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| **Date:** | May 31, 2015 |
| **To:** | California Department of Food and Agriculture |
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| **Subject:** | **Preliminary Analysis: 2015 Drought Economic Impact Study** |

## Introduction

California is facing another year of severe drought in 2015. Following three critically dry years, many irrigation districts have exhausted their surface water reserves, and the groundwater table has been drawn-down in many parts of the Central Valley. This memorandum summarizes a preliminary assessment of the economic impacts of the 2015 drought conducted by the UC Davis and ERA Economics research team1.

The results summarized here are preliminary and will be revised as we get new information and a clearer picture of irrigation water availability, major water transfers for the 2015 season and acreage of major crops. We know how much water will be delivered from the state and federal projects, and have surveyed districts to assess local surface water supplies and groundwater substitution. But some factors remain uncertain. Many irrigation districts have not made final water allocation decisions and other districts are working to secure transfers from areas with more senior water rights. Drought impacts on livestock and dairies derive from forage and pasture estimates. Decisions of many participants in the system will change water deliveries and economic impacts; therefore our analysis will be updated in July.

## Summary

As in 2014, agricultural water districts and farmers will show more resilience to the 2015 drought than many anticipated earlier this year. Groundwater substitution has again substantially buffered crop fallowing and will reduce employment losses. This study does not address long-term costs of groundwater overdraft, such as higher pumping costs and greater water scarcity. The socioeconomic impacts of an extended drought, in 2016 and beyond, could be much more severe.

In estimating the drought's economic impact, we control for confounding factors. That is, we calculate the known changes in irrigation water deliveries and groundwater substitution and then estimate the corresponding planting decisions, market prices and fallowing. By using changes in water availability to estimate economic impacts, we avoid the problems from ascribing all changes in aggregate measures of economic production and employment to the drought. Changes in business conditions, commodity prices and other factors also affect agricultural revenues and employment, regardless of hydrologic conditions, and it is important to net out these influences.

[1] We want to acknowledge Jennifer Scheer and Kabir Tumber of ERA Economics for leading the irrigation district survey and compiling the surface and groundwater data used in the analysis.

We estimate about 564,000 acres will be fallowed because of the drought, resulting in a statewide reduction in gross crop farm revenue of about $856 million. Livestock and dairies may add another $350 million in direct revenue losses for 2015. Regional economic impacts of these cuts were estimated using the IMPLAN model for the Central Valley, and show approximately 18,600 full-time, part-time and seasonal jobs lost once multiplier effects are included. The total economic loss to agriculture is estimated to be $2.7 billion.

The 2015 drought is not as severe as initially anticipated, but worse than 2014 in terms of reduced water availability and economic impact to agriculture. Groundwater substitution, water market transfers and grower use of limited water for the most profitable crops are key factors buffering the economic and employment effects of drought. Regions with reliable access to groundwater are able to irrigate most of their land. Regions with groundwater access also benefit from small (less than a few percent) increases in some crop commodity prices because of greater fallowing in more water-stressed regions. Water market transfers allow water to move from lower value to higher value uses, which also dampen some of overall economic impacts.

**Table 1. Statewide 2015 Drought Impacts Summary**

| Drought Impact | Loss Quantity |
|---|---|
| **Water Supply** | |
| Surface water reduction | 8.7 million acre-feet |
| Groundwater pumping increase | 6.2 million acre-feet |
| Net water shortage | 2.5 million acre-feet |
| **Statewide Costs** | |
| Crop revenue loss | $856 million |
| Additional groundwater pumping cost | $595 million |
| Livestock revenue loss | $100 million |
| Dairy revenue loss | $250 million |
| **Total direct agricultural costs** | **$1.8 billion** |
| **Total statewide economic cost** | **$2.7 billion** |
| **Total job losses** | **18,600** |

## Comparing 2015 with 2014

Our analysis compares the impacts of the 2015 drought with an average water supply year. This shows that the 2015 drought will be worse than the 2014 drought. Surface water shortage to agriculture will be greater in 2015 than in 2014. Net water shortage to agriculture, after additional groundwater pumping will be nearly 67%, or 1 million acre-feet, greater than in 2014. Cropland fallowing because of water shortage is expected to increase by 33% over 2014. The drought is expected to decrease direct farm-gate revenues by 6%. Groundwater pumping costs are expected to increase by 31%.

The ability of California's agriculture to adjust to drought conditions is driven by several factors. The primary adjustment – increased groundwater pumping – is expected to reduce the surface water shortage by more than 70%. Regional crop shifting in 2014 was significant. For example, contracts for growing processing tomatoes shifted to the Sacramento Valley, resulting in strong yields and a small net

increase in the statewide tomato harvest. Water market transfers, another important adjustment to drought, eased the impact on perennial crops throughout the Central Valley last year. Early reports this year show some transfers from senior water-right holders to perennial crop producers in the eastern San Joaquin Valley. In addition, our survey of water districts suggests there will be more transfers of groundwater within districts than in 2014. Taken together, these adjustments blunt much of the economic costs of drought to crop growers and consumers.

# Methods

This preliminary assessment of the socioeconomic impacts from reduced availability of water for California's agriculture during the 2015 drought uses the same approach as our estimation of losses in the 2014 drought.

Our analysis of economic impacts relies on the amount of water available, as estimated by operators of irrigation districts and water projects. Water availability drives the acreage and type of crops planted and corresponding economic losses. For this preliminary analysis, we:

1. Surveyed irrigation districts
2. Determined CVP and SWP deliveries
3. Estimated changes in groundwater levels using DWR CASGEM and C2VSim data
4. Estimated water market transfers between and within districts

We integrated this information into the SWAP model. Using an "average" water year as the baseline of comparison, we estimated economic impacts of the 2015 drought. Changes in direct farm-gate value, livestock and dairy costs and additional groundwater pumping costs were then run through the IMPLAN input-output model to estimate the multiplier effects in ancillary industries and overall economic and employment impacts to agriculture.

Expected impacts on California crop prices are determined with the analysis. That is, we model the statewide supply and demand for each crop commodity and estimate the market-clearing price. Price changes will be discussed in more detail in our final analysis, but most crop price increases are quite small — generally less than 2%. However, when the price of a crop increases, even by less than 1%, this benefits producers in regions less affected by the drought. For example, the Central Coast and Southern California, which generally have access to irrigation water, will benefit from any statewide price increase.

## Irrigation District Survey

We surveyed more than 72 irrigation districts from late April to mid-May to estimate irrigation water availability. Our preliminary survey included:

1. Estimated fallowing in 2014
2. Expected fallowing in 2015
3. Increases in irrigation water charges (fixed and volumetric)

4. Dry wells and whether these were domestic, agricultural or municipal/industrial (M&I)
5. Groundwater substitution, on-farm and within the irrigation district
6. Transfers in and out of the district: volume, price and import/export region

Many irrigation districts reported that water transfers ameliorated some of the 2014 drought impacts. In addition, surface storage, banking and within-district transfers were extensively used. Most districts reported that some domestic and M&I wells went dry, but few agricultural wells went dry because they are typically drilled deeper than domestic wells. Most districts confirmed new, deeper wells were being drilled in 2014 and currently.

Most districts reported being uncertain about 2015 fallowing. Many are delivering smaller allotments of water to growers, with deliveries ranging from a few inches to 36 inches per acre, which is less than normal. Other districts were delivering no water to growers, but allowing them to ship groundwater through their system at a yet unspecified cost. Growers with private wells can transfer water to other growers within these districts.

Many growers have standby wells for irrigating early and late in the season and to increase irrigation scheduling flexibility. Growers with standby wells can use them to move water through the system (if the district permits it), supplement reduced district deliveries or, depending on the size of these wells, run them to fully irrigate their crops. In most areas groundwater is significantly more expensive than district surface water. This groundwater substitution allows growers to avoid fallowing land, but the higher pumping cost reduces profits and is an important economic cost.

Water market transfers in 2015 are still uncertain. Feather River contractors with senior water rights initially planned to transfer water south of the Delta; however, an allocation of 75% caused the district board to delay this transfer. It is not clear if and when this transfer and others might be completed. San Joaquin River Exchange Contractors recently agreed to transfer water to Friant Canal users, effectively increasing Friant surface water deliveries from 0% to about 5%. Other similar transfers are pending across the state and will be included in our final analysis.

The amounts of water transferred so far this year varied by district. The average price to agricultural users was reported to be $750 per acre-foot, across all districts surveyed. Many districts are still negotiating transfers. We expect water values to increases as the drought progresses.

## Agricultural Economic Impact Results

We linked the changes in water availability to the SWAP model and, in turn, linked the SWAP model output to the IMPLAN model. We include a preliminary review of losses to the California dairy and the cattle and calf industries because they derive primarily from higher costs and lower availability of California-grown hay, silage and pasture. Lastly, increased pumping costs reduced farm returns that were entered into the IMPLAN model. We use this integrated framework to estimate regional and statewide agricultural economic impacts of the 2015 drought. Economic impacts are estimated in terms of direct revenue losses to agriculture, changes in agricultural income, value added and employment. We also report spillover effects of these four impact measures on the California economy as a whole.

## Total Water Availability

Our preliminary drought-impact analysis is based on expected Central Valley Project and State Water Project deliveries announced by the U.S. Bureau of Reclamation and California Department of Water Resources (DWR). In addition, as described above, we surveyed major water districts in the Central Valley to determine expected shortages in local surface water supplies and the availability of carry-over storage. The ability to increase groundwater pumping in the short term is based on DWR's maximum groundwater-pumping estimates for 2006 - 2010 and the C2VSim model data.

The preliminary drought scenario shows a reduction in surface water of 8.7 million acre-feet and groundwater replacement of 6.2 million acre-feet, for an approximate net shortage of 2.5 million acre-feet. Table 2 summarizes the estimated 2015 surface water shortage by region and the estimated ability to replace lost surface water with groundwater.

**Table 2. Estimated Change in Water Use in 2015 Drought Relative to Average Conditions [millions of acre-feet (maf)]**

| Region | Surface Water (maf) | Groundwater (maf) | Net Delivery Shortage (maf) |
|---|---|---|---|
| Sacramento | -2.17 | 1.28 | 0.89 |
| San Joaquin | -1.86 | 1.40 | 0.46 |
| Tulare | -4.75 | 3.45 | 1.30 |
| Central Coast and Southern CA | -0.01 | 0.02 | -0.01 |
| **Total** | **-8.7** | **6.2** | **2.5** |

### Irrigated Crop Acreage

Changes in the crop mix estimated by the SWAP model show the drought resulted in the fallowing of nearly 565,000 acres, almost all within the Central Valley. Table 3 summarizes the estimated impact of the drought on irrigated agricultural land use by region and crop group. These estimates will be updated when planted area data for major field crops becomes available.

As noted, the decrease in water supply in the Central Valley slightly increases the estimated statewide price for some crops. This causes a small increase in plantings in some Central Coast and Southern California regions with better access to irrigation water supplies, and the slightly higher groundwater use.

**Table 3. Estimated Change in Irrigated Crop Acreage Due to 2015 Drought, Relative to an Average Year (acres in thousands)**

| Region | Feed Crops | Vegetables | Orchard & Vines | Grain | Other Field | Total |
|---|---|---|---|---|---|---|
| Sacramento | -84.9 | -3.4 | -7.9 | -77.9 | -3.4 | **-177.6** |
| San Joaquin | -42 | -0.2 | -6.6 | -18.7 | -12.9 | **-80.5** |
| Tulare | -59.4 | -23 | -31.6 | -97.6 | -91.6 | **-303.2** |
| Central Coast and Southern CA | 2.8 | -1.4 | 0.2 | -1.8 | -2.3 | **-2.5** |
| **Total** | **-183.6** | **-28** | **-45.9** | **-196** | **-110.2** | **-563.8** |

## Dairy and Other Livestock Impacts

The dairy industry generates more revenue than any other farm commodity in California. The most important economic changes are that milk prices are lower and dairy price-to-cost margins are lower than normal—especially compared with 2014, a profitable dairy year. California milk production already is down by more than 3%, while milk production has risen elsewhere in the United States. Not all of this loss is due to the drought. But abnormally high forage prices are causing ranchers to cull more cows than they would because of lower milk prices alone. Alfalfa hay shipments to the dairy region are down relative to 2013 and 2014, even though the lower ability to pay has lowered prices from 2014 peaks. We estimate milk revenue will decrease by about 3%, or $250 million, because of the drought.

The cattle and calf industry depends on pasture (both rain-fed range and irrigated pasture). Lack of rain in early 2015 caused cow and calf numbers to be lower than normal, and the shift away from irrigated pasture will decrease forage for feeder cattle. The California feedlot industry relies primarily on grain from the Midwest. But California feedlots fatten beef calves from California and dairy steers, so will again have a lower supply of cattle. Overall, we expect the cattle and calf industry will lose about $100 million, comparable to 2014. Other livestock industries, primarily poultry and eggs, will be minimally affected because most of their feed is imported.

## Gross Farm-Gate Crop Revenues

Financial impacts can be decomposed into crop revenue losses, livestock losses, additional pumping costs, and multiplier effects in ancillary industries. Total gross crop revenue losses are estimated to be $856 million. Table 4 summarizes the change in gross crop revenues by region and crop group.

The Central Coast and Southern California farm regions benefit from slightly higher commodity prices because of decreased production elsewhere in the state. For example, lower hay production in the Central Valley will increase hay revenues for Southern California. Likewise, lower berry and wine grape production in the Central Valley will increase berry and wine grape revenue in the Central Coast.

**Table 4. Estimated Change in Irrigated Crop Revenues Due to Drought, 2015 (dollars in millions)**

| Region | Feed Crops | Vegetables | Orchard & Vines | Grain | Other Field | Total |
|---|---|---|---|---|---|---|
| Sacramento | -52.4 | -4.1 | -2 | -170.6 | -2.7 | **-231.6** |
| San Joaquin | -21.4 | 3 | 15.7 | -35.7 | -13.5 | **-51.9** |
| Tulare | -87.6 | -102.3 | -115.5 | -141.4 | -173.6 | **-620.3** |
| Central Coast and Southern CA | 29.4 | -4.4 | 18.9 | -2.2 | 5.8 | **47.5** |
| **Total** | **-131.9** | **-107.7** | **-82.8** | **-349.9** | **-184** | **-856.3** |

## Statewide Economic Impacts

We estimate direct drought impacts of $856 million in gross crop revenue losses, $250 million for dairies and $100 million for other livestock industries. When we recognize farm income losses due to increased pumping costs ($595 million) and multiplier effects, the statewide impact to agriculture and related industries is $2.7 billion. Estimated direct job losses in agriculture are estimated to be nearly 8,560 full- and part-time jobs. However, when increased pumping costs and spillover effects are factored in, total job losses are close to 18,600 statewide. These job loss figures do not include estimates of adaptation in labor intensity (hours of work per job) or other non-agricultural impacts of the drought. Losses in value added, a measure of the California's gross domestic product, are estimated to be about $1.3 billion for the 2015 drought. Labor income, which includes salaries and proprietor income, is expected to fall by about $716 million.

**Table 5. Estimated Regional Agriculture Economic Impacts Due to Drought, 2015**

| Impact | Jobs | Labor income | Value Added | Sector Output |
|---|---|---|---|---|
| Direct | -8,546 | -287 | -421 | -1,206 |
| Indirect | -5,286 | -191 | -372 | -744 |
| Induced | -4,764 | -238 | -460 | -716 |
| **Total** | **-18,597** | **-716** | **-1,253** | **-2,667** |

# Analyzing 2014 Drought Employment Loss Estimates

Our 2014 analysis estimated that the drought would result in a loss of 17,100 California farm-related jobs (full- and part-time) – about 7,500 of them directly related to farms. Aggregate agricultural employment statistics nonetheless show an overall increase of about 2% in 2014, according to the state Employment Development Department (EDD).

It important to understand that there is no conflict between these numbers.

A detailed analysis of the EDD base data shows that contract field work employment in the San Joaquin Valley decreased substantially during the irrigation growing season of 2014 (Figure 1). The aggregate increase in agricultural employment was due to two components. First, there is a growth in summer agricultural employment in areas with better water availability--the Sacramento Valley and Coastal regions with increases in high value vegetable and field crops in these regions. Second, the winter season (January through March and October through December) employment grew in several regions, which were largely not drought related.

In addition, agricultural employment in California has been on a long-term increase driven mostly by long-term shifts to higher revenue per acre (and acre-foot) crops. The small, 2% increase in 2014 farm employment should be viewed as a slowing of this long-term growth trend and is consistent with a loss of agricultural jobs because of drought. Figure 1 shows the difference in average monthly employment in agriculture from 2013 to 2014 across time and regions. The irrigation season runs from April to September. The first and last three months of the year define the off- season.

The drought in 2014 and 2015 is causing substantial land fallowing and significant job losses. Global and national market forces and farm adjustments are important for mitigating drought impacts to agriculture and California's economy. Regions with greater surface water shortages and less access to groundwater will suffer larger employment losses due to drought.

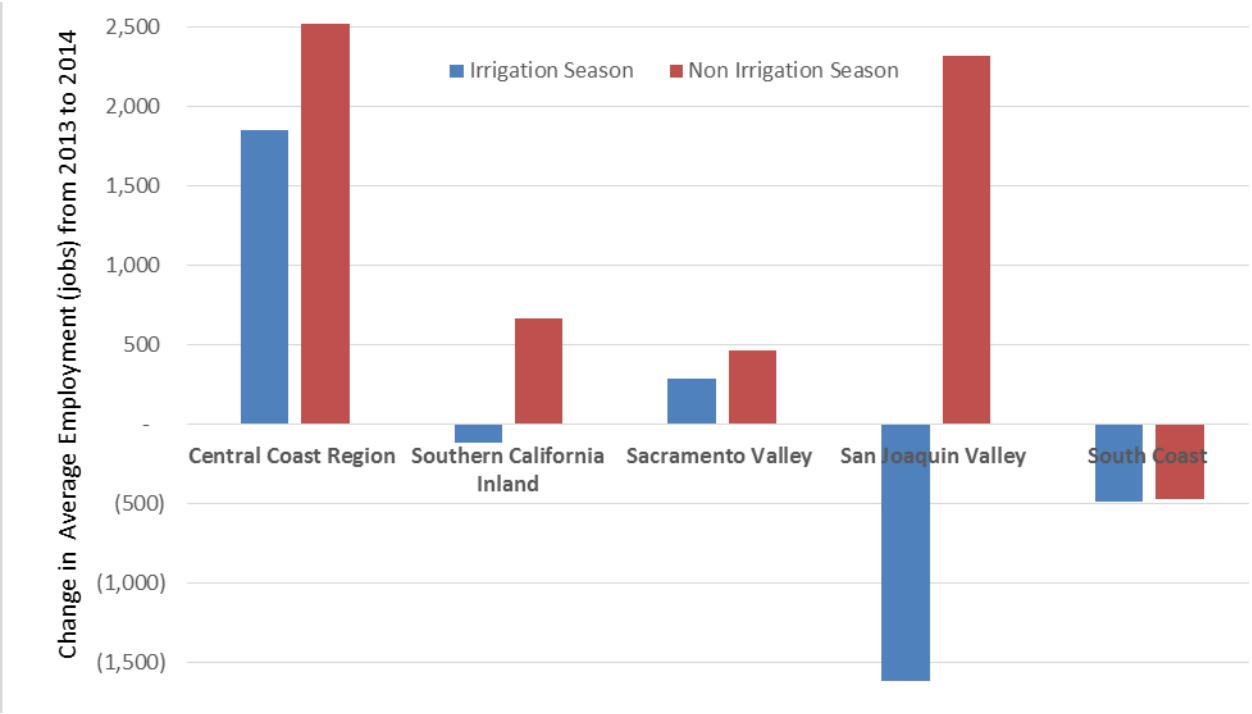


**Figure 1. Changes in average monthly agricultural employment between 2013 and 2014. Source: Authors calculations using California Employment and Development Department.**

## Preliminary Impact Summary and Ongoing Work

We estimate the 2015 drought will cause direct farm revenue losses of about $1.2 billion, relative to an average water year, with a net water shortage of about 2.5 million acre-feet. The total surface water shortage is estimated to be 8.7 million acre-feet, of which 6.2 million acre-feet will likely be replaced through increased groundwater pumping. The additional pumping will cost $595 million.

When the spillover effects of water shortage on agriculture are considered, total losses of $1.25 billion in value added and $2.7 billion in total value of sector output can be expected.

These preliminary drought impact estimates depend critically on water transfers and the regional capacity to substitute groundwater for surface water. We are working with DWR to link the SWAP model to the DWR's C2VSim groundwater-surface water model to better estimate the capacity to pump groundwater and the short- and long-run effects on water levels. This will provide a basis for estimating groundwater availability and cost impacts should the drought continue for several more years. We anticipate using USDA crop acreage data in calibrating and refining our analysis of livestock industry losses. Lastly, we anticipate using remotely sensed estimates of fallowed acres from NASA and DWR studies to crosscheck the SWAP model results.

## Further Reading


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