The length we go

MEASURING ENVIRONMENTAL BENEFITS OF CONSERVATION PRACTICES

The 2002 farm bill substantially increased funding levels for conservation programs, and established the new Conservation Security Program. How can the American public and legislators know the money will be well spent? A new project—the Conservation Effects Assessment Project (CEAP)—will provide the agricultural community, the public, and others involved with environmental policy issues an accounting of the benefits obtained from these conservation program costs. Now the question: How will CEAP be implemented?

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Conservation practices are designed to reduce losses of soil, nutrients, pesticides, pathogens, and other biological and chemical materials from agricultural lands, conserve natural resources, enhance the quality of the agro-ecosystem, and enhance wildlife habitat. The Farm Security and Rural Investment Act of 2002—referred to as the 2002 farm bill—substantially increased funding levels of conservation programs—up nearly 80 percent above the level set for conservation under the 1996 farm bill. While it is widely recognized that these conservation programs will protect millions of acres, the environmental benefits have not previously been quantified for reporting at the national scale. Moreover, while an extensive body of literature exists on the effects of conservation practices at the field level, there are few research studies designed to measure the larger effects.

The Natural Resources Conservation Service (NRCS) and the Agricultural Research Service (ARS) are working together on the Conservation Effects Assessment Project (CEAP) to quantify the environmental benefits of conservation practices at the national and watershed-scales as a measure for how the money being spent is meeting the goals.

CEAP is an on-going mix of data collection, model development, model application, and research. One of the goals is to develop the appropriate databases and applications over the course of the project. It is anticipated that some of the new indicators and performance measures will be included in the 2006 and 2007 annual reports, and that the 2008 annual report will include more accurate estimates for the chosen performance measures.

There are two main components of CEAP—a national assessment provides modeled estimates of conservation benefits for annual reporting, and the second component quantifies the environmental benefits from specific conservation practices at a watershed scale. The assessment provides an accounting of the environmental benefits obtained from USDA conservation program expenditures for farmers and ranchers, landowners, conservationists, the public, Congress, Office of Management and Budget, or others involved with environmental policy issues. The second component—the watershed scale approach—provides detailed, landscape-specific assessments of environmental benefits that are not possible at the national level.

THE NATIONAL ASSESSMENT

The purpose of the national assessment is to estimate environmental benefits for conservation practices implemented in each year, allowing benefits to be tracked over time. This will also allow for direct comparisons between benefits obtained and program expenditures year-by-year. Benefits will be in terms of physical measures, such as tons of soil saved, reductions in in-stream nutri-

THE SCOPE OF CEAP

What conservation programs does it cover?

- Environmental Quality Incentive Program (EQIP),
- Conservation Reserve Program (CRP),
- Conservation Security Program (CSP),
- Wetland Reserve Program (WRP), Wildlife Habitat Incentives Program (WHIP),
- NRCS Conservation Technical Assistance Program (CTAP)
- Grassland Reserve Program (GRP)

Conservation practices to be emphasized

- Conservation buffers
- Nutrient management
- Pest management
- Tillage management
- Irrigation-, drainage-, manure-, and grazing-management practices
- Establishment of wildlife habitat
- Wetland protection and restoration

Resource concerns

Environmental benefits will be estimated for each of the five resource concerns that conservation programs are designed to address:

- Water quality (nutrient, pesticide, and sediment delivery to lakes, rivers, and streams)
- Soil quality (including soil erosion and carbon storage)
- Water conservation (including flood and drought protection)
- Air quality (including particulates and odors)
- Wildlife habitat (including aquatic and terrestrial habitats)

Agricultural land use categories

Benefits will be estimated separately for four agricultural land use categories:

- Cropland, including cropland enrolled in CRP
- Grazing lands
- Agro-forestry lands
- Wetlands

CEAP GOES ACROSS AGENCIES AND GROUPS

CEAP is a multi-agency effort that will also include involvement from groups outside of the Federal government. The U.S. Department of Agriculture (USDA) collaborators in addition to NRCS and ARS include: Farm Service Agency (FSA), Cooperative State Research, Education, and Extension Service (CSREES), National Agricultural Statistics Service (NASS), and Office of Risk Assessment and Cost Benefit Analysis (ORACBA).

The core group of USDA agencies will coordinate with other Federal agencies involved in natural resource issues, such as the Forest Service (FS), Economic Research Service (ERS), U.S. Environmental Protection Agency (USEPA), and U.S. Geological Survey (USGS), to seek opportunities for further collaboration.

A national panel consisting of experts not directly involved in the project—including representatives outside of government—will be established to provide guidance and recommendations on CEAP.

Forums and workshops will be held periodically to obtain comments and suggestions from academic institutions, state agencies, private organizations, and the public on the analytical approach and findings. Professional societies meetings will also provide an important forum for the exchange of information and ideas. For example, the fourth annual joint symposium of Soil Water Conservation Society (SWCS) and Soil Science Society of America (SSSA) "Assessment of Measurements of Conservation" was presented during the 2003 annual meetings of the SWCS and SSSA.

This initial meeting was so successful that the fifth annual joint symposium of the SWCS and SSSA during 2004 was expanded to "Assessment of Effectiveness of Conservation Practices in North America, Including Watershed Case Studies." SWCS, SSSA, Canadian Society of Soil Science, and the Mexican Soil Science Society will sponsor the 2004 fifth joint symposium. At this meeting we will have American, Canadian, and Mexican soil scientists that will interact and talk about how to assess conservation practices throughout North America.

ent and sediment concentrations, etc.

A literature review will be the first step of the national assessment. ARS and NRCS will organize, with the help from the Soil and Water Conservation Society, a review of research literature and prepare a summary report on what is known about the environmental effects of conservation practices at both the field and watershed scale. Initially, the ARS National Agricultural Library will prepare a set of abstracts from the published literature on environmental effects/results from USDA conservation programs from 1985 to the present for each of the five resource concerns (water quality, soil quality, water conservation, air quality, and wildlife habitat). The set will also contain abstracts about studies on implementation barriers and incentives, and research needs from 1985 to the present; and data and modeling for environmental credit trading from 1993 to the present.

The summary report will establish the state-of-the-science of benefits derived from conservation practices, and consequently, will establish the scientific underpinning for the national assessment. Also, this report will identify the gaps in scientific understanding that need to be addressed to fully be able to quantify environmental benefits. Workshops will provide the content for a synopsis of findings by resource concern. Scientists and technical experts from Federal and state agencies, universities, and consultant organizations will be invited to participate in these workshops which are currently being planned for 2005.

Initially, CEAP will focus on water quality, soil quality, and water conservation on cropland and land enrolled in CRP, reflecting the availability of research findings, national-level databases, and nonpoint source modeling capabilities. During the second year, expert teams will be formed to identify the appropriate

indicators and performance factors for estimating the environmental benefits from grazing lands and wetlands, as well as benefits to wildlife. These teams will identify the data needs and develop modeling approaches needed to estimate environmental benefits at the national level.

Modeling capabilities and databases will be enhanced for all estimates throughout, and initial estimates will be revised to reflect the improved modeling capabilities and information developed during the project.

The national assessment for cropland will be built using existing modeling capabilities. This assessment will connect the conservation practice with the estimates for reductions in nutrient, pesticide, and soil losses, improvements in water quality and water use efficiency, and enhancement of soil quality.

The data

A sampling and modeling approach will provide the basis for estimating reductions in sediment, nutrients, and pesticides from farm fields, increased water use efficiency, and enhancement of soil quality. A simulation model will be built on the National Resources Inventory (NRI). The NRI is a scientifically based survey designed to assess conditions and trends of soil, water, and related resources of the Nation's nonfederal lands. In the past, the NRI has been conducted at five-year intervals, but is currently in transition to an annual cycle of data collection (Goebel, 1998).

(For more information see www.nrcs.usda.gov/technical/NRI/.)

While the NRI is designed to provide statistical information on the natural resources on private lands, it can also be used as an analytical framework for simulation modeling (Goebel and Kellogg, 2002). NRCS has previously made extensive use of the NRI as an analytical framework for modeling to address issues related to natural resources and agriculture.

A subset of about 30,000 NRI cropland sample points will be necessary for constructing the simulation model for the national assessment on cropland. For these sample points, a farmer survey is being implemented to obtain the additional information needed for the fate and transport process model, such as crops grown, tillage, nutrient and pesticide applications, and conservation practices implemented. A separate set of about 10,000 sample points will be selected and surveys conducted over 4 years—2003, 2004, 2005,

OBJECTIVES FOR THE ARS BENCHMARK WATERSHEDS

There are five specific objectives for the 12 ARS Benchmark watershed assessment studies:

1. Assess water quality, water conservation, and soil quality effects and benefits of conservation practices at the watershed scale, and begin investigations into how to quantify wildlife and air quality benefits beyond the edge of the farm field. Assessments will include estimates of uncertainties associated with achieving targeted improvements, such as water quality standards. Practice costs and cost efficiencies will also be evaluated as part of the watershed assessment. Some watersheds will address all resource concerns, while others will be focused primarily on one or two resource concerns.
2. Develop a set of regional watershed assessment models that can be used to address benefits of conservation practices and other environmental issues in the major agricultural regions of the nation and for use in future watershed and national assessments.
3. Develop water quality, water conservation, and soil quality databases that can be used to evaluate effects of conservation practices, and to compile air quality and wildlife habitat data for future assessment. These databases will be used periodically to validate and enhance the models used in the watershed and national assessments and to validate and verify the regionalized models.
4. Develop indicators or performance measures for documenting water quality, soil quality, air quality, and aquatic and terrestrial habitat benefits associated with conservation practices.
5. Expand research on the effects of conservation practices at the watershed scale for different soils, climates, topography, farming practices, cropping systems, and other land uses.

WATERSHED ASSESSMENT STUDIES

There are seven major questions that will be addressed by in the watershed assessment studies:

1. What are the measurable effects of agricultural conservation and management practices on ground and/or surface water quality and other environmental effects at the watershed scale?
2. Within the hydrologic and geomorphic setting of a watershed, how does the timing and location of a suite of conservation practices affect water quality or other environmental effects?
3. What is the appropriate time scale to expect changes in surface or ground water conditions and other environmental effects from conservation practices?
4. What are the uncertainties associated with achieving these water quality and other environmental effects from conservation practices?
5. What social and economic factors within the study watershed facilitate or impede implementation of conservation practices?
6. What are the relationships among agricultural conservation and management practices implemented in a given watershed with respect to their impact on water quality and other environmental effects? Are the effects additive? Multiplicative? Contradictory? Independent?
7. What is the optimal collection and placement of conservation management practices in a watershed to achieve water quality and other environmental goals?

and 2006. The final dataset is obtained by pooling the samples for the four years. For the 2006 annual report, model results for the first three years will be used.

NRCS is collaborating with NASS and FSA to conduct the farmer survey. In the fall, workers will interview farm operators to obtain field-specific data associated with the selected sample points. Questions are asked about physical characteristics of the field and conservation practices associated with the field, for the most recent three years. The local NRCS field office will provide information on the operator's participation in conservation programs, conservation practices associated with the field, and resource concerns.

When the data collection is completed, NRCS will release summaries of the full set of survey results at an appropriate level of aggregation for use by other researchers. Since the sample frame is based on the NRI points—which are geospatially located—NRCS will explore possibilities for summarizing the results of the survey for large watersheds and ecosystems in addition to national-level summaries.

Modeling benefits for cropland

Estimates for each sample point will be generated using the field-level physical process model called EPIC—the erosion-productivity impact calculator. EPIC is a continuous simulation model that can be used to determine the effect of management strategies on agricultural production and soil and water resources. EPIC was initially developed to assess the effect of

soil erosion on soil productivity (Williams et al., 1984). Since then, the model has been expanded and refined to allow simulation of many processes important in agricultural management as well as fate and transport of potential pollutants such as nitrogen, phosphorous, soil erosion, salt, and pesticides. EPIC operates on a daily time step, integrating daily weather data, soil characteristics, farming operations such as planting, tillage, and nutrient applications, and a plant growth model to simulate the growth and harvest of a crop. All farming operations that take place on the field throughout the year are taken into account. On a daily basis, EPIC tracks the movement of water, the cycling of nitrogen, phosphorus, and carbon, and water induced soil erosion. The drainage area considered by EPIC is generally a homogeneous field-sized area of up to about 100 ha (250 ac). Model outputs represent pollutant and water movement to the bottom of the root zone and edge of the field. A wide variety of soil, weather, and cropping practice data input options allow simulation of most crops on virtually any soil and climate combination.

For more information on how EPIC simulates the various processes, see www.brc.tamus.edu/epic/documentation.

The final step in the calculation of conservation benefits is to multiply the per-acre estimates of reductions in soil erosion, nutrients, and pesticides from farm fields, increased water use efficiency, and enhancement of soil quality from the EPIC model by official USDA accounting records on the number of acres of practices implemented from the EQIP practice database, the NRCS Performance Results System database, or FSA's database on CRP enrollments. The calculation will be done on a regional basis to account for regional differences in per-acre estimates. The calculation will be done for each year, providing a time series of national estimates of reductions in soil erosion, nutrients, and pesticides from farm fields, increased water use efficiency, and enhancement of soil quality associated with conservation practices implemented each year.

Water quality benefits will also be assessed at the eight-digit hydrologic unit code watershed scale using a combination of models and databases called HUMUS, which stand for Hydrologic Unit Modeling for the United States (Arnold et al., 1998). HUMUS includes databases on land use and sources of nonpoint and point source pollutants that are used with the Soil and Water Assessment Tool (SWAT) model, which simulates the transport of water from the land to receiving streams and routes the flow downstream to the next watershed and ultimately to the oceans and estuaries. Outputs from the EPIC model runs will be combined with HUMUS databases and the SWAT watershed model to estimate in-stream concentrations of nutrients and sediment at the outlet of each watershed in agricultural regions. This will allow estimation of the reduction in in-stream concentrations attributable to implementation of conservation practices. Other outcome measures are also possible, such as: 1) reductions in the number of days during the year that in-stream nitrogen concentrations exceed the drinking-water-standard, and 2) reductions in the number of days during the warm summer months that in-stream nitrogen and phosphorus concentrations exceed critical thresholds related to algal blooms and eutrophication. (For more information on HUMUS, see srph.brc.tamus.edu/humus; for more information on the SWAT model, see www.brc.tamus.edu/swat/.)

To assure that the national assessment is based on the best possible models and fully captures the existing research findings on the environmental effects of conservation practices, a component of the national assessment will focus on model evaluation, and will make recommendations on enhancements that are needed.

WATERSHED ASSESSMENT COMPONENT

The watershed assessment studies component of CEAP complements the national assessment by providing more in-depth assessment of water quality and other benefits at a finer scale of resolution than is possible for the national assessment. An extensive body of literature exists that describes plot or field-scale conservation practices aimed at protecting water quality, and in some cases, improving soil quality or enhancing water conservation (Hapeman et al., 2003; Hatfield et al., 2001; Howell, 2001; and Sharpley et al., 2003). However, research results from plot- and field-scale studies are limited in that they cannot capture the complexities and interactions of conservation practices within a watershed.

Which watersheds

Only a few watersheds will be selected for study. No attempt will be made to aggregate estimates of benefits for the watershed studies to represent national-level estimates, since too many watersheds would be needed to properly represent the various environmental and resource-based characteristics in the country. The objective is to select watersheds where there is on-going research that includes, either, monitoring, modeling or both in agricultural areas with databases and resource concerns (Hatfield et al., 2000; 2002). Funding and assistance will be provided to adapt and augment the existing watershed models and databases for the specific purpose of evaluating environmental benefits associated with implementation of conservation practices.

There are three categories of watershed studies that will be conducted as part of the CEAP—ARS "benchmark" watersheds, "special emphasis" watersheds, and a collection of watershed case studies funded through a competitive grants program by Cooperative State Research Education and Extension Service (CSREES) and NRCS.

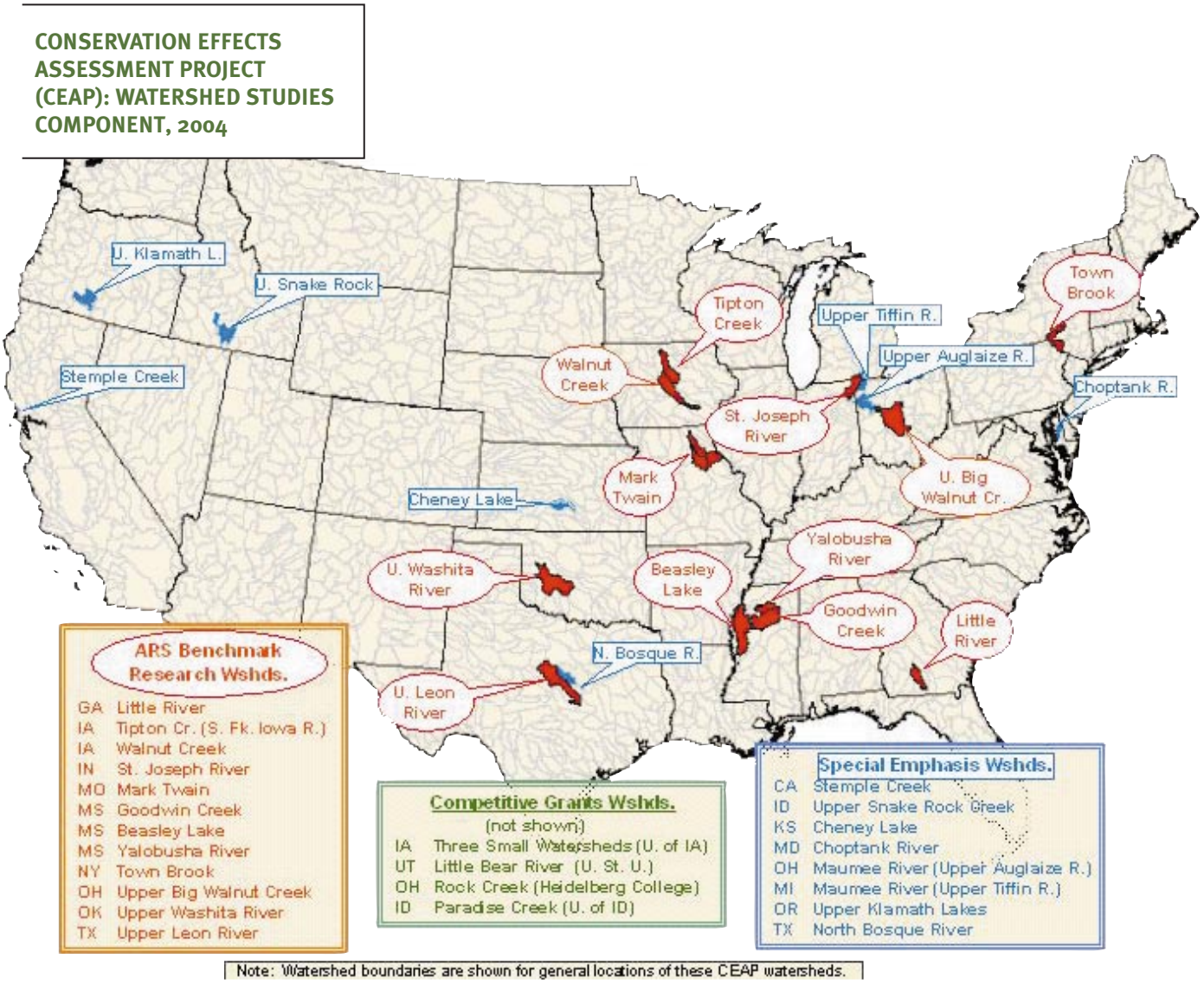
The first set of watersheds is the ARS "benchmark" watersheds where ARS has conservation effects research projects underway. These are primarily long-term research sites where it is anticipated that watershed-scale research and assessment will be continued over many years. Most of these already have water resource and soil quality research projects underway. Development of the regional watershed models will be associated primarily with the ARS research watersheds. The ARS watersheds contribution to CEAP became fully operational on January 1, 2004. (For information on the present research being conducted on the ARS watersheds, see the Water Quality and Management National Program at www.ars.usda.gov/research/programs.)

The 12 ARS benchmark watersheds are located near Ames, Iowa; Tifton, Georgia; El Reno, Oklahoma; Temple, Texas; Oxford, Mississippi; University Park, Pennsylvania; Columbia, Missouri; West Lafayette, Indiana; and Columbus, Ohio

(See map of the ARS benchmark watersheds). In addition to these ARS locations, scientists from Ft. Collins, Colorado are assisting with a portion of the modeling activities. Environmental effects will be estimated for water quality, soil quality, and water conservation. These watersheds represent primarily rainfed or non-irrigated cropland. ARS anticipates selecting additional benchmark watersheds in 2005 and 2006 that represent irrigated cropland and grazing lands. The ARS project plan for the 12-benchmark watersheds will undergo comprehensive scientific peer-review.

The ARS Benchmark watersheds will also focus on field data collection along with laboratory data management issues. ARS Benchmark watersheds will provide information needed to verify the accuracy of models used to conduct the national assessment. In the first phase of the watershed assessments, both the Soil and Water Assessment Tool (SWAT) and the Annualized Agricultural Non-Point Source (AnnAGNPS) models will be utilized to conduct comparative evaluations of environmental benefits associated with conservation practices.

One of the goals of the ARS benchmark watersheds is to develop a set of USDA Watershed Assessment Models that can address environmental quality assessments for specific regions of the nation. Although the USDA Watershed Assessment Models will be designed to primarily address the watershed scales, the set of regionalized models will also be able to evaluate conservation-planning measures at the field scale on a preliminary



assessment basis as requested by USDA agencies such as NRCS and Farm Services Agency (FSA). Currently, these technologies have not been integrated into a unified tool for application by action agencies. The integration of these technologies into a unified USDA Watershed Assessment Model will provide an opportunity to perform watershed analyses of conservation practices beyond water quality impacts.

The second set of watersheds is called "special emphasis" watersheds. These have been selected to address specific resource concerns over a 2-3 year period of time. Two specific concerns to be addressed by these watershed studies are manure management from animal feeding operations and water use on irrigated cropland. Other issues of concern that may be addressed are: drainage management practices, declining surface or groundwater supplies, flood control structures or reservoirs, wetland construction and rehabilitation, or other special land use activities that relate to the management and operation of primarily cropland (irrigated and rainfed) watersheds. Special emphasis watersheds selected for study beginning in 2004 include:

1. Choptank River in Maryland
2. Maumee River-Upper Tiffin River in Michigan
3. Maumee River-Upper Auglaize River in Ohio
4. Upper Snake Rock Creek in Idaho
5. Cheney Lake in Kansas
6. Upper Klamath Lakes in Oregon
7. North Bosque River in Texas
8. Stemple Creek in California

The third set of watersheds will be selected through the CSREES Water Quality Initiative Competitive Grants Program. This program will sponsor a collection of watershed case studies that will explicitly investigate the linkages among a variety of conservation and land management practices as implemented over space and time and the resultant effects on water quality. The ultimate goal of the program is to understand how to optimally locate and schedule the implementation of conservation practices within a watershed in order to achieve locally defined water quality goals. The request for applications responds to the need to conduct research that evaluates the interactions among conservation practices and their biophysical setting on water quality at the watershed scale. The request for applications became available in 2004, and is sponsored by CSREES and NRCS for approximately $3 million dollars. Four to six watershed projects will receive funding each year for up to three years. The four watersheds selected for study in 2004 include:

1. Paradise Creek watershed in Idaho
2. Rock Creek watershed in Ohio
3. Three small watersheds in Iowa
4. Little Bear River watershed in Utah.

Conclusion

The 2002 farm bill substantially increased funding levels for existing conservation programs and established the Conservation Security Program (CSP). NRCS and ARS have joined together, in collaboration with other Federal agencies and universities to initiate studies that will quantify the environmental benefits of conservation practices implemented through these programs. A national assessment is being implemented to track environmental benefits over time at the national scale. In selected regions, watershed studies are being initiated to provide more in-depth assessments at a finer scale of resolution. This national effort will advance the knowledge of how watershed scale assessments should be done and provide additional research findings and insights on the expected off-site effects of conservation practices. Annual reports that document the environmental benefits of conservation practices will be published beginning in 2006. Tracking the progress of conservation programs in terms of the outcomes achieved will allow policymakers and program managers to improve the effectiveness of existing programs and design new programs to increase the conservation of our nation's natural resources.

Endnote

This paper was presented at two symposia events held at the 2003 annual conferences of the Soil Water Conservation Society, in Spokane, Washington, July 28, 2003, and at the Soil Science Society of America in Denver, Colorado, November 3, 2003. Together these two symposia, that addressed the effectiveness of conservation practices, mark the fourth annual joint symposium organized by the two societies and presented at both societies' annual meetings.

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Reprinted from the *Journal of Soil and Water Conservation*
Volume 59, Number 5