Structural Conservation Practices in U.S. Corn Production: Evidence on Environmental Stewardship by Program Participants and Non-Participants

by

Glenn D. Schaible, C. S. Kim, and Dayton Lambert

Topic Area: Resource & Environmental Policy Analysis

Contact: Glenn D. Schaible
Economic Research Service, USDA
Room S4048
1800 M Street, NW
Washington, DC 20036-5831

Phone: (202) 694-5549
Email: Schaible@ers.usda.gov

A Selected Paper for the 2007 AAEA meetings in Portland, Oregon, July 29 – August 1, 2007.
The views expressed are the authors' and do not necessarily represent those of the Economic Research Service, the U.S. Department of Agriculture, or the University of Tennessee

Structural Conservation Practices in U.S. Corn Production: Evidence on Environmental Stewardship by Program Participants and Non-Participants

In recent years, in support of its environmental and conservation policy goals, USDA conservation programs have placed greater emphasis on working-land conservation, primarily through its EQIP and CSP programs. Working-lands programs assist farmers in implementing and maintaining such land-management and structural practices as conservation tillage, crop rotations, cover crops, enhanced nutrient management, precision agriculture, irrigation water management, crop/livestock diversity, and the use of infield and perimeter-field structures such as strip cropping, terraces, and stream-side herbaceous buffers. USDA funding for working-land conservation programs has increased from $174 million in 2000 to roughly $1.3 billion in 2005 (Claassen, 2006; Aillery, 2006). The environmental effectiveness of USDA conservation programs is currently being evaluated by USDA's Natural Resource Conservation Service (NRCS), through its Conservation Effects Assessment Project (CEAP). The project's primary data source is an annual farmer survey of field-level conservation practices and program participation, integrated with environmental data at National Resources Inventory (NRI) data points (for the survey years 2003 – 2006). However, our hypothesis is that the environmental performance of U.S. agriculture is affected by many factors other than conservation program incentives (Smith and Weinberg, 2004; Lambert et al., 2006). Good land stewardship and its environmental benefits often make good business sense even without program participation (Hopkins and Johansson, 2004).

In an effort to better understand the relationships between farmer motivations, program incentives, and the environmental benefits of conservation programs, USDA also initiated the pilot national survey integration program, the Conservation Effects Assessment Project ─ Agricultural Resources Management Survey (CEAP-ARMS). CEAP-ARMS integrates National Resource Inventory (NRI) data on field-level physical characteristics and CEAP production practice and program participation information with USDA ARMS data on cost-of-production, operator, farm household, and farm resource/economic data. CEAP-ARMS was completed in 2004 for wheat (882 farms across 16 States) and in 2005 for corn (489 farms across 4 States). By linking producer behavioral, farm resource, and environmental data, USDA hopes that this survey instrument will help to improve its ability to design, implement, and monitor conservation programs consistent with its resource and environmental policy goals.

This study used the 2005 CEAP-ARMS data for corn production to first compare key operator, field, farm, economic, and environmental characteristics of conservation program participants with non-participants, by farm-size class. We hypothesize that producer decisions to allocate acres to infield or perimeter-field conservation structures are likely correlated with the acreage allocation decision for crop production on the field. We then estimate a cost-function based technology adoption model of producer decisions regarding the allocation of field-level acres between corn production and infield and perimeter-field conservation structures to examine how these conservation choices differ between program participants and non-participants, while accounting for differences in other field, farm, and environmental factors. Our null hypothesis is that the average number of conservation structural practice acres across U.S. corn acres supplied by growers participating in a conservation program is not different from non-participants. Infield conservation structures include terraces, grassed waterways, vegetative buffers, contour buffers, filter strips, and grade stabilization structures. Perimeter-field conservation structures include hedgerow plantings, stream-side forest and herbaceous buffers, windbreaks and herbaceous wind barriers, field borders, and critical area plantings. A Generalized Estimating Equations (GEE) procedure is used to estimate two models. The cost-function models estimate field-level, producer acreage allocation decisions, first, as a function of normalized production input prices (Model I), and second, as a function of normalized input prices and several key exogenous variables reflecting the potential influence of a variety of field, farm, and environmental characteristics (Model II). The

GEE estimation procedure allows one to account for the correlation between adoption decisions measured as a continuous variable while maintaining the integrity of the discrete choice model.

A National Integrated Field/Farm Production Practice, Resource, Economic, and Environmental Survey

CEAP-ARMS integrates two producer-based surveys ─ one, the National Resources Inventory (NRI) point-based production practice/environmental data survey (CEAP), and two, the field/farm level production practice, resource use, farm household and economic survey (ARMS).[1] ARMS, conducted for USDA's ERS, is designed to primarily serve information objectives involving cost-of-production, farm finances, and production practices. Using a streamlined integrated questionnaire, CEAP-ARMS directly links more detailed production practice, program participation, and site-specific environmental data from the NRCS CEAP, with the economic, farm resource, and farm-household/operator characteristic data from ARMS.

The 2005 Phase II CEAP-ARMS included a sample of 489 NRI point-based farm fields (for corn) across 4 States,[2] with an average completion rate of 78 percent. When integrated with associated NRI data, the usable Phase II sample was 380 observations with associated field-level production practice, input use, program participation, and NRI environmental data. However, when the Phase II/NRI data is integrated with the corresponding farm-level Phase III data, the usable sample is 226 field/farm observations. This integrated production practice, program participation, farm resource/economic, farm-household, operator, and environmental database provides the unique opportunity to summarize initial characteristic differences for corn producers between conservation

---

[1] CEAP, ARMS, and CEAP-ARMS are all surveys conducted by USDA's National Agricultural Statistics Service. ARMS is a crop-specific survey based on a list frame sample with the survey conducted in three phases: Phase I involves survey planning/design and sample selection; the Phase II questionnaire collects field-level production practice, input use, and cost-of-production data (for the annual survey crop of choice), and the Phase III follow-on questionnaire collects associated farm-level resource, economic, and operator/household data. CEAP and CEAP-ARMS, being NRI-point based, use an area frame sample design.

[2] CEAP-ARMS for 2004 wheat included the States of Washington, Oregon, Idaho, Montana, North Dakota, South Dakota, Nebraska, Colorado, Kansas, Oklahoma, Texas, Minnesota, Missouri, Illinois, Michigan, and Ohio. CEAP-ARMS for 2005 corn included the States of Indiana, Illinois, Iowa, and Nebraska.

program participants and non-participants, and by selected ERS farm typology class across the 4-State study area.

Characteristics of Corn Producers by Conservation Program Participants vs. Non-Participants (in IN, IL, IA, and NE)

We identified significant characteristic differences between conservation program participants and non-participants, and across farm-size classes. Using Phase II data, program participants are defined as survey respondents that indicated they had a written conservation plan for the field (or conservation tract), and who also identified either conservation financial assistance programs in their conservation plan for the field or that conservation compliance applies to the field [i.e., the field is registered as meeting the requirements for "Highly Erodible Land Conservation Compliance (HELCC)"].[3,4] The definition of farm-size class makes use of the associated Phase III ARMS follow-on data. However, because of the relatively small Phase III sample size for the 2005 CEAP-ARMS, we aggregated the ERS typology into two farm-size classes: (1) retired/residential/-lifestyle farms plus farms with total sales < \$100,000 and the operator's primary occupation was farming ('low-sales'); and (2) farms with total sales ≥ \$100,000 and the operator's primary occupation was farming ('high-sales').[5]

The 2005 CEAP-ARMS indicates that only about 14 percent of the farms growing corn (in the 4-State study area) were associated with conservation program participation (on corn acres), i.e., most corn producers (86 percent) did not enroll corn acreage in USDA conservation programs (fig.

---

[3] In addition to HELCC, conservation financial assistance programs included in the definition of "participants" involved the following programs: Conservation Security Program (CSP), Environmental Quality Incentives Program (EQIP), Klamath Basin Water Conservation Program, Ground and Surface Water Conservation Program, Wetlands Reserve Program (WRP), Wildlife Habitat Incentives Program (WHIP), Conservation Reserve Program (CRP), Farmland Preservation Programs, and State Cost-Share Programs.

[4] Phase II data was used to define conservation program participants versus non-participants: (1) to ensure maximum use of CEAP-ARMS Phase II data (use of 380 integrated Ph. II/NRI observations versus only 226 integrated Ph. II/NRI/Ph. III observations) when evaluating alternative conservation practice issues; and (2) because the Phase III conservation program participation information applies to the whole farm, however, it does not necessarily apply to the detailed field-level, Phase II conservation practice data linked to the NRI environmental data.

[5] For the 2004 CEAP-ARMS (for wheat) data, three farm-size classes were defined. However, for the 2005 CEAP-ARMS (for corn) data, because the sample size was much smaller, we were only able to redefine the ERS farm

1). However, among program participants, most (about 70 percent) are from the higher-sales farming-occupation farms (accounting for about 10 percent of all corn farms in the study area). The average conservation program participation rate ranges from 9 percent for the retired/residential/-lifestyle/low-sales farming occupation farms to 18 percent for higher-sales farms. These relatively low participation rates underscore the importance of improving our understanding of the characteristic differences between conservation program participants and non-participants.

While nearly 83 percent of corn acres for 2005 (in the 4-State study area) were associated with farms that did not participate in conservation programs (on corn acres), farms growing corn that did participate in such programs (on corn acres) differed in a number of important ways from non-participant farms. In addition, differences in characteristic values are generally statistically significant across the two farm-size classes we examined (table 1). Higher-sales farms among program participants operated about 1,263 acres (on average), while similar type farms among non-participants operated about 1,019 acres. The situation is similar for the retired/residential/lifestyle/-low-sales farm-size classes, that is, acres operated were slightly larger for participants than for non-participants, but even so, the farm sizes for both low-sales groups were much smaller (163 – 298 acres) than for higher-sales farms. However, participant corn farms generally owned more land relative to the farmland they operated (a higher land-tenure rate), with retired/residential/lifestyle/-low-sales farms among program participants with the highest tenure rates (at 92 percent).

From a 2005 farm financial perspective, non-participant farms (growing corn) were generally less dependent on farm revenue from corn production across both farm-class types than were participants. These non-participant farms also produced higher 2005 farm production value, with both results suggesting greater farm diversification. On the other-hand, program participants

---

typology into two farm-size classes. For a detailed definition of the full ERS farm typology, see the ERS website: http://www.ers.usda.gov/Briefing/FarmStructure/glossary.htm#typology .

generally had larger farm equity (net farm worth) compared to similar non-participants. Even so, the retired/residential/lifestyle/low-sales farms among participants had slightly higher net farm incomes than did similar non-participant farms, while the net farm income for non-participating higher-sales farms significantly exceeded that for similar participating farm types by nearly 84 percent.

For conservation program participants and non-participants, farm operators of higher-sales farms were generally slightly younger than operators of other farm types. Operator age ranged from 52 – 54 years for higher-sales farms, to 55 – 64 years for retired/residential/lifestyle/low-sales farming occupation farms. The distributional effects were slightly different for college education and off-farm work. The percent of operators (for farms growing corn) with some college education was highest for non-participant, higher-sales farms (at 21 percent), while only about 14 percent of higher-sales farms among program participants had some college education. On the other hand, retired/residential/lifestyle/low-sales farming occupation farms had the highest percent of operators who worked off-farm, ranging from 37 to 71 percent, for participants and non-participants, respectively. Higher-sales farms among program participants are least associated with operators working off-farm.

For farms growing corn in the 4-State study area, higher-sales farms for both participants and non-participants received the largest total government payments (ranging from $58,541 to $71,752 per farm). However, these payments are heavily influenced by the average size of their direct government (AMTA) and loan-deficiency (LDP) payments. Even so, in 2005, higher-sales farming-occupation farms participating in conservation programs (on corn acres) received higher government conservation payments ($6,299 per farm) than did other farms participating in conservation programs (at $2,428 for participating retired/residential/lifestyle/low-sales farms).

From an agri-environmental perspective, it was the retired/residential/lifestyle/low-sales farms participating in a conservation program (on corn acres) that produced the highest corn yields for 2005 (averaging 183 bu./acre) versus 125 bu./acre for similar non-participating farms. But it was the higher-sales farms participating in a conservation program that applied the highest amount of nitrogen (at 138 lbs./acre) versus 133 lbs./acre for similar non-participating farms, and between 105 to 122 lbs./acre for the retired/residential/lifestyle/low-sales farms. However, participating farms accounted for less than 16 percent of the corn acres planted in the study area in 2005. Even so, it was the corn farms participating in a conservation program that incurred the larger average Universal Soil Loss Equation (USLE) measure of soil loss, averaging from 4.8 to 5.4 tons/acre/year, while soil loss for corn acres for non-participating farms ranged from 3.5 to 4.2 tons/acre/year.

Additionally, the corn fields for higher-sales farms participating in a conservation program were more likely to be more agri-environmentally sensitive. For example, the percent of farms with gully erosion occurring in the corn field was highest for higher-sales farming occupation farms participating in a conservation program (at 14 percent). (For retired/residential/lifestyle/low-sales farms there was insufficient data to describe the occurrence of gully erosion.) Additionally, for higher-sales farms participating in a conservation program, the corn field was more likely to be adjacent to a water body, intermittent stream, or wetlands than were the corn fields for other farm types. This critical environmental linkage was associated with approximately 44 percent of higher-sales participant farms, but only about 28 percent for similar non-participant farms. Likewise, the percent of corn acres where *Highly Erodible Lands* (HEL acres) are present is largest for higher-sales participating farms (at 14 percent) than for other farm types. However, for the 2005 CEAP-ARMS, the occurrence of wetlands in the corn field was either non-existent, or there was insufficient data to evaluate this characteristic.

Conservation Practices Applied to Corn Production (in IN, IL, IA, and NE)

Producers have adopted a variety of land-management and structural conservation practices on corn producing acres for a variety of economic, conservation, and environmental reasons. These practices have included crop rotations, conservation tillage, scouting for pests, applying nutrient tests, use of variable rate technology (VRT) for seed and/or fertilizer application, use of Global Positioning System (GPS-based) soil map information, installation of one or more conservation structural practices, and intensive use of alternative pest management practices.[6] In 2005, farms not participating in conservation programs (on corn acres) were by far the primary users of all ten land-management practices (fig. 2). These farms accounted for 83 percent of planted corn acres within the 4 surveyed States. Higher-sales, non-participating farms (on corn acres) were the primary users of all land-management practices (except for use of variable-rate technology for seed and/or fertilizer application — here, retired/residential/lifestyle/low-sales farms among non-participants were the primary users of this practice). Higher-sales farms were also the primary users of conserving land-management practices among conservation program participants. Use of contours and strip cropping was the primary land-management practice for these producers. The 2005 CEAP-ARMS data for corn suggest that while higher-sales farms among conservation program participants likely make a positive contribution to reducing agriculture-induced environmental damages, the largest contribution to environmental benefits likely originates with non-participants,

---

[6] "Pest-management intensity" is identified when a producer applies five or more pest-management practices to a survey field. Alternative pest-management practices for a survey field may include such direct activities as scouting for pests (at various levels of intensity), keeping detailed written or electronic records, making use of published threshold information, using field mapping data, use of diagnostic laboratory analysis for pest identification, use of soil/plant tissue testing, use of beneficial organisms in the field, use of a trap crop, as well as other indirect activities designed to manage or reduce the spread of pests such as plowing down of crop residue, rotating crops, use of ground cover or mulches, use of no-till or minimum till, adjusting row spacing, plant density, or row direction, cleaning field equipment after completing a field operation, removal of crop residue from the field, use of cultivation for weed control, and/or chopping, spraying, mowing, plowing or burning field edges, ditches, roadways, or fence lines.

and particularly with high-sales farms (growing corn) that do not participate in conservation programs (on corn acres).

Corn producers have also installed a variety of in-field and perimeter-field structural practices within and around corn fields designed to reduce wind and water-based soil erosion, protect surface-water sources, and enhance agricultural bio-diversity, including creating/enhancing natural habitat pathways across the agricultural landscape (fig. 3).[7] In 2005, acres devoted to grassed-waterways were the dominant structural practice installed across corn acreage (in the study area) by producers not participating in a conservation program (on corn acres). However, for conservation program participants, terraces were the dominant structural practice installed on corn acres. Field borders and filter strips were the next dominant structural practice installed by program participants and non-participants alike.

Model: A Cost-Function Based Technology Adoption Approach

Traditional probabilistic models of agricultural technology adoption have been based on the log of the odds of choosing an advanced technology over the conventional technology, but *under the assumption that available cropland is fully utilized or cropland is predetermined* (Caswell and Zilberman, 1985; Lichtenberg,1989; Schaible, Kim, and Whittlesey, 1991; Alexander, Fernandez-Cornejo, and Goodhue, 2003). Given that a probabilistic model is not suitable for the study of crop-specific technology adoption where acreage allocated for the crop-specific production is not predetermined, this paper applies a generalized, cost-function based acreage allocation approach to model the economic decision-making process of producers for structural conservation practices used on corn production acreage. Both conservation program participants and non-participants are presumed to recognize the changes in output and costs associated with shifting field acres from corn production to conservation structural practices. It is assumed that decisions to allocate field acres to infield or perimeter-field conservation structures are correlated with the field acreage allocation decision for corn production.

The theoretical approach, based on prior work by Kim, et al. (CJAE 2005), compares cost functions across alternative conservation technologies by conservation program participants and non-participants. First, letting $\mathbf{c}_{i,p}(\mathbf{y}_{i,p})$ and $\mathbf{c}_{j,p}(\mathbf{y}_{j,p})$ be per acre cost functions (where $\mathbf{y}$ is per acre yields) for the i^{th} and j^{th} technologies for the p^{th} program participation class ($p = 1, 2$ for conservation program participants and non-participants, respectively), there exists for the p^{th} participation class an acreage supply function $\mathbf{A}_j(\mathbf{y}_j)$ for the j^{th} conservation or production practice such that:

$$(1) \qquad a^{\rho_{i,j}(p)} = \mathbf{A}_{j,p}(\mathbf{y}_{j,p}),$$

where $a = \mathbf{y}_i / \mathbf{y}_j$ and a conservation or production technology cost relationship such that:

$$(2) \qquad \mathbf{c}_{i,p}(\mathbf{y}_{i,p}(x_1, x_2, .., x_n)) = a^{\rho_{i,j}(p)}\mathbf{c}_{j,p}(\mathbf{y}_{j,p}(x_1, x_2, .., x_n)) = \mathbf{A}_{j,p}(\mathbf{y}_{j,p})\, \mathbf{c}_{j,p}(\mathbf{y}_{j,p}(x_1, x_2, .., x_n)),$$

where $\rho_{i,,j}(p)$ is the relative cost elasticity of relative output for the i^{th} and j^{th} technology and p^{th} participation class, a is constant, and x_k is the kth input per acre. If the production function, $\mathbf{y}_{j,p}(x_1, x_2, .., x_n)$, is linearly homogeneous, then the cost relationship holds. (However, the cost relationship does not imply that production is linearly homogeneous.)

With minor mathematical application, and applying Shephard's lemma, we obtain an equation for acreage shares for the j^{th} technology and p^{th} participation class relative to the k^{th} input cost shares, for example, $[\partial \ln \mathbf{A}_{j,p}(\mathbf{y}_{j,p}) / \partial \ln p_k] = [p_k x_k(\mathbf{y}_{i,p}) / \mathbf{c}_{i,p}(\mathbf{y}_{i,p})] - [p_k x_k(\mathbf{y}_{j,p}) / \mathbf{c}_{j,p}(\mathbf{y}_{j,p})]$ where p_k is the k^{th} per unit input price ($k = 1, 2, \ldots, n$). The associated derived acreage function for the j^{th} conservation or production technology and p^{th} participation class has the following exponential form:

---

[7] Structural practices may include field (and/or conservation tract) acres devoted to terraces, infield vegetative buffers, stream-side forest buffers, windbreaks, field borders, grassed waterways, hedgerow plantings, stream-side herbaceous buffers, infield contour buffers, filter strips, critical area plantings, and grade stabilization structures.

$$(3) \qquad \mathbf{A}_{j,p}(\mathbf{y}_{j,p}) = exp\{[p_k x_k(\mathbf{y}_{i,p}) / \mathbf{c}_{i,p}(\mathbf{y}_{i,p})] - [p_k x_k(\mathbf{y}_{j,p}) / \mathbf{c}_{j,p}(\mathbf{y}_{j,p})]\} = exp[\partial \ln \mathbf{A}_{j,p}(\mathbf{y}_{j,p}) / \partial \ln p_k]$$

for $k = 1, 2, \ldots, n$, where $\sum_{\kappa} [\partial \ln (\mathbf{A}_{j,p}) / \partial \ln p_k] \neq 0$ implies that the j^{th} conservation or production technology in the p^{th} participation class is non-homothetic (Antle, 1984).

An estimable econometric acreage supply function for the j^{th} conservation or production technology within the p^{th} class is derived from equation (3) as:

$$(4) \qquad \mathbf{A}_{j,p}(\mathbf{y}_{j,p}) = exp\{\alpha_{o,p} + \sum_{k} \sum_{j} \alpha_{j,p,k} (p_k / \mathbf{P}_y) + \varepsilon_p\},$$

where $\alpha_{j,p,k}$ ($k = 1, 2, \ldots, n$) is the k^{th} input parameter for the j^{th} technology, $\mathbf{P}_y$ is output price, ε_p is an error term for the p^{th} participation class, and $\alpha_{j,p,k}(p_k / \mathbf{P}_y) = [\partial \ln \mathbf{A}_{j,p}(\mathbf{y}_{j,p}) / \partial \ln p_k]$ so that

$\sum_{k} \sum_{j} \alpha_{j,p,k} (p_k / \mathbf{P}_y) \neq 0$ also implies that the j^{th} conservation or production technology for the p^{th} class is non-homothetic.

Model Estimation

For our analysis, this cost-function based technology adoption approach is assumed to model the economic decision-making process of producers allocating acres between crop production and infield and perimeter-field structural conservation practices (i.e., $A_{j,p}$, alternative field-level production technology choices). Because the dependent variable in this analysis is continuous, we use a Generalized Estimating Equations (GEE) procedure to estimate two models. The GEE estimation procedure (Liang and Zeger, 1986) accounts for the correlation between adoption decisions measured as a continuous variable, while maintaining the theoretical integrity of a multinomial discrete-choice model typically used in technology adoption studies. Our two cost-function models estimate field-level, producer acreage allocation decisions for corn, first, as a function of normalized production input costs (prices) and structural technology class and installation time-period attributes (Model 1), and second, as a function of Model 1 variables plus socio-environmental variables reflecting the potential influence of a variety of field, farm, and environmental characteristics (Model 2).

GEE equations model the correlation resulting from repeated measures on a given subject, or dependencies across clusters of observations. The method is also flexible enough to model correlation within subjects or between groups using a variety of covariance structures. In our case, we assume that the farmer (the "subject effect") is faced with a set of land-management practices [which he may choose to implement, i.e., crop field acres without or with in-field or perimeter-field conservation structures, or both] (the "within-subject" effects). Because of the trade-offs between crop production and field acres set aside for conservation structures, the decision to allocate acres to one production technology or another may be correlated. We specify an unstructured working correlation matrix to model the potential correlation between these technology choices (i.e. the correlation matrix structure typically associated with SUR or multivariate probit models).

Corn field acreage-supply equations are estimated for four alternative production technology decision options: (1) acres of corn production for fields with no conservation structural practices (i.e., only corn acres); (2) acres of corn production for fields involving only infield structural practices; (3) acres of corn production for fields involving only perimeter-field structural practices; and (4) acres of corn production for fields involving both infield and perimeter-field structures. These acreage supply equations were estimated for both conservation program participants and non-participants. The acreage supply equations were linearized by taking the natural logarithm of the acreage function. To account for the problem of zero acres allocated to a particular structure, "one acre" was added to each crop, in-field, perimeter-field, or (both) technology option, for each respondent. The GENMOD procedure in SAS version 9 was used to estimate the GEE system.

Because of the complex survey design of CEAP-ARMS, variances of estimated parameters are calculated based on standards established by the National Agricultural Statistical Service – USDA, using the delete-a-group jackknife variance estimator (Kott, 1997; Dubman, 2000; El-Osta, Mishra, and Ahearn, 2004). The delete-a-group jackknife procedure was used to estimate the variances of the censored regressions.

For Model I, acreage allocation decisions for 2005 corn fields (without structural practices, with only infield structures, with only perimeter-field structures, or with both infield and perimeter-field structures) were modeled as a function of normalized per-unit input prices for nitrogen, agricultural wages, and diesel fuel, as well as three technology choice variables and three structural-installation time-period variables. These acreage-supply equations were estimated jointly for conservation program participants and non-participants. Input prices were normalized using average corn price (per bushel) by State.[8] These normalized prices are expected to reflect the effect of the primary economic factors affecting a conservation program participant/non-participant's perception of field production profitability for the alternative acreage allocation choices for the field. Conservation technology class variables (for infield, perimeter-field, or both structures) and installation time-period variables (installed in 2005, within the last 10 years, or prior to 1990) were defined as (1,0) variables, where 1 defined participation for that variable.

For Model II, field acreage supply equations were modeled similar to Model I, but with additional covariates to control for influences of farm structure, field crop management, and several environmental attributes. Farm structure was proxied using total cropland acres operated for the farm and a variable measuring land tenure (proportion of acres owned to total farm acres operated). Total cropland acres are hypothesized to measure the influence of farm size on operator decisions to install working-land conservation structures. Land tenure is hypothesized to reflect differences in ownership perceptions, where farms with higher ownership rates are hypothesized to be more likely to allocate smaller parcels of cropland to working-land conservation structures. Field management, specifically the use of a crop rotation plan for the field, is hypothesized to capture the marginal effects of farm operator concerns with longer-term crop productivity for the field.

Four covariates were included in Model II to capture the influence of site-specific environmental attributes, including the use of surface drainage structures, the occurrence of gully erosion on the field, whether the field was adjacent to a water body, intermittent stream or wetland, and whether the farm operator expressed a concern with improving the quality of nearby fish or wildlife habitat. Surface drainage and gully erosion are likely indicators of field-level soil fragility. Covariates identifying the proximity of a field to nearby water sources and producer concerns for fish and wildlife are likely indicators of conservation structures installed to improve offsite environmental benefits.

Both models were estimated using the integrated Phase II/NRI 2005 CEAP-ARMS data for corn (380 field/farm observations representing 39 million planted corn acres across the 4 surveyed States).[9] Weights were provided by USDA's National Agricultural Statistics Service.

Empirical Results

Estimated GEE coefficients for Model I and their significance tests indicate that relative prices do explain producer choices in allocating field acres between corn production, and infield and perimeter-field conservation structural practices (table 2). It is not surprising that estimation results demonstrate stronger statistical significance across coefficients for conservation program non-participant equations, since these producers accounted for 86 percent of the farms growing corn across the study area in 2005. For program non-participants, estimated coefficients for nitrogen

---

[8] State-level average input/output prices for 2005 were USDA National Agricultural Statistics Service statistics acquired through the Market & Trade Economics Division, ERS, USDA.

price across alternative technology equations for Model I appear to reflect perceived productivity/-profitability and field-level cost (or productive capacity) effects. Normalized nitrogen prices were positively correlated with corn acres planted on fields with no structural practices, but with a smaller and negative effect on corn field acres with either infield or perimeter-field conservation structures present. Together with the significance of the nitrogen price coefficients for the case with no structural practices and significant but smaller when infield structures are present, these results suggest that corn producers recognize field-level productivity/profitability effects of adopting conservation structures. That is, infield conservation structures are more likely to be adopted on smaller-sized corn fields, while the scale-effect of nitrogen productivity maintains larger field sizes for the case with no structural practices present. These results are not surprising given that infield structures (specifically grassed waterways, terraces, and filter strips) account for nearly 70 percent of the conservation structure acres on corn fields across the study area. Grassed waterways alone account for 48 percent of structure acres adopted by conservation program non-participants (fig. 3).

For program non-participants, Model I results imply that higher relative nitrogen prices will likely result in reduced adoption of conservation structural practices.[10] For program participants, the nitrogen price effect appears to be the opposite of that for non-participants. In other words, for these producers higher relative nitrogen prices will likely encourage greater program participation, resulting in an increase in corn-producing acres associated with producer adoption of conservation structural practices. Even though fewer of the estimated coefficients for program participants are statistically significant, there individual effects remain important as part of a jointly estimated

---

[9] Phase III CEAP-ARMS data, which included farm-household, operator, and farm economic data, was not used because of its limited sample size (only 212 observations). This sample size was determined to be insufficient to estimate the three acreage supply equations for both conservation program participants and non-participants.

[10] For program non-participants, the negative nitrogen price coefficients for the infield and perimeter-field equations indicate the marginal reduction effect in corn-producing acres (associated with a nitrogen price increase) for fields with the respective conservation technology. At the same time, the positive nitrogen price coefficient (for fields with no structural practices) implies an increase in corn-producing acres for these fields with a nitrogen price increase.

system. The results here imply that producers likely do recognize the productivity/profitability benefits of program participation/incentives under a rising input cost environment.

An increase in agricultural wages results in a similar effect as that for nitrogen prices, but with a different emphasis. Here, the effect of an increase in agricultural wages, for program non-participants, is to reduce adoption of conservation structures, while it also encourages adoption through greater conservation program participation. The stronger effect, however, appears to be focused on reduced adoption of perimeter-field structures by program non-participants, but with program participants emphasizing increased adoption of these structures. For diesel-fuel prices, a price increase will have an opposite effect, likely because the effect here reflects a field-level cost (or productive capacity, i.e., scale) effect. For non-participants, an increase in diesel-fuel prices will likely encourage these producers to give increased priority to the productivity benefits of conservation structures while also reducing the field-level costs as more field acres are devoted to conservation structures. On the other-hand, increased diesel-fuel prices will also discourage conservation program participation, resulting in corn fields with fewer acres devoted to conservation structural acres. These results likely imply that past conservation program incentives have not been sufficient to overcome a field-level cost (scale) effect associated with increased energy costs.

It is also not surprising that for program participants, the coefficient signs for the three price parameters are the reverse of those for non-participants. In addition, what is of greater importance here is the stronger significance of these parameters within the perimeter-structure equation for program participants. These results may reflect a shift for these producers from less reliance on the influence of productivity/profitability effects, accounted for more via the non-participant equations, to a larger reliance on the influence of a field-level cost (or scale) effect.

Also of particular interest for Model I results is the prevalence of statistical significance of relative prices for both infield and perimeter-field structural practice equations for program non-participants, while for program participants, this stronger significance effect appears only in the perimeter-field structural equation. These results would seem to suggest that program non-participants (for corn farms in the study area) tend to respond to a rising relative input-price environment with adjustments in the adoption of both infield and perimeter-field conservation structural practices (attributable to productivity/profitability and field-level cost or scale effects), while a response by program participants emphasizes adjustments in the adoption of perimeter-field structures (primarily attributable to field-level scale effects). Non-participant corn producers likely do give significant recognition to the productivity/profitability benefits of infield structural practices as sufficient to encourage their adoption without program incentives (these practices account for nearly 70 percent of their conservation structural acres). On the other hand, all producers also likely recognize that the primary benefits of perimeter-field practices are off-site, but that program participants adopting these practices tend to require a program incentive to encourage their adoption, particularly in response to the field-level cost (scale) effect associated with a rising energy price environment.

Additionally, coefficients for the technology class variables (i.e., corn field acres with only infield structural practices, only perimeter-field structures, or with both infield and perimeter structures) were not highly statistically significant. Only the technology class variable for the presence of both infield and perimeter-field structures was significant at the 15 percent level. These coefficients reflect the relative effect on corn field acres for the adoption of a structural conservation practice associated with the respective structural (technology) class. The results indicate that producer relative responsiveness to reducing corn field acres is greatest when adopting both types of conservation structures, and lowest when adopting only infield structures.

Model I results also indicate that the variables for installation timing of conservation structures installed on 2005 corn fields in the study area were not statistically significant. Therefore, accounting for structural practice installation timing likely does not impact estimated model parameters.[11]

Model II, which includes additional socio-environmental variables in the estimated conservation-practice adoption model, demonstrates results quite similar to those found with Model I (table 3). First, Model II results also demonstrate the stronger statistical case that conservation program non-participants give to adoption of infield and perimeter-field conservation structural practices, while for program participants, program incentives appear to be needed to encourage the adoption of perimeter-field structural practices. Model II results also demonstrate the robustness of cost-function parameter coefficients, and that producers likely do account for more than just economic factors when making field-level acreage allocation decisions. For 2005 corn producers (in the study area) variables for farm cropland acres, use of crop rotations on the field, and whether surface drainage structures are present on the field are the more important socio-environmental factors with respect to whether producers allocate corn field acres to different conservation structures. However, whether gully erosion was present on the field and whether the corn field was located next to a water body, intermittent stream, or wetland are additional site-specific environmental attributes also relatively important to producers when making field-acreage allocation decisions, i.e., when deciding on the adoption of conservation structural practices.

The relatively strong significance of four of the additional socio-environmental parameter estimates likely suggests that farm size (as measured by farm cropland acres), as well as the field-specific environmental attribute identifying surface drainage structures on the field positively influence corn-field size, i.e., the corn-producing acres for the field. On the other-hand, field

---

[11] Model estimation without the installation-timing variables did not impact the model's estimated parameters, i.e.,

production management (measured by use of crop rotations), as well as the off-site environmental factor identified by the presence of an adjacent water body, stream, or wetland, negatively influence the corn-producing acres for the field (but positively affect structural practice acres). Even though farm size appears to play a somewhat stronger role in these decisions than do individual field-specific environmental factors, the significance of multiple site-specific environmental factors highlights the critical importance of accounting for these factors (together with other socio-economic factors) in the producer field acreage allocation decision.

Input-Price Field-Acreage Response Elasticities

The critically-important effect of accounting for additional socio-environmental factors lies in their impact on estimated input-price elasticities for field-level corn acreage response for each of the four technology-based acreage supply equations.[12] Not accounting for appropriate field/farm/environmental decision factors could either under- or over-estimate technology-specific price elasticity of acreage response for either conservation program participants or non-participants (table 4). This result is important, particularly when addressing conservation program practice adoption impacts associated with alternative conservation program options.

Estimated elasticity results show that not accounting for socio-environmental decision factors will generally under-estimate corn acreage response across field technology choices for program non-participants. On the other hand, for conservation program participants, not accounting for these decision factors will likely under-estimate the acreage response elasticity for corn fields with infield and/or perimeter-field structures, but over-estimate acreage response for corn fields with no structural practices present. In addition, the under- or over-estimate of acreage response is

---

model estimation results were rather robust. However, in the interest of conceptual completeness, the installation timing variables were kept in the final estimated model.

[12] The k_{th} input-price elasticity of acreage response for the j^{th} technology choice and p^{th} program participation class is measured as $[\partial \mathbf{A}_{j,p} / \partial p_k][p_k / \mathbf{A}_{j,p}] = [\alpha_{j,p,k} \bullet (p_k / \mathbf{P}_y)]$.

slightly larger for program participants than for non-participants, depending upon the field production technology choice.

Consistent with the earlier interpretation of equation-specific parameter estimates, elasticity estimates for Model II also illustrate that program participants and non-participants react differently to specific input-price changes, depending upon the technology choice being made. These results highlight not only that producers account for socio-environmental factors when making structural conservation-practice decisions, but that these decisions may vary across economic parameters. This response variance is complicated by the interaction of producer perceptions on how alternative structural practices affect field-level productivity, costs, and off-site benefits.

Summary and Conclusions

While retirement of fragile lands remains a key component of USDA conservation policy, greater emphasis on working-land conservation practices, particularly since passage of the 2002 Farm Security and Rural Investment Act, highlights the need to understand the likely impact of USDA's EQIP and Conservation Security Programs on farm well-being and agriculture's relationship to the environment. In 2004 and 2005, USDA integrated two field/farm surveys, CEAP and ARMS, to extend its ability to assess the impact of working-lands programs beyond just associating practices with environmental outcomes, but to also account for the impact of other producer behavioral and economic factors affecting producer production practice decisions. Development of CEAP-ARMS reflected recognition of the fact that producers adopt conservation practices for reasons other than program incentives. To appropriately identify the impact of conservation programs, one needs to identify the role of other producer decision factors, including a broad range of farm, economic, and environmental factors affecting producer practice decisions.

We first used the 2005 CEAP-ARMS for corn to summarize the characteristic differences between conservation program participants and non-participants, by farm-size class. Because of the relatively small sample size for the 2005 CEAP-ARMS, farm-size was defined for only two classes (for both conservation program participants and non-participants). We then formulated and estimated a cost-function based, crop-specific acreage allocation model of producer adoption of conservation structural practices. Corn field acreage-supply equations were estimated for four production technology decision options, including corn-field acres with no structural practices, with only infield structures, with only perimeter-field structures, and with both structural practices, all evaluated jointly for both conservation program participants and non-participants. A GEE procedure, designed to account for the correlation between producer practice adoption decisions, was used to estimate two models. In the first model, field-level acreage allocations for 2005 corn were evaluated as a function of normalized per-unit input prices for nitrogen use, agricultural wages, and diesel use, as well as for three technology choice variables and three practice-installation time-period variables. For the second model, similar acreage-allocation equations were estimated, but with additional covariates to control for influences associated with farm structure, field-crop management, and site-specific environmental attributes.

The 2005 CEAP-ARMS Phase II data show that for farms growing corn (in IN, IL, IA, and NE), significant differences exist between conservation program participants and non-participants, and across farm-size types. For example, while higher-sales participating farms operated 1,263 acres (on average) relative to 1,019 acres for similar non-participants, participant farms accounted for only 14 percent of farms growing corn and for only about 17 percent of corn acres planted in 2005. Most corn farms in the study area (and most corn acres planted) were not participating in USDA conservation programs in 2005. Participating farms were also less diversified (a larger share of farm revenue came from corn production) than were non-participant farms. However, the net farm income for higher-sales non-participant farms exceeded that for similar participant farms by nearly 84 percent. Higher-sales participant farms also received higher government conservation payments in 2005 ($6,299 on average) than did other farm participants (averaging $2,428 per farm). Participating farms had the highest USLE (soil loss) rates on corn acres (averaging between 4.8 to 5.4 tons/acre/year), but these farms accounted for only 18 percent of corn acres planted. The percent of farms growing corn with gully erosion in corn fields ranged from about 9.0 percent for non-participant higher-sales farms to nearly 14 percent for similar participant farms. Similarly, the percent of corn farms with the corn field adjacent to a water source was highest for higher-sales participant farms (at 44 percent) than for non-participant farms (ranging from 16 – 28 percent). And finally, the percent of corn acres identified with *Highly Erodible Lands* (HEL acres) present in the corn field was also highest for participating farms (ranging from 8 – 14 percent).

In general, farms not participating in conservation programs (on corn acres) adopted conservation land-management practices much more intensively for 2005 corn than did program participants. These non-participant farms accounted for 83 percent of planted corn acres across the study area. Higher-sales non-participating farms (growing corn) were the dominant users of most all land-management practices, accounting for between 40 - 52 percent of practice acres for each practice. Since the higher-sales, non-participant farms accounted for nearly 73 percent of corn acres planted in 2005, these farms likely made the largest contribution to environmental benefits associated with the adoption of land-management practices on corn acres in 2005.

Applying a cost-function based technology adoption model provides some meaningful insights into producer field-level acreage allocation decisions associated with the adoption of conservation structural practices on corn fields in the 4-State study area. Econometric results suggest that program non-participants will likely respond to a rising relative input-price environment with adjustments in the adoption of both infield and perimeter-field conservation structural practices. For higher relative nitrogen prices, the adjustment by program non-participants appears to emphasize fewer corn field acres associated with infield structural practices. On the other-hand, the adjustment for program participants likely encourages greater program participation, with an emphasis on increased adoption of perimeter-field structural practices. However, for higher relative agricultural wage costs, the conservation adjustment is slightly different. Here, the stronger effect appears to be focused on reduced adoption of perimeter-field structures by non-participants, while program participants likely increase adoption of these structures. For higher relative diesel-fuel prices, non-participants will tend to adjust their conservation behavior by increasing acres devoted to both infield and perimeter-field structural practices, while increased energy costs also tend to discourage conservation program participation (most likely due to a field scale effect associated with a rising energy cost environment).

Increased relative prices for nitrogen and agricultural wages appear to affect producer conservation practice behavior largely through producer recognition of an adoption decision's impact on field productivity and/or profitability. For increased diesel-fuel prices, conservation behavior may be more influenced by producer recognition of field-level cost (or scale) affects. Most corn producers, particularly program non-participants, appear to recognize the productivity/profitability benefits of infield structures as sufficient to promote their adoption without program incentives. However, it is likely that because the benefits of perimeter-field structures are often viewed as being off-site, program incentives may be necessary to encourage their adoption.

The robustness of parameter estimates for Model II results confirm Model I results and demonstrate the importance of including field, farm, and environmental decision covariates in the cost-function derived behavioral model. However, the greater benefit of accounting for the influence of these factors is their likely impact on estimates of producer input-price elasticity of acreage response for corn-field acres under alternative conservation structural practices. The results here suggest that failure to account for appropriate field, farm, and environmental decision factors could either under- or over-estimate producer conservation practice responses for conservation program participants and non-participants.

Finally, these study results indicate that significant characteristic differences do exist between conservation program participants and non-participants across corn production in the 4-State study area; that non-program factors do heavily influence producer conservation practice decisions; and that farm-size matters. These results also suggest that corn producers not participating in a USDA conservation program (on corn acres) tend to adopt infield conservation structures much more intensively while program participants emphasize the adoption of perimeter-field conservation structures. In addition, even though conservation program participants and non-participants may view field-level acreage allocation responses differently, based on differences in perceived productivity/profitability and field-level cost (or scale) expectations, policy decision-makers are generally also interested in a policy's aggregate impact. Therefore, because the working-farmland acreage base for corn is much larger for non-participants growing corn, and because perimeter-field structural practices can involve differential productivity/field-level cost effects and off-site benefits, program incentives may need to play a greater role in encouraging their adoption than they do for infield structural practices.

References

Aillery, M. 2006. *Contrasting Working-Land and Land Retirement Programs*, **Economic Brief**, No. 4, Economic Research Service, USDA, pp. 6 (March), at http://www.ers.usda.gov/Publications/eb4/.

Alexander, C., J. Fernandez-Cornejo, and R. E. Goodhue. 2003. *Effects of the GM Controversy on Iowa Corn-Soybean Farmers' Acreage Allocation Decisions*, **J. Agri. & Res. Econ.**, Vol. 28, No. 3 (December) pp. 580-95.

Antle, J. M. 1984. *The Structure of U.S. Agricultural Technology, 1910-78*, **Amer. J. Agri. Econ.**, Vol. 66, pp. 414-21.

Caswell, M., and D. Zilberman. 1985. *The Choices of Irrigation Technologies in California*, **Amer. J. Agri. Econ.**, Vol. 67, pp. 224-34.

Claassen, R. 2006. *Emphasis Shifts in U.S. Conservation Policy*. **Amber Waves** (July), at: http://www.ers.usda.gov/Amberwaves/July06SpecialIssue/Features/Emphasis.htm.

Dubman, R. 2000. **Variance Estimation with USDA's Farm Costs and Returns Surveys and Agricultural Resource Management Survey**, Staff Report, AGES 00-01, Economic Research Service, U.S. Dept. of Agriculture (April).

El-Osta, H., A. Mishra, and M. Ahearn. 2004. *Labor Supply by Farm Operators Under 'Decoupled' Farm Program Payments*, **Review of Economics of the Household**, Vol. 2, No. 4, pp. 367-85.

Hopkins, J., and R. Johansson. 2004. *Beyond Environmental Compliance: Stewardship as Good Business*, **Amber Waves** (April), at: http://www.ers.usda.gov/Amberwaves/April04/Features/BeyondEnvironmental.htm.

Kim, C. S., G. Schluter, G. Schaible, A. Mishra, and C. Hallahan. 2005. *A Decomposed Negative Binomial Model of Structural Change: A Theoretical and Empirical Application to U.S. Agriculture*, **Canadian J. Agri. Econ.**, Vol. 53, pp. 161-176.

Kott, Phil S. 1997. **Using the Delete-a-Group Jackknife Variance Estimator in NASS Surveys**, National Agricultural Statistics Service, U.S. Dept. of Agriculture.

Lambert, D., P. Sullivan, R. Claassen, and L. Foreman. 2006. *Profiles of U.S. Farm Households Adopting Conservation-Compatible Practices*, **Land Use Policy** 23(2), pp. 1-17.

Liang, K. Y and S. L. Zeger. 1986. *Longitudinal Data Analysis Using Generalized Linear Models*, **Biometrika**, Vol. 73, pp. 13-22.

Lichtenberg, E. 1989. *Land Quality, Irrigation Development, and Cropping Patterns in the Northern High Plains*, **Amer. J. Agri. Econ.**, Vol. 71, pp. 187-94.

Schaible, G. D., C. S. Kim, and N. Whittlesey. 1991. *Water Conservation Potential from Irrigation Technology Transitions in the Pacific Northwest*, **West. J. of Agri. Econ.**, Vol. 16, No. 2, (December) pp. 194-206.

Smith, K., and M. Weinberg. 2004. *Measuring the Success of Conservation Programs*, **Amber Waves** 2(4): pp. 14-21, at http://www.ers.usda.gov/Amberwaves/September04/Features/measuringsuccess.htm .

Table 1. Average field/farm characteristics for 2005 corn producers, by conservation program participation and by farm-size class.

Field/Farm Characteristics	Non-Participant farms		Participant farms	
	Retired/Residential/-Life-style + Farming-Occupation/Low Sales Farms [Sales < \$100,000]	Farming-Occupation/-Higher Sales Farms [Sales ≥ \$100,000]	Retired/Residential/-Life-style + Farming-Occupation/Low Sales Farms [Sales < \$100,000]	Farming-Occupation/-Higher Sales Farms [Sales ≥ \$100,000]
General Field/Farm Values				
Percent of farms (horizontal sum = 100)	42.5	43.7 CD [c]	4.2 B	9.6 B
Farm acres operated (ac.)	163 BD	1,019 AC	298 BD	1,263 AC
Farm corn acres harvested (ac.)	66 BD	480 AC	120 BD	515 AC
Percent of corn acres planted (horizontal sum = 100)	10.3 B	72.6 ACD	1.8 BD	15.3 BC
Acres owned to acres operated (ratio)	.67 B	.37 AC	.92 BD	.46 C
Farm Financial Values				
Farm total value of production (\$)	72,336 B	423,979 AC	66,647 BD	354,582 AC
Ave. farm revenue share from corn (%)	29.0	38.0 C	50.0	41.0 C
Total farm net worth [equity] (\$)	394,168 BD	1,208,947 A	856,921 BD	1,515,128 A
Ave. net farm income (\$)	15,401 BD	161,853 AC	16,410 BD	88,070 AC
Operator Characteristics				
Ave. operator age	55	52	64	54
Percent corn farm operators with some college (column %)	6.2 B	20.9 AD	X	13.6 B
Percent corn farms with primary operator working off-farm (column %)	70.8	17.4	36.6	8.6
Government Payments (\$/farm)				
Direct government (AMTA) payments	5,005 BD	21,479 AC	7,162 BD	29,970 AC
Counter-cyclical payments	3,519 BD	15,416 AC	4,226 BD	20,499 AC
Conservation payments [a]	4,858	3,207	2,428	6,299
Loan deficiency payments (LDP's, etc.)	8,545 BD	25,565 AC	7,983 BD	27,613 AC
Total government payments:	15,314 BD	58,541 AC	20,523 BD	71,752 AC
Agri-Environmental Values				
Ave. harvested corn yield (bu./ac.)	125	152	183	148
Ave. nitrogen applied per treatment acre (lbs./ac.)	105.2	132.6	122.2	138.0
USLE soil loss (tons/ac./yr.)	4.2 D	3.5 CD	4.8 B	5.4 AB
Percent corn farms with gully erosion in corn fields (column %)	X	9.4	X	13.5
Percent corn farms with corn field adjacent to a water body, intermittent stream or wetland (column %)	16.3	27.8 D	X	44.1 B
Percent of corn acres [with HEL acres in corn field] (column %)	2.6 BD	1.6 AC	7.9 BD	14.0 AC
Percent of corn acres [with wetlands in the corn field] (column %)	0.0	X	0.0	X

Source: 2005 CEAP-ARMS Corn Survey (integrated Phase II & III data), Economic Research Service, U.S. Department of Agriculture.

a/ Conservation payments here, for non-participants and participants, include government payments for all conservation activities, including land retirement from such programs as the CRP and WRP, and for conservation activities for the entire farm that are not included in our definition of participant (which is based on Phase II-based program participation information).

b/ X indicates that there were insufficient observations for these estimates.

c/ Letters A,B,C, and D indicate significant column difference tests based on pairwise two-tailed [Ho: $\beta_1=\beta_2$] delete-a-group Jackknife t-statistics at a 90 percent confidence level or higher with 15 replicates and 28 degrees of freedom. A=column 1, B=column 2, etc.

Table 2. Model I estimated GEE coefficients for corn field acreage allocation equations by field structural practice (technology), and by conservation program participation.
[Model I: ($A_{j,p}$) = f(normalized input prices, technology class & installation variables)].

	Program Non-Participants		Program Participants	
Equation/Variable	Estimate	T-Tests [b]	Estimate	T-Tests
Model I				
Constant	2.8045	1.13	5.6368 ***	1.71
Corn Field Acres Planted (with):				
EQ1: No structural practices: [a]				
N price	119.8528 *	3.78	- 50.6681	- 0.78
Ag. Wage	0.4036	1.41	- 2.3509 *	- 3.88
Diesel price	- 21.9501 *	- 3.48	16.7863	1.43
EQ2: Only infield structures: [a]				
N price	- 66.1984 *	- 2.48	2.9938	0.07
Ag. Wage	0.1891	0.76	0.2749	0.61
Diesel price	8.9845 **	1.88	- 4.7731	- 0.59
EQ3: Only perimeter-field structures: [a]				
N price	- 13.4583	- 0.93	29.6982	0.91
Ag. Wage	- 0.3608 *	- 3.83	1.1760 *	4.73
Diesel price	5.8741 **	1.96	- 13.4898 *	- 2.27
EQ4: Both structural practices: [a]				
N price	- 4.4147	- 0.82	- 24.6257	- 1.25
Ag. Wage	0.1283	0.95	0.1979	0.52
Diesel price	2.2566	1.17	0.1968	0.04

Technology class variables:	Units	Estimate	T-tests
Only Infield structures	(Yes = 1)	- 1.2985	- 0.36
Only perimeter-field structures	(Yes = 1)	- 4.3706	- 1.31
Both structures	(Yes = 1)	- 4.7776 ***	- 1.56
Installation dummy variables:			
Installed in 2005	(Yes = 1)	- 0.0131	- 0.18
Installed within last 10 years	(Yes = 1)	0.0128	0.31
Installed prior to 1990	(Yes = 1)	- 0.0106	- 0.04

Log Likelihood Value (L_1) = - 2906.1413 R^2 = 0.09

# of corn farms surveyed [c] = 380 [for 39 million planted corn acres]
Conservation program participants = 15 %
Conservation program non-participants = 85 %

Corn field observations (weighted) with:
no conservation structures = 61.0 %
only infield conservation structures = 25.9 %
only perimeter conservation structures = 9.0 %
both infield and perimeter structures = 4.1 %

[a] State average per unit prices (2005) for nitrogen ($/lb.), agricultural wage ($/hr.), and diesel ($/gal.) were normalized using State average 2005 corn price ($/bu.).

[b] Critical values for the t tests are 1.52 (***), 1.76 (**), and 2.14 (*) for the 15 %, 10 %, and 5 % significance levels, respectively. Standard errors were computed using the delete-a-group Jackknife approach (Dubman, 2000).

[c] Surveyed States for the 2005 Ceap-Arms for corn included IN, IA, IL, and NE.

Note: Infield conservation structural practices included terraces, grassed waterways, vegetative buffers, contour buffers, filter strips, and grade stabilization structures. Perimeter-field conservation structural practices included hedgerow plantings, stream-side forest buffers, stream-side herbaceous buffers, windbreaks or herbaceous wind barriers, field borders, and critical area plantings.

Source: 2005 CEAP-ARMS Phase II data (for corn), Economic Research Service, USDA.

Table 3. Model II estimated GEE coefficients for corn field-acreage allocation equations by field structural practice (technology), and by conservation program participation.

[Model II: ($A_{j,p}$) = f(normalized input prices, technology class, installation, & socio-environmental variables)].

	Program Non-Participants		Program Participants	
Equation/Variable	Estimate	T-Tests [b]	Estimate	T-Tests
Model II				
Constant	2.5478	1.04	4.4805	1.30
Corn Field Acres Planted (with):				
EQ1: No structural practices: [a]				
N price	119.9414 *	3.64	- 41.1041	- 0.62
Ag. wage	0.4437 ***	1.56	- 2.2255 *	- 4.25
Diesel price	- 21.7852 *	- 3.37	15.5230	1.30
EQ2: Only infield structures: [a]				
N price	- 68.3726 *	- 2.56	4.6041	0.10
Ag. wage	0.1951	0.77	0.3661	0.75
Diesel price	9.3637 **	1.96	- 4.5506	- 0.51
EQ3: Only perimeter-field structures: [a]				
N price	- 14.6446	- 0.94	29.8064	0.91
Ag. wage	- 0.3468 *	- 3.54	1.2607 *	4.37
Diesel price	6.1154 **	1.97	- 12.9867 *	- 2.20
EQ4: Both structural practices: [a]				
N price	- 5.4257	- 0.98	- 25.2886	- 1.37
Ag. wage	0.1431	0.93	0.2792	0.71
Diesel price	2.4690	1.20	0.8440	0.19

Technology class variables:	Units	Estimate	T-tests
Only infield structures	(Yes = 1)	- 0.9789	- 0.25
Only perimeter-field structures	(Yes = 1)	- 4.1142	- 1.43
Both structures	(Yes = 1)	- 4.5246 ***	- 1.71
Installation dummy variables:			
Installed in 2005	(Yes = 1)	0.0080	0.12
Installed within last 10 years	(Yes = 1)	- 0.0088	- 0.20
Installed prior to 1990	(Yes = 1)	0.0213	0.19
Socio-Environmental Variables:			
Farm tenure rate	(owned/operated acres)	0.0735	1.04
Farm cropland acres	(acres)	0.0001 *	3.06
Crop rotation	(Yes = 1)	- 0.2240 *	- 2.46
Gully erosion on field	(Yes = 1)	0.1264 ***	1.52
Field next to water body	(Yes = 1)	- 0.1150 **	- 1.98
Surface drainage	(Yes = 1)	0.1811 *	2.75
Improve wildlife habitat	(Yes = 1)	- 0.1356	- 1.25

Log Likelihood Value (L_2) = - 2872.0891 $R^2 = 0.10$ Likelihood Ratio (L1:L2) = 68.10, d.f. = 7, p = .05

---

[a] State average per unit prices (2005) for nitrogen ($/lb.), agricultural wage ($/hr.), and diesel ($/gal.) were normalized using State average 2005 corn price ($/bu.).

[b] Critical values for the t tests are 1.52 (***), 1.76 (**), and 2.14 (*) for the 15 %, 10 %, and 5 % significance levels, respectively. Standard errors were computed using the delete-a-group Jackknife approach (Dubman, 2000).

Note: Infield conservation structural practices included terraces, grassed waterways, vegetative buffers, contour buffers, filter strips, and grade stabilization structures. Perimeter-field conservation structural practices included hedgerow plantings, stream-side forest buffers, stream-side herbaceous buffers, windbreaks or herbaceous wind barriers, field borders, and critical area plantings.

Source: 2005 CEAP-ARMS Phase II data (for corn), Economic Research Service, USDA.

Table 4. Estimated price elasticities of acreage response for corn field acres by field structural practice, by conservation program participation.

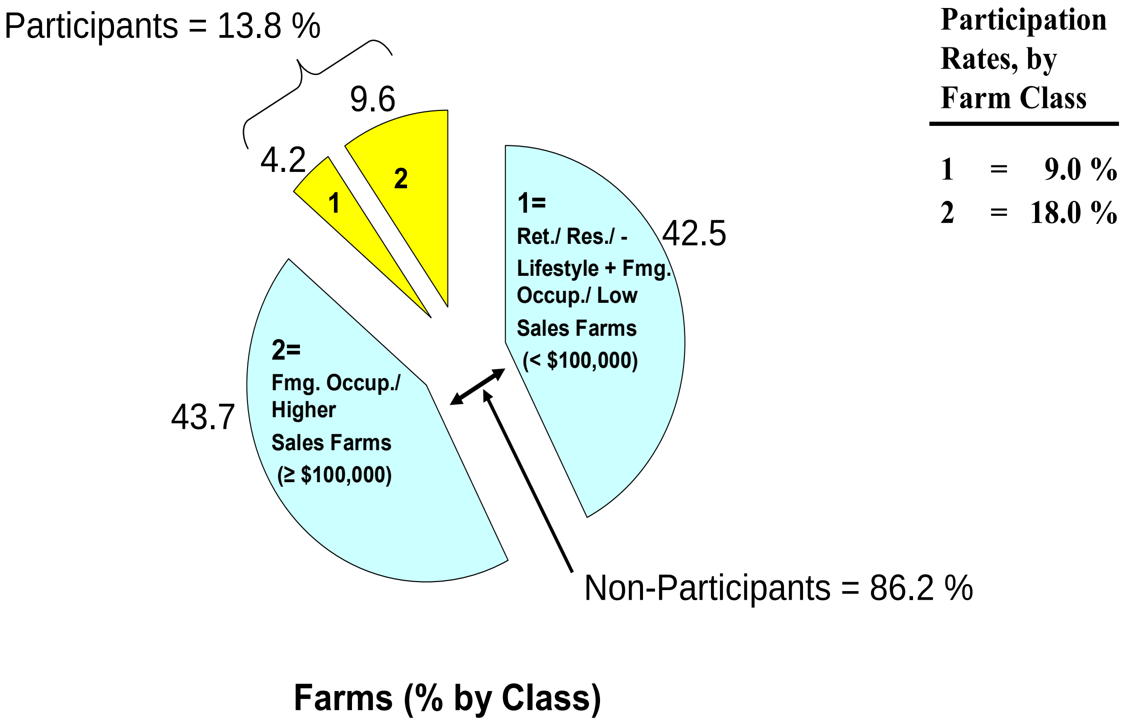
	Model 1 Elasticities (without socio-environmental variables)		Model II Elasticities (with socio-environmental variables)	
Equation/Variable	Program Non-Participants	Program Participants	Program Non-Participants	Program Participants
<u>Corn Field Acres Planted (with)</u>:				
EQ1: No structural practices: [a]				
N Price	18.3999	- 7.7786	18.4135	- 6.3103
Ag. Wage	1.9541	- 11.3814	2.1480	- 10.7745
Diesel Price	- 21.0342	16.0859	- 20.8762	14.8753
EQ2: Only infield structures: [a]				
N Price	- 10.1628	0.4596	- 10.4966	0.7068
Ag. Wage	0.9156	1.3311	0.9443	1.7722
Diesel Price	8.6096	- 4.5740	8.9730	- 4.3607
EQ3: Only perimeter-field structures: [a]				
N Price	- 2.0661	4.5593	- 2.2483	4.5759
Ag. Wage	- 1.7468	5.6937	- 1.6789	6.1035
Diesel Price	5.6290	- 12.9270	5.8602	- 12.4448
EQ4: Both structural practices: [a]				
N Price	- 0.6777	- 3.7806	- 0.8330	- 3.8823
Ag. Wage	0.6212	0.9581	0.6927	1.3518
Diesel Price	2.1625	0.1886	2.3659	0.8088

[a] State average per unit prices (2005) for nitrogen ($/lb.), agricultural wage ($/hr.), and diesel ($/gal.) were normalized using State average 2005 corn price ($/bu.).

Source: 2005 CEAP-ARMS Phase II data (for corn), Economic Research Service, USDA.

Figure 1. Percent distribution of the 2005 CEAP-ARMS for corn (IN, IA, IL, NE)

Conservation Program Participants vs. Non-Participants by Farm-Size Class



Participation Rates, by Farm Class

1 = 9.0 %
2 = 18.0 %

Figure 2. Land-Management & Structural Conservation Practices for 2005 Corn (IN, IA, IL, NE)

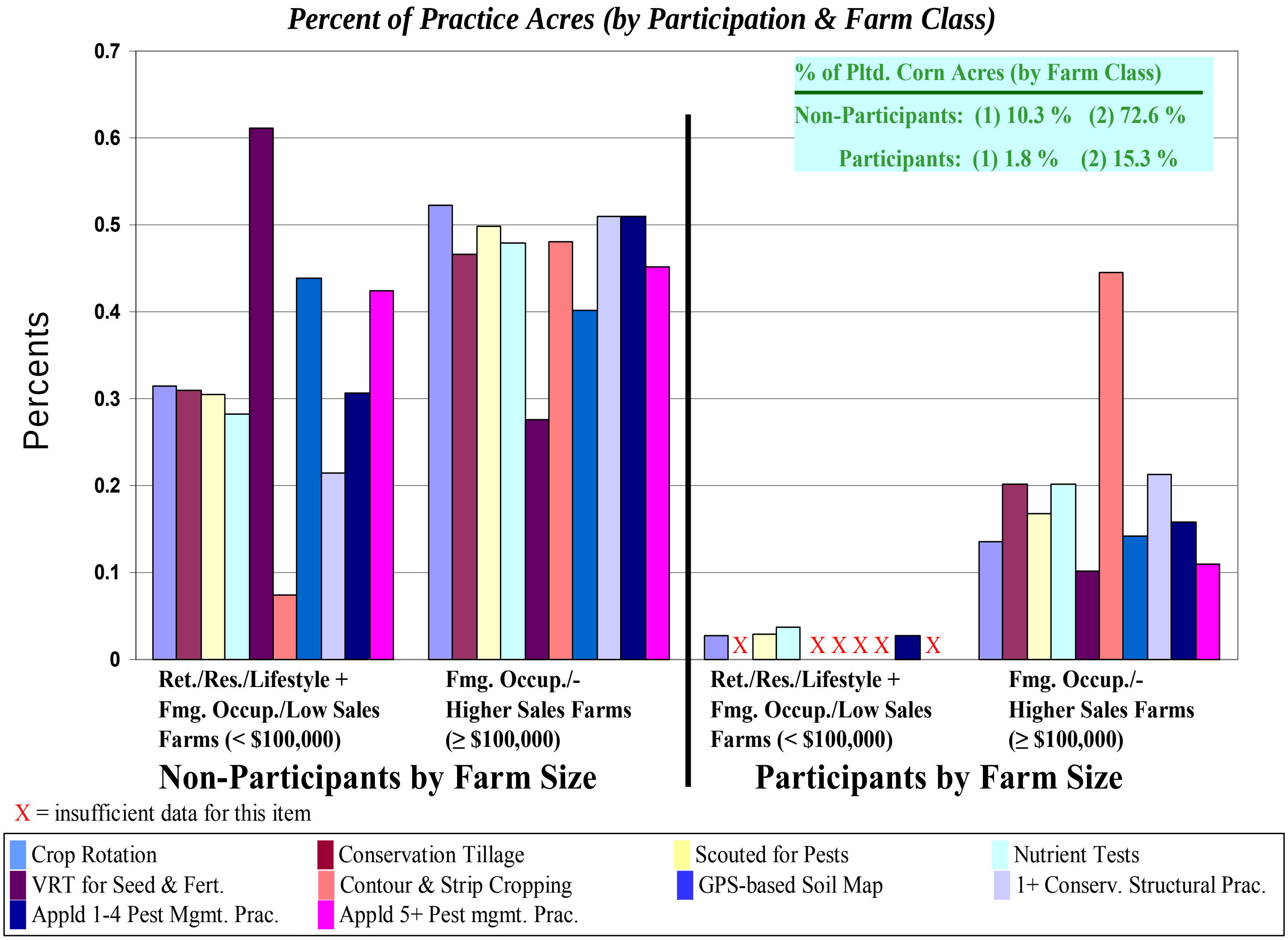


Figure 3. Conservation Structural Practices for 2005 Corn (IN, IL, IA, NE)

Percent of Structural Practice Acres (separately, by Participation Class)