Greenhouse Gas Emissions Offsets from Agriculture: Opportunities and Challenges

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As the scientific evidence of global climate change continues to accumulate (IPCC, 2007) and the predicted impacts of a warming planet become more widely known, national policies and international agreements designed to mitigate global warming have sought to strike a balance between environmental sustainability and economic achievement. Agriculture is at the center of this balancing act. On the one hand agriculture will need to adapt to a changing climate by developing new crop varieties and management practices, and on the other hand it has the opportunity to help mitigate future climate change by reducing the greenhouse gas emissions (GHGs) it generates. To learn more about the effects of climate change on Indiana agriculture, please refer to the article by Shively, et al. in the August 2008 edition of the *PAER*. The principal GHGs emitted from agricultural activities are carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4). Agriculture accounts for 6% of all anthropogenic U.S. GHG emissions, including 32% of all methane and 80% of all nitrous oxide emissions (EPA 2009b). Methane is 25 times more potent and nitrous oxide is 300 times more potent than CO_2 at trapping heat in the earth's atmosphere.

Under the 1997 Kyoto Accord, a global framework for reducing GHG emissions to pre-1990 levels established binding emissions reduction targets and timetables for industrialized countries and included flexibility provisions intended to reduce the overall cost of emissions reductions. Countries could design their own domestic policies to meet their emissions targets and Kyoto's flexibility provisions allowed for cooperation between industrialized and developing countries to achieve emissions reductions.

Despite the fact that not all countries ratified the 1997 agreement, many countries and states have enacted policies individually or in cooperation to reduce GHG emissions through an emissions trading framework. The largest GHG market in the world is the European Union-Emissions Trading Scheme, which began trading in 2005. The first such initiative in the U.S. is the Regional Greenhouse Gas Initiative (www.rggi.org) involving ten Northeastern and Mid-Atlantic states. A group of western states and Canadian provinces are organizing a similar regional exchange under the Western Climate Initiative (www.westernclimateinitiative.org), and several Midwestern states (Indiana is an observer that has not committed to capping state emissions) is called the Midwestern Greenhouse Gas Reduction Accord (www.midwesternaccord.org). In addition to binding regulatory approaches taken by state and national governments there has also been a similar voluntary private market initiative called the Chicago Climate Exchange (www.chicagoclimatex.com).

Cap and Trade

Economists have taken a strong interest in helping governments to evaluate different policy instruments that can be used to achieve emissions reductions. On the basis of the success of the United States' sulfur dioxide (SO_2) emissions trading program

and a large body of research, policy designs that establish enforceable property rights to verifiable quantities of emissions have been pursued most frequently and are the focus of the majority of ongoing national and international policy debates dealing with climate change. This type of policy design is commonly referred to as a "cap and trade" program, because the government establishes a "cap" on total emissions, allocates permits that constitute individual property rights to emit an allowable quantity of a pollutant, and allows firms to trade these emissions "allowances." An allowance entitles its owner to one metric ton (tonne) of carbon dioxide equivalent (tCO2e) emissions. The total emissions cap is expressed in terms of millions of tCO2e (MtCO2e) and the sum of all individual allowances equals the emissions cap or target.

Because different firms operating in many sectors of the economy use very different technologies, they have different GHG abatement costs and there are potentially significant gains from trade if regulated firms are allowed to exchange emissions allowances in a market. By allowing firms to trade allowances, firms with the lowest abatement costs can abate more pollution than required

by the cap and sell excess allowances to firms with higher abatement costs. This allows society to achieve the desired environmental objective at a lower total cost than if all firms were only allowed to generate emissions equal to the amount of allowances they hold and no trade of allowances were allowed. All else equal, a more stringent emissions cap will place greater pressure on all firms operating under the cap and is expected to result in greater demand in the market for allowances; this will have the effect of driving up the market price of allowances and thus firm compliance costs. Many factors in cap and trade program design can influence the overall cost to society, but that is not the focus of this article. To learn more about how cap and trade works, please refer to the short online "Primer" by Purdue professors Raymond and Shively (2007).

Including mechanisms that give firms time to develop and transition to less carbon-intensive technologies and energy sources reduces the overall cost of achieving emissions reductions while increasing the political feasibility of a cap and trade policy. There are several commonly proposed mechanisms to achieve this, but the one most relevant for Indiana agriculture is allowing regulated firms

to pay for GHG emissions reductions by unregulated sources that have the effect of offsetting emissions released by regulated firms. This mechanism is called an emissions *offset* and is the focus of this article. Agriculture is eligible to supply emissions offsets under proposed cap and trade legislation in the US because agriculture will not be subject to the emissions cap under currently proposed legislation being debated in Congress. Unlike power plants and other large stationary sources of emissions, farms will not be involved in buying and selling emissions permits because agriculture will not be directly regulated. Farmers, like all American households, will bear a share of the cost capping CO2 emissions through expected increases in the cost of goods and services that generate GHG emissions.

Agriculture and forestry are two of the most commonly considered sources of offsets in an emissions trading market because these economic sectors have the potential to adjust management practices in ways that reduce emissions of CO2, CH4 and N2O(IPCC 2007; EPA 2005). The remainder of this article discusses potential sources of GHG emissions offsets that represent *opportunities* for agriculture under policies to address climate change and the *challenges* that must be addressed in order for agricultural offsets to provide income to farm households.

Agricultural Offsets

Agricultural management practices can be altered or changed in many ways to reduce emissions from existing practices, to enhance the removal of CO2 from the atmosphere (called carbon sequestration), or displace emissions from fossil fuels by using dedicated energy crops or residues as sources of energy (IPCC 2007). Displaced fossil fuel emissions from bio-energy crops represent an

important opportunity for agriculture going forward and remain a fertile topic for research as the US continues to rely on a renewable fuel standard as an important component of energy and climate change policies. Fossil fuel emissions displaced have not been treated as a source of offsets under cap and trade policies to date, but do provide an important income opportunity that should counteract the expected increase in agricultural input costs discussed below.

The most widely discussed source of agricultural offsets come from sequestration of atmospheric carbon in agricultural soils. Soil management practices that increase sequestration include conservation tillage (e.g. mulch till, strip till and no till) and crop residue management (Lal, et al. 1998). Vegetative carbon storage can be enhanced through use of cover crops, perennial grass plantings and grazing management (Follett, et al. 2000). Reduced or more precise application of nitrogen fertilizer or livestock manure can reduce N2O emissions if greater nitrogen use efficiency can be achieved. Methane emissions from livestock can be reduced by improving feeding and manure management practices (e.g. by covering lagoons or capturing methane through use of anaerobic digesters). Increased feeding efficiency can be achieved through the use of dietary additives that suppress methanogenesis or improved forages, and opportunities for manure management, treatment and storage that reduce methane emissions both represent mitigation options in livestock management. While existing agricultural practices already play a role in mitigating the global warming effect of some fossil fuel emissions that result from fertilizer production and fuel use, there is considerable potential to expand and improve upon existing practices. This potential for wider use of mitigating practices is what creates the *opportunity* for

farmers to sell emissions offsets in a market for CO2 equivalent emissions.

In moving from the science of carbon sequestration and methane capture to thinking about the adoption of new cropping or manure management systems, it is necessary to take into account whether there are adequate incentives for farmers to adopt these practices. Policy makers can only realistically expect farmers to adopt these practices if the costs of implementation are covered by the benefits farmers receive.

The economic analysis done by the US EPA (2005) to assess the domestic carbon sequestration potential of forestry and agriculture found that for market prices over US$30/tCO2e, the economic incentives are such that crop and pasture lands are expected to be converted to forests because the sequestration potential of forest exceeds soil carbon sequestration and high prices cover the cost of land use conversion. Over the higher range of prices considered, agricultural soil carbon has lower relative economic potential than afforestation. While it is true that farmers can plant trees on marginal lands, this illustrates one reason why agriculture should not be analyzed in isolation of other sectors that can supply offsets. It is also important to consider both domestic and international sources of offsets because the demand side of the emissions market will be seeking to minimize its cost of compliance and it stands to reason that if another country can supply the offsets needed for compliance at a lower cost than American farmers, the lowest cost source of abatement will be exhausted before firms consider paying for higher cost alternatives.

Domestic Policy Situation

In June 2009 the House of Representatives narrowly passed the American Clean Energy and Security Act (ACES or Waxman-Markey bill after

its sponsors) of 2009 (H.R. 2454) that would create a cap and trade system and reduce domestic CO2 emissions 83% by 2050. The different Titles and Subtitles contained in its 1400 pages cover renewable energy, energy efficiency, greenhouse gas emissions, "transitioning to a clean energy economy," and the supply of emissions offsets from agriculture and forestry. As the Senate continues to take up this issue, it does so knowing that the EPA administrator signed an "endangerment finding" in December 2009 stating that "the current and projected concentrations of the six key well-mixed greenhouse gases…in the atmosphere threaten the public health and welfare of current and future generations." The EPA was forced to determine if GHGs should be regulated under the Clean Air Act by a 2007 Supreme Court ruling. The administration and members of Congress would prefer to address GHG emissions through legislation, but regulation may follow if ACES or something similar is not passed in the near-term.

Opportunities and Challenges

The main economic motivation for including offsets as part of a cap and trade policy is to reduce the overall cost of achieving the emissions target or cap. Economic analysis of cap and trade legislation is perhaps the best place to look to see the estimated effect of including offsets on the cost of allowances, and thus the overall cost of achieving a GHG emissions target. Recent analysis of ACES by the U.S. Congressional Budget Office found that the inclusion of both domestic and international offsets has "a significant effect on allowance prices" and decreases the market price 69% in 2012 to US$35 compared to when offsets are not a compliance option under the legislation (CBO 2009, p.16). The US EPA's economic analysis of

the same legislation similarly found that "offsets have a strong impact on cost containment" and that "without international offsets, the allowance price would increase 96%" to US$25-34 in 2015 (EPA 2009a, p.3). Both analyses of the most recent federal cap and trade legislation in the U.S. illustrate how incorporating offsets into a cap and trade program may significantly influence the cost to society of climate change mitigation.

The USDA estimates that gross annual revenue from carbon offset trading could total $2.1 billion within a few years after Waxman-Markey becomes law. By 2042, when the proposed emissions cap becomes more stringent, annual gross revenue from offsets could reach $28.4 billion (USDA 2009). It is not possible to determine from these early analyses what share of Indiana agricultural land is predicted to be converted to conservation tillage or planted in trees. The most recent IN State Department of Agriculture statistics indicate that 68% (3.03M acres) of all soybean acres and 26% (1.59M acres) of all corn acres in Indiana were planted in some form of conservation tillage in 2007.

Because of agriculture's strong reliance on fossil fuels, it stands to reason that the cost of farm inputs is expected to increase under the cap and trade legislation before Congress. The USDA's preliminary analysis of the legislation estimates that per acre variable cost of production for corn and wheat will increase 4.5% and for soybeans 2.2% by 2027 due input price increases. The biggest impact comes from increased fertilizer prices after 2025. The estimated effect of these changes in costs translates into a 3.5% drop in net farm income in 2027 (USDA 2009). It is important to note that these estimates only include the effect of increased input costs on 2009 production costs, and *do not take*

into account the increased demand for bio-energy crops to adapt to higher energy prices and future changes in the renewable fuel standard, technological and management changes to adapt to higher input costs, or the effect of emissions offsets on commodity prices. All of these factors excluded from the USDA's preliminary analysis are expected to offset the cost of implementing the proposed ACES legislation. Current estimates of the increase in net farm income from biofuels crop revenue under the most recent renewable fuel standard suggest that the increase in revenue will more than offset the increased costs from CO2 limits.

In order for farmers to be able to be paid for offsetting GHG emissions an offset registry has to be created to verify emissions reductions, ensure reductions are over-and-above what would occur under "business as usual" in the absence of the legislation, and ensure that management practice changes that create offsets are permanent. The USDA is charged with establishing and maintaining the offset registry under the ACES legislation.

Conclusion

Agricultural offsets are often viewed as a tool to bridge the gap between the present and the time when new technologies and fuel sources can be developed that achieve emissions reductions that are not subject to the same challenges. By lowering the cost of reducing emissions in the near term, offsets can help reduce the overall cost to society of transitioning away from fossil fuels, increasing energy efficiency, and developing new technologies. The precise long-term implications of climate change for agriculture remain uncertain and the challenge of operationalizing a national offset registry is a significant undertaking,

but agriculture certainly wants to be at the table when a major policy is enacted.

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The Profitability of Transitioning to Organic Grain Crops in Indiana

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Recent Organic Landscape

Organic agriculture is a rapidly growing industry fueled by growing consumer demand. In 2006, breads and grains made up 9% of organic consumer food sales (Organic Trade Association 2007). The demand for organic field grains is growing with the sales of breads and grains rising 19% from 2005 to 2006. The organic meat sector has seen the most growth in demand—55% in 2006. This growth in the meat sector translates into increased demand for organic feed grains by organic livestock producers. Thus, growth opportunities exist in the organic grains sector, and Indiana farmers have the potential to exploit these opportunities. Significant room for organic acreage expansion is present, as certified organic cropland and pasture amounted to only 5,156 acres statewide for 2005 (ERS 2005).

To take advantage of these opportunities, current organic farmers may expand, or new organic farmers may enter the market. Either way, producers will make business decisions. The basic tool for making crop business decisions is the crop budget. Conventional crop budgets are widely used and accessible to farmers in Indiana. Yet, organic crop budgets are not as common or accessible. Currently, there are no organic crop budgets specific to Indiana, and the limited numbers of existing organic budgets elsewhere are not regularly updated with current costs and prices.

Similar Organic/Conventional Studies

Previous studies have illustrated that organic farms can be profitable when compared to conventional farms (Chavas, Posner, & Hedtcke 2009; Mahoney et al. 2004). Research shows that the organic yield penalties associated with transitioning to organic production can be overcome in regards to profitability due to the lower direct costs that organic farms incur as compared with conventional farms (Delate and Cambardella 2004; Klepper, et al., 1977). In addition, research indicates that organic price premiums are very helpful and in some cases necessary for organic field crops to be more profitable than conventional crops. That said, none of these studies have been conducted in Indiana. However, this preliminary study modifies existing organic and conventional crop budgets in an attempt to apply them to typical Indiana farm operations. This will provide Indiana producers with more information regarding their production options, organic transition profitability, and optimal transition rotations.

Methods

The primary goal is to compare continued conventional production to an investment in transitioning to organic production using a net present value (NPV) analysis to compare each alternative. The NPV analysis takes cash inflows, outflows, and opportunity costs into account in order to determine a net return to land, labor, and management per acre for the entire analysis period. For each alternative, the analysis period is six years: 2009-2014, and we use a discount rate of 9.05% calculated as the weighted average cost of capital using metrics from the University of Minnesota FINBIN Farm Financial Database over the years 2003-2007.

The organic and conventional crop budgets utilized in the analysis are modified from existing crop budgets to be more representative of an Indiana farmer's crop selection. The conventional production system (CPS) uses a two-year Corn-Soybeans rotation, while the organic production system (OPS) uses a Corn-Soybeans-Wheat/Alfalfa-Alfalfa four-year rotation. The National Organic Program (NOP) standards require a minimum rotation of three years, where each year a different crop is planted. In addition, the NOP requires that the land in transition to organic certification is managed under the NOP standards for three years before the crops can be sold as certified organic and be eligible for the premiums.

Organic Prices and Premiums

One of the main factors influencing the profitability of transitioning to organic production is the existence of organic price premiums. For corn, soybeans, and wheat, implied organic premiums were calculated using monthly data from the National Agriculture Statistics Service (2009) and the Agricultural Marketing Service (2009). Historically, organic corn premiums ranged from 81%-238% with an average of about 142%. Organic soybean premiums were from 65%-139% and averaged about 107%. Organic wheat premiums ranged from 14%-74% and averaged just over 47%. Alfalfa hay premiums were calculated using historical hay prices (USDA: NASS 2009) and assuming a 0%-20% premium based on industry and current producer recommendations (Anderson 2007; Reding, pers. comm.).

To capture the variation exhibited in the implied organic premium, we examine the impact on revenues of a premium at the low end, the average, and the high end of the observed

Table 1. Projected Conventional & Organic (with Premiums) Cash Crop Prices; 2009-2014

Cash Prices ($/bu.)	2009	2010	2011	2012	2013	2014
Conventional Corn	$3.98	$4.15	$4.25	$4.35	$4.45	$4.55
Organic Corn						
High (200%)	$11.94	$12.45	$12.75	$13.05	$13.35	$13.65
Avg. (142%)	$9.63	$10.04	$10.29	$10.53	$10.77	$11.01
Low (80%)	$7.16	$7.47	$7.65	$7.83	$8.01	$8.19
Conventional Soybean	$9.00	$9.24	$9.33	$9.43	$9.53	$9.63
Organic Soybean						
High (130%)	$20.70	$21.25	$21.46	$21.69	$21.92	$22.15
Avg. (107%)	$18.63	$19.13	$19.31	$19.52	$19.73	$19.93
Low (65%)	$14.85	$15.25	$15.39	$15.56	$15.72	$15.89
Conventional Wheat	$4.09	$4.69	$4.90	$5.10	$5.30	$5.50
Organic Wheat						
High (70%)	$8.65	$9.67	$10.03	$10.37	$10.71	$11.05
Avg. (47%)	$7.48	$8.36	$8.67	$8.97	$9.26	$9.56
Low (15%)	$5.85	$6.54	$6.79	$7.02	$7.25	$7.48
Cash Prices ($/ton)						
Conventional Alfalfa/Hay	$120.56	$122.54	$124.51	$126.49	$128.47	$130.44
Organic Alfalfa/Hay						
High (20%)	$144.67	$147.05	$149.42	$151.79	$154.16	$156.53
Avg. (10%)	$132.62	$134.79	$136.97	$139.14	$141.31	$143.49
Low (0%)	$120.56	$122.54	$124.51	$126.49	$128.47	$130.44

Table 2. Yield Penalties from Selected Organic Transition Studies

Yield Penalties	Corn	Soybeans	Wheat	Hay/Alfalfa
Delate & Cambardella	8.2%	0.4%	----	----
Porter et al. #1	9.0%	19.0%	----	8.0%
Porter et al. #2	7.0%	16.0%	----	0.0%
Creamer et al.	----	----	11.2%	----
Hanson et al.	28.9%	0.0%	23.1%	22.2%
Dabbert & Madden	20%	20%	20%	20%
McBride & Greene	----	34.0%	----	----
Average	*14.6%*	*14.9%*	*18.1%*	*12.6%*

Table 3. Projected Conventional System Yields & Projected Organic System Yields with Corresponding Yield Penalties, 2009-2014

Yields (bu./ac. & ton/ac.)	2009	2010	2011	2012	2013	2014
Corn						
Conventional	161.39	163.67	165.95	168.23	170.51	172.79
Organic: 14.6% Yield Penalty	137.80	139.74	141.69	143.64	145.59	147.53
Soybeans						
Conventional	47.42	47.77	48.13	48.48	48.83	49.18
Organic: 14.9% Yield Penalty	40.36	40.66	40.96	41.26	41.56	41.86
Wheat						
Conventional	69.89	71.02	72.14	73.26	74.38	75.50
Organic: 18.1% Yield Penalty	57.24	58.16	59.07	59.99	60.91	61.83
Alfalfa/Hay						
Conventional	3.77	3.77	3.77	3.78	3.78	3.78
Organic: 12.6% Yield Penalty						
Establishment Year	0.82	0.82	0.82	0.83	0.83	0.83
Fully-Established Year	3.30	3.30	3.30	3.30	3.30	3.31

premiums. Under each of the three scenarios, we apply the implied organic premiums to projected conventional cash crop prices to obtain future organic cash prices. The projected conventional cash prices are based on grain futures prices less an assumed basis. The organic and the respective conventional prices (Chicago Board of Trade 2009) are shown in Table 1.

Organic Yield Penalties

Crop yields also affect profitability during transition. To predict yields for the organic system, we examine seven studies comparing organic and conventional yields. Without commercial chemicals and fertilizers, the OPS may experience increased weed populations and lower crop yields (Delate and Cambardella 2004). Thus, we project organic crop yields using an assumed organic yield penalty relative to conventional crop yields (Table 2).

After the initial transitional yield penalties, yields should return to the level of conventional yields due to the accumulation of organic soil matter (MacRae et al. 1990). However, the yield penalties could continue for as long as six years (Dabbert and Madden 1986). To be conservative, we assume the yield penalties continue for all six years. Conventional crop yields are projected using estimations calculated from historical Indiana yields collected by the USDA (2009). Table 3 shows the projected organic yields with their respective penalties and the projected conventional yields.

Crop Budgets

The Purdue crop budgets (Miller et al. 2009; Dobbins et al. 2007), with minor modifications to normalize fertilizer costs, are good representations of Indiana conventional crop budgets. Iowa State (Chase, Delate, and Smith 2008) and N.C. State (Bullen 2007) organic crop budgets were modified (added costs for fertilizer, cover crops, and seeding alfalfa)

and combined to form representative Indiana organic crop budgets. After modifying the budgets to establish current crop budgets, we need to project budgets and input costs for the subsequent years. To do so, we increase the current input costs by an average yearly percentage change to capture inflation and the changing market for crop inputs. Not all crop inputs change by the same amount; therefore, we estimate the average percentage price increase for each input using the prices paid index from 2000-2006 (USDA: NASS 2009). Table 4 shows each crop input, which index we applied to it, and the average percentage change of that index.

Combining these current and projected input costs with projected crop prices and yields results in projected crop budgets over the six-year analysis for both the CPS and OPS. Overall, there are five scenarios between the two production systems. Scenario A and B represent the two possible rotation combinations in the CPS and their respective costs and returns. Scenario A begins with corn, while B begins with soybeans. Table 5 represents the budget for Scenario A and illustrates an example of a complete crop budget and returns for the CPS.

Scenarios C, D, and E represent the three possible rotation combinations in the OPS. Scenario C begins with corn, Scenario D with soybeans, and Scenario E with the wheat/alfalfa crop. Table 6 shows the costs for Scenario C and illustrates an example of cost portions of the budgets under analysis in the OPS. There are four organic premium cases for each scenario. The low alfalfa price premium is the same as no price premium case. In addition, prices are always at the zero premium level for 2009-2011, since the NOP standards require a 36-month transition period. Thus, we assume the 2012 crop is the first certified organic crop eligible for organic price premiums. Table 7 demonstrates the yields, prices and premiums, revenues, and net

Table 4. Conventional & Organic Crop Inputs with Respective Prices Paid Indices

Crop Input	Prices Paid Index Applied	Average Yearly % Change
Crop Seed	Seeds	4.15%
Alfalfa Seed	Grasses/Legumes	0.75%
Fertilizer	Fertilizer	5.00%
Pesticides	Chemicals	0.82%
Fuel & Lubrication	Fuels	6.34%
Repairs	Repairs	2.41%
Machinery Costs	45% Repairs & 55% Fuels	4.57%
Drying	LP Gas	5.53%
Hauling	Fuels	6.34%
Cover Crop	Seeds	4.15%
Operating Interest	Interest	1.80%
Miscellaneous	Supplies	2.54%
Machinery Ownership	Machinery	3.36%

Table 5. CPS Revenues, Costs, & Net Returns: Scenario A

CPS C-B Rotation	2009 Corn	2010 Soybean	2011 Corn	2012 Soybean	2013 Corn	2014 Soybean
Yield (bu./acre)	161.39	47.77	165.95	48.48	170.51	49.18
Price ($/bu.)	$ 3.98	$ 9.24	$ 4.25	$ 9.43	$ 4.45	$ 9.63
Gross Revenue	*$ 642.32*	*$ 441.43*	*$ 705.28*	*$ 457.16*	*$ 758.76*	*$ 473.64*
Seed	$ 89.00	$ 54.16	$ 96.54	$ 58.75	$ 104.72	$ 63.72
Fertilizer	$ 87.09	$ 39.35	$ 96.01	$ 43.39	$ 105.84	$ 47.83
Pesticides	$ 41.00	$ 29.24	$ 41.68	$ 29.72	$ 42.36	$ 30.21
Fuel & Lubrication	$ 18.00	$ 8.51	$ 20.36	$ 9.62	$ 23.02	$ 10.88
Repairs	$ 12.00	$ 9.22	$ 12.58	$ 9.67	$ 13.20	$ 10.14
Drying	$ 24.00		$ 26.73		$ 29.76	
Hauling	$ 17.00	$ 5.32	$ 19.22	$ 6.01	$ 21.74	$ 6.80
Operating Int.	$ 17.00	$ 9.16	$ 17.62	$ 9.49	$ 18.26	$ 9.84
Total Direct Costs ($/acre)	*$ 305.09*	*$ 154.95*	*$ 330.74*	*$ 166.65*	*$ 358.90*	*$ 179.42*
Machinery Ownership	$ 77.00	$ 79.58	$ 82.25	$ 85.01	$ 87.87	$ 90.81
Total Costs ($/acre)	*$ 382.09*	*$ 234.54*	*$ 412.99*	*$ 251.66*	*$446.77*	*$ 270.23*
Net Return ($/acre)	*$ 260.23*	*$ 206.89*	*$ 292.29*	*$ 205.50*	*$ 312.00*	*$ 203.41*

Table 6. OPS Costs: Scenario C

OPS C-B-W/A-A Rotation	2009 Corn	2010 Soybean	2011 Wheat/Alfalfa	2012 Alfalfa	2013 Corn	2014 Soybean
Alfalfa Seed			$57.69			
Crop Seed	$108.32	$48.81	$21.18		$127.44	$57.43
Fertilizer	$69.49	$62.54	$172.61		$84.45	$76.01
Machinery Costs	$40.63	$24.36	$62.35	$43.77	$48.58	$29.13
Drying	$33.24				$41.22	
Hauling	$4.79	$1.22	$16.56	$7.16	$6.12	$1.56
Cover Crop	$26.04	$27.12			$30.64	$31.91
Miscellaneous	$7.18	$7.36	$7.74	$7.74	$7.94	$8.14
Operating Int.	$8.69	$6.11	$2.67	$0.30	$9.34	$6.57
Total Direct Costs ($/acre)	*$298.36*	*$177.53*	*$340.81*	*$58.97*	*$355.72*	*$210.74*
Machinery Ownership	$56.64	$41.21	$80.79	$50.67	$64.63	$47.03
Total Costs ($/acre)	*$355.00*	*$218.74*	*$421.60*	*$109.63*	*$420.35*	*$257.77*

Table 7. OPS Yields, Prices, Premiums, Gross Revenue, & Net Returns: Scenario C

OPS C-B-W/A-A Rotation	2009 Corn	2010 Soybean	2011 Wheat/Alfalfa	2012 Alfalfa	2013 Corn	2014 Soybean
Yields						
Crop (bu./acre)	137.80	40.65	59.07		145.59	41.85
Alfalfa (ton/acre)			0.82	3.30		
Straw (bales)			25.00			
Prices & Prem.						
Crop Prem. ($/bu.)						
High					$13.35	$22.15
Avg.					$10.77	$19.93
Low					$8.01	$15.89
None	$3.98	$9.24	$5.90		$4.45	$9.63
Alfalfa Prem. ($/ton)						
High				$151.79		
Avg.				$139.14		
Low			$124.51	$126.49		
Straw Price ($/bale)			$3.50			
Gross Rev.						
Premium: ($/acre)						
High				$501.24	$1,943.57	$926.97
Avg.				$459.47	$1,567.81	$834.28
Low				$417.70	$1,166.14	$665.00
None	$548.43	$375.62	$538.76	$417.70	$647.86	$403.03
Net Return						
Premium:						
High				$391.60	$1,523.22	$669.20
Avg.				$349.83	$1,147.46	$576.50
Low				$308.06	$745.79	$407.23
None	$193.43	$156.88	$117.16	$308.06	$227.50	$145.26

returns for Scenario C. This also is an example of how these measures were computed for Scenarios D and E in the OPS.

Results

After computing all of the net returns per acre each year for each scenario, we calculate a final NPV for each scenario under each of the three price premium cases.

Computing the NPV allows you to compare the profitability of all five of the scenarios. Table 8 shows the computed NPV for each scenario under the different price premiums.

Scenario D has the highest NPV in the positive premium cases. In this rotation, the higher-value corn and soybean crops are the first to receive organic premiums. In Scenario E, there is no certified organic corn crop and there are two years each of the organic wheat/alfalfa and established alfalfa crops, which do not receive as high an organic percentage premium as organic corn and soybeans. However, scenario E has the highest NPV in the zero premium case when compared to Scenarios C and D.

The organic corn and soybeans consistently have lower organic total costs when compared with the conventional corn and soybeans. On average, total expense for corn is $26.70 lower, while soybeans are $14.48 lower. Although the organic system has slightly lower costs, the yield penalties associated with organic production reduce the overall net return. A comparison of average net returns excluding any premiums shows that the conventional corn and soybeans are more profitable than the organic corn and soybeans. Conventional corn has revenue about $77.01 higher per acre on average, while conventional soybeans are about $53.05 higher per acre on average.

Once price premiums are introduced, organic corn and soybeans generate higher net returns than conventional corn and soybeans. An explanation for the significantly higher returns in the OPS compared with the CPS is that the net returns do not explicitly reflect labor costs, as they are returns to land, labor, and management. Organic production tends to be more labor intensive and may require additional managerial time. Without chemical herbicides, labor-intensive, mechanical weed control is much more prevalent.

Table 8. Organic & Conventional Production Systems' Net Present Values: Scenarios A-E

| Production Systems | Net Present Values ($/acre) | | | |
	Zero Premium	Low Premium	Average Premium	High Premium
Conventional:				
Scenario A: C-B	$1,206.67			
Scenario B: B-C	$1,218.35			
Organic:				
Scenario C: C-B-W/A-A	$928.39	$1,464.71	$1,890.68	$2,248.68
Scenario D: B-W/A-A-C	$870.33	$1,476.85	$1,983.53	$2,394.29
Scenario E: W/A-A-C-B	$952.64	$1,188.31	$1,436.59	$1,603.46

There can also be a learning curve associated with organic production, and there is additional work for organic certification. According to Lang (2005), labor costs average about 15% higher in organic systems. Also, Hanson, Lichtenberg, and Peters found that hired and family labor costs together averaged about 26.6% higher in OPSs (1997). If these additional labor costs were included, organic corn and soybeans would have similar to higher total costs compared with conventional corn and soybeans. The lower returns to organic production without premiums and the additional labor costs suggest that some price premium is necessary for farmers to grow organic crops.

The price premiums received during the last three years of organic production compensate for the reduced organic yields. If there are no opportunities for organic price premiums, the conventional Scenario B has the highest NPV. With opportunities for organic price premiums, Scenario D has the highest NPV in all three premium levels.

Concluding Points

Premiums Provide Profitability
This analysis provides evidence that organic crops with yield penalties can be profitable and competitive with conventional crops. The lower organic production costs coupled with adequate organic price premiums make organic production competitive and profitable. These findings regarding lower organic costs and profitability with premiums are consistent with previous organic/conventional comparison studies.

Rotational Transition Strategies
In addition, this analysis provides strong evidence that it is important to plan the transition to certified organic production so that corn and soybeans, which receive the highest premiums, are the first crops to receive organic premiums. Scenario D, in which corn and soybeans are

the first and second crops in the organic system, has the highest profitability followed by Scenario C where corn and soybeans are the second and third organic crops. Scenario E where wheat/alfalfa and alfalfa are the second and third crops to receive organic premiums clearly has the lowest profits.

Subsequent Work & the Future
Besides the two take-home points previously mentioned, certain aspects of the study might warrant further research. In regards to profitability, fertilizer costs, both commercial and manure, are a large, and variable, part of the total cost in grain production. Labor expenses are another cost that can be quite variable and have a significant effect on net returns. Further investigation involving these costs and their specific effect on both conventional and organic transitional profits would be beneficial. Likewise, future research should investigate both long-term organic/conventional profitability, as this research only examines transitional profitability.

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