Agricultural and Resource Economics
ARE UPDATE

Giannini Foundation of Agricultural Economics, University of California Vol. 24, No. 1 Sep/Oct 2020

ALSO IN THIS ISSUE

Modifying Marketing Orders to Face New Challenges

Rachael E. Goodhue and Harry M. Kaiser

Growers' strategies to enhance the economic sustainability of their farms are constantly evolving to address changing markets and production conditions. State or federal marketing orders enable farmers, farmer-organizations, and, in some cases, handlers to act collectively to further their mutual economic interests without violating anti-trust law. In order for marketing orders to be relevant with changing agricultural conditions, they must periodically have modifications made to their rules and regulations. Changing the scope of a marketing order's regulations involves undertaking a thorough rule-making process, which generally takes significant lead time before approval and implementation of changes. In this article, we examine recent efforts by the California Walnut Board to update its order in three key dimensions.

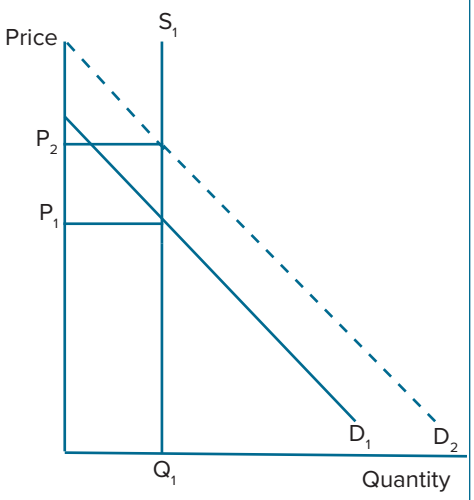
A marketing order is formed when a majority (usually two-thirds) of growers accounting for a majority of production vote in favor of it, although specific rules vary. Once formed, participation is mandatory for all producers and first handlers of the given crop in the relevant geographic area. (A first handler takes the commodity from the farmgate and introduces it into the marketing chain.) A per-unit assessment on sales funds the marketing order's activities. Federal marketing orders can engage in activities in the following categories: promotion and advertising, research and development, quality regulation, pack and container requirements, marketing information, quantity regulation, and import regulation. They cannot use funds for political lobbying.

While activities in all of these categories can be included in a marketing order, the specific activities permitted for a specific marketing order are defined in federal or state regulation when it is formed. Changing these activities requires completing a federal rule-making process. One federal marketing order, the California Walnut Board (CWB), has recently initiated processes for three changes in its activities, each within a different category. We examine these proposed changes and distill lessons for other orders that may consider updating their regulations.

The CWB is proposing to implement a "credit-back" program within the portion of its order dealing with advertising and promotion. It requires review through a formal rule-making process and a grower referendum. The other two proposed changes require review through a relatively streamlined informal rule-making process. One proposes suspending an existing volume control authority, which has not been exercised in decades (quantity regulation). The other proposes expanding the information collected from handlers (marketing information).

The proposed credit-back program is intended to incentivize handlers to engage in advertising and promotion activities by refunding them a portion of the money they spend, which effectively lowers the marginal cost of

Figure 1. Effect of Advertising on Price when Supply is Constant



these activities. If handlers perceive a marginal benefit to additional expenditures and set marginal benefit equal to the marginal cost as predicted by economic theory, then they will increase spending. The program would refund handlers up to 70% of their spending on eligible advertising and promotion expenditures, subject to a handler-specific maximum.

The maximum amount available to a handler is the same share of the credit-back program budget as its share of total walnut acquisitions in the previous year. Thus, a handler who had 10% of total acquisitions would be eligible to be reimbursed for eligible expenditures totaling up to 10% of the total funds budgeted for the credit-back program. If the program budget were $1 million, the handler would be eligible for $100,000 in reimbursement. At the proposed maximum 70% reimbursement rate, the handler would need to spend $142,857 in eligible expenditures to receive the entire reimbursement.

The proposed credit-back program would require handlers to include 'California Walnuts' on the primary face label and include the handler's name or brand on the package. This requirement could aid in differentiating California walnuts from walnuts produced elsewhere, potentially leading to higher prices for California producers. Handlers participating in the credit-back program will have a decrease in net assessment costs because a portion of their marketing expenses will be credited back. Costs will be unchanged for handlers who do not participate. Handlers can choose whether to participate, and will only do so if they perceive a positive net benefit from the program.

The credit-back program intends to expand total advertising and promotion expenditures for California walnuts, thereby enhancing demand and market price. Its effectiveness will depend on the extent to which handlers increase their expenditures beyond those they already make.

Advertising and Promotion: Credit-back Program

Advertising is predicted by economic theory to increase demand for the advertised product by "shifting" it outward, increasing the price for any quantity sold, and increasing the quantity sold at any given price. Empirical analyses of commodity advertising and promotion for specific marketing order programs, including many in California, have found these programs to be highly effective in expanding demand. If the credit-back program prompts an increase in total advertising and other demand-enhancing expenditures, including those by handlers and by the Board, economic theory predicts that gross revenues accruing jointly to growers and handlers will increase.

There are multiple ways in which additional advertising and promotion expenditures could increase demand. First, current walnut consumers could purchase more walnuts. Second, new consumers could choose to purchase walnuts. Finally, handlers could create or expand additional sales channels due to the development and sale of value-added products, potentially increasing net returns above those obtained by commodity sales.

Figure 1 illustrates the effects of an increase in demand on price when supply (S1) is fixed at quantity Q1. The fixed supply approximates the situation within a single marketing year when the crop has limited or no storability across years. Demand curve D1 represents the quantity buyers will purchase as a function of price, where Q1 is sold at the price P1. D2 represents an increase in the demand curve due to advertising, which increases the price for Q1 to P2. Thus, an increase in demand due to increased total advertising and promotion expenditures from a credit-back program would increase the observed market price when the quantity supplied is fixed.

Figure 1 holds the supply curve constant. However, the production of most crops tends to increase over time due to technological innovations, and growers may respond to changes in the relative profitability of different crops by changing their acreage allocations. All else equal, an increase in supply, regardless of its nature, will reduce price. This behavior is represented in Figure 2 by the annual quantity harvested increasing year-on-year from Q1 to Q2. As in the previous figure, the initial market price P1 is where the initial demand curve D1 intersects with the initial supply. The second demand curve D2 again represents the effect of advertising on price. The new market price P3 is at the intersection of the increased demand curve (D2) and the increased supply curve (S2). In this example, due to the increase in quantity, price declines to P3; the negative effect of the increase in supply on price outweighed the positive effect of advertising.

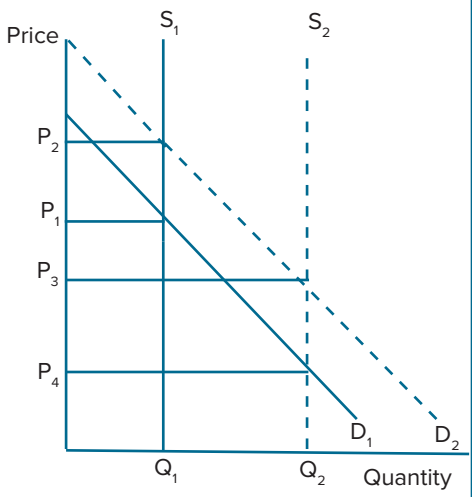
Depending on the nature of the shifts in supply and demand, the observed price may decline, increase, or stay the same. However, the observed price will always be higher than the price would have been if demand did not increase. In other words, observing a price increase is not a requirement for demonstrating that advertising is effective.

Figure 2 illustrates this point. The price determined by the interaction of the initial demand curve and the second supply curve is lower than the price when advertising shifts out demand as well. All else equal, an increase in demand due to advertising and promotion would increase the market price. However, the substantial increase in production can more than offset any such effect, so that a net price decrease is observed. In that case, while the price is lower (P3) than the initial price (P1) due to the increase in supply, it would have been even lower (P4) had there not been an advertising-induced demand increase.

Table 1 quantifies potential benefits of a credit-back program for the specific case of the California walnut industry. Earlier work by one of the authors estimated that each dollar invested in advertising and promotion of California walnuts generated $19.75 in total revenue and $15.67 in net returns on average. Assuming a $0.04 assessment rate per hundredweight and total production of 625 million cwt., the CWB's total annual budget is approximately $25 million. If the credit-back program budget is assigned 10% of assessments, then it would have $2.5 million to allocate each year.

The success of the credit-back program will depend on the extent to which it increases total expenditures on advertising, promotion, and other demand-enhancing expenditures, including those by handlers and the CWB, all else equal. If handlers do not increase their expenditures, then there will be no positive impact on price, although handlers' net returns would increase due to the partial reimbursement of their current costs.

Figure 2. Effect of Advertising on Price when Supply Increases



At the other end of the spectrum, if all handlers requested their maximum amount of credit-back and used all of the funds to match new expenditures rather than substituting for any existing ones, then they would invest an additional $3.25 million in advertising and promotion: 70% of these expenditures would be credited back, totaling the $2.5 million in the program budget. The remaining 30% would be a $1.07 million increase in total advertising and promotion expenditures, paid by handlers. Multiplying the estimated returns per dollar by the additional expenditures by handlers, the program would generate roughly $21.2 million in additional total revenues and roughly $16.8 million in additional net returns.

Volume Control: Suspending the Reserve Authority

One of the CWB's authorized activities is the annual creation of a reserve based on market conditions that assigns "free" (eligible for sale domestically), export, and reserve percentages to production volumes. It has not exercised this authority in over thirty years, due to a strategic decision in the 1980s to focus on enhancing demand rather than regulating supply.

Table 1. Calculating the Impacts on Total Revenues and Net Returns of the Credit-back Program

	Calculation	Value
Total Production (cwt.)	(A)	625,000,000
Assessment Rate ($/cwt.)	(B)	0.04
Total CWB Budget ($)	(C=A*B)	25,000,000
Share of Budget Allocated to Credit-back Program (%)	(D)	10
Credit-back Program Budget ($)	(E=C*D)	2,500,000
Credit-back Rate (%)	(F)	70
Total Advertising and Promotion Expenditures with Credit-back Program ($)	G=E/F	3,571,429
Increase in Advertising and Promotion Expenditures ($)	H=G-E	1,071,429
Increase in Total Revenues per Dollar of Advertising/Promotion ($)	(I)	19.75
Increase in Net Returns per Dollar of Advertising/Promotion ($)	(J)	15.67
Increase in Total Revenues ($)	(K=H*I)	21,160,714
Increase in Net Returns ($)	(K=H*J)	16,789,286

Sources: Authors' calculations and Kaiser, 2018

The CWB is seeking to suspend this authority through the USDA's informal rule-making process. Suspending the authority would eliminate the need for a committee to evaluate the desirability of establishing a reserve when market conditions have made the concept of a reserve effectively obsolete.

Marketing Information: Expanding the Scope of Reporting

Currently, the CWB is authorized to collect information regarding walnut shipments from handlers. While assessment income is based on shipments, shipment data does not provide a complete picture of walnut volume availability. The CWB is currently seeking the authority to expand permitted reporting to include volumes that have purchase commitments but have not been shipped.

This proposed change enables the information collected by the CWB to better reflect the conditions of modern agricultural markets in which an increasing share of purchases are committed to prior to shipment. Knowing the volume that already has a purchase commitment in addition to knowing the volume that has been shipped will provide handlers with a more complete picture of market conditions when negotiating sales.

Modernizing Marketing Orders for Other Commodities

As markets continue to evolve, marketing orders will continue to adapt to meet market conditions. Adaptations will include modifying traditional functions—as the CWB is proposing for information collection—and introducing and expanding new ones. The California Rice Commission, for example, has increased its focus on environmental quality and regulatory compliance and reduced its direct marketing-related activities since it was founded in 1999 as a replacement for earlier industry organizations. (It remains involved in marketing through its membership in the U.S. Rice Producers Association.) Increasing regulation of agriculture may make moving in the same direction more attractive for other marketing orders as well.

While production research has long been a traditional marketing order function, over time, funding health research has emerged as a priority for many commodities. As consumers' interest in designing a diet to meet their individual health needs continues to increase, health research is likely to continue to be a growth area for enhancing consumer demand for individual commodities. However, funding health research must be included as one of a marketing order's approved activities. If it is not, the marketing order must be amended to include it. These types of successful adaptations by marketing orders will enable them to continue to meet the original objective of enhancing the economic sustainability and stability of U.S. agriculture.

Suggested Citation:
Goodhue, Rachael E., and Harry M. Kaiser. 2020. "Modifying Marketing Orders to Face New Challenges." *ARE Update* 24(1): 1-4. UC Giannini Foundation of Agricultural Economics.

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The opinions expressed in this article are the authors' own and not those of the California Walnut Board or the United States Department of Agriculture.

For additional information, the authors recommend:

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Going Nuts for More Bees: Factors Influencing California Almond Pollination Fees

Brittney K. Goodrich and Jennie L. Durant

Due to low almond prices, 2021 pollination expenses will be scrutinized. Using grower survey data, we find the following were associated with higher pollination fees and potential benefits for growers: contracting with a pollination broker compared to a beekeeper, an out-of-state beekeeper compared to one in California, and high colony strength compared to low-strength requirements.

Over the past two decades, expanding almond acreage and the corresponding demand for pollination services has increased almond pollination fees. Pollination costs now represent a substantial share of annual operating expenses for almond operations, rivaling both harvest and irrigation costs.

Currently, almond prices are roughly 30% below their 5-year average of $2.90/lb, while almond pollination fees are 7% above their 5-year average of $183/colony. Tight profit margins mean almond operations will closely scrutinize their pollination expenses as they establish contracts in the coming months. In this article, we investigate the factors that influence almond pollination fees using 2019 survey data collected from over 300 almond growers.

Background

Most almond varieties require cross-pollination for commercial production, so orchards contain multiple varieties. When almond trees begin blooming in mid-February, honey bee colonies are brought in to facilitate the transfer of pollen between varieties. Almond growers have traditionally relied on two colonies per acre to guarantee sufficient pollen transfer. In recent years, self-fertile varieties have been put into production. These varieties do not require cross-pollination, so an entire orchard can be planted with one variety. Self-fertile varieties still require bees to transfer pollen, but fewer colonies per acre can be used.

As almond acreage has increased over time, so has the demand for honey bee colonies (Figure 1). The demand far exceeds the supply of colonies within California, so colonies are shipped from all over the U.S. to pollinate almonds each February. Almond pollination fees have risen in response to this increasing demand to attract additional colonies. Beekeepers not already participating in California almond pollination may have relatively high transportation costs or the potential for honey production in their home state during almond bloom, thus requiring increased fees to ship their bees to California.

For the 2020 almond bloom, roughly 1.2 million almond acres required an estimated 2.4 million honey bee colonies for pollination; 1.9 million colonies these colonies were shipped into California from other states (Figure 1). In February 2021, an estimated 2.5 million colonies will be required for almond pollination, approximately 88% of the total colonies in the United States.

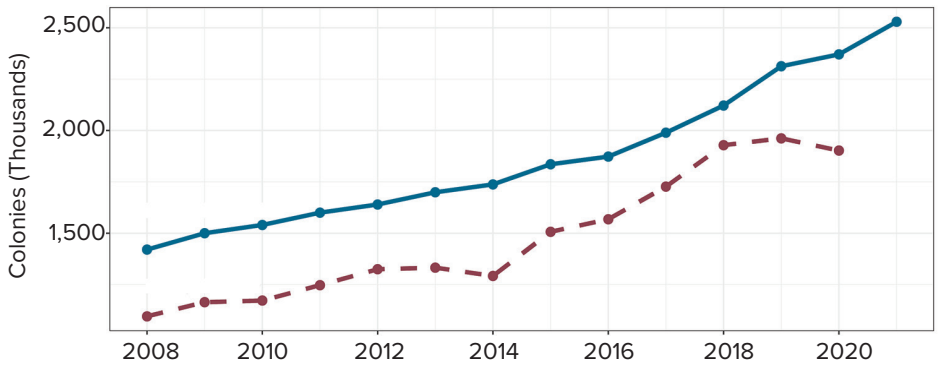
Colony Strength in Almond Pollination Contracts

A honey bee colony with a large population is able to provide more pollination services than a colony with a small population. Consequently, many growers provide incentives in almond pollination agreements for beekeepers to provide large colonies.

Almond bloom occurs in mid-February, when honey bee colonies are naturally at their smallest population due to the lack of pollen and nectar from flowering plants. Normally, a colony would begin increasing its population as flowers bloom in early spring. However, to deliver a colony with a large population at the beginning of almond bloom, a beekeeper must supplement a colony with pollen or a pollen substitute to stimulate population expansion weeks before bloom begins.

Due to the clustering nature of the honey bee colony within a hive (the physical box containing the colony), industry participants use a standard of

Figure 1. Estimated Demand for Almond Pollination Services and Colony Shipments into California, 2008-2021



Sources: Apiary Shipments through California Border Protection Stations, CDFA Plant Health and Pest Prevention Services; USDA NASS 2008–2019 Almond Acreage Reports

Note: Estimated demand calculated as 2 colonies/acre for traditional almond varieties and 1 colony/acre for self-fertile varieties.

Table 1. Average Almond Pollination Fees by Average Colony Strength Requirement, 2015 and 2019

Minimum Average Colony Strength Requirement	2015 Survey (N=74)			2019 Survey (N=205)			
	Percentage of Responses	Average Pollination Fee	Premium/Discount compared to 8-frame	Percentage of Responses	Average Pollination Fee	Premium/ Discount compared to 8-frame	Percentage Change in Real Pollination Fees 2015-2019
No. of Frames	Percent	2019 U.S. Dollars	Percent	Percent	$US Dollars	Percent	Percent
<6-frame	5	$179.73	-1.9	10	187.25	-3.1	4.2
6-frame	7	$177.05	-3.4	24	189.96	-1.7	7.3
7-frame	7	178.12	-2.8	8	191.41	-1.0	7.5
8-frame	61	183.27	-	48	193.30	-	5.5
>8-frame	20	187.57	2.3	10	205.28	6.2	9.4
Average		183.17			192.78		5.2

Sources: 2015 Almond Pollination Contract Survey, B. Goodrich and R. Goodhue, 2015;
2019 Survey on Bee-Friendly Practices in Almond Orchards, J. Durant and E. McNamara, 2020
Note: 2015 fees adjusted to 2019 dollars using U.S. Bureau of Economic Analysis GDP Implicit Price Deflator.

measurement to estimate the size of a colony: counting the number of active frames within a hive. An active frame meets one of two criteria: 1) bees cover at least 75% of both sides of a standard frame of comb within the hive, or 2) at least four bees per square inch of comb are present.

Almond pollination contracts can contain many types of colony strength requirements, but the most commonly used is the minimum average (active) frame count. To determine the average frame count for the colonies in an orchard, typically 10–25% of the colonies are inspected to determine the number of active frames in each colony. The inspector averages the active frame counts across the sample. If the average frame count across the sample does not meet the minimum specified in the contract, the grower may request an increase in the number of colonies brought in to make up for the shortfall or may impose monetary penalties.

Almond Pollination Fees

In December 2019–February 2020, researchers at UC Davis and Duke University conducted an online survey of over 300 almond growers to better understand pollination decisions. The sample represented roughly 14% of almond acreage in 2019. Of the 321 growers who participated in the survey, 273 rented some or all of their honey bee colonies for almond pollination in 2019, 18 had almond orchards not mature enough for pollination, and 28 were integrated beekeeping/almond operations that supplied all of their own bees for pollination.

Colony Strength Requirements

Among the growers who rented colonies, 75% of the respondents received the minimum colony strength requirements associated with their largest almond pollination contract. The remaining 25% may have not known or not required a minimum colony strength.

Table 1 shows the average almond pollination fee by the minimum average frame count requirement for growers' largest pollination contracts in 2015 and 2019. Pollination fees in 2015 were converted to 2019 dollars to adjust for inflation. The 2015 data come from a survey conducted at the 2015 Almond Conference. The 2015 survey has a smaller sample size than the more recent survey. However, paired together these surveys provide the first documentation of how fees have changed across colony strength categories over time.

Across both surveys, the 8-frame minimum average frame count was the most frequently used colony strength requirement. It is clear across both surveys that pollination fees increase as the colony strength requirement increases. This reflects both the value of increased pollination services from larger colonies, as well as increased inputs from the beekeeper.

Across all colony strength requirements, inflation-adjusted pollination fees increased by 5% between 2015 and 2019. This varied by category: the highest colony strength requirement of a minimum average above 8 frames increased by 9% on average, while the smallest colony strength requirement of less than 6 frames increased by 4%. The premiums associated with the highest colony strength category went from 2% to 6% above the 8-frame minimum average. This increase in premium could reflect either increased costs associated with beekeepers supplying high-strength colonies, and/or an increase in the demand for high-strength colonies relative to 8-frame colonies.

Pollination Provider

Approximately 28% of respondents said an independent almond pollination broker supplied some or all of their colonies in 2019. Typically, a pollination

broker will contract with multiple beekeepers and multiple growers and act as a middleman, coordinating colony placement and payments with beekeepers and growers individually.

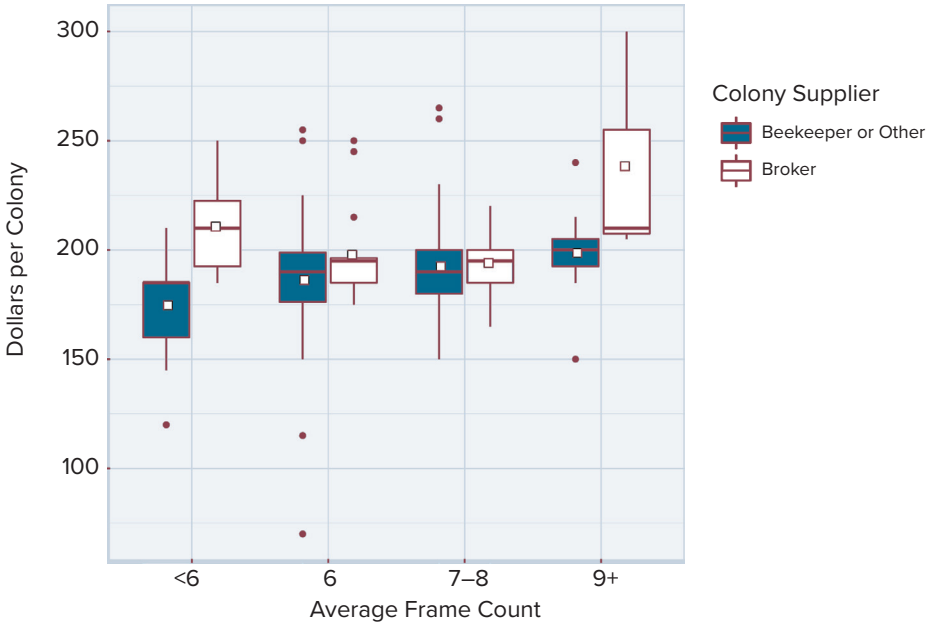
Brokers provide a service by taking on risks on both sides of almond pollination agreements. Brokers can guarantee timely payments to beekeepers, guaranteeing little to no risk the beekeeper will not be paid. Brokers also ensure growers receive the number and strength of colonies desired. For example, if a beekeeper comes up short on the contracted number (or strength) of colonies due to adverse colony health issues, the broker will find additional colonies to fill the grower's contract.

To take on risk from the contracting parties, pollination brokers charge the grower more money than they pay out to the beekeeper, taking the difference as the brokerage fee. Figure 2 shows box plots of almond pollination fees separated by colony strength category and whether the grower contracted with a broker or another pollination provider (direct with beekeeper, another grower, or other). The white squares in Figure 2 display the average fee for each group. Within each colony strength category, colonies contracted through a broker were more expensive on average than those contracted through another supplier. On average, growers paid $9.50 more per colony when contracting through a pollination broker compared to other sources.

Origin of Colonies: Within California or Out of State

Out-of-state colonies are shipped into California by the semi-truckload, typically in amounts of 400–450 colonies per truck. Shipment costs vary based on the distance traveled. Costs to ship colonies from the Pacific Northwest range from $10 to $14/colony, while shipment from the Northeast can cost up to $50/colony. Thus, higher fees are necessary to get participation from beekeepers further away. On average, growers paid $7 more per colony for colonies originating outside of California compared with colonies from within.

Figure 2. Box Plots of Almond Pollination Fees by Colony Strength Category and Pollination Provider, 2019



Source: Survey on Bee-Friendly Practices in Almond Orchards, J. Durant and E. McNamara, 2020

Note: Box plots represent the distribution of fees within each group where groups are separated by colony strength category and whether the grower obtained colonies through a broker or beekeeper. The lower and upper sides of each rectangle are the 25th and 75th percentiles of each group's fee distribution. The horizontal line in each rectangle represents the group median, white squares represent the group average, and red circles represent outliers in each group. Within each colony strength category, on average brokers charged more than beekeepers.

Regional Variation in Almond Pollination Markets

There are three regions of almond production in California: Sacramento Valley (SV), Northern San Joaquin Valley (NSJV) and Southern San Joaquin Valley (SSJV). Due to differences in almond production conditions, e.g., irrigation water availability and microclimates, one would expect pollination markets to vary regionally as well. For example, the SV is home to many queen and packaged bee producers who keep colonies in California year-round, while NSJV and SSJV have much more almond acreage requiring pollination than the SV.

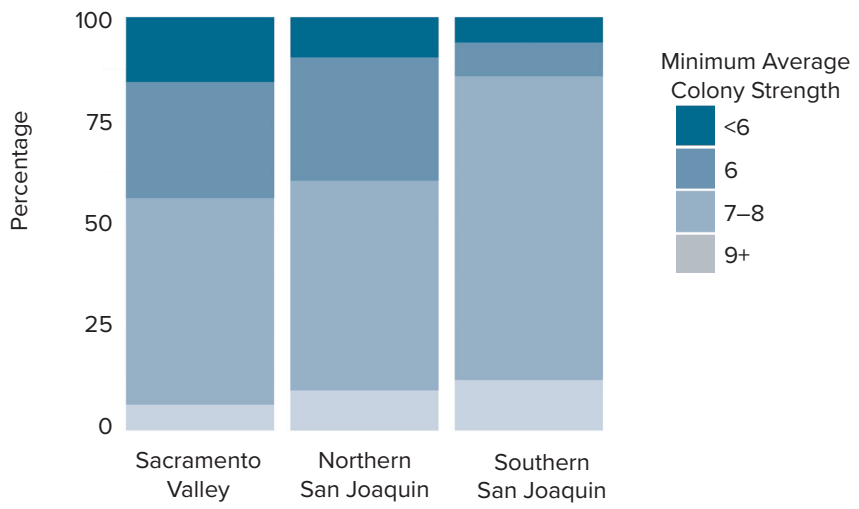
Table 2 shows regional variation in characteristics of almond pollination markets, and Figure 3 shows the percentage of each colony strength category required for each region. As discussed in the previous sections, one would expect that markets with a higher percentage of brokered colonies, a higher percentage of out-of-state beekeepers, and higher colony-strength requirements on average would result in higher average pollination fees.

Table 2. Regional Almond Pollination Market Characteristics, 2019

Region	Average 2019 Pollination Fee	Respondents with Out-of-State Beekeepers	Respondents Using Broker
	($/Colony)	Percent	
Sacramento Valley (SV)	200.86	33	23
Northern San Joaquin Valley (NSJV)	190.41	55	28
Southern San Joaquin Valley (SSJV)	196.34	40	32

Source: Survey on Bee-Friendly Practices in Almond Orchards, J. Durant and E. McNamara, 2020

Figure 3. Percentage Minimum Average Colony Strength Requirement by Region, 2019



Source: Survey on Bee-Friendly Practices in Almond Orchards, J. Durant and E. McNamara, 2020

The NSJV and SSJV regions were relatively similar in most characteristics, except for colony strength requirements. Over half of the respondents in the NSJV region received colonies from out of state, compared to 40% in the SSJV. The percentage of respondents who contracted through an independent pollination broker was similar across the two regions: 28% in the northern region and 32% in the southern region. Roughly 86% of SSJV respondents reported colony strength requirements of 7 frames or higher, compared to 60% in the NSJV. Corresponding with these higher colony strength requirements, pollination fees in the southern region were on average $6/colony higher than that of the northern region.

The SV was an outlier with respect to the previously discussed fee determinants. It had the lowest percentage of respondents receiving colonies from out of state, the lowest percentage of respondents contracting through a broker, and the lowest percentage of colony strength requirements above 7-frames, yet it had the highest average fee. One explanation is that the SV growers in the sample may have smaller orchards compared to the NSJV and SSJV. Logistically, it is less costly for beekeepers to drop many colonies at once. If a beekeeper must make many colony placements in a large number of small orchards, the grower may have to pay the beekeeper more per colony to cover those costs.

Another potential explanation is that many queen bee producers in the SV have an effect on the market. Queen bee operations depend heavily on the health of their managed colonies at the beginning of the year so that they can supply other beekeepers with bees in the spring. Outside colonies coming within 3 miles of the queen producers' colonies may result in the spread of pests and diseases. Because many growers and beekeepers have worked together for many years, it is possible that a queen producer might insist that any outside colonies brought into the area go through extensive pest and disease health checks. The expense of this may require higher pollination fees.

Conclusions

Growers need to consider the value associated with pollination decisions in addition to the cost. Contracting for colonies through a pollination broker, from an out of state beekeeper, or above the 8-frame colony strength were associated with higher fees. However, each of these may provide benefits to the grower in excess of the premiums paid. Using a pollination broker or contracting from a portfolio of beekeepers from in and out-of-state will likely decrease risks associated with colony health. Contracting higher-strength colonies may allow growers to employ fewer colonies per acre.

Suggested Citation:
Goodrich, Brittney K., and Jennie L. Durant. "Going Nuts for More Bees: Factors Influencing California Almond Pollination Fees." *ARE Update* 24(1) (2020): 5–8. University of California Giannini Foundation of Agricultural Economics.

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For additional information, the authors recommend:

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COVID-19 and Urban Water Consumption

Mehdi Nemati

This article examines the impacts of COVID-19 restrictions on water usage in California, using anonymized customer water consumption daily data from a mid-sized city in Northern California (City). Results suggest increases in residential use and reductions in non-residential use. However, from June 2020, daily usage became stable and similar to the 2018–2019 levels.

On January 11, 2020, China reported its first death from COVID-19, and on January 26, California reported its first case. On February 25, San Francisco Mayor London Breed announced a state of emergency, requiring city officials to step-up preparedness. As the numbers of positive COVID-19 cases rose and the first death occurred, on March 4, Gov. Gavin Newsom declared a state of emergency in California.

By mid-March, most of the schools and businesses in California were shut down. On March 19, Gov. Newsom announced a statewide order to shelter-in-place, which restricted all non-essential travel and activities outside of the home. After almost two months, on May 8, the state started the reopening process. However, as the number of cases began surging again by mid-July, the governor partially closed some businesses, such as bars, hair and nail salons, barbershops, and indoor dining. All counties with elevated rates of COVID-19 infections, hospitalizations, and deaths that were on the Department of Public Health County Data Monitoring list for three consecutive days were required to shut down certain industries and activities unless they could be modified to operate outdoors or through pick-up.

These measures have changed urban water consumption patterns. In this article, I explore changes in water usage during the COVID-19 pandemic by examining data from the City from January 2018 to the end of July 2020. I investigated these changes by customer type, including single-family residential (SFR), multifamily residential (MFR), schools (SC), and commercial, industrial, and institutional (CII).

Understanding the impacts of COVID-19 on urban water consumption using disaggregated high-frequency data is beneficial for water managers and policymakers. First, it offers insights on how COVID-19 impacted the water bills of residents, especially for disadvantaged communities, as well as the revenue and finances of water agencies. In addition, measuring real-time changes in sectoral water consumption during COVID-19 can provide timely information on local short-run economic activities—compared to traditional indicators of economic activities that are available with substantial lags at the national and state levels.

Examples of proxies on short-run economic activities include when significant drops in CII water consumption occurred after the lockdowns, how quickly it returned to normal levels after the start of the reopening, how people responded to the stay-at-home orders, and what the heterogeneities are in the response by community characteristics (e.g., by income, education, etc.).

Data and Methods

I analyzed anonymized daily water usage from customers of the City. The City's water agency is equipped with Advanced Metering Infrastructure (AMI), also known as smart meters, which provide real-time daily water usage data from January 2018 through the end of July 2020.

Summary statistics for the data used in this analysis are presented in Table 1. The City's water service area has more than 20,000 single-family residential accounts, constituting 85 percent of the total. The March–July water usage in the service area increased from 2,470 million gallons in 2019 to 3,050 million gallons in 2020 (roughly by 23%). The average water consumption for each account from March through July of the 2018–2019 baseline period was 768 gallons per day. This number increased to 918 gallons per day during the same period in 2020. The data show that, as one might expect, residential water use increased while non-residential use decreased.

The subsequent analysis estimates the changes in water consumption during the COVID-19 pandemic while considering several factors affecting consumption, including seasonality, fluctuations in weather, and account-specific factors. For

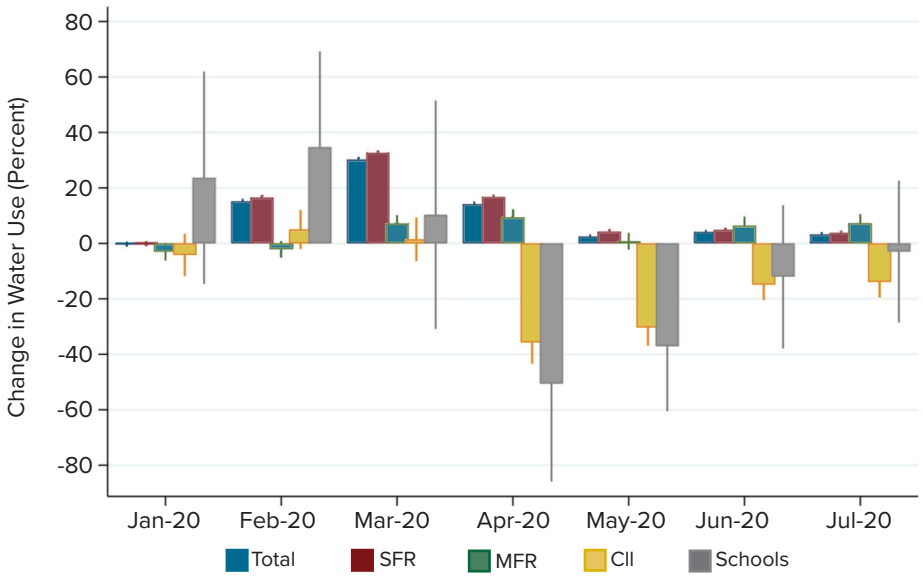
Table 1. Summary Statistics of Data Used in the Analysis

	Total	SFR	MFR	CII	Schools
Number of Accounts	24,408	20,693	1,322	1,152	50
Average Daily Water Use (gallons)					
March-July 2018 and 2019	767	487	777	4,460	12,440
March-July 2020	918	533	958	3,466	11,746
Percentage Change (%)	20	9	23	-22	-6

Source: Author's calculations

Note: * Percent change does not control for factors such as household characteristics and weather.

Figure 1. Estimated Monthly Impact of COVID-19 on Water Use by Sector in 2020



Notes: Lines associated with the boxes are the 95% confidence intervals clustered at the account level. Estimated impacts are according to the fixed-effects regression model with controls for calendar month, account-specific characteristics, and weather.

this regression analysis, I organized a panel dataset of customers' daily usage from January 2018 to July 2020 and controlled for the week of the year, day of the week, and account-specific characteristics (e.g., lot size, income). Using PRISM Climate Group data, I also controlled for weather variations (e.g., daily minimum and maximum temperature, and total daily precipitation). The analysis measured usage during a specific day/week and how it differed from the same day/week of prior years (2018–2019) while taking into account weather conditions.

Results

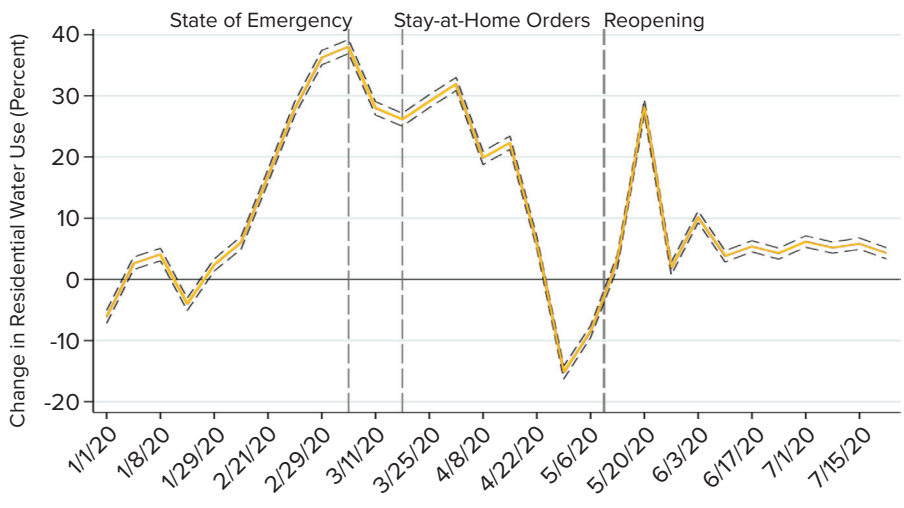
First, I estimated a fixed-effect regression model with an indicator for the dates after the shelter-in-place orders. The regression results indicate that after the shelter-in-place orders, total daily water consumption within the water service area, on average, increased by 10.79% from March to the end of July, compared to the same period in 2018–2019. As expected, breakdown by customer type showed that SFR and MFR sectors increased by an estimated 11.8% and 6.36%, respectively. Note that increases in the MFR sector could potentially be due to increases in indoor water use; however, increases in the SFR could be due to the rise in indoor use as well as outdoor use. I estimated, on average, reductions of 18.39% and 19.52%, respectively, in CII and schools.

I also explored monthly changes to measure how different restriction levels, including emergency orders, shelter-in-place, and the reopening affected consumption in different sectors. As expected, I did not observe any significant difference in water use in January 2020, compared with January 2018–2019 levels. I observed that total water use started to increase in February 2020, reached the peak in March, and continued to increase but in much smaller amounts in May, June, and July 2020 (Figure 1).

The residential (SFR and MFR) sector is the primary driver of the changes in total use. As indicated in Figure 1, residential use followed the same pattern as the total. CII and schools showed the largest reductions in use in April and May 2020. Note that even though households (SFR and MFR) were in some sense resuming normal activities, CII use remained down through June and July, indicating that economic activities are not fully restored.

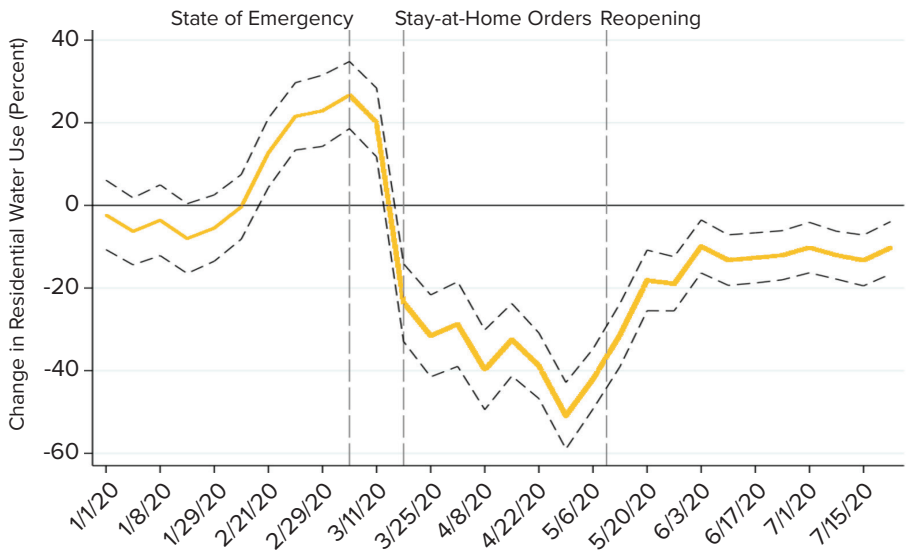
Next, I explored daily changes in use from January 2020 through July 2020, compared to the same levels in 2018–2019. Figure 2 shows the changes in daily water consumption (gallons per day) by sector for the beginning of January to the end of July in 2020, compared to the average in 2018 and 2019. Vertical dashed lines indicate the

Figure 2. Estimated Impact of COVID-19 on Residential Daily Water Use in 2020



Notes: Dashed black lines indicate the 95% confidence interval. The gold solid line is the estimated impact of COVID-19 on residential water use, according to the fixed-effects regression model, with controls for the week of the year, day of the week, household-specific characteristics, and weather.

Figure 3. Estimated Impact of COVID-19 CII and Schools' Daily Water Use in 2020



Notes: Dashed black lines indicate the 95% confidence intervals clustered at the account level.

The gold solid line is the estimated impact of COVID-19 on CII and schools water use according to the fixed-effects regression model, with controls for the week of the year, day of the week, account-specific characteristics, and weather.

emergency order by Gov. Newsom on March 4, the shelter-in-place orders on March 19, and the start of the reopening on May 8.

Figure 2 shows that residential use, compared to 2018–2019 levels, started to increase in early February and reached a peak increase in March 2020. Figure 2 also shows a rise in consumption immediately after the reopening in May. The residential use was stable during June and July, and similar to the 2018–2019 levels—a roughly 5% increase in use compared to June and July 2018–2019.

Figure 3 indicates the regression results for daily water use change in 2020, compared to 2018–2019 levels. Similar to the residential sector, we observe an increase in use by CII and schools in February. The use starts to decline after the emergency orders and reaches the largest reductions in late March and during April. Usage began to return to normal levels after the reopening in May.

The observed changes early on during the pandemic were due to people staying at home and, as a result, using more water for indoor (e.g., personal hygiene, cooking) and outdoor (e.g., gardening) purposes. Also, most businesses were closed (e.g., restaurants, bars), which resulted in less water use by CII and schools. The data indicate that usage became stable in June and July. Residential use is still slightly higher than the 2018–2019 levels (5% higher), but CII and schools are lower than the 2018–2019 levels (10% lower). The net effect of COVID-19 on total water use, in this case, was positive, but other districts' use depends on the restriction levels and mix of the accounts (number of residential and non-residential).

Since the pandemic's extent and duration are still uncertain, analyzing real-time changes in water use is valuable for the water agencies, water managers, and policymakers. To summarize, our findings indicate that residential water use has increased while non-residential use has decreased. These changes were particularly large during the early months (March-May) of the pandemic and are slowly returning to the pre-pandemic levels.

The large increases in residential water use have likely increased customers' water bills, at a time when many are also experiencing economic hardships such as job loss. Understanding the changes in water bills due to COVID-19 are especially crucial for districts with the tiered or budget-based rate structure (i.e., customers pay higher rates for these additional units of consumption) and those with a high proportion of low-income customers. Currently, Gov. Newsom's executive order protects homes from water shutoffs, but this could be problematic later on.

This study finds that the effect of COVID-19 on total water use is positive for this specific water agency. However, the net impact of COVID-19 on water use for other water districts depends on the relative proportion of residential and non-residential accounts. Regardless of the net effect, these massive consumption changes could affect water agencies' operational conditions, revenue, and finances. Besides, changes in water use have important implications for wastewater agencies. Some water and wastewater agencies are facing higher operating costs (e.g., additional training and supplies) and loss of revenue that could put further pressure on the agencies.

Suggested Citation:
Nemati, Mehdi. 2020. "COVID-19 and Urban Water Consumption." *ARE Update* 24(1): 9–11. University of California Giannini Foundation of Agricultural Economics.

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Acknowledgment: I would like to thank Robb Barnitt and Dropcountr for sharing the anonymized dataset for this analysis.

Agricultural and Resource Economics
ARE UPDATE
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GPBS

Agricultural and Resource Economics UPDATE

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Published by the

Giannini Foundation of Agricultural Economics

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