FY 2006 Annual Report for National Program 201 - Water Resource Management

Introduction

Water is fundamental to life and is a basic requirement for virtually all of our agricultural, industrial, urban, and recreational activities, as well as the sustained health of the natural environment. As the world's population tripled during the last century, demand for the finite amount of Earth's fresh water resources increased by six-fold. The United Nations estimates that over 1 billion people live without access to clean water, and over 2.4 billion people lack the basic sanitation needed for human health. The U.S. Environmental Protection Agency has estimated that it will cost in excess of $150 billion to provide clean and safe water to the Nation. Fresh water supply shortages—already evident in the drought-ridden western United States—annually cost the Nation in excess of $8 billion per year in addition to untold environmental impacts. When only freshwater withdrawals are considered, agriculture is clearly the largest user of water in the United States; thus agriculture has the greatest opportunity to conserve water supplies and improve water quality through scientific discovery.

The goal of USDA/ARS Water Availability and Watershed Management National Program is to manage water resources effectively and safely while protecting the environment and human and animal health. This goal will be achieved by characterizing potential hazards, developing management practices, strategies and systems to alleviate problems, and providing practices, technologies and decision support tools for the benefit of customers, stakeholders, partners, and product users. Research in this National Program addresses six component problem areas: (1) effectiveness of conservation practices; (2) irrigation water management; (3) drainage water management systems; (4) integrated soil erosion and sedimentation technologies; (5) watershed management, water availability, and ecosystem restoration; and (6) water quality protection systems.

The mission of this National Program is twofold: (1) to conduct fundamental and applied research on the processes that control water availability and quantity for the health and economic growth of U.S. citizens; and (2) to develop new and improved technologies for managing the Nation's agricultural and water resources. Advances in knowledge and technologies provide producers, action agencies, local communities, and resource advisors with the practices, tools, models, and decision support systems they need to improve water conservation and water use efficiency in agriculture, enhance water quality, protect rural and urban communities from the ravages of drought and floods, improve agricultural and urban watersheds, and prevent the degradation of riparian areas, wetlands, and stream corridors.

ARS, in cooperation with the Natural Resources Conservation Service (NRCS), the Cooperative Research Extension and Education Service, the Environmental Protection Agency, and other Federal and State agencies, has developed a watershed assessment project called the Conservation Effects Assessment Project (CEAP). The purpose of CEAP is to provide a methodology for documenting the national and regional environmental effects and benefits obtained from USDA conservation program expenditures.

The National Agricultural Library (NAL), Beltsville, MD, has developed a series of 6 CEAP-related bibliographic databases that are available to the public through the NAL web site: http://www.nal.usda.gov/wqic/. This dynamic relational database offers more than 5,200 citations of current research findings from around the globe to help scientists and the public understand the environmental effects and benefits of conservation practices implemented through various USDA conservation programs.

National Program Staff continue to coordinate ARS water resource related activities with regional, national, and international partners. Outreach activities during FY2006 included sponsorship of national and international conferences to address the availability and quality of recycled water for use in agricultural sectors in association with the WaterReuse Association and the Council on Agricultural Sustainable Technology (CAST). A milestone of CEAP activities during FY2006 was the workshop, “Managing Agricultural Landscapes for Environmental Quality,” organized by the Soil and Water Conservation Society in support of USDA’s Conservation Effects Assessment Project, held Oct. 11-13, 2006, in Kansas City, MO. The workshop featured 114 contributed papers and 72 poster presentations describing the results of CEAP-related research by ARS and affiliated scientists. The proceedings of this workshop are available through the Soil and Water Conservation Society web site: http://www.swcs.org/.

The National Program Staff coordinates with other government agencies to leverage agency resources through its active participation in the following intergovernmental committees: (1) the Committee on Environment and Natural Resources (CENR) (the relevant National Science and Technology Council committee for water research) Subcommittee on Water Availability and Quality (SWAQ), a subcommittee within CENR devoted to water issues that serves as a forum for agency representatives to share information about their respective programs ; (2) the National Agricultural Research, Extension, Education and Economics (NAREEE) Advisory Board, which evaluates USDA Research and Development Programs and provides recommendations to the Secretary and REE Undersecretaries; (3) the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, charged by Congress with conducting a reassessment of (i) nutrient load reductions and the response of the hypoxic zone, (ii) water quality throughout the Mississippi River Basin, and (iii) economic and social effects, that is scheduled to be completed in November 2007; (4) the Scientific Assessment of Freshwater Harmful Algal Blooms; (5) the Federal Principals’ Meeting on Chesapeake Bay Protection and Restoration and various activities related to water quality in Chesapeake Bay; and (6) the Conservation Effects Assessment Project Steering Committee and a variety of other CEAP-related activities, to name just a few.

Selected Accomplishments:

1. Effectiveness of Conservation Practices

Minimizing erosion and sediment loss. Agricultural practices can be a significant source of sediment in a watershed. Modern agriculture uses conservation practices to minimize erosion and sediment loss, while other land uses (e.g., urban and suburban development) can also represent significant sources of sediment. Until recently, there have been no readily available techniques for determining the primary sources of sediment in a watershed. ARS scientists at the National Sedimentation Laboratory in Oxford, MS, compared the physical and chemical properties of suspended sediments in the stream at the mouth of a watershed to soil characteristics of discrete areas within that watershed. The physical, chemical, and isotopic signatures of the suspended sediment collected at the six subwatersheds were used in a mathematical model to identify the primary contributing source within the watershed. Based on this analysis, subwatersheds with the lowest Aggregation Index (a measure of soil structure) contributed the largest amounts of sediment exported. In a complementary study, ARS scientists in Tucson, AZ, developed methodologies for using tracers to quantify sediment detachment, transport, and deposition in rangeland landscapes. As a result of these studies, it is now possible to estimate source, fate, and transport of carbon and sediment transport based on soil properties in agricultural watersheds.

Summer land management practices impact runoff and water quality. Scientists from ARS' Grazinglands Research Laboratory in El Reno, OK, used rainfall simulators to show that runoff, sediment, nitrate, and phosphorus (P) levels were higher from winter wheat followed by summer fallow (WWF) than for winter wheat followed by summer legumes. They found that the worst case scenario was grazed WWF pastures, where 71% of applied rainfall was lost as runoff, accompanied by the greatest losses of sediment, nitrate, bio-available and water soluble phosphorus. Understanding how alternative summer management practices interact with late summer storms will help producers reduce soil erosion, enhance the capture of water resources, and increase production in these water limited agricultural landscapes.

A model for predicting non-point source pollution in agricultural watersheds. The AGricultural Non-Point Source Pollution Model (AGNPS) is a joint USDA-ARS and -NRCS system of computer models developed to predict non-point source pollutant loadings within agricultural watersheds. It contains a continuous simulation, surface runoff model designed to assist with determining BMPs, the setting of TMDLs, and for risk & cost/benefit analyses. Within the USDA Conservation Effects Assessment Project (CEAP), the National Sedimentation Laboratory in Oxford, MS, is using CEAP to assess the effects and benefits on agriculture and in-stream conservation practices. Subsurface hydrologic components have been incorporated into the AGNPS system to describe tile drainage and lateral subsurface flow processes within individual fields draining to downstream channels. Earlier, aquaculture, stream erosion, stream channel restoration, and in-stream structures features along with RUSLE2, used by NRCS to evaluate the degree of erosion on agricultural fields, were incorporated into AGNPS. Summaries of AGNPS capabilities can be found at http://www.ars.usda.gov/Research/docs.htm?docid=5199. Recent AGNPS success stories include working with the State of Mississippi and Louisiana to conduct TMDL assessments; working with the NRCS Special Emphasis CEAP Stemple Creek watershed in California to develop watershed management plans on how best to reduce sediment and nutrients that would otherwise travel directly into the Pacific Ocean; and working with the State of Arkansas to evaluate irrigation technologies and intense poultry farming practices that are presenting unique water quality problems. ARS scientists at Oxford are continuing to partner with the USACE, USEPA, NRCS, ARS, and Ohio state agencies to integrate watershed technologies into the USDA conservation programs and to develop potential water quality trading applications within the Ohio River Basin. The AGNPS system has been or continues to be used on over 500 watersheds throughout the United States

Minimizing the effects of agriculture on Chesapeake Bay water quality. ARS scientists are actively engaged in research to minimize the effects of agricultural practices on nutrient export to Chesapeake Bay. Scientists at the Beltsville Agricultural Research Center (BARC) are examining the effectiveness of conservation practices on water quality at the watershed scale, as part of CEAP. BARC scientists are using the AGNPS watershed model to evaluate the effects of various management decisions/options on water, sediment, and chemical transport to Chesapeake Bay from the Choptank watershed on Maryland's Eastern Shore. ARS scientists are working with the Maryland Department of Natural Resources to provide this tool to producers for use in evaluating management decisions regarding poultry litter applications and various cover crop management practices on water quality in this portion of the Chesapeake Bay watershed.

Improving water quality within the Chesapeake Bay. ARS scientists at University Park, PA, examined within-field spatial variability in crop nitrogen (N) requirements in two fields—one in Pennsylvania's Ridge and Valley Region (PRVR), and the second on Maryland's Eastern Shore (MES). The MES field did not show significant differences in corn response to increasing N fertilizer applications among selected field locations, but N requirements varied by more than 100 lbs. per acre between toe and head slope positions in the PRVR field. Thus in some physiographic regions within the Chesapeake Bay watershed, there can be sufficient spatial variability in N requirements to warrant varying fertilizer application rates. Based on these studies, adopting precision agricultural techniques in these physiographic regions will help reduce N transport to the Chesapeake Bay, thus improving Bay water quality.

2. Irrigation Water Management

Adopting crop water use estimates nation-wide. ARS scientists at the Water Management Research Unit in Parlier, CA, have developed methods to predict crop water use and irrigation scheduling that can be generalized to a wide range of horticultural crops. They used sophisticated weighing lysimeter and multi-spectral photography to show that the water use of lettuce, peppers, and garlic were all closely related to plant canopy cover and the percent of light that the plants intercepted. In a complementary study, the Soil and Water Management Research Unit in Bushland, TX, in collaboration with university scientists and private consultants, released new sets of standardized equations for crop water use. These improvements are being used by the Texas Cooperative Extension (TCE) AgriPartner program, the Panhandle Water District, the North Plains ET Network, numerous Federal and state Agencies, producers, professional societies, and the international community via the United Nations; and a web site (http://txhighplainset.tamu.edu/) provides current information to producers and the general public worldwide. These results have significant impact on irrigation management to increase agricultural water use efficiency. According to NRCS data, USDA conservation programs provided cost sharing incentives for total irrigation water management, which increased irrigation scheduling in combination with some irrigation practice improvements, on nearly 4 million acres in 2005 and 2006. The associated water and pumping cost savings from primarily improved irrigation scheduling should exceed many tens of millions of dollars per year.

Improving irrigation efficiency based on remote sensing technologies. Increasing irrigation efficiency in arid environments in the western US requires the identification of sensitive spectral indices associated with salinity and water deficit. ARS scientists at the George E. Brown, Jr., Salinity Laboratory at Riverside, CA, conducted lysimeter studies using two forage crops ('Salado' alfalfa and 'Jose' tall wheatgrass) to show that remotely-sensed crop response offers growers, irrigation managers, and extension specialists a reliable tool for detecting plant stress prior to the onset of visual signs of crop injury and for preventing irreversible stress-induced changes that reduce crop yields. In a complementary study, ARS researchers at the Arid Land Agricultural Research Center in Maricopa, AZ, developed wheat crop coefficients (Kc) via remote sensing for accurate determinations of crop water use during the growing season. According to the NRCS Performance Result System, remote sensing and/or plant stress detection practices similar to these are currently used on about 2000 acres, with the goal of optimizing irrigation scheduling and reducing irrigation water application amounts by at least 10 percent. Use of these practices is projected to exceed one million acres by 2010.

Improving surface irrigation practices based on new decision methods. Engineers at the U.S. Arid-Land Agricultural Research Center, Maricopa, AZ, in cooperation with researchers from Delft University of Technology, developed and applied Model Predictive Control (MPC) to canal operations at the Maricopa Stanfield Irrigation and Drainage District in central Arizona. MPC regulates the delivery of water through irrigation canals, so that only the precise amount of irrigation water needed is delivered to the surfaces of irrigated fields in a timely manner. Another decision tool developed by scientists at Maricopa is the comprehensive surface irrigation software product, winSRFR, which consolidates the surface irrigation programs SRFR, BORDER, and BASIN, and routines for analyzing surface irrigation evaluation data, into a single Windows-based, user-friendly application and is available free to the public at http://www.ars.usda.gov/services/software/download.htm?softwareid=146. The combined usage of automated irrigation canals along with on-farm improvements based on the latest irrigation software product will improve surface irrigation deliver and application efficiencies by as much as 5 percent beyond the current 55 percent throughout the western United States. NRCS alone provided irrigation design and other on-farm improvements for surface irrigation practices on some 130,000 acres in FY 2006 using ARS based technology.

Economic evaluation of irrigated agriculture in the Ogallala Aquifer region. ARS scientists at Bushland, TX, developed Groundwater Availability Models (GAMs), for each county of the southern Ogallala Aquifer region, with the overall goal of maximizing the net income from crop production. Results from the 60-year analysis involving 9 major crop species, indicated a significant transition from irrigated agriculture to dryland farming. Using the Panhandle sub-region as an example, total irrigated crop acres in the study area decreased by approximately 83% from 1.79 million acres to 0.30 million acres while total dryland crop acres increased by about 125% from 1.20 million acres to 2.69 million acres. Total groundwater use in the study area declined by 71%, from 2.16 million acre-feet to 0.63 million acre-feet, and the average saturated thickness of the Ogallala Aquifer in the 23 counties showed a 21% decline over the planning period. Similar results were found for the other sub-regions when no water-use policy changes were anticipated. In 2006, ARS scientists incorporated crop and animal data, well locations, bed rock geology from agricultural statistics reports, long-term climatic datasets, and more recent information from other state and Federal agencies into a Geographic Information System (GIS), and a preliminary analysis was conducted to estimate potential reduction in agricultural water use with alternative crops such as cotton and sorghum. Future plans are to use this GIS database in combination with a GAM, to evaluate five alternative economic scenarios or water-use policy changes. At the same time, ARS scientists in Lubbock, TX, showed that their BIOTIC system (which continuously measures canopy temperatures) is a visible approach for producing profitable cotton yields under a high level of water use efficiency where the crop remains in a water deficit throughout the growing season. ARS is providing leadership by identifying: 1) opportunities for reducing irrigated acreages; 2) alternative economic scenarios for the continuation of highly-efficient irrigation technologies; and 3) deficit irrigation practices that can successfully be implemented throughout most of the southern Ogallala Aquifer region. A new web site (www.ogallala.tamu.edu) has been developed to distribute fact sheets, published materials, and specific information about this project.

3. Drainage Water Management Systems

Managing water quality and nutrients using surface drainage systems. ARS scientists at University Park, PA, are working closely with faculty at the University of Maryland Eastern Shore (UMES) to expand basic science and cutting-edge research capabilities of UMES, and train UMES students. Their studies have shown that surface drainage water management practices can reduce dissolved reactive phosphorus (DRP) loadings to the Chesapeake Bay by 30 to 50 percent. In a complementary study, ARS scientists at Oxford, MS, conducted a two-year study of ditches draining no-till cotton fields, monitoring nutrient flux along both spatial and temporal gradients and found that managed drainage ditches retained 22-64% of nitrate and ammonium, and 31-60% of DRP and particulate phosphorus (PP), carried in stormflow nutrient loads, but that nutrient retention was governed by hydrologic variations. Similarly, ARS scientists at the National Soil Erosion Research Laboratory in West Lafayette, IN, examined whether the sediments in tile-fed surface drainage ditches served as a sink for P by adsorbing P from the water column, or as a source of P to the water column. As the area drained by the ditch increased, the amount of organic matter, clay and silt decreased in the ditch sediments. They found that land use also has an impact on P dynamics--the greatest increase in P in the water column, and decrease in P buffering capacity, were noted between two sites upstream and downstream of an animal feeding operation. These three studies showed that surface drainage water management systems can improve downstream water quality with very little cost (estimated at > $5 per acre) to the farmer. The Chesapeake Bay Foundation, the Agricultural Drainage Management Systems (ADMS)Task Force, the Hypoxia Task Force for the Northern Gulf of Mexico, and NRCS have all expanded their efforts to apply surface drainage technologies based on these and other ARS and university research. According to NRCS, the use of surface drainage ditches improved 12,000 acres of agricultural lands in 2005 and 2006, principally in the Midwest.

Surface and subsurface drainage management systems provide ecological benefits. In 2005, ARS' Soil Drainage Research Unit in Columbus, OH, initiated research to determine the influence of grassed buffers and farming practices on the physical habitat and aquatic communities within agricultural drainage ditches. Initial results indicate that drainage ditches are important habitats for fish within agricultural watersheds, and suggest that incorporation of environmental considerations into the management of ditches will benefit the fish within these systems. Additionally, these findings suggest that those conservation practices that alter the hydrological characteristics of drainage ditches will have the most impact on fish and other aquatic animals living within ditches. Improvements in surface and subsurface drainage management systems have been showcased at a number of field days, conferences, and professional meetings attended by farmers, technical agency employees, administrators, elected officials, and other scientists; and the web site (http://extension.osu.edu/~usdasdru/ADMS/ADMSindex.htm) for the Agricultural Drainage Management Systems(ADMS)Task Force is maintained by ARS in Columbus, OH. Surface and subsurface drainage ditches, as reported in the NRCS Performance Result System, were improved on nearly 40,000 acres in 2005 and 2006.

Quantifying the economic benefits of improved drainage water management systems. ARS scientists from the Midwest (Ames, IA), Pacific West (Tucson, AZ), and Northern Plains (Fort Collins, CO) regions have been collaborating on quantifying the effects of tillage, crop rotation, N management (application method, timing, and rate), and winter cover crops along with controlled subsurface drainage, as part of a drainage water management systems, to determine their combined and individual effects on N loading, corn and soybean yields, and economic returns. Various management systems/options are being simulated using a suite of models developed by ARS (RZWQM, RZWQM-DSSAT, and APSIM); with model results then being compared to observed data from ARS field studies and the scientific literature. During testing of RZWQM-SWAW, ARS scientists found that a plant's response to water stress varied from crop to crop, requiring slightly different water stress indices. This knowledge is now included in crop growth models. The collaborative effort received the Federal Laboratory Technology Transfer Award for FY 2006.

4. Integrated Soil Erosion and Sedimentation Technologies

Rapid assessment of sediment accumulation in water reservoirs. As dams and reservoirs reach the end of their life expectancy, their state and performance must be assessed, and decisions made regarding their future. The traditional approach for determining accumulated sediment volumes and sediment characteristics is sediment coring, which is both time-consuming and expensive. ARS scientists at Oxford, MS, developed a prototype acoustic sediment probe to complement current methods of assessing sediment accumulation in reservoirs. This probe was used in three small reservoir sites in conjunction with the extraction of physical core samples. Preliminary analysis indicates a good correlation between the bulk density profile of the core samples and the acoustic speed profile measured at the same location, which could lead to the development of acoustic measurement and monitoring technologies for characterizing the relationships between acoustic attributes (e.g., acoustic velocity) and sediment physical properties (e.g., bulk density). The acoustic method is preferable because it is both fast and non-invasive, thus reducing the time and cost of measurements.

Using reservoir sediments as long-term pollution indicators. Concentrations of chemical contaminants in reservoir sediments provide a record of pollution, but because most chemicals are adsorbed to and transported with the sediment clay fractions, comparisons of pre- and post-impoundment sediment chemical composition cannot be made directly without normalizing these two sample sources for clay content. Otherwise, the higher clay concentrations associated with the post-impoundment sediments would falsely suggest greater chemical transport and reservoir contamination in the years since construction. ARS scientists from Oxford, MS, analyzed sediment cores from Grenada Lake for aluminum, arsenic, chromium, copper, mercury, lead, and zinc. When concentrations of these elements were normalized for clay contents, post-impoundment sediments had lower concentrations than pre-impoundment sediments, suggesting that agricultural activities in the watershed have not impacted sediment chemistry in the reservoir. These findings are useful to environmental scientists charged with monitoring and assessing long-term water and sediment pollution trends in water reservoirs.

Managing soil erosion near structures in streams and rivers. Managing local erosion in streams and rivers is important to protect key infrastructure (e.g., road bridge supports, pipelines, and other utility crossings) that can be seriously damaged or destroyed during flooding events. ARS scientists at the National Sedimentation Laboratory in Oxford, MS, with the Dept. of Civil Engineering at Michigan Technological University, used laboratory flume channels to develop techniques to limit erosion near structures in streams and rivers. They developed and published standard protocols for the use of these techniques. These new tools provide cost-effective options to aid watershed managers and engineers reduce the impact of erosion on the Nation’s transportation infrastructure.

A new rangeland erosion model released in 2006. Four computer-implemented erosion prediction models were combined and improved: the Water Erosion Prediction Project (WEPP), the Revised Universal Soil Loss Equation (RUSLE), the Kinematic Runoff and Erosion Model (KINEROS), and the internet-based Hillslope Erosion Model (HEM). Development and application of these models were major accomplishments achieved by ARS scientists at numerous locations since 1995, including West Lafayette, IN, Oxford, MS, Boise, ID, and Tucson, AZ. ARS scientists at the Southwest Watershed Research Center in Tucson, AZ, assembled the world's largest rangeland rainfall simulator database, including over 2000 rainfall simulator events from experimental sites throughout the West. These data were collected, analyzed, and then modeled using the new HEM. The use of this new model, and the rangeland databases upon which they are based, is having a major impact on the economic survival of rural America and agricultural sustainability. This new rangeland erosion prediction tool is available at http://eisnr.tucson.ars.ag.gov . The new HEM will be used to administer national policy through the implementation of the Farm Bill, Emergency Watershed Protection programs, management of public lands, and provide technical assistance to cooperators and stakeholders on western rangelands.

5. Watershed Management, Water Availability, and Ecosystem Restoration

Conserving phosphorus under no-till and conventional-till systems. The advent of phosphorus-based management plans has resulted in conflicting recommendations regarding surface application of manures in no-till systems, which can cause stratification of P in soil profiles, exacerbating dissolved P losses in runoff waters. ARS scientists at University Park, PA compared surface application of dairy manure with incorporation of dairy manure by plowing. While plowing manure into the soil significantly lowered losses of dissolved P in runoff, an increase in erosion following plowing caused total P losses to be roughly equivalent to those observed under surface application of manure. However, leaching losses of phosphorus from surface applied manure were 1.3 times greater than those of incorporated manure, likely due to preferential transport along intact cracks that are disrupted by plowing. These results indicate that incorporation of manure into soil by plowing has mixed benefits to the conservation of P compared to no-till systems, particularly under conditions of high erosion. No-till is still the preferred strategy, with the caveat that some additional P leaching to ground waters may eventually occur. Over the years, ARS scientists have transferred numerous research findings to NRCS, leading to the delivery of nutrient management plans on over 8.7 million acres of farmlands in 2005 and 2006.

Estimating watershed hydrology and hydraulic properties using remote sensing techniques. Fluctuations in soil moisture and flooding, especially in wetlands, affect biogeochemical processes governing vegetation conditions and the fate of agrochemicals. ARS scientists in Beltsville, MD used synthetic aperture radar backscatter images collected by the ENVISAT satellite over the Choptank Watershed, MD, to map the surface hydrology of forested areas within the watershed. Results demonstrate the utility of satellite radar for mapping surface hydrology in complex landscapes. Resulting maps are useful in water quality management for providing a better understanding of the impact of select agrochemicals on Chesapeake Bay, contributing to Federal interagency efforts to restore the health of the Bay ecosystem.

Large-scale monitoring of drought and crop water stress. Data from the Geostationary Operational Environmental Satellites (GOES) operated by NOAA to support weather forecasting, were used in a model by ARS scientists in Beltsville, MD to map evapotranspiration and moisture stress across the continental United States for 2002-2004. The resulting stress maps correlated well with maps of antecedent precipitation and standard Palmer drought indices. However, the GOES-based stress maps have a higher spatial resolution (5-10 km) and do not depend on precipitation data, making this technology particularly promising for developing regions/countries that lack intensive precipitation measurement networks. The algorithm and data ingestion infrastructure has been automated, paving the way for daily operational moisture stress assessments across the U.S. that could be incorporated into the national drought monitoring program.

Stream restoration in agricultural landscapes. Ecosystems in agricultural watershed streams throughout the US have been degraded by severe erosion, but the links between ecological damage and erosion are often unclear, complicating restoration planning. ARS scientists at Oxford, MS, studied one form of erosion-related stream damage, examining streambed carbon concentrations and fish communities in four streams in northern MS with varying degrees of channel erosion. In general, lightly degraded streams had higher carbon concentrations and more natural, diverse fish communities, suggesting that rehabilitation of stream ecosystems requires restoring riparian vegetation and in-channel features that retain carbon-rich debris and sediments. These findings will be directly useful to planning and designing stream channel restoration and management.

A powerful watershed assessment tool developed and released. The PC-based Automated Geospatial Watershed Assessment (AGWA) tool provides rapid qualitative estimates of runoff and erosion relative to land use change. AGWA is multi-purpose environmental analysis system that integrates a geographical information system (GIS), national watershed data, and state-of-the-art environmental assessment and modeling tools into one convenient package. Full documentation and tutorials was released in April, 2006, by the Southwest Watershed Research Center at Tucson, AZ, and can be downloaded at http://www.tucson.ars.ag.gov/agwa. AGWA currently has over 1200 users from local, state and federal agencies; universities; environmental groups; and, consulting firms, and over 75 countries are using this decision support tool. The decision aid is available through the U.S. EPA Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) water quality website: http://www.epa.gov/waterscience/BASINS/.

6. Water Quality Protection Systems

Improving Mississippi River water quality. ARS scientists in St. Paul, MN, developed a new approach to reducing nitrate losses from subsurface tile-drained fields, involving the planting of cool-season perennial forages, such as alfalfa or grass, directly over subsurface tile drains. Plants remove nitrate from the water table before it enters the tiles, improving the quality of water that eventually enters the Mississippi River. The strips can be harvested for forage or left as wildlife feed and habitat.

Matrix fertilizer reduces leaching losses. Leaching and transport of plant nutrients from agricultural soils to surface waters are linked to eutrophication of fresh water bodies and estuaries downstream. Reducing leaching losses has the potential to increase the protection of off-site water bodies from nitrogen and phosphorus eutrophication and increase fertilizer plant use-efficiencies. ARS scientists from Kimberly, ID, evaluated the effectiveness of several combinations of an aluminum and iron sulfate-starch-chitosan-lignin matrix as a fertilizer additive to reduce nutrient losses from agricultural fields. When the designed chemical matrix was added to a slow release N+P fertilizer, ammonium, and soluble and total phosphorus leaching losses were reduced 75% to 82%.

Benchmark developed for documenting improvement in water quality. ARS scientists in Beltsville, MD, compared the use of best management practices with the frequency and amount of herbicides and pesticides measured in receiving streams in the Choptank watershed. Samples were obtained from 14 subwatersheds at 4 equally-spaced time intervals over a year; concentrations of parent compounds and their major degradates were compared across each subwatershed, and plotted versus the percent of agricultural usage within each watershed. Concentrations of atrazine and its major degradate, desethyl atrazine (DEA), were most strongly correlated with percent agriculture (varying from 0.37 to 0.54), with DEA being consistently the most strongly correlated. These data provide baseline values for discerning differences between tillage and cover crop rotations and are essential information for documenting the environmental impacts of conservation practices.

Wetlands improve water quality. Wetland Reservoir Subirrigation Systems (WRSIS) use wetlands to partially remove nutrients and sediment from surface runoff and subsurface drainage. In order to improve quantification of this benefit, ARS scientists in Columbus, OH, have been monitoring all waters entering and leaving the constructed wetland at the Defiance County WRSIS site since 2003. Based on data from 2003 through 2005, average nutrient (nitrate-N and total P) and sediment concentrations in water discharged from the wetland are significantly less than concentrations in runoff and subsurface drainage routed into the wetland. Average nitrate-N concentration leaving the wetland is only 18% of that for the subsurface drainage routed into wetland. Based on its research findings, ARS assisted NRCS in creating over 12.1 million acres of new wetlands in 2005 and 2006.

Wetlands reduce impacts of pesticides. ARS scientists at Oxford, MS, applied a mixture of two synthetic pyrethroid insecticides, cyfluthrin and lambda-cyhalothrin, to a constructed wetland designed to mitigate runoff from an agricultural field. Populations of an aquatic invertebrate, *Hyallela azteca*, were exposed to samples of water, sediment, and leaf litter collected from the wetland 0 (pre-treatment), 1, 7, 13, 27, 42, and 61 days after pesticide mixture application. Examination of water, detritus, and sediment contamination showed movement of pyrethroids through the wetland cells, and toxicity assessments revealed that *H. azteca* toxicity was greater for water and leaf litter than for sediment. This research introduces a novel technique for assessing toxicity in the often overlooked environmental component (plants) of constructed wetlands.

Vegetative buffers reduce nutrient losses associated with sediment transport. ARS scientists in Ames, IA, evaluated changes in the P content of plant roots and shoots growing in multi-species vs. single species riparian buffers, as an index of P capture potential. Switchgrass, a mixture of alfalfa and smooth brome, or fast growing superior cottonwood were planted in a riparian buffer. Cottonwood accumulated the greatest amount of P compared to the smooth brome control. Estimates of potential P export via biomass harvest from a mixed buffer over a four year interval a 63% increase in export capacity due largely to the inclusion of cottonwood. Addition of a fast growing woody species combined with periodic biomass harvests would help reduce P movement to surface waters. NRCS planted over 172,000 acres of forested riparian buffers in 2005 and 2006, as compared to less than 160 acres of herbaceous buffers based in part on the research findings developed by the ARS.

A new approach to improve groundwater quality in agricultural landscapes. ARS scientists in Beltsville, MD developed an innovative chemical transport model that quantifies the complete spectrum of soil pores without combining the contributions of various pore diameters. This approach was used to improve our ability to model and predict the impact of agricultural practices on groundwater quality. Scientists utilized this information to develop a software package to estimate soil water retention and hydraulic conductivity, and how these properties will change under various agricultural management scenarios. This software has been incorporated into a hydrologic model (Soil - Plant - Atmosphere - Water Field & Pond Hydrology - SPAW) which has been adopted by NRCS and is used across the Nation to help improve water management. This model is available to the public through the ARS Hydrology and Remote Sensing web site: http://hydrolab.arsusda.gov/SPAW/Index.htm.