A Retrospective Estimate of the Economic Impacts of Reduced Water Supplies to the San Joaquin Valley in 2009

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The effect of reduced water supplies as a result of drought and environmental pumping restrictions in 2009 on the San Joaquin Valley economy was, and continues to be, the subject of significant discussion. Economic effects were quantified in terms of agricultural production, revenues, and jobs and income. In the midst of a severe recession, it is no surprise that job loss estimates generated the most interest and debate. In the months following the 2009 growing season, data have been released that offer a clearer picture of the effects of reduced water supplies. As such, the purpose of this report is to take a retrospective look back at 2009 and summarize changes in agricultural production and employment in the San Joaquin Valley due to reduced water supplies. Model results and survey data now closely coincide and provide conclusive evidence on the final effects of reduced water supplies in 2009.

During 2009, the authors of this report independently issued conflicting estimates of the job losses due to reduced water supplies to San Joaquin Valley agriculture. The varying estimates generated significant controversy. As more reliable data has become available, the differing estimates are converging to a relatively narrow range. By issuing a joint retrospective report, our intention is to provide an accurate range of estimates for policy and planning purposes and place the focus on the similarities rather than the differences.

Before getting to the estimates, it important to emphasize two additional points on which we agree. First, a significant increase in the amount of water transfers was critically important to reducing the negative impacts of water scarcity. A higher than anticipated level of water transfers is a key reason these revised estimates of losses are smaller than we estimated last year. Building on these successful transfers will be important in minimizing the losses from future

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water shortages. Second, the impacts of reduced water availability were highly concentrated geographically on the west sides of Fresno, Kings, and Kern counties. Although our impact estimates are now lower, they still represent very large losses for these communities in the southwest part of the San Joaquin Valley.

In this report we use two approaches to estimating the economic impact of drought and environmental pumping restrictions on San Joaquin Valley agriculture. We first present the approach conducted by the University of the Pacific which uses the 2009 County Crop Reports[2] (Crop Reports) issued by Agriculture Commissioners of the eight San Joaquin Valley Counties to calculate the change in harvested acres and crop revenue. The 2009 data in the Crop Reports is still preliminary and subject to future revision, but represent the most current official estimates of 2009 crop production. The second approach, conducted by the University of California at Davis, uses the Statewide Agricultural Production Model (SWAP)[3] calibrated exactly in inputs and outputs to a normal water and price year (2005). Using realized water deliveries and transfers in 2009, SWAP estimates changes in agricultural production and revenue resulting from drought and environmental pumping restrictions. The revenue losses are then put into an input-output model to estimate additional employment and income losses in related industries with slight differences in the input-output models used in each approach. In a final step, the impacts are separated into the effects of drought and environmental restrictions, and here the two approaches also differ. Finally, we compare the estimated losses in jobs to those recorded by EDD surveys and the QCEW as context and corroboration for both estimates.

Change in Harvested Acres

Changes in harvested acres reflect the localized effects of drought on San Joaquin Valley agriculture. Counties including Kern, Kings, and Fresno show significant losses while other Counties including Madera, Merced, San Joaquin, Stanislaus, and Tulare show steady or increases in harvested acres between 2008 and 2009 based on Crop Reports. There was also significant variation within Counties, for example, within Fresno County, east-side regions saw little change in harvested acres compared to west-side regions. This is a reflection of both the localized effects of drought and pumping restrictions on regions dependent on State and Federal Project deliveries and/or groundwater pumping.

According to the Water Transfer Database[4] compiled by the University of California at Santa Barbara from water transfers reported in the Water Strategist, there was over 500,000 acre feet of water transferred for agricultural use in 2009. The United States Bureau of Reclamation (USBR) has suggested that this figure may actually be as high as 800,000 acre feet. In addition to water transfers, realized local surface water supplies to east-side Valley regions were higher than

[2] Available at County Agricultural Commissioner websites. These reports are based on initial surveys that are then compiled and analyzed by NASS, at which point they will become final estimates. The NASS report is not yet available, but can be found in the future at http://www.nass.usda.gov

[3] http://swap.ucdavis.edu

[4] http://www.bren.ucsb.edu/news/water_transfers.htm

initially anticipated. Higher local surface water supplies and increased levels of groundwater pumping allowed production to shift to relatively water rich regions on the east-side of the Valley. Combined with a shift in cropping pattern to lower water use crops, actual crop losses and land fallowing were lower than originally projected.

Table 1. Known Water Transfers for San Joaquin Valley Agriculture in 2009

Transfer (af/yr)	Avg Price/af	Seller	Buyer
7,292	129.75	San Luis & Delta Mendota WA	Westlands Water District
33,420	223.83	San Joaquin River Exchange Contractors WA	Westlands Water District
24,932	161.90	Yuba County Water Authority	Westlands Water District
60,000	33.89	Yuba County Water Agency	California DWR
15,000	39.71	Yuba County Water Agency	SWP Contractors and San Luis & Delta-Mendota WA
16,100	52.95	Yuba County Water Agency	SWP Contractors and San Luis & Delta-Mendota WA
88,900	132.38	Yuba County Water Agency	SWP Contractors and San Luis & Delta-Mendota WA
74,102	145.62	17 entities through Drought Water Bank	9 entities through Drought Water Bank
750	8.07	Ventura County	14 SWP Contractors
1,250	4.03	Ventura County	14 SWP Contractors
216,474	n/a	San Joaquin River Exchange Contractors WA	USBR, San Luis & Delta Mendota WA, and Madera ID
538,220	93.21		

The first approach to calculating change in acreage tabulates change in crop acres between 2008 and 2009 using 2009 preliminary Crop Reports, as shown in Table 2. The entire decline in harvested acres occurred in the three counties most impacted by reduced water deliveries from the Delta and drought: Fresno, Kern and Kings. Across the entire San Joaquin Valley, virtually the entire decline in net harvested acreage was in lower-value field and seed crops as farmers rationally directed more of their scarce water resources to protecting high value fruit and nut orchards. Vegetable production was able to shift north and east from water limited areas on the southwest side of the Valley. In particular, processing tomato production reached record levels in 2009 as processors were very successful in shifting production to new areas. Preliminary crop reports show significant growth in processing tomato, melon and other miscellaneous vegetable acreage in Stanislaus, Merced, and Tulare counties in 2009. Some of the new vegetable acreage was shifted from field crops, but others included new acreage brought into production in response to the drought. In particular, Stanislaus County reported record levels of harvested acres, and conversations with County agriculture officials confirmed that thousands of new acres were planted in 2009 in response to the land fallowing in other areas of the Valley using supplemental water supplies and groundwater.

Table 2. Change in Harvested Acres Between 2009 and 2008 from County Crop Reports.

	San Joaquin Valley Total	Fresno, Kings, and Kern Counties	Other San Joaquin Valley Counties
Field Crops	-246,143	-202,824	-43319
Seed	-4,420	-8469	4049
Vegetables	20,482	-21769	42251
Fruit and Nuts	12,462	2150	10312
Total Acres	**-217,619**	**-230,912**	**13,293**

(Note: Harvested acres differs slightly from crop report summaries, because we exclude rangeland and unirrigated pasture land from harvested field crop acres. Source: County Crop Reports available on the website of each Counties' commissioner of agriculture. Other San Joaquin Valley Counties include Tulare, Madera, Merced, Stanislaus, and San Joaquin.)

The one year change in acreage in Table 2 is insightful, but does not tell the full story. First, the Valley experienced three years of drought from 2007 to 2009, and the impact of reduced water supplies was already being felt to some extent in 2008. Comparing 2009 to 2006, the last year of full contract water deliveries, shows a total decline of 256,000 harvested acres in Fresno, Kings and Kern counties, an additional decline of 25,000 acres. Second, although there was no total harvested acreage change in fruit and nut crops, it would be incorrect to assume that there was no loss to these high-value permanent crops. Over the past decade, there has been a rapid increase in permanent crop plantings in Fresno, Kings and Kern counties, particularly almond orchards, and it is likely that fruit and nut acreage would have increased substantially more with full water supplies. Data on almond plantings and recent trends in fruit and nut acreage growth suggest that fruit and nut harvest in the San Joaquin Valley would have increased by an additional 25,000 acres in 2009, mostly almonds. Thus, the first approach estimates roughly 243,000 acres were fallowed due to reduced water supplies to the San Joaquin Valley in 2009. This includes approximately 256,000 fallowed acres in Fresno, Kings, and Kern Counties, and a gain of 13,000 acres in other Counties in response to the shortages elsewhere.

The second approach to estimating change in crop acres uses the SWAP model calibrated to a normal water year with average prices, namely 2005. In light of significant structural changes in agriculture in the San Joaquin Valley between 2006 and 2008, it is also important to consider changes between 2009 and the last normal water and price year. This better reflects the full combined effect of drought and pumping restrictions. We explicitly model the known water transfers (Table 1) and increased east-side water supplies in SWAP. We note that, aside from the updated water data, the model is unchanged from previous reports using this approach. Water transfers account for about 538,000 acre feet of water shifted involving regions in the San Joaquin Valley. Increased east-side water supplies account for an additional 225,000 acre feet.

Table 3 summarizes change in total acres for the total water supply reduction, drought plus environmental pumping restrictions.

Table 3. Estimated Change in Harvested Acres Due to Drought and Pumping Restrictions in 2009 from the UC-Davis SWAP Model.

Crop Group	West-side Regions	East-side Regions	Kern	San Joaquin Valley Total
Vegetables	-1,598	-33	-1,018	-2,649
Grain/Cotton	-132,470	-5,298	-62,710	-200,477
Fruit & Nuts	-1,566	-792	-3,415	-5,773
Alfalfa	-11,411	-2,011	-11,497	-24,919
Field	-8,349	-8,865	-10,707	-27,920
Grapes	-380	-171	-2,810	-3,361
Proc. Tom	-2,873	-5	-606	-3,483
Total	**-158,646**	**-17,175**	**-92,762**	**-268,583**

Preliminary estimates based on remotely sensed satellite images of crop cover estimate that between 260,000 and 290,000 acres were fallowed[5] due to combined water shortages in 2009. The SWAP model calibrated against realized water conditions, as described above, in 2009 yields an estimated 269,000 acres out of production due to drought and environmental pumping restrictions. The results of the model, 269,000, are very close to those estimated using remote sensing data, 260,000. The largest declines are in various field crops, with moderate declines in fruit and nut acreage. However, to the extent that orchards were deficit irrigated during the current drought, there are long term carry over effects on yield which may speed up replanting times leading to additional costs in the future.

The most striking result from analyzing Crop Reports and SWAP model results is the disparity between regions within the San Joaquin Valley. West-side Valley regions show significant losses in harvested acres due to drought and environmental pumping restrictions. In fact, when broken down into more detailed SWAP model regions the difference is even more striking. We return to this effect in the context of revenue losses, in the following section. In contrast, east-side regions show increases, or slight decreases, in acres across the same time frame. This is largely explained by differences in water source between regions, as summarized in Table 4. The west-side of the San Joaquin Valley relies on State Water Project (SWP) and Central Valley Project (CVP) deliveries for over 80% of water in an average water year compared to only 14% for east-side regions. Consequently, in severe drought years and/or with increased environmental pumping restrictions west-side regions and Kern County can be expected to experience relatively higher losses. In the short run, increased groundwater pumping may be a feasible, albeit more costly, solution to replace reduced water supplies. However, during drought and pumping restrictions over several years, as was the case from 2007-2009, this may draw down the water table which increases pumping costs and leads to long term water quality considerations.

[5] Personal communication with David's Engineering, Davis, CA. September 27, 2010.

Table 4. Water Supply Proportion in an Average Water Year for San Joaquin Regions

Region	CVP and SWP	Local Surface Water	Groundwater
East-side	14.80%	52.60%	32.60%
West-side	85.05%	4.96%	9.99%
Kern	57.27%	12.92%	29.81%

Change in Agricultural Revenues

Changes in agricultural revenues due to drought and environmental pumping restrictions follow directly from changes in harvested acres. As such, they also reflect the localized effects of drought on San Joaquin Valley agriculture. We summarize changes in agricultural revenues using the two approaches in this section.

The first approach, using Crop Reports, is detailed in Table 5. Crop losses are valued using typical 2008 prices to allow for comparisons and to be consistent with the base year of the economic impact model in the next section. Cotton and grain production experienced the largest acreage declines, followed by other field crops, most of which is silage. Most of the lost nut and fruit acreage was allocated to almonds which yielded an average of $3,500 per acre in 2008. Because vegetable acreage substantially increased in San Joaquin Valley as a whole in 2009, no vegetable production is included. For the entire San Joaquin Valley, the $342.6 million decline is 2.3% of total crop production exceeding $15.1 billion in 2008.

Table 5. Estimated Acreage and Revenue Losses due to Reduced San Joaquin Valley Water Supplies from County Crop Reports.

Crop	Decrease in Harvested Acres	Per acre value	Revenue Loss
Cotton	-70,000	$1,400	-$98,000,000
Alfalfa Hay	-25,000	$1,500	-$37,500,000
Other field crops	-53,000	$1,200	-$63,600,000
Grain	-70,000	$800	-$56,000,000
Nuts and Fruit	-25,000	$3,500	-$87,500,000
Total	**-243,000**		**-$342,600,000**

(Per acre values are set at typical 2008 prices for consistency with the input-output model, and to separate water effects from the large 2009 decline in field crop prices partially due to the dairy crisis.)

The second approach uses the SWAP model, with realized water deliveries in 2009, to estimate total change in agricultural revenue by region and crop. The water scenario is the same as that used in May 2009, and a subsequent update in September 2009. The scenario reflects the final, actual, water deliveries to the San Joaquin Valley 2009. Specifically, 10% CVP agricultural water service contract, 100% for all Settlement and Exchange regions, 100% Friant Class 1, 0%

Friant Class 2 and 40% SWP. The only change to the model is to allow for water transfers and increased east-side local surface water supplies, as discussed previously.

Change in agricultural revenue due to drought and pumping restrictions is summarized in Table 6. All dollars are reported in $2008. We estimate that $368 million was lost due to drought and pumping restrictions across the entire San Joaquin Valley. This represents a 2.5% decline in revenue[6] across the entire San Joaquin Valley. Of the $368 million in losses, $328 million (89%) is in Kern and the west-side regions.

As discussed in the acres section, there is significant variation in changes in revenue across regions in the San Joaquin Valley. West-side regions that are more reliant on State and Federal Project deliveries realize higher fallowing, and thus higher revenue losses than east-side regions. Additionally, regions adjust water use by shifting cropping patterns to lower water use crops. Finally, stress irrigation and increased groundwater pumping in west-side regions can have long term effects on yields, water quality, and revenues in the future. To the extent that these are not included, these cost estimates represent a lower bound.

Table 6. Estimated Change in Revenues Due to Drought and Pumping Restrictions in 2009 from UC-Davis SWAP model. (dollar values in thousands).

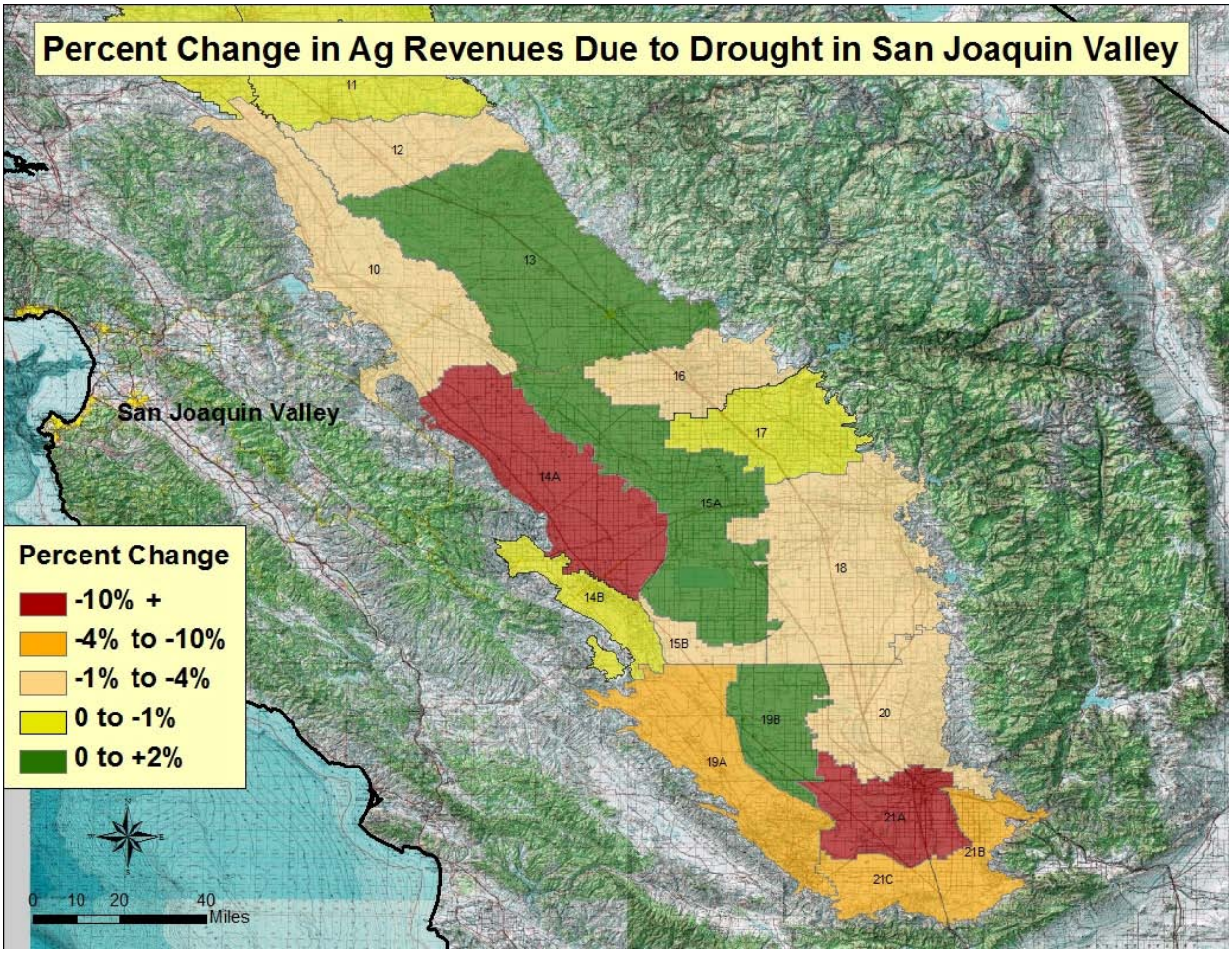
Crop Group	West-side Regions	East-side Regions	Kern	San Joaquin Valley Total
Vegetables	-$9,487	-$446	-$6,654	-$16,587
Grain/Cotton	-$149,085	-$12,813	-$52,098	-$213,996
Fruit & Nuts	-$14,455	-$9,973	-$30,447	-$54,874
Alfalfa	-$13,159	-$6,674	-$16,231	-$36,065
Field	-$5,370	-$8,651	-$4,499	-$18,519
Grapes	-$1,799	-$347	-$13,396	-$15,542
Proc. Tom	-$10,850	-$36	-$1,616	-$12,502
Total	**-$204,204**	**-$38,939**	**-$124,940**	**-$368,084**

To illustrate the importance of regional differences for the effects of drought and pumping restrictions, Figure 1 shows a map of revenue changes in the San Joaquin Valley. The largest revenue losses are concentrated in Kern County and west-side Valley Regions. However, it is important to note that there is significant variation within Counties which is not captured when analyzing County level survey estimates and Crop Reports. For example, within Fresno County west-side regions, specifically Westlands Water District, realize losses in revenue over 10% whereas the east-side of the County sees unchanged to slightly positive revenue growth. The west-side of Fresno County relies heavily on SWP and CVP deliveries, which are cut significantly under drought and pumping restrictions. The same is true within Kern County

[6] Note, total SWAP output value for the San Joaquin valley is 13.6 billion dollars. SWAP model regions are agronomic regions that may omit agriculture in fringe areas of some Counties, which accounts for approximately $800 million in omitted agriculture.

where regions with relatively higher groundwater availability realize small increases in revenues compared to regions dependent on Project deliveries which see declines in revenue up to 14%.

Figure 1. Map of Percent Change in Agricultural Revenues Due to Drought



Change in Agricultural Employment

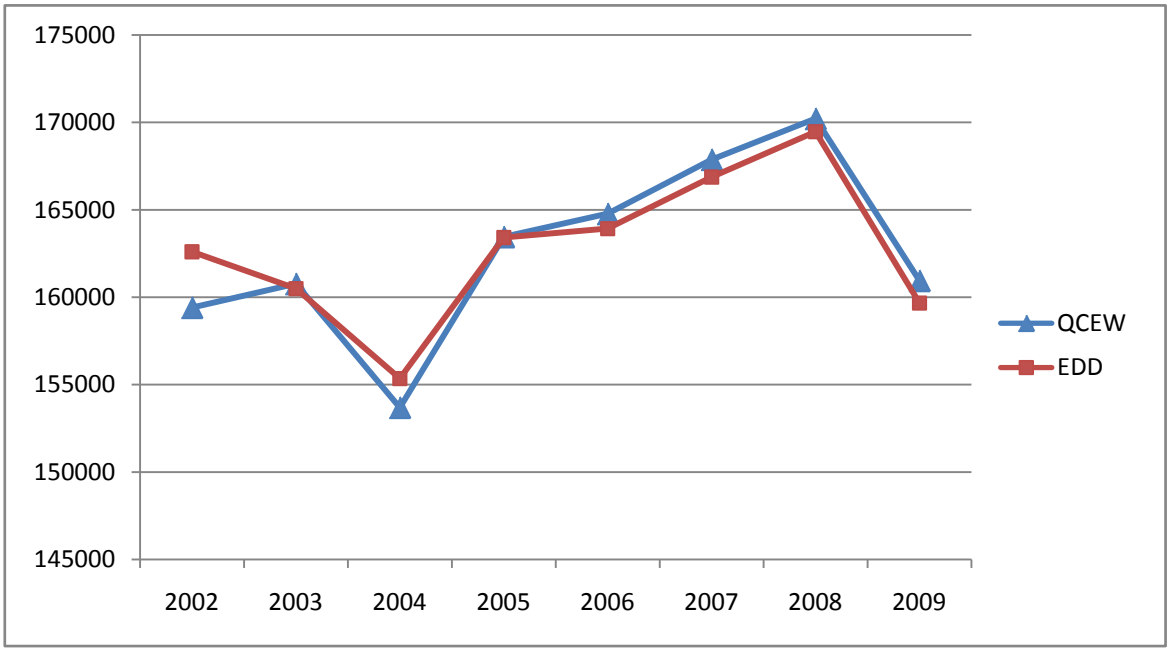
Before estimating the effect of drought and environmental pumping restrictions on agricultural employment, we summarize the actual total change in agricultural employment in the San Joaquin Valley during the drought. There are many factors, including water availability, that cause agricultural employment to change from year to year. The total changes in employment put the subsequent estimates into context and demonstrate that they area of a reasonable scale.

Two sets of highly reliable data are now available to examine the total change in agricultural employment in the San Joaquin Valley between 2008 and 2009. The California EDD has finalized its 2009 agricultural employment survey results and the QCEW is a census of jobs from

unemployment tax filings of agricultural employers. Both sources are more accurate than the employment estimates released each month by California EDD that initially showed an increase in farm jobs in 2009. In order to focus more closely on crop production, we exclude direct employment from Animal Production enterprises (NAICS 112) and show the sum of Crop Production employment (NAICS 111) and Support Activities for Agriculture (NAICS 115) which is primarily farm labor contractors. Animal Production enterprises also hire contract labor, but Crop Production accounts for the vast majority of contract labor. Thus, this focus reduces, but does not completely eliminate, the influence of animal operations such as dairy farms on employment levels.

Figure 2 graphs the two data series between 2002 and 2009, the years for which both have consistent data. Both data sources track closely over time. Between 2008 and 2009, employment decreased by nearly 9,800 jobs (5.8%) in the EDD data and decreased by 9,300 (5.5%) in the QCEW data. When 2009 is compared to the last normal water and price year, 2005, jobs decline by 3,750 (2.3%) in the EDD data and 2,500 (1.5%) in the QCEW data. This data suggests that reasonable estimates of water-related employment loss should be between 2,500 and 9,800 lost jobs. The next section shows that the estimates from both approaches fall within this range.

Figure 2. Crop Production and Agricultural Support Employment in the San Joaquin Valley, 2002-2009.



Estimating Change in Employment Due to Drought and Pumping Restrictions

The impact of the lost agricultural revenue on jobs and income in the San Joaquin Valley can be calculated with an input-output model. The IMPLAN model is used to translate a change to final sales or output from farms into total jobs, income and output within the region. The impact on

jobs, income, and output are categorized as direct, indirect, and induced effects. Direct effects are the changes in employment to direct farm employees, and direct changes to income from farm employee compensation, farm proprietor income, and other farm income. Indirect effects represent the iterative impacts from farms' purchase of intermediate inputs such as fuel, chemicals, transportation services, accounting and professional services, and labor supplied by agricultural labor contractors. Induced effects reflect local household consumption expenditures of direct and indirect sector employees. Examples of induced effects include employee's local expenditures on retail goods, housing, restaurants, recreation, medical services, and other goods and services. Output measures total final sales of businesses within the region and therefore double-counts some expenditures, whereas income measures value-added at each level of economic activity. Although it is a useful measure of economic activity, output is not directly comparable to commonly cited value-added based measures of the economy such as Gross State Product. Income is a preferable measure of the change in regional economic welfare within a region, and facilitates comparisons to other economic data.

The University of the Pacific analysis utilizes IMPLAN 3 and 2008 base data to create an input-output model for the eight counties in the San Joaquin Valley. IMPLAN 3 is the most recent update to the software, and the 2008 base economic data is used to be consistent with the 2008 agricultural prices used throughout the report. Although data in the IMPLAN model is calibrated to local conditions in the base year, the industry production functions are based on historical national averages and require some adjustments to capture San Joaquin Valley agriculture's unusually heavy reliance on contract labor. For example, in 2008, direct employment on San Joaquin Valley crop farms averaged 65,000, whereas the agricultural support services sector averaged 105,000 jobs primarily with farm labor contractors. In contrast, crop farms in California outside the San Joaquin Valley directly employed 110,000 workers, and there were only 74,000 agricultural support services jobs in these areas. If we used the IMPLAN default production functions, only about half of the 105,000 agricultural service workers in the Valley would be hired by San Joaquin Valley farms, so we increased contract labor purchases across crop sectors until the regional farm sector used all the agricultural service workers in the region. We also made some minor adjustments to direct employment by detailed farm sector to match the published estimates for 2008 from the California EDD and Department of Food and Agriculture. These adjustments cause our estimates of lost employment and income to be considerably larger than if we had utilized the IMPLAN models default levels, but the results more accurately describe local conditions and more closely match the data on actual employment losses. UC Davis employs IMPLAN Version 2.0 and the California County database for the base year 2006. The ten IMPLAN default crop categories were grouped into six crop groups to better reflect SWAP output, namely: grain, vegetable and melon, tree nut, fruit, cotton and all other crops. As discussed in the preceding paragraph, the default IMPLAN production functions do not reflect current conditions in California. Consistent with previous analysis by UC Davis, we adopt a different approach than that of University of the Pacific to adjust the IMPLAN model. We modified the default IMPLAN production functions coefficients to match the reported

proportion of contracted labor (as agricultural services NAICS 115) in the EDD 2006 breakdown of agricultural employment. Overall, the coefficient change was slightly less than double the default value. We allow the production function to then re-balanced using the IMPLAN default algorithm. No additional adjustments were used.

Results

Using the Crop Report data, the University of the Pacific approach estimates a total of $342.6 million in revenue losses across the San Joaquin Valley due to drought and pumping restrictions. Table 7 shows the impact of the $342.6 million decline in San Joaquin Valley agricultural output (from Table 5). Total job loss, including, all multiplier effects totals 5,567. The indirect effects include approximately 2,850 agricultural services jobs, so the total job loss of 5,567 breaks down to 4,515 agricultural jobs and 1,052 non-agricultural jobs. Total lost income is $287 million which includes an estimated $136.3 million in employee compensation and $150.7 million in non-employee farm income. The $342.6 million decline in farm output resulted in an additional $243.2 million decline in regional economic output for a total output decline of $585.8 million.

Table 7. San Joaquin Valley Impact of Reduced Water Supplies based on a $342.6 million decline in output estimated from Crop Reports.

Impact Type	Employment	Income	Output
Direct Effect	-1,663	-$145,787,345	-$342,600,000
Indirect Effect	-3,096	-$89,179,500	-$142,944,720
Induced Effect	-808	-$52,010,240	-$100,230,032
Total Effect	**-5,567**	**-$286,977,005**	**-$585,774,720**

Using results based on the SWAP model, the University of California at Davis approach estimates a total of $368.1 million in lost agricultural revenues due to drought and pumping restrictions (see Table 6). Table 8 shows the impact of the $368.1 million decline in agricultural output in the San Joaquin Valley. Total job loss, including, all multiplier effects totals 7,434. Total income loss is estimated at $278 million with a $796 million decrease in output.

Table 8. San Joaquin Valley Impact of Reduced Water Supplies based on SWAP Model Results of $368.1 (2008) million decline in agricultural revenues.

Impact Type	Employment	Income*	Output
Direct Effect	-2,117	-$90,700,000	-$359,300,000
Indirect Effect	-2,823	-$75,000,000	-$152,300,000
Induced Effect	-2,494	-$113,000,000	-$284,400,000
Total Effect	**-7,434**	**-$278,700,000**	**-$796,000,000**

*As total labor income.

Breaking Down the Effect of Drought and Environmental Pumping Restrictions

Thus far we have used two approaches to estimate the change in acreage, revenues, and jobs and income due to the combined effects of drought and environmental pumping restrictions in the San Joaquin Valley. Equally as important is the proportional effect of drought and pumping restrictions, considered separately. In this section we provide an estimate of the percent of economic losses attributable to pumping restrictions which differ from share of water supply lost to pumping restrictions.

The first approach, conducted by the University of the Pacific, is to allocate 25% of economic losses to pumping restrictions and 75% to drought in proportion to their average relative contribution to reduced water deliveries. This simple approach does not take a stance on whether the drought is an incremental impact on the environmental restrictions or whether the environmental effects are incremental to the drought. Table 9 shows the allocation of losses between the two causes. The effect of environmental pumping restrictions is estimated at 1,392 lost jobs, a $71.7 million decline in income, and a $146.4 million decline in output.

Table 9. Relative Impacts of Drought and Pumping Restrictions based on decline in output estimated from Crop Reports, and proportional changes to economic losses and water supplies.

Impact Type	Employment	Income	Output	Acres	Revenue
Drought	-4,175	-$215,232,754	-$439,331,040	-182,250	-$256,950,000
Pumping Restrictions	-1,392	-$71,744,251	-$146,443,680	-60,750	-$85,650,000
Total Effect	**-5,567**	**-$286,977,005**	**-$585,774,720**	**-243,000**	**-$342,600,000**

The second approach, conducted by UC Davis, runs two scenarios in the SWAP model, one with drought only and one with drought and environmental pumping restrictions. In contrast to the University of the Pacific approach, this allows for modeling the shift in cropping pattern and production across regions with and without pumping restrictions. As such, this captures the marginal adjustments by farmers in response to pumping restrictions and the allocation of effects is not a strict percentage across all categories. The effect of pumping restrictions on San Joaquin Valley agriculture depends solely on the amount of water restricted for delivery, which depends on the type of water year. In average and wet years, pumping restrictions account for a higher total amount of water reductions relative to drought years. This is a function of both the legal aspects of the Wanger ruling and the fact that in wet and average years there is more water available, thus it is feasible to allocate more to fish without damaging agriculture. It's estimated that pumping restrictions account for 500,000 af in a critical year and up to 2,000,000 af in wet years. Since 2009 was a dry year, we attribute 500,000 af of reduced water supplies due to environmental pumping restrictions.

Table 10 summarizes the results of the two SWAP model runs. The total effect is estimated at $368 million in lost revenues, 7,500 jobs, and 268,000 fallowed acres. The drought alone accounts for $222 million in revenue losses which translates into 4,400 jobs lost including 1,300 direct and 3,100 indirect and induced. Under drought only, an estimated 138,700 acres are fallowed. We estimate that environmental pumping restrictions accounted for $146 million in lost agricultural revenues in 2009, representing 39% of the total combined effect of reduced water supplies. Additionally, of the estimated 7,500 jobs lost 3,000 can be attributed directly to pumping restrictions for fish, representing 40% of total agricultural jobs lost due to reduced water supplies in 2009. Finally, of an estimated 268,500 fallowed acres, 129,800 can be attributed directly to pumping restrictions, representing 36% of total fallowing.

Table 10. Relative Impacts of Drought and Pumping Restrictions based on decline in output estimated from SWAP.

Impact Type	Employment	Income	Output	Acres	Revenue
Drought	-4,460	-$166,900,000	-$477,200,00	-138,700	($222,000,000)
Pumping Restrictions	-2,973	-$111,800,000	-$318,800,000	-129,800	($146,000,000)
Total Effect	**-7,434**	**-$278,700,000**	**-$796,000,000**	**-268,500**	**($368,000,000)**

Conclusion

This report conducted a retrospective look at 2009 to estimate the total effect of reduced water supplies due to drought and environmental pumping restrictions for agricultural regions in the San Joaquin Valley. Economic impacts were summarized in terms of change in acres, revenues, employment, and income for San Joaquin Valley. No attempt was made to quantify the long term effects of groundwater overdraft, stress irrigation, or rotational adjustments due to the prolonged drought. To the extent that these effects are important, all estimates in this report represent lower bounds on total economic impacts.

This report considers two approaches to estimate the total economic impacts of drought and water pumping restrictions on San Joaquin Valley agriculture. The approaches and the results they yield are similar in many ways, but there are three significant differences. The first approach conducted by the University of the Pacific utilized County Crop Reports to estimate the decrease in agricultural production, and allocated impacts between drought and environmental pumping restrictions. The second approach, conducted by UC Davis, uses the Statewide Agricultural Production Model (SWAP) calibrated exactly to an average water and price year to estimate changes in agricultural production due to realized water deliveries and water transfers in 2009. This approach also uses the SWAP model to estimate changes in agricultural production attributable to drought alone and environmental pumping restrictions alone. Both approaches also use slightly different input-output models to estimate total economic impacts including indirect and induced effects. The results of both approaches were compared to direct measures of agricultural employment change to ensure consistency and reasonableness. Table 10

summarizes the total economic impact on the San Joaquin Valley of reduced water supplies for agriculture in 2009. Table 11 summarizes the portion of the total impacts attributable to the environmental restrictions on Delta water pumping.

Table 10. Total Economic Impact of Drought and Pumping Restrictions on San Joaquin Valley Agriculture in 2009.

	Pacific	UC-Davis
Fallowed Acres	243,000	269,000
Agricultural Revenue	-$342,600,000	-$368,084,000
Employment	-5,567	-7,434
Income	-$286,977,005	-$278,700,000
Output	-$585,774,720	-$796,000,000

Table 11. Total Economic Impact of Pumping Restrictions on San Joaquin Valley Agriculture in 2009.

	Pacific	UC-Davis
Fallowed Acres	61,000	129,800
Agricultural Revenue	-$85,650,000	-$146,000,000
Employment	-1,392	-2,973
Income	-$71,744,251	-$111,800,000
Output	-$146,443,680	-$318,800,000

To conclude we want to emphasize the importance of regional differences within the San Joaquin Valley and even within specific Counties. At the County level, Fresno, Kings, and Kern are the most significantly affected by drought and pumping restrictions in terms of fallowed acres, lost revenue, and lost jobs. However, even County level data masks some of the regional differences. Agronomic regions within Fresno County realize revenue losses ranging between 1.5% growth, in the East-side of the County, to over 10% declines, in Westlands Water District. These differences indicate a strong economic gradient and emphasize the importance of water markets for mitigating the localized effects of reduced water supplies. Looking forward to 2011, early

weather predictions are attributing a high probability to another dry year. Following dry years in 2006-2009 and with increased attention on Delta exports, California agriculture faces significant challenges.