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Economic Impacts of Reductions in Delta Exports on Central Valley Agriculture

Richard E. Howitt, Duncan MacEwan, and Josué Medellín-Azuara

We estimate the short run effects of environmental and drought induced reductions in Delta exports using a regional model of farmer decisions in California. Economic results are summarized in terms of losses in employment, revenues, and income. They indicate that current projections of reductions in Delta exports have significant impacts that are mostly concentrated among low-wage workers, but a South-of-Delta water market could mitigate these effects.

Also in this issue

In the next issue...

California is currently experiencing its third major drought in the last 30 years. Droughts in California are a normal occurrence but this time state agriculture is facing an unprecedented crisis. Californians, acutely aware that water is the driving force and limiting variable for urban development and agriculture, have taken steps to prevent shortages. Irrigated agriculture reacted to the droughts in the mid-1970s and early 1990s with a combination of increased groundwater pumping, crop changes, better technology, and an emergency water market. When facing the drought of 2009, farmers have less of these coping mechanisms available and those that are available are not as effective as in the past.

According to the California Department of Water Resources (DWR) 70% of California's water runoff occurs north of the Bay Delta but 75% of California's agricultural and urban demands are to the south, leaving the Delta as a central hub for conveying California's water. More than simply a means of conveying water, the Delta is the largest estuary in the western United States and is home to a wide variety of unique wildlife. Unfortunately, three consecutive years of below average rainfall and an increased awareness of the effect of water exports on key native species has put significant strain on the ability to export enough Delta water to meet urban and agricultural demands. Further complicating the situation, recent legal decisions have clearly linked the well-being of Delta fish and farmers.

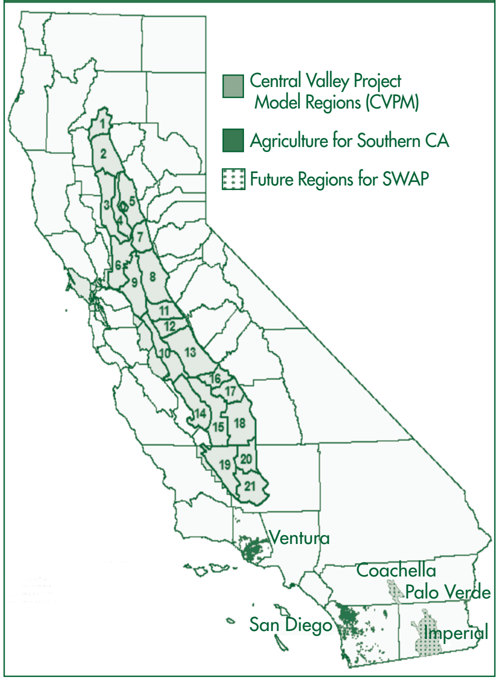
The current drought presents a situation that is unique relative to previous events for several reasons. During the drought of the early 1990s, farmers increased groundwater wells and rates of pumping. However, wells drilled in the 1990s are still operating and many aquifers have a limited capacity for even short run increases. Droughts always spur irrigation efficiency, but steady advances in technology over the past 15 years have made rapid improvements harder to achieve. Crop fallowing and changing cropping patterns were common responses in previous droughts, but this avenue of adjustment has been trimmed by increasing areas of perennial crops due to market growth. Reduced irrigation that stresses the crop is yet another short-term water management strategy, although the effectiveness is a source of contention in current literature. Stress irrigation depends on the timing of application which, in turn, depends on crop and soil specific characteristics. Additional limitations, as a result of recent legal rulings designed to protect endangered Delta fish, have further complicated matters by restricting Delta exports. The combined effect of these factors is one of "hardening" the demand for water and making it less flexible and price responsive.

The two largest water storage and conveyance projects in California are the State Water Project (SWP) and the Central Valley Project (CVP) which pump water from the south part of the Delta that flows in from the north and across the Delta. Water inflows to the Delta are essential for sustaining native fish species such as the Delta Smelt and Chinook Salmon, and Delta exports are important for Central Valley agriculture and urban demands. In addition to legal restrictions on allowable exports, three consecutive drought years have reduced the level of Delta inflows to critical levels. Based on current data, 2009 Delta exports are projected to be zero for CVP water, and 10% of normal deliveries for SWP water. Furthermore, based on data from 1992, it is likely that regions on the east side of the Central Valley will realize reduced local surface supplies to about 75% of normal allocations. Total expected reductions in Delta exports are around 3.6 million acre-feet (maf), with an additional 800 thousand acre-feet in reductions of local supplies. Combined, these represent just under 30% of average Central Valley water use.

Using an Economic Model to Predict Drought Response

A modified version of the Statewide Agricultural Production Model (SWAP) is used to estimate the impacts of reduced Delta exports and other Central Valley water supplies. SWAP is calibrated against past farmer decisions and uses this to predict reactions to changed circumstances. The model implicitly assumes that farmers optimize their cropping decisions to maximize profits. Constraints on minimum regional corn silage production and perennial crop abandonment are included to be consistent with the regional dairy herd feeding requirements and farmers' reluctance to lose all but those perennial crops close to retirement. Drought impacts are summarized in terms of valley-wide economic losses. However, results from SWAP allow for more detailed analysis of impacts both in terms of crop changes and fallowing, and also changes in the intensity of use of other inputs.

Figure 1. Map of California CVPM Regions



Agricultural regions in SWAP include 21 Central Valley Production Model (CVPM) regions as shown in Figure 1. Shaded areas indicate the 21 regions in addition to areas included in the model but outside of the valley. Central Valley regions, defined as regions 10 thru 21, represent the focus of this study. Regional irrigated crop production is classified into twenty crop groups which are defined using 2005 geo-referenced land use surveys and DWR land use data. Inputs to crop production include supplies, labor, land, and water. Water use is based on 2005 applied water data combined with 2000 regional water use proportions from DWR. The year 2000 is taken as a base because it represents the most recent normal water year data available from DWR. All input costs are in 2005 dollars to be consistent with land and input use numbers; model results are indexed to 2008 dollars.

As discussed previously, farmers are likely to respond in the short run through stress irrigation, increased groundwater pumping, and land use changes. The model allows for up to 15% stress irrigation across all crops. New groundwater wells have steadily increased over the last two drought years and are likely to continue to increase in the short run. However, the ability of farmers to pump additional groundwater depends on both its availability and the cost of pumping. Due to uncertainty in the ability of farmers to increase pumping in the short run, results are calculated for a range of groundwater pumping increases of 25, 50, 75, and 100%. All scenarios are analyzed with and without a South-of-Delta water market. Environmental regulations restrict voluntary water markets among districts and farmers south of the Delta.

Results

Results are summarized in terms of revenue loss, income loss, employment loss, and land use changes over the next year. Revenue losses for Central Valley farmers range from $1.2 to $1.6 billion for 2009, depending on farmer groundwater pumping response. Reductions in farm revenue are then combined with the results of a Central Valley regional economic model (REMI, http://remi.com/) and are used to generate estimates of the losses in income and employment. The combination of gross direct plus indirect income loss to the Central Valley is estimated to range from $1.6 billion to $2.2 billion. When converted into jobs lost in the Central Valley, model results show losses over a range of 60–80,000. In the case of a sustained drought, the increases in groundwater pumping and stress irrigation are unlikely to be sustainable and losses in revenue, employment, and income are expected to rise by 30 percent.

Total revenue losses across all regions in the Central Valley are summarized in Figure 2. Depending on the ability of farmers to increase groundwater pumping, gross revenue losses could range as high as $1.6 billion. It is important to note that the short run model does not capture the effects of reduced levels of groundwater and, more importantly, results are in terms of gross revenues. Thus, they do not reflect the increasing costs of groundwater pumping as depletion occurs. As such, results should be viewed as a lower bound on plausible losses.

Employment losses are estimated in Figure 3 for alternative assumptions regarding the increase in groundwater pumping. This represents between 20–26% of total direct and indirect Central Valley agricultural employment in a normal year. The majority of these job losses will be to farm workers and employees of packing houses and processing plants. Farm workers are typically low-wage workers with few alternatives for other work. As such, job losses as a result of reduced Delta exports will be concentrated among a group poorly equipped to absorb the effects.

Central Valley income losses are estimated to be as high as $2.2 billion and are summarized in Figure 4. Using a different set of results from the REMI model, statewide income losses are estimated to be up to $2.8 billion. Income losses represent both direct and indirect effects and a sustained drought is expected to increase losses.

An important consideration for mitigating the impacts of drought and reduced Delta exports is setting up a functional voluntary market for water. Trades between regions north of the Delta and southern regions are unlikely, as Delta pumping will be infeasible at most times. However, a South-of-Delta water market is feasible and plausible under the projected conditions. To summarize the effects of a water market, Figures 5 and 6 (page 4) show expected reductions in total irrigated acres without and with water transfers. Land fallowing is significantly reduced with water transfers and effects are spread across regions more evenly. Allowing regions to transfer water enables it to flow to highest value uses first, which significantly reduces farmer revenue losses. Additionally, with a South-of-Delta water market, income, employment, and revenue losses are significantly reduced in affected regions. It is important to note that computer generated projections do not take into account the increased reluctance to sell water in a severe drought, and overestimate the ease with which water can be transferred east-west across the Central Valley. Accordingly, these results should be viewed as upper bounds on the likely effect of markets.

Figure 2. Projected Direct Farm Revenue Loss for 2009

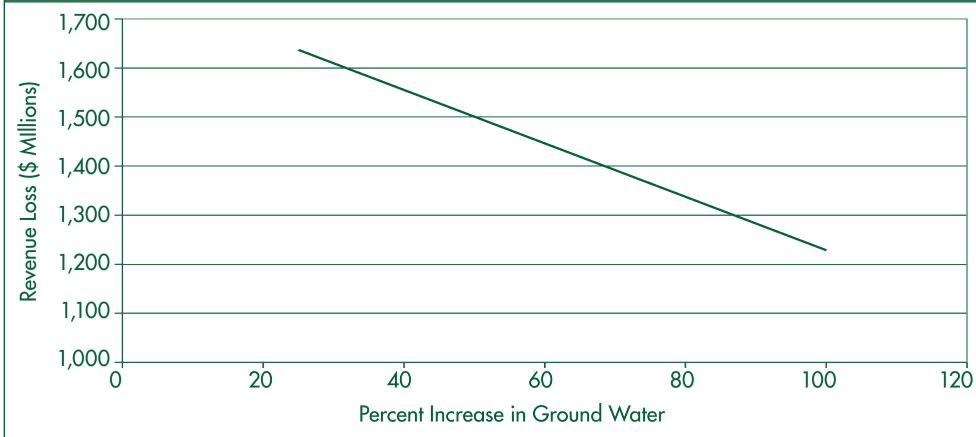


Figure 3. Projected Central Valley Employment Loss for 2009

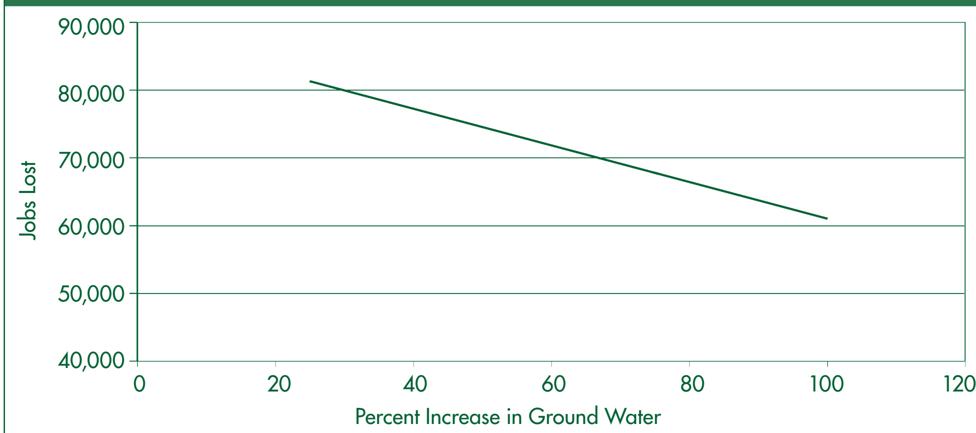
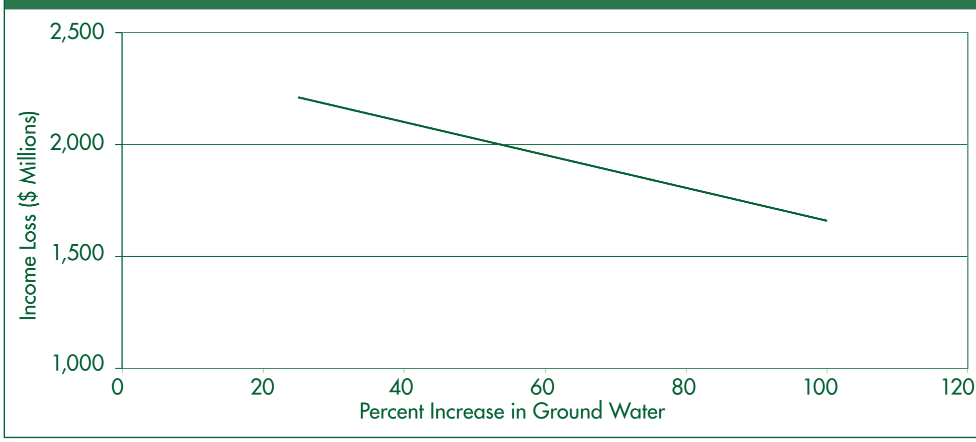


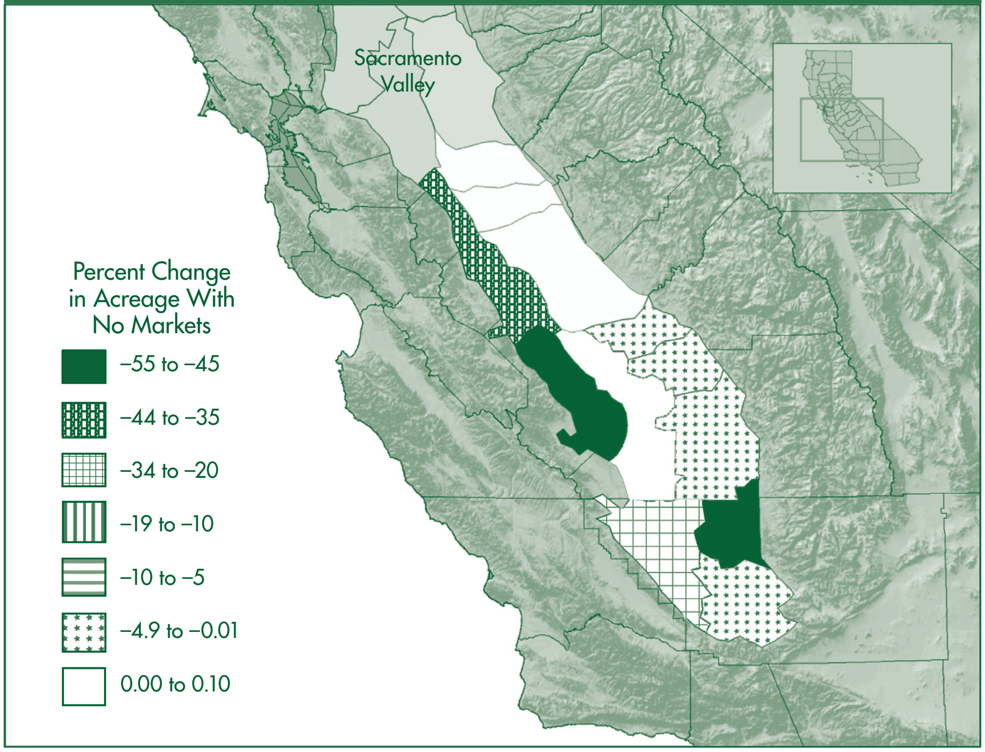
Figure 4. Projected Central Valley Income Loss for 2009



Conclusion

SWAP model results show that substantial reductions in available water from CVP and SWP deliveries, as well as reduced local supplies to the eastern regions, will severely reduce Central Valley income, employment,

Figure 5. 2009 Change in Crop Acres with No Markets



revenues, and cropped acres. Under minimal increases in groundwater pumping, income loss to the Central Valley could be as high as $2.2 billion with 80,000 jobs lost. When measured on a statewide basis, the income losses rise to $2.8 billion in 2009, and the job loss to 95,000. Most of the unemployment impacts are concentrated among low-wage workers who have the least options for enduring the effects. In the long run, farm production costs are expected to rise by 30% and introducing a South-of-Delta water market could substantially reduce effects in some regions.

The projected drought impacts in 2009 are the result of a biological and hydrological crisis in the Central Valley of California. Both farmers and native fish depend on the Delta for water, and solutions to reconcile the needs of these two parties have been the focus of much research. Recent research on the role of the Delta includes short run options of regional water markets and fish habitat enhancement, and long-term solutions such as a peripheral canal. While water deliveries are uncertain in any given year and future droughts will occur, aligning the needs of the environment, farmers, and urban users is an important step for preventing future crises.

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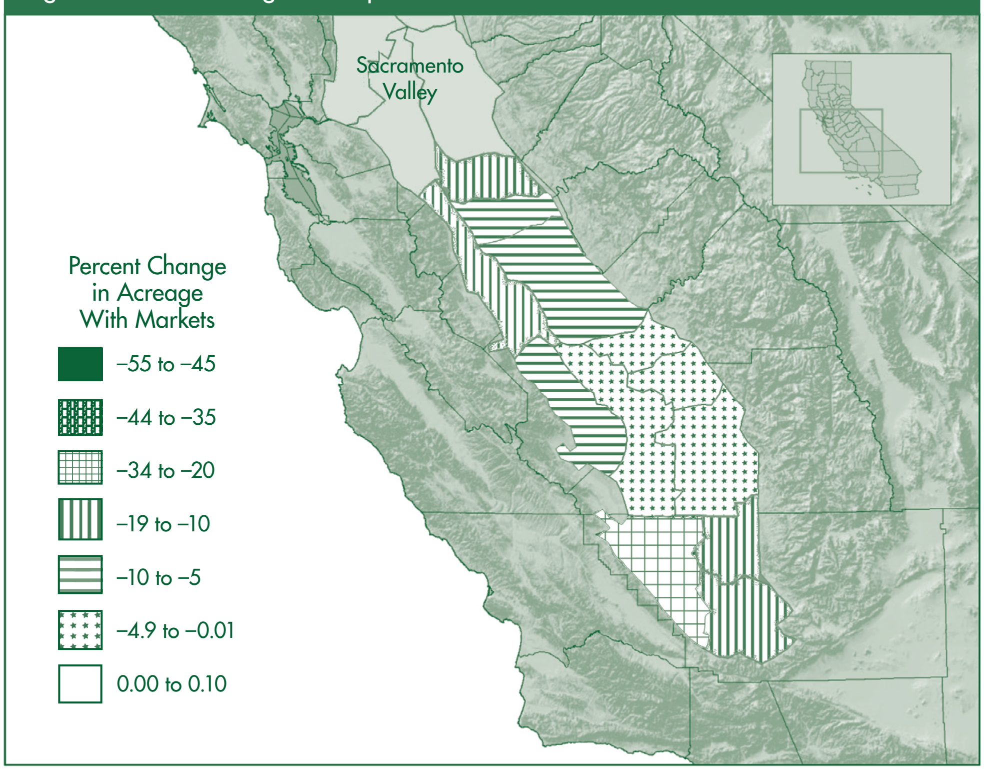
Figure 6. 2009 Change in Crop Acres with Markets



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California Water Quality: Is It Lower for Minorities and Immigrants?

Hossein Farzin and Kelly Grogan

We examine the relationship between California water quality and the population share of racial minorities and immigrants at the county level. We find that, while for most of the water quality indicators minorities are associated with *lower* water quality relative to whites, for some pollutants, some minority groups are associated with *better* water quality than that for whites.

California contains a very diverse population, and its racial composition varies by region. As a result, it provides an excellent place to examine the relationship between an area's racial composition and its environmental quality. This study focused on water quality and examined the statistical relationships between water quality indicators and the percentage of various racial groups at the county level. The question of interest was: do the counties with lower water quality have larger shares of minority populations? The study also examined the relationship between water quality and the percentage of a county's population that has immigrant status. Here the question was: Are counties with lower water quality those with higher shares of immigrants in their populations?

Studies in the field of environmental justice suggest that racial minorities face poorer environmental quality than Caucasians. There are several reasons why this may occur. First, minorities tend to have lower incomes than whites, and demand for environmental quality may increase as income increases. As a result, minorities may not demand as high a level of environmental quality than whites do due to income effects. Minorities may have more pressing needs to meet, so environmental quality gets pushed aside. Second, minorities may have less political voice, so areas with a high proportion of minority residents may not be high priority areas for government clean-up projects. Third, some economic sectors employ larger portions of minority workers, so these minorities will be subject to the pollutants associated with these sectors.

"If minority groups welcome industry into their communities in order to create employment opportunities, they could be trading lower water quality in exchange for employment and earning incomes."

For example, many agricultural workers are Hispanic, suggesting that there may be a correlation between agricultural production and an area's proportion of population that is Hispanic.

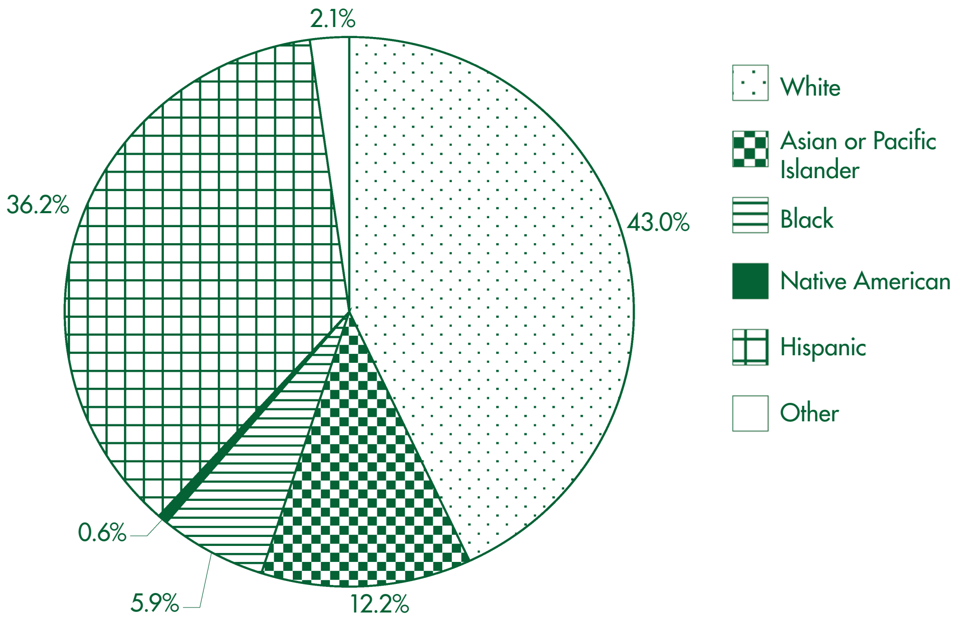
Of course, the relationship between water quality (or more generally environmental quality) and the population shares of racial minorities or immigrants could be a two-way relationship. Locations with lower water qualities may particularly attract minorities or immigrants, for example, because of greater job opportunities, lower residential rents, lower transportation costs, and lower prices in general. In this case, instead of water quality deteriorating in areas where minority populations are already established, areas with poor water quality attract minorities by providing them with opportunities and accommodating polluting industries.

By itself, this study cannot determine the "cause and effect" relationship between water quality and population share of racial minorities or immigrants. Nor can it determine which of the above-mentioned economic and political factors drives any of the relationships found. However, it can illuminate geographic areas where further work should be conducted to determine if minorities are unjustly facing higher levels of pollution due to political forces.

Data

The water quality data for the study came from the EPA's STORET (short for STOrage and RETrieval) database. This database collects water quality data from a wide variety of sources such as the California Department of Water Resources, the EPA National Aquatic Resource Survey, the California Surface Water Monitoring Program, the California State Water Resources Control Board, and the National Park Service. Each sample in the STORET database represents one water sample that was taken from a specific location. Since most of the socioeconomic data are available at the county level, all samples were aggregated up to the county level by water body type and pollutant. For example, if county x had fifteen samples of nitrate levels in rivers, the mean, median, maximum, and standard deviation of these 15 samples were calculated. Similarly, if county y had 32 samples of sulfate levels in lakes, the mean, median,

Figure 1. Racial Composition of California in 2008



maximum, and standard deviation of these 32 samples were calculated. Each observation in the analysis that is reported below captures the underlying samples in this manner. At www.agecon.ucdavis.edu/people/grad_students/info.php?id=143, a table can be found that lists all water pollutants included in the study, as well as the major sources for these pollutants.

Racial composition data came from the California Department of Finance's Demographic Research Unit. For each county, we computed the percent of the population that was African American, Asian or Pacific Islander, Native American, Hispanic, or non-white other. Additionally, we included the number of new immigrants to a county in a given year as a percent of each county's total population (Table 1).

Other socio-economic-demographic variables, such as agricultural production intensity, per capita income, educational attainment, gender composition, and age structure, may also influence water quality, so we included variables capturing these effects. The inclusion of these variables allowed us to isolate the relationship between racial composition and water quality. We included a time trend to account for statewide improvements or deterioration due, for example, to changes over time in water pollution standards, monitoring, enforcement, or related technologies. Finally, we account for the naturally occurring variation of pollutants among different types of bodies of water such as rivers, oceans, lakes, and estuaries. All data are at the county level for 1993 to 2006.

Empirical Analysis

To determine the relationships between water pollution on the one hand and racial composition and immigrant share of populations on the other, we estimated three regression models for each of the water quality indicators listed in the Table 1. These three models examined the statistical relationship between the mean, median, or maximum level of a pollutant and variables that one might expect to affect the pollution level. For example, we estimated the relationship between the mean level of ammonia and various measures of county and water body characteristics that might affect ammonia levels.

Table 2 presents the relationships between measures of racial composition and new immigrant share of populations and water quality indicators. From Table 2, we see that counties with high proportions of African American, Hispanic, or "other" populations have higher levels of several pollutants than those counties with high proportions of white populations. Every minority group, however, is associated with lower levels of some water pollutants, too.

Counties with higher percentages of African Americans, such as Alameda and Solano, tend to have higher levels

Table 1. Summary of Racial Composition Statistics

Variable	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
% New Immigrants	2446	0.45%	0.39%	0.00% Alpine, 2004	1.78% San Francisco, 1993
% White	2471	64.26%	18.14%	19.15% Imperial, 2002	93.78% Nevada, 2000
% African Americans	2471	4.12%	3.80%	0.17% Sierra, 2000	16.83% Alameda, 1993
% Asian or Pacific Islander	2471	7.35%	8.18%	0.25% Sierra, 2000	32.45% San Francisco, 1999
% Native American	2471	2.22%	3.21%	0.23% San Mateo, 2002	17.02% Alpine, 2004
% Hispanic	2471	20.22%	14.34%	2.14% Alpine, 2000	74.83% Los Angeles, 2006
% Other	2471	1.87%	0.87%	0.26% Lassen, 1993	4.38% Solano, 2004

Source: State of California, Department of Finance. 2007. Population Projections for California and Its Counties 2000-2050. Available: http://www.dof.ca.gov/html/DEMOGRAP/ReportsPapers/Projections/P1/P1.php of fecal coliform, lead, magnesium, nitrites, and alkalinity in their water. These pollutants are associated with plumbing-system corrosion, industrial runoff and dumping, septic tank leakages, and agricultural runoff. Counties with higher proportions of African Americans may allow more industrial activity in order to create jobs for communities that are poorer than predominantly white communities. They may also have inadequately maintained plumbing and septic units, leading to higher pollution levels. These poorer areas may also receive less state-level funding for clean-up projects. Interestingly, counties with higher proportions of African Americans have *lower* levels of cadmium, a pollutant associated with pipe corrosion, metal refineries, and phosphate fertilizer runoff. If fertilizer runoff is the main source of cadmium in surface water in California, then this relationship is likely due to the paucity of African Americans in the agricultural workforce. This racial group makes up only 0.3% of the agricultural workforce while it makes up 6% of the non-agricultural workforce.

Table 2. Correlation between Water Quality Indicators and Racial Composition and Immigrant Share

Water Quality Indicator	% Immigrants	% African Americans	% Asian or Pacific Islander	% Native American	% Hispanic	% Non-White or Other
Biological O2 Demand						
Cadmium			–			
Dissolved Oxygen		–		–		+
Fecal Coliform		+				
Lead		+				
Magnesium		+		+	–	–
Manganese	–		–		+	
Nickel					+	
Ammonia						
Nitrate	–				+	+
Nitrite		+			+	+
pH		+			+	
Phosphorous					+	
Total Suspended Solids						
Specific Conductivity						–
Sulfate						–
Zinc						
Iron						
Total Coliform						
Mercury						
Arsenic						
Copper		–		–		+
Chronium						
Selenium					+	+

Notes: Blanks indicate no statistically significant correlation.
(-) indicates a negative correlation between the ethnic group's share and the pollution level. This correlation is statistically significant at the 90% confidence level.
(+) indicates a positive correlation between the ethnic group's share and the pollution level. This correlation is statistically significant at the 90% confidence level.

Counties with higher percentages of Hispanics, such as Imperial and Tulare, also experience worse water quality than counties with high percentages of whites. These counties have higher levels of manganese, nickel, nitrates, nitrites, alkalinity, phosphorous, and selenium. Many of these pollutants are agricultural pollutants, and Hispanics make up 68.7% of the agricultural workforce in California (compared to 32% of the non-agricultural workforce in the state). In these instances, people experience a lower level of water quality due to the type of work chosen by or available to them. Some of the pollutants associated with Hispanic communities are commonly caused by corroding pipes, power plants, industrial emissions and dumping, and septic tank leakage. Again, Hispanic communities are generally poorer than predominantly white communities so they may be more apt to accept polluting industries to attract jobs and may be less apt to have high-functioning septic tanks. While a higher percentage of African Americans is associated with lower levels of cadmium, a higher percentage of Hispanic people is associated with lower levels of magnesium—a pollutant caused by electrical-industry emissions, construction, and fertilizer runoff. Hispanic workers make up a significant portion of both the agricultural and the construction industry work forces. Since they most likely make up a very low portion of the electrical industry workforce, and because this industry is one of the main sources of magnesium discharge in California, the Hispanic employment patterns may well explain our finding of a negative correlation.

Native Americans, a group of people historically allocated marginal lands, are associated with higher levels of magnesium and lower levels of dissolved oxygen. Lower levels of dissolved oxygen can be caused by runoff from forests, pastures, and cropland, thermal pollution, and wastewater treatment plant effluent, while elevated magnesium can be

It appears that much of the worsened water quality is due to pollution from various industries.
iStockphoto

caused by construction, the electrical industry, and fertilizer runoff. Most likely the association between this ethnic group, which is higher in population share in counties such as Alpine and Inyo, and these two pollutants are due to allowing industry to enter their communities to create jobs.

The conglomeration of "other" racial groups, found in higher amounts in counties such as Solano and Sacramento, is associated with both higher and lower levels of water quality than whites. This group is associated with higher levels of dissolved oxygen and lower levels of magnesium, specific conductivity, and sulfates—pollutants generally caused by industry, mining, agriculture, and fossil fuel combustion. The group is also associated with higher levels of nitrites, pH, copper, and selenium—pollutants also caused by industry, mining, and agriculture, as well as septic tanks and wastewater treatment plants.

Interestingly, while most minority groups are associated with poorer water quality, Asian and Pacific Islanders are not associated with higher levels of any pollutants, relative to white populations. However, the Asian and Pacific Islanders are associated with lower levels of cadmium and magnesium—pollutants associated with metal refineries, pipe corrosion, construction, the electrical industry, and fertilizer runoff. There are two similar explanations for why we observe this pattern. First, counties with higher levels of Asian and Pacific Islanders, such as Santa Clara and San Francisco, tend to have higher per capita income levels. So, demanding higher water quality, these communities may not allow polluting industries since they are not in urgent or acute need of low-paying and highly polluting employment opportunities. Second, and also related, this group may tend to work mostly in less polluting industries and/or service activities.

In regard to the relationship between water quality and the new immigrant population, we find, somewhat surprisingly, that counties with high percentages of new documented immigrants are associated with lower levels of manganese and nitrates than counties with low levels of immigrants. These pollutants are associated with corroding pipes, septic tank leakages, sewage, and fertilizer runoff. The breakdown of immigrants by racial category is not available, but a high percentage may be Asian and Pacific Islanders, a group associated with higher water quality. Additionally, San Francisco contains the highest concentration of new immigrants in the country, and this area tends to attract those who are highly skilled. The skill level of new California immigrants may be one factor leading to the correlation between immigrant concentration and improved water quality. One should, however, keep in mind that California has a sizeable undocumented immigrant population, which is not included in our data.

Conclusions

We found that minority populations are, indeed, associated with worsened water quality relative to white populations for most of the water quality indicators. But with respect to some pollutants, some minority populations are associated with better water quality than white populations. Thus, the environmental justice picture is not as bleak as expected. It appears that much of the worsened water quality is due to pollution from various industries. If minority groups welcome industry into their communities in order to create employment opportunities, they could be trading lower water quality in exchange for employment and earning incomes. To address higher pollution levels in this case, policy should be targeted at (1) providing low-polluting employment opportunities in areas with high levels of minorities, and (2) undertaking greater pollution mitigating measures in such areas.

Future work should be conducted to determine if the same industries located in areas with different racial compositions vary in their pollution emissions. If this is the case, then it is likely that the lack of political voice by minorities can explain the poor water quality associated with minorities. If so, policy should address the political facets of the problem and re-target pollution-control funds to areas with high levels of minorities. It should also work on ways to politically empower minority groups to more effectively voice their environmental preferences.

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What's Extra Virgin? An Economic Assessment of California's Olive Oil Labeling Law

Christopher R. Gustafson and Travis J. Lybbert

Quality standards for olive oil have long lacked legal backing in the United States, exposing olive oil quality premia to mislabeling and exploitation. A new California law adopts international olive oil grades. This paper examines the likely effects of the legislation on the burgeoning Californian industry and market.

American per capita olive oil consumption has exploded since 1990, but until recently there was no legal or regulatory definition of olive oil grades and label content in the United States. With legislation effective January 2009, California broke this legal void and now requires that olive oil sold in the state must be labeled according to international standards. Several other states are on this same path, and federal regulation may not be far off. How might giving the coveted term "Extra Virgin" legal or regulatory bite affect olive oil markets?

Olive Oil in the United States and California

Annual per capita olive oil consumption in the United States increased over 650% since 1980. Imported Mediterranean olive oil filled most of the increase in demand. While California olives have historically been canned, with culled olives diverted for oil, many orchards planted in the past two decades are geared to oil production. Barrio and Carman report that the acreage planted for oil production increased threefold, to over 6000 acres, between 1998 and 2004. By the end of 2009 this is expected to expand to 25,000 acres.

California's burgeoning industry currently produces less than 1% of U.S. oil consumption, but production is expected to increase from around 500,000 gallons in 2008 to 20 million gallons by 2020—which is projected to account for up to 10% of U.S. olive oil consumption. This industry is primarily oriented toward high-value oil markets. An estimated 90% of California oil production already qualifies as extra virgin olive oil (EVOO) by international standards.

There are important marketing and cost differences between the few large firms (>100,000 gallons per year) and many smaller firms (<15,000 gallons) that make up this industry. Larger firms aim for consistent flavor from year to year, while smaller producers produce small batches and blend to create "boutique" oils. Average per-gallon production costs for EVOO are $14 for the large firms, but $33 for the small firms.

Defining Olive Oil

There are several systems used to define olive oil grades. The United States Department of Agriculture (USDA) enacted a voluntary labeling system in 1948 that graded olive oil as A, B, C, or D based on chemical and sensory standards, but the system, while still extant, is not widely used. In recent years, there has been a push for increased label regulation in the United States, with California and Connecticut the first to take action. New Jersey, New York, Rhode Island, Texas, and the United States Department of Agriculture (USDA) are also considering regulation.

Many of the major olive oil producing and consuming countries are party to the International Olive Council's (IOC) standards (Table 1). EVOO, the most desirable grade, is cold-processed to prevent degradation of aromatic compounds and has higher levels of healthy fats and antioxidants. Refined oil is made from processed substandard virgin oils. For olive-pomace oil, solvents are used to extract oil from pressed olive solids.

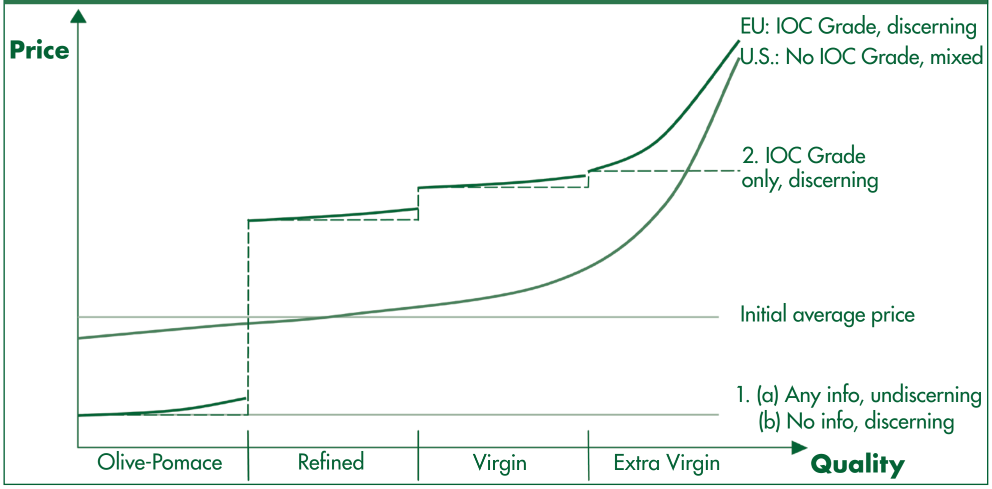
Most non-virgin oils are mixed with virgin oils to add flavor before they are sold at retail. The exact chemical and sensory standards for refined oils and olive-pomace oils change depending on the blend. Refined or olive-pomace oils intended for human consumption have stricter sensory requirements and acid limits than do those oils intended for industrial purposes. Refined oils, when blended, are labeled as light olive oil or, simply, olive oil.

Table 1. International Olive Oil Council (IOC) Grades, Standards, and Average Prices

Olive Oil Grade	Maximum Acid Content	Sensory Requirements		Production Method	Average Premium over Olive-Pomace Oil (%)*
		Positive	Negative		
Extra Virgin	0.8%	Fruity	None	Mechanical	75%
Virgin	2.0%	Fruity	Low	Mechanical	73%
Refined	0.3%	Acceptable/good		Chemical/ Physical Filters	68%
Olive-Pomace	1.0%	Acceptable/good		Solvents	0%

**Source: International Olive Council data and Poolred.com*

Figure 1. Stylized Depiction of How Label Information, IOC Grades, and Consumer Discernment Affect the Price of Quality in Olive Oil Markets



Markets for Olive Oil and "Lemons"

Consumers cannot fully evaluate olive oil prior to purchase. Producers, on the other hand, have complete information about their production techniques and the composition and quality of their oil. This informational asymmetry between consumers and producers creates wrinkles in these oil markets.

In the typical model of asymmetric information, consumers unable to discern product-level quality differences are willing to pay for the average expected quality. High-quality producers are unwilling to sell their oil for less than it is worth, which narrows the distribution of quality in the market. In some cases, high-quality products will be driven out of the market completely—leaving behind a market of "lemons" (e.g., the bad used cars that often drive good ones from the used car market).

Asymmetric information problems can be remedied by providing credible information to consumers. Label regulations are a common solution. These may be mandatory (e.g., nutritional information that firms must divulge) or optional (e.g., organic certification that firms may use if they qualify). Firms may also signal quality by making testable claims about their products' contents, by entering competitions such as the L.A. County Fair's Oils of the World, or by applying for quality certification from trade groups. With both informed and uninformed consumers, high retail prices can signal quality because higher-cost firms are harmed less by foregone sales, and low-quality firms would lose more sales from informed consumers by misrepresenting their product. A survey of retail olive oils in 2008 revealed that many labels included at least one of these devices. This has partly resolved the "lemons" problem in U.S. olive oil markets.

Consumer familiarity with and preference for quality is central to solving the "lemons" problem. Given the previous lack of regulation and the rapid growth of U.S. consumption, many U.S. consumers know too little about olive oil quality to have strong preferences for quality. While most California consumers are as yet unaware of the new labeling laws, this regulation is a pre-condition for consumer education and for the formation of oil quality preferences.

Quality Information, Consumers, and Olive Oil Pricing

To explore the impacts of this law, consider two types of consumers—discerning and non-discerning—and two types of label information—regulated grades and other information. Figure 1 depicts olive oil price as a function of quality and these consumer and information types. For simplicity, we order olive oil quality along one dimension. The price corresponding to a given level of quality is depicted on the vertical axis. Production costs increase with oil quality. Again for simplicity, we assume that olive oil markets are competitive so that these costs directly affect prices.

We consider four price profiles, each corresponding to a set of assumed consumer and information types and each implying different producer-signaling devices. The two numbered profiles represent extreme cases and serve as a benchmark to the European (EU) and U.S. profiles.

Consider first the two numbered profiles and an olive oil market with oils from across the quality spectrum. We can use initial prices in this market, assumed to equal production costs given perfect competition, to compute an average price across this quality spectrum (dotted line). Relative to this baseline, profile 1 captures two distinct cases. If the consumers in this stylized market are undiscerning about oil quality, the prevailing market price will correspond to the price of olive-pomace oil since they are unwilling to pay a quality premium with any label information (case 1(a)). The same low market price will emerge even with discerning consumers if no information is provided because of a market for "lemons" problem (case 1(b)).

Introducing IOC grades only to a market with discerning consumers creates the tiered price profile 2. If no additional producer signaling occurs (i.e., no additional label information), a sub-market for "lemons" develops: all oil within each grade is assumed to satisfy only the minimum quality standards for that grade. Hence, a flat price profile exists within each grade.

The U.S. and EU price profiles roughly represent the current relationship between price and quality in these markets. In both markets, producers find ways to signal oil quality, but only the EU has regulated grading standards. The

U.S. profile has a mix of discerning and undiscerning consumers and producer signaling exists. Some U.S. consumers are as discerning as their European counterparts and willing to pay as much for high-end olive oil. In contrast, the EU profile represents a long-established market with regulated grades that are familiar to discerning consumers.

California Label Regulation and Producer and Consumer Welfare

Given the rapid growth of olive oil consumption in the United States, the full effects of the labeling change will not be seen immediately. California consumers' knowledge of olive oil and ability to interpret product information vary much more than in established markets. Adoption of IOC labeling eliminates one source of asymmetric information between producers and consumers and allows consumers to develop more discerning quality preferences. Over time, the price profile in California (and ultimately in the United States if federal law intervenes) will mold closer to the EU profile in Figure 1. This area between the U.S. and EU price profiles helps us explore the welfare implications of this new labeling law.

With the label regulation and growing consumer awareness, some groups will gain and some will lose. Switching from no regulation to IOC standards will be most harmful to producers of olive-pomace oil. Prior to the enactment of labeling standards, olive-pomace oil could be sold as a higher grade of oil. With the standards in place, olive-pomace oil producers will have many fewer outlets to sell their product.

The greatest beneficiaries of the labeling legislation and associated consumer awareness are likely those producers who produce refined olive oil and lower quality EVOO—oils for which producers could not signal quality to consumers. The most viable producer signals likely exist at the upper end of the range of qualities; absent labeling regulation, oils in this quality range will be less susceptible to the "lemons" problem than lower quality oils.

Consumers will also benefit, particularly with respect to the health benefits of EVOO, and eliminating food-allergy concerns caused by unlabeled blending. Additionally, with label regulation consumers should expect less variability in quality, which will allow them to buy their preferred oils with greater precision.

California olive oil producers will benefit in general from the adoption of IOC labeling standards, though the benefits may be distributed unevenly amongst producers. Around 90% of the olive oil produced in California is estimated to be EVOO.

A few large California firms produce lower-cost EVOO for distribution through major retail channels. A fringe of smaller producers also exists. These firms create boutique oils, which tend to be sold directly to consumers, through specialty shops and local groceries. Smaller firms rely less on the IOC system to communicate quality, and the proportion of discerning customers is higher at the upper end of the quality spectrum. California's larger firms are competing with importers of EVOO. Large firms will likely see gains due exclusively to the change in labeling. Both large and small firms may benefit in the long run from increases in consumer sophistication.

While domestic producers will nearly all benefit to some degree from the labeling change, importers' experiences will be mixed, and will depend on the quality of oil they sell and how accurately they represented their product pre-regulation. Importers of the lowest quality oils will likely be most negatively affected, while higher grades should benefit. This is borne out by prices collected in European markets over the past few years. Producer prices for refined oils are on average only 5% below prices for EVOO, while average prices for olive-pomace oil are 57% of the average for EVOO.

These changes in Californian olive oil markets are unlikely to occur immediately for two reasons. First, standard implementation and enforcement delays may apply. Producers selling mislabeled oils may not immediately comply with the regulation. Indeed, compliance may require some further legal wrangling. Secondly, consumer awareness of these standards and their preferences will take time to adjust. The U.S. price profile may start changing soon, but will only gradually mold to the EU profile.

Our assessment of the possible impacts of California's new olive oil labeling law is stylized and exploratory. The impact on producers and consumers is an important empirical question—and one that grows in relevance as momentum builds for federal regulation of olive oil grades. The USDA has considered a voluntary system in recent years, but mandatory regulation has growing support in state-level legislation. In addition to legislation enacted by California and Connecticut, New Jersey, New York, Rhode Island, and Texas are considering this course. The spread of these grade-labeling laws across the United States will only improve market opportunities for California olive oil producers.

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