

# Drought Study

## Impact of Drought on Central Valley's Agriculture and Energy Usage

**Fayzul Pasha**

Assistant Professor, Department of Civil and Geomatics Engineering  
California State University, Fresno

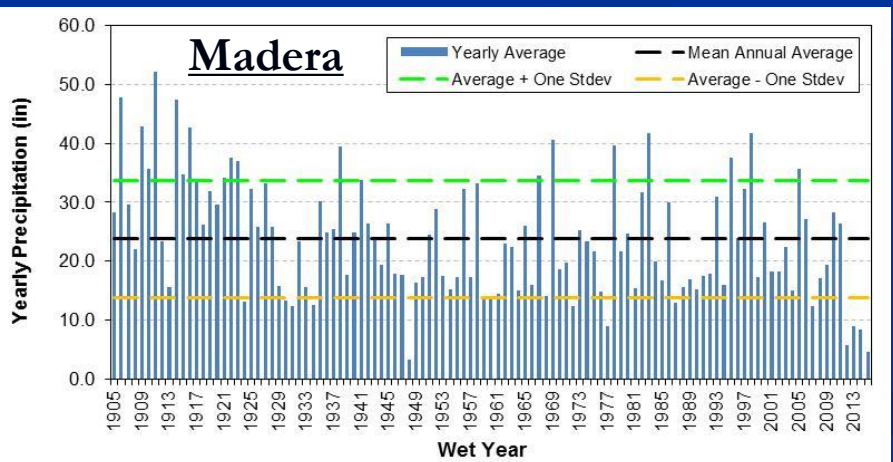
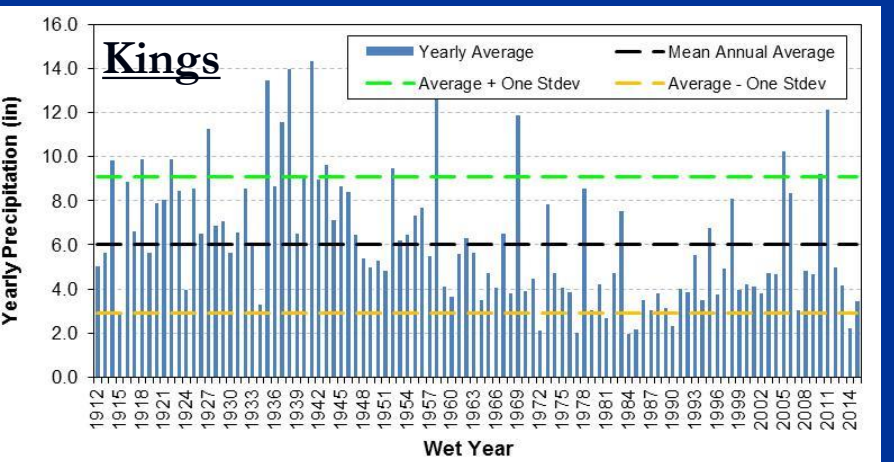
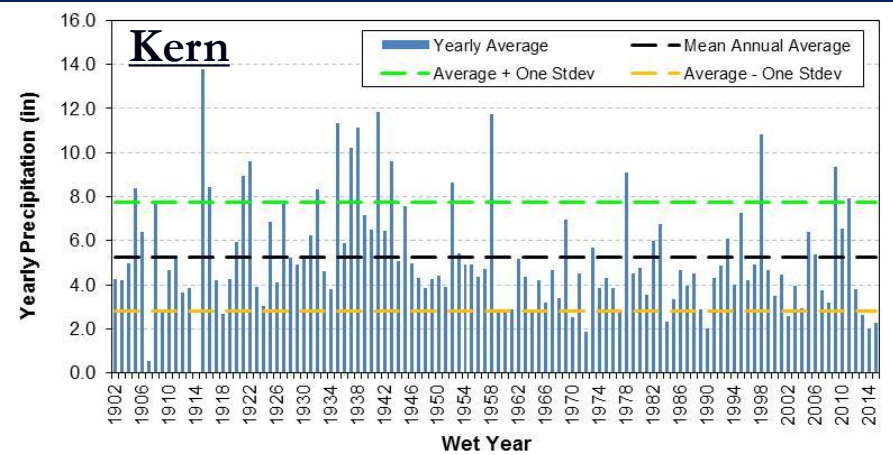
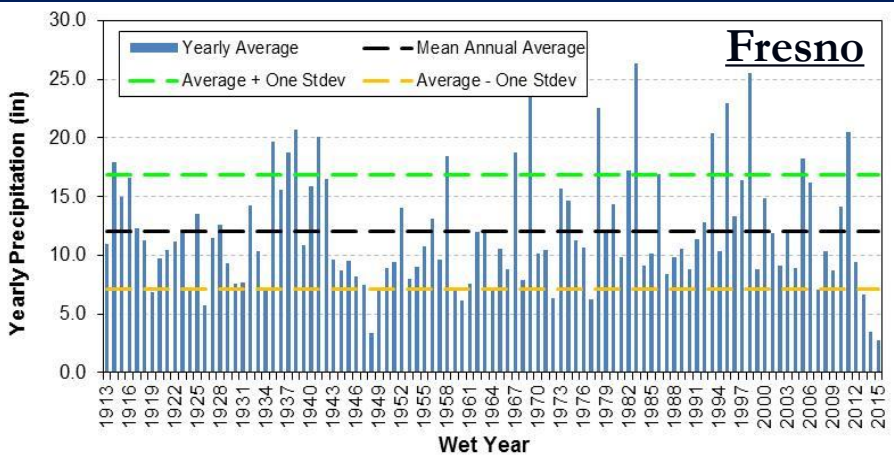
# Acknowledgement

## Sincere gratitude to

- ❑ Provost Dr. Lynnette Zelezny
- ❑ Dr. Xuanning Fu, Dr. David Zoldoske, Mr. Sargeant Green, Dr. Dilruba Yeasmin
- ❑ Wells Fargo Bank

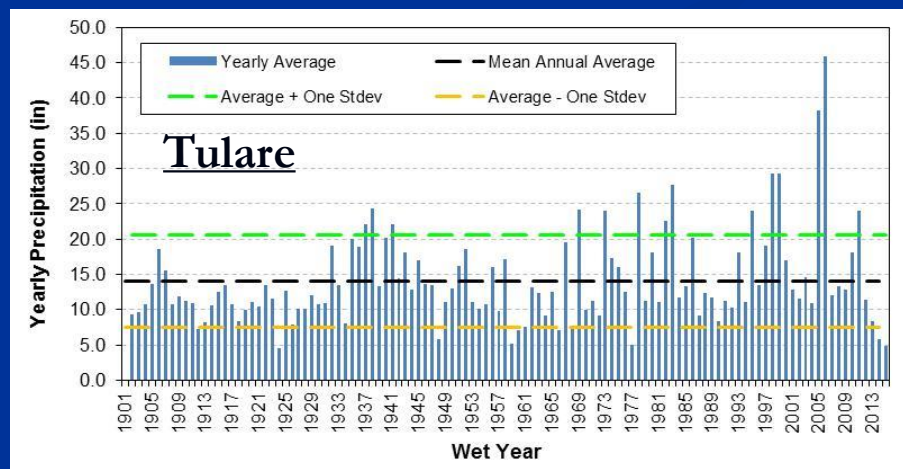
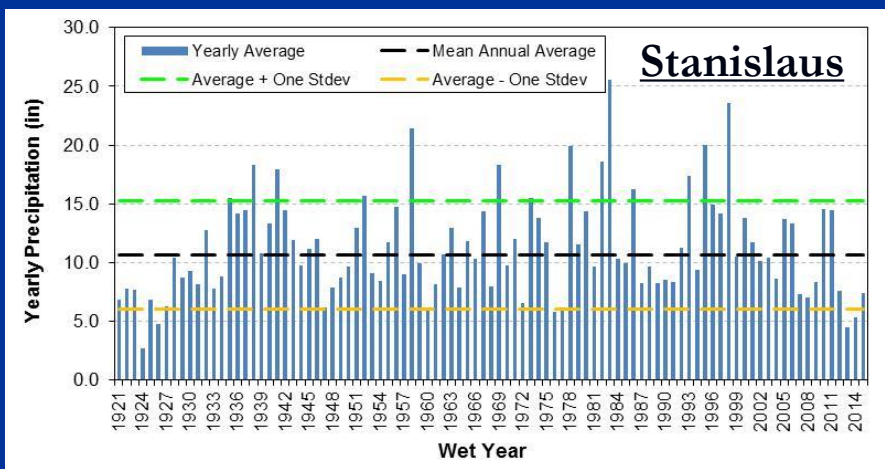
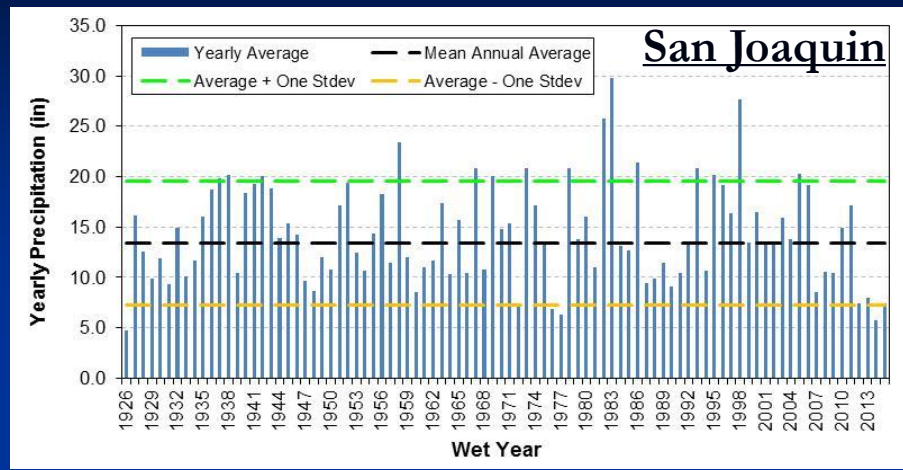
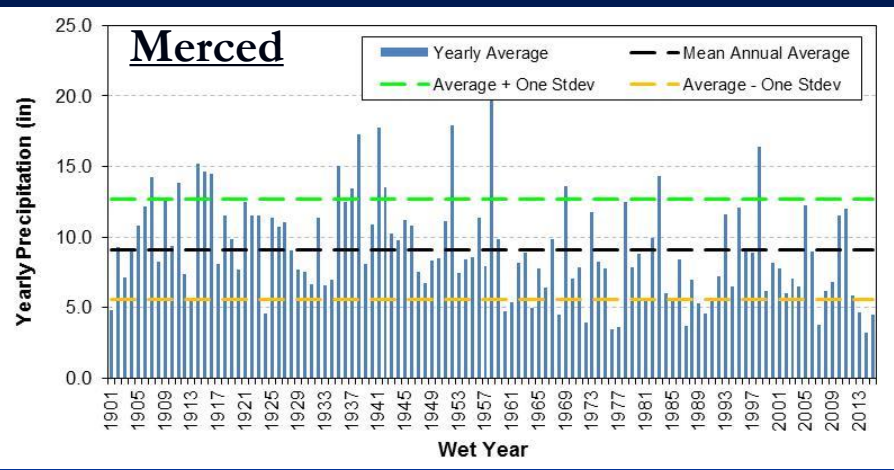


# Do we have a drought?





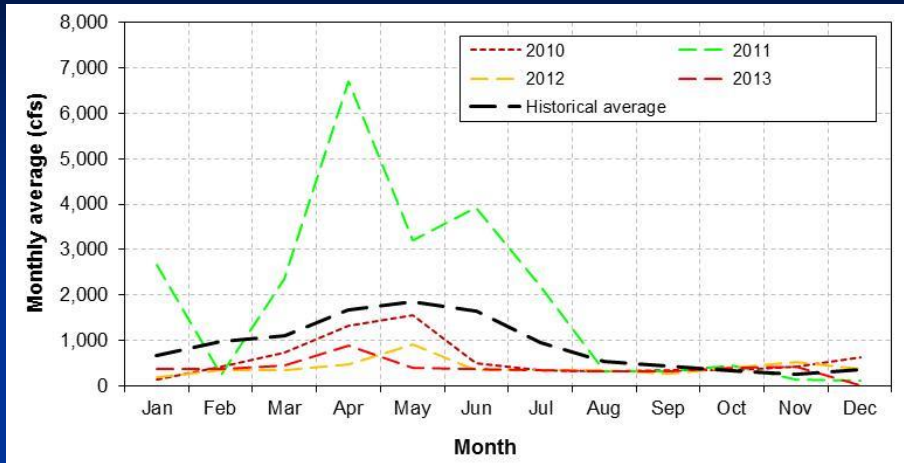
# Do we have a drought?



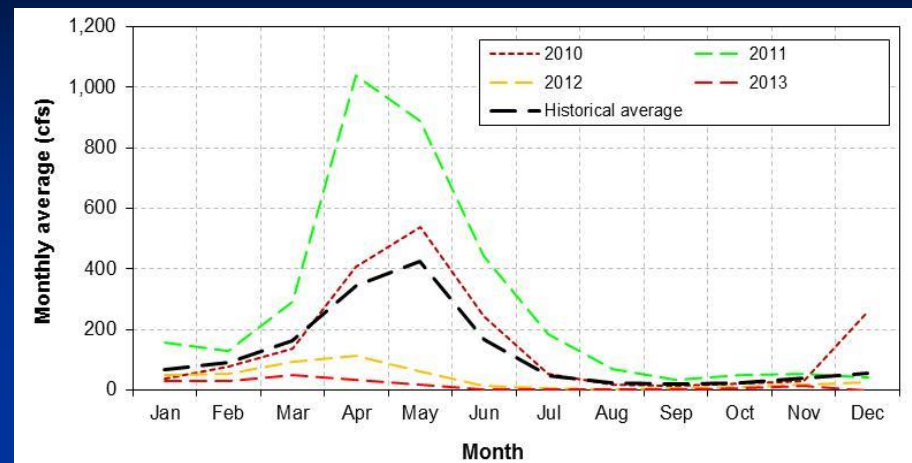
# Do we have a drought?

Statistics	Total Rainfall Station	Start year	End year	Mean (in)	Yearly Precipitation (in)				
					2010	2011	2012	2013	2014
Fresno	4	1912	2015	<b>12.0</b>	<b>14.2</b>	<b>20.5</b>	<b>9.4</b>	<b>6.6</b>	<b>3.5</b>
Kern	3	1901	2015	5.7	6.6	7.9	3.8	2.6	2.0
Kings	4	1900	2015	6.0	9.2	12.1	5.0	4.2	2.2
Madera	2	1904	2015	23.7	28.2	26.4	5.8	9.0	8.4
Merced	3	1900	2015	9.1	11.5	12.0	5.8	4.7	3.3
San Joaquin	4	1900	2015	13.4	14.9	17.1	7.5	8.0	5.7
Stanislaus	2	1906	2015	10.7	14.5	14.5	7.6	4.5	5.4
Tulare	6	1900	2015	14.1	18.2	24.0	11.4	8.4	5.7

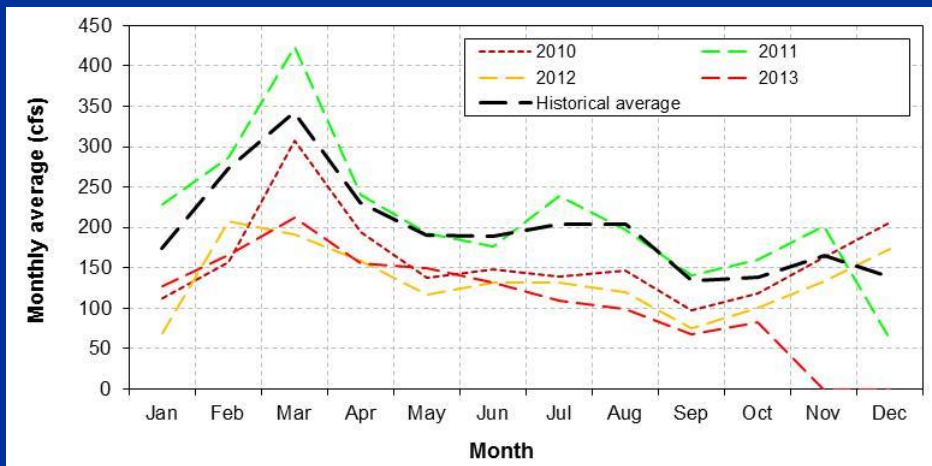
# Do we have a drought?



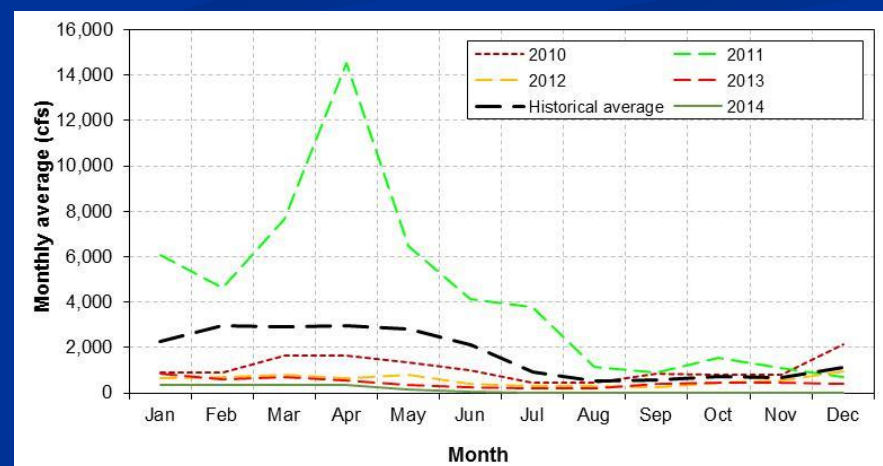
Monthly mean streamflow at USGS 11251000  
San Joaquin in Fresno County



Monthly mean streamflow at USGS 11261100  
Salt Slough in Kern County

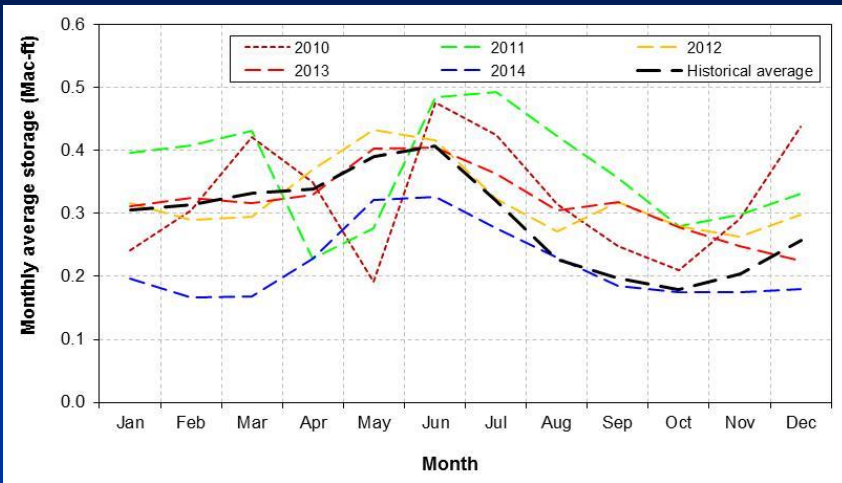


Monthly mean streamflow at USGS 11261100  
Salt Slough in Merced County

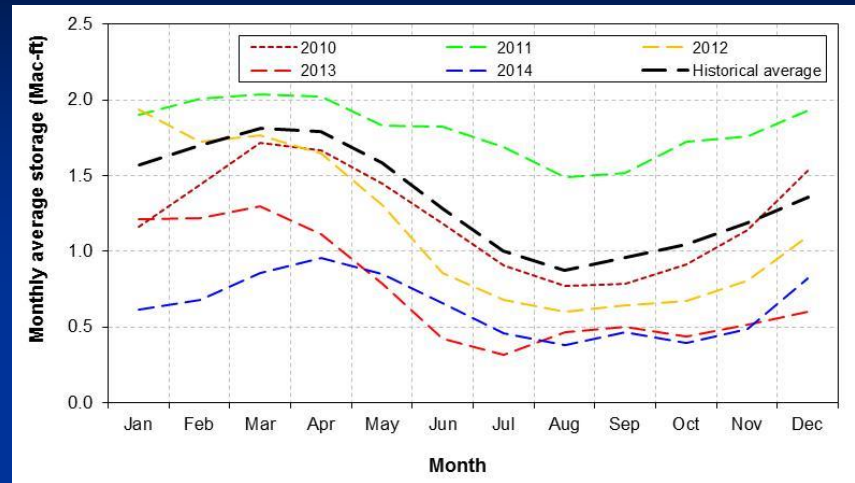


Monthly mean streamflow at USGS 11274000 San  
Joaquin in Stanislaus County

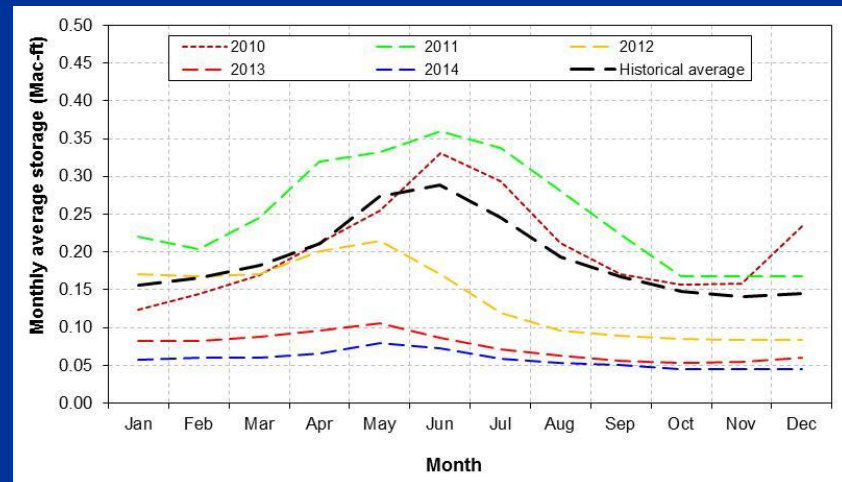
# Effect on Reservoir Storage



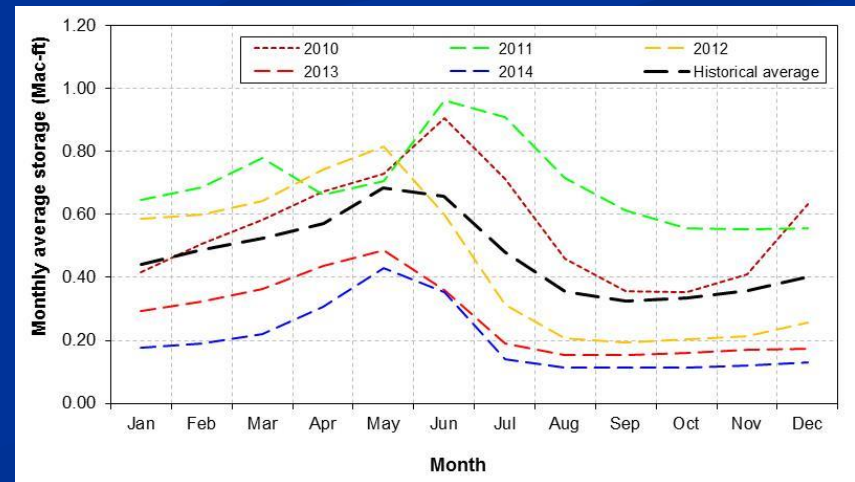
Water storage in Millerton Lake



Water storage in San Luis Reservoir



Water storage in Isabella Lake



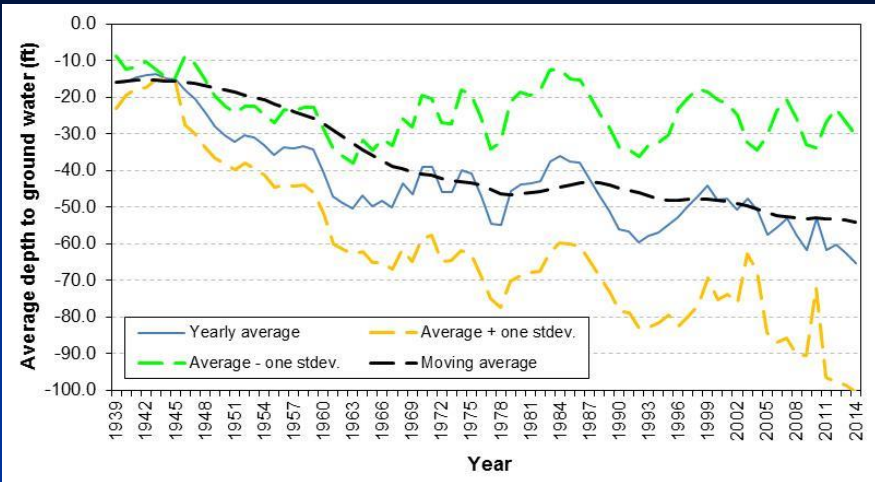
Water storage in Pine Flat Lake



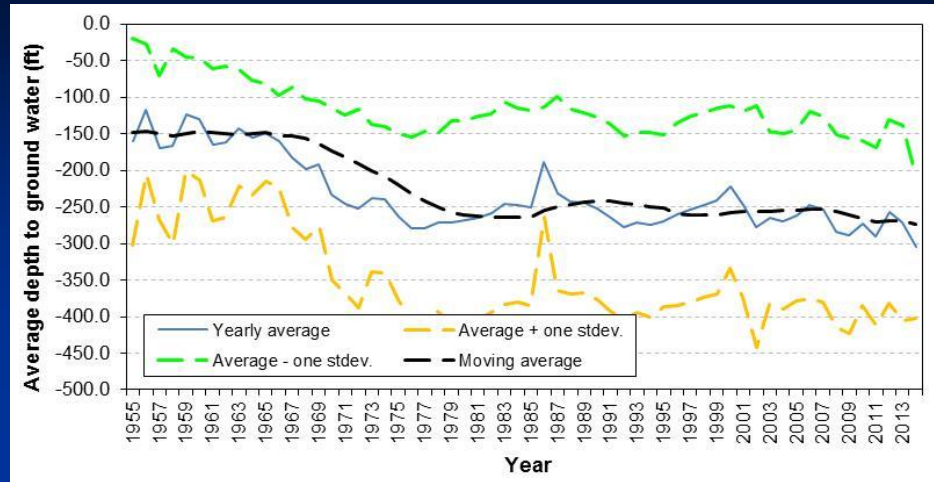
# Effect on Reservoir Storage

Reservoir	Area (ac)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
San Luis	13,000	<b>0.959</b>	<b>1.022</b>	<b>0.958</b>	<b>0.834</b>	<b>0.741</b>	<b>0.623</b>	<b>0.543</b>	<b>0.492</b>	<b>0.498</b>	<b>0.649</b>	<b>0.698</b>	<b>0.540</b>
Isabella	11,400	0.099	0.106	0.122	0.146	0.193	0.216	0.188	0.140	0.118	0.102	0.095	0.100
Camanche	7,700	0.033	0.049	0.072	0.095	0.133	0.163	0.149	0.135	0.118	0.105	0.109	0.101
Pine Flat	5,970	0.265	0.297	0.302	0.266	0.254	0.304	0.340	0.241	0.211	0.221	0.239	0.272
Friant	4,900	0.110	0.147	0.165	0.111	0.069	0.080	0.043	-0.002	0.012	0.004	0.029	0.077
Success	2,450	0.010	0.016	0.022	0.029	0.038	0.036	0.022	0.013	0.008	0.005	0.005	0.008
Terminus	1,945	0.009	0.006	0.012	0.021	0.035	0.058	0.024	-0.001	-0.005	-0.003	-0.003	-0.006
Hidden	1,500	0.019	0.024	0.034	0.039	0.040	0.036	0.026	0.018	0.015	0.012	0.011	0.012
Courtright	1,480	0.004	0.003	0.007	0.005	-0.012	0.000	0.051	0.015	0.024	0.017	0.018	0.015
Wishon	970	-0.003	-0.007	-0.016	-0.019	0.035	0.058	0.009	0.039	0.022	0.020	0.013	0.007

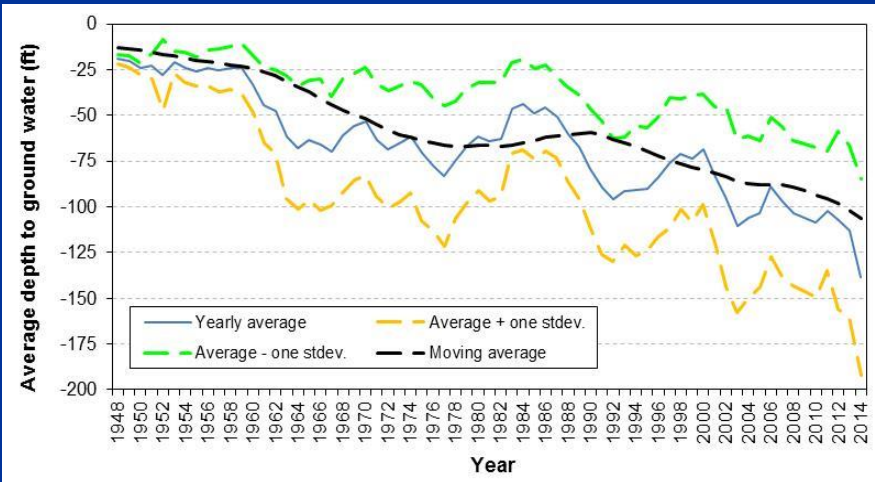
# Effect on Groundwater



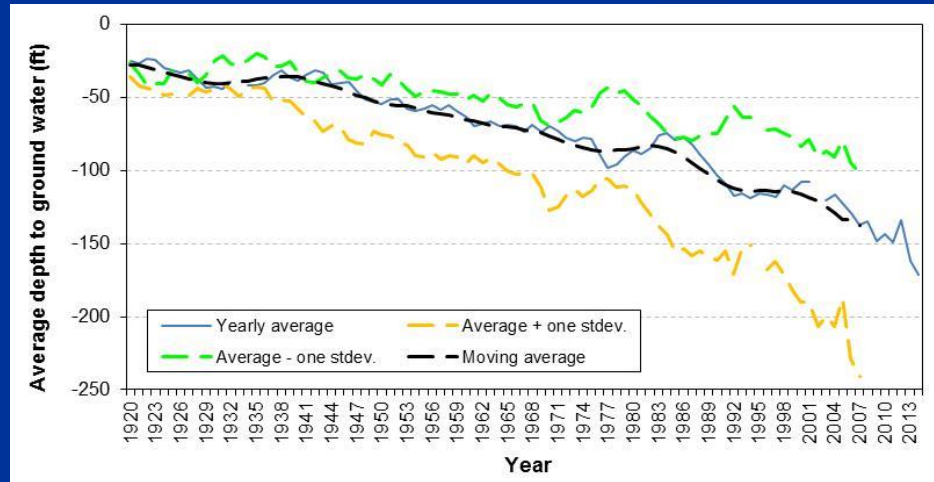
Average depth to groundwater in Fresno County



Average depth to groundwater in Kern County

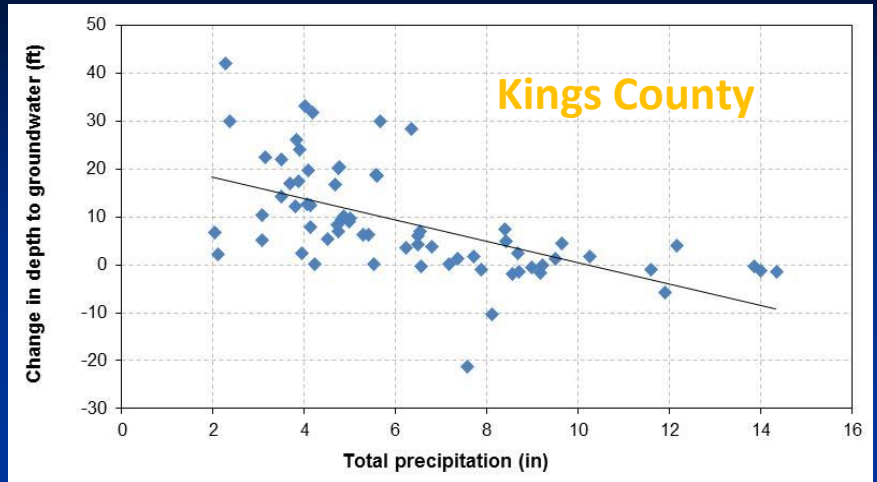
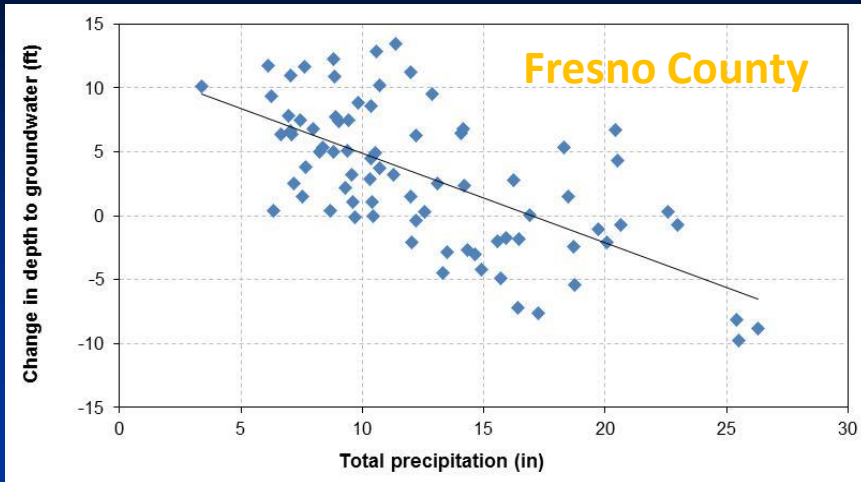


Average depth to groundwater in Kings County



Average depth to groundwater in Madera County

# Effect on Groundwater



County	Change in depth to groundwater level (ft) at given precipitation depth (in)			
	2	3	4	5
Fresno	10.5	9.8	9.1	8.4
Kern	29.8	25.6	21.5	17.4
Kings	18.3	16.1	13.9	11.6
Madera	16.0	15.6	15.1	14.7
Merced	6.5	6.0	5.5	5.0
San Joaquin	9.3	8.8	8.3	7.8
Stanislaus	7.9	7.3	6.8	6.2
Tulare	15.7	15.0	14.3	13.7

Predicted additional  
change in groundwater  
depth



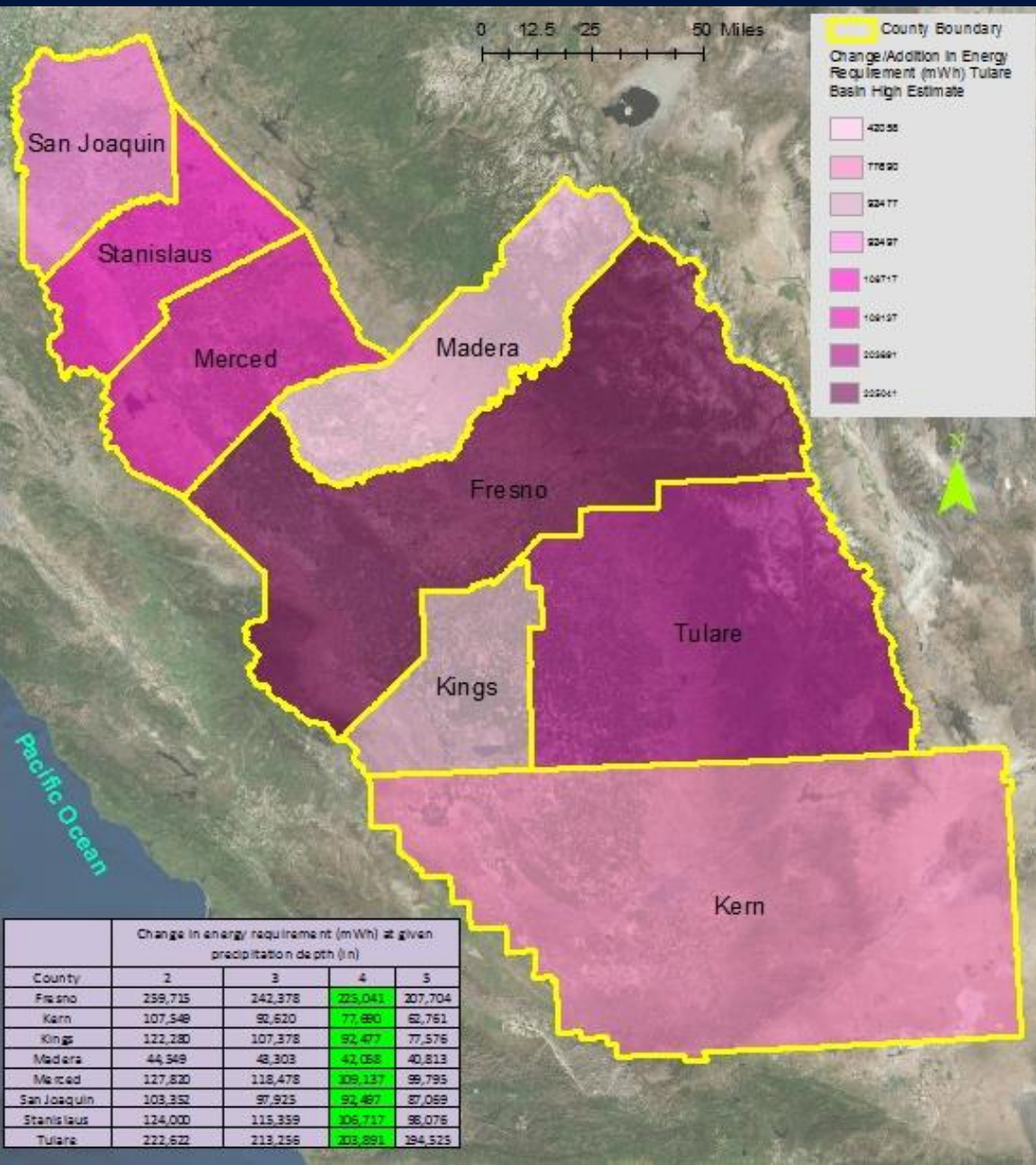
# Effect on Groundwater/Energy

**Predicted additional energy requirement (mWh) for pumping groundwater based on Tulare Basin Low Estimate**

	Additional energy requirement (mWh) at given precipitation depth (in)			
County	2	3	4	5
Fresno	<b>170,532</b>	<b>159,149</b>	<b>147,765</b>	<b>136,381</b>
Kern	70,618	60,815	51,013	41,210
Kings	80,290	70,506	60,722	50,938
Madera	29,251	28,433	27,616	26,798
Merced	83,928	77,794	71,661	65,527
San Joaquin	67,862	64,298	60,735	57,171
Stanislaus	81,420	75,746	70,072	64,398
Tulare	146,176	140,027	133,877	127,728



# Effect on Groundwater/Energy



Impact of precipitation on additional energy requirement for pumping groundwater Tulare Basin High Estimate

# Effect on Irrigation Water Usage

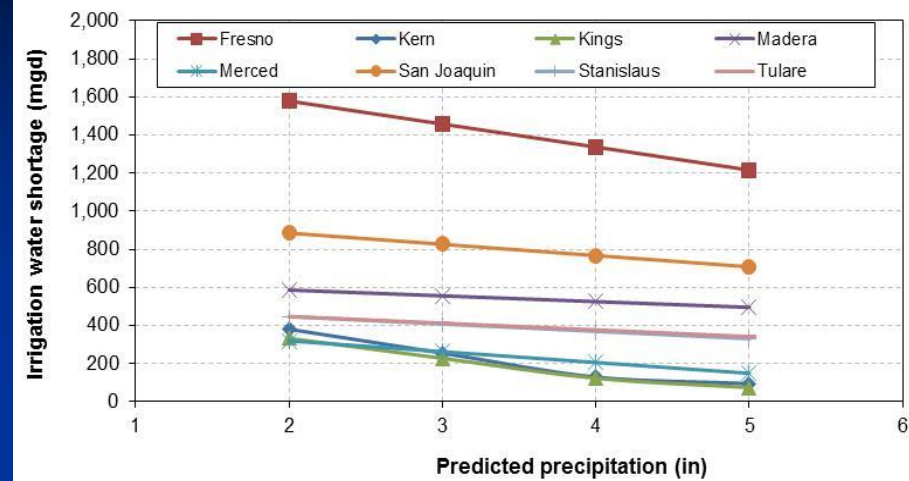
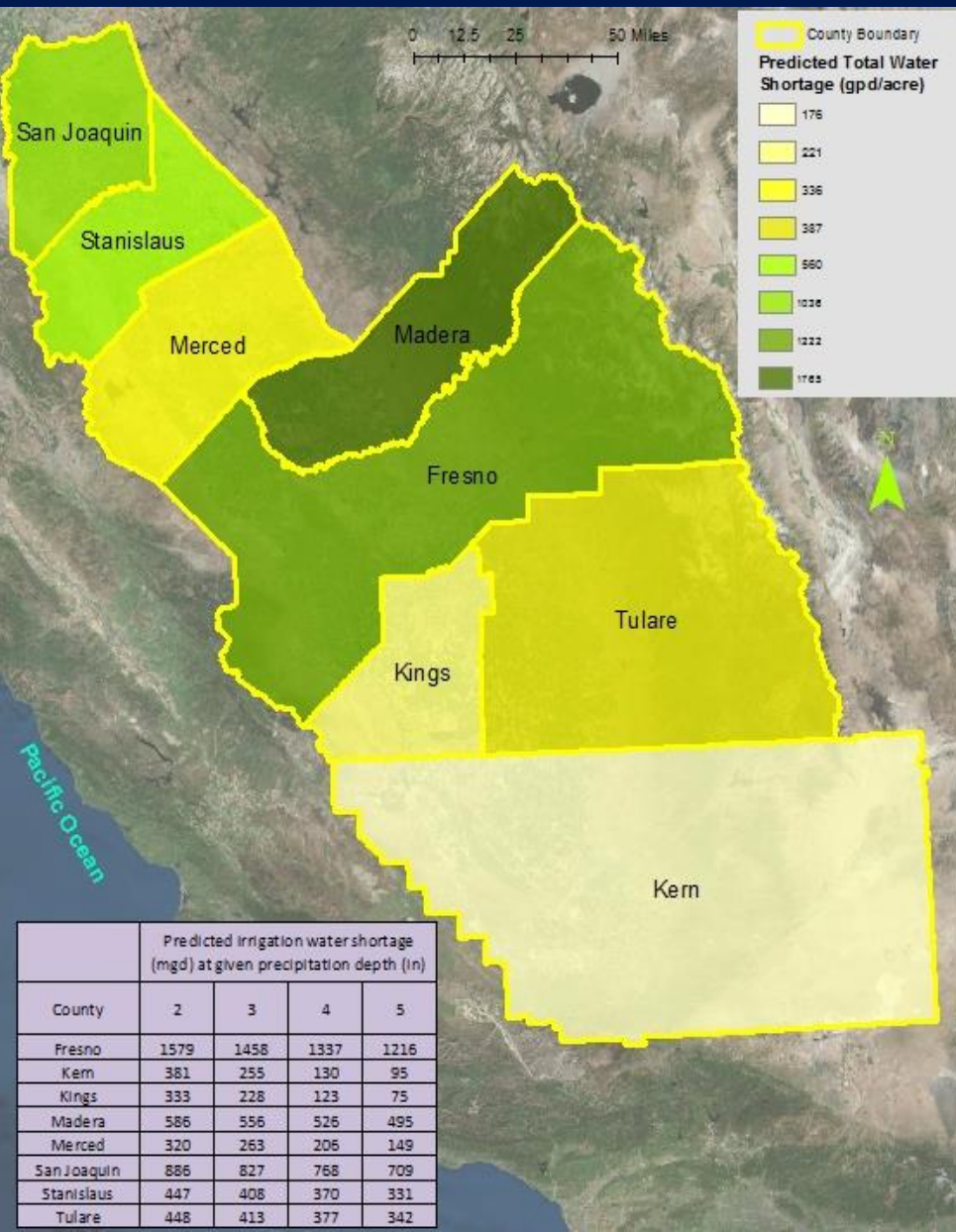
## Predicted surface water shortage for irrigation

County	Irrigated land (acres*10 <sup>3</sup> )	Predicted water shortage (mgd) at given precipitation depth (in)			
		2	3	4	5
<b>Fresno</b>	1093.78	<b>765</b>	<b>697</b>	<b>629</b>	<b>561</b>
<b>Kern</b>	737.79	165	95	25	46
<b>Kings</b>	558.95	102	58	15	28
<b>Madera</b>	297.84	345	327	309	291
<b>Merced</b>	613.34	128	113	97	82
<b>San Joaquin</b>	740.77	509	472	435	398
<b>Stanislaus</b>	659.31	256	232	207	182
<b>Tulare</b>	974.67	380	348	317	286

## Predicted groundwater shortage for irrigation

County	Irrigated land (acres*10 <sup>3</sup> )	Predicted water shortage (mgd) at given precipitation depth (in)			
		2	3	4	5
<b>Fresno</b>	1093.78	<b>814</b>	<b>761</b>	<b>708</b>	<b>655</b>
<b>Kern</b>	737.79	216	161	105	50
<b>Kings</b>	558.95	232	170	108	47
<b>Madera</b>	297.84	241	229	217	205
<b>Merced</b>	613.34	192	150	109	67
<b>San Joaquin</b>	740.77	377	355	333	311
<b>Stanislaus</b>	659.31	191	177	163	149
<b>Tulare</b>	974.67	68	64	60	56

# Effect on Irrigation Water Usage

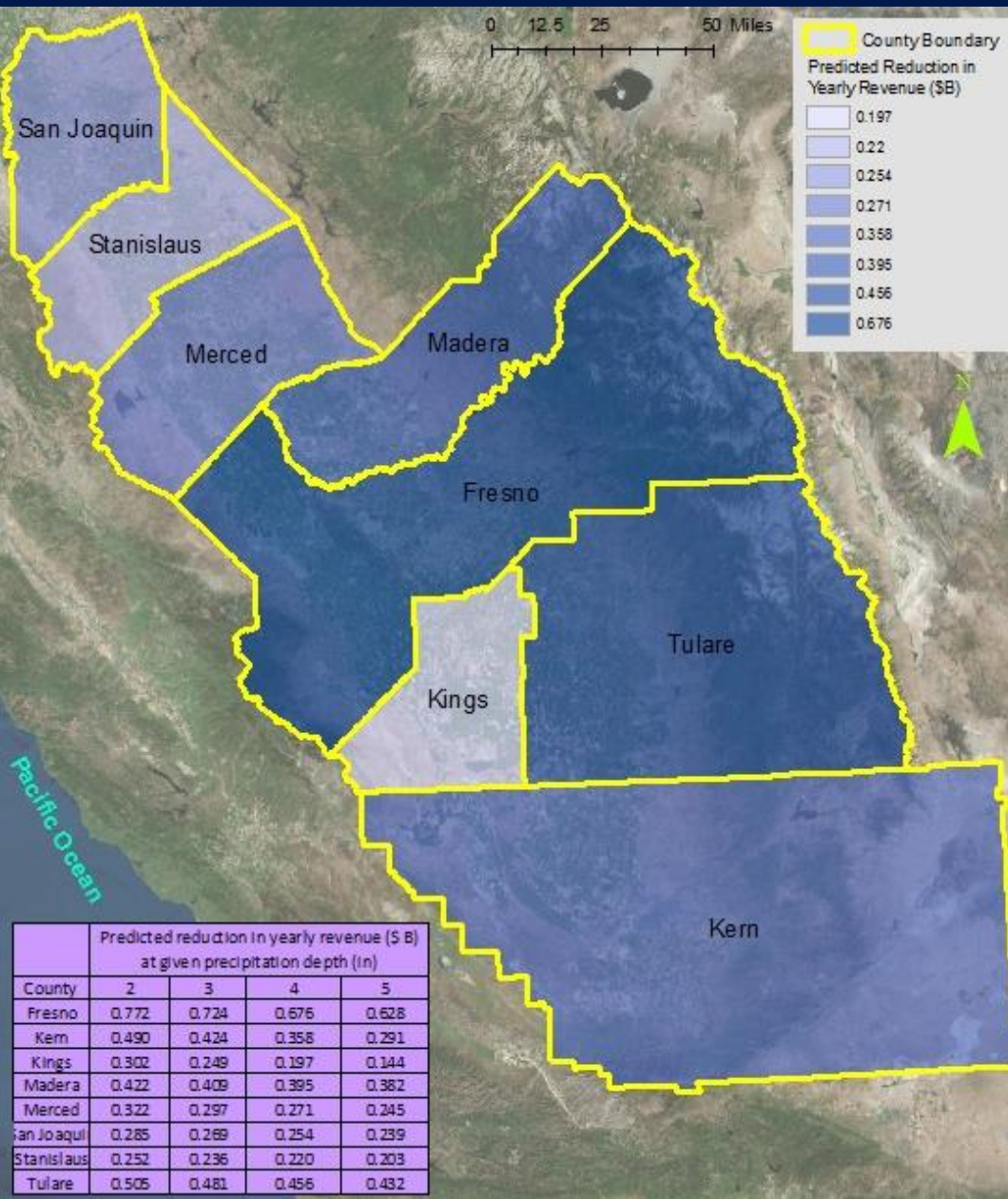


Predicted total irrigation water shortage at different total annual precipitation

County	Irrigated land (acres*10 <sup>3</sup> )	Predicted water shortage (mgd) at given precipitation depth (in)			
		2	3	4	5
Fresno	1093.78	<b>1579</b>	<b>1458</b>	<b>1337</b>	<b>1216</b>
Kern	737.79	381	255	130	95
Kings	558.95	333	228	123	75
Madera	297.84	586	556	526	495
Merced	613.34	320	263	206	149
San Joaquin	740.77	886	827	768	709
Stanislaus	659.31	447	408	370	331
Tulare	974.67	448	413	377	342



# Effect on Agricultural Revenue



**Predicted reduction in yearly revenue (\$ B at today's price) at given precipitation depth (in)**

County	2	3	4	5
Fresno	<b>0.772</b>	<b>0.724</b>	<b>0.676</b>	<b>0.628</b>
Kern	0.490	0.424	0.358	0.291
Kings	0.302	0.249	0.197	0.144
Madera	0.422	0.409	0.395	0.382
Merced	0.322	0.297	0.271	0.245
San Joaquin	0.285	0.269	0.254	0.239
Stanislaus	0.252	0.236	0.220	0.203
Tulare	0.505	0.481	0.456	0.432

County	Predicted reduction in yearly revenue (\$ B) at given precipitation depth (in)			
	2	3	4	5
Fresno	0.772	0.724	0.676	0.628
Kern	0.490	0.424	0.358	0.291
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San Joaquin	0.285	0.269	0.254	0.239
Stanislaus	0.252	0.236	0.220	0.203
Tulare	0.505	0.481	0.456	0.432



Thank You