This presentation premiered at WaterSmart Innovations

watersmartinnovations.com

Simulating Future Water Demand in California with a Changing Climate

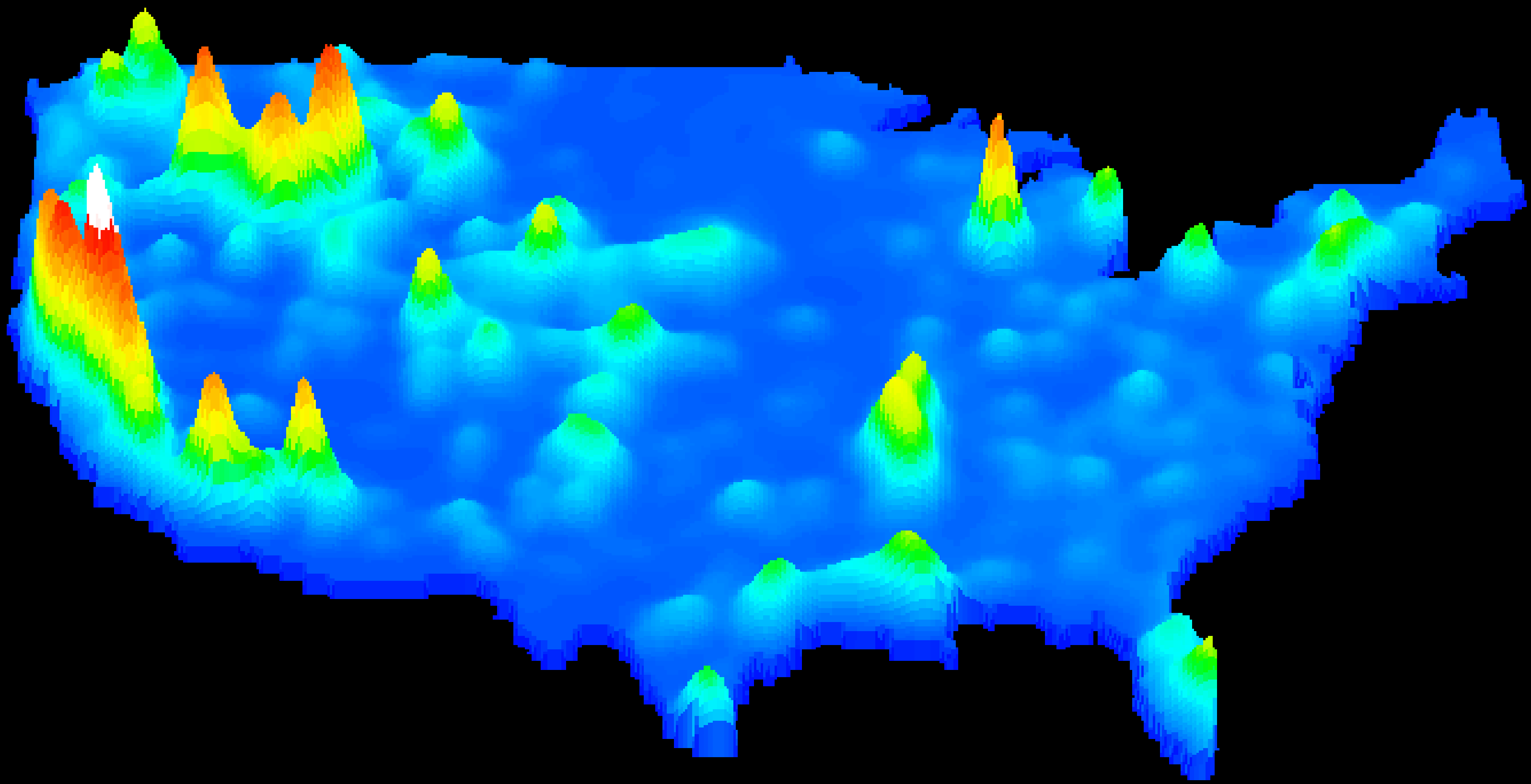
Matthew Heberger
Pacific Institute
October 6, 2011

Overview

- Water planners and managers have historically used various methods to forecast future water demand
- We have attempted to incorporate recent climate-change science to improve these estimates.
- Other important factors include population and demographics, water conservation programs and regulations, economics.
- Scenario-based planning aids water planners and managers in forecasting future demands, analyzing the impacts of policies, and ensuring the sustainability of future water supplies

Pacific Institute

1990 TOTAL WATER WITHDRAWALS
(excluding power)

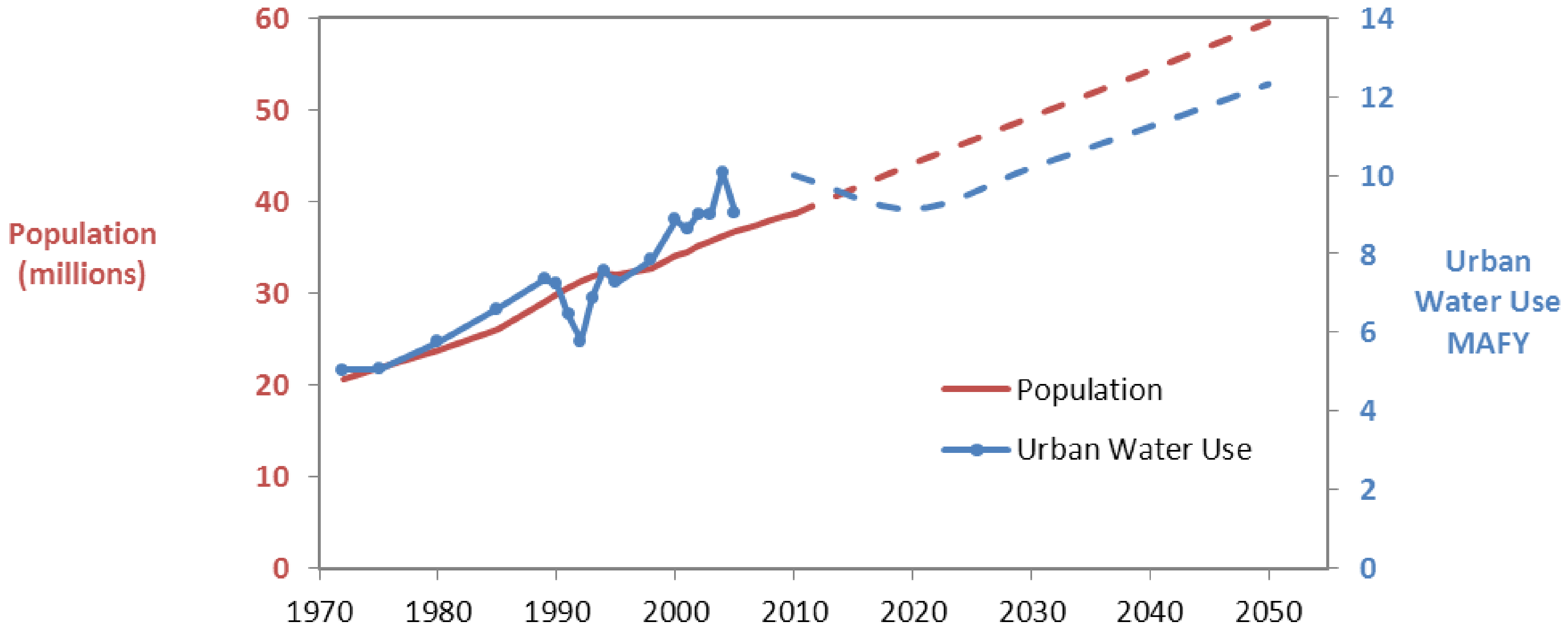


Water Demand in California

- In recent years, California used an average of 43 million acre-feet per year (53 billion m^3).
- While 70% - 80% of withdrawals are for use by irrigated agriculture, urban use is growing
- 98% of California's 38 million people currently living in cities and suburbs.
- Los Angeles, San Diego, and Sacramento were among the 12 fastest-growing US cities in the last decade
- State has added 4.5 million people since 2000.

Pacific Institute

Urban Water Use



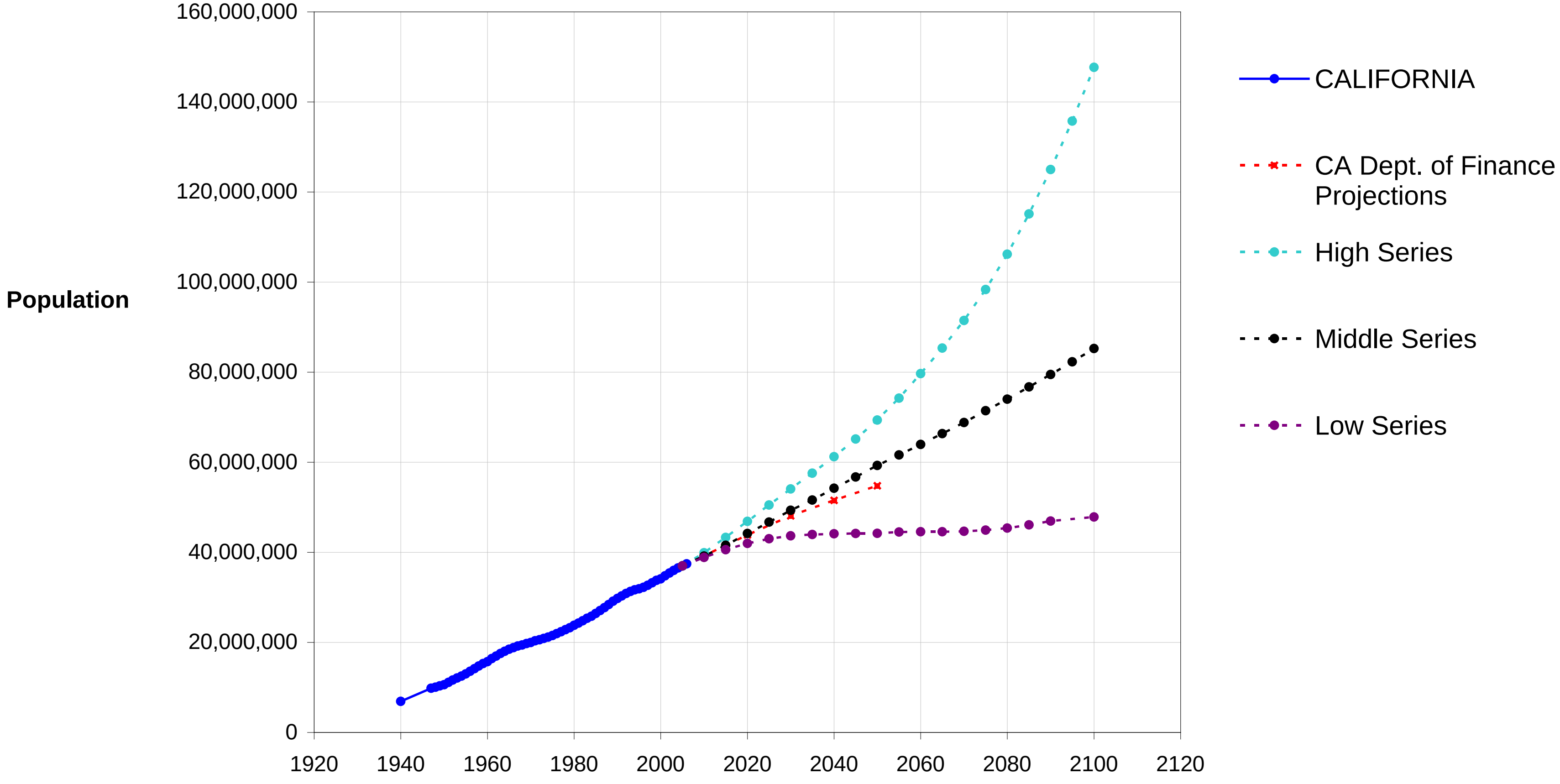
Pacific Institute

Other Factors Influencing Future Demand

- Population (how many people?)
- Demographics (where they live?)
- Land Use (what kinds of houses and yards do they have?)
- Technology (effect of water conservation)
- Commerce and Industry (changes in type and location)
- Laws (effect of landscape ordinances and plumbing codes)
- Economics (effect of water pricing policies)

Pacific Institute

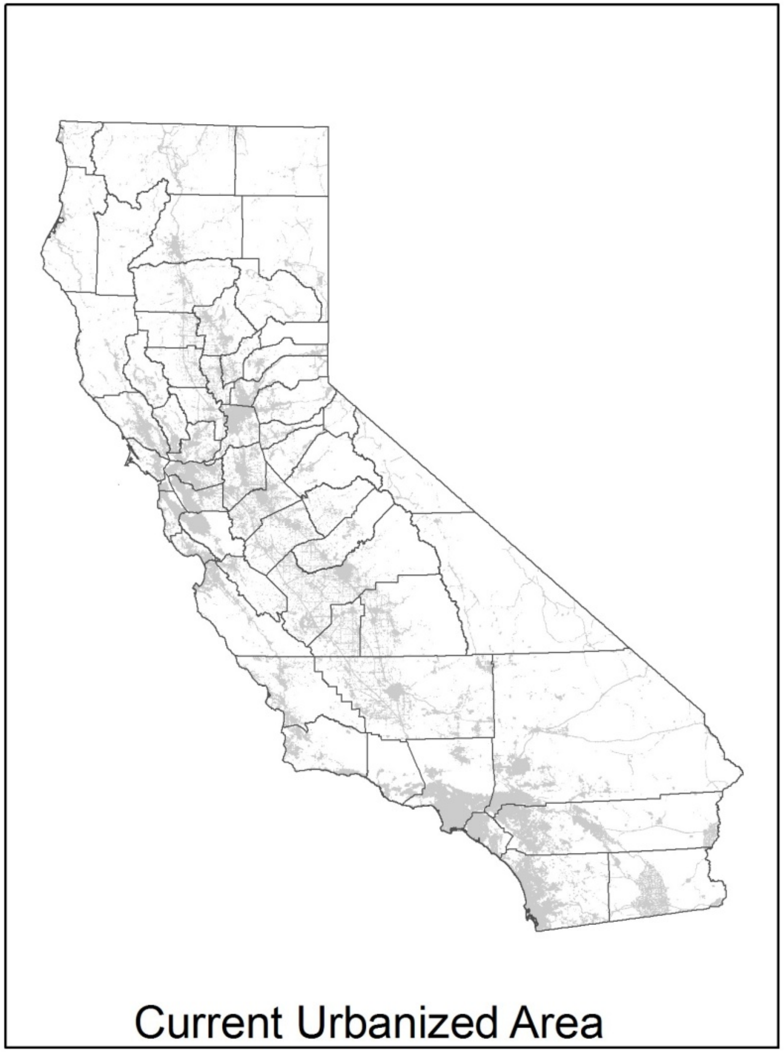
Population Projections

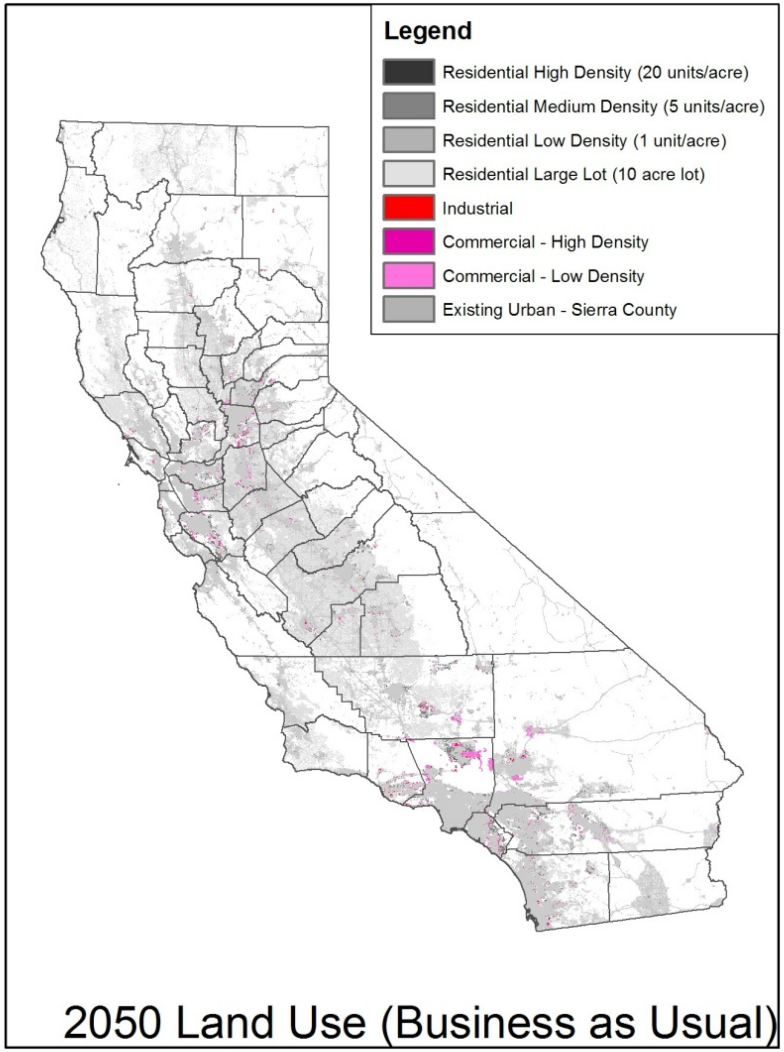


Source: California Department of Finance, Demographic Research Unit
http://www.dof.ca.gov/Research/Research.asp

Pacific Institute

Forecasts of Future Land Use

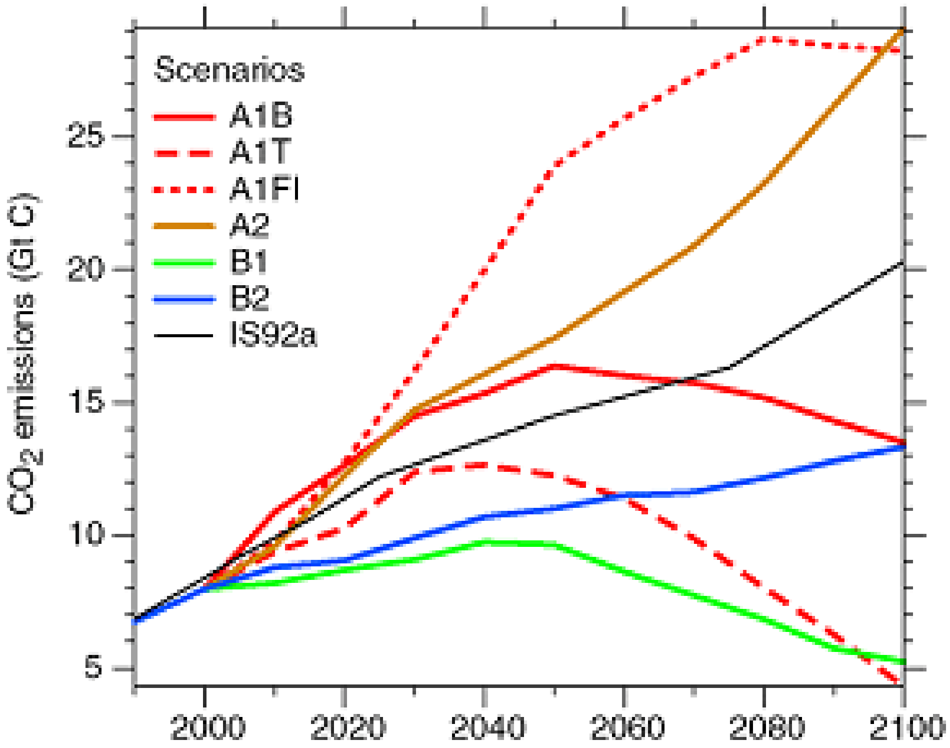




From Urban Growth Model UPlan by researchers at UC Davis

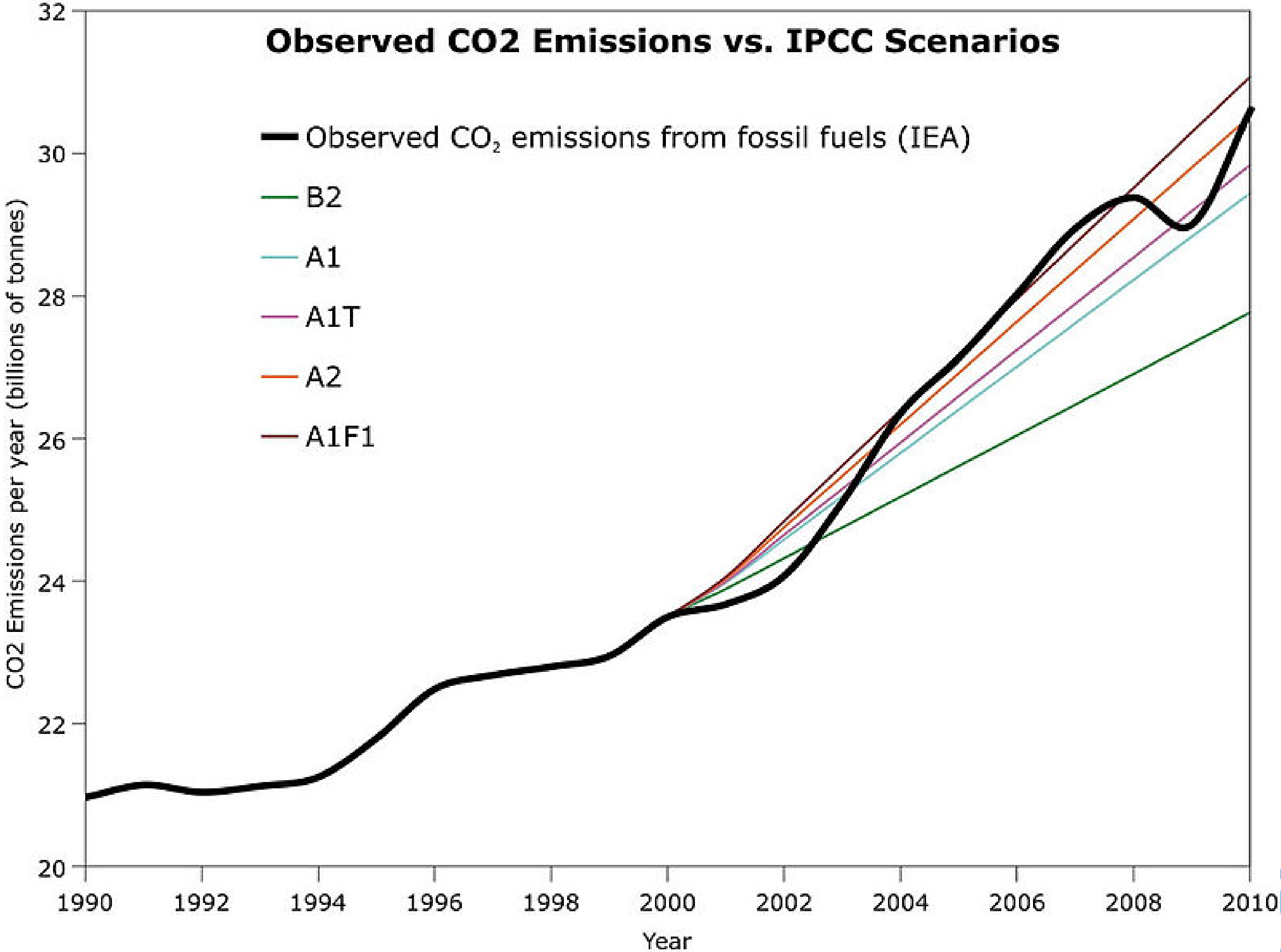
Pacific Institute

Climate Change/Emissions Scenarios



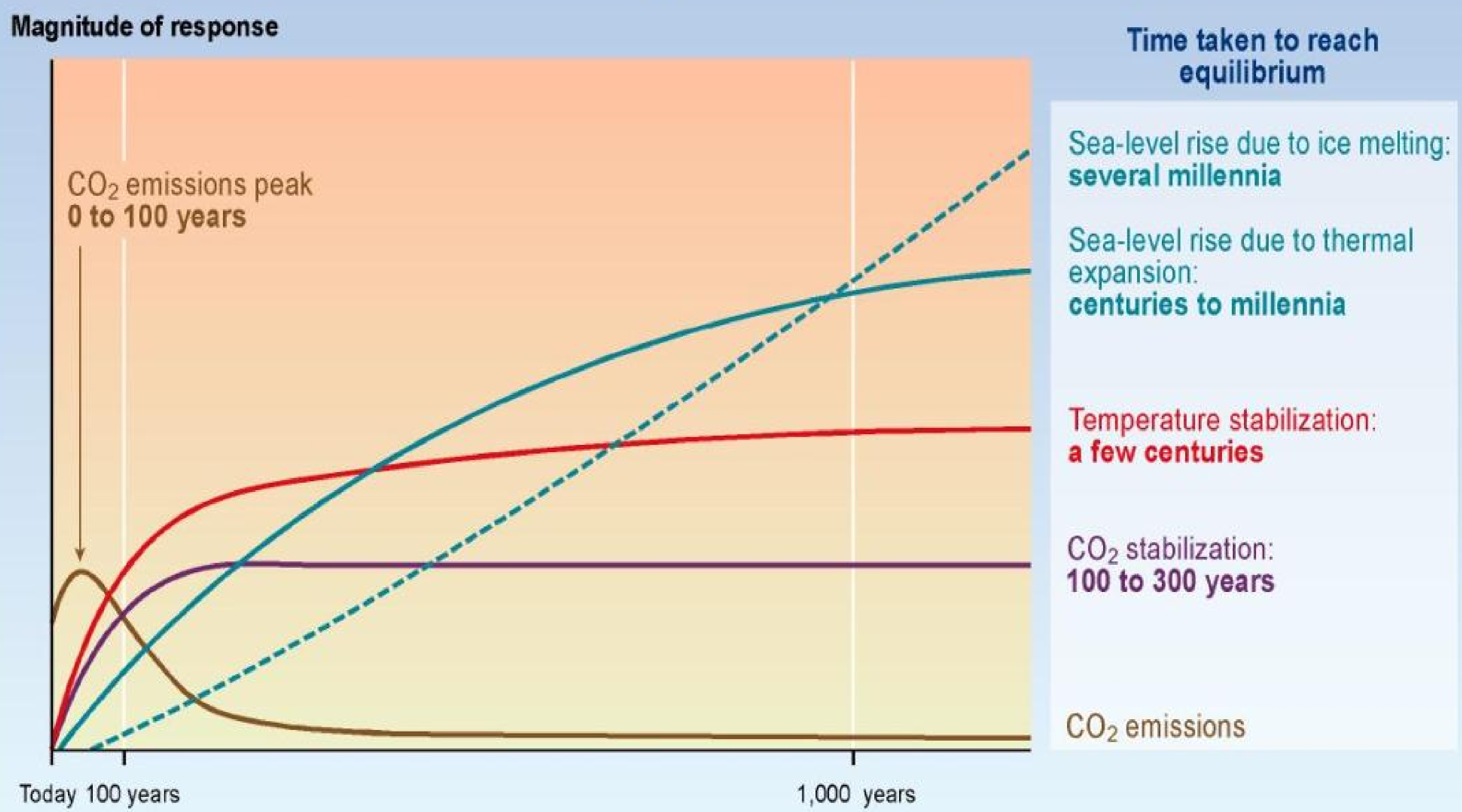
Pacific Institute

Which Climate Scenario is Most Likely?



Pacific Institute

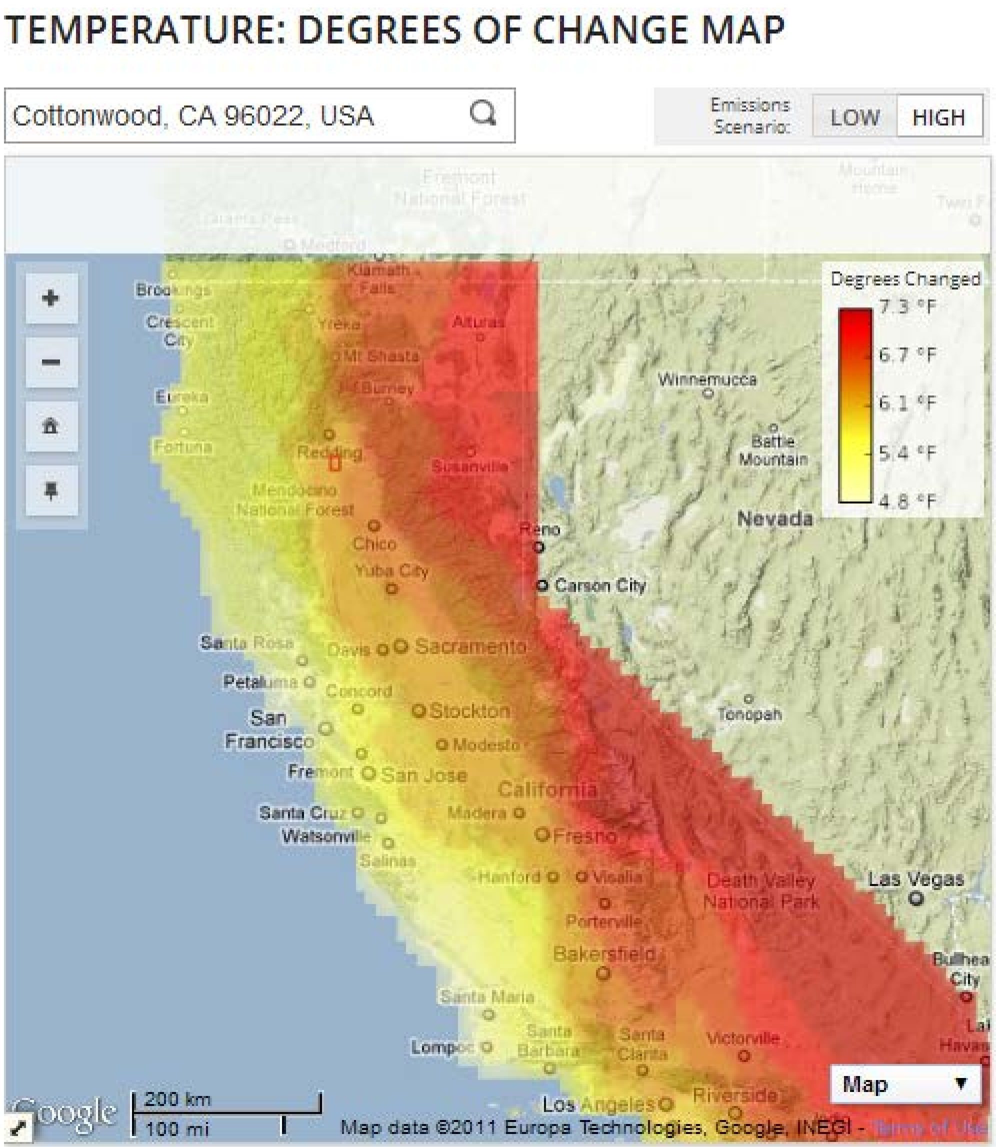
CO_2 concentration, temperature, and sea level continue to rise long after emissions are reduced

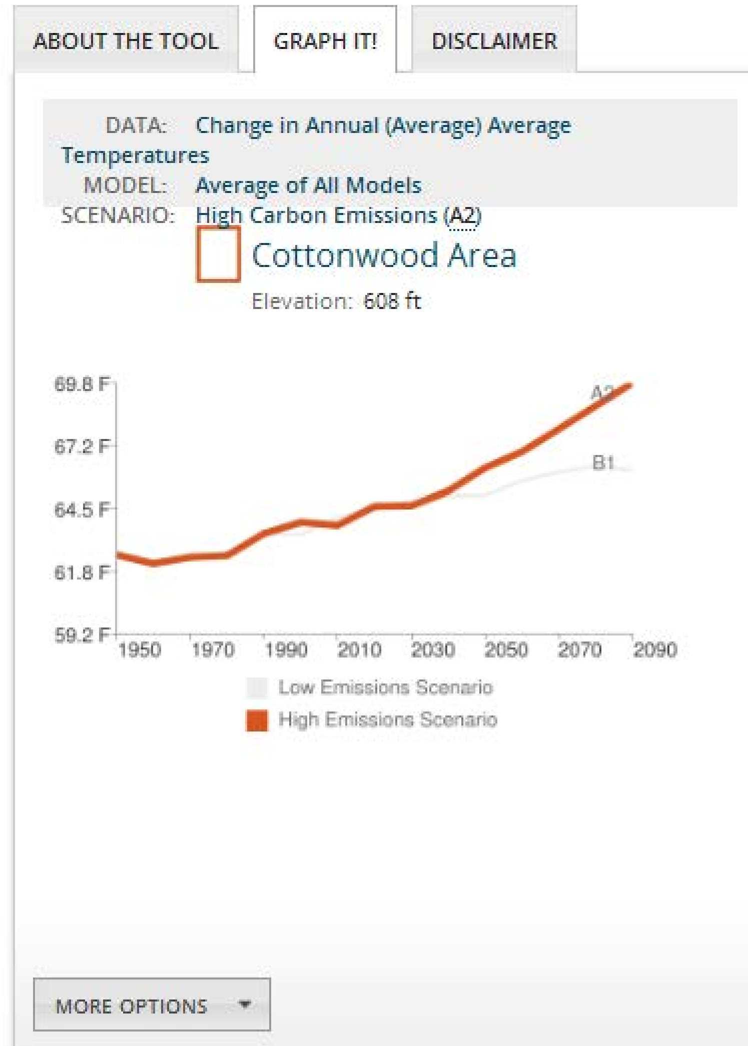


SYR - FIGURE 5-2

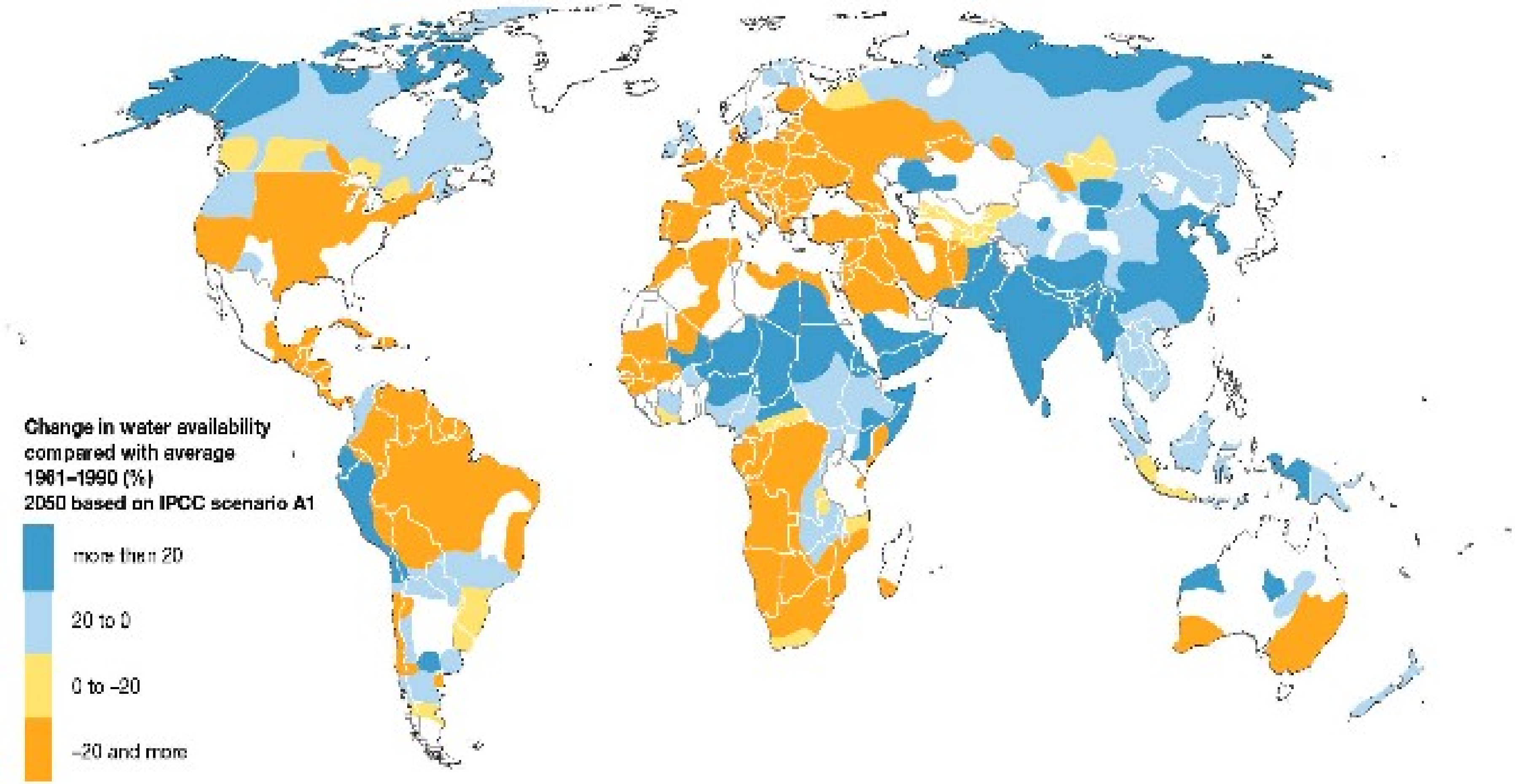
Warming

Courtesy of cal-adapt.org





Climate Change's Impact on Water Availability



Source: Arnell 2004.

Likely Effects of Climate Change on Water Demand

- Increased temperatures likely to cause an increase in evaporation
- Warming projected to cause increased demand for landscapes and evaporative cooling.
- Impacts on precipitation patterns less clear

Pacific Institute

Evaporation & Transpiration

- Consumptive water use by landscapes measured as ET = Evaporation + Transpiration
- Transpiration = loss of water vapor from pores in plant's leaves;
- Potential Evapotranspiration (PET): upper limit for how much ET would occur if sufficient moisture is available
- PET influenced by sunlight, air temperature, wind, humidity

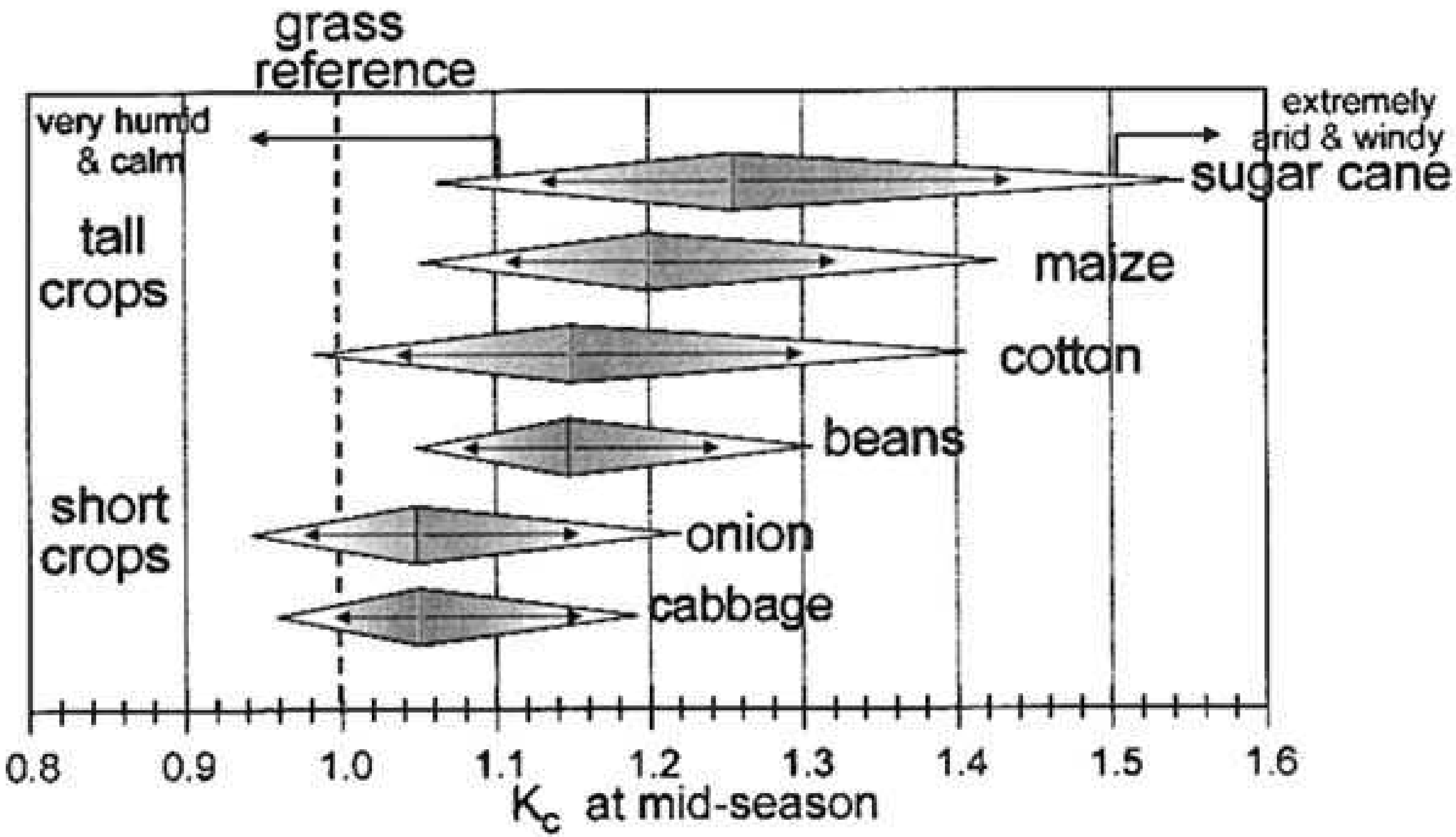
Pacific Institute

ET_o: Reference Crop ET

- Standard conditions: a well-watered grass crop.
- Can be either measured or calculated
- Water Use for any crop can be computed with the use of a "crop coefficient," k_c

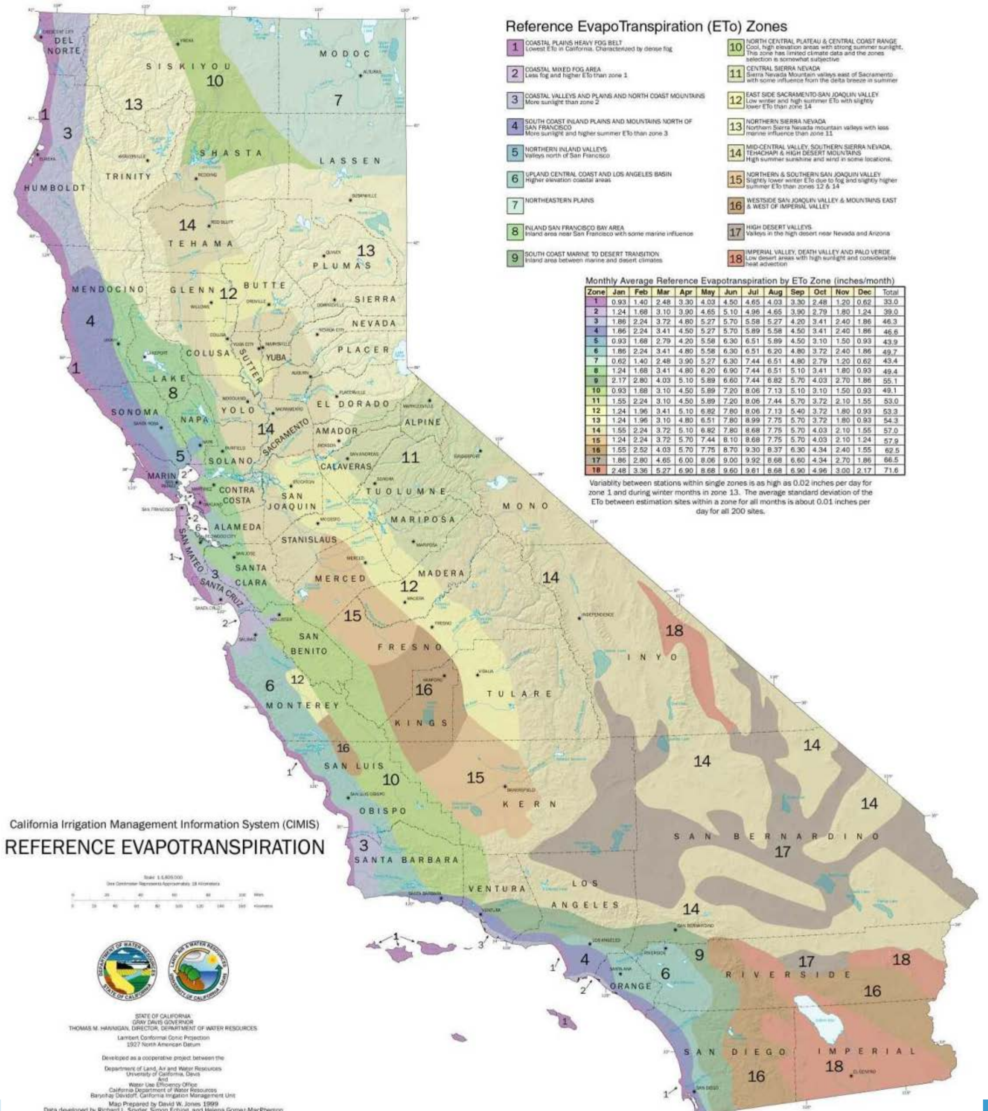
  $$ET = k_c \, ET_o$$
- Tables of coefficients have been compiled for many crops, growing conditions, times in the plant's life cycle…
- Standard Reference: Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and Drainage Paper 56

Ranges for crop coefficients



Pacific Institute

Historical & Current ET_0



Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.40	2.48	3.30	4.03	4.50	4.65	4.03	3.30	2.48	1.20	0.62	33.0
2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0
3	1.86	2.24	3.72	4.80	5.27	5.70	5.58	5.27	4.20	3.41	2.40	1.86	46.3
4	1.86	2.24	3.41	4.50	5.27	5.70	5.89	5.58	4.50	3.41	2.40	1.86	46.6
5	0.93	1.68	2.79	4.20	5.58	6.30	6.51	5.89	4.50	3.10	1.50	0.93	43.9
6	1.86	2.24	3.41	4.80	5.58	6.30	6.51	6.20	4.80	3.72	2.40	1.86	49.7
7	0.62	1.40	2.48	3.90	5.27	6.30	7.44	6.51	4.80	2.79	1.20	0.62	43.4
8	1.24	1.68	3.41	4.80	6.20	6.90	7.44	6.51	5.10	3.41	1.80	0.93	49.4
9	2.17	2.80	4.03	5.10	5.89	6.60	7.44	6.82	5.70	4.03	2.70	1.86	55.1
10	0.93	1.68	3.10	4.50	5.89	7.20	8.06	7.13	5.10	3.10	1.50	0.93	49.1
11	1.55	2.24	3.10	4.50	5.89	7.20	8.06	7.44	5.70	3.72	2.10	1.55	53.0
12	1.24	1.96	3.41	5.10	6.82	7.80	8.06	7.13	5.40	3.72	1.80	0.93	53.3
13	1.24	1.96	3.10	4.80	6.51	7.80	8.99	7.75	5.70	3.72	1.80	0.93	54.3
14	1.55	2.24	3.72	5.10	6.82	7.80	8.68	7.75	5.70	4.03	2.10	1.55	57.0
15	1.24	2.24	3.72	5.70	7.44	8.10	8.68	7.75	5.70	4.03	2.10	1.24	57.9
16	1.55	2.52	4.03	5.70	7.75	8.70	9.30	8.37	6.30	4.34	2.40	1.55	62.5
17	1.86	2.80	4.65	6.00	8.06	9.00	9.92	8.68	6.60	4.34	2.70	1.86	66.5
18	2.48	3.36	5.27	6.90	8.68	9.60	9.61	8.68	6.90	4.96	3.00	2.17	71.6

Variability between stations within single zones is as high as 0.02 inches per day for zone 1 and during winter months in zone 13. The average standard deviation of the ETo between estimation sites within a zone for all months is about 0.01 inches per day for all 200 sites.

Pacific Institute

Monthly Water Balance Model

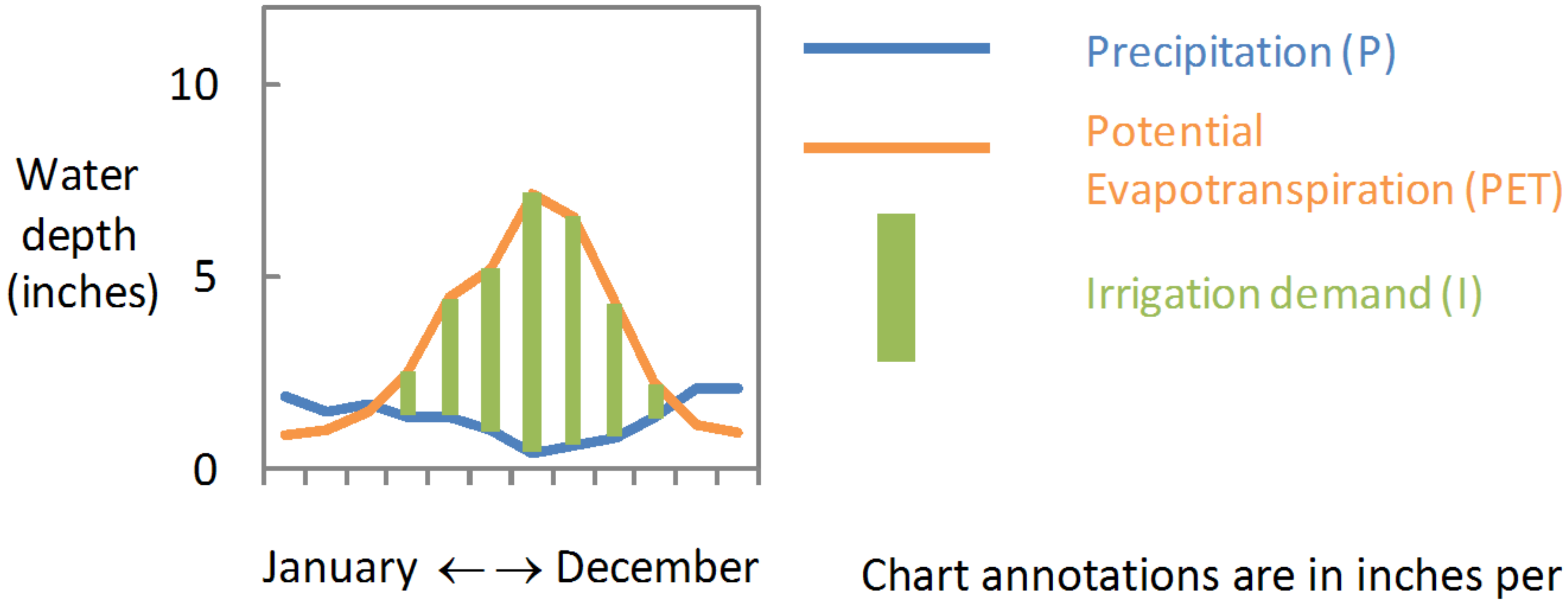
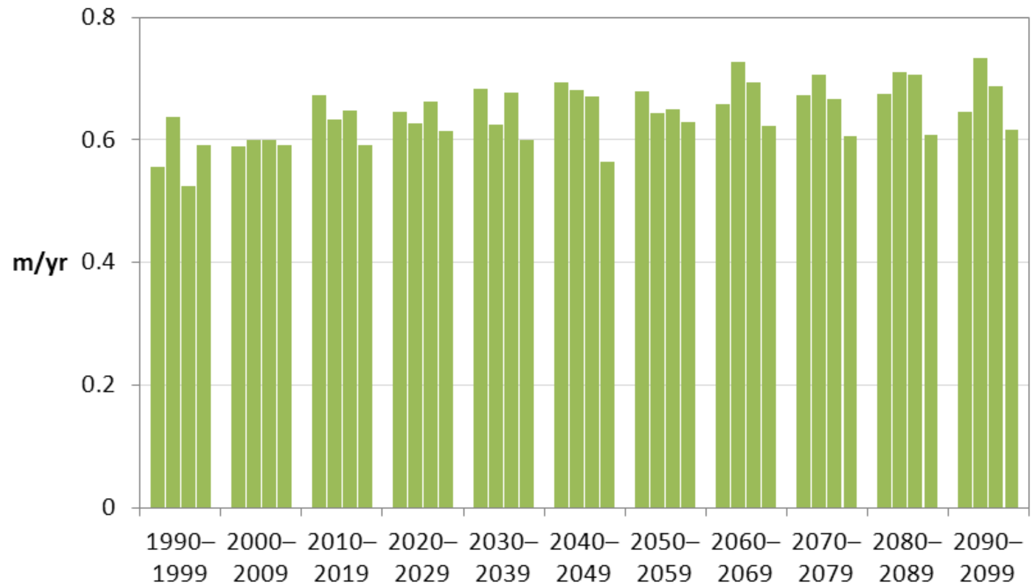


Chart annotations are in inches per year

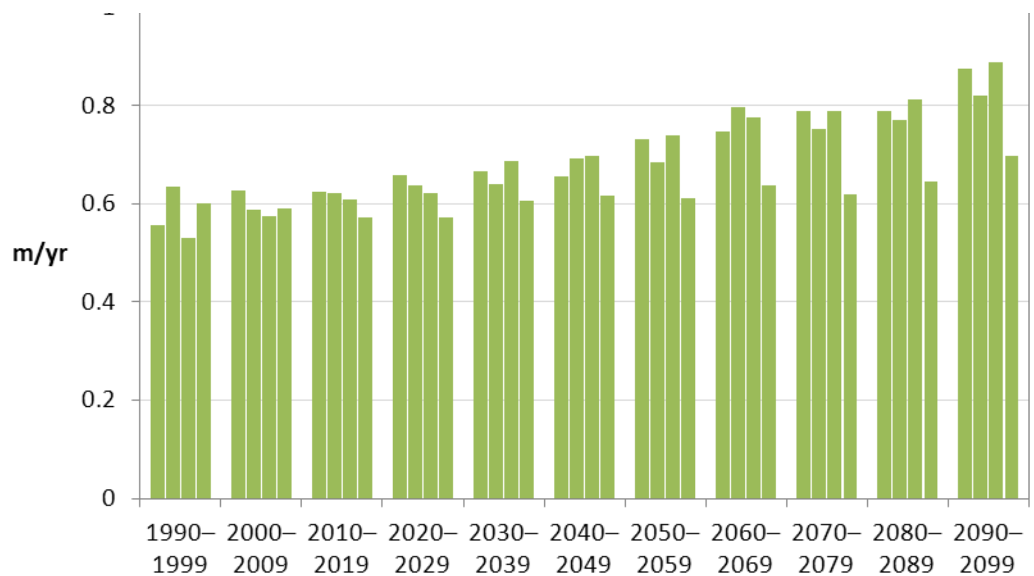
Pacific Institute

Projected Irrigation Requirements

SRES B1 Scenario

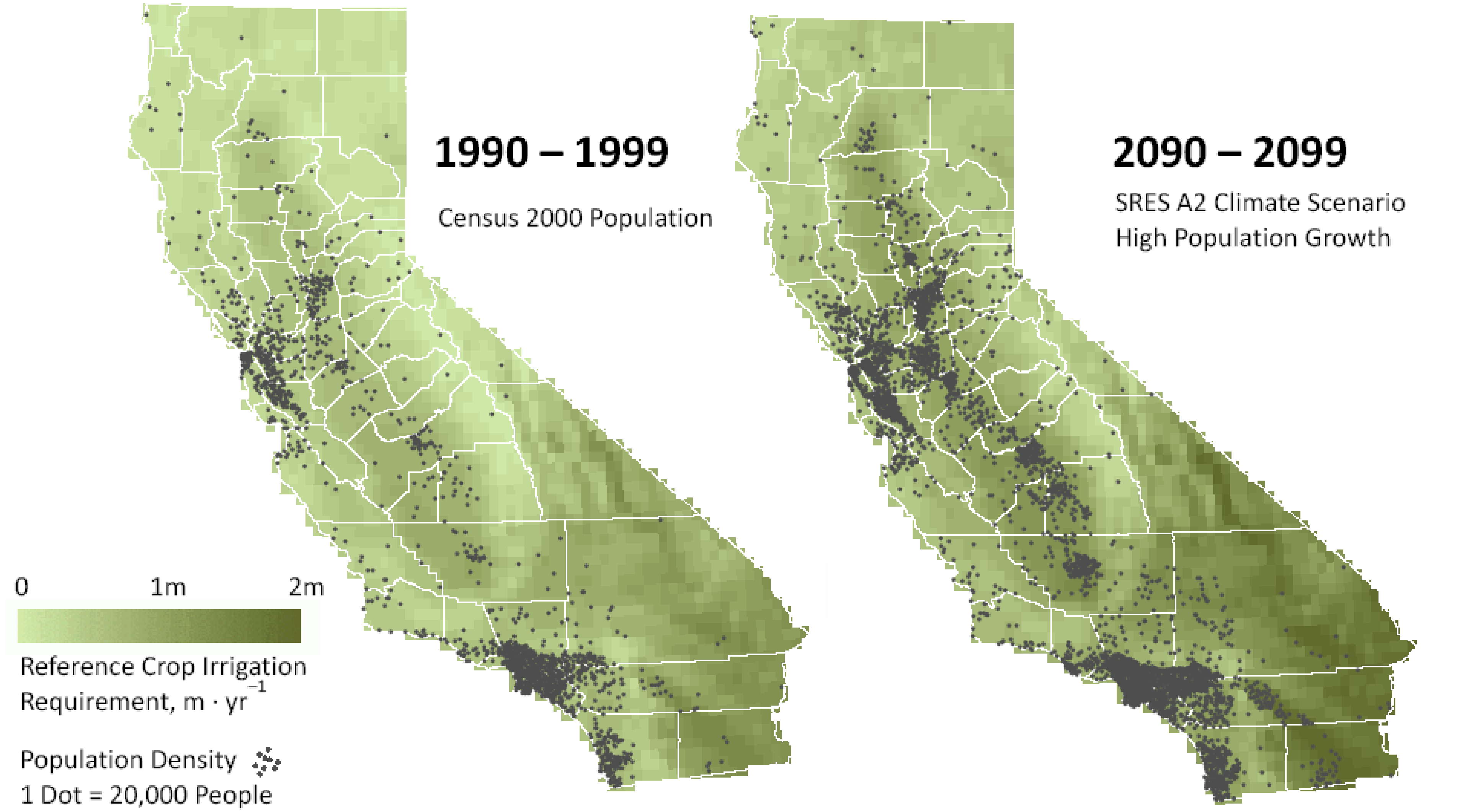


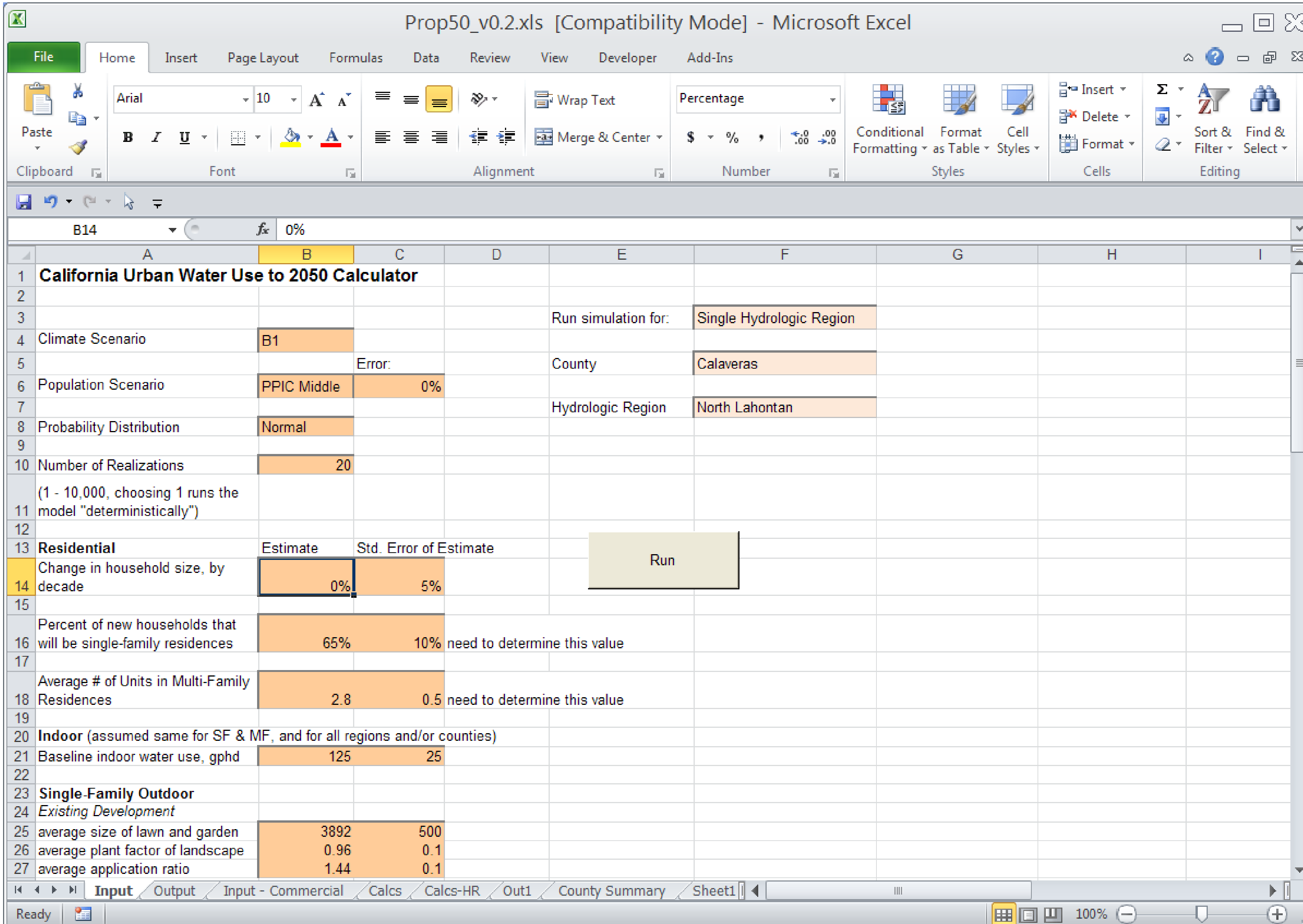
SRES A2 Scenario



Showing results from 4 different climate models

One Scenario of Future Climate and Population





Prop50_v0.2.xls [Compatibility Mode] - Microsoft Excel

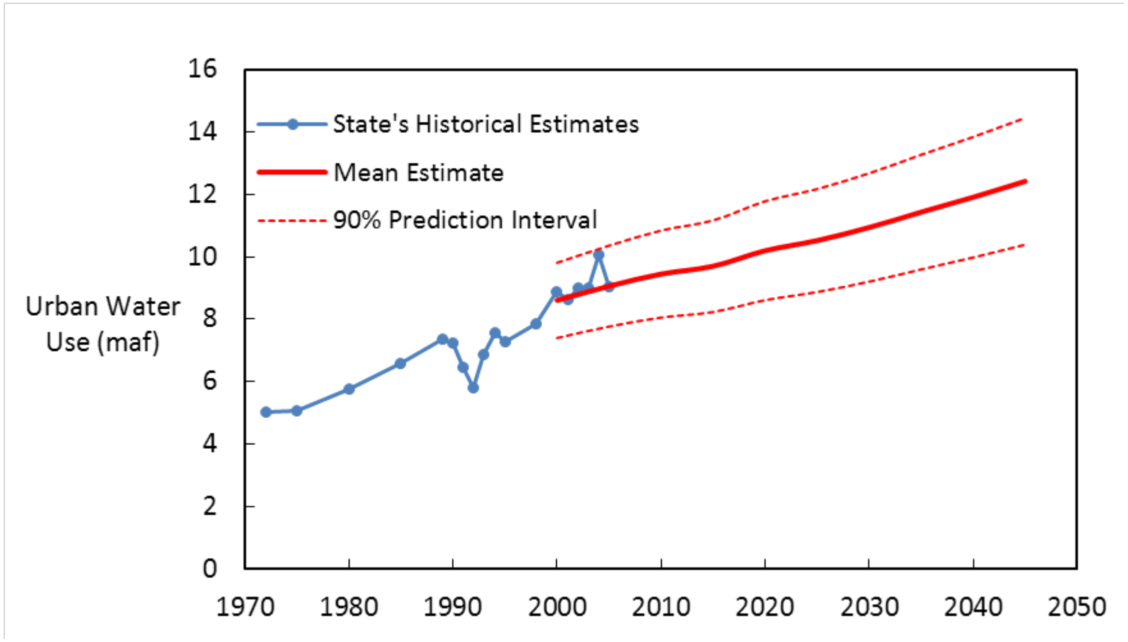
	A	B	C	D	E	F
1	**California Urban Water Use to 2050 Calculator**					
2						
3					Run simulation for:	Single Hydrologic Region
4	Climate Scenario	B1				
5			Error:		County	Calaveras
6	Population Scenario	PPIC Middle	0%			
7					Hydrologic Region	North Lahontan
8	Probability Distribution	Normal				
9						
10	Number of Realizations	20				
11	(1 - 10,000, choosing 1 runs the model "deterministically")					
12						
13	**Residential**	Estimate	Std. Error of Estimate			
14	Change in household size, by decade	0%	5%		Run	
15						
16	Percent of new households that will be single-family residences	65%	10%	need to determine this value		
17						
18	Average # of Units in Multi-Family Residences	2.8	0.5	need to determine this value		
19						
20	**Indoor** (assumed same for SF & MF, and for all regions and/or counties)					
21	Baseline indoor water use, gphd	125	25			
22						
23	**Single-Family Outdoor**					
24	*Existing Development*					
25	average size of lawn and garden	3892	500			
26	average plant factor of landscape	0.96	0.1			
27	average application ratio	1.44	0.1			

Input | Output | Input - Commercial | Calcs | Calcs-HR | Out1 | County Summary | Sheet1

Pacific Institute

Model Outputs

- Water Use by decade, summarized by:
  - County
  - Hydrologic Region (10)
  - Entire State



Preliminary Conclusions

- Under current trends, statewide urban water demand may increase from 9 million acre-feet (maf) in 2005 (11 billion m^3) to 12 maf (15 billion m^3) in 2050.
- Climate change likely to cause increases in urban water use by mid-century
- Climate change explains up to 15% of the growth in urban water use by 2050 under a high scenario
- Growth in the hot, dry Central Valley may drive increased outdoor water use

Pacific Institute

Conclusions

- Encouraging or requiring low-water use and native vegetation can offset this increase or lower overall urban demand
- Aggressive conservation measures allow for continued population growth without increasing water use.
- Scenario-based planning can help forecast future demand, analyze the impacts of policies, and better understand the uncertainty around factors affecting water use.

Pacific Institute

To Test and Review...

To obtain a copy of our computer model or report, or to test and review, please contact:

Matthew Heberger

Pacific Institute
654 13th Street
Oakland, California 94612
(510) 251-1600

mheberger@pacinst.org

www.pacinst.org

Pacific Institute

Acknowledgments

- Funded by the California Department of Water Resources, with funds approved by California voters via Proposition 50, the *Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002*
- Downscaled climate data was provided by *the Scripps Institution of Oceanography* at UC San Diego. Thanks to Dan Cayan, Mary Tyree, and others.
- Demography and land use projections were developed by the *Information Center for the Environment* at UC Davis. Thanks to Jacquelyn Bjorkman, James Thorne, and Ryan Boynton.

Pacific Institute