Integrating Economic Surveys in Agriculture: Lessons Learned from the CEAP-ARMS Survey

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Abstract: There is a growing need for information that is integrated across the food chain, from farm production forward to processors, wholesalers, and retailers and backward to resources and input providers. This need stems in part from policy issues that cut across links in the chain, such as tracing products, food safety monitoring or linking policy initiatives to farm practices and environmental outcomes. But the need also stems from the increasingly integrated nature of food production; the expanding use of formal contracts, vertical integration, and multi-unit farms means that one reporting unit may not contain all the relevant information needed to assess policy impacts on production practices, productivity, and financial performance, even at that unit.

Although policy analysis frequently requires development of more integrated, and less fragmented, databases, integrated databases are rarely available. Survey designers and analysts face formidable practical challenges to build integrated databases for policy-oriented research. Specifically, an integrated survey will almost certainly entail a reexamination of sample design, unit definition, questionnaire content, training, and data handling. USDA has worked on a number of survey integration projects, including ARMS-Census, ARMS-AELOS, and CEAP-ARMS.

This paper highlights lessons learned from one such effort to integrate two surveys – ARMS and CEAP—an effort that was prompted by the changed focus of USDA's conservation programs away from traditional land retirement programs and towards conservation on "working farmlands." To measure the success of USDA's working-lands conservation programs, a database was needed to isolate the influence of program incentives from other factors governing farmers' conservation decisions. The CEAP-ARMS pilot survey integration program was conducted for wheat (2004) and corn (2005). The integrated CEAP-ARMS database linked farm production practices, farm economic and producer characteristics, and site-specific environmental characteristics, enabling a comparative assessment of how USDA conservation program incentives affect economic behavior and environmental outcomes.

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Survey Integration: A Response to Information Gaps

The integration of economic, financial, and environmental surveys has been an on-going activity in the United States since at least the early 1980's (figure 1). By integration we mean the merger of two or more surveys into a unified data collection program characterized by a common sample design and instruments that feature common questions and the ability to be used as a part of the same data set. Early interest in survey merger activity within the Economic Research Service (ERS) focused on melding work to collect field-level production practice data with farm-level economic and financial data. First efforts at merging field and farm-level data also featured a limited amount of socio-economic and demographic information about the primary operator of the farm business and his or her household. Over time, inquiries about individuals and households that operate farms were also enhanced enabling one instrument to provide data to inform field-level (or animal specie) production practice and cost issues, farm-level finance and performance measurements, and household-level assessments of income and economic well-being. Merger actions to develop this survey program were instituted by the Economic Research Service (ERS) and the National Agricultural Statistics Service(NASS) in order to (1) directly obtain data for use in preparing economic indicators for which the agencies were responsible, (2) estimate the data series more accurately and reliably, (3) provide additional data to respond to questions about economic well-being and performance of farms, including the provision of information about the distributional characteristics of farms and the producers of selected crop and livestock enterprises, and (4) obtain economies inherent in the merging of two separate surveys (Johnson, et al., 1985).

Since the initial work to merger practice and finance data in the early 1980's, ERS and NASS have continued to evolve their economic statistics program by carrying out additional merger/integration action. The second of these merger actions was implemented in 1996 when the Agricultural Resource Management Survey (ARMS), the U.S. Department of Agriculture's primary survey for the annual collection of data from farm operators about the financial condition, production practices, resource use and economic performance of farm businesses, and the economic well-being of farm households was created (figure 1). The ARMS was produced by merging the finance/economic survey that originated from the first merger activity with surveys designed to collect data on cropping practices and chemical use. This merger had the benefit of linking chemical use data with economic data. The third and fourth merger actions related to economic and financial data for U.S. farms focused on combining the annual ARMS survey with the quinquennial Census of Agriculture. In the years that the Census is conducted, the ARMS questionnaire features all Census of Agriculture questions. Completing the ARMS interview, in effect, fulfills a respondent's Census of Agriculture responsibilities. Implementing this merger required that the sample survey and Census of agriculture cover the same farm population, include the same questions and wording, and reflect the same conceptual framework for the questions that are asked of respondents. Training and data handling also have to be considered so that responses are handled consistently across survey programs so that the way that data are handled do not introduce differences in indications.

Each of the merger actions taken to date to improve USDA's farm economic and finance data systems have been influenced by at least three major forces. First, surveys can be expensive to conduct, especially if contacts are made in person. Survey funds compete with staff salaries and expenses, training, travel and other agency operation costs. Thus, funding to continue large scale surveys is an issue that has to be considered on an on-going basis. Juxtaposed with survey costs is on-going evolution in how farms are organized and operated as business entities. In the U.S., farms have become larger and more complex in their ownership and operating structures. Production is more concentrated in larger farms. Business arrangements such as contracts and land leases are commonly used to gain access to resources and/or markets. More use is made of newer legal forms of business such as Limited Liability Companies. Moving from the farm to either the enterprise or to the household brings additional complexity to the types of data needed to reflect modern agricultural activity. For example, at the enterprise level emerging biological, mechanical, and information technologies are changing how farmers' produce crops. Changes range across the board from the types and amounts of inputs used, to how they are applied, to how crop tillage, planting, maintenance, and harvest are handled. Meanwhile, at the household level farmers' are engaged in a wide variety of economic activity that stretches beyond the boundaries of the farm to include not only work for wages but engagement in self-employment activities that may or may not be associated with farming along with other saving and investment actions.

Changes in how farmers' have chosen to organize and operate their farms and handle their household economic and financial affairs have expanded the need for data. As a result, more surveys may be conducted or additional questions may be added to existing instruments, assuming that the survey platform and questionnaire are appropriate. Either way the issue of time constraints is raised. From a respondent's perspective this may be interpreted as burden which can be characterized as a longer, more time consuming interview, an increased frequency of being selected for interview, or an increase in the difficulty or sensitivity of questions that are being posed. From our perspective, each of these forces — costs of conducting surveys, structural changes in the sector, and respondent and survey instrument time constraints — contributed to mergers that resulted in the combined ARMS and ARMS-Census survey program.

The fifth, and most recent, merger of field-farm-household data collection with another activity focused on how to collect data that may be used to examine participation in USDA conservation programs, and to accurately measure the economic and environmental impacts of producer conservation program participation (figure 2). With passage of the 2002 Farm Security and Rural Investment (FSRI) Act, USDA's conservation programs have increasingly sought to enhance farm-level environmental benefits through improved conservation on "working farmland" — land used primarily for crop production and grazing — relative to traditional land-retirement programs. Associated budgetary and environmental tradeoffs underscore the importance of measuring the success of these programs. In response, USDA's Natural Resources Conservation Service (NRCS), ERS, and NASS instituted a pilot national survey integration project in 2004, the Conservation Effects Assessment Project — Agricultural Resource Management Survey (CEAP-ARMS). This project integrated NRCS's CEAP with ERS's ARMS to provide a stronger economic foundation to measure physical effects associated with producer conservation practice decisions.

An accurate assessment of a conservation program's environmental contribution requires linking program incentives with producer conservation practice decisions and the producer/field/farm characteristics influencing those decisions, and then linking these decisions with environmental outcomes. An integrated database that links farm production practice data with specific program participation and goals, farm economic and producer characteristics, and site-specific environmental measurements, provides a more appropriate data framework for conservation program analysis.

However, the challenge for measuring the true impact of working-lands conservation program success must involve an accounting of both economic (farmer behavioral) and environmental dimensions, that is, isolating the influence of program incentives from other factors affecting farmers' conservation choices. Program impacts must also account for the bias associated with aggregate environmental or socio-economic data used to measure inferences about producer conservation behavior. Therefore, this research, using CEAP-ARMS data, first examined how key field/farm characteristics and use of production conservation practices differ among U.S. wheat producers, in particular, between conservation program participants and non-participants, and among farm-size classes. Second, the research examined the value-added of integrating high resolution, on-site environmental data with traditional producer survey data within a producer behavioral technology adoption model.

Integrating Field/Farm-Level Production Practice, Economic, and Environmental Data

Farmers do not make conservation practice decisions within a policy vacuum. Therefore, measuring conservation program success is a more complex issue than assessing an environmental quality change for a particular conservation practice or evaluating relative cost differences between alternative practices. Good land stewardship and resultant environmental benefits often make good business sense even without program participation (Hopkins and Johansson, 2004). Other factors besides a conservation program incentive, such as operator/farm characteristics, household lifestyle concerns, farm succession and off-farm income, and even site-specific environmental characteristics influence a producer's production practice decision (Claassen, 2004; Smith and Weinberg, 2006; Lambert, et al., 2006).

In 2003, USDA's NRCS initiated the Conservation Effects Assessment Project (CEAP), a project designed to quantify the impact of conservation practices and evaluate the environmental effectiveness of conservation programs both at the watershed scale and from an aggregate national perspective. The project's primary data source is an annual farmer survey of field-level conservation practices and program participation, integrated with environmental data available for Natural Resources Inventory (NRI) data points.

In 2004 and 2005, using a streamlined integrated questionnaire, CEAP-ARMS directly linked more detailed production practice, program participation, and site-specific environmental data from CEAP, with the economic, farm resource, and farm-household/operator characteristic data from ARMS (figure 3). Integrating the broader set of CEAP conservation-management and structural practices into CEAP-ARMS enables USDA to analyze alternative conservation practices for a wider spectrum of farm types at the national level. It also allows USDA to more accurately account for the distribution of payments across conservation practices when evaluating alternative program design and incentive payment structures. This type of analysis could not be accomplished by using CEAP or ARMS alone. The CEAP survey focused on the environmental outcomes of conservation practices, but ignored the economic characteristics of farms and farmers which are important factors influencing the adoption of those practices. On the other hand, ARMS focused on farm business performance and farm household well-being, which can explain technology adoption, but ignores the potential environmental causes and implications of adoption. The CEAP-ARMS survey bridges this information gap by accounting for farmer and farm household characteristics, and their resource concerns and constraints, as well as environmental characteristics of the farmland they operate.

The CEAP-ARMS surveys for wheat and corn production (conducted in 2004 and 2005, respectively) were each conducted in three phases: Phase 1 involved survey planning/design and sample selection; Phase 2 implemented the integrated CEAP-ARMS questionnaire which was used to collect field-level production practice, cost-of-production, program participation, and associated NRI environmental information; and Phase 3, a follow-on ARMS questionnaire, was used to collect associated farm-level economic, farm-resource, and farm-household/operator information. ARMS is a list frame based sample, while CEAP, being NRI-point based, used an area frame sample design.

Research Approach and Data

Using the 2004 CEAP-ARMS integrated Phase II/NRI and Phase III wheat data, characteristic differences between conservation program participants and non-participants, across three farm-size classes, were examined based on: (1) comparisons of univariate statistics for key field, farm, economic, operator, and agri-environmental variables; and (2) the percent distribution of acres associated with alternative land-management conservation practices for 2004 wheat production. The value-added of using high resolution, on-site environmental data within a producer-based behavioral model was examined by first integrating on-site environmental data with production practice, program participation, farm enterprise, resource, operator, and household economic data. Second, the research tested whether inferences and forecasts drawn from the behavioral model about producer production practice decisions and program participation using on-site environmental data qualitatively and quantitatively differed from those obtained using aggregate environmental data. The environmental data of focus was the 1997 NRI survey's Universal Soil Loss Equation (USLE) estimate in tons/acre/year. The behavioral model — a conservation structure acreage allocation model — examined the influence of incentives, extension information, farm structure, household characteristics, and on-site physical features on the wheat field acres producers allocate to vegetative conservation structures (e.g., terraces, grassed waterways, riparian buffers, and filter strips). The model, using a censored ("tobit") regression, was estimated for three scenarios. Scenario 1 is a baseline scenario which is estimated using on-site (field-level) USLE data. In Scenarios 2 and 3, the hydrologic unit and county-level soil loss information replace the on-site (field-level) soil loss information in the regression, respectively. Differences in predicted acres under conservation management were evaluated using estimated USLE coefficients as influenced by their geo-spatial resolution.

The 2004 CEAP-ARMS for wheat Phase 2 included a sample of 882 NRI-point based wheat fields across 16 States, with an average completion rate of 85 percent. When Phase 2 survey data was integrated with NRI data, the usable Phase 2 sample was 732 observations. After integrating the Phase 2/NRI data with corresponding farm-level Phase 3 ARMS data, the integrated Phase 2/Phase 3 data included a usable sample of 472 field/farm observations. USDA's NASS computed separate weights for both Phase 2 and Phase 3 data.

Producer Conservation Practice Decisions Differ by Program Participation and by Farm-Size

The 2004 CEAP-ARMS wheat data indicates that most wheat producers adopt conservation practices on wheat acres without a conservation program incentive, especially among the larger wheat producing farms. Survey results show that only about 33 percent of the farms growing wheat participated in a USDA conservation program. Most wheat producers (67 percent) did not enroll wheat acreage in USDA conservation programs. Among wheat producers participating in a conservation program in 2004, a larger share of these farms (50.0 percent) were higher-sales farms (with farm-sales greater than $100,000). In addition, about 30 percent of all wheat producing farms were larger farms that adopted conservation practices on wheat acres without participating in a USDA conservation program.

The CEAP-ARMS data for wheat also shows that in 2004, higher-sales wheat farms that did not participate in a USDA conservation program (on wheat acres) were by far the primary users of land-management practices on wheat acres (figure 4). These farms accounted for 40 percent of planted wheat acres across the 16 CEAP-ARMS surveyed States. Land management practices include such practices as crop rotation, 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) soil map information, use of conservation structural practices, and use of alternative pest management practices. Therefore, 2004 CEAP-ARMS wheat data suggests that the largest contribution to environmental benefits is likely attributable to higher-sales farms (of those producing wheat) that do not participate in conservation programs (on wheat acres). That is, farm-size matters in producer decisions on conservation practices.

As table 1 demonstrates, significant differences among U.S. wheat producer characteristics help explain differences in conservation practice adoption decisions, both between program participants and non-participants, and across farm-size classes. While significant differences exist among producers in general field/farm characteristics, farm finances, operator characteristics, and government payments received, agri-environmental attributes also likely play an important role in producer practice decisions. However, the relative importance of these factors also likely differs in the conservation program participation decision. For example, a higher USLE measure of soil loss and a high percentage of HEL land tend to be attributes associated with wheat acres positively correlated with producer conservation program participation. However, wheat fields characterized by an adjacent water body, intermittent stream, or wetlands appear to be attributes more strongly associated with producers who adopt conservation practices on their own, i.e., without conservation program participation, particularly among lower-sales wheat farms.

The Value-Added of Integrated CEAP-ARMS Data

The CEAP-ARMS pilot study presents a natural experiment to test the accuracy of the implications drawn about conservation behavior based on aggregated information. Our research evaluated inference differences between using soil loss data based on: (1) empirical density functions of soil loss values at the field (on-site), HUC, and county-levels; and (2) inference differences drawn from a behavioral model of producer conservation practice decisions (Lambert et al., 2007).

Figure 5 illustrates, in general, that use of on-site environmental data reduces the bias associated with using aggregate data, and as a result, will most likely enhance conservation policy analysis and the design of agri-environmental policies. While the means of each distribution appear similar, the range and higher moments are nearly eliminated by the aggregations. Assuming a critical soil loss threshold of 5 tons/acre/year, figure 5 illustrates that about 16 percent of the 2004 farms analyzed (representing 175,214 wheat farms) and 5.03 million wheat acres (representing 8 percent of survey-weighted acres) of associated farmland classified as "highly erodible" are ignored. These results illustrate that mean county and HUC interpolations significantly underestimate the mean farm-level soil loss information by 1.31 and 1.36 tons/acre/year, respectively (where the overall on-site mean is 2.42 tons/acre/year). Therefore, an estimate of the total "loss" of information associated with county or HUC interpolations (or the "value" of on-site information) amount to 316 and 334 million tons/year, respectively.

Figure 6 results demonstrate that significant differences exist between predicted adoption of structural practices using soil data resolutions for on-site, county, or at the HUC level. Holding all other factors constant and varying only the soil loss measures, conservation practice acres estimated using aggregate soils information (at the HUC or county level) overestimate acres allocated to vegetative conservation structures, compared to acres predicted when using on-site soil loss information. This error margin grows significantly as mean soil loss values increase. Use of county-level aggregates result in the largest margin of error. Ultimately, in a policy evaluation setting, using on-site environmental data combined with data on other production decision factors significantly improves the reliability of program response estimates.

Summary and Conclusions

Examining CEAP-ARMS survey results for 2004 wheat production indicate that most wheat producers adopt conservation practices on wheat acres without a conservation program incentive, especially among the larger wheat producing farms. CEAP-ARMS also suggests that the largest contribution to environmental benefits is likely attributable to higher-sales farms (of those producing wheat) that do not participate in conservation programs (on wheat acres). In other words, farm-size matters in producer decisions on conservation practices. Simple univariate analysis demonstrate significant differences among U.S. wheat producer characteristics, which help to explain differences in conservation practice adoption decisions, both between program participants and non-participants, and across farm-size classes.

Empirical density functions of on-site versus aggregate soil loss data and analysis of producer conservation structural practice decisions demonstrates that estimated benefits from conservation program participation may be biased when landscape heterogeneity is not accounted for in conservation program analysis. Specifically, use of farm-level environmental data significantly reduces the bias associated with using aggregate data, improving the reliability of research results. In addition, use of aggregate soil loss data tends to over-estimate conservation program response; that is, on-site soil loss information significantly improves predictions of acres under conservation management.

The bottom line conclusion suggested by USDA's effort to merge ARMS and CEAP is that survey integration can help in strengthening the analysis of economic data and improve the reliability of impact assessments of conservation policy. More work is planned in this area as ERS continues to examine the factors influencing producer conservation practice decisions for the 2005 corn data, in addition to the 2004 wheat data.

Table 1. Average field/farm characteristics for 2004 wheat producers, by conservation program participation and by farm-size class

Field/Farm Characteristics	Non-Participant farms			Participant farms		
	Retired/-Residential/-Life-style	Farming-Occupation/-Sales < $100,000	Farming-Occupation/-Sales ≥ $100,000	Retired/-Residential/-Life-style	Farming-Occupation/-Sales < $100,000	Farming-Occupation/-Sales ≥ $100,000
General Field/Farm Values	A	B	C	D	E	F
Percent of farms (horizontal sum = 100)	19.3 CE [c]	17.9 CE	30.0 ABDEF	10.8 C	5.6 ABCF	16.4 CE
Farm acres operated (ac.)	797 CF	609 CF	2,258 ABDE	1,124 CF	902 CF	2,478 ABDE
Farm wheat acres harvested (ac.)	119 CF	179 CF	559 ABDE	153 CF	202 CF	517 ABDE
Percent of wheat acres planted (horizontal sum = 100)	13.1 CDE	16.6 CDE	40.2 ABDEF	6.2 ABCF	5.7 ABCF	18.3 CDE
Acres owned to acres operated (ratio)	.61 E	.75 CF	.41 BE	.69	.87 ACF	.31 BE
Farm Financial Values						
Farm total value of production ($)	58,531 CF	47,804 CF	474,013 ABDE	133,554 CF	41,845 CF	462,172 ABDE
Ave. farm revenue share from wheat (%)	21.0 E	31.0	26.0 E	14.0	52.0 ACF	21.0 E
Total farm net worth [equity] ($)	307,137 CDF	686,364 C	1,728,406ABDE	839,473 AC	494,133 C	1,233,541 A
Ave. net farm income ($)	– 7,719 C	13,706 C	85,049 ABE	48,358	2,694 C	8,969
Operator Characteristics						
Ave. operator age	55	60 CF	52 B	54	58	49 B
Percent wheat farm operators with some college (column %)	16.3 C	20.6	28.4 AE	40.0	15.9 CF	25.4 E
Percent wheat farms with primary operator working off-farm (column %)	83.8 C	30.6	22.9 AF	47.3	45.8	14.1 C
Government Payments ($/farm)						
Direct government payments	3,088 CF	3,469 CF	24,104 ABDE	9,952 C	4,719 CF	19,059 ABE
Counter-cyclical payments	2,828 CF	1,932 CF	5,544 ABF	10,418	2,913 F	9,121 ABCE
Conservation payments [a]	2,739 F	1,914 CF	4,922 BF	11,970	5,971	12,187 ABC
Loan deficiency payments (LDP's, etc.)	3,607 CF	1,313 CF	13,733 ABE	8,165	364 CF	9,103 ABE
Total government payments:	4,281 CF	5,401 CF	34,976 ABE	29,709	8,841 CF	31,546 ABE
Agri-Environmental Values						
Ave. harvested wheat yield (bu./ac.)	48	46	57 EF	48	39 C	43 C
Ave. nitrogen applied (lbs./ac.)	59.7 E	46.9 CF	73.6 BDE	46.1 CF	39.6 ACF	80.4 BDE
USLE soil loss (tons/acre/year)	1.4 F	4.7	2.0 F	8.1	1.9 F	4.1 ACE
Percent wheat farms with gully erosion in wheat fields (column %)	8.1	17.6	7.8	X [b]	7.5	8.8
Percent wheat farms with wheat field adjacent to a water body, intermittent stream or wetland (column %)	18.5	46.6	28.4 DE	20.7 C	22.9 C	35.1
Percent of wheat acres [with wetlands in the wheat field] (column %)	X	14.0	4.4	X	14.2	1.7
Percent of wheat acres [with HEL acres in wheat field] (column %)	7.7 CF	12.7 CF	15.4 ABDE	23.9 CF	7.9 CF	53.6 ABDE
Percent of wheat farms [meeting HELCC for surveyed wheat field] (column %)	NA [d]	NA	NA	66.8	57.9 F	54.5 E

Source: 2004 CEAP-ARMS Wheat 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/ Pairwise statistical significance tests were conducted between farm typologies across program participation classifications using 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. The letters A, B, C, D, E, and F identify the column classifications with associated pairwise statistical significance, for example, for the value "19.3 CE," the "CE" indicates that this value was statistically different from corresponding row values for columns 3 and 5.

d/ Indicates "not applicable". (Consistent with the definition for conservation program participation, there are zero observations for non-participants for this variable.)

Figure 1. Evolution of Business Formation, Finance & Household Data Collection

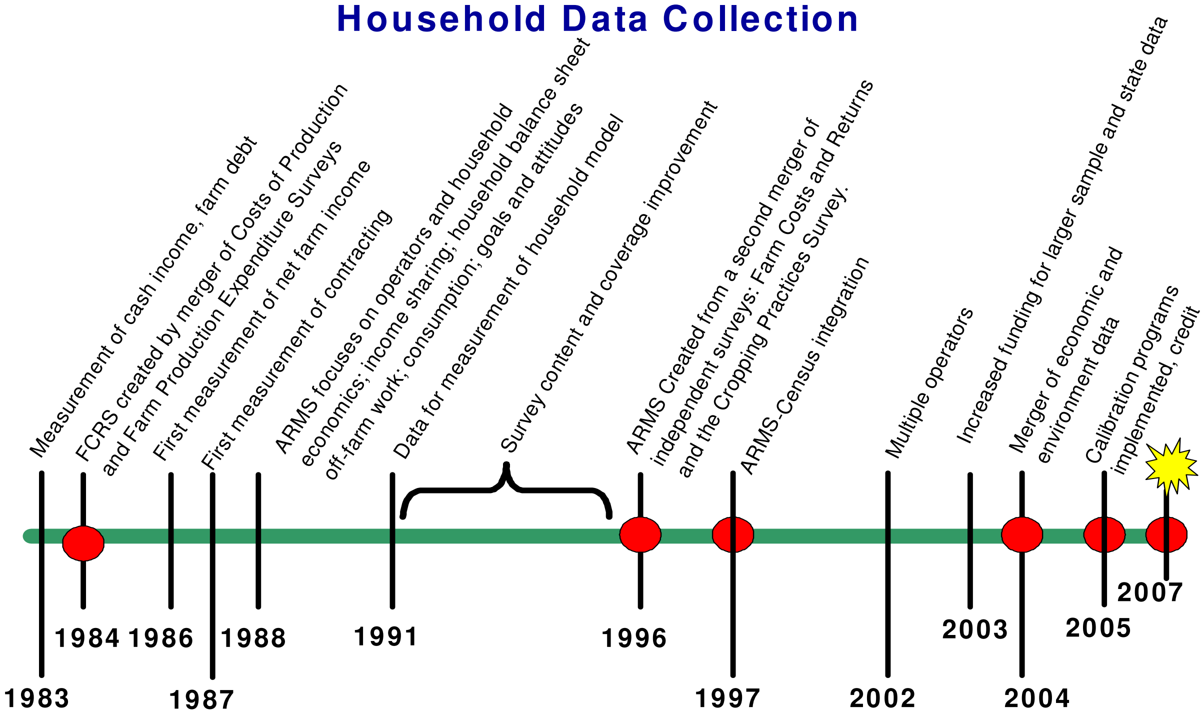


Figure 2. CEAP/ARMS Survey Integration Concept Plan

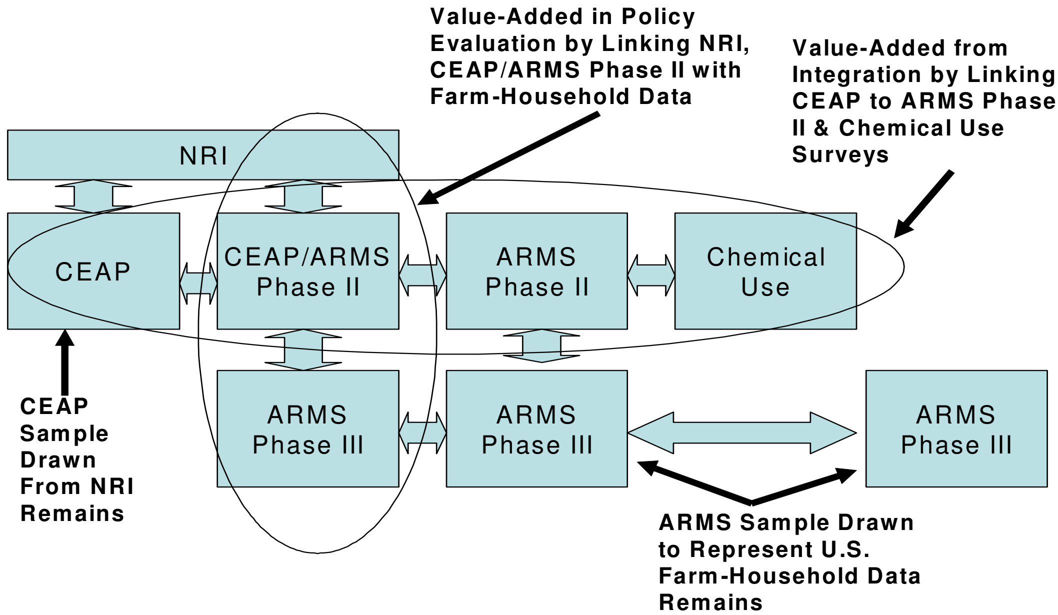
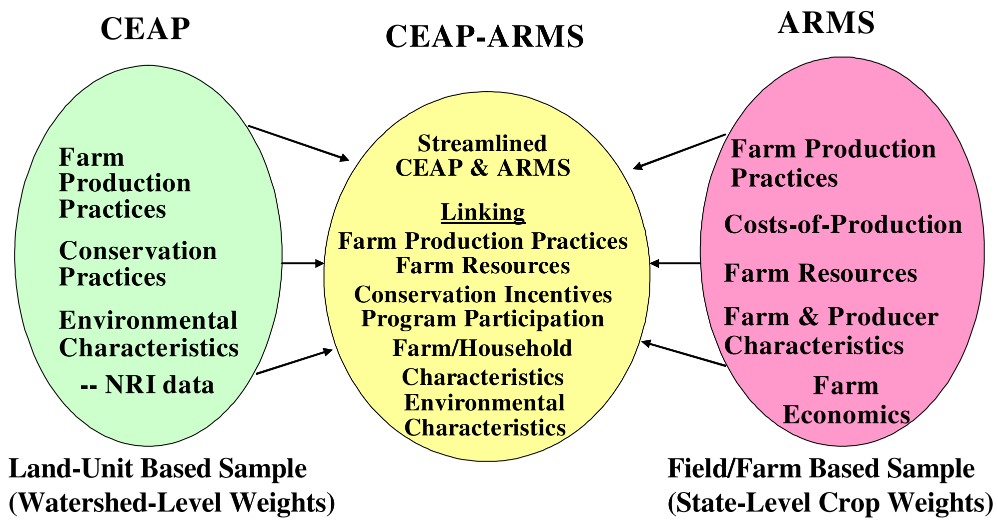
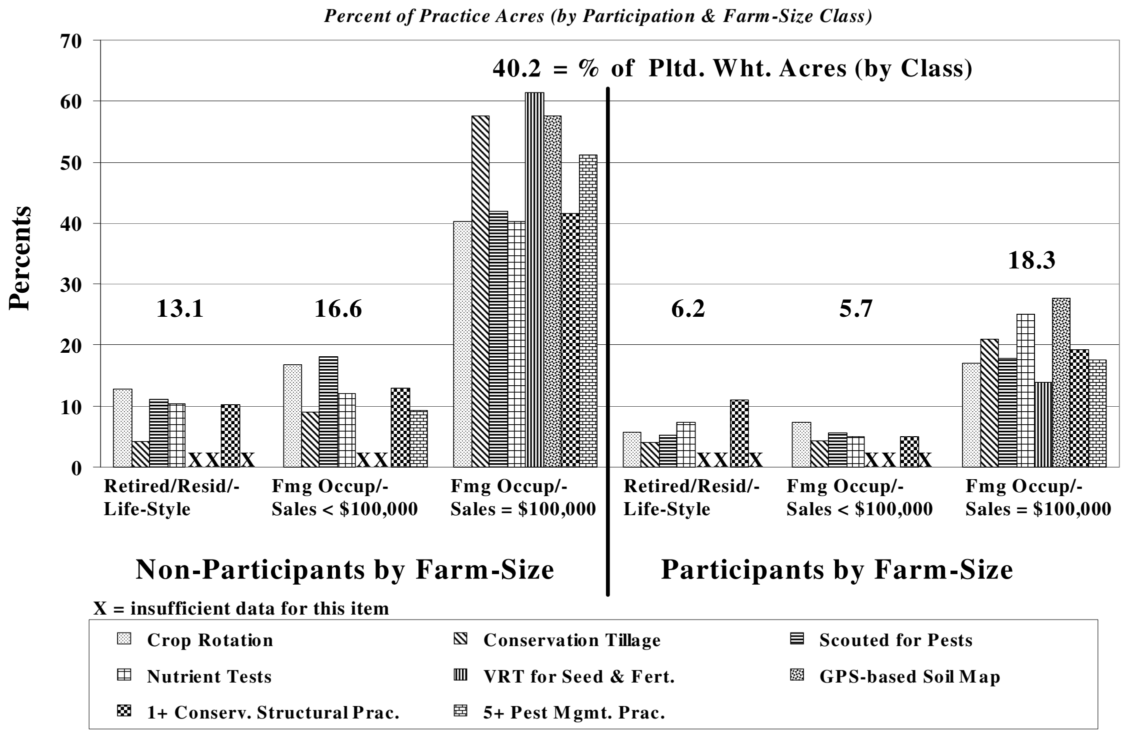


Figure 3. CEAP-ARMS: An integrated farm production practice, economic, and environmental data survey



Source: 2004 CEAP-ARMS Wheat Survey, Economic Research Service, USDA

Figure 4. Land management conservation practices for 2004 wheat



VRT = Variable Rate Technology, and GPS = Global Positioning System.
Source: 2004 CEAP-ARMS Wheat Survey, Economic Research Service, USDA.

Figure 5. Empirical densities of aggregated and on-site field-specific 1997 NRI Universal Soil Loss Equation (USLE) readings

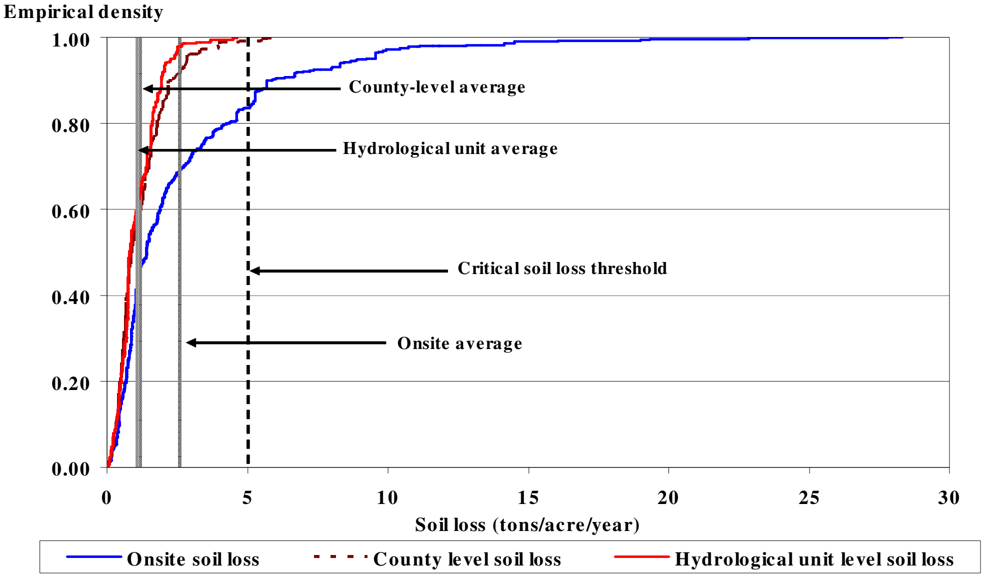
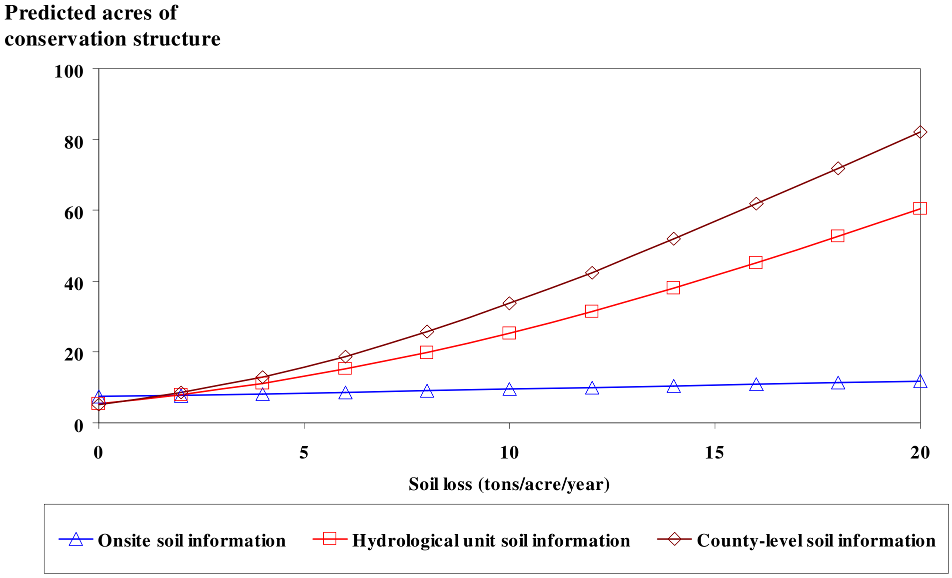


Figure 6. Values of predicted acres under vegetative conservation structures as influenced by USLE data resolution (aggregate vs. site-specific data)



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