SYNESIS
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The Commoditization of Intangibles: Overcoming Impediments to Reducing Water Pollution through Market Incentives

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Abstract
Through law-making and regulations point source water pollution control has advanced substantially in the United States. However, non-point source pollution has been more difficult to address through regulation. Development of innovative conservation strategies, like market incentives that reward actual performance of deliverables offer to improve the environment, improve taxpayer and private environmental return on investment and put environmental quality and economic opportunity into alignment instead of opposition. The Sand County Foundation has undertaken the development, deployment, testing and evaluation of a market-based incentive program for farmers that can be replicated on a large scale throughout the US and in other nations. Among the factors addressed by this project are: documentation of environmental performance of specific management practices, documentation of costs, establishing common metrics that may be used by "producers" and "consumers", and opening forums for discussion of exchange of ecosystem services.

Key words: Clean Water Act, nitrogen pollution, non-point source, market incentive, ecosystem services, environmental performance

Since the adoption of the Clean Water Act in 1972 the United States has made substantial progress toward clean-up of point source pollution. However, progress on non-point source pollution lags far behind. This typifies much of the success and the failures of environmental policies of the last half of the 20th Century: point source problems that can be addressed through command and control regulatory programs largely have been addressed, where less tangible, more diffuse problems like sprawl, non-point source pollution, and loss of biodiversity have not. Development of innovative conservation strategies, like market incentives that reward actual performance of deliverables offer to improve the environment, improve taxpayer and private environmental return on investment and put environmental quality and economic opportunity into alignment instead of in opposition.

In the US and other nations with significant agricultural production, loss of nutrients to waterways makes an important contribution to non-point source pollution. This is a growing world wide environmental problem. Rachel Ehrenberg notes that hypoxic zones now occur in more than 400 marine locations. Over the past 30 years the marine area covered by hypoxic zones has doubled about every ten years (1). Agricultural runoff of nutrients is causing significant degradation of our nation's fresh and marine waters. The most profound domestic example is the hypoxic zone in the Gulf of Mexico that is affected by Mississippi River discharge. Yet, approximately 80% of the nation's estuaries face significant eutrophication problems. Hundreds of hypoxic zones around the world threaten the production of marine fisheries, thereby not only causing large-scale pollution but directly threatening nutrition and economic opportunity for millions of people. This degradation results in the loss of productive habitat for fish and wildlife, billions of dollars in lost economic activity, shifts the burden costs of contamination to others, and contributes to profoundly negative implications for human health. Addressing nutrient loss from agriculture is one of the nation's most significant environmental problems, yet there is not any systematic policy to address it. Sand County Foundation has undertaken to develop, deploy, test and evaluate a market-based incentive program for farmers that can be replicated on a large scale throughout the US and in other nations.

Hypoxia

Hypoxia (aka- oxygen depletion) is a condition of aquatic engironments in which dissolved oxygen becomes reduced in concentration to a point detrimental to aquatic organisms living in the system. A hypoxic condition represents a major deficiency of oxygen to the point of being incapable of supporting aquatic life and basic biological functions (1). Hypoxia can exist in marine or freshwater systems. Typically it is caused by an over supply of nutrients (nitrogen or phosphorous) that promote excessive algae growth, which in turn decays, consuming most of the available oxygen supply as part of the decomposition process. Hypoxic conditions can cause significant fish kills and disrupt conditions that sustain flora and fauna. The loss of these productive ecosystems can cause the collapse of important fisheries and reduced value for those dependent upon them for livelihood and food (2).

Traditional regulatory structures & innovation

Traditional environmental policies have focused on 1) informing people what they can or cannot do, or 2) creating incentives to take land out of production. These strategies have worked well to reduce point source pollution and create "reserve" areas, but have not been effective to address non-point source and more defused environmental problems. These strategies tend to be expensive for both the government and private sector. The government has had to build large bureaucracies to implement regulatory programs. Enforcement has typically involved significant government oversight and the threat or use of legal action. Compliance costs have largely been shifted to the private sector. While these strategies may be appropriate for many environmental problems, they can be expensive, foster opposition to pressure for increased environmental performance, and often put economic opportunity and environmental quality at odds. Frankly, they work well to solve some environmental problems, but poorly to solve others. Innovative strategies are needed to address the more amorphous environmental problems that challenge us today to produce a better environmental return on investment, and promote rather than create disincentives for improved environmental performance. It would be logical for a structure that provides for the best environmental performers to have an economic advantage.

Command and control, or land retirement systems are well understood by government agencies and the private sector. By in large, they are simple – they prohibit certain activity or specify what is permissible. These regulatory programs can direct specific action or leave it up to the regulated party on how to comply. Market driven incentive strategies that recognize actual environmental performance are not so well understood, and many impediments must be overcome to move to adopt these strategies. Several steps must be taken in this process, these include:

1. The actual environmental quality or benefits that result from a specific management practice must be established. Commonly environmental practices are known as "Best Management Practices" or BMP's. However, BMP's are rarely quantified as related to actual environmental performance, cost, or costs per unit of environmental improvement achieved compared to other strategies. This pilot project seeks to gain first order information on actual environmental performance per investment unit to improve environmental return on investment. It is entirely possible, particularly in a field as diverse and complex as agriculture, that a practice instituted in one place will have a very different impact in another. For example, conventional plowing will result in much more soil loss from steep slopes and erodible soils than on relatively flat and "tight" soils. Therefore, there is a need to develop a sufficient body of knowledge about specific environmental outcomes of management practices across types of farms in order to anticipate the actual environmental benefits that will be delivered.

2. There is a need to understand the full costs of implementing an environmental practice. Typically costs can include the price, or cost savings, of a specific management technique (such as change in fertilizer application rates), capital cost (such as change in equipment requirements) and infrastructure costs (such as delivering the expertise to assess which change to make and how to deliver it.)

3. Once the two questions above can be answered, a third environmental management question can be addressed (that is distinct from issues of the past 50 years) – "Where do we get a better environmental return on investment?" This is not a radical question for just about anything else we spend money on, but it is a very different way of looking at how to spend environmental funds. It will draw fire from many environmental traditionalists who will attack it as putting money first, but in fact it does not displace moral priorities such as the protection of health and opportunity. Instead, asking this question is an important tool to better protect the environment and deliver the superior quality of health, and ecological stability. There is simply a need to produce more environmental quality, and to move from always too limited resources available for environmental management. Unfortunately, this is not generally available in most environmental toolboxes.

Case study – reducing nutrient loss from agriculture

Analysis

The problem is particularly difficult to address because 1) sources are small scale from diverse locations 2) sources are remote from impact area (e.g.- hypoxic zones may be 1,000 kilometers form the nutrient source), 3) regulatory and traditional incentive programs are not sufficiently precise to address sources in a cost effective manner, and 4) there are increasing demands for the agricultural products that are the major contributors to excess nutrient discharge from agricultural lands. (For example, corn production has increased substantially in recent years, driven by a combination of increased demand for food and feed, and as a feedstock for fuel (3).) To overcome these impediments Sand County Foundation has worked with mainstream farm, science and conservation organizations to develop, deploy and evaluate an innovative conservation delivery strategy that engages farmers directly through a series of prioritized, market-based conservation investment strategies.

Reasons for nutrient loss

Nitrogen is a nutrient that can make dramatic improvements in agricultural yields in a very short term. Adoption of widespread use of synthetic nitrogen is one of the key contributing factors to our nation having a reliable abundance of affordable food. Use of nitrogen has made major contributions to increased productivity and therefore to the economic viability of farms, and to increased standards of living for millions of people worldwide. From a societal perspective, use of nitrogen to enhance the productivity of agricultural lands makes great sense because it supports the ability of relatively few farmers to cost-effectively feed millions of people on a limited base of agricultural lands. From an environmental perspective, however, the discharge of nitrogen from agricultural lands threatens environmental quality and could significantly disrupt marine and freshwater ecosystems that are also critical food producers.

Nitrogen by-in-large is water-soluble, it can readily be taken up by water and carried from the soil to plants where they increase productivity, or can be lost from systems when a molecule of water carrying nitrogen leaves the agricultural field as discharge. Once nitrogen is lost from an agricultural field to a waterway it contributes to a variety of environmental problems including hypoxia, drinking water contamination and climate change. (Much nitrogen lost from agriculture converts to N_2O when it eventually returns to the atmosphere. This gas is 310 times as powerful a greenhouse gas as CO_2. Given the water solubility of nitrogen, and that many projections suggest that climate change is anticipated to increase the intensity of precipitation events, this could further exacerbate nitrogen loss from agriculture.) When nitrogen is lost from productive agricultural systems, there is little opportunity to recover it for productive use.

Three major factors have contributed to increased discharge of nitrogen from agriculture: increased use of synthetic nitrogen, major changes in the hydrology of agricultural areas, and shifting from forage and "tight crops" to increased production of large grain crops. These are discussed in detail:

1. Use of nitrogen in agriculture increased after the Second World War, particularly with the advent of significant synthetic production capacity in the mid 1960's. Agricultural use continued rapid expansion through the 1990's when it leveled off for approximately ten years in the United States. During this time, farmers became acutely aware of how important sufficient amounts of nitrogen could be in increasing productivity and farm economic viability. Worldwide, use of nitrogen in agriculture has continued a rapid growth. With the spike in the price of agricultural commodities in 2006 – 2008 use of nitrogen increased again, although increased price of nitrogen to some extent mitigated use. Historically, because synthetic nitrogen was relatively inexpensive and provided increased likelihood of increased yields, most farmers adopted practices of fertilizer application that ensured enough nitrogen was available for a bumper crop. However, rarely do such conditions occur. As a result, nitrogen was over-applied for typical annual needs.
2. The hydrology of agricultural lands has been substantially altered. For example, in the Upper Midwest, over 60 million acres of subsurface drainage have been installed. These "tile lines" serve much the same function as storm sewers, removing "excess" water from the field to allow equipment to get in early in the spring and plant high yield, long developing crops. Likewise, the majority of wetlands are gone and almost all riparian areas are cut off from annual flooding. We have diked, rip raped, dammed, drained and filled our riparian systems such that most water runs

off of the land very quickly. Flood waters that once backed up on areas now in agricultural production have been managed to move downstream as quickly as possible. Water that once took months to move from the headwaters of the Mississippi to the sea now reaches the Gulf of Mexico in only a few weeks.

3. Agricultural interest has shifted away from crops that do not discharge much nitrogen to crops that do. Forages such as grasses, alfalfa, and even small grains like wheat and oats do not discharge much nitrogen. These crops have substantial cover of the ground, and do not require large nitrogen inputs. Food production practices in recent generations have tended to shift from animal forage, to feed working animals, to support feedstock operations for animals used in human consumption. This has increased demand for large grain, like corn and soybeans, to feed livestock. Most recently, ethanol production as a replacement or supplement to gasoline has increased demand for corn as an alcohol fuel feedstock. The 2008 U.S. corn crop was the second largest in history, with prices well above historic norms (4). The 2009 corn crop is also expected to be at or near record levels. (5) Shifting to larger grains from forage crops has fostered nutrient loss. (See Figures 1 and 2 below).

Charting a New Course

The old command and control system, while somewhat flawed and controversial, was an effective means of dealing with point source pollution. It has, however, to date proven ineffective in dealing with non-point source pollution. An innovative strategy is needed to address these challenges- where marketbased incentives that reward performance enhancements can be effective.

In a regulatory system, there is a natural tendency to seek to make the minimum expenditure in compliance. In other words, regulations will set a floor for compliance that most actors will adopt as their goal. If however, the framework is built to reward environmental performance instead of penalizing environmental shortcomings the framework is turned upside down. The greatest rewards then shift to the best environmental actors, rather than those in minimal compliance. The race then moves from meeting the floor, to establishing a new cost-effective ceiling. Perhaps more significantly, it becomes the best interest to be an early adopter in meeting environmental goals, rather than a late actor.

Markets can operate in a variety of forms. For example, federal subsidies for conservation could be shifted from program incentives that make no assessment of environmental performance to those that prioritize efforts that will have the greatest improvement in environmental quality. Other, more traditional markets could operate, where parties that can make cost-effective improvements can sell the environmental "credits" they establish for going beyond compliance standards, to those who need credits because their operations cannot as efficiently adopt cleaner

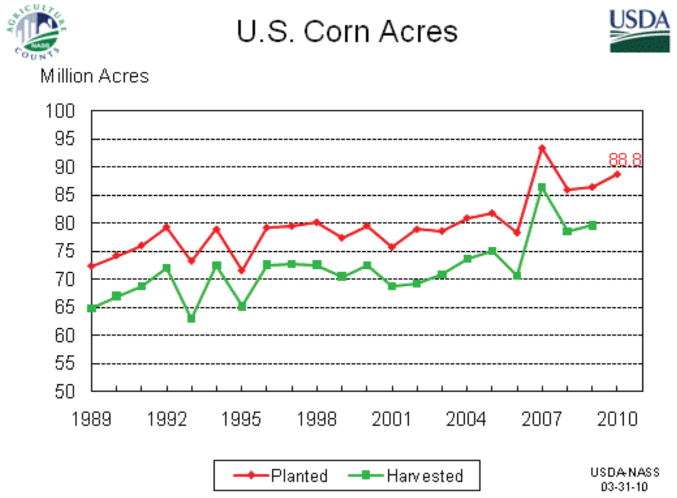

Figure 1: Corn: Acreage by Year, US
Source: http://www.nass.usda.gov/Charts_and_Maps/Field_Crops/cornac.asp

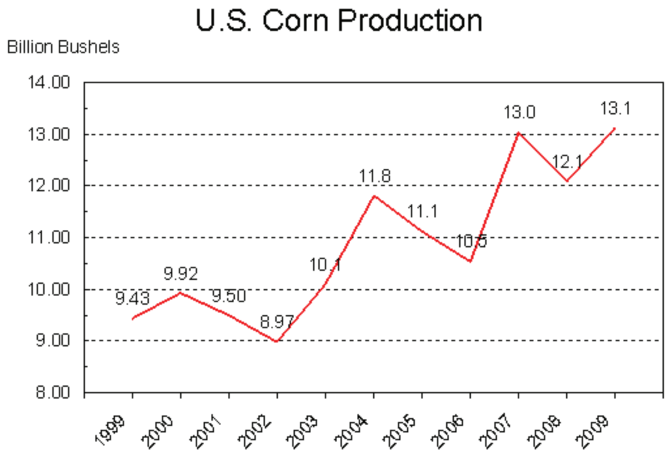

Figure 2: Corn: Production by Year, US
Source: http://www.nass.usda.gov/Charts_and_Maps/Field_Crops/cornprod.asp

strategies. Ecosystem service markets are beginning to emerge in the delivery of environmental goods and services like clean water, air shed management, greenhouse gas reductions or sequestering etc.

For these markets to operate, the property rights associated with producing environmental goods and services need to be established and sanctioned, and recorded as transferable assets. Performance expectations for a particular practice in a given location, as well as price discovery, and transparent exchanges all need to come into being. While there may be fewer advocates for markets than a few years ago, market-based strategies may be on the cutting edge of advancing environmental quality in the first part of the 21st Century. Markets may be fostered by government guidelines, caps, incentives, etc. but many environmental markets are likely to develop on their own as these processes become sanctioned.

Priorities for action

Priorities for action can be divided into three classes: Social, Physical, and Scientific.

1. Social

This has been the most important component of the Sand County Foundation project and is the most meaningful priority for further investment. By locating intellectual understanding, the network and its leaders promote change as advocates to large-scale reduction in nutrient loss from agriculture. Without a substantial common agreement on strategies to address this issue it is unlikely that reform required to foster sufficient large-scale change will occur.

Our work to date has emphatically demonstrated that farmers will change management practices in response to specific incentives. These decision makers assess return from their actions, and readily accept incentives to institute enhanced nutrient management practices that protect their net income. At the macro level, decisions about implementing enhanced nutrient management practices are relatively simple and focus on protecting yield (and increasingly income), and offsetting costs associated with the management practice. Independent of conservation pressures, simply avoiding added costs is a significant contributor to avoiding over-application of nutrients. With the addition of market-based, targeted conservation incentives, we have found exceptional compliance with instituting enhanced management practices. (Simple contracts were used to specify payment amount and management practice to be implemented. Payment was not made until the farmer indicated the management action was fulfilled. Contract fulfillment was 100% except in exceptional circumstances such as a flood or major personal crisis.) We believe there is no question that farmers will respond to incentives; the challenge is to select which practices to incentivize, and what level of incentives are necessary to effect sufficient scale changes.

Essential to our success in enrolling lands has been to work through well-regarded farm leaders. Individuals from within their own community have been the principal outreach personnel to deliver enhanced nutrient management strategies. To effectively promote enhanced management, this farmer leadership has to operate both at the one-on-one farm scale, as well as the regional scale. Our experience has shown that farmers listen best to other farmers about farm management. In addition, farm groups, suppliers and technical advisors are extremely effective in supporting enhanced conservation practices.

Building substantial capacity to connect and partner farmers with other groups is essential to delivering enhanced management strategies. In particular, conservation, education, scientific and policy groups need to engage in this effort. Each of these groups has unique expertise that is required to deliver the intellectual capacity to develop, demonstrate, assess, and replicate - on a large-scale - strategies to improve nutrient management. In addition, creating a coalition of these groups is extremely powerful to promote societal change. A modest coalition has been established to date. An enhanced network is a top priority for further action.

To establish broad based reform, urban, suburban, rural, freshwater, marine constituencies need to support action. With the backing of this kind of coalition, policy leaders can easily engage to policy change. However, if political leaders are forced to choose among their constituents they are more likely to develop a narrow approach (if do anything at all). A common broad based agreement reduces such resistance to change.

To foster this reform, investment should focus on building structure that connects a variety of interests, and generates consensus for action. This network can foster scientifically designed and coordinated replication of management techniques, assessment of those techniques, communication within the farm community about cost effective techniques, and communicate between sectors about technical information and strategies. This same network can then effectively communicate with political leaders about reforms to enhance nutrient management.

A critical next step is to educate, cultivate and develop political leaders – within both partner institutions and policy positions – to help foster reforms that shift from program expenditure targets to performance-based market driven strategies.

2. Physical

In four years of fieldwork we have learned a substantial amount about the effects and cost effectiveness of nutrient management techniques. Even the best farmers can continue to cost effectively improve their nitrogen management. We want to emphasize, however, that to take reform to a sufficient scale to effectively reduce marine contamination from nutrient discharge, continued research is required over a multi year timeframe.

Based on our research to date, we rank several actions as high priority. Sufficient information is available on each of these to recommend widespread use. These recommendations are listed in order of priority within class of activity. In general, we believe that creating incentives is more important in the long term. We anticipate that source reduction techniques (changes in nutrient application in rate, timing form etc., commonly referred to as agronomic practices) will typically have a lower incentive requirement if fertilizer prices continue to be high. Again, there is not a single “magic bullet” to solve the problem of nutrient loss. Rather, different techniques are appropriate for different locations and classes of farms.

Management options break largely into two classes of action: Source Reduction and Sink Creation

Source Reduction

- Soil Test: Relatively few farmers regularly test the nutrient availability in their fields. Because changes in environmental conditions dramatically affect how much nitrogen may be leached from a field, or how much may be taken up by a crop, there is substantial variation in year-to-year nutrient application requirements to maximize efficient crop production. Soil testing should become an annual or semiannual practice. Only a modest incentive (if any) is required to promote widespread adoption of this practice.

- Credit all nutrients: Substantial portions of farmers only include commercial nutrients in their fields in the calculation of fertilizer application. Manure application or nitrogen fixed by plants often goes unrecorded in these calculations. All nutrients applied to a field should be included in calculations of fertilizer load; particularly in areas with substantial livestock production, nutrients are often over-applied. In many cases this is because manure is managed as a waste product instead of a nutrient source and “disposed of” to the maximum level allowed by the law, instead of being used to produce crops efficiently. Again, the cost of incentivising this practice is extremely low. Investing in education can effectively support this reform.

- Spring/split/and precision application: Traditionally most nutrients have been applied in the fall, after the crop is harvested. This practice occurs for two principal reasons: 1) because farmers have more time in the fall after the crop is harvested to prepare their fields and 2) because nutrient prices typically have been lower in the fall than in the spring. However, fall application results in significant nutrient loss over the winter, wasting farmers’ investment and increasing discharge. By shifting to spring application or split application, significant cost-effective savings can occur. Progress is being made in this area through market forces associated with nutrient costs. A large number of farmers are more carefully applying nutrients today than they were even a few years ago.

Sink Creation

- Manage agricultural drainage: Approximately 60% of the 100 million acres of cropland in the Upper Midwest is drained through intensive tile lines. A high percentage of other agricultural areas manage water levels in fields though surface (ditches) or subsurface drainage. Drainage is important to improving productivity on limited farmlands, and subsurface drainage generally reduces phosphorous loss from these lands. Removal of excess water from agricultural fields typically allows crops to be planted earlier, which results in higher yields. In addition, yields are typically lower in parts of field that remain wet through much of the growing season. Phosphorous tends to move out of fields when soil erosion occurs. The phosphorous molecule attaches itself to a soil particle and stays with that soil. Where there is soil loss there is phosphorous loss. Because tiled lines provide for drainage of water, surface runoff is reduced. With reduced surface runoff there is less soil loss and therefore less phosphorous loss. There continues to be some phosphorous loss – particularly of phosphorous in soluble form - but less than in fields where the principal discharge of excess water is through surface runoff. Unfortunately, these are major contributors to increased nitrogen loss. The acreage subject to intensive drainage is increasing in both the Upper Midwest and other key agricultural regions of the country. Top priority is to capture tile line discharge and treat for nitrogen removal. At this time, it appears that the most cost-effective technique for treating tile line discharge is through the installation of bioreactors. These systems can be installed for a relatively low cost (approximately $2000 to $10,000 depending on scale, and design) and have an anticipated life cycle of 10 years, and they do not require taking land out of production. Unless there is an incentive to install bioreactors, farmers are unlikely to take this initiative on their own. Additional research is needed to asses if bio reactors can be designed to reduce N_2O production, how to best "size" reactors to fit particular fields, and how to reduce the cost of instillation while effectively removing nitrates from water. Simply closing down drainage systems when there is no crop in the field can hold nitrogen, making it available for uptake and reducing loss to waterways. Active management systems, that allow manipulation of tile line drainage during both the off-season and the growing season can further reduce nitrogen loss. These systems have the added advantage of providing limited increase in agricultural production in some years. (Very limited data have shown that by holding water in the field during dry periods yields can be increased. Yields may not increase every year, and are most likely to increase during drought periods. Income is typically increased disproportionately when yields are increased during drought periods.) Economics favor managed drainage because of potential increases in income, which can be coupled with modest incentives for environmental performance, thereby making a substantial contribution to farms' fiscal viability.

- Cover Crops: Where appropriate, cover crops help hold nutrients in the field when a commodity crop is not in production. Typical cover crops are tight systems that reduce soil erosion, take up significant nutrients and help hold both water and nutrients in the field. (A "tight" cover is one that has dense ground cover that reduces erosion and water loss. Examples of tight crops include winter wheat, oats, barley and similar forage materials.) Typically cover crops are not harvested for their economic value as a commodity, but are used principally used for environmental benefits. There can be some direct economic benefits, such as use of this material for forage or bedding, but these crops are not allowed to mature before a spring crop is planted. Modest incentives have been required to foster use of cover crops. We anticipate such incentives will continue to be required to foster widespread use of this practice. Additional research on the environmental performance and cost effectiveness of this technique is a priority.

- Strategic Wetland Restoration: A less cost-effective technique, but one that offers substantial secondary benefits, is to target installation of wetlands at the bottom end of tile lines. These systems are efficient at capturing nitrogen and provide some benefits for phosphorus and pathogen reduction. Most notably, if properly designed, they can provide substantial wildlife and aesthetic benefits. Wetland design is critical to both making them effective at reducing nutrient loss and providing a net improvement in wildlife habitat. To remove nitrogen, the wetland must have sufficient holding time and stem density to allow the bacteria to strip nitrogen from the water. To provide a net improvement to wildlife, the wetland must contain sufficient cover to afford nesting waterfowl shelter from predators. All too often, isolated small wetlands have served more as killing zones for waterfowl than have contributed to waterfowl and wildlife production. Wetlands are much more expensive to install than bioreactors because they take land out of production. To date, most wetlands designed to treat agricultural discharge have been designed to have a 20-to-1 drainage ratio. Taking five acres out of production to treat a 100 acre field is expensive. Techniques are available to generate additional income from wetland operation, but these techniques appear to be less economically attractive as a stand-alone, cost-effective nutrient treatment. A substantial incentive already exists to encourage the restoration of farmed wetland in

> the Wetland Reserve Program (WRP). The WRP can become a significant tool for reducing nutrient loss to waterways. Simply changing the enrollment scoring process to inquire whether the site had the potential to intercept and treat nitrogen will shift the location of WRP restorations to improve water quality.

Finally, strategies are needed to target areas with significant potential environmental gain at relatively lower costs. Currently, we do not prioritize areas for enhanced management. It makes little sense to continue to offer nutrient management incentives equally across the landscape. The science is adequate to identify priority areas for action. Limited information is available from the US Geologic Survey and other sources that identify which small watersheds typically lose the most nitrogen into major waterways. Developing more robust information about which areas are high priority for investment in enhanced conservation delivery should be a priority. Yet, simply targeting highest priority waterways will not be adequate. Nutrient management decisions are made on the field-by-field level. We believe that broad based incentives that target high priority areas can substantially promote widespread adoption of more cost-effective nutrient management techniques. Developing farmer leadership for structuring these incentives is important. In addition, engaging farmers to develop strategies to address the relatively few "bad actors" is important to address this limited subset of the industry.

3. Scientific

There are substantial scientific questions that still need to be addressed to scale up a strategy to cost-effectively reduce nutrient loss from agricultural lands. This section will identify several recommendations for overcoming these impediments.

Measure effects

As noted in this and previous reports, it is difficult to measure the effects of management practices because of the numerous variables that operate across the agricultural landscape. Scaling up from measuring the effects of a suite of practices on the discharge from a field to the impact on a waterway is an even greater challenge.

To overcome the costs and uncertainty of measuring effects, we believe that it makes sense to focus on tile line discharge as an initial area of action. Tile lines respond quickly to changes in management practice, are relatively simple to monitor and are probably one of the most important vectors to nutrient discharge to waterways and marine systems. The cost of monitoring nitrogen loss from tile lines is a fraction of the cost of monitoring loss from surface discharge.

As this work progresses, it is important to develop consistent metrics for measuring environmental performance. Those metrics should be similar to those used by potential ecosystem services. This will promote the potential "commoditization" of environmental performance and be a key step in advancing market principles. With the development of these metrics, there can be a variety of markets that come into being – some of which we can predict today, but there are likely to be others that have not yet emerged, but have potential to play a leading role in this century's economic climate.

Conclusion

Significant progress has been made in understanding the contribution of agricultural nutrients to both fresh water and marine environmental issues. This is an area where our limited pilot project has demonstrated that market-based incentives can be effective in improving environmental quality, while protecting farm economic viability. Most significantly the environmental performance from limited conservation dollars is improved through a market-based approach that targets areas of investment and focuses on performance-based outcomes.

Ultimately, additional information and research will be required to cost-effectively reduce nutrient loss from agricultural lands. To address where limited conservation dollars should be invested to most cost effectively improve environmental quality we require data assessing a larger landscape. The recently announced Mississippi River Basin Water Quality Initiative provides a structure that can resolve the key science, economic and social questions to substantially reform conservation strategies. (On September 24 the Secretary of Agriculture announced a 12 state, $80 million a year program to assess (6).)

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Competing Interests

The author declares that he has no competing interests.

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