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Incentive-Based Groundwater Conservation Programs: Perverse Consequences?

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We consider two voluntary, incentive-based groundwater conservation programs and estimate their effects on groundwater extraction for irrigated agriculture. We find that the programs do not have the intended effect; the subsidization of more efficient irrigation technology induces the production of more water-intensive crops, thus increasing total extraction, and land retirement programs are generally not utilized on irrigated land, thus having little effect on groundwater extraction.

Also in this issue

Voluntary, incentive-based water conservation programs for irrigated agriculture are often billed as policies where everyone gains. They are politically feasible, farmers are able to install or upgrade their irrigation systems at a reduced cost, resulting in substantial increases in profits, less groundwater is "wasted" through runoff, evaporation, or drift, marginal lands can be profitably retired, and farmers can choose whether to participate. However, such policies can have unintended, even perverse, consequences. Here, we empirically evaluate two policies that have been used to decrease groundwater extraction.

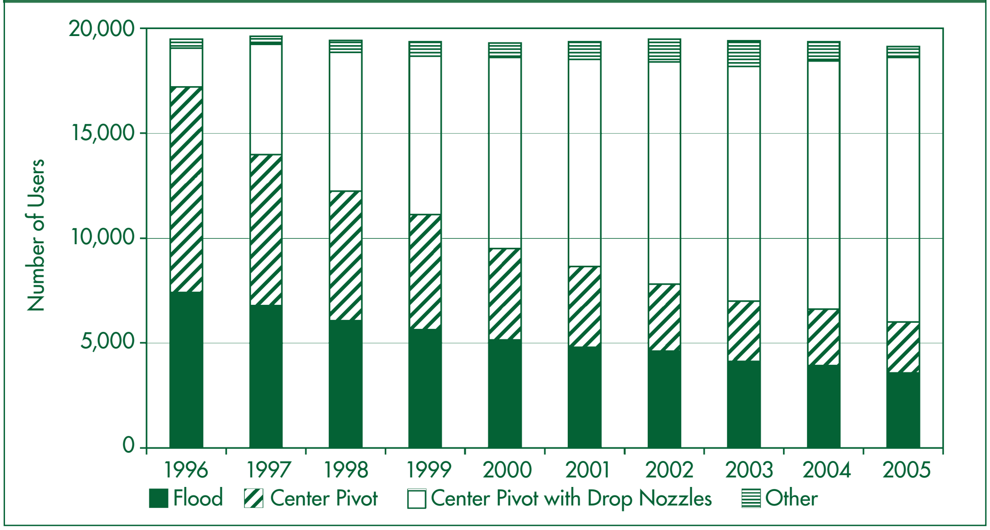
Agriculture accounts for 99% of groundwater withdrawals from the High Plains Aquifer of the midwestern United States, the largest freshwater aquifer system in the world. The region has experienced a decline in the level of the water table since intensive irrigation became widespread, starting in the 1970s. In parts of southwestern Kansas and in the Texas panhandle, the water table has declined by more than 150 feet. While declines in the water table are expected given rates of extraction that far exceed the recharge to the aquifer, concerns that the aquifer is being depleted too rapidly have become common in public policy and debate. Similar concerns have risen in many of the world's most productive agricultural basins, including California's agricultural regions. In many places, policymakers have attempted to decrease rates of extraction through incentive-based measures.

The state of Kansas was chosen for the analysis because of the availability of data; Kansas is a leader worldwide in the collection of data concerning groundwater extraction, water table levels, and policies affecting agriculture. The lessons from the analysis, however, are general and can be applied to agricultural groundwater basins anywhere. In fact, the same programs that are evaluated for Kansas also fund agricultural producers in California. Additionally, Pacific Gas and Electric is currently funding an Agricultural Pumping Efficiency Program that provides cash incentives for energy efficiency upgrades. Similar programs have been available in the past.

Incentive-Based Conservation Programs

The state has been subsidizing a shift toward more efficient irrigation systems. State and federal agencies have invested considerable resources in equipment cost sharing and technical assistance to farmers since about 1990. Between 1998 and 2005, more than $5.5 million was allocated to farmers through the Irrigation Water Conservation Fund and the Environmental Quality Incentives Program. Such programs pay up to 75% of

Figure 1. Irrigation Technology in Use in Western Kansas



the cost of purchasing and installing new or upgraded irrigation technology.

The irrigation technology employed by groundwater users in western Kansas has changed significantly since intensive irrigation development began. Land was converted from flood irrigation systems to center pivot systems. With flood irrigation, water is pumped to one edge of a field, then allowed to run down furrows through the fields between rows of crops and allowed to soak in. Flood irrigation necessitates flat land and quality soil with a high water holding capacity, and is relatively labor intensive. Center pivot systems, on the other hand, are generally self-propelled, can be used on sloped or rolling land, and the quantity of water delivered to the crop can be adjusted to soil and climatic conditions. Center pivots can be thought of as land-quality enhancing; they enhance the ability of lower quality soils to provide water and nutrients to crops, reducing the productivity differences between low and high quality land. Figure 1 shows the general trends in the change in irrigation technology use in western Kansas in the period 1996 to 2005. From figure 1, it can be seen that the conversion from flood to center pivot systems was well underway by 1996. Rather, most of the change comes in the conversion from center pivots to center pivots with dropped nozzle packages. Dropped nozzle packages (also called low-pressure nozzles) suspend the sprinkler heads just above the canopy of the crop. They increase the efficiency of water applied to the field by decreasing the amount lost to evaporation and drift, especially in hot and windy climates. More efficient irrigation systems decrease the amount of water that needs to be extracted for a given benefit to the crop, thus decreasing the cost to the irrigator. Thus, increased irrigation efficiency has been touted as an ideal way to decrease total water extraction.

The Conservation Reserve Program (CRP) was created by the federal government in 1985 to "provide technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner." These programs include payments to landowners to retire, leave fallow, or plant non-irrigated crops on their land. Kansas has used the CRP and other more recent programs to retire (at least temporarily) land in areas of the state where the water table has been falling most rapidly. An average of 2.7 million acres of land has been under the CRP in Kansas each year since 1996, and an additional 600,000 acres have been placed under other land conservation programs since 2003. The largest recent increases in the number of acres under conservation programs have been concentrated in counties with the largest changes in the depth of the water table. These programs are an effort by the state to reduce water extraction in areas that may have been over-appropriated.

The state of Kansas has spent nearly $6 million on incentive programs (cost-sharing or subsidizing the purchase) to fund the adoption of more efficient irrigation systems. An additional amount of farm and environmental program money goes toward land fallowing and land and water rights retirement programs each year. About $8 million per year is spent on Conservation Reserve Program acres, and an additional $3 million in 2004 and $5 million in 2005 was used for other programs in western Kansas alone, including the Conservation Security Program, the Grasslands Security Program, and the Environmental Quality Incentives Program (EQIP) Ground and Surface Water program. These policies are implemented under the auspices that they will decrease

Table 1.Estimated Effects of Irrigation Systems and Conservation Programs on Crop Choice

	Acres of alfalfa	Acres of corn	Acres of soybeans	Acres of wheat	Acres of sorghum	Acres non-irrigated
Flood irrigation system	Control group					
Center pivot system	33.59***	26.27***	27.99***	16.03**	20.77**	
Center pivot w/ dropped nozzles	30.90***	27.01***	26.80***	15.64***	18.02***	
Acres in CRP and env conservation programs in the county (thousands)	0.03**	-0.01*	0.10***	0.05***	0.06***	0.24***

** significant at 5%, ** significant at 1%, *** significant at 0.1%*

the total consumptive use of groundwater, a key goal of state water managers, and are in response to declining aquifer levels that are occurring in some portions of the state due to extensive groundwater pumping for irrigation.

Definition of Irrigation Efficiency

Gross irrigation is the quantity of water diverted (extracted, in the case of groundwater), and net irrigation is the quantity of water consumed by the crop. Efficiency, therefore, is the share of gross irrigation that is used by the crop. More efficient irrigation systems reduce the amount of water that must be extracted for a given benefit to the crop. Center pivot systems with dropped nozzles use about 8% less water than traditional center pivot systems by reducing drift and evaporation, and standard center pivot systems use up to 30% less water than flood irrigation systems through reduced runoff, improved timing, and more uniform application.

Economics of Incentive-Based Water Conservation Programs

Recent work has suggested that policies of encouraging the adoption of more efficient irrigation technology may not have the intended effect. Irrigation is said to be "productivity enhancing"; it allows the production of higher value crops on previously marginal land. Thus, a policy of subsidizing more efficient irrigation technology can induce a shift away from dry-land crops to irrigated crops. They may also induce the planting of more water-intensive crops on already irrigated land, as by definition, more efficient irrigation increases the amount of water the crop receives per unit extracted.

A similar story emerges when one considers land retirement programs. Such programs operate on an offer-based contract between the landowner and the coordinating government agency. The contractual relationship is subject to asymmetric information, and adverse selection may arise because the landowner has better information about the opportunity cost of supplying the environmental amenity than does the conservation agent. There is substantial evidence that farmers enroll their least productive, least intensively farmed lands in the programs while receiving payments higher than their opportunity costs, thus accruing rents. It is quite unlikely that an irrigated parcel, which requires considerable investment in a system of irrigation (which, in turn, enhances the productivity of the parcel), will be among a farmer's plots with the lowest opportunity cost and thus enrolled in the program. Enrolling a non-irrigated plot in the CRP program will not have any effect on the amount of irrigation water extracted.

Table 2. Estimated Effects of Irrigation Systems and Conservation Programs on Water Pumping

	Estimated coefficient from water pumping regression (given crop choice)	Total marginal effect
Flood irrigation system	Control group	
Center pivot system	-15.20***	30.683
Center pivot with dropped nozzles	-14.42***	29.727
Acres in CRP and environmental conservation programs in the county (thousands)	0.15***	0.209

** significant at 5%, ** significant at 1%, *** significant at 0.1%*

An Empirical Economic Model to Estimate the Effects of the Programs

A large dataset of more than 20,000 agricultural groundwater wells from western Kansas, over the years 1996 to 2005, is used to investigate the effectiveness of voluntary land retirement and subsidized irrigation technology adoption on groundwater extraction. The well locations are geo-referenced, and we match them to soil quality characteristics, precipitation, and hydrological information about the aquifer from which they are drawing, such as the depth to groundwater.

We develop an empirical model that assumes that farmers optimize their cropping decisions to maximize profits. They choose between the five most common irrigated crops grown in western Kansas (corn, alfalfa, soybeans, sorghum, and wheat) or decide not to irrigate a parcel. Then, given their crop choice, they decide how much water to pump. Both stages of the estimation are important because irrigators can adjust their water use in two ways: along the "extensive" margin by shifting their cropping patterns, and along the "intensive" margin by adjusting groundwater extraction. The full effect (the "total marginal effect") is a combination of the two.

Results

In our empirical models of irrigators' crop choice and water pumping decisions, we include indicators of the type of irrigation system that is installed in the field. Efficient irrigation systems have the desired negative impact on water extraction along the intensive margin in the pumping model, as indicated in table 2. For example, given crop and acreage choice, users with center pivot systems use 15.2 fewer acre-feet of water than those with flood irrigation systems, and those with dropped nozzles extract 14.4 fewer acre-feet of water than those with flood irrigation (see table 2). However, center pivot systems allow the production of water-intensive crops and are installed where those crops can be produced. Thus, the impact of efficient irrigation technology on crop

Center pivots with dropped nozzle packages (low-pressure nozzles) suspend the sprinkler heads just above the canopy of the crop. They increase the efficiency of water applied to the field by decreasing the amount lost to evaporation and drift, especially in hot and windy climates.

Photo courtesy of Gene Alexander, USDA Natural Resources Conservation Service

choice must be considered. As reported in table 1, center pivot and dropped-nozzle center pivots increase the number of acres planted to all the irrigated crops as compared to flood irrigation. For example, an irrigator with a center pivot system will plant 26.2 more acres of corn, at the margin, than if he had a flood irrigation system, and 27 more acres of corn if he had a dropped nozzle system. Additionally, the effects are the largest effect on corn, alfalfa, and soybeans, the most water-intensive crops.

The total marginal effects (a combination of the effects on crop choice and water pumping) reported in table 2 are also positive, indicating that when crop choices are considered, efficient irrigation technology does not reduce overall water use. It is unlikely that the shift in irrigation technology has resulted in real water savings. In fact, it has significantly increased water use relative to flood irrigation systems.

From table 1, conservation programs have a small negative effect on the number of acres in thousands planted to corn in a county (-0.01), and a positive effect on the amount of acres not irrigated (0.24). Program acres have a small positive effect, however, on the planting of alfalfa, soybeans, wheat, and sorghum. While sorghum and wheat are relatively low water-use crops, alfalfa and soybeans are not. The total marginal effect is also very small, but positive (0.15). This may indicate a substitution *toward* irrigated cropland; if a user retires a low opportunity cost plot elsewhere on his land, he may be more likely to plant a higher profit (and possibly more water intensive) crop on his irrigated land.

Conclusion

The depletion of the High Plains Aquifer has become an important topic of policy in western Kansas, as it has in agricultural basins all over the world. Crop and livestock systems form the base of the economy and depend almost exclusively on water extracted from the High Plains Aquifer. As high volumes of water are extracted, the water table drops and extraction becomes more expensive. In some areas, the economic systems that depend on the water are not sustainable because recharge to the aquifer is very small. In order to make the water last longer, policy has focused on reducing rates of extraction.

Policy makers must consider the legal ramifications of policies designed to reduce groundwater extraction; reductions in allowed extractions can amount to a taking of property, depending on the state's groundwater laws. Third party effects are also a concern; seed and farm implement dealers, restaurants and other services, and even schools may be adversely affected by policies that reduce groundwater extraction. Therefore, voluntary, incentive-based measures are generally the most politically feasible types of policies to enact. An additional incentive is that the full costs of such programs are rarely borne by the beneficiaries. Two such policies, the subsidization of efficiency-enhancing irrigation technologies and conservation land retirement programs, are analyzed here for their effect on groundwater extraction. A myriad of other states, regions, and countries have experimented with similar measures, often funded by state and national governments, and often with the help of international organizations in the case of developing countries.

The measures taken by the state of Kansas to reduce groundwater extraction have not been effective in reducing groundwater extraction. The subsidized shift toward more efficient irrigation systems has in fact increased extraction through a shift in cropping patterns. Better irrigation systems allow more water-intensive crops to be produced at a higher marginal profit. The farmer has an incentive to both increase irrigated acreage and produce more water-intensive crops. Similarly, land and water conservation and retirement programs have done little to reduce groundwater extraction, although billed as such. Theoretically, we know that because the programs are offer-based, farmers will enroll their least productive land. Our empirical results support this conclusion; we find essentially no effect of land conservation programs on groundwater pumping, which occurs, by definition, on irrigated, and thus, very productive land.

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The Impact of Delta Export Restrictions on Urban Water Consumption in Southern California

David Sunding and Newsha Ajami

Environmental restrictions have reduced Delta water supplies available to Southern California. In the short-run, the cost of these restrictions could exceed $3 billion annually and will average nearly $470 million. With aggressive investments in conservation and other supplies, costs can be reduced to just over $150 million annually, but may still exceed $1 billion in dry years. Research is underway at UC Berkeley to improve the economic models used to calculate shortage losses to urban and agricultural consumers.

On December 14, 2007, Judge Oliver Wanger of the United States District Court for the Eastern District of California issued an Interim Remedial Order Following Summary Judgment and Evidentiary Hearing (the "Interim Order" or the "Wanger Decision"). To protect the threatened Delta smelt, the Interim Order remanded the U.S. Fish and Wildlife Service's (FWS) 2005 Biological Opinion on the effects of the Central Valley Project (CVP) and State Water Project (SWP) on the Delta smelt.

The Court Findings of Fact stated that the strong negative flows in the Old and Middle Rivers (OMR) and corresponding entrainment of smelt can be mitigated by reducing diversions at the CVP and SWP export facilities. The Court Findings of Fact focused on the benefits to the pre-spawning adult smelt of reducing the winter pulse flows from the facilities and the benefits to larval and juvenile smelt of curtailing water exports from the CVP and SWP from mid-April to mid-May.

The OMR flow targets in the Interim Order will reduce the reliability of SWP and CVP water supplies. This section of the report describes the water supply changes resulting from the court-imposed restrictions on federal and state pumping from the Delta. In this article, we focus on SWP impacts since that project is of vital importance to urban water providers in the South Coast region. Urban Southern California is also the region most likely to benefit from improvements in Delta conveyance such as a Peripheral Canal.

Impacts to SWP Water Supplies

State Water Project base and surplus supplies were modeled by the Metropolitan Water District (MWD) of Southern California under two scenarios: 1) baseline conditions, and 2) the midpoint of the high- and low-OMR flow targets in the Interim Order. The mean annual reduction in deliveries across all simulated years is 318 thousand acre-feet (TAF). Annual deliveries are reduced in nearly all years, with an average reduction of 11%.

Importantly, the Interim Order has the largest proportional impact on SWP water deliveries in near-average years. The absolute supply loss is greatest in wet years.

Impact Model

Impacts to urban water users in Southern California are modeled using the Least-Cost Planning Simulation Model (LCPSIM), developed and maintained by the California Department of Water Resources. LCPSIM is a yearly time-step simulation model that was developed to measure the economic benefits and costs of improving urban water service reliability at the regional level. The primary objective of the model is to develop an economically efficient regional water management plan by minimizing the total cost of reliability management.

Total cost measured by LCPSIM is the cost of reliability enhancement plus shortage losses incurred when available supplies are insufficient to meet baseline demands. Water supply reliability can be achieved through demand reduction and through supply augmentation, including recycling, groundwater storage and recovery, and water transfers. The cost of reliability enhancement is comprised of three elements: the cost of reliability enhancements such as conservation and recycling, the cost of system operations, and the cost of buying and transferring water. The cost of unreliability is the

Table 1: Change in SWP Deliveries for Different Water-Year Types

	Water-year	Total change in deliveries (TAF/yr)	Percent change in deliveries
SWP Table A	Wet	-319	-10%
	Above average	-414	-14%
	Below average	-399	-14%
	Dry	-277	-11%
	Critical	-183	-11%
	Avg. across all year types	-318	-11%

Table 2: Direct Economic Impacts from Reduced SWP Water Flow to the South Coast Region

Impact	Economic impact short-run (million $)	Economic impact long-run (million $)
Average direct impacts	$467.3	$90.3
Average increase in water market cost	$7.2	$2.7
Average shortage losses	$508.6	$46.6
Average increase in system operational cost	-$48.5*	-$24.7
Average increase in cost of alternative supplies	$0**	$65.7

**The system operational cost decreases due to reduced delivery volumes.*

*** No alternative supplies are available in the short-run scenario.*

Figure 1: Annual Short-Run Percent Shortage in the South Coast Region

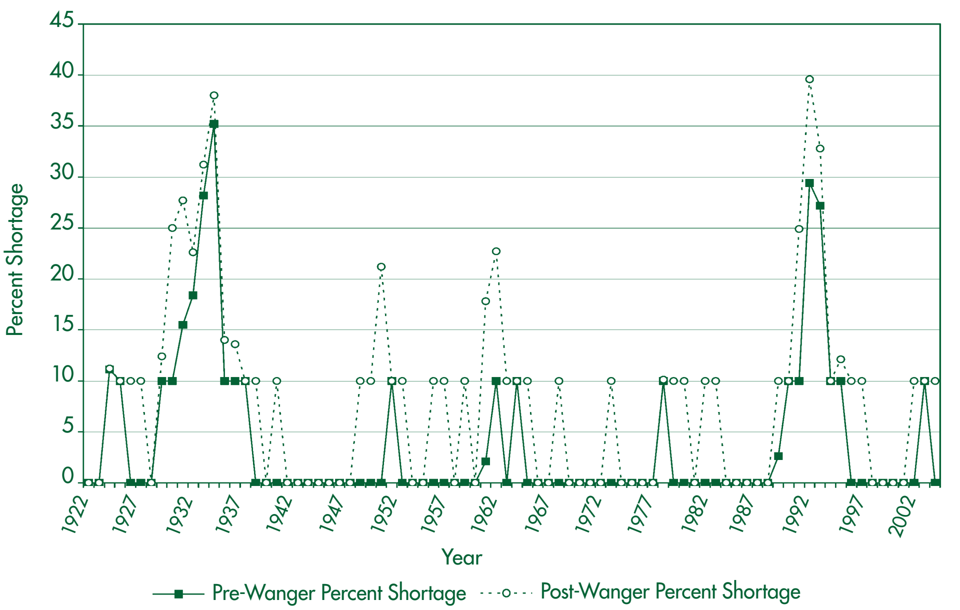


Figure 2: Annual Long-Run Percent Shortage in the South Coast Region

welfare cost to consumers of a water shortage. LCPSIM optimizes the degree of reliability over the entire simulation period by determining the portfolio of reliability-enhancing investments that minimizes the cost of these investments plus the cost of shortage in the event that demand cannot be satisfied.

LCPSIM allows for a number of conservation and recycling investments to be made to cope with water scarcity. These investments all require capital expenditures to complete, and will take a number of years to implement. The unit costs of these investments vary considerably, and are described in detail in the LCPSIM manual.

Spot water transfers from the Central Valley are also available to address potential water shortages. For the South Coast region, we set these transfers at a maximum of 600 TAF per year in the baseline. The Interim Order impacts the potential size of the spot water market because of restrictions on through-Delta conveyance. Hence, we decreased the maximum water transfers to 300 TAF for the post-Interim Order scenario. While these transfer volumes are considerably higher than direct transfers to MWD and Bay Area water agencies in recent years, note that they are theoretical limits and LCPSIM endogenously determines how much water to transfer to minimize costs.

Direct impacts on urban users are calculated under two scenarios which we term short-run and long-run. In the short-run scenario, it is assumed that water transfers and currently existing storage, conservation, and recycling programs are available to deal with periodic shortage. In the long-run scenario, we allow for investment in the full range of conservation, recycling, and groundwater storage options specified in the South Coast and Bay Area versions of LCPSIM.

Our rationale for distinguishing between short- and long-run impacts is to highlight the central role of investments in conservation, recycling, and transfer/storage opportunities. While such options may be technically feasible, they take time to implement. In the case of certain recycling facilities or groundwater storage programs, for instance, the time required to obtain permits and build these options may be a decade or more. The Interim Order may have significantly larger costs should a drought occur before these options are constructed.

Moreover, the current legal climate with respect to water supplies in California is not ideal for making billions of dollars in capital investments. The Interim Order is relatively recent, and it is unclear how the Department of Water Resources and the U.S. Bureau of Reclamation intend to deal with the associated pumping restrictions. A state program of investment in alternative conveyance in the Delta, for example, would leave many such investments "stranded" in the sense that they would not be ex post optimal. Water agencies may wait to see how events in the Delta play out before committing their ratepayers to significant investments in new recycling, conservation, and storage projects.

In this article, we focus on State Water Project impacts since the project is of vital importance to urban water providers in the South Coast region.

Results for the South Coast Region

Table 2 presents a summary of the direct economic impacts to the South Coast region of the Delta export restrictions specified in the Interim Order. Recall that direct impacts are defined as the sum of increases in supply cost and shortage losses borne by customers.

Short-run losses from the Delta pumping restrictions in the South Coast area average $467 million per year. The majority of this cost is in shortage losses experienced by consumers. This result is illustrated by figure 1, which shows South Coast water shortages over the simulation period under the assumption that capital investments are not available to deal with shortages and water transfers are limited to historic quantities. The Interim Order significantly increases the magnitude and frequency of water shortages, implying that Delta pumping restrictions destabilize water supplies available to customers in the South Coast region.

The long-run analysis of the LCPSIM indicates that recycling and conservation options can reduce the cost of the Interim Order to around $90 million annually, on average. Most of the cost under this scenario is accounted for by the investments in conservation and alternative supplies, amounting to $66 million per year. Relative to the short-run scenario, slightly less water is purchased on the transfer market. Average shortage losses are reduced from $509 million to $47 million annually.

Figures 1 and 2 compare shortages in the South Coast region before and after the Delta pumping restrictions for the smelt. Without significant investment in alternative supplies, shortages can reach nearly 40% in severely dry periods like the 1978–1992 drought.

The average annual impacts shown in table 2 are informative. However, the average impacts mask the significant variation in losses experienced over the simulation period. While the average annual cost to the South Coast region is $467 million in the short-run scenario, the annual impacts in the same scenario range from -$141 million to over $3 billion, as shown in figure 3. Under the

Figure 3: Annual Short-Run Economic Impacts in the South Coast Region

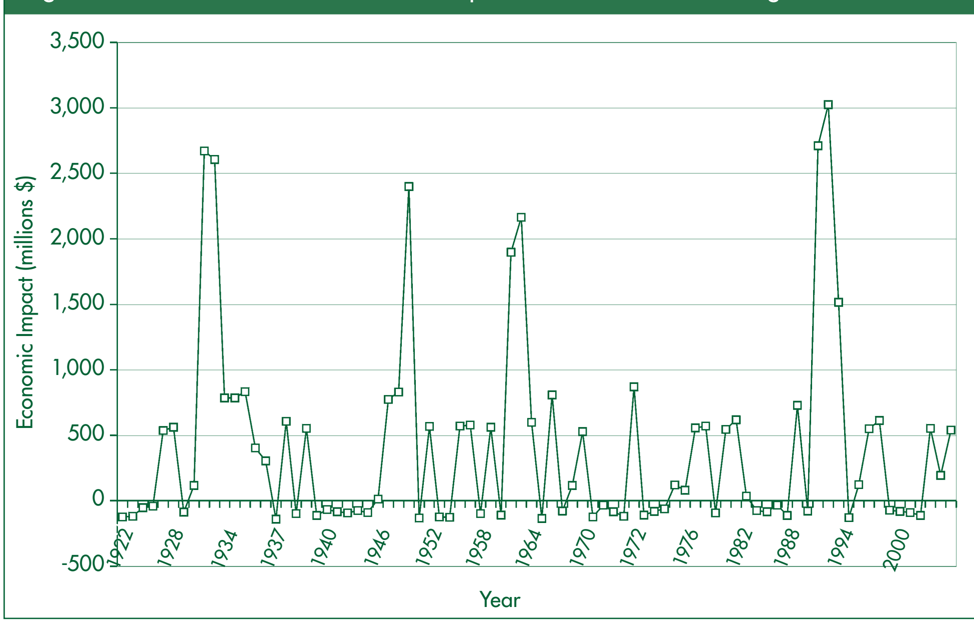
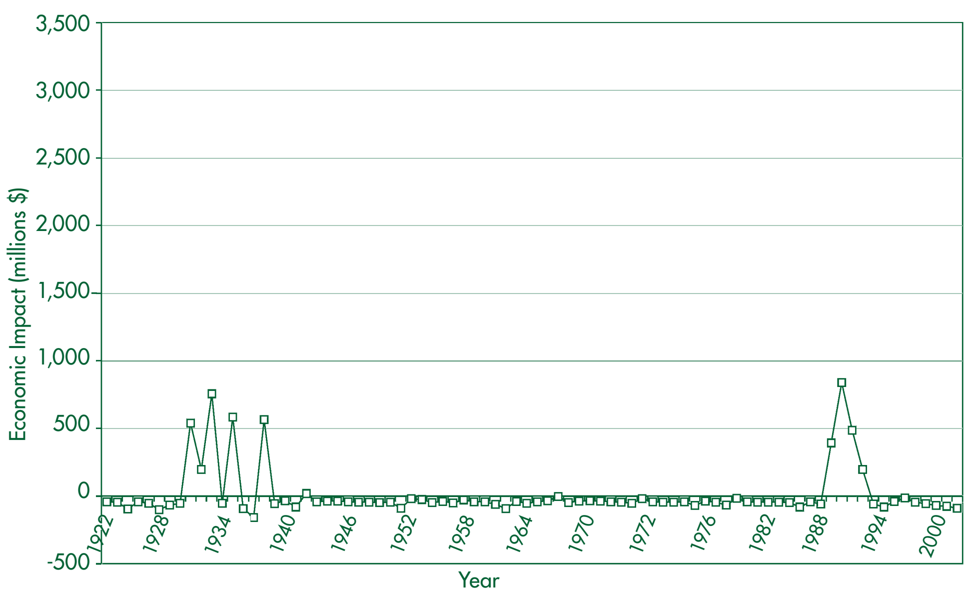


Figure 4: Annual Long-Run Economic Impacts in the South Coast Region



long-run scenario the annual impacts ranges from -$160 million to $839 million, while the average annual cost to the South Coast region is $90 million (figure 4).

It is important to note that the timing of economic losses resulting from pumping restrictions do not match the timing of the associated water supply losses. That is, proportional and absolute supply losses are largest in above-average water years. Yet, economic losses

Delta pumping restrictions will destabilize urban water supplies in Southern California, and have the potential to cause billions of dollars in annual losses.

from the Wanger Decision are largest in dry years. What explains the difference? Recall that LCPSIM is a dynamic simulation model that captures the sequence of additions to and subtractions from storage (both reservoir and groundwater storage). Environmental restrictions that reduce wet-year water supplies have the effect of reducing additions to storage, the consequences of which are felt in dry years when agencies make withdrawals from storage. This observation highlights the importance of using a dynamic model to measure the impacts of Delta export restrictions.

It is likely that the economic impacts calculated by LCPSIM understate the true economic costs of Delta pumping restrictions. As discussed earlier, a main feature of LCPSIM is that it is highly aggregated, meaning that nearly all of Southern California is treated as a single region. Within the region, LCPSIM essentially assumes that water is allocated efficiently, for example by a frictionless water market. This assumption is not very realistic, and future research will disaggregate the Southern California region into actual water utilities.

Conclusions

This analysis highlights the additional risk on California's water system that results from pumping constraints designed to protect the Delta smelt. If hydrologic conditions are unfavorable, the resulting Delta export reductions would impose large costs on the South Coast region. With current levels of conservation, recycling, and storage, the estimated annual impacts of Judge Wanger's Interim Order exceed $3 billion during a prolonged drought. Even with significant new investments in alternative supplies and additional conservation, annual losses can exceed $800 million during a very dry period.

Researchers at UC Berkeley are continuing to work with the state and federal water users receiving Delta exports to refine estimates of the economic impacts resulting from protection of the Delta smelt. In particular, we are working to improve our understanding of urban water impacts by developing an alternative to the state's LCPSIM model. Based on MWD's integrated resource planning platform, the model will be more disaggregated than LCPSIM, which assumes frictionless water allocation among agencies in the South Coast—an obviously unrealistic assumption. While not discussed in this article, we are also working to improve our understanding of agricultural water use and are working with Delta exporters to develop a new generation of agricultural impact models that can more accurately capture the value of water supply reliability in agriculture.

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California Corporate Farms: Myth and Reality

Hoy Carman

California corporate farms have grown in terms of numbers, share of all farms, size, asset values and product sales. The average California corporate farm continues to be larger than the average single proprietor and partnership farm but corporate farms are represented in all of the size, asset and product sales categories, from smallest to largest. Corporate advantages available to large family farms continue to encourage incorporation.

Many agricultural observers view corporate farms as a serious threat to the survival of family farms and the communities that support them, encouraging legislators in nine mid-western states, including Oklahoma, Nebraska, North Dakota, South Dakota, Wisconsin, Minnesota, Kansas, Missouri, and Iowa, to enact anti-corporate farming laws. California agriculture has not shared this view and the proportion of California farms that have incorporated has increased over time with 5,750 corporate farms (7.1%) out of the total of 81,033 farms in 2007. Just over 80% of California corporate farms are classified as family held corporations and 93.7% of all California farm corporations have fewer than 10 shareholders. This article uses data from the U.S. Department of Agriculture's 2007 Agricultural Census to describe the changing organizational structure of California farms over time, together with comparisons of characteristics of corporate and non-corporate farms. As is often the case with generalities, some perceptions of corporate farming are not supported by the data.

Choice of Legal Organization

A farmer's choice between organizational alternatives (single proprietorship, partnership or corporation) has operational, legal, and financial considerations and implications. Without going into detail, the corporate form of organization may offer advantages for inter-generational transfer of farm assets, income tax planning, employee benefit programs, and risk management. At the same time, corporate organizational, operational, and reporting requirements require time, legal and accounting assistance, and other costs not incurred by the sole proprietor or partnership. Detailed discussion of the pros and cons of the alternatives are beyond the scope of this article.

The number of corporate farms in California has been increasing over time. There were 2,601 corporate farms in California in 1974, more than double the 1,212 reported in 1969. Note in table 1 that corporate farm numbers grew to 5,750 out of a total of 81,033 California farms in 2007. The increase in corporate numbers during the most recent two decades was much slower than occurred from 1969 through 1987.

A Comparison of Family and Corporate Farms

A comparison of California corporate farms with individual proprietor family farms shows that, on average, corporate farms are substantially larger, have more assets, and higher product sales. For example, individual proprietor family farms had average sales of $162,179 in 2007, they had an average of 200 acres of land, the estimated market value of land and buildings averaged $1,292,699, and the estimated market value of all machinery and equipment averaged $63,809. In contrast, California corporate farms had average sales of $2,187,321; their average size was 784 acres; the estimated market value of land and buildings averaged $6,315,180; and the estimated market value of all machinery and equipment was $396,451. Net cash farm income tells a similar story. Of the 64,001 individual proprietor family farms, 24,963 (39%) reported net income averaging $127,443 per farm while 39,038 reported net losses averaging $27,785 per farm. For the 5,750 corporate farms, 3,399 (59%) reported net income averaging $967,108 while 2,351 reported net losses averaging $172,014 per farm.

All individual proprietor family farms are not small and not all

Table 1. Number of California Farms, Number of Corporate Farms, and Corporate Farms Proportion of Total Farms, Census Years 1978 through 2007

	Census Year						
	1978	1982	1987	1992	1997	2002	2007
Total farms	73,194	82,463	83,217	77,669	87,991	79,631	81,033
Corporate farms	3,871	4,849	5,367	5,067	5,504	5,070	5,750
Corporate farm %	5.29%	5.88%	6.45%	6.52%	6.26%	6.37%	7.10%

Source: USDA, Census of Agriculture for each year noted.

Figure 1. Acreage Distribution of Single Proprietor and Corporate Farms, California 2007

corporate farms are large. For example, there were 2,954 California farms with an estimated market value for land and buildings of over $10 million each. Of these, 1,163 were individual proprietor family farms, 895 were partnerships, and 805 were corporations. In terms of income, there were 5,693 California farms with 2007 sales and government payments over $1 million. Of these, 34.2% were single proprietor farms, 33.2% were partnerships, and 30.3% were corporations. There were 1,365 California farms with sales and government payments over $5 million. Of this highest sales category, 25.5% were single proprietor farms, 34.4% were partnerships, and 37.9% were corporations.

At the other end of the distribution, 148 corporate farms had a total value of land and buildings of less than $50,000, and another 133 fell in the range of $50,000 to $100,000. Looking at products sold and government payments, 42,956 (67%) individual-proprietor family farms had total product sales and government payments of less than $25,000 while 1,318 (23%) corporations also had total product sales and government payments of less than $25,000. In fact, 595 corporations (10.3%) had total product sales and government payments of less than $1,000.

Each type of legal organization has farms in both the smallest and the largest size, income, and value categories. While the statistical distribution of measured characteristics for each legal type of farm covers the full range of measured sizes, incomes and values, the shape of each distribution differs significantly from a normal distribution. The percentage distribution of single proprietor and corporate farms by acreage category, shown in figure 1, is typical.

Farm Typology

The Economic Research Service, USDA, has developed eight farm typology categories. There are two major groupings of farms: five subcategories of small family farms with sales of less than $250,000, and three subcategories of other farms. The subcategories are shown in table 2 with the number of single proprietor, partnership, and corporate farms in each subcategory. The market value of agricultural product sales varies by farm type. Limited-resource and farming occupation/lower sales farms have total sales less than $100,000; farming occupation/higher sales farms have sales between $100,000 and $249,999; retirement and residential/lifestyle farms have sales of less than $250,000; large family farms have sales between $250,000 and $499,999; and very large family farms have agricultural product sales of $500,000 or more. Nonfamily farms include nonfamily corporations and farms operated by hired managers.

The numbers and proportion of farms by type for each structural category make interesting comparisons. For example, limited resource, retirement, and residential/lifestyle farms made up 1,166 out of 5,750 (20.3%) corporate farms; 3,804 out of 9,552 (39.8%) partnerships; and 45,557 out of 64,001 (71.2%) single proprietor farms in California. While 2,386 corporations (41.5%) are classified as nonfamily farms, single proprietors and partnerships together (with 3,822 farms) have more farms in the category. Single proprietors and partnerships each have more farms in the large and very large family farm categories than do corporations (table 2).

Corporate Farm Activities

Corporations are more prevalent in some production sectors than in others. Overall, corporations account for 7.1% of all California farms, but they make up 22.0% of all greenhouse, nursery, and floricultural operations, 16.1% of vegetable and melon farms, 9.5% of oilseed and grain farms, and 9.1% of cotton farms. Corporate fruit and tree nut farms are at the average of 7.1%, as are poultry and egg farms, while all other sectors are below the average. The largest numbers of corporate farms, 2,674 out of the total 5,750, are fruit and tree nut farms.

Corporate farms accounted for $12.58 billion (36.9%) of California's $34.125 billion of 2007 product sales and farm payments. Corporate sales shares were 72.6% of total greenhouse, nursery, and floricultural sales, 69.9% of poultry and egg sales, 49.5% of vegetable and melon sales, 37.0% of cattle and calves sales, 35.5% of cotton and cottonseed sales, 34.6% of fruits and tree nuts sales, and only 8.8% of milk and other dairy product sales.

California corporate farms employ more farm labor than do individual and family farms, partnerships, or other (cooperative, estate, trust, institutional, etc.) farms. During 2007, 4,137 corporate farms employed 175,836 workers and paid over $3.26 billion in payroll and contract labor expenses. This was 39% of total farm workers and almost 45% of total payroll and contract labor expenses. Not surprising was that 1,628 (28%) of California's 5,750 farm corporations were operated by hired managers. Hired managers operated only 2.8% of individual and family farms and 14.6% of partnerships.

Corporate farms are involved in the same activities as other California farms, including organic crop production and sales. Organic farmers are often characterized as small-scale individuals with a passion for protecting the environment, a description that is not typical for corporate farmers. While individual and family farms substantially outnumber corporate farms and have more acreage in organic production, corporate farms dominate organic sales. There were 3,515 California farms producing organic crops in 2007. Of these 2,596 were individual and family operations, 456 were partnerships and 367 were corporations. In terms of organic crop acres per farm, individual and family operations averaged 57.87 acres per farm, partnerships averaged 156.78 acres per farm, and corporations averaged 374.19 acres per farm. Overall, corporate farms had total organic sales exceeding $272 million in 2007, accounting for over 41% of California's organic sales of $656.8 million.

Table 2. California Single Proprietor and Corporate Farms by ERS Farm Typology, 2007.

Farm Typology	Single proprietor	Partnership	Corporate	Total
	------------ number of farms --------------------			
Limited-resource farms	7,897	654	201	8,752
Retirement farms	15,532	1,349	328	17,209
Residential/lifestyle farms	22,128	1,801	637	24,566
Farming occupation/lower sales	8,791	975	363	10,129
Farming occupation/higher sales	2,245	500	204	2,949
Large family farms	2,017	775	405	3,197
Very large family farms	2,959	2,108	1,226	6,293
Nonfamily farms	2,432	1,390	2,386	7,938*
Total	64,001	9,552	5,750	81,033*

** Includes 1,730 other farms (cooperative, estate or trust, institutional, etc.)*

Concluding Comments

California's average corporate farm has more acreage and higher sales than the average partnership or the average individual proprietor farm. One must be careful, however, about generalizing from these averages. While the majority of California's farms with the smallest land holdings and product sales are individual proprietor farms, some are also partnerships and corporations. Just over 20% of California's farm corporations are limited resource, retirement, and residential/lifestyle farms, but these same three farm types account for 71.2% of all single proprietor farms. At the same time, 23% of farm corporations and 67% of individual proprietor family farms had total product sales and government payments of less than $25,000. The distributions of acreage, product sales, value of land, buildings and equipment, and farm types span a similar range of values for single proprietors, partnerships, and corporations. If one were to randomly choose a farm from among all California farms with a total value of land and buildings of over $10 million, the probability that it will be a corporation is 27.3%; the probability that it is an individual proprietor family farm is much higher at 39.4%; and the probability that it is a partnership is 30.3%.

Most of California's farm corporations are owned and operated by farm families. These corporate family farms range in size and product sales from very small to very large; they grow the same crops as do single proprietor family farms; and as subchapter S corporations, they pay income taxes at the individual rather than the corporate rate. Incorporation continues to provide a framework for resource ownership as well as the allocation of income, control and risk, and it can be an important tool for estate planning and the intergeneration transfer of the farm business. For these reasons, one can expect further increases in the number of California farm corporations with the prime candidates being larger family farms interested in growth and the extended business life of the family farm firm.

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