July 1997 EB 97-10

"Maximizing the Environmental Benefits per Dollar Expended"

An Economic Interpretation and Review of Agricultural Environmental Benefits and Costs

by
Gregory Poe

Department of Agricultural, Resource, and Managerial Economics
College of Agriculture and Life Sciences
Cornell University
Ithaca NY 14853-7801

"Maximizing the Environmental Benefits per Dollar Expended": An Economic Interpretation and Review of Agricultural Environmental Benefits and Costs

Gregory L. Poe[1]

I. Introduction

In a notable departure from previous farm legislation, the 1996 Federal Agricultural Improvement and Reform Act (FAIR - the 1996 Farm Bill) expressed the intent that Conservation Title programs should "maximize the environmental benefits per dollar expended". This new environmental focus is not only a potential harbinger of a philosophical shift in Federal environmental legislation, but has fiscal prominence because Conservation Title expenditures exceed $2 billion annually. Replacing supply control, least-cost, or physical criteria (e.g., acres, tons of erosion) approaches previously employed in Conservation Title programs, it is anticipated that this new emphasis on environmental benefits maximization will lead to a substantial geographical reorientation of acreage enrollment [Ribaudo, 1989; Ribaudo *et al.*, 1994; Heimlich, 1994; Kuch and Ogg, 1996]. As agencies and society move to promulgate and implement rules and practices to meet this mandate, it is critical to establish a common understanding of the meaning and magnitude of agricultural environmental benefits, and to incorporate these concepts and values into program design.

The broad objectives of this paper are to provide an overview of the economic policy foundations underlying the 1996 Farm Bill language and to survey research to date that has

---

[1] Assistant Professor, Department of Agricultural, Resource, and Managerial Economics, Cornell University. Helpful comments, without implication, on earlier drafts of this manuscript by Nelson Bills, Jonell Blakeley, and Duane Chapman, Cornell University are greatly appreciated. Sections of this text previously appeared in the author's paper *ARME E.B. 94-16* entitled "Extra-Market Considerations in Farmland and Agricultural Policy" and presentation "The Social Costs of Agricultural Pollution to the Watershed Community" published in the proceedings of the NRAES-96 conference on *Animal Agriculture and the Environment: Nutrients, Pathogens, and Community Relations*. The interested reader is also referred to a more extensive discussion on agricultural environmental policy options provided in "Extra-Market Values and Conflicting Agricultural Environmental Policies" forthcoming in *Choices*, 1997.

attempted to quantify agricultural environmental benefits. The paper is organized around these two themes. Section II provides a background for non-economists on fundamental concepts in environmental benefit estimation and non-market valuation. In addition to establishing an historical policy and theoretical perspective on such estimates, techniques used to measure these values are briefly introduced and classified. Section III discusses these techniques in greater detail by using examples taken from prior valuation research on agricultural environmental benefits. Reflecting historical emphases in valuation research, this section concentrates on separate expositions of positive (amenity values) and negative (ground and surface waters). The final section assimilates the findings from the previous research and identifies areas for future policy and research. While the text tries to provide an introductory overview of basic principles and central citations, selected suggestions for advanced readings on valuation theory and methods are provided throughout.

Importantly this paper both follows and challenges the mainstream of non-market valuation research and policy in this area. Most of the presentation remains within the dominant agricultural environmental policy and research paradigm by maintaining a separation between the positive and negative externalities of agriculture. Yet, it is argued in the final section that such a unilateral approach is artificial and inappropriate if the goals of such policy are truly to maximize the environmental benefits of agricultural land use. Both policy and research need to be redesigned to address this issue.

II. Economic and Policy Concepts

In order to understand the reasons that economists seek to quantify, in monetary terms, the benefits and costs of policies and government actions, and argue for public sector intervention in environmental issues, it is helpful to have some background in welfare economics and the notion of market failure. As a first step, one should distinguish welfare economics from welfare programs that focus on public relief programs. Welfare economics is a branch of economics oriented toward evaluating policies and actions under the assumption that the goal of society is to maximize the total well-being that society derives from goods and services which people produce and consume, including those provided by natural resources and environmental quality. Alternatively stated, it is assumed that society's objectives should be to attain the highest good for the greatest number of people. Using this criterion, welfare economists compare alternative policies or states of the world, typically using the present situation as a reference point. For example, a welfare economist might ask if the welfare of society would be improved by imposing agricultural environmental best management practices on dairy farms in New York, compared with the current status of manure management[2]. But, ". . . at this point, a fundamental question arises: How can the well-being of a whole society, say the citizens of New York, be conceptualized? How is society's welfare to be defined?" [Bishop, 1987, 24].[3]

To create a conceptual framework for making such evaluations, economists have relied on two basic value judgements. First, individuals are the sole judges of their own well being -- i.e, I can

---

[2] This is not a simple hypothetical policy issue. As discussed in a recent article by R. T. McGuire [1993], the former New York State Commissioner of Agriculture and Markets, this is a multimillion, indeed multibillion, policy question for New York City and other watersheds because of filtration avoidance criteria imposed by the 1986 amendments to the Safe Drinking Water Act. The 1990 Coastal Zone Act Reauthorization Amendments have the potential to regulate over two-thirds of farmland in New York State [Poe, 1995] and impose substantial costs on certain farms [Heimlich and Bernard, 1995].

[3] The presentation in this and the following paragraphs builds upon the initial structure developed by Bishop [1987] in an excellent expository paper "Economic Values Defined".

determine whether a particular change makes me better or worse off, while you can best assess whether it is good or bad for you. Yet, under this assumption, neither of us is entitled to judge whether a particular change increases or worsens the other's well-being. Second, social welfare should be somehow defined in terms of the aggregated welfare of individuals.

A logical extension of these value judgements is the so-called *Pareto Criterion*, named for a philosopher who first formalized these concepts at the turn of the century [Pareto, 1909; Little, 1950]. This criterion states that society should adopt only *Pareto Improving* projects or policies that make at least one person better off and no one worse off, and a *Pareto Efficient* situation is said to exist when no one can be made better off without making at least one person worse off. Continuing with the manure management example, the Pareto Criterion would say that social welfare will increase with the manure management regulations only if it makes water consumers and/or non-farm neighbors better off while making none of the affected farmers worse off.

Few would debate the desirability of policies that meet the Pareto Criterion -- How could we complain about making someone better off without harming anyone? Yet, reliance on this principle as the basis for public decision making is impractical and would lead to social paralysis. By their very nature, real world policy decisions involve tradeoffs between people or groups, implying that policy decisions must result in some winners and some losers. In our example, if one farmer is made worse off then the project should not be adopted under the Pareto Criterion. Adopting a more pragmatic stance, applied welfare economics has modified the Pareto Criterion in the form of the compensation test. This test states that a policy is socially beneficial if the winners from the action (i.e., the people who feel that they would be made better off with the policy in place) could, in principle, fully compensate the losers (i.e., the people who feel that they would be made worse off) and still be better off. With respect to manure management regulations, the compensation test would require that the people who benefit from improved ground and surface water quality be able to compensate the farmers for their lost profits (and other non-pecuniary inconveniences), and still feel better off after having paid the compensation.

It is this test, as well as the need to express disparate inputs and outcomes in a common metric, that provides the motivation for assigning monetary values to benefits and costs. On one hand, we need to measure the maximum willingness to pay for the policy change -- i.e., the economic benefits of the proposal. We also need to compare this with costs of the policy change or the minimum amount required to fully compensate losers. Of course, this approach is based on ethical premises that have obvious problems and very few economists would claim that the compensation test should serve as the sole criterion for social decision making[4]. A critical limitation is that the compensation test is a purely hypothetical exercise wherein the "in principle" clause is of fundamental importance -- actual compensation is typically not paid[5]. Thus, there will be some winners and some losers under any policy choice even when the compensation test is passed. As such, the test ignores equity issues; it focuses only on maximizing the size of the economic pie rather than investigating how the pie is divided. It also does not account for the rights of future generations and non-human species. At an equally fundamental level, there is a question of the ethos of trading off environmental quality for income as implied by the compensation test. Yet, in spite of these ethical limitations, the compensation test should be regarded as one of possibly several fundamental

---

[4] Indeed, a subset of economists decry the use of benefit-cost analysis as the basis for making policy decisions. See, for example, the article by Vatn and Bromley, 1994.

[5] Because actual compensation is not required, this test is also referred to as the potential Pareto improvement criterion. Historically, these concepts stem from seminal contributions by Kaldor [1939] and Hicks [1939] and have thus also been called the Kaldor-Hicks criterion.

criteria for policy decisions. All we "economists are saying is that society may want to think twice about doing things when those who would be made better off could not fully compensate those who would be harmed . . . in cases that fail the compensation test, would it not make sense to clearly and objectively consider reasons for going ahead?" [Bishop, 1987, p. 26.]

It is important to note at this point that such comparisons are not isolated academic musing, but instead have long been an essential component of Federal policy making. Whereas the theoretical foundations of welfare economics trace their origins to Dupuit's [1844] classic demonstration that the total social value of a bridge exceeds the tolls paid, contemporary applications and theoretical developments find their impetus in a few key lines in the Flood Control Act of 1936 [Dorfman, 1976]:

> ...the Federal Government should improve or participate in the improvement of navigable waters or their tributaries, including watersheds therefore, for flood control purposes *if the benefits to whomsoever they may accrue* are in excess of the estimated costs . . ., (emphasis added)

In subsequent years, the scope of "benefits to whomsoever they may accrue" has been clarified and extended beyond flood control issues and actual expenditures in a series of Federal statutes (e.g., the 1950 "Green Book" by the Federal Inter-Agency River Basin Committee), Executive Orders (e.g., Reagan's 1981 E.O. 12291), and legal rulings (e.g., the 1989 *State of Ohio v. United States Department of Interior* ruling).[6] Importantly, in contrast to the original Flood Control Act focus on use value, both theory and policy now recognize the need to incorporate non-use values such as option values (I <u>may</u> use the resource in the future) as well as existence (I want to protect a resource regardless of whether it is used), altruistic (I want the resource to provide benefit to others), and

---

[6] Hanemann [1992] provides an informative overview of the evolution and broadening of environmental benefit-cost theory and policy.

bequest (I want the resource to be available to future generations) motives.

Interestingly, as a digression, major water quality acts such as the Clean Water Act and the Safe Drinking Water Act have prohibited trade-offs or comparisons between economic costs and health or other benefits, providing some of the fodder for renewed Congressional interest in benefit-cost analysis requirements for major guidances and regulations [Portney, 1995]. Senator Muskie's impassioned response in leading the fight to override President Nixon's benefit-cost motivated veto of the Clean Water Act demonstrates the type of argument used against applying benefit-cost analyses to environmental legislation [Adler *et al.*, 1993, p. 2];"

> Can we afford clean water? Can we afford rivers and lakes and streams and oceans which continue to make life possible on this planet? Can we afford life itself? Those questions were never asked as we destroyed the waters of our Nation, and they deserve no answers as we finally move to restore and renew them. These questions answer themselves. And those who say that raising the amounts of money called for in this legislation may require higher taxes, or that spending this money may contribute to inflation simply do not understand . . . this crisis.

Presently, however, there is a felt need among policy makers to "rationalize" environmental policy decision, and calls that policies adhere to fundamental precepts of benefit-cost analysis are heard across the political spectrum. In proclaiming a regulatory philosophy, President Clinton's 1993 Executive Order 12866 states that agencies should adopt regulations "only upon a reasoned determination that the benefits of the intended regulation justify the costs." Legislation passed by the "Contract with America" dominated 104th Congress similarly maintained that no regulation shall be promulgated unless "the incremental risk reduction or other benefits of any strategy chosen will be likely to justify and be reasonably related to, the incremental costs incurred by . . . public and private entities" [H.R. 9, Sec. 422], or alternatively, that the "guidance maximizes net benefits to society" [H.R. 961, Sec. 324][7]. The Conservation Title language of the 1996 Farm Bill corresponds with these principles as demonstrated by the legislative intent that Conservation Title programs "maximize the environmental benefits per dollar expended".

But how do we estimate these values? Economists have long relied on market prices as a signal of economic values and a basis for determining social benefits and costs. The rationale supporting this approach is that market exchanges involve voluntary transactions in which participants are concerned with their own best interests. In choosing whether or not to purchase a parcel of land, for example, I implicitly weigh the value of that land against the value of all the other goods that I must give up to purchase it. Thus, in making such a market decision, I am said to reveal my preferences. If I decide to purchase the land at a given price, then the value I place on that land is greater than the opportunity costs, measured in dollars, of all other goods that I have to give up to buy the parcel. In contrast, the relative value of the land and the other goods is reversed if I decide not to buy it. At some intermediate price level I will be indifferent between purchasing the land and not purchasing the land. This price is said to be my maximum willingness to pay for the land. When aggregated across all other possible land purchasers and different quantities/qualities of land to provide a demand function, such values are the most appropriate value for compensation tests involving policies that affect goods traded in markets.

However many "public" goods, such as environmental quality and open space amenities, are

[7]There is a subtle welfare economic difference in meaning between Clinton's and Congress's statements. Clinton's Executive Order follows Reagan's previous order in proclaiming that major regulations should simply pass a benefit-cost test. The wording of the Congressional statement instead goes a bit further by suggesting the environmental policies be designed at "optimal" levels in which the net societal benefits are maximized. Using the terminology in the text, Clinton is promoting a Pareto Improving approach, while Congress is apparently striving for Pareto Efficiency. This distinction is moot, however, as the bills mentioned here were passed by Congress, but never enacted.

not traded in markets and thus do not have a price to serve as a benchmark for valuation -- an instance of what economists call market failure. This does not mean that such goods have no value, it merely indicates that markets cannot be relied upon to send signals reflecting the scarcities of, and preferences for, these commodities. Since markets fail to reflect price signals about the relative scarcities of certain goods, it follows that, in the absence of alternative institutional arrangements to allocate resources, the allocation of these goods will likely deviate from the optimal allocation if all preferences and values were considered. That is, the allocation will be inefficient. In cases where positive values are unaccounted for, the environmental commodity will likely be underallocated relative to the social optimum.

For example, as Ready [1993] notes, a scenic "pastoral" view along a country road is said to have some value if it brings pleasure to someone driving down the road. Although markets do not presently exist for such items (with the exception of park entrance fees), the concept of opportunity cost, indifference, and maximum willingness to pay are equally relevant in this instance. The difference between the privately purchased land parcel (private good) and the pastoral view (public good) is that the driver has probably never had to compare his or her personal value with a market price, since he/she does not have to pay for it directly. Moreover, in contrast to purchasing a private good, which entitles exclusive use (other people can't use it without my permission) and which is characterized by rivalness (your consumption detracts from my benefits), one viewer's consumption of the pastoral view does not take away any value from subsequent viewers, at least to the point where congestion becomes an issue. Thus many individuals may jointly receive value from one scenic view. As such, the sum of maximum willingness to pay across individuals for preserving this setting is the appropriate benefit measure in welfare analyses of public goods. If, in the aggregate, these benefits are large, then private land markets that fail to account for these values will tend to underallocate land to agriculture [Lopez *et al.*, 1994].

A similar logic and possible source of inefficiency extends to public disamenities or damages such as water contamination. In many instances, people would be willing to give up scarce resources in order to protect themselves from actual or perceived harm. For such situations the damages of contamination, or conversely the benefits of protection, can be measured by the maximum willingness to pay for a program that protects groundwater from contamination. If these benefits are large relative to the costs of controlling the polluting activities, then public sector intervention may be desirable.

In a long evolution and expansion of theory [Dupuit, 1844; Kaldor, 1939; Hicks, 1939; Hotelling, 1939; Samuelson, 1954; Weisbrod, 1964; Krutilla, 1967; Bradford, 1970], economists have developed the concepts of individual and aggregate willingness to pay for environmental goods and bads by utilizing the concept of indifference between policy options and the present state. Conceptually, my maximium willingness to pay is the amount of money that would make me just as well off with the project (and the payment) as without the project. In other words, the payment is the amount of money that just makes me indifferent between policy options. In the last few decades economists have developed techniques that try to measure these extra-market willingness-to-pay values (see Hanemann, 1992; Mitchell and Carson, 1989a; Freeman, 1993 for reviews). Although relatively new, these valuation techniques are accepted for use by many U.S. agencies including the EPA, various agencies within the Department of Interior, and resource oriented agencies within the USDA. Such techniques are also accepted for use in environmental damage litigation [Kopp and Smith, 1993] and can be divided into "indirect" measures based on market transactions as well as "direct" measures of willingness to pay based on survey methods. For the most part, economists tend to be more comfortable with indirect measures, such as travel costs for recreational goods or property value shifts for environmental goods and bads, because they rely on revealed preferences as expressed in voluntary market transactions. Thus, my decision to expend my money and time on a salmon fishing trip is said to provide an indicator of my worth for that resource. Similarly, decisions about housing purchases and acceptable prices may reflect underlying environmental quality. Yet, as will be discussed, such measures exclude some value components. As a result, there is an increasing interest and reliance (as well as controversy) on survey methodologies, such as contingent valuation, for directly measuring values. The remainder of this paper introduces these techniques through a summary of applications to the extra-market benefits and costs of agriculture.

III. Review of Agricultural Environmental Valuation Research

III.a. The Amenity Benefits of Agricultural Lands

In recent decades there has been widespread legislative effort at local and state levels to directly preserve farmland from conversion to urban and other non-farm uses, and to indirectly protect agricultural land by reducing agriculture's exposure to "unreasonable" regulations and lawsuits associated with residential intrusion into agricultural areas. All 50 states, and a myriad of local entities, have adopted some form of "right to farm" legislation [Bills, 1993] and preferential use-value assessment programs to reduce farmland property tax burdens [Wunderlich, 1997], while others utilize a circuit breaker taxation approach that offsets state income taxes if the property tax bill exceeds a certain proportion of taxable household income [Barrows, 1986]; several states have authorized the adoption of local zoning ordinances that restrict land use to agriculture [Rose, 1984], and still others have established purchase of development rights (PDR) programs to compensate farmers for unrealized financial gains that could have been obtained by converting land to non-agricultural uses [Buist *et al.*, 1995]. In many areas, this blend of public protection policies has been supplanted by substantial private efforts to purchase development rights [Weibe *et al.*, 1996].

While the motivations for establishing farmland protection programs differ across programs [Gardner, 1977; Rose, 1984; Furuseth, 1987; Kline and Wilchens, 1994], Gardner effectively argues that market failure, and hence a justification for public intervention, is only found in the case of environmental and open-space considerations. All other motivations such as food sufficiency, rural viability, maintaining the farming way of life and other "nostalgic" or "agrarian" motivations are primarily associated with equity concerns, and, as such, do not correspond to standard economic justifications for public intervention.

In spite of Gardner's off-cited objections, there is substantial public intervention, and substantial public and private monies are being devoted to farmland protection, apparently for motivations including and beyond providing environmental amenities. For example, cumulative expenditures for state and local PDR programs in 14 states have exceeded $644 million through 1994, while contributions to American Farmland Trust approach $4 million per annum [American Farmland Trust, 1996]. Tax shifts from exempt to non-exempt parcels associated with agricultural use-value assessments exceed $40 million per annum in New York alone [NYSDAM, 1996], while the Conservation Title of the 1996 FAIR promises $35 million to be invested in the purchase of development rights over a seven-year period. In the aggregate, the combined public and private expenditures for the purposes of preserving agricultural land are not inconsequential. However, one must be cautious about interpreting revealed government preferences and expenditures as a measure of societal willingness to pay. Frequently this level of expenditures is determined by legislatures, begging the question of how effectively political decision making reflects the preferences of individuals in society. Even when direct referenda are used, as in bond referenda in Massachusetts, New Jersey, Pennsylvania, and other states [Kline and Wilchens, 1996], the conditions for voting models to optimally allocate resources, and truly represent social willingness to pay, are quite stringent and unlikely to be met in most instances [Stiglitz, 1988]. Similarly, voluntary contributions, such as donations to land trusts, are not expected to reveal willingness to pay for farmland protection [Boadway and Wildasen, 1984].

Instead, economists have turned to the "non-market" contingent valuation technique in order to directly estimate the value of amenity benefits. The contingent valuation method uses in-person, mail, or phone surveys to ask about the values people would place on specified improvements in environmental commodities if ideal markets did exist or other means of payment were in effect. Initially suggested by Ciriacy-Wantrup in 1947, it is only in the last two decades that this technique has been widely used by resource economists. As of 1995, over 2,000 studies had been reported [Carson, *et al.* 1995]. In spite of its widespread use, much concern has been raised recently about the validity of contingent valuation, especially in the wake of applications of, and subsequent attacks on, this technique to the Exxon Valdez oil spill [Harvard Law Review, 1992; Hausman, 1993]. On one hand, a number of validity studies comparing contingent values to actual market transactions demonstrate that, if the study is well done and addresses a familiar commodity, the contingent valuation technique can provide reasonable estimates of actual values for public goods [Bishop and Heberlein, 1990; Hanemann, 1994], although there is some concern even among supporters that such validity does not hold for goods with large non-use components [Brown *et al.*, 1996]. On the other hand, detractors have argued that these hypothetical questions provide hypothetical values, which are too biased and unreliable to make critical environmental decisions which may have billion dollar consequences [Desvousges *et al.*, 1993; Diamond and Hausman, 1994]. The controversial nature of this technique led the National Oceanographic and Atmospheric Administration (NOAA) to organize a "blue ribbon panel", consisting of two Nobel laureates in economics and other eminent scholars, to consider whether this technique is an appropriate method for determining lost passive use values associated with oil spills. Although concern was raised about certain aspects of this approach, this panel concluded that contingent valuation studies "convey useful information . . . [and] can produce estimates reliable enough to be the starting point of a judicial process" [Arrow *et al.*, 1993, p. 4610].[8] The findings of this panel are widely used by Federal and State agencies whose scope does not include oil-related issues.

With respect to the contingent valuation applications to agricultural lands, willingness-to-pay values have been elicited for protecting farmland from further urban encroachment or development. A summary of the farmland amenity value contingent valuation studies that have been conducted in the United States is provided in Table 1. Comparisons across studies demonstrate a wide variation in estimated annual household willingness to pay, ranging from $7 to $252. Explanatory variables included in individual studies, as well as comparisons of average values reported across studies, suggest that several factors have been found to affect willingness-to-pay estimates and offer insight

[8] For a discussion and criticism of the contingent valuation technique, the reader is referred to symposia in *Choices* [1993, Second Quarter] and in the *Journal of Economic Perspectives* [Fall, 1994]. Mitchell and Carson [1989a] provide an excellent, albeit somewhat dated, overview of this technique, and Bjornstrad and Kahn, 1996, provide a fairly current perspective on methodological issues and research needs.

to the source of this dispersion in values. Notably, willingness to pay rises with the ratio of urban to agricultural land in the region and the degree of perceived threat to agricultural lands, a factor that partly accounts for the disparity in values found between the estimated values in South Carolina and Massachusetts. For example, in discussing the low estimates found in their study of agricultural lands in South Carolina, Bergstrom *et al.*, [1985] note that the study area is "located in a predominantly rural area: alternative supplies of agricultural land are not difficult to find" (p. 146). All studies demonstrated "scope", a concern raised about contingent valuation [Arrow *et al.*, 1993], in that agricultural programs that protected more farms or acres were valued equally or more highly than programs that protected less farmland. Standard explanatory variables in estimating willingness-to-pay functions generally demonstrated the expected sign (e.g., income and education were non-negative) and reasonable orders of magnitude.

Researchers also note that quality/quantity issues may be important determinants in estimated willingness-to-pay values. That is, the type of agriculture being protected is at least as important as the amount of land or number of farms being protected. For instance, Ready [1993] argues that estimates of average willingness to pay for protecting horse farms in Kentucky are higher than those found in other farmland protection studies because Kentuckians have a particular affinity for horse farming. Similar arguments might be associated with nostalgic or scenic motivations attributed to smaller farm operations, and an aversion to farms that produce unsightly or odorous outputs. A second quality issue raised in these studies is the fact that it is not clear whether these willingness-to-pay values are for farmland preservation *per se*, or if the values are motivated by a broader need for open space. While in some areas farmland and open space preservation are synonymous, in other areas a conflict between the two land uses may arise. Obviously such research suffers from a lack of product differentiation, and both these limitations should be taken into account when considering policies that will affect the total land in farming as well as the composition of the farm sector.

It should be noted that other non-market valuation techniques are available, but have not yet been used, for estimating components of societal values attributed to preserving farmland. For example, in areas in which tourism is motivated, in part, by open-space environmental amenities or nostalgic preferences associated with agriculture (e.g., Pennsylvania Dutch Country or Vermont), recreational trip expenditures might be used as a proxy for estimating consumer willingness to pay. As noted previously, this so-called travel cost method has some appeal, because it relies on actual, rather than hypothetical, decisions made in related markets[9]. Another related markets approach, called hedonic pricing or property values, might be to look at how property prices vary with proximity to agricultural lands[10]. If proximity to agricultural land is a desirable component of a house, then housing markets should reflect this characteristic: in the sense that, after accounting for other features, homes that are closer to agricultural areas should be valued more highly than homes that are more distant. To a certain extent the reverse has been found in selected research, suggesting that proximity to agriculture (or at least certain types of agriculture) may reduce housing values and cause economic losses. For example, Palmquist *et al.* [1997] found a statistically significant reduction in housing prices associated with the proximity and the number of hogs in rural North

---

[9] The travel cost model was originally suggested by H. Hotelling in a letter to the National Park service in 1947. Rudimentary introductions to this method are found in Anderson and Bishop [1986] with greater detail provided in Bockstael [1995].

[10] Although the concept of measuring the value of components in differentiated consumer products traces back to Court [1941], Ridker [1967] is generally recognized as the first economist to use residential property values as the basis for estimating the benefits of changes in measure of environmental quality, such as air pollution. See Freeman [1993] for a theoretical and historical overview.

Carolina. Abeles-Allison and Connor [1990] report similar results for residential land near Michigan hog operations.

In all, while there is a strong indication that amenity benefits may be substantial, there is still much research left to be conducted in the measurement of these values in order to disentangle the motivations for valuing farmland preservation. As society's needs and the composition of agriculture change, then so must perceptions of the desirable quantity and type of agriculture. Socio-economic research efforts need to be directed toward establishing a better understanding of society's evolving preferences about agriculture and agricultural land use, and toward identifying the value of the different components of farmland and agriculture[11]. From a policy perspective, an equally important issue at the local level is to compare these perceived benefits of protecting agricultural land with the perceived costs of certain agricultural practices discussed below.

III.b. The Costs of Groundwater Contamination

Agricultural contamination of groundwater is the dominant agricultural environmental policy issue in many areas. Nationwide, the Environmental Protection Agency has detected the presence of 74 pesticides in groundwater in 38 states [USEPA, 1988], and a 1990 United States Department of Agriculture study projected that as many as 53.8 million people could be negatively affected by agricultural contamination of groundwater [Lee and Nielsen, 1987; Nielsen and Lee, 1987]. More

[11] One promising valuation approach in this direction is conjoint analysis which is a variant of the contingent valuation approach which allows the investigator to infer implicit prices based on choices made from a designated set of multi attribute alternatives [Louviere, 1988]. Value for the different attributes can be derived from choices or rankings if one of the attributes varied is the price of the commodity [Roe *et al.*, 1996; Mackenzie, 1993]. Farmland valuation research using this technique is currently underway in Delaware [Mackenzie, 1996], with similar research being conducted in Europe [Bergland, 1997; Hanley *et al.*, 1997].

recent analyses suggest that the actual, as opposed to the potential, exposure is likely to be less extensive [e.g., Kellogg *et al.*, 1992]. But it should be noted that nitrates and agricultural pesticides remain leading sources of public and private supplies [USEPA, 1994], that violations of nitrate health standards in residential wells are substantially higher in agricultural than non-agricultural areas [Mueller *et al.*, 1995, Nolan and Ruddy, 1996], that nitrate levels in groundwater respond to changes in fertilizer use [Mueller and Helsel, 1996] particularly in areas with well drained soils [Nolan and Ruddy, 1996], and that evidence suggests that nitrate levels in wells are continuing to rise in agricultural areas [Mueller and Helsel, 1996].

In fact, and in public perception, it is clear that agricultural contamination of groundwater is no longer simply a problem of farmers polluting their own wells. Public opinion polls have long demonstrated that people perceive agricultural practices as a problem affecting their well being. For example, a poll in Iowa found that 52 percent of those surveyed identified farm chemicals as the major threat to drinking water, and 78 percent favored limiting the amount of fertilizers, herbicides, and insecticides that farmers could use even if such action resulted in reduced agricultural production [Batie, 1988].

The costs of groundwater contamination have not been adequately addressed at the regional or national level, and have not been traced back to practices on individual farms. However, there are some strong indications that economic damages associated with degradation in groundwater quality are being incurred because of agricultural practices. In some areas of the United States, public wells have been closed because of nitrate and pesticide contamination, neighbors are suing farmers for contaminating the groundwater, cities and towns are annexing lands to protect their well heads, households with contamination are investing in water purification systems, and banks are requiring safe drinking water tests for nitrates. All these actions serve as indicators that society is willing to give up scarce resources to protect its drinking water from agricultural contamination. In other words, there are economic costs associated with groundwater contamination.

Over the years, economists have applied various techniques to estimate the magnitude of these damages in dollar terms. One approach has been to use averting costs as a proxy for damages. For example, how much would a household have to pay to clean its water if it were determined to be contaminated? Using these techniques, studies suggest that the damages associated with removing nitrates and pesticides from water may exceed several hundreds of dollars per year depending on the option selected and the number of people in the household [Lee and Nielsen, 1987]. For example, Table 2 provides estimates of some of these costs for households in Northern New York. In examining water related health risks, Raucher [1983, 1986] correctly argues that water treatment costs do not, however, adequately reflect maximum willingness to pay for water quality[12]. Damages avoided should include costs of illness avoided. Harrington *et al.,* [1991] provide evidence suggesting that these costs (lost wages, doctor bills etc.), when aggregated across an affected population may be much larger than water treatment costs. An analysis by Abdalla *et al.*, [1992]. further indicates that studies which quantify actual treatment costs undertaken as a proxy for willingness to pay may further understate the true level of damages if there is a low awareness of contamination and thus a low level of adopting averting behavior.

A second possible approach to valuing the cost of groundwater contamination would be to

---

[12] The literature cited here focuses specifically on groundwater quality. This represents only a portion of the substantial literature on the relationship between averting costs, damages avoided, and "true" willingness to pay. Major papers in this area include Courant and Porter [1981], Harrington and Portney [1987], Bartik [1988], Berger *et al.* [1987], Shogren and Crocker [1991], and Quiggen [1992]. Tolley *et al.* [1994] provides a good literature review and starting point for this topic.

examine the effects on private property values, under the assumption that homeowners are willing to accept a lower price when selling their homes in order to avoid the risk of drinking contaminated water and that buyers similarly prefer houses without contamination. From an economic perspective the reduction in property value would be approximately equal to the amount that a household would be willing to pay to avoid such exposure[13]. Whereas some studies have found that residential values are reduced if a site is near a sanitary landfill, a hazardous waste site, or hog farms [e.g., McClelland *et al.,* 1990; Reichart *et al.*, 1992, Palmquist *et al.*, 1997], other research that has focused on the relationship between actual contamination levels and the value of residential properties has found little or no effect of contamination on property values [Page and Rabinowitz, 1993; Malone and Barrows, 1990]. These latter studies note, however, that the lack of a statistically significant relationship between contamination and property values may be attributed to other factors in the study design, location, and analysis.

In addition to the limitations or biases associated with empirical estimates of the avoided costs and the property value approaches, it is likely that the costs of groundwater contamination exceed estimated costs that are based on averting expenditures or changes in property values. Recall that from an economic perspective the benefits of a project that reduces groundwater contamination are equal to the maximum amount that individuals would be willing to pay in order to experience that reduction. With respect to averting expenditures, bottled or treated water may not be perceived as a perfect substitute for pure unpolluted water, and individuals may be willing to pay much more for groundwater protection than they would be for groundwater treatment [Blomquist *et al.*, 1997]. Averting expenditures and property value reductions might also underestimate true willingness to

[13] As noted in the previous section, this property value, or hedonic, method is detailed in Freeman [1993].

pay for groundwater protection because individuals may also value groundwater protection for stewardship, altruistic, or bequest motivations [O'Neil and Raucher, 1990]. Such motives have been demonstrated for groundwater protection [Mitchell and Carson, 1989b] and exert a substantial effect on willingness to pay [Edwards, 1988]. In addition to these non-use motivations, households may be worried about their exposure levels outside the home, such as at school, at work, at restaurants, or at a neighbor's home, which would further drive a wedge between household averting costs and true willingness to pay.

Recognizing these limitations, several contingent valuation studies have been conducted to try to estimate the total value of groundwater contamination (or conversely the benefits of protection). Results from these studies indicate that the average annual willingness to pay for protection of groundwater from contaminants may be in the one to several hundred dollar range. Agriculturally related water contamination studies which reported willingness-to-pay values for protecting groundwater contamination levels from exceeding government standards are presented in the top portion of Table 3[14]. In addition to the average values reported, a statistical "meta" analysis across the willingness-to-pay values reported in these studies determined that willingness to pay is positively correlated with exposure risks: households with high levels of exposure were willing to pay much more for protection than households with low levels of exposure [Boyle *et al.*, 1994]. Again, this raises the point observed in amenity valuation that the perceived benefits of alternative policies will vary across sites and communities, depending on the existing level of

[14] The data in this table represent a subset of groundwater quality contingent valuation studies reported in the U.S. but are not provided here because either they did not focus on the safety threshold, e.g., Zoysa [1995] or were not directly associated with agricultural contamination [Edwards, 1988; Shultz and Lindsay, 1990; Caudill, 1992; Jordan and El Nagheeb, 1993; McClelland *et al.*, 1992; and Barrett, *et al.*, 1996].

contamination. Estimated values in these studies were also affected, in expected directions, by survey design characteristics (e.g., elicitation method, information provided) and socio-economic attributes (e.g., income, price of substitutes).

In comparing the values associated with contamination to the benefits of agriculture, Poe and Bishop [1992] estimated that the damages associated with groundwater contamination from nitrates corresponded to less than 7 percent of the net returns to farming in the county. In another comparison, Smith [1992] estimated that the value of the crops produced was about 16 times the costs associated with groundwater contamination from agricultural practices in states that had counties with potential agricultural contamination. Whether these costs seem large or small is a matter of personal perspective.

Moreover, it may be that such broad comparisons are largely irrelevant for the compensation test criteria. Instead, from a policy perspective, it would be more appropriate to compare incremental benefits and costs associated with alternative agricultural practices [Burrows, 1995; Conrad and Olsen, 1992]. In some instances small changes in practices might lead to substantial reductions in contamination, and hence have very high benefit to cost ratios. In others, very costly changes in practices might result in fairly low benefits. Towards this goal, two contingent valuation studies have provided estimates on one unit changes in exposure levels, which would enable a comparison of incremental benefits and costs[15]. These studies are depicted in the lower part of Table 3. Unfortunately, as noted previously, economists, hydrologists, and agronomists have not yet linked

[15] The value reported from the Poe and Bishop study [1994] is the maximum willingness-to-pay value associated with the steepest part of the total damages curve, which occurred in the area where the exposure reductions would cross a government safety limit of 10 mg/l. That is, as expected from economic theory with substitution alternatives, the total damage function is a non-linear sigmoid shape that is initially convex but reaches a plateau. Marginal damages approach zero at both low and high levels of exposure.

the values associated with groundwater contamination back to the farm level, and thus such a comparison remains an important area of future research.

III.c. The Costs of Soil Erosion

Soil erosion has on-site and off-site costs; both of which are generally not accounted for in the market. On-site costs of erosion are primarily associated with the long-term impact of soil loss on productivity potential. Excessive erosion diminishes this potential by reducing nutrient supply, water infiltration, and soil water holding capacity, which have economic consequences in terms of lost productivity.

Conceptually, erosion related reductions in land productivity will have a negative impact on land values (e.g., McConnell, 1983; Saliba and Bromley, 1986). However, this finding has not been universally supported in land valuation studies. Some empirical investigations have concluded that reductions in soil depth and/or potential erosivity are associated with lower land values (e.g., Palmquist and Danielson, 1989; Miranowski and Hammes, 1985). Other research indicates that there is a market failure, in that conservation investments and reduced erosion are not capitalized into land values (e.g., Ervin and Mill, 1985; Gardner and Barrows, 1985). Given the evidence that on-site costs are not universally apparent in markets, direct measures of soil loss productivity have been used to quantify the economic consequences of erosion. One method of evaluating productivity losses is to estimate soil depth and yield relations for individual soils. These "microstudies" compare the yields on land that has had varying levels of topsoil removed with the yields on undisturbed land of the same soil type. Aggregating the results from a number of soil loss microstudies, Lyles [1975] arrived at an average linear yield reduction per inch of top soil lost equal to 6.3 percent (s.d.

= 1.3 percent). In a separate review, Langdale and Schrader [1982] found a much wider variation in observed yield loss: ranging from over 6 percent per inch of soil lost in one study to no observed effect when 10 inches of top soil were removed in another study. The principal conclusion to be drawn from these microstudies is that productivity losses from erosion are site and soil specific.

An alternative approach of estimating the impacts of soil loss on crop productivity focuses on the average impacts of cropland erosion at a regional or national level. These "macrostudies" are generally reported in terms of percentage reductions in potential productivity per period of time for an entire region. Using this approach, the USDA estimated that productivity losses associated with 1977 erosion rates were approximately 8 percent over 50 years [USDA, 1981]; a University of Minnesota model estimated that the average change in productivity for each of the Major Land Resource Areas in the Corn Belt ranged from 1.0 to 4.9 percent over 50 years [Pierce *et al.*, 1984]; and a Resources for the Future study estimated that 1980 corn and soybean production was 2-3 percent lower than it would have been without erosion in the period from 1950-1980 [Crosson and Stout, 1983].

Off-site costs of soil erosion and erosion related pollutants are incurred by the public and can be separated into in-stream damages (biological impacts, recreational impacts, water storage damage, navigation, and other "preservation values") and off-stream effects (flood damage, sediments in water conveyance, water treatment). Statistics compiled by the Environmental Protection Agency indicate that agricultural erosion and runoff are leading causes of surface water impairment and that agricultural nonpoint source pollution is the largest remaining water quality problem in the United States: individual states attribute 41 percent of their nonpoint source pollution problems to agriculture, and 60 percent of the nation's impaired river miles are impacted by agricultural runoff and erosion [USEPA, 1994].

In a series of papers, Clark, Ribaudo, and co-authors [1985, 1989, 1994] have sought to combine secondary data from defensive expenditure studies, incremental cost of production studies, travel cost, and other recreational studies to provide an estimate of off-site costs associated with erosion. As Table 4 suggests, the estimated average off-site costs per ton of soil erosion are substantial and are not uniform across the country. The wide deviations in these estimated costs across cropping regions are primarily attributed to regional differences in the demand for surface water. For example, with high population concentrations and high demands for in-stream and withdrawal uses of water, the Northeast has relatively high off-site damages per ton of soil eroded. In contrast, although the aggregate levels of soil erosion are much higher in the Northern Plains and the Mountain States, the average damages per ton are much lower due to lower demands for surface water. This finding is important. It demonstrates that, at a national level the value of a ton of soil loss is not a constant because different populations with different uses of the resource are affected. What is evident at the national level is also likely to occur within states, watersheds, and even sub-watersheds. Importantly, these site-specific results hold for all other extra-market benefits and costs.

In general, off-site costs of agricultural erosion exceed the on-site costs of erosion by a factor of 2 to 8. For example, Crosson and Stout [1983] estimate that the national on-site costs of agricultural soil erosion to be $600 to $800 million annually. For comparison, Clark [1985] estimates that the national off-site costs of agricultural erosion are at least $2.2 billion annually.

This widely used relationship between on- and off-site costs of erosion is, however, challenged by a Pimentel *et al.* [1995] study which argues that national costs greatly exceed those discussed above: i.e., national annual on-site costs are $27 billion while off-site costs are $17 billion.

This translates into an average cost per acre of $79. The aggregated costs are at least an order of magnitude higher than those cited previously, and, quite notably, result in an inversion of the ratio between on and off-site costs. Differences in the estimates between this and previous research may be attributed, in part, to alternative approaches to estimating losses. For example, the on-site losses in Pimentel *et al.* [1995] are based on the asset replacement approach increasingly being promoted by proponents of Natural Resource Accounting (e.g., Repetto, 1994). In this approach values of complete replacement of nutrients and soil water associated with erosion are used instead of observed or modeled losses in productivity. The off-site costs also include wind erosion and health effects. While these new estimates raise concerns that current cost estimates used in evaluating government programs may underestimate the true costs, substantive criticism about assumptions and methods used in this study, and related studies, have been raised [Crosson, 1995; National Research Council, 1989]. It is also important to note that such an approach deviates from the conventional economics approach based on preferences and maximum willingness to pay.

Taking data from Ribaudo's [1989] research, Table 5 translates on-site and off-site estimates of costs to the farm level for soil conditions and three different crop rotations that might be found in Southwestern Wisconsin. Using continuous corn as an example, a farm with 200 acres of cropland eroding at 7.9 tons per acre could result in $6,372 in on and off-site costs per year. From the perspective of the compensation test, the important question in examining these costs is, Do they matter? In other words, would farm production decisions change if farmers took these costs into account. The answer depends on many factors.

For example, in comparing costs taken from Ribaudo [1989] with the profitability of alternative rotations on an individual farm basis, Poe *et al.* [1991] found that the change in profits from adopting less erosive rotations would be less than the social benefits associated with reduced erosion for those Wisconsin farmers who did not participate in government commodity programs. The benefit-cost relationship was reversed, however, for farmers who did participate in government commodity programs. Similarly, Leathers [1991] examined the costs and benefits of installing Soil Conservation Service best management practices on individual farms in Maryland, and found that the costs of adopting practices exceeded the social benefits of reducing erosion in 28 percent of the cases studied. In both these studies, it is important to recognize that the production changes investigated involved relatively large investments or shifts in practices. It is likely that more marginal changes in production, such as contour plowing or strip cropping, might incur relatively low production costs but result in large societal benefits.

Similar "mixed" results have been found when comparing benefits and costs of controlling agricultural runoff and sedimentation at regional and national levels. Using benefit estimates of reducing off-site erosion, related to those in Table 4, Ribaudo *et al.* [1994] concluded that, at the national level, costs of erosion control through a major, regionally balanced land retirement program would likely exceed the benefits. However, these authors also concluded that the benefits of a carefully targeted program could approach or exceed costs. A similar conclusion is reached by Lyon and Farrow [1995], who instead employed Carson and Mitchell's [1993] contingent valuation estimates of willingness to pay for water quality improvements. Their analysis concluded that the incremental benefits exceeded the costs associated with planned Clean Water Act programs. They imply, however, that targeted programs addressing agricultural non-point source pollution may result in positive net benefits in individual watersheds.

IV. Discussion

This paper has provided a rationale for measuring agricultural environmental extra-market values, and incorporating these values into policy design and evaluation. Given this conceptual base, a review of applications of valuation techniques to select agricultural environmental issues was provided. Three key points should be taken from this review. First, extra-market values associated with agricultural amenity benefits and costs linked to surface and ground water contamination are large, and thus merit policy consideration[16]. Second, these benefits and costs occur jointly: an agricultural parcel may concurrently convey public benefits as well as impose public costs. And third, perceived benefits and costs may vary across sites and affected populations: amenity benefits associated with protecting farmland have been shown to vary with the perceived scarcity or threat to farmland and type of farm operation, as well as systematic features of the population surveyed; agricultural damages to ground and surface waters are affected not only by the degree of impairment or load but also by the use of the resource and the characteristics of the population affected. Combined, these three key issues suggest that there will be a widely varying mosaic of benefit-cost ratios associated with agricultural land use across localities.

Elements of this mosaic need to be taken into account in designing a set of policies intended to maximize the environmental and social benefits of agricultural land use. Clearly, the magnitude

---

[16] Current policy topics (and their 1996 FAIR Programs) such as wetlands use (the Wetlands Reserve Program), wildlife habitat protection (the Wildlife Habitats Incentive Program) and off-site costs of manure (Environmental Quality Incentives Program) have been and are being valued by economists. At the time this paper was written, however, a sufficient body of valuation literature on these subjects had not emerged. In some cases, like wetlands, much research has been conducted (e.g., Anderson and Rockel, 1991) but has typically focused on a narrow part of the entire issue (e.g., Whitehead and Blomquist, 1991) and has yet to be brought together in a cohesive or meaningful manner. Other resources, like the wildlife benefits of agricultural easement lands or the costs of livestock operations, are in a nascent stage with first studies being either conducted (e.g., Boyle, 1997) or recently completed (e.g., Palmquist *et al.*, 1997).

and variety of agricultural environmental market failure extends beyond the scope of a single program such as the Farm Bill. Instead, as has already occurred to some extent, an overlapping hierarchy of local, state, and Federal programs needs to be developed to address the joint and concurrent nature of agricultural environmental benefits and costs.

The policy challenge is to develop a cohesive set of programs that individually, and jointly, recognize that agricultural land use practices convey both benefits and costs [Harvey 1991; Poe, 1997a]. At all levels, policymakers have tended to identify separate and disconnected policies to protect farmland and to protect water quality. Within each level it is essential that policies be better coordinated so that farmland protection efforts are viewed as a part of water quality programs and vice versa. For instance, farmland protection efforts such as the 1996 FAIR Farmland Protection Program should explicitly account for water quality and other "negative externalities" in developing an easement site ranking program. Similarly, conservation and environmental programs should consider amenity values in making enrollment acceptance criteria. At present, such considerations have not entered into rule making, and programs largely continue to proceed independently. To a degree, the development of separate and often conflicting programs mirrors academic research on land use practices cited, which tends to focus on only one side of the benefit-cost equation at a time. For instance, a study of the amenity benefits side of agriculture concluded that "land is under allocated to agriculture" [Lopez *et al.*, 1994]. In a striking contrast, a study of the benefits and costs of erosion control concluded that "land retirement as a primary pollution control tool is expensive, but if appropriately targeted, could generate sufficient benefits (i.e., reduced off-site costs) to outweigh social costs" [Ribaudo *et al.*, 1994]. In arriving at these competing conclusions, neither analysis considered both sides of the benefits (open space) to costs (water quality) relationship.

Coordination of policies may require explicit changes through rule making, but may also require "top level" efforts to coordinate agency actions (e.g. Moore, 1997). Furthermore, public policy making in agriculture may need to evolve away from an either/or bifurcation of policy interventions along purely regulatory (e.g., 1990 Coastal Zone Management Act Reauthorization Amendments) or voluntary (e.g., 1996 FAIR) lines to more integrated programs that recognize the joint needs or rights of the agricultural and non-agricultural publics. Several recent "mixed right" policy innovations have been developed in state and local experiments. Promising examples include: only imposing regulations when observed inputs (e.g., cows per acre: Pennsylvania) or outputs (e.g., nitrates in groundwater: Nebraska) cross a given threshold; linking property tax credits to adoption of conservation practices (e.g., Conservation Credit Intitiative: Wisconsin); targeting priority watersheds based on use and population affected (e.g., Florida Everglades or New York City Watershed); trading pollution credits; or regulating only bad actors [Poe, 1997a]. Effort should also be taken to coordinate efforts across policy levels. This may involve explicit local, state, and Federal interagency cooperation (e.g., New York State Department of Environmental Conservation, 1997). It may also require resolution of conflicting incentives sent to farmers by different governmental levels, such as local tax policies inhibiting participation in Federal conservation easement programs [Poe, 1997b].

It is equally incumbent upon researchers to take steps towards integrating the various environmental benefits and costs attributed to agricultural land use to engender less myopic policy recommendations. This may prove difficult as, all too often, funding and research interests are driven by immediate policy problems. For instance, economists jumped on the erosion bandwagon in the early 1980's and followed the policy money toward groundwater contamination in the later part of the decade. More thought, as well as funding, needs to be directed towards creating a longer term holistic framework for research and a more encompassing perspective on agricultural environmental and social relationships. Only when an integrated research agenda has been established can an informed policy be developed so as to meet the FAIR intent to "maximize the environmental benefits per dollar expended" as well as meet the broader policy mandate of "maximizing the benefits to whomsoever they may accrue".

References:

Abdalla, C. W., B. A. Roach, and D. J. Epp, 1992. "Valuing Environmental Quality Using Averting Expenditures: An Application to Groundwater Quality", *Land Economics*, 68(2):163-169.

Abeles-Allison, M. and L. J. Connor, 1990. "An Analysis of Local Benefits and Costs of Michigan Hog Operations Experiencing Environmental Conflicts", A.E. Report No. 536, Department of Agricultural Economics, Michigan State University, East Lansing.

Adler, R. W., J. C. Landman, and D. M. Cameron, 1993. *The Clean Water Act: 20 Years Later*, The Natural Resource Defense Council, Washington, D.C.: Island Press

American Farmland Trust, 1996. *American Farmland, Summer*.

Anderson, G. D., and R. C. Bishop, 1986. "The Valuation Problem", in D. W. Bromley, ed., *Natural Resource Economics: Policy Problems and Contemporary Analysis*, Kluwer Nijhoff Publishing, Boston.

Anderson, R., and M. Rockel, 1991. "Economic Valuation of Wetlands", Discussion Paper No. 65, American Petroleum Institute.

Arrow, K., R. Solow, E. Leamer, P. Portney, R. Radner, and H. Schuman, 1993. "Report of the NOAA Panel on Contingent Valuation", *Federal Register,* 58(10: Jan. 15):4601-4615.

Barrett, C., T. H. Stevens, and C. E. Willis, 1996. "A Comparison of CV and Conjoint Analysis in Groundwater Valuation", *W-133: Benefits and Costs Transfers in Natural Resource Planning*, 9:79-104.

Barrows, R. L., 1986. "The Political Economy of Farmland Tax Relief: An Historical Perspective", Staff Paper 258, Department of Agricultural Economics, University of Wisconsin-Madison.

Bartik, T. J., 1988. "Evaluating the Benefits of Non-Marginal Reductions in Pollution Using Information on Defensive Expenditures", *Journal of Environmental Economics and Management*, 15:111-127.

Batie, S. S., 1988. "Agriculture as the Problem: The Case of Groundwater Contamination", *Choices*, 4-7.

Berger, M. C., G. C. Blomquist, D. Kenkel, and G. SW. Tolley, 1987. "Valuing Changes in Health Risks: A Comparison of Alternative Measures", *Southern Economics Journal,* 53:967-984.

Bergland, O., 1997. "Valuation of Landscape Elements Using a Contingent Choice Method", paper presented at the eighth annual conference of the European Association of Environmental Economists, Tilburg University, The Netherlands.

Bergstrom, J.C., B.L. Dillman, and J.R. Stoll, 1985. "Public Environmental Amenity Benefits of Private Land: The Case of Prime Agricultural Land", *Southern Journal of Agricultural Economics*, 17(2):139-149.

Bills, N. L., 1993. "A Perspective on New Right to Farm Legislation in New York State", *Policy Issues in Rural Land Use*, 6(3).

Bishop, R. C., 1987. "Economic Values Defined", in D. J. Decker and G. R. Goff, Eds., *Valuing Wildlife: Economic and Social Perspectives*, Boulder, CO: Westview Press.

Bishop, R. C., and T. A. Heberlein, 1990. "Chapter 6: The Contingent Valuation Method". In D. V. Johnson, ed., *Economic Valuation of Natural Resources: Issues, Theory, and Applications*, 181-204.

Bjornstad, D. J., and J. B. Kahn, 1996. *The Contingent Valuation of Environmental Resources: Methodological Issues and Research Needs*, Cheltenham: Edward Elgar.

Blomquist, W., E. K. Flanagan, S. Ainsworth, K. J. Boyle, J. Crook, B. L. Cross, G. L. Poe, and G. D. Stedge, 1997. "Task Group 3: Preventing Microbial Contamination of Source Water", *Groundwater Disinfection Regulations Conference*, Irvine: National Water Research Institute.

Boadway, R. W., and D. E. Wildasen, 1984. *Public Sector Economics*, 2nd edition, Boston: Little, Brown, and Company.

Bockstael, N. E., 1995. "Chapter 29: Travel Cost Models", in D. W. Bromley, ed., *The Handbook of Environmental Economics*, Oxford: Basil Blackwell.

Boyle, K. J., G. L. Poe, and J. C. Bergstrom, 1994. "What Do We Know About Groundwater Values? Preliminary Implications from a Meta Analysis of Contingent-Valuation Studies", *American Journal of Agricultural Economics,* 1055-1061.

Boyle, K. J., 1997. Personal communication regarding current USDA valuation of Wildlife Benefits Contract.

Bradford, D. F., 1970. "Benefit-Cost Analysis and Demand Curves for Public Goods", *Kyklos*, 775-791.

Brown, T. C., P. A. Champ, R. C. Bishop, and D. W. McCollum, 1996. "Which Response Format Reveals the Truth about Donations to a Public Good?" *Land Economics*, 72(2):152-166.

Buist, H., C. Fisher, J. Michos, and A. Tegene, 1995. "Purchase of Development Rights and the Economics of Easements", USDA-ERS Agricultural Economic Report Number 718.

Burrows, P., 1995. "Non-Convexities and the Theory of External Costs", in D. W. Bromley, ed. "The Handbook of Environmental Economics", Oxford:Basil Blackwell.

Carson, R. T., and R. C. Mitchell, 1993. "The Value of Clean Water: The Public's Willingness to Pay for Boatable, Fishable, and Swimmable Quality Water", *Water Resources Research,* 29(7): 2445-2454.

Carson, R. T., J. Wright, N. Carson, A. Alberini, and N. Flores, 1995. "A Bibliography of Contingent Valuation Studies and Papers", La Jolla: Natural Resource Damage Assessment, Inc.

Caudill, J. D., 1992. "The Valuation of Groundwater Pollution Policies: The Differential Impacts of Prevention and Remediation", unpublished Ph.D. dissertation, Department of Agricultural Economics, Michigan State University.

Ciriacy-Wantrup, S. V., 1947. "Capital Returns for Soil-Conservation Practices", *Journal of Farm Economics*, 29:1181-1196.

Clark, E. H. II, 1985. "The Off-Site Costs of Soil Erosion", *Journal of Soil and Water Conservation*, 40:19-22.

Clark, E. H. II, Haverkamp, J. A., and W. Chapman, 1985. *Eroding Soils: The Off-Farm Impacts*, The Conservation Foundation, Washington, D.C.

Conrad, J. M., and L. J. Olson, 1992. "The Economics of a Stock Pollutant", *Environmental and Resource Economics*, 2:245-258.

Courant, P. N., and R. C. Porter, 1981. "Averting Expenditure and the Cost of Pollution", *Journal of Environmental Economics and Management,* 8:321-329.

Court, L. M., 1941. "Entrepreneurial and Consumer Demand Theories for Commodities Spectra", *Econometrica,* 9(1):139-162.

Crosson, P. 1995. "Soil Erosion Estimates and Costs [Letter to the Editor]", *Science*, 269:461-463.

Crosson, P. R., and A. T. Stout, 1983. *Productivity Effects of Cropland Erosion in the United States*, , Washington, D.C.: Resources for the Future

Delavan, W. A., 1997. *Valuing the Benefits of Protecting Groundwater from Nitrate Contamination in Southeastern Pennsylvania*, unpublished Master of Science thesis, Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University.

Desvousges, W. H., A. R. Gable, R. W. Dunford, and S. P. Hudson, 1993. "Contingent Valuation: The Wrong Tool to Measure Passive Use Values", *Choices*, Second Quarter.

Diamond, P. A., and J. A. Hausman, 1994. "Contingent Valaution: Is Some Number Better Than No Number?", *Journal of Economic Perspectives*, 8(4):45-64.

Dorfman, R., 1976. "Forty Years of Cost-Benefit Analysis", Unpublished Working Paper, Harvard University.

Dupuit, J., 1844. "De la Mesure de l'Utilité des Travaux Publics", *Annales des Ponts et Chaussées*, 2nd series, 8(1844). Translated in *International Economic Papers,* 2(1952): pp. 83-110.

Edwards, S. F., 1988. "Option Prices for Groundwater Protection," *Journal of Environmental Economics and Management*, 15:475-487.

Ervin, D. E., and J. W. Mill, 1985. "Agricultural Land Markets and Soil Erosion: Policy Relevance and Conceptual Issues", *American Journal of Agricultural Economics*, 67: 55-62

Freeman, A. M., III, 1993. "The Measurement of Environmental and Resource Values: Theory and Methods", Washington: Resources for the Future.

Furuseth, O. J., 1987. "Public Attitudes toward Local Farmland Protection Programs", *Growth and Change*, 18(3):49-61.

Gardner, K. and R. Barrows, 1985. "The Impacts of Soil Conservation Investments on Land Prices", *American Journal of Agricultural Economics*, 67:943-949.

Gardner, B. D., 1977. "The Economics of Agricultural Land Preservation", *American Journal of Agricultural Economics*, 59(5):1027-1036.

Halstead, J. M., 1984. "Measuring the Nonmarket Value of Massachusetts Agricultural Land: A Case Study", *Journal of the Northeastern Agricultural Economics Council*,13(2): 12-19.

Hanemann, W. M., 1992. "Preface", in S. Navrud, ed. "Pricing the European Environment", Scandinavian University Press.

Hanemann, W. M., 1994. "Valuing the Environment Through Contingent Valuation", *Journal of Economic Perspectives*, 8(4):19-44.

Hanley, N., D. MacMillan, R.E. Wright, C. Bullock, I. Simpson, D. Parsisson, and R. Crabtree, 1997. "Contingent Valuation vs. Choice Experiments: Estimating the Benefits of Environmentally Sensitive Areas in Scotland", paper presented at the eighth annual conference of the European Association of Environmental Economists, Tilburg University, The Netherlands.

Harrington, W., A. J. Krupnick, and W. O. Spofford, Jr., 1991. *Economics and Episodic Disease: The Benefits of Preventing a Giardiasis Outbreak*, Washington: Resources for the Future.

Harrington, W., and P. Portney, 1987. "Valuing the Benefits of Health and Safety Regulation", *Journal of Urban Economics*, 22:101-112.

Harvard Law Review, 1992. "Ask a Silly Question...": Contingent Valuation of Natural Resource Damages", 105(8):1981-2000.

Harvey, D. R., 1991. "Agriculture and the Environment: The Way Ahead?", in Nick Hanley, ed., *Farming and the Countryside: An Economic Analysis of External Costs and Benefits*, Oxon: C. A. B. International.

Hausman, J. A., ed., 1993. *Contingent Valuation: A Critical Assessment*, Amsterdam: North-Holland.

Heimlich, R. E., 1994. "Cost of an Agricultural Wetland Reserve", *Land Economics*, 70(2):234-246.

Heimlich, R. E., and C. H. Barnard, 1995. "Economics of Agricultural Management Measures in the Coastal Zone", USDA-ERS, Agricultural Economic Report Number 698.

Hicks, J. R., 1939. *Value and Capital*, Oxford: Oxford University Press.

Hotelling, H., 1939. "The General Welfare in Relation to Problems of Taxation and of Railway and Utility Rates", *Econometrica*, 6:242-269.

Hotelling, H., 1947. Letter to the National Park Service, June 18. Reprinted in *Economic Studies of Outdoor Recreation*, Outdoor Recreation Resources Review Commission, Study Report No. 24, Washington D. C., 1962, p. 56.

Inter-Agency River Basin Committee, 1950. *Proposed Practices for Economic Analysis of River Basin Projects,* Wshington, D. C.

Jordan, J. L. and A. H. El Nagheeb, 1993. "Willingness to Pay for Improvements in Groundwater Quality", *Water Resources Research*, 29:237-245.

Kaldor, N. 1939. "Welfare Propositions and Interpersonal Comparisons of Utility", *The Economic Journal*, XLIX:549-552.

Kellogg, R. L., M. S. Maizel, and D. W. Gross, 1992. *Agricultural Chemical Use and Ground Water Quality: Where are the Potential Problem Areas?*, USDA-SCS Report.

Kline, J., and D. Wilchens, 1994. "Using Referendum Data to Characterize Public Support for Purchasing Development Rights to Farmland", *Land Economics*, 70(2):223-233.

Kline J., and D. Wilchens, 1996. "Public Preferences Regarding the Role of Farmland Preservation Programs", *Land Economics*, 72(4):538-549.

Kopp, R. J., and Smith, V.K. eds., 1993. *Valuing Natural Assets: The Economics of Natural Resource Damage Assessment*, Washington, D.C.: Resources for the Future.

Krutilla, J., 1967. "Conservation Reconsidered", *American Economic Review*, 57:787-796.

Kuch, P. J., and C. W. Ogg, 1996. "The 1995 Farm Bill and Natural Resource Conservation: Major New Opportunities", *American Journal of Agricultural Economics*, 78(5):1207-1214.

Langdale, G. W., and W. D. Shrader, 1982. "Soil Erosion Effects on Soil Productivity of Cultivated Cropland", in B. L. Schmidt, R. R. Almaras, J. V. Mannering, and R. J. Papendick, eds. *Determinants of Soil Loss Tolerance*, American Society of Agronomy and Soil Science of America, Special Publication No. 45, Madison, Wisconsin.

Leathers, H. D., 1991. "Best Management Practices versus Socially Optimal Practices", in Just, R. E. and N. Bockstael, eds., *Commodity and Resource Policies in Agricultural Systems*, 293-310.

Lee, L. K., and E. G. Nielsen, 1987. "The Extent and Costs of Groundwater Contamination by Agriculture", *Journal of Soil and Water Conservation*, 42:243-248.

Little, I.M.D., 1950. *A Critique of Welfare Economics*, Oxford: Clarendon Press.

Lopez, R.A., F.A. Shah, and M.A. Altobello, 1994. "Amenity Benefits and Optimal Allocation of Land", *Land Economics*, 70(1):53-62.

Louviere, J., 1988. "Conjoint Analysis Modeling of Stated Preferences", *Journal of Transport Economics and Policies*, 22(1):93-119.

Lyles, L., 1975. "Possible Effects of Wind Erosion on Soil Productivity", *Journal of Soil and Water Conservation*, 30:279-283.

Lyon, R. M. and S. Farrow, 1995. "An Economic Analysis of Clean Water Act Issues", *Water Resources Research,* 31:213-223.

Mackenzie, J., 1996. Personal communication.

Mackenzie, J., 1993. "A Comparison of Contingent Preference Models", *American Journal of Agricultural Economics*, 75(3):593-603.

Malone, P., and R. Barrows, 1990. "Groundwater Pollution's Effect on Residential Values, Portage County, Wisconsin", *Journal of Soil and Water Conservation*, 45:346-348.

McClelland, G. H., W. D. Schulze, and B. Hurd, 1990. "The Effect of Risk Beliefs on Property Values: A Case Study of a Hazardous Waste Site", *Risk Analysis*, 10:485-497.

McClelland, G. H., W. D. Schulze, J. K. Lazo, D. M. Waldman, J. K. Doyle, S. R. Elliot, and J. R. Irwin, 1992. *Methods for Measuring Non-Use Values: A Contingent Valuation Study of Groundwater Cleanup*, USEPA Cooperative Agreement #CR-815183.

McConnell, K. E., 1983. "An Economic Model of Soil Conservation", *American Journal of Agricultural Economics,* 65:83-89.

McGuire, R. T., 1994. "A New Model to Reach Water Quality Goals", *Choices,* (2nd Quarter):20-25.

Miranowski, J. A., and B. D. Hammes, 1985. "Implicit Prices of Soil Characteristics of Farmland in Iowa", *American Journal of Agricultural Economics*, 67:55-62.

Mitchell, R. C., and R. T. Carson, 1989a. *Using Surveys to Value Public Goods: The Contingent Valuation Method.* Washington, D.C.: Resources for the Future.

Mitchell, R. C., and R. T. Carson, 1989b. "Existence Values for Groundwater Protection". Draft Final Report prepared under Cooperative Agreement CR814041-01, U.S. Environmental Protection Agency.

Moore, R. A., 1997. "Controlling Agricultural Nonpoint Source Pollution: The New York Experience", *Drake Law Review*, 45(1):103-124.

Mueller, D. K., P. A. Hamilton, D. R. Helsel, K. J. Hite, and B. C. Ruddy, 1995. Nutrients in Ground Water and Surface Water of the United States--An Analysis of Data through 1992: U.S. Geological Survey Water-Resources Investigations Report 95-4031, Washington.

Mueller, D. K., and D. R. Helsel, 1996. *Nutrients in the Nation's Waters--Too Much of a Good Thing?* U.S. Geological Survey Circular 1136, National Water-Quality Assessment Program, Washington.

National Research Council, 1989. *Alternative Agriculture*, Washington: National Academy Press.

New York State Department of Environmental Conservation, 1997. "Agricultural Environmental Management: Building form Experience: A State-Wide, Multi-agency Conference and Workshop", Auburn, New York.

New York State Department of Agriculture and Markets, 1996. Agricultural Districts and County Agricultural and Farmland Protection Plans - A Status Report. Albany.

Nielsen, E. G., and L. K. Lee, 1987. *The Magnitude and Costs of Groundwater Contamination from Agricultural Chemicals: A National Perspective*, Natural Resource Economics Division, Economic Research Service, Staff Report.

Nolan, B. T., and B. C. Ruddy, 1996. *Nitrate in the Ground Waters of the United States--Assessing the Risk,* Electronic version of Fact Sheet FS-092-96, National Water-Quality Assessment Program, Washington.

O'Neil, W. B., and R.S. Raucher, 1990. "The Costs of Groundwater Contamination", *Journal of Soil and Water Conservation*, 40:180-183.

Page, G. W., and H. Rabinowitz, 1993. "Groundwater Contamination: Its Effect on Property Values and Cities", *Journal of the American Planning Association,* 59:473-481.

Palmquist, R. B., and L. E. Danielson, 1989. "A Hedonic Study of the Effects of Erosion Control and Drainage on Farmland Values", *American Journal of Agricultural Economics*, 71:55-62.

Palmquist, R. B., F. M. Roka, and T. Vukina, 1997. "Hog Operations, Environmental Effects, and Residential Property Values", *Land Economics*, 73(1): 114-124.

Pareto, V., 1909. *Manuel d'Economie Politique*, Paris: Girard and Briere.

Pierce, F. J., R. H. Dowdy, W. E. Larson, and W. A. P. Graham, 1984. "Soil Productivity in the Corn Belt: An Assessment of Erosion's Long-term Effects", *Journal of Soil and Water Conservation*, 37: 131-136.

Pimentel, D., C. Harvey, P. Resosudarmo, K. S. Sinclair, D. Murz, M. McNair, S. Crist, S. Shpritz, L. Fitton, R. Saffouri, and R. Blair, 1995. "Environmental and Economic Costs of Soil Erosion and Conservation Benefits", *Science*, 267:1117-1122.

Poe, G. L., 1993. *Information, Risk Perceptions and Contingent Values: The Case of Nitrates in Groundwater*, Ph.D. Dissertation, University of Wisconsin-Madison.

Poe, G. L., 1995. "New York Agriculture and the Coastal Zone Management Act", *Policy Issues in Rural Land Use*, 8(1).

Poe, G. L., 1997a. "Extra-Market Values and Conflicting Agricultural Environmental Policies", forthcoming in *Choices*.

Poe, G. L., 1997b. "Property Tax Distortions and Participation in Federal Conservation Programs: An Exploratory Analysis", Revised *ARME WP-96-06*, Cornell University.

Poe, G. L. and R. C. Bishop, 1992. "Measuring the Benefits of Groundwater Protection form Agricultural Contamination: Results from a Two-Stage Contingent Valuation Study", *Agricultural Economics Staff Paper Series 341*, University of Wsiconsin-Madison.

Poe, G. L. and R. C. Bishop, 1994. "Exposure-Based Risk Perceptions and Conditional Damages and Benefits", in R. C. Ready, ed., *W-133 Benefits and Costs in Natural Resource Planning*, 7:387-415.

Poe, G. L., M. Duroe, and H. van Es, 1995. Malone Area Well Water Study, Nitrogen Information Sheet, unpublished mimeo.

Poe, G. L, R. M. Klemme, S. J. McComb, and J. E. Ambrosious, 1991. "Commodity Programs and the Internalization of Erosion Costs: Do They Affect Crop Rotation Decisions?", *Review of Agricultural Economics*, 13:223-235.

Portney, P. R., 1995. "Cartoon Caricatures of Regulatory Reform, *Resources*, 121:21-24.

Powell, J. R., 1991. "The Value of Groundwater Protection: Measurement of Willingness-to-Pay Information and its Utilization by Local Government Decision-Makers", unpublished Ph.D. dissertation, Department of Agricultural Economics, Cornell University.

Quiggen, J., 1992. "Risk, Self-Protection and *Ex-Ante* Economic Value - Some Positive Results", *Journal of Environmental Economics and Management*, 23:40-53.

Raucher, R. R., 1983. "A Conceptual Framework for Measuring the Benefits of Groundwater Protection", *Water Resources Research,* 19:320-326.

Raucher, R. R., 1986. "The Benefits and Costs of Policies Related to Groundwater Protection", *Land Economics*, 62:33-45.

Ready, R. C., 1993. "The Value to Kentuckians of the Kentucky Equine Industry: A Contingent Valuation Study", Working Paper, University of Kentucky.

Reichert, A., M. Small, and S. Mohanty, 1992. "The Impact of Landfills on Residential Property Values", *Journal of Real Estate Research,* 7:297-314.

Repetto, R., 1994. "Chapter 2: What Can Policy Makers Learn from Natural Resource Accounting?", in *Assigning Economic Value to Natural Resources*, Washington: National Academy Press.

Ribaudo, M. O., 1989. "Targeting the Conservation Reserve Program to Maximize Water Quality Benefits", *Land Economics*, 65(4):320-332.

Ribaudo, M. O., C. T. Osborn, and K. Konyar, 1994. "Land Retirement as a Tool for Reducing Agricultural Nonpoint Source Pollution", *Land Economics*, 70(1):77-87.

Ridker, R. G., 1967. *Economic Costs of Environmental Pollution: Studies in Measurement*, New York: Praeger.

Roe, B., K. J. Boyle, and M. F. Teisl, 1996. "Using Conjoint Analysis to Derive Estimates of Compensating Variation", *Journal of Environmental Economics and Management,* 31(2):145-159.

Rose, J. G., 1984. "Farmland Preservation Policy and Programs", *Natural Resources Journal*, 24(3):591-640.

Saliba, B. C., and D. W. Bromley, 1986. "Soil Management Decisions - How Should They Be Compared and What Variables Influence Them?", *North Central Journal of Agricultural Economics*, 8:306-317.

Samuelson, P., 1954. "The Pure Theory of Public Goods", *Review of Economics and Statistics*, 40:332-338.

Schultz, S. D., and B. E. Lindsay, 1990. "The Willingness to Pay for Groundwater Protection", *Water Resources Research*, 26:1869-1875.

Shogren, J. F., and T. C. Crocker, 1991. "Risk, Self-Protection and *Ex-Ante* Economic Value", *Journal of Environmental Economics and Management*, 20:1-15.

Smith, V. K., 1992. "Environmental Costing for Agriculture: Will It Be Standard Fare in the Farm Bill of 2000?", *American Journal of Agricultural Economics*, 74:1076-1088.

Sparco, J., 1995. "Marginal Valuation of Health Related Attributes of Ground Water Using Conjoint Analysis", paper presented at the Northeastern Agricultural and Resource Economics Association Meetings, Burlington.

Stiglitz, J. E., 1988. *Economics of the Public Sector*, 2nd edition, New York: W.W. Norton and Company.

Sun, H., J. C. Bergstrom, and J. H. Dorfman, 1992. "Estimating the Benefits of Groundwater Protection Control", *Southern Journal of Agricultural Economics*, 19(4): 63-71.

Tolley, G., D. Kenkel, and R. Fabian, 1994. *Valuing Health for Policy: An Economic Approach*, Chicago: University of Chicago Press.

United States Department of Agriculture, 1981. *"Soil, Water, and Related Resources in the United States: Analysis of Resource Trends. 1980 RCA Appraisal*, Part II, Washington D. C.

United States Environmental Protection Agency, 1988. Pesticides in Groundwater Database, 1988 Interim Report, Washington, D.C.

United States Environmental Protection Agency, 1994. *National Water Quality Inventory: Report to Congress.*

Vatn, A., and D. W. Bromley, 1994. "Choices without Prices without Apologies", *Journal of Environmental Economics*, 26(2):129-148.

Waddington, D. G., 1990. "Willingness to Pay for Farmland Preservation", Master of Science Thesis, Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University.

Weibe, K., A. Tegene, and B. Kuhn, 1996. "Partial Interests in Land: Policy Tools for Resource Use and Conservation", USDA-ERS Agricultural Economic Report 744.

Weisbrod, B. A., 1964. "Collective Consumption Services of Indiviual Consumption Goods", *Quarterly Journal of Economics*, 78(3):471-477.

Whitehead, J. C., and G. C. Blomquist, 1991. "Measuring Contingent Values for Wetlands: The Effects of Information about Public Goods", *Water Resources Research*, 27: 2523-2531.

Wunderlich, G., 1997. "Land Taxes in Agriculture: Preferential Rate and Assessment Effects", *American Journal of Economics and Sociology*, 56(2):215-227.

Zoysa, A. D. N. de, 1995. "A Benefit Evaluation of Programs to Enhance Groundwater Quality, Surface Water Quality, and Wetland Habitat in Northwest Ohio", unpublished Ph.D. dissertation, The Ohio State University.

Table 1: Willingness to Pay (WTP) for Amenity Benefits of Agricultural Land

Authors (Date)	Location	Good	Average Annual WTP/Household ($)	Aggregate Annual WTP/ Acre ($)
Bergstrom, Dillman and Stoll (1985)	Greenville Co. SC	General Farmland	7-12	18-44
Halstead (1984)	3 Counties MA	General Farmland	34-230	56-492
Waddington (1990)	PA	General Farmland	80-106	n.a.
Ready (1993)	KY	Horse Farms	73-252	n.a.

Note: Dollar Values Converted to 1990 Using the Consumer Price Index. Average WTP values vary in some studies because different subgroups were included or different protection levels were elicited.

Table 2: Estimated Costs of Household Remedial Responses to Reduce Agricultural Chemicals in Drinking Water

Option	Estimated Costs per Year
Water Treatment Unit:	
Distillation ^{P,N}	$360 (lease)
Ion Exchange ^{N}	$360 (lease)
Reverse Osmosis ^{P,N}	$216 - 580 (rent/lease)
Bottled Water ^{P,N}	$160-175 per person per year delivered to home

Source: Poe, Duroe, and van Es, Malone Area Well Water Study, 1995
P= Pesticide, N= Nitrates

Table 3: Willingness to Pay (WTP) for Groundwater Protection from Agricultural Contamination ($/household/year)

Authors (Date)	Location	Contaminants	Average Annual WTP ($)
WTP for "safe" water			
Powell (1991)	15 Communities: MA, PA, NY	General, including agricultural sources	55
Jordan and El Nagheeb (1993)	GA	Nitrates	142-184
Poe (1993)	Portage Co., WI	Nitrates	211-353
Sun, Bergstrom, and Dorfman (1992)	Dougherty Co., GA	Nitrates and Pesticides	493-890
Delavan (1997)	South Eastern, PA.	Nitrates*	25-59
WTP for a one-unit improvement			
Poe and Bishop (1994)	Portage Co., WI	Nitrates	102
Sparco (1995)	Sussex Co., DEL	Nitrates Atrazine	112 298

Note: Dollar values converted to 1990 by Consumer Price Index. Average WTP values vary in some studies because different subgroups were included or different base levels of exposure were produced;
*Delavan's values are for a reduction in probability of exceeding standards form a "staus quo" 50 percent to a reduced exposure risk of 25 percent.

Table 4: Off-Site Damages per Ton of Soil Erosion and per Acre of Farmland by Farm Production Region

Farm Production Region	Erosion (1,000 tons)	Damages per ton ($)	Damages per Acre ($)
Northeast	185,000	7.80	27.62
Delta States	234,000	2.70	13.92
Appalachian	484,000	1.56	11.37
Lake States	181,000	4.13	11.05
Southeast	250,000	2.12	9.94
Corn Belt	970,000	1.27	8.62
Pacific	669,000	2.73	7.29
Southern Plains	490,000	2.23	5.08
Mountain States	1,003,600	1.24	2.32
Northern Plains	671,000	0.63	1.77

Source: Ribaudo, M., 1989. Dollar values updated to 1990 by Consumer Price Index.

Table 5: USLE Values and On- and Off-Site Costs of Erosion ($)

	USLE (T/A)	On-Site Costs/ Acre	Off-Site Costs/ Acre
Continuous Corn	7.9	9.19	22.67
Corn/Corn/Corn/ Small Grain/Hay/Hay	2.0	2.33	5.74
Corn/Corn/Small Grain/Hay/Hay	0.5	0.58	1.44

Note: USLE Assumptions: 8 percent 200-foot slope; 20 percent residue cover; contour strip cropping where appropriate; fall plowing; Rosetta silt-loam soil. On-site costs calculated following Poe *et al.*, *Review of Agricultural Economics* [1991]; 20 year time horizon, 2 percent discount rate.

OTHER A.R.M.E. EXTENSION BULLETINS

EB No	Title	Author(s)
97-09	Dairy Farm Business Summary, Northern Hudson Region, 1996	Smith, S.F., L.D. Putnam, C.S. Wickswat, S. Buxton and D.R. Wood
97-08	Dairy Farm Business Summary, New York Large Herd Farms, 300 Cows or Larger, 1996	Karszes, J., W.A. Knoblauch and L.D. Putnam
97-07	Dairy Farm Business Summary, Southeastern New York Region, 1996	Knoblauch, W.A., L.D. Putnam, S.E. Hadcock, L.R. Hulle, M. Kiraly, C.A. McKeon
97-06	Dairy Farm Business Summary, Western and Central Plateau Region, 1996	Knoblauch, W.A., L.D. Putnam, C.A. Crispell, J.S. Petzen, J.W. Grace, A.N. Dufresne and G. Albrecht
97-05	Dairy Farm Business Summary: Western and Central Plain Region, 1996	Knoblauch, W.A., L.D. Putnam, J. Karszes, M. Stratton, C. Mentis and George Allhusen
97-04	Fruit Farm Business Summary, Lake Ontario Region, New York, 1995	White, G.B., A. DeMarree and L.D. Putnam
97-03	Labor Productivities and Costs in 35 of the Best Fluid Milk Plants in the U.S.	Erba, E.M., R.D. Aplin and M.W. Stephenson
97-02	Micro DFBS: A Guide to Processing Dairy Farm Business Summaries in County and Regional Extension Offices for Micro DFBS Version 4.0	Putnam, L.D., W.A. Knoblauch and S.F. Smith
97-01	Changing Patterns of Fruit and Vegetable Production in New York State, 1970-94	Park, K., E.W. McLaughlin and C. Kreider
96-20	Supermarket Development in China	German, G., J. Wu and M.L. Chai
96-19	New York Economic Handbook, 1997: Agribusinss Economic Outlook Conference	A.R.M.E. Staff
96-18	Farm Income Tax Management and Reporting Reference Manual	Smith, S. and C. Cuykendall
96-17	Income Tax Myths, Truths, and Examples Concerning Farm Property Dispositions	Smith, S.
96-16	Dairy Farm Business Summary, Eastern New York Renter Summary 1996	Smith, S.F. and L.D. Putnam

To order single copies of ARME publications, write to: Publications, Department of Agricultural, Resource, and Managerial Economics, Warren Hall, Cornell University, Ithaca, NY 14853-7801.