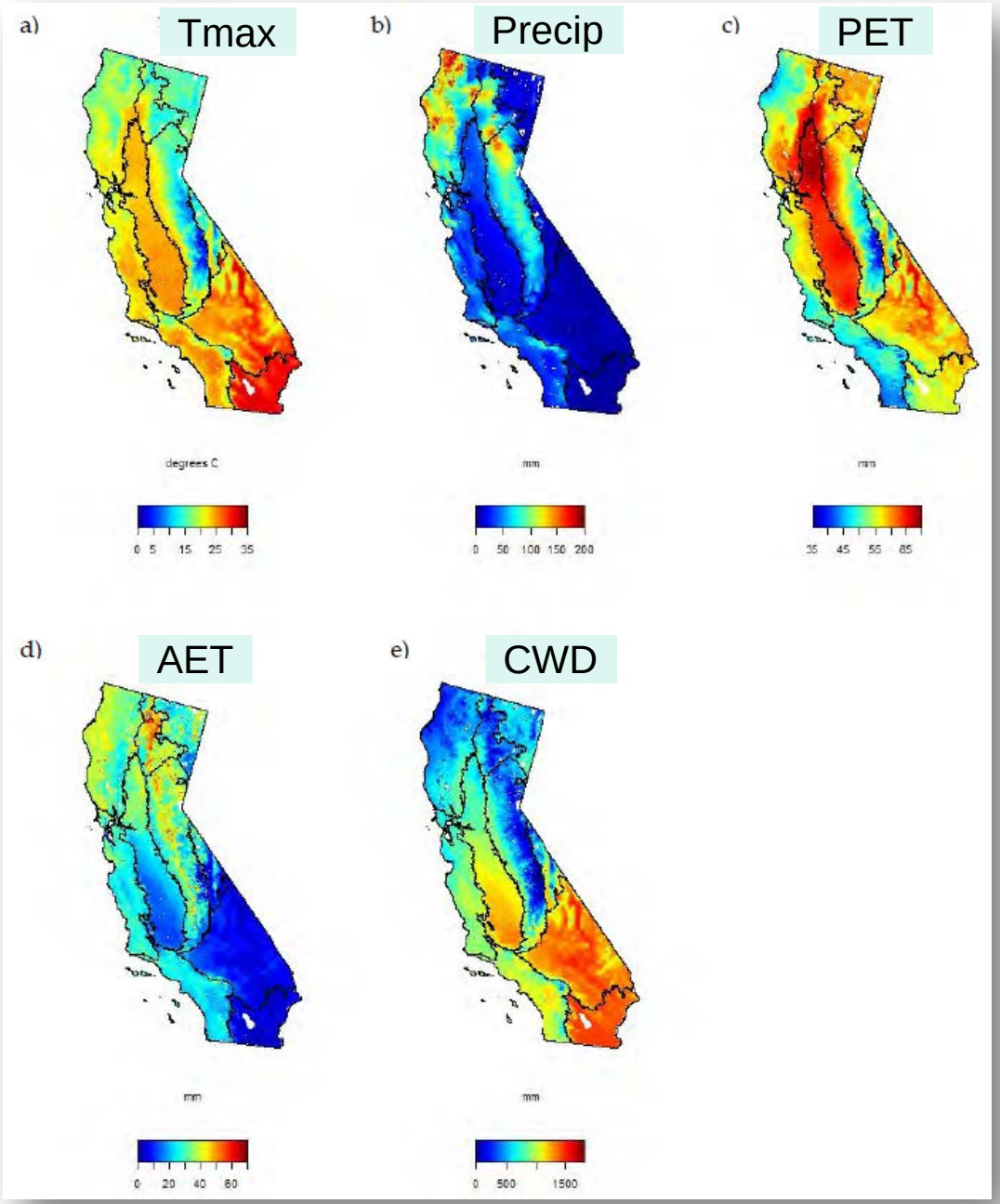
Modeled fire risks in Sonoma County

Management Question

How are fire risks projected to impact the combined parks and open space portfolio?

Statewide Fire Risk Model: BCM data inputs

Spatial Patterns in Explanatory Climate Variables
1971–2000



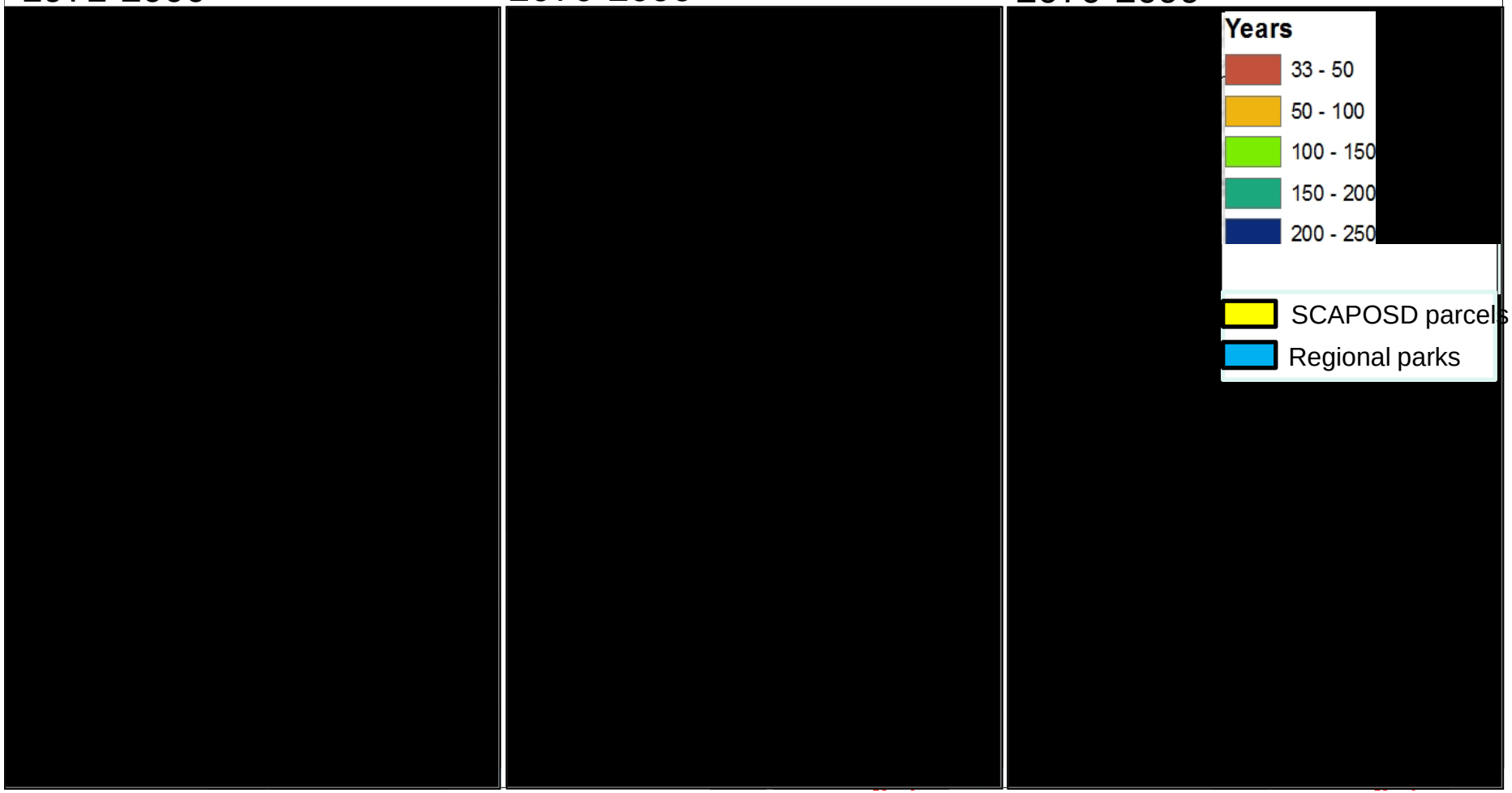
Krawchuk and Moritz 2012 PIER report

Estimated fire return intervals (years)

1971-2000

2070-2099

2070-2099

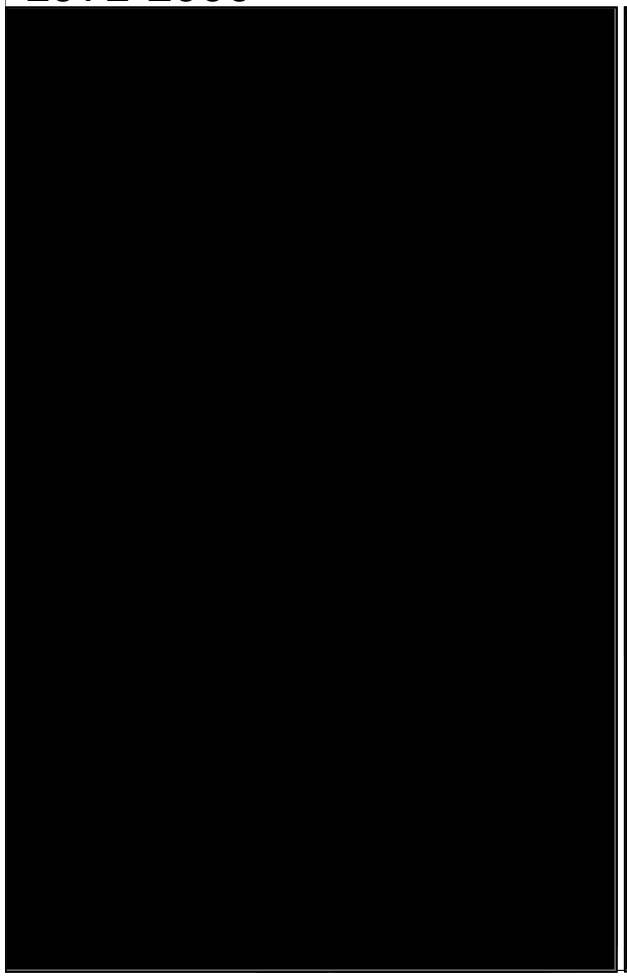


Fire return intervals cut by approximately 25%

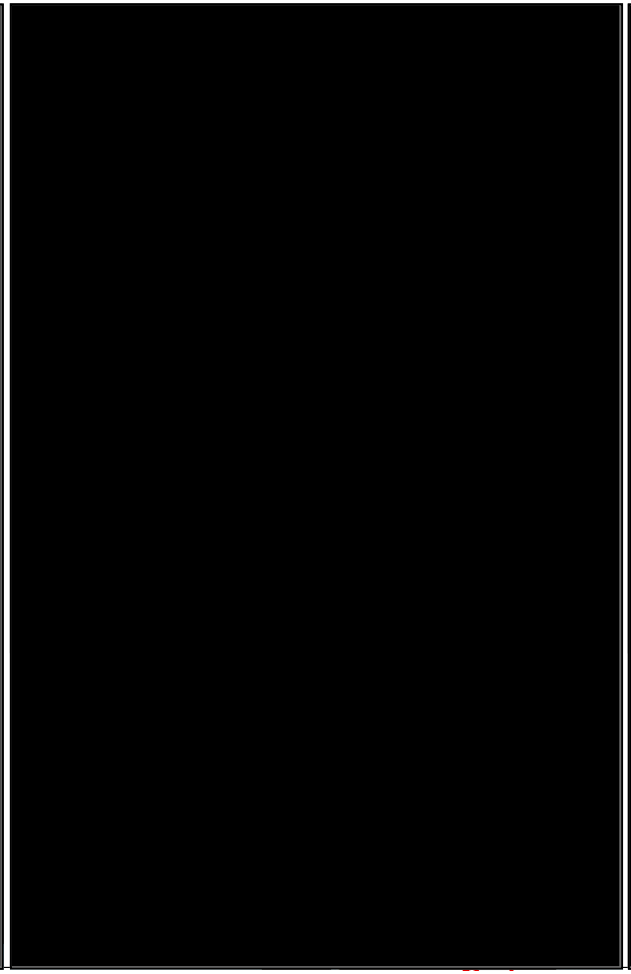
		Current	Hot, Low Rainfall		Warm, Moderate Rainfall	
Variable	Units	1971-2000	2040-2069	2070-2099	2040-2069	2070-2099
Fire return interval	Years	172	137	117	142	120
	SD	58	53	32	54	40

Probability of a fire within next 30 years

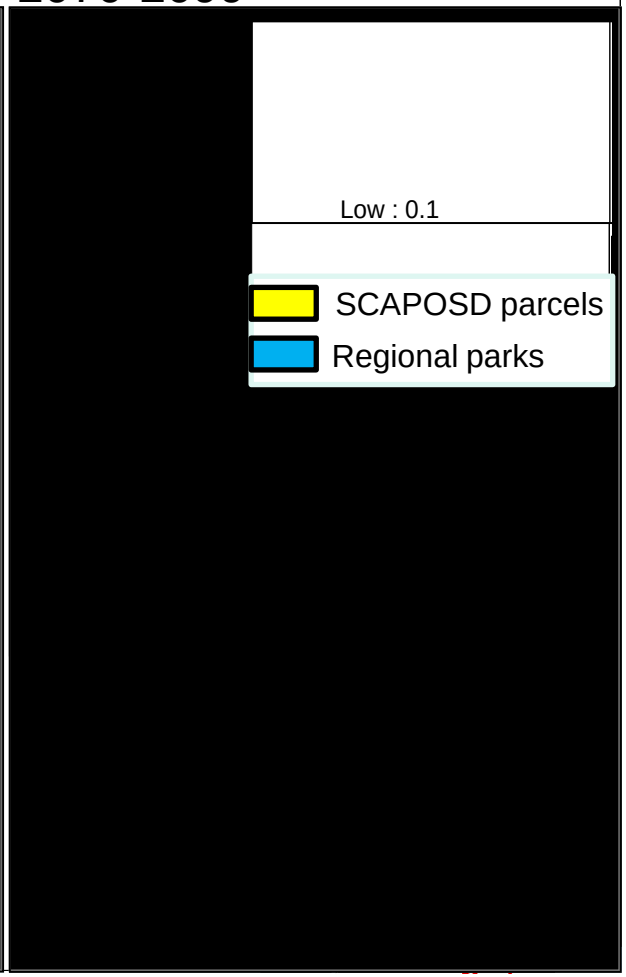
1971-2000



2070-2099



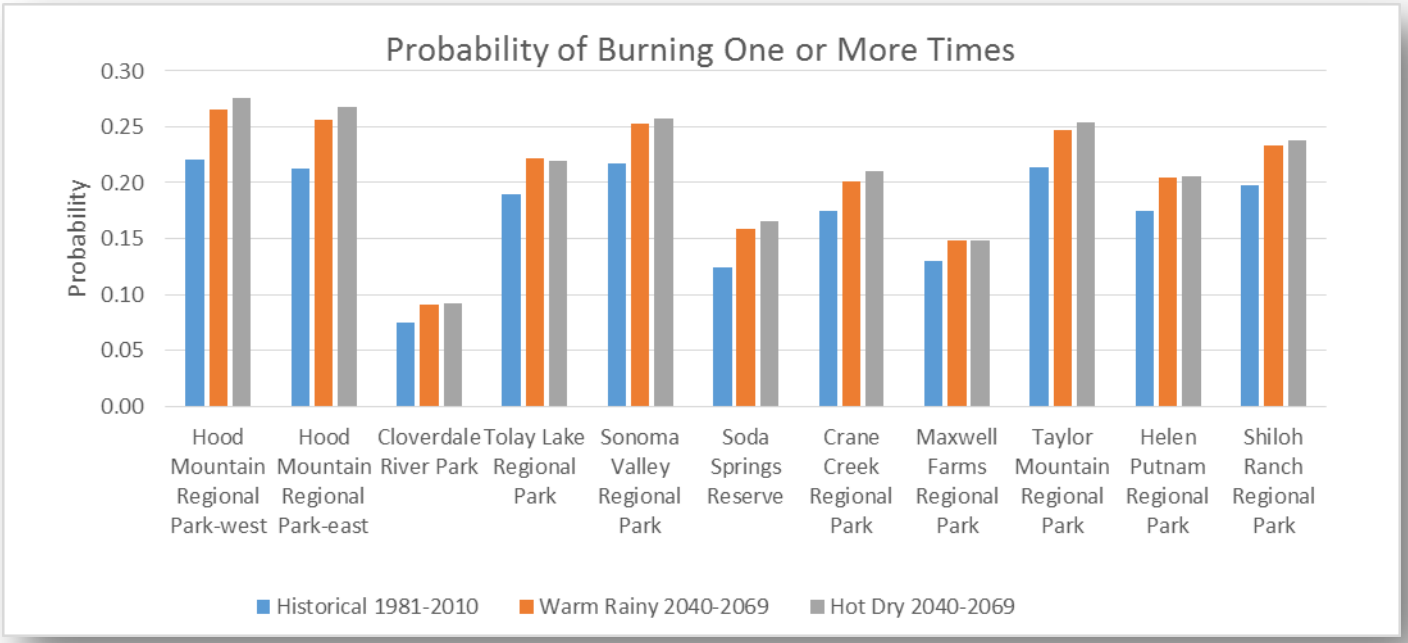
2070-2099



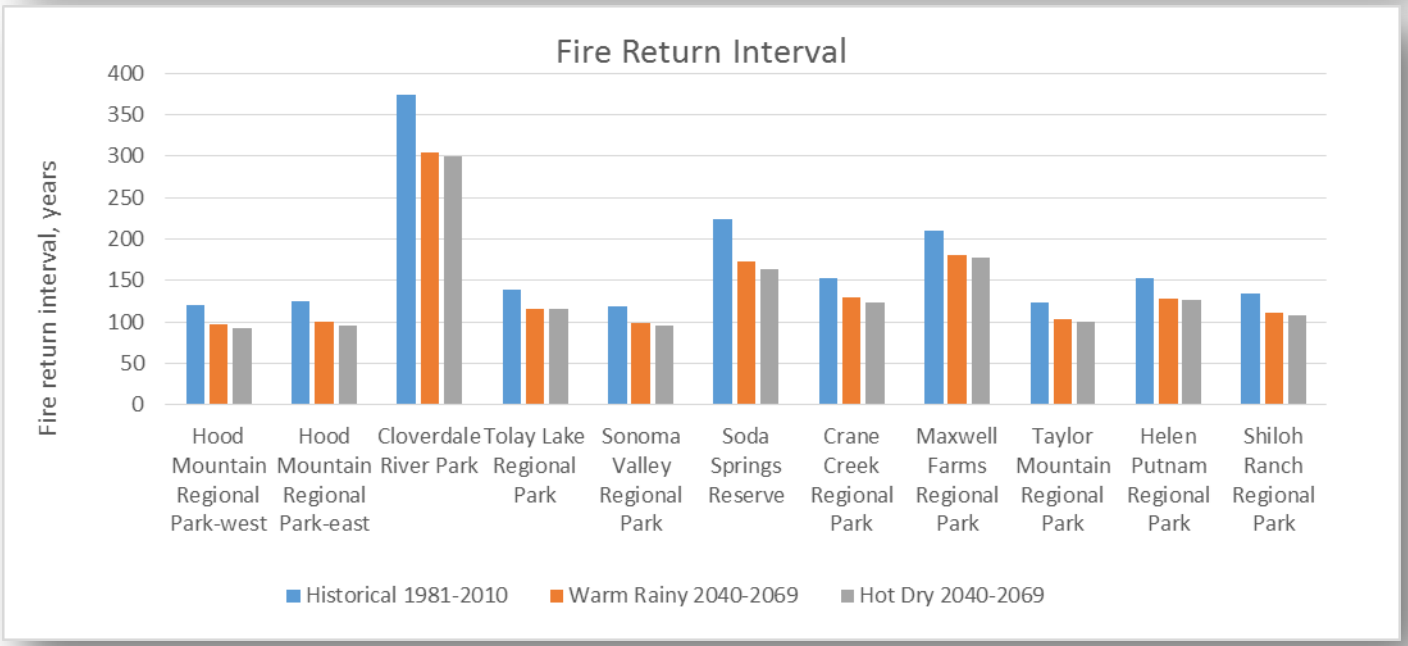
Probability of fire doubles in some locations

		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

parks



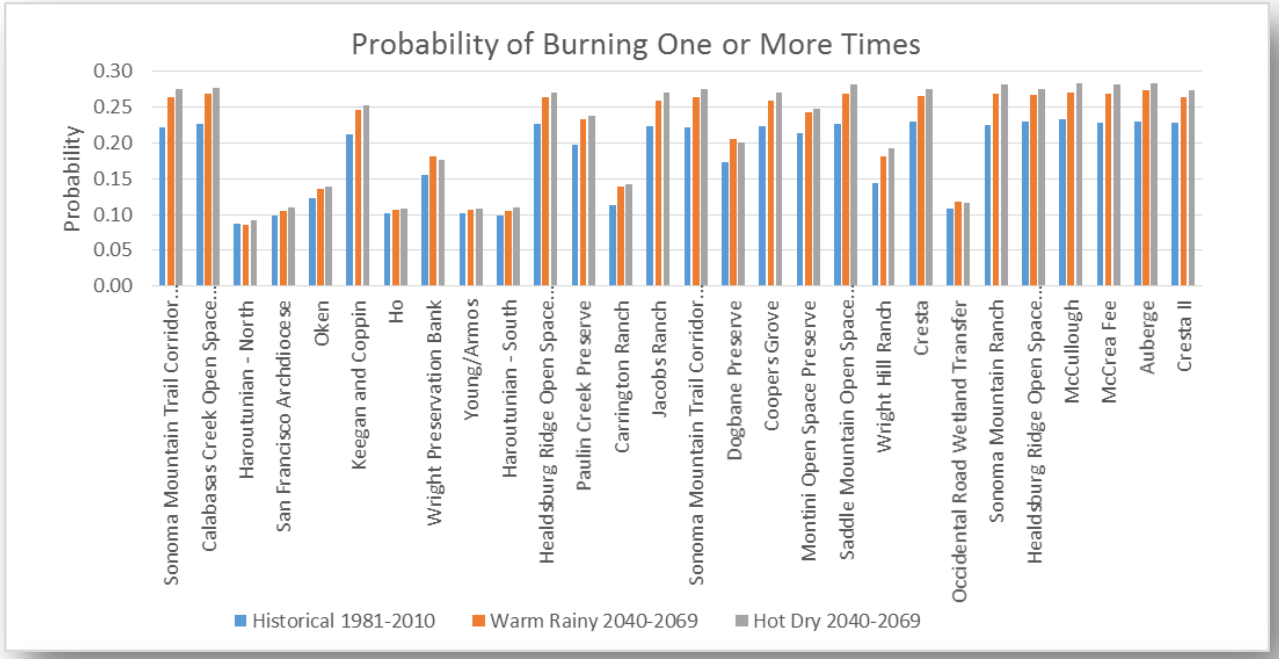
Average probability of a burn within 30 years goes up 18% by mid-century



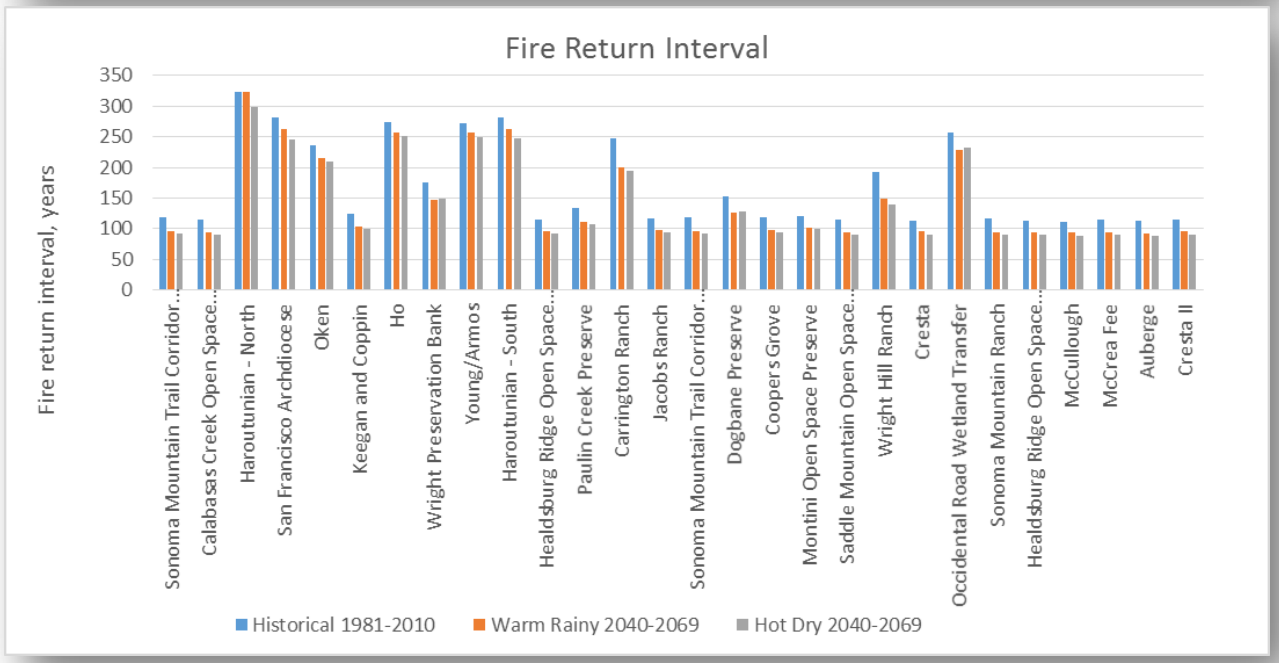
Average fire return interval goes down 18% by mid-century

See Table in "FireRisk.xls" spreadsheet

scaposd



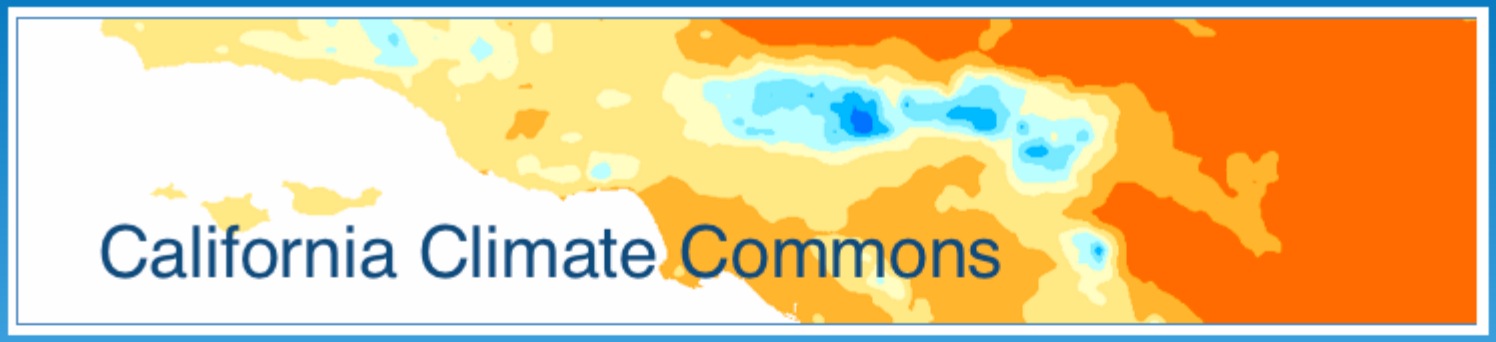
Average probability of a burn within 30 years goes up 16% by mid-century



Average fire return interval goes down 13% by mid-century

See Table in "FireRisk.xls" spreadsheet

The California Climate Commons Climate Ready Exchange Page
will showcase products selected by users



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Search the Commons

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Password *

- Create new account
- Request new password

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
  d annually

climate.calcommons.org
will host “Climate Smart Exchange” page for users