5-1995

Program Participation and Farm-Level Adoption of Conservation Tillage: Estimates from a Multinomial Logit Model

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Abstract
Over the past decade, conservation compliance has reduced soil erosion. What will happen to these erosion benefits if commodity programs are eliminated or if the subsidy level is greatly reduced? This study investigates whether there will be a significant decline in the amount of acreage on which conservation practices are adopted if future farm program benefits are not tied to conservation compliance.

Disciplines
Agricultural and Resource Economics | Agricultural Economics | Economics

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Working Paper 95-WP 136
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This research was partially supported by EPA Cooperative Agreement No. CR 822045-01-1. The views in this paper are those of the authors.

ABSTRACT

The conservation compliance provision of the 1985 Food Security Act requires highly erodible land to be cropped according to a locally approved conservation plan. There is overwhelming evidence that conservation compliance has reduced soil erosion. A key issue confronting Congress as they consider 1995 Farm Bill options is the fate of these erosion benefits if commodity programs are eliminated or if the subsidy level is greatly reduced. This study provides policymakers with additional insights into the relationship between conservation tillage practices and government programs by using observed farmer behavior. The central question addressed is: If future program benefits are not tied to conservation practices, will there be a significant decline in the amount of acreage on which conservation practices are adopted?

Tillage adoption decisions are modeled within a multinomial logit framework. There is limited evidence to argue that there will be a significant decline in conservation tillage for corn if program benefits are reduced. For wheat, the results suggest that conservation tillage practices are costly, and that wheat farmers may reduce conservation tillage if conservation compliance provisions are weakened or eliminated. However, no-till on wheat fields may increase with more flexibility. For corn, there is significant support for an increase in no-till if more corn-soybean rotations are adopted.

PROGRAM PARTICIPATION AND FARM-LEVEL ADOPTION OF CONSERVATION TILLAGE: ESTIMATES FROM A MULTINOMIAL LOGIT MODEL

The conservation compliance provision of the 1985 Food Security Act required highly erodible land to be cropped according to a locally approved conservation plan. Under the provision, farmers had until January 1, 1990, to develop a conservation plan and until January 1, 1995, to fully implement those plans to remain eligible for farm program benefits. There is overwhelming evidence that conservation compliance has reduced soil erosion. Kellogg et al. (1994) reports that most of the 270 million tons of soil saved annually on the highly erodible land that remained in production since 1982 is attributable to the conservation compliance provision. In an interview with *Choices* magazine, Keith Collins reports that conservation compliance decreased erosion on highly erodible land from 15 to 20 tons per acre per year to about 5 to 6 tons (Ayer 1995).

A key issue confronting Congress as they consider 1995 Farm Bill options is the fate of these erosion benefits if commodity programs are eliminated or the subsidy level is greatly reduced. If farmers have adopted conservation practices solely to remain eligible for government subsidies, then removal of these subsidies will likely lead to large increases in soil erosion rates. However, if farmers have adopted soil-conserving practices because they are more profitable than traditional practices, then elimination of government subsidies will have little effect on soil erosion rates.

Crop residue management is an important conservation practice in most approved conservation plans. Nearly 75 percent of acreage subject to conservative compliance will use some sort of crop residue management (Ayer 1995). Crop residue management includes conventional tillage, reduced tillage, and no-till. While there is no consensus on the exact characteristics of these systems, their differentiation can be thought of as a continuum based on the amount of previous crop residue left on the field and the extent of soil disturbance (Duffy and Hanthorn 1984). While conventional tillage involves extensive field cultivation with minimum residue cover (less than 30 percent), conservation tillage (reduced tillage and no-till) is characterized by minimum soil disturbance and increased residue cover.

Soil erosion benefits attributable to conservation tillage are significant. However, the economic benefits of conservation tillage in terms of input use and returns have not been conclusively determined for all crops. Adoption of conservation tillage typically involves some substitution of herbicides for mechanical weed control. The reluctance of some farmers to adopt conservation tillage is believed by some analysts to be due to the lack of adequate information regarding its economic benefits.

Evidence about the extent to which program participation influences the adoption of conservation practices is also inconclusive at best. Helms, Bailey, and Glover (1987) simulated a dryland wheat farm in Utah and concluded that risk-averse farmers prefer a combination of minimum tillage and no-till with program participation. Their study did not consider rotation impacts and they assumed identical yield distribution for all tillage practices. Williams, Llewelyn, and Barnaby (1990) studied Kansas wheat and sorghum farms under seven different rotation systems using tillage-specific actual yields. They conclude that commodity programs do not generally encourage no-till practices.

The objective of our research is to provide policymakers with additional insight into the relationship between conservation tillage practices and government programs by using observed farmer behavior rather than simulation results. The central question we address is, if future farm program benefits are not tied to conservation practices, will there be a significant decline in the amount of acreage on which conservation practices are adopted? Although farmers may choose to adopt conservation tillage due to private incentives from increased production efficiency and sustained long-term productivity, it is not clear whether private benefits alone will lead to widespread adoption of conservation tillage.

We model tillage adoption decisions as a trichotomous choice variable in which farmers adopt conventional tillage, reduced tillage, or no-till. We estimate the model using multinomial logit. We test the hypothesis that participation in government programs plays an important role in determining tillage choice using four years of data (1990-93) from the USDA Cropping Practices Survey conducted on U.S. corn, cotton, and wheat farms. We also test how crop rotation affects tillage adoption decisions. An informal study of conservation tillage practices (MAX Report 1992) suggests that crop rotation is an important factor affecting tillage decision because conservation systems tend to yield different returns for various types of rotation. Disaggregated data are also employed to evaluate the extent to which differences in potential erosion characteristics of survey farm fields explain the use of the three tillage practices.

This paper discusses the important factors that influence tillage adoption decisions of farmers, presents the multinomial logit model, presents the USDA Cropping Practices Survey data along with preliminary results, presents the econometric results from the analysis, and discusses potential policy implications.

Optimal Crop Residue Management Decisions

A primary factor affecting technology adoption decisions of producers is the increased profit from the new technology. If the new technology is also riskier, adoption rates may slow, but competitive pressures will eventually force adoption of profit-increasing technologies. The profit increase can come from production cost decreases or increases in yields or product quality. In addition, profits can be increased if eligibility for subsidies is tied to technology adoption. The choice of tillage system affects costs (both fixed and variable) and, in the long run, it may also affect yields, especially on highly erodible soils. Also, if a farmer is cropping highly erodible soil, subsidies may be withdrawn unless soil-conserving practices are adopted.

Moving from conventional tillage to conservation tillage will often reduce the number of tillage operations and increase the amount of pesticides used. Increased pesticides substitute for the pest control benefits of tillage operations. In addition, adopting conservation tillage typically requires investing in new planting equipment. Ignoring, for now, the effects of cropping highly erodible soils on adoption decisions, farmers who expect to achieve the largest reduction in variable costs, and those that can get by with little new investment are the ones who are most likely to adopt conservation tillage practices. What production environment is likely to lead to these cost changes? Consider the effects of crop rotation.

By interrupting the life cycles of weeds, insects, and disease, farmers who rotate their crops typically use less pesticide than those farmers who do not rotate. Because pest pressure is greater on farmers who do not rotate, the marginal pest control benefits from tillage operations are typically higher than the marginal benefits to farmers who rotate their crops. If true, then farmers who do not rotate their crops and who adopt conservation tillage practices will rely more heavily on pesticides than farmers who rotate. This implies that the cost savings from adopting conservation tillage practices is likely lower for farmers who do not rotate than for those who rotate. In addition, farmers who do not rotate but who do adopt conservation tillage are likely to be more susceptible to crop loss from pest damage. From this discussion, we can hypothesize that farmers who operate in a crop rotation system are more likely to adopt conservation tillage than those who are in a continuous cropping system.

Now consider the effects of cropping on highly erodible soils. First, consider farmers who do not participate in government commodity programs. The soil loss from conventional tillage practices can greatly reduce a field's potential productivity. Thus, farmers who have highly erodible fields have an incentive to adopt soil-conserving practices, particularly farmers who have a relatively low discount rate. We hypothesize that farmers who crop highly erodible fields will adopt conservation tillage practices faster than farmers who do not crop highly erodible fields. Now consider the incentive to maintain farm program payments.

Farmers who crop fields that have been designated highly erodible had to implement an approved conservation plan by January 1, 1995. A major component of most plans is adoption of conservation tillage practices. Thus, when 1995 data become available, most farmers who receive program payments and who farm highly erodible soils will have adopted conservation tillage practices. The last year of data we have for our analysis is 1993. By 1993, all participating farmers had approved conservation plans, and some of the plans were at least partially implemented. Also, farmers who knew they would eventually have to invest in conservation tillage equipment, and who needed to replace worn-out equipment in the 1990-93 period, likely made the investment. Thus, we hypothesize that farmers who participated in the farm programs over this period, and who cropped highly erodible soils, were more likely to adopt conservation tillage practices than those who did not. If we accept this hypothesis, we can conclude one of two things. If nonparticipants were also adopting conservation tillage practices, albeit at a slower rate, we can conclude that conservation compliance increased the adoption rate of a practice that both increased profits and decreased soil erosion. However, if nonparticipants did not adopt conservation tillage practices in this period, we can conclude that although conservation compliance induced farmers to adopt conservation tillage practices, it is likely that eliminating the conservation compliance requirements would result in decreased acreage planted under conservation tillage practices.

What could we conclude if we reject the hypothesis that participation increased adoption rates? One conclusion is that farmers delayed implementing their farm plans for as long as possible because conservation tillage practices are costly to adopt. If we accept this first alternative hypothesis, then we also conclude that eliminating farm programs would likely cause decreased adoption of conservation practices. A second alternative hypothesis is that adopting conservation tillage practices is so profitable that farmers do not need to be induced into adoption by conservation compliance. That is, both participants and nonparticipants adopted conservation compliance at an equal speed. This discussion demonstrates that a careful examination of the regression results is required before any definitive conclusions can be made about the relationship between commodity programs and adoption of conservation tillage.

The Empirical Model

The discussion so far suggests that tillage adoption should be considered as a choice among three types of tillage practices: conventional till, reduced till, and no-till. We define the three tillage systems by the amount of crop residue left on the field. Conventional tillage is any system that leaves zero to 30 percent residue in the field, reduced tillage leaves 30 percent to 70 percent residue, and no-till leaves more than 70 percent residue. Technology adoption decisions are typically modeled as the outcome of a utility maximization problem. Let U_{iC}, U_{iR}, and U_{iN} denote the i^{th} producer's expected utility from adopting conventional till, reduced till, and no-till systems. The observed variable in this case is not expected utility but the technology choice decision Y_i, where

$$Y_i = \begin{cases} 0 \text{ if } U_{iC} > U_{iN} \text{ and } U_{iC} > U_{iR} \\ 1 \text{ if } U_{iR} > U_{iC} \text{ and } U_{iR} > U_{iN} \\ 2 \text{ if } U_{iN} > U_{iC} \text{ and } U_{iN} > U_{iR}. \end{cases} \quad (1)$$

Each individual's expected utility under the alternative tillage systems is assumed to be a function of a vector of explanatory variables, x_i, plus a random disturbance that captures unmodeled effects. We model the choice of tillage system using multinomial logit.

As discussed in Maddala (1983), a multinomial logit specification gives rise to a system of three probabilities:

$$\text{Prob}(Y_i = j) = \frac{e^{\beta_j' x_i}}{\sum_{m=0}^{2} e^{\beta_m' x_i}} \quad j = 0, 1, \text{or } 2, \quad (2)$$

where β_j is a vector of parameters that relates the field characteristics x_i to the probability that $Y_i = j$. Because the three probabilities must sum to one, a convenient normalization rule is to set one of the parameter vectors, say β_0, equal to zero. The probabilities for the three alternatives then become (Greene 1990):

$$P_j \equiv \text{Prob}(Y_i = j) = \frac{e^{\beta_j' x_i}}{1 + \sum_{m=1}^{2} e^{\beta_m' x_i}} \quad j = 1 \text{ or } 2, \tag{3}$$

$$P_0 \equiv \text{Prob}(Y_i = 0) = \frac{1}{1 + \sum_{m=1}^{2} e^{\beta_m' x_i}}. \tag{4}$$

The estimated parameters of a multinomial logit system are even more difficult to interpret than those in a bivariate choice model. Insight into the effect that the explanatory variables have on the tillage adoption decision can be captured by examining the derivative of the probabilities with respect to the k^{th} element of the vector of explanatory variables. These derivatives are defined as (Greene 1990):

$$\frac{\partial \text{Prob}(Y_i = j)}{\partial x_{ik}} = P_j \, [\beta_{jk} - \sum_{m=0}^{2} \text{Prob}(Y_i = m)\beta_{jk}] \, j = 0,1,2; \quad k = 1, \ldots, K. \tag{5}$$

Clearly, neither the sign nor the magnitude of the marginal effects need bear any relationship to the sign of the coefficients. We use crop rotation, soil erodibility, and program participation to explain tillage adoption decisions.

Data and Preliminary Analysis

The Cropping Practices Survey is an annual survey of farmers conducted by the U.S. Department of Agriculture (USDA) to collect data on production practices and input use as well as behavioral practices such as program participation. The survey samples from total U.S. corn and soybean acreage and from 65 percent to 99 percent of acreage for other crops. We use 1990 to 1993 data on corn and wheat, two major program crops that accounted for 70 percent to 80 percent of annual crop deficiency payments over this period. In addition, 75 percent of the conservation compliance plans for these two crops emphasized residue management. We also conducted a preliminary examination of cotton data. But, because the common erosion control practices used in cotton fields are terracing, contour cropping, strip cropping, and grassed waterways, we found very little adoption of conservation tillage practices. Thus, we did not have a balanced distribution of alternative tillage practices to justify estimating an econometric model for cotton. However, we include summary statistics for cotton as well as corn and wheat.

Description of Variables

One of the survey questions asked farmers to list the tillage and planting implements used on the field in question. From these lists, we judged whether the tillage system was no-till, reduced till, or conventional till. Farmers were also asked to report their previous crop on the field. The variable ROT equals one on corn land if soybeans were planted the previous year, but otherwise ROT equals zero. On wheat land, ROT equals one if fallow was "planted" the previous year, but otherwise ROT equals zero. The frequency of occurrence of other crop rotations was minimal. The variable PAR equals one if the field is part of a participating ASCS farm unit; otherwise, PAR equals zero. If the Natural Resource Conservation Service designated the field as being highly erodible, then the variable HEL equals one, otherwise HEL equals zero.

Preliminary Analysis

Table 1 reports the proportion of sample fields under each of the tillage systems as well as the mean values ROT, PAR, and HEL for corn, wheat, and cotton. Adoption of no-till on corn (13 percent) is much higher than on wheat and cotton. Wheat and cotton have higher participation rates than corn. And, of the three crops, wheat is generally the least erosive, which perhaps explains why the frequency of planting wheat on highly erodible fields is higher than for corn and cotton.

Table 1. Proportion of sample fields under alternative tillage systems and sample means of data, 1990-93

Variable	Corn	Wheat	Cotton
Conventional Tillage	.65	.81	.988
Reduced Tillage	.22	.15	.006
No-Till	.13	.04	.007
PAR	.79	.90	.90
ROT	.58	.56	.26
HEL	.20	.34	.22

Some insight into the extent to which use of tillage practices on corn and wheat is affected by participation, rotation, and erodibility is shown by Figures 1 through 3 for 1990 to 1993. Figure 1 shows trend lines for use of no-till and reduced till for program participants and nonparticipants for corn and wheat. Overall, adoption rates of soil-saving tillage practices on corn have increased for both participants and nonparticipants. But there is no clear pattern for wheat. Figure 2 shows how rotation considerations affect adoption rates. For corn, rotation appears to encourage no-till adoption and to discourage adoption of reduced till. For wheat, rotation appears to favor no-till, and there is no clear effect on reduced till. Figure 3 shows how

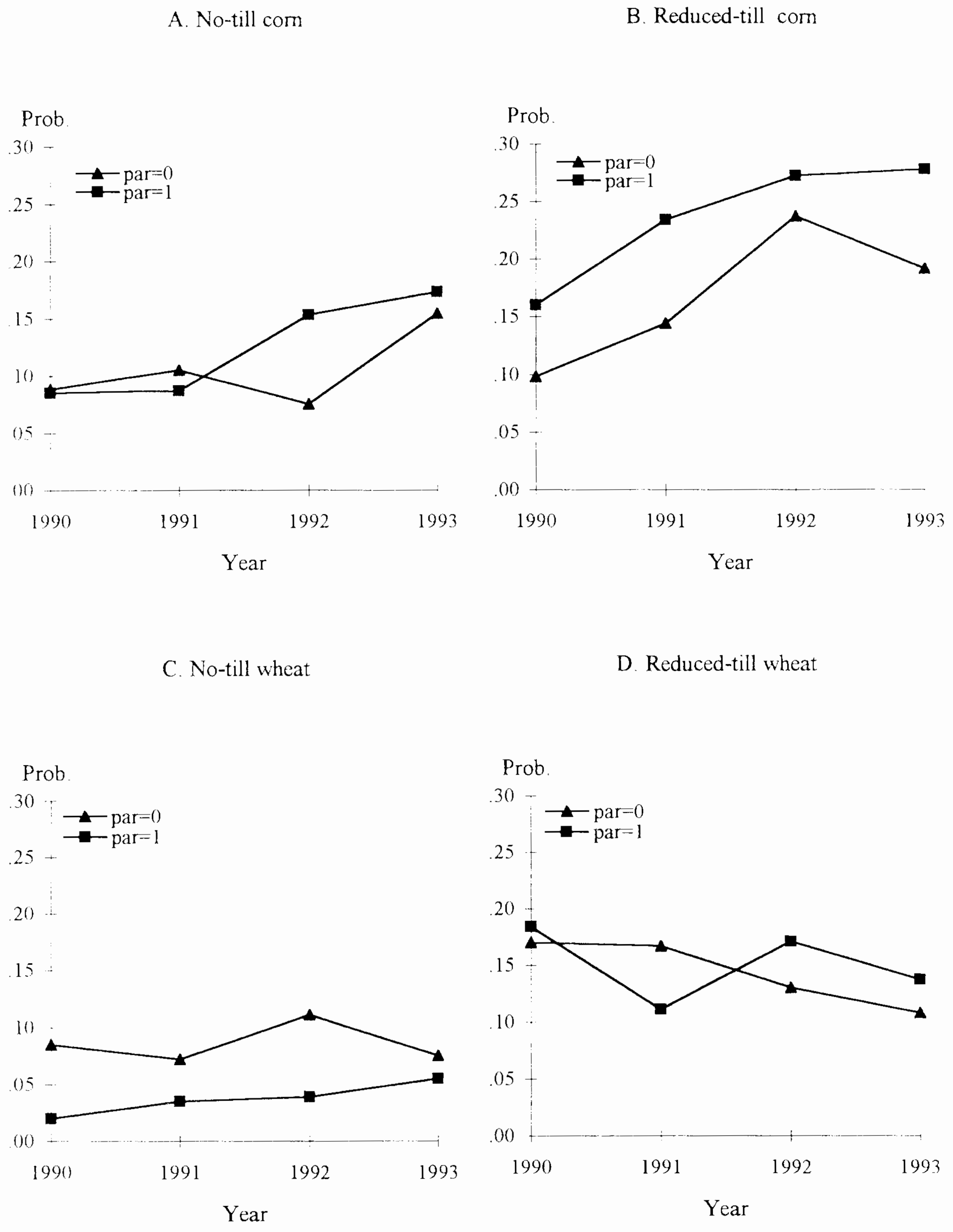

Figure 1. Conservation tillage adoption rates among nonparticipants and participants in corn and wheat

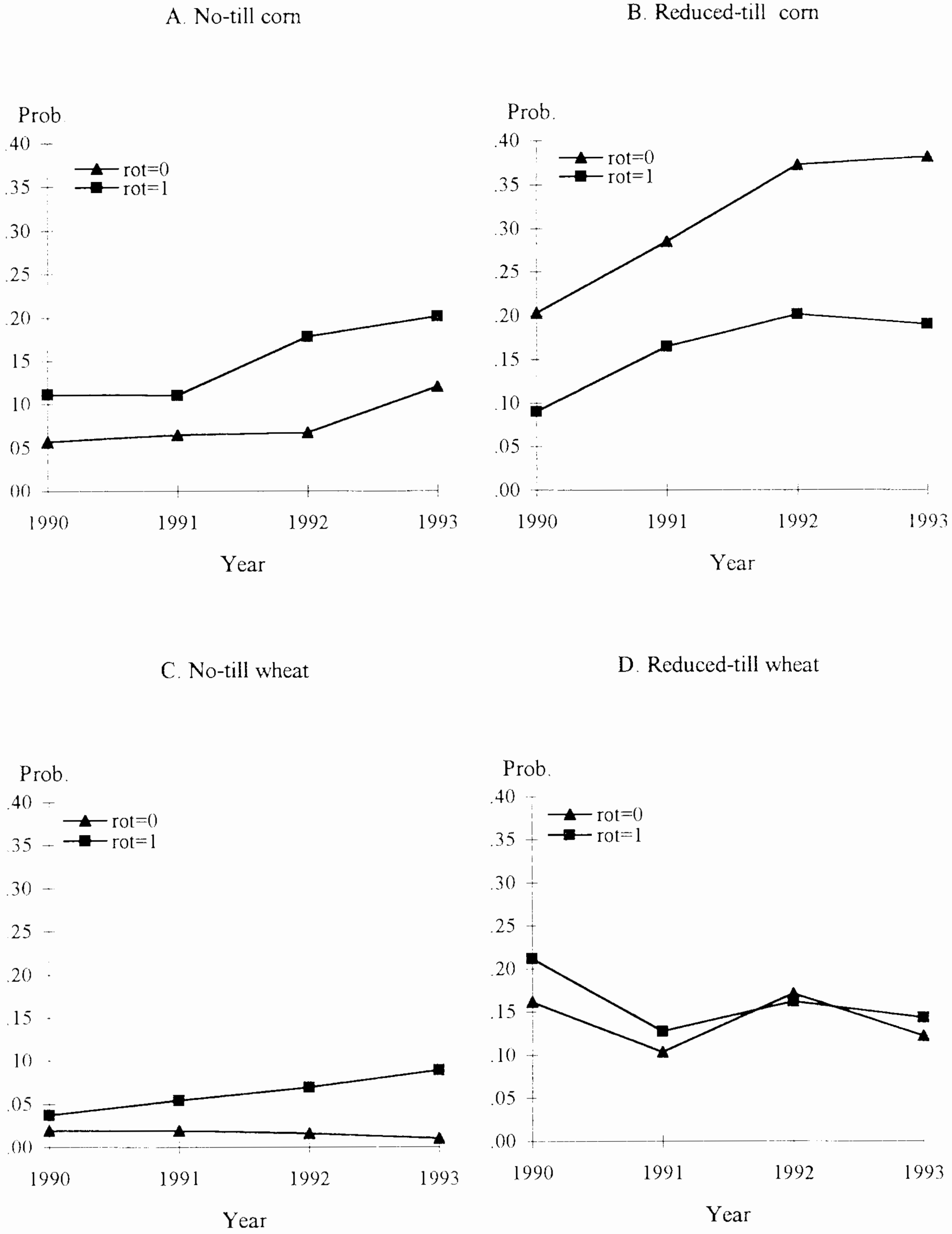

Figure 2. Conservation tillage adoption rates in continuous and rotation cropping in corn and wheat

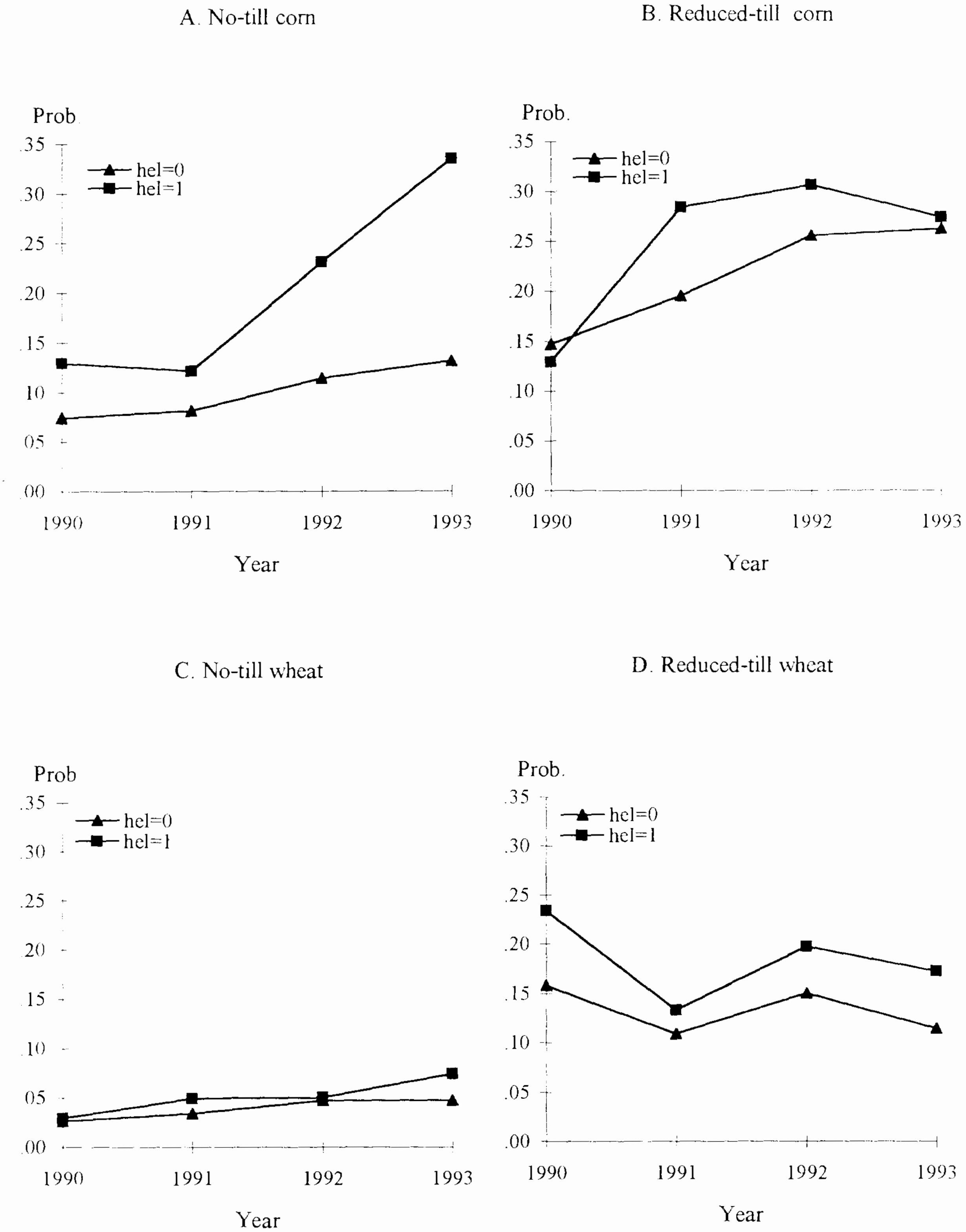

Figure 3. Conservation tillage adoption rates in non-HEL and HEL fields in corn and wheat

adoption is affected by erodibility. Farmers who plant corn on highly erodible soils use no-till practices to a greater extent than farmers who do not, especially in 1992 and 1993. And there are no clear patterns for reduced till on corn or for either tillage practice on wheat.

Insights from Figures 1 through 3 are tentative at best because the impacts of participation, rotation, and erodibility on adoption rates require a multiple regression analysis in order to offset possible compounding effects. The multinomial logit estimation looks at the simultaneous impact of several attributes on the tillage adoption decision.

Estimation Results

Our empirical model attempts to explain what tillage systems are selected for a sample of fields using information about crop rotation, participation in commodity programs, and by the fields' soil erosion potential. We include a time trend to capture possible "demonstration effects" that may increase the probability that a nonadopter of a technology adopts in a given year, independently of the other explanatory variables, because a technology's feasibility is increasingly demonstrated as adoption rates increase over time. The multinomial logit routine in LIMDEP (Greene 1992) was used to estimate the model defined in equations (2) and (3).

Estimated coefficients and asymptotic t-statistics for the corn model are reported in the first two columns of Table 2. Estimates for the wheat model are given in the first two columns of Table 3. Also reported are multinomial regression results when the sample is stratified by HEL.

All the estimated coefficients in the corn model are significantly different from zero. In the wheat model (Table 3), only HEL has a significant effect on adoption of reduced tillage on wheat

Table 2. Multinomial Logit Estimates of Corn Tillage Adoption

	All Fields		Highly Erodible Fields		Non-HEL Fields	
Variable	Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
Reduced Tillage						
Constant	-29.16	-13.46	-39.45	-8.16	-26.62	-10.98
PAR	.51	6.57	.51	2.82	.52	5.99
ROT	-.80	-13.65	-.88	-6.47	-.77	11.87
HEL	.26	3.56	-	-	-	-
TREND	.30	12.92	.42	7.98	.28	10.49
No-Till						
Constant	-34.52	-12.45	-53.16	-10.10	-26.81	-8.21
PAR	.22	2.42	.35	1.97	.20	1.82
ROT	.56	7.00	1.05	7.14	.31	3.32
HEL	1.08	13.70	-	-	-	-
TREND	.35	11.57	.56	9.73	.27	7.52
LR Test[a]	788		304		376	
Sample Size	7676		1565		6111	

[a]Likelihood ratio test statistic.

land, and all variables except HEL have a statistically significant effect on adoption of no-till. Not surprisingly, the likelihood ratio test statistic suggests rejection of the null hypothesis that the explanatory variables have no effect on tillage adoption for both corn and wheat. For both the corn and wheat models, conventional tillage is used as the reference practice. Hence, the estimated coefficients reflect the effect of the participation, rotation, erodibility, and time on the likelihood of adopting one of the conservation tillage practices relative to conventional tillage.

Table 3. Multinomial Logit Estimates of Wheat Tillage Adoption

	All Fields		Highly Erodible Fields		Non-HEL Fields	
Variable	Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
Reduced Tillage						
Constant	3.61	1.01	2.01	.36	4.23	.92
PAR	-.03	-.22	.14	.58	-.10	-.58
ROT	.15	1.72	.10	-.70	.28	2.64
HEL	.38	4.38	-	-	-	-
TREND	-.06	-1.55	-.04	-.62	-.07	-1.34
No-Till						
Constant	-20.89	-3.16	-24.74	-2.29	-19.13	-2.25
PAR	-.83	-4.51	-.86	-2.72	-.80	-3.54
ROT	1.37	7.03	1.03	3.22	1.54	6.30
HEL	.22	1.48	-	-	-	-
TREND	.19	2.66	.23	2.02	.17	1.85
LR Test[a]	127		28		80	
Sample Size	4654		1574		3080	

[a]Likelihood ratio test statistic.

The policy importance of the regression results are not immediately apparent because the sign and magnitude of the estimated coefficients do not necessarily imply anything about the sign and magnitude of the effects on tillage adoption caused by changes in the explanatory variable. The estimated marginal effects, as calculated by equation (5), are reported in Table 4 for the corn model and Table 5 for the wheat model. These marginal effects have been calculated at the mean of the data.

Table 4. Estimated Marginal Effects for Corn Tillage Adoption

Variable	Conventional Tillage	Reduced Tillage	No-till
All Fields			
PAR	-.089*	.079*	.010
ROT	.070*	-.144*	.074*
HEL	-.119*	.017	.102*
TTREND	-.070*	.042*	.027*
Highly Erodible Fields			
PAR	-.106*	.073*	.033
ROT	.000	-.203*	.203*
TTREND	-.118*	.050*	.069*
Non-HEL Fields			
PAR	-.086*	.079*	.007
ROT	.087*	-.131*	.044*
TTREND	-.057*	.039*	.018*

* Indicates significance at the 95 percent level.

Marginal Impact of Participation

For corn, the marginal impact of participation on no-till is not significantly different from zero. However, there is strong evidence that participation increases the likelihood of reduced-till adoption. The effect of participation is to increase the probability of using reduced tillage by about 8 percent. For wheat, participation decreases the probability that no-till is used by 2.7 percent and has no effect on the probability that reduced tillage is used. These results corroborate the primary result in Williams, Llewelyn, and Barnaby (1990) that deficiency payments do not generally encourage the use of no-till practices in wheat production in the central Great Plains.

Table 5. Estimated Marginal Effects for Wheat Tillage Adoption

Variable	Conventional Tillage	Reduced Tillage	No-till
All Fields			
PAR	.027	.000	-.027*
ROT	-.056*	.012	.044*
HEL	-.052*	.046*	.005*
TTREND	.002	-.009	.006*
Highly Erodible Fields			
PAR	.009	.029	-.037*
ROT	-.022	-.023	.045*
TTREND	-.003	-.008	.010*
Non-HEL Fields			
PAR	.030	-.008	-.022*
ROT	-.069*	.027	.042*
TTREND	.003	-.008	.005*

* Indicates significance at the 95 percent level.

Marginal Impact of Rotation

For both corn and wheat, a farmer who rotates crops is more likely to adopt no-till. For corn, crop rotation is associated with the use of both no-till and conventional tillage practices, but not reduced till. These results support claims that no-till tends to yield the best results when a corn-following-soybeans rotation is adopted and that reduced tillage works best with corn-following-corn (Iowa MAX Report 1992). For wheat, a wheat-fallow rotation tends to encourage the use of no-till. Wheat-fallow rotation is a common practice, which preserves soil moisture and increases yield significantly. Williams, Llewelyn, and Barnaby (1990) analyzed experiment station data on soil moisture and crop yield from no-till wheat-fallow plots and found both yield and soil moisture to be significantly higher than in conventional-tillage continuous wheat systems.

Farm Policy Implications

The central issue facing Congress is the extent to which use of soil-saving tillage practices would be reduced if commodity programs were eliminated or made significantly less attractive. As shown in Table 4, participating farmers in the corn program were significantly more likely to adopt reduced tillage practices between 1990 and 1993 than nonparticipants. But program participation had little, if any, impact on adoption of no-till. Furthermore, as shown by the regression results of the stratified model in Table 2, and by the reported marginal effects in Table 4. the effect of program participation is the same whether or not highly erodible fields were being cropped. That there is no difference in adoption patterns by farmers subject to conservation compliance suggests that the increase in adoption of conservation tillage practices on corn (shown in Figure 1) was not caused primarily by conservation compliance. Rather it appears that farmers have increased conservation tillage because of its direct benefits. The implication of this finding is that the rate at which corn farmers adopt soil-saving tillage practices would remain largely unchanged by eliminating commodity programs.

The story is much different for wheat farmers. From 1990 to 1993, wheat farmers who participated in commodity programs were actually less likely to have adopted soil-saving tillage. And. as shown in Table 5, this result even holds for farmers who cropped highly erodible fields. As indicated in Figures 1 through 3, there are no clear trends in tillage adoption patterns for wheat farmers. Thus, for wheat farmers, conservation tillage practices are not beneficial unless they rotate wheat and fallow in alternate years. This result suggests that wheat farmers who adopted conservation tillage to satisfy conservation compliance after 1990-93 would be more likely than corn farmers to revert to conventional tillage if commodity programs were eliminated.

In addition, these results suggest that, if program benefits are cut significantly, then the costs of meeting conservation compliance provisions may be high enough that wheat farmers would opt out of the program in much higher numbers than would corn farmers.

One caveat to these conclusions about the role that commodity programs have on tillage adoption decisions is their influence on rotation decisions. It is commonly believed that commodity programs discourage crop rotation because subsidies are paid on only a subset of crops. The estimation results for corn and wheat show that rotation encourages adoption of no-till. This implies that, if elimination of the commodity programs would result in more rotation, it would cause more corn and wheat farmers to practice no-till. This could counteract any movement away from conservation tillage because of the ending of conservation compliance.

The estimation results also indicate that introducing greater flexibility in planting decisions through, for example, expanding mandatory flex acreage, should increase use of no-till as crop rotation increases.[1] The 1992 National Resources Inventory (NRI) data support the claim that increasing planting flexibility will increase the acreage under rotation. In 1992, 58 percent of corn acreage was under a rotational system compared with 52 percent in 1987 and 42 percent in 1982. The 1992 NRI data show that wheat acreage in a crop rotation system increased from 56 percent in 1982 to 61 percent in 1992.

[1] According to the flex policy producers may plant any crop, excluding fruits and vegetables, on up to 25 percent of the crop acreage base without suffering a reduction in base. In return for increased planting flexibility, producers have to lose deficiency payments on flex acres.

Summary and Concluding Remarks

The primary focus of this analysis has been to explore the relationship between tillage practices and participation in government programs. The results indicate that the impact is crop-specific. While participation has a positive influence on no-till and reduced-till, the marginal impact on no-till is, however, not significant for corn. For wheat, the results support findings in other studies that suggest that commodity support programs do not encourage no-till. Reduced tillage is not significantly affected by participation. The results also indicate that the impact of participation is not significantly higher for highly erodible lands even though the erodibility factor is very important when choosing a tillage practice. In addition, and perhaps of more importance, the rotation choice tends to encourage no-till while continuous row cropping increases reduced-till practices in corn. For wheat, using a rotation tends to encourage no-till and does not have a significant impact on reduced-till. A farmer is more likely to practice conservation tillage when a crop is grown on a highly erodible field.

Based on these results and the trends observed in reduced-till and no-till adoption, there is limited evidence to argue that there will be a significant decline in conservation tillage on corn if farm program benefits are reduced. For wheat, the results suggest that conservation tillage practices are costly, and that wheat farmers may reduce conservation tillage if conservation compliance provisions are weakened or eliminated. However, no-till on wheat fields may increase as more flexibility is provided. In the case of corn, there is significant support for a future increase in no-till if more corn-soybean rotation is adopted.

The modeling reported in this study can be refined in two important ways. First, the analysis can be extended to look at geographic differences in the interactions among conservation tillage practices, participation, and rotation. Preliminary results indicate that there may be significant differences in adoption patterns across production regions. Second, the results reported here fail to consider the possible simultaneity among tillage decision, participation, and rotation use.

REFERENCES

Ayer, H. 1995. Keith Collins on the 1995 Farm Bill. *Choices* 1:14-18.

Boehm, T. P., H. W. Herzog, and A. M. Schlottmann. 1991. Intra-Urban Mobility, Migration, and Tenure Choice. *Rev. of Econ. and Stat.* 73:59-68.

Duffy, M., and M. Hanthorn. 1984. Returns to Corn and Soybean Tillage Practices. Agriculture Economics Report No. 508. Washington, D.C.: USDA/ERS, 1984.

Gabriel, S. A., and S. S. Rosenthal. 1989. Household Location and Race: Estimates of a Multinomial Logit Model. *Rev. of Econ. and Stat.* 71:240-9.

Greene, W. 1990. *Econometric Analysis*. Macmillan.

Greene, W. 1992. *LIMDEP User's Manual & Reference Guide*. New York: Macmillan.

Helms, G. L., D. V. Bailey, and T. F. Glover. 1987. Government Programs and Adoption of Conservation Tillage Practices on Nonirrigated Wheat Farms. *Amer. J. Agr. Econ.* 786-95.

Iowa MAX Report. 1992, 1993. A Publication Sponsored by *Successful Farming* Magazine, Conservation Technology Information Center and CIBA.

Kellogg, R., G. TeSelle, and J. Goebel. 1994. Highlights from the 1992 National Resources Inventory. *Jour. of Soil and Wat. Cons.* 49(6):521-527.

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

Norris, P. E. and R. T. Clark. 1994. Conservation Compliance Policy. In *1995 Farm Bill Issues Briefs*. ed. R. Knutson, Ames. Iowa State University, University Extension.

Phillips, R. and J. H. VanderHoff. 1994. Alternative Mortgage Instruments, Qualification Constraints and the Demand for Housing: an Empirical Analysis. *Jour. of the Amer. Real Est. and Urb. Econ. Assoc.* 22(3):453-77.

U.S. Department of Agriculture (USDA). 1990, 1991, 1992, 1993. Annual Cropping Practices Surveys, Unofficial data files.

Williams, J. R., R. V. Llewelyn, and G. A. Barnaby. 1990. Risk Analysis of Tillage Alternatives with Government Programs. *Amer. J. Agr. Econ.* 72:172-81.