Chapter 8

Synthesizing the Experience of the 13 National Institute of Food and Agriculture–Conservation Effects Assessment Project Watershed Studies: Present and Future

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The Conservation Effects Assessment Project (CEAP) watershed studies were intended to quantify the measurable effects of agricultural conservation practices on water quality patterns and trends at the watershed scale using a retrospective design (Duriancik et al. 2008). Specifically, the National Institute of Food and Agriculture (NIFA) CEAP studies were charged with answering four key questions about how timing, location, interactions, and socioeconomic factors affect the optimal implementation of conservation practices in a watershed to achieve water quality goals:

1. Within the hydrologic and geomorphic setting of a watershed, how do the timing, location, and suite of implemented agricultural conservation practices affect surface and/or groundwater quality at the watershed scale?
2. What are the relationships among conservation practices implemented in a given watershed with respect to their impact on water quality? Are the effects additive, contradictory, or independent?
3. What social and economic factors within the study watershed either facilitate or impede implementation or proper maintenance of conservation practices?
4. What is the optimal set or suite of conservation practices and what is their optimal placement within the watershed in order to achieve water quality goals or to provide acceptable reductions in water quality impairments?

Most projects were unable to answer all of these questions because of limitations in water quality data, land treatment information, and/or other data or technical constraints. This was due in part to the retrospective nature of the projects and the current state of science. Nevertheless, much can be learned from these projects. Assembling the lessons learned from these efforts was the charge of this project—Synthesizing and Extending Lessons Learned from the 13 NIFA–CEAP Watersheds, which will be referred to as this synthesis project. Many gaps that could not be filled by any single project were addressed using supplemental information gathered through this synthesis, including site visits with the research teams, review of project documents, key informant interviews, and the merging of all of these information sources from multiple projects.

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The first part of this chapter summarizes information and provides some recommendations relative to the three questions that this synthesis sought to answer:

1. What are the key findings from projects that addressed the original four CEAP questions? How do these findings differ by location and agricultural production activities, social, or economic factors? What patterns emerge from this effort?
2. What combinations of practices work to protect or improve water quality in different geographic settings?
3. What outreach techniques were most effective at communicating information for different audiences, achieving adoption of practices, and improving management and/or maintenance of practices in different geographic settings?

This synthesis is built along topical lines, such as land treatment, monitoring, modeling, socioeconomics, and outreach, and each topic was addressed in Chapters 2 through 7. These chapters provide details, concluding with lessons and recommendations. The second part of this chapter pulls together all of the information to explore how conservation agencies and organizations can better use available resources to design and implement conservation programs that more effectively protect water quality.

Lessons Learned from the National Institute of Food and Agriculture–Conservation Effects Assessment Project

The first synthesis question that is addressed (Synthesis Question 1) had its direct roots in the fundamental issues that all 13 NIFA–CEAP watershed studies addressed. As previously noted, each NIFA–CEAP tried to address four specific questions. In order to answer the first synthesis question, the four key questions directed toward each of the NIFA–CEAP studies also had to be addressed.

Synthesis Question 1: What Are the Key Findings from Projects That Addressed the Original Four CEAP Questions? How Do These Findings Differ by Location and Agricultural Production Activities, Social, or Economic Factors? What Patterns Emerge from This Effort?

The primary goal of most NIFA–CEAP watershed studies was to determine the overall effect that conservation practices had on water quality. We will start with addressing the first key question, “Within the hydrologic and geomorphic setting of a watershed, how do the timing, location, and suite of implemented agricultural conservation practices affect surface water and/or groundwater quality at the watershed scale?”

Water quality monitoring among the NIFA–CEAP watershed studies had limited success in documenting the effects of implemented agricultural conservation practices on surface water or groundwater quality at the watershed scale. However, six of the NIFA–CEAP studies (the Walnut Creek Watershed in Iowa, the Paradise Creek Watershed in Idaho, the Central Platte Natural Resources District in Nebraska, the Cannonsville Reservoir in New York, Rock Creek in Ohio, and Spring Creek in Pennsylvania) were able to successfully document changes in water quality attributed to land treatment through monitoring; in most cases, the water quality monitoring largely preceded the NIFA–CEAP studies themselves. The other NIFA–CEAP studies could not document effectiveness of conservation practices using observed hydrologic

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and water quality data. In some cases, water quality changes or trends were observed through monitoring but could not be reliably linked to the implementation of conservation practices.

Reasons for this lack of linkage varied. Identification of pollutants and pollutant sources was the critical first step for selection of appropriate conservation practice(s). Once pollutants and pollutant sources are identified, then the conservation practices must be properly matched to the pollutant(s) of concern—the best conservation practices simply will not work if they do not treat the problem. In several watersheds, prior conservation practice implementation was not linked to the primary pollutant(s) of concern; as a result, incorrect conservation practices were installed. For example, erosion control practices were applied in many watersheds, although the water quality problems of concern were caused by soluble nutrients or pesticides. The NIFA–CEAP research teams could only evaluate what had already happened in the watershed and had to use existing water quality and land monitoring programs that may not have collected information optimally. Nevertheless, this demonstrates a key problem for projects that attempt to retrospectively relate water quality changes to conservation practice adoption when the conservation program was not properly designed.

Many NIFA–CEAP studies also found it difficult to match practice adoption with water quality because data on land use and agronomic management are difficult to collect, especially retrospectively. Lack of such data impaired detection and understanding of trends or changes observed in water quality data for several of the projects. Often, projects were stymied in their land-use collection due to confidentiality restrictions on conservation practice implementation and land management data. The success of individual projects in obtaining necessary and useful land treatment data depended not only on the quality of the historical recordkeeping but just as often on personal relationships and luck. In addition, changes in land use can confound the assessment of water quality; two agricultural projects in urbanizing watersheds were unable to show water quality changes, in part because of changing nonpoint sources over the course of the project. Other physical effects, such as climate variability, lag time in response to treatment, and spatial distribution of land treatment, may have affected the ability to relate the actions of conservation practices to water quality. Finally, it appears that maintenance of long-term conservation practices has generally not been vigorously pursued and that management practices (e.g., nutrient management) generally were not sustained as well as structural practices.

None of the projects were able to directly determine the effects of timing and location of conservation practices relative to water quality changes. Modeling, however, was used to explore these relations, as well as hydrologic and geomorphic influences of conservation practices and their locations.

The Missouri and New York NIFA–CEAP watershed studies investigated influences of hydrology on pollutant losses. In the Goodwater Creek Watershed in Missouri, modeling demonstrated that runoff volume and atrazine concentrations at the field outlet increased with increasing length of backslope (given constant slope). This result indicated that focusing on backslopes could improve conservation practice performance. Similarly, modeling in the Cannonsville Reservoir Watershed in New York clearly demonstrated how the extent of runoff generation in the watershed was controlled by soil saturation conditions, and, thus, how critical source areas within the watershed varied spatially and temporally. Modeling results were used to target conservation practices to variable source areas, where the majority of runoff was likely to be generated.

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Soil properties, in particular, saturated hydraulic conductivity, depth to restrictive soil layers (e.g., claypan soil horizons), and topographic characteristics of fields, were identified as primary controls for generation of runoff and movement of chemicals in runoff in the following NIFA–CEAP studies: the Goodwater Creek Watershed in Missouri, the Paradise Creek Watershed in Idaho, and the Cannonsville Reservoir in New York. Indices, similar to the soil topographic index, were developed by combining these factors to identify hydrologically sensitive areas prone to runoff generation. These indices identified critical source areas, particularly for chemicals that moved primarily in dissolved form in runoff. Importantly, pollutant source identification using these simple indices agreed, overall, with results from the Soil and Water Assessment Tool (SWAT), the Agricultural Policy Environmental eXtender (APEX), and the Water Erosion Prediction Project (WEPP) models.

The Arkansas, Missouri, and New York NIFA–CEAP modeling studies revealed that suites of conservation practices had variable performances due to interactions between practices and climatic conditions. Analysis of 171 conservation scenarios in the Lincoln Lake Watershed in Arkansas showed that buffer strips were more effective in reducing total nitrogen (N), soluble phosphorus (P), and total P losses when combined with optimal grazing scenarios rather than over-grazing scenarios. The Missouri Project found that fate and transport of atrazine in the Goodwater Creek Watershed were dominated by the interaction between weather and application dates. The Cannonsville Reservoir Project in New York confirmed that the fate and transport of dissolved P was determined by interactions between manure application date and weather conditions.

Modeling was also used to investigate the impacts of land-use change and conservation practices on channel erosion. According to long-term simulations of channel erosion processes with the Conservational Channel Evolution Pollutant Transport System (CONCEPTS) model in the Paradise Creek Watershed in Idaho, bed and/or bank erosion from the channel network was a major source of watershed sediment loads. Modeling results also indicated flushing legacy sediments in the channel network could take nearly 19 years (Newson 2007). Other NIFA–CEAP watershed studies (the Walnut Creek Watershed in Iowa, the Cheney Lake Watershed in Kansas, the Goodwater Creek Watershed in Missouri, and the Spring Creek Watershed in Pennsylvania) confirmed the vulnerability of streams to erosion in the study watersheds after implementation of soil erosion control practices and/or conversion of agricultural fields to natural prairie or forest.

The second key question addressed by the NIFA–CEAP watershed studies was, "What are the relationships among conservation practices implemented in a given watershed with respect to their impact on water quality? Are the effects additive, contradictory, or independent?"

None of the NIFA–CEAP studies were able to demonstrate additive or independent relationships among conservation practices, but several projects were able to show contradictory relationships between practices. For example, the conservation system that includes terraces, grassed waterways, and inlet drains decreased sediment losses from fields but increased shallow groundwater nitrate-nitrogen losses (the Walnut Creek Watershed in Iowa and the Goodwater Creek Watershed in Missouri). In the Missouri Watershed, researchers noted the potential conflict between reduced tillage (decreased sediment losses) and herbicide runoff (increased herbicide losses).

Water quality monitoring in the NIFA–CEAP watershed studies generally did not address the objective of identifying relationships among conservation practices in a watershed with respect

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to impacts on water quality. Monitoring to meet this objective must be carefully designed; earlier monitoring programs were generally not intended to meet such an objective. Most of the new or continued monitoring in the case study projects was conducted at a watershed or subwatershed scale that did not allow the effects of individual practices or combinations of practices to be detected. Although some projects included monitoring data on individual practices that supported or informed the application of the practice in the watershed, water quality monitoring was not applied to investigate specific interactive relationships between multiple practices.

Several NIFA–CEAP watershed studies addressed the relationships among conservation practices implemented in a given watershed with respect to their impacts on water quality through modeling. However, none determined if practices were additive, contradictory, or independent.

Unlike many previous watershed-scale projects, there was special emphasis put on socioeconomic factors, as encapsulated in the third key question, "What social and economic factors within the study watershed either facilitate or impede implementation or proper maintenance of conservation practices?"

Information on social and economic factors influencing conservation practice adoption was derived from an analysis of the social and economic studies (Chapter 6) and from the key informant survey (Chapter 2).

The most often cited determinant of conservation practice adoption was the availability of economic incentives (Chapters 2 and 6) (Prokopy et al. 2008). Farmers expressed a willingness to adopt conservation but also a need for agencies to offer more cost-share dollars for specific practices, although there are always exceptions and some farmers would never participate regardless of the level of support.

Government can significantly influence the impact a practice will have on farm profitability and how readily a practice can be integrated into farm operations. The authors heard, for example, that conservation practice standards are inflexible and are overengineered, raising costs beyond what farmers were willing to bear, even with cost sharing. Plans were criticized as being broader than producers were willing to accept, especially when presented as an all-or-nothing choice.

Working with government agencies, such as the USDA Natural Resources Conservation Service (NRCS), was considered to be more costly in terms of both time and money than necessary due to excessive rules and paperwork. Advocates of conservation would be more effective if they were to demonstrate or at least discuss how conservation practices can directly help producers, especially if they can show a positive impact on profit. Perceptions about efficacy also mattered to conservation practice adoption, with those with higher potential reduction efficiencies being more likely to be considered than those with low reduction efficiencies. The ability to adjust cost share as programs evolve was shown to increase adoption. In Nebraska, for example, the USDA NRCS initially cost shared only one center pivot irrigation system per farmer per lifetime for US$3,000 (Chapter 16). After adoption stalled, the USDA NRCS began cost sharing one center pivot per farmer per year for up to US$7,500 per lifetime. This change stimulated additional adoption of improved irrigation practices. Finally, government policies or market forces that increase commodity prices could actually curtail conservation efforts. During our site visits, some farmers and agency personnel discussed the real possibility of Conservation Reserve Program (CRP) lands reverting to agricultural production as a result of rising commodity prices. Financial security may increase conservation, but opportunities to increase income, especially in the short run, may work against investment in conservation.

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Additional funding through outside entities can be critical to increasing conservation practice adoption because of the added resources for technical assistance and conservation practices brought to bear in the watershed. Three of the NIFA–CEAP watershed studies had significant outside support that helped them achieve results. In the Cannonsville Reservoir in New York and the Cheney Lake Watershed in Kansas, major cities helped the watersheds by infusing money into the efforts to increase adoption in order to help protect the urban drinking water supplies. The money they provided and cooperation with local farmers and others to plan how to use these funds increased the use of conservation and generally improved the attitudes of farmers about conservation. In the Lincoln Lake Watershed in Arkansas, it was the threat of a lawsuit from an outside entity that motivated change. Nutrients from poultry litter had been targeted for reduction because the nutrients were assumed to flow into a pristine river in Oklahoma. A subsequent lawsuit forced farmers in that region to look hard for ways to conserve and brought in focused amounts of money and technical assistance.

The mixtures of people, businesses, and agencies trying to influence outcomes in any one watershed can have a profound impact. They can work together well or send mixed messages that undermine each other and confuse farmers. Most of NIFA–CEAP watershed studies had excellent working relationships with multiple entities within the watershed, but in one situation where agencies and organizations provided contradictory messages, farmer participation in the project was reduced.

There also are some very fundamental reasons that farmers do not adopt practices, such as lack of control, lack of trust in government agencies, and farm characteristics (such as size). Farmers are less likely to adopt a practice they believe has limited flexibility to be adapted to their production system and/or to potential changes in conditions. Some farms are simply too small to consider conservation; others are too big, and the equipment they use is incompatible with some field conservation practices. Some small farmers are unaware of pollution or solutions because outreach education has failed to reach them.

There are many different sociological factors that increase conservation. The literature suggested that very few variables consistently explain conservation adoption. A list of factors that often promoted or impaired adoption could be developed from this synthesis with some confidence. A comprehensive list is provided in Chapter 6, but the five main themes that increase the likelihood of adoption include the following:

1. Conservation practices that increase profits. This includes increased product sales or reduced costs, whether caused directly or indirectly by adopting the conservation measure. It would also include government subsidies or regulations if they were to apply.
2. Conservation practices with on-farm benefits that are easy to observe. Some practices, like reduced tillage or terraces, have direct benefits to a farmer that he or she can observe. Others, like reduced nutrient runoff, are more difficult to get a farmer to adopt because the impact occurs outside his or her sphere of recognition.
3. A strong belief in stewardship or conservation ethic is held by the farmer. Some farmers will adopt conservation on their own, either believing it is profitable in the long run or because they believe they have a responsibility to protect the environment. Sometimes the responsibility grows from stewardship on the farm; other times, it emanates from understanding of the off-site consequences of actions on the farm.
4. A strong network of financial, technical, and peer support. Working independently does not appear to stimulate a lot of conservation adoption by farmers. They like to discuss

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issues with peers and to have financial or technical help when they need it. Producers in Oregon told us that the experts did not know how to help them when residue burning was banned and that they had to learn how to use reduced tillage themselves. They learned how to get better seed contact from other farmers—not from experts. Farmer-to-farmer contact needs to be an integral part of USDA NRCS and the Farm Service Agency efforts to make payments and extension efforts to educate.

5. Flexibility and inclusion in the solutions. Interviewers were told many times and in many ways that farmers felt the government approached conservation from the top down. This diminished inclusion of ideas from producers and did not allow them flexibility to make adaptations that they felt appropriate at the local level.

The Little Bear River Watershed Project in Utah (Chapter 21) explicitly investigated long-term maintenance of conservation practices, and it was the only NIFA–CEAP that conducted a follow-up survey. To assess implementation and maintenance of conservation, project staff conducted a series of field visits and interviews with the 90 landowners who had participated in Little Bear River Watershed protection projects since 1990. Survey results indicated that not all practices were fully implemented—75% of management conservation practices, 13% of planting conservation practices, and 4% of structural conservation practices were not fully implemented, even though the producers thought they were doing a good job. The survey indicated that 61% of management practices, 4% of planting practices, and 35% of structural practices were not maintained and had essentially been abandoned. Reasons for discontinuation of practices included the following: the practice was designed to be temporary, the practice was undone by natural events, new structures replaced old structures, the producer no longer wanted to follow the management practices, or the farm system had changed. Other NIFA–CEAP watershed studies had additional knowledge that informed this question. In the Cheney Lake Watershed in Kansas, nutrient management was discontinued as a promoted conservation practice due to its lack of use (Chapters 2 and 14). Researchers in the Pennsylvania NIFA–CEAP noted that fencing was often not maintained when land ownership changed (Chapter 20). Taken together, management practices or structural practices that require management (e.g., fencing, controlled drainage) are less likely to be implemented or to be maintained after implementation.

The fourth key question addressed by the NIFA–CEAP watershed studies was, “What is the optimal set or suite of conservation practices and what is their optimal placement within the watershed in order to achieve water quality goals or to provide acceptable reductions in water quality impairments?”

In a relatively short-term program, such as the NIFA–CEAP, this question was essentially impossible to answer directly through water quality and land treatment monitoring. This objective was primarily addressed through modeling. Note however, that because modeling required water quality monitoring data for calibration and validation, monitoring did contribute, at least indirectly, to this objective. It should also be noted that both the Cheney Lake Project in Kansas and the Goodwater Creek Project in Missouri employed water quality monitoring and land treatment data in combination with modeling to identify critical pollutant source areas and to assess, albeit retrospectively, the appropriateness of past placement of conservation practices in the watershed. Both projects found conservation practices had not been efficiently targeted to the most critical source areas in the watershed.

Modeling was able to investigate the optimal set and placement of conservation practices to achieve water quality goals or to provide acceptable reductions in water quality impairments. Two of

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the NIFA–CEAP watershed studies (the Lincoln Lake Watershed in Arkansas and the Walnut Creek Watershed in Iowa) used integrated simulation-optimization frameworks to determine the optimal set of practices for water quality protection. The Arkansas study revealed implementation of all practices in the low-cost solution would reduce total P loads by 76%, while increasing total watershed cost by less than 2% when compared to the baseline scenario (Rodriguez et al. 2011). A similar simulation-optimization framework was developed by the Iowa NIFA–CEAP team to search for the most cost-effective set of conservation practices in the Squaw Creek Watershed for reduction of total N (Rabotyagov et al. 2010). The lowest marginal cost of reducing mean annual N loadings by 30% on a per-cropland acre basis was approximately US$1 per year. In general, the use of simulation-optimization frameworks was found to be an efficient approach for identification of critical sources areas and allocation of optimal suites of practices, within the context of modeled projections. These tools can help decision makers evaluate feasibility of meeting water quality targets at different budget levels, prioritize subwatersheds for implementation of watershed plans, and identify the optimal locations and types of conservation practices. However, model results should not be used alone to identify critical areas and prioritize conservation practices without additional professional judgment and common sense. For example, the Iowa optimization suggests grassed waterways, terraces, and conservation tillage practices as the best solution for reducing N. Yet all of these practices usually increase N leaching and loss through tile drains, which was the source of the pollution—not overland runoff. This finding points to the importance of asking the right questions of a modeling application.

Synthesis Question 2: What Combinations of Practices Work to Protect or Improve Water Quality in Different Geographic Settings?

Although six (the Walnut Creek Watershed in Iowa, the Paradise Creek Watershed in Idaho, Rock Creek in Ohio, the Central Platte Natural Resources District in Nebraska, the Cannonsville Reservoir in New York, and Spring Creek in Pennsylvania) of the 13 NIFA–CEAP watershed studies were able to show water quality effects due to the adoption of particular conservation practices, there were not enough similarities among projects to definitively answer this question.

Two of the projects, the Paradise Creek Watershed in Idaho and Rock Creek in Ohio, were able to reduce sediment losses due to large increases in the use of conservation tillage (Chapters 12 and 18), and long-term monitoring was able to demonstrate a water quality change. However, these were not the only projects to use conservation tillage. The watersheds in these two states represented very different agroecological conditions, and the tillage systems were not identical, although the results were similar: decreases in sediment. A regional effort in the northwest that began in 1976 was funded by the USDA and state agricultural experimental stations in order to combat excessive erosion. This program, Solutions to Environmental and Economic Problems (STEEP), provided research and education that focused on reduced- or no-tillage and changes in cropping systems. As a consequence of the STEEP efforts and in association with the USDA NRCS conservation programming, estimated or computed cropland erosion rates were reduced by over 75%, which included the project area in Idaho.

Farmers in Rock Creek Watershed in Ohio were responsible for changing to conservation tillage and farming systems once John Deere no-tillage planters were available. A large number of watershed farmers purchased this equipment because of their faith in the product and interest in reducing costs. The increase in conservation tillage decreased soil losses.

Due to a system of conservation practices—exclusion fencing, stream crossings, and stream armoring—sediment was reduced in streams running through pastures in the Spring Creek

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Watershed in Pennsylvania. There appeared to be some improved habitat associated with this reduction of sediment.

Nitrogen was reduced in the Iowa and Nebraska NIFA–CEAP watersheds, but the agroecological areas and conservation practices differed significantly (Chapters 11 and 16). In the Iowa Project, the Walnut Creek Watershed was slowly transforming from row crop to tall grass prairie; the conservation practice was essentially widespread replacement of crop agriculture with restored native prairie to which no N fertilizer was applied. This land-use change was successfully reducing stream nitrate concentrations. The only groundwater NIFA–CEAP was located in the Central Platte Region of Nebraska and was part of a large 30-year effort to reduce groundwater nitrate concentrations through the use of improved nutrient and water management. A quasi-regulatory program was implemented in this watershed that included attendance at educational programs and annual reporting of irrigation use and quality; millions of dollars have been targeted toward conservation and educational programs. Monitoring documented a statistically significant decrease in groundwater nitrate levels, although concentrations still exceeded water quality standards.

Phosphorus reductions were evident in the New York Cannonsville Reservoir paired-watershed, where a single dairy farm was the focus of intensive treatment (Chapter 17). Multiple conservation practices were installed on the dairy—from barnyard improvements to a nutrient management plan that focused manure applications on fields less likely to generate surface runoff. These conservation practices were based on comprehensive nutrient management plans, crop rotations, strip cropping, riparian buffers, and associated cattle exclusion from the riparian areas; alternative water development using springs; barnyard improvements, including the development of a lagoon; filter areas for barnyard runoff; relocation of the stream and the silage storage area; targeted manure spreading schedule; and interceptor drainage ditches to reduce flow to frequently saturated areas. Adaptive management was used so that as monitoring data revealed continued impairment and as additional pollutant sources were identified, more conservation practices were added, including precision feeding, an additional stream crossing, and streambank restoration. This project showed that almost every P source and pathway from the dairy farm had to be treated to achieve the desired level of water quality improvement. The discrete effects of individual practices were not identified, but the complete conservation system was necessary to achieve the net reduction of nutrient pollution required.

Synthesis Question 3: What Outreach Techniques Were Most Effective at Communicating Information for Different Audiences, Achieving Adoption of Practices, and Improving Management and/or Maintenance of Practices in Different Geographic Settings?

The most effective outreach technique for promoting conservation practice adoption was one-on-one communication by a trusted, local education point-of-contact who was experienced with local farming practices and was respected in the agricultural community. This was confirmed by both the key informant survey (Chapter 2) and analysis of project outreach information (Chapter 7). This contact could also be made in a peer-to-peer context. In addition, education effectiveness was enhanced when early adopting farmers implemented conservation practices and served as demonstration farms for neighbors to learn through participatory observation and when producers established farmer-to-farmer programs. These education activities were most effective when focused on the most meaningful farmer incentives: profit, flexibility, and fit of the conservation practices into the overall farming system.

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Education and outreach programs delivered from short-term projects have limited ability to produce meaningful changes in behavior. Furthermore, traditional methods of educational delivery—fact sheets, trainings, field days—no longer reach as many farmers as in the past, due to multiple pressures, such as off-farm work, increasing farm size, or lack of confidence in traditional sources of information (e.g., extension, the USDA NRCS, and/or Soil and Water Conservation Districts). Simple transfer of information and knowledge alone will not change behavior. Increasing conservation practice adoption will require dedicated personnel who provide, or know where to obtain, individualized technical and financial assistance for their farmer-clients on a consistent basis. Conservation education is unique because it involves merging the goals of the larger community with individual farmers. Therefore, conservation practice outreach education must have long-term funding to hire dedicated staff to work one-on-one with farmers as technical-transfer agents. Most conservation outreach personnel who work directly with farmers are funded by short-term grants that end before or just as essential trust-based relationships that can truly achieve change are formed. It might also help if there were dedicated outreach professionals at the federal level, where local advisors could find specialized information and training about conservation practices and educational programming.

Human dimensions are critical to the role of outreach education. Effective outreach alone is insufficient to increase adoption of conservation practices. Other social and economic factors described in this chapter are essential to facilitating adoption and maintenance of conservation practices.

How to Design More Effective Agricultural Conservation Programs

Beyond addressing the three specific synthesis questions, many lessons revealed during this synthesis can be applied to increase the effectiveness of conservation practice planning, implementation, and maintenance. Furthermore, lessons were learned or rediscovered about effective watershed investigations to demonstrate conservation practice and water quality relationships that can be applied to improve watershed project assessment. As many of the project personnel themselves related during site visits, the lessons learned from this synthesis point to a clear need to change course in how agricultural conservation programs to protect water quality are designed and delivered.

Improve Implementation of Conservation Practices

During this synthesis, it became evident that conservation practice adoption is a complex, multivariate decision, not simply a binary, yes-no choice on the part of farmers who must implement and maintain the practices. Key elements of these decisions include selection of appropriate conservation practices, application of practices to critical source areas, use of outreach education and incentives to enhance practice adoption, and encouragement of long-term operation and maintenance of practices by farmers. Addressing agricultural nonpoint source problems at the watershed level must ensure participation in the planning, implementation, and maintenance of conservation practices by agency personnel, farmers, other watershed landowners, and interested organizations.

Specific observations and recommendations for improved delivery of conservation practices were developed during the synthesis process and were presented in Chapters 2, 3, 6, and 7. Based on the lessons learned from the case-study NIFA–CEAP watersheds, the following steps

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are essential to improve the effectiveness of conservation practice implementation in order to protect water quality:

- Engage in deliberate and effective watershed planning using the following considerations:
    - First and foremost, identify the water quality impairments, pollutants, and pollutant sources in order to select the appropriate conservation practices.
    - Match the conservation practice(s) to the pollutant(s) and source(s) of concern.
    - Set goals for implementing conservation practices on a sufficient scale to influence water quality.
    - Define objectives in a collaborative approach that facilitates positive public discussion about tradeoffs between water quality and farming goals.
- Engage in deliberate conservation practice implementation using the following considerations:
    - Implement conservation practices selected to treat the pollutant(s) and pollutant sources. Most NIFA–CEAP watershed studies implemented conservation practices that targeted erosion and sediment abatement, even when the principal water quality impairment was nutrients, herbicides, or bacteria. Some projects learned only during the project that the pollution source was different from what was assumed; thus implemented practices had little effect on the pollutant(s) of concern.
    - Target conservation practices to critical source areas to lower the cost and improve the effectiveness of pollution prevention. With the benefit of hindsight, three projects found that only about 25% of conservation practices had been implemented on important pollutant source areas. Modeling can be a useful tool (as discussed later) for determining the location of critical areas before conservation practices are implemented.
    - Tailor conservation practices to the farm management systems used within each watershed and incorporate sufficient flexibility such that practices can be adapted to meet the needs and expectations of individual farmers while still achieving conservation goals.
    - Streamline the conservation practice selection process and allow flexibility to allow for innovation and farmer input.
- Apply effective outreach education programs using the following strategies:
    - Encourage one-on-one contact between valued conservation agency staff and farmers and respect the need to include farmer-to-farmer learning opportunities. This method often requires concentrating and combining financial, technical, and educational assistance.
    - Build on the way most farmers learn—from each other. Develop a network of early adopting farmers to serve as demonstration farms for neighbors to learn about conservation practices through observation and to gain verification that the practices work in their production systems.
    - Understand how farmers make decisions about conservation practice adoption and maintenance. Social or family norms, social networks, stewardship attitudes, and many other subtle human dimension characteristics affect conservation practice adoption outcomes.
    - Develop a comprehensive outreach education plan with goals, objectives, target audiences, implementation strategies, and responsibilities at the beginning of the project and evaluate progress and employ adaptive management throughout the process to optimize educational outcomes.

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  - Streamline the conservation practice selection process and coordinate programs across federal and state conservation agencies to encourage and secure participation by land owners/manager; particularly those controlling critical source areas.
  - Use education programs to market conservation practices and programs to encourage participation and to support postimplementation management of installed practices. Extension should be actively engaged to work in close concert with technical and financial assistance agencies to design marketing strategies that target farms with critical land area in need of conservation and to provide education on practice management to ensure sustained effectiveness.
  - Recognize that short-term project outreach education is unlikely to generate true behavior changes. Beyond a specific project focus, there is a need to charge and support extension with national ongoing conservation education. Such outreach is needed in all watersheds and could be amplified where specific water quality impairments exist.
  - Place renewed emphasis at the national level on outreach education at the watershed level to advance conservation among farmers. Working directly with farmers (education and outreach) was critical to increased adoption of conservation measures. It may take special educational skills and a unique understanding about how the benefits from conservation are divided on and off farm to work effectively with farmers. Here, it is recommended that dedicated agents provide education. It is also recommended that they need independent information and training. A training center should include contributions and cooperation from the USDA NRCS, extension, and the Farm Service Agency. Enough funding should be secured to ensure that information about which technologies and education methods work best can be collected, synthesized, and provided to field staff.
- Improve incentives to promote conservation practice adoption with the following considerations:
  - Recognize that because farming is a business, the most important incentive to farmers is profit, followed by conservation practice fit with the remainder of the farming operations. Time management is an important component of this fit.
  - Develop better incentives that include funding, flexibility, and ease of management and more convincing ways to demonstrate benefits to encourage farmers to implement conservation practices. In addition to increased profitability, flexibility, and ease of adoption, issues of yield, aesthetics, neighborliness, wildlife benefits, labor reductions, and regulatory avoidance may be important.
  - Recognize that some practices are easier or harder for farmers to adopt. More difficult or less acceptable practices, such as riparian buffers and nutrient management, will require greater incentives than practices that farmers are more willing to adopt (e.g., conservation tillage).
  - Bring outside beneficiaries of water quality improvement into the process, if possible. Such outside partners may reside far outside the immediate watershed, but as stakeholders, may bring substantial resources, energy, and expertise into the program.
  - Recognize that despite the best possible incentives, some farmers will not adopt conservation practices. To achieve implementation objectives—and to focus treatment on critical source areas—governments and agencies may need to consider applying more persuasive means than simply offering cost share to increase adoption of

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    - needed conservation measures. This may ultimately include application of pollution control regulations.
    - Look for funding opportunities, and be creative. Notably holistic programs were seen in the Cannonsville Reservoir in New York and the Cheney Lake Watershed in Kansas, where the watershed programs developed effective relationships with end users—the municipalities that supply the water. These holistic programs included increased funding opportunities and farmer-led organizations. Projects that rely on end-users cannot work everywhere, but they can be expanded, perhaps significantly.
- Follow up after installation of conservation practices with the following steps:
    - Track the location and timing of implemented conservation practices and make sure the information is available in a format useful for project assessment.
    - Ensure that operation and maintenance of conservation practices is sustained over time. As a whole, this synthesis found that management practices, such as nutrient management, were more difficult for producers to implement and were more often abandoned (Jackson-Smith et al. 2010).
    - Provide education and technical support specifically designed to encourage and ensure the continuation and maintenance of implemented practices. Assess how installed practices are functioning and provide guidance on how to adapt as practices mature and/or when local conditions fluctuate (e.g., drought or flood) or change (e.g., crops or cropping systems).
    - Ensure that new practices do not reduce or change the functionality of conservation practices, especially as farmers change agricultural management. For example, conservation tillage that replaces terraces may or may not decrease erosion.

Failure of agencies and organizations to follow these steps in the design and implementation of conservation practices will, in all likelihood, lead to unnecessary and/or ineffective conservation treatment. Many of these recommendations are not new. Similar recommendations were drawn from the Rural Clean Water Program experience (Gale et al. 1993) and were echoed by findings from the Agricultural Research Service CEAP watershed studies (Tomer and Locke 2011). Sanders et al. (1999) published a book over ten years ago titled, *Incentives in Soil Conservation: From Theory to Practice*, which is filled with many of the same observations and recommendations that are made here.

Because the NIFA–CEAP watershed studies were retrospective and most conservation practices were installed under typical USDA NRCS cost-share programs, there was little systematic effort to implement land treatment in the watersheds using the steps listed above, except in the Little Bear River Watershed in Utah and the Central Platte Natural Resources District in Nebraska NIFA–CEAP studies that did consider data from a Management Systems Evaluation Area Project and groundwater studies, respectively, in implementing conservation practices. Some projects had an identified water quality problem (e.g., sediment or P), and conservation practices were matched to the pollutant, but other implementation steps, such as placing the practices in critical areas or using sufficient numbers of practices, were missing. With reductions in federal and state funding for conservation planning and practice implementation, and increasing costs for both, it is critical that resources be used as effectively as possible to protect water quality. Agencies and organizations promoting practice implementation will need to carefully design conservation programs so that they effectively target specific problem(s) and watershed

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locations. We can no longer afford to continue to disregard lessons learned from watershed-scale analysis; these lessons must be incorporated into national conservation planning.

Improve Project Assessment by Integrating Monitoring and Modeling

Monitoring and modeling are primary tools of watershed conservation assessment; both were key elements in the NIFA–CEAP watershed studies. Because it provides essential data about the resource, water quality monitoring has long been the foundation of water quality management. Monitoring can, however, be expensive and challenging and requires careful design and execution to achieve objectives. Modeling, on the other hand, is indispensable in evaluating alternative scenarios and in forecasting water quality over time. It must be recognized that effective modeling requires actual water quality data for calibration and validation and that application of a model in the absence of observed data can contribute to skepticism and uncertainty about model results that can compromise the utility of modeling for watershed management.

Monitoring can play key roles in watershed projects. Examples of these roles follow:

- Identify problems and impairments
- Assess compliance with regulations
- Establish baseline conditions
- Provide data to support modeling
- Document change
- Provide credibility to project planning
- Assess program or project effectiveness
- Inform stakeholders
- Contribute to behavior change by documenting actual watershed conditions

Water quality monitoring also presents important challenges in watershed projects. Monitoring must be conducted under appropriate objectives with a statistical design that can meet those objectives. Monitoring must be conducted at a frequency adequate to meet objectives (e.g., to document change) and for an adequate duration (e.g., to overcome lag time). Water quality monitoring must be executed effectively, with careful attention to procedural issues like collection of collateral information, regular data evaluation, and institutional coordination. These issues were discussed in detail in Chapter 4.

Modeling also plays a number of critical roles in watershed projects. Examples of these roles follow:

- Support informed choices among alternatives
- Link sources to impacts and evaluate relative magnitudes of sources
- Quantify impacts of management actions
- Identify critical areas for management
- Provide initial estimates of flow and pollutant loads
- Predict pollutant reductions and waterbody response
- Guide monitoring design
- Analyze cost-effectiveness of alternatives
- Help build knowledge of natural processes and response to treatment
- Provide opportunities for collaborative learning and stakeholder involvement

Modeling, too, presents important challenges in watershed projects. Some data are always required for model parameterization, calibration, and validation, and inadequate supporting data can significantly degrade model performance. Technical and financial resources are required for

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modeling that may be difficult to obtain and maintain. Modeling may be impaired by inappropriate or outdated information (e.g., soil surveys, use of curve numbers) or by lack of fundamental understanding of how agroecosystems function. The credibility of model application may be threatened by lack of appropriate or consistent algorithms for simulating conservation practices and by failure to adequately analyze uncertainties associated with model results. Model results nearly always require analysis and interpretation to be useful; failure to provide such support can lead to justifiable skepticism about model results. These and other issues associated with modeling applied to watershed assessment were explored in Chapter 5.

Clearly, monitoring and modeling are not mutually exclusive and can be better integrated in future watershed projects. Each tool has its own strengths and weaknesses, and alone, neither can provide all the information needed for water quality decision making or program accountability.

Future programs should employ the strengths of both tools. Monitoring data can provide real evidence of water quality impairment and can represent the best evidence of water quality restoration. Modeling can extend and apply the knowledge gained and can forecast future response to alternatives. Monitoring can provide fundamental knowledge about the generation, fate, and transport of nonpoint source pollutants. Modeling provides the means to assemble, express, and test the current state of that knowledge and point the way for future investigations.

This synthesis presented specific recommendations for improving the applications of water quality monitoring and watershed modeling for watershed assessment in Chapters 4 and 5. Based on what has been observed among the NIFA–CEAP watershed studies, this synthesis makes the following recommendations for the future integration of water quality monitoring and watershed modeling:

- Use the strengths of both tools by following these guidelines:
  - Simulations and extrapolations must not entirely replace on-the-ground monitoring.
  - Modeling can provide guidance on where and how the on-the-ground monitoring is best conducted.
  - Monitoring cannot practically compare numerous scenarios or extrapolate effects far into the future.
  - Data collected through monitoring are essential for calibration and validation of models and for establishing credibility for model-derived information.
  - The validity of model application and the type of questions that are addressed must be corroborated by watershed stakeholders.
  - Models are underutilized for collaborative learning purposes. Their use within collaborative frameworks must be promoted to incorporate feedback from stakeholders while demonstrating how decisions at the field-scale affect the environment.
- Start from objectives, not from a budget bottom line, for the following reasons:
  - Models selected by cost or convenience before setting objectives are unlikely to meet needs—select a model suitable for the project.
  - A monitoring program based solely on budget may collect too few samples too infrequently, yielding data that cannot serve project objectives.
- Pay attention to source data while heeding the following considerations:
  - Availability of data at consistent scales and of known quality is essential to an integrated monitoring-modeling effort.

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  - Spatially and temporally explicit land treatment and agricultural management data are necessary for both water quality monitoring and watershed modeling.
- Evaluate the suitability of both existing monitoring data/programs and proposed model(s) for the project with these concepts:
  - Evaluate existing monitoring data for quality, consistency, and suitability for project purposes.
  - Evaluate candidate watershed models for applicability to watershed characteristics, technical competence, and resources necessary to apply and support modeling in the project. Application of multiple models can enhance the credibility of model-derived information.
  - Verify that important watershed characteristics (e.g., claypan soils) and conservation practice functions can be adequately represented in the selected model(s).
  - Insist that these issues of data and model suitability be addressed in the project planning and proposal review stage. Funding agencies should ensure these items are addressed before a project is approved and funded.
- Include a documentation plan for both monitoring and modeling that includes the following:
  - Use a formal quality assurance project plan to guide and document all aspects of the monitoring and modeling efforts.
  - Lay out the purpose of model application and the justification for the selection of a particular model.
  - Document the model name and version and the source of the model.
  - Identify and document model assumptions.
  - Document data requirements and sources of datasets to be used.
  - Provide estimates of the uncertainty associated with modeling results, particularly when they are used to quantify the environmental benefits of practices.
- Coordinate water quality monitoring and watershed modeling activities in a project so that information from each effort can be collected, shared, and combined at appropriate times to meet project goals.

Conclusions

To improve water quality, it is essential to carefully and strategically manage how and where conservation practices are implemented, regardless of whether conservation efforts are managed through federal, state, or private programs. Not all of these conservation efforts, however, need modeling or monitoring; such activities require significant financial and professional resources, and there are many examples where modeling or monitoring did not provide benefits. Agencies, including the USDA and the US Environmental Protection Agency, as well as nonprofit organizations, should fund a subset of watershed conservation efforts that include intensive effects assessment. When monitoring and modeling are included, these tools must be used correctly to develop project assessment relative to improving water quality.

This synthesis provides many observations and recommendations to improve conservation planning and ultimately improve and protect soil and water resources in the United States. The most important lesson learned is that an effective watershed management program requires many participants working in concert, with input from key stakeholders, including farmers and others affected by water quality concern and the actions proposed to address it. Conservation practices that managers recommend must be based on solid science and economics and must

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have the potential to achieve water quality goals of stakeholders. Once science has identified what is needed, farmers, agency personnel, and the private and nonprofit sectors must work together to get those practices on the ground in the right places and ensure that they are properly managed and maintained. This requires that all parties understand what farmers can and will accept and that practices be tailored to meet those demands while still achieving water quality goals. It also is critical that education, technical assistance, and financial assistance be consistent, well organized, and highly coordinated. Finally, correcting water quality problems and protecting water resources at the watershed scale are on-going processes that will require effective support and adaptive management to achieve true, long-lasting sustainability.

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