An Assessment of Performance-Based Indicators and Payments for Resource Conservation on Agricultural Lands

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I. Introduction

If better reporting of the impacts of resource conservation policy and practices is not forthcoming in the near future, the millions of dollars allocated for federal funding to protect our at-risk wildlife and water quality, and prevent soil erosion could be severely jeopardized. Increasingly, taxpayers and their representatives are demanding to know what the benefits are from resource conservation investments which currently run at nearly three billion dollars a year on agricultural lands alone. Perhaps more important, information on actual impacts can guide the strategic use of funds to maximize available funding for the greatest conservation benefit. In order to achieve reportable environmental improvements, however, we need to develop, use, and fund better means to measure the impacts of conservation effort and to move in the direction of a system of conservation payments that are based on actual environmental performance or outcomes.

This paper has two objectives. The first is to provide a general overview of the types, use, and conditions for employing bio-physical indicators for measuring the impact of resource conservation practices on environmental outcomes. Our emphasis is on agricultural lands[2] and a few selected examples of indicator types are described. The second objective is to examine the potential for implementing a performance-based payment system for conservation activities on agricultural lands. There is a direct link between these two objectives. If public or private markets are going to pay landowners based upon the environmental outcomes they achieve (i.e. green payments), there must be indicators for measuring the level of environmental performance attained. We describe a few indicators at three scales (national, regional, and on-farm) that illustrate various measurement approaches.

Our emphasis in this paper is on reviewing the attributes of indicators that would inform us as to what level of environmental and economic performance is being achieved via conservation practices and programs funded by the United States Department of Agriculture (USDA). This topic is timely because of pending reauthorization of the Farm Bill in 2007 and the serious consideration that is being given to developing a system of conservation payments that are market based and reflect actual environmental performance. The current administration is proposing a new program in the 2007 Farm Bill that would pilot test a market driven ecosystems services payment program.

The paper suggests criterion for selecting feasible and effective indicators. In addition, we review methods for measuring the environmental outcomes of on-farm environmental management practices, especially as they relate to measuring the performance of conserving wildlife habitat and biodiversity conservation practices and programs. This assessment concludes with some policy recommendations related to indicator selection and for implementing a new system of compensating landowners for conservation activities based on actual performance through stewardship payments.

A recent and very much more thorough treatment of specific technical indicators and performance-based payment systems can be found by consulting the papers and presentations that were made a recent conference entitled "Managing Agricultural Landscapes for Environmental Quality: Strengthening the Science Base" (Soil and Water Conservation Society 2006b). At this conference, over 200 papers and posters were presented that evaluated conservation practice performance, investigated useful indicators, and/or made recommendations for the implementation of

[2] The majority of at-risk, threatened, and endangered species, and their populations, are found on non-federal lands, the majority of which are in some form of agricultural production.

performance-based payment systems. Many of these references are posted at http://www.swcs.org/en/swcs_international_conferences/managing_agricultural_landscapes/presentations/.

The remainder of this paper consists of four additional sections. Section II provides an overview of what performance-based conservation payments are and what benefits they may have over practice-based payments. Section III conveys the importance of developing a measurement *system* as opposed to defining a single indicator and provides a very basic description of the types of indicators that may be useful for measuring environmental performance on agricultural lands. Section IV reviews selected environmental performance programs and the type of indicators those programs have employed. Section V considers policy issues and recommendations as well as providing some conclusions related to selection of indicators and the institutionalization of performance-based payment systems.

II. Overview of Performance-based Conservation Payments

The success of federal and state agricultural conservation programs is currently measured by indicators such as acres enrolled, allocated and spent funds, by how many acres or feet of a given practice are installed on the landscape, and numbers of practices adopted by participants. Gains in environmental performance are assumed to result from the adoption of conservation practices. Whereas practice-based systems pay farmers for the adoption and implementations of specific conservation inputs, performance-based systems link payments to conservation outcomes. Although great gains have been made in reducing soil erosion by using the current practice-based system, many environmental goals remain unmet and problems still persist. A stronger incentive to generate and consolidate real environmental gains on working farmland could be to link payments to actual or reliable predicted outcomes or performance (Kenney and Boody). Performance is defined as the degree of success in meeting a specified environmental goal or standard. As we will discus later, resource-specific indices can be employed to measure performance.

Performance-based systems are considered to have several potential benefits, including improved environmental outcomes from conservation efforts at the farm and watershed level, increased cost effectiveness at the farm-level, more accountability in the use of public funds, providing a foundation for creating non-point source pollution trading programs, implementing markets for ecosystem services, and for instituting a system of green payments. One of the reasons for the focus on performance-based payment systems and policies has been the gradual evolution of federal farm conservation programs from resource protection for production purposes to programs more focused on environmental management. Continued problems with water quality and quantity, soil quality, and wildlife habitat are driving policy makers to demand the demonstration of positive environmental outcomes (Land Stewardship Project 2005, 2006).

Improved environmental outcomes can be generated through a performance-based system in three ways. First, producers can have the flexibility to choose a conservation practice or set of practices that best suits their agri-environmental conditions. Secondly, there is a motivation for producers to maintain performance and payments over a long period rather than investing in a one-time cost-share project. Thirdly, it may be more likely to encourage continuous improvement with regard to conservation than a one-time cost share payment for a particular practice.

There is considerable agreement that performance-based systems tend to reduce costs and lead to innovative conservation practices by farmers. Payments based on performance are more cost effective because producers have more flexibility for innovation and can find the least-cost way of achieving a defined environmental outcome. It is necessary, however, to be careful about how cost effectiveness is defined in the context of conservation. Is it defined as the increasing rate of environmental improvement that exceeds increased cost (over some baseline situation) or, as the same amount of conservation outcome at less cost? The definition makes a difference in terms of policy choices. For example, given the difficulty in measuring *increasing* (i.e. dynamic environmental outcomes within a limited time frame, the more efficient approach from the perspective of program management would be to adopt the least cost approach. There is also a question of how an incremental or marginal environmental improvement is valued in economic and financial terms.

A performance-based system can serve as a market mechanism for providing environmental goods such as agricultural pollution control (Casey and Kroeger). Winsten has indicated that performance-based payments could represent the price for pollution control and therefore markets could start to function. Thus, environmental performance becomes incorporated into farm business planning. The challenge here is to define the unit of trade and to avoid the problem of "thin" markets, i.e. where there are few buyers and/or sellers and prices tend to become distorted.

With all public conservation programs there is an increasing call for accountability of the use of public funding by private landowners. From a taxpayer and public investment perspective, it is better policy to pay on the basis of goals achieved rather than just strictly for practices. This approach has not been central to conservation policy in the past, but the federal government is currently attempting to measure the effects of its conservation practices (the Conservation Effects Assessment Program-CEAP-is discussed in more detail below). The public has also increased its demand for real evidence of environmental outcomes such as erosion control, wildlife habitat, and improved water quality for their tax dollars (van Schaik). Furthermore, the Natural Resources Conservation Service (NRCS) of USDA is currently funding various projects to pilot test the performance-based payment concept.

There are four essential components for developing a performance-based approach to conservation payments. First, there must be the design, testing, evaluation, and selection of relevant performance *indicators*. Secondly, a cost-effective monitoring and evaluation system must be put in place. Third, an appropriate level of incentive, or price, must be set to define the payment level. Lastly, administrative procedures for managing a public performance-based payment system need to be established.

In addition to these components, Kenney and Boody have elucidated three basic principals for implementing performance-based payments. First, payment levels have to be fair to taxpayers and farmers. The public benefits found in water quality, habitat, and erosion control merit public compensation on farms of all sizes. Second, there must be continuous progress on farm in terms of conservation outcomes. Lastly, there should be a system of graduated payments whereby farmers who provide increasing conservation benefit should receive higher levels of compensation.

Although more will be said later in this report about the possible institutional mechanisms for applying performance-based systems, current agricultural resource conservation initiatives such as the Conservation Security Program and the Environmental Quality Incentives Program may serve as good implementation vehicles, at least on a pilot scale.

III. The Importance of a Measurement System

Instituting a new approach to landowner compensation based on performance-based conservation payments requires more than identifying, measuring and evaluating selected indicator levels for resources of concern. There is a need for a performance measurement *system*, of which indicators are but one component. A measurement system consists of several essential components. The most important is to have an explicit goal or outcome by which to measure performance against (Batie and Irvin; Casey et al.; Eco-Agriculture Partners). Other components that improve the validity of the indicators include defining the appropriate unit of measure, research or measurement protocols, performance reporting mechanisms, and adaptive management. The measurement system tells us whether we are gaining or losing ground in biodiversity conservation. Indicators alone won't do the job (Oregon State University).

In reviewing the literature on the use of indicators, it is important to distinguish between indicators that actually measure bio-physical response to management practices, and those that describe a level of landowner or public effort in meeting desired outcomes. The emphasis on this paper is on the former. The indicators used to measure the performance of public programs (acres enrolled, funds allocated and spent, etc.) are quite distinct from the indicators used to measure actual biophysical performance of a given management practice (less soil erosion, improved water quality, etc.). Although both types of performance measures are important, and complementary, for achieving stated environmental goals, they require different measurement systems and capture different values about the effectiveness of conservation programs.

Types of Biophysical Indicators

There are two basic types of biophysical indicators. The first type constitutes a direct or proxy measurement of a single variable such as the presence of chemical element or compound in streams or groundwater (level on nitrogen or phosphorus), or the occurrence of a single animal or plant species. One type of proxy indicator that is particularly relevant to wildlife habitat and species viability is changes and patterns in land use. If there is high level of certainty that changes in land use can serve as proxy for counting species and conducting field work, then the cost of indicator generation will be lower than conducting periodic biological surveys.

The second general type of indicator is the output from what is referred to as "process models"[3]. Process models usually take on-farm land management and production practices, and then "predicts" the level of erosion, non-point source pollution, etc. Direct measurements include on-farm observations and interviews. Both direct measurement and modeled predictions are in use today. Although direct measurements can be expensive, there is some effort to involve farmers as "citizen scientists" to observe and record the environmental impacts of their conservation practices. Modeling can demand fewer financial resources, but there is a need to periodically ground truth and verify the results of the environmental processes models.

In this section, we provide a brief description of a sample of various types of soil productivity, water quality and wildlife habitat predictive models and indices currently used on agricultural lands. Other types of models/indicators gaining acceptance include a pesticide environmental risk screening tool

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[3] Other types of process models not discussed here include the Soil Tillage Intensity Rating, the Irrigation Water Management Index, and the Water-Quality Risk Reduction (WIN-PST) Model.

and new approaches to assessing rangeland conditions. Modeling programs and indices have been developed to determine the impacts of conservation practices on environmental outcomes with respect to soil erosion, soil quality (mostly organic matter), and water quality. The policy implications of these models for determining performance-based payments are discussed in Section V.

Soil Erosion and Quality

The "erosion productivity impact calculator" (EPIC) is a simulation model that can be used to determine the impact of management strategies on agricultural production but also on the condition of crop and water resources. EPIC also can simulate the fate and transport of potential pollutants such as nitrogen, phosphorus, soil erosion, salt, and pesticides. The drainage area considered by EPIC is generally a homogeneous field-sized area of 100 ha (about 250 acres). Model outputs are indicators of pollutant and water movement to crop root zones and the edge of the field.

Two models that complement EPIC can be used to measure the impacts of conservation practices on water quality benefits. These include the HUMUS (Hydrologic Unit Modeling for the United States) model and the Soil and Water Assessment Tool (SWAT) model which simulates transport of water from the farm to receiving streams. SWAT requires monitoring data about the hydrologic system that is not available in all areas (see www.landstewardshipproject.org/programs-mba.html).

The Soil Conditioning Index (SCI) is a computer model to predict the effect of cropping systems and tillage practices on Organic Matter (OM) and is reported on a scale from -1 to +1. Negative SCI values predict declining OM, while positive values predict increasing OM. The three main components that are measured as part of the SCI are organic matter returned or removed from the soil, the effect of tillage and field operations on OM decomposition, and the effect of predicted soil erosion associated with soil conservation and other field management practices. Major contributing practices to increased index scores include: forage or small grains in the rotation, reduced tillage (and especially no-till planting), and fall cover crop planting following corn silage or soybean harvest. Soil conservation practices and structures such as waterways, contouring, contour buffers, terraces, headland planting, and sediment control structures also can have a positive impact on OM. One drawback with the SCI is that it undervalues organic farming by focusing only on tillage.

The Soil Conditioning Index (SCI) is now used by NRCS to determine eligibility for entry into the Conservation Security Program (CSP). NRCS requires an SCI value of 0 or above to be eligible for the CSP. Thus, the SCI is currently used is an applicant screening tool and is not yet employed as an indicator to measure performance.

Continued soil degradation through erosion, loss of soil organic matter, reduced fertility and productivity, or chemical and heavy metal contamination and the resultant degradation of air and water quality have sparked interest in the concept of soil quality and its assessment. The soil management assessment framework (SMAF) is a tool that land managers, conservationists, and producers can use to better understand the multiple interactive effects that their soil management decisions are having on the resource. The goal of the SMAF model is to improve soil assessment efforts by evaluating the impact of soil management practices on soil function. This tool allows researchers to continually update and refine the interpretations for many soils, climates, and land use practices, thereby making it more conducive for use as an indicator on which to base a performance-based payment (Andrews et al.).

Water Quality and Aquatic Species

The Phosphorus Index (PI) is a simple spreadsheet model used to assess the risk of phosphorus (P) movement from fields to nearby water bodies. The primary components of the PI, which include soil type, slope, soil loss (erosion), soil test P, the rate and method of P application, field distance to water, as well as others, are divided into source and transport factors. A one page field-by-field questionnaire of management practices provides computer modeling input for calculating the PI.

The end-of-season corn stalk nitrate test is also being used as an indicator for nitrogen management on farms. The result is a direct performance evaluation of nitrogen or manure N management measured by the Nirtrate-N concentration in the lower corn stalk. More nitrogen than needed for maximum yields is indicated by nitrate accumulation in the lower cornstalks at the end of the season. Multiple-year testing to account for seasonal variability is necessary in order to increase confidence in refining nitrogen management. The SCI, PI, and the corn stalk nitrate test are all being used in a performance-based payment pilot project managed by Winrock and the University of Vermont

The Agricultural Drainage and Pesticide Transport (ADAPT) is biophysical process model and is described and reported in Westra et al. and Boody et al. Output from ADAPT model simulations include environmental parameters such as edge of field estimates for nitrogen and phosphorus losses (surface and subsurface), sediment losses and water runoff (per unit surface-area of that system). ADAPT can be used with Transport Hydrologic Response Units (THRUs), a software subroutine, to calculate area-weighted estimates of environmental impacts at the mouth of the watershed (Gowda et al.). This estimation accounts for surface area under each management system and the location of each system within the watershed. In this manner, the heterogeneity of the practices and the biophysical properties of the landscape throughout each watershed are preserved, while allowing an analysis of the environmental and economic effects of changes in those practices by location within the watershed. This modified ADAPT model was used in a Minnesota study (Boody et al.) to estimate sediment, nitrogen, and phosphorus loadings for baseline land use (as of 1999) and for estimating the impacts of four different farm management scenarios. The authors found that there was more confidence in estimates of sediment, N, and P loss than in estimates of pesticide leaching potential or pesticide loss.

ADAPT can also be used to simulate impacts on in-stream fish populations (Westra et al.). Daily suspended sediment concentrations were calculated based on sediment loading predicted by the ADAPT model and combined with stream flow and stream bank erosion estimates. By calculating the number of days each year that concentrations of suspended sediment reached lethal or sub-lethal thresholds for fish assemblages, estimates can be made on the magnitude of sediment effects on resident fish. The number of lethal and sub-lethal events was estimated using a meta-analysis (Newcombe and Jensen) which quantitatively related fish response to concentrations of suspended sediment and duration of exposure.

Wildlife Habitat and Biodiversity

Indicators for wildlife habitat and biodiversity are mostly based on species counts or land use monitoring. Species indicators are usually based on population abundance. Land use indicators consist of assessments of overall changes in and mapping of the distribution, configuration, and condition of various ecosystems or habitats. Other indicators include the degree of disturbance and functional components such as fire, water yield, carbon sequestration, soil productivity, and energy flow.

One example of indicators used for wildlife habitat has been on agricultural lands in Nebraska[4]. However, results from this effort have not yet been made available. Indicators are related to land use and include the overall distribution and pattern of natural habitat within the agricultural landscape, non-native species, and amount of perennial cover on farmed lands, riparian protection, and presence of at-risk species. Natural habitat and distribution indicators comprise measurements for ecosystem extent (distribution of native habitats relative to modified ones), and landscape pattern (degree of fragmentation of native habitats). These measures are complemented by indicators for water quantity and availability for ecological needs, and water quality, using index of aquatic integrity that includes biological factors. Other useful indicators included soil organic matter, terrestrial invertebrates, and the historical range of variability relative to existing conditions to evaluate ecosystem risk.

Indices of biotic integrity combine information from structural, compositional, and functional stream parameters into a single metric known as the IBI. In addition to a few selected hydrological, physical, and water quality measures, indices of biotic integrity hold promise as indicators of healthy aquatic habitat (Mausbach and Dedrick). The best known bio-assessment index for aquatic communities is Karr's index of biotic integrity, which has been developed for fish and macro-invertebrates. This index combines data on aquatic species richness and compositional, trophic composition, and organism abundance and condition. The Ohio Environmental Protection Agency has developed indices of integrity based on benthic invertebrate communities. Another indicator to track aquatic health is the Oregon Water Quality Index. The Index includes indicators such as gravel size, width-to-depth ratio, large woody debris, riparian condition, and other features.

The 'Coordinated Conservation Planning' (CCP) analysis tool was developed by the US Geological Survey to predict bird success within its refuges. Based on user-defined species/habitat relationships – in this case, a detailed land cover spatial database and 280-bird matrix that incorporates the Upper Mississippi - the model calculates potential species occurrence, species richness, and habitat area for a selected landscape. The impact on a single species (for example, the bobolink) or groups (selected grassland birds) can be analyzed.

The CCP user also has the ability to make polygon-specific changes to the landscape and to then re-run the analysis for the impact of those changes on species-habitat relations. This allows an evaluation of different landscape management scenarios in light of local, regional, and/or agency goals. Habitat potential for each land cover type is ranked on a simple scoring scheme (e.g., 0 = no potential, 1 = low, 2 = medium, 3 = high) for each species. The tool was designed to quickly generate information about specified wildlife species or habitats for managed lands. It should be noted that land cover themes are general in nature and typically do not provide information concerning the specific habitat requirements of a given animal species. This model has been tested by the Land Stewardship Project's Multiple Benefits of Agriculture Initiative in the Whitewater Watershed in Minnesota for use as a predictive tool for land-use change impacts on bird species. See: http://www.landstewardshipproject.org/programs_mba.html.

[4] See The Institute for Environmental Research and Education at http://www.iere.org/

IV. Selected Efforts Using Indicators to Measure Environmental Performance

In this section we provide a brief overview of selected programs that have attempted to measure environmental performance of conservation practices, and some selected indicators that they have used in doing so. These programs represent different scales: national, regional (watershed and/or ecosystem type) and farm level. Although the primary concern of this paper is the farm or ranch scale, all of these geographical scales must be linked if progress towards meeting national environmental objectives is to be documented and for continued financial support of conservation programs.

National Level Indicators

The Heinz Center[5]

The Heinz Center has instituted an on-going process to identify and measure indicators of ecosystem "condition." This effort has been reported in a series of documents entitled *The State of the Nation's Ecosystems* (John H. Heinz III.Center). However, there is no explicit attempt to link the condition of six selected ecosystems to any specific conservation practices, and thus the Heinz Center indicators for farmland ecosystem types cannot serve as a basis for performance-based payments. Furthermore, there is no explicit environmental goal or outcome by which an indicator condition is compared. The lack of a pre-determined objective is to avoid the perception of a value judgment as to whether a particular indicator level is good or bad. For farmland ecosystems, there are individual indicators collected for system dimensions (total cropland acreage, farmland landscape, fragmentation, natural patches), chemical and physical conditions (nitrates in streams and groundwater, phosphorus in farmland streams, pesticides in stream and groundwater, soil organic matter, and soil erosion), and biological components (soil biological condition, status of animal species on farmlands, native vegetation, and stream habitat quality).

Although the Heinz Center national level indicators are not conducive to the design of an on-farm, performance-based payment system, in the future they may be able to serve as a check against whether on-farm environmental conditions are improving. In addition, it may be possible at some time to link on-farm indicators to some sub-set of the Heinz indicators and develop the capacity to "map" environmental conditions across several geographical scales. One attempt, at least in the agricultural sector, to map farm level to national level impacts is the USDA Conservation Effects Assessment Program.

USDA Conservation Effects Assessment Program

The USDA Conservation Effects Assessment Project (CEAP) is an effort to document the environmental benefits of federally approved conservation *practices* funded through the conservation title of the US Farm Bill. The goal of CEAP is to develop a greater understanding of what conservation practices achieve in terms of environmental improvement. The findings from CEAP could help identify new indicators to measure performance levels, and link them to specific environmental goals.

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[5] The H. John Heinz III Center for Science, Economics, and the Environment. For a thorough description of the Heinz Center effort see www.heinzctr.org/ecosystems.

USDA conservation practices, implemented through the NRCS are designed to reduce losses of soil, nutrients, pesticides, pathogens and other biological and chemical materials from agricultural production, conserve natural resources, enhance the quality of agro-ecosystems and improve wildlife habitat. However, the environmental benefits of these programs have not previously been quantified for reporting at any scale. Moreover, while an extensive body of literature exists on the technical impacts of conservation practices at the field level there are few research studies designed to measure much larger effects (Mausbach and Dedrick).

CEAP is an on-going mix of data collection, model development, model application, and research. It is anticipated that new indicators and performance measures will be included in the 2006 and 2007 annual NRCS reports, and that the 2008 report will include more accurate outcome estimates for the chosen performance measures (Mausbach and Dedrick). With respect to soil and water resources, the CEAP will attempt to measure outcomes in terms of biophysical benefits: tons of soil saved, reductions in in-stream nutrients and sediment concentrations, etc. It is anticipated that the data generated by CEAP will also be useful for modeling environmental credit trading and facilitating the development of ecosystem service markets.

The CEAP national assessment is broken down into several steps. The first comprises a literature review and preparation of a summary report on what is known about the environmental effects of conservation practices at both the field and watershed scale. The USDA Agricultural Research Service and National Agricultural Library will prepare a set of abstracts from the published literature on the environmental impacts of USDA conservation programs. These abstracts will address five resources of concern: water quality, soil quality, water conservation, air quality, and wildlife habitat. There will be a summary report to establish the state-of-the-science benefits/outcomes from conservation practices. The report will also identify research and data gaps.

The CEAP has initially focused on water quality, soil quality, and water conservation on cropland and land enrolled in the Conservation Reserve Program. Teams have been or will be formed to identify appropriate indicators and performance and to identify data gaps. For the national assessment of crop land, existing models (described in Section III) will be used to determine the impacts of conservation practices on the goals of reducing nutrient, pesticide and soil losses, improvements in water quality and water use efficiency, and enhancement of soil quality[6].

In order to determine the impacts of water and soil quality practices, the CEAP has started using process modeling based on EPIC. For measuring of water quality benefits, the CEAP will use a combination of process models and databases called HUMUS (Hydrologic Unit Modeling for the United States) and SWAT. Other outcome measures (indicators) will include reductions in the number of days during the year that in-stream nitrogen concentrations exceed the drinking-water-standard; and (2) reductions in the number of days during the summer months that in-stream nitrogen and phosphorus concentrations exceed critical thresholds related to algal blooms and eutrophication. In addition, the CEAP will also include a validation component to evaluate whether the right indicators are being used.

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6 A simulation model will be built to use data from the Natural Resources Inventory (NRI) of USDA. A subset of the 30,000 NRI cropland sample points will be necessary for constructing the simulation models for the national assessment on cropland. Farmer surveys are planned to gather management and input data. When the data collection is completed, NRCS will release summaries of the survey results at the appropriate level of aggregation.

The wildlife component of CEAP assesses and measures the fish and wildlife benefits of USDA conservation programs and practices. The results will inform USDA's efforts to tailor conservation practices to increase their effectiveness. Because funding for fish and wildlife-specific assessments pursuant to CEAP has been limited, the highest priority has been given to gathering *existing* fish and wildlife information and relating it to conservation practices to the extent possible[7].

To date, the results of these efforts are generally inconclusive because conservation programs and practices have not been well monitored in the past and the indicators to measure outcomes have not been clearly specified. For example, an initial CEAP report on wildlife impacts has shown that there is too little data to show if conservation practices have been beneficial (Haufler). There are some exceptions. For example, the Farm Services Administration (FSA) of USDA is supporting specific regional projects to assess the impacts of the Conservation Reserve Program (CRP) on selected wildlife, primarily avian, populations. The CEAP wildlife effort also includes primary research to gauge the effects of the Wetland Reserve Program, and using NatureServe ecological data to evaluate the impacts of practices on various ecosystems.

To capture changes in wetland ecosystem services, NRCS has developed initial indicators referred to as biological elements, which include local amphibian populations and water bird use. These indicators are expected to be useful in describing the wildlife response to wetland restoration practices. NRCS is also working with a variety of partner agencies and groups to develop an approach for reporting changes in wetland ecosystem services resulting from conservation practices. This effort involves development of a predictive wetland functional model to periodically assess changes in wetland ecosystem services. Ecosystem services to be modeled include sediment deposition, flood storage, carbon sequestration, and biodiversity. Similar research is underway that looks at the impacts of practices on the restoration of northern bobwhite quail habitat and populations, Western sage grouse (practices to be evaluated include prescribed grazing, water development, brush management, and prescribed burning), and on various other bird species.

A NatureServe research project in Missouri will develop and evaluate methods for assessing benefits of conservation practices on wildlife habitat. The key objective is to demonstrate processes that can evaluate the benefits of previously installed conservation practices as well as help prioritize farm bill program allocations. Thus, there will be a direct link between the measuring a biological outcome (wildlife habitat), conservation practices designed to achieve that outcome, and strategic allocation of conservation funding.

Land cover/use is a principal factor in determining the base level of wildlife abundance in agricultural ecosystems. The extent of and changes in land cover/use can be used to estimate the effect on habitat and abundances of select species if a sufficiently large sample is obtained. The NRI use its point samples (known as Primary Sample Units [PSU]) to document the spatial configuration of habitats, and to capture finer scale habitat elements. The habitat elements could include hedgerows, grass-backed terraces, or other odd areas that may provide habitat. Digitizing the earth cover characteristics of a PSU for input into a GIS can provide needed information to quantify the amount of and changes in habitat cover.

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7 Several NRCS institutes have been involved in studies that have assessed fish and wildlife response to conservation practices. Examples documenting fish and wildlife response include grassland birds, northern bobwhites, butterflies to field borders and other buffer practices, changes in stream fish assemblages following riparian buffer establishment, response of amphibians and other wildlife to wetland restoration, and associated micro-topography development, and response of upland nesting birds to various vegetation management regimes on Conservation Reserve Program lands.

In 2006, the Soil and Water Conservation Society released its *Final Report from the Blue Ribbon Panel Conducting an External Review of the U.S. Department of Agriculture Conservation Effects Assessment Project* (Soil and Water Conservation Society 2006a). In general, the Panel made several key recommendations and observations. First, the panel recommended that the environmental effects of conservation practices should be evaluated within the context of state environmental goals, and "linked to the ecological and economic context in which the estimated effect occurs" (p. 5). Second, the Panel insisted that process models cannot be a substitute for periodic field monitoring and inventories to verify that stated environmental outcomes are indeed taking place. Third, the CEAP should become oriented more in the direction of setting strategic resource management goals and focus on regional rather than national assessments. Lastly, the Panel recommended that the CEAP work in collaboration with other resource management and monitoring efforts. Specific recommendations include the integration with fish and wildlife habitat conservation with soil and water conservation efforts, and developing indicators and estimating the benefits for aquatic and terrestrial habitat conservation

Regional Indicators: State, Watershed and Ecosystem Scales

At an interim level between the national and on-farm/field scales, there are indicators are performance measures that attempt to determine the impacts of conservation practices on a state, watershed, or ecosystem scale. This section briefly touches upon some of these efforts.

In addition to developing national level indicators, the CEAP is also working at the watershed level. The watershed assessment component of CEAP complements the national effort by providing more in-depth information on water quality and other benefits at a finer scale of resolution than at the national level. In the first phase of the CEAP assessment, two process models, the SWAT and the Annualized Agricultural Non-Point Source (AnnAGNPS), are being utilized to conduct comparative evaluations of environmental benefits associated with conservation practices.

In a program initiated by the Land Stewardship Project in Minnesota (Boody et al.), individual field data from 16 farms were used to develop a process model to determine the impacts of selected conservation and management practices on water quality in two watershed study areas. Land management practices were organized into four scenarios that reflected differences in cropping patterns and grazing. Field-level data were employed to inform an ADAPT model to estimate sediment, nutrient load (P and N) and run-off which were then aggregated up to the watershed level. Indicators for habitat and species richness were developed using farm landscape configuration and the presence of natural habitats. (See http://www.landstewardshipproject.org/mba/Multifunc_Jan05_BioSc.pdf).

The Oregon Progress Board (OPB) has spent several years developing a set of state-level environmental indicators that technically serve as benchmarks for improving water quality. However, only seven of the sixteen benchmarks are ecological indicators, the other nine are more procedural in nature (Defenders of Wildlife). One specific indicator used to monitor habitat is an extensive/gross level data base known as the National Land Cover Data available from the USGS at 10 year intervals. However, this does not capture rapid landscape change and more frequent data collection and mapping are necessary. The OPB has found that describing habitat condition as an indicator is particularly challenging. Habitat condition might be quantified by the percentage of some structure, vegetation type, indicator species, or ecological process. A simpler, alternative approach may be to indicate and classify habitat as good, fair, or poor, similar to the way that single species are categorized as threatened, endangered, or at- risk.

Another regional effort to select and measure indicators of environmental health is taking place under the Eco-agriculture Outcome Measures Project (Eco-agriculture Partners). Based in several countries, the overall goal is to make a convincing case for the benefits of eco-agriculture through a systematic analysis of outcomes at a landscape scale for diverse types of eco-agriculture systems. Although the project is just underway, it will identify and field test practical indicators and methods to monitor conservation outcomes at a landscape scale.

The Outcome Measures Project consists of four components. The first consists of a literature review to identify and/or monitor various indicator measurement methodologies and applications. The second step defines eco-agriculture indicators to measure the impacts of practices and management of natural areas on productivity, livelihoods, and ecosystem services, and biodiversity. The third step is to field test selected indicators and adjust them as necessary. The final step will integrate and disseminate the lessons learned from a series of case studies, resulting in an Eco-agriculture Outcome Measures Toolkit. A learning network has been established to refine indicators and improve upon them (See: http://www.ecoagriculturepartners.org/programs/programs.php.).

Farm and Field Scale Indicators

In this section we describe four efforts that use identified indicators to measure environmental performance at the farm and field level. Each program is unique and they range from employing specific biophysical indicators to very general activity level indicators.

Winrock International and the University of Vermont

Winrock International and the University of Vermont have established an initiative known as Performance-based Environmental Policies for Agriculture (PEPA). The PEPA initiative consists of two projects with an overall objective of improving the cost-effectiveness of agricultural pollution control by facilitating the development of performance-based environmental policies. The projects focus on the creation of performance-based incentives that allow lower-cost conservation solutions by giving farmers greater flexibility in pursuing conservation activities that are appropriate and cost-effective for their specific farm businesses.

One of the PEPA projects is designed to conduct education and outreach across the U.S. and to work with interested stakeholders to design and develop watershed-specific recommendations for the use of performance-based incentives. It is hoped that this project will be the necessary precursor to the development of a successful non-point source trading program and achieve Total Maximum Daily Loads (TMDLs) by providing the missing link between farm management decisions and water quality outcomes.

The second PEPA project is called Pilot-Testing Performance-based Incentives for Agricultural Pollution Control. This activity is designed to demonstrate the applicability of performance-based incentives to address non-point source pollution from agriculture. Performance-based incentives are currently being pilot-tested in 6 watersheds in the Upper Mississippi River Basin of Iowa and the Lake Champlain Basin of Vermont. Incentive payments to producers are based on achieving farm-level environmental performance targets defined by farmers, agency staff, and scientists. By setting conservation targets, farmers will seek the most cost-effective approaches for their operations. It is hoped that this approach will be transferable to other agricultural operations and watersheds. The importance of local stakeholders to help design appropriate performance measures and targets is emphasized.

The performance indicators being used by the PEPA pilot project were described in Section II and they include the Weighted Whole-farm Phosphorus Index (PI) score (WWPI), the end-of-season cornstalk nitrate test, and the Soil Conditioning Index (SCI). For the WWPI, all field scores are weighted by the field size to attain a weighted average risk of P loss from the farm.

Central Coast Vineyard Team: The Positive Points System

The Positive Points System (PPS) of the Central Coast Vineyard Team is aimed at wine-grape growers taking steps to maintain ecosystem health on their operations. The PPS is a grower self-assessment tool for evaluating *the adoption of* sustainable resource management practices used in California Central Coast vineyards. The PPS allocates points to sustainable practices for improved pest, soil, water and viti-cultural management, as well as wine quality and continuing education. Sustainability is defined by the adoption of various production and natural resource management practices, and producer knowledge of various resources and natural systems. It is assumed that there is a direct link between adoption of a practice and a resulting positive environmental performance or outcome. In other words, the "indicator" is the implementation of a conservation practice, and not a measurement of the effect of that practice on, say, pesticides or nutrients in groundwater or as non-point run-off. There are no identified indicators to measure the impacts of practices on wildlife species or their habitats.

Because there is no link between the indicator measures and improved environmental outcomes, the PPS cannot be described as a performance-based system that could serve as a guideline for determining conservation payments. This does not mean that positive outcomes are not occurring; it is that they are simply not being measured at this time, nor are they tied to any type of payment system.

Wisconsin Healthy Grown Natural Community Standard

In 1996, the Wisconsin Potato and Vegetable Growers Association, the World Wildlife Fund, and the University of Wisconsin formed what has become known as the WPVGA/WWF/WI Collaboration ("the Collaboration"). The two major goals of the Collaboration have been to lower the toxicity level of pesticides used in potato production and to increase fresh potato marketing through an eco-label known as "Wisconsin Healthy Grown". In 2005, the Collaboration decided to go beyond decreasing toxicity levels by adding in the restoration and conservation of natural habitats on and around Healthy Grown farms. The expectation is that restoring areas to natural conditions will have a beneficial impact on selected threatened and at-risk species, and perhaps augment additional ecosystem services (University of Wisconsin 2005).

Given the difficulty and cost of collecting traditional technical indicators to measure conservation performance, the Collaboration has decided to use land management activities as a measure for the outcomes of restoring native habitats. This effort culminated in the development of a restoration protocol specific to the Central Sands, known as the Natural Community Standard.

The Natural Community Standard revolves around the creation of individual farm restoration plans in the context of The Nature Conservancy's (TNC) Central Sands eco-regional plan. The farm plans are developed in collaboration with landowners and reviewed by conservation partners. The regional plan is based upon The Nature Conservancy's (TNC) planning tool - the *Conservation Project Management Workbook*. For each plan, regional focal conservation targets, indicators of target health and accepted management strategies are listed along with both quantitative minimum ratings and mandatory practices required to ensure the viability of the restoration effort. The implementation of specific management practices called for by a grower's habitat restoration plan serves as the as certification criteria under the Standard.

The use of a regional plan is intended to link the management activities of individual farms to wider regional conservation targets. The conservation targets within the plan include marginalized natural communities including: Oak/Pine Barrens, Sedge Meadow, Oak Savanna, Wet-mesic Hardwood Forest and Tallgrass Prairie. The plan also includes a single "species of concern", the Karner Blue Butterfly. Corresponding management techniques are selected by both the grower and an ecologist and written into a management plan. The standards and management plan are reviewed with the landowner and adjusted based on the first year's experience.

Following the structure within the *Conservation Project Management Workbook*, indicators of each target's viability are determined by referencing both historical records that document pre-settlement ecosystem conditions, as well as contemporary research focused on the targets. Where possible, quantitative measures are used for the indicator's "goal" status based on the minimum requirements necessary to ensure a conservation target's viability. If an indicator's status cannot be measured a categorical system is utilized to indicate the required minimum management. The categorical system takes the place of a quantitative assessment based on completion of the management activity. Strictly speaking, meeting the Natural Community Standard continues to be practice-based and not outcome-based, although there is a very strong link between practices and outcomes.

Certification to maintain eligibility in the Wisconsin Healthy Grown program is determined by establishing adherence to the grower's plan. Additionally, management activity at or above established minimum expenditures is required for certification. Records of expenditures for each activity on an individual natural area are required to be maintained by the grower. Expenditure data will be complied by the Collaboration to document effort and refine expenditure estimates in future planning (University of Wisconsin 2004).

Within the regional plan are potential monitoring/documentation methods for each indicator. Many methods are inherent to the specific activity and best demonstrated in the field should an audit be required. Other methods require specific documentation to demonstrate completion of the activity. Within the grower plan, the documentation method best suited to the farm will be selected by the grower and listed for each activity within the plan.

Vickerman[8] has recommended a similar approach to the identification of indicators and ecosystem service payments. She indicates that the best surrogate for biodiversity is the amount, composition, location, and structure of natural or semi-natural vegetation. This indicator can be measured with satellite imagery that is supplemented with random field surveys to verify imagery interpretation and agents can confirm the presence of targeted species. Ecosystem service payments could be structured into three tiers with graduated payment schedule based on the amount and type of habitat protected, and whether the area conserved is consistent with a regional plan that addresses at-risk plant and animal communities.

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[8] Vickerman, Sara. Personal communication, April 27, 2007.

Food Alliance Standards of Certification

The Food Alliance uses a set of "stewardship indicators" rather than actual measurements of ecological condition. The Food Alliance has developed evaluation/certification criteria in order to promote agricultural landscapes in which native plant and animal communities co-exist with agriculture and that can sustain ecosystems over time. The farm level *goals* include avoiding the conversion of priority habitats to agricultural production; restoring sensitive habitats to native vegetation; providing vegetation around water bodies; management of habitat on farms and ranchers with the goal of protecting larger landscapes; preventing the introduction of and eradicating invasive species; managing crop and rangeland to meet the habitat needs of fish and wildlife; developing a working knowledge of plants and animals in the area; and managing pests (when they are not threatened or endangered) using integrated pest management techniques. Higher performance scores are linked to intensity of effort, but not the actual biophysical outcomes that result from the implementation of conservation practices. To encourage implementation of habitat and biodiversity conservation practices, and to help off-set the costs of these practices, the Food Alliance certifies sustainable agricultural products and helps promote them. The idea is that Food Alliance Certification will provide producers with either a premium on their agricultural products or increased market share.

For each of the criteria listed above, there are four levels of effort that are defined from low to high. Different points are awarded for low and high impact improvements, which basically comes down to the types of practices implemented, number of acres involved, and whether or not landowners participate in habitat conservation programs. These criteria are not explicitly outcome or performance-based indicators, except in as much as practices may be highly correlated with environmental outcomes. Some of the criteria, such as threatened and endangered species protection, are simply defined according to the level of a land owner's knowledge and not on the level of conservation outcome or implementing a conservation practice.

V. Policy Assessment, Recommendations, and Conclusions for Indicator Selection and Performance-based Payment Systems

In this section we summarize some of the policy issues and recommendations concerning, first, the selection and use of environmental indicators for measuring the outcomes of resource conservation practices, and second, the implementation of performance-based payment systems on agricultural lands for demonstrated improvements in resource quantity or quality. Issues and recommendations are discussed at a general level in order to guide implementation of future monitoring and evaluation activities. For an excellent review of the efficacy of individual environmental indicators and performance-based systems see Soil and Water Conservation Society (2006b).

Indicator Policy Assessment

We provide an initial assessment and recommendations for indicators on two levels. First, we address some general issues which are common to all agro-environmental indicators. Second, we discuss some specific concerns such as scaling up indicators to more extensive geographical and temporal scales, the challenge in using direct indicators as outcome measures, the usefulness of physical process models, employing action versus performance indicators, and determining the institutional mechanisms for monitoring and reporting on performance indicators.

There are two major tasks that outcome indicators/measures must respond to. The first is confirming linkages between changes in specific elements of landscape management and conservation outcomes, and the selection of indicators to establish this linkage. The second is the appropriate sampling and stratification of information on agricultural and environmental outcomes and/or productivity.

A major issue surrounding indicators is the cost of measurement, in terms of both time and money. Keeney and Boody have asked if there are common sense indicators that can show net economic, social, and environmental gains. For example, could wildlife habitat criteria established by the Natural Community Standard or the Food Alliance be recognized when certified farmers apply for federal stewardship payments? This in essence, inquires whether adoption of a set of practices or activities can substitute for developing biophysical indicators designed to measure actual environmental outcomes. The more basic question is whether an indicator should be direct, modeled, or simply observed. Given decreasing levels of technical support combined with the lack of farmer experience in measuring the outcomes, less technical approaches in indicator measurement should be recommended at the outset of a performance-based payment program.

Another policy issue is the geographical scale at which indicators should be measured. Can an indicator of on-farm or in-field performance be scaled-up to an expanded geographical area such as a watershed or eco-region? There is an extensive body of literature exists that describes plot or field scale conservation practices aimed at protecting water quality, soil quality and enhancing water conservation, but which are of limited use for drawing conclusions from fields to whole watersheds (Weinberg and Claassen). Farm and regional level indicators may not be consistent, and linking farm-level *actions* and outcomes with landscape actions and outcomes may be difficult (Ecoagriculture Partners).

Developing indicators that demonstrate improved environmental outcomes across *all* farms on a landscape scale can also be a challenge. A basic constraint in developing a uniform set of indicators is the complexity of eco-agriculture landscapes (Ecoagriculture Partners), characterized by different resource management practices, multiple objectives of producers, and the lack of information/data on environmental interaction effects. All of these considerations have made it difficult for project managers to select consistent indicators to document landscape scale environmental outcomes.

Mausbach and Dedrick observe that there are limitations on human, financial, and information resources to collect and process a wide range of indicators. At the regional or ecosystem scale, there are two general types of indicators which can classify as either (1) "broad or comprehensive"; or (2), as either "deep or intensive". The selection of the specific type of indicator depends on the scale at which at which an outcome is to be measured. For example, at the farm or field level, we may want to have an intensive indicator that a process model generates, whereas at the watershed level it may be more practical to have a few broad intermediate indicators.

It is difficult to directly measure the outcomes of management practices on specific species or biodiversity because the indicators required are costly in terms of time and expense. For example, in the green-labeling community, there has been a call for the development of a quantitative monitoring system that addresses the increased data collection requirements of traditional "indicator" approaches used for the certification. However, the time and money required for hiring biologists with the expertise to determine the health of plant, bird or other taxonomic groups, or the population of individual wildlife species typically used as indicators, is expensive. Adding to the unsuitability of many of the current quantitative indicator approaches is the natural, stochastic fluctuations inherent to many individual and related groups of species. These fluctuations can operate completely independent from the management efforts of an individual attempting to manage for the species in question (Anchor).

Many physical process models estimate the effectiveness of some practices in changing field level performance or emissions standards. But, using such models on a field by field or farm level can be costly. Even in the case of water quality models where good estimates of edge of field soil losses are available, links between those losses and sediment loads or concentrations in rivers can be tentative. Physical process models for field-level use are not yet available for many agricultural emissions or environmental impacts. Furthermore, those models that do exist for nutrient runoff are more complex (i.e. data intensive) and require extensive user training and data for successful implementation (Smith and Weinberg). Lastly, all process models must be periodically verified on the ground and calibrated to remain valid. The use of process models to date, particularly in agricultural conservation programs, has been limited to ranking participant applications for financial assistance, *not* as a basis for determining performance-based payments.

Given the expense of measuring very technical indicators of conservation practice outcomes, most efforts have been centered on monitoring conservation actions or practices. However, verifying the actual execution of a practice is only an interim step (Oregon State University). Putting a conservation practice on the ground should not be a replacement for in some way defining and measuring indicators that are meant to measure performance of that practice. Ideally, conservation actions will be monitored to demonstrate progress toward strategy goals. Some conclusions can be drawn regarding the effects or outcomes at the site level and more broadly across the landscape. Research on cause and effect will enhance knowledge about which conservation actions produce the best results (outcomes) at lowest cost (Oregon State University). As we learn more through the process of measuring and monitoring biophysical indicators, costs will decrease and we can employ benefit-transfer models to extend the findings of research in one area to other sites.

As was discussed in Section II, there has to be a focus on developing a measurement system, not just collecting data on a single indicator. The system also has to include the specification of an environmental goal that is targeted, a research protocol for collecting data on the indicator, a reporting system, and an adaptive management component. There is the risk of being dependent on one indicator and how unpredictable events may compromise its reliability. This may require more than one measure for determining conservation outcomes.

The institutional structure within which indicators are measured, aggregated and reported is important. The scale at which indicators are collected and used partly determines the institutional structure that will be appropriate. For example, at the national level, the US Geological Society or the National Academy of Sciences may be the appropriate institution. At the state level, universities or public-private collaborative partnerships could play a role.

The allocation of resources for monitoring and evaluation continues to be an important institutional constraint. Recent budget cuts at the federal level suggest that there may be weak political support for data gathering and analysis, despite the demand for information on conservation effects, for measuring and reporting on the environmental impacts of conservation practices, and linking that information to public policies. Irrespective of geographical scale or institutional mechanism, it is important to build a constituency for collecting and reporting data related to conservation outcomes. One way to develop this constituency is to develop a citizen science program aimed at ranchers and farmers to collect basic data on a defined set of indicators and report that information to researchers attempting to measure the performance of conservation practices. The Land Stewardship Project's Monitoring Toolbox is one such an approach. The Monitoring Tool Box includes goal setting, observation approaches, and data tracking systems. Used within a team of other farmers and community members with specialized skills in observing birds, stream organisms, or soil quality, it can provide a way of tracking ecosystem impacts of management decisions over time (http://www.landstewardshipproject.org/mtb/lsp_toolbox.html.) . Still, specific indicators must be defined by professionals. Mausbach and Dedrick have observed that although the role of citizen science is evolving, well trained citizens can not only reduce the cost of data collection and verification, they can also become engaged supporters of resource conservation.

Our recommendations concerning indicators fall into two categories. The first is developing criterion for the selection of reliable indicators, and the second category addresses measurement and collection systems. Recommended criteria for the selection of outcome indicators include:

-A limited number of quantifiable indicators;
-Identification of the level uncertainty for each indicator;
-Standardization over multiple scales, to the extent possible;
-Easily understood by policy makers;
-Linked to spatially-specific models;
-Cost-effective and streamlined monitoring;
-Measurement systems that include validation and adaptive management;
-Includes not only biophysical measurements, but also activities and practices.

There is a need to balance the cost of measuring and interpreting outcome indicators with what is relevant and affordable. This may mean the selection of indicators that are highly targeted and focused on one or two resources. In terms of wildlife, this may require the selection of one particular "indicator species" that represents overall habitat health, or the use of vegetation maps which can serve as a baseline for how wildlife habitat has changed over time.

We have emphasized adaptive management with respect to indicator selection and continued use, but there is a trade-off between consistency and complexity. Although indicator choice must be flexible over time, flexibility needs to be balanced with consistency. Indicators that change too much or fail to provide comparable data over time are not very informative. On the other hand, a system of indicators that is too rigid will result in information that is less relevant as conditions change.

There is an on-going need for research and dissemination of information related to identifying performance indicators that are appropriate for various mixtures of ecosystems and practices. Farm Bill legislation, program implementation and research presents a good opportunity for continuing research on existing indicators and developing new ones either through the Agricultural Research Service or through the various resource research institutes managed by NRCS. Research is required to develop and automate advanced agri-environmental process models and to expand the spatial data that these models employ.

There is a need to establish and maintain a clearinghouse of monitoring and evaluation results of performance based indicators, and the various research methodologies and models used in estimating indicator values. This centralized data base would include a description of the various indicators used, where they were employed, what practice whose impact was being measured, and what environmental problem was addressed. A starting point for this centralization effort would be to combine the work and experience of the recent SWCS conference on environmental management and the EcoAgriculture Outcomes research effort. USDA's Cooperative State Research, Education, and Extension Service could provide funding support for research and results aggregation.

There will always be a role for activity-based and practice-based indicators as long as the relationship between the implementation of a conservation practice is known to result in a specific environmental outcome within reasonable bounds of certainty. Or, another approach may be to identify key indicators that measure multiple environmental outcomes. For example, perennial cover alone may be a sufficient indicator of both enhanced wildlife and erosion control (Kenney and Boody).

Performance-based Payment Systems

The policy question regarding a performance-based payment system can be illustrated with the question posed by Weinberg and Claassen: Should conservation programs provide payments to farmers who adopt conservation tillage practice (an activity) or should they pay for per ton reductions in soil erosion (an outcome)? The authors state that both economic theory and common sense would suggest that the most efficient way to achieve an environmental objective would be to pay on the basis of reductions in soil loss. However, developing the institutions and mechanisms for instituting such a system is just getting under way and is not particularly easy to establish. The discussion above on the identification of appropriate indicators and their measurement has been one of the primary constraints.

Because implementation of a performance-based payment system can be difficult, the focus has been on practice-based payments. Although performance-based programs can result in increased benefits in terms of environmental quality and program participation, they are also more complex and costly to implement. More and better agri-environmental process models, and the geographic data they rely on, will help reduce the costs of implementing performance-based programs in the future.

A performance-based payment system on agricultural lands would require USDA to gather a great deal of information, plan extensively, and enforce contracts (Weinberg and Claassen). A farm-level or field-specific baseline of past production management and conservation practices would also be required to assess the extent to which an improvement has actually occurred. Measuring improvements over a baseline (which is not widely available) would require extensive on past land use, crop rotations, input use, and cropping practices (Weinberg and Claassen). Collecting baseline information after establishing a performance-based system could invite gaming whereby producers could temporarily abandon environmentally favorable practices to obtain a more favorable baseline and hence higher payments for improved performance (Weinberg and Claassen). A performance-based system requires considerable resources at a time when funding for conservation planning and technical assistance has been shrinking.

Other important issues surrounding performance-based payments have been enumerated by Keeny and Boody. These include (1) aligning conservation goals at both the farm and ecosystem scale; (2) designing programs whereby producers receive timely payments when ecological outcomes take years to materialize and may be negatively influenced by on- as well as off-farm factors; and (3) if environmental benefits extend past the farm gate, how are these benefits valued and what fiscal instruments can be efficiently employed to compensate landowners. A related issue is assigning good or bad outcomes to specific individuals when it is difficult to track environmental performance to specific parcels of land.

In order to address some of the concerns described above, it may be possible to design a hybrid payment system (Weinberg and Claassen) that is a combination of performance-based and practice-based payment systems. "For example, payments for practices may vary by 'expected' performance levels, e.g. paying more for practices thought to be the most effective, or enrolling just those farmers offering to adopt the most practices likely to generate environmental benefits" (Weinberg and Claassen). A current example of this mixed system is the continuation of farm income support payments conditional upon farmers achieving minimum soil protection requirements. A performance goal is set by specifying soil loss standard and producers can then adopt a conservation plan that will attain that standard. But, conservation payments are still made on the basis of the practices adopted in the conservation plan, and not the actual reduction in soil loss. A complementary approach may be to offer bonus payments when it is verified that an individual's resource management has actually resulted in environmental improvements.

Keeney and Boody have suggested conducting research that compares the results of a practice versus performance-based payment system in different regions but which also addresses the social and economic impacts of a performance approach. This research would also evaluate the indicators used to measure the real or modeled outcomes of a given conservation practice

One indicator on which to base performance payments on crop land has been developed by Weinberg and Claassen. The authors simulated a performance-based system that determines payment levels on an "aggregate environmental index" (AEI). This is similar to the Environmental Benefits Index used by the Conservation Reserve Program and the Environmental Quality Incentives Program to evaluate and select landowner applications seeking to enroll in these programs. Using the AEI, simulated performance-based payments were based on an aggregate environmental index constructed to represent the overall environmental impact of various cropping systems. This index represents a weighted sum of nine agricultural environmental outcomes: pesticide, sediment, nitrogen, and phosphorus loadings to surface water; pesticide and nitrogen loadings to ground water; wind erosion; soil carbon emissions, and soil quality. The individual indicators are combined to generate an aggregate environmental index score specific to each production system and region. Wildlife and wildlife habitat are not included.

There are currently some USDA/NRCS conservation programs that either come close, or could be modified to achieve, a performance-based payment system. Although still practice-based, the Conservation Security Program (CSP) is the first program to provide increased payments for higher levels of performance of resource protection. The CSP includes performance-based components, including meeting minimum conservation standards to be eligible for program participation, an increased payment level based on the number of "resources of concern" that are addressed, and the availability of enhancement payments for going beyond minimum resource conservation standards. The CSP is still practice-based in that resources of concern are defined by quality criteria and these criteria comprise a set of discrete conservation practices. The CSP includes an enhancement payment for monitoring and evaluation of conservation practices, but it is not known how many landowners participate in this activity, what indicators are used, or what outcomes are being sought and measured. However, this is not the same a measuring improved habitat or water quality and then paying for an incremental improvement in performance over an established baseline condition.[9]

Other USDA/NRCS programs that could be adapted to a performance-based means of payment include the Environmental Quality Incentives Program (EQIP) and the Partnerships and Cooperation Program. Under EQIP, special projects have been funded under the Conservation Innovation Grants program to target resource conservation goals in place-based prioritization system. One such effort is the Winrock/University of Vermont program described above. Another is a new project to develop performance-based payments and ecosystem service markets for decreasing phosphorous run-off into water bodies in Florida. More funding in the 2007 Farm Bill will be required to continue and expand upon these efforts.

There are two types of benefits provided by landowners when they produce environmental improvements. The first is the private benefit that landowners themselves receive through either cost-savings accrued as a result of meeting regulatory standards, or through direct increases in income. An example of a direct increase in income may be revenue received from hunters as a result of the practices adopted to restore a wetland.

In most cases, the public benefits embodied in less soil erosion and sediment run-off, improved water quantity and quality, and increased biodiversity and wildlife habitat far outweigh the private benefits achieved. The major hurdle for a performance-based payment system to overcome is to how translate these non-market public benefits into monetary compensation for individual landowners? What is the increased performance worth? Assuming you have measurable indicators and enough funds to pay for outcomes, how do we value the incremental increase in environmental performance? Cost reimbursement is very different from payments based on how much the public values the non-market benefits of improved environmental performance on agricultural lands.

There are two possible sources of revenue to compensate private landowners for the public goods they are providing through the adoption of conservation practices. One is for federal or state governments to pay landowners on the basis of the public's willingness to pay for environmental

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[9] A revised structure of the CSP is currently being discussed as part of the 2007 Farm Bill legislation.

improvements. For example, from a two watershed study in Minnesota (Boody et. al) Minnesota residents expressed a willingness to pay about $200/Household/year to cut soil erosion by 50%, cut pollutant runoff by 50%, reduce farmland flooding by 25%, increase bird and wildlife habitat by 50%, and reduce greenhouse gases by 10-20%. Mechanisms to transfer this amount to landowners could be in the form of innovative tax credits, or developing markets for ecosystem services such a carbon sequestration, wildlife habitat, water storage, or water quality. With respect to ecosystem service markets, there would remain an important role for the public sector in terms of assuring that "public" environmental benefits are achieved and maintained at minimum acceptable levels.

Another route to take would be to use public funds to help initiate alternative product markets. This could take the form of eco-labeling support as in the case of Wisconsin Healthy Grown, or investing in some other types of marketing strategies that would assist producers and landowners to capture the public benefits of the improved environmental conditions they are providing.

Conclusions

The potential shift from practice-based to outcome-based agricultural resource conservation programs is being given increased attention a high policy levels, and is also a topic of intensified research. The rational for this transition is four-fold: improved environmental outcomes; more flexibility and innovation on the part of landowners to address environmental issues; more efficient use of taxpayer dollars; and as an alternative mechanism for supporting rural incomes (i.e. green payments).

Despite these advantages, establishing and managing a performance-based system of environmental payments is not a simple or straightforward task. In addition to institutional and funding requirements, a major stumbling block has been the identification of appropriate, reliable, and measurable indicators of environmental performance. There is a great deal of research that has been accomplished in developing reliable models of environmental processes (described in Section IV), and which could serve as adequate proxies for real conservation performance. However, these models must be applied, tested, and ground-truth over time and in different locations for them to remain valid indicators. To the extent that several model applications have been successful in predicting environmental outcomes, it may be appropriate to utilize benefits-transfer models between locations. Benefit-transfer models could also avoid the high costs associated with intensive monitoring programs.

In the near future, and until more knowledge is gained about the relationships of conservation practices and outcomes, there will most likely be payment system that is both practice based and performance based. Once there are more reliable linkages between practices and outcomes, especially in such stochastic processes that can affect wildlife habitat, species viability, and water quality, the next challenge will be to "value" the units of measure being used as outcomes. This valuation process must not only reflect the cost of maintaining environmental goods and services, but also reflect the environmental values that society as a whole gains from private conservation efforts. Establishing indicators that are easily monetized will be essential to capturing these values and for increasing landowner participation in conservation programs.

As indicated at the outset of this paper, the public at large is starting to ask what environmental benefits are being achieved as a result of resource conservation programs and practices on agricultural lands. While there is ample evidence that progress is being made, such progress needs to be more clearly demonstrated through a consistent measuring and reporting system. Adopting reliable, yet flexible, indicators and measurement systems that demonstrate real environmental outcomes, implementing a performance based payment system, and valuing the outcomes that are achieved are essential elements to quantifying conservation benefits and maintaining public and individual landowner support for resource conservation programs.

The provision of adequate funding for maintaining and improving the development of indicators and performance measurement systems is crucial for both the suppliers and the demanders of improved environmental services. In particular, increased funding should be made available for the USDA's CEAP program in the next Farm Bill, as well as special grants through various conservation programs and/or Cooperative State Research, Education, and Extension Service to continue to pilot test various performance-based payment systems. Currently, the emphasis of pilot test programs has been on water quality. More needs to be done for wildlife habitat and species. Finally, in order to economize on the resources required for monitoring performance, increased investments should be made in verifying existing and developing new process models and indices that can serve as the basis for ecosystem service payments.

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