Allocating Land to New York's Conservation Reserve Enhancement Program To Maximize Net Environmental Benefits

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(May 2000)

Abstract:

A programming model is used to assess the welfare effects of regional and practice specifications contained in New York State's Draft Conservation Reserve Enhancement Program (CREP) proposal. Net social benefits are nearly 75% lower than options that explicitly account for opportunity costs of production, environmental benefits, and participation response functions.

Selected Paper to be presented at the annual meetings of the American Agricultural Economics Association in Tampa, Florida, USA, August 2000.

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Key words: benefit cost analysis, conservation programs, participation, linear programming

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Background

Motivated by language in the 1996 Farm Bill that Conservation Programs should maximize the environmental benefits per dollar expended, the USDA established the Conservation Reserve Enhancement Program (CREP) to reduce agricultural non-point source pollution in priority areas where the environmental effects are high. To do so, CREP provides substantially greater financial benefits to participants than does the Conservation Reserve Program (CRP), and state and federal governments share program costs. As of June 1999, eight states had approved CREPs, and a number of other states, including New York, were in various stages of drafting proposals.

Whereas most states' CREP target a single area of concern, Chesapeake Bay, for example, New York, in its draft proposal, is proposing a 20,000-acre, statewide program. Land is to be allocated to 11 resource areas across the state in proportion to the number of river miles that fail to meet the standards of the Clean Water Act. Enrolled acreage is also partitioned across eight approved practices (e.g., trees, riparian strips, etc.).

This paper assesses the net social benefits of a program designed under these specifications for allocating land by region and practice relative to other options that explicitly account for opportunity costs of production, environmental benefits, and participation. For the analysis, we develop a programming model to allocate program acreage across the 11 regions and eight practices to maximize net social benefits subject to budget, institutional, and participation constraints. While this model is an extension of a standard allocation model, the explicit consideration of participation constraints is unique. In contrast to other models used in similar research, we allow participation rates to vary by region, depending on incentive payments, farm income, and type of farm enterprise.

In addition to assisting in an evaluation of the acreage allocation strategy in New York's proposal, this analytical framework provides program administrators with a means for examining other policy scenarios in a systematic fashion. Consistent with previous efforts at the national level (e.g., Heimlich, 1994; Ribaudo *et al.*, 1994), we find that net benefits and the optimal land allocation can be improved substantially when variations in benefits, costs, and participation rates across regions and practices are accounted for in program design.

After reviewing New York's CREP, we describe the conceptual framework and model. A discussion of the data is followed by the empirical results, including a discussion of their sensitivity to underlying assumptions. Finally, we present policy implications.

New York State's Conservation Reserve Enhancement Program

The New York State CREP, designed to improve water quality in areas that suffer problems due to nutrients, pesticides, and sediments, intends to enroll 20,000 acres that border streams and water bodies. The proposal highlights the importance of the agricultural sector to the state's economy, and as a source of non-point source pollution. Because of the state's topography and the location of productive soils, much of New York's cropland is near waterways. The problems relate to agriculture's contribution to non-point source pollution, unbuffered areas along water bodies, the needs of wildlife, and pollution prevention opportunities (NYS Department of Agriculture and Markets, 1998).

Based on the draft proposal, the 20,000 acres available through the New York CREP are to be allocated across 11 regions, which constitute most of the state, and eight conservation practices (USDA, FSA 1998). Allocations are based on percentages of impaired water bodies by region, and are also specific to authorized practices (Table 1).

Table 1. Total Acreage Allotment by Region and Practice

Resource Area	**CREP Acreage Allotment (acres)**
A1: Finger Lakes Region	4,340
A2: Lake Ontario Direct Drainage Basin	2,754
A3: Black River / St. Lawrence River Basins	1,929
A4: Lake Erie Direct Drainage Basin	2,454
A5: Mohawk River Basin	1,647
A6: Upper Hudson River Basin	96
A7: Lower Hudson River	1,931
A8: Lake Champlain River Basin	2,311
A9: Chesapeake Bay / Susquehanna River Basins	1,778
A10: Allegany River Basin	690
A11: Peconic River	70
Totals:	20,000
Conservation Practice	**CREP Acreage Allotment (acres)**
P1: Riparian Buffers	4,842
P2: Filter Strips	9,053
P3: Grass Waterways	105
P4: Contour Grass Strips	4,211
P5: Establishment of Permanent Introduced or Native Grasses	1,053
P6: Tree Planting	210
P7: Diversions	105
P8: Wetland Restoration	421
Totals:	20,000

The Finger Lakes Region is the third largest by area and has the most farms, cropland, and pasture. It has the largest land allotment. The Peconic River region is the smallest area by size, and it has only a token allotment. Although it is home to several endangered species, the Upper Hudson receives only a token allotment. The largest and most populous region, the Lower Hudson, has less than 10% of the total allotment, while the least populous area, the Lake Champlain area, receives more than 10%. Nearly 70 percent of the acreage is supposed to be committed to filter strips and riparian buffers; only 1% is in the most expensive practices, grass waterways and diversions (Jaroszewski, 2000).

In evaluating this CREP proposal, we must understand the implications of these decisions regarding the allocation of program acreage. To this end, we develop a model to allocate the acreage, recognizing that social, private, and governmental benefits and costs differ by region and conservation practice.

The Land Allocation Decision and Model Structure

Decisions made to enroll land in a conservation program that removes agricultural land from production implicitly reflects a tradeoff between benefits and costs. From society's perspective, benefits are due to improved soil, air, and water quality, and through wildlife and landscape conservation (Ribaudo (1989a, 1989b), Magleby, *et al*. (1995), and Feather *et al*. (1999)). While government payments add to farm income, they are best characterized as transfer payments that should not be accounted for in benefit cost analyses.

Nevertheless, the benefits come at a cost to taxpayers and lost agricultural production, which may result in higher commodity prices and a loss of sales in the agribusiness supply sector. As additional acres are removed from production and placed in conservation practices, both the program's benefits and costs increase. The number of acres enrolled in the program in turn depends on participation rates, which are influenced by the private benefits and costs to participants.

The private benefits to landowners include the rental value and any governmental cost share, as well as reduced expenditures for planting, cultivating, and harvesting crops on the enrolled acres. There might also be productivity increases due to reduced soil erosion, and farmers might value the environmental improvements, but we do not account for these factors in this analysis. Costs include the value of foregone production and resources needed to establish and maintain the conservation practice. Such benefits and costs clearly vary by region and practice (Ribaudo, 1989b).

To reflect these considerations in a model to allocate CREP acreage, let Y_{ij} be the number of acres of land enrolled in the program in region i (i=1,2,…,m) in conservation practice j (j=1,2,…,n). To maximize net social benefits, we find Y_{ij} that:

$$\underset{\{Yij\}}{Max}\sum_{i=1}^{m}\sum_{j=1}^{n}[b_{ij}-c_{ij}]\cdot Y_{ij}\ , \qquad (1)$$

where b_{ij} and c_{ij} are the social benefits and costs, respectively, of an acre in region i and practice j. While many believe that benefits and costs rise non-linearly with acreage enrolled (rather than linearly as assumed here), our simplifying assumption may provide reasonable results for allocating this relatively small acreage across the entire state. This allocation process must also reflect budget and participation constraints and institutional considerations.

Program Limits Constraint: First, land enrolled in all areas and conservation practices, must not exceed what is available through the program, A^{PL}:

$$\sum_{i=1}^{m}\sum_{j=1}^{n}Y_{ij}\leq A^{PL}\ . \qquad (2)$$

Budget Constraints: To keep the program within its budget, total government outlays must only be less than BC, but there also may be legitimate reasons for imposing budget limits by region and practice. To recognize this possibility, we define w_{ij} = budgetary cost to the government of enrolling an acre from area i in practice j; W_i = total budgetary cost in region

i; and W_j = total budgetary cost for practice j. We have separate budget constraints for each region (3) and practice (4):

$$\sum_{j=1}^{n}[w_{ij}Y_{ij}] - W_i = 0, \quad (i=1,2,\ldots,m) \text{ and} \tag{3}$$

$$\sum_{i=1}^{m}[w_{ij}Y_{ij}] - W_j = 0, \quad (j=1,2,\ldots,n). \tag{4}$$

The combined budgets for all practices must also equal the combined budgets committed to all regions, and these totals must not exceed the overall budget constraint, BC:

$$\sum_{j=1}^{n} W_j = \sum_{i=1}^{m} W_i \leq BC. \tag{5}$$

Participation Constraints: Just because public officials offer a land retirement program, they cannot guarantee widespread participation, and if the incentives offered through the program are low, participation rates may be low and acreage enrollment goals by region or practice may not be met. Thus, the farmer's participation decision, which depends on a number of factors, including the rental payment and the opportunity cost of participating, must be in the model. Since the willingness to participate may vary by region and is unknown, the government must agree initially to enroll acreage over and above its goal for each region. The final allocation, which satisfies the acreage constraints in equation (2), will only be known at the end of the enrollment period.

To model this participation behavior, think of S_{ij} as the number of acres offered by the government in region i for enrollment in practice j. Further, let $1 \geq p_{ij} \geq 0$ be the probability that landowners in area i will participate in conservation practice j. Letting S_i be the acres offered in region i and S_j be the acres offered for practice j, we require:

$$Y_{ij} - p_{ij} S_{ij} = 0,\ (i=1,2,\ldots,m; j=1,2,\ldots,n), \qquad (6)$$

$$\sum_{j=1}^{n} S_{ij} - S_i = 0,\ (i=1,2,\ldots,m) \text{ and} \qquad (7)$$

$$\sum_{i=1}^{m} S_{ij} - S_j = 0,\ (j=1,2,\ldots,n). \qquad (8)$$

From equation (6), we see that only a proportion (equal to the participation rate) of the acres offered by the government will finally be enrolled in the program by farmers. Equations (7) and (8) show that the sum of S_{ij}'s over practices equals the total number of acres offered in each area and that the sum of S_{ij}'s over regions equals the total number of acres offered for the jth practice. Total acreages allocated to all practices and all regions must be reconciled:

$$\sum_{j=1}^{n} S_j = \sum_{i=1}^{m} S_i\ . \qquad (9)$$

Supply Constraints: Clearly, policymakers cannot contract for more than the eligible land in a region. Thus, the acres offered through the program to a region, S_i , must not exceed the A_i^{Elig}, the acres eligible for the program in region i:

$$S_i \le A_i^{Elig}\ (\text{i}=1,2,\ldots,\text{m}). \qquad (10)$$

Institutional Considerations: For additional flexibility in conducting policy evaluation, we also accommodate a number of constraints that reflect various institutional concerns. Specifically, the idea that decisions might be made to ensure that every region or practice receives some of the acreage available through the program is addressed.

For example, due to institutional or political considerations, we could set lower and upper limits (A_j^{LB} and A_j^{UB}, respectively) on the acreage enrolled in practice j:

$$A_j^{LB} \le \sum_{i=1}^{m} Y_{ij} \le A_j^{UB}\ . \qquad (11)$$

These constraints could be to insure certain levels of commitment to a particularly desirable conservation practice. Similarly, to control for the potential effects on the regions' agricultural economies, we could place lower and perhaps, more important, upper limits (A_i^{LB} and A_i^{UB}, respectively) on the acreage enrolled in each area *i*:

$$A_i^{LB} \leq \sum_{j=1}^{n} Y_{ij} \leq A_i^{UB} \ \ (i=1,2,\ldots,m), \qquad (12)$$

Alternatively, the institutional constraints could be based on some type of weighting scheme. As is the case in New York's current CREP proposal, the weights, v_i, reflect the i^{th} region's contribution to the total number of impaired water bodies:

$$Y_i = v_i \cdot \ A^{PL} \ (i=1,2,\ldots,m), \qquad (13)$$

where A^{PL} is the number of acres available through the program from equation (2). The weights could, of course, be based on other regional characteristics such as the proportion of farms, farmland, cropland, farm or non-farm population, endangered species, etc.

By solving this model both with and without the constraints in (11) and (12), we obtain a sense of the cost (in terms of reduced net social benefits) due to institutional or political considerations inherent in program administrative decisions. To do so, we must have sufficient data to specify the model empirically. It is to this issue that we now turn.

Data for the Analysis

As with all similar studies, data at the farm and land parcel level ideally suited for the analysis were not available, but aggregate data for most of the model components are available by county. Therefore, once the parameters were calculated by county, the data were aggregated for each region, weighting the county estimates by the proportion of acres harvested (Jaroszewski, 2000). This process disguised some variation within regions, but continued to reflect substantial differences in resource vulnerabilities and agricultural production costs and output among regions. Critical data include estimates of social benefits, governmental costs, social opportunity costs, and participation rates.

Social Benefits: Clearly, estimates of the social, environmental benefits for enrolling land are among the most important information for this analysis. While there have been several attempts to estimate the benefits of the CRP nationally,[1] there are no similar estimates specific to New York. To circumvent this problem, we anchor our estimates of environmental benefits in New York to the most recent national figures, and then adjust them to reflect differences across the 11 resource areas. Based a benefit-cost analysis required under Executive Order 12866, environmental benefits from the CRP were estimated at $2.7 billion annually, or $74.18 per acre enrolled (USDA, FSA 1997).[2]

To begin to capture differences in environmental benefits by region in New York, we calculated the regional average environmental benefit indices (EBI) reported on acreage enrolled in CRP over the past several years (USDA, FSA 1997). The USDA has invested considerable effort in developing the EBI, which has been used by the Agency since 1991 to rank farmer's bids for CRP. "Scores are based on the expected environmental improvement in soil resources, water quality, wildlife habitat, and other resource concerns during the

[1] See, for example, Ribaudo (1989b), Ribaudo (1990), Young and Osborn (1990), as well as Magleby, *et al*. (1995), and Feather, *et al*. (1999).

[2] Benefits are for improvements in soil productivity and water quality and increases in the consumptive and non-consumptive uses of wildlife. The authors stressed that the value is an incomplete measure of benefits; they would most likely be larger if a more comprehensive analysis were performed.

time the land is to be enrolled in the program" (USDA, FSA 1999, p.1).[3] To adjust for the relative differences in benefits, we divided each regional index by the average across regions. These "normalized" regional-level EBIs were then multiplied by the $74.18 per acre value (Table 2).

Table 2. Social Benefits Coefficients

Area	EBI	Indexed EBI	Dollar Benefits
A1	200	1.05	$78.09
A2	183	0.96	$71.58
A3	171	0.90	$66.61
A4	208	1.10	$81.41
A5	225	1.18	$87.85
A6	166	0.87	$64.91
A7	174	0.92	$67.94
A8	153	0.80	$59.62
A9	222	1.17	$86.50
A10	225	1.18	$87.89
A11	163	0.86	$63.89
Mean	*190*		

Budget Coefficients: The budgetary costs, w_{ij}, of enrolling an acre include rental, RR_i, and incentive payments, IP_i to the landowner, plus the administrative costs of implementing the program. Since benefits and costs are measured on an annual basis, budget costs include only the government's cost share, CS_{gj}, of the annualized portion of establishment costs, AEC_{ij}, and normal administrative costs, AC, and a subsidy to help with the costs of maintaining the practices, MF_i, for this program. Hence we have: $w_{ij} = RR_i + IP_i + MF_i + CS_{gj} (AEC_{ij}) + AC$.

Data on the cost of establishing the practices were available in the USDA's July 1998 draft proposal for the program (USDA, FSA 1998). Under the current structure of the policy, the government is only responsible for 50% of these costs. An estimate of $11 per

[3] Feather, *et al*. (1999) used EBI data to allocate CRP acreage in a recent analysis.

acre for the administrative costs was also available from the USDA (USDA, FSA 1998). The proposed incentive payments for CREP effectively double the current rental rate (Table 3).

Table 3. Components of Budget Costs

Area	RR_I	IP_I	MF_i	AC
A1	$ 37.47	$ 37.47	$ 5.00	$ 11.00
A2	$ 35.39	$ 35.39	$ 5.00	$ 11.00
A3	$ 30.20	$ 30.20	$ 5.00	$ 11.00
A4	$ 35.73	$ 35.73	$ 5.00	$ 11.00
A5	$ 38.29	$ 38.29	$ 5.00	$ 11.00
A6	$ 30.92	$ 30.92	$ 5.00	$ 11.00
A7	$ 39.71	$ 39.71	$ 5.00	$ 11.00
A8	$ 28.48	$ 28.48	$ 5.00	$ 11.00
A9	$ 31.26	$ 31.26	$ 5.00	$ 11.00
A10	$ 33.07	$ 33.07	$ 5.00	$ 11.00
A11	$125.00	$125.00	$ 5.00	$ 11.00

Annualized Establishment Costs by Practice							
P1	P2	P3	P4	P5	P6	P7	P8
$84.65	$49.48	$596.12	$43.22	$48.43	$31.74	$573.76	$68.55

Social Opportunity Costs: The opportunity cost to society of enrolling an acre includes foregone income to the farmer and expenditures by the government beyond simple transfers. The opportunity cost to the government is estimated as part of the budgetary costs. To account for the opportunity cost to the farmer, it is reasonable to assume for this relatively small program, there are no increases in agricultural prices due to reduced output. Thus, the opportunity cost of agricultural production is the value of agricultural output less the variable costs not incurred if land is enrolled in the CREP.

To summarize, let these opportunity costs per acre be c_{ij}, and denote the farmers' share of establishment costs for practice *j* as, $(1\text{-}CS_{gj})$,and NVP_i as net value of agricultural production in region *i*: $c_{ij} = \{(1- CS_{gj})\cdot \ AEC_j - (RR_i + IP_i + MF_i)\} + \{w_{ij}\} + \{\delta * NVP_i\}$, other variables are as above. Since RR_i, IP_i, and MF_i are transfer payments and appear in w_{ij}, as well, we have: $c_{ij} = AEC_j + AC + NVP_i$. Estimated social costs are provided in Table 4.

The term δ^*NVP_i is the only component that has not been discussed so far. NVP_i are estimates for the harvested acres-weighted averages of revenues per acre less variable costs of production for seven predominant crops in New York: corn for grain and for silage, alfalfa, hay other than alfalfa, oats, wheat, and soybeans. Data on yields by county for each crop are from the New York Agricultural Statistics Service (NYASS 1994-1998). Variable costs of production are from enterprise budgets (USDA, ERS, 1999c; Pennsylvania State University, 1998; and the Ohio State University, 1999). Prices are converted to 1998 dollars using an index of prices received by farmers (USDA, ERS 1995, 1998, 1999b). The variable δ, ranging from 0 to 1, reflects the extent to which acreage placed in the CREP is offset by production increases elsewhere. If δ=0, the production foregone is offset by increases on the individual farm or elsewhere, at approximately the same NVP and there is no opportunity cost to society. In contrast, if δ=1, foregone production is not offset and its value as an opportunity cost is real. The associated costs associated with each extreme case are presented in Table 4. However, unless otherwise noted, we assume δ=0 in the analyses that follow.

Table 4. Social Opportunity Costs per Acre

All	P1	P2	P3	P4	P5	P6	P7	P8
Regions [a]	$95.65	$60.48	$607.12	$54.22	$59.43	$42.74	$584.76	$79.55

[a] These are social cost coefficients, c_{ij}'s, if we ignore the opportunity cost of production.

Region [b]	P1	P2	P3	P4	P5	P6	P7	P8
A1	$223.65	$187.88	$734.52	$181.62	$186.84	$170.15	$712.17	$206.96
A2	$217.37	$182.20	$728.84	$175.94	$181.15	$164.46	$706.48	$201.27
A3	$203.41	$168.24	$714.88	$161.98	$167.19	$150.50	$692.52	$187.31
A4	$227.16	$191.99	$738.63	$185.73	$190.94	$174.25	$716.27	$211.06
A5	$210.82	$175.65	$722.29	$169.36	$174.61	$157.92	$699.94	$194.73
A6	$210.96	$175.79	$722.43	$169.53	$174.74	$158.05	$700.07	$194.86
A7	$199.08	$163.91	$710.55	$157.65	$162.87	$146.17	$688.19	$182.98
A8	$210.52	$175.35	$721.99	$169.09	$174.31	$157.62	$699.64	$194.43
A9	$195.75	$160.58	$707.22	$154.32	$159.54	$142.84	$684.86	$179.65
A10	$217.67	$182.50	$729.14	$176.24	$181.46	$164.77	$706.79	$201.58
A11	$228.70	$193.53	$740.17	$187.27	$192.48	$175.79	$717.81	$212.60

[b] These are social cost coefficients, c_{ij}'s, when the opportunity costs of production are included.

Participation: The inclusion of a participation function in the optimization model is an important, unique feature of this research, but there was neither the time nor the funding available to collect original data on which to estimate participation functions specific to the proposed New York CREP. Following benefits transfer methods used in environmental valuation, we instead estimated a participation function for New York using data from a "filter strip" participation survey conducted by Purvis in Nawaygo County, Michigan (Purvis, 1989; Purvis *et al.*, 1989). These data, in contrast to more recent data from research into conservation program participation (e.g. Lant et al. 1995; Cooper and Keim, 1996; Cooper and Osborn, 1998; Kingsbury and Boggess, 1999), are more consistent with the New York situation. The field crops and animal agriculture in Michigan are similar to those in New York. Purvis also focused on enrolling new lands in filter/buffer strips that were only expected to constitute a minor proportion of the cropped area in any farm parcel.

Purvis used a dichotomous choice contingent participation question to assess which landowners would enroll in a filter strip program across a range of rental rates from $20 to $550. Those respondents who answered 'yes' to the participation question were asked a follow-up question concerning the proportion of eligible land that they would actually enroll at that price. In analyzing these data, Purvis modeled this two stage process in a two-limit Tobit framework. The dependent variable, bounded by 0 and 1, was the proportion of eligible acres enrolled in the proposed program. A total of 22 explanatory variables were used, ranging from objective farm and enterprise data to demographic characteristics and perceptions of respondents concerning conservation programs.

Despite the similarity between the New York and Michigan situations, it was impossible to apply Purvis' equations directly. We had no data for many of the variables and we needed regional level participation functions Therefore, building on the general dichotomous choice framework suggested in Hanemann (1984) and the more specific applications to conservation program participation (Lohr and Park, 1994, 1995), we reframed the participation decision for use in our model as a discrete choice, random utility framework in which a subject is assumed to participate in the program if the benefits of participation exceed the costs.

Assuming a logistic distribution for the error term, a "full" model was estimated using nine variables for which New York county-level data could be obtained. The explanatory variables that were retained at this modeling stage include "objective" financial data (e.g., net payment to farms and household income), and descriptors of the farming enterprise (e.g., total crop acres and identification of farm enterprises that contributed an important share of the farm's cash income). All economic variables were adjusted to 1998 using appropriate indices.

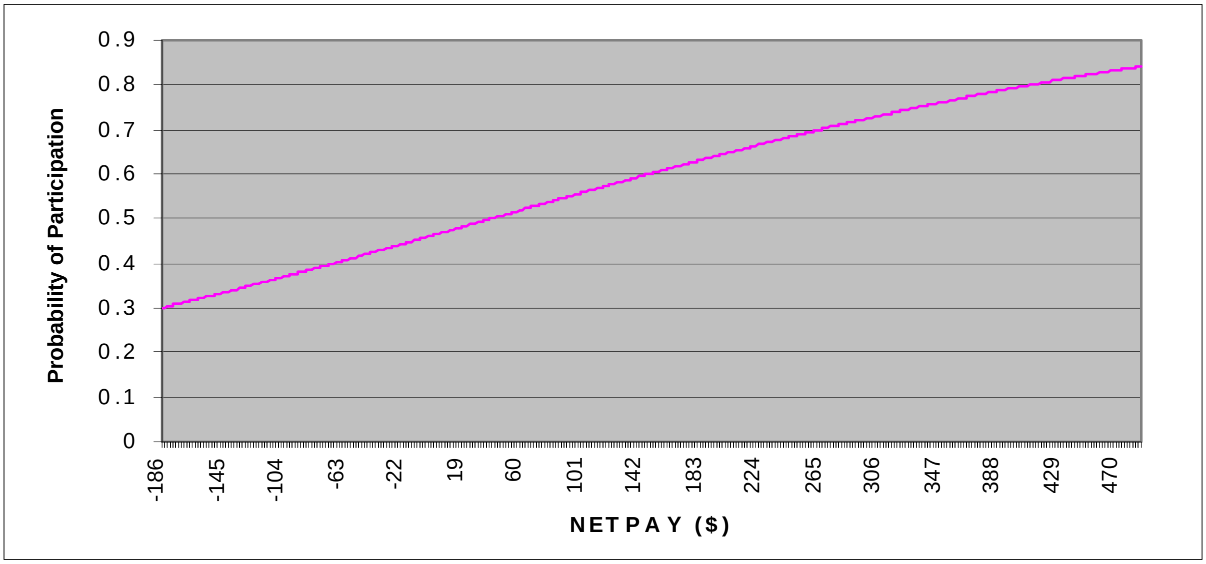
As discussed in detail in Jaroszewski (2000) standard likelihood ratio test procedures and a cutoff significance level of 25% were then used to remove variables with non-significant coefficients from the analysis. The result was a fairly parsimonious New York Participation Function, as indicated in Table 5. The coefficients on NETPAY and HAY are positive and significant. The coefficient on INCOME is also positive, but because of the relatively high standard error, we are less confident about the size of the effect. As with previous research on agriculture's participation in environmental programs, the estimated participation function is relatively flat across NETPAY values, suggesting that landowners are not highly responsive to increases and decreases in the incentive payments (see Figure 1). Overall, the mean willingness to accept compensation is approximately $40, yet the estimated logistic function suggests that a large proportion of respondents would participate in the program even at a net financial loss.

Table 5. Logistic New York Participation Function: Pr(yes) = $[1 + e^{-(\alpha + \beta x)}]^{-1}$

Variable	Definition (variable type)	Estimated Coefficient (s.e)
α	Constant	-1.4224* (0.5698)
NETPAY	Yearly governmental payment for participating less the private opportunity cost of participating (continuous)	0.0037* (0.0016)
INCOME	Annual household income (continuous)	1.230 E-05 (8.69E-06)
HAY	Hay is a significant enterprise (=1) (categorical)	1.1951* (0.4706)

* indicates significance at the 10% level.

Figure 1: The Estimated New York Participation Function



To use this estimated function we constructed a NETPAY variable for New York. Data on rental and other incentive payments, corn for grain prices and yields, as well as the variable cost of producing corn were needed. Data on the current rental rates and other incentive fees are reported in Table 3. To estimate the farmers' opportunity cost in a manner consistent with Purvis' analysis, we used five year average corn yields and corn grain prices (in 1998 dollars as above). County-level data on corn yields from the New York Agricultural Statistics Service (NYASS 1994, 1995, 1996, 1998) were aggregated to a regional level using the procedure outlined above. A 1998 estimate for the variable costs of producing corn for grain in the Northeast is from Pennsylvania State University (1998). These data are summarized in Table 6.

County-level data on the number of acres harvested of hay and the total number of acres by crop are used from the 1997 Census of Agriculture estimate of the proportion of cropland in hay. County-level data on median household income in 1989 are available from the United States Census Bureau's Census of Population and Housing. They are converted to 1998 dollars using the CPI, and aggregated to a regional level as above. A sample of this data, assuming that CS_{gj} is 100 percent for all practices, is provided in Table 7.

Table 6: Components of private opportunity cost of enrolling land

Area	Price of Corn ($/bushel)	Corn Yield (bushels/acre)	Variable Cost	Net Returns
A1	2.97	111	$203	$126
A2	2.97	111	$203	$126
A3	2.97	101	$203	$ 96
A4	2.97	112	$203	$130
A5	2.97	105	$203	$108
A6	2.97	108	$203	$119
A7	2.97	104	$203	$106
A8	2.97	109	$203	$121
A9	2.97	102	$203	$100
A10	2.97	105	$203	$110
A11	2.97	120	$203	$153

Table 7: Values for $NETPAY_{ij}$, $INCOME_j$, HAY and Unadjusted probabilities of Participation Assuming Cost Share (CS_{gj}) = 100 percent.

	NETPAY (CS_{gj} = 100%)	INCOME	HAY	Participation Rate (CS_{gj} = 100%)
A1	-$46	$38,545	0.261	0.31
A2	-$50	$38,741	0.256	0.30
A3	-$30	$32,326	0.570	0.39
A4	-$53	$36,535	0.303	0.31
A5	-$27	$33,289	0.494	0.37
A6	-$53	$40,764	0.435	0.35
A7	-$21	$42,734	0.393	0.38
A8	-$59	$35,395	0.444	0.34
A9	-$33	$35,025	0.491	0.37
A10	-$39	$31,400	0.453	0.35
A11	$102	$64,580	0.021	0.44

Based on past participation rates in the CRP, it should be clear that the estimated participation levels in Table 7 grossly exceed historical participation rates in New York. Two adjustments were made to these rates to more closely reflect the actual situation in the field. The first adjustment corrects for respondent awareness. Because the survey informed people about the program's existence and rules, it raised program awareness to 100%. To correct for this bias, our participation rates were multiplied by an "awareness factor" ranging from 0 to 1. Because CREP is a new program and participation rates have historically been low in the Northeast for the CRP, we assumed only 25% awareness for our analysis. (Personal Communication with Allien LaPierre, FSA 1999).

Based on Purvis' data indicating that people only enrolled a fraction of their awareness adjusted eligible land, all participation rates were further multiplied by 0.91.

Empirical Analysis and Model Results

To conduct the empirical analysis, we established a baseline solution, against which the sensitivity of the model and policy options in New York's CREP could be judged. In our baseline scenario, there are really four separate solutions, or panels (see Table 8). The first panel (Table 8a) assumes no prior allocation restrictions by region or by practice The other three panels are solutions assuming regional and practice restrictions indicated in the New York CREP proposal, both separately and together.

Each of the base solutions is constructed to maximize net social benefits as defined above, but assuming that social opportunity cost of foregone agricultural production is zero (i.e., δ=0). To simulate a realistic situation, a budget constraint was set at $2.4 million, the amount found in New York's CREP proposal. Because of the limited available acres, it was necessary to elevate the awareness percentage from 25 to 44% in the Lake Champlain region and 35% in the Peconic Bay region. These adjustments raise participation rates enough to ensure a feasible solution to the model in all four baseline situations.

In this base scenario, environmental benefits are also assumed not to differ by practice, and thus it is not surprising that all land is allocated to trees, the least expensive conservation practice, when no constraints on allocation across practices are imposed (Table 8a). In this case, land is planted to only five resource areas (Finger Lakes, Lake Erie, Mohawk River, Chesapeake Bay and Allegany).[4] Net social benefits reach nearly $818,000 annually or about $41 per acre. Annual budgetary costs total nearly $2,024,000 or $101 per acre.

By comparing this solution with the other three in Table 8, we can begin to identify the implications of the initial guidelines for allocating acreage. If we constrain the allocation based on the portion of stream miles at risk by region, budgetary costs rise by less than 1% annually, but net benefits fall by 21% (Table 8c). All land is still planted to trees.

If the only concern from a political standpoint is to ensure that land is distributed by conservation practice as reflected in the CREP proposal, net benefits would fall by 75% (Table 8b). The annual budgetary costs would increase by less than $20 per acre. Again, land would be enrolled in the same regions as above.

If we impose both these sets of *a priori* allocation rules written into the draft CREP proposal, budget costs would rise by 16%, and net benefits would plummet by 96% -- from $41 to just $2 per acre. Clearly, the political desirability of making CREP a statewide program must be balanced against the increase in net benefits to society by targeting regions or even smaller areas where the program is most effective.

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[4] The entries in all tables are the acreage allocated to the region by row and the practice by column. See tables 1 and 2 for names of regions and practices.

Table 8a. Baseline Results With No Institutional Constraints

ij	1	2	3	4	5	6	7	8	Totals
1	0	0	0	0	0	5,997	0	0	5,997
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	2,492	0	0	2,492
5	0	0	0	0	0	2,324	0	0	2,324
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	7,430	0	0	7,430
10	0	0	0	0	0	1,756	0	0	1,756
11	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	20,000	0	0	20,000

	Value	Per Acre
Net Benefits:	$817,607	$41
Budgetary Costs:	$2,023,612	$101

Table 8b. Baseline Results With Constraints By Practice

1	2	3	4	5	6	7	8	Totals
0	5,997	0	0	0	0	0	0	5,997
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	2,071	0	0	0	0	0	421	2,492
0	0	0	2,324	0	0	0	0	2,324
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
4,842	984	0	1,499	0	0	105	0	7,430
0	0	105	388	1,053	210	0	0	1,756
0	0	0	0	0	0	0	0	0
4,842	9,053	105	4,211	1,053	210	105	421	20,000

	Value	Per Acre	% Change
Net Benefits:	$203,321	$10	-75%
Budgetary Costs:	$2,330,755	$117	15%

Table 8c. Baseline Results With Constraints By Region

ij	1	2	3	4	5	6	7	8	Totals
1	0	0	0	0	0	4,340	0	0	4,340
2	0	0	0	0	0	2,754	0	0	2,754
3	0	0	0	0	0	1,929	0	0	1,929
4	0	0	0	0	0	2,454	0	0	2,454
5	0	0	0	0	0	1,647	0	0	1,647
6	0	0	0	0	0	96	0	0	96
7	0	0	0	0	0	1,931	0	0	1,931
8	0	0	0	0	0	2,311	0	0	2,311
9	0	0	0	0	0	1,778	0	0	1,778
10	0	0	0	0	0	960	0	0	960
11	0	0	0	0	0	70	0	0	70
Total	0	0	0	0	0	20,000	0	0	20,000

	Value	Per Acre	% Change
Net Benefits:	$648,320	$32	-21%
Budgetary Costs:	$2,040,861	$102	1%

Table 8d. Baseline Results With Constraints By Region and Practice

1	2	3	4	5	6	7	8	Totals
0	4,340	0	0	0	0	0	0	4,340
2,754	0	0	0	0	0	0	0	2,754
402	1,527	0	0	0	0	0	0	1,929
0	1,928	0	0	0	0	105	421	2,454
0	0	0	1,647	0	0	0	0	1,647
96	0	0	0	0	0	0	0	96
1,590	0	0	341	0	0	0	0	1,931
0	1,258	0	0	1,053	0	0	0	2,311
0	0	105	1,673	0	0	0	0	1,778
0	0	0	480	0	201	0	0	960
0	0	0	70	0	0	0	0	70
4,842	9,053	105	4,211	1,053	210	105	421	20,000

	Value	Per Acre	% Change
Net Benefits:	$33,944	$2	-96%
Budgetary Costs:	$2,348,004	$117	16%

Because of the differential implications of these policy options, it is important to understand how sensitive the results are to the assumptions in the model. It is to this issue that we now turn.

Allowing Benefits to Vary By Practice: Our assumption that benefits are constant across practices is clearly a critical one. To better understand its importance, and based on conversations with Professor Harold van Es, an environmental scientist at Cornell, we solved the model again assuming that benefits for riparian buffers and filter strips were scaled up by 25% and values for contour grass strips and trees were scaled down by 25%.

Ignoring the institutional constraints from the CREP proposal, the change in relative benefits by practice shifts all land enrollment to filter strips. The slightly higher costs of filter strips compared with trees, are outweighed by the much higher benefits. The allocation of land across regions is not affected, but net benefits rise to $44 per acre, and budgetary costs falls slightly to $100 per acre (see Table 9).

To assess how robust the solution is to the adjustment in benefit values by practice, we performed a series of simulations. According to these simulations, as long as the benefits to filter strips are less than 20% higher than for trees, the preferred practice remains trees. However, if the benefits from filter strips are at least 23% greater than trees, the preferred practice is filter strips. Between 20 and 23%, both practices are employed.

Changing the Assumption About "δ": Another critical assumption in the base scenario is $\delta = 0$, implying that there is sufficient agricultural land elsewhere in non-environmentally vulnerable areas and of approximately equal net returns to replace any loss in output from enrolled acreage. Thus, there is no effect on aggregate supply or the price of agricultural output and no loss to society from the reduction in agricultural output. This assumption,

Table 9. Results With No Institutional Constraints, Allowing Benefits to Vary Across Practices

ij	1	2	3	4	5	6	7	8	Totals
1	0	5,997	0	0	0	0	0	0	5,997
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	2,492	0	0	0	0	0	0	2,492
5	0	2,324	0	0	0	0	0	0	2,324
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	7,430	0	0	0	0	0	0	7,430
10	0	1,756	0	0	0	0	0	0	1,756
11	0	0	0	0	0	0	0	0	0
Total	0	20,000	0	0	0	0	0	0	20,000

Total Net Benefits: $881,035; $44 per acre
Total Budget Costs: $2,200,957; $110 per acre

Table 10. Results With No Institutional Constraints (δ=1)

ij	1	2	3	4	5	6	7	8	Totals
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	3,813	0	0	3,813
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	2,324	0	0	2,324
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	4,677	0	0	4,677
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	7,430	0	0	7,430
10	0	0	0	0	0	1,756	0	0	1,756
11	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	20,000	0	0	20,000

Total Net Benefits $1,402,234; -$70 per acre
Total Budget Costs $1,997,816; $100 per acre

Table 11. Results With No Institutional Constraints: Setting Awareness at 100 Percent

ij	1	2	3	4	5	6	7	8	Totals
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	3,813
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	9,267	0	0	9,267
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	4,677	0	0	4,677
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	3,678	0	0	3,678
10	0	0	0	0	0	7,024	0	0	7,024
11	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	20,000	0	0	20,000

Total Net Benefits $ 897,478; $ 44.87 per acre
Total Budget Costs $2,044,020; $102.20 per acre

while perhaps naïve, is either explicitly or implicitly maintained in most analyses conducted of the CRP.

Alternatively, by assuming that this social opportunity cost is real (δ=1), land allocated to the Finger Lakes and Lake Erie regions in the baseline model, when no institutional constraints by region or practice are imposed, moves into the Black/St. Lawrence and Lower Hudson regions. On average, the opportunity costs of farming are higher in the Finger Lakes and Lake Erie regions than in the Black/St. Lawrence and Lower Hudson regions (see Table 10).

Perhaps the most significant result from altering these opportunity costs explicitly is that total net benefits become negative, and would remain so as long as $0.35 \leq \delta \leq 1$. Put differently, net benefits to society are positive as long as at least 65% of the foregone agricultural output due to enrollment in the program is accommodated by production elsewhere. Viewed from a yet a different perspective, as long as we account totally for the opportunity cost of foregone agricultural output, environmental benefits would have to rise to $140 per acre for the net social returns of the program to be positive. This is nearly double the $74 estimate from the CRP used in this study.

Awareness: To explore how the assumption about the level of farmers' awareness affects the results, we resolved the base model with no institutional restrictions, but assumed awareness to be 100%. With full awareness, the value of net benefits increased from $41 per acre in the baseline panel to $45 per acre, an increase of about 10%. As expected, land enrolled in the program remains entirely in trees. However, the land was spread across only three regions, the Mohawk, Chesapeake Bay, and Allegheny, instead of five. No land was allocated to either the Finger Lakes or the Lake Erie resource areas. (see Table 11)

This result highlights the importance of recognizing the differences in participation and awareness rates by region. With increased awareness, the supply constraints are not binding in the Mohawk and Allegheny resource areas and more land is enrolled in regions where net benefits are higher. Alternatively, when awareness assumption is reduced to 10%, the model has no feasible solution. Clearly, the additional benefits must be balanced against additional costs of advertising and promotion to raise awareness.

Summary and Policy Implications

According to mandates in the Conservation Title of the 1996 Farm Bill, geographically dispersed conservation programs are to be designed to maximize the environmental benefits per dollar expended. By augmenting the standard allocation model, we provide a framework for making this type of assessment. Our model not only accounts for differences in social and private costs and benefits across regions and practices, but also explicitly recognizes how participation rates differ across regions and are affected by the economic incentives offered by the program. Using data specific to a proposed CREP in New York, we demonstrate that, like previous research at the national level, efforts to distribute acreage across the state and across practices may result in substantial reductions in the net social benefits of the program. Although the exact numbers reported are specific to our assumptions and the data used, the broader implications are evident: the political desirability associated with spreading enrollments across regions and practices must be weighed against potentially large reductions in realized net benefits.

At a more general policy design scale, the empirical example demonstrates the importance of recognizing regional differences in participation rates, and identifies a method for incorporating such considerations into a programming framework. Our results suggest that these factors could have substantial effects on the enrollment patterns as well as the economic efficiency of the program.

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