Public Payments for Environmental Services from Agriculture: Precedents and Possibilities

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Agricultural market realities and the agri-environmental aspirations of developed countries' governments have merged under political economic influences to create myriad programs that pay established agricultural producers for taking environmentally beneficial actions. Arrived at in piecemeal fashion under disparate driving forces, resultant schemes to pay for so-called "environmental services"[1] from agriculture satisfy neither economic nor bureaucratic efficiency criteria.

This article briefly reviews the major characteristics of past and current public agri-environmental payment programs, outlines problems with these precedents, especially those arising as scientific advancement allows finer designation of multiple environmental services, and proposes future program decision-making possibilities that would better approximate market-like equilibria for public good environmental services from agriculture.

Precedent Programs Are Supply Driven

The United States, Canada, European Union (EU), and EU member countries, use a mixture of voluntary incentive-based programs, cross-compliance programs, and limited regulatory programs to create increased harmony between agricultural production and environmental quality. This review focuses on those voluntary incentive-based programs under which payments are made for identifiable environmental benefits.

Land retirement programs such as the U.S. Conservation Reserve Program (CRP), pay agricultural producers an annualized fee to obtain a stream of environmental benefits over a predetermined contractual period. Under the CRP selection process, bids from eligible applicants are ranked using an environmental benefits index (EBI) that measures and weights multiple environmental benefits from specific parcels or bundles of lands' retirement, along with bid parameters that proxy opportunity cost. The EBI weights are set by the government program administrators.

Canada's National Farm Stewardship Program, the Environmental Quality Incentives and Conservation Security (CSP) programs of the United States, and the United Kingdom's Countryside Stewardship and Organic Farming Scheme are examples of a growing number of public programs that cost-share, subsidize, or otherwise "pay" farmers to provide environmental benefits from land that remains in production. While each of these programs has a unique mode of implementation, they all basically give farm operators the opportunity to pick from a menu of environmentally oriented best management practices and/or structural improvements, and compensates those farmers by paying all or some of the actual and opportunity costs incurred by adopting the practice(s) or installing the structure(s). In some cases, the best management practices are customized for the potential program participant as a result of a farm-specific environmental plan; in others, the practices menu is outlined in a set of technology standards common to any and all program participants. Some programs "pay" farm operators for maintaining practices employed before the existence of

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[1] Although government programs refer to the purchase of "environmental services," a tighter definition, such as that for "ecosystem services," as thoroughly explicated by Boyd and Banzhaf (2006), is more appropriate for conceptual and analytical purposes. For this article, I am using the term "environmental service" to mean a measurable, end-use product of ecosystem processes, such as drinking water quality, bird population levels, or acres of open space in a metropolitan area.

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the incentives program; others only for new adoption of practices, and still others (like the CSP) for a combination of both.

Finally, most developed countries also have in place programs to preserve agricultural land or to prevent such land from being abandoned, and in many cases these too involve a direct payment to the land's operator or an indirect payment in the form of tax advantages.

These land retirement, working lands, and land use preservation programs' payment priorities are agriculture-centric. They are based on what the producers of the agri-environmental benefits can supply, rather than what is necessarily demanded by the population that would benefit from ensuing environmental service enhancement. True, in a number of these programs, eligibility or selection for payments relies on the ability of producers to supply environmental benefits that have been prioritized or "targeted" by government program administrators. But the choice of *how* benefits are targeted derives from a universe of acreage-based attributes; in other words, what existing, independent farm production facilities can supply.

To date, even targeted benefits are multidimensional and geographically dispersed. Research by Cattaneo et al. (2006), which shows that small changes to the CRP's index weights made little difference in environmental outcomes, supports the logical conclusion that using land to target programs while allowing multiple objectives in the decision function causes benefits to be widely dispersed across objectives. This is besides the fact that weighting reflects program administrators' choices rather than public preferences. Program administrators' goals of rewarding any movement toward more environmentally responsible farming, and the political forces begging for broad distribution of payments among farm operators contribute to effective dispersal of potential environmental benefits across space as well as multiple objectives.

There is no good evidence that any existing public agri-environmental payment program purchases a given "environmental service." It is more accurate to say that their participants are paid for environmentally friendly agricultural activities. Whether the sum of those activities affects an ecosystem function or provides an environmental service is not a revealed objective of the programs as they have been formulated and implemented to date. This is true despite the fact that government agencies and the agricultural economists whose work informs them (e.g., Cattaneo et al. 2005; Babcock et al. 1997) spend tremendous effort generating implications from choices about which producers are eligible to receive payments, what practices or activities constitute compensable actions, how to "target" program benefits, and how to construct indices of environmental contributions that calibrate bids and/or payment levels. The efforts are all directed toward figuring out how to allocate or leverage a fixed and limited amount of funds to agricultural producers whose practices could, but may not necessarily, contribute to the production of a (typically unspecified) end-use environmental service.

The failure of payment programs to add up to a measurable change in an environmental service is exacerbated by the growing menu of potential environmental benefits associated with agricultural production. From an original focus strictly on soil conservation (to retain agricultural productivity, produce less constricted waterways, and reduce particulate matter in the air), the list of potential environmental contributions that agricultural incentives programs envelop has grown to include such things as carbon sequestration, energy conservation, wildlife habitats of various kinds, open space, landscape features and cultural heritage, along with water and air quality. As the number of options increases, how does one allocate limited funds in a way that accomplishes a single environmental objective? Which of multiple environmental objectives should be accomplished?

Undiscovered Production and Preference Functions Limit Program Possibilities

Conceptually speaking, an economist's design from scratch for an efficient public program for the purchase of environmental services from agricultural producers would seek to estimate the relative, nonmarket demand for various environmental services from agriculture, and utilize technical production functions and associated cost estimates to determine what agricultural activities to pay for and at what price. In the real world, this remains difficult or impossible since few if any appropriate production functions for environmental services from agriculture have been estimated, and the cost of estimating true nonmarket demand functions for public program decision making is prohibitive.

Antle and Capalbo (2002) argue eloquently for the interdisciplinary development

of "econometric-process models" capable of translating agricultural management factors into environmental outcomes. They describe the policy decision-making advantages of output from a managed ecosystem model that incorporates feedback loops and other complexities to simulate the dynamic, nonlinear characteristics of the production function for commodities and noncommodity outputs. As insightful the concept and as daunting the task of estimating the interrelationships in agriculture as a managed ecosystem, the supplying ecosystem is only one component of the production function for most ecosystem services.[2]

Other studies (e.g., National Research Council 2004; Boyd and Banzhaf 2006) support the need for integrated ecological and economic methods to account for and value ecosystem services as outputs of natural (nonagricultural) ecosystems. These approach the approximation of ecosystem service production from the other side of the lens and do not explicitly account for the quality, quantity, or value of the portion of end services whose production is some function of bioeconomic phenomena at the managed agricultural ecosystem level. There is, thus far, a failure to connect agriculture-centric and natural ecosystem-centric models of ecosystem services from agriculture.

Similar "disconnects" exist on the demand side. Randall (2002) provides a clear and practical overview of what would be required to appropriately value all of the nonmarket goods arising from a "multifunctional agriculture." He proposes some clever but terrifyingly complex (and likely very costly) strategies for estimating "green" demands in the context of marginal rates of substitution among commodity and noncommodity outputs. While demand rather than supply-oriented, Randall also (like Antle and Capalbo) presumes the farm as the factory for production of the sorts of environmental services demanded by people, and Randall would set purchase prices based on bids from the farm supplier.

The National Research Council (2004) report, on the other hand, approaches the valuation of ecosystem services from the natural ecosystem point of view. Its authors advocate using a total economic value framework to comprehensively value the services from a particular ecosystem as comprehensively as possible. While noting that how one would go about this task should be influenced by the availability of information that links ecosystem values to changes in the system, this natural ecosystem-centric perspective fails to inform the specific policy questions that arise in the agri-environmental payment program context. Also, estimating preferences relative to all those provided by a given ecosystem would give different guidance than would a demand function based on relative preferences for agriculture's contributions to the ecosystem.

To Summarize to This Point

Precedent agri-environmental incentives programs allocate a fixed budget or acreage among farmers and ranchers whose land has characteristics that suggest that it could contribute to natural ecosystems' services that may be preferred, in some unidentified way, by consumers who face a menu of commodity and noncommodity outputs from agriculture. From a conceptual point of view, this is unsatisfying, but it does make good use of available data and information to inform a decision framed by policy makers. Adhering to good economic theory and concepts, however, would involve the merger of already demanding research effort to: (*a*) estimate the production function for environmental services from agriculture, just the agri-centric portion of which is challenging to estimate (even parsimoniously); (*b*) estimate values of local and particular public goods produced within agricultural systems on a natural ecosystem scale, which Randall (2002, p. 302) terms "frontier stuff"; and (*c*) use supply and demand relationships to infer a market approximation to set appropriate prices for preferred environmental services from agriculture. There must be something more powerful and conceptually satisfying than the practices now employed in designing agri-environmental payment programs, but less overwhelming and more practical than attempting a full definition of supply and demand for services created by the interaction of agri-ecosystems and natural ecosystems.

Pragmatic Possibilities

I contend that demand, rather than supply, should be the driver in designing strategies for public purchase of agriculturally related environmental services. Environmental service-specific preferences are a better guide for

[2] Some ecosystem services, such as farm views, or nonmigratory wildlife numbers, may derive directly from the managed agricultural ecosystem.

program targeting than agricultural program administrators' notions of priorities among broad environmental objectives like reduction of soil loss or nutrient runoff. Having knowledge of a set of highly demanded, specific, end-use environmental services that relate to agricultural activities would facilitate true targeting of the land or producers from which the preferred services can be obtained. For example, if it is discovered that there is relatively high demand for migratory goose habitat, an agri-environmental target would involve creating a land use pattern along specific flyways. Having a flyway target in mind would lead to different program decisions than would targeting producers whose land could generally be suitable as habitat for migratory birds. Furthermore, threshold effects of agricultural actions on natural ecosystems, and interplays between agricultural and industrial or municipal contributions to the ecosystem providing the preferred services, can only be taken into account if it is the environmental services rather than farm management criteria that drive the program's design. A pragmatic strategy is needed for determining relative preferences for ecosystem services affected by agriculture.

A first step would need to be to determine the group(s) of consumers from whom preferences would be solicited. Ideally, both national and local perspectives would be represented. Secondly, the end-use environmental services associated with agriculture would need to be identified, again from national and local perspectives. Finally, a simple method for collecting and interpreting preferences is required. Lessons learned from a decades-long history of agri-environmental incentives programs in the United States suggest that a practical approach to solicitation of preferences would embody the following characteristics.

- *Ease and quickness*: If the method is not easy and quick to use, any preferences revealed from it will have a limited useful lifespan and, in an age of resource constraints, would be unlikely to get updated for consistent program decision making over time.
- *Flexibility*: The method should be flexible enough to determine preferences for use in making local, regional, or national program decisions, and for decisions about different government programs.
- *Transparency and reproducibility*: Models for federal government decision making must, by the provisions of the Quality of Information Act meet demanding standards for transparency and reproducibility. In essence, it must be clear to any challenger of a program decision based on data, analysis, or modeling, precisely how the particular decision arose from application of the decision tool applied.
- *Agri-environmental payment program relevance*: The most economically correct, flexible, and transparent approach will be useless if it cannot be applied within the context of actual programs' management.

One strategy to meet these criteria could be to employ panels of interest groups and elected officials at each of various geographic scales to relatively value environmental services from agriculture according to the Analytical Hierarchy Process (AHP) described by Saaty (1990).

The Analytical Hierarchy Process

AHP is a multi-criteria decision tool akin to conjoint analysis, but without an underlying utility function and more user-friendly. It has been used in a wide variety of decision problem contexts, including the allocation of scarce fishing rights to competing groups (Mardle, Pascoe, and Herrero 2004), the determination of biotechnology research priorities in Chile (Braunschweig and Janssen 1999), and the selection of natural resource management options for Queensland, Australia (Hajkowicz, McDonald, and Smith 2000).

In practice, AHP would establish a normalized set of weights by making pair-wise comparisons among ecosystem services, describe, based on scientific knowledge and/or expert information, how each of multiple agricultural management alternatives affect those services, and employ the services' weights and the alternatives' characteristics to rank alternatives. In application to program decisions for the purchase of environmental services from agriculture, alternatives would be identified as environmentally friendly land uses and farm practices. Each alternative land use or farm practice would then be characterized (using a Likert or similar scale if scientific information is not available to measure in relevant descriptive units) according to the extent to which it would be likely to contribute to a range of environmental services. For example (see figure 1), applying fertilizer according to soil testing for nutrient balances, farmland retirement, and creating buffer strips (three of many

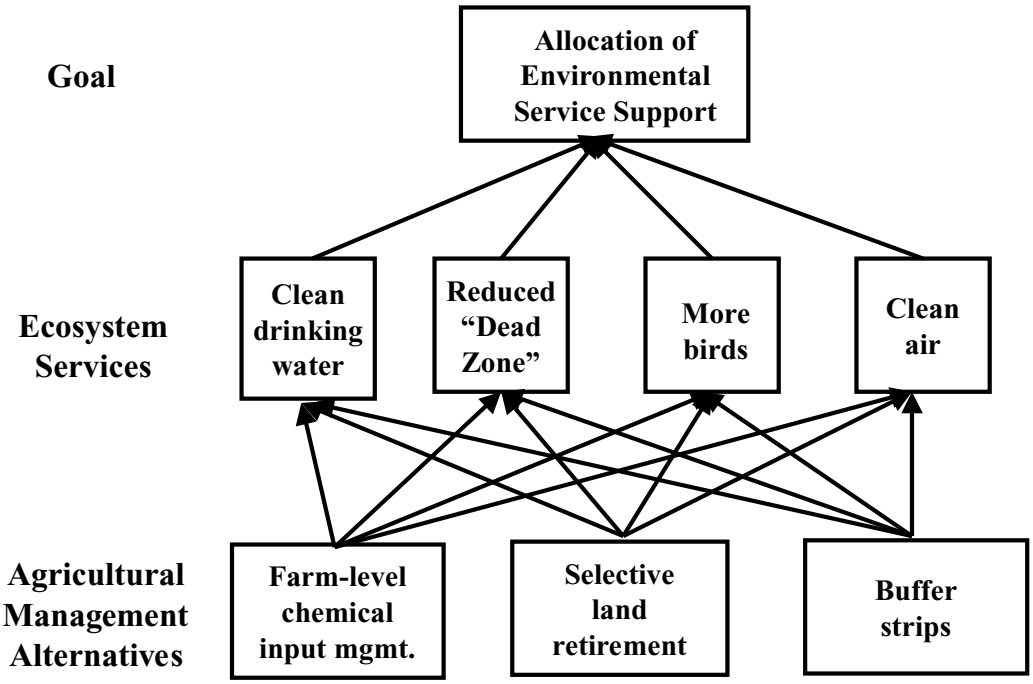

Figure 1. Illustrative analytical hierarchy for agricultural management program decision making to obtain preferred environmental services

"alternatives") each has a different potential as a contributor toward, say, increased migratory bird populations in the United States, decreased area of hypoxia in the Gulf of Mexico, clean air, and clean drinking water (four different environmental services). Preferences would be elicited through pair-wise comparisons of individual services' importance to the group queried. Resultant normalized weights on services would then be multiplied by those services' ratings for each alternative, to obtain a value for use in ranking the importance of the alternative farm-level practices in achieving environmental service preferences.

The ease and quickness of the AHP are magnified by the availability of software programs (e.g., from Expert Choice, Inc.) that facilitate populating matrices for alternatives and services, capture pair-wise comparisons from a large, face-to-face group, and instantaneous calculate "importance" values. The group software also encourages Delphic learning that improves the final outcome of the exercise. The ease of AHP software application, coupled with the use of public and private representatives of an environmental service consuming population, permits the consideration of an identical set of preference parameters at multiple geographic scales, or different locations. Population numbers could be used to further weight importance values to derive a composite, national set of alternative actions for which farmers could get paid. And these actions would be directly associated with environmental services that rank highly on a national basis, accounting for population effects.

This approach is not without limitations. The preferences revealed as weights on alternative environmental services provide only a rough and partial indicator of the demand for environmental services. No transitivity is required (although the normalized matrix will reveal if there are inconsistencies), and resultant rankings are ordinal (though derived on the basis of quantitative information). Despite these limitations, the choices from AHP application of which farm-level practices would warrant agri-environmental payments, where, and how, would derive from some notion of demand rather than supply, and resultant importance values on alternatives could be used to gauge relative payment levels. This type of approach also precludes the need for specific scientific data linking actions with environmental outcomes. It can thus be considered a stopgap strategy while data collection and analysis of complex systems and their interrelations are being performed and validated. AHP can

actually integrate objective cause and effect information on some relationships, as it becomes available, with qualitative judgments reflecting associations between farm-level actions and other environmental services' provision. There may well be other methods unknown to this author that are similarly useful in making farm practice subsidization decisions based on alternatives' contributions to environmental servicing.

Conclusions

In any case, if we in the profession are to live up to the goal of informing policy and program decisions about the purchase of environmental services from agriculture, we will have to radically revise how we, ourselves, posit optimal conditions, frame analytical questions, and develop methodologies in this area. A first necessity is to venture outside of the closed agricultural system and acknowledge, in our thinking about program possibilities, the links between managed agricultural ecosystems and the natural systems from which environmental services originate.

A second necessity, whether we are pursuing market-based solutions or government payment for services, is to assure that we have some knowledge of what environmental services from agriculture are demanded by consumers. This suggests that we turn our thinking about agri-environmental programs upside down. Rather than focusing exclusively on the details of farm-centric program eligibility, bidding, and selection criteria that may not make large differences in how well particular environmental services are targeted for purchase, we need also to be asking such questions as:

- *For what groups(s) of consumers will the government program be purchasing environmental services that the market cannot provide?* This is both a scale issue (national, regional, or local) and, if the choice is not for broad representation of consumers at the national level, an issue of equity. Would weights on consumer preferences be greatest for denser population centers? How would urban versus rural weighting affect the preference structure?
- *For what menu of environmental services should relative preferences be estimated?* The menu could either be selected from a universe of natural ecosystem services, or constructed from the smaller set of environmental services likely to be linked to a set of potential farm-level actions. As the list of environmental benefits to which agriculture is presumed to contribute grows, the criteria for winnowing a list down to a manageable number of options become more critical.
- *How well can agricultural actions be characterized with respect to their effect on environmental services from natural systems?* A concerted interdisciplinary research agenda is needed to develop now missing information on the agriculturally related production function for off-farm environmental services. A demand-oriented program approach requires performance rather than technology standards as the basis for program decision making, and these will come only from better knowledge of how land use and practices affect environmental outcomes. In the meantime, pragmatic approximations of the function need to be employed.

I cannot imagine how current agri-environmental programs could be changed at the margin to achieve this recommended shift in orientation to environmental service provision. If government programs are geared to how farmers can satisfy the preferences of environmental service consumers, rather than how farmers can be compensated for generic environmentally beneficial actions, substantial program redesign will be needed.

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