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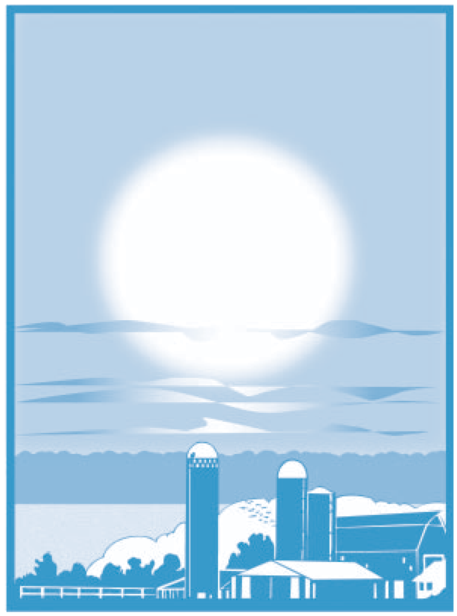
Costs and Benefits to Agriculture from Climate Change Policy

Bruce A. Babcock
babcock@iastate.edu
515-294-6785

Consideration and subsequent passage of the American Clean Energy and Security Act of 2009 by the U.S. House of Representatives focused attention on whether agriculture would be helped or hurt by the policy's objective of reducing U.S. greenhouse gas emissions. Even though Collin Peterson, chairman of the House Agriculture Committee, sought and obtained changes to the legislation that were favorable to agriculture, many farm groups came out in opposition to the bill. One example is the American Farm Bureau Federation, which estimated that U.S. net farm income would decrease by at least $5 billion per year by 2020. Other farm groups supported the legislation, including the National Wheat Growers Association, which found that the Peterson changes helped shape a policy that will "…ensure that agriculture has a place in any climate change legislation and that producers are able to reap potential benefits rather than just accept coming costs."

Whether agriculture will be a net winner or loser from climate change policy will depend on the details contained in any final piece of legislation. But the sources of agricultural costs and benefits are well known, so it is possible to identify how agriculture could be affected. For example, to the extent that climate change policy leads to increased energy costs, farmers will have to pay more for diesel, electricity, fertilizer, and pesticides. The effects of these



cost increases on production levels and market prices will ultimately determine the extent to which farm income is negatively affected by higher energy costs. Another source of costs to agriculture would arise if agricultural emissions of greenhouse gases were subject to a cap. Such a cap could force crop farmers and livestock producers to limit emissions of methane and nitrous oxide, much as the electricity-generating sector will have to meet a cap on carbon dioxide emissions. The House bill explicitly treats agriculture as an uncapped sector, and it is likely that the Senate will follow suit in any bill that they pass. In the House bill, a capped sector would be able to offset excess greenhouse gas emissions by buying emission reductions from uncapped sectors, such as agriculture. This possibility, of farmers selling emission credits, explains why there are supporters of climate change policy within agriculture.

Why a Carbon Cap-and-Trade System Will Increase Farm Production Costs

Currently, U.S. companies face no limits on their emissions of greenhouse gases. A lack of any constraint means that U.S. industry has been able to choose manufacturing methods and technologies that minimize their costs without consideration of their impact on atmospheric greenhouse gas concentrations. In economic terms, greenhouse gas emissions have been external to the internal decision-making processes of companies. Having companies put a non-zero weight on emissions is the first step in cutting emissions.

The fairest policy would seem to be one that requires all companies to reduce their emissions by the same percentage. But economists have shown that such a uniform policy can greatly increase the total cost of meeting a target reduction. It makes more sense for companies that can most easily reduce greenhouse gas emissions to do the greatest share of the cutting, thereby allowing other companies to continue to emit, as long as the overall target is met.

Two policies can achieve efficient emission reductions: a carbon tax and a cap-and-trade program. Under a carbon tax (or a carbon dioxide equivalent tax for nitrous oxide and methane), companies choose to either emit and pay the tax or cut emissions. A straightforward calculation will reveal the best alternative. Companies that can easily cut their emissions will do so. Those that cannot easily cut emissions will pay the tax. The tax is set at a level that increases the price of carbon enough to induce companies to cut their emissions enough to meet the overall targeted reduction.

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IN THIS ISSUE

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Under a cap-and-trade program, overall emissions are capped. Companies are free to emit as much as they want as long as they have a permit for each ton of emissions. The trade part of the program allows companies to buy and sell the permits. Those companies that can easily reduce emissions can make money by cutting their emissions and selling their excess permits. Companies that find it too expensive to cut emissions can buy permits and continue to emit.

The key for either policy option is to increase the price of emission, which automatically creates a profit incentive for companies to figure out whether it is better to cut emissions or pay to emit. Thus, it doesn't really matter which option is adopted. What does matter is increasing the cost of emitting greenhouse gases, which in turn will automatically increase the cost of producing those goods that currently result in large greenhouse gas emissions. The industries that are targeted by the House bill are electric utilities, oil refiners, natural gas producers, and some manufacturers that produce energy on site. This means that the price of electricity, gasoline, diesel fuel, home heating oil, and natural gas will increase. It naturally follows that products that rely heavily on these energy sources will also become more expensive.

Although agriculture contributes about 6.7 percent of total U.S. greenhouse gas emissions, it faces no future emissions cap under the House bill. This does not mean that agriculture will be unaffected by the cap-and-trade program in the energy sector. Higher energy costs will translate directly into higher prices for electricity, propane, and diesel fuel, and domestically produced fertilizer and pesticides. The cost of producing fertilizer and pesticides in other countries will not be directly affected by U.S. legislation, but if other countries limit their greenhouse gas emissions, then their production costs will also increase.

Magnitude of Cost Increases

The amount by which farmers' costs will increase depends on the quantities of energy-intensive inputs they use, the amount of flexibility they have in moving away from more expensive inputs, and the price at which carbon settles. An example for Iowa corn and soybean production illustrates an analysis of energy costs under cap and trade.

Iowa farmers who plant both corn and soybeans use approximately four gallons of diesel per acre to cultivate, plant, and harvest their crops. They also use about 60 pounds of nitrogen fertilizer, 50 pounds of phosphate, and 65 pounds of potash across the two crops. And corn farmers typically use propane to dry their corn.

The carbon dioxide (CO_2) emission from using a gallon of diesel fuel is 10.1 kilograms. Thus, Iowa crop farmers emit about 40 kilograms (0.04 metric tons) of CO_2 per acre in diesel. If the price of CO_2 is \$20 per ton, then farmers will have to pay \$0.80 per acre extra for their diesel fuel.

Natural gas is the primary source of energy used to produce fertilizer. One source (Gellings and Parmenter, 2004) estimates that the energy used to produce, package, and transport different fertilizers is approximately 33,000 British thermal units (Btu) per pound for nitrogen, 7,000 Btu per pound for phosphate, and 5,500 Btu per pound for potash. Natural gas emits 117 pounds of CO_2 per million Btu. This adds up to about 0.14 tons of CO_2 per acre across corn and soybeans. At a price of \$20 per ton of CO_2, this amounts to \$2.85 per acre.

To dry a bushel of corn from 19 percent moisture to 15 percent moisture uses about 0.088 gallons of propane. With a yield of 180 bushels per acre, this amounts to 15.84 gallons of propane per acre for corn drying costs. Emission of CO_2 from burning a gallon of propane is 5.525 kilograms. Thus, at a CO_2 price of \$20 per ton, propane costs would increase by \$1.75 per acre of corn, or by \$0.87 per acre across corn and soybeans (assuming no drying costs for soybeans).

Adding up the extra costs from diesel, fertilizer, and propane at a price of \$20 per ton of CO_2 results in a cost increase of \$4.52 per acre for Iowa's corn and soybean farmers, assuming that farmers make no adjustments to their operations. A different price for CO_2 would change this cost estimate proportionately. To put a cost increase into perspective, the variable cost of producing corn and soybeans in Iowa in 2009 is somewhere around \$300 per acre. Thus even a \$10.00 increase in the cost of production represents a 3.3 percent increase. To add more context to this increase, Iowa corn and soybean farmers receive approximately \$20 per acre in direct payments as part of the 2008 farm bill. In addition, most farmers receive between \$5.00 and \$20.00 per acre in crop insurance subsidies.

Livestock farmers would also be affected by energy cost increases. According to livestock enterprise budgets put together by John Lawrence at Iowa State University, fuel, repairs, and utilities account for about 5 percent of total costs in swine when hogs are produced in confinement. Thus a 20 percent increase in this cost category would increase Iowa's average cost of producing hogs by about 1 percent.

Magnitude of Benefits from Agricultural Carbon Offsets

The price of emission permits in a cap-and-trade program will be determined by the cost of reducing greenhouse gas emissions from capped sectors of the economy, or by the cost and availability of offsets from uncapped sectors, such as agriculture. The Peterson amendment to the House bill identified offset activities that agriculture could provide. Some of these include conservation tillage, reduced nitrous oxide emissions caused by fertilizer use, increased biomass sequestration from use of winter cover crops and reduced use of fallow, and reductions in methane emissions from livestock production. In addition, crop producers could convert their land from crop production to tree production.

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Benefit for Crops

Conservation tillage has been advocated for years as a way to reduce costs and increase soil health. And it is now the rare farmer who does not try to keep tillage operations to a minimum. But adoption of no-till has stagnated. A widely used estimate of the annual amount by which soil carbon can be increased from adoption of no-till farming is one ton of CO_2 per hectare, or about 0.4 tons per acre. At a \$20-per-ton carbon price, this amounts to \$8.00 per acre.

The costs of no-till must help explain the stagnation in the number of farmers willing to adopt this method. Some of these costs in Iowa are the cost of a no-till planter, the perceived benefit of fall tillage after corn to help break down the corn stover, and, for farmers who plant continuous corn, the delay in planting and/or germination caused by late-to-warm soils. Despite these costs, a significant number of farmers would likely move to no-till with an offer price of \$8.00 per acre.

Farmers obtain large benefits from nitrogen fertilizer, and there is uncertainty about how to control nitrous oxide emissions from crop production. Therefore, the only prescription for low-cost reduction of nitrous oxide emissions is to increase the efficiency with which nitrogen fertilizer is used. But this prescription holds true with or without energy policy incentives, particularly with the high fertilizer prices recently, so for now it is unclear how much crop farmers can benefit by trying to reduce nitrous oxide emissions.

According to the U.S. Environmental Protection Agency, planting trees can sequester between two and nine tons of CO_2 per year (see www.epa.gov/sequestration/rates.html). In the Corn Belt, sequestration rates are about four tons per acre. At a price of \$20 per ton, this can generate between \$40 and \$180 per acre per year (\$80 for Corn Belt land). Of course, to obtain this revenue, a farmer must quit growing crops and put up an investment to establish a forest. It is unlikely that crop farmers on productive land will increase profits by swapping cropland for forests. Even if the CO_2 price were to double, the returns to growing crops would quickly rise if a lot of prime cropland were taken out of production and put into forests. It is more likely that owners of land that is more suitable for forests than crops will find it worth their while to establish trees as a carbon offset. But most of this type of land has already been taken out of crops over the last 30 years, so the amount of U.S. land that can be converted in response to the cap-and-trade policy is probably quite limited.

Benefits for Livestock

Livestock producers can reduce methane emissions by covering their anaerobic lagoons or by investing in anaerobic digesters to stabilize their manure. Estimates of the reduction in methane emissions vary dramatically across types of operations and adopted mitigation technologies. There are examples of

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Measuring Unmeasurable Land-Use Changes from Biofuels

Bruce A. Babcock
babcock@iastate.edu
515-294-6785

The debate over whether biofuels are good for the environment used to hinge on the credibility of studies published by David Pimentel, professor of ecology at Cornell University, who concluded that it took much more energy or fossil fuel to grow, transport, and process corn into ethanol than the ethanol could ever hope to replace as transportation fuel. A preponderance of other studies on the issue found the data and methods used by Pimentel to be suspect, and most concluded that biofuels generally, and corn ethanol specifically, have a positive net energy balance, and their use as a replacement for gasoline leads to a reduction in greenhouse gas emissions.

The debate about whether biofuels are a good thing now focuses squarely on whether their use causes too much conversion of natural lands into crop and livestock production around the world. The worry is that the loss of carbon stocks on the converted land would more than offset the direct reduction in greenhouse gas emissions caused by lower gasoline use. The California Air Resources Board (CARB) has concluded that corn ethanol causes such large amounts of land conversion that it does not qualify as a low-carbon fuel. In its recent analysis of greenhouse gas emissions from biofuels, the U.S. Environmental Protection Agency (EPA) estimates that corn ethanol and biodiesel made from soybean oil cause enough land-use changes to call into question whether these biofuels meet required greenhouse gas reductions.

The debate over land-use changes caused by biofuels has two main threads. The first is a policy question focusing on whether the United States should even account for land-use changes in other countries when considering greenhouse gas regulations of biofuels. The second is on the actual measurement of land-use changes and whether the models used by CARB and EPA are accurate enough to support regulations that have billion-dollar consequences on the biofuels industry.

The debate about whether biofuels are a good thing now focuses squarely on whether their use causes too much conversion of natural lands into crop and livestock production around the world.

Most of the audience in the debate over measurement of the land-use impacts of biofuels has little understanding of the approach that is used by CARB and EPA to estimate land-use changes from biofuels. Hence, it is difficult for most to judge whether the approach is accurate enough to justify its use. An overview of the procedures used to estimate indirect land use should help clarify the most important issues involved.

Why Are Economists Doing the Measuring?

The three groups that have been most involved in estimating land-use changes from biofuels are economists at Iowa State University, Texas A&M University, and Purdue University (see the Editor's note at the end of the article). Economists are involved because land-use changes from biofuels expansion is a response by farmers and other landowners to a change in the supply of crops available to meet non-fuel demands. The economic story for corn ethanol is as follows. Expansion of U.S. corn ethanol production increases the demand for corn. This demand increase causes the market price of corn to rise. The increase in the price of corn causes U.S. farmers to grow more corn. Growing more U.S. corn can be done by increasing yields on existing land, by allocating more land to corn and less to other crops, and by creating more farmland. Cutting acreage to other crops can lead to price increases for these crops also. Because agricultural commodities are traded worldwide, the price changes for corn and other crops seen in the United States will also be seen by farmers in other countries, thereby affecting their agricultural supplies. Those farmers around the world who see higher market prices will also increase yields, reallocate land among crops, and bring new land into production.

Each step of this corn ethanol story requires an economist to estimate the likely response of farmers, livestock producers, the food industry, other industrial users of agricultural commodities, and non-farming landowners to a change in market price. The key factors that influence how much land is converted to cropland include the following:

- Which crops will U.S. farmers decrease in response to higher corn prices?
- How much U.S. pasture and forest land will be converted to crops?
- How much will farmers increase yields in response to price?
- How much will prices, demand, and production change in each important producing

or consuming country in response to a change in U.S. production and exports?

Economists understand that the answers to each of these questions depend greatly on how much time passes before the response is measured. For example, a $1.00-per-bushel increase in the price of corn will cause almost no U.S. land to be converted from pasture or forest to cropland after a single year. But a sustained $1.00-per-bushel increase for five years will likely result in some land being converted. Similarly, supply and demand in other countries will respond a great deal more after five years than after one year.

Economists also understand that the precision with which these responses can be measured depends greatly on the quality and availability of data. We have a fairly good idea of the response of U.S. livestock producers to higher feed costs: given enough time, livestock supplies will be reduced, resulting in higher meat and dairy prices. But economists' ability to estimate how Brazilian cattle ranchers will respond to the resulting increase in demand for Brazilian beef is less precise. The Brazilian cattle sector is simply less well understood than the U.S. livestock sector (even by Brazilian economists). The sector has had less scrutiny, and data measuring its performance and structure is much less developed.

More often than we want to admit, economists face situations in which we do not have adequate data to make precise estimates of the response of a sector to a price change. The backup strategy is to rely on economic theory to determine the direction of the response, and then to make a reasonable assumption about the magnitude of the response. For example, as anybody who has taken Econ 101 knows, supply curves slope up. This means that the quantity supplied to the market will increase if market demand increases. Thus, economists know that the Brazilian cattle herd will increase by some amount if U.S. meat supplies decrease. But an informed judgment about the magnitude of the change will rely on a trade economist looking at Brazilian trade policy to determine the extent to which a change in U.S. meat supplies will affect Brazilian prices. Then an experienced agricultural economist will know something about the cattle cycle and estimate how long it might take for the Brazilian cattle herd to respond to a price increase. A dedicated Brazilian agricultural economist with detailed knowledge of Brazilian environmental enforcement mechanisms will then make an estimate of the extent to which pasture can expand in frontier forests. This estimate will then be linked with the cattle cycle and the price transmission to come up with an informed estimate of the timing and extent to which the Brazilian cattle herd will change in response to an increase in feed prices caused by biofuels expansion.

Most of the parameters used to capture supply and demand responses to price changes that populate the models economists use to estimate the impact of biofuels on land are based on less detailed knowledge than the given example assumes. Rather, estimates are based on previous work (the applicability and quality of which is typically not addressed), insight of the analyst, and overall "reasonableness" with respect to the problem at hand. Economists need not apologize for constructing models in this manner: it simply is the only way to proceed because of a lack of data and specialized knowledge about agricultural and food systems around the world.

One implication of this reliance on a combination of theory and judgment is that it is quite difficult to construct confidence intervals around model predictions. The distribution of most model parameters is not known because most are not estimated statistically. Furthermore, those parameters that are taken from the original studies in which they were estimated are generally not directly applicable to the new use for which they are being gathered. Thus, there is no way that model predictions can be tested statistically.

Modelers will conduct sensitivity analyses in recognition of the uncertainty underlying key model parameters. The parameters are varied from what might be considered reasonable lower and upper bounds on their values, and then model predictions over the parameter range are calculated. Although useful as a way to identify which model parameters are most important in determining outcomes, this procedure cannot be represented as a statistical test of the model.

Why Model Predictions Will Not Be Consistent with History

One criticism of the models used by CARB and EPA to estimate indirect land use is that their predictions of land-use changes seem not to track with the actual changes in land use that we have observed in the last few years in response to sharply higher biofuels volumes. One might hope that the land-use changes we have seen could be used to validate or discredit the model predictions. For example, two recent studies (Tokgoz et al. 2007 and Hertel et al. 2009) of the impact of expanded biofuels on U.S. and world agriculture both estimate that expansion of corn ethanol would be accompanied by a large increase in corn production, a large decrease in soybean production, and significant decrease in corn and soybean exports. History differs from these predictions. Since 2005, corn ethanol has increased by about six billion gallons. Corn acreage has increased by about 6 percent, which is consistent with predictions. But soybean acreage has increased by more than 7 percent, corn exports are projected to be flat in the 2009/10 marketing year, and soybean exports are projected to increase by more than 25 percent. The model predictions completely missed the large expansion in U.S. soybean production that has accompanied corn ethanol expansion and the ability of the United States to maintain or expand its exports of corn and soybeans.

The problem with comparing actual outcomes with model predictions is that they are not comparable. The impacts of biofuels are estimated by modelers relative to what their models predict will be the agricultural situation under a baseline volume of biofuels, and under a set of assumptions about future macroeconomic growth, growing conditions, crop yields, exchange rates, and government policies. The models are then re-run with a higher biofuels volume and the same set of conditioning assumptions. By subtracting the model results with higher biofuel volumes from the baseline model results, modelers hope to isolate the effects of biofuels expansion because all other factors that affect the agricultural economy are held constant.

But of course, economic growth, weather, yields, exchange rates, and policies change every year. Thus, the projected agricultural situation will never line up with what actually occurs. The hope of modelers is that estimates of the change in production and market prices caused by biofuels expansion relative to baseline projections of production and prices are robust to changes in the conditioning assumptions. So even if the commodity boom and bust, the worldwide recession, and the major drought in Australia have moved agriculture away from its projected path, modelers assume that their estimated impact of biofuels on production and prices remain valid.

One advantage that modelers have is that their estimates are largely irrefutable because the world that they use to make their projections is never actually observed. For example, the expansion of U.S. soybean acreage since 2005 would seem to refute model predictions about how U.S. farmers would adjust their acreage in response to expansion of corn ethanol. But we will never know because we cannot re-run history with lower ethanol volumes. If we could, it may well be that U.S. soybean acreage would have been much larger than it actually was, in which case the model predictions would be correct. Because model predictions cannot be refuted by past data, the credibility of models relies on submitting the models and results to peer review, being transparent about model assumptions and parameters, and putting in place a process by which the models reflect the latest knowledge about agricultural and food systems.

New Uses for Agricultural Models

Perhaps economists' greatest social contribution is their ability to anticipate unintended consequences of seemingly good policy ideas. A classic unintended consequence is the market response of producers and consumers to a price change. When agricultural intervention is large enough to affect prices, then we must anticipate that there will be a response. And if the affected prices are for commodities that are traded, then some of the response will occur in other countries. The fact that the world will respond to a U.S. policy that diverts 30 percent of an expanded U.S. corn crop from other uses to biofuels is not surprising. Predictions that expanded biofuels will cause expansion of cropland are not new. For example, in 1992, researchers at the Center for Agricultural and Rural Development conducted a study on the implications of increased cellulosic biofuels production and concluded that "higher crop prices in the biomass scenarios induce a conversion of nonagricultural land to crop production" (Reese et al. 1992).

What are new are legislative mandates to quantify the response of the world agricultural system to U.S. biofuels policy, with severe financial consequences for those biofuels having estimates of unintentional consequences deemed too great. The models that have been employed to estimate changes in domestic and international crop acreage have not traditionally been used in a regulatory context. Rather they have been used to give policymakers an idea of the likely consequences of changes in agricultural and trade policy. As a guide to policy development and understanding, these models have proved invaluable in facilitating policy agreements. The jury is still out on their use as a regulatory tool.

Economists know that agricultural supply curves slope up and that expanded agricultural production will require some additional land. This means that expansion of U.S. biofuels will result in more land being devoted to crop production on an aggregate worldwide basis. However, given all the forces that affect agricultural production decisions, it is impossible to attribute any given agricultural development project to U.S. biofuels expansion, which is why CARB and EPA have to rely on models that attempt to isolate the effects of U.S. biofuels.

The financial stakes involved in the estimation of land-use changes from biofuels have created a large incentive for interest groups to know more about the models and the approaches that are used. Those whose interests have been harmed by model estimates will have an incentive to identify and change model assumptions and approaches that will serve their interests. Given the lack of data and detailed knowledge about exactly how the world's producers and consumers will respond to a change in U.S. policy, the models used to estimate land-use changes are populated with parameters that reflect judgment calls, modeler insights, and economic wisdom rather than hard data. Thus, these models,

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Agricultural Situation
Spotlight

Odds of an ACRE Payment for Corn and Soybean Farmers

Bruce A. Babcock
babcock@iastate.edu
515-294-6785

The recent sharp drop in commodity prices has increased producer interest in the new farm bill program called ACRE (Average Crop Revenue Election). If the prices currently indicated by the futures markets for the 2009 crop actually materialize, then corn, soybean, and wheat farmers have a good chance of receiving substantial ACRE payments. Farmers have until August 14 to enroll in ACRE so there is still time for farmers to determine if ACRE is better for them than traditional farm programs.

Farmers who sign up for ACRE are not eligible for countercyclical payments, receive 20 percent lower direct payments, and receive a lower loan rate. Enrollment is through the 2012 crop year. Because payments from both ACRE and traditional farm programs depend on the level of future prices and yields, it is impossible to say with certainty that one program or the other will generate more payments. However, looking at different yield and price scenarios can help farmers make a judgment about the odds that enrolling in ACRE will provide fruitful returns. A good place to begin is to look at the prices used to calculate the ACRE guarantees.

State Guarantees

June USDA projections suggest that the prices used to set ACRE state guarantees for corn and soybeans will be $4.20/bu for corn and $10.05/bu for soybeans. The recent drop in prices may affect these prices by a small amount because the ACRE price is the average of the 2007/08 and 2008/09 average price received by farmers, and the marketing year for corn and soybeans runs until August 31. Using future prices and historical basis, as of July 7, the expected average price for the 2009/10 marketing year is $3.25/bu for corn and $8.56/bu for corn. Because these market-indicated prices are so far below the ACRE prices, it looks like the odds are good that ACRE payments could be substantial. However, ACRE guarantees state revenue, which is the product of state average yield per planted acre and the marketing year price. Thus, we must look at both price and yield to calculate the odds of a payment. A close look at the Iowa situation shows how this can be done.

The yield used to set the 2009 ACRE state guarantees equals the average of the state average yield per planted acre from 2004 through 2008 with the highest and lowest yields eliminated from the average. Table 1 provides the five-year history for Iowa and the subsequent ACRE yield.

The 2009 ACRE guarantees for Iowa equal 90 percent of the product of the ACRE yield and the ACRE price. For corn this amounts to $650.16 per acre. For soybeans the state guarantee is $456.77 per acre. Farmers who sign up for ACRE will receive a payment if the product of the 2009 actual yield per planted acre and the 2009/10 season average price falls below these levels. The amount of the per acre payment is capped at 25 percent of these guarantees and the per acre payment is made on 83.3 percent of planted acres. Farm payments are calculated by multiplying the state ACRE payment by the ratio of farm yields to the ACRE yield. Total farm payments are also subject to a $65,000 payment limit plus the 20 percent decrease in direct payments. If the farm is at the $40,000 direct payment limit, the effective ACRE payment limit is therefore $73,000.

Table 1. Data used to calculate Iowa ACRE yields

	Acres Planted* (million)		Production (million bu)		Yield** (bu/ac)	
Year	**Corn**	**Soybeans**	**Corn**	**Soybeans**	**Corn**	**Soybeans**
2004	12.40	10.20	2,244	497	181	49.0
2005	12.53	10.05	2,163	525	173	52.0
2006	12.36	10.15	2,050	510	166	50.5
2007	13.90	8.65	2,377	449	171	52.0
2008	12.81	9.75	2,189	445	171	45.5
ACRE Yield					172	50.5

Source: Data are from the National Agricultural Statistics Service.
*Acres planted equals harvested acres plus failed acres as measured by the Farm Service Agency (FSA).
**FSA rounds soybean yields to the nearest half bushel and corn yields to the nearest bushel.

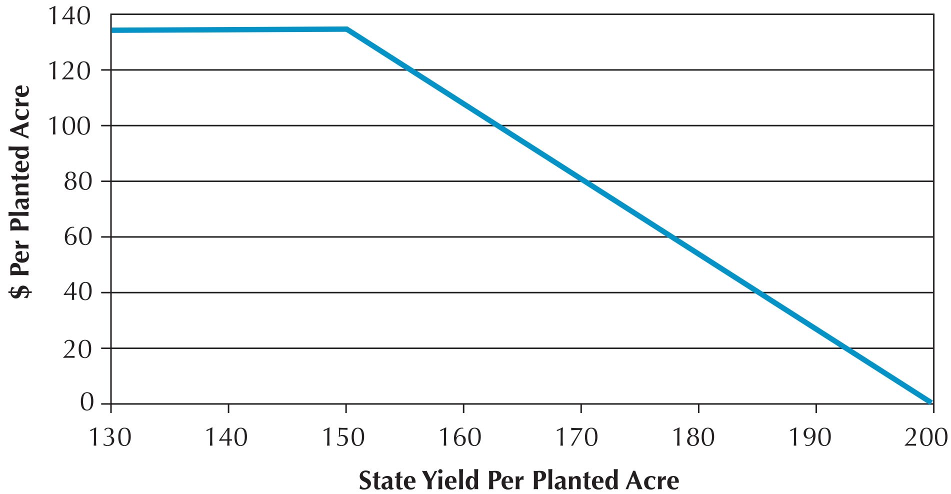

Figure 1. ACRE payments to Iowa corn for various yields if price equals $3.25

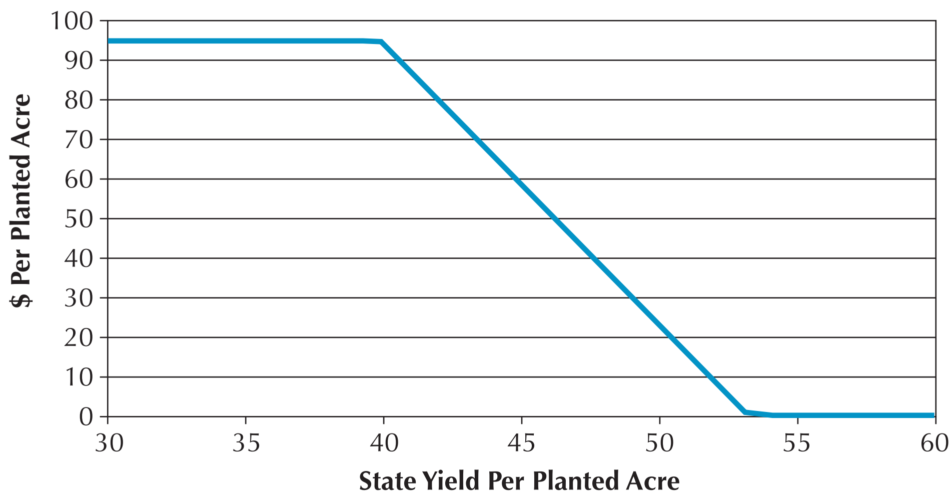

Figure 2. ACRE payments to Iowa soybeans for various yields if price equals $8.56

Potential ACRE Payments

To see that ACRE has the potential to generate substantial payments, Figures 1 and 2 show what ACRE payments would be for alternative state average yields if the 2009/10 marketing year prices turn out to be $3.25 for corn and $8.56 for soybeans. As shown, if yields are equal to the ACRE yield calculated in Table 1, then corn ACRE payments would be almost $75 per planted acre for corn and about $22 per acre for soybeans. These estimated payments account for payments being made on only 83.3 percent of planted acres. State average corn yields would have to exceed 200 bu/ac to receive no ACRE payment with a $3.25 price. Soybean yields would have to exceed 54 bu/ac for ACRE payments to drop to zero with a price of $8.56. ACRE can generate a maximum of more than $135 per acre for corn and $95 per acre for soybeans.

A limitation in Figures 1 and 2 is that they do not reflect the probability of yield outcomes or uncertainty about prices. An early July forecast of Iowa yields and national prices can provide an estimate of the odds of receiving an ACRE payment in 2009. Given the late signup date for ACRE, farmers can update these estimates in early August before making a final decision.

Calculating the Odds

As of the second week of July, Iowa crops are off to a great start, with 82 percent of corn and 80 percent of soybeans rated good to excellent. This is higher than any crop has been rated at this point in the growing season since 2003, when both crops received the same rating. Of course a good early-July crop rating does not guarantee a good crop. The 2003 soybean crop was a disaster because of a late drought and associated pest damage. And the state-average corn yield in 2003 was 2.5 percent below trend. But a good rating in July does tilt the odds in favor of a good crop, particularly if soil moisture is plentiful, as it is this year.

Iowa trend yields per planted acre (with a linear trend from 1980 to 2008) are 172 bu/ac for corn and 49 bu/ac for soybeans. The largest trend-adjusted yield per planted acre for corn since 1980 is 193 bu/ac which occurred in 2004. For soybeans, 1994 was the best year, with a technology-adjusted yield of 57 bu/ac. For corn, the probability of below-trend yields is minimal because of the great start to the crop and abundant-to-surplus soil moisture throughout the state. So a reasonable lower bound on yield may be 12 bushels below trend yield for 2009, or 160 bu/ac. For soybeans, dry weather and an outbreak of pests in August could still cause problems, but it looks like El Niño conditions are returning, which, combined with abundant soil moisture, suggests that a repeat of 2003 is extremely unlikely. A reasonable lower bound on 2009 yields may be eight bushels below trend, or 40 bu/ac.

We can then construct a probability distribution of yields given

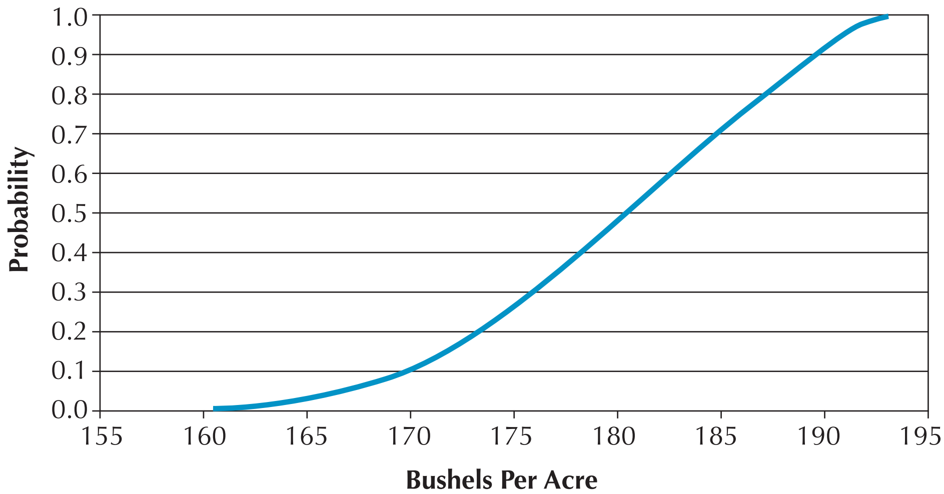

Figure 3. Probability distribution of 2009 Iowa corn yields

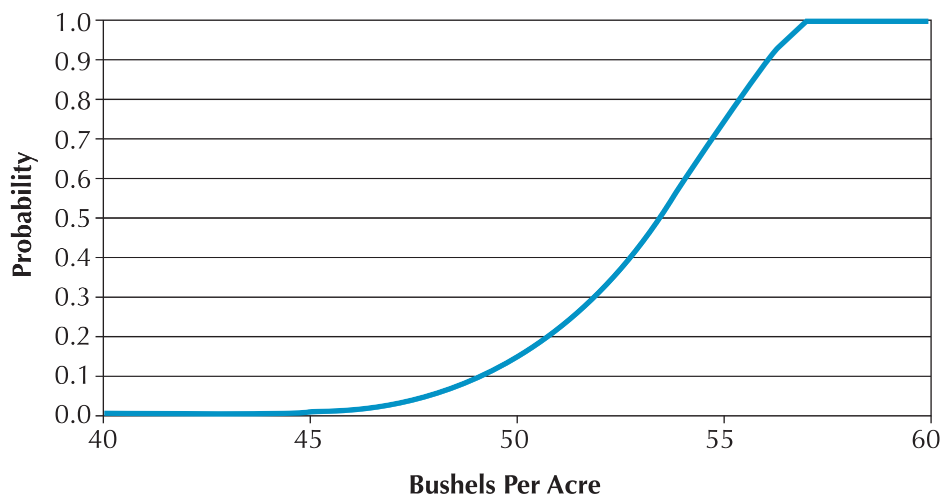

Figure 4. Probability distribution of 2009 Iowa soybean yields

these upper and lower bounds if we set the expected yield for 2009 at 180 bu/ac for corn and 53 bu/ac for soybeans. Figures 3 and 4 present the resulting probability distribution of Iowa corn and soybean yields for 2009 as of the second week of July. The figures show the probability that 2009 yields will be less than or equal to any yield on the horizontal axis. Thus, for example, there is a 10 percent chance that Iowa corn yields will be less than 170 bu/ac, which means that there is a 90 percent chance that yields will be greater than 170 bu/ac.

The next step is to figure out how much price uncertainty exists in the market. We can find this by looking at the price of put and call options on the Chicago Mercantile Exchange. The price of a put option for December corn and November soybeans gives a good indication: the higher the price of the option, the greater the uncertainty. And finally, the correlation between Iowa yields and the season-average price needs to be accounted for. Market prices already reflect the likelihood of a bumper crop for both corn and soybeans. If yields turn out to be lower than expected, prices will tend to be higher than current levels. If growing conditions improve even more, then we should see additional price weakness.

Combining the yield variability shown in Figures 3 and 4 and the price variability revealed by the price of put options with a reasonable degree of negative correlation results in the distribution of state revenue for Iowa corn and soybeans. These distributions are shown in Figures 5 and 6 on page 10. The figures show the probability that state revenue will be less than or equal to any given level. They also show the revenue levels that will trigger ACRE payments. For corn, there is a 78 percent chance that Iowa farmers who sign up for ACRE will receive a payment. For soybeans, there is a 55 percent chance. Thus, the odds are good for both crops that ACRE will pay out in 2009.

With a bit more calculation, the data shown in Figures 5 and 6 can also be used to estimate the average size of the payment from ACRE. For corn, when ACRE pays out, the average payment is about $80. For soybeans, the average payout is $40 per acre. Multiplying these average payouts by the probability of a payout results in the overall expected or average payout. For corn, farmers should expect to see about $62 per planted acre. For soybeans, the expected payout is about $22 per acre.

Iowa farmers must give up 20 percent of their direct payments to participate in ACRE. Across corn and soybeans, this amounts to about $4.40 per planted acre. Weighting the corn and soybean expected ACRE payments by 2009 planted acreage gives an overall expected ACRE payment across corn and soybeans for 2009 of $45, which is 10 times as large as what farmers are being asked to give up in direct payments. This suggests that the high odds of receiving an ACRE payment in 2009 can compensate farmers for their loss in direct payments over the life of the farm bill.

What Should Farmers Do?

The signup rules for ACRE allow farmers to wait until August 14 to decide whether ACRE makes sense for them. By the first week of August, farmers will have more information about 2009/10 marketing year prices, the condition of the 2009 crop, and final ACRE guarantee levels. Therefore, they will have more information about the potential size of ACRE payments. If corn prices stay in the low $3.00 range and soybean prices stay below $8.50, then ACRE becomes even more of a sure bet than is indicated by the early July calculations. If for some reason corn and soybean prices increase dramatically and crop conditions do not deteriorate, then perhaps waiting until next year would be a better bet.

Producers who do not want to wait until August to enroll in ACRE can rest reassured that if market prices unexpectedly increase and no ACRE payment is triggered in 2009, this increase in market price will provide them with a high guarantee for their 2010 crops because the 2010 guarantee will be based on market prices received in the 2008/09 and 2009/10 marketing years. Odds are good that in at least one year over the next four, Iowa farmers will receive more in ACRE payments than they will give up in direct payments over the life of the farm bill. ◆

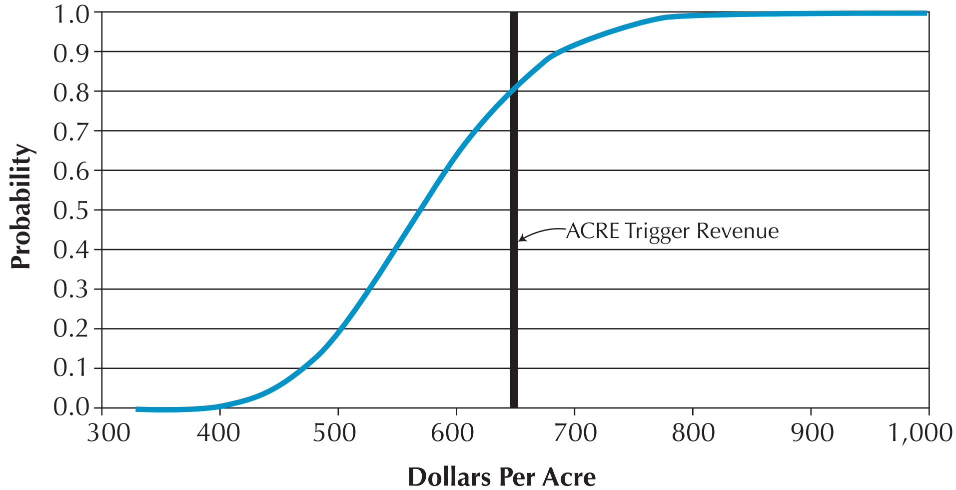

Figure 5. Distribution of Iowa corn revenue

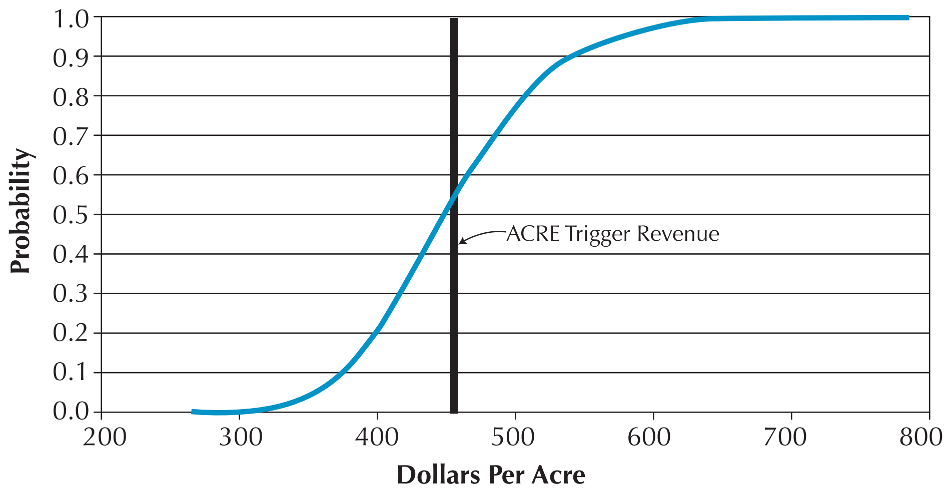

Figure 6. Distribution of Iowa soybean revenue

Costs and Benefits to Agriculture from Climate Change Policy
Continued from page 3

dairy farms that produce the equivalent of five tons of CO_2 reductions per year per cow. At a price of $20 per ton, this generates $100 per cow per year. Of course, any net benefit or net cost of using and capturing the methane must be added or subtracted from this $100. For comparison, the same cow may produce 20,000 pounds of milk per year, which generates perhaps $1,000 per year in milk revenue in excess of feed costs at a milk price of $15 per hundredweight.

Is Agriculture a Net Winner or Loser from a Carbon Cap-and-Trade Policy?

If the United States adopts a cap-and-trade policy to combat climate change, the negative impacts on agriculture will likely be relatively small, particularly if agricultural emissions remain uncapped. Once companies here and abroad have a profit incentive to find low-cost ways to reduce greenhouse gas emissions, it is doubtful that carbon dioxide prices will rise high enough to dramatically increase agricultural production costs. If other major agricultural producers also face increasing production costs because their countries adopt carbon-reducing policies, then U.S. producers will not lose their competitive advantage. Furthermore, if production costs do rise significantly, and if most of the world's farmers face these higher production costs, then most, if not all, of the higher costs will soon be reflected in higher commodity prices that will compensate farmers for their higher costs.

Similarly, the benefits from providing carbon offsets to capped sectors of the economy will be modest as well. Benefits will accrue as more crop farmers will move to no-till farming, and a price for carbon will enhance the economics of methane recovery systems in livestock operations.

Given the likelihood of modest costs and benefits from a cap-and-trade system, perhaps agriculture should look at whether a cap-and-trade policy will change growing conditions for the better or worse as a deciding factor in whether to support a change in policy. Given how much irrigated agriculture in the West relies on consistent mountain snowfall and Corn Belt agriculture relies on warm summers with abundant rainfall, any disruptive change in climate will have a far greater impact on livelihoods than will the price of carbon. ◆

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Measuring Unmeasurable Land-Use Changes from Biofuels
Continued from page 6

like most economics models, are ripe ground for aggrieved parties.

As we look to agriculture and forestry as a means of offsetting carbon at low cost, the demand for economic models of land use will increase. If greater investment in data and knowledge of agriculture around the world occurs, then the precision with which these models can estimate the impact of biofuels on the quantity of land brought into production, where the land-use expansion will occur, what the land will be planted to, and how the new lands will be managed will only improve. ◆

Editor's Note

Researchers in the Center for Agricultural and Rural Development at Iowa State University have worked for the last 18 months with EPA staff and other academic modelers at Texas A&M University and Purdue University to estimate the impacts on agriculture from expanded biofuels. EPA staff then used the results of this analysis in their life cycle assessment of biofuels.

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