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ALSO IN THIS ISSUE

Bee-conomics Revisited: A Decade of New Data Is Consistent with the Market Hypothesis

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In the past decade almond acreage has expanded, causing growth in demand for honey bee pollination. However, pollination fees have fallen, indicating an even larger shift-out in the supply of honey bee pollination services and a reduction of marginal costs of pollination.

Honey bees have been much in the news for more than a decade. The observation of a puzzling and extreme winter die–off of honey bee hives in the United States was dubbed "colony collapse disorder" and captured the attention of scientists, industry members, and the general public. (The terms hive and colony are used interchangeably here, as in the literature.) Over the same decade, the continued rapid growth in the demand for honey bee pollination services by the California almond industry added to the importance of a better understanding of interactions among honey bees, pollination, and factors that drive pollination service supply and demand.

In 2006 Sumner and Boriss (2006) referred to the well–established and long–studied market for pollination services. They considered the rapid rise in pollination fees that had recently occurred for almonds and a few other crops in the context of basic economics. Sumner and Boriss pointed out that the prices and quantities of pollination services behaved much like other markets did when they experienced increases in marginal costs and expansion in demand. The present article reviews the current facts and market relationships for pollination from honey bees and highlights forces that may drive changes in pollination markets in coming years.

Economic Patterns and Relationships

Most honey bees are raised as domesticated livestock by commercial beekeepers. Commercial beekeepers migrate extensively, searching for pollination crops and forage sources. According to the United States Department of Agriculture (USDA), there were about 2.6 million colonies in the United States on January 1, 2016, of which 1.14 million were in California. During the almond bloom in 2016, California had a maximum of 1.4 million colonies. To illustrate hive migration, we note that California had 730,000 colonies in the state on July 1, 2015. In contrast, North Dakota had 460,000 hives present on July 1, 2015, but only 82,000 hives on January 1, 2016.

Honey bees contribute revenue to their beekeepers from three sources: pollination services, honey sales, and a set of miscellaneous products such as beeswax, propolis, and queens. In 2016 U.S. beekeepers had revenues of about $338 million from pollination, about $336 million from honey, and about $149 million from other products. Pollination is now the top income source and accounted for about 41% of 2016 revenue of beekeepers nationally.

Beekeepers tend to specialize among revenue-generating alternatives. According to the USDA Honey report, hives based in North Dakota and South Dakota together produced about $100 million in honey revenue in 2016, whereas in California only about $22 million was generated in honey revenue. Those beekeepers focusing on pollination services tend to get relatively little revenue from honey. Pollination revenue from

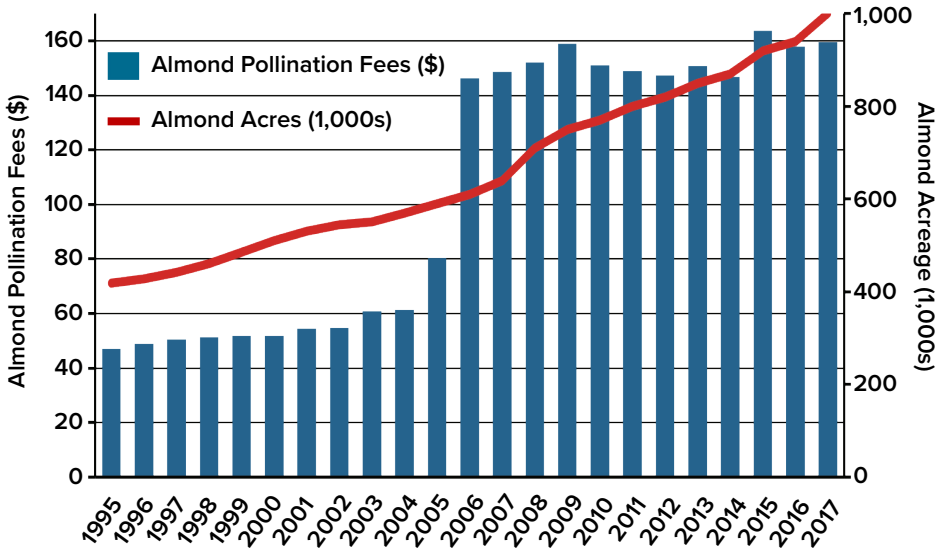

Figure 1. Almond Pollination Fees and Acreage, 1995–2017

Note: Pollination fees adjusted for inflation using GDP deflators with 2010=100
Source: California State Beekeepers Association (CSBA) pollination survey (various years) for fees and USDA National Agricultural Statistics Service (NASS) for acreage.

almonds was about $281 million in 2016, which was more than 90% of California pollination revenue and more than 80% of all pollination income nationwide.

Growth in the Importance of Almonds and Trends in Pollination Fees

Bearing acreage of almonds in California has grown steadily, from about 400,000 acres in 1995 to one million acres in 2017 (Figure 1). This growth implies that with two hives per acre, almond pollination required close to two million hives (USDA data vary on paid pollination acres of almonds, depending on the survey source). With about 300,000 acres of young trees to come into production in the next three years, the bearing acres in 2020 are likely to rise to more than 1.25 million acres, even allowing for removal of old trees. This rapid growth in almond acreage implies an equally rapid growth in demand for pollination services.

The bars in Figure 1 show, with reference to the left axis, that pollination service fees for almonds grew steadily in real terms (in 2010 dollars) from 1995 to 2005 as almond acreage also grew steadily. From just over $80 per hive in 2005, the pollination fee jumped about 80% in 2006. Since 2006, pollination fees for almonds drifted slightly to between $150 and $160 per hive and have not risen for more than a decade despite much larger almond acreage.

The jump in the 2006 pollination fee was likely caused by a sudden reduction in supply when the colony collapse disorder first appeared over that winter, which left the almond orchards with too few bees. The jump in fees was needed to draw bees out of other activities and from across the United States with little preparation time.

In the following years, the price has remained steady because an efficient system has quickly evolved to deliver bees to the expanding almond acreage, even with fluctuations in disease pressure on the honey bee industry. The fee of about $160 per colony is, together with income from other activities, to attract enough colonies to the almond pollination each February.

A further note about pollination fees is important. There is informal evidence that the number of active bees per colony has increased over the past decade. Colony strength is generally measured by "frame count," and pollination contracts are more likely now to specify minimum active frames per colony and contain financial incentives for more frames per colony. If frames per colony have risen since 2006, as those in the industry affirm, that means the fee per unit of pollination services has fallen by even more than the decline in fee per colony would indicate. The decline in fees per colony in the face of rapid steady increases in demand indicates that honey bees are more available than ever and the often–repeated claim of declining supply of pollinators does not apply to honey bees in the United States.

Seasonality, Honey, and Pollination Fees Across Crops

Seasonality and honey production are the important factors for understanding pollination fees across crops. Figure 2 presents the 2016 pollination fees per colony for California crops by the months of their flowering season. The shaded boxes are those crops that provide little or no marketable honey from pollination. Pollination fees range from $18 for prunes to $185 for plums, according to the Survey of the California State Beekeepers Association.

The earliest period, February and March, which is the period of peak demand from almond pollination, shows very high pollination fees for almonds and the crops that compete with almonds (early cherries and plums) during that pollination season. After almond pollination, beekeepers search for post–almond pollination contracts or safe foraging space. The crops that follow almonds demand at most 100,000 colonies, and relatively few pollination opportunities are available in other states. The post–almond pollination fee drops to its minimum of $18 for prunes just after the almond bloom. The difference in

fees between plums and prunes exemplifies the importance of pollination seasonality.

The potential of honey revenue from a crop also seems to affect pollination fees, but the evidence is limited. The other factor is availability for safe forage for bees, so crops in regions with no dangerous pesticide use during the bloom have low or zero pollination fees. This may partly explain why alfalfa seed has relatively high pollination fees during the later spring and early summer season when non-honey crops have lower fees.

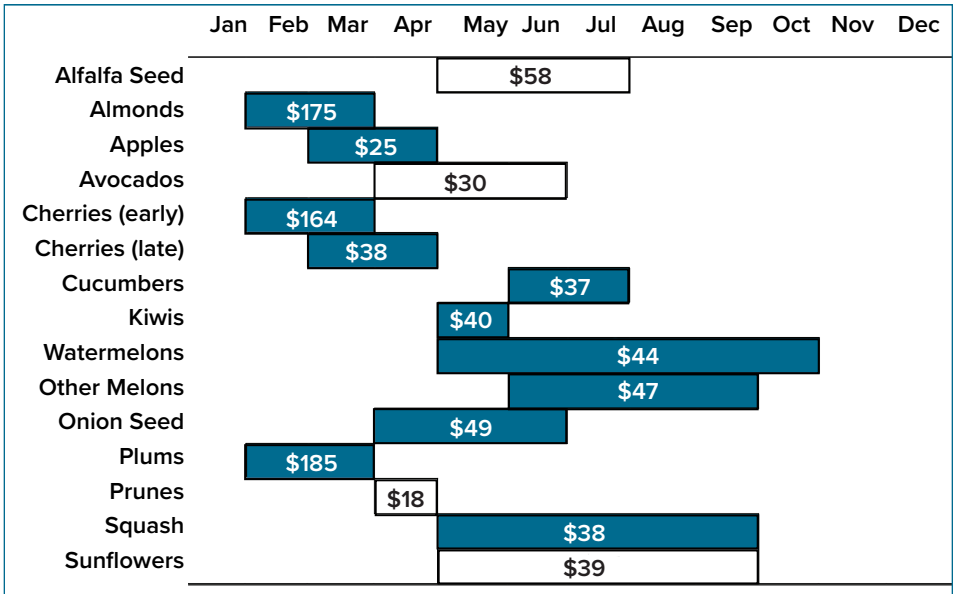

Figure 2. 2016 Pollination Fees Per Hive by Seasonality and by Crop's Honey-Producing Characteristics

Note: Darker shading indicates low honey production from the crop.

Source: 2016 CSBA pollination survey results for fees.
Various web sources are used for seasonality and honey producing capacity, including:
http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-90162011000600007
http://beeaware.org.au/pollination/pollinator-reliant-crops/onions/
http://www.beesource.com/forums/archive/index.php/t-227800.html

Emerging or Potential Drivers Affecting Bee-conomics in California

Costs of Supplying an Active Hive for Almond Pollination

Beekeepers face many challenges. The data illustrated in Figures 1 and 2 document the economic importance of almond pollination for the honey bee industry. Supplying about two million strong and active honey bee colonies to the almond orchards in February of each year is equally crucial for the economics of honey bees, and doing so is challenging and costly.

Honey bee disease management, control of mites and other pests, and effective and healthy long–distance transport are vitally important. The search for safe and secure forage before and after almond pollination, and cost–effective honey production, are also economic and management challenges facing beekeepers. The cost of hive splitting and creating replacement colonies and renovating colonies are also important for the supply-side of the pollination equation.

Slowing or Reversal of Demand Growth for Almonds

As almond acreage has grown, demand for honey bee pollinators has also grown in the approximately fixed ratio of two hives per bearing acre. As noted earlier, the number of active bees may have grown even faster as the average number of active frames per hive has risen. At the same time, almond production has risen rapidly with equally rapid growth in demand. Prices have fluctuated from $1.10 per pound in 2001 to $3.74 per pound in 2014 (in 2010 dollars), with several of the higher price years within the last five.

Despite this record of growth, there is no guarantee that demand growth will allow almond prices to remain high. Not only is competition from other nuts growing stronger, but many regions around the world are attempting to develop more acreage to compete with California's dominance of the world market. When almond acreage stops growing or even begins to recede, pollination prices and hive counts in almonds will recede. With about two-thirds of all commercial hives relying on almonds for a large share of their revenue, any almond reversal is serious for the population of honey bees.

Increase in Costs of Production or Resource Limits for Almonds

The most prominent supply-side issue facing almonds is the availability and cost of irrigation water in the San Joaquin Valley, where most almonds are grown. The most recent University of California Cost and Returns Studies for almonds (https://coststudies.ucdavis.edu/current/) show irrigation water accounting for between 13% and 33% of operating costs, depending on the cost of surface water and depth of groundwater. In contrast, pollination accounts for between 11% and 17% of operating costs.

Higher water costs or less reliability of water available for irrigation would halt growth or reduce acreage of almonds. Pressure from other crops increases as grapes, processing tomatoes, or alfalfa become more efficient in use of water, and compete for land and other resources. Almonds compete with dozens of other significant crops and there is nothing assured about the ability of almonds

to dominate prospective crop profitability, especially if irrigation water availability becomes less secure.

Emergence of Self–Fertile Almond Varieties

Being "self–fertile" means that fruit setting does not require cross–variety pollination, resulting in much easier pollination with little requirement for honey bees or other insect pollinators. Self–fertile almond trees became commercially available more than a decade ago, and the variety "Independence" has recently gained popularity among those planting new almond orchards. Acreage planted to the Independence variety was a small share of bearing acreage in 2016, but accounted for almost 20% of the variety–identified, non–bearing acres (trees planted within the previous three years).

Of course, adoption of a variety is not driven solely by cost considerations because almond kernel characteristics are important to market price. How fast and to which extent self-fertile almonds will replace conventional high–pollination varieties remains uncertain. Yet, the emergence of this option would reduce pollination demand for a given almond acreage.

Concluding Remarks

This article documents and explains how honey bee pollination is a commercial enterprise and how patterns of pollination services and prices for those services follow standard expectations of supply and demand. The gradual decline of pollination fees for almonds (and other crops) in the face of continued increase in pollination acreage of almonds indicates increased availability of honey bees, not the decrease that one might expect from popular press accounts or even some of the scientific literature. The relevant data indicate more pollinators are available at lower fees, and in many places for much of the spring and summer, pollinators are available for very low or zero fees.

That is not to say that there are no environmental pressures on honey bees or wild pollinators. Commercial beekeepers have a challenging task in seeking safe foraging locations after almonds pollination. Moreover, wild pollinators, with no active manager, may be more vulnerable to environmental challenges. Entomologists, ecologists, and other researchers are now engaged in better understanding the vulnerabilities of both managed and wild pollinators.

The joint production of pollination services, honey, and other products has long been a significant commercial enterprise in California. The industry has grown rapidly along with the demand for pollination from expanding almond acreage. Total revenue of pollination services in California is now well above $300 million per year, with 90% from almond pollination. Almonds depend on honey bees and the size and economic health of the beekeeping industry depends crucially on the economic health of the almond industry.

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For additional information, the authors recommend:

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President Trump and U.S. Migration after 100 Days

Philip Martin

President Trump issued four executive orders dealing with immigration since taking office January 20, 2017, setting in motion plans to build a wall on the 2,000 mile Mexico–U.S. border, increase deportations, reduce refugee admissions, and protect U.S. workers. These executive orders signaled a new era in migration policy that emphasizes enforcement against unauthorized foreigners and protections for U.S. worker.

President Trump issued 30 executive orders in his first 100 days in office. Many lay out ambitious goals, but most request that agencies review programs and provide options to achieve the president's goal to "make America great again." For example, after issuing the border and interior enforcement executive orders, President Trump said: "Beginning today, the United States of America gets back control of its borders," an ambitious goal that may require years to persuade Congress to appropriate the necessary funds, construct a wall, and hire agents to detect and remove unauthorized foreigners.

The Border Security and Immigration Enforcement Improvements (BSIEE) executive order, issued January 25, 2017, asserts that "border security is critically important to the national security of the United States" and directs the Department of Homeland Security (DHS) to plan for the construction of a wall on the 2,000–mile Mexico–U.S. border, and develop "a strategy to obtain and maintain complete operational control of the southern border," defined as the "prevention of all unlawful entries." A third of the Mexico–U.S. border is currently fenced to prevent the unauthorized entry of people and vehicles.

The BSIEE executive order requires DHS to add 5,000 Border Patrol agents "as soon as practicable" to the current 20,000. It also instructs DHS to detain unauthorized foreigners who are apprehended rather than releasing them until they appear in court to explain why they should be allowed to remain in the United States. It allows DHS to use expedited removal procedures to deport unauthorized foreigners detected anywhere within the U.S. if they have been in the U.S. less than two years and cannot make credible claims that they need protection from persecution in their country of citizenship. The BSIEE executive order requires all federal agencies to report on the U.S. aid they provided to the government of Mexico over the past five years.

The Enhancing Public Safety in the Interior of the United States (EPS) executive order, also issued January 25, 2017, tackles sanctuary cities and cooperation between federal and state and local law enforcement agencies. State and local police in sanctuary cities do not hold persons arrested for certain crimes at the request of DHS so that these foreigners can be placed in federal custody. Without defining sanctuary, the EPS executive order requires DHS to designate "sanctuary" jurisdictions, and a follow–up implementation memo requires state and local governments to certify by June 30, 2017, that they are in compliance with a 1996 federal law requiring them to cooperate in immigration enforcement or risk loss of U.S. Department of Justice grants.

The EPS authorizes DHS to resume so–called 287(g) agreements that involve federal immigration agents training state and local police officers to detect unauthorized foreigners and to hold them for federal agents. The EPS emphasizes that DHS should focus on the detection and removal of unauthorized foreigners convicted of U.S. crimes. However, it also makes more unauthorized foreigners priorities for removal, including those arrested but not convicted of U.S. crimes as well as any other unauthorized foreigners encountered while searching for criminals. The EPS directs DHS to add 10,000 U.S. Immigration and Customs Enforcement (ICE) agents to the current 10,000 to detect and remove unauthorized foreigners inside the United States.

In the first two months under President Trump, arrests of removable foreigners away from the border were 21,400, including 5,400 who did not have criminal records in the United States. Most of these arrests have not yet led to more removals, since many of those arrested have an opportunity to ask an immigration judge to allow them to remain in the United States. The EPS instructs DHS to detain more of those arrested and waiting for trials before immigration judges.

The third executive order, Protecting the Nation from Terrorist Attacks by Foreign Nationals (PNTAFN), was issued January 27, 2017, and prompted chaos and controversy. The PNTAFN executive order suspended the entry of nationals of Iran, Iraq, Sudan, Syria, Libya, Somalia, and Yemen; halted refugee admissions for 120 days and reduced refugee admissions from 110,000 to 50,000; and called for "extreme vetting" of some foreigners seeking visas to enter the United States.

The PNTAFN executive order led to chaos at airports, as immigrants and visitors with valid visas were denied entry to the United States. Thousands protested what they called President Trump's Muslim ban, and several states sued, prompting a federal judge to enjoin PNTAFN implementation, a

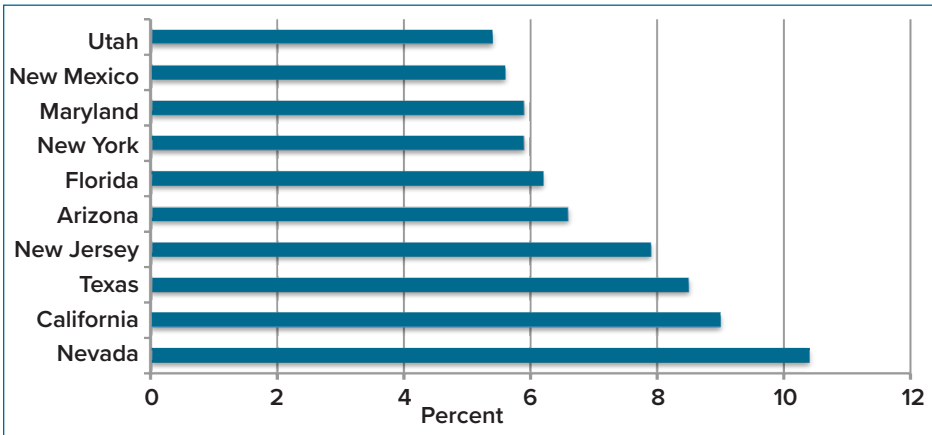

Figure 1. Share of Unauthorized Workers by State, 2014

Source: Passel and Cohn, 2016

decision upheld on appeal. President Trump issued a new executive order on March 6, 2017, that bars the issuance of new visas to nationals of six countries (not Iraq) but permits green–card holders from these countries to travel in and out of the United States. This executive order was blocked by two federal judges who cited the president's campaign pledges to stop Muslim immigration as reasons why the order was unconstitutional religious discrimination; these decisions are being appealed.

The Buy American and Hire American (BAHN) executive order, issued April 18, 2017, directs federal agencies that deal with guest workers—the Departments of Labor, Justice, Homeland Security, and State—to study existing guest worker programs and recommend changes "to protect the interests of U.S. workers in the administration of our immigration system, including through the prevention of fraud or abuse." The U.S. has a dozen visas that permit foreigners to work temporarily in the U.S., but the focus of the BAHA executive order is on the H–1B program.

The H–1B program makes it easy for most U.S. employers to hire college–educated foreigners to fill U.S. jobs that normally require college degrees. Most employers are not required to try to recruit U.S. workers before being certified to hire H–1B foreigners, and most employers may legally replace U.S. workers with H–1B workers. The major protection for U.S. workers is a cap on the number of H–1B visas, 65,000 a year plus 20,000 for foreigners with master's degrees. Employers requested 200,000 or more H–1B visas in recent years, and 35–50% went to so–called body shops, which are typically outsourcing firms that do some of a firm's IT work in the U.S. with H–1B workers and send the rest to India.

U.S. employers must agree to pay H–1B workers at least the prevailing wage for the occupation. There are four wage levels in the H–1B program, ranging from entry–level to experienced. Over half of H–1B visas go to entry–level workers who are paid relatively low wages, and over 80% are in the two lowest wage levels.

U.S. employers often say that they need to "raise the cap" on the number of H–1B visas in order to hire the world's "best and brightest" workers and stay competitive in a globalizing world, but some research finds that the easy availability of H–1B workers depressed the wages of similar U.S. workers and discourages U.S. students from working in IT. The BAHA executive order instructs DHS to ensure that H–1B visas go to the most–skilled or highest–paid foreign workers, ending the current practice of selecting those who get H–1B visas by lottery.

Immigrants and Immigrant Workers

The United States has 20% of the world's 244 million international migrants and perhaps half of the unauthorized foreigners in industrial countries. The 43 million foreign–born U.S. residents in 2014 were almost one–seventh of the 320 million residents, and the 26 million foreign–born workers were one–sixth of the 160 million U.S. workers. Foreign–born workers have a higher labor force participation rate, 65%, than U.S.–born workers, although they earn less—an average $680 a week in 2015 versus $835 a week for U.S.–born workers.

President Trump's executive orders deal primarily with the 11 million unauthorized foreigners, including eight million who are in the U.S. workforce, making 5% of all U.S. workers unauthorized. There are three salient facts about unauthorized foreigners. First, two–thirds have been in the U.S. at least a decade, and 40% of the 10 million unauthorized adults live in families with U.S.–born and U.S. citizen children. Second, most newly arrived unauthorized foreigners arrived legally, as with tourist visas, and did not leave, and most of these new unauthorized foreigners are not Mexicans. Third, apprehensions at the Mexico–U.S. border are at their lowest levels in decades, and most of those apprehended just inside the U.S. border are non–Mexicans.

Unauthorized workers are concentrated by geography, industry, and occupation, so stepped–up enforcement is likely to have different effects by state and sector. California had the most unauthorized workers in 2014, some 1.7 million, followed by 1.1 million in Texas and 600,000 in New York. However, the share of workers who are unauthorized is highest in Nevada, over 10%, followed by about 9% in California and Texas (Figure 1).

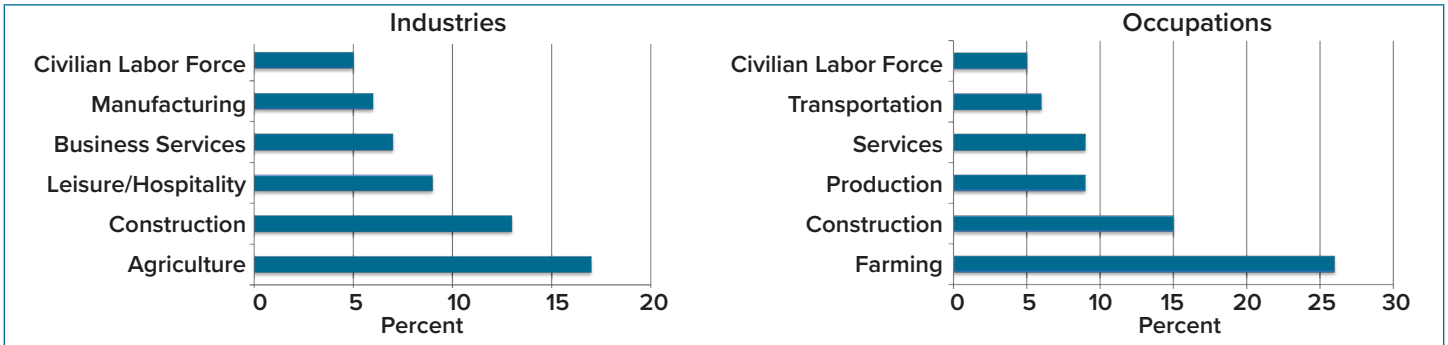

Figure 2. Share of Unauthorized Workers by Industry and Occupation, 2014

Source: Passel and Cohn, 2016

Employers sometimes say they would go out of business without unauthorized workers, suggesting that such workers are critical to business survival. However, most employers assert that the workers they hire present documents that show they are legally authorized to work in the U.S., so employers do not know they are violating laws against employing unauthorized workers when particular workers are hired.

Employers may enroll in E–Verify to check worker documents. E–Verify is a mostly voluntary DHS internet–based system that checks data submitted to employers by newly hired workers against government databases to determine whether new hires are legally authorized to work in the United States. Over 600,000 employers were enrolled in E–Verify at the end of 2016, including 88,000 in Georgia, one of 20 states that require some or all of their employers to participate in E–Verify.

Non–participating employers complete I–9 forms for newly hired workers that involve workers providing identity and work authorization documents to employers. Both employers and new hires sign documents stating that they completed this verification process, and DHS may audit these I–9 forms. DHS audited 1,300 employers in FY16 and made 239 arrests of unauthorized workers at their workplaces, suggesting a very low risk of detection for employers and workers who do not participate in E–Verify.

Data on where unauthorized foreigners work is collected in household surveys that may not detect unauthorized foreigners in non–standard housing, and should be treated as lower–bound estimates. Agriculture and farming are at the top of lists of unauthorized workers as a share of all workers employed in particular industries and occupations. (Figure 2). One–sixth of those employed in agriculture, and a quarter of those with farming occupations, are believed to be unauthorized based on household survey data.

Construction employs an average seven million workers, versus two million in agriculture. A seventh of those in construction are unauthorized, suggesting there are as many unauthorized construction as farm workers. Leisure and hospitality employ almost 16 million workers, so 9% unauthorized would mean 1.4 million unauthorized workers, which is more than the one million in construction work. Of the 20 million workers employed in business services, 7% are unauthorized—meaning there are as many unauthorized janitors and temp workers as there are unauthorized hotel maids and food–service workers.

More specialized surveys find higher shares of unauthorized workers in particular sub–sectors. For example, the National Agricultural Worker Survey (NAWS) interviews 2,000 to 3,000 crop workers each year, and finds that half are not authorized to work in the U.S. About 70% of crop workers were born outside the U.S., usually in Mexico, and 70% of foreign–born workers are unauthorized, making half of all crop workers unauthorized.

Over 1.1 million unauthorized farm workers were legalized in 1987–88 under the Special Agricultural Workers program, and these SAWs were one–third of crop workers in the early 1990s. However, most quickly left agriculture for nonfarm jobs and were replaced by unauthorized workers, whose share of crop workers has been about 50% since the mid–1990s (See Figure 3).

Agriculture is unusual because it is the industry that is widely considered the source of unauthorized Mexico–U.S. migration via the Bracero program, and farmer and worker advocates were the only group to propose an industry–specific plan to legalize unauthorized farm workers and make it easier to hire legal guest workers. Between 1942 and 1964, over 4.5 million Braceros were admitted to the U.S., giving one to two million rural Mexicans experience working in the U.S., and making them willing to return illegally in the 1970s as U.S. farm wages soared and the Mexican peso was devalued.

The Immigration Reform and Control Act (IRCA) of 1986 allowed 1.1 million unauthorized farm workers to become immigrants under the Special Agricultural Worker program (SAW) and eased employer requirements to hire H–2A guest workers, but illegal migration surged, SAWs left agriculture, and the H–2A program shrank. The

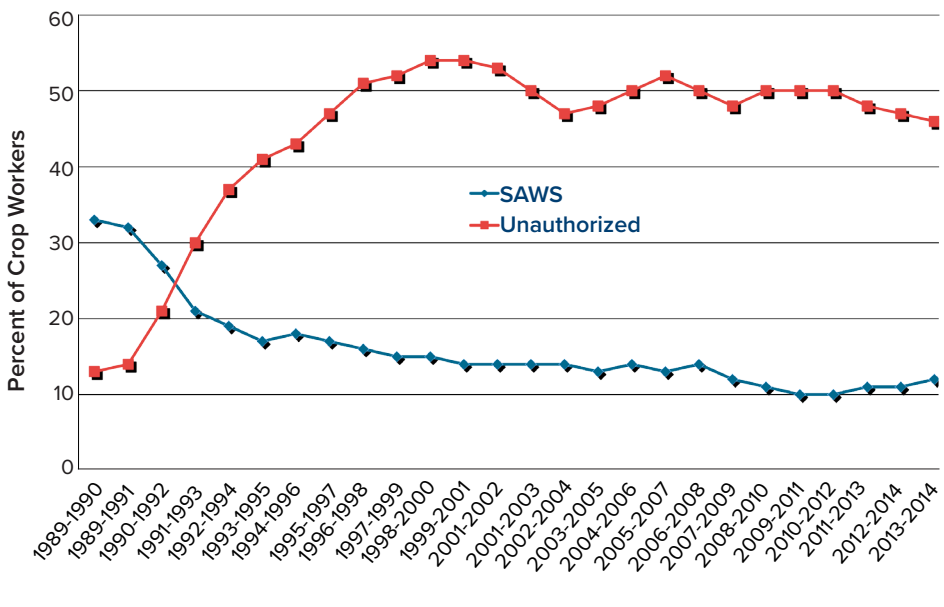

Figure 3. SAWs and Unauthorized Crop Worker Shares, 1989–2014

Source: National Agricultural Workers Survey, www.doleta.gov/agworker/naws.cfm

Agricultural Job Opportunity Benefits and Security Act (AgJOBS), negotiated between workers and employers in 2000 and included in all comprehensive immigration reform proposals since, would repeat the IRCA approach of legalizing unauthorized farm workers and making it easier to hire guest workers in the future. Under AgJOBS, worker exits are to be slowed by a requirement that they continue to do farm work up to five years in order to earn an immigrant status.

On April 25, 2017, President Trump issued the Promoting Agriculture and Rural Prosperity in America (PARPA) executive order. The PARPA did not mention immigration or labor, but called for recommendations from federal agencies within 180 days on how to "ensure access to a reliable workforce and increase employment opportunities in agriculture–related and rural–focused businesses," making it almost certain that there will be options offered to change the H–2A and H–2B guest worker programs.

President Trump and Immigration

Donald Trump struck a chord with disaffected whites in areas that have shrinking manufacturing and mining sectors, appealing for their support with promises to restrict the free trade that can lead to closed factories and the types of immigration that can put downward pressure on wages. The president's attacks on Mexico, a country he accused of stealing U.S. jobs and sending drugs and crime to the U.S. via migration, were expected to ensure that the first–time candidate for public office would be defeated by more experienced rivals in the Republican primary and in the general election.

President Trump defied the elite consensus and became president by winning in six states that voted for President Obama in 2012, including Florida and midwestern states. Many polls find wide gaps between elite and mass opinion on immigration, trade and globalization, generally, with elites welcoming globalization while masses prefer protection from outsiders. The Chicago Council on Foreign Relations has several times found that 50–60% of Americans see immigration as a "critical threat" to the U.S., while less than 15% of opinion leaders see immigration as a threat. There is a similar gap between elites and masses on the virtues of free trade.

Over two centuries ago, George Washington, the first U.S. president, asserted that "the bosom of America is open to receive not only the Opulent and respectable Stranger, but the oppressed and persecuted of all Nations and Religions." Donald Trump, the 45th president, has changed America's migration message to the world, questioning the virtues of immigration in the 21st century. President Trump wants the U.S. to make a U–turn in many areas, from immigration and trade to climate change. After 100 days, President Trump has continued the America–first rhetoric that got him elected, but is only at the beginnings of his journey to change U.S. immigration policies.

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Papers of George Washington. From George Washington to Joshua Holmes, 2 December 1783. The National Archives. https://founders.archives.gov/documents/Washington/99-01-02-12127

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State Introduces Additional Requirements for Pesticide Applications Near Schools

Rachael Goodhue, Karen Klonsky, Christopher De Mars, and Minghua Zhang

The California Department of Pesticide Regulation will require growers to notify public schools and licensed daycare centers annually of pesticides that may be used within one–quarter mile and prohibits some applications on weekdays between 6 a.m. and 6 p.m. The regulation is scheduled to go into effect on January 1, 2018. While notification costs in total are small on average, they are highly heterogeneous across growers. The economic impact of the prohibition on certain classes of applications is unclear. Insufficient information is available on the potential benefits of the regulation to determine whether it is socially desirable.

On January 1, 2018, the California Department of Pesticide Regulation (CDPR) will implement regulation regarding pesticide applications near public K–12 schools and licensed child daycare facilities, referred to collectively as schoolsites. The regulation prohibits some classes of pesticide applications within one–quarter mile of schoolsites between 6 a.m. and 6 p.m. on weekdays. There is also a requirement for agricultural property owners to prepare an annual plan stating which pesticides they may apply and notify schoolsites of that plan.

This article examines the potential economic effects of the notification requirement for growers. The analysis includes 13 counties, which accounted for over half of California's total value of crop production in 2014 (Fresno, Imperial, Kern, Kings, Madera, Merced, Sacramento, San Joaquin, Santa Barbara, San Luis Obispo, Stanislaus, Ventura, and Yolo). These counties represent two–thirds of the value of production and two–thirds of the harvested acres in California in 2014 (Table 1).

Data

In order to evaluate the potential cost of the notification requirements, we utilized historical data regarding pesticide applications. The analysis required identifying sites with "pesticide applications made for the production of an agricultural commodity" located within one–quarter mile of schoolsites. CDPR requires reporting of all commercial pesticide applications in the state. The data collected are aggregated into an annual Pesticide Use Report (PUR). PUR data provided information on pesticide product applications from July 1, 2013 to June 30, 2014. The PUR data supplied the crop treated, the pesticide used, application type (aerial or ground), as well as the date and time of day of the application and information identifying the grower and site location.

Attributes of pesticide applications incorporated into the data include federal and state restriction status, sprinkler chemigation label options, and whether the application occurred during the week or a weekend. Data regarding field boundaries, parcel maps, public school addresses, licensed child daycare addresses, and street and number geocoding data to map those addresses were obtained from a variety of sources.

Table 1. Value of Crop Production and Harvested Acres for the 13 Counties Studied, 2014

	All Crops			
	Value of Production		Acres Harvested	
County	Value ($1,000)	Percent of State	Number of Acres	Percent of State
Fresno	$4,910,871	10%	890,959	10%
Imperial	$1,298,740	3%	482,281	6%
Kern	$5,495,819	12%	804,285	9%
Kings	$1,282,094	3%	416,746	5%
Madera	$1,563,457	3%	284,810	3%
Merced	$2,088,430	4%	597,173	7%
Sacramento	$324,374	1%	130,551	2%
San Joaquin	$2,520,519	5%	650,266	8%
San Luis Obispo	$760,830	2%	97,348	1%
Santa Barbara	$1,450,076	3%	122,695	1%
Stanislaus	$2,533,735	5%	502,027	6%
Ventura	$2,125,115	4%	98,830	1%
Yolo	$767,018	2%	289,441	3%
Total (13 counties)	$27,121,078	57%	5,367,113	62%
State Total	$47,450,342	100%	8,617,708	100%

Source: California Department of Food and Agriculture (2015). California Agricultural Statistics Review 2014–2015. www.cdfa.ca.gov/Statistics/PDFs/2015Report.pdf.

Table 2. Estimated Notification Costs

Activity	Total Annual Cost	Cost/ Grower	Cost/ Field
Preparation of Annual Notifications	$1,594,843	$1,108	$620
Delivery of Annual Notifications	$17,787	$12	$7
Understanding Requirements	$37,198	$26	$14
Total	$1,649,828	$1,147	$642

Source: California Department of Food and Agriculture (2015). California Agricultural Statistics Review 2014–2015. www.cdfa.ca.gov/Statistics/PDFs/2015Report.pdf.

The time required for each cost component for the notifications was estimated utilizing the federal government's estimate of the time required for compliance with various provisions of the soil fumigant risk mitigation regulation promulgated by the U.S. Environmental Protection Agency (EPA). We paired these time estimates with federal wage data to estimate costs. The resulting costs were $25.85 for each affected grower to understand the requirements, $620.32 per field to prepare the annual notification, and $2.58 for delivery of the annual notification for each affected field to each schoolsite and the County Agricultural Commissioner's Office (CAC).

Schoolsites Subject to Regulation

The thirteen counties have 2,853 public K–12 schools, of which 795 are within one–quarter mile of fields. The draft regulation would affect 28% of all public K–12 schools in these counties. They have 2,972 licensed child daycare facilities, of which 896 are within one–quarter mile of fields. The draft regulation would affect 30% of all licensed child daycare facilities in these counties.

Growers and Fields Subject to Regulation

According to 2014 PUR data, there were 25,836 unique grower identification numbers in the thirteen counties. Of those, 1,439 (5.6%) have one or more fields within one–quarter mile of one or more schoolsites. Accordingly, each of those growers would need to become familiar with the regulatory requirements. In total, there are 2,571 fields within one–quarter mile of one or more schoolsites—constituting 478,773 acres, of which 36,471 acres are within one-quarter mile of a schoolsite. Each field must have an annual notification of planned pesticide use delivered to each schoolsite and the County Agricultural Commissioner (CAC).

Schoolsites may be sufficiently close to each other for some fields to be within one–quarter mile of more than one schoolsite. Each schoolsite must be provided with an annual notification, so notification costs are higher for a field if more schoolsites are near it.

Estimated Notification Costs

Table 2 reports notification costs in total, per grower, and per field. Total estimated annual notification costs are $1,649,828, or $1,147 per affected grower, and $642 per affected field. The vast majority of these costs, $1,594,843, are for preparation of the annual notification of pesticides, which could be applied in the following July 1 to June 30 period.

Prohibited Applications

It is difficult to create a counterfactual that would enable us to estimate the cost of prohibiting certain pesticide applications between 6 a.m. and 6 p.m., Monday through Friday. We instead simply provide an evaluation of the extent to which applications would have been impacted by the draft regulation from July 1, 2013–June 30, 2014. The regulation defines prohibited applications in the schoolsite buffer zone as the use of sprinkler chemigation, aerial, and air blast (including air assist) applications.

We examine two classes of applications: aerial and air blast. A total of 6,907 applications would have been impacted out of a total of 12,005 aerial and air blast applications. Aerial applications accounted for 1,089 (16%) of the two types of prohibited applications, while 84% (5,818 applications) of prohibited applications were air blast.

Importantly, just over half of aerial and air blast applications (58%) occurred during the prohibited weekday time period between 6 a.m. and 6 p.m. Thus, evenings and weekends are already standard time windows for aerial and air blast applications. Weekday evening applications accounted for 18% of the total. Most striking, one–fourth of all applications took place on weekends.

Air blast applications are made primarily to perennial crops, while both annual and perennial crops utilize aerial applications. The commodities with the largest numbers of applications impacted were almonds and grapes—with 1,757 applications to almonds, 979 applications to grapes, and 580 applications to wine grapes. These three crops comprised 48% of all prohibited applications in this 2013–2014 period. Slightly over half of the almond and grape applications were prohibited, about one–fourth were on the weekends and one–fifth on weekdays after 6 p.m. Of all weekend aerial and air blast applications, 27% were on almonds and 24% were on grapes or wine grapes.

Of the field crops, alfalfa would have had the largest number of impacted applications followed by corn, wheat, cotton, and processing tomato. All of these were aerial applications. Well over half of the applications to these

crops were prohibited. Over a fourth of the applications to these crops were weekend aerial applications.

Conclusion

The estimated notification costs for 2013–14 would have been small on a per grower basis. However, it is important to keep in mind that averages do not provide a complete picture of the impact of notification costs on growers. Notification costs are heterogeneous across growers. Differences in the number of fields and the number of schoolsites that must be notified cause differences in notification costs across growers.

The most obvious way growers can mitigate the impact of the prohibition of certain types of applications at certain times is to move pesticide applications outside the prohibited window. However, weather and field conditions are not always suitable for applying pesticides. Forecasted rain events can in themselves prohibit certain pesticide applications. Thus, growers may sustain losses due to the regulation because they lose the option of treating during the weekday 6 a.m–6 p.m. window.

More broadly, we do not consider the costs of possible strategies for adaptation to the prohibition of certain types of applications on certain times, including change in crops or pest management practices. Changes in crop choices or varieties would change costs of production, revenue, and profit at the farm level. Growers may choose pesticides that have longer residuals and/or are more toxic, may replace applications of targeted pesticides with applications of broad–spectrum pesticides, may replace monitoring and applications of pesticides only as needed with a schedule of preventative applications, or may apply at maximum label rates instead of lower ones.

Such responses will have economic implications, although the direct effect on per-acre costs may be an increase or decrease. Similarly, if the efficacy of pest control changes with a change in materials, application method or timing, the income to the grower could decrease, impacting profit. There also may be implications for environmental quality and human health. All such considerations affect the net social benefit of the regulation.

Additionally, evaluating the social benefit that offsets these costs requires additional information regarding the nature of the benefit and its quantification. The benefit of the regulation must be incremental; existing regulations, labels, and permit requirements all address mitigating risks of exposure to pesticides. In its Initial Statement of Reasons for the regulation, CDPR states that "... concerns about the risks associated with pesticide use at or near schools and child daycare facilities have persisted through the years due to children's potentially increased sensitivity and exposure."

Suggested Citation:

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For additional information, the authors recommend:

"Pesticide Use Near Schoolsites." Proposed Text. California Department of Pesticide Regulation. www.cdpr.ca.gov/docs/legbills/rulepkgs/16-004/16-004_text.pdf

"Initial Statement of Reasons and Public Report." California Department of Pesticide Regulation. www.cdpr.ca.gov/docs/legbills/rulepkgs/16-004/16-004_initial_statement.pdf

Goodhue, R., K. Klonsky, C. DeMars, R.V. Steenwyck. 2016. "Draft Regulation Regarding Pesticide Applications Near Schoolsites: Potential Economic Effects for Agriculture." UC Davis. Prepared for California Dept. of Food and Agriculture, Office of Pesticide Consultation and Analysis. www.cdpr.ca.gov/docs/legbills/rulepkgs/16-004/economic_effects.pdf.

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