USING BMP INSURANCE TO IMPROVE FARM MANAGEMENT

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I. Introduction

In the United States, more than 330 million acres of farmland supply an abundance of high quality marketable products (EPA, 2012). Although farmers are praised for efficient production of food, fuel, and fiber, agriculture is criticized for negative environmental impacts. The 2004 National Water Quality Report cites agriculture as the leading contributor of nonpoint source (NPS) pollution impairing rivers and streams (EPA, 2004). A 2012 EPA report estimates that agriculture is responsible for 6.3 percent of total U.S. greenhouse gas emissions (EPA, 2012). Best management practices (BMP) have been developed to reduce environmental degradation while maintaining productivity. However, for a variety of reasons, some farmers have not adopted BMPs. Studies suggest that farmers may be hesitant to incorporate BMPs – even profit enhancing BMPs – because of perceived down-side yield risk (Mitchell, 2004).

Agricultural BMPs are economically sound "voluntary practices that are capable of minimizing nutrient contamination of surface and ground water" (Randall et al., 2003). Guided by research and university recommendations, BMPs are developed by agricultural agencies and presented to farmers as practical, cost-effective actions that can improve environmental quality. Examples of BMPs include using comprehensive nutrient management plans (CNMP), precision agriculture, integrated pest management (IPM), improving the timing of input applications, incorporating cover crops, and installing riparian buffers (Mitchell and Hennessy, 2003). Many BMPs generate savings by reducing. Agricultural research and technological advancements have led to the development of Pareto-dominant BMPs that generate environmental benefits without adversely affecting farm profitability – a CNMP is one example (Baerenklau, 2005).

Adoption of BMPs in the U.S. is a voluntary decision made by individual farmers. Farmers are often hesitant to adopt suggested practices – even Pareto-dominant BMPs – because of perceived risk and/or beliefs that BMPs will lower average productivity. Government programs have traditionally used cost-share or payment programs to encourage adoption.

Programs such as the Environmental Quality Incentives Program (EQIP) use cost-shares to promote BMP usage. While financial incentives may be necessary to achieve adoption of costly BMPs, payments may not be the appropriate mechanism to promote Pareto-dominant BMPs that can preserve or improve profitability. Instead of aiming to offset perceived costs of implementation, incentive mechanisms for these BMPs must address factors such as exaggerated risk perceptions and uncertainty that directly impact adoption decisions (Feather and Amacher, 1994; Mitchell and Hennessy, 2003).

Farmers decide to adopt BMPs they think will improve farm functionality without adverse effects on profitability. Perceptions about BMPs are formed from prior experience and advice from other farmers, input suppliers, and extension personnel (Mitchell, 2004). Regardless of accuracy, these perceptions influence adoption decisions. Without accurate information, even profit enhancing BMPs may not be adopted. Overcoming misperceptions about risk and profitability of BMPs involves altering strongly held beliefs of farmers. BMP insurance, also called "green insurance" has been identified as one tool to overcome risk perceptions and promote BMP adoption by allowing farmers to try the management practices risk-free (Mitchell and Hennessy, 2003). BMP insurance provides an incentive for farmers to adopt BMPs, but unlike direct payments which must compensate farmers for anticipated losses based on subjective probabilities, insurance contracts only pay indemnities for actual losses (Baerenklau, 2005). Insuring Pareto-dominant BMPs may be a cost-effective incentive to encourage the widespread adoption of improved agricultural technologies and practices when farmers perceive exaggerated down-side yield risk.

This paper provides an overview of how green insurance contracts can be used to improve environmental outcomes in agricultural landscapes through the adoption of conservation practices. Section II describes how BMP insurance can be incorporated into farmers' expected utility function to motivate the adoption of Pareto-dominant BMPs that farmers' consider to be risky. Adoption of an insured BMP provides the farmer with an opportunity to try the improved practice and adjust their subjective views on the relative profitability and riskiness compared to conventional practices. Section III describes two contract designs for BMP insurance. The first contract involves making indemnity payments if BMP yields or profits are lower than the yields or profits on a check strip managed with conventional practices. The second contract monitors a group of participating BMP adopters and pays individual farmers if their profits fall below the long-run group average more so than profit deviations of a group of non-participating conventional farmers. The feasibility of BMP insurance is discussed in Section IV with particular emphasis placed on concerns of high transactions costs, moral hazard, and adverse selection. Section IV also considers how BMP insurance could be integrated with current multiple peril crop insurance purchased by farmers through private providers. The final section summarizes the findings and provides concluding remarks regarding the cost-effectiveness and feasibility of using green insurance as an incentive for BMP adoption.

II. Conceptual Framework

BMP insurance offers single peril coverage that protects the farmer against losses caused by BMP failure. Insurance is suggested as a policy tool to incentivize environmentally sound farm management based on the assumption that farmers are risk averse and have misperceptions regarding the effect of BMPs on farm profitability (Feather and Amacher, 1994). For example, farmers may over-apply nutrients or pesticides to protect against potential yield losses before facing a real threat. Excessive input applications do not improve yield, but instead the chemicals contribute to nonpoint source pollution via runoff. In a way, farmers treat the additional inputs as their own insurance policy against uncertainty. Studies in the Midwest find that chemical inputs and crop insurance are treated as substitutes for corn and wheat producers (Babcock and Hennessy, 1996; Smith and Goodwin, 1996). Following a CNMP for input applications and employing precision agriculture are examples of Pareto-dominant practices that can maintain high yield while producing less pollution.

Farmers are regularly faced with a variety of risks related to production, finances, marketing, and liability (Miranowski and Carlson, 1993). Farmers lacking first-hand experience using a particular BMP face uncertainty about the associated risks, particularly risks related to yield and profitability (Mitchell, 2004). Farmers develop risk perceptions based on past experiences, feedback from neighbors, information from extension services or input suppliers, and exposure to media resources. Based on available information, farmers then form beliefs about the BMP. Mitchell (2004) describes the decision-making process as a time when farmers use subjective probabilities based on their knowledge and beliefs to estimate the profitability of the BMP and decide to adopt the practice or stick to the status quo. If a farmer adopts a BMP, the subjective probabilities should converge with the objective probabilities over time, but the initial decision is based on perceptions.

Technology adoption decisions involving income risk can be modeled using expected utility theory and incorporating risk preferences in the farmer's utility function. If the new practice offers a higher expected utility compared to current production methods then the farmer is expected to adopt the technology. Building upon Mitchell's framework, let $u(\pi_q)$ be a risk-averse farmers' utility function where $u'(\pi_q) > 0$, $u''(\pi_q) < 0$, and π_q is random per acre profit using production technology q. Although numerous variations and combinations of production methods are used in agriculture, this stylized framework uses two technology classifications: the current practice ($q = cp$) and the best management practice ($q = bmp$). Expected utility of profits is depicted in equation (1). Per acre market prices and production functions for N commodities are respectively represented by p_i and $f_{iq}(\mathrm{Z}, \mathrm{K}, \mathrm{E})$, where Z is a vector of variable inputs, K is a vector of fixed inputs, and E is a random vector of environmental indicators. Input quantities and prices for M variable inputs are represented by w_j and z_j, respectively.

$$EU_q = E\left[u(\pi_q)\right] = E\left[u\left(\sum_{i=1}^{N} p_i * f_{iq}(\mathrm{Z}, \mathrm{K}, \mathrm{E}) - \sum_{j=1}^{M} w_j * z_j\right)\right] \tag{1}$$

Let CE_q be the certainty equivalent defined by $EU_q = u(CE_q)$. The benefit, B, of BMP adoption can then be calculated as, $B = CE_{BMP} - CE_{CP}$. Farmers are expected to adopt BMP technologies if $CE_{bmp} > CE_{cp}$ (thus, $B > 0$). Farmers would be indifferent between the technologies when the certainty equivalents are equal.

When subjective probability distributions for yield and profits using BMPs do not align with objective distributions, BMP adoption rates are suppressed by the misperception of down-side risk (DeVuyst and Ipe, 1999; Mitchell, 2004). Following Mitchell's (2004) framework, $\widetilde{EU}_q$, $\widetilde{CE}_q$, and $\tilde{B}$ respectively represent the expected utility, certainty equivalent, and adoption benefit when subjective probability distributions are used. Thus, the subjective evaluation of expected benefits is expressed as $\tilde{B} = \widetilde{CE}_{BMP} - \widetilde{CE}_{CP}$.

Incentives aim to increase the expected benefits using BMP technologies by increasing the expected utility of profits. Direct payments, for example, are structured to offset the perceived cost increase from using BMPs. Cost-shares and other payments may be necessary to incentivize profit-decreasing BMPs or technologies with associated overhead costs, but these incentives may not be necessary or appropriate when trying to promote profit-enhancing BMPs. BMP insurance, also known as "green insurance" aims to shift the subjective probability distribution so that farmers will try BMPs that they previously considered too risky. Equation 2 defines ${EU_{bmp}}^D$ – the EU using the BMP with a direct payment, D. Equation 3 defines ${EU_{bmp}}^I$ – the EU using the BMP with BMP insurance, where I_{bmp} is the insurance indemnity and M_{bmp} is the insurance premium.

$$
{EU_{bmp}}^D = E\left[u\left(\sum_{i=1}^{N} p_i * f_{iq}(\mathrm{Z}, \mathrm{K}, \mathrm{E}) - \sum_{j=1}^{M} w_j * z_j\right)\right] + D \tag{2}
$$

$$
{EU_{bmp}}^I = E\left[u\left(\sum_{i=1}^{N} p_i * f_{iq}(\mathrm{Z}, \mathrm{K}, \mathrm{E}) - \sum_{j=1}^{M} w_j * z_j + I_{bmp}\right)\right] - \mathrm{M}_{bmp} \tag{3}
$$

Encouraging BMP adoption using a cost-share or payment requires the payment, D, to be at least as great as the expected decrease in revenue and/or increase in costs. Likewise, for BMP insurance to induce adoption, the expected indemnity would have to offset revenue and cost changes in addition to offsetting the cost of the insurance premium. Assume that subsidized insurance covers all profit loss and is offered to the farmer at no cost ($\mathrm{M}_{bmp} = 0$). Equating ${EU_{bmp}}^D$ and ${EU_{bmp}}^I$ requires that $E[u(D)] = E[u(\tilde{I}_{bmp})]$, where $\tilde{I}_{bmp}$ is the expected indemnity based on the farmer's subjective probability distribution of profitability.

Assume the farmer has the option to participate in one of two different incentive programs. The first program, BMP-D, offers the farmer a direct payment and, in exchange, the farmer adopts a BMP. The second program, BMP-I, offers the farmer fully subsidized (i.e. free) BMP insurance if the farmer adopts the BMP. Farmers participating in BMP-D will require a positive payment ($D > 0$) to adopt BMPs that are perceived to be risk increasing or profit decreasing. Farmers participating in BMP-I know that an indemnity will be paid in the case of a profit loss from BMP adoption.

BMPs that are falsely perceived to reduce profits can be adopted using both programs. If, on average, these BMPs do not decrease profits, the average indemnity payment will be zero which is strictly less than the average direct payment that would have to be offered in the BMP-D program.

$$D = E[\tilde{I}_{bmp}] > E[I_{bmp}] = 0 = \text{average indemnity for Pareto-dominant BMPs} \quad (4)$$

Assuming no transactions costs[1], using BMP insurance would be a cheaper incentive relative to direct payments to achieve the same level of BMP adoption. Direct payment amounts would be based on subjective probabilities, whereas, indemnity payments would be based on objective probabilities. If farmers exaggerate the risk and losses expected from Pareto-dominant BMPs, then they will demand higher payments upfront than the average indemnity that would be paid in an insurance scheme. Hence, green insurance offers a more cost-effective incentive mechanism to promote adoption of Pareto-dominant BMPs.

III. Designing BMP Insurance Contracts

Based on past research and experience with BMP guarantee programs, two contract designs have been proposed for BMP insurance. Both designs protect farmers from potential productivity differences (yield or profit) based solely on BMP adoption and do not cover losses due to unrelated events such as weather conditions[2]. The more common approach involves maintaining a check strip using status quo inputs and paying adjustments based on yield or profitability differences between the check strip and fields managed with BMPs. Maintaining

[1] As we move from theoretical framework to real world applications, the assumption of zero transactions costs is no longer valid. This assumption will be relaxed in Section IV when the feasibility of BMP insurance is evaluated.

[2] Multiple peril crop insurance (MPCI) is available to insure farmers for loss that may occur due to factors outside of BMP adoption. MPCI insurance will be discussed further in Section IV.

and evaluating check strips is time consuming for both the farmer and program administrators. Furthermore, this approach can fail if participants attempt to cheat the system by mismanaging the check strip to receive higher indemnities – a problem known as moral hazard[3]. The second approach, known as a group insurance contract, pays indemnities to farmers based on the annual deviation from long run production averages among a cohort of nearby farmers. This approach aims to lower transactions costs by using county wide information to inform claims. The following sections will examine both insurance contracts in greater detail and will discuss applications of each design. Table A, in the Appendix, presents an overview of BMP insurance case studies and lists the contract design used in each example.

Contracts employing check strip and field comparisons

The check strip approach was proposed for the U.S. Department of Agriculture's Risk Management Agency (USDA-RMA) pilot project in 2003 and is currently employed by the BMP CHALLENGE™ run by American Farmland Trust (AFT) and Agflex (AFT, 2012; Mitchell, 2004). The RMA insurance product was designed to insure farmers who adopt a comprehensive nutrient management plan (CNMP). The BMP CHALLENGE™ is available to farmers who adopt CNMPs or use reduced tillage practices[4]. Although the programs focus on two particular types of BMPs, the concept can be applied to other technologies.

Farmers participating in this type of program enroll part of their property in the insurance contract and agree to employ the BMP on enrolled acres. After enrollment, a crop consultant visits the farm and, in cooperation with the farmer, designs a CNMP for nitrogen and phosphorus inputs (and can provide advice about tillage practices). During the visit the consultant marks a comparison strip (approx. 40 by 60 feet) that the farmer would manage using current, status quo production methods. Both sides of the check strip are bordered by similarly sized strips of land on which the farmer follows the BMP guidelines prescribed by the consultant. The crop consultant returns at the time of harvest to inspect the check strip and insured acreage. Insurance

[3] Problems with moral hazard and adverse selection are mentioned later in this section and addressed more fully in section IV.

[4] Information about the BMP CHALLENGE™ was acquired through personal communication with Brian Brandt, Director, Agricultural Conservation Innovations Center, American Farmland Trust.

payments are made if productivity of the BMP strips fell below that of the check strip. Productivity can be measured by comparing yields or profitability. The RMA pilot program insured against yield differences, whereas the BMP CHALLENGE™ pays the farmer if profitability of BMP fields is lower. By basing payments on differences in profitability, the BMP CHALLENGE™ accounts for changes in input costs – for example, although yield from BMP fields may have been slightly lower than the status quo check strip, the farmer could have increased profits because of savings from reduced inputs.

Although both programs used the check strip contract design, the contracts differ in implementation. The RMA pilot insurance was offered in four states (Iowa, Minnesota, Pennsylvania, and Wisconsin) and participants were charged a premium of $5.65 or $9.39 per acre, depending on location (Campbell, 2003; Mitchell, 2004). To provide additional incentive, the program offered a credit of $2 per acre paid toward the insurance premium if the farmer did not request an adjustment after harvest. After experiencing low enrollment, the pilot program ended in 2004 and has not been replaced by a similar program.

The BMP CHALLENGE™ is an externally funded program to promote BMP adoption and is not technically an insurance product. Farmers can enroll limited acreage free of charge and are reimbursed for profit loss. If BMP adoption increases profit, farmers contribute one-third of their profit (up to $6 per acre) back into the program. The BMP CHALLENGE™ is intended to be a short term program to allow farmers to test Pareto-dominant BMPs with hopes that farmers will update their risk perceptions through experience and continue using the practice in the future. Since the project was initiated in 2004, more than 7000 acres across the Midwest have been enrolled in the Nutrient BMP CHALLENGE™ and Reduced Tillage BMP CHALLENGE™.

Group incentive contracts

Group incentive contracts have been developed to overcome the moral hazard issues associated with paying farmers for productivity losses based on individual, on-farm yield measurements. Moral hazard occurs if farmers change their production behavior in a way that manipulates the insurance contract and results in greater indemnity payments. In BMP insurance, moral hazard arises because it is difficult to distinguish loss due to BMP adoption from loss due to other management factors. Contracts based on group indicators of productivity that cannot be manipulated by a single farmer are less likely to encounter moral hazard (Baerenklau, 2005; DeVuyst and Ipe, 1999). If appropriately designed, these contracts can also incentivize change in aggregate behavior by motivating farmers to improve production practices relative to neighbors. Additionally, group contracts lower monitoring costs by eliminating the need to inspect individual fields.

This type of green insurance mechanism was originally proposed by DeVuyst and Ipe (1999) and was extended by Baerenklau (2005). The contract pays indemnities to participating farmers if their profits fall below their long-run group average more so than profit deviations of nonparticipating farmers. The nonparticipating farmers act like a control group as they are subject to the same stochastic shocks as the insured participants. Indemnities are paid based on the following equation:

$$I_t = \max\left\{\left[\left(\frac{\bar{\pi}_{LR}^P - \bar{\pi}_t^P}{\bar{\pi}_{LR}^P} - \frac{\bar{\pi}_{LR}^N - \bar{\pi}_t^N}{\bar{\pi}_{LR}^N}\right) * \bar{\pi}_{LR}^P\right], 0\right\} * \min\left\{\left[\frac{P_{it} * (\varphi_i^0 - \varphi_i^t)}{\frac{1}{n_p}\sum_{j=1}^{n_p} P_{jt} * (\varphi_j^0 - \varphi_j^t)}\right]^{\sigma}, K\right\}. \quad (5)$$

I_t is the indemnity paid per unit in time t, $\bar{\pi}$ is the average profit per unit with $\bar{\pi}_{LR}$ representing long-term average profit, φ_i^t is the farmer i's input choice in period t, and φ_i^0 is farmer i's baseline input choice. P_{it} is an indicator function that take the value 1 only if the agent's input choice qualifies her to participate in the program. The superscripts P and N represent the participating farmers and nonparticipating farmers, respectively. The number of participating farmers is denoted by n_P. Parameters σ and K are set by the regulator to provide flexibility in the incentive mechanism. Setting $\sigma > 1$ adds curvature to the scaling term and can be used to reward farmers who adopt nutrient management plans in which they apply fewer chemicals relative to other participants. Parameter K places an upper limit on the size of the scaling term.

The "max" term functions as a signal to first determine if an indemnity is due and then the indemnity is scaled by the "min" term to minimize free riding. The "max" term provides an indemnity to participants if the average profit in time t of the insured BMP adopters deviates below their average long run profit more than the deviation from the long run average profit experienced by the nonparticipants in time t. The "min" term then scales the indemnity by allowing the incentive to vary depending on the extent of adoption relative to other BMP participants. Scaling rewards farmers who make above average reductions in input applications and discourages farmers from only adopting the minimum requirement to qualify for the program. The K term in the minimization operator can be set by regulators to place an upper limit on the magnitude of the scaling coefficient, thus limiting the size of each indemnity.

This contract is similar to the "area yield" insurance that is currently offered as a multiple peril crop insurance (MPCI) option by crop insurance providers. These insurance contracts pay farmers if the yield in a geographic area (e.g. county) falls below a predetermined threshold. "If no single farm is large enough to significantly affect this average yield, then each agent's dominant strategy is to operate his or her farm in good faith; hence there is no moral hazard dilemma" (Baerenklau, 2005 pp. 96).

Although this type of insurance contract avoids the transactions costs associated with establishing and monitoring check strips, it introduces other data requirements and costs of implementation. First of all, the insurance provider would need to have accurate data about the long-run profitability of both participating farmers and non-participating farmers. Furthermore, providers would need to know the profit experienced by participating and non-participating farmers each year in which BMP adopters are insured. Group contracts can provide an effective incentive for farmers who feel that production on their farm is positively correlated with the other group members. However, group contracts could deter participation from farmers who are not comfortable with indemnities relying on group averages that may or may not reflect their experience with the BMP(s) being insured.

Baerenklau (2005) analyzed the effectiveness of the group BMP insurance contract (eq. 5) on the adoption of reduced-phosphorus diets in Wisconsin. In Wisconsin, farmers were known to feed dairy cows approximately 4.8 grams of phosphorus per kilogram of dry matter (g/kg DM) despite research that showed that cows only need 3.3–3.8 g/kg DM to maintain the same level of milk production. The additional phosphorus supplement increased feeding costs by $13 per cow annually and contributed to nutrient runoff that threatened local waterways. Although reducing the level of phosphorus in dairy feed would be Pareto-efficient, farmers were not adopting the new diet recommendation. Simulation results based on a theoretical model of rational decision-making under uncertainty indicated that the group insurance contract had a significant impact on adoption behavior. Furthermore, by charging an insurance premium, the insurance product could be offered at no cost to the program administrator. The study concluded that, when subjective beliefs limit BMP adoption, environmental benefits could be achieved at a lower cost by using a green insurance mechanism rather than relying on payment schemes.

IV. Is Agricultural BMP Insurance Feasible?

In general, insurance is purchased by risk averse individuals who are willing to pay a premium for coverage that offers protection against the possibility of large financial losses. In an agricultural setting, crop insurance is purchased by farmers who desire protection from crop loss due to uncertain factors like annual climate. Agricultural BMP insurance would provide similar protection by insuring farmers against lower yields or profits after adopting specified BMPs. The question remains, is BMP insurance feasible in today's agricultural setting? Will farmers demand this type of insurance and who will supply the policies?

One might assume that rational farmers would adopt a BMP if it was coupled with a green insurance mechanism because the policy would protect the farmer from perceived negative welfare effects. One might also assume that insurance providers would be willing to offer policies for Pareto-efficient BMPs at low rates (or free with government subsidies) because these BMPs should not lower farm productivity hence indemnities would not need to be paid. In a theoretical world these predictions may be sensible, but they are naïve without considering the complexities of implementing BMP insurance in the real world. Insurance providers will require compensation to issue BMP policies to cover overhead and administrative costs and maintain a profitable business.

Transactions Costs, Moral Hazard, and Adverse Selection

BMP insurance will only be effective if transactions costs, moral hazard, and adverse selection problems are minimal. Until now, we have assumed that transactions costs in a BMP insurance contract are zero, thus allowing farmers to obtain insurance at little or no cost. The reality, however, is that an insurance program carries numerous transactions costs for both the regulator and the participating farmers. Regulators face costs during contract development in addition to the costs of monitoring and enforcing the policies. Farmers also incur costs of participating in the insurance contracts – many of these costs involve the opportunity cost of time to enroll in the program and to learn how to implement a new BMP as specified in the contact. The magnitude of costs affects the feasibility of an insurance program. If costs – including transactions costs – are higher than the benefits offered, farmers will not willingly obtain BMP insurance. Likewise, companies won't offer BMP insurance products that are expensive to implement.

BMP insurance contracts must also be designed to address two classic insurance problems: moral hazard and adverse selection. Moral hazard and adverse selection are both problems that occur because of asymmetric information that exists when farmers hold information that insurance firms lack. The farmer could choose to manage carelessly after obtaining insurance coverage (moral hazard) or the farmer who knows her farm operation is riskier than most could be more prone to buy insurance (adverse selection). Obtaining additional information can mitigate both issues, but acquiring this information is expensive due to the increased transactions costs of monitoring. Feasible contract designs must be able to effectively limit asymmetric information while maintaining modest costs of implementation.

Moral hazard is likely the more problematic of the two concerns because insured farmers may have perverse incentives to make riskier or less practical management decisions than they would have without insurance. Furthermore, many of these decisions are not observable, thus they cannot be easily monitored by program administrators. Policies include "several provisions to mitigate this moral hazard, including documentation requirements, requiring a certified crop consultant to develop the nutrient BMP, as well as denying claims when evidence of differential weed or insect management is apparent" (Mitchell, 2004, pp. 671).

Potential behavioral changes of insured farmers can greatly affect the environmental impact of incentive programs. Risk reduction from insurance has the potential to increase production of riskier crops that require more inputs. Research has suggested that crop insurance may promote the expansion of more input intensive and riskier crops such as corn or cotton (Coble et al., 2003; Seo et al., 2005; Turvey, 1992; Wu, 1999). If farmers obtaining BMP insurance allocate additional acreage to input intensive crops, the environmental benefits of lowering input levels per acre could be outweighed by the impact of additional acreage of input hungry crops which require higher fertilizer levels even when a strict CNMP is followed. Future research should address the question of how BMP insurance may stimulate behavioral changes and how these changes will impact the environment.

Adverse selection is a problem if insurance contracts allow farmers to select plans that are more likely to pay indemnities. This concern can be directly addressed through appropriate program design that limits manipulation of the contracts for personal gain. For example, contracts using a single state-wide premium may be more prone to adverse selection. Mitchell (2004) finds that premiums based on state average yields require farmers with lower than average yields to pay too much and high performing farmers pay too little. Above average producers have an incentive to buy the insurance because they will likely receive more money from claims than they will pay for their annual premium.

Integrating BMP insurance with current crop insurance policies

BMP contracts must be carefully stipulated so they can be offered in conjunction with current crop insurance policies. Since the 1930s, multiple peril crop insurance (MPCI) has been available to U.S. farmers and has traditionally insured against yield losses until 1996 when the USDA began offering revenue insurance options (Coble et al., 2003). Since 1980, the US crop insurance program has functioned as a private-public partnership. Private companies offer insurance contracts to farmers, evaluate claims, and offer adjustments. The U.S. government, through the USDA Risk Management Agency (RMA), approves insurance rates and reinsures the policies issued by private companies. Government involvement helps overcome challenges that may prevent private firms from entering the market such as adverse selection, moral hazard, and other transactions costs.

Private insurers are run as profit maximizing firms and as such are concerned about their own exposure to risk and uncertainty. The lack of homogeneous and uncorrelated losses increases risk for private insurers, thus increasing rates for farmers. "A private insurance company seeking to maximize profits will charge a premium rate that exceeds the expected indemnity for the individual policy," (Coble et al., 2003, pp. 398). Government is better able to absorb losses from widespread shocks such as drought or flood events. Government involvement allows farmers to receive insurance at a subsidized rate and allows insurance companies to offer policies to a broader base of clients. Without federal reinsurance it could be difficult for small farmers or producers of more risky crops to obtain affordable coverage.

The public-private partnership was designed to balance private sector goals and the needs of American farmers – this partnership would also be important when supplementing MPCI policies with BMP insurance coverage. Government reinsurance would be instrumental to expand the availability of green insurance by protecting private companies against uncertainty surrounding the new product. Public benefits from environmental improvements would motivate government involvement, but private insurers would also need to find value in selling BMP contracts. The 2003 RMA pilot project provides evidence that it may be difficult to generate interest in selling green insurance. Well-designed and easily implemented contracts are necessary to receive support from the private insurance sector.

Contract design would be critical when integrating MPCI and BMP insurance contracts to avoid doubling coverage and limiting exposure to moral hazard or adverse selection, as discussed earlier. Losses from compounding factors affecting production, such as rainfall and temperature, are covered by multiple peril insurance and should not be double-counted when evaluating claims. Designing a contract that clearly delineates between BMP failure and losses due to factors such as climate would be crucial to avoid payment of undue indemnities.

Linking supply and demand

The existence of agricultural insurance markets depends on the presence of demand and the ability of suppliers to offer effective BMP insurance policies (Coble et al., 2003). Since crop insurance policies already exist, one could argue that, under certain circumstances, demand for BMP insurance could be met by the same companies. It is unclear, however, where the demand would originate. Furthermore, careful consideration must be given to the conditions under which insurance providers will be able to offer BMP insurance.

Demand could come from farmers or from other stakeholders with an agenda to promote BMPs to improve environmental quality. The nature of the demand would influence the type of policies offered by insurance providers. Farmer demand could be spurred by numerous factors, including regulation, environmental concern, or because BMP adoption provides the farmer with additional recognition in a certification or verification program. Regulation of agriculture, or the threat thereof, may spur farmers to seek additional support and protection when changing agricultural practices (Coble et al., 2003). For example, if the EPA imposed strict rules regarding nonpoint source pollution originating from agriculture and outlined approved BMPs that farmers could adopt, farmer demand for BMP insurance could grow significantly. Without regulation some farmers may seek BMP insurance when trying new production practices to improve environmental stewardship. Demand driven by regulation may target long term insurance options, whereas more short term policies to support BMP trials may be adequate in other circumstances.

Adequate supply of BMP insurance at a national level would likely involve a public-private partnership as discussed in the previous section. Federal support and participation from crop insurance companies would lead to the creation of BMP policies that could meet new demand. Federal involvement would protect private insurance firms from uncertainty and risk surrounding the new policies while allowing heterogeneous groups of farmers to obtain coverage. The feasibility of continued BMP insurance provision would depend on the providers' ability to offer coverage while maintaining low transactions costs and avoiding problems of asymmetric information. Increasing demand and the development of effective policies could set the stage for strong growth of the BMP insurance market that promotes enhanced environmental stewardship.

V. Conclusion

Agricultural BMPs are designed to improve the environment while sustaining profitability, yet farmers are sometimes hesitant to adopt the practices due to perceived risk of lower and more variable yields. Instead, many farmers tend to overuse fertilizers and other inputs to protect against the uncertainty of annual growing conditions. In this sense, the premature or excessive use of agricultural inputs often serves as self-provided insurance against yield losses. But the resulting chemical runoff can have detrimental effects on the ecosystem. Furthermore, research has shown that many BMPs developed through university and federal research result in the same average yield as that obtained by over applying chemicals. These BMPs are considered Pareto-dominant as they limit nonpoint source pollution while maintaining profitability. Motivating adoption of Pareto-dominant BMPs requires addressing the risk perceptions of farmers and creating an incentive for farmers to test BMPs on their own fields.

Agricultural BMP insurance protects farmers from the perceived risk of BMP adoption by paying indemnities for losses due to BMP failure. BMP insurance can be designed in different ways to address the common insurance issues of moral hazard and adverse selection. Two contracts have been suggested for BMP insurance. One involves planting check strips and comparing yields between BMPs and status quo production methods. The other contract design pays BMP adopters if their annual yield deviates from long-run production averages more drastically than the yield of non-adopters in the same year. Each contract aims to differentiate loss from BMP failure from loss from other correlated risks such as weather.

The transactions costs of measuring and monitoring conventional crop performance and paying indemnities are important impediments to cost effective provision of BMP insurance. Contracts that require insurance adjusters to visit individual farms are costly and still cannot always identify moral hazards that would require the company to make high indemnity payments. Group contracts aim to lower transactions costs by comparing yield deviations between groups of participating and non-participating farmers. Although the costs to monitor farm-level yields are lower, they still represent significant transaction costs. Also, while this approach lowers the occurrence of moral hazard, it is still subject to adverse selection.

For BMP insurance to be successful, it must be integrated into the current crop insurance market. However, past programs have found it difficult to generate support for green insurance in the private sector due to high transactions costs and uncertainty surrounding the new policy (Campbell, 2003). Furthermore, farmers have been reluctant to purchase the unfamiliar and often complex policy. Overcoming impediments surrounding the use of BMP insurance requires generation of both supply and demand. Offering additional incentives (e.g. subsidies) to insurance providers may expedite the process of incorporating BMP policies in existing crop insurance contracts. Government regulators can also spur farmer demand by providing incentives to purchase green insurance. But supporting the BMP insurance market is a costly endeavor. For the investment to be worthwhile, the environmental benefits of providing BMP insurance must outweigh the costs.

More empirical research is needed to explore the effect of BMP insurance on farmers' decisions to adoption conservation practices. If BMP insurance can induce farmers to require disproportionately lower financial incentives to adopt environmentally beneficial BMPs, then it may be part of a cost-effective solution to improve agro-environmental management. However, if BMP insurance does not reduce other subsidy costs enough to cover its direct and transaction costs, then BMP insurance may not be justifiable as a cost-effective public policy.

In conclusion, if designed appropriately, BMP insurance has the potential to be a cost-effective way to meet public environmental goals while protecting farmers against perceived risks to their livelihoods. However, recent attempts to offer BMP insurance have failed due to the high transactions costs imposed on private insurance companies and low demand from farmers. In light of these costs, future research should explore the justifiable level of subsidy for BMP insurance. Specifically, there is a need to determine 1) how much BMP insurance influences farmers' willingness to adopt BMPs and 2) what is the value of the environmental benefits associated with BMP adoption.

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V1. Appendix

Table A: Summary of BMP insurance papers and programs

Case Study	Author or Agency	Year	Type of Study	BMP	Type of Insurance Contract
Some Simulation Results for a Green Insurance Mechanism	Baerenklau, K.A.	2005	simulation	low phosphorus dairy cow diet	group incentive based on profitability; bonus for above average adopters
A Group Incentive Contract to Promote Adoption of Best Management Practices	DeVuyst, E.A. and Ipe, V.C.	1999	simulation	reduced nitrogen inputs on corn fields	group incentive based on profitability
Nutrient Best Management Practice Insurance and Farmer Perceptions of Adoption Risk	Mitchell, P.D.	2004	simulation	nutrient management plan	check strip
Agricultural Insurance as an Environmental Policy Tool	Coble, K.H., Hanson, T., Miller, J.C., and Shaik, S.	2003	review and simulation	reduced nitrogen inputs on corn and soybean fields	check strip
Insuring Best Management Practices	Campbell, S.	2003	review	review of USDA-RMA pilot program for nutrient management plans	check strip
Factors Determining Best Management Practice Adoption Incentives and the Impact of Green Insurance	Mitchell, P.D. and Hennessy, D.A.	2003	review	n/a	n/a
Best Management Practice Adoption Incentives and Green Insurance: Corn Rootworm IPM Insurance	Mitchell, P.D. and Babcock, B.A.	2002	Monte Carlo simulation	corn rootworm integrated pest management (IPM)	group indicators
USDA-RMA Pilot Project	USDA-RMA	2003 - 2004	pilot project in 4 states: Iowa, Minnesota, Pennsylvania, and Wisconsin	nutrient management plan	check strip
BMP CHALLENGE™	AFT and Agflex	2004 - ongoing	current initiative in many states across the U.S.	nutrient management plan; reduced nitrogen; reduced tillage	check strip