PURDUE UNIVERSITY

PURDUE AGRICULTURAL ECONOMICS REPORT

APRIL 2006

Will Higher Fertilizer Prices Drive Adoption of Precision Fertilizer Management?

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One of the most appealing concepts of site-specific agriculture is in the precise application of crop inputs—giving each part of a field exactly what is needed vs. uniformly across a field, where the soil, past treatment, drainage, or any other number of factors can vary. Especially for crop nutrients, the potential exists in precision application to not only increase crop yields but to reduce costs and reduce yield variability, all of which can increase returns.

Most studies, however, have shown only modest returns, at best, to site-specific, variable rate applications of crop nutrients when compared to whole-field approaches. But with higher input costs, there is a greater chance that more efficient fertilizer use and its associated cost savings can overcome the labor, sampling, and equipment costs associated with site-specific management. But cost savings and yield increases do not always accompany site-specific fertilizer management. This paper looks at two studies conducted at Purdue University to assess the economics of site-specific input applications.

A study conducted from 1993-1995 (Lowenberg-DeBoer and Aghib, 1999) compared three scenarios—a traditional whole-field approach, a three acre grid approach, and a soil zone management approach to phosphorus (P) and potassium (K) management on several farms growing corn, soybeans, and wheat in Indiana, Michigan, and Ohio. With the soil zone approach, soil testing and nutrient applications are made according to soil mapping units. Most of the fields tested had areas that, according to university recommendations, would require fertilization and some areas not, setting up a situation where the additional P or K could generate yield gains on low and medium testing areas and where input costs could be eliminated on the high or very high testing areas. Working with the farmer's fertilizer dealer, fertilizer applications were based on the Tri-State (IN, OH, and MI) Fertilizer Recommendations. And since the influence of P and K fertilization extends well beyond the current crop year, fertilizer effects and costs were amortized over a multi-year period.

The results of the study showed yields for the grid and soil zone approaches were slightly higher when averaged across all farms. Fertilizer requirements were higher for the grid sampling approach compared to the whole field approach, but lower for the soil zone system. It was typically assumed that the grid and the soil type schemes will lead to less fertilizer use, but in this short-term real-world study that did not turn out to be the case. It is speculated that the soil zone scheme was more proficient at correctly delineating areas of nutrient deficiency vs. sufficiency.

In the end, the returns for each fertilization system were similar using commodity and input prices typical of the late 1990's. Compared to the whole field application the soil zone system had slightly higher returns, the grid scheme less (Table 1). Returns on each farm each year varied less with the site-specific approaches compared to whole field approach, reducing risk. Inputting the higher fertilizer prices of recent months provides the expected

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Table 1. Returns to using a grid or soil zone fertilizer sampling and application system vs. a whole field approach at two fertilizer cost levels: composite of six Midwestern farms.

	Management Scheme		
	Whole Field Management	3 Acre Grid (Grid vs. WFM)	Soil Zone (Soil Zone vs. WFM)
Fertilizer Prices	Net Return on Investment, $/A		
$0.22 P_2O_5 and $0.12 K_2O	158.98	152.13 (-6.85)	161.65 (+2.67)
$0.33 P_2O_5 and $0.22 K_2O	154.04	146.61 (-7.43)	157.45 (+3.41)

result—if fertilizer is used more efficiently, for instance with the soil zone scheme, the returns become more favorable with higher input costs. But if fertilizer use increases and yields do not, as was the case in this study with a grid approach, the returns become less favorable.

Included in the calculations above is the cost of being precise. Field variation needs to be quantified, and the current method is to collect soil samples and have them analyzed in a lab, adding labor and lab analysis costs. Maps need to be constructed to guide applications, and then special effort or specialized application equipment is needed to modify the nutrients across the field accordingly. Personnel have to be in place that can interact with the grower and correctly integrate the testing, analysis, and implementation phases.

The second study completed in 2004 (Peone, 2004) used six intensely sampled Indiana corn/soybean rotation fields to simulate various site-specific sampling and recommendation schemes. Like the other study, the fields tested had areas that would require some additional fertilization, especially for potassium, but phosphorus was generally sufficient. The scenarios were somewhat different, but included a whole-field approach and a 2.5 acre grid sampling approach. In this study the site-specific approach led to slightly lower yields and slightly less fertilizer required when compared to a whole field approach—the 2.5 acre grid was too coarse to detect some of the low-testing parts of the field. Considering all costs the whole field approach achieved slightly greater returns (Table 2). Higher fertilizer prices narrowed the difference between the approaches, but the end results were still quite similar.

These studies demonstrate that if yields are not greatly impacted, then the force driving returns sits squarely with lowering costs. Additional analysis of the Peone study showed that about 20% of a field must contain isolated low-fertility areas to justify site-specific management, and then only if both P and K are low and sampling density is intense enough to pick up the low fertility areas. Many crop fields that have been managed well in the past may not have areas where P and K levels are a limiting factor for yields.

A different situation exists with soil pH management and liming. Lime is different in that there is an optimum range for crop response, as opposed to most crop nutrients where there is little penalty for over-application. Studies in the Eastern Corn Belt (i.e., Bongiovanni, 1998) have shown good returns to site-specific liming, where soil pH can vary significantly across a field but soils tend to be acid. And if the cost of lime rises because of higher trucking cost, variable rate lime should become even more profitable than it was when the original studies were done.

The concept of site-specific soil nutrient management became popular in some U.S. farming regions in the mid-90's, and by the late 90's over half of U.S. agricultural retailers surveyed were offering soil sampling using GPS. These same retailers reported then that about 10-15% of the acres in their areas were using some type of precision fertilizer application (Whipker and Akridge, 2005). While those numbers are somewhat higher today, they are not nearly as high as many would have predicted.

One of the greatest limitations to profitably using site-specific technology—the cost and effort of collecting and analyzing enough samples to capture all of the variability—may become a lesser factor in the future with technology being developed. On-the-go sensing systems for soil pH are already on the market, and research is underway to develop on-the-go sensors for other crop nutrients, as well as other related soil factors that can affect fertilization strategies, such as organic matter and soil texture. A cost-effective solution in the future could be to combine on-the-go sensing with on-board analysis and nutrient application to eliminate many of the costs associated with site-specific approaches. Combined with the

Purdue Agricultural Economics Report is a quarterly report published by the Department of Agricultural Economics, Purdue University.

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possibilities for precision nutrient placement and timing that RTK auto guidance can offer, remote sensing, or other tools, innovators will continue to look for ways to increase crop yields, lower costs, and reduce risks.

For a farmer or for those who advise farmers, the bottom line is that there are costs involved in site-specific management, and getting a return in precision fertilizer management depends on the ability to save on fertilizer costs or increase yields. Fields that have isolated low-testing areas have the greatest chance of being able to increase yields or reduce fertilizer costs enough to pay for the site-specific approach. And, a sampling scheme needs to be in place that is spatially intense enough to detect these different areas.

Table 2. Returns to using a grid sampling scheme vs. a whole field approach at two grid sizes and at two fertilizer cost levels: composite of six Indiana fields.

	Management Scheme	
	Whole Field Management	2.5 Acre Grid (Grid vs. WFM)
Fertilizer Prices	Net Return on Investment, $/A	
$0.22 P_2O_5 and $0.13 K_2O	181.76	176.93 (-4.83)
$0.33 P_2O_5 and $0.20 K_2O	179.41	175.24 (-4.17)

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Risk Sharing and Transactions Costs in Producer-Processor Supply Chains

*Allan W. Gray, Associate Professor and Michael D. Boehlje, Professor**

Several forces are converging to encourage the agricultural industry to form more tightly aligned supply chains. Efficiency, synergies, inter-firm pooling of resources, customer responsiveness, and risk sharing are the four key objectives that firms seek to improve by forming such chains (Besanko, Dranove, & Shanley, 2000). Efficiencies are often gained by more accurately sharing information between parties in the chain. For example, a pork processor may be able to manage the flow schedule of hogs through the slaughter plant by contracting or even owning the production stage of the pork chain. And complementary inter-firm synergies resulting from, for example, alliances between research and development (R&D) and manufacturing firms and downstream distribution and marketing firms can also be captured with effective supply chains.

Responsiveness to consumer demand is another reason for developing supply chains. Products that can be differentiated at various stages of the food chain allow for the potential to meet the demands of certain segments of the market. Retailers as well as processors argue that their supply chains allow them to respond to an ever changing set of consumer preferences more quickly than they could with traditional open-market transactions.

In addition to efficiency, inter-firm synergy, and responsiveness, supply chain participants often express a desire to manage risks as a reason for forming supply chains. The risks may be input/output price risk, quantity/quality risks, and/or safety/health risks. The recent interest in food safety and traceability are often cited as reasons for forming tighter vertical alliances. Agricultural producers often state that reductions in price and volume variability are key influencers in their decision to join a supply chain (Hennessey & Lawrence, 1999; Rhoades, 1995).

Supply chains have been a dominant focus of both academic research and business strategy in the food and agribusiness industries for the

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** An earlier version of this article appeared in the 4th Quarter 2005 • 20(4) issue of CHOICES, an online publication of the American Agricultural Economics Association available at: http://www.choicesmagazine.org/. Go to that site for numerous articles on farming, policy, food, textiles and agribusiness management.*

past decade. Much discussion, analysis, and experimentation with various forms of vertical alignment using governance structures such as strategic alliances, joint ventures, contracts, and vertical integration has occurred. Much of the recent debate and discussion, as well as the controversy concerning the development of these arrangements have focused on the production sector, and in particular, the linkages between producers and processors.

The effectiveness and long-term viability of a supply chain is determined in no small part by how well the coordination governance structure manages the sharing of the risks and rewards of the supply chain among its participants. The different types of risks encountered in alternative supply chain business structures, the incidence of risk on the part of individual supply chain partners and the sharing of risk and reward among supply chain participants has important implications for who will be the most likely participants in a supply chain, as well as the benefits the various players will receive.

Risk Sharing and Costs of Vertical Alignment

The research on supply chain risk/reward sharing in agriculture has often been focused on producer impacts. As noted, producers are often seeking avoidance of risk in these arrangements. However, governance structures such as contracting that lead to risk avoidance also result in lower returns on average. Governance structures that reduce risks for producers can lead to misalignment of incentives resulting in shirking behavior (moral hazard) if not monitored carefully. For example, producers on fixed payment contracts may be more inclined to deliver lighter weight hogs to the slaughter facility than the processor desires. In addition, governance structures that reduce risks for producers can attract producers that are relatively more risk averse (adverse selection). This risk averse nature often manifests itself in less aggressive adoption of new technologies and business practices – behaviors that do not enable a value chain to reap full benefits of efficiency and productivity improvements over time. Thus, channel partners that absorb more risk in their agreement with producers generally expect and receive higher returns to compensate for the higher risk and/or risk mitigation costs.

For some firms, the risk sharing transactions cost of monitoring channel partners exceeds the willingness of the marketplace to compensate them. In these cases, the firm may choose to acquire the chain (vertically integrate), thereby avoiding the transactions costs associated with moral hazard and adverse selection. These firms have decided that the internal transactions costs associated with owning both stages of the chain (agency costs, influence costs, increased production risks, employee risks, etc.) are less than the external transactions costs (moral hazard, adverse selection, and risk premia). Smithfield Foods and Tyson Foods offer examples where vertical ownership has been the preferred choice in an industry where other governance structures continue to be employed. These two firms, with their international brand identity and diverse product bases, may be in a position where the transactions costs of open-market, contract, or joint venture agreements exceed their internal transactions costs of owning the chain.

Figure 1. Risk/Reward Sharing Between the Processor and Producers at Various Risk Aversion Levels

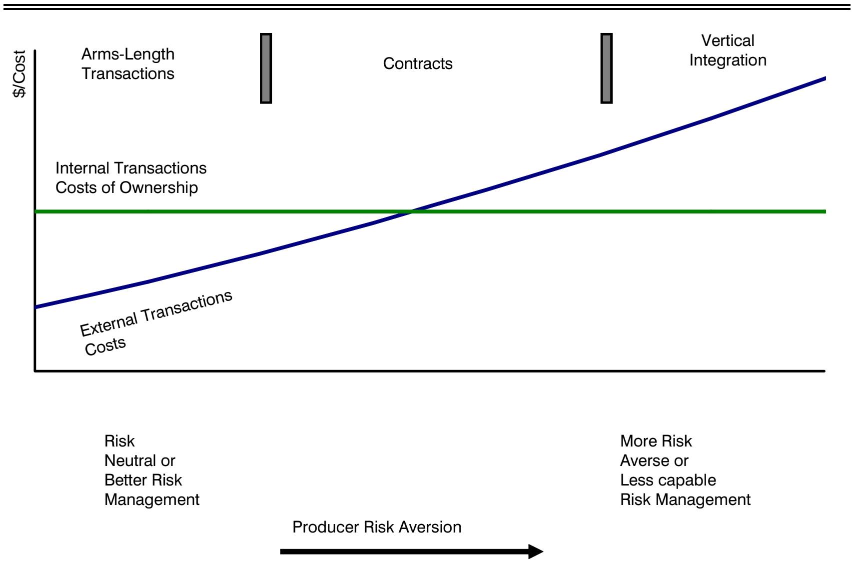

Figure 1 depicts the conceptual framework of external transactions costs of risk sharing in comparison to internal transactions costs of ownership. The vertical axis measures the total cost of the transactions of products, services, information, and compensation between stages of the chain. The horizontal axis represents the risk aversion and/or ability to manage risk for producers from whom the processor may choose to acquire products. The processor is assumed to have a lower relative risk aversion than producers. Thus, as channel captain, if the processor wants to source products from more risk averse producers, they must design vertical arrangements to either take on more of the risk, or compensate the risk averse producers more for accepting the same share of the risk.

Two separate lines are displayed in Figure 1. The external transactions costs line reflects the additional risk-sharing cost borne by the processor when the exchange is between the processor and producers in a vertical arrangement. This line increases at an increasing rate as producer risk aversion increases. Increasing external transactions costs reflect the additional costs that must be borne by the processor in the form of either increased risk taking or increased compensation to the more risk averse producer for taking on more risk.

The internal transactions costs line reflects the cost of ownership to a processor that owns both stages of the chain where separate firms are replaced with employees. Internal transactions costs of ownership are initially assumed to be higher than external transactions costs. That is, we assume that the efficiencies of an open-market transaction in the absence of risk aversion by the producer result in lower transactions costs than vertical ownership.

As producer risk aversion increases, the internal transactions costs of ownership do not change — only the risk sharing transactions costs of a market-based exchange increase. There is a point where the additional transactions costs of risk sharing cause the transactions costs of the market exchange to exceed the internal transactions costs of ownership.

The delineations across the top of the figure illustrate the different governance structures likely to be employed. When producers have risk management capabilities or have low enough risk aversion that risk sharing transactions costs are low, channel partners are likely to align in an arms-length exchange such as open markets, strategic alliances, or joint ventures. As producer risk aversion rises or management ability declines, the external transactions costs rise for the processor due to increased risk sharing costs. The increase in external transactions costs lead to more formal vertical arrangements such as contracts, where the risks and returns are dictated by the channel captain (processor). There is a point along the producers' risk aversion/management scale where the risk sharing transactions cost of the market exchange are higher than the internal transactions costs of owning the chain. It is at or just beyond this point where ownership of the channel (vertical integration) becomes an option because the transactions costs of risk sharing exceed the internal transactions costs of ownership. Producers at this level of risk aversion would likely choose to become a grower for a vertically integrated firm, receiving a flat fee for their services much like an employee of the company.

Research in supply chains in other industries shows that eventually external transactions costs decline below the internal transactions costs of chain ownership as firms become more accustomed to working together and better equipped to handle the risks in the exchange between segments of the chain (a learning supply chain as described by Sporleder & Peterson, 2003). If the goal is to reduce external transactions costs, then firms will favor partners that are less risk averse or better able to manage risk. As such, contracts and similar vertical arrangements would likely accrue to larger producers. However, for processors willing to absorb more risk, the preferred partner may be more risk averse producers in very tightly linked production contracts, where producer risks are transferred to the processor but rewards to the producer are lower. The framework presented here ignores any concept of market power among channel participants, and yet illustrates a logical economic reason for more tightly aligned vertical arrangements and industry consolidation to occur even in the absence of market power.

Risk Premiums and Contract Production

A common governance structure that more explicitly shares risks and rewards between supply chain partners is the contract. Figure 2 illustrates the nature of the risk premium required to entice more risk averse producers into contract arrangements that share more risk. The horizontal axis is the proportion of returns shared by producers in a vertical arrangement with a processor. The vertical axis is the risk shared by the producer. There are three lines in the graph, each representing different levels of producer risk aversion. If the producer is risk neutral (the vertical line in figure 2) then the sharing of risk would be irrelevant to the producer and the share of returns would be just enough to entice the producer to enter the arrangement. If the processor wishes to maintain a certain level of risk sharing, but must do so with more risk averse producer, the processor will have to give a greater share of the returns to the more risk averse producer to compensate them for sharing the risk. And, the greater the producer's risk aversion, the more sizeable the risk premium becomes. To minimize this risk premium payment, the processor would prefer to contract with producers who are less risk averse or have more capacity to

Figure 2. Conceptual Framework for External Transactions Cost of Risk Sharing Versus the Internal Transactions Cost of Vertical Ownership

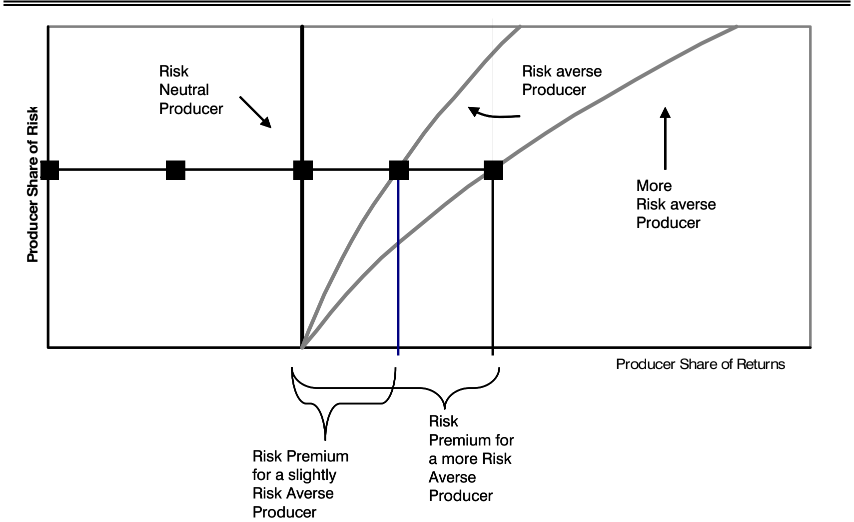

Table 1. Financial performance of various pork production business arrangements.

	Financial Structure		
	0% Debt	40% Debt	80% Debt
Pork Production Business Arrangement	Mean Return on Equity (%)	Mean Return on Equity (%)	Mean Return on Equity (%)
Independent Farrow-to-Finish	17.0	23.5	56.5
Efficiency and Marketing Incentive Finishing Contract	10.4	12.5	23.1
Death Loss Incentive Only Finishing Contract	11.3	14.0	27.6

manage or absorb risk; this motivation again favors larger producers.

Contracts frequently spell out portions of both "fixed" payments and incentive payments from buyers to suppliers based on performance variables. The balance of fixed versus incentive payments depends, ultimately, on the relative risk aversion/management capability of the partners in the chain. If a processor seeks a governance structure that allows the risks to be shared between the parties, then they will seek a governance structure with more incentive payments. To entice risk averse producers to accept more incentive payments (share more of the risk), the fixed payment would have to be greater than for less risk averse producers (this is reflected in Figure 2 as the risk premium).** The risk sharing transactions cost of governance structures with more incentive payments will be less if the producers are relatively less risk averse or relatively more capable of managing risk. This again suggests that agribusinesses seeking production partners in a contract-coordinated supply chain that will share the risks and rewards will tend to favor larger producers with the ability to spread risk and/or producers that are less risk averse. For processors that are more willing and/or able to manage risk, a fixed payment contract may be the preferred arrangement to attract risk averse producers that are willing to take less return for lower risk.

*** The discussion here is based on incentive contract literature and more explicitly from the discussion of the "Second-Best" Contract by Besanko, Dranove, and Shanley (2000).*

Implications for Producer Financial Performance

The transfer of risk and the accompanying reward from supplier (producer) to buyer (processor) suggests that suppliers will likely be less profitable under a vertically aligned governance structure compared to the traditional open-market governance structure that has dominated agriculture. And in fact most studies support this argument when profitability is measured by traditional metrics such as profit per unit of production or return on assets (ROA). But vertical arrangements that share business risk and rewards allow producers to access more debt capital if the business risk is reduced through contracting or similar business arrangements.

Analysis of pork contracting illustrates the financial implications of using more debt in the capital structure of the contract production farm compared to an independent grower. Contract swine growers can in fact finance their operations with debt comprising a large portion of their capital structure (Lins, 1997; Roberts et al., 1997). Table 1 illustrates the implications of different capital structures for different business arrangements on the return on equity (ROE). Note that with no debt, independent business arrangements generate a higher ROE (and ROA since they are equal when no debt is used) than the typical contract business arrangements analyzed. As debt becomes a larger proportion of the capital structure of the business, the ROE increases for all business arrangements. But the independent grower who does not manage operating risk will likely not be able to use as much debt as part of his/her capital structure as the contract grower. Comparing the ROE of the independent grower at 40% debt (23.5%) with that of contract growers at 80% debt (23.1% and 27.6%), it is apparent that vertically aligned systems that transfer risk to the buyer (processor) have equal or superior financial performance. By accessing more external financing these firms also have increased capacity to expand their business.

Increased access to debt capital allows vertically aligned producers to generate competitive financial performance, grow at a more rapid pace, and adopt new technologies more quickly than those not vertically aligned; further separating these producers from those with less access to vertical markets and debt capital. This outcome may, again, lead to a more rapid consolidation as well as vertical coordination of the industry as has been witnessed in poultry, pork, and potato industries.

Risk of Vertical Alignment

The development of more tightly aligned supply chains creates new and less easily quantifiable risks for the participants in the supply chain. For example, one of the supply chain risks faced by both suppliers and buyers is contractual or relationship risks. A grower may have a contract that guarantees a price for his/her products, and enticements to invest in specific assets, but what happens if the processor goes bankrupt? What happens to the contract (availability or terms) and the capital investments made by the producer next year if the processor finds other suppliers in other areas who can satisfy their needs at a lower price? This risk is not unlike that of losing a critical supplier or a lender, but losing access to the product market has typically not been a significant risk for producers in commodity-based agriculture.

The adoption of more tightly aligned supply chains in agriculture is likely to compound the risk and uncertainty related to the effectiveness of markets in providing accurate messages to consumers and suppliers in the food chain concerning prices, quantities, and qualities of products and attributes.

With the formation of more tightly aligned food supply chains, it can be argued that messaging is much more precise, timely, and generally more accurate for participants in the chain than might be provided by market forms of coordination. But, what about the risk faced by those who are not part of the tightly aligned supply chain – are not qualified suppliers? Is there more volatility in the prices they receive because of thin markets? Do they have access to a market or are they closed out because only qualified suppliers can participate? Because of the thinness of these markets, are they not only subject to more volatility, but also more potential for manipulation? Do the prices and other information conveyed by these thin markets provide accurate messages to consumers and suppliers concerning quantities, qualities, cost, and value?

Conclusions

Tightly aligned supply chains are forming at a rapid pace in the agricultural section. Traditional transactions costs are a critical determinant of the appropriate governance structure for these supply chains. However, risk considerations and the risk aversion/sharing characteristics of the players are also important. The search for reduced risk sharing transactions cost leads to the formation of supply chains among participants that are more willing to share risks as well as rewards. More specifically, strategies to reduce internal/external transactions costs lead to the formation of supply chains among participants who are less risk averse or have more ability to manage or mitigate risk. This suggests that, in general, most tightly aligned supply chains that seek to share risk and rewards among participants will be increasingly dominated by larger firms at both the buyer and supplier level – leading to more consolidation, particularly the production end of those industries. However, channel captains that have the willingness and ability to absorb the risk may allow producers with less ability to manage risk to maintain a role in the industry as service providers for these risk absorbing processors. At the same time, the transformation of the industry to more tightly aligned supply chains will introduce new strategic risks which will require additional analysis and skills to manage and/or mitigate those risks.

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The Economic and Environmental Effect of Adding Conservation Buffer Areas in the Matson Ditch Watershed

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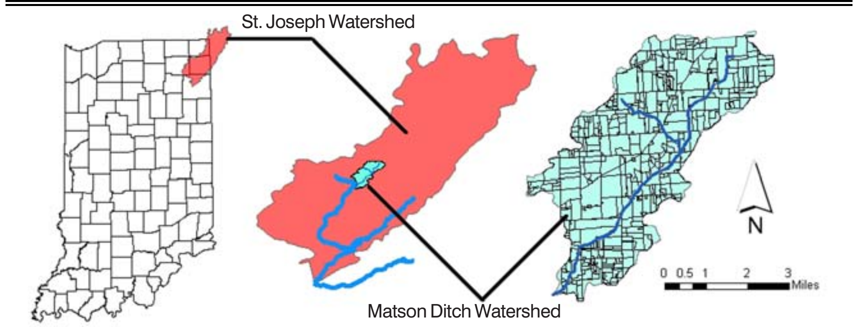
Production of commodity row crops, such as corn and soybeans, is the main economic activity of Midwest farmers. By its very nature, row crop agricultural production may be detrimental to the environment. Production practices such as planting, tillage, and side-dress fertilizer application disturb the soil surface and allow for detachment from the soil profile. This disturbance can lead to detached sediment which can be transported to surface water resources. Fertilizers, pesticides, herbicides, and other applied chemicals have the potential to runoff from farm fields during rain events or through subsurface drainage, contributing to water quality problems. While the farmer, through his or her production activities, contributes to this pollution, they are seldom held accountable for these impacts. The cost of degraded water is paid by those individuals using the water further downstream. In short, the production choices farmers make may have implications that reach far from the farm and involve numerous and diverse stakeholders.

Non-Point Pollution

Water pollution may be categorized into two types: point-source and non-point source. Point-sources enter water resources directly through a pipe, ditch, or other delivery (e.g. industrial and municipal waste). Non-point source pollution enters water diffusely in the runoff of pollutants and is often a function of land use. Agriculture is listed as a source of pollution for 48 percent of impaired river miles in the U.S. (EPA, 2002a). The primary agricultural pollutants are sediment, nutrients, pesticides, salts, and

** This research was funded, in part, by a cooperative agreement from the Conservation Effects Assessment Program, Agricultural Research Service, USDA. The views expressed are solely those of the authors and do not represent the views of ARS/USDA or Purdue University.*

Matson Ditch Watershed Area



pathogens (EPA, 2002a). Monitoring non-point agricultural pollution is problematic because its source is not easily identifiable; it's difficult to determine from which farm or which field a specific pollutant in the water supply originated.

Cost of Water Pollution

Soil erosion alone is estimated to cost water users between $2 billion to $8 billion annually in the U.S. These estimates include damages or costs to navigation, reservoirs, recreational fishing, water treatment, water conveyance systems, and industrial and municipal water use (Ribaudo, 1999). In the state of Indiana 7,335 miles of river and streams, or approximately 40 percent of all rivers and streams, are impaired. 71 percent of the impairments are the result of non-point pollution (EPA, 2002b). Applications of fertilizers, manure, and pesticides in agricultural areas have degraded the quality of many streams and shallow groundwater. It is difficult to put an exact cost on these damages because many of them are indirect and have no true market value. While it is possible to measure the cost of something like filtration for municipalities dealing with contaminated water, other transactions may possibly never occur as a result of the pollution. For example, a family may decide not to go swimming or fishing in the river, and because that transaction never occurred the value of the river as a place for recreational activities is decreased.

Best Management Practices

Mostaghimi et al. (2001) reported that the main approach used in minimizing pollution resulting from agricultural activities is the implementation of best management practices (BMP). BMPs are practices that the farmer can adopt to help control point and not-point pollutions sources in order to lessen the environmental impacts of agricultural production. These practices must be economically feasible if landowners are to adopt them for pollution control. BMPs can be classified as either structural practices such as terracing, impoundments, fencing, and filter strips, or non-structural such as conservation tillage (Park et al., 1995). Almost 2.5 million acres of buffers, waterways, and riparian areas are signed up in the Continuous Conservation Reserve Program (CCRP), with annual payments totaling $217 million in 2005 (FSA, 2005). This program allows farmers to voluntarily adopt conservation practices in exchange for economic incentives such as annual land rental payments, installation cost-share, and sign-up bonuses. Farmers agree to take land out of crop production for 10 to 15 years in exchange for these incentives. The farmer is able to place these lands back into production after the contract expires, however the long-term hope is that farmers either reenroll these areas or alternatively find value in having the land out of production. The USDA reports that buffers can help farmers reach a number of important conservation objectives such as the prevention of soil erosion, improving water quality by removing sediment, fertilizers, pesticides and other pollutants from runoff, improve air quality, enhance fish and wildlife habitat, control flooding, improve farm safety, protect buildings, roads, and livestock, conserve energy, and beautify landscape. More than 250,000 buffer contracts are enrolled with the USDA and nearly 160,000 farms and ranches have buffers installed under voluntary programs (NRCS, 2004). The positive environmental impacts of buffer areas have been well documented. Green and Haney reported effectiveness of properly placed and maintained vegetative buffers can be greater than 70 percent for sediment removal and 50 percent for soluble pollutants such as nitrates, phosphorus, and pesticides.

Objectives

This study examines the potential effectiveness of incentives of farm firms in the Matson Ditch Watershed to adopt buffer practices into their production systems. Farm level economic and environmental modeling was conducted to examine the trade-offs the farmer must make when establishing buffer areas. To accomplish this objective it was necessary to determine the expected revenues and sedimentation levels for the farm firm when placing acres into buffer systems versus leaving those acres in crop production. The area of interest in this study is the Matson Ditch, a sub-section of the St. Joseph Watershed, located in DeKalb County, Indiana (see above map).

Farm Level Modeling

Nine different representative farms were developed for the Matson Ditch Watershed. Three farm sizes**; small (500 acres), medium (1000 acres), and large (2500 acres) were examined under three different tillage systems;

*** Farm sizes were based on landowners and input providers' assessments of production sizes in their area; these estimates fall in line with USDA farm typology.*

conventional, reduced, and no-till***. Production costs for corn and soybean rotations were established using local input prices and machinery complements. The model assumes that land that will be placed in buffer areas has lower productivity than the rest of the fields. This analysis assumes that land lying adjacent to streams and forest boundaries will be marginally productive, approximately 23 percent less productive****, than the rest of the farm field on average. It is assumed that land near streams and forests are more prone to the effects of erosion, sedimentation, and/or light deprivation, leading to lower productivity. A three percent yield drag was added to no-till corn in order to compensate for lower observed yields in research settings*****. Production revenues, including subsidy payments******, were estimated for the nine representative farm types.

Table 1. Net Revenues[1] per Acre on Marginal Lands

	Tillage System	Small	Medium	Large
Corn				
	Conventional	$ 28.62	$ 45.71	$ 69.08
	Reduced	22.34	37.04	60.46
	No-Till	32.14	41.26	63.64
Soybeans				
	Conventional	$ (7.64)	$ 0.71	$ 19.53
	Reduced	(2.37)	3.47	21.57
	No-Till	(2.93)	(2.82)	16.78

1 *Net Revenues per acre = Gross Returns per acre from the sale of crops – (land rent per acre + variable input and machinery costs per acre + (fixed yearly machinery costs/acres)) + crop subsidy payments per acre.*

Net Revenues from Marginal Cropland

The farm model predicts that corn production is more profitable than soybeans across all farm sizes and tillage systems (Table 1). Soybean production on marginal lands seems less feasible for small farmers than for large farmers. Farm firms examined in this study indicate economies of scale exist across farm sizes; large farms have the ability to minimize production costs per acre by putting their respective machinery compliments to work over more acres. They also have greater bargaining power in terms of input prices. These effects of scale allow large farms to maximize profits per acre.

Buffers

Three different buffer widths were established; 20 feet, 35 feet, and 120 feet, utilizing four different vegetative options; all grass, alfalfa, half grass and half trees, and two-thirds grass one-third trees. Per acre revenues for the adoption of these practices can be seen in the following chart. Revenues were estimated over the life of the practice, CCRP grass buffers have a 10 year contract while tree and grass mix buffers have a 15 year contract. Alfalfa buffers are not eligible for CCRP contracts; we assume the alfalfa stand has a life of 5 years. Alfalfa stands yield 2 tons per acre in the establishment year and 4 tons per acre each subsequent year. The establishment cost of non-alfalfa buffers are heavily offset by the cost-share program and sign-up bonus offered by the Farm Service Agency.

Revenues for Buffers

As the width of the buffer increases there is little effect on the per acre expected revenues (Table 2). Alfalfa has the largest average returns over the life of the practice at $19.53 per acre. Establishing alfalfa areas is capital intensive, but it is the only option that provides a harvestable crop. However alfalfa requires additional labor and agronomic expertise; competing with corn and soybean production during critical plant and harvest times. A buffer composed of half trees and half grass has the second largest average return when subsidy payments are included. For grass and grass-tree mix buffers

Table 2. Expected Net Revenues per Acre from Buffer Areas

Buffer Type	Establishment Year	Second Year	Third Year and Beyond	Average Over Life of Practice
Grass	$102.40	$5.05	$5.05	$14.79
Alfalfa	($178.44)	$69.02	$69.02	$19.53
1/2 Grass, 1/2 Trees	$87.80	$0.02	$11.17	$15.53
2/3 Grass, 1/3 Trees	$101.63	$1.67	$9.16	$14.82

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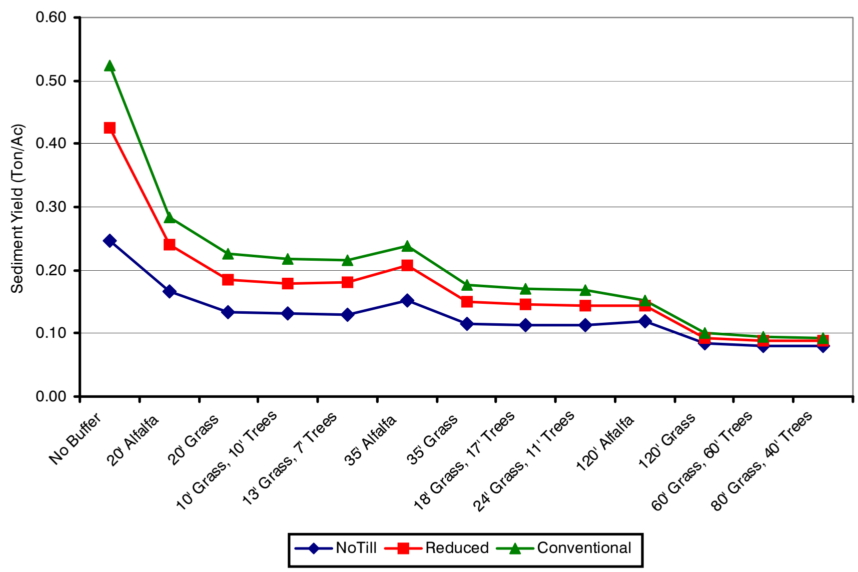
**** Tillage systems were based off of recommendations from the National Soil Erosion Research Laboratory. In this study Conventional systems use spring plowing and cultivation for corn along spring and fall disking for beans. Reduced systems use one spring cultivation for beans and spring plowing and cultivation for corn. No-Till systems use a harrow before corn and soybean planting to spread residue.*

***** The June 2005 Purdue Land Survey (Dobbins and Cook) found that average land in Northeast Indiana produced 134 Bu/Ac corn while poor land produced 104 Bu/Ac corn. This ratio was extended to soybeans; average land is assumed to produce 41 Bu/Ac soybeans thus poor land is expected to produce 32 Bu/Ac soybeans.*

****** No-Till yield drag based on the recommendations of Purdue Agronomist Dr. Tony Vyn.*

******* Direct, Counter-cyclical, and LDP rates were calculated based |on historical yield and price averages along with the 2005 marketing year average and posted county price average for DeKalb Co.*

Figure 1. Yearly Sediment Yield Predictions based on Buffer Typology and Tillage System



the revenues after the establishment year indicate the amount of the annual rental payment that is left after the cost of land rental, mowing, and chemical applications are deducted. Farms receive the same financial incentives per acre for buffer areas regardless of size; eliminating the effects of economies of scale. Thus a large farm would not expect buffers to be more or less profitable than a small farm. However, all of the buffer alternatives are less profitable than a corn and soybean rotation for large farms. As farm size decreases the buffer areas become more financially competitive. Small farms have the greatest incentive to adopt conservation buffers, they would gain higher per acre revenues than they could achieve through corn and soybean production.

Environmental Effects

Buffers need to be economically feasible in order to induce adoption by farmers; however, the economic benefit is only half of the picture. The economic cost of erosion to the farmer depends on the time horizon. While erosion will decrease the farmer's future productivity, it may have very little effect on current productivity. Thus the immediate cost of erosion is not always apparent, yet by reducing the production potential of the soil the land asset is decreased in value to future buyers or generations who hope to make a living from farming. It is important to understand the environmental repercussions of adopting conservation practices. The Water Erosion Prediction Project (WEPP)******* program was utilized to predict the sediment yields over the three tillage systems and various buffer types. Sediment yield is the amount of soil that enters into the ditch or creek from the field. This soil maybe transported downstream or deposited in the stream bed. Sediment is a pollutant alone, but fertilizer and chemical molecules may also attach to soil particles, making sediment a carrier for various pollutants. The results can be seen in the following graph (Figure 1).

The WEPP model predicts that switching from a conventional tillage system to a reduced or no-till system can greatly affect the amount of sediment that enters the water from field practices. A no-till system can reduce sediment entering the ditch by 53 percent and a reduced till system by 19 percent in comparison to a conventional tillage system. Getting producers to switch tillage practices should be an easy sell from an environmental standpoint, utilizing a no-till system instead of conventional tillage cuts sediment loading in half without any land being taken out of production.

WEPP predictions also show the environmental benefits of buffer systems. No-till production systems consistently lead to the lowest sediment yields, but as buffer widths are expanded the production system has less effect on sediment yield. As buffers get larger the effect of the tillage system on sediment yields is decreased. However, the initial 20 feet of buffer accounts for the greatest sediment reduction. Adding a 20 foot grass buffer reduces sediment yields by 57 percent in conventional systems, 56 percent in reduced tillage systems, and 46 percent in no-till systems. Adding a 20 foot grass buffer to a conventional system decreases the sediment yield more than switching to a no-till system without a buffer; the tradeoff is taking that 20 feet out of crop production. Increasing the grass buffer to 35 feet leads to an additional 9 percent decrease in sediment yields in conventional systems, 8 percent in reduced systems, and 7 percent in no-till systems. The sediment yields of conventional, reduced and no-till practices become more similar as the buffer width increases. Buffers function by reducing the velocity of the field runoff, allowing the sediment to fall out of suspension and be absorbed by the buffer. The buffer has a limited capacity as a sediment sink, so utilizing tillage practices that produce more sediment causes more sediment to reach the buffer, ultimately leading to a decreased functional lifespan of the buffer. The model shows that maximum environmental benefits are derived from utilizing conservation tillage in conjunction with a buffer area.

The ratio of trees to grass has little overall effect on reducing sediment yields, thus it might not

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******* *WEPP modeling was made available for this study by James Frankenberger at the USDA/ARS National Soil Erosion Research Laboratory in West Lafayette, Indiana.*

be cost effective to add trees into buffer areas. On average, adding trees to the buffer mix reduces sediment yields by 3 percent in no-till, 4 percent in reduced tillage and 5 percent in conventional tillage over grass alone. However this does not account for the positive impact trees have on wildlife and aquatic communities, and the potential long-term benefits of timber harvest. High-value hardwoods, such as walnut, could potentially be planted in these buffer areas; however forest ecologists recommend a mix of species of different canopy heights to maximize benefit to wildlife. Monoculture hardwood planting could possibly be profitable to landowners long-term, but there is a definite trade off between timber value and habitat quality. Alfalfa strips can reduce sediment yields, yet they consistently lead to lower overall reductions in sediment yields in comparison to grass and grass-tree mixes. Having an alfalfa buffer is better than no buffer, but alfalfa does not provide the sediment reducing capacity of grass and grass-tree mixes.

Research Results

This study reaches some important conclusions about the implementation of voluntary buffer programs. Farm level economic modeling shows there is more financial incentive for smaller farms to adopt buffer areas than larger farms. Also, the farmer has more perceived financial incentive to adopt conservation practices in soybean production cycles due to low per acre revenues. This study also indicates that while alfalfa buffer areas have the greatest returns over the life of the practice they also require the greatest initial expenditure of capital, additional labor, and agronomic expertise. However, alfalfa buffers are not as effective in reducing sediment as buffers utilizing grass or grass-tree mixes. When looking at the composition of buffers, it seems that adding trees to grass buffers has little effect on sediment yields and per acre revenues, but may have significant benefits for riparian and aquatic wildlife. When installing buffer areas there are diminishing returns to increasing buffer size; the largest reduction to sediment yields is gained in the initial 20 feet of buffer area. Switching to a no-till system from conventional or reduced tillage can have a dramatic impact on reducing sediment yields, but as buffer widths are increased, the choice of tillage system has less impact on overall sediment yields in the short term.

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New Generation Grain Marketing Contracts: How Have Producers' Opinions and Usage Changed Between 2003 and 2005?

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New generation grain marketing contracts (NGC) were introduced to the market 5 years ago and are now widely available to producers. The purpose of this research is to develop a better understanding of the opinions of Midwestern producers regarding the use of NGC, to learn who is most likely to use NGC, and whether opinions and use have changed between 2003 and 2005.

What are New Generation Grain Marketing Contracts?

NGCs are generally classified into three categories. First, there are automated pricing contracts that follow predetermined and nondiscretionary pricing rules over a specific time period (the pricing window). The most common contract is an average pricing contract that is designed to give the producer an average price by pricing an equal amount of bushels every business day during the pricing window.

Table 1. Producers' planned use of New Generation Contracts in 2003 and 2005.

	2003		2005	
Action	Producers who use NGC N=10	Producers who do not use NGC N=28	Producers who use NGC N=12	Producers who do not use NGC N=30
Increase in future	60%	61%	42%	37%
Stay at current usage	20%	39%	50%	63%
Decrease in future	20%	0%	8%	0%

There are more complex automated pricing contracts that allow the producer to establish more parameters in the pricing criteria. These more complex contracts will typically use technical systems such as moving averages, the relative strength index, and stochastics.

The second category of contracts is called managed hedging contracts where pricing decisions are made by an individual analyst chosen by the producer. The producer will choose the number of bushels to price and the analyst, at which point the producer takes a passive role in pricing the designated bushels.

The third type of NGC are called combination contracts where the producer still utilizes automated pricing rules but is allowed to share in gains (if any) from pricing decisions made by the pricing analyst. The AgMAS report by Hagedorn et al. (2003) provides a detailed description of some of these contracts.

How Producer Usage of NGC Has Changed

To better understand how NGC are, or are not being used, and how their usage has changed, this analysis draws on surveys of Midwest producers that were conducted in July 2003 and again in July 2005 at the Purdue Top Farmer Crop Workshop. The Purdue Top Farmer Crop Workshop participants tend to operate commercial size farms. In 2003, the average farm size for the 46 respondents was 2,501 acres, and in 2005, the average farm size for the 47 respondents was 2,861 acres. In addition, these producers are generally technological innovators. Thus, they are an ideal group to survey about their use of NGC. Although this group is not statistically representative of farmers in general, they may be typical of large-scale commercial producers.

NGC are widely available with over two-thirds of the respondents (68% in 2003 and 71% in 2005) saying that the grain handlers to whom they deliver offer NGC. However, of the producers who have access to NGC, only about a third of these producers have used them (37% in 2003 and 29% in 2005). Table 1 reports how producers expect their usage of NGC to change, and these plans are examined separately for those producers who use NGC and those who don't use them. Of the 2005 respondents who use NGC,42 percent plan to increase their use, 50 percent plan to remain at their current level of use, and 8 percent plan to decrease their use. Of the 2005 respondents who do not use NGC, 37 percent plan to start using them, while the other 63 percent do not plan to use them. In contrast, respondents in 2003 were more likely to say that they planned to increase usage of NGC, with about 60 percent of all producers planning to increase usage.

Table 2. Producers' advantages and disadvantages of using New Generation Contracts in 2003 and 2005.[1]

	2003		2005	
Advantages	Producers who use NGC	Producers who do not use NGC	Producers who use NGC	Producers who do not use NGC
Provides discipline in pricing	4.55	4.22	4.55	4.00
Provides pricing diversification	4.33	3.88	4.27[2]	3.33[2]
Helps get the emotion out of pricing	4.33	3.77	4.55	4.00
No margin calls	4.25[2]	3.77[2]	4.00	4.07
Provides more pricing alternatives	4.00	3.77	3.73	3.20
Reduces time spent marketing	3.66	3.25	3.27	3.87
May increase net price	3.44	2.88	3.55	2.93
Disadvantages				
Service fees	3.55	2.75	3.64	3.60
May lower net price	3.44	2.88	3.36	3.67
Too many pricing alternatives	2.22	2.12	2.45	2.53
Too complex to understand	2.00	3.37	2.45	2.33

1 *1= strongly disagree, 3= neutral, and 5= strongly agree.*

2 *Statistically significant at the 90% level of confidence.*

Producer Opinions about NGC

Producers were asked their opinion regarding the perceived advantages and disadvantages of NGC. They were asked to indicate their agreement or disagreement with a series of statements based on a 5-point scale where 1 is strongly disagree, 3 is neutral, and 5 is strongly agree. An average response of greater than 3 means that the respondents, on average, agree with the statement and an average response of less than 3 means that the respondents, on average, disagree with the statement. Responses are reported separately in Table 2 for those who use NGC and those who do not use them because an individual's experience with NGC would be expected to affect their opinions. The user and non-user responses were tested for statistical differences.

Consistent from 2003 to 2005, all groups of producers believe that the biggest advantage of NGC is "to provide producers with discipline in their pricing strategy". In 2005, an equally important advantage among all producers is that NGC "helps get the emotion out of pricing," and this advantage ranked higher than it did in 2003.

In both years, all producer groups agree that NGC "provide the producer with pricing diversification". In 2005, producers who use NGC are significantly more likely to agree that providing pricing diversification is an advantage than producers who do not use NGC. This is the only statistically significant difference of opinion between the two groups of producers in 2005. This suggests that the producers who use NGC do so in order to diversify their pricing strategy.

In both years, all producer groups agree that "not having margin calls" is an advantage of NGC to producers. In 2003, producers who used NGC agreed more strongly that no margin calls is an advantage than producers who do not use NGC. This was the only statistically significant difference of opinion between the two groups. By contrast, in 2005, producers who do not use NGC rated no margin calls more highly as an advantage than did producers who use them. While the advantage of no margin calls may have been the reason producers used NGC in 2003, producers now appear to be more interested in NGC as a tool for pricing diversification.

In both years, all producer groups agreed that an advantage of NGC is to "provide more pricing alternatives" and disagreed that a disadvantage of NGC is that "too many pricing alternatives" are offered. This indicates that producers continue to appreciate the expanded marketing alternatives.

In both years, producers who use NGC weakly agree (3.44 and 3.55) that NGC "may increase net price". However, they also weakly agree (3.44 and 3.36) that NGC "may lower net price". This inconsistency may imply producers who use them do not believe NGC will have a major impact on net price in either direction and that these producers use NGC for reason other than increasing their net price. In contrast, the producers who do not use NGC disagree (2.88 and 2.93) that they may increase net price in both years. Further, in 2005 producers agree that NGC may lower net price. This suggests that one reason producers do not use NGC is that they believe these contracts will lower their net price.

In 2003 producers who used NGC agreed the "service fees are a disadvantage", while producers who did not use NGC tended to disagree, but the difference was not statistically significant. In 2005, however, both users and non-users agreed that service fees are a disadvantage.

In 2005, both users and non-users disagreed (2.45 and 2.33) that NGC are "too complex to understand". This marks a sharp change from 2003 when producers who did not use NGC weakly agreed (3.37) that they were too complex to understand. This sharp change suggests that producers now feel they have a better understanding of NGC, and when producers choose not to use NGC it is for reasons other than a lack of understanding.

Who is Using NGC

A thorough look at who is using NGC is necessary to identify those producers who may benefit the most from the use of NGC. Table 3 reports the descriptive characteristics of those who use NGC and those who do not use them. For both 2003 and 2005, the average age of the producer who used NGC was about 50 years of age, while the average age of those who did not use NGC was younger, at about 42 years of age in 2003 and about 45 years of age in 2005. One explanation for this age difference is that more experienced marketers may be more realistic about their ability to "beat the market" and thus more accepting of the NGC goal of achieving an average price. In both 2003 and 2005, all of the producer groups have an average of about 15 years of schooling. Producers who used NGC tended to operate larger farms. In 2003 and 2005 the average total acreage operated by those who used NGC was approximately 2,700 and 2,950 acres, respectively, while those who did not use NGC operated 2,600 acres on average in both years.

In 2003, the initial users of NGC were predominantly grain producers, but by 2005 more diversified operations with either livestock or specialty crops had started using NGC. Producers who used NGC in 2003 attributed a very small percentage (1%) of their gross farm income to livestock

Table 3. Mean characteristics of producers who used and did not use NGC in 2003 and 2005.

	2003		2005	
Characteristic	Producers who use NGC	Producers who do not use NGC	Producers who use NGC	Producers who do not use NGC
Years of Age	50.00	41.82	50.42	44.80
Years of Education	14.56	15.48	15.50	15.63
Total Acres Farmed	2708.00	2599.59	2946.08	2633.90
Percentage of Gross Farm Income Attributed to Livestock	1%	17%	12%	15%
Percentage of Gross Farm Income Attributed to Specialty Crops	6%	13%	20%	12%
Debt to Asset Ratio	36%	26%	40%	28%
Willingness to Accept Risk	3.70	3.64	3.92	3.80
Grain Marketing Skill			3.83	3.33
Grain Marketing Performance			3.75	3.87
Number of Times Sold Corn			12.18	9.86
Number of Times Sold Beans			7.18	5.87

production compared to the 2005 producers who on average attributed 12 percent of their gross farm income to livestock. Producers who used NGC in 2003 attributed only 6 percent of their gross farm income to specialty crop production compared to the 2005 producers who on average attributed 20 percent of their gross farm income to specialty crops.

Those producers who use NGC report a significantly higher debt-to-asset ratio for their farming operations. In 2003, those who used NGC had an average debt-to-asset ratio of 36 percent compared to 26 percent for those who did not use NGC. Similarly, in 2005 producers who used NGC had an average debt-to-asset ratio of 40 percent compared to 28 percent for who did not use NGC. This may suggest that operations with higher debt capital structures adopt NGC to help mitigate price risk.

Producers were asked to rate their willingness to accept risk in their farm businesses relative to other farmers on a scale of 1 to 5, with 1 indicating "much less willing" to accept risk and 5 "much more willing" to accept risk. In 2005, on average, producers were more willing to accept risk than those in 2003. In both 2003 and 2005, producers who used NGC indicated that they were slightly more willing to accept risk, on average, than those who did not use NGC, however this difference was not significant. Again, this may suggest that those who use NGC view NGC as a diversification tool which reduces price risk and therefore they may view themselves as more comfortable with risk in their farm business relative to other farmers because of they use strategies to actively manage risk.

In 2005 producers were asked a series of questions concerning their perception of their current grain marketing practices relative to other farmers. Producers rated their grain marketing skill relative to other farmers on a scale of 1 to 5, with 1 designating a "much less skillful" marketer and 5 designating a "much more skillful" marketer. Both the user and non-user groups felt that they were above average in skill at grain marketing relative to other farmers. Those who used NGC felt that they were more skilled with an average response of 3.83 compared with those who did not use NGC at 3.33. Similarly, producers were asked to rate their current grain marketing performance with their performance five years ago on a scale of 1 to 5, with 1 designating "much worse" performance, 3 designating an equal or "same" performance, and 5 designating "much improved" performance. Both groups of producers felt that they had improved their grain marketing performance from 5 years ago. Those who used NGC had a slightly lower performance rating of 3.75 than those who did not use NGC who reported a performance rating of 3.87.

Producers were asked to estimate the average number of times they sold corn and soybeans during the entire marketing season over the previous 5 years. On average producers who used NGC were more active marketers of both corn and soybeans. Producers who used NGC responded that they sell corn around 12 times and soybeans around 7 times on average per marketing season. Those who did not use NGC sold corn about 10 times and soybeans about 6 times on average per marketing season.

Summary and Conclusions

New generation grain marketing contracts (NGC) offer producers additional tools for pricing grain. A survey of participants at Purdue's Top Farmer Crop Workshop in 2003 and 2005 elicited opinions of the attributes and use of NGC. Between 2003 and 2005, producers have gained experience with these pricing tools and their opinions have changed accordingly. While producers continue to consider the biggest advantage of NGC to be "providing discipline in pricing", producers now rank "helps get the emotion out of pricing" as an equally important advantage. Producers in 2005 also appear to be more interested in NGC as a tool for "pricing diversification", while the advantage of "no margin calls" may have been the reason producers used NGC in 2003.

Producers continued to rank service fees as the primary disadvantage of NGC. While producers who use NGC have mixed responses on their ability to impact net price, producers who do not use NGC believe that they may lower net price. One of the most dramatic changes between 2003 and 2005 is that in 2005 both users and non-users disagreed that NGC are "too complex to understand," while non-users in 2003 agreed that NGC were complex. This change suggests that producers now feel they have a better understanding of NGC, and when producers choose not to use NGC it is for reasons other than lack of understanding.

This research also examined the characteristics of producers who are using NGC. For both 2003 and 2005, operations with a higher debt-to-asset ratio were more likely to use NGC perhaps because they view them as a diversification strategy that may help reduce their exposure to price risk. For both 2003 and 2005, producers who used NGC were on average older than those who did not use NGC was younger and one explanation for this age difference is that more experienced marketers may be more realistic about their ability to "beat the market" and thus more accepting of the NGC goal of achieving an average price.

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