Measuring the Nonmarket Value of Massachusetts Agricultural Land: A Case Study

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Agricultural land provides a variety of "nonmarket" services to the Commonwealth, including wildlife habitat, scenic vistas, and recreation. This study utilizes an iterative bidding game to estimate willingness-to-pay of residents of three central Massachusetts counties to preserve state agricultural land. Through the use of these data, estimates of the value of these nonmarket amenities are derived so that a fuller measure of the value of agricultural land can be obtained. This information may be useful to policy makers administering such programs as the Agricultural Preservation Restriction Act (Chapter 780) which are designed to arrest the conversion of Massachusetts farmland to urban uses.

Between 1967 and 1977 approximately 300,000 acres of Massachusetts active and potential farmland were converted to urban and related uses. About one-third of this land was cropland and or pasture prior to conversion; most of the remainder was forestland with agricultural potential. Bailey *et al.* note that the loss of this land has been primarily a function of urban demand rather than a decline in the viability of agriculture. Developers are typically able to outbid farmers, even successful farmers, for parcels which come on the market, since the return on development far exceeds the return from agriculture. However, agricultural lands provide a variety of "nonmarket" services which do not yield revenue to farmers. These services include wildlife habitat, recreation, and scenic vistas. While farmers can obtain revenue from the use, sale or development of agricultural land, no revenue can normally be derived from the habitat, scenic, and other externalities provided by agricultural land. As a consequence, agricultural land may be undervalued by the market and more may be sold for development than is socially optimal.

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This problem resulted in the passage of the Massachusetts Agricultural Preservation Restriction Act (Chapter 780) which enabled the state to purchase development rights to agricultural land. The act established a voluntary program under which farmers can apply to sell the rights to develop their land for nonagricultural uses to the state. If the application is approved, the state will pay the farmer the difference between the agricultural value of the land and its appraised commercial market value. The farmer sells the "development rights" but keeps the land and all other ownership rights. The farmer receives payment for the land's development value without having the land itself converted to other uses. The farmer is, in effect, accepting an "agricultural preservation restriction" on the deed wherein it is agreed that the land be restricted in perpetuity to farming purposes. However, given present budgetary constraints only a small percentage of the state's agricultural land can be preserved by this program.

In order to identify those agricultural lands with the highest preservation priority, several factors must be considered, including the productivity of the land, the type of commodities that can be grown, the nonmarket values of the land, and its relative risk of being developed. The issue to be addressed here is the magnitude of the nonmarket values provided by agricultural lands and the willingness of the citizens of the state to pay the cost of its preservation. Measurement of these values can be useful in gauging public support for and estimating optimal levels of farmland preservation.

The Study Area

Three central Massachusetts towns were chosen as study areas to estimate nonmarket values of agricultural land. Deerfield and Greenfield in Franklin County and East Longmeadow in Hampden County were selected for their diversity of population and land use characteristics. Population varied from 4,257 in Deerfield to 13,093 in East Longmeadow and 19,066 in Greenfield. Population density (people/square mile) ranged from 130.7 in Deerfield to 885.2 in Greenfield and 1004.8 in East Longmeadow. Deerfield had the highest percentage of land area devoted to agricultural use (30.0 percent) while East Longmeadow had the highest percentage of land in urban use (33.4 percent).

Methodology

Several procedures are currently utilized to estimate nonmarket values of certain public goods. These include the iterative bidding technique (Randall *et al.*), the hedonic property value model (Correll *et al.*), and the travel cost method (Smith). For the services in question, the travel cost approach was deemed inappropriate as a measurement tool. Several formulations of property value models utilizing the hedonic technique were tested as a measurement tool. However, due to inconclusive results and overly restrictive theoretical assumptions, these models were not used as a measurement tool in this study (further discussion of these models can be found in Bailey *et al.* and Halstead *et al.*). Therefore, the iterative bidding model was employed to measure the social values of agricultural land.

The Iterative Bidding Model

Following Brookshire *et al.*, a bidding game was constructed using a household survey to determine willingness-to-pay (WTP) to avoid development on nearby agricultural land. The game consisted of three steps. First, alternate levels of development were described in detail in terms of quantity, quality, and location. Second, a hypothetical market was created. It is especially important during this step to assure the respondent that all users of the good[1] will pay equally and to create a credible vehicle of payment for the good. Finally, the respondent reacts to prices posed by the interviewer, indicating whether he would pay the price or go without. The price is varied iteratively until a level is identified where the respondent is indifferent to provision of further levels of the good.

The actual survey used photographs to depict various levels of development which might occur on agricultural land near the respondent's home. The respondent was confronted with a photograph (A) representing the undeveloped agricultural land near his home, followed by three photographs representing scenarios (B, C, and D) of increasing development, and asked to make an annual bid of the maximum amount he (she) would be willing to pay to avoid each succeeding scenario. Three alternative vehicles of payment were suggested for making this payment: increased local sales tax, increased state income tax, or a special fund specifically allocated to preservation of agricultural land. The respondent was also asked to choose which payment vehicle (if any) he preferred. His (her) bid was then based on this preferred payment vehicle. Additional survey questions sought data on distance to and size (in acres) of nearest parcel of agricultural land, property value, and household income.

Several OLS model specifications[2] were constructed to ascertain the influence of certain variables on respondent bid levels.

(1) X = f (INC, DAG)
(2) Y = f (INC, DAG)
(3) Z = f (INC, DAG)

X = annual WTP to avoid light development on nearby agricultural land
Y = annual WTP to avoid moderate development on nearby agricultural land
Z = annual WTP to avoid heavy development on nearby agricultural land
INC = respondent's annual income, in increments of $5,000

[1] In this case, the "good" is the amenity which the survey is attempting to measure.

[2] Alternative functional forms were tested, and the linear formulation was deemed superior to log formulations.

and DAG = distance in feet, to nearest agricultural land.

A fourth specification was also formulated to provide a greater number of degrees of freedom by combining the first three models:

(4) BID = f (INC, DAG, LDEV)

where BID = annual WTP

and LDEV = level of development related to bid, where LDEV = 1 for light development scenario (A), LDEV = 2 for moderate development scenario (B), and LDEV = 3 for heavy development scenario (C).

Data Collection

The principal data collection method was a household survey in the three towns. Additional data on household characteristics were acquired from the Multiple Listing Service of the Hampshire County Board of Realtors and through deed and map searches at the Deerfield, Greenfield, and East Longmeadow assessors' offices.

Several problems were encountered in administering the survey. First, a certain amount of measurement error occurred in respondents' estimates of the distance from their home to the nearest tract of agricultural land and the tract's size. However, following Freeman's reasoning, it was felt that the perceived value of these variables was more important than their actual values. Second, and perhaps more important, many respondents were unwilling to divulge their family income. As a result, about one-third of the completed surveys were discarded due to the omission of this critical variable. A total of 85 usable surveys were obtained for the model: 23 from Deerfield, 29 from Greenfield, and 33 from East Longmeadow.

Results

The bidding game used in this experiment was designed to estimate the annual value of preserving agricultural land near the respondent's home and to assess the effect that annual income, proximity to agricultural land, and level of proposed development had on this bid. Mean annual bid levels for each scenario by town are summarized in Table 1.

As the results show, increasing levels of development on agricultural land near the respondent's home provoke substantially increased bids. It is interesting to note that mean bid for Deerfield respondents shows an increase of over 500 percent from Scenario D, while respondents' bids in the other two towns increase by about 100 percent in the same situation. This may indicate a more tolerant attitude on the part of Deerfield residents towards light development and a much more pronounced aversion to heavy development.

The results of equation 1 (Table 2) show a mean annual bid of about $28 for Deerfield, $37 for Greenfield, and $61 for East Longmeadow. The income variables (INC) in the Greenfield and East Longmeadow models were statistically significant at the 90 percent confidence level, indicating that a change of one level of income (income was measured in $5,000 increments) would elicit an increase of $12.30 in the respondent's bid. No other model variables were significant at the 90 percent level for the equation.

Equation 2 (Table 3) mean bids increased markedly to $46 in Deerfield, $44 in Greenfield, and $81 in East Longmeadow. The income variable was significant at the 90 percent level or higher for all three towns. The

Table 1. Mean Annual Bids and Income by Town for Iterative Bidding Survey, WTP to Avoid Development

	Mean Bid			
Town	Scenario B (vs. A) (Light Development)	Scenario C (vs. B) (Moderate Development)	Scenario D (vs. C) (Heavy Development)	Mean Annual Income of Respondent
East Longmeadow	$60.58	$81.03	$127.27	$24,249
Deerfield	28.26	46.09	176.09	25,449
Greenfield	37.41	44.31	70.69	20,499

Table 2. Results of Iterative Bidding Model Willingness-To-Pay to Avoid Development. Equation 1. Dependent Variable = BID, Light Development Scenario (Scenario B vs. Scenario A)

	Deerfield		Greenfield		East Longmeadow	
Variable	Coefficient (Standard error)	T-statistic	Coefficient (Standard error)	T-statistic	Coefficient (Standard error)	T-statistic
Constant	24.717 (22.891)	1.08	−15.908 (26.872)	−.592	−53.435 (77.281)	−.691
INC	2.171 (5.463)	.397	12.3 (6.254)	1.967**	30.057 (17.787)	1.69**
DAG	−.019 (.013)	−1.512*	.005 (.003)	1.38	−.001 (.011)	−.127
R^2	.1029		.1557		.0895	
Dependent Variable Mean	28.261		37.414		60.576	
d.f.	20		26		30	

* Significant at 80 percent level.
** Significant at 90 percent level.

DAG variable exhibited moderate significance in Deerfield.

Results of equation 3 (Table 4), WTP to avoid heavy development, again show significance for the INC variable, with the largest coefficient ($119) in the Deerfield model. An interesting aspect of this formulation is that the Greenfield DAG variable is significant at the 99 percent level, but with a positive sign, indicating that increased proximity (lower DAG values) had a negative effect on bid levels. However, due to the small coefficient of the variable ($.009), this effect is not considered meaningful.

In order to obtain more degrees of freedom, equations 1–3 were combined and a variable, LDEV, added to represent level of development associated with the respondent's bid (see Table 5). Results from this formulation were similar to results from equations 1–3 in that INC was statistically significant in all three models, indicating that income level had a substantial effect on bid level and that the DAG variable had little effect on the bid. The

Table 3. Results of Iterative Bidding Model Willingness-To-Pay to Avoid Development. Equation 2. Dependent Variable = BID, Moderate Development (Scenario C vs. Scenario B)

	Deerfield		Greenfield		East Longmeadow	
Variable	Coefficient (Standard error)	T-statistic	Coefficient (Standard error)	T-statistic	Coefficient (Standard error)	T-statistic
Constant	−5.761 (36.283)	−.159	−13.448 (26.422)	−.509	−57.892 (79.999)	−.724
INC	14.931 (8.659)	1.724**	13.093 (6.149)	2.129**	36.803 (18.412)	1.999**
DAG	−.033 (.020)	−1.642**	.005 (.003)	1.587*	−.002 (.011)	−.201
R^2	.1911		.1830		.129	
Dependent Variable Mean	46.087		44.31		81.03	
d.f.	20		26		30	

* Significant at 80 percent level.
** Significant at 90 percent level.

Table 4. Results of Iterative Bidding Model Willingness-To-Pay to Avoid Development. Equation 3. Dependent Variable = BID, Heavy Development Scenario (Scenario D vs. Scenario C)

	Deerfield		Greenfield		East Longmeadow	
Variable	Coefficient (Standard error)	T-statistic	Coefficient (Standard error)	T-statistic	Coefficient (Standard error)	T-statistic
Constant	−263.624 (281.836)	−9.35	−17.981 (25.024)	−.719	−95.19 (108.574)	−.877
INC	118.636 (67.261)	1.764*	18.883 (5.824)	3.242**	58.845 (24.989)	2.355**
DAG	−.164 (.157)	−1.04	.009 (.003)	2.94**	−.003 (.015)	−.218
R^2	.1526		.3759		.1611	
Dependent Variable Mean	176.087		70.69		127.273	
d.f.	20		26		30	

* Significant at 90 percent level.
** Significant at 95 percent level.

significance of the new LDEV variable and its large coefficients suggest that the degree of proposed development on agricultural land near the respondent's home has a major influence on bid levels.

One problem which may have biased results of the survey was a large number of zero bids to preserve agricultural land in all three study areas. Nearly 25 percent of the total sample responded that their WTP to preserve agricultural land was zero dollars per year. However, 18 of the 21 zero bidders felt that agricultural land conversion was a problem in Massachusetts, and 14 were opposed to at least one development scenario (with 5 voicing no opinion). Since 15 of the 21 were opposed to all 3 payment vehicles proposed and the remaining 6 chose the special fund vehicle, it was con-

Table 5. Results of Iterative Bidding Model, Willingness-To-Pay to Avoid Development. Equation 4: Dependent Variable = BID To Avoid Development

	Deerfield		Greenfield		East Longmeadow	
Variable	Coefficient (Standard error)	T-statistic	Coefficient (Standard error)	T-statistic	Coefficient (Standard error)	T-statistic
Constant	−229.382 (118.42)	−1.937	−49.055 (21.312)	−2.302	−135.536 (70.636)	−1.919
INC	45.246 (22.992)	1.968**	14.758 (3.447)	4.282***	41.902 (11.684)	3.586***
DAG	−.072 (.054)	−1.34*	.006 (.002)	3.435***	−.002 (.007)	−.326
LDEV	73.913 (34.431)	2.147***	16.638 (7.663)	2.171***	33.348 (24.558)	1.358*
R^2	.1265		.2621		.1379	
Dependent Variable Mean	88.478		50.805		89.626	
d.f.	65		83		95	

* Significant at 80 percent level.
** Significant at 90 percent level.
*** Significant at 95 percent level.

cluded that a strong case of vehicle bias existed.[3] This conclusion was substantiated by comments from 5 zero bidders that there should be no more state taxes, and 2 others who indicated that the developers should pay the taxes. Three other respondents refused to bid because they did not believe the money would be used for its intended purpose. Therefore, if these zero bids are the result of disagreement with the payment vehicle rather than legitimate zero valuation, mean bids for the total sample may be biased downward.

Pooling of Data Sets

In attempting to apply the findings of the iterative bidding model to larger areas, it is first necessary to determine whether the respondent populations are homogeneous. F (Chow) tests on the iterative bidding models yielded values indicating that the Deerfield-Greenfield and the East Longmeadow-Greenfield models should not be pooled. The Deerfield-East Longmeadow test, however, yielded an F-value of .82 (F critical is 2.37 in this case), so that a pooled formulation was attempted (Table 6). Pooling had the effect of lessening the significance that the DAG variable had in the Deerfield model. In spite of the low F-value, other factors such as differences in mean bids between the towns for equations 1–3, differences in income level, and differences in variable significance in equation 4 seem to argue against pooling East Longmeadow and Deerfield populations.

[3] Vehicle bias occurs when the mean bid or protest votes vary significantly across payment mechanisms, indicating dissatisfaction with the methods of payment (Brookshire et al.).

Table 6. Results of Pooled Model: East Longmeadow-Deerfield. Willingness-To-Pay to Avoid Development. Equation 4: Dependent Variable = Bid To Avoid Development

Variable	Coefficient (Standard error)	T-Statistic
Constant	−170.766350 (61.211952)	−2.789755
INC	40.659878 (10.653673)	3.816513
DAG	−.003190 (.007403)	−.430934
LDEV	50.008929 (20.174207)	2.478855

R^2 = .1149.
n = 168; degrees of freedom = 164.
Mean of dependent variable = 87.101190.
Standard errors in parentheses.

Analysis

One of the prime objectives of this study was to obtain an estimate of the social value of farmland and, if possible, express that social value on a per acre basis to be used in estimating the full value of agricultural land. Mean bids for each of the towns surveyed were substantial (see Table 1). Although mean bid levels varied widely by town, the median was exactly the same for all three towns ($25 for Scenario B, $25 for Scenario C, and $50 for each town for Scenario D). The means in all cases were increased by several extreme values which raised the average bid. However, the high number of zero bids (many of which probably resulted from vehicle bias) would tend to hold the median bid at a lower level.

Several methods of calculating the total value of agricultural land can be applied to the data. The first method would be to obtain the average size of the nearest parcel of agricultural land (from a survey question), then divide the mean bid by this figure. The result is a per acre social value for the average household. Values vary from $2.13/acre in Greenfield to $4.15/acre (East Longmeadow) and $5.19/acre (Deerfield). One problem with this approach is that it assumes that the nearest parcel is the only one that the respondent is bidding on, when in reality the social value that he (the respondent) is bidding on may encompass far more land than that parcel. A second problem is in measurement error, since perceptions of the size of an acre vary widely across respondents (perceptions of the size of one particular tract of farmland were seen to vary from 40 to 65 acres among different individuals).

A second approach estimates social value by town by multiplying mean bid times the number of households to obtain social value, then dividing by the number of acres of agricultural land in that town. The results again vary widely, with a low of $43.64/acre in Deerfield (low population, large number of acres in agriculture) to a high of $377.44/acre in East Longmeadow (high population, low level of agriculture). The problem with this approach is that social value does not end with town lines; per acre results vary widely, with the highest values occurring in towns like East Longmeadow with large populations and relatively little farmland. The problem is in isolating exactly what farmland the respondent is bidding to preserve.

The final method is to obtain total willingness-to-pay per town by multiplying the mean bid by the total number of households in the town. This figure ranges from $275,440/year in Deerfield to $542,500/year in Greenfield and $672,592/year in East Longmeadow. This value is proposed as the final result of this study.

In order to obtain a per acre estimate of social value of agricultural land by this last method, it would be necessary to include a wide cross section of the population. Then, an extrapolation could be made to include the whole state. Once total social value for the state was estimated, dividing by total acres of farmland in Massachusetts would yield a per acre social value.

The total benefits of preservation can be calculated by summing the area under the willingness-to-pay curves generated by the survey. It is interesting to note that for low levels of development, bids are consistently low, while increasing the development level draws major increases in bids (when comparing the increase from levels A to B, B to C, and C to D). This would indicate diminishing marginal utility per acre preserved, since preservation of the last few acres elicits the highest bids, while preservation of a relatively few acres (in the lower development scenario) draws lower bids.

Critique of Methodology

The main criticism of the bidding model was the population size surveyed. When the survey was formulated, the initial plan was to obtain 40 surveys from each of six towns; this was subsequently reduced to three towns. Even so, the unexpectedly high mortality rate of the surveys coupled with logistical problems served not only to double the expected survey period but to reduce the number of usable surveys to 85. This fact should be considered in future survey design.

As for the survey it would be helpful to find a more generally acceptable payment vehicle than taxes, which might reduce the number of zero bids. Given the nature of the present survey, sample areas should be chosen within some maximum distance of working farmland, as response to the survey was generally less favorable when the distance was one mile or greater. This result was probably caused by the survey design, which focuses the respondent's attention on the nearest parcel of farmland; if the respondent is unsure of that parcel's location, he may have difficulty conceptualizing the proposed 'market.''

Conclusions

The final product of this study is a measure of the nonmarket benefits (social values) of agricultural land for Franklin and Hampden Counties in Massachusetts. The survey discovered that citizens of the area were prepared to pay substantial amounts to avoid residential development on agricultural land. Mean values of the study areas ranged from $28 to $60 annually to avoid even low levels of development to $70 to $176 annually to avoid high density development on this farmland. These estimates are considered a conservative lower bound due to income limitations, zero bids due to vehicle bias rather than legitimate zero values, and findings of prior empirical studies on the willingness-to-pay technique (Bishop and Herberlein).

Policy Implications

From the standpoint of a statewide policy, the evidence seems to justify expenditures towards such projects as the Massachusetts Agricultural Preservation Restriction Act. In order to obtain a useful dollar figure of social valuation in all of Massachusetts which could be used in deciding how much to set aside from the general fund for the Act, additional studies are needed. One of the findings of this study was that the three communities tested, though within a small geographical area, registered radically different valuation measures; therefore, any attempt to measure total social value for the state must be done using enough sample variation to obtain a truly representative cross section. Model formulations would in some cases have to be modified to achieve this. This might also serve to address some of the welfare economics issues inherent in the preservation question. Low income city dwellers may be in favor of development for the jobs and additional living space it would create. Applying state general funds for farmland preservation might have the effect of lower income groups and city dwellers subsidizing higher income groups' and rural residents' enjoyment of these amenities if a comprehensive method to measure social valuation is not used.

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