


A Geospatial Analysis on Benefits of Water Portfolio In Agriculture

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ESRI International User Conference 2014




Problem/ Question

- Semi-arid and arid regions experiencing less precipitation, more aridity, and longer periods w/o precipitation (drought)

- Demand for water increasing due to population growth and environmental concerns

=> More variable and scarce water supplies

Question:

How will agriculture – the largest user of freshwater supplies (~75%) – be impacted and respond?

Past research shows…

- Climate change can impact agriculture directly via impact on yields (Mendelsohn et al. 1994)

- Agriculture might adapt by engaging in irrigation (Mendelsohn and Dinar 2003; Schlenker et al. 2006)

  - Irrigation reduces temperature and precipitation effects

- Yet water supplies (mean values) themselves might decrease (Schlenker et al. 2007)

  - Lower water supplies do affect agricultural property values (Selby 1945; Hartman and Anderson 1962; Crouter 1987; Faux and Perry 1989; Mendelsohn and Dinar 2003)

Some unresolved issues…

Do different water supplies have differential impacts?

- Suggested in Crouter (1987); Not found in Faux and Perry (1999)

Can groundwater help?

- Crouter (1987), Mendelsohn and Dinar (2003), and Schlenker et al. (2007) found no relationship
- Stage and Williams (2003) and Hornbeck and Keskin (2011) suggest yes.

Does water supply variability matter and water quality matter?

- Yes based on Connor et al. (2012) using programming approach

Can a portfolio approach help?

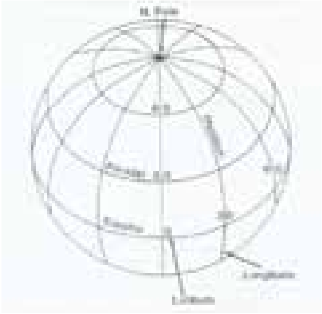
Objectives

Using an integration of *GIS* and *Economic valuation approach*, we investigate:

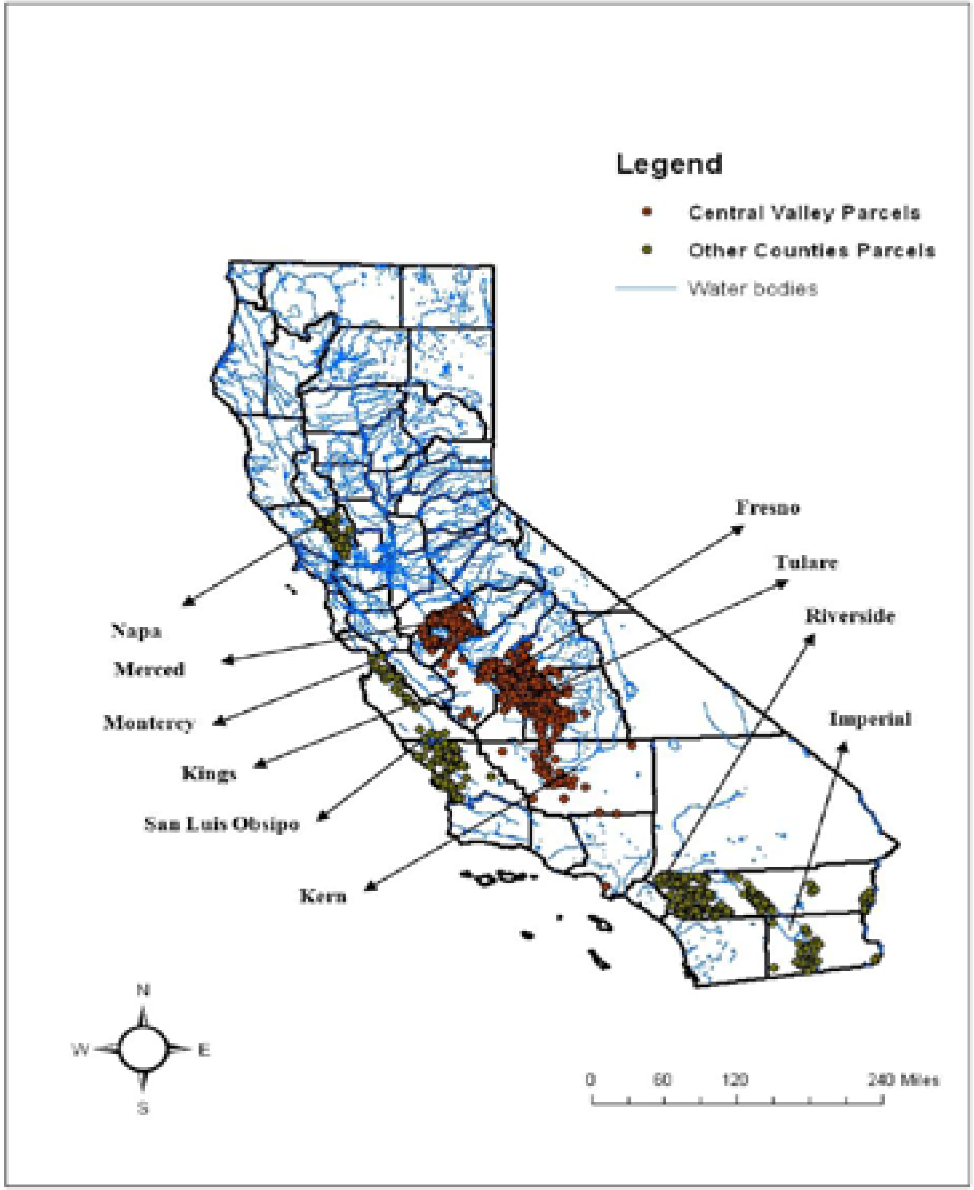
- Impact of groundwater depth and salinity on land values
- Impact of lower and less reliable water supplies on land values
- Whether and to what extent different types of water supplies impact land values
- Whether access to multiple water supply sources—a portfolio approach—can reduce the impacts of lower, less quality, and less reliable water supplies

Data – Farm Characteristics

- California agricultural parcels
- Sale price of parcels sold from 2004-2010 (~ 2000 obs)
- Size of the land in acres.
- Latitude and longitude of the farm.
- Crops grown (i.e., orchards, vineyards)
- Population by zip code
- Distance from nearest freeway

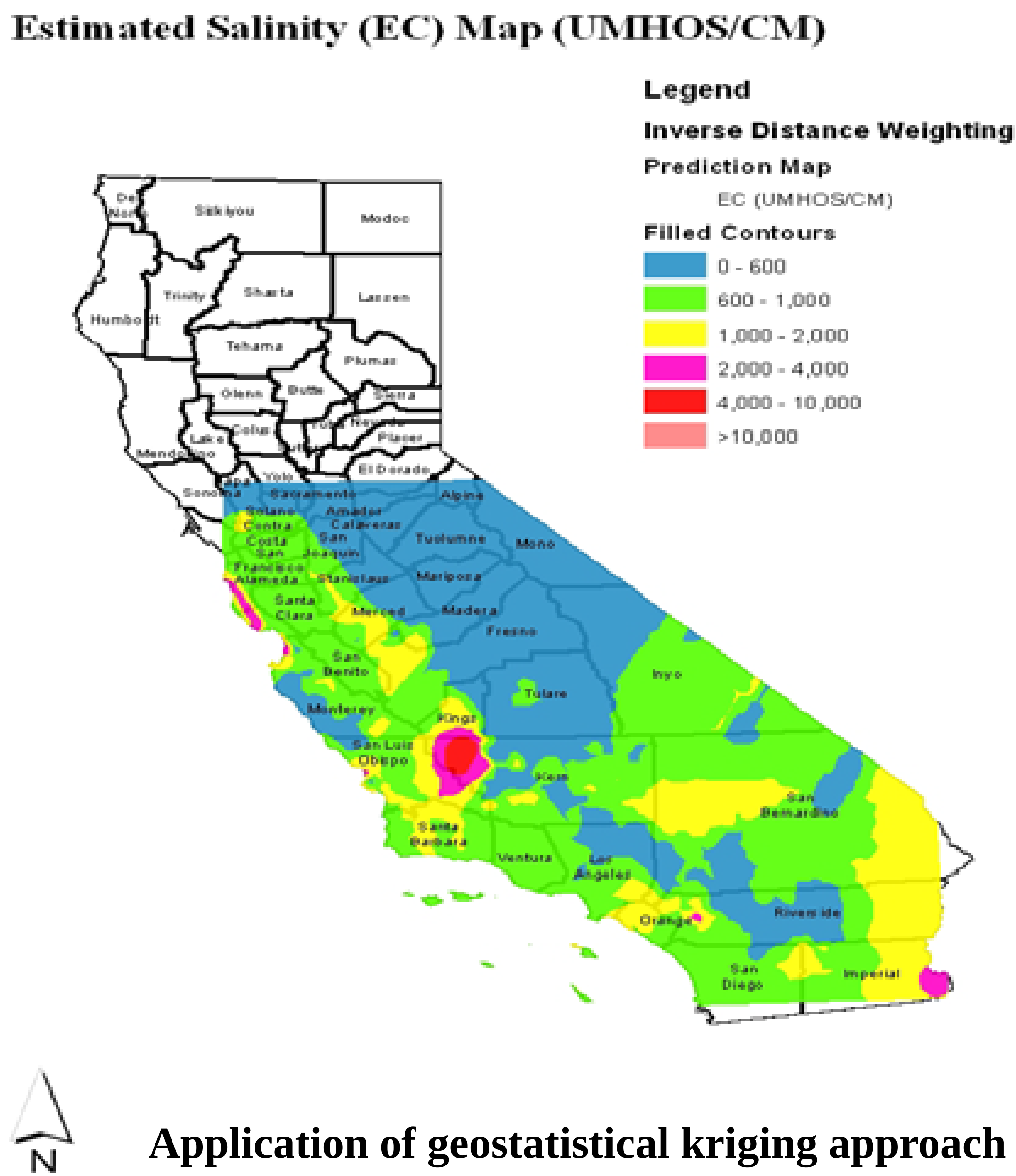


Data –Geocoding Agricultural Parcels



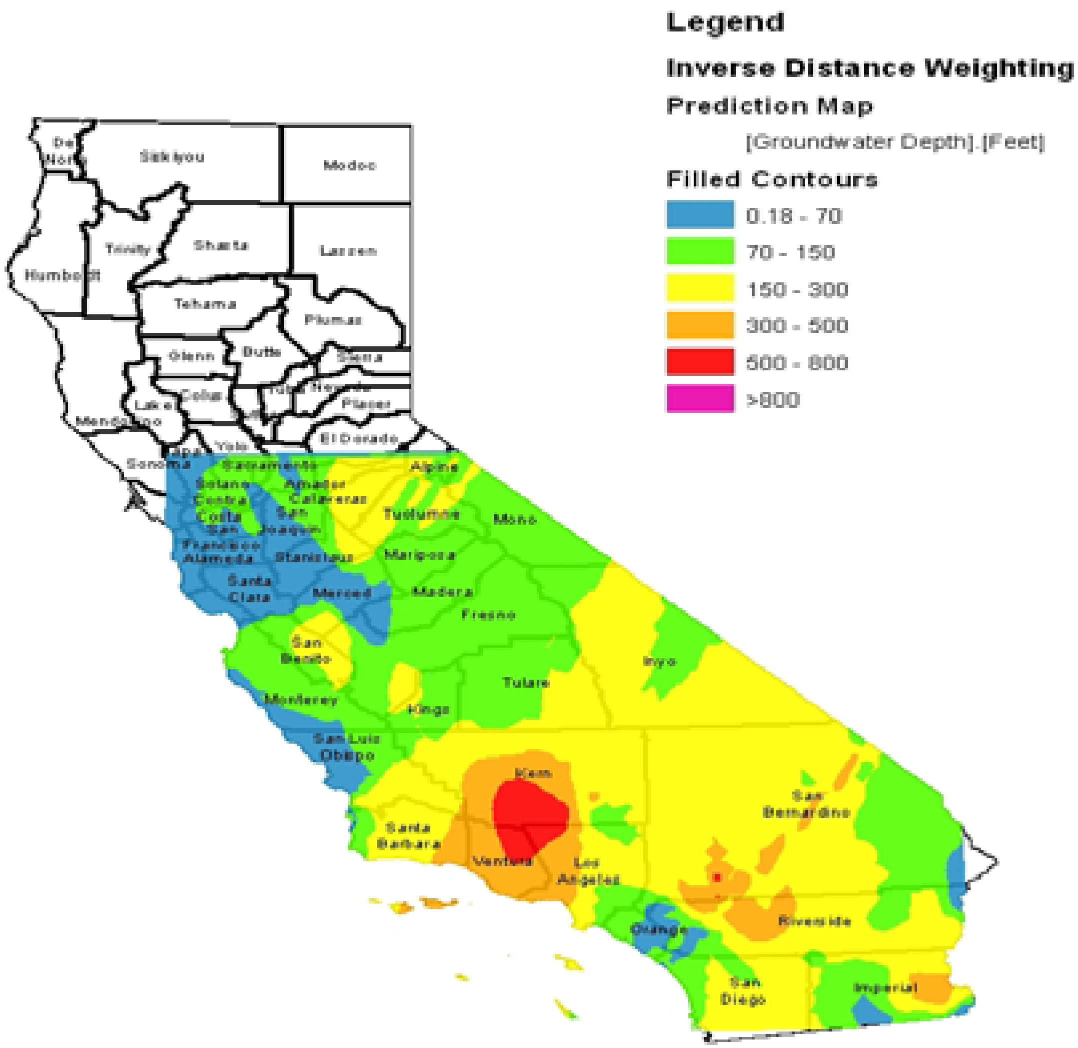
Data – biophysical characteristics

- Groundwater (25 years of data)
  - groundwater depth of the closest well.
  - groundwater quality (salinity) of the closest well
- Two measures of soil quality
  - Storie Index
  - Irrigated Capability Class Index
- Climate (25 years)
  - temperature (degree days): Jan, April, July ,Oct
  - precipitation: Jan, April, July, Oct



Application of geostatistical kriging approach

Estimated Surface Groundwater Depth (Feet)



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Application of geostatistical kriging approach

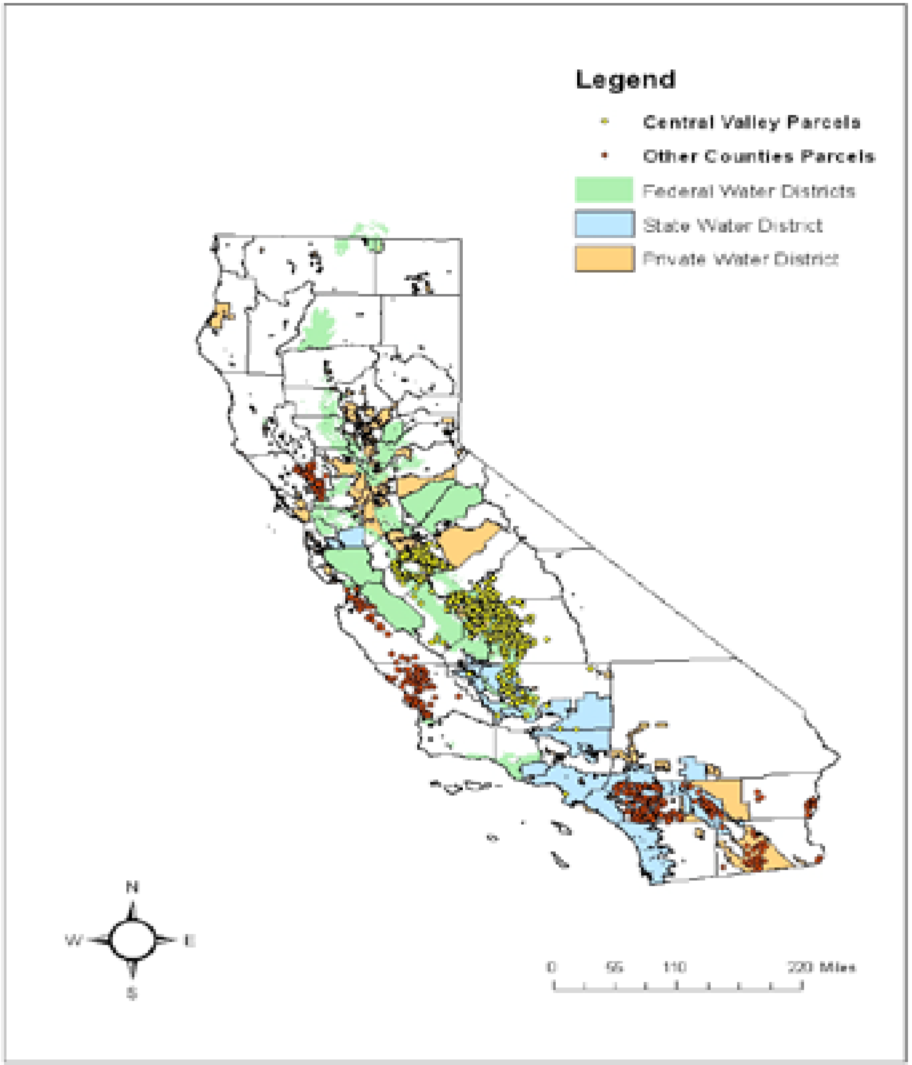
Data – water districts and water supply

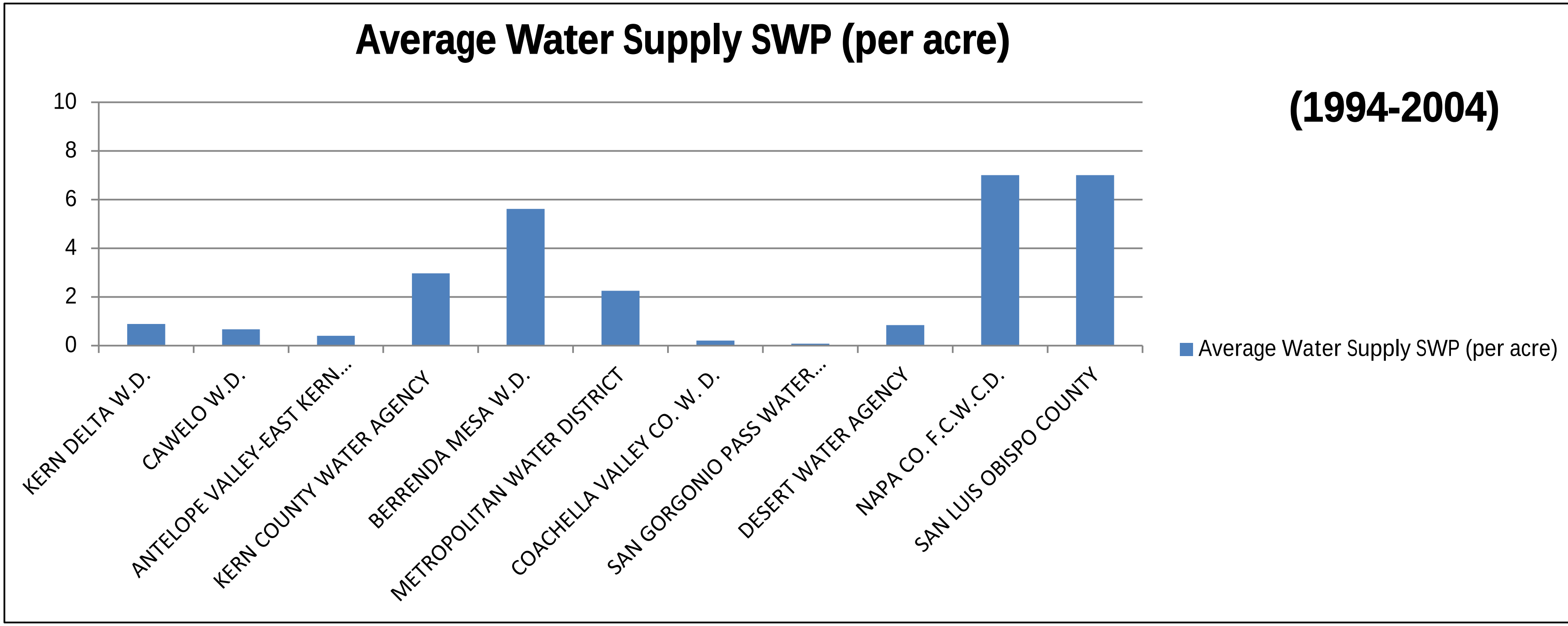
- Does farm belong to water district?
- State, Federal or Private water district member.
- Sources of water for water district

  - Appropriative, Riparian or Groundwater

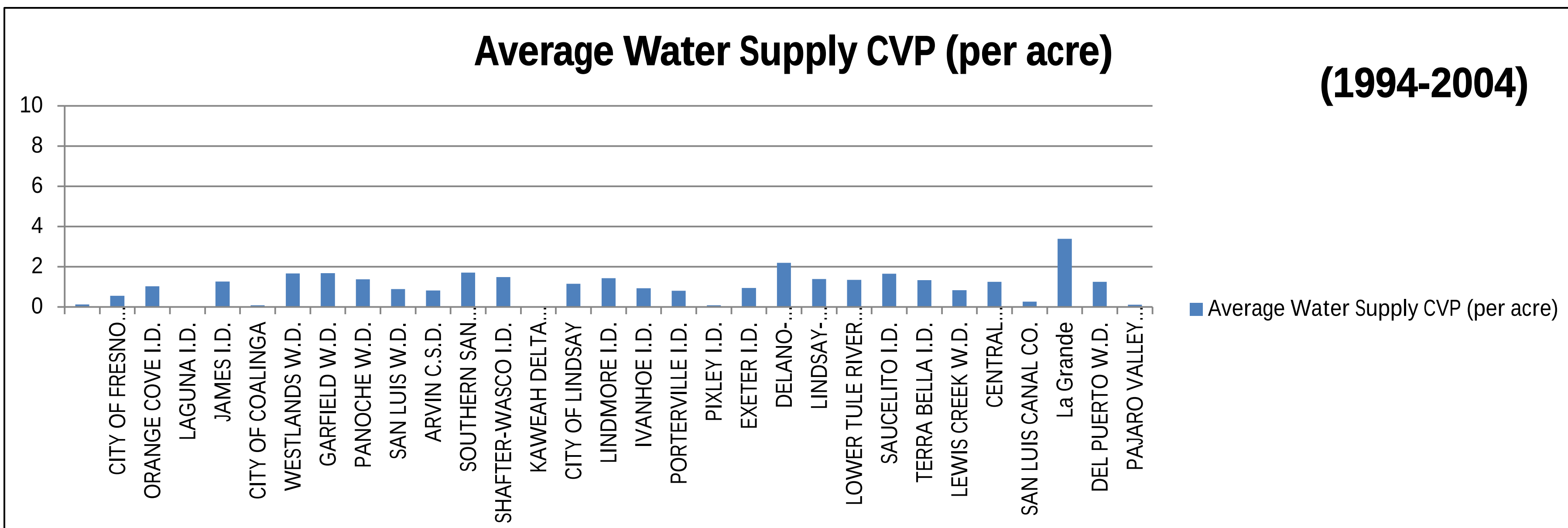
- Mean and variance of State Water Project (SWP) supply (1994-2004)
- Mean and variance of (Federal) Central Valley Project (CVP) supply (1994-2004)
- Maximum water allocation (Face Value) for Private, State and Federal Water districts.

Data – Water districts
Application of spatial intersection



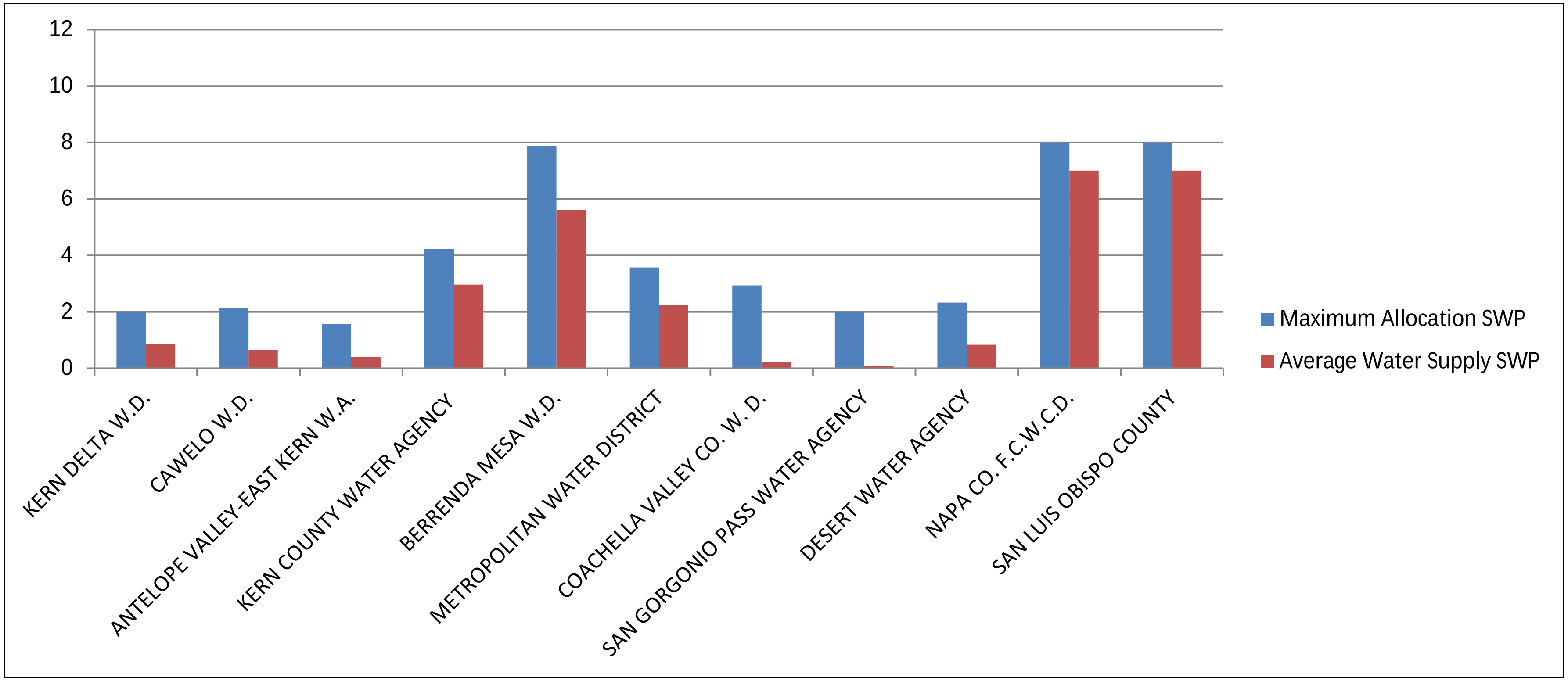


Average Water Supply SWP (per acre)
(1994-2004)
10
8
6
4
2
0
KERN DELTA W.D.
CAWELO W.D.
ANTELOPE VALLEY-EAST KERN...
KERN COUNTY WATER AGENCY
BERRENDA MESA W.D.
METROPOLITAN WATER DISTRICT
COACHELLA VALLEY CO. W. D.
SAN GORGONIO PASS WATER...
DESERT WATER AGENCY
NAPA CO. F.C.W.C.D.
SAN LUIS OBISPO COUNTY
Average Water Supply SWP (per acre)

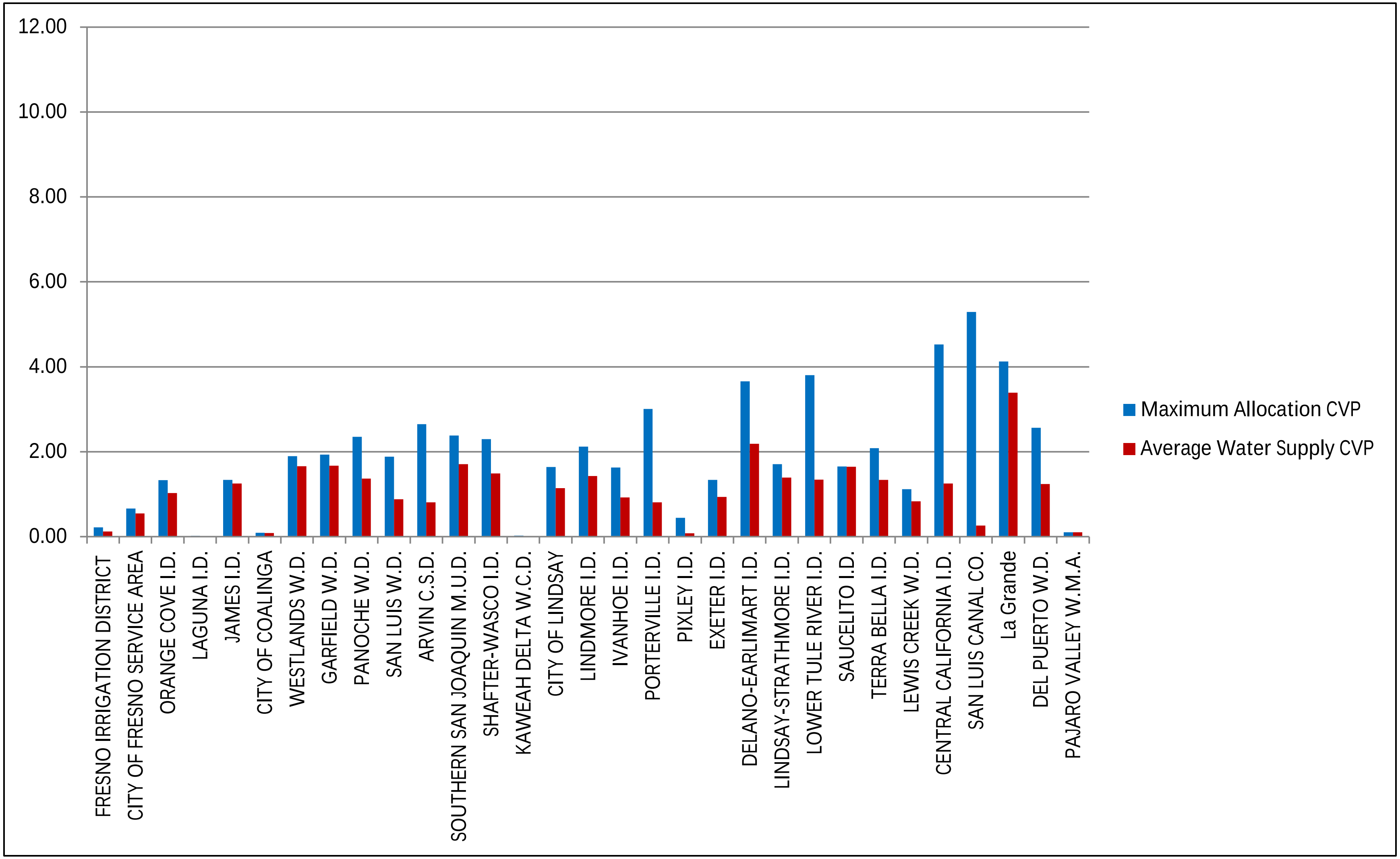


Average Water Supply CVP (per acre)
(1994-2004)
10
8
6
4
2
0
CITY OF FRESNO...
ORANGE COVE I.D.
LAGUNA I.D.
JAMES I.D.
CITY OF COALINGA
WESTLANDS W.D.
GARFIELD W.D.
PANOCHE W.D.
SAN LUIS W.D.
ARVIN C.S.D.
SOUTHERN SAN...
SHAFTER-WASCO I.D.
KAWEAH DELTA...
CITY OF LINDSAY
LINDMORE I.D.
IVANHOE I.D.
PORTERVILLE I.D.
PIXLEY I.D.
EXETER I.D.
DELANO-...
LINDSAY-...
LOWER TULE RIVER...
SAUCELITO I.D.
TERRA BELLA I.D.
LEWIS CREEK W.D.
CENTRAL...
SAN LUIS CANAL CO.
La Grande
DEL PUERTO W.D.
PAJARO VALLEY...
Average Water Supply CVP (per acre)

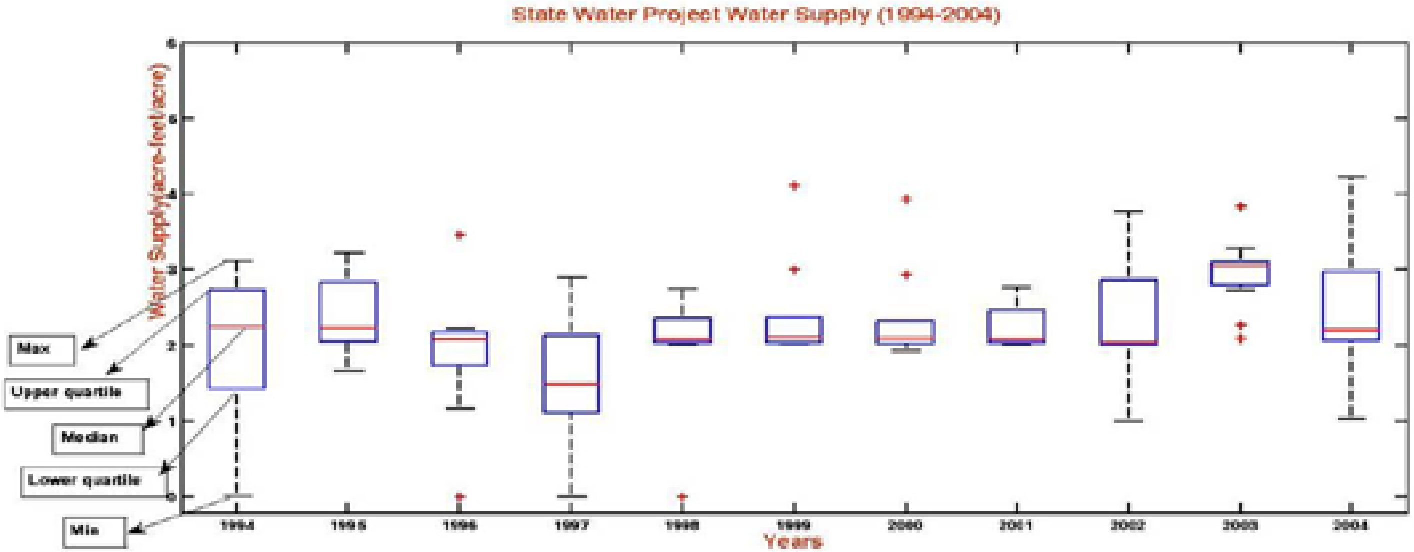
Maximum Allocation versus Average Water Supply (acre-feet/acre) : State Water Districts

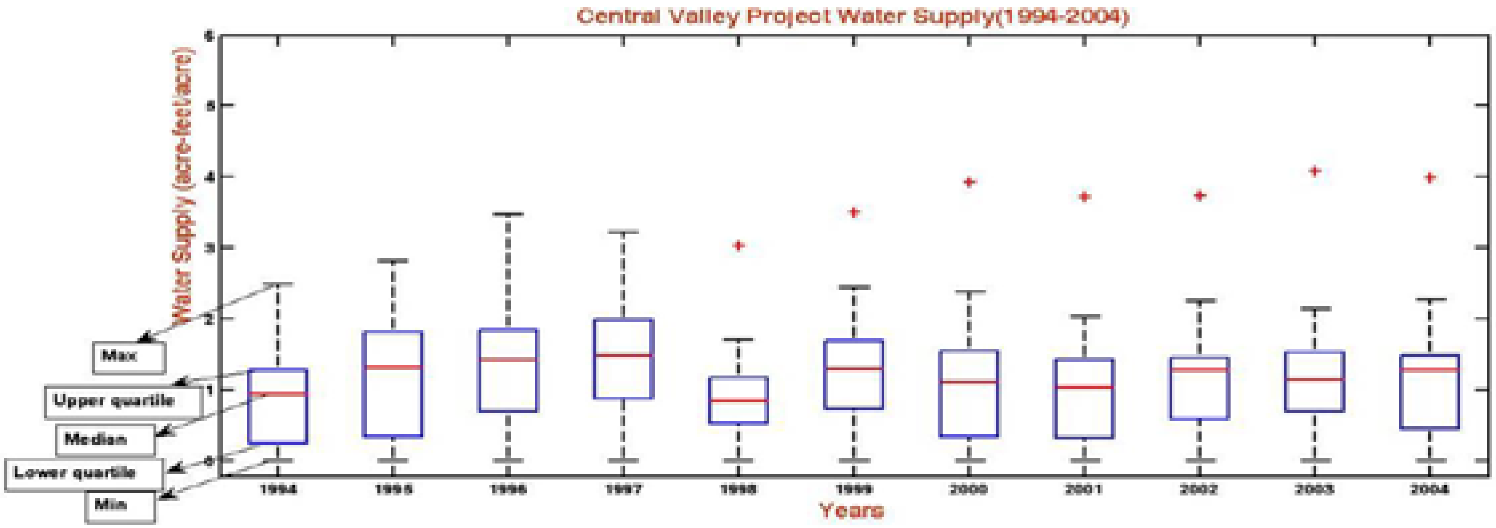


Maximum Allocation versus Average Water Supply (acre-feet/acre) – Federal Water Districts



Variability in water supply: whisker plots





Methodology: General Hedonic Model

(3) $salevalue_{it} = \beta_0 acres_{it} + \beta_1 orchard + \beta_2 vineyard +$

$\beta_3 distance\ from\ freeway_i + \beta_4\ population_i + \beta_5\ Storie\ Index_i +$

$\beta_6\ year\ fixed\ effects + \beta_7\ Jan\ Dgd_i + \beta_8\ April\ Dgd_i +$

$\beta_9\ JulyDgd_i + \beta_{10}\ OctDgd_i + \beta_{11}\ Jan\ Precip_i +$

$\beta_{12}\ AprilPrecip_i + \beta_{13} JulyPrecip_i + \beta_{14} OctPrecip_i +$

$\beta_{15} Private\ WD + \beta_{16} State\ WD + \beta_{17} Fed\ WD + \beta_{18} PrivateState +$

$\beta_{19} PrivateFed + \beta_{20} State\_othersupplies + \beta_{21} Fed\_othersupplies +$

$\beta_{22} Private\_othersupplies + \beta_{23} MeanWater\ Supply\_SWP\ _i +$

$\beta_{24} MeanWater\ Supply\_CVP_i + \beta_{25} VariabilityWater\ Supply\_SWP_i +$

$\beta_{26} Varibility\ Water\ Supply\_CVp_i + \beta_{27} Groundwater\ depth_i +$

$\beta_{28}\ Groundwater\ salinity_i + \varepsilon_{it}$

Analyzing Benefits of Water Supply Portfolios: *4 Scenarios*

Scenario 1 Baseline Model	Scenario 2 Portfolio 1	Scenario 3 Portfolio 2	Scenario 4 Portfolio 1&2
No allowance for multiple water supply sources	Acknowledge farms in districts which have access to groundwater and/or riparian sources	Acknowledge farms that are members of multiple water districts	Account for farms in a district that also has access to riparian or groundwater, or has access to water from another district

Variables [Dependent Variable: ln Sale price/acre]	Scenario 1 No Portfolio (Baseline Model)	Scenario 2 Access to multiple sources of water within a district	Scenario 3 Member of multiple water districts	Scenario 4 Access to multiple sources within and across districts
Population	0.033** (0.011)	0.067*** (0.000)	0.043*** (0.001)	0.050*** (0.000)
Distance from freeway	-0.012** (0.011)	-0.004 (0.460)	-0.009* (0.069)	-0.001 (0.233)
Orchard	0.058** (0.047)	0.073** (0.024)	0.080** (0.053)	0.099** (0.035)
Vineyard	0.011 (0.825)	0.013 (0.819)	0.035 (0.525)	0.0467 (0.925)
Acres	-0.541*** (0.000)	-0.572*** (0.000)	-0.542*** (0.000)	-0.569*** (0.000)
Storie Index	0.072*** (0.002)	0.069*** (0.003)	0.085*** (0.000)	0.074*** (0.002)

Variables	Scenario 1	Scenario 2	Scenario 3	Scenario 4
State Water District	**0.840*** (0.000)**	0.901** (0.016)	0.542** (0.014)	**0.795** (0.018)**
Federal Water district	**0.183** (0.011)**	0.198** (0.016)	0.368*** (0.000)	**0.436*** (0.000)**
Private Water District	**0.130*** (0.004)**	0.219*** (0.000)	0.115** (0.051)	**0.235*** (0.001)**
StateWD_other		0.517** (0.007)		**0.789** (0.007)**
FedWD_other		0.112* (0.088)		**0.059 (0.371)**
PrivateWD_other		0.087 (0.162)		**0.006 (0.928)**
PrivateState_top25%_SWP			-0.056 (0.514)	**-0.084 (0.337)**
PrivateState_bot25%_SWP			0.012** (0.008)	**0.026** (0.040)**
PrivateFed_top25%_CVP			0.047 (0.531)	**0.062 (0.421)**
PrivateFed_bot25%_CVP			0.039*** (0.000)	**0.061*** (0.000)**

Variables [Dependent Variable: ln Sale price/acre]	Scenario 1 No Portfolio (Baseline Model)	Scenario 2 Access to multiple sources of water within a district	Scenario 3 Member of multiple water districts	Scenario 4 Access to multiple sources within and across districts
Jan_Precip	0.087 (0.291)	0.031 (0.699)	0.079 (0.357)	0.037 (0.718)
April_Precip	0.315*** (0.000)	0.146** (0.048)	0.371*** (0.000)	0.183** (0.014)
July_Precip	-0.487*** (0.000)	-1.178 (0.224)	-0.512*** (0.000)	-0.621*** (0.000)
Oct_Precip	0.385*** (0.000)	0.367*** (0.000)	0.391*** (0.000)	0.355*** (0.000)
Jan_Dgd	0.440** (0.009)	0.503*** (0.004)	0.401** (0.019)	0.066*** (0.000)
April_Dgd	3.750*** (0.000)	3.279*** (0.000)	3.452*** (0.000)	3.723*** (0.000)
July_Dgd	*-1.916*** (0.002)*	*-1.511** (0.005)*	*-1.557*** (0.004)*	*-1.115*** (0.000)*
Oct_Dgd	5.848*** (0.020)	5.320*** (0.000)	5.367*** (0.000)	5.660*** (0.000)

Variables [Dependent Variable: ln Sale price/acre]	Scenario 1 No Portfolio (Baseline Model)	Scenario 2 Access to multiple sources of water within a district	Scenario 3 Member of multiple water districts	Scenario 4 Access to multiple sources within and across districts
Groundwater Depth	-0.056*** (0.000)	-0.065*** (0.000)	-0.057*** (0.000)	-0.056*** (0.000)
Salinity	- 0.107*** (0.000)	-0.096 (0.114)	-0.047 (0.394)	-0.016** (0.037)
Mean Water Supply_SWP	1.101*** (0.000)	0.067 (0.840)	1.021*** (0.003)	0.070 (0.834)
Mean Water Supply_CVP	0.122*** (0.002)	0.148*** (0.000)	0.074 (0.130)	0.087* (0.077)
Variability_SWP	-0.623*** (0.000)	-0.059 (0.743)	-0.590*** (0.001)	-0.072 (0.695)
Variability_CVP	-0.012*** (0.000)	-0.003 (0.885)	-0.025 (0.307)	-0.018 (0.466)

Summary of Results

- Water supply portfolios are shown to….
  - reduces impact of salinity (degrading aquifers)
  - help growers adapt to lower <u>and</u> less reliable water supplies
  - reduce impacts of high summer temperatures
- Type of water supply matters
- Water portfolios may be an effective adaption strategy to reduced water supplies and climate change
  - Type of water portfolio matters though

Implications: Methodological and Policy

- Geospatial analysis capturing spatial characteristics with the integration of GIS and Economic Valuation methods

- Estimating impacts of climate change require accounting for
  - Means, variability, and quality

  and full range of adaptation opportunities and characteristics

- Policies that increase opportunities for water districts, growers, etc., to diversify their water portfolio can be an effective adaptation strategy
  - Ultimate diversification => water markets