Ecosystem Service Valuation and Watershed Resources

An annotated literature review

Prepared for The Water Challenge Program
Theme 2: Multiple Use of Upper Catchments

by

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Introduction

The annotated literature review is divided into three sections. The first section of the literature review is the largest and it summarizes the theoretical thinking behind the valuation of ecosystem services. It is by far the largest section of the review because the bulk of thinking on ecosystem valuation has been theoretical or analytical. The second section of the review summarizes the limited number of studies that have attempted to empirically value ecosystems services. The third section is composed of studies related to ecosystem service valuation in areas such as the measurement of the multifunctional attributes of agriculture. These studies provide a contrasting vision of how to expand the value of agricultural production into food and functional values.

Before the annotated bibliography is presented, a categorized bibliography that can act as a table of contents is presented to organizes the citations into the three sections. After all sections of the annotated review, a standard alphabetized bibliography of all three combined sections is provided.

Categorized Bibliography

Section 1: The theory behind ecosystem service valuation

Farber, S., Costanza, R., and Wilson, M. (2002). "Economic and Ecological Concepts for Valuing Ecosystem Services," *Ecological Economics*, 41(3), 375-392.

Bockstael, N., Freeman, A., Kopp, R., Portney, P., and Smith, V. (2000). "On Measuring Economic Values for Nature," *Environmental Science and Technology*, 34(8), 1384-1389.

Hannon, B. (2001). "Ecological Pricing and Economic Efficiency," *Ecological Economics*, 36, 19-30.

Howarth, R., and Farber, S. (2002). "Accounting for the Value of Ecosystem Services," *Ecological Economics*, 41(3), 421-429.

Alexander, A., List, J., Margolis, M., and d'Arge, R. (1998). "A Method for Valuing Global Ecosystem Services," *Ecological Economics*, 27, 161-170.

Wilson, M., and Howarth, R. (2002). "Discourse-based Valuation of Ecosystem Services: Establishing Fair Outcomes Through Group Deliberation," *Ecological Economics*, 41, 431-443.

Farber, S., and Griner, B. (2000). "Using Conjoint Analysis to Value Ecosystem Change," Environmental Science and Technology, 34(8), 1407-1412.

Limburg, K., O'Neill, R., Costanza, R., and Farber, S. (2002). "Complex Systems and Valuation," Ecological Economics, 41(3), 409-420.

Kaiser, B., and Roumasset, J. (2002). "Valuing Indirect Ecosystem Services: the Case of Tropical Watersheds," *Environment and Development Economics*, 7, 701-714.

Antle, J., and Capalbo, S. (2002). "Agriculture as a Managed Ecosystem: Policy Implications," *Journal of Agricultural and Resource Economics*, 27 (1), 1-15.

Polasky, S., and Solow, A.R. (1996). "Conserving Biological Diversity with Scarce Resources."

Ando, A., Camm, J., Polasky, S., and Solow, A. (1998). "Species Distributions, Land Values, and Efficient Conservation," Science, 279, 2126-2128.

Heal, G. (2000). *Nature and the Marketplace: Capturing the Value of Ecosystem Services*. Washington, D.C.: Island Press

Section 2: Application of ecosystem service valuation

Klauer, B. (2000). "Ecosystem Prices: Activity Analysis Applied to Ecosystems," Ecological Economics, 33, 473-486.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., and van den Belt, M. (1997). "The Value of the World's Ecosystem Services and Natural Capital," *Nature*, 387, 253-260.

Pearce, D. (1998). "Auditing the Earth," *Environment*, 40(2), 23-28.

Kaplowitz, M. (2000). "Identifying Ecosystem Services Using Multiple Methods: Lessons from the Mangrove Wetlands of Yucatan, Mexico," Agriculture and Human Values, 17, 169-179.

Kerr, J. (2002). "Watershed Development, Environmental Services, and Poverty Alleviation in India," *World Development*, 30(8), 1387-1400.

Chomitz, K.M., Brenes, E., and Constantino, L. (1998). "Financing Environmental Services: The Costa Rican Experience and its Implications." World Bank, rev. 25.

Section 3: Multifunctional attributes of agriculture and ecosystems valuation

Pattanayak, S., and Kramer, R. (2001). “Worth of Watersheds: a Producer Surplus Approach for Valuing Drought Mitigation in Eastern Indonesia,” *Environment and Development Economics*, 6, 123-146.

Portela, R., and Rademacher, I. (2001). “A Dynamic Model of Patterns of Deforestation and their Effect on the Ability of the Brazilian Amazonia to Provide Ecosystem Services,” Ecological Modelling, 143, 115-146.

Smith, J., Mourato, S., Veneklaas, E., Labarta, R., Reategui, K., Sanchez, G. (1998). “Willingness to Pay for Environmental Services Among Slash-and-Burn Farmers in the Peruvian Amazon: Implications for Deforestation and Global Environmental Markets,” American Agricultural Economics Association Annual Meeting, Salt Lake City, UT, August 2-5, 1998.

Peterson, J.M., Boisvert, R.N., and de Gorter, H. (2002). “Environmental Policies for a Multifunctional Agricultural Sector in Open Economies,” European Review of Agricultural Economics, 29(4), 423-443.

Babcock, B.A., Lakshminarayan, P.G., Wu, J., and Zilberman, D. (1997). “Targeting Tools for the Purchase of Environmental Amenities,” Land Economics, 73(3), 325-339.

Horan, R.D., Shortle, J.S., and Abler, D.G. (1999). “Green Payments for Nonpoint Pollution Control,” American Journal of Agricultural Economics, 81(5), 1210-1216.

Helfand, G.E., and House, B.W. (1995). “Regulating Nonpoint Source Pollution Under Heterogeneous Conditions,” American Journal of Agricultural Economics, 77(4), 1024-1023.

Randall, A. (2002). “Valuing the Outputs of Multifunctional Agriculture,” European Review of Agricultural Economics, 29(3), 289-307.

Annotated Bibliography

<u>Section 1: The theory behind ecosystem service valuation</u>

Farber, S.C., Costanza, R., and Wilson, M.A. (2002). “Economic and Ecological Concepts for Valuing Ecosystem Services,” *Ecological Economics*, 41(3), 375-392.

Overview of special issue on valuation:

“Values ultimately originate from within the constellation of shared goals to which a society aspires – value systems – as well as the availability of ‘production technologies’ that transform things into satisfaction of human needs.” (8)

Economic valuation versus ecological valuation: ecology relies on energy theory of value. Also addresses critical zones/threshold conditions for ecosystems – non-linear relationship. This leads to idea that there is an insurance premium that society will pay to avoid a natural catastrophe. In non-linear, non-marginal region, sustainability values are more important than efficiency values. Uncertain critical thresholds require valuation under uncertainty. Depends on how risk-averse people are.
WTP and WTA are important valuation concepts for social value of services. Six major techniques:

1. avoided cost
2. replacement cost
3. factor income
4. travel cost
5. hedonic pricing
6. contingent valuation

Small group deliberation has gained recognition in the literature. Does not involve aggregation of separately measured individual preferences, but comes from open public debate. Establishes two validity criteria: "decentralized forms of environmental policy formulation, and direct involvement of non-experts in small decision-making groups." Assumes that citizens can render informed judgments about environmental goods for society as a whole. Treats small group deliberation not as a diagnostic tool, but as an explicit mechanism for value elicitation.

Bockstael, N., Freeman, A., Kopp, R., Portney, P., and Smith, V. (2000). "On Measuring Economic Values for Nature," *Environmental Science and Technology*, 34(8), 1384-1389.

Value must be state in comparative terms – the answer to a question with two clearly defined alternatives. "Compensation measures cannot be defined in isolation. They are entirely dependent on the context and may change as there is change in one or more elements of that context." (1385) Therefore, need to be specific about both the default and changed situation.
Individuals WTP or WTA measures are affected by endowments of wealth – can't aggregate.
Problem with Costanza, et al. – study based on other studies that value small changes in ecosystem, holding all else constant. You cannot multiply these out to estimate the value of the loss of the global environment, "failure of additivity" (1387). Also, person's WTP cannot conceptually be greater than what they have to give, unless the alternative state of nature is "nothingness," in which there is no finite compensation for ecosystem services.
Replacement cost is only valid under three assumptions: human-engineered system is least cost, equivalent in quality and magnitude to natural system, and individuals would incur these costs in the absence of natural function (Critique Kaiser's use of desalinization to value groundwater).

Hannon, B. (2001). "Ecological Pricing and Economic Efficiency," *Ecological Economics*, 36, 19-30.

Attempts to combine ecological and economic systems into single input/output matrix framework. Assumes system is static, linear, and requires a system equilibrium assumption. Does not address computation of biological costs – process of contingent valuation is crucial. Classifies unrecovered flows as part of total output, but not net output – allows calculation of technical system efficiency (measures the avoidance of waste of the net input factors). His three novel elements – defines metabolism as net input of the ecosystem, uses economic techniques to evaluate metabolic costs, and adds lost capital to the net output definition to determine the system efficiency.

Howarth, R.B., and Farber, S. (2002). "Accounting for the Value of Ecosystem Services," *Ecological Economics*, 41(3), 421-429.

Utilizes shadow prices (the marginal contribution that ecological resources make to the satisfaction of human preferences in monetary units) to calculate VES. Have to use non-market valuation techniques to determine shadow price – travel cost, hedonic, CV. Accounting problem is to extend consumption indicators to include direct environmental services that are not linked to market transactions (indirect benefits are already accounted for). Welfare measures that rely on "representative" person can obscure inequality. Ecosystem valuation sheds little light on social fairness and ecological sustainability.

Alexander, A., List, J., Margolis, M., and d'Arge, R. (1998). "A Method for Valuing Global Ecosystem Services," *Ecological Economics*, 27, 161-170.

"Green" GDP accounting does not take into account productivity of ecological inputs (treats them as a depreciating stock).

"Weak complementarity" – ecological services are absolutely essential in production and consumption – their value can be as much as the surplus generated in all production and consumption processes.

Hypothetical – a monopolist owns all ecological services in global economy, can extract all rents (short of those that allow subsistence). They derive value of services in wage bill and in land rents. They then impose constraint of sustainability (human and physical capital replacement costs), and the possibility of reduced market power (if not purely complementary) to generate an estimate of ecosystem services. Also examine the value of inputs to consumption by looking at compensating wage differentials (included in previous calculation) by estimating values in hypothetical "Nirvana," "Low County," and the average ($2.8-5.2 trillion). Estimate of ecological services 44-88% of total world output.

Wilson, M., and Howarth, R. (2002). "Discourse-based Valuation of Ecosystem Services: Establishing Fair Outcomes Through Group Deliberation," *Ecological Economics*, 41, 431-443.

Valuation of ecosystem services should be elicited through free and open public debate. This will enhance the social equity of the final decision, in contrast to other methods that rely on individual estimates of WTP or WTA. Ideally, "fair social decisions are defined as those that would be unanimously agreed upon by individuals conceived as free and equal moral persons." (p.433).

Conventional techniques rely on socially efficient resource allocation generated by competitive markets. "The problem is that due to its focus on utility maximization and a heavy reliance on individual preferences, the social equity of ecosystem goods and services tends to be effectively excluded from the results of non-market valuation." (p.434). Literature review concludes that individual and social group outcomes tend to be complements.

Farber, S., and Griner, B. (2000). "Using Conjoint Analysis to Value Ecosystem Change," Environmental Science and Technology, 34(8), 1407-1412.
Revealed preference (hedonic, travel cost, averting cost) vs. stated preference (CVM, CJ) – latter more appropriate for non-use values.
CJ appropriate for ecosystem valuation because it allows the valuation of "complex multi-attribute values to people" (1408). Also permits valuation in cases of high correlation. They apply CJ to watershed quality study in PA.
"…it offers the opportunity to explicitly determine tradeoffs in environmental conditions through its emphasis on discovering preference structures and not just monetary valuation." (1412).
Its disadvantage is the difficulty of administration and ease of understanding.

Limburg, K., O'Neill, R.V., Costanza, R., and Farber, S. (2002). "Complex Systems and Valuation," Ecological Economics, 41(3), 409-420.
As an ecosystem approaches a state of rapid bifurcation (non-marginality), ecological methods of valuation are more appropriate than economic valuation. This suggests a combined system based on both forms of valuation depending on where the system is in terms of its marginality. There will be a shift towards the boundary of this non-marginal region away from utility valuation to risk-avoidance/insurance premia. This requires in-depth knowledge of the workings of complex systems, which may be unrealistic to a degree.

Kaiser, B., and Roumasset, J. (2002). "Valuing Indirect Ecosystem Services: the Case of Tropical Watersheds," *Environment and Development Economics*, 7, 701-714.
Focuses on estimation of the value of indirect ecosystem services that do not contribute to the production of a well-valued final good (e.g. public goods). Uses the shadow price as calculated from an optimizing model to estimate the discounted net present value of water resources with a conservation policy aimed at the indirect service (tropical forest cover, in this instance), and without the conservation policy. Then calculates the difference in NPV in these two cases to estimate the value of the conservation project and therefore the value of the indirect environmental service. Does not explicitly take into account the direct services offered by the forest cover. Results emphasize the importance of preventive measures. Economic model involves consumer surplus formulation.
"Forests and forested watersheds are of particular interest among developing countries, whose governments are said to 'often look to their forests as a standing asset that can be liquidated to solve financial problems.'" (p.702).
"…conventional methods of project evaluation and measuring economic indicators such as NNP, which often overlook natural capital, are more seriously flawed in developing countries." (p.701).

Antle, J., and Capalbo, S. (2002). "Agriculture as a Managed Ecosystem: Policy Implications," *Journal of Agricultural and Resource Economics*, 27 (1), 1-15.

The environmental and health impacts of agricultural systems have been neglected in analysis of returns to ag research or in evaluation of ag technologies, because appropriate data and methods were lacking. (2). Current ability to link disciplinary models is limited because of their design. "…an integrated system would have a single set of drivers and endogenous variables for all disciplinary components." (7). It also "incorporates all of the feedback loops associated with the relevant processes; therefore, the integrated system does not impose arbitrary constraints on the dynamic properties of the system caused by incomplete linkages between the processes." (7). Argue that these types of models will be particularly useful in the case where systems are pushed beyond range of observed behavior.

Uses Ecuador example to demonstrate the limitations of using economic decision models that are not integrated with biophysical processes (9). "By integrating ecosystem and economic models, it would be possible to investigate the properties of these systems, taking into account the dynamics and feedbacks both within and between systems." (10). Long quote p.12 "The environmental economics…"

Polasky, S., and Solow, A.R. (1996). "Conserving Biological Diversity with Scarce Resources."

Conservation problem: (i) define a measure of biological diversity, (ii) assess the probable biological effects of alternative strategies, (iii) assess the probable net cost of alternative strategies (p2).

Addresses difficulty of "select[ing] an affordable set of reserves that represents the greatest number of species at least once," or "the maximal coverage problem" (p14).

"In theory, it is important to include all of the potential costs and benefits accruing from conservation strategy. In practice, it will be difficult to accurately account for non-market and speculative (potential) costs and benefits as well as account for the distribution of those costs and benefits across various members of society" (p20).

Ando, A., Camm, J., Polasky, S., and Solow, A. (1998). "Species Distributions, Land Values, and Efficient Conservation," Science, 279, 2126-2128.

The analysis compares optimal site selection when the loss is measured by the number of sites with optimal site selection when the loss is measured by the cost of the sites. "…results serve to underline the importance of considering both ecological and economic factors in efficient species conservation" (p2128). For example, cost-min. solution includes sites in Inner-Mountain West and Midwest, that are not rich in species, but this deficiency is offset by lower cost (p2127).

Section 2: Application of ecosystem service valuation

Klauer, B. (2000). "Ecosystem Prices: Activity Analysis Applied to Ecosystems," *Ecological Economics*, 33, 473-486.

Based on analogy between ecological and economic systems – uses mathematical economic price theory and applies to ecosystems to derive values based on gross ecosystem outputs. Estimated prices are not comparable to economic prices because there is no relation to individual evaluations, nor are they comparable over time (and structural changes). "Recommendations cannot be directly concluded for actions for society from ecosystem prices since they reflect the functional interrelations in an ecosystem but not directly the social desirability. However, the aggregate information about functional interrelations can of course support the decision-making process." (484)

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., and van den Belt, M. (1997). "The Value of the World's Ecosystem Services and Natural Capital," *Nature*, 387, 253-260.

Compiles >100 studies that estimate the ecosystem services of various biomes. Values these services using one of three methods: the sum of consumer and producer surplus, producer surplus, and price times quantity. The multiply these values by the surface area of each respective biome to generate an estimate of the total value of all ecosystem services. There are major problems with this method, especially the assumption that there are no irreversible environmental thresholds, and there is no interaction between services (static formulation). They estimate the total value to be in the range of $16-$54 trillion.

Pearce, D. (1998). "Auditing the Earth," *Environment*, 40 (2), 23-28.

Critique of Costanza, et al. – they have violated all principles of economic valuation. The results are inconsistent with WTP as the estimate (33tr.) exceeds world income. They focus only on benefits of protecting environment, not costs. They do not conduct a marginal analysis, the "find the value of everything," but WTP is for relatively small changes, not the changes that Costanza assumes – "The changes that Costanza and his coauthors have in mind are vast indeed, including the disappearance of entire ecosystems." (28).

Costanza replies – same difficulties as with all macro analysis. They have done the same thing as in GNP accounting. "At the macro level, the value of any major component of the economy (such as agriculture) is infinite because without it there would be no economy – or at least non structured anything like the current one" (26). "The point of our paper was to estimate that income, which has no direct relationship with the current, incomplete value of GNP. If this income were to be included (via ecotaxes, for example), both the structure and the magnitude of GNP would be very different." (26).

Kaplowitz, M. (2000). "Identifying Ecosystem Services Using Multiple Methods: Lessons from the Mangrove Wetlands of Yucatan, Mexico," *Agriculture and Human Values*, 17, 169-179.

Empirical test of the use of focus groups versus individual interviews to identify and value ecosystem goods. Examine hypothesis that focus groups and individual interviews, all else equal, "reveal similar sets of information about a shared mangrove ecosystem." (171). Find that it is 9 times more likely for focus group to raise topic of beauty than for individuals, also much more likely in case of crab collection, salt extraction, and fishing for shrimp. "…wetland beauty was significant to individuals but only accessible after a dynamic exchange of information." (175). "Since valuation methods such as contingent valuation or contingent ranking rely upon individuals, not in groups, making trade-off

choices to reveal nonuse and total economic values, the findings suggest the import of designing better valuation survey instruments." (175). The lower mention of shrimp collection may be because of decreased economic role of this activity, but discussion may lead people to realize the loss of the service.
"…the notion of a nonconsumptive or nonuse ecosystem service may be difficult for individuals to conceptualize and associate with an ecosystem without the benefit of a dynamic exchange of information" (177).

Kerr, J. (2002). "Watershed Development, Environmental Services, and Poverty Alleviation in India," *World Development*, 30(8), 1387-1400.
Looks at watershed development projects initiated in India under various types of organizations and qualitatively analyzes the impact of those projects on the poorest sector of society. Based on informal personal interviews. Finds that, in the case where public lands are closed to use for revegetation, women and the poorest in the villages were hurt the most, although frequently the effort failed in the closing of the commons was not enforced. They find that land holding size is positively correlated with satisfaction with the development project, and that those reliant on the commons express the greatest dissatisfaction.

Chomitz, K.M., Brenes, E., and Constantino, L. (1998). "Financing Environmental Services: The Costa Rican Experience and its Implications." World Bank, rev. 25.
Details particulars of Costa Rican federal program for four forest benefits: biodiversity, carbon sequestration, watershed protection, and ecotourism and scenic values.
In terms of equity, "fragmented smallholder properties may be less important for biodiversity than large holdings" (p18). Implies that equity and environmental goals may be in conflict in this case.

Section 3: Multifunctional attributes of agriculture and ecosystems valuation

Pattanayak, S.K., and Kramer, R.A. (2001). "Worth of Watersheds: a Producer Surplus Approach for Valuing Drought Mitigation in Eastern Indonesia," *Environment and Development Economics*, 6, 123-146.
Uses producer surplus approach to estimate the value of forested watersheds in terms of drought mitigation by estimating the impact of a change in base-flow on agricultural profit through increased production of coffee and rice. Their analysis requires that the environmental service be used in the production of a market-valued good. Their key assumption is that the market for that good must be complete. The policy implication is that there are other factors that go into increasing base flow (climate, etc), and that policy-makers should target specific watersheds with those characteristics for conservation. This can be applied to other resource management problems as long as there is a final market good.
"A watershed service can be defined as the improvement or maintenance of the ecological characteristics of the watershed that results from soil and water conserving land uses." (p.124)

See Dixon (1997) for a list of ecological services provided by watersheds.

Portela, R., and Rademacher, I. (2001). "A Dynamic Model of Patterns of Deforestation and Their Effect on the Ability of the Brazilian Amazonia to Provide Ecosystem Services," *Ecological Modelling*, 143, 115-146.
Examine four ecosystem services in Brazilian Amazonia's river drainage basin. Deforestation drivers – economic incentives and population growth. Land cover stocks – land use patterns impact the quality and value of eco services. Four services – climate regulation, erosion control, nutrient cycling, specie diversity. Use estimates from Costanza, et al. to value the four services. Run a 100 year simulation in which forest area declines to 44% or original forest with pasture and abandoned pasture as dominant land cover. Vale of eco services declines from $1431 per year to $657 and $781 per hectare year for agriculture and pasture, respectively. Overall per hectare value of services declines by 45% for ranching, and by 54% for farming in simulation. Results from disruption of nutrient cycling by agriculture. The value of services from land used for farming is 7 times greater than the revenue from farming activities. They assume that the value of eco services decreases linearly, but it may not. "The current non-market – and hence non-priced – nature of ecosystem services is an impediment to creating a system of incentives that would lead land holders in Brazilian Amazonia to see a loss in the value of ecosystem services as significant opportunity cost." (129). "The monetary approach to ecosystem valuation provides one means of overcoming the incompatibility of public and private preferences." "What a monetary valuation of ecosystem services cannot convey, however, is a sense of the intrinsic or inherent value of an intact ecosystem that exists regardless of human benefit." (129).

Smith, J., Mourato, S., Veneklaas, E., Labarta, R., Reategui, K., and Sanchez, G. (1998). "Willingness to Pay for Environmental Services Among Slash-and-Burn Farmers in the Peruvian Amazon: Implications for Deforestation and Global Environmental Markets," Presented at 1998 American Agricultural Economics Association Annual Meeting.
Look at possibility that small-scale farmers in Peruvian Amazon could provide carbon sequestration services. If gains to trade exist, farmers could be compensated for increased forested areas on farms, by carbon emitters in developed countries. Uses Contingent Valuation Method. Values are compared to cost of emission reduction by switching to cleaner fuels. Looks at two scenarios, preservation of natural forest on one hectare of farm, or shift to multi-strata agroforestry system which combines crops with tree species to "mimic natural succession" (2). Taxation is considered undesirable alternative because of equity considerations and enforcement difficulties. They estimate WTA for economic losses from the two options, and then ask how much they are willing to discount compensation because of environmental services provided by change. The difference is the WTP for environmental services. Estimated to be $67 for preservation and $41 for agroforestry, which indicates that farmers are willing to forgo income to obtain eco services. They find that the ratio of global benefit to local cost are more favorable for agroforestry. Possibility of mutually profitable trade exists if emission reduction targets are set high enough. "This market-based approach could fundamentally

alter the economics of forested land versus other land uses and thus considerably enhance the effectiveness of traditional efforts to save tropical forests." (6).

Peterson, J.M., Boisvert, R.N., and de Gorter, H. (2002). "Environmental Policies for a Multifunctional Agricultural Sector in Open Economies," European Review of Agricultural Economics, 29(4), 423-443.
3 causes of jointness: (i) technical interdependences in production processes, (ii) non-allocable inputs, where inputs are devoted to a process that produces more than one output and the input's separate contribution to each output cannot be determined, (iii) allocable fixed factors, were outputs are produced in separate processes and inputs can be allocated across the processes, but they compete for inputs that are fixed at the firm level (e.g. producing several crops on a fixed land base). (425).
Output subsidy only efficient if all multi- goods have positive social values, and production of non-commodity outputs is fixed in proportion to production of commodity outputs. Decoupled policies only work if every input can be allocated separately in the production of either public or private goods. (439)
"Because the public outputs themselves are generally unobservable, the optimal policy scheme is necessarily a complex set of input taxes, subsidies or regulations that must be chosen jointly in a way that takes their interactions into account" (p440).

Babcock, B.A., Lakshminarayan, P.G., Wu, J., and Zilberman, D. (1997). "Targeting Tools for the Purchase of Environmental Amenities," Land Economics, 73(3), 325-339.
Examines implications of using alternative decisions rules that do not maximize total environmental benefits (cost, benefits, and C/B ratio targeting). "…the wrong targeting mechanism can lead to increasing returns to public expenditures, and…the magnitude of the difference in total environmental benefits from alternative targeting criteria depends upon the relative variability of costs and benefits and the correlation between them" (p326).
If cost variability>benefit variability, then acreage maximization is more consistent with envir max than enrolling based on benefits, particularly if benefits and costs positively correlated. If opposite, then enrolling land on basis of benefits offered more consistent with envir max than acreage max, particularly when B and C positively correlated. (333)
The appropriate target varies by which amenity is most important (groundwater vulnerability, water erosion, wind erosion, or wildlife habitat). However, benefit ranking is superior to cost ranking for all four because var of B>var of C on current CRP land (b/c program rules limit amt of cost var by setting an upper limit on CRP bids) (336).

Horan, R.D., Shortle, J.S., and Abler, D.G. (1999). "Green Payments for Nonpoint Pollution Control," American Journal of Agricultural Economics, 81(5), 1210-1216.
Literature deals with economic efficiency and gives no weight to farm income objectives important in designing a g. payments program (Smith). G. Payments: "…any payments to producers based on either specific actions taken to reduce nonpoint pollution or on the probably environmental results of such actions" (p.1210). Payments must be based on "observable aspects of the nonpoint pollution process" (p1211).

Considers 2 types of input-based payments – (1) input subsidies – based on reductions in use of polluting inputs or increased use of pollution-reducing inputs (p1211). Producers decide on input-by-input basis whether to take actions to receive subsidy. (2) Contracts – pay producers a specified amt to take specific set of actions. Optimal subsidies will "distort markets in ways that might increase income" and the lump sum components will provide direct payments that may increase income. "As with the input subsidies, however, payments may provide a degree of income transfer so that contract payments more than cover producers' cost of compliance" (p1212). The optimality of the two is an empirical issue.

The above maximize the social welfare function, however there are practical limitations to doing so. Second-best payment plans should take into account:

Budget limitations and transaction costs – want to give more weight in function to those with larger expected impacts on damages.

Need environmental proxies that lead to "decreased damages for a large number of possible outcomes of random events." (1213).

Uncertainty about producer responses and outcomes.

Subsidy base must be truncated to a subset of choices.

Uniform payments reduce cost-effectiveness.

Contracts limited – "all-or-nothing" – producers can't respond to price signals or reduce control costs using private info., also costly to ensure participation.

G. Payments may produce an incentive for producers to enter an industry, or limit exit. Production would increase, reducing profits, and eliminating any potential program gains through market price effects. Also, production may occur in sensitive areas is subsidies larger in these areas than in others (perversion).

"the only green payments that would not alter production are pure abatement subsidies. Such a program would probably not be very cost-effective and might or might not produce significant environmental gains" (p1215).

Helfand, G.E., and House, B.W. (1995). "Regulating Nonpoint Source Pollution Under Heterogeneous Conditions," American Journal of Agricultural Economics, 77(4), 1024-1023.

Estimates the losses due to use of second-best regulatory instruments when pollution sources vary in characteristics, as applied to lettuce production in California's Salinas Valley.

Non-uniform input incentives could achieve a social optimum, but difficult to implement, and must be specific to each site's pollution function. Second-best alternatives: identical input taxes for all sources, identical reductions in inputs contributing to pollution on a percentage basis for all sources, identical taxation of single inputs, or identical restriction on single inputs. Relative efficiency is empirical matter (p3). With fixed output price, social welfare is maximized by max. aggregate profits subject to restrictions imposed by different instruments.

Find that, three of 2nd-best policies (water tax, identical input tax, and uniform reduction in input use) are nearly as efficient as use of individual input taxes. "When the complexity and cost of getting separate instruments 'right' for both inputs and soil types are considered, one of these alternative, uniform measures may be a preferable method of achieving reduced nitrate runoff" (p5).

Randall, A. (2002). "Valuing the Outputs of Multifunctional Agriculture," European Review of Agricultural Economics, 29(3), 289-307.

Overestimation of multi- outputs transfers too much money to farmers and causes overproduction of those outputs, but it also distorts commodity markets (reduce/increase imports/exports, and perhaps depress world prices). "The right green prices…are particular and contextual to an extent that is difficult to comprehend, and must be estimated on a national or continental scale, but implemented farm by farm" (p290). Generally, for green products whose production is complementary to commodity production, green payments will increase domestic production and reduce imports, or, if they are competitive with commodity production (e.g. pollution reducing techniques, or pre-modern technologies), they will reduce production and increase imports (293). "The blunter the green pricing instrument – in the extreme, all farmers would receive identical green payments per hectare or per unit of commodity production – the more the whole enterprise looks like (and probably is) a crude attempt to subsidize domestic farming regardless of the impacts on international trade." (p293)

Includes description of various valuation methods reviewed above.

* Perhaps under current policies, there is an excess supply of conservation in southwestern Iowa, where farmers are low-cost producers of conservation and public expenditures for conservation are targeted to reflect soil characteristics but not demand for conservation services (p302).

2 proposed strategies:

1. CV estimate of holistic WTP as upper bound to sum of all local component values (estimated with decomposition CV procedures) and tested using convergent validity and RP techniques.
2. Contingent choice experiments and RUM w/ CJ analysis, with a large number of respondents addressing only a small sample of array of alternatives, can estimate local virtual prices (p303).

Value of a green output should be f(quality, sub/comp, size/demog characteristics of demanders, other).

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