BENEFITS AND COSTS FOR CALIFORNIA FROM WATER TRANSFERS

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In this chapter, we summarize research on water supply in the state and the potential impacts of transferring water from agricultural to urban usage. There has been increasing concern about pressure on California water supplies arising from climate change, state economic and population growth, and less availability of out-of-state water. Since much of the state's current water use is in agriculture, the option of transferring water from agriculture to urban use has received much attention.

We focus our efforts on measuring the impact of reduced water supply on agricultural output by studying a "natural experiment," the drought of 1987-91. The drought led to more abrupt and less anticipated declines in farms' water usage than transfers would. Also, the drought effects show the total declines in farm output then, due both to reduced water usage, as well as to reduced usage of other inputs. On both counts, the drought effects *overstate* the agricultural costs of water transfers. Otherwise, the production problem farmers faced during the drought is essentially the same as what they would face under water transfers: how to maximize farm income with reduced water usage.

- We find that the 1987-91 drought had only a minimal impact on farm output in the sixteen largest farm counties of California. While harvested acreage appears to have declined, yields per acre held up fine. Meanwhile, while farm incomes declined, those declines were substantially offset—in some cases, more than fully offset—by net gains in non-farm income, so that third-party effects in the local economy as a whole were mitigated or outweighed by the positive effects, even in these drastic, emergency circumstances.

- On net, we find that in the large, representative counties of Fresno and Kern—for which water consumption estimates were available in 1991, the worst year of the drought - **total farm income appears to have declined by $95-$165 per acre-foot (AF) of reduction in water usage**. As stated above, this overstates the marginal revenue product of water on two counts (including losses due to reduced usage of farm inputs other than water and occurring in a more abrupt, drastic environment than that within which water transfers are likely to occur). If we allow for income mitigation by farm inputs displaced by lower water usage, the actual marginal revenue product of farm water looks to be on the order of $18 per AF in Fresno County, possibly lower in Kern. These results are in line with apparent water costs faced by farmers. (A profit-maximizing farm enterprise would adjust its output and inputs until marginal revenue products equaled marginal costs for each productive input.)

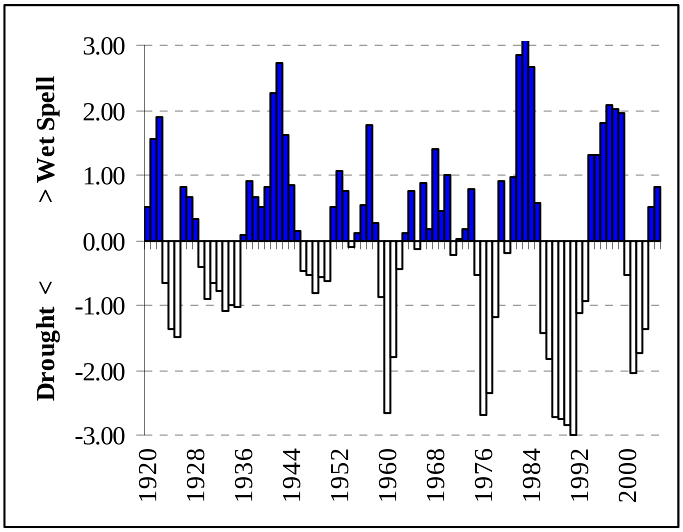
- Some other researchers have found more disruptive effects of the drought on California farming. However, they generally failed to distinguish between farm losses due to drought and those due to falling farm prices and to a winter freeze in 1990-91. Furthermore, those studies often looked at only incomplete data and made no attempt to put 1987-91 data into proper historical perspective.

- **<u>In urban areas, market prices range from $330 to $445 per acre-foot for wholesale water and as high as $1300 per acre-foot at the retail level</u>**. The clear and large gap between estimated costs to agricultural communities and estimated benefits to urban communities indicates that water transfers will be beneficial to the state's economy, so that both urban and agricultural regions could benefit from the exchange. This "positive-sum" outcome would be possible because of the change in water usage from the transfers.

I. BACKGROUND

California seems to have either too much water or too little. The state regularly goes through extended periods of both droughts and deluges, and the length and severity of these cycles have increased in recent years. Various water resource agencies work to control floods and store water for use in dry periods through a variety of projects and programs. However, current infrastructure is under stress due to increased demand and reduced supply. While the issue is currently off the public's radar screen because of adequate rainfall in recent years, long-run planners are well aware that shortages will again be a problem in some areas at some point in the near future. With little or no unused sources of fresh water, it is important that urban California find ways to avoid serious water shortages in the future.

Palmer Drought Severity Index
Smoothed Annual Average[1]



On the demand side, population growth in the state remains one of the highest in the U.S., and is expected to continue at its rapid current pace. Conservative estimates put California's population at fifty million by 2050, with the vast majority of these new people ending up in urban centers. Those fourteen million new residents will need approximately four million AF of water per year. Furthermore, growing awareness of the impact of extensive consumption of ground and river water has led to calls for additional set-asides of water for the purposes of environmental mitigation.[2]

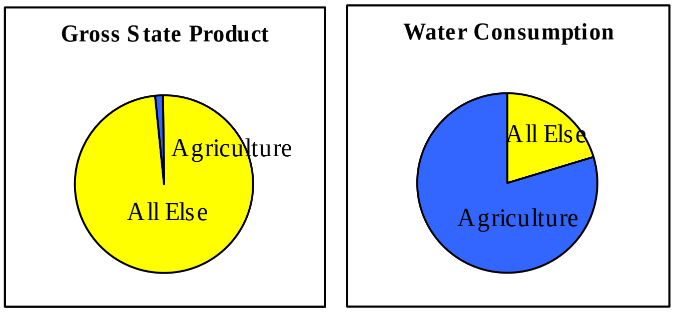
Meanwhile, development is occurring even more rapidly in our neighboring states of Nevada and Arizona. This trend is important, because California no longer can rely on water unused or surplus to the needs of the other states in the Colorado River Basin. California has in fact reduced its take of Colorado River water from an average of over 5 million AF to its basic apportionment of 4.4 million AF per year.[3]

With excess water a thing of the past, the state clearly needs to be able to use its existing resources more efficiently, both in order to sustain long-run growth as well as to be able to deal effectively with the next drought period. Such a drought is sure to come within the next decade. There are no easy solutions to meeting these needs. Desalinization is not presently cost-effective. While conservation has reduced urban water waste, most of the slack has already been worked out of the system and, perversely, these efforts have limited the potential for using further reductions during drought periods.

There have been substantial efforts to increase storage capacity through the construction of new reservoirs. These efforts will mitigate some of the effects of droughts, but they do not provide an *ongoing* source of increased water supplies. Given current technology and the cost of constructing these facilities, it isn't clear that these efforts will be able to keep pace with population growth or be sufficient to be able to deal with a drought on par with what we experienced in the early nineties.

California Output and Water Usage: 2001

Source: California DWR[4]



The Water Transfer Option

A potential source of water for urban California's future water needs is the transfer of water supplies from agricultural to urban users. Agriculture consumes nearly 80% of California's consumable water, even while its share of state economic output is 2% (as of 2001) and is shrinking.[5] More importantly, the disparities between agricultural and urban water user costs are so huge that is clear that water transfers would improve state welfare (efficiency). Of the 20% of state water supplies going to urban use, approximately two-thirds went to residential use and the rest went to commercial, industrial, and recreational uses. For each acre foot of water consumed, the agricultural economy produced $520 worth of gross state economic output in 2001. For each acre-foot of water consumed in non-agricultural portions of the state, $150,000 worth of gross economic output were produced (which, it should be appropriately noted, does not include the very significant "psychic," non-monetary benefits received by households).

The Multiplier Objection to Water Transfers

The standard reply to these facts is that these statistics understate the true impact of the farm sector because they do not include the third party or 'multiplier' effects. As will be discussed in detail below, multiplier analyses at best are measurements of short-run effects and are clearly erroneous and irrelevant for discussion of long-run issues. What is more, if multiplier effects were relevant to this analysis, then they would hold on the non-agricultural side as well as the farming side, and the disparities stated above between farm- and non-farm sector GDP, wages, and user costs for water are far too huge to be bridged by even the bloated multipliers commonly attributed to the farm sector.

A Hypothetical Efficient Water Market

If a functioning state water market existed, then agricultural-to-urban transfers would be a normal aspect of state water usage, and there would be no question as to their efficacy. Water prices would move to a level at which aggregate urban and agricultural demand matched supply, and the market price would determine who would receive water supplies. The prices bid and paid for water would fully reflect the benefits to the users (purchasers).

Water transfers in any direction would occur if and only if the benefits to the recipients met or exceeded the costs to the supplies of the transferred water.[6] Unfortunately there is no consistent state water market. Instead, water rights have evolved over the decades within a hodgepodge, Byzantine system. Farmers can buy water at very low fixed prices, but they have very limited ability to sell or otherwise transfer those rights, and this is also the case for the original suppliers of the water.[7]

Crude Water Transfers

In the absence of water markets, one way to orchestrate a transfer from agricultural to urban users is by a program of land-fallowing, where farmers are paid not to cultivate acreage, and water so conserved is allowed to run downstream to urban agencies. This is in many ways a form of a water market, but the nature of the program ensures that the functional price being paid to farmers is fixed at a relatively high level, and that the amount of water actually transferred remains at a small controlled level. It also creates a scenario where farmers are required to maintain the land at a certain level to prevent environmental damages. A number of these programs have already been implemented. San Diego is currently receiving a portion of its water supply from Imperial Irrigation District via a conservation and transfer program; a land-fallowing program has also been implemented in the Palo Verde water district.[8]

Even in the absence of a "free" market, it can be inferred that these transfers provide a net benefit to all parties involved because they are entered into voluntarily by both sides. The considerations (payments) received by agricultural suppliers of water meet or exceed the benefits they otherwise would have received from use of the water--else they would not agree to the transfer. The benefits received by urban areas meet or exceed the considerations they pay for the water, else they would not agree to the transfer.

The Third-Party Objection

Even so, some commentators worry about "third-party effects." When farmers consume less water, the presumption is that the also utilize less of other farm inputs such as labor, fuel, fertilizer, etc. The workers and businesses providing those inputs thus supposedly suffer financial losses as a result of the transfers. Indeed, the structure of some current water transfer programs typically includes special development funds for the mitigation of alleged third party effects, as well as payments for the farmers who are fallowing their land. Despite these provisions, opposition to the programs continues, with claims that third-party effects are larger than gains to urban communities.

We argue here that the fear of water transfers as potential destructive forces on California agricultural communities is largely misplaced. While it cannot be denied that reduced water usage in agricultural areas – via transfers or otherwise – does impose costs on those communities, we find scant evidence of third-party effects in farming communities. We find that the gulf between potential direct benefits of transfers to urban areas and direct costs to farming communities is so great as easily to swamp whatever third-party effects might actually occur. Therefore, we conclude that water transfers would effect an improvement in the state's allocation of water resources. Urban areas will be willing and able to provide sufficient considerations to agricultural areas to more than offset the costs borne by them from the transfers.

To measure the potential losses to the agricultural communities from water transfers, we must measure the sensitivity of farm output to changes in water inputs, specifically the declines in farm output caused by a reduction in water supplies. We estimate these by measuring the incidence of declines in farm output that occurred during the instances of "forced" reduction in water usage during the drought of 1987-91. That measurement overstates the potential costs of water transfers for at least two major reasons: in effect, this measurement bunches together initial third-party effects along with the direct output losses due to reduced water usage.

Note that these changes also occurred in a sudden emergency environment that would likely not be repeated with well-planned water transfers. This over-statement of the costs of transfers can be trimmed toward more realistic levels by adjusting it for third-party mitigation effects that occurred in farm communities during the drought. Still, even the "over-statements" we derive for the drought effects are smaller than has commonly been estimated and smaller than the under-statements we derive of urban benefits of the transfer.

Adjusting for Non-Water Influences

There is no doubt that the years 1988-1991 were not hard ones for California farm regions. However, we find that much of the hardships suffered by various counties' farm sectors in those years were in fact due to falling crop prices and to a winter freeze occurring over December 1990 and January 1991. Adjusting for these non-drought factors, the effects of the drought itself, while considerable, were less than horrific. On the other end, we estimate the benefits of water transfers to urban areas via the market prices that urban users pay for water and via the consumer surplus urban water users will gain from additional supplies. Even conservative estimates of the elasticity of urban water demand show very large gains here.

The structure of this report is follows. Section II provides an historical view on agriculture in California's economy and debunks various objections to water transfers, including the usage of multiplier effects. Section III analyzes the effects of the 1987-91 drought on farm output, farm incomes, and non-farm personal incomes in the largest farm counties of the state, including estimates of farm- and total-income losses per acre-foot reduction in farm water usage. Section IV analyzes the prospective benefits of water transfers to urban areas. Section V summarizes the results.

II. AN OVERVIEW OF CALIFORNIA FARMING AND FARM WATER USAGE

Section III will provide estimates of the "value" of water to the California farm sector by measuring the costs of reduced farm output and income occurring in response to a forced reduction in water usage. Another estimate of the value of water to farming can be derived by analyzing current water usage, without the forced reduction of a drought. A quick analysis of current usage can provide some perspective for the drought-period effects.

Furthermore, state water politics typically concentrate on the *prospective* third-party costs that transfers are alleged to impose. Often lost in that rhetoric are the *actual* costs that the present system already imposes due to inefficient allocation of existing water resources. An analysis of the current water usage in the state can provide a context within which both cost elements can be put into perspective. It will also allow us to address the multiplier effects aspect of third-party effects head on. So this section provides that overview.

Total farm revenues equal the total output of productive factors in the farm universe: land, farm equipment, farmers' time, water, other materiel inputs, and labor. With free and open markets for the other materiel inputs and purchased labor, the value of their output – their marginal revenue product – can be measured via their factor costs. The value of the outputs of land, farm equipment, and farmers' time can be measured only indirectly, via the profits – net revenues – the farm sector produces. Farm irrigation water is somewhere in between.

While most California farm water is purchased, the lack of a free market in water – discussed above – implies that the explicit monetary cost of irrigation water may misstate its true marginal revenue product. What is more, purchases of irrigated water do not pick up the productive effects of what rainwater and non-purchased groundwater California farms utilize in their operations. We can derive an upper bound – or over-estimate – of the marginal revenue product of water in farm operations by looking at farm revenues net of the cost of those productive factors purchased in open markets.

In effect, this measure is just net farm revenues (profits) plus the costs of purchased water. This measure includes the marginal revenue products of farm irrigation water as well as of farm land, plant and equipment, and farmers' time, which is one reason this is a gross overestimate of the marginal revenue product of water.[9] The Census of Agriculture provides estimates by state of net farm revenues: farm revenues less costs of purchased inputs.

Estimates of Water Value in Agriculture

California 2002 net farm revenues were $4.36 billion. The year 2002 was an average year with net farm income amounting to 17.5% of farm revenues. In terms of purchased water usage, this amount means there was $130 of net income per AF of purchased water. Upon adding in an average cost of irrigated water of $30/AF, this total implies that the average value of water to the farm sector is quite a bit less than $160/AF, since we are not allowing for the values of land, plant and equipment, and farmers' time. At the other extreme, we can obtain a lower-bound estimate of the marginal revenue product of water by taking its $30/AF user cost. (If the additional value the farmer got from the water was any less than this, they would simply not use the water.)

These estimates of the productivity of water in farming are consistent with farmers' observed behavior. During the water-bank program of the early-1990s, farmers sold over 800,000 AF into the bank at a price of $125 per acre AF The program was over-subscribed: supplies of water from farmers at that price exceeded the needs (demands) of the bank. In 1992, in a smaller program, another 200,000 acre feet were purchased at $50 per AF.[10] In other words, during drought conditions, farmers were willing to sell water in bulk at prices of $50/AF to $125/AF, prima facie evidence that the marginal revenue product of water to them was less than or equal to this range.

Estimates of Water Value in Urban Uses

Now consider the urban side of prospective transfers. Wholesale purchasers of imported water in Southern California pay about $330/AF for untreated water or $450 per acre foot for treated water. Since buyers willingly pay this price in an open market, the net marginal revenue product of water in urban uses must equal or exceed these prices. (Since agriculture usage does not require treated water, the $330 price is a more relevant comparison to the values in agricultural sectors.)

The Welfare Loss

The distortions caused by this situation are extensive. Economists recognize that true cost is opportunity cost: the lost benefits from utilizing resources in their alternative pursuits. When true costs are not taken into account, incentives are distorted, and inefficiencies occur. The opportunity cost of water is the wholesale price farmers could receive should they sell it, that is, a wholesale price of about $330/AF less transport costs.[11] Instead, farmers' use the water in agriculture, at an estimated value of $30/AF to $160/AF. The lack of a functioning water market results in a net "welfare loss" of up to $300/AF.

Estimated Revenue per Acre of Irrigated Cropland net of Opportunity Cost of Water, 2003

	CA Irrigated Acres	Acre Feet used per Acre	Revenue per Acre	Water Opp. Cost per Acre*	Revenue / Acre net Water	Estimated Profit per Acre**
Sweet corn	22,539	3.3	$6,195	$660	$5,535	$579
Land in vegetables	926,839	2.9	$5,982	$580	$5,402	$616
Potatoes	49,065	2.5	$5,898	$500	$5,398	$680
Lettuce and romaine	191,396	2.4	$5,849	$480	$5,369	$690
Orchards, berries, nuts	2,749,578	2.4	$3,332	$480	$2,852	$186
Tomatoes	354,804	2.8	$3,054	$560	$2,494	$51
Sugar beets for sugar	129,594	3.2	$1,545	$640	$905	-$331
All cotton	757,008	2.9	$1,086	$580	$506	-$363
Beans, dry edible	76,179	2.7	$650	$540	$110	-$410
Corn for grain or seed	198,869	2.4	$464	$480	-$16	-$387
Rice	595,932	4.1	$801	$820	-$19	-$660
Corn for silage	466,109	3.0	$525	$600	-$75	-$495
Alfalfa	1,008,458	3.7	$651	$740	-$89	-$610
Wheat for grain or seed	406,582	2.2	$262	$440	-$178	-$388
Other small grains	62,285	1.7	$160	$340	-$180	-$308
Barley for grain or seed	29,781	1.8	$177	$360	-$183	-$325
All other hay	344,531	2.5	$270	$500	-$231	-$446

**Based on $200 per acre foot opportunity cost of irrigated water*[12]

*** Based on estimate of 20% return on revenues*[13]

There are secondary distortions that arise from this mis-pricing of water. When choosing crop mix, farmers allocate inefficiently, because they "undervalue" the water they use. They grow crops that are too water intensive for the California climate and the true water-supply situation.[14] Besides producing crops that are overly water-intensive, farmers also fail to internalize the full benefits of water-saving techniques, such as more efficient irrigation, canal-lining, etc. The resulting water losses are substantial. For example, agricultural communities in Mexico area are able to irrigate their crops from groundwater seeping out of the All-American Canal in Imperial Valley.

In sum, current operations suggest that a transfer of water from agricultural to urban users would provide a net economic benefit to the state of as much as $300 per AF[15] However, as noted earlier, such value-creating transfers are not freely practicable under the current system. Farmers can use the water for crops – they can sell the water when it is embedded in output – but they are not allowed to sell it in its more beneficial, direct form.

Water Use Distortion

To show the degree of distortion in place in California agriculture, consider a simple experiment. While few public data are available for California profits per acre for various crops, data from studies of irrigation done in 2003 and from the agricultural Census of 2002 are available on the average amount of water used and total revenues produced for various crop types. These data allow construction of estimates of revenues net of the opportunity cost of water usage for various crops.

For example, for cotton, the average farm in 2003 had to use 2.9 acre feet of water per acre for irrigation. Average total farm revenue per acre was $1,086. Using a conservative estimate of $200 per AF for the opportunity cost of water, the true economic revenue per acre –

net of water costs – is only $506 per acre. With production costs excluding water likely at 80% or more of revenues,[16] economic loss per acre of cotton comes to $360 or worse.

Cotton is a medium example of the distortions caused by California's use-it-or-lose-it water rights system. Many crops grown in California are low-value/high-water-usage. When the true economic costs of water are taken into account, many crops show negative economic revenues even before other production costs are considered. Farmers would be better off to sell the water at or near its true economic value and leave the land fallow. Examples are corn, rice, alfalfa, wheat, barley, and hay. These "negative economic revenue" crops use 10 million AF of water per year, nearly one-third of all California agricultural water usage. Even if we assumed a low opportunity cost of $100 per acre foot, sugar beets, cotton, corn, rice, alfalfa and wheat would all remains crops with economic losses attached.

Offsetting Efficiencies of Proper Water Pricing

Clearly these distortions are enormous. But California farm production is not inefficiently high. Indeed, if water were freely traded in California, it is likely that overall crop production would change only very little. There are a number of reasons for this surprising conclusion:

1. *If the true cost of water were taken into account, production would shift away from low revenue per acre foot crops such as barley, hay and wheat to higher revenue per acre foot crops such as vegetables, sugar beets, and orchards.*

2. *Given the much larger water consumption volumes in agricultural regions, farm output would not have to fall much in order to satiate urban demand. Our projections for California population growth indicate a need for no more than 4 to 5 million AF of transfers per year by 2050, which is less than 10% to 15% of California farm water usage. This transfer would be reflected in the water market as a large decline in the price of water paid by urban areas. The drop would lower the opportunity costs of water paid to farmers.*

3. *On average, California uses 50% more water to irrigate its crops than the national average. This result may be due to lower rainfall in California than other areas. However, it may also be due to more efficient irrigation elsewhere. If water in California had higher market value, farmers would have incentives to irrigate more efficiently, thus saving water for urban use with less crop reduction than otherwise.*

4. *Not all land is created equal. The first land from which water would be withdrawn would be that providing the least output and profits. So farm output would decline by a much smaller proportion than total farm water usage. Thus, average farm profit per acre would rise.*

Misleading Multiplier Criticisms of Water Markets

The economic losses from a lack of water markets are clear. Many farmers and the urban areas in the state would be willing participants in a functioning water market. Yet various groups continue to resist reform of state water allocations. A good bit of the stigma associated with water transfers stems from popular misperceptions of the effects of the purchase of land and related water rights in the Owens Valley by Los Angeles Department of Water and Power over 1905-1935.[17]

Another criticism of transfers is that analysis such as ours fails to account of the indirect (third-party) effects of water transfers. These effects are alleged to arise because reductions in farm output reduce employment and incomes of farm workers and farm suppliers, supposedly leading to further declines in spending by these groups, resulting in lower income and spending across the region. These are the "multiplier effects" alluded to earlier. Multiplier analyses are flawed for many reasons, and their use in any context tremendously overstates the economic impact of the changes they analyze, for the reasons tallied below.

*Multiplier Analyses Confuse Benefits and Costs; They Assume No Alternative Uses For Resources***.** When calculating its bottom line, a private company properly counts its revenues as the benefits of its operations and its payroll among its costs. The jobs it creates are a cost of its operations, not a benefit from it. Indeed, a firm is considered to be more efficient if it uses fewer resources to create the same amount of output. From a macroeconomic perspective, these gains in efficiency help the entire economy, as they free scarce resources for utilization elsewhere. Therefore, if a farm should reduce employment as a result of lower water usage, it is the costs of farm operations that decline, not their benefits. It is the lower level of farm output that is the cost of the transfer, not the lower level of labor utilization.

Counting the supposed declines in farm jobs as a cost of a water transfer erroneously converts a benefit into a cost. Alternatively, it can be seen to double-count the costs, since the "lost" value due to labor's reduced input is already included in the value of lost output. Such confusion would be unacceptable in the analysis of a business, but it is a cornerstone of the tortured logic behind multipliers.

When farm output declines after a water transfer, any accompanying declines in farm jobs or in purchases of farm supplies lead to declines in total employment and income *only* if the displaced workers are unable to find gainful employment elsewhere and *only* if the farm suppliers can find no other products to sell to the community. Otherwise, workers and resources "freed" from utilization at a farm are available for usage elsewhere. Jobs and income are not "lost," but transferred, and so the "lost income" the multiplier analyses imply do not occur.

Multiplier analyses' assumption of no alternative usage might have made sense in the Great Depression environment that gave rise to Keynesian economics, but it has no validity in a thriving economy such as urban California, where every unit of labor and land is precious and scarce. Indeed, as we will see in the next section, even during the worst of the 1987-91 drought, non-farm incomes rose by as much or more than farm incomes fell when lower water supplies reduced farm output. There was little or no "lost income" for farm workers' and farm suppliers' to drive any multiplier effects even in such drastic circumstances.

Continued Use of Misleading Multiplier Estimates

Despite these underlying flaws, many researchers utilize multipliers to calculate the impacts of land fallowing programs. Two of the more common such packages RIMS II, from the Bureau of Economic Analysis, U.S. Department of Commerce, and IMPLAN. In most sectors of the U.S. economy, multipliers are estimated to be around 2-to-1. In California agriculture, analysts claim a multiplier effect over 3-to-1. So, while farm income is less than 2% of the total, the sector is purported to support 6.5% of the state economy.

For example, a study from the University of California's Giannini Foundation of Agricultural Economics[18] claims that agriculture was directly and indirectly responsible for 1,130,000 million jobs in California in 1998, about 7.4% of the total then. Since direct employment data show the California farm sector employing only 400,000 workers in 1998, the Giannini study must be claiming that 730,000 secondary jobs were created or supported by the existence of the farm sector. These workers supposedly would not have been employed were the farm sector not in operation. Remember, this usage is taken as a *benefit* of the farm sector.

One might argue instead that the "no alternate use" assumption makes sense in the short-run, when workers might not have time to adjust to new market conditions. However, our drought-episode results in Section III below contradict this assertion. Moreover, a planned water transfer is not a sudden shock. These are negotiated over substantial periods of time, and they are, once again, voluntarily entered into. Both farm workers and farm suppliers would have plenty of time to adjust to any initially negative effects of a transfer (if they need that time).

Failure to Account for Substitution Possibilities

Multiplier Analyses Assume fixed input proportions. Input-output analyses (such as the RIMS II and IMPLAN models) assume proportional inputs to production. In other words, if the amount of water declines by 10%, then inputs of other inputs will similarly decline by 10%. In reality, inputs are typically substitutes. Reduced availability of one input such as water will typically be offset by increased consumption of other inputs. For example, with less water, a farmer may use more-sophisticated irrigation techniques, which are more labor-intensive. Less water may also shift the mix of crops, with an unknown—and not necessarily negative— impact on the demand for other factors. The input-output models utilized in multiplier analyses fail to capture such interplay and so over-estimate the true impact of changes such as water transfers.

Neglect of the Revenue from Water Sales

Multiplier Analyses Ignore Beneficial Effects of Proceeds of Water Sales. Besides the assumption of no alternate usage for resources, a multiplier analysis must also ignore the cash flows into the farm community that water transfers would generate. Reduced revenue from crop sales is offset by these transfer revenues, whether it is spent on local labor, supplies, and consumables, or invested in local banks. There is no reason to presume that the cash inflows associated with water transfers will be smaller than any declines in payrolls or input usage that they might cause. That is, transfers may well be a net benefit even to farm communities.

Neglect of Urban Gains

Multiplier Analyses Ignore Offsetting Effects in Urban Areas. Even if one were to presume that declines in farm output lead to unmitigated declines in farm employment and income, the same logic implies that increased water usage in urban areas leads to gains in employment and income there that would not occur. With reduced water usage in agricultural communities exactly offset by increased usage in urban communities and with water prices generally much higher in urban areas than in rural, even a multiplier analysis stubbornly pursued in the present case would have to conclude that positive direct and secondary effects occurring in urban areas would be orders of magnitude larger than any negative direct and secondary effects supposedly occurring in agricultural areas. As was emphasized above, both the urban and agricultural sides of this picture should be considered when contemplating the total effects of water transfers in the state.

Each of these flaws of multiplier analyses involves some form of myopia. Such analyses ignore all alternative usages for inputs, all changes to production patterns that can mitigate output losses, all alternative usages of funds not spent on farm activity, all usage of the revenues accruing from water transfers, and all benefits occurring on the urban side of the transfers. Such misstatements have no place in a serious costs-benefit analysis. There is ample evidence on farm output and urban water usage that can be utilized to estimate the costs and benefits of water transfers, without resorting to specious techniques.

III. HISTORICAL EVIDENCE ON THE COSTS OF WATER TRANSFERS: THE DROUGHT AS PROXY FOR WATER TRANSFERS.

Water transfers themselves are a relatively new concept. However, the drought of 1987-91 provides a good estimate of many of the effects of water transfers and land-fallowing programs. The lack of available water during the drought caused farmers both to shift their mixes of crops and to fallow substantial amounts of acreage[19] in much the same way as would occur in the case of water transfers. Consequently, we take the observed effects of the drought on farm output and incomes as an estimate – albeit an over-estimate – of the costs of water transfers to agriculture.[20] We pursue this analysis on two levels: first, the direct effects of the drought on farm output and, second, the effects – direct and indirect – on aggregate county incomes that pertain to purported third-party effects.

Upward Bias of Drought-Based Estimates

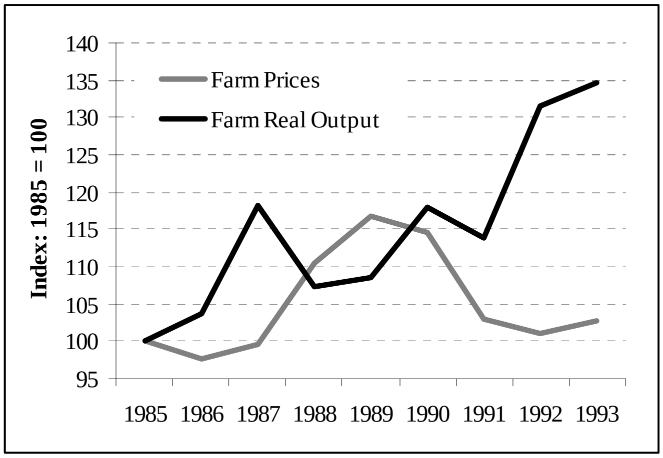
There are a number of reasons to believe that the drought experience overstates the costs to the agricultural community of water transfers. Whereas the 1987-91 drought was a sudden, adverse "shock" to water availability with little or no advance notice, water transfers would be voluntary agreements that the farm sector would have years to prepare for, and adjust to, before they are put into place. Also, whereas the drought was understood – correctly – to be temporary, so that long-term reduction of water usage was not pursued assiduously, the longer the transfers can be expected to last, the more it will be in farmers' and farm suppliers' interest to adjust operations to conserve water.

Furthermore, as explained above, the correct measure of the "costs" of reduced farm-water usage is the marginal product of water: the reduction in farm output due only to reduced water usage. However, the observed farm output losses during the drought years measure both the marginal revenue product of water and also those of other farm inputs that were used in lower volumes due to the drought. In other words, the observed losses already include third-party effects in addition to those due only to reduced water usage. Analyzing changes in non-farm income in farm counties will provide some offset that can be "charged" against those third-party effects in order to focus in on the direct effects of reduced water usage. That is, the initial secondary effects are the reduced utilization of non-water factors in agriculture, and the further, secondary effects are whatever additional income those factors received elsewhere in the economy.

Our Work Versus Others' Analyses

Our work differs from past studies of the drought in that we focus on the *real* output of agricultural products, not merely the *nominal* revenues received by the farming community. With their focus on nominal (current-dollar) revenues, past studies of the drought have mistakenly combined two separate factors: the lack of water caused by the drought and a severe drop in farm prices seen over 1989-92 period. As seen in the chart at right, California farm prices declined over much of the 1987-91 period for reasons obviously unrelated to the drought. (The drought by itself would tend to *raise* farm prices.) The lower farm prices reduced farm revenues and incomes, as well as overstating the observed decline in farm output. And all these non-drought effects are included in the findings of other studies purporting to measure the impact of just the drought. To focus on the effects of the drought, we construct measures of real--price-adjusted aggregate farm output.

California Farm Prices and Output



Source: BEA Gross State Product Statistics

Furthermore, just as falling farm prices over 1989-91 were an adverse effect on the farm community distinct from the drought, so, too, was a severe winter freeze that occurred in January 1991 in the lower San Joaquin Valley. This freeze also worked to reduce farm output for reasons unrelated to the drought, and yet such freeze-related output declines have inevitably become "bundled in" with drought effects in other analyses of the drought years. The 1991 freeze worked primarily to reduce production in citrus and broccoli fields in Fresno, Kern, and Tulare Counties. We abstract from the effects of this freeze by analyzing real aggregate farm output in these counties both excluding and including these freeze-affected crops.

As discussed above, we derive (over) estimates of the total – direct and secondary – effects of water transfers by deriving estimates of the net change in farm output and county income (declines in farm income possibly offset by remedial gains in non-farm income) due to the drought of 1987-91. For three key counties, Fresno, Kern, and Tulare, we also use estimates of drought-induced declines in irrigation water usage so as to derive (over) estimates of total losses per acre-foot of water in the event of negotiated water transfers.

Our analyses of real farm output and farm and non-farm income are relevant to our discussion of the drought as a proxy for water transfers. In order fully to compare our discussion of the drought itself with the earlier studies, we also analyze the effects of the drought on harvested acreage, output per acre, and farm (and non-farm) employment.[21] We detail these effects for the sixteen largest agricultural counties in California, as per 2003 dollar value of farm output: Butte, Colusa, Fresno, Glenn, Imperial, Kern, Kings, Madera, Merced, Riverside, San Joaquin, San Bernardino, Sutter, Stanislaus, Tulare, and Yolo.[22]

We do not find the drought to be a non-event. However, we do find *the output losses attributable to the drought to have been statistically insignificant*. While they were not zero, these losses were no more serious than the purely random fluctuations in farm output occurring in other years. The drought did induce significant declines in harvested acreage, but output per acre was not found to have been affected. Finally, we did find farm-sector income to have been adversely affected during the drought years, but our analysis indicates that a good bit of those declines were due to falling prices and to the winter freeze of 1991.

The declines in farm-sector income properly due to the drought, while substantial, were generally substantially offset by equally significant increases in non-farm income, as labor and other inputs "freed" from the farm sector – due to reduced farm utilization due to the drought – generally found gainful employment elsewhere in the local economies. In the final analysis, we estimate net losses in Fresno and Kern Counties of about $18/AF of farm irrigation water lost to the drought.

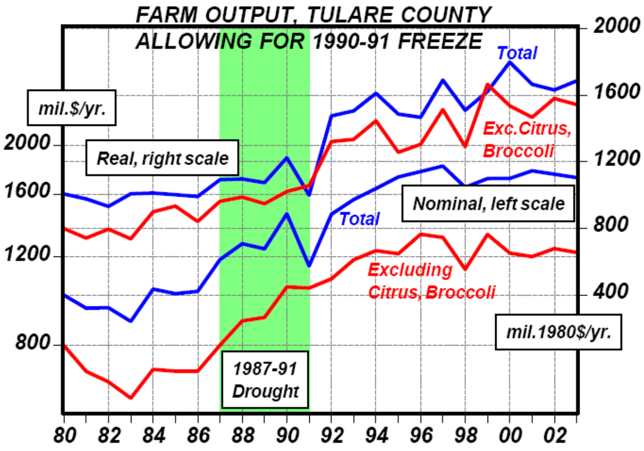
The Drought and Real Farm Output

Rather than focusing only on farm employment or income/revenues from individual crops, we examine aggregate farm output. To abstract from the effects of falling farm prices, we construct price deflators for aggregate farm output in each county and calculate real (price-adjusted) output measures. Aggregate real output is superior to measures of individual crop outputs, because it allows for possible substitutions by farmers from more to less water-intensive crops, once the incidence of the drought became known to them. It is preferable to measures of farm-sector incomes, because we can abstract from the effects of falling prices on incomes and thus focus more directly on drought-specific effects.[23]

Our measures of aggregate output, prices, and harvested acreage are compiled from the annual reports of County Commissioners of Agriculture. For each county, the Commissioners' reports list as many as 200 different crops, showing acreage, physical production, prices, and dollar value of production. The findings we report concern farm-sector (crop) outputs. That is, we abstract from outputs at non-farm, “agricultural” establishments, such as fisheries, apiaries, livestock ranches, and non-irrigated pasture land.[24]

For some crops, explicit product prices are listed in the Commissioners’ reports. For the others, harvested acreage and/or physical production are usually reported. To obtain uniform price data for crops for which explicit prices are not reported, when output volume data are available, we take product prices as the ratio of dollar value to physical output (thus dollars per physical unit).[25] When physical volume data are not available, but harvested acreage data are reported, we calculate product prices for those crops as the ratio of dollar value to acreage (dollars per acre). When neither acreage nor physical volume data are available, we exclude these crops from calculations of aggregate price deflators.[26]

The resulting price series for crops are used to derive aggregate farm output price deflators for each county, with those deflators calculated as the weighted geometric average of individual crop prices, set to a 1980 base year (i.e., the 1980 values set to 100). Current-period weights for each crop in the deflator are taken as the shares of that crop in previous periods’ total nominal output.[27] Real aggregate farm output is then derived as the ratio of nominal aggregate output to this aggregate deflator.

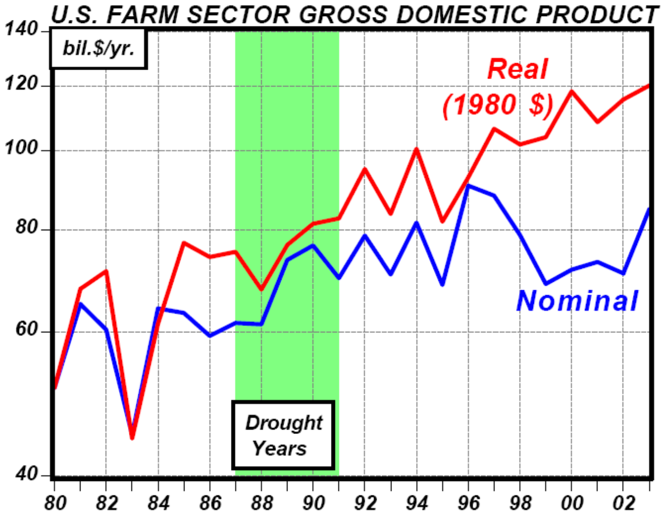


Our estimates indicate that only a few counties show any discernible decline in real aggregate farm output during the drought period in general or even in the last, worst year of the drought, 1991. Furthermore, for several counties, slow-growth or declines in nominal farm output during drought years disappear upon estimating real aggregate output. That is the case for Imperial, Madera (in 1991), and San Joaquin Counties. For other counties, observed declines in nominal 1991 farm output are far more severe than those in real output. This is the case for Colusa, Fresno, Kings, Merced, Riverside, Tulare, and Yolo Counties. These, then, are the counties where generally falling crop prices worked to reduce nominal farm revenues, just as did the drought.

The 1991 Freeze

As for the effects of the 1991 freeze, this event hindered growth of citrus trees and broccoli plants, reducing aggregate harvests and revenues from these crops. As we detail further below, the drought itself had no discernible impact on aggregate output *per acre* in any county, and it had only minor effects on per-acre yields of individual crops. Still, citrus and broccoli yields in Fresno, Kern, and Tulare County declined sharply in 1991. (Physical production declined sharply, while harvested acreage did not decline much, if at all.) We take this as evidence of effects of the freeze.

The Tulare chart shows farm crop output in total and excluding citrus and broccoli, in both nominal and real terms. It is clear that this abstracting from citrus and broccoli output results in a much different perspective in 1991 from what one finds upon looking only at total output. Nominal farm output in Tulare County shows a much smaller decline excluding citrus and broccoli than it does in total. Furthermore, while total real farm output in Tulare shows a decline in 1991, once citrus and broccoli are excluded, the resulting measure actually shows an increase. In other words, *abstracting from the effects of the freeze, the physical volume of farm production in Tulare County generally rose in 1991, despite the incidence of the drought.* In Fresno and Kern, the effects of the freeze were similarly clear, though not as extreme as in Tulare.



Establishing Controls

So far, we have analyzed only whether or not farm output declined in the drought years. However, with most large farm counties seeing rising farm output over time, significant drought effects could show up merely as smaller gains in the drought years than were seen in other years. So we need to establish some control metric to determine whether observed drought-year fluctuations in real output were statistically significant. To this end, we estimated two “control,” trend series for each county's real farm output, one based on national, real farm output and one based only on the time-series behavior of real, county farm output itself.

Farm output can vary from year to year for a number of reasons, including business-cycle fluctuations. For each county, we constructed an econometric model expressing its real farm output as a function of lagged values of itself and current and lagged values of U.S. farm real GDP.[28] Modeling county farm output on national farm GDP provides an innocuous control for county output trends, picking up nationwide swings in real farm production, but leaving more-local fluctuations to be potentially explained by our drought-effect variables.[29]

Relative to these models, the effects of the drought were estimated by running three separate regressions, each using a different dummy variable.[30] The first equation used a dummy variable for 1987-1991, the second one a dummy variable for the years 1990-1991, and the third a dummy for 1991 only. These dummy variables test for whether real farm output was higher or lower in drought years than would otherwise be predicted by our models and whether the observed differences are statistically significant. The results of these tests for the GDP-control models are summarized in the following table.

Across the whole five-year, 1987-91 period of the drought, only five of sixteen counties show any declines in real output, and only San Bernardino and Tulare show significant declines. San Bernardino is outside the Central Valley drought area, while, as we have remarked above and will see shortly, the declines in Tulare are due to the freeze-induced declines in citrus and broccoli harvests in 1991. The paucity of significant effects here is not surprising, given the common observation that the early years of the drought were inconsequential for farmers, thanks to the ability of water agencies to tap into emergency reserves.

Turning to the next set of columns, the table shows that over the 1990-91 period, ten out of sixteen counties showed lower-than-normal farm output, but that only for Tulare County was this effect significant, and, here, again, that decline was mostly due to the 1990-91 winter freeze. Finally, looking at the dummy variable for 1991 alone, eleven of the counties show negative "effects" on farm output in that year. Only the effects for Kern and Tulare County are statistically significant at the 5% critical level, and both of these counties were affected by the freeze.

In order to abstract from the effects of the freeze as innocuously as possible, as discussed earlier, we calculated measures of aggregate real farm output excluding broccoli and citrus fruits for six counties especially intensive in those crops during the drought years: Fresno, Imperial, Kern, Riverside, San Bernardino, and Tulare. For these counties, we estimated separate models with the same structures as those already discussed, but with the dependent variable now being real farm output excluding citrus and broccoli. The three dummy variables described above were then successively applied to these models. The effects for the 1991-only dummy are shown in the last column. As seen there, both the magnitude and the significance of the 1991 dummy variables for these San Joaquin Valley counties declined sharply when the effects of the freeze are allowed for. No Central Valley county showed statistically significant declines in aggregate real farm output during the drought years, once the effects of the 1991 freeze are allowed for.

In summary, when we allow for the effects of falling farm prices and the 1991 freeze in order to focus on the impact of the drought proper, we find the drought to have caused declines in farm output which appear non-negligible – generally from –3% to –7%--but which fall within the range of "normal" output fluctuations in these counties.[31] In other words, the drought-related declines are not statistically significantly different from the normal fluctuations occurring in other years. This is not to say that the drought had no effects whatsoever. Rather, the results suggest that farmers were able to adjust to the changed circumstances sufficiently successfully that the observed declines – from trend – in countywide farm output fall well within the range of normal annual fluctuations that the counties exhibited in other, non-drought periods.[32] Land fallowing programs will introduce no more uncertainty to agricultural economies than what already exists.

DROUGHT EFFECTS WITHIN MODELS FOR REAL FARM OUTPUT								
	Effects of Drought-Year Dummy Variables						*1991 dummy fixed for freeze*	
	For 1987-1991		***For 1990-91***		***For 1991***			
County	***Effect***	***t-stat.***	***Effect***	***t-stat.***	***Effect***	***t-stat.***	***Effect***	***t-stat.***
Butte	***14.3%***	***2.9***	***15.4%***	***2.0***	***6.2%***	***0.6***		
Colusa	***0.5%***	***0.1***	***-6.5%***	***-1.1***	***-3.4%***	***-0.4***		
Fresno*	***2.3%***	***0.5***	***-0.4%***	***-0.1***	***-8.7%***	***-1.2***	***-5.1%***	***-0.7***
Glenn	***4.6%***	***0.9***	***-5.7%***	***-0.8***	***-9.5%***	***-1.0***		
Imperial	***4.8%***	***2.1***	***4.4%***	***1.2***	***-0.5%***	***-0.1***	***-1.4%***	***-0.3***
Kern*	***2.8%***	***0.6***	***-2.1%***	***-0.3***	***-15.4%***	***-2.1***	***-6.4%***	***-0.8***
Kings*	***6.2%***	***0.7***	***0.5%***	***0.0***	***7.2%***	***0.7***		
Madera*	***-2.9%***	***-0.5***	***-9.3%***	***-1.1***	***-6.6%***	***-0.5***		
Merced*	***2.8%***	***1.1***	***5.4%***	***1.3***	***2.4%***	***0.3***		
Riverside	***-4.7%***	***-1.4***	***-6.8%***	***-1.4***	***-8.3%***	***-1.3***	***-9.1%***	***-1.5***
San Bernardino	***-8.5%***	***-1.6***	***-8.4%***	***-1.1***	***-10.6%***	***-1.0***	***16.9%***	***1.3***
San Joaquin*	***1.7%***	***0.4***	***-1.5%***	***-0.2***	***-4.3%***	***-0.5***		
Stanislaus*	***12.9%***	***2.2***	***9.4%***	***1.0***	***6.6%***	***0.5***		
Sutter	***-5.1%***	***-1.1***	***-4.6%***	***-0.7***	***3.0%***	***0.3***		
Tulare*	***-12.4%***	***-2.9***	***-11.4%***	***-1.6***	***-22.2%***	***-2.7***	***-3.6%***	***-0.4***
Yolo	***-0.4%***	***-0.1***	***2.5%***	***0.4***	***-3.6%***	***-0.5***		

***Counties in San Joaquin Valley.**

Items with t > 1.5 and with negative effects match intuition: significant, large, negative effects of drought on output.

Items with t > 1.5 and positive effects contradict intuition: significant, large, positive effects in drought years.

Statistical Significance is taken as 5% significance level for 1-tailed test: t-stat > 1.5.

Since the regression equations are in log terms, the actual coefficients for the dummy variables are logs as well. Shown are percent versions of these variables: Y = exp(X)-1, where Y is the representation shown and X is the actual estimated coefficient.

Bottom Line: No Major Drought Impact

All in all, it is hard to find any clear, creditable evidence in the literature that the drought was a serious blow to farming even in its worst year, 1991. Our analysis found the drought to have reduced farm output and farm-sector incomes, although generally to a statistically insignificant extent.[33] Still, it is clear that the drought must have had some deleterious effect on farm-sector output, and we take our point estimates of these effects to be upper bounds of the total costs inflicted by the drought (upper bounds for the reasons discussed earlier).

Dollar Cost Per Unit of Water

In order to convert these estimates into measures of dollar cost per unit of water, we need to apply reliable estimates of the decline in total water consumption by farm counties affected by the drought. The California Department of Water Resources and the U.S. Bureau of Reclamation provide estimates of the decline in surface water *deliveries* to California farms. (The declines in these deliveries were cited by Villarejo and others.) However, these data overstate the decline in water usage (and thus would understate the “costs” per unit of water), since they don’t pick up increased usage of groundwater by farms in response to the drought.

The estimates of total water usage that we have been able to find were reported in Dale and Dixon. Consistent with their assertion that the drought was not much of an issue in Merced, San Joaquin, and Stanislaus Counties, they report increases or insignificant declines in total water usage by farms in these counties in 1991. Comparing the changes in water usage in these counties with the estimated 1991 effects on gross farm output, one can see that the directions of changes match only with respect to Merced, and there the *gains* in both water usage and gross farm output are small enough that a meaningful estimate of the “benefits” of greater water supplies there cannot be obtained.

ESTIMATES OF CHANGE IN TOTAL FARM WATER USE, FROM 1987-89 TO 1991*	
County	***Change, 1987-89 to 1991 (AF/yr.)***
Fresno	***-550,100***
Kern	***-434,500***
Merced	***+32,940***
San Joaquin	***-15,540***
Stanislaus	***+45,570***
****As reported in Dale and Dixon, Table A.2, attributed to Coachella Valley Project Environmental Team.***	

It is a different story for the “drought-affected” counties of Fresno and Kern. There, the reported declines in total water usage on farms are on the order of 500,000 AF in both counties, and that amount is far larger than any land fallowing program would likely aim at redirecting. These estimates can be used to derive rough (over)estimates of the per-unit costs of the drought, and these are shown in the following table.

ESTIMATED DROUGHT-INDUCED DECLINES IN 1991 OUTPUT/INCOME PER UNIT OF WATER				
County		***Gross Farm Output***	***Total Farm Income***	***Total County Income***
Fresno	***In $***	***$-109.8 mil.***	***$-52.3 mil.***	***$-10.0 mil.***
	$/AF	***$199.6/AF***	***$95.07/AF***	***$18.18/AF***
Kern	***In $***	***$-108.0 mil.***	***$-71.1 mil.***	***$0.0 mil.***
	$/AF	***$248.56/AF***	***$163.64/AF***	***$0/AF***

Not allowing for any mitigation of lost income by farm-sector participants outside the farm sector and including losses by out-of-county suppliers to local farms, the experience of the drought appears to be that each acre-foot of sudden, short-term reduction in farm water usage led to a decline of $200 to $250 in total farm output. Abstracting from income losses to non-farm sectors of the local economy and elsewhere – that is, focusing on observed declines in total farm income – it appears that each acre-foot reduction of farm water usage lowered local farm-sector incomes $95 to $165.

Finally, allowing for apparent (short-term) mitigation of income losses by farm-sector participants via pursuit of opportunities elsewhere in the local economy, the aggregate losses from a reduction in farm water usage become imperceptibly small, totaling $18 per acre-foot in Fresno and literally disappearing in Kern. In other words, in the final analysis, our analysis of the incidence of the drought delivers estimates of the marginal revenue product of farm water that are of the same order of magnitude as average user costs for farm water of $30/AF

While these last results are not unassailable, their reliability is as high as that of the findings of lost output and income in these and other counties due to the drought. Meanwhile, the studies asserting large, negative effects of the drought do not even attempt to measure the statistical reliability (significance) of their results. Certainly, the occurrence of the drought on farm communities was a constraint, and so it must have inflicted some net declines on general economic well-being there. Suffice it to say, though, that even in the farm sector, these declines were less than calamitous, and there are strong indications that drought-displaced farm-sector participants had alternative opportunities elsewhere in their local economies, so that multiplier analyses are inappropriate here, and the whole issue of 3rd party impacts fades in importance.

Meanwhile, even at the upper bound (gross overstatement) of cost estimates derived from estimated declines in total farm output, that is, even within a range of $200 to $250 per acre-foot, the total (overstated) costs to farm communities from reductions in water usage (via drought, water transfer, or whatever), can be seen to be smaller than the wholesale-price benefits that urban areas would derive from increased water usage, as we will see below in Section IV.

The most important thing to take away from this table is that in one case an urban water district has already committed to paying amounts that add up to $240 per acre foot of water through a land fallowing program. This amount is larger than any of these estimates – estimates that by design overstate the true economic losses of water transfers. With this fact in mind, we can see clearly the economic efficiencies of these programs.

IV. BENEFITS TO URBAN COMMUNITIES

The preceding section analyzed the short- and long-term effects of water transfers on agricultural regions. The other side of the transfers issue is the benefits to urban consumers of water transfers. Most studies on the impact of declines in water consumption within agricultural areas ignore this critical other side of the equation. The impact of reduced water availability on urban communities can be divided into the following categories:[34]

- reduced availability for industrial purposes, reducing industrial-sector efficiency,
- reduced ability to build new housing, with consequent increases in housing costs, and
- reduced water consumption by residential and commercial final users.

Note that by committing to paying more than the economic costs of water in some programs, urban water agencies have already essentially shown that the benefits to urban communities are larger than the losses to agricultural centers. Still, it is worthwhile to make an explicit estimate of this value.

Estimating Urban Welfare Effects

While the 1988 to 1991 drought in California spilled over into urban areas, the degree of reduced water availability was very small relative to the level of economic output, making empirical estimation at the level of detail of the last section largely impossible. Furthermore, the largest impact was on residential and commercial consumers. These two groups consume 80% of urban water, but for final consumption purposes, so that the benefits of their water consumption are not reflected in available measures of economic (business) output. Most urban water conservation efforts during times of shortage were focused on these groups. Changes in water availability for these groups affects consumer surplus (the welfare measure for consumers). Resulting gains or losses in consumer surplus will not show up in economic statistics and can be measured only indirectly.

Of course we do not need to measure things so indirectly, at least at the margin. Final retail consumers in California pay on the low end between $900 to $1200 per AF for treated water, with the gap between retail and wholesale prices due to costs of urban delivery and treatment for consumption.[35] Therefore, the final consumer values this water by at least this much, and a reduction in water supply would "cost" at least this much to the consumer. This price includes the cost of cleaning and transporting the water from the original source to local facilities as well as through local water systems, costs that should be included in order to measure correctly the net benefits of water transfers. These costs are not insubstantial. But instead of this approach, we can use another: estimates of the price elasticity of demand for urban water in order to show the urban effects of a decrease in the availability of water and the necessary increase in costs to offset the decline in availability.

The logic of this experiment is as follows. The gap between the total value of water to consumers and the total amount paid for that water is what economists refer to as "consumer surplus." When prices rise, consumption and consumer surplus shrink. The loss in consumer surplus is roughly one half the change in price multiplied by the change in quantity, in absolute terms. The relationship between the change in price and the change in quantity is determined by price elasticity. With low price elasticity, a reduction in water consumption can only be met with a large increase in price.

A rough estimate of the potential costs of reduced urban consumption (lost consumer surplus) can be obtained from estimates of the price-elasticity of urban water demand.[36] Numerous studies indicate that demand is highly inelastic, ranging from -.2 to -.5.[37] This range implies that a 10% decrease in the price of urban water leads to only a 2% to 5% increase in urban consumption.[38]

Estimated Economic Value of Land Fallowing

	Low	***High***
Elasticity	-0.2	-0.5
Urban Price w/ No Fallowing	$1,147	$1,000
Urban Price w/ Fallowing	$900	$900
Direct Urban Gain ($Mil)	$68.1	$27.5
Efficiency Gains ($Mil)	$55 to $165	
	Low	***High***
Range of Benefits ($Mil)	***$82.5***	***$281.3***

Consider this scenario: demand for water at current prices by urban sources increases by 550,000 AF (roughly 5.5% of current urban demand), due either to a drop in available supply (a drought) or an increase in demand (due to rising population). Note that this amount is equivalent to the loss of water in Fresno County during the 1991 drought. For simplicity, further assume that the price of urban consumption is $900 per acre foot. Assuming that there is no other water available, the only choice for urban communities is to raise prices to restrain consumption to its former level.[39]

The following table details the estimated effects of an increase in water prices. Urban prices might have to rise to as high as $1,150 per AF to keep urban consumption at current levels. If demand elasticity is at the high end of the estimated range, then prices need rise only to $1,000 per AF The loss of consumer surplus is approximately $27.5 million to $68.8 million.

Of course, this uses the low end of average prices. When prices are higher, the absolute increase in the price is that much larger and increases these losses accordingly. For example, if the residential price of water were $1200 per acre-foot, the range of losses would be between $36 million and $90 million. If the cost was $1,500 per acre foot, then the losses would be between $45 million and $113 million.

We must add the efficiency gains of such a transfer. Remember that agriculture consumes water at an artificially low price. Thus, agricultural production also imposes losses on the economy in the form of excess water consumption to an amount that ranges between $100 and $300 per acre foot used. This loss adds another $55 to $165 million. In total, conservative estimates of the urban value of the water transfer program range from $82.5 million to $281.3 million.

Conservative Estimates

These numbers are clearly larger than the $52 million in total farm income losses we estimate were sustained by Fresno as a result of the drought, and, of course, they are much larger than the net $10 million estimate of total county income losses. As already noted, the true benefits of a transfer are likely to be much larger than this, because we have deliberately overestimated the costs of the reduction in water usage and similarly under-estimated the gains to the urban communities.

- The damage estimates to Fresno are far larger than any land fallowing program would impose because a fallowing program, by definition, can be planned. The drought cannot. Thus, the total drought costs would include costs that would not be incurred under land fallowing. Similarly, third-party effects would be lower as well, in part due to planning and in part due to the mitigating efforts of the water authority running the program.

- In our example we considered the net value of a 550,000 acre foot transfer of water. Land fallowing programs to obtain this water for urban uses would occur across many regions, rather than concentrated in one, as is the case of the drought in Fresno. The economic impacts of a decline in water availability are not linear. Rather they increase with the size of the losses. By spreading fallowing programs across many regions the level of economic disruption at any specific region would be minimized. Therefore, the total amount of damages would be much smaller.

- To the extent land fallowing-based transfer programs could or would be concentrated in regions which have low transport costs to urban centers of demand, the imposed transport costs and would push the efficiency gains of the fallowing towards the higher estimate of $300 per acre.

V. CONCLUSIONS

The analysis presented in this chapter suggests two central results. By considering the actual impact of the 1987-1991 drought on the California agricultural economy, we created an overestimate of the potential costs of land fallowing programs. By deriving a reasonable measure of lost consumer surplus in urban areas due to water consumption reductions, we estimated a lower bound for the estimates of urban losses from reduced availability. Use of such conservative estimates demonstrates that the potential net value of such rural-to-urban water sales is enormous.

The best aggregate solution for California would be to create a functioning statewide water market, allowing farmers to sell their water rights freely and letting the price of water rise or fall to a market-clearing level. The land-fallowing programs currently envisioned actually favor agricultural communities tremendously relative to this basic free-market solution, because the amount of water available for transfer far exceeds the needs of urban areas. Limiting water transfers to the amounts envisioned by fallowing plans would support urban water prices far above a free-market rate.

Those farmers who are able to participate in transfer programs will receive “supported” water prices, and the amount of water used by farms would also be above what would occur under a market solution. Offsetting this result is the fact that fewer farmers will be able to sell their water. The gains will be larger per acre-foot, but will accrue to fewer individuals. Nevertheless, in the long run, the ability of urban areas to obtain greater supplies to allow expansion is a valuable tool. It goes some way at least towards ameliorating the inefficiencies of the current system, while also helping assure adequate water supplies for urban areas.

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Endnotes

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[1] Source: National Climatic Data Center, Climate Monitoring Program.

[2] The most recent example of this was a court order requiring the Los Angeles Department of Water and Power to restore water flow to a 62 mile stretch of the Lower Owens River, diverting water from the Los Angeles Aqueduct. The river had been run dry by reduction in ground water supplies and by nearly one hundred years of water transfers to Los Angeles.

[3] California is legally entitled to its basic apportionment of 4.4 million acre-feet per year of Colorado River water plus 50% of any surplus water, based on a Supreme Court decision and consequent usage allocations dating back to the early-20th century.

[4] Source: California Water Plan, http://www.waterplan.water.ca.gov/cwpu2005/index.cfm.

[5] There is no doubt about the contribution of farming to California's historical development. The state still has the largest agriculture sector in the U.S. In 2003, the agricultural sector contributed over $20 billion to Gross State Product, compared to $8 billion for Texas, the nation's second largest farm sector (as per the Bureau of Economic Analysis). However, as a contributor to the overall state economy and as a force for economic growth, agriculture has been overshadowed by industrial development and urban growth of the state throughout the past century. While non-farm employment in California increased by nearly 8 million jobs from 1969 to 2003, from 7.9 million to 15.7 million, agricultural employment added only 50,000 jobs, from 175,000 to 225,000. The agricultural services sector expanded from 60,000 to 200,000 over the same period. Agriculture contributed slightly more than 2% of all new jobs in the state over the past 35 years. In 2001, agriculture consumed 33.7 million AF of water, enough to supply 60 to 65 million families or 200 million people.

[6] Many articles on water in the state refer to our problem as a 'shortage' issue. A shortage occurs when the quantity demanded is greater than the available supply. When markets function properly, there can be no such thing as a shortage, as the price mechanism works to equilibrate supply with demand. Shortages, in this context, occur only when markets fail or aren't allowed to form at all, as when governments recognize non-market allocations, as has occurred in California.

[7] Water markets of sorts have been temporarily established during periods of extreme water shortage, such as the Water Bank program during the early-1990s drought. While these systems functioned very effectively, they are not in place presently

[8] The Palo Verde Water District was one of the first to enter into a land fallowing program. The contract it entered into has a special provision for a $6 million development fund to be established once water transfers begin.

[9] In addition, we will divide this measure by the volume purchased irrigation water, which understates total water usage on farms, so that the derived measure of value per acre-foot is overstated on this count as well.

[10] Source Water Education Foundation, http://www.westlandswater.org/wtrsupply/droughtwb.htm

[11] Transport costs vary widely depending on where the farmer is and where the closest urban demand is. The transport costs (including power) for transfer water to Southern California are about $255 per acre foot, but this could vary widely in other parts of the state and includes capital costs on existing infrastructure, which are not marginal and thus would not be counted in this marginal calculation.

[12] Cf. The Farm & Ranch Irrigation Survey (USDA NASS):
http://www.nass.usda.gov/census/census02/fris/fris03.htm for degree of irrigation and California Historic Data
http://www.nass.usda.gov/ca/indexhist.htm for average value of crops in 2003 per acre.

[13] In 2002 California farms earned $25.5 billion in revenues and had costs of $20.5 billion, for a gross margin of slightly over 20%. This clearly over-estimates the true margin since it does not include the labor costs of owner-operators, the equity capital costs of owned equipment and buildings (although depreciation of assets is included, as are interest expenses) or the implied rental value of equity in the farm land.

[14] It should be clearly stated that the farmers are in no way acting in an improper or immoral manner. They are simply responding properly and logically to the economic incentives provided them in the current water allocation system.

[15] Depending on where the water is located, some of this gain would be erased by the costs of transporting (wheeling) water from the source to the demander. As such, water sales or land fallowing programs are most efficient when water sources are close to urban points of consumption.

[16] This is a very generous estimate of a 20% profit margin when it's more likely to be 5% to 10% at best.

[17] While some accounts blame the transaction for an evisceration of Owens Valley agriculture, more objective analysis indicates that the rancor over the land and water rights purchase stemmed from the fact that the LADWP dealt negotiated the transfer of rights with individual owners rather than the community as a whole and the resulting

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split of benefits between those who sold and those who remained. In his study of the transfer, Libecap (2004) finds that the transfer had wide-ranging positive impacts for residents of both regions. Property values rose in both Owens Valley and Los Angeles as a result of the transfer. He attributes the animus among Owens Valley residents toward the transfer to the fact that Los Angeles property value gains were ten times greater in magnitude than those in Owens Valley. We conclude that the Owens Valley transfer was a net benefit to California as a whole, but that the gains from the transfer were not fairly divided between Los Angeles and the Owens Valley. The Owens Valley land purchases were also voluntary, though some Owens farmers may have been misled as to underlying goal of the purchases. This point only emphasizes the fact that dissatisfaction with the transfer stemmed from the terms of the deal, not from the transfer itself.

[18] Sumner, Bervejillo, and Kuminoff (1998).

[19] See Dale and Dixon (1998).

[20] 1991 is a key year for study of the effects of the drought. While the drought extended from 1986 through 1991, as researchers reporting on this episode invariably point out--and as our own findings affirm, California farms suffered little loss of water availability and little or no losses in farm output in the initial years of the drought, when water agencies allowed emergency water supplies to be utilized. It was only by 1990 and 1991, when emergency stores were depleted and rainfall still hadn't replenished reservoirs, that farmers were forced to reduce water usage in some counties. It was also in 1991 that the state Water Bank was first created, compounding the water usage reductions in some regions, but mitigating them in others. Finally, as we will see below, while water usage is thought to have declined starting in 1990, our analysis detects little or no declines in farm output in 1990, so that 1991 is the year when the drought-induced output declines show up most clearly.

[21] Besides providing an over-estimate of the costs of water transfers, a careful examination of the 1987-91 drought is worthwhile in providing perspective on various other studies that found the drought to be a devastating event. Many of these studies reported sharp declines in farm-sector employment during the drought and cited other evidence implying sharp resulting declines in farm output. Those studies did not derive explicit estimates of costs (economic losses) per acre-foot of water not available to affected farmers during the drought, so they don't directly pertain to this study of water transfers. Still, the harrowing tales recounted in these studies have left a common impression among the public and even among some farm-sector experts that the 1987-91 was a disaster for farm communities. These very negative connotations have naturally migrated over to attitudes in farm communities concerning any potential reduction in water supplies, including water transfers.

[22] Of these large farm counties, Butte, Colusa, Glenn, Sutter, and Yolo are in the Sacramento Valley portion of the Central Valley region. Fresno, Kern, Kings, Madera, Merced, San Joaquin, Stanislaus, and Tulare are located in the San Joaquin Valley portion of the Central Valley. Imperial, Riverside, and San Bernardino are all in Southern California and border on or extend through the Mojave Desert.

[23] Note that falling prices typically lead to reduced output in their own right. We do not factor this into our estimates, again creating an over-estimate of the true impact of the drought itself.

[24] We did perform aggregations and calculations for total “agricultural output,” including the "non-farm activities" listed in the text. The results for these “total agriculture sector” output measures conformed uniformly to those reported here for farming proper.

[25] We did check these results with the reported product prices, when the latter were available and found no discrepancies between calculated product prices and reported product prices, once physical units were properly stated.

[26] For some crops, reporting practices differ from year to year, so that physical volume might be available one year, but only acreage the next. In those cases, where some acreage or volume data were available in each year, we calculated a “spliced” price index for the crop in question, calculating the evolution of dollars/physical-output data where available and interpolating interim price observations using acreage information.

[27] That is, the weights are each crop’s share in the sub-total of output for which continuous price data are obtainable. Note also that since some crops are not reported for all years and since other crops do not have price data available for all years, the subset of crops used for price deflator calculations varies from year to year for each county.

[28] Effects were estimated out to two-year lags both for farm GDP and for county real output (lagged dependent variable).

[29] It might be argued that using national farm GDP as a control variable biases the results, because California is a significant contributor to national farm output and also because the drought affected other states as well as California, so that on both counts U.S. farm GDP swings reflect drought effects, possibly “stealing” from our

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estimates of drought effects. Our counter to this is that California is only a modest 14% of U.S. farm GDP and that there are no drought effects apparent in the 1987-91 data for national farm GDP. Still, to deal with these concerns, we also constructed "control" trends for real farm output in each county using only the time-series behavior of county farm output (ARMA models). These models are even more innocuous than the GDP-control models described above, in that they don't even pick up clearly nationwide factors affecting local farm output in a particular period. A full, hands-on modeling of local farm output might be biased against detecting drought effects, since it explains a predominant amount of observed farm output fluctuations via the non-drought elements in the model. Our more innocuous model is, if anything, biased in favor of finding drought effects, since we explain only nation-wide fluctuations via the non-drought elements of this model. In any case, the results for the ARMA models were qualitatively identical to those for the models reported in the text.

[30] Dummy variables are "dichotomous" variables, taking the value of one in selected observations and zero everywhere else. Within the context of a regression model such as those estimated for county real farm output, insertion of a dummy variable will result in the attribution of all unexplained variation in the "dummy" period or periods to the dummy itself. Thus, a dummy variable will be statistically significant only if the years it covers (for which its value is one) show significantly different behavior from that of the rest of the sample. This is exactly what we are trying to detect in identifying drought effects.

[31] Most counties show lower farm output in 1991 than would be suggested by the trend models we constructed. That is, the dummy variables for 1991 are mostly negative. However, these effects are in all cases relatively small and within the range of fluctuations observed in non-drought years. Thus, for the Central Valley counties, the largest t-statistic for a county (upon allowing for freeze effects) is the -1.03 found for Glenn. This statistic indicates that there is about an 15% chance that the observed 1991 decline could have arisen solely due to random fluctuations around a zero (true) value. For other counties, the chances that the observed negative effects are due to random fluctuation are even higher.

[32] The adjustments that farmers could have made in response to the reduced water supplies are recounted at length in the literature on the drought. Writers typically cite land fallowing, more efficient irrigation techniques--such as sprinkler and drip systems--laser-leveling of fields, etc., shifts to different (higher-value) crop types, and deficit irrigation (insufficient irrigation to allow leeching off of salt accumulation) as possible farmer responses to reduced water supplies. We look at fallowing below, via harvested acreage. As for deficit irrigation, our analysis below of aggregate farm yields by county further below does not indicate any decline in yields in the years AFTER the drought, which suggests that deficit irrigation—if it did occur--was not a common enough practice in these counties to visibly affect subsequent soil yields.

[33] Remember that all the dummy variables for various versions of the drought in the real farm output models were found to be insignificant once we controlled for the effects of the freeze. Meanwhile, while farm incomes in some cases were found to have declined significantly in 1991, much of those declines can be attributed to falling farm prices and to the winter freeze, so that even here, the effects of the drought alone would not be statistically significant.

[34] See Moore, Pint, and Dixon (1993).

[35] Again, this estimate is quite low. Consumers pay a wide variety of prices depending on where they are and their sources of water. This number includes, for example, cities that have their own supply of water. Those agencies that do not have their own supplies and must buy from wholesale urban suppliers tend to charge higher prices—for some locations close to $2000 per acre foot. Note that the wide gap between retail and wholesale prices reflects the cost of local treatment and delivery. Note how this is the largest majority of the cost paid by the final user. Still even at these rates people are paying much less than a penny per gallon.

[36] This estimation is difficult due to the average price pricing schemes used by many water districts. This prevents easy estimation of the marginal price being paid by consumers. Hence, the various studies have tried different methods and used new data sets. Interestingly, despite this breadth of methods in the literature, the range of results is relatively small, as discussed in Renwick, Green, and McCorkle (1998).

[37] See Olmstead, Hanemann, and Stavins (2005).

[38] This works the other way around as well. Large increases in cost lead to relatively small declines in consumption. One general implication is that urban consumers are not the best target group for conservation efforts. Given how inelastic farm output is relative to water consumption, as shown in the preceding section, clearly, conservation efforts would be better focused on agricultural usage, where price elasticity is clearly much larger.

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[39] In the early nineties drought urban areas enforced a number of regulations such as low-flow toilets and reduced lawn watering to help conservation occur without increasing prices. While expanding these measures may imply that price need not rise by as much to reduce output to the necessary level, it need be remembered that consumers would consume that water if they had the choice. In other words, non-priced base conservation efforts effectively create consumer loss, even if not through higher prices.