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Biofuels Policy in Limbo

Aaron Smith

Federal legislation requires increasing quantities of biofuel to be blended into the fuel supply, but the EPA is vacillating on whether it will enforce this mandate. Biofuel mandates are an expensive way to reduce carbon emissions. The EPA's indecisiveness makes them even more expensive.

Also in this issue

Any game works better when the rules are enforced consistently, whether it is the Superbowl or Monopoly around the kitchen table. If the referee is indecisive, then the players are uncertain about how to play and the game degenerates.

Transportation fuel markets in the United States currently resemble a game with inconsistently enforced rules. The EPA plays the role of the referee. It is charged with implementing federal legislation known as the Renewable Fuel Standard (RFS), which requires ambitious quantities of biofuels such as ethanol and biodiesel to be blended into motor fuels.

Until recently, the fuel industry was able meet the RFS mandate without too much difficulty. However, the mandate now requires more biofuel than the fuel industry can easily absorb, and the EPA has vacillated on whether it will enforce the standard. We are almost at the end of the year, and the EPA still has not told the industry how much biofuel it must use in 2014.

This article explains how we got to this point and outlines the future prospects for biofuels policy.

Background

The transportation sector burns too much fossil fuel because motorists do not pay for their effects on the environment. In particular, fossil fuels generate carbon dioxide emissions that contribute to global climate change. Most economists recommend addressing this problem either by levying a tax on each gallon of motor fuel equal to the marginal emissions damages from using it or by implementing a cap-and-trade system.

Political impediments present an obstacle to a carbon tax or cap-and-trade system in the United States. Instead, the Obama administration has adopted an "All-Of-The-Above" policy, in which it subsidizes or mandates numerous potential low-carbon technologies. The aim of this policy is to reduce carbon emissions without explicitly "picking a winner," which is an admirable goal.

Many economists have argued that the RFS picks an expensive winner. Holland et al. (2014) estimate that renewable-fuel standards are about three times more costly than a cap-and-trade system. Stated simply, it is much cheaper to reduce oil use than to increase biofuel use.

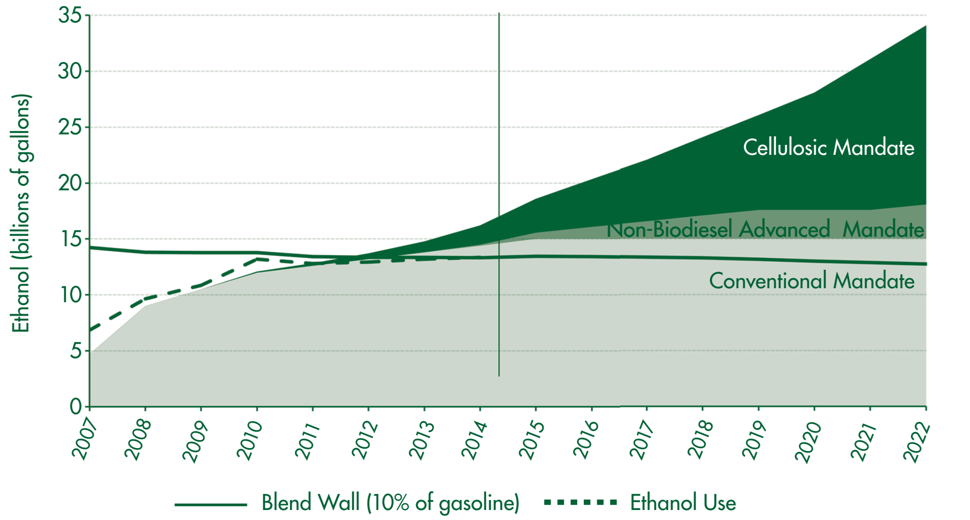
By legislating the RFS rather than a carbon tax, Congress has chosen an inefficient game for the industry to play. The EPA's job is to manage the game in the least costly way.

Current State of the RFS

The RFS requires increasing amounts of three categories of biofuel. The categories are defined by the estimated reduction in lifecycle greenhouse gas (GHG) emissions from using biofuel instead of gasoline. They are:

Cellulosic biofuels. These fuels are produced from the inedible part of

Figure 1. The Ethanol Blend Wall and the RFS Mandate



plants, e.g., corn stover, switchgrass. They are required to generate more than 60% GHG reduction.

Advanced biofuels. These fuels include biodiesel (produced mostly from vegetable oils and animal fats) and ethanol produced from sugarcane. They are required to generate more than a 50% GHG reduction.

Conventional biofuels. Corn ethanol is essentially the only fuel in this category. They are required to generate more than a 20% GHG reduction.

The EPA estimated that, by 2022, the average corn-ethanol gallon would generate a 21% GHG reduction and the average Brazilian sugarcane-ethanol gallon a 61% reduction relative to gasoline. Numerous researchers have challenged these numbers, including some who estimate that corn ethanol has GHG emissions at least as high as gasoline. EPA estimated that the average biodiesel gallon made from soybean oil would generate a 57% reduction relative to diesel. It also estimated that cellulosic ethanol fuels made from switchgrass or corn stover could generate more than a 100% reduction in GHG emissions relative to gasoline.

The mandate is nested, which means that advanced or cellulosic biofuels can be used to satisfy the conventional component of the mandate, and cellulosic biofuel can be used to satisfy the advanced component. Fuel producers are required to blend biofuels with gasoline and diesel at a rate sufficient to get the mandated amount of biofuel into the fuel supply. By 2022, the RFS specifies that about one-quarter of motor fuel should be biofuel.

The RFS faces two significant obstacles in 2014: (i) the blend wall, and (ii) the lack of cellulosic biofuel production.

The blend wall refers to a technical barrier on the amount of ethanol that can be blended into gasoline. The blend cannot exceed 10% ethanol without violating air quality standards and potentially damaging engines. However, the RFS now requires more biofuel than can be consumed by blending ethanol into gasoline up to 10%.

Figure 1 illustrates the blend wall by showing that ethanol use increased rapidly until 2010 when it reached 10% of gasoline consumption. Since that time, ethanol use has remained stagnant in the United States.

Breaching the blend wall will require either expanded consumption of biodiesel, which does not face any relevant blend restrictions, or increasing sales of a high-ethanol blend of gasoline known as E85, which contains up to 85% ethanol and can be used in flex-fuel cars. Although about 6% of registered vehicles in the U.S. have flex-fuel capability, very few gas stations sell E85. Since the mandate exceeded the blend wall in 2013, the market has chosen to comply with the RFS by increasing biodiesel production rather than expanding E85.

Figure 1 also shows the three components of the RFS. It shows the large increase in mandated volumes for cellulosic biofuels in the coming years. The RFS restricts the advanced component of the mandate by specifying a minimum contribution of biomass-based diesel. For the advanced component in Figure 1, I subtracted the required biodiesel quantity so as to show the ethanol quantities that would satisfy the mandate.

Cellulosic biofuel is the only category that entails substantial reductions in GHG emissions, so the level of cellulosic production will determine whether the RFS is ultimately considered to be a successful policy. Although cellulosic biofuel production is technically possible, it is currently very expensive. The statute allows the EPA to waive the cellulosic component of the mandate if there is inadequate domestic supply, and it has exercised this option each year so far. If cellulosic technology remains expensive, then it may be waived each year until 2022. In that case, the cellulosic mandate will not be costly to fuel markets, but nor will we see noticeable GHG benefits from the RFS.

In November 2013, the EPA announced that it also intended to waive the above-blend-wall quantities of the conventional and advanced mandates for 2014. It justified this rule on the grounds that the inadequate domestic supply provision extends to the distribution of fuels. In particular, there currently exists about 15 billion gallons (bgal) of production capacity for corn ethanol, whereas the blend wall binds at about 13.4 bgal. The EPA argued that it could not set the mandate at a level that requires more than 13.4 bgal of ethanol because the surplus would need to be sold as E85, and there aren't enough flex-fuel cars on the road with access to filling stations that sell E85. This announcement garnered a strong reaction from the biofuel industry and seemed unlikely to survive a court challenge.

Since that preliminary announcement, the EPA has been unable to come to a final rule for 2014. This leaves the industry in flux, not knowing what it is expected to produce this year or what technologies it should be investing in for future years.

Navigating the Blend Wall

I characterize three options for the EPA:

1. Extensive waivers. Set the cellulosic mandate at expected production (essentially zero), the advanced mandate at 2013 biodiesel production (1.5 bgal), and the conventional mandate at the ethanol blend wall. This is essentially the 2014 proposed rule.
2. Cellulosic, advanced and total waiver. Set the cellulosic mandate at expected production and leave the advanced and conventional mandates as in the statute.
3. Cellulosic waiver only. Set the cellulosic mandate at expected production and increase the advanced mandate to compensate for the lost cellulosic quantity. This is the rule the EPA used in 2013 and before.

Option 1 seems untenable under the law. Options 2 and 3 can both be justified using the provision that there is inadequate domestic supply of cellulosic biofuel. The statute gives the EPA Administrator the right to use either of these options. So, which one should it choose?

The open questions are, in the absence of additional policy measures, (i) how much would additional biodiesel demand drive up fuel prices, and (ii) at what price does E85 become cost-effective?

Table 1: EPA Options for Setting Mandate and Compliance Options for the Industry

		RVO					Compliance Possibilities			
							Plan 1		Plan 2	
	Year	Total	Corn Ethanol	Adv. Biofuel	Cell. Biofuel		BBD[1]	E85	BBD	E85[2]
RFS	2014	18.15	14.4	3.75	1.75					
	2015	20.50	15.0	5.50	3.00					
	2016	22.25	15.0	7.25	4.25					
EPA Option 1	2014	15.54	13.3	2.25	0		1.5	0	1.5	0
	2015	15.70	13.4	2.25	0		1.5	0	1.5	0
	2016	15.63	13.4	2.25	0		1.5	0	1.5	0
EPA Option 2	2014	16.40	14.4	2.00	0		2.1	0	1.5	1.3
	2015	17.50	15.0	2.50	0		2.7	0	1.5	2.7
	2016	18.00	15.0	3.00	0		3.1	0	1.5	3.6
EPA Option 3	2014	18.15	14.4	3.75	0		2.5	0	1.5	3.9
	2015	20.50	15.0	5.50	0		3.7	0	1.5	7.2
	2016	22.25	15.0	7.25	0		4.8	0	1.5	10.0

All quantities in billions of gallons. BBD = biomass based diesel. Amount of E10 equivalent gallons sold equals 132.94, 134.46, and 133.75 bgal in 2014, 2015, and 2016 respectively. The "corn ethanol" column would perhaps be better labeled "conventional biofuel" as this component could be met by any biofuel.

1. Billions of wet biodiesel gallons, i.e., (total – corn ethanol)/1.5. For compliance, a gallon of biodiesel counts for 1.5 gal of ethanol because of differences in energy content.

2. Billions of E85 gallons sold, assuming E85 is 74% ethanol and achieves 75% the fuel efficiency of E10.

In Table 1, I outline the compliance possibilities for 2014–16. I set the cellulosic mandate to zero for simplicity. If significant cellulosic production comes online by 2016, then the amounts of biodiesel and/or E85 required to achieve compliance under Option 3 will decrease accordingly. The table also ignores the California low-carbon fuel standard and other state policies. One effect of the California low-carbon fuel standard will be to substitute corn ethanol for sugarcane ethanol. However, this substitution does not affect this analysis as long as the ethanol blend wall binds.

I consider two compliance possibilities that represent possible extremes. In Plan 1, all above-ethanol-blend-wall biofuel comes from biodiesel. For convenience, I set E85 to zero in this scenario. Actual E85 sales are likely around 0.3 bgal this year, but this amount is measurement error around the blend wall, i.e., with this amount of E85, total ethanol use is about 10% of total motor gasoline sales. In Plan 2, biomass-based diesel production is set to the 2013 level of biodiesel production (1.5bgal), and the remainder of the mandate is met with E85.

Consider Option 2. So far, biodiesel production and imports in 2014 have been similar to 2013, so it is reasonable to expect about 1.9 bgal of biodiesel this year. This is close to the required 2014 amount under Option 2. By 2016, Option 2 requires 3.1 bgal of biodiesel production if E85 remains close to zero. To meet the mandate with E85 would require 3.6 bgal of additional E85. The E85 number is higher because (a) each gallon of E85 has about half the energy content of a gallon of biodiesel, so it contributes only half as much towards RFS compliance, and (b) E85 is less fuel-efficient than standard 10% ethanol-blend gasoline (E10), so more gallons need to be sold to produce the same vehicle miles.

Based on the numbers in Table 1, Option 3 seems infeasible at present. It would require a substantial increase in biodiesel production capacity and/or E85 sales. Next, I explore the implications of Option 2 for agricultural and fuel prices.

The U.S. used 1.8 bgal of biodiesel last year, so Option 2 would require an increase of about 70% by 2016. Some of this increase would come from soybean oil and other oilseeds, some from corn oil, some from animal fat, and some from other sources such as recycled cooking oil. The relative proportions of each depend on the responsiveness of supply from each source; more responsive sources will provide more of the increment.

Soybean oil is the most prominent biodiesel feedstock; it generated about 40% of 2013 biodiesel. About 25% of U.S. soybean oil is used to produce methyl ester, which becomes biodiesel, so a 70% increase in biodiesel demand would imply a $0.7*0.25 = 17.5\%$ increase in demand for U.S. soybean oil. It would require rigorous analysis to generate a precise estimate of the price effect of this demand increase, but 10–20% is the likely magnitude.

If the EPA were to follow Option 2 and if the industry were to comply using biodiesel, which seems likely, then U.S. diesel fuel would still be less than 10% biodiesel. In recent months, biodiesel has been about $0.50 per gallon more expensive than petroleum-based diesel. If the mandate pushed biodiesel prices up another 20%, then we may observe biodiesel prices as much as a dollar more than petroleum-based diesel. However, with biodiesel being only a small ingredient in the final fuel, consumers would see diesel prices rise by less than 10 cents.

Conclusion

As a tool for reducing carbon emissions, the RFS has been ineffective so far. It prompted a huge expansion of corn ethanol use, which offers little reduction in GHG emissions. The only real chance the legislation had to generate significant climate benefits was by spurring substantial production of cellulosic biofuel. When conventional ethanol hit the blend wall, the EPA signaled in November 2013 that it was unwilling to mandate any further expansions in biofuels, so this possibility seemed remote.

The lack of action in the past year suggests that biofuel proponents have swayed the EPA from this position, but these vacillations still bode poorly for future expansion of biofuels. In recent work, Gabriel Lade, Cynthia Lin, and I show how such policy uncertainty undermines the RFS by removing the incentive to develop cellulosic biofuels. Quantity mandates such as the RFS, which require large transfers from petroleum producers to biofuel producers, can easily be undermined if a regulator balks at enforcing the mandate when it gets expensive.

Where should we go from here? The obvious answer is to repeal the RFS and replace it with a carbon tax. Give the industry a better game to play.

Assuming that politics prevents that outcome, it seems likely that the EPA will follow a path like Option 2 in Table 1. This path will raise fuel prices by a negligible amount, raise food commodity prices by a noticeable amount, and benefit biodiesel producers at the expense of petroleum diesel producers. At best, we can hope that it will also signal to cellulosic developers that the EPA is willing to enforce the mandate and thereby inspire more investment in this technology.

The worst outcome would be for policymakers to add new subsidies to the RFS to further distort fuel and agricultural markets. In recent years, diesel blenders have received a $1 per gallon tax credit for blending biodiesel. This tax credit shifts the burden of blending biodiesel from diesel producers and consumers to taxpayers and could be reinstated retroactively for 2014. In addition, several analysts have proposed subsidies for E85 filling stations so as to lower the cost of compliance by expanding the E85 market. This action would expand corn ethanol use, providing little environmental benefit and again shifting the compliance burden from the fuel industry to taxpayers. If these possibilities eventuate, then an already inefficient policy will be made worse.

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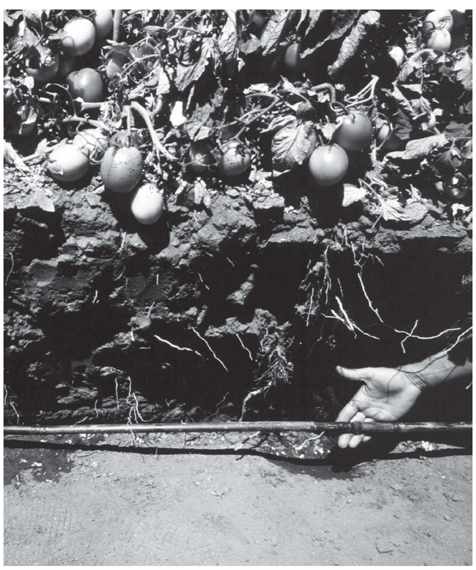
Holland, S.P., J.E. Hughes, C.R. Knittel and N. Parker, 2014. “Some Inconvenient Truths About Climate Change Policy: The Distributional Impacts of Transportation Policies,” *Review of Economics and Statistics*, forthcoming. www.mitpressjournals.org/doi/abs/10.1162/REST_a_00452#.VHt5-tZ0zSE

Lade, G.E., C.C-Y. Lin, and A. Smith, 2014. “Policy Shocks and Market-Based Regulations: Evidence from the Renewable Fuel Standard,” working paper, UC Davis. http://gabriellade.weebly.com/uploads/2/3/8/5/23857398/lade_policy_shocks.pdf.

Contribution of University of California Cooperative Extension to Drip Irrigation

Rebecca Taylor, Doug Parker, and David Zilberman

In the 100th anniversary year of University of California Cooperative Extension (UCCE), this study examines the role UCCE has played in the evolution and adoption of one noteworthy technology in California agriculture—drip irrigation. With UCCE personnel responsible for both introducing and continually adapting drip irrigation to numerous California crops and locations, we estimate the value of UCCE's work in drip irrigation brings the state $78 to $283 million annually in water savings and yield increases.



Soil cut away to expose a buried drip irrigation line in a tomato field.

Photo courtesy of Pete Mortimer, USDA ARS

The Cooperative Extension of the University of California (referred to as UCCE) is celebrating its 100th anniversary this year. UCCE is part of the Division of Agricultural and Natural Resources and comprised of 200 locally based farm advisors, 130 campus-based Extension specialists, 57 county offices throughout the state, and nine Research and Extension Centers. While UCCE's specific goals, methods, and name have changed over the last century, its basic vision has endured: "practical education for the people can lead to a better society for all."

In honor of 100 years of UCCE, we embarked on a study to assess the impact of Cooperative Extension in California, focusing on a handful of case studies. We chose a case-study approach because the literature on the distribution of benefits of Research and Extension Programs suggests that a small number of projects account for most of the effects of a research program.

We decided to start with drip irrigation for two reasons: At their fall 2013 meeting, an informal survey of County Directors identified drip irrigation as one of the major success stories of UCCE. Furthermore, it is timely to look at this technology during this period of severe drought in California. Moreover, the history of drip irrigation in California showcases the many roles UCCE plays: identifying, testing and disseminating new technologies, reducing adoption risk, training technology users, and continually collaborating with various clientele.

Drip Irrigation in California

Drip irrigation (and related low-volume irrigation technologies like trickle) requires investment in equipment that increases water-use efficiency (amount of water actually consumed by the crop), and improves the precision of water delivery in terms of the timing and location of irrigation. Its higher water-use efficiency tends to increase yields and frequently saves water used per acre. In choosing drip technology, farmers trade off higher equipment cost for better performance. The impact of drip technologies varies across locations and crops—for example, providing higher gains in sandy areas or on steep hills.

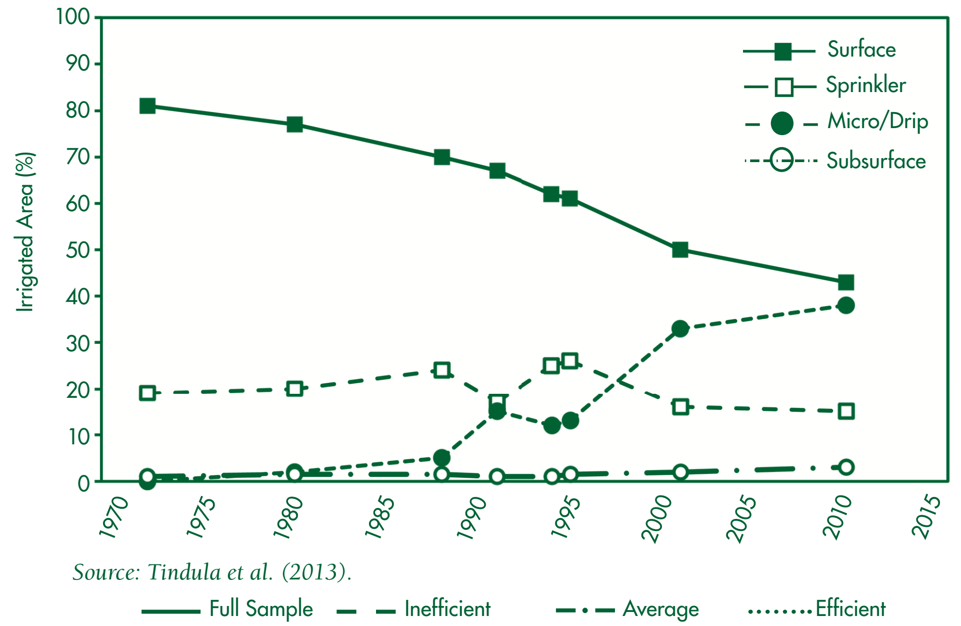
Drip was introduced to California agriculture in 1969, but its take-off was slow. By 1988, only 5% of irrigated acres in California were using drip irrigation, as switching to drip irrigation seemed costly and risky. From the beginning, UCCE farm advisors, specialists, and economists worked to provide information to improve these tough irrigation choices. UCCE initiated field experiments across the state and in numerous crops and raised awareness through research reports, demonstrations, and meetings.

UCCE efforts complemented that of drip manufacturers and distributors, with the private sector handling technical concerns and UCCE identifying how drip irrigation can improve economic and agronomic performance. Drip irrigation has since been widely adopted in the last 25 years, with almost 40% of the irrigated cropland in California now using drip. Below, we detail the different stages of its adoption.

Development, Introduction, and Early Adoption: 1965–1975

Israel introduced modern drip irrigation in 1965. Don Gustafson, a

Figure 1. Trends in Irrigated Area (Percent) by Irrigation System Category



Source: Tindula et al. (2013).

farm advisor in San Diego County, returned from a sabbatical in Israel in 1969 and initiated the drip irrigation movement in California, with a small, five-acre, experimental avocado orchard in San Diego County.

In 1970 the first drip irrigation seminar was held in Escondido, drawing 600 people and 18 equipment manufacturers. By 1974, only five years after drip's introduction into California, San Diego was invited to host the Second International Drip Irrigation Congress, drawing over 2,000 persons from 29 countries and 70 exhibitors.

Adoption of drip began to grow slowly in California. In 1976 there were about 60,000 drip-irrigated acres, in 1980 there were 305,000, and in 1985 there were 350,000. A major reason for the big increase between 1976 and 1980 was the drought of 1977–78.

Adoption of drip first occurred in avocados because of high water costs and hillside plantings. Another early application was in high-value strawberries, where UCCE farm advisor Bernarr Hall combined the use of drip irrigation and plastic mulching to grow strawberries on marginal land. Hall also introduced drip irrigation to fresh market tomatoes and is known for his promotion of drip tapes.

Technical Problems and Reputation Effects: 1980–1987

In the 1980s drip was mostly adopted in high-value fruit and vegetable production. However, its diffusion slowed. This was a period of low agricultural commodity prices and for most crops, the high cost of the technology—and several widely publicized failures in the design and service of new systems—made drip risky and unattractive.

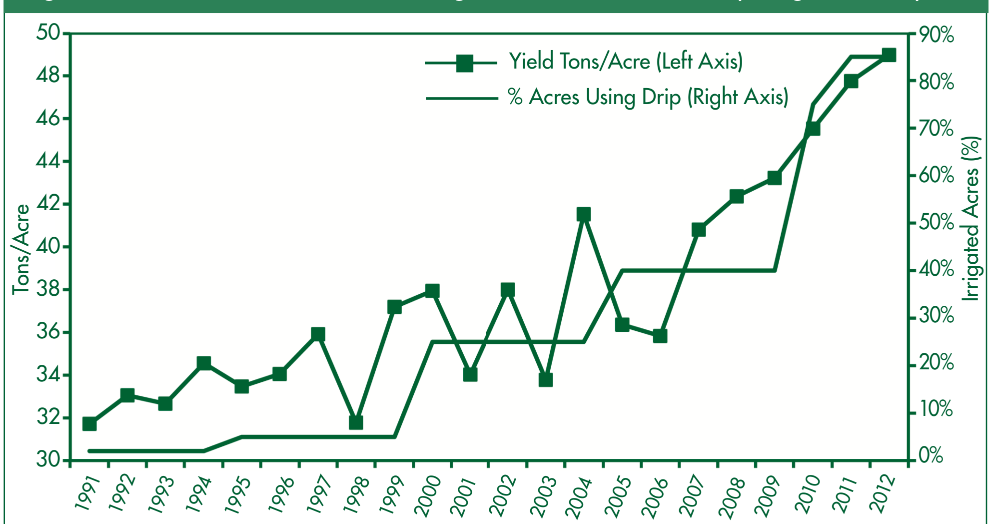
The private and public sectors labored to reduce the perceived risks of adopting drip. Private-sector firms worked on improving the product and its reputation. Fresno State's Center for Irrigation Technology (CIT) and Cal Poly's Irrigation Training and Research Center (ITRC) assisted the private sector in testing, evaluating, and improving irrigation equipment. UCCE initiated field experiments with drip irrigation systems on many crops across the state in order to gauge where and under what circumstances drip irrigation would be most successful. Together, these efforts mended the reputation of drip irrigation and developed a viable product for growers.

However, knowledge and availability of a viable product do not mean immediate and widespread adoption. When assessing a new technology, individuals consider not only whether to adopt, but when to adopt; timing is important and, as shown in Figure 1, the turning point for drip was the drought of 1987–91.

California Drought: 1987–1991

Between 1987 and 1991, California suffered a severe drought with annual precipitation averaging less than 50% of normal. During the first two years of the drought, reservoirs maintained surface water supplies. However, by 1991 the Central Valley

Figure 2. Trends in California Processing Tomatoes Yields and Drip Irrigation Adoption



Project's major reservoirs held less than 50% of their storage capacity.

This led growers to make a number of difficult decisions. One strategy was to fallow land with low-value crops. Another strategy was to expand the use of groundwater. The third strategy was to adopt water conservation technologies like drip. Between 1987–91, drip acreage in fruit production went up by more than 50%, and as much as 10% of vegetables were drip irrigated.

The fast adoption of drip took advantage of water management systems that were initiated by UCCE efforts—in particular, the California Irrigation Management Information System (CIMIS). From 1986 to 1991, the number of CIMIS users increased from 500 to 2000, and many more benefited from CIMIS indirectly by using information provided by consultants who were often trained by UCCE.

Adapting Drip to Other Crops and Regions: 1992–Present

After the drought years, private-sector innovation made drip systems more reusable, lowering the fixed costs associated with adopting drip and making it more economical. UCCE focused on researching methods for more effective water, fertilizer, and pest control management using drip, as well as training irrigators on how to operate and maintain drip systems.

The lower cost of equipment, combined with the high effectiveness of the technology, increased the range of crops and regions in which drip was profitable. A prime example is the work UCCE did in adapting drip technologies to processing tomatoes —a relatively large crop in California, with 317,000 acres in production, generating $984 million in revenue in 2010. Drip increased tomato yields, but canning companies were resistant to buy drip-grown fruits and vegetables because as yields go up, soluble solids and fruit sugars go down. UCCE Vegetable Specialist Tim Hartz identified a field sampling protocol for optimal ripening that increased yields with drip while maintaining high levels of soluble solids.

The adoption of drip in processing tomatoes also drastically increased because of efforts undertaken by Blaine Hanson and Don May to adapt drip irrigation to saline conditions, profitably increasing yields by up to 60%. Drip irrigation in processing tomatoes has gone from 0% of growers in 1987 to 5% in 1995, to 85% of growers in 2011. The trend in drip irrigation adoption among California processing tomato growers is shown Figure 2, alongside the trend in processing tomato yield. While there are other important factors likely at work in yield growth, the similarity between trends is striking.

Table 1. Value of Water Savings from Drip Irrigation, Annually

Marginal Cost of Water ($/acre-foot)	Value of Annual Water Savings from Drip Irrigation ($millions)	Value of UCCE's Work in Drip with Respect to Water Savings ($millions)
80	$128	$32
150	$240	$60
220	$352	$88

Assumptions: Agricultural water use is 33.32 million acre-feet.
Percentage of irrigated crops adopting drip is 40%.
Percentage of agricultural water saved from adopting drip is 12%.
Percentage of water savings accredited to UCCE is 25%.

Quantifying the Role of UCCE in Drip Irrigation

Quantifying the economic benefits from UCCE's contribution to the adoption of drip irrigation is a significant challenge. First, we must determine the value of drip irrigation to California, and second, decide the proportion of this value that accrues to UCCE. A common practice is to attribute 25% to the research and 25% to the development leading to a new technology. Since UCCE personnel are responsible for both introducing and adapting drip technologies to California crops, we believe it is fair and conservative to also attribute 25% of the value of drip irrigation to UCCE.

The value of drip irrigation in California has several dimensions—saving water, reducing chemical usage and increasing yield—leading to a net surplus for consumers and producers. Starting with water savings, though there are numerous farm-level studies showing that the water-saving effects of drip range from 5%–40%, they do not provide reliable aggregate estimates of impacts. Thus, to obtain an estimate of the water savings associated with using drip irrigation, we employ detailed data from Monterey Country.

According to the Center for Irrigation Technology, on average, 33.22 million acre-feet of water is used by the agricultural sector in California annually. Using 18 years of data on water extraction and irrigation methods from the Monterey County Water Resources Agency, we estimate that full adoption of drip irrigation in Monterey County is correlated with an 11.9% decrease in total agricultural water pumped per year.

Extrapolating the Monterey County estimates to the rest of the state, an increase in the percent of drip acres in California to 40% in 2010 would be associated with a 4.76% decrease in total water pumped (11.9% * 40%). Subtracting roughly 5% of the 33 million acre-feet used per year would mean 1.58 million acre-feet in annual water savings for California.

Table 2. Increase in Farm Income from Drip Irrigation, Annually

Yield Effect of Drip Irrigation	Increase in Farm Income from the Yield Effect ($millions)	Value of UCCE's Work in Drip with Respect to the Increase in Farm Income ($millions)
5%	$185	$46
15%	$508	$127
25%	$778	$195

Assumptions: Net farm income in crop production is $7.2 billion
Percentage of irrigated crops adopting drip is 40% (60% of high-value crops and 15% of low-value crops).
Percentage of agricultural crop value from high-value crops is 86%.
Percentage of yield effect accredited to UCCE is 25%.

To put this in monetary terms, the cost of an incremental unit of water varies across location and season, and it can be between $80/acre-foot to $220/acre-foot, with an average cost of $150/acre-foot for water use in drip (Table 1). Thus, using $150/acre-foot, the average water-saving effect of drip irrigation will be $240 million per year.

We realize these estimates reflect the impact of the adoption of drip within a water system that has been affected by other factors—such as water availability, consumer demand, and environmental regulation. However, when the water-saving effect of drip irrigation in different studies ranges from 5% to 50%, our estimate is quite conservative.

Drip irrigation has also been shown to augment crop yields; however, the estimated yield effects of drip irrigation vary. For instance, in the case of processing tomatoes, a major study found that drip irrigation increases yields by as much as 60%; while using aggregate country data, we find that drip adoption is correlated with a 41.6% increase in processing tomato yields.

In light of the variability of drip's effect on yields, depending on crop type, location and timing, the yield effect of drip is likely to be between 5% and 25%, with an average of 15% (Table 2). The yield effect is approximately equal to the effect on farm income from crop production (i.e., the total revenue excluding input costs).

Crop production comprised roughly 68% of California's $10.6 billion net farm income in 2010 (revenue excluding input costs, etc.), which equates to $7.2 billion. Given statewide adoption of 60% among high-value crops—which produce roughly 86% of the total agricultural income—and adoption of 15% among low-value crops, the value of the yield effect of drip in California lies between $185 million for a yield effect of 5% and $778 million for a yield effect of 25%, with an average of $508 million for a yield effect of 15%.

The sum of the value of water saving and the additional income from the yield effect lies between $313 million and $1.13 billion, with an average of $748 million. Accrediting UCCE one-fourth of this value means that UCCE's work in drip irrigation brings the state between $78 million and $283 million annually. Considering the entire UCCE budget in 2010 was $99 million, this is a remarkable return on investment. Furthermore, UCCE is involved in hundreds of projects every year, and drip irrigation is only one. Thus, these estimates are conservative with respect to the total value UCCE brings California.

It is important to note that these results do not take into account benefits of drip to consumers, as well as the environment, which may be substantial. The value of drip is also much higher in years of drought when water prices increase and water-use shifts towards high-value crops. In years of water abundance, we see the opposite effect. Lastly, our results do not include the quality-enhancing effects of drip irrigation in several crops, where deficit and precision irrigation lead to a superior crop quality.

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Taylor, R., D. Parker, and D. Zilberman, 2014. "Contribution of University of California Cooperative Extension to Drip Irrigation." *ARE Update* 18(2):5-8. University of California Giannini Foundation of Agricultural Economics.

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For additional information, the authors recommend:

Caswell, Margriet, and David Zilberman, 1985. "The Choices of Irrigation Technologies in California," *American Journal of Agricultural Economics*, 67(2): 224-239. http://ajae.oxfordjournals.org/content/67/2/224.

Tindula, Gwen N., Morteza N. Orang, and Richard L. Snyder, 2013. "Survey of Irrigation Methods in California in 2010." *Journal of Irrigation and Drainage Engineering,* 139(3): 233-238. http://ascelibrary.org/doi/abs/10.1061/%28ASCE%29IR.1943-4774.0000538.

Scheuring, Ann F., 1988. "Sustaining Comradeship: The Story of University of California Cooperative Extension, 1913-1988." Regents of the University of California.

Farm Labor and Immigration: Outlook for 2015

Philip Martin

Fears of farm labor shortages have made California farmers keen observers of immigration patterns and policies. On November 20, 2014, President Obama announced a new Deferred Action for Parental Accountability program to allow unauthorized foreigners with legal U.S. children who have been in the United States at least five years to obtain renewable three-year work permits. The effects of DAPA on farm workers are unclear. Up to 500,000 farm workers, half in California, may qualify for DAPA status, which may encourage some to seek nonfarm jobs.

Three major issues—labor shortages, the growing role of farm labor contractors in bringing workers to farms, and the impact of Obama's executive orders—will shape California's farm labor market in 2015. This article examines these issues.

About 60% of the workers employed on the state's farms have been unauthorized for the past decade. Most new entrants to farm work have been young, Mexican-born men who filled seasonal farm jobs for about a decade. The slowdown in Mexico-U.S. migration since the 2008–09 recession, reflecting a combination of fewer U.S. jobs, fewer Mexicans in rural Mexico eager to move to the U.S., and more fences and agents on the Mexico-U.S. border, has prompted fears of wage spikes linked to labor shortages.

There were signs of a labor shortage in the San Joaquin Valley in 2012, when the average hourly earnings of farm workers rose over 10%. Complaints of labor shortages and wage increases have since decreased, except in the Napa-Sonoma and Salinas Valleys that have higher living costs. Some Salinas vegetable growers, who use H-2A guest workers when producing vegetables in Yuma, Arizona, are bringing experienced guest workers to Salinas during the summer months to ensure sufficient harvest workers.

The state's minimum wage, now $9 an hour and scheduled to increase to $10 on January 1, 2016, has combined with expectations of fewer and more expensive farm workers to prompt labor-saving changes. One of the most important labor-saving changes is the switch from labor-intensive crops, such as raisins and canning peaches, to mechanically harvested almonds and walnuts. Rising consumer demand combined with less need for farm labor explain some of the 40% expansion of bearing almond acreage over the past decade. In contrast, periods of low prices and fears of labor shortages help to explain the almost 25% decline in bearing raisin acreage.

Farmers producing labor-intensive crops are mechanizing, as with the state's raisin grape industry. Harvesting raisins in the 1990s involved over 50,000 workers during a six-week period who cut bunches of green grapes and laid 25 pounds on a paper tray to dry in the sun. Workers were paid piece-rate wages of about $0.31 per tray in 2014, and most picked 30 to 40 trays an hour to earn about $10 an hour.

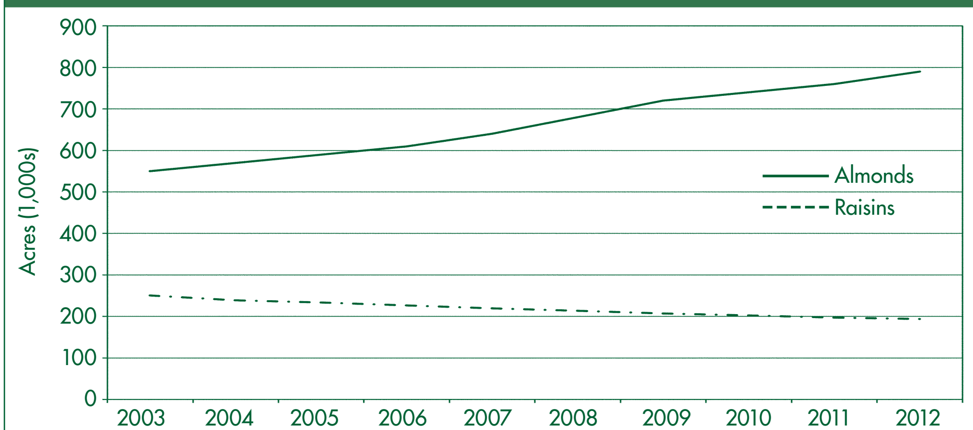
However, raisin harvesting today involves half as many workers because of declining acreage and labor-saving mechanization. Harvesting raisins is a race between sugar and rain. Letting grapes stay on the vine increases sugar levels, but later harvesting raises the risk of rain damaging the drying raisins.

Raisins have traditionally been made from Thompson seedless grapes. Varieties such as Selma Pete ripen earlier so that the canes holding bunches of green grapes can be cut and the grapes dried partially or fully into raisins while they are on the vine. A wine grape harvester can lay partially dried raisins on a continuous tray in the vineyard until they dry into raisins on the ground.

An alternative involves fully drying grapes into raisins while on the vine (DOV). Yields are often higher in DOV systems because vines can be planted closer together, since land between the rows is not needed for drying. A third alternative has raisins growing on an overhead trellis. The canes are cut so that the grapes dry into raisins, and a machine travels under the trellises to harvest the raisins. Researchers are working on grape varieties that automatically begin to dry into raisins, eliminating the need to sever canes.

Very low raisin prices in 2001–03, less than $1,000 a ton, drove many raisin farmers out of business and encouraged others to replant their vineyards to earlier maturing and higher-yielding varieties

Figure 1. California Almond and Raisins, Bearing Acreage, 2003–12



Source: California Department of Food and Agriculture

Figure 2. California: Average Crop, Crop Support, and FLC Employment, 2004–13

Source: U.S. Employment Development Department

suitable for DOV systems. California raisin production fell from 400,000 tons a year a decade ago to about 330,000 tons a year recently, bringing supply and demand into balance and reducing the need for harvest workers.

Labor Contractors

Farm labor contractors (FLCs) have long been associated with low wages and poor conditions for farm workers. One reason is that contractors often compete with each other to bring workers to farms. The usual transaction involves a farm employer and contractor agreeing on an hourly or piece-rate wage that will be paid to workers, and then negotiating an overhead to cover the contractor's payroll taxes, compliance with field sanitation and other regulations, and profits.

Contractors rely on crew bosses to supervise a crew of 20 to 60 workers. Most crew bosses have assistants, often relatives, to help them to recruit and monitor workers. Work crews often include members of the same family, which can facilitate recruitment and car-pooling but can also lead to uneven productivity, since getting the "good" workers in an extended family may also require accepting less-productive workers.

The labor contracting industry is growing. Between 2004 and 2013, California crop farms hired fewer workers directly, but one-third more workers were brought to farms by non-farm crop support services, which are dominated by FLCs. Contractors are rapidly becoming the major employers of workers on the state's crop farms.

The contracting industry appears to be segmenting. Large contractors may hire several thousand workers, have professional managers to supervise crew bosses, and announce overhead rates to farmers and refuse to cut them. Farmers who use these "good" contractors pay commissions of 30% or more above the $9 or $9.25 wage paid to workers. In exchange, growers get assurance that they will not be found jointly liable for labor law, immigration, tax, and other violations. Smaller contractors may be willing to work for much lower and sometimes money-losing commissions, but survive by paying some workers in cash and thereby saving on required payroll taxes, among other things.

Many of the state's 460 table grape growers use good contractors to obtain harvest workers. Table grape growers produced 116 million 19-pound boxes of grapes in 2013, including 48 million boxes that were exported. The number of California table grape growers has shrunk by more than half in the past two decades, while production has increased five-fold.

The Delano area that straddles the Tulare-Kern county border is considered the "Napa of table grapes" because of its high-quality and often proprietary varieties of table grapes. Most table grape growers use contractors to find teams or "trios" of two pickers and one packer. Pickers cut bunches of grapes and put them into plastic bins that are wheeled to a packing station. Here, the packer trims the bunches and places them into the bags that appear in supermarkets.

If wages are $9.25 an hour plus $0.33 a box, a trio picking and packing 10 cartons an hour earns $10.35 an hour, since the three workers share the per box bonus. During the 12-week harvest, many workers work 800 hours and earn over $8,000.

Crew bosses supervise 60-person table grape harvesting crews—40 pickers and 20 packers. The major responsibility of the crew boss is to ensure that the crew is at full strength and the workers are doing a good job. The table grape labor force in the Delano area is local and diverse, dominated by Mexican-born workers but including U.S.-born Filipinos. Contractors large and small acknowledge that one-half or more of the workers they hire are unauthorized, although all workers present documentation—usually social security cards and green cards or immigrant visas.

President Obama and DAPA

On June 30, 2014, President Obama promised to "fix as much of our immigration system as I can on my own, without Congress." After the Republicans took control of Congress in the November 2014 elections, Obama said that he would give them "some time" to act; but, if they did not, he would "take the steps that I can to improve the system."

President Obama acted on November 20, 2014, outlining the Deferred Action for Parental Accountability (DAPA) program, an executive action that would allow an estimated four million unauthorized foreigners whose children are American citizens or legal permanent residents and who have been in the U.S. at least five years, to apply for renewable three-year deportation deferrals and work permits. DAPA, expected to be in place before May 2015, allows unauthorized foreigners seeking temporary legal status to undergo background checks, submit fingerprints, and pay $465 for renewable work permits and Social Security numbers.

President Obama also extended the Deferred Action for Childhood Arrivals (DACA) program that began in 2012. By eliminating the requirement that applicants be under 31 when they apply, DACA now allows more unauthorized foreigners brought into the U.S. before the age of 16 to obtain a temporary protected status. About half of the 1.2 million unauthorized eligible for the current version of DACA have registered, and another 300,000 are expected to become eligible.

Those legalized under the DAPA and DACA programs will not be eligible for federal health-care subsidies or federal welfare benefits such as food stamps and Medicaid, although some states are likely to allow DAPA and DACA registrants to receive driver's licenses and pay in-state tuition. President Obama ordered DHS to waive the three and ten-year bars for obtaining legal immigrant status for unauthorized foreigners residing in the U.S. more than six months and a year, respectfully, so that unauthorized spouses and children of immigrants can receive immigrant status without leaving the United States.

Studies of unauthorized foreigners legalized in 1987–88 found that their wages rose 10–15% within five years, primarily because legal status gave them more freedom in the U.S. labor market. With documents, workers were more likely to seek higher-wage jobs, and some moved up the U.S. job ladder, even though most still had low levels of education.

Farm workers were not granted any special status but up to 500,000, including half in California, may qualify under DAPA and DACA. For the 70% of U.S. crop workers who are foreign-born, almost 90% were in the U.S. for at least five years. The average age of farm workers was 37, and almost 55% had an average of two children under 18 living with them when they were interviewed doing farm work.

These data refer to an estimated 1.8 million U.S. crop workers, making 935,000 crop workers unauthorized and 820,000 in the U.S. at least five years. If 55% of these 820,000 have children, then 450,000 parents have qualifying children. If two-thirds of these children were U.S.-born or are legal immigrants, than 300,000 parents would satisfy the five-years in the U.S. and legal children requirements, or one-third of unauthorized crop workers.

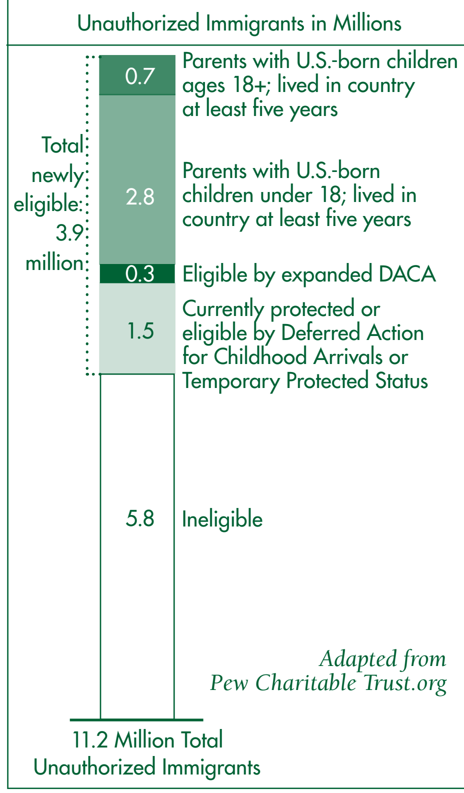
Similar calculations for the 700,000 workers employed in livestock would suggest another 120,000 eligible unauthorized farm workers, for a total of 420,000. In addition, there may be 50,000 unauthorized farm workers who were brought to the U.S. as children who can qualify for DACA status, which requires a high-school education or completion of U.S. military service.

Some farm groups expressed concern that DAPA and DACA will encourage current farm workers to move to nonfarm jobs that offer higher wages, more hours of work, or benefits. If a significant number of unauthorized farm workers register and leave the farm work force, and they are not replaced by new entrants or guest workers, then the labor-saving crop changes and mechanization underway are likely to continue.

Conclusions

The availability of farm workers has long been a concern for California's farmers. The slowdown in Mexico–U.S. migration since 2008–09, economic growth in Mexico, and stepped-up enforcement of U.S. immigration laws prompted complaints of farm labor shortages and a sharp jump in wages in 2012. Since then, crop changes and labor-saving mechanization have stabilized the farm labor market, as some "super" labor contractors evolve into preferred employers.

Figure 3. Who Will Benefit from President Obama's Executive Action?



There are about eight million unauthorized workers in the U.S., including 1.5 million in restaurant and hospitality occupations, 1.3 million in construction jobs, one million in agriculture, and 750,000 in wholesale and retail trade. President Obama's executive actions potentially give legal status to half of them. Up to 20% of the 2.5 million U.S. farm workers, and up to 30% of the 800,000 California farm workers, could receive work permits under DACA and DAPA, introducing new uncertainties about whether they will stay in the farm work force.

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