Amenity Benefits and Public Policy: An Application to the Connecticut Dairy Sector

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Abstract

This article develops a conceptual framework for analyzing the role of state-level policies towards the dairy sector in the presence of farmland amenity benefits, and applies it to Connecticut. Milk supply, demand and amenity benefit functions are estimated, and three exogenously determined milk prices are considered. The empirical findings show, under each price scenario, the extent to which land is underallocated to the dairy sector if amenity benefits are ignored. Analysis of policy options reveals that a partial production cost subsidy represents the least-cost alternative for attaining the socially optimal solution for the region.

Keywords: amenity benefits, policy, dairy, land use, open space.

Introduction

Population and economic growth in many regions of the world have resulted in the conversion of significant amounts of agricultural land to urban uses. The remaining farmland often yields nonmarketed environmental amenity benefits such as those accruing from scenic landscape and open space. Many governments seek to encourage and support agriculture with programs for farmers based on sustaining the food production capability of a region, maintaining family farms and income levels, and preserving cultural identity (Fishel 1982; Plaut 1980; Moore 1990). From an economic perspective, however, another justification for government intervention is the failure of the land market to fully consider environmental amenity benefits from agriculture (Beasley, Workman and Williams 1986; Bergstrom, Dillman and Stoll, 1985; Halstead 1984; Gardner 1977; Lapping and Forster 1982; Young and Allen 1986). In the case where dairy farms yield nonmarketed amenity benefits, there may be justification for the government to intervene and support the dairy industry.

Land in dairy often represents a significant portion of agricultural land in urbanizing areas. For example, in Connecticut, which is a densely populated state with a high per capita income, 37 percent of the total land in farms is in dairy (USDA, 1991). Furthermore, the amount of land linked to dairy exceeds 50 percent of total farmland when the acreage of field corn and hay used to feed dairy cows is included (Waggoner, 1986). In spite of the State's efforts, land in dairy continues to decline in Connecticut (Andersen and Malia, 1991;

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USDA, 1991). Furthermore, federal deregulation of milk markets has contributed to falling incomes of dairy farmers. As a result, several states are considering programs to support the industry. Although such efforts are based primarily on ensuring the economic viability of the industry, they may also be viewed as policies which indirectly maintain open space from dairy land.

This article has two objectives. The first is to develop a conceptual model for analyzing the role of public policy in the presence of amenity benefits from land in dairy. The second is to provide an empirical framework for determining the socially optimal size of a regional dairy industry and the welfare implications of alternative government policies. Using Connecticut as a case-study, the analysis considers three state-level support policies which focus on milk production and, at the same time, indirectly influence the amount of land in dairy and associated amenity benefits.

The Conceptual Model

It is widely recognized that farmland yields nonmarketed amenity benefits in densely populated regions (Foster, Halstead, and Stevens, 1982; Bergstrom, Dillman, and Stoll, 1985). Let AB denote the value of nonmarketed amenity benefits, net of any negative externalities often associated with agricultural production such as water pollution and odors. Because of the public-good character of amenity benefits associated with land in dairy farms, it is reasonable to assume that AB will increase as population (POP) increases. As with any other normal good, these amenity benefits can also be expected to increase as the amount of farmland (L) increases and as income of the region (I) increases. Mathematically, the foregoing can be expressed as

$$AB = h(L,\ POP,\ I), \tag{1}$$

where the derivatives $h_L > 0$, $h_{POP} > 0$ and $h_I > 0$. Following the empirical evidence in Brookshire, Randall, and Stoll (1980), and Lopez, Shah and Altobello (1994), it is assumed that $h_{LL} < 0$, which means that there is diminishing marginal utility with respect to open space.

Let the total quantity (Q) of milk produced in the region be expressed as $Q = Y{\cdot}L$, where Y is "yield" of milk per unit of land. Using this expression and holding population, income, and yield constant (at POP^o, I^o and Y^o, respectively),[1] amenity benefits can be expressed as

$$AB = h(L, POP^o, I^o) = h(Q/Y^o, POP^o, I^o) = f(Q). \tag{2}$$

The marginal amenity benefits (MAB) with respect to milk production can be derived from (2) as $MAB = \partial AB/\partial Q = f_q$. Since $h_{LL} < 0$, it follows that $\partial MAB/\partial Q = f_{qq} < 0$. That is, marginal amenity benefits decrease as milk production increases, *ceteris paribus*.

Let the region in question be a small producer of milk which competes in a relatively large market and assume a downward sloping demand for milk within the region. If no imports or exports of milk were allowed, and there were no government price controls, market equilibrium would occur where the region's demand curve intersects the supply curve as given by the industry's marginal cost (MC) curve. However, since the region under consideration is relatively small, one may assume that the price of milk is determined outside the region. This exogenously determined price of milk is termed "reference price" and is denoted by P^r.

Assume that the objective is to maximize net social benefits (NSB) to the region which are defined as net private benefits plus amenity benefits from the regional production of milk.[2] The social planner's problem is to select Q in order to

$$\text{Maximize} \quad NSB = P^r Q - C(Q) + f(Q), \tag{3}$$

where $C(Q)$ is total cost of milk production for the region. Assuming an interior solution, the first-order condition for maximizing NSB is given by

$$\frac{\partial NSB}{\partial Q} = P^r - MC(Q) + MAB(Q) = 0. \tag{4}$$

That is, the socially optimal quantity Q^* is obtained when the marginal cost of production equals the exogenously determined market price plus the marginal amenity benefits. Since land in dairy yields amenity benefits and MC does not reflect the true social costs of milk production, following standard procedure (Just, Hueth, and Schmitz, 1982), the marginal social cost (MSC) for milk production is obtained by subtracting the marginal amenity benefits (as given by MAB) from the MC equation. In other words, equation (4) says that $P^r = MSC(Q^*)$.

The situation for a region importing milk is illustrated in Figure 1. If amenity benefits are not considered, equilibrium occurs where the industry marginal cost of production curve intersects the supply curve at market price P^r and production level Q^r. If amenity benefits are fully considered, equilibrium occurs where the marginal social cost of production equals P^r at a production level given by Q^*. The socially optimal production level Q^* is greater than Q' which is the level of production which maximizes net private benefits in the absence of government intervention. This implies that, by ignoring amenity benefits from local milk production, the market underallocates the amount of land area that should be devoted to dairy farms since $L^* = Q^*/Y^o > L' = Q'/Y^o$.

The regional welfare gains from fully considering the farmland amenity benefits are illustrated in Figure 1. The increase in production costs from attaining the optimal level of milk production is given by abQ^*Q'. The increase in amenity benefits is given by $abcd$, and the increase in milk production would bring additional milk sales of $P^r(Q^* - Q')$. Hence, the net welfare gain to the producing region is given by the shaded area acd (additional sales plus additional amenity benefits minus additional production costs).

In the case of relatively small milk producing regions, market distortions, such as those introduced through Federal support prices, marketing orders and foreign trade barriers, are to be taken as given and are reflected in the actual milk price received by producers. Under these conditions, the welfare maximizing strategy in (3) will utilize the actual price, P^a, as the reference price. For purposes of comparison, two other reference prices which represent different degrees of regulation are considered: a price under minimal marketing order regulation with only the Federal support price in place, denoted as P^m, and a world price for milk, P^w. This exercise reflects the on-going discussions of policy reform occurring at the national and international levels concerning deregulation of the milk market. However, since these two additional reference prices are only applicable if the relevant policy scenarios occur exogenously, no attempt should be made to make normative comparisons, such as those regarding social welfare levels, across reference prices.

Model Estimation

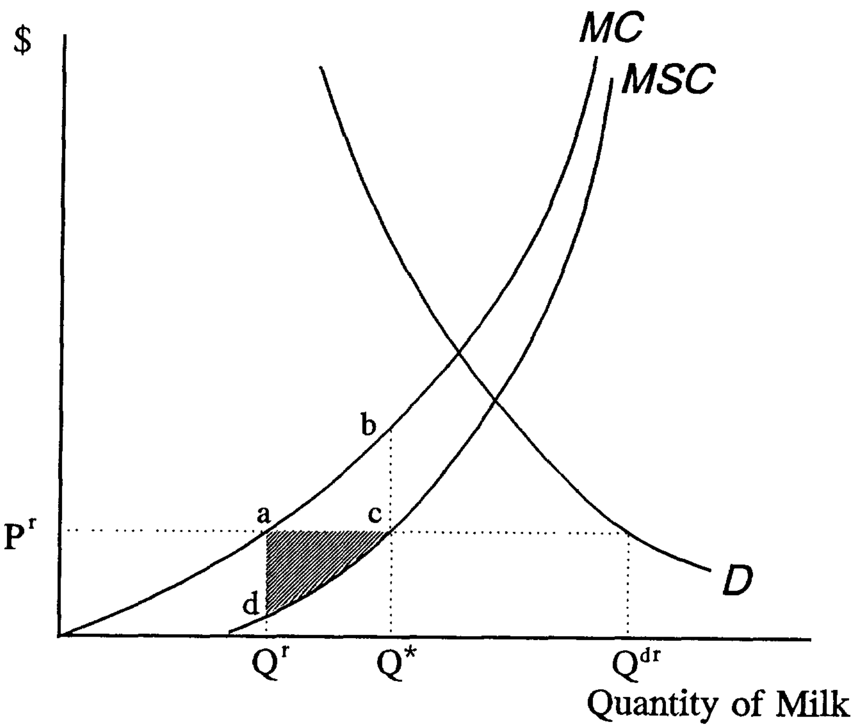
This section illustrates how the above conceptual model can be implemented to ascertain the optimal size of the Connecticut dairy sector in the presence of amenity benefits. More specifically, the objective of this section is to estimate marginal cost (MC), marginal amenity benefits (MAB) and demand (D) functions for milk in Connecticut. All of these functions are assumed to be log-linear in their parameters.

Given inflexibilities in the short run, due to asset fixity, technological constraints, and time required to adjust production choices in dairy (Quiroga and Bravo-Ureta, 1992), it seems reasonable to develop an analysis of partial adjustment behavior. Let an empirical model for milk production be expressed as

$$\ln Q_t^d = \alpha_o + \alpha_1 lnP_t + \sum \alpha_{2i} W_{it} + e_t, \tag{5}$$

where $\ln$ is the natural log operator, Q_t^d is the desired level of milk output in period t, P_t is the price of milk, W_{it} is a vector containing the price of inputs, αs are parameters; and e_t is a random disturbance. Following Gujarati (1988), the partial adjustment model is given by $\ln Q_t - \ln Q_{t-1} = \lambda(\ln Q_t^d - \ln Q_{t-1})$, where λ is the degree of partial adjustment and $0 \leq \lambda \leq 1$. Substituting for $\ln Q_t^d$ above, the observed level of milk production Q_t is given by:

Figure 1. **Market and Optimal Milk Production Levels in the Presence of Farmland Amenity Benefits.**



$$\ln Q_t = \beta_o + \beta_1 \ln P_t + \sum \beta_{2i} W_{it} + (1-\lambda)\ln Q_{t-1} + \mu_t, \tag{6}$$

where $\beta_i = \lambda\alpha_i$ and $\mu_t = \lambda e_t$. All data for estimating the parameters in (6) were collected for the 1960-90 period from *USDA Agricultural Statistics*. The input vector consisted of the agricultural wage rate (W_1), a feed price index (W_2), and a price index for energy (W_3). Observations on W_2 and W_3 were expressed as indexes whose values were set equal to 1 for 1990.

The regression results for equation (6) were corrected for first order serial correlation of the error terms. The results are as follows:

$$\begin{aligned} lnQ_t = {} & \underset{(2.42)}{0.940} + \underset{(3.04)}{0.267}\ln(P_t/W_{3t}) - \underset{(4.44)}{0.204}\ln(W_{1t}/W_{3t}) \\ & - \underset{(1.27)}{0.065}\ln(W_{2t}/W_{3t}) + \underset{(10.06)}{0.784}\ln Q_{t-1}, \end{aligned} \tag{7}$$

$R^2 = 0.913$ $N = 31$ $\hat{\rho} = -0.37$

where the values in parentheses are the absolute values of the t-statistics, $\hat{\rho}$ is the estimated first-order correlation parameter, and the other notation is as previously defined. The above regression equation predicts the 1990 Connecticut milk production level within one percent of the actual level of production. Furthermore, all the parameters estimated have the expected sign and, with the exception of feed price, are significant at the 5 percent level. Thus, the results were deemed reasonable and reliable for further use.

The regression results in (7) indicate that Connecticut's short-run price elasticity of supply is approximately 0.27, while the long run elasticity is estimated at 1.24.[3] Assuming competitive conditions ($P = MC$) and using the (fully-adjusted or long-run) inverse supply function, the marginal cost function (in 1990 \$/cwt) is given by:

$$MC = 0.0998Q^{0.808}. \tag{8}$$

To estimate the amenity benefit function, we use the relationship expressed in (1) and let the empirical form of this function be:

$$AB = \theta L^{\gamma_1} POP^{\gamma_2} I^{\gamma_3}, \tag{9}$$

where θ and the γs are the parameters to be estimated and other notation is as previously defined.[4] Estimates of total willingness-to-pay to prevent moderate levels of development on agricultural land are used to measure AB, and were obtained from Foster, Halstead, and Stevens (1982) for three Massachusetts communities and from Beasley, Workman, and Williams (1986) for a community located in the Matanuska-Susitna Valley outside Anchorage, Alaska. These studies were chosen because they used very similar surveys and because all four communities represent rapidly urbanizing areas with similar per capita incomes, where the loss of farmland is a concern. Values for farmland were also taken from these studies, while population and income data were collected from the *City and County Data Book*. All monetary values were expressed in 1990 dollars. The estimated amenity benefits function is given by:

$$AB = 1.024x10^{-14} L^{.172} POP^{.796} I^{3.877}. \tag{10}$$

These results show that amenity benefits are an increasing function of farmland, population, and income, and are consistent with our modeling assumptions regarding AB in the previous section.[5] Substituting Q/Y for L, the marginal amenity benefits accruing from milk production are given by:

$$MAB = .176x10^{-14} Y^{-.172} Q^{-.828} POP^{.796} I^{3.877}. \tag{11}$$

Equation (11) was applied to the case of the Connecticut dairy sector in the following manner. First milk yield was estimated from the *1987 Census of Agriculture* for Connecticut by dividing milk production by land in dairy. This resulted in a value of Y^o equal to 3,679 pounds per acre. Second, POP^o was set equal to the non-urban population in the state (686,000) since this group is more likely to enjoy dairy farmland amenity benefits on a regular basis relative to the remaining population. Third, I^o was taken as the 1990 per capita income for that segment of the population (\$18,716).[6] Using these values of Y^o, POP^o, and I^o in (11) gives:

$$MAB = 783.458Q^{-.828}. \tag{12}$$

Finally, a demand curve (D) for Connecticut was derived by utilizing observed price and quantity data and an elasticity of demand of -0.26 (Haidacher, Blaylock, and Myers, 1988). The estimated demand curve is given by:

$$Q^d = 1652.36P^{-0.26}, \tag{13}$$

where Q^d is milk consumption in millions of pounds and P is the farm-level price of milk in dollars per cwt.[7]

Three reference prices, P^a, P^m and P^w, are used to generate six equilibrium situations for the Connecticut dairy sector for 1990. The actual price received by Connecticut farmers, P^a, is \$14.70 per cwt for 1990 (USDA, Agricultural Statistics, 1991). The price under minimal marketing order regulation, P^m, is estimated at \$12.30,[8] and the world price, P^w, is estimated at \$10.06 per cwt.[9] For each reference price, two equilibrium solutions are obtained: one which equates the relevant reference price with marginal cost of production (MC) and another one which equates that price with the marginal social cost $MSC = (MC - MAB)$. The values of MAB and MC are derived from (8) and (12). The results and policy implications are presented below.

Empirical Results

The results in Table 1 show that in each of the three scenarios, when $P' = MSC$, the optimal amount of land in dairy exceeds that which would occur when only MC is considered. Also, the milk production level is higher when amenity benefits are taken into account. More specifically, under the actual situation, the optimal amount of land in dairy is estimated to be 31 percent higher than when land allocation is left to market forces. The additional amount of land devoted to dairy farms increases milk production and thus lowers import requirements. Under minimal marketing order regulation and world price, the increases in land are, respectively, 42 percent and 58 percent higher than in the allocation which ignores amenity benefits. Note that the percent change in land is higher the lower the reference price, primarily due to higher marginal amenity benefits stemming from lower dairy acreages. Also note that land in dairy is estimated to be 1 percent lower under the world price with amenity benefits than under the actual situation without considering amenity benefits.

The regional welfare implications of the three scenarios are outlined in Table 1. In all three cases, a comparison of the optimal solution (P', Q^*) with the corresponding market situation (P', Q') shows increased production costs (area abQ^*Q') in amounts ranging from \$21.74 million, using world price, to \$24.71 million in the actual situation. Increases in amenity benefits (area $abcd$) also occur and these range from \$9.55 million under world price to nearly \$6 million in the actual situation. Finally, milk sales also increase (area acQ^*Q') with gains of \$22 million accruing in the actual situation, about \$20 million under P^m, and \$17.7 million occurring under the world price. The result of all of the changes noted above is a net welfare gain (area adc) in all three scenarios.

To assess the impacts of exogenous variables on the allocation of resources in dairy, simulations were conducted where the milk reference price, wage rate, population, and income variables were increased by one percent in order to obtain elasticity coefficients. The results are

Table 1. Analysis of the Connecticut Dairy Sector Under Alternative Reference Prices and Policy Options, 1990.

	Actual		Minimal Marketing Order Regulation		World Market	
	$P^a=MC$	$P^a=MSC$	$P^m=MC$	$P^m=MSC$	$P^w=MC$	$P^w=MSC$
Policy Allocations						
Reference Price (\$/cwt)	14.70	14.70	12.30	12.30	10.06	10.06
Marginal Amenity Benefits (\$/cwt)	4.49	3.59	5.39	4.03	6.62	4.52
Marginal Cost (\$/cwt)	14.70	18.29	12.30	16.33	10.06	14.58
Production (million lbs)	482.25	631.93	386.77	549.27	301.58	477.57
Consumption (million lbs)	821.49	821.49	860.46	860.46	906.63	906.63
Imports (million lbs)	399.24	189.56	473.69	311.19	605.05	429.06
Land in Dairy (acres)	131,096	171,786	105,142	149,316	81,982	129,824
Welfare Changes from the Market Solution						
	Million Dollars					
Increased Production Cost	0	-24.71	0	-23.30	0	-21.74
Increased Amenity Benefits	0	5.99	0	7.53	0	9.55
Increased Milk Sales	0	22.00	0	19.99	0	17.70
Net Welfare Gain	0	3.28	0	4.22	0	5.51
Policy Program Costs						
Price Subsidy	0	22.67	0	22.13	0	21.61
Two-Tier Pricing	0	5.37	0	6.55	0	7.96
Production Cost Subsidy	0	2.71	0	3.31	0	4.04

presented in Table 2. A one percent increase in each of the three values for p^r results in increases of 0.65-0.83 percent in the optimal level of milk production and land devoted to dairy (since milk yield is assumed constant). The resulting change in NSB is only 1.25-1.43 percent lower than the corresponding results presented in Table 1. The main consequence from an increase in the agricultural wage rate is a reduction in the optimal size of the dairy industry, while the main consequence from increases in population is moderately increased net social benefits. Although the impact of a one percent increase in income on optimal quantity produced and land in dairy is moderate, the impact on NSB is substantial (6.91-7.30 percent increase). Thus, the potential contribution of public policy toward improving resource allocation in the face of amenity benefits is particularly strong in the more affluent areas.

Policy Implications and Conclusions

Within the context of our analysis, we consider three possible state-level policy programs

Table 2. Sensitivity Analysis for the Connecticut Dairy Sector.

Endogenous Variables	Exogenous Variables — 1% Increase in			
	P^r	Wage Rate	Population	Income
	Percent Change			
P^r = *Actual Price*				
Q*	0.83	-0.78	0.16	0.79
L*	0.83	-0.78	0.16	0.79
Q^a	1.24	-0.94	0.00	0.00
L^a	1.24	-0.94	0.00	0.00
NSB^a	-1.43	0.50	1.47	7.30
P^r = *Minimal Reg. Price*				
Q*	0.75	-0.75	0.19	0.95
L*	0.75	-0.75	0.19	0.95
Q^m	1.24	-0.94	0.00	0.00
L^m	1.24	-0.94	0.00	0.00
NSB^m	-1.28	0.53	1.50	7.20
P^r = *World Price*				
Q*	0.65	-0.71	-0.23	1.14
L*	0.65	-0.71	-0.23	1.14
Q^w	1.24	-0.94	0.00	0.00
L^w	1.24	-0.94	0.00	0.00
NSB^w	-1.25	0.42	1.39	6.91

for attaining the socially desirable level of milk production, and hence, land in dairy: a price subsidy, a two-tier pricing scheme, and a production cost subsidy. In principle, all three lead to the same aggregate social welfare, although they have quite different distributional consequences, as reported in Table 1.

First consider the case of a producer price subsidy. If a subsidy per cwt (equivalent to the value of MAB at Q^*) was added to P' in each of the three scenarios, this would yield P^*, the price at which the desired level of production would be obtained. The cost to the taxpayers is estimated at $MAB \times Q^*$ and is nearly equivalent in each of the three cases: \$22.67, \$22.13, and \$21.67 million, respectively. Next consider the use of a two-tier pricing scheme, where subsidies equal to the value of MAB at Q^* are paid only for each additional unit of milk beyond Q' (and up to Q^*). The cost of such a program is considerably lower than in the previous case and ranges from \$5.37 million in the actual situation to \$6.55 million under minimal marketing order regulation to nearly \$8 million under the world price.

Finally, a production cost subsidy program would entail payments to cover the net extra costs of expanding production from Q' to Q^*. The extra cost of expanding production is given by area abQ^*Q' in Figure 1. However, part of these costs can be covered by the additional milk sales (area acQ^*Q'). Hence, the minimum subsidy required to expand production is given by area abc. The cost of this policy would be slightly lower than that of the two-tier pricing scheme and would range from \$2.71 million in the actual situation to \$3.31 million under minimal marketing order regulation to \$4.04 million under world price. Hence, a production cost subsidy promises to be the most cost-effective option of the three programs considered.

Considering the distributional consequences of the alternative policy programs, milk producers would prefer a price support program which subsidizes all production. From the taxpayers' viewpoint, the production cost subsidy program would be preferable in view of the much higher costs associated with programs which subsidize the price of all or part of total regional milk production. From an implementation standpoint, objections to the production cost subsidy or two-tier pricing scheme can center on the administrative complexities of such programs. The adoption of these systems might be facilitated if complemented with producer quotas (Hubbard, 1992). An interesting modification of the use of quotas is to vest producers with the right to market $Q^* - Q'$ and let them trade their assigned quotas which qualify for the subsidy. In addition, the above programs might employ certain elements from the Federal set-aside programs for grain crops (USDA, 1990), such as making payments conditional upon land use. Note however that in the Federal set aside programs, the goal is to take land out of production, but in the case at hand the objective is to expand acreage due to positive externalities. Hence, payments to milk producers under any of the three programs mentioned above could be made conditional upon keeping land in dairy.

In summary, farmland in urbanizing regions often provides important amenity benefits that are not taken into account by agricultural commodity markets. This dual role of farmland, both in providing market goods and nonmarketed amenity benefits, can result in underallocation of land to agriculture if left to market forces. This article presents a simple model that accounts for farmland amenity benefits with the objective of analyzing the effects of alternative policy scenarios. An empirical illustration is provided using the Connecticut dairy sector.

The empirical findings show that the amenity benefits increase with farmland, population, and income. Simulation results indicate that land is underallocated to dairy in Connecticut, a relatively affluent and densely populated state. Although alternative policy programs can, in principle, attain the socially desirable level of production and land in dairy, they have quite different distributional consequences. Subsidizing the price of all or part of total regional production would entail relatively large transfers of income from taxpayers to producers. However, a production cost subsidy, which applies only to the additional production up to the socially desirable level, seems to be a cost-effective and reasonable alternative if supplemented with tradeable quotas, and if payments are conditional upon keeping land in dairy.

An important limitation of the analysis is the assumption of constant output/land ratio used in the specification of the amenity benefit function. Technological breakthroughs and the adoption of alternative management techniques could dramatically change this ratio and, hence, the results and policy implications. Also, it should be noted that the empirical procedures in this article are for illustrative purposes only. Ideally, data for estimating the amenity benefit function should be collected for a specific study area in order to make accurate site-specific policy recommendations.

The dual role of farmland in providing amenity benefits and agricultural commodities is likely to gain importance in the future as urban pressure on farmland increases. This article highlights the importance of quantifying and including amenity benefits in public decision making concerning the agricultural sector. Although it represents a first step in that direction, the agenda is wide open for extending the model. For example, Gardner (1994) advocates including considerations of land use dynamics, spatial heterogeneity, and political economy in models of this type. Extension of the analysis in any of these dimensions should prove fruitful.

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Endnotes

1. By holding yield constant, we assume that all inputs (including the number of cows) increase in the same proportion as land and that production technology remains the same. In other words, we assume that there are constant returns to scale. This assumption is supported by previous studies (Lee, Bravo-Ureta, and Ling, 1986; Grisley and Gitu, 1984). Since it is possible to increase milk production through more intensive application of non-land inputs or through adoption of land-saving technologies, an approximately constant production/land ratio can be ensured by using payment subsidies conditional on dairy land use, as discussed in the policy implications section.

2. The consumer surplus from milk does not enter the objective function since, given the small size of the region, the reference price, p', and the corresponding milk consumption remain unchanged.

3. Following Gujarati (1988, p. 250) and using equation (6), the long run parameters can be obtained by simply dividing β_i by λ and omitting the lagged dependent variable. In terms of our regression results, the long run supply function is given by:

$$lnQ_t = 4.35 + 1.24\ln(P_t/W_{3t}) - 0.93\ln(W_{1t}/W_{3t}) - 0.27\ln(W_{2t}/W_{3t}).$$

4. The empirical specification of the AB function is supported by the work of Brookshire, Randall, and Stoll (1980). They argue that total nonmarketed value of natural resources increases at a decreasing rate; i.e., the Hicksian compensated demand curve is downward sloping. This condition is satisfied if $0<\alpha_1<1$.

5. Note that the estimation of equation (9) involves four parameters necessitating a minimum of four observations, whereby dropping any observation requires omitting a parameter. The results were quite sensitive to the elimination of any observation. For example, deleting the Matanuska-Susitna observation and the income parameter, the results for equation (9) are:

$$AB = 15.4 \; x \; 10^5 L^{-0.431} POP^{0.285}$$

Note that the exponent of L is negative, which contradicts the theoretical conditions cited in footnote 4. Given problems of this type and that all variables in (9) are important determinants of AB, it was decided to keep the results in equation (10), using all four observations.

6. The 1990 population and income data for Connecticut were obtained from a report by the Connecticut State Data Center (1992).

7. The price elasticity of demand at the farm level was assumed to be the same as that at the U.S. consumer level. While studies generally yield mixed results, all agree that farm-level demand elasticity for fluid milk is quite low. Huang (1985) reported a direct-price elasticity of -.2588, with processed dairy products elasticities ranging from -.121 to -.3319.

8. The Northeastern price for milk under minimal marketing order regulation of McDowell, Fleming and Spinelly (1990) was used as a proxy for this price. This price was estimated at \$12.30/cwt for 1990 after the estimated 1988 price was adjusted upwards by 5.3 percent, based on a 8.9 percent increase in the producer price index for farm inputs (from Agricultural Statistics, 1991) and subtracting a 3.6 percent increase in productivity in the New England milk sector (from Cocchi, Bravo-Ureta, and Cooke, 1994). The Minnesota-Wisconsin manufacturing grade milk price, a price often quoted as a benchmark price for marketing orders, was reported at \$12.21/cwt for 3.5 percent milkfat milk in New England in 1990 (USDA, 1993), which is close to our estimate of \$12.30/cwt for price under minimal regulation.

9. The price of milk FOB North Europe and other world ports was used as the proxy for the world price, as it is often used in analyzing world dairy markets (USDA, *World Dairy Situation*). This price, which averaged \$8.05/cwt in 1990, was adjusted upward by 25 percent to account for transportation cost differences as well as the fact that Connecticut mainly produces milk for fresh consumption which carriers a premium over milk used for manufactured dairy products.