# Which California Foods You Consume Makes Little Impact on Drought-Relevant Water Usage

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To be relevant to California's drought, discussions of water used to produce food items should focus on the irrigation water relevant to production in California. By that measure, drought-relevant water used to produce livestock products such as beef and milk is moderate compared to crop products such as wine and broccoli.

California's long drought drove mandatory water delivery cuts, mandates for changes in water practices, and recommendations for farmers and others to reduce water usage more than ever before. Much of the media surrounding the California drought contains information on farmer techniques used to save water and lessen economic losses. It also provides expert advice for households on how to reduce their water footprint. The mandates and recommendations were based on more and better information on how water is distributed across uses.

Because farming is a heavy user of irrigation water, most observers highlighted how efficient water use within agriculture is important. Experts point out that calculating water used by crops, for example, must account for water applied to fields but that is drained off for use again on another field or water that percolates into the groundwater table to be used in subsequent irrigation seasons.

Central to household use is water used indirectly through consumption of food products that consume water in their production, processing, and distribution. Because food products from California farms and ranches are consumed all over the United States and globally, food consumption by households outside California uses California water.

Newspapers such as *The New York Times* and the *Los Angeles Times* calculated and publicized quantities of water embedded in California food products, and therefore how much water households consume indirectly. They review the water embedded in long lists of food items produced in California.

Topping the lists—by a huge margin—in terms of water per ounce or per serving are livestock products such as meat and milk, because of the vast quantities of water used to grow the hay, corn, soybeans, and grass that make up a bovine diet. That is, just as most of the water used by humans is embedded in our diets, the same is true of livestock.

Governor Jerry Brown spoke to this issue in the "Water in the West" event at the University of Southern California. Governor Brown wondered aloud whether it was better or worse to export alfalfa rather than use it to feed cattle in California. He answered his own question by stating, "I don't know, I mean if you ask me I think you should be eating veggie burgers, but that's not the predominant sentiment," (*LA Times*, 2015).

## Why is Water Use a Government Issue at All?

Of course, California, the U.S. Federal government, and many local jurisdictions are heavily engaged in the collection, storage and conveyance of irrigation water, as well as local purification and distribution for urban use. With governments at all levels dominating the supply side of the water balance, users could be charged the cost of water, and uses might reflect the social value of that water on the margin.

But, the general consensus is that neither of these conditions hold, and there are many situations in which water is supplied at prices well below its cost and well below its value for alternative uses. Government ownership and elaborate government regulations fail to generate optimal allocation of water across locations, time or use, and water prices are poor indications of the marginal social value of water. Thus, controversies continue and accusations abound of water being used for "low-valued" purposes.

The analysis below cannot answer those controversial issues, but we can contribute to clarifying some facts and their relevance.

## All Water Versus Drought-relevant Water

California agriculture produces food products using water from several sources. First are those sources and uses that are directly relevant to competition for water during a drought. Crop irrigation usually competes for water that may also provide environmental and ecological benefits and services, such as water that flows through streams and is stored in lakes and reservoirs. Water used in urban water systems has value to industrial and commercial (including food processing) users and households, and these uses often compete with irrigation and environmental and ecological uses. Farms also pump groundwater from underground aquifers that could be available for later use or used for other purposes. These sources, both surface water and ground water used for irrigation, are California drought-relevant water (drought water) for which agriculture must compete with other uses.

The second large category of agricultural water is water imported from outside of California in the form of commodities used to produce livestock products here in California. The largest

Table 1. Water Use of Wine Produced from California Winegrapes

| Evapo-transpiration (ET) Acre-Ft./Acre | Grape Yield (Tons/Acre) | Gallons Wine/Ton | Gallons ET Water/ Gallon Wine | Gallons Winery Process Water/ Gallon Wine | Total Gallons Water/ 5 oz. Wine Serving |
|---|---|---|---|---|---|
| 1.84 | 8.75 | 170 | 403 | 4.15 | 15.9 |

*Note: There are about 25.6 5-oz. servings in one gallon of wine.*
*Source: Authors' calculations using Jim Lapsley and Dan Sumner's draft of "Water into Wine." See additional information for detailed methodology, calculations, and a full list of sources.*

part of such water is that embedded in feed grains, oilseed meals, hay, and other animal feeds shipped into California to feed the cattle and poultry that are raised in intensive feeding operations.

The water embedded in feed shipped into California may be relevant to a drought in Nebraska, Idaho, Alberta, or some other state or province from which the feed is shipped, but it is not part of the drought-relevant water allocated in California. Therefore, when accounting for California drought-relevant supplies, such imported water must be carefully netted out.

A third source of water is that embedded in livestock shipped into the state after spending part of their life consuming water in other places. So, for example, steers shipped into California from Oregon for intensive feeding here or dairy heifers shipped to milk herds in California bring with them water that the animal has consumed earlier in its lifecycle. This imported water is also not California drought water.

The fourth major source of water for California agriculture is the precipitation that falls directly on hills and mountains in California. Some of this water, that which is not absorbed where it falls, enters streams and becomes the drought-relevant water used for environmental, urban, or irrigation purposes.

Some of the precipitation is absorbed and used to grow forage in pastures located in the hills and mountains that cover about 15 to 20 million acres of agricultural land in California. This water, which nourishes pasture forage used primarily by cattle in California, does not flow into streams and would not be used for any other purpose if not grazed by livestock. Indeed, the grazing of such pastures likely allows more water to flow into streams and enter the natural river and storage systems. In this way, grazing likely has a small positive impact on the amount of drought water.

The main point, however, is that the water that nourishes the non-irrigated pastures used largely by the cow-calf and feed cattle industry in California has a direct impact on food produced in the state, but is not available for competing uses and is therefore not drought water.

In sum then, we define agricultural drought water that enters the food supply from California to include all irrigation water from whatever source, but to exclude water embedded in livestock feeds shipped into the state and water that falls onto non-irrigated pastures that are used by grazing livestock in California.

Drought water used for food production is available for competing uses in California. Water embedded in livestock feed shipped into California and livestock forage produced on non-irrigated pastures play no role in relieving the California drought, even when such water is located in California.

The next sections present calculations that illustrate the role of drought water in the production of food and how food consumers use water that is relevant to California drought. We begin with two cases of California crops, almonds and lettuce, grown entirely with drought water. We then highlight drought water used for the production of wine. Finally, we consider the more complex cases of livestock products that have been deemed the most water-intensive foods by Governor Brown and many others. Below, we only provide summaries of the detailed calculations; the complete sources of information are available on our website at http://aic.ucdavis.edu.

## Irrigation Water Used to Grow California Crops

In this section we consider all irrigation water consumed in production and processing of crops as drought water consumed. We use estimates of the amount of water actually used up by the plants or evaporated into the atmosphere (evapotranspiration) and not simply irrigation water applied to the fields. In that way, for example, water that percolates down to the underground aquifer is not counted as "used" by the consumption of the crop.

With more acres than any crop in California, and with rapid acreage increases in recent years, almonds have received a great deal of attention during this drought. California almonds are grown in the Central Valley under irrigation and about two-thirds of California almonds are exported. Almonds, and other Central Valley orchard crops, use substantial amounts of water per acre and generate high revenue per acre ($6,772/acre for almonds in 2014). Evapotranspiration of almond trees is estimated at 3.1 acre-feet per acre and yield averages about 1 ton per acre in the northern San Joaquin Valley. At about 326,000 gallons per acre-foot, it takes approximately 1 million gallons of drought water to produce one 2,000-pound ton of almonds. A 1-ounce serving therefore requires about 31.8 gallons of irrigation water.

Lettuce is another high-revenue per acre California crop ($10,343/acre in 2014), but uses substantially less irrigation water than almonds for several reasons. First, lettuce plants are smaller; second, much of the lettuce

is grown in cooler regions along the coast or during the cooler times of the year; and third, lettuce matures in a matter of a few weeks, not over a six-month irrigation season. Evapotranspiration of lettuce is approximately 1.4 acre-feet per acre and yield averages about 20 tons per acre for iceberg lettuce grown in the Central Coast. This equals 23,000 gallons of drought water per ton, or 1.8 gallons for a 1-cup serving that weighs about 2.5 ounces.

We also calculate that one cup of broccoli uses about 7.6 gallons of irrigation water and one cup of processed tomatoes uses about 8.3 gallons. All water used to produce these vegetables in California is drought water.

Winegrapes are grown throughout California with major centers of production in the hot and dry San Joaquin Valley and along the much cooler North and Central Coast regions. Water use per acre of winegrapes differs widely by region, as does tons of grapes per acre and the price of grapes per ton. Using statewide averages, evapotranspiration of California winegrapes is estimated to be about 1.8 acre-feet per acre and yield averages about 8.75 tons per acre. Winery production also uses water at a statewide average rate of about 4 gallons of winery water per gallon of wine. Putting this all together, we get about 16 gallons of total water use for a 5 oz. serving of wine (Table 1).

## All Water and Drought Water Used to Produce California Beef

This article takes the case of a beef animal that is born, raised, and slaughtered in California, even though most of the beef consumed here is actually fed and processed out of state. The water used to produce a California beef animal can be separated into the following seven categories: (1) rainfall onto pasture that cows and calves use as forage, (2) irrigation to grow roughage in the intensive feeding phase, (3) water used to grow protein-rich feed ingredients, (4) water to grow grain feed ingredients, (5) water used in the production of mineral supplement feed, (6) drinking water, and (7) water used for processing the carcass.

Figure 1 summarizes water used to grow the pasture consumed during the first phase of the beef animal's life, corn, soybeans, and alfalfa consumed during the feedlot phase, and relatively small amounts for feed supplements, drinking water consumed throughout the animal's life, and processing the carcass.

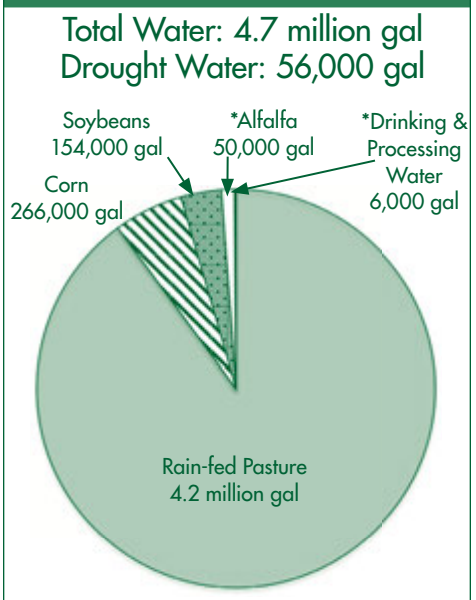
By far the largest water use is for the one-year pasture phase, where we assume about 13 acres of California pasture with about one acre-foot of rainfall per acre are attributed to each cow-calf pair. This equates to about 13 acre-feet or 4.2 million gallons of non-drought water for each calf that moves into the feeding process. As noted above, the feed during this phase of the animal's life does not use drought-relevant water.

Using the typical daily ration of a steer finishing in a 6-month feedlot phase, we find average amounts of feed consumed per day, accounting for weight gain. In total, one California steer eats about 3,200 lbs. of corn, 800 lbs. of soybeans, and 600 lbs. of alfalfa during its lifetime.

Corn and soybeans are typically imported from the Midwest, and are therefore not drought water. We estimate about 266,000 gallons of water for corn and 154,000 gallons for soybeans are consumed during the feeding of a beef steer or heifer.

Alfalfa differs from corn and soybeans in that it is produced in California and uses drought water. The evapotranspiration and typical yield of alfalfa were used to find total acre-feet and gallons consumed over the steer's life. A total of 50,000 gallons of drought water are used to grow the 600 lbs. of alfalfa consumed in the steer's life. Additionally, less than 10,000 gallons of drought water are consumed for feed supplements, direct animal consumption, and through the processing of the carcass.

Figure 1. Water Used for a Steer Born and Raised in California



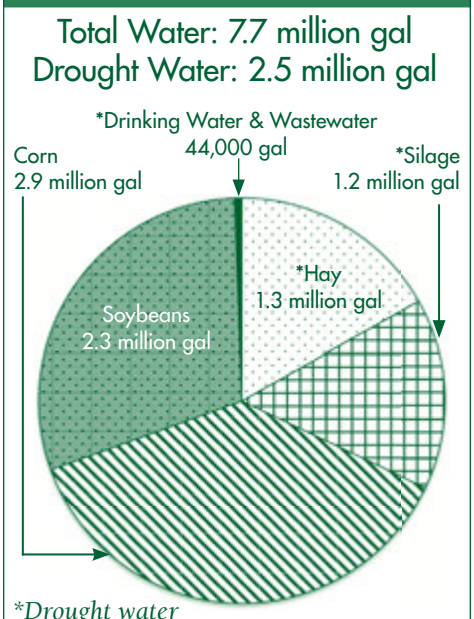

**Drought water*
*Note: Most of the rain-fed pasture water use is attributed to the mother cow.*
*Source: Authors' calculations. See additional information for detailed methodology, calculations, and a full list of sources.*

Putting these pieces together, we find that a total of 4.7 million gallons of water are used to produce a 1,400-lb. live steer with a 1,000-lb. carcass. For a steer with a 1,000-lb. carcass, approximately 4,700 gallons of total water are used to produce one pound of meat, or about 884 gallons for a 3-oz. steak. But out of these 884 gallons per serving, only 10.5 gallons are California drought water—water to grow alfalfa, drinking water, and water for processing—that could be potentially shifted to other uses during a California drought.

## All Water and Drought Water Used to Produce Dairy Products

On the next page, Figure 2 summarizes the water use by a dairy cow in California. A total of about 23.7 acre-feet or about 7.7 million gallons of water are used by a dairy cow over her lifecycle. For simplicity, we assume the cow spends her whole life in California and all the water use is attributed to milk production—not

Figure 2. Water Used During a Dairy Cow's Life Cycle




**Drought water*
*Source: Authors' calculations.*
*See additional information for detailed methodology, calculations, and sources.*

to the value of her male calves that may be raised for beef or to the meat contributed by her carcass when she is culled from the dairy herd.

The distribution in Figure 2 assumes each cow spends one year as a calf and one year as a heifer before entering the milking herd. The following three years are spent as a milking cow, with two months of each of those years spent as a dry milking cow. Multiplying typical rations in each stage of a dairy cow's life over the respective time periods, we find that over her life, a dairy cow consumes about 8 tons of alfalfa and other hay, 29 tons of corn and other silage, 17.5 tons of corn (or the equivalent in grain), and 6 tons of soybeans (or the equivalent).

The calculations are similar for the feeding of a beef steer for corn, soybeans, and other items. About 2.9 million gallons are used for corn and 2.3 million gallons for soybeans, none of which is drought water. About 1.3 million gallons of drought water are used to grow hay, about 1.2 million gallons are for silage, and 44,000 gallons of drought water are used for drinking and other uses.

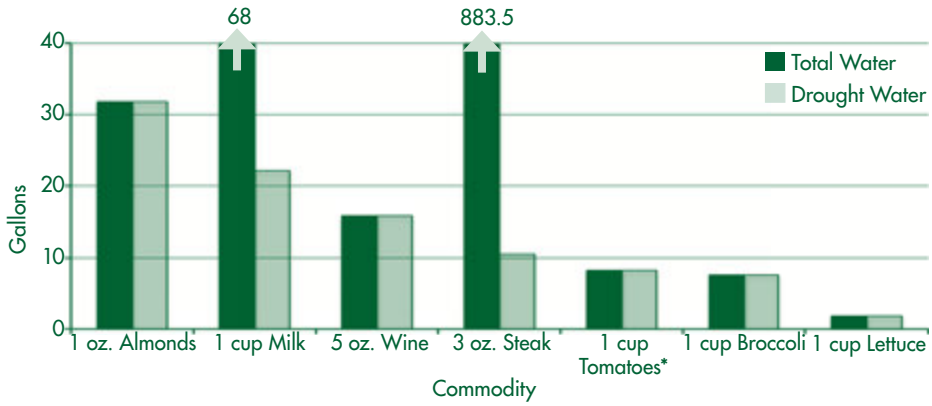
A California dairy cow produces about 7,000 gallons of milk during her life. Therefore, it takes almost 1,100 gallons of water to produce one gallon of milk—354 gallons of which are drought water. Each 8-ounce serving of milk requires about 68 gallons of total water and 22 gallons of drought water.

## Summary and Conclusion

Figure 3 summarizes the total water and drought water used to produce a variety of foods in California per typical serving. By these measures, the livestock products top the chart in total water use but are moderate in terms of drought water implied per serving.

Remarkably, a serving of steak uses much less water than a serving of almonds, or a glass of milk or wine, and about the same as a serving of broccoli or stewed tomatoes.

Figure 3. Total Water and Drought Water per Serving for Select Commodities




** Crushed Tomatoes*
*Source: Authors' calculations. See additional information for detailed methodology, calculations, and a full list of sources.*

The drought relevance of water consumption depends on where that water falls and how it is used.

This article has clarified that discussion of water use in the California drought should at least focus on water use relevant to that topic. But more fundamentally, a measure of water per unit of output might be better measured per unit of value generated or by the enjoyment of consumers buying the product. Different products are intensive in the use of farm or land area or water. None of these simple ratios of inputs to outputs in themselves tell us much about efficient allocation of resources.

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### For additional information, the authors recommend:

Special Issue - Climate Change: Challenges to California's Agriculture and Natural Resources, *ARE Update*, 18 (1), Sep/Oct, 2014. http://giannini.ucop.edu/media/are-update/files/issues/V18N1.pdf.

Buchanan, L., J. Keller, and H. Park. "Your Contribution to the California Drought." *The New York Times*, May 21, 2015. www.nytimes.com/interactive/2015/05/21/us/your-contribution-to-the-california-drought.html?_r=0.

Kim, K., J. Schleuss, and P. Krishnakumar. "491 Gallons of Water Were Used to Make this Food." *Los Angeles Times*, April 7, 2015. http://graphics.latimes.com/food-water-footprint/.

For full documentation of methods and sources and details of our calculations, see http://aic.ucdavis.edu/water-in-food_background.