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State Regulation on Livestock Methane and Challenges Faced by the California Dairy Industry

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Methane emission from livestock manure will be, for the first time, subject to regulation under a new state law. Enforcement of regulations on livestock manure will begin on January 1, 2024. Compliance with new regulations on manure handling is likely to become a major factor determining dairy economics in California.

On Sept 19, 2016, Governor Brown signed into law Senate Bill (SB) 1383, the latest California state government effort to set policies that will allow California to meet its greenhouse gas (GHG) reduction targets. SB 1383 authorizes the state to regulate the release of short-lived climate pollutants (SLCPs) such as methane, black carbon, and fluorinated gases. The California livestock industry is a significant contributor to methane emissions in the state.

Ruminants (primarily cattle, sheep and goats) release methane from enteric (digestive) activity and from manure, while other livestock (primarily poultry in California) generate methane mostly only from manure. Livestock manure handling in California is subject to many environmental regulations. But, under SB 1383, methane emission from livestock manure will be, for the first time, subject to detailed regulation. Enforcement of regulations on livestock manure will begin on January 1, 2024, but several regulatory steps occur before then.

Methane is generated from manure when it decomposes in anaerobic conditions like those used in confined animal feeding operations rather than pasture-based operations. In California, over 90% of methane from livestock manure is generated by the dairy industry. Thus, the upcoming regulations have potentially important implications for the California dairy industry.

SB 1383 specifies a target reduction of 40% by 2030 for methane emissions from California livestock manure. The California Air Resources Board (CARB) has proposed manure digester technology as a chief strategy to reduce methane emission from dairy manure.

Short-Lived Climate Pollutants and SB 1383

SB 1383 deals with short-lived climate pollutants (SLCPs) across many sectors of the economy. The major emission sources of SLCPs include: diesel combustion that emits black carbon; refrigeration and air-conditioning systems that emit hydrofluorocarbons; and livestock operations, waste treatment, oil and natural gas systems that emit methane. Of these three, methane has the largest share of GHG emissions in California, accounting for 60% of the total. SB 1383 targets emission reductions of 40% for methane, 40% for hydrofluorocarbon and 50% for black carbon by 2030 from their 2013 levels.

The life spans of SLCPs in the atmosphere are relatively short, less than 20 years. Climate scientists measure the near-term climate impacts of SLCPs using global warming potential (GWP) based on a 20-year timeframe (GWP20) instead of the 100-year timeframe (GWP100), which is usually used for carbon dioxide (CO_2). Since all GWPs are measured relative to CO_2, the GWP20s of SLCPs are much larger than their GWP100s. For example, for methane, the GWP20 of 72 is almost three times the GWP100 of 25 (IPCC 4th Assessment Report).

Given the potency of SLCPs in the near term, controlling SLCP emissions plays an important role in the state's effort toward meeting the overall GHG reduction goals called for by AB 32. An earlier senate bill directed CARB to develop a plan to rapidly reduce emissions of SLCPs. This plan was

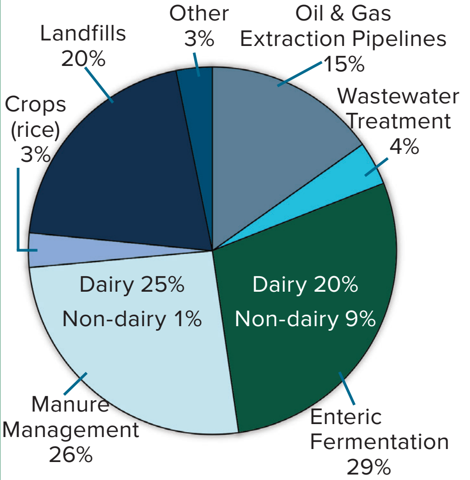

Figure 1. Short-Lived Climate Pollutant Methane by Source in 2013 (Total=118 MMTCO2e)

Source: CARB, www.arb.ca.gov/cc/inventory/slcp/slcp.htm

Note: Emission calculations use GWP20.

published as "Proposed Short-Lived Climate Pollutant Reduction Strategy," on April 11, 2016 (referred to as the Strategy hereafter), and provided the guidance for the specific mandates in SB 1383. Most importantly for our topic, methane emissions from livestock manure will be regulated beginning in 2024, and CARB is directed to set its comprehensive SLCP emission reduction strategy by January 1, 2018.

Methane Emissions

Figure 1 provides estimates of California methane emissions by source in 2013—the benchmark year for SB1383. Agriculture accounts for almost 60% of the total. Within agriculture, livestock accounts for almost all methane emissions. Livestock operations generate methane in two basic ways: enteric fermentation and manure decomposition. Enteric fermentation takes place in the digestive systems of ruminants and methane, produced in the rumen during the fermentation process, is released mostly through animal belches.

Methane is also produced during the decomposition of manure under anaerobic conditions. Such conditions are common in confined animal facilities, where manure is stored in large piles or processed in lagoons. Dairies are almost the sole source for manure-based methane (Figure 1). In California's large dairy industry, cows are mostly confined, fed a high-energy, concentrated diet, and manure is kept in conditions leading to anaerobic fermentation. Emissions from enteric fermentation can be reduced by changing animal diets, but considerable uncertainty exists about the long-term consequences. This is partly why enteric fermentation is not subject to regulation under SB 1383.

The Proposed Strategy to Reduce Methane Emissions

CARB and others have recognized several possible ways to reduce methane emissions from dairy manure. The Strategy by CARB recommends that dairy manure management be changed from current lagoon systems without methane capture.

The Strategy documents five pathways: 1) scrape conversion and onsite digestion for pipeline-injected natural gas vehicle fuel; 2) scrape conversion and centralized digestion for pipeline-injected natural gas vehicle fuel; 3) solar drying of manure onsite; 4) digestion for onsite renewable electricity; and 5) conversion of dairy operations to pasture-based management.

Pathway 3, solar drying, is expensive for dairies even though it is less capital intensive than other options. Solar drying generates no bio-energy output and thus no energy-related revenue. Pathway 4, electricity generation, is also very costly for farms in the Central Valley, where 90% of milk in California is produced. A major cost of using methane from manure to generate electricity on farms is in meeting Central Valley air quality standards. Combustion of methane, which is required for electricity generation, emits nitrogen oxides (NOx), a pollutant regulated in this region. Complying with Central Valley air quality rules on NOx requires using high-cost micro-turbines, making generation of electricity on farms in the Central Valley very expensive.

Pathway 5, the pasture-based operation, is also expensive and difficult for Central Valley dairies without a large conversion of cropland to irrigated pasture. In fact, California currently produces a tiny fraction of its milk from pasture-based dairies, mostly along the North Coast, where high-cost organic production methods are practiced.

CARB devoted most attention in its strategy to pipeline-injected natural gas production. This method produces pipeline-quality natural gas which can be used in natural gas vehicles. Biogas produced from a methane digester has to be processed to purity standards before it is injected into the pipeline. In the CARB cost analysis, pipeline-injected natural gas, especially pathway 2 which calls for a large centralized system, was found to be most favorable in net present value analysis. In addition to this advantage, to curtail methane by as much as 40%, the pathway must be feasible for commercial dairies in the Central Valley, and, according to the CARB calculations, a pipeline-injected natural gas system may meet this criterion.

SB 1383 includes specific provisions related to natural gas production from dairy manure. SB 1383 directs CARB to plan for potential infrastructure development that could facilitate widespread adoption of digester technology. By January 1, 2018, CARB, together with the Public Utilities Commission and the California Energy Commission, is required to adopt policies and incentives to increase renewable gas production and to implement at least five dairy bio-methane pilot projects to demonstrate interconnection to the common carrier pipeline system.

Financial Profile of a Pipeline-Injected Digester Investment for a Dairy Farm

Digesters have been proposed for manure management on California dairies for decades. Substantial federal and state government subsidies and incentives have been available. Nevertheless, only 13 digesters operate in California (as of Aug 2016) and many more have been abandoned (US EPA). All existing digesters produce electricity or thermal energy with none producing natural gas that is injected into pipelines.

Pipeline-injected natural gas production is highly capital-intensive, and thus this option makes economic sense only when the project is large enough to fully exploit economies of scale. The centralized digester system that CARB explored is based on this rationale, and our discussion below focuses on the CARB analysis of a centralized digester that turns methane from dairy manure to natural gas that is injected into a pipeline.

For a centralized digester, manure is collected from a group of farms. The hypothetical scenario considered by CARB assumes manure is transported from one million cows (500 farms with 2,000 cows each), which is about two-thirds of the Central Valley cows. The digester would be located in the Southern San Joaquin Valley where the greatest number of dairy cows are located within the smallest radius. Costs and revenue can be developed on a per-farm basis (2,000 cows).

The initial capital costs include conversion to a manure scrape system and the farm's share related to the central operation, which includes trucks, the digester, a pipeline, interconnection, etc. According to CARB calculations, these add up to about $3 million per farm. The annual operating and maintenance costs (O&M) for the farm share of the centralized digester are about $158 million.

To put these numbers in context, a 2,000 cow farm in the Southern San Joaquin Valley would produce about 500,000 hundredweight of milk. The price of milk has recently been in the range of $15 per hundredweight. Such a farm would generate $7.5 million in milk revenue on a total asset value (cows and other capital) of about $5.6 million based on CDFA data. (In 2015 and 2016, a typical dairy in California had operating cost above milk revenue.) Thus, a $3 million capital investment in manure handling alone would be a substantial investment relative to the investment in the dairy operations themselves.

Table 1. Net Present Value of Pipeline-Injected Digester by Eligibility for Carbon Destruction Credits in LCFS Carbon Intensity Calculation

	Full Carbon Destruction Credit	No Carbon Destruction Credit
	LCFS credit price = $100/MT CO2e	
LCFS credits (revenue per year)	**$0.845 Mil**	**$0.163 Mil**
Net Present Value	**$5.5 Mil**	**$0.3 Mil***

Source: CARB and author's calculation

Additional data used in NPV calculations include: capital cost=$3.026 mil, annual O&M=$0.315 mil, annual fuel revenue=$0.083 mil, annual RIN=$0.537 mil, interest rate=7%, discount rate=5%. These data are adopted from Appendix D of the Strategy.

*Author's calculation. All other numbers are adopted from CARB (2016).

Of course, a capital investment must be evaluated in relation to the stream of both benefits and costs during the lifetime of the investment. Using the 10-year horizon, CARB calculated the net present value (NPV) of this digestion system to be about $5.5 million. This positive net return hinges, especially, on details of the revenue stream.

CARB assumes that the natural gas will be used for transportation fuel which creates three revenue sources: natural gas sales plus two types of government credits available for biofuels. The California low-carbon fuel standard (LCFS) credits and the federal renewable fuel standard credits (also known as renewable identification number (RIN) credits) provide the bulk of the revenue. Of the total annual revenue of about $1.5 million per farm, only $83,000 comes from sales of the natural gas. Almost all the revenue (94%) comes from the government-created fuel credits.

Thus, the economic feasibility of the project hinges fully on a continuation of these two fuel credit policies and ensuring that natural gas from the digester qualifies fully under both programs. Any change in these policies, or in specifics of the regulations, could fundamentally alter the viability of the digester project. For example, the federal renewable fuels credits are under intense political pressure as environmental contributions of ethanol are challenged. Policy risk is a major component in evaluating the economic feasibility.

The reliance on government-created credits for revenue deserves further discussion. First, LCFS credits, which account for more than half of revenue, are not guaranteed to continue for 10 years. Unless regulations specify otherwise, once methane regulations take effect on dairies, their baseline in carbon accounting would be updated to include shipping manure to the digester as the "baseline" practice. The carbon intensity of the manure-based fuel would increase in LCFS accounting, causing a large reduction in LCFS credits, by as much as 80%, from $845,000 to $163,000, according to the CARB estimate (Table 1). If we use this lower LCFS credit revenue, the NPV falls to $0.3 million (Table 1).

The second issue with LCFS credits relates to the volatility of the LCFS credit market. Figure 2 shows the historical monthly prices of LCFS credits since the inception of the program. The monthly average price of credits has fluctuated from $20 to $120, with a

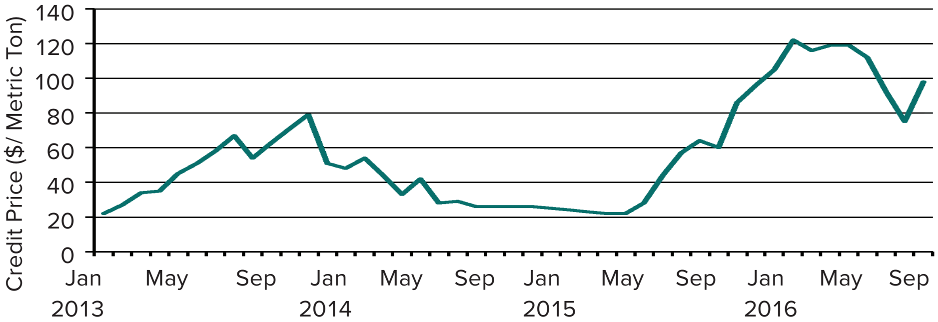

Figure 2. Monthly Average Low Carbon Fuel Credit Price, January 2013 - September 2016

Source: CARB, https://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm

mean of $56 from January 2013 to September 2016. Over the past 12 months, the prices have averaged about $100 per ton—after rising from $60 to $122 and then falling back to $75. Calculations in Table 1 are based on $100 per ton.

Historical prices of LCFS credits are highly volatile with a coefficient of variation of 56%, which can be compared to 19% for the coefficient of variation of monthly milk prices for the same period. Counterbalancing such variability of credit prices would require a substantial risk premium in the present value calculation.

Implications

Based on current law, methane emissions from dairy cows must be reduced. The law also requires detailed assessment of the economic feasibility of options. Compliance with new regulations on manure handling is likely to become a major factor determining dairy economics in California. Important questions are: will methane emission rules raise milk production costs or generate new revenue, and will this help or hinder efforts of the California dairy industry to remain competitive?

The California dairy industry grew rapidly for decades until about a decade ago, and has had no growth since 2007. California's milk production and processing costs used to be below those of industries in most other states because of scale economies and high-quality management. However, as dairy operations in other states have become larger and cost reductions in California have not kept pace, California's advantage has eroded. California remains a large net exporter of dairy products to the rest of the country and the world and, as a source of shipments of dairy products, California milk prices remain low.

The California dairy industry is already under economic pressure. If new methane regulations further erode the economic position of dairy farms in California, we would expect substantial exit from the industry with resultant reduction in economic activity, especially in the San Joaquin Valley.

SB 1383, in fact, stipulates that regulations on dairy methane be implemented only after evaluating whether the regulations are economically feasible and whether the regulations mitigate potential "leakage" to other states or countries. Implementing the new regulations will be a challenge for both the government and the industry. Government regulators must meet the environmental targets while minimizing any negative economic impacts. The dairy industry must struggle to comply with new regulations while maintaining economic viability in the face of many other challenges, including other environmental demands. Economists can help in this process with careful, objective analysis of the costs and benefits of alternative regulatory approaches.

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Valuing the Dissemination of Integrated Pest Management Information in California

Madeline Schatzberg and David Zilberman

The challenge of controlling pests economically and protecting the environment led to the creation of Integrated Pest Management. This concept originated, to a large extent, from researchers at the UC system; and over the years, Extension activities brought it to the fields. We present three methods of estimating the benefits of the UC IPM program. From a few case studies, we find a benefit of $323-500.5 million annually; from the website use, $57 million dollars annually; and assessing the contribution of UC IPM to PCA industry approach, $34 million annually. This suggests that the overall benefits of the program exceed the total UCCE annual budget on extension, which includes many other programs.

Integrated Pest Management (IPM) is one of the University of California Cooperative Extension's most successful programs. It is a management approach to pest management that aims to profit agriculture while protecting the environment. IPM techniques emphasize monitoring of pest populations and weather to target chemical and other applications when they are most effective. The increased precision of IPM may result in increased yields, reduced costs, and improved environmental quality compared to traditional methods—such as spraying pesticides on a set schedule. IPM combines multiple approaches, including biological and cultural controls with chemical control of damaging pests and disease.

The UC IPM Extension program has several components. It provides training to pest control professionals; it provides free knowledge to professional farmers, pest control consultants, and garden hobbyists within and outside the state of California through a website and other means.

The fact that UC IPM provides freely available public good makes valuation of the program difficult. Valuation of government programs is critical to optimally allocate taxpayer funds. We use three methods to estimate the value of the program. The first method, the case study approach, relies on peer-reviewed articles that estimate the direct economic effect of IPM methods. Unfortunately, the literature only estimates the impact of particular IPM programs on profitability per acre and reduction of pesticide per crop, ignoring environmental improvement and other effects such as worker safety. This method, which involves aggregating the benefits across the studies, will therefore underestimate the true value.

Due to the limitations of the case study approach, we augment our analysis with two alternative indirect (revealed preference) approaches. These methods will also help distinguish the value of the research done in IPM and the value of the dissemination of the knowledge done by UC IPM. The first infers the value of Extension from the earnings of pest control advisors (PCAs). The second method estimates the value of UC IPM information conveyed to users of the IPM website. Each method provides a partial estimate of the value of UC IPM, but together they provide a rough estimate of the order of magnitude of the benefit to aid in assessment of the program. In the rest of the paper, we first provide a history of the IPM program and then present the results of our estimation technique.

History and Impact of IPM

While discussing the benefits of University of California Cooperative Extension (UCCE) with Extension specialists, we asked them what programs they thought constituted UCCE's greatest success stories. All of them placed IPM near the top of the list. The history of IPM is a story of how a fringe idea touted by environmentalists and scientists became mainstream practice. The timeline in Figure 1 displays the most important events in UC IPM history.

1939-	Michelbacher writes "Recommendations for a More Discriminating Use of Pesticides," beginning a concept of IPM
1959-	Stern, Smith, van den Bosch, and Hagen outline sustaibnable pest control systems
1962-	Rachel Carson's "Silent Spring" published
1972-	Council on Environmental Quality defines IPM
1972-	First PCAs licensed
1976-	Environmental impact report required for hazardous pesticides
1979-	UC IPM founded
1979-	Center for Integrated Pest Management initiated
1980-	UC IPM first staffed
1980-	IPM manuals established
1981-	IMPACT system operational
1988-	88% of growers own IPM manuals
1988-	PCA licensing exam study materials published by UC IPM
1988-	Farmworker safety training begins
1990-	IPM manuals for gardeners published
1994-	IPM website launched
2009-	Funding for competitive research grants ends

Figure 1. Timeline: UC IPM

Note: Center for Integrated Pest Management (CIPM)

The University of California has spearheaded the concept of IPM since the 1930s. In 1939, UC Berkeley Professor and Entomologist, A.E. Michelbacher, laid the foundation of IPM concepts in his work "Recommendations for a More Discriminating Use of Pesticides," and he later coined the term "integrated control" for integration of biological and chemical controls.

In 1959, a group of UC Berkeley researchers—Vernon Stern, Ray Smith, Robert van den Bosh, and Kenneth Hagen—wrote the "Integrated Control Concept," as part of a study on control of the spotted alfalfa aphid. The basic goals and methods outlined in this paper are the backbone of modern IPM. Their system is based on three basic tenets: measure the pest before applying chemicals; consider the economic thresholds of damage; and avoid damaging natural predators with pesticide use. The term "Integrated Pest Management" was officially defined by the Council of Environmental Quality in 1972. This gave the fledgling field legitimacy as a tool for environmental protection.

The publication of Rachel Carson's "Silent Spring" in 1962, increased already existent public concern about overuse of chemical pesticides. The UC IPM program was first founded in 1979 at the end of a decade of growing environmental concern to encourage more environmentally safe methods of pest control. The public nature of the program was considered critical to offset the power the pesticide companies had over the information provided to growers. These fears had real basis in policy. Pest Control Advisors (PCAs) were licensed from the year 1972 to advise growers on choices they made about pest management.

In 1976, the California Attorney General ruled that an environmental impact report must be filed before most pesticide applications. Licensed PCAs provided these reports, making them necessary for most growers. Most of these licensed PCAs were affiliated with pesticide companies, creating a potential conflict of interest.

UC IPM began funding research early in its history with the creation of the Center for Integrated Pest Management (CIPM) in 1979. CIPM funded and organized research on IPM practices in alfalfa, apples, cotton, and soybeans by researchers across 17 universities. UC IPM was an early adopter of computers. In 1981 the "IMPACT" (Integrated Management of Production in Agriculture using Computer Technology) computer system went live. The IMPACT system allowed Extension employees and eventually growers to access data on weather, pest production, and crop information.

Dissemination of pest management information has consistently been a central aspect of the UC IPM program. The UC system's early attention to IPM and the diversity of the crops grown in California account for the UC system's place as an international powerhouse of IPM information. The program translates academic research ideas and introduces them to growers.

While short courses and grower meetings have been used, the publication of pest management manuals was historically the largest source of information from UC IPM. These manuals were sold throughout the country and the world, not merely in California. In 1994 the UC IPM website launched. This website contains much of the information published in the manuals, albeit in a shortened form for easy reference. Today it is considered an encyclopedia of pest management, where users from around the world can access IPM information for free.

The main goal of the modern UC IPM program is the dissemination of information. In earlier years, however, the program also funded researchers to implement new IPM management techniques. These projects fostered interdisciplinary growth and resulted in publications and new IPM methodology to be put to use in the field. To further aid in the dissemination of IPM methodologies, the program also works with the Department of Pesticide Regulation in training and credential upkeep courses for its PCAs.

Case Study Approach

After 80 years of the program, there are numerous IPM programs in existence. California grows roughly 200 crops, each vulnerable to multiple pests and pest problems, and solutions vary by region, crop, and season. Over time, new solutions replace old ones. Unfortunately, there are only a few empirical studies on the value of IPM programs, and even they provide limited impact measurements. Even so, the few case studies that we selected indicate that the value of IPM knowledge is substantial relative to its cost even though these studies often ignore benefits to the environment, farm worker safety, product quality, and price effects.

We summarize the findings of four studies in the following paragraphs. The studies we highlight were performed in the last several decades. Therefore, we will estimate the current value, both by converting the estimated benefit to 2016 dollars with a purchasing power conversion, and by determining the percent of the industry the benefit made up in the original year. We then apply this percentage to the value of the industry in 2016.

The first study is based on surveys collected in the 1980s on the impact of an IPM program in almonds. This program improved cultural practices, including pruning, weed control and monitoring pests, and contributed to increase yields and reduced pesticide costs. The net annual gain was estimated at $12.8 million (in 1990 dollars), or $23.2 million in 2016 dollars. The $12.8 million is 2.3% of the $550

Table 1. Summary of the Estimated Benefits from IPM from Four Selected Studies

Crop	Year of Study	Original Estimated Value	Benefit in 2016 Dollars	Income in Industry in Year of Study	Benefit as a Share of Income of Industry	Income of Industry Now	Estimated Value[1]
Almond	1990	$12.8 M	$23.2 M	$550 M	2.3%	$6.4 B[2]	$147 M
Cotton	1977	$9.8 M	$38.3 M	$844 M	1.2%	$120 M[3]	$1.4 M
Cotton	1989	$175 M	$334 M	$792 M	42%	$120 M	$50 M
Citrus	1977	$1.9 M	$7.4 M	$276 M	2.7%	$1 B	$27 M
Grapes	2016	$80 M	$80 M	$5.2 B[4]	1.5%	NA	$80 M
Pears	2016	$17.6 M	$17.6 M	$88.6 M[5]	20%	NA	$17.6 M
Total		**$297.1 M**	**$500.5M**				**$323 M**

[1] We multiply the benefit as a share of industry with the current income of the industry.

[2] Most recent number from 2013; [3] Most recent number from 2011;

[4] Most recent number from 2014; [5] Most recent number from 2014

million in almond revenue at the time. In 2013 the almond revenue in California was $6.4 billion. If IPM still creates a net annual gain of 2.3%, the current value would be about $147 million. Some of the practices continue today and other IPM programs have been added.

Another early study on the economic impact of IPM written in the 1970s concludes that IPM practices reduce pesticide use, pest management costs, and risk compared to conventional methods, but require fixed monitoring costs. The net gain was estimated to be $7 per acre for both cotton and citrus. In cotton, this corresponds to $9.8 million (1977 dollars), or $38.3 million in 2016 dollars. In 1977 this corresponded to 1.2% of the $334 million industry. The cotton industry has shrunk; 1.2% of today's $120 million industry is $1.4 million. For citrus, the estimates are $1.9 million (1977 dollars) or $7.4 million in 2016 dollars. In 1977 this corresponded to 2.7% of the $276 million industry. Today, California citrus is valued over $1 billion, so 2.7% is $27 million.

One of the major successes of IPM was the program to fight Pink Bollworm in cotton by reducing the growing season and improving timing of application through enhanced monitoring. A 1989 study on the economic impact of this program shows that farmers gain $168 per acre taking into account secondary benefits, and primary and secondary pests, which is $175 million annually in 1989 dollars, or $334 million in 2016. In 1989 this made up 42% of revenue, which would correspond to $50 million of today's industry.

Finally, a 2016 study on the impact of UC IPM in grapes and pears estimates that (i) the prevention of Pierce's Disease and damage by the glassy winged sharp shooter saved the grape industry $80 million annually, and (ii) disrupting the mating of the codling moth saved the pear industry between $11.7 and 23.4 million annually, on average $17.6 million. Given that pear industry revenue was $88.6 million in 2014, this savings corresponds to 20% of their total revenue.

Given just the results for these five crops summarized in Table 1, IPM has an annual benefit of $500.5 annually when the results from the studies are translated into 2016 dollars using a simple purchasing power calculator. When using a share of the industry calculation, an annual benefit of $323 million is realized. These numbers are massive and can be attributed to research faculty, Extension specialists, and farm advisors. However, we can not disentangle the value of extension—disseminating knowledge done by researchers—and the value of the original research. Therefore, we will turn to revealed preference approaches to value the work of extension.

Website and Opportunity Cost

As mentioned in the history section, one of the main tools UC Extension uses to distribute information about IPM is the IPM webpage. We will attempt to value the webpage to pinpoint the value of the Extension work. We use data for the traffic on the IPM webpage, combined with estimates on hourly wage and average hit time, to estimate the value of the IPM website. This is based on opportunity cost theory.

In a given hour, individuals can choose to sell their labor to the market or participate in another activity. Therefore, any activity they participate in must have an equal or higher value to them than their hourly wage. That is, the value of an hourly wage gives us a lower bound on the agent's valuation of the activity. To estimate the value of the IPM website, we apply different assumptions about hourly wage to the data, given that each hit to the website takes 10 minutes.

The website receives an average of 40,000 to 50,000 hits per day, with 85% of the hits from California. Given our assumption that each hit takes ten minutes, this is 6,667 to 8,333 hours of use per day. Preliminary website use data shows that not only are there many hits for pages aimed at commercial growers, but also for pages aimed at homeowners and home gardeners—such as hits about rats, squirrels, insects and spiders.

We use different measures of average wage in America from the Bureau of Labor Statistics (BLS) to estimate a range of values for the website. We include an estimated yearly wage of $80 thousand annually for agribusiness professionals, including PCAs. We use three average hourly wage estimates:

the average U.S. wage ($25), the average Californian wage ($26), and the average wage of an agricultural professional ($33). We then multiply the number of hours we estimate are spent on the website in total each day, to give a range of daily values for 40 to 50 thousand daily hits. We then take a daily average. Lastly, we create an annual average by multiplying the daily average by 300, which assumes 300 working days. The results of these calculations are shown in Table 2.

These estimates give us an idea of the lower bound on the value that the users have for the UC IPM website. We believe that the first calculation of an annual value of $57 million is the most reasonable. We do not know the careers of the website users, but search evidence suggests they are not all working farmers. Zilberman et al. 1991 suggest that the value of pesticides is around twice the value of the direct costs of purchasing them. If we apply this theory to the value of pesticide information, the information is worth twice the amount spent on obtaining it, we conclude that there is a net value of the IPM webpage of around $56 million dollars.

PCA Approach

While the UC IPM program does not trade its products directly in the market, it does aid in the training of PCAs who do trade their services in the market. PCAs are people licensed by the state to approve the use of chemical pesticides and to advise growers in IPM and other alternative pest control activities. UC IPM has been creating training materials for the PCA since 1988. According to the California Assocation of Pest Control Advisers, there are 4,000 PCAs in California making an approximate average of $75 thousand a year. This amounts to a $300 million industry. This is not the value of the pesticide industry as a whole, of course, but simply the value of the work done by the PCAs.

Table 2. Valuation of the IPM Website Using Different Hourly Wages

Average Hourly Wage	40K-50K Hits	Daily Average	Average Annual
$25 (US)	$167-208K	$188K	$56M
$26 (CA)	$173-217K	$195K	$59M
$33 (AG PRO)	$220-275K	$248K	$74M

Research on information consumption by agribusiness intermediaries suggests that PCAs would receive 30-60% of their information from the public. Since UC IPM participates in the licensing of PCAs, we expect the percentage of their information from public sources to be at the higher end of that range. If we assume 25% of the value of the service of the PCA comes from their information, then 7.5-15% of the value of the PCA industry comes from UC IPM. That is, $22.5-45 million annually, which we average at $34 million.

Conclusion

We have presented three different methods of estimating the benefits of the UC IPM program. From the partial case studies approach, we find a benefit of $323-500 million annually; from the website use approach, we find a benefit of around $56 million dollars annually; from the PCA industry approach we find a benefit of $34 million annually. Each of these approaches has limitations, and ways in which our numbers undervalue the true benefit of UC IPM.

We described how the case studies number does not include all crops or microclimates. The $56 million number we estimated from the website will not include some beneficiaries of the program that do not access their information through the website, but use traditional published manuals or Extension courses. The value of UC IPM to the PCA industry does not include the use of IPM by home gardeners. However, the shortcomings of the estimates of the benefits of UC IPM are due to an inability to control for all the ways that UC IPM benefits California agriculture, environment, and people. Our estimates suggest that the value of the program is certainly in the tens of millions annually, and probably valued above $100 million.

As we mentioned before, even a partial assessment of the impact of the UC IPM program suggests that it provides value in the hundreds of millions of dollars. But the revealed preference provides two measures of the value of the Extension program that together generate an annual benefit of about $80 million (even assuming some overlap, it is above likely to be $50 million). Since the annual budget of Extension is $67 million, and IPM is a modest part of Extension, we can conclude that investments made into UCCE generate enormously disproportional benefits.

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Where is the Social Safety Net for California's Agricultural Workforce?

Alexandra E. Hill

Eligibility restrictions based on legal status, family composition, and county residency impose significant barriers to social welfare program participation for California's agricultural workers.

Agricultural laborers are one of the poorest populations of workers in the United States. While the proportion of workers below the poverty line has fallen substantially over the last decade, recent estimates still find that roughly 22% of U.S. crop workers live in poverty. Despite this, participation by agricultural workers in social assistance programs is well below national averages. In 2003 program participation rates of eligible non-farm households reached 50 percent—almost double the rates for eligible farm households, at about 20 percent.

Even compared to workers in other low-wage occupations, U.S. agricultural workers have substantially lower participation rates. For example, in 2012, public program enrollment for agricultural workers was around 15%; around 52% for restaurant and food service workers; and around 30% for construction workers. In California, the state with the largest population of agricultural laborers, the picture is no different. Program participation rates among California agricultural workers are higher than national averages, but these still fall below participation rates for other California low-wage industry workers.

Examining specific program eligibility criteria identifies three main barriers to participation that are relevant for the agricultural workforce: (1) legal status, (2) family structure, and (3) seasonal employment. Figure 1 shows the participation rates for the families of California crop workers represented in the National Agricultural Workers Survey (NAWS) for several federal means-tested social welfare programs (programs that restrict eligibility based on income).

The most heavily utilized programs by these workers are Medi-Cal (the California name for Medicaid), CalFresh (the California name for the Supplemental Nutrition Assistance Program, SNAP), and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). Given the low average annual earnings of these households, these participation rates are much lower than expected.

Program Eligibility

The eligibility criteria for federal means-tested welfare programs shed some light on these low participation rates. Almost all of these means-tested programs restrict eligibility based on legal status. Among the programs presented in figure 1, WIC is the only one that provides equal benefits for undocumented and citizen workers. Medi-Cal and CalFresh allow undocumented workers to receive emergency medical services and emergency food assistance, respectively. The remaining programs— Low-Income Housing and CalWorks (the California name for Temporary Assistance for Needy Families, TANF)— strictly limit eligibility to lawfully present applicants, i.e., citizens and green card holders.

While these programs do not allow undocumented workers to receive full program benefits for themselves, they do allow them to receive benefits on behalf of their children. WIC is only accessible for women, infants, and children under the age of five, but places no restrictions on legal status.

Both Medi-Cal and CalFresh provide benefits for children under the age of 18, regardless of legal status. However, because these programs do not allow undocumented parents to receive full program benefits, mixed-status households (households with some citizens and some undocumented family members) are subject to different income eligibility thresholds and benefit amounts than all-citizen households. For both Medi-Cal and CalFresh, mixed-status families are treated as households with only the number of citizen members. For example, for a family of four, with two undocumented parents and two citizen children, they are treated as a household of two.

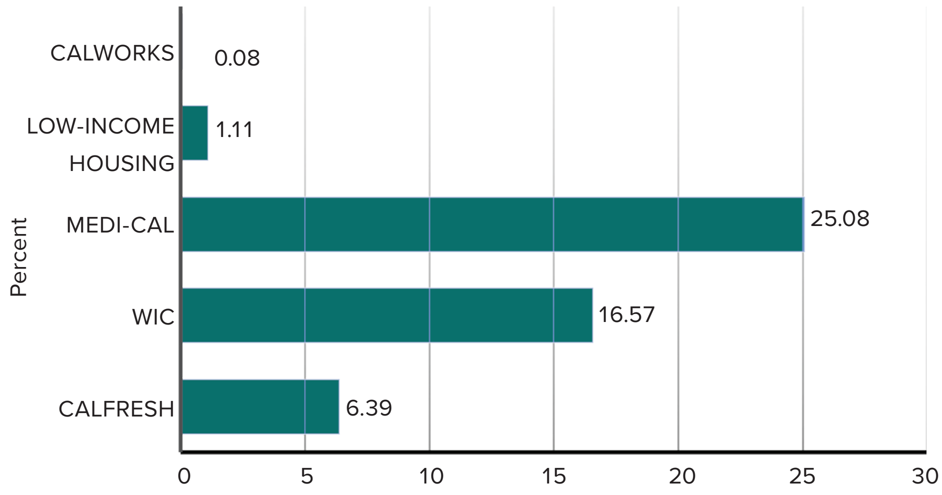

Figure 1. Program Participation Rates for California Crop Workers

Source: National Agricultural Workers Survey (NAWS).

Table 1. Mean Characteristics of California Crop Workers by Program Participation

	Participants				Non-Participants
	CalFresh	Medi-Cal	WIC	CalWorks or LI Housing	
N	1,259	4,110	2,715	230	8,778
Household Composition					
Family Size	4.43	4.05	4.26	4.58	2.76
# Kids <18 in Household	2.24	1.94	2.15	2.13	0.39
# Kids <18 Non-residents	0.08	0.07	0.06	0.11	0.51
Spouse in Household	81.12%	88.39%	92.52%	81.74%	54.61%
Non-resident Spouse	5.39%	1.68%	0.68%	5.32%	43.91%
Worker Characteristics					
Female (%)	29.39	28.13	28.55	36.52	14.09
Citizen (%)	9.29	10	7.07	10.87	9.14
Green Card Holder (%)	43.45	46.96	39.59	55.22	28.15
Undocumented (%)	34.55	40.56	50.46	15.65	61.38
Migrant (%)	15.17	9.84	9.46	19.63	35.45
Income					
Hours Worked per Week	41.16	44.73	44.73	41.02	44.39
Hourly Wage Rate	6.82	7.8	7.73	6.71	7.87
Per Person Annual Income	4,145.51	5,020.84	5,583.38	4,813.66	7,029.88

Source: National Agricultural Workers Survey (NAWS).

This has three implications for mixed-status families compared with families with all lawfully present members. First, mixed-status families are eligible for lower benefit amounts. Second, mixed-status households face different income thresholds. And third, these incredibly complicated programs are made exponentially more difficult to understand. For many agricultural workers, these program criteria inhibit households from applying for and receiving program benefits.

In addition to restricting eligibility based on legal status and family composition, the programs also impose state and county residency requirements that restrict access for many workers. Because benefits for all these programs are administered by county enrollment offices, program participants either have to reapply or submit proof of address changes after moving to a different county.

Particularly for migrant crop workers who relocate with the crop seasons, often changing counties, states and countries, these residency restrictions pose significant barriers to participation. To overcome this, both CalFresh and Low-Income Housing offer some expedited services for migrant workers; but despite simplifying the application process, this still requires workers to reapply after moving.

Characteristics of Program Participants

Using the NAWS data, Table 1 provides comparative summary statistics for California crop workers based on program participation. Relevant to family composition, compared with non-participants, program participants tend to have larger household sizes with more children under 18 living with them and fewer non-resident children living abroad. Participants are also substantially more likely to be living with a spouse in the United States, and much less likely to have a spouse living abroad.

Relevant to worker characteristics, compared with non-participants, a higher proportion of program participants are female or green card holders, while a lower proportion are undocumented or migrant. The dispersion of citizens varies across the programs, with CalWorks/Low-Income Housing participants having the highest proportion of citizen workers.

Finally, relevant to worker incomes, program participants tend to have lower wages and much lower per-person annual household incomes compared with non-participants. In general, average incomes for agricultural households are incredibly low. The lower incomes among program participants likely reflect both the income thresholds for program eligibility and the increased need for benefits for families with very low incomes.

The average hours worked varies across the programs. Medi-Cal and WIC participants work similar hours to program non-participants, while CalFresh and CalWorks/Low-Income Housing participants work fewer hours at substantially lower wages.

In light of the previously discussed eligibility criteria, these worker differences make sense. Undocumented workers are not eligible for full benefits for these programs, so they are less likely to participate. Additionally, undocumented workers tend to have fewer children living in their household, which likely contributes to their lower participation. Finally, the lower prevalence of migrant workers among participants compared with non-participants could be due to program residency requirements.

The variation in these worker attributes among participants in the different programs also aligns with the differences in eligibility criteria. For example, WIC has no restrictions on legal status for applicants, while CalWorks and Low-Income Housing have the most stringent restrictions. Among NAWS respondents, WIC participants have the highest proportion of undocumented workers, while CalWorks/Low-Income Housing have the lowest.

Similarly, CalFresh and Low-Income Housing participants have the highest prevalence of migrant workers. This is most likely because both programs have expedited services, specifically for migrant workers. Contrarily, for Medi-Cal and WIC, migrant workers must reapply for benefits after moving.

Finally, participants in these five programs, on average, have around two children living in their households, while non-participants have less than one. This family composition aligns with the increased eligibility for all of these programs for applicants with children. This could additionally reflect the higher benefit amounts for which workers with children are eligible.

Implications for the Workforce

In recent years, the agricultural labor market has been seeing a lower supply of workers, and, as an effect, producers have been increasingly competing with each other to attract the necessary labor. Employers have been increasing wages and offering their workers non-monetary benefits such as: facilitating enrollment in welfare programs; offering food donations at the farm; and providing child care and health care services. Limited by the prices they receive for agricultural products, employers are unable to raise wages substantially, so they rely heavily on these non-monetary benefits.

The combination of low wages and strenuous working conditions has made agricultural labor an undesirable industry for many workers. California agricultural employers have had growing difficulties competing for labor with employers in other low-wage industries. Many other low-wage jobs require far less effort and do not expose workers to the same grueling conditions.

Because of this, and many other reasons, the California agricultural workforce has long been dominated by immigrants who either have limited alternatives for work or who have experience in agriculture. Over the span of NAWS, this has been contributing to a growing proportion of undocumented immigrants working in California agriculture.

Many low-wage workers depend on program benefits to support themselves and their families. Unfortunately, the increase in undocumented workers means that California's agricultural workforce is increasingly ineligible for many social assistance programs.

There have been some legislative changes to these programs that have improved accessibility for some workers. For example, the Children's Health Insurance Program Reauthorization Act of 2009 extended Medicaid benefits to many children of undocumented workers. Like Medicaid, some programs have improved access for the children of undocumented applicants. Others, like SNAP, have increased spending for emergency services provided to undocumented workers.

Despite some legislative updates, none of these programs have removed the legal status restrictions. These eligibility restrictions and benefit reductions based on immigration status, family composition, and county residency continue to reduce program accessibility for workers.

For many low-wage workers, benefits from the social safety net are vital for ensuring the families are able to access food, housing, health care, and other necessities. For agricultural workers who are paid low wages, work long hours and face strenuous work conditions, the lack of accessibility to program benefits remains a dominating concern for both the workers and California agricultural producers.

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Low Income Housing: www.ilw.com/immigrationdaily/news/2011,0113-crs.pdf

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