Factors Affecting the Adoption of Sustainable Agricultural Practices

Gerard D'Souza, Douglas Cyphers, and Tim Phipps

The extent to which individual factors influence the adoption of sustainable agricultural practices is estimated using a logit model and data from a 1990 survey of West Virginia producers. The results are, as expected, different than those for conventional agricultural technologies. For example, the effects of human capital characteristics are significant, while those for structural and institutional characteristics are not. However, the likelihood of adoption of sustainable agricultural practices is affected most by the environmental characteristic of whether or not the producer is aware that ground water contamination exists on his farm. This creates an important "awareness effect" upon which policies to promote sustainable agriculture adoption can be formulated. It also implies the existence of a derived demand for sustainable agriculture.

The issue of technology adoption by agricultural producers has been extensively studied. These studies have generally focused either on the technology adoption processes at the firm level (e.g., Feder and Slade; Feder, Just and Zilberman; Thirtle and Ruttan) or on identifying significant characteristics associated with adopters of individual technologies (e.g., IPM adoption by Harper, *et al.;* McNamara, Wetzstein, and Douce; bST adoption by Zepeda; adoption of soil conservation practices by Nielsen, Miranowski, and Morehart; Rahm and Huffman). This study belongs to the latter category, focusing on significant characteristics associated with adoption of sustainable agricultural production practices. Such knowledge is important because it can be used to formulate specific policies and/or target specific groups of producers to promote adoption of sustainable agricultural practices.

There is no general agreement in the sustainable agriculture (SA) literature as to what specific practices constitute a sustainable production system. One classification scheme might categorize a SA system as one involving: a) a combination of sustainable production practices, rather than a single practice used in isolation, even if, like integrated pest management (IPM), it is generally considered to be a member of the sustainability set; in conjunction with b) the discontinuation or the reduced use of production practices with the potential for causing environmental damage. Thus, for purposes of this study, a SA system is defined as one involving the continued or increased use of a combination of appropriate practices or technologies selected from among the following: a) manure utilization, crop rotations, IPM, rotational grazing, tillage for seed bed preparation, and cultivation for weed control and simultaneously, b) the reduced use or non-use of petroleum-based products, commercial fertilizers, pesticides, hormones or growth stimulators, and antibiotics.

The objective of this study is to determine the characteristics associated with the SA adoption decision and to explore the resulting policy implications. The role of specific factors on the adoption of SA practices is analyzed using data from a survey of West Virginia (WV) producers and a SA adoption model. A description of the model and the data follows.

Framework and Model

The technology adoption literature (as embodied in studies by Feder, Just and Zilberman; Harper, *et al.;* McNamara, Wetzstein, and Douce; and Rahm and Huffman) is used to guide the formulation of the model. According to this literature, factors af-

The authors are an associate professor, a former graduate research assistant, and an associate professor of agricultural and resource economics, respectively, Division of Resource Management, West Virginia University, Morgantown, WV 26506-6108 Scientific article No. 2369, West Virginia University Agricultural and Forestry Experiment Station, Morgantown. We gratefully acknowledge the input of Dale Colyer, the assistance of Jim Brueggen and the USDA, NASS staff with the survey, the computer programming support of Mohammed Miah, and the helpful review comments of Alan Collins, Bob Diener, Jerry Fletcher and, in particular, the comments of two anonymous referees, on earlier drafts. The usual caveat applies.

fecting technology adoption can be grouped under human capital, structural, institutional and environmental categories. The adoption of a SA system can be expected to be influenced by the same characteristics as those that influence adoption of conventional technologies. However, because a SA system differs in many respects from a conventional production system, one could also expect that the relative influence of these characteristics would differ between these systems. For example, given the close relationship between SA and the environment, it can be hypothesized that environmental characteristics such as ground water quality will have a significant influence on the adoption of a SA system. Accordingly, an econometric model is formulated to test such hypotheses.

The dependent variable of the model represents whether a producer is an adopter or a non-adopter of SA practices. It is measured depending on whether or not the use of a minimum number of sustainable practices was maintained or increased, in conjunction with a minimum number of inappropriate (from the viewpoint of sustainability) practices that was reduced or not used during a 5-year period (1984–1989). An adopter is one whose use of at least four of the six previously specified practices was maintained or increased, and whose use of at least three out of the five specified inappropriate practices was reduced or discontinued. These minimums were arbitrarily selected.

The characteristics and associated variables (Table 1) influencing the adoption of a SA system are hypothesized to be as follows:

(a) *Human capital characteristics* are represented by age and education. Education, similar to its role in the adoption of other technologies, is expected to be positively and significantly associated with adoption of sustainable technologies. Age is likely to be negatively associated with adoption; younger farmers are more likely to adopt new technologies and/or are more likely to be early adopters.

(b) *Structural and financial characteristics* are represented by farm size, debt/asset ratio, off-farm employment, and hired labor. With the possible exception of farm size whose sign is indeterminate on an *a priori* basis, these factors are likely to be negatively associated with the SA adoption decision. Thus, a highly leveraged farmer, for example, is not as likely to change from a conventional production system because of actual or perceived internal constraints (e.g., the need for cash-flow to service debt) and external constraints (e.g., those that are lender-imposed). Because SA does not have a scale effect like computers or tractors (unless there are learning considerations) there is no reason to believe *a priori* that its use will be affected by farm size. Also, unlike conventional technologies, there is no reason to expect that large farmers will necessarily be the early adopters. In addition, because SA involves the partial substitution of management for other factors of production and is therefore more time-intensive, it is more likely to be adopted by full-time farmers. Thus, the presence of off-farm employment on the part of the farmer is likely to be negatively associated with his or her SA adoption decision. Because SA, by definition, relies more on natural processes and is therefore labor-saving, the use of hired labor on SA farms is likely to be less than on conventional farms. Thus, the use of hired labor on the part of the farmer is hypothesized to be negatively associated with his or her SA adoption decision.

(c) *Institutional characteristics* are represented by a policy variable reflecting participation in farm commodity programs. Given the possible inflexibility for producers who participate in government programs to change production practices it is likely that this factor will be negatively related to the adoption decision.

(d) *Environmental characteristics* are represented in the model by ground water quality. Conceptually, the likelihood that certain agricultural produc-

Table 1. Definition of Variables Used in the Sustainable Agriculture Adoption Model

Variable	Description
Dependent variable	1 if the producer adopts a package of sustainable agriculture techniques; 0 for a non-adopter or "conventional" producer
Explanatory variables:	
AGE	1 if the producer is over 55 years old; 0 otherwise
EDUCATION	1 if the producer has more than a high school education; 0 otherwise
GROUNDWATER	1 if the producer is aware that ground water contamination presently exists on the farm; 0 otherwise
EMPLOYMENT	1 if the producer works more than 200 days off the farm; 0 otherwise
SALES	1 if farm sales exceeds $10,000; 0 otherwise
GOVT PROGRAMS	1 if the producer participates in government farm programs; 0 otherwise
LABOR	1 if the producer uses hired labor; 0 otherwise
DEBT/ASSET	1 if the producer's farm-related debt/asset ratio exceeds 10 percent; 0 otherwise

tion decisions contribute to a reduction in environmental quality is embodied in the framework Just and Antle developed to capture the impacts of farm policy decisions on the environment. This raises the possibility that reverse linkages (i.e.,—environmental characteristics affecting production decisions) also exist. In the context of technology adoption, Harper, *et al.*, for example, generalize that "a broad class of environmental variables appears relevant in explaining technology adoption behavior" (p. 1003), based in part on their finding that the nature of neighboring land uses significantly affects insect-management technology adoption. Therefore, awareness that an environmental characteristic such as ground water contamination exists on a farm is likely to increase the likelihood that the producer will use sustainable production practices to ameliorate such contamination if production practices are the source of the contamination and/or ground water is the source of the household water supply. Accordingly, this variable is hypothesized to have a positive sign.

The model used to analyze the factors affecting the adoption of SA practices is given by:

$$\begin{aligned} Y_i = {} & \beta_0 + \beta_1 AGE_i + \beta_2 EDUCATION_i \\ & + \beta_3 GROUNDWATER_i \\ & + \beta_4 EMPLOYMENT_i + \beta_5 SALES_i \\ & + \beta_6 GOVTPROGRAMS_i + \beta_7 LABOR_i \\ & + \beta_8 DEBT/ASSET_i + \epsilon_i \end{aligned}$$

with variables as defined earlier.

The dichotomous nature of the dependent variable suggests that either a probit/normit or a logit model is appropriate.[1] The specification of these models is discussed in econometric texts (e.g., Maddala; Pindyck and Rubinfeld).

Data and Estimation

The model was estimated using cross-sectional data obtained from a 1990 mail survey of WV agricultural producers. A stratified random sample of 600 producers were surveyed. While the mailing list for the 600 producers surveyed was obtained from the USDA, NASS, the survey itself was conducted by the authors. A comparison of producer characteristics in the sample (summary descriptive statistics for which were also obtained from the USDA, NASS) with those reported in the 1987 Census of Agriculture (U.S. Department of Commerce) confirmed that the sample was representative.

The response rate obtained from two mailings was 53 percent, with a 39 percent usable response rate. On completion of the survey, another comparison was made, this time to compare respondent and non-respondent characteristics. Except for the average size of fruit farms and poultry farms, these characteristics are similar. The relatively small number of fruit and poultry farms in WV, plus the fact that one or more of the larger operations responded is a possible reason for the larger average size of these operations among the respondents.

Given the nature of the variables and the fact that the corresponding survey data for these variables were in the form of responses to discrete categories rather than a specific number, all variables were binary choice. If data were available to represent some of these variables as continuous, it could have led to improved results.[2] However, previous logit studies that were similar in this regard (e.g., Harper, *et al.*) have yielded satisfactory results. Descriptive statistics for the variables included in the model, for the sample as a whole as well as for the adopter and non-adopter subsets, are summarized in Table 2.

Maximum likelihood is used in estimation. With regard to the functional form, both the logit and the probit forms were tried. Because they yielded similar results, only one set (the logit) coefficients is presented and discussed below.

Results

The estimated coefficients of the SA adoption model are presented in Table 3. Four of the eight variables are significant at the 10-percent or higher level, with all four possessing the hypothesized signs. The coefficients for AGE and EDUCA-

[1] While the choice of which specification to use is usually a matter of convenience (neither seems to dominate on theoretical—or empirical—grounds according to Capps and Kramer), the logit formulation is preferred according to Hanushek and Jackson, because of its convenient mathematical properties and desirable S-shape. According to Pindyck and Rubinfeld (p. 289), an important appeal of the logit model is that ". . . it transforms the problem of predicting probabilities within a (0, 1) interval to the problem of predicting the odds of an event's occurring within the range of the entire real line." Further, according to Maddala, while the slope estimates from the two methods are not directly comparable, in the absence of a large sample size the empirical results obtained from the two specifications are not likely to be very different.

[2] The related issue of whether or not, for a study such as this, a dependent variable that is continuous would be preferable to one that is not, is more debatable. For instance, an alternative to the binary dependent variable that was used would have been to use a continuous variable, such as percentage of practices adopted out of a given maximum, to represent intensity of adoption. However, some adherents of sustainability would object to such a classification scheme on the basis that there is no such thing as *degree* of sustainability—according to them, an operation is either sustainable or not sustainable.

Table 2. Descriptive Statistics for the Binary Variables Used in the Sustainable Agriculture Adoption Model, by Sample and Sub-Sample Categories

	Sample (n = 233)		Adopters (n = 37)		Non-Adopters (n = 196)	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Y (dep. var.)	0.159	0.366				
AGE	0.489	0.501	0.297	0.463	0.526	0.501
EDUCATION	0.378	0.486	0.541	0.505	0.342	0.476
GROUNDWATER	0.064	0.246	0.135	0.347	0.051	0.221
EMPLOYMENT	0.369	0.484	0.297	0.463	0.378	0.486
SALES	0.24	0.428	0.189	0.397	0.25	0.434
GOVT PROGRAMS	0.142	0.349	0.108	0.315	0.143	0.351
LABOR	0.33	0.471	0.27	0.45	0.342	0.476
DEBT/ASSET	0.262	0.441	0.351	0.484	0.245	0.431

TION are significant at the 1-percent level, whereas the coefficients for EMPLOYMENT and GROUNDWATER are significant at the 5- and 10-percent levels. Among the significant variables, age and off-farm employment are negatively correlated with the SA adoption decision. Education and groundwater contamination, on the other hand, have positive signs.

In contrast to results from some previous technology adoption studies (but not necessarily contrary to expectations), with the exception of off-farm employment none of the other structural or the institutional variables is significant. Variables representing hired labor, financial leverage, and participation in government farm programs fall in this category. With regard to the farm size variable, as hypothesized, adopters of SA cut across all size categories.

Comparing these results to other technology adoption studies, farm size, for example, is found to be a significant determinant of technology adoption by Putler and Zilberman, Rahm and Huffman, and Rook and Carlson. It is not found to be significant by Harper, *et al.* With regard to the role of environmental characteristics in technology adoption, Rahm and Huffman found that soil type and crop rotation are significant determinants of reduced tillage adoption, while Caswell and Zilberman found that the source of irrigation water is a significant determinant of irrigation technology. Education is found to be a significant variable by Harper, *et al.*, Putler and Zilberman, and Rahm and Huffman for example; unlike other studies, however, Harper, *et al.* find that the influence is negative.

The R^2 is 0.10. A low R^2 is to be expected, since an upper bound R^2 for binary-choice models is about .33 (Pindyck and Rubinfeld). The likelihood ratio test is significant at the one-percent level, indicating that the model has good explanatory power. The ratio of correct predictions is 85 percent.

Table 3. Maximum Likelihood Estimates, Goodness-of-Fit Measures, and Changes in Probability for the Sustainable Agriculture Adoption Model

Variable	Coefficient	t-Ratio	Change in Probability for Significant Coefficients
AGE	−1.1501***	−2.6066	−0.1440
EDUCATION	0.9184***	2.3630	0.1983
GROUNDWATER	1.0368*	1.6073	0.2275
EMPLOYMENT	−0.8444**	−1.9413	−0.1165
SALES	−0.5971	−1.1561	
GOVT PROGRAMS	−0.1500	−0.2653	
LABOR	−0.3504	−0.7980	
DEBT/ASSET	0.2226	0.5090	
CONSTANT	−1.2044***	−2.8848	
McFadden R^2	0.10		
Likelihood Ratio Test	21.07***		
# Right Predictions	198 (85%)		

***Indicates significance at the 1-percent level.
**Indicates significance at the 5-percent level.
*Indicates significance at the 10-percent level.

The probabilities presented in Table 3 show the effects of changes in the individual explanatory variables on the likelihood of adoption of SA practices assuming that all other explanatory variables are set to zero. Only those probabilities associated with statistically significant (at the 10-percent or better level) variables are reported and discussed. Thus, for WV producers, the likelihood of adoption of SA systems increases by almost 23 percent if the producer is aware that groundwater contamination exists on their farm. If the producer has at least a high school education there is a 20 percent increase in the likelihood of adoption. On the other hand, a producer over 55 is 14 percent less likely to adopt a SA system (this is consistent with the finding by Taylor and Dobbs, for example, that almost 80 percent of SA producers are under age 55). A producer who is employed off the farm for more than 200 days of the year is 12 percent less likely to adopt SA practices. The positive and negative probabilities reflect the fact that the influence of factors could offset each other.

Using the method described earlier to categorize producers as sustainable or conventional, 16 percent of WV producers are characterized as adopters of SA practices (in 1989, the Environmental Law Institute found that five percent of all U.S. farmers are adopters). Assuming that a policy goal is to increase this number, programs that promote on-farm water quality testing are likely to be effective in stimulating adoption. This "awareness effect" can be magnified if water quality prevention programs are targeted towards producers who are more educated, and/or those who are relatively younger and work full-time on the farm.[3] Such programs are likely to be most beneficial in areas especially vulnerable to contamination such as Karst areas.[4] This is especially critical during a time of fiscal restraint and, when in WV, as in most other states, agencies such as the Extension Service and/or the Soil Conservation Service are substantially expanding water quality testing programs.

It should be noted that legislation such as the 1987 Water Quality Act (as well as other policies affecting agriculture, summarized by Reichelderfer) and more recently, the Water Quality Incentive Program, is already in place to reduce groundwater contamination and other nonpoint-source pollution threats. If policies such as the targeting strategy are implemented and prove successful, the need for additional regulations could be preempted.

It should also be emphasized that the objective of this study was to identify the characteristics significantly influencing the sustainable agriculture adoption decision (i.e., the "who"). Thus, while the issue of "why" is not directly addressed, it is relevant and needs explanation. If, as is generally assumed, patterns of adoption correspond to the nature of the technology, sustainable agriculture may be adopted by a producer because of three reasons: 1) demand by consumers for chemical-free or organic products, and therefore potential for increased producer revenue, 2) potential cost savings for producers, and 3) personal beliefs of the farmer. The cost savings may be associated either with reduced chemical, fertilizer, and other input use, or with the ability of producers to deal more effectively with environmentally-related regulations. Thus, profit-maximizing producers are more likely to reduce their use of an input when it causes negative off-site impacts that could be subject to taxation or regulation (the same is not necessarily true for utility-maximizing producers because changes in input use in this case depend, in addition, on the type of risk aversion of the producer, e.g., decreasing absolute risk aversion (DARA) or constant absolute risk aversion (CARA), as well as the type of input, i.e., risk-reducing or risk-increasing[5]). Either because regulations already exist or may be anticipated (for example, owner liability for environmental contamination) profit-maximizing farmers whose practices are associated with water quality problems—regardless, or perhaps in spite, of their belief system—are more likely to adopt sustainable systems. Whether or not this is true, of course, needs empirical verification.

Conclusions and Other Implications

Data from a survey of West Virginia farmers were used in a logit model to determine the characteristics associated with the adoption of sustainable ag-

[3] It must be recognized that while monitoring ground water quality may be essential and desirable, it involves relatively sizable costs. USDA estimates of initial monitoring costs for private wells in vulnerable counties nationwide (as reported by Lee) range from almost $1 billion to over $2 billion. In addition, issues relating to who should pay what share of the monitoring and, if necessary, treatment costs need to be resolved.

[4] These are areas characterized by a limestone aquifer medium, where chemicals leaching into ground water spread quickly across large distances.

[5] DARA (CARA) producers are defined as those for whom the risk premium and wealth level are inversely related (constant). Alternatively, for DARA (CARA) producers, the degree of risk aversion is a decreasing (constant) function of wealth. Risk-reducing (increasing) inputs are defined as those associated with a decrease (increase) in the coefficient of variation of yields.

ricultural practices. Human capital characteristics such as a producer's age and education were found to be significant determinants of the adoption decision. Except for off-farm employment, the hypothesis of zero parameters for other structural and financial characteristics such as farm size and debt/asset ratio, contrary to the findings of many previous technology adoption studies, could not be rejected. This is probably because of the nature of the technology, something that future research can confirm. Along these lines, future research is needed to focus on or resolve issues such as the intensity of adoption (and whether this is applicable to sustainable agriculture), and substitution or complementarity between practices constituting a sustainable production system.

As hypothesized, an environmental characteristic does have a significant influence on adoption of a sustainable production system. In this study, the likelihood of adoption of sustainable agriculture is affected most by an environmental characteristic, ground water quality. The fact that ground water is contaminated, of course, does not in and of itself affect farming practices; rather it affects the farm operator. If, for instance, the presence of ground water contamination is traced to a producer's existing practices and/or if the ground water is the source of household water to the farm family, then farm practices become the vehicle for change from a conventional to a sustainable production system to reduce or eliminate such contamination. However, it is not always possible to trace the source of contamination, nor is it always possible to contain it if it can be traced. Given the common property problem inherent in this situation, and the importance to society of a pure ground water supply, policy intervention is justifiable whether or not the source of contamination can be traced to an individual's farming practices.

Thus, the results can provide a useful framework for decision-making as producers and policy makers confront growing environmental problems caused by, and affecting, agriculture. Implications can be derived for producers for whom local environmental quality is closely linked to production practices. In addition, the results can facilitate the policy formulation process as policy makers, responding to societal pressures, attempt to move agriculture in a more sustainable direction while trying to improve environmental quality in general.

If the finding that sustainable agriculture adoption is strongly affected by environmental characteristics such as ground water quality is borne out by additional research, this could have profound impacts for farm policy formulation. It could, for instance, alter the mix of incentives and regulation in favor of increased incentives and possibly preclude the need for additional regulations. Yet, there remains an unresolved issue of whether it is the actual or perceived increase in environmentally-related regulations causing the adoption of this technology in the first place. Conceptually, to address and/or reconcile such issues it is useful to postulate the existence of a derived demand for sustainable agriculture. That is, one derived from the demand for a cleaner environment in general or clean water in particular, to satisfy increased regulations.

These deal with causal issues that are beyond the scope of this study (which focuses on the individual), but can be addressed in future research. Along these lines, future research could focus on additional issues such as partitioning farms by type (e.g., row-crop, mixed crop and livestock) or determining response to different types and degrees of ground water contamination. It would also be valuable to conduct a Chow test of equality to determine stability of coefficients across space and/or time.

The modeling results indicated that the sustainable agriculture adoption decision in WV and other similar areas is not likely to be affected by policies that influence physical and financial characteristics like traditional farm commodity programs. Instead, an effective water quality testing program, targeted at certain producers, is likely to ensure that sustainable agriculture gains in adoption. Increased adoption, in turn, could contribute to achieving the societal goal of improved environmental quality.

References

Capps, O. Jr. and R.A. Kramer. "Analysis of Food Stamp Participation Using Qualitative Choice Models." *American Journal of Agricultural Economics* 67(1985):49–59.

Caswell, M.F. and D. Zilberman. "The Choice of Irrigation Technology in California." *American Journal of Agricultural Economics* 67(1985):224–33.

Environmental Law Institute. "The Promise of LISA." *Environmental Forum* 6(1989):23.

Feder, G., R.E. Just, and D. Zilberman. "Adoption of Agricultural Innovations in Developing Countries: A Survey." *Economic Development and Cultural Change* 33(1985): 255–98.

Feder, G. and R. Slade. "The Acquisition of Information and the Adoption of New Technology." *American Journal of Agricultural Economics* 66(1984):312–20.

Hanushek, E.A. and J.E. Jackson. *Statistical Methods for Social Scientists*. New York: Academic Press, 1977.

Harper, J.K., M.E. Rister, J.W. Mjelde, B.M. Drees, and M.O. Way. "Factors Influencing the Adoption of Insect

Management Technology." *American Journal of Agricultural Economics* 72(1990):997–1005.

Just, R.E. and J.M. Antle. "Interactions Between Agricultural and Environmental Policies: A Conceptual Framework." *American Economic Review* 80(1990):197–202.

Lee, L.K. "Farm Chemicals and Groundwater Quality." *Agricultural Outlook*. ERS, USDA. Washington, D.C., September 1987. pp. 18–20.

Maddala, G.S. *Limited-Dependent and Qualitative Variables in Econometrics*. New York: Cambridge University Press, 1990.

McNamara, K.T., M.E. Wetzstein, and G.K. Douce. "Factors Affecting Peanut Producer Adoption of Integrated Pest Management." *Review of Agricultural Economics* 13(1991):129–39.

Nielsen, E.G., J.A. Miranowski, and M.J. Morehart. "Investments in Soil Conservation and Land Improvements: Factors Explaining Farmers' Decisions." Agr. Econ. Rep. No. 601, ERS, USDA. Washington, D.C., January 1989.

Pindyck, R.S. and D.L. Rubinfeld. *Econometric Models and Economic Forecasts*. New York: McGraw-Hill, Inc., 1981.

Putler, D.S. and D. Zilberman. "Computer Use in Agriculture: Evidence from Tulare County, California." *American Journal of Agricultural Economics* 70(1988):790–802.

Rahm, M.R. and W.E. Huffman. "The Adoption of Reduced Tillage: The Role of Human Capital and Other Variables." *American Journal of Agricultural Economics* 66(1984):405–13.

Reichelderfer, K. "A Survey of Resource and Environmental Policies Affecting Agriculture." *Agricultural Outlook*. ERS, USDA. Washington, D.C., March 1988. pp. 28–33.

Rook, S.P. and G.A. Carlson. "Participation in Pest Management Groups." *American Journal of Agricultural Economics* 67(1985):563–6.

Taylor, D.C. and T.L. Dobbs. "South Dakota's Sustainable Agriculture Farmers." *Economics Newsletter,* No. 264. Economics Department, South Dakota State University, Brookings, November 1988.

Thirtle, C. and V.W. Ruttan. *The Role of Demand and Supply in the Generation and Diffusion of Technical Change*. New York: Harwood Academic Press, 1987.

U.S. Department of Commerce, Bureau of the Census. *1987 Census of Agriculture: Part 48: West Virginia State and County Data*. Washington, D.C.: U.S. Government Printing Office, 1988.

Zepeda, L. "Predicting bST Use by California Dairy Farmers." *Western Journal of Agricultural Economics* 15(1990):55–62.